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STORK Asset Tracker

User Guide

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1 Product Description

1.1 Overview

This document provides a user manual for the *STORK Asset Trackers* developed by TEKTELIC Communications Inc. This document includes descriptions of both STORK variants and instructions regarding the HW capabilities. For more information on the functional operation and SW behaviour, please refer to the TRM document.

The STORK is a low-power LoRaWAN IoT sensor run on a single C-cell LTC battery and packed into a compact IP67 polycarbonate casing. Its primary purpose is to track assets indoors and outdoors using a combination of location-tracking technologies:

- ***Low-Power GNSS:*** Outdoor tracking using satellite geolocation.
- ***Wi-Fi Sniffing:*** Outdoor and/or indoor tracking using Wi-Fi access point geolocation.
- ***BLE Tracking:*** Indoor tracking using BLE beacon network localization.

STORK is a multipurpose device equipped with a variety of technology in addition to geolocation:

- **Core design**: Based on the low-power, IoT-targeted STM32 MCU, which runs the system SW and has a built-in BLE module. The LR1110 transceiver from Semtech handles the LoRa, GNSS, and Wi-Fi operations.
- **Accelerometer**: Detects device motion state so geolocation updates can be sent more frequently while in motion. Motion alarms and the raw acceleration vector can also be reported if knowledge of sensor orientation is of interest.
- **BLE beacon mode**: In this mode, the sensor broadcasts BLE advertisements which make it discoverable by other nearby trackers or BLE-capable devices.
- **Ambient environment sensing**: The temperature and relative humidity of the surrounding environment can be reported, and additional reports can be sent if the conditions cross configurable thresholds.
- **Battery data**: The remaining capacity and lifetime can be reported. The battery lifetime has been estimated to be up to 4.3 years with default settings[1], or 16 months with default Beacon mode settings[2].
- **Magnetic detection**: A magnet can be used to wake from the DEEP SLEEP state (used for shipping) and to force ULs during normal operation.

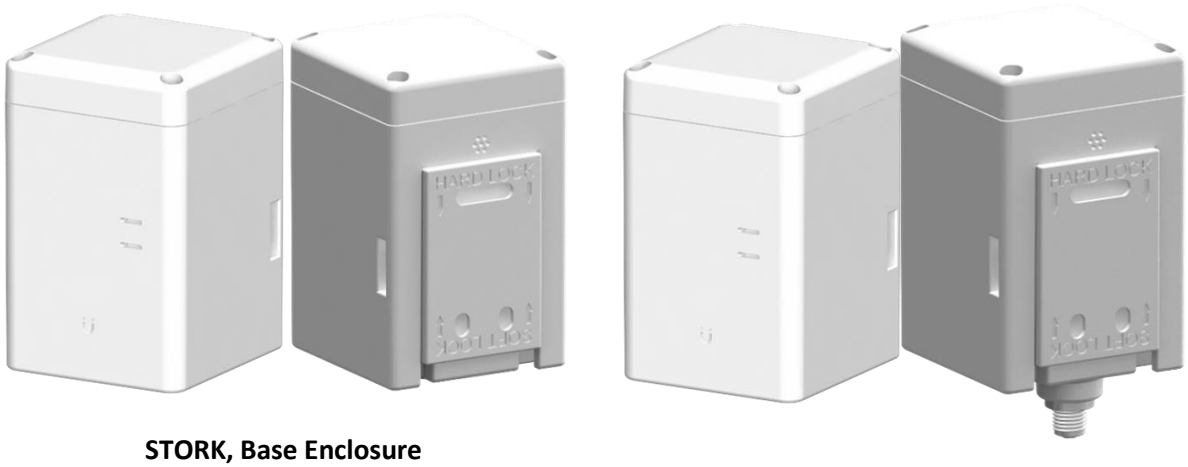
[1] Default settings with 8 hours of movement and 16 hours of stillness, operating at DR3 in the US region.
[2] Default settings with no event-based reports, operating at DR3 in the US region.

1.2 External Appearance and Interfacing

Table 1-1 presents the currently available sensor HW variants, and Figure 1-1 shows the enclosures.

Table 1-1: STORK HW Models

Product Code, Module-Level T-Code	Product Code, PCBA-Level T-Code	Model Name	Description	LoRaWAN Regions Supported[3]
T0008781	T0008357	STORK (NA), Battery Power	GNSS-Wi-Fi-BLE Asset Tracking Sensor (NA Region)	US915
T0008396		STORK (NA), External Power		
T0008953	T0008945	STORK (EU), Battery Power	GNSS-Wi-Fi-BLE Asset Tracking Sensor (EU Region)	EU868
T0008952		STORK (EU), External Power		
T0008781	T0008357	STORK, Battery Power	GNSS-Wi-Fi-BLE Asset Tracking Sensor	AS-923



STORK, Base Enclosure

STORK, External Power Enclosure

Figure 1-1: STORK Enclosure variants

The appearances and external interfacing are shown in Figure 1-1. These are the same for both the base and external power variants.

[3] Other regional variants available upon request.

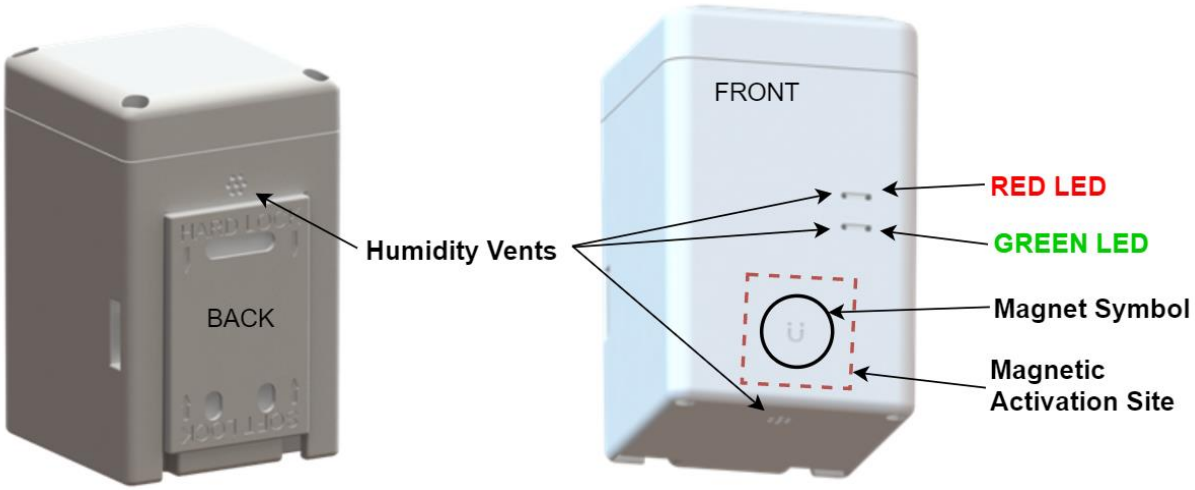


Figure 1-2: STORK Enclosure and External Interfacing

1.3 Information Streams

The information streams supported by the SW are shown in Figure 1-2.

Table 1-2: List of STORK Information Streams

Stream Direction	Data Type	Sent on *LoRaWAN Port* [decimal]
UL (Sensor to NS)	Reports containing sensor data: • Battery life data • Accelerometer vectors and alarms • Ambient temperature • Ambient RH • Geolocation cycle failed message	**10**
	Reports containing GNSS diagnostic information	**16**
	Reports containing discovered BLE device data	**25**
	Responses to read/write configuration and control commands	**100/101**
	GNSS scan results to be forwarded	**192**
	Wi-Fi scan results to be forwarded	**197**
DL (NS to Sensor)	Putting sensor into DEEP SLEEP	**99**
	Configuration and control commands	**100**

1.4 Specifications and Sensing Functions

The STORK specifications are listed in Table 1-3. The main sensing functions are described in the following subsections.

Table 1-3: STORK Specifications

Parameter	Specification
Environmental Rating	IP67 Outdoor
Enclosures and Mounting	Custom design by TEKTELIC
Operating Temperature	-40°C to 70°C
Storage Temperature	-25° to 55°C
Operating Relative Humidity	5% to 95% non-condensing
Storage Relative Humidity	10% to 100% non-condensing
Dimensions	65 mm x 45 mm x 41 mm (with bracket) 65 mm x 43 mm x 41 mm (without bracket)
Weight	63.5 g enclosure + 56.5 g battery = 120 g total (without bracket or probe)
Power Source	Battery: 1x C-cell LTC (3.6 V) External: 9 to 16 V DC, 100mA Supply (external power variants only)
Network Technology/Frequency Band	LoRaWAN in the following Global ISM bands[4]: EU868, US915
Air Interfaces	LoRa, BLE, Wi-Fi, GNSS
Maximum Tx Power	• 15 dBm (LoRa) • 0 dBm (BLE)
Sensing Elements	GNSS receiver, Wi-Fi receiver, BLE transceiver, accelerometer, thermometer, hygrometer, magnetic hall-effect transducer, battery gauge
GNSS Constellations	• GPS L1 + GPS geostationary SBAS: EGNOS and WAAS • BeiDou B1 + BeiDou geostationary GEO/IGSO
Wi-Fi Compatibility	802.11b/g/n
Bluetooth Compatibility	BLE based on Bluetooth 5.3
LoRa RF Sensitivity	Up to -137 dBm (SF12, 125 kHz BW)
BLE Sensitivity (0.1% BER)	125 kbps: -103 dBm 500 kbps: -98 dBm 2 Mbps: -91 dBm
Accelerometer Sensitivity	Sample rate: 1, 10, 25, 50, 100, 200, 400 Hz Measurement range: ±2, ±4, ±8, ±16 *g* Precision: 16, 32, 64, 192 m*g*
LEDs	Green: Joining the network activity or LoRa Rx activity Red: LoRa Tx activity
Battery Gauge Features	Measures remaining capacity [%] and remaining lifetime [days]
Battery Lifetime	4.3 years[5]

[4] Other regional variants available upon request.
[5] With default settings operating at DR3. Applicable to NA region only.

2 Installation

2.1 Included Product and Installation Material

The following items are shipped with each sensor:

- 1x sensor with 3.6 V C-cell LTC battery installed.
- 1x Quick Start Guide.
- 1x mounting bracket.

NOTE: for activation you will need a magnet that is not provided. Suggested magnet: Sintered Ferrite Magnet, Br = 3800-3900 Gauss, Grade 5 = Grade Y30, or Grade 8 = Gradey30h-1.

2.2 Unpacking and Inspection

The following should be considered during the unpacking of a new sensor.

1. Inspect the shipping carton and report any significant damage to TEKTELIC.
2. Unpacking should be conducted in a clean and dry location.
3. Do not discard the shipping box or inserts as they will be required if a unit is returned for repair or reprogramming.

NOTE: to ensure safe installation and maintenance of the device please read Safety Precautions.

2.3 Commissioning

Each sensor has a set of information that must be entered into the network server before activation. For instructions, please refer to the Quick Start Guide in the box (available in the *Knowledge Base*).

You can find the commissioning keys inside the box. If you don't have the box, please raise a ticket in our support portal and provide the Tcode and serial number on the tag placed on the device.

Figure 2-1: STORK Commissioning Keys

2.4 Activation

The sensor is shipped in a secured enclosure with the battery preinstalled in a state of DEEP SLEEP. Activation requires use of a magnet that is not provided by Tektelic and has to be purchased separately.

To activate/reset the device:

1. Place magnet for **3 to 10 seconds** against the enclosure at the magnetic activation site as shown in Figure 2-2 below.
2. Sensor activation will be displayed by **GREEN** and **RED** LEDs turning on.
3. Once activated, the sensor will automatically begin the join process.

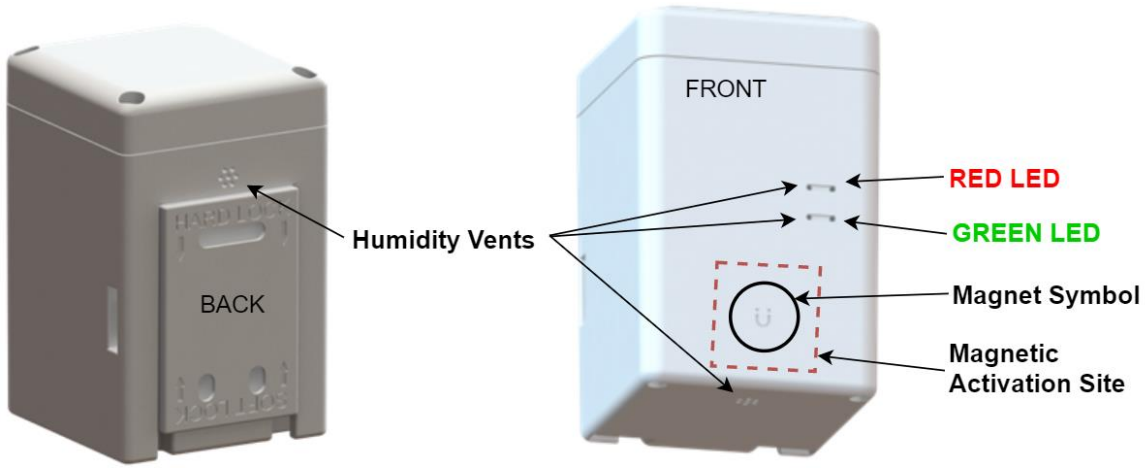


Figure 2-2: STORK Enclosures and External Interfacing

To return to DEEP SLEEP there are two options:

1. Send a Downlink to port 99 (must be joined to network)
2. Apply the magnet for **3-10 seconds** while device is in state of network search (process is indicated by **GREEN** LED active blinking)

2.5 Default Configuration

Table 2-1 lists the default reporting behaviour of the STORK. Reporting behaviour can be changed from default through OTA DL commands.

Table 2-1: Default Reporting Periods

Report	Report Type	Default Periodicity
Battery data	Periodic	24 hours
	Event-based	When magnetic sensor is triggered
Geolocation Update	Periodic	10 min when in motion; 1 hour when still
Acceleration vector	Periodic	Disabled
Accelerometer motion alarm	Event-based	When starts/stops moving
Ambient temperature	Periodic	1 hour
	Event-based	Disabled
Ambient RH	Periodic	1 hour
	Event-based	Disabled

2.6 Reconfiguration

The STORK supports a full range of OTA configuration options. Specific technical details are available in the corresponding TRM documents. All configuration commands need to be sent OTA during the sensor's DL Rx windows.

2.7 Mounting Procedure

The mounting bracket needs to be secured to a wall or another solid surface by using an adhesive or mounting screws. The mounting bracket can be seen in 2-3.

Figure 2-3: Mounting Bracket View

A. For releasable mounting install with "SOFT LOCK" indication with the arrows pointing up.
B. For permanent mounting install with "HARD LOCK" indication with the arrow pointing up.
C. After the bracket has been secured, the sensor can be mounted by sliding the enclosure into the bracket ridges until a click is heard, indicating it is fully inserted.

2.8 Cable Connection

The STORK External Power variants (T0008396 and T0008952) can be powered using an external DC power source following these steps:

1. **Find M5 Connector:** Locate it on the sensor's bottom.
2. **Check Pinout:** Refer to Figure 2-4 and Table 2-2.
3. **Connect Carefully:** Avoid pin damage.
4. **Fuse for High Power:** Use a 5A fuse if power exceeds 100W.
5. **Internal Battery Backup:** Operates without external power.
6. **Verify Voltage:** Ensure input is 9-16V DC.

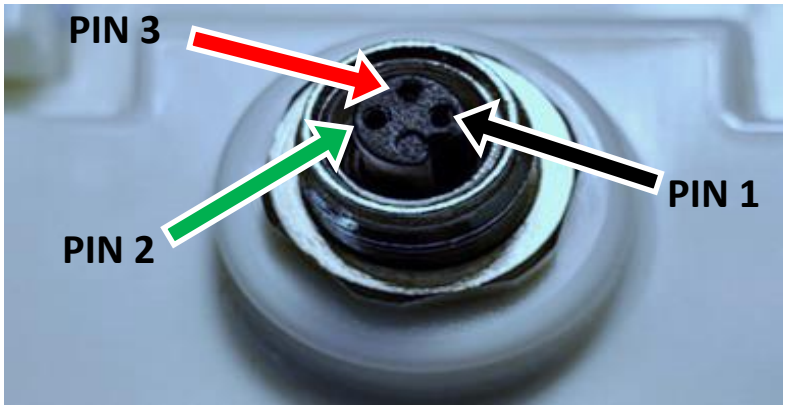


Figure 2-4: Cable Connector Pins

Table 2-2: Cable Connector

Pin	Signal
1	0 V
2	Alarm input
3	+9 to +16 V DC

The external cable is not supplied with STORK. The recommended mating cable is listed in Table 2-3.

Table 2-3: Recommended Cable

Manufacturer	Part Number	Description
Tensility International Corp	10-03011	CBL CIRC 3POS MALE TO WIRE 6'

2.9 RF LED Behaviour

The LEDs are normally off and the main patterns are summarized in Table 2-4. The detailed sequence and timings for each are described in the following subsections

Table 2-4: Summary of LED Patterns

LED Pattern	Meaning
GREEN blinking rapidly and single **RED** flash every 36 s	JOIN mode; attempting to join the network
Single **RED** flash	UpLink sent
Single **GREEN** flash	DownLink received
3 quick **RED** flashes	Entering DEEP SLEEP

2.9.1 Power-On and Network Join Patterns

When the sensor is activated or reset:

Table 2-5: LED Patterns

Condition	Green LED	Red LED	Duration	Notes
Initial activation/reset	OFF	OFF	0.5 sec	Both LEDs are off upon activation/reset.
Power-On Self Test (POST) starts	ON	ON	-	Both LEDs turn on signaling the start of POST.
POST ends	OFF	OFF	~2 sec	LEDs turn off after POST completes.
POST pass	Blink 3 times	OFF	-	Green blinks 3 times if POST is successful.
POST fail	OFF	Blink 3 times	-	Red blinks 3 times if POST fails, and the process restarts.
JOIN mode	Actively blinks	Flashes once every 36 s wile trying to join the network (once per JOIN REQUEST)	Until device joins. Will timeout after 1-hour	Green actively blinks; Red flashes once after sending JOIN REQUEST. Green flashes once after receiving JOIN ACCEPT. Normal operation begins after JOIN ACCEPT.
Unsuccessful network join after 1 hour	OFF	Flash twice	Every 8 s	Green stops blinking; Red flashes twice every 8 seconds during join back-off to conserve power.

2.9.2 Normal Operation Patterns

After the Sensor has joined the network:

a. **RED** flashes after transmitting an uplink.

b. **GREEN** flashes after receiving a downlink.

2.10 Battery Replacement

The battery cover is marked with a battery symbol and uses Phillips Head H1 screws. This cover needs to be removed to replace the battery.

1. Remove the battery cover by unscrewing the 4x Phillips head screws using a size #1 Phillips head screwdriver (see Figure 2-5).

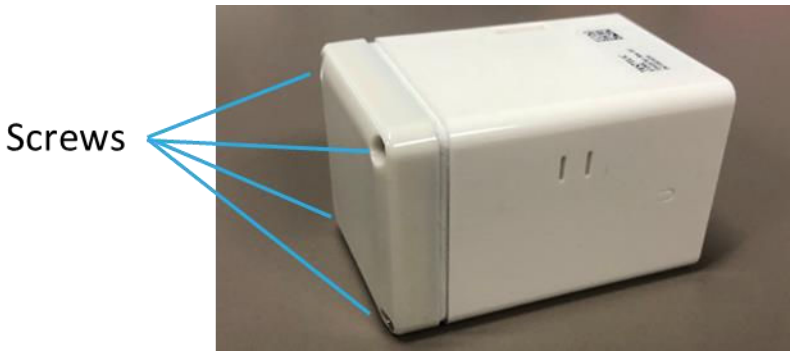


Figure 2-5: Removing the Battery Cover Screws

2. Remove the depleted battery and replace it with a new 3.6V Lithium Thionyl Chloride C-size battery **ONLY**. Insert the battery negative terminal side first. The battery contact on the battery cover is the positive contact and is marked with a plus-sign as shown in Figure 2-6.

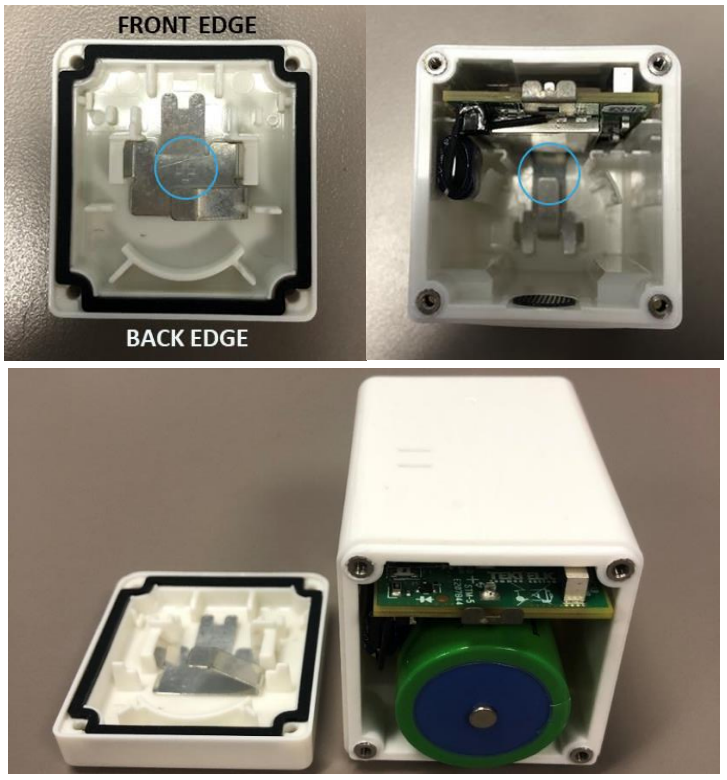


Figure 2-6: Polarity Markers and Battery Insertion

3. Check that the gasket is undamaged and is properly seated and adhered to the battery cover.
4. Before reattaching the battery cover, align it correctly with the sensor chassis based on the rounded corners at the front and sharper corners at the back.
5. Reassemble the cover to the chassis by using the 4x Phillips head screws, using a #1 size screwdriver and up to 0.23 Nm of torque.

2.11 Reset Function

To physically reset STORK perform same steps as to get in out of DEEP SLEEP state:

1. Place magnet against the enclosure at the magnetic activation site as shown in 2-7.

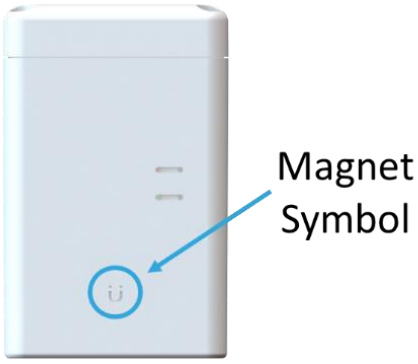


Figure 2-7: Magnet Symbol

2. Sustain magnet for **3 to 10 seconds**. Sensor activation will be displayed by **GREEN** and **RED** LEDs turning on (described in Section 2-11).
3. Once activated, the sensor will automatically begin the join process.

NOTE: Shutting down or resetting the sensor will cause all unsaved user configurations to be lost. Save the desired configuration to the sensor flash before powering off or resetting.

3 Functionality and Operation

3.1.1 Tracking with Geolocation

STORK tracks assets indoors and outdoors using low-power ***GNSS, Wi-Fi, and BLE scanning***. Geolocation cycles occur regularly, with up to three scans in each cycle.

It's vital to set the geolocation update period longer than the expected cycle duration to prevent data loss. If GNSS scanning is on, the update period shouldn't be less than 3.5 minutes, and for BLE scanning, it shouldn't be less than 20 seconds.

The supported scan type options and behaviours are summarized in Table 3-1.

Table 3-1: Supported Geolocation Scan Technologies

Technology	Function	Results Format	Scan Failure Behaviour	Configurable Options
GNSS	LR1110 performs a low-power GNSS scan, then sends the scan results via LoRaWAN UL to compute the position.	NAV message or message fragments containing satellite information.	Fail criteria: too few satellites are detected, almanac is out of date, or clock is out of sync. No UL is sent unless all other scans in the cycle also fail.	• Clock sync parameters • Almanac update parameters • Assist coordinates • Satellite constellation (GPS/BeiDou/both) • Scan mode (mobile/static)
Wi-Fi	LR1110 performs a Wi-Fi scan then sends the scan results via LoRaWAN UL to compute the position.	Discovered Wi-Fi access point MAC addresses and RSSIs [dBm].	Fail criterion: less than 3 Wi-Fi access points are discovered. No UL is sent unless all other scans in the cycle also fail.	None
BLE	MCU performs a BLE scan then sends the scan results via LoRaWAN UL for the GRB to compute the position.	Discovered BLE device MAC addresses and RSSIs [dBm].	Fail criterion: 0 BLE beacons detected. UL containing an empty list is sent.	• Scan duration • Scan duty cycle • Up to 4 discovered BLE device filters

Geolocation cycles can be configured to end after a successful scan, which saves battery life. This prioritizes scan types based on their success likelihood, such as GNSS being available 90% of the time. See Table 3-2 for supported scan order logic options.

Table 3-2: Scan Order Logic Options

A:	1st scan	→	2nd scan if 1st scan fails	→	3rd scan if 2nd scan fails
B:	1st scan	→	2nd scan	→	3rd scan if 2nd scan fails
C:	1st scan	→	2nd scan if 1st scan fails	→	3rd scan
D:	1st scan	→	2nd scan	→	3rd scan

3.1.1.1 BLE Operation with LOCUS and the GRB

The BLE scan results are formatted to enable the TEKTELIC LOCUS application to determine and display the sensor's position. Indoor BLE beacon networks can be virtually created in LOCUS to mirror the physical setup. When LOCUS receives a sensor's uplink with raw BLE scan data, it sends it to the Geolocation Resolver Backend cloud service. GRB calculates and returns the estimated position within the beacon network. For a description of BLE scan behaviour, see the TRM.

3.1.1.2 Geolocation Strategies

The ability to define up to 3 scan types and choose 1 of 4 scan order logic options results in 12 possible configurational combinations. This combination is called the *geolocation strategy*. Of the 12 geolocation strategies, only 7 result in unique device behaviour, as shown by the green shaded boxes in Table 3-3.

Table 3-3: Geolocation Strategies

Strategy Description	Scan Order Logic	Number of Defined Scans		
		3	2	1
FALLBACK • 1st priority scan always done. • Fallback to other scan(s) upon failure. • End cycle upon successful scan.	A	**#1**	**#2**	#7
1 BACKUP • 1st and 2nd priority scans always done. • 3rd scan if both 1st and 2nd scans failed.	B	**#3**	#6	#7
2 BACKUPS • 1st priority scan always done. • 2nd and 3rd scans done if 1st scan failed.	C	**#4**	#2	#7
ALL SCANS • All defined scans always done.	D	**#5**	**#6**	**#7**

Tailor the geolocation strategy to the STORK deployment's specific use case. For instance:

1. **Delivery vehicle tracking:** Use FALLBACK with priority on GNSS, then Wi-Fi, and finally BLE. Since vehicles are mainly outdoors, GNSS is likely to be the most successful, followed by Wi-Fi and BLE.

2. **Pallet tracking in a multi-building site:** Employ 2 BACKUP with BLE as the primary method, then Wi-Fi, and lastly GNSS. As pallets are often indoors with BLE Beacon networks, BLE is the most reliable. If BLE fails, Wi-Fi and GNSS can provide an estimate.

The default strategy is FALLBACK with GNSS, Wi-Fi, and BLE in priority order (scan logic A). See Figure 3-2 for details, with additional strategies in Appendix 3.

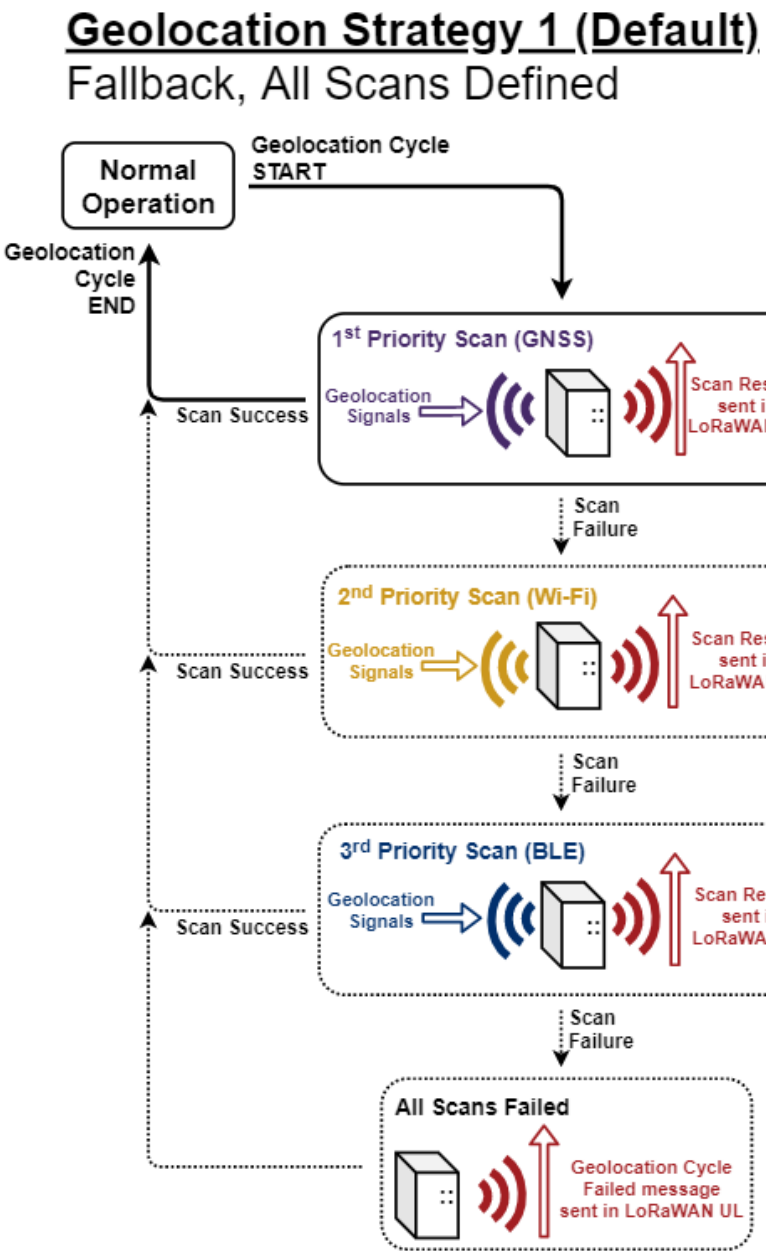


Figure 3-2: Default Geolocation Strategy Cycle Flow

With all geolocation strategies, if all scans fail, the *geolocation cycle failed* message is sent.

3.1.1.3 GNSS and Wi-Fi Operation

GNSS and Wi-Fi scan results are formatted to determine the sensor's position. Key requirements for valid GNSS scans include:

- **Valid clock synchronization**: Periodic sync of internal time, configurable.
- **Valid almanac**: Keep it up-to-date, with configurable update settings.
- **Assist coordinates**: Provide initial location estimate, configurable or auto-obtained.

GNSS scanning options like satellite choice and mobility are configurable, unlike Wi-Fi scanning, which has no options.

3.1.2 Temperature and Relative Humidity Transducer

STORK features a temperature and RH transducer, though its response time may not be immediate due to its location inside the housing. Vents allow air to reach the transducer, and airflow over the sensor can speed up response time. Users can set thresholds and alarm points for temperature and RH. Sample rates for checking the transducers are configurable based on the measured value's operating range.

3.1.3 Accelerometer Transducer

The STORK integrates a 3-axis accelerometer for motion sensing, with optional disabling. It generates customizable acceleration alarms triggered by defined thresholds within a specified period. Detected motion can prompt transitions between geolocation update periods with enabled by default Accelerometer Assist, ensuring timely tracking. Enabled by default, it adjusts update rates for asset tracking: faster when moving and slower when stationary. The accelerometer's output acceleration vector can also be periodically polled for orientation-based applications.

3.1.4 BLE Beacon Mode

The STORK supports a *beacon mode* function as an alternative to geolocation tracker mode.

NOTE: tracker mode is default for the sensor, so it must be switched into beacon mode.

When in beacon mode, the BLE operates in Tx only. It sends out periodic BLE *advertisements* which are small packets of data. These packets are discoverable by other STORKs operating in tracker mode, as well as any other device capable of BLE scanning. Tx power level is a configurable parameter.

After a device joins the LoRaWAN network, it begins broadcasting BLE advertisements. This continues throughout normal operation as a background process.

The user-configurable advertising interval is the time between the beginnings advertisement transmissions as shown in Figure 3-3.

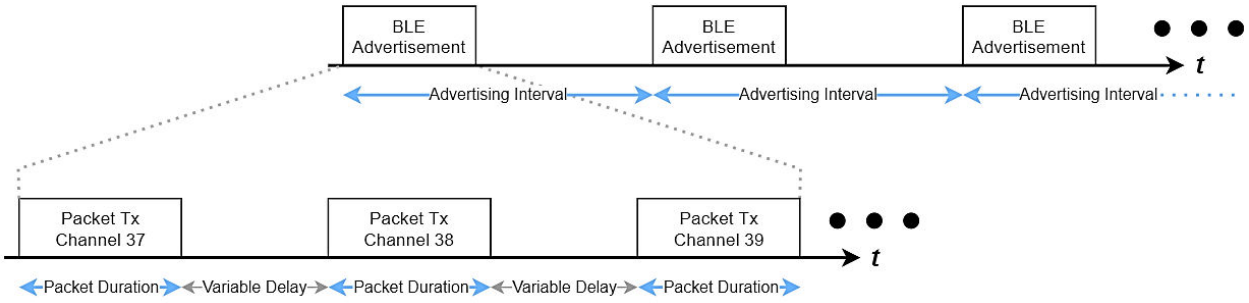


Figure 3-3: The BLE Advertisement Scheme

Figure 3-3 also shows that each single BLE advertisement comprises 3 individual packet transmissions, sent one after another on BLE channels 37, 38, and 39. This is to maximize the chances of a BLE device scanning on a single channel receiving 1 packet per advertising interval.

NOTE: The BLE advertisement and LoRa radio transmission are mutually exclusive. If any LoRaWAN report is due the BLE advertisements are paused while the LoRa activity is occurring.

The BLE advertising packet formatting supports 3 major BLE standards: iBeacon, Eddystone UID, and Eddystone TLM. By default, only iBeacon is enabled.

See the TRM for more details about tracker mode operation and configuration.

3.1.5 Magnetic Sensor

The STORK is equipped with a magnetic hall-effect sensor[6]. Since the enclosures are fully sealed, there is no ability to have a battery pull-tab or reset button pinhole. The magnetic sensor therefore is included to address these purposes:

1. To wake the device from sleep (the sensors are shipped in a state of DEEP SLEEP).
2. To put the device to sleep.
3. To reset the device.
4. To force a LoRaWAN UL.

For more information on how to use the magnetic please refer to the TRM.

[6] A magnet is not included with the STORK.

4 Basic Downlinks

STORK use a "tick" system for reporting data. Generally, the sensor will report most important data every tick. A tick can be measured in seconds.

There are two sets of settings that must be configured in conjunction - "Core reporting tick in seconds" and "Ticks per [data/report]".

"Core reporting tick in seconds" will determine the interval between ticks. For example, you may set it to 30 seconds or 180 seconds (3 minutes) for each tick.

"Ticks per [data/report]" determines how many ticks it will take before the sensor reports it. For example, if you set "Ticks per Battery report" to 2, it will report battery data after 2 ticks.

To Change The Core Report To Every Minute

With ATLAS: check the box for Core report tick in seconds and ticks between ambient temperature reports. Write the values shown in the Figure 4-2 and click send.

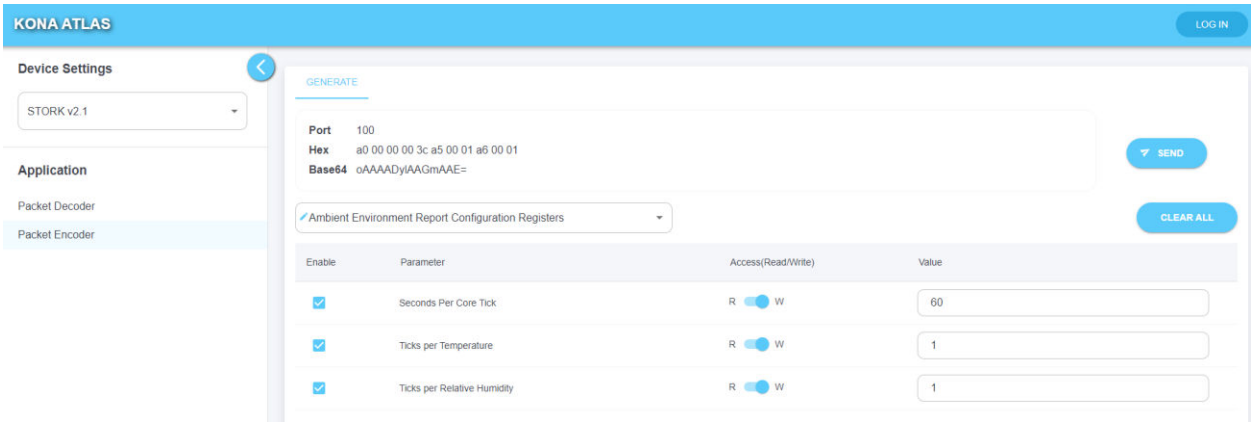


Figure 4-1 ATLAS

Examples Of Uplinks

Example 1

```
"data": {
        "raw": "03 67 00 B9 04 68 4E",
        "fPort": 10,
        "temperature": "18.50",
        "relative_humidity": "39.00"
},
    "errors": [],
    "warnings": []
```

5 Device Configuration with ATLAS

To perform more configuration or read the data of device you can use TEKTELIC's complementary service, ATLAS at www.atlas.tektelic.com.

There are two ways to access ATLAS:

1) Using in Offline mode

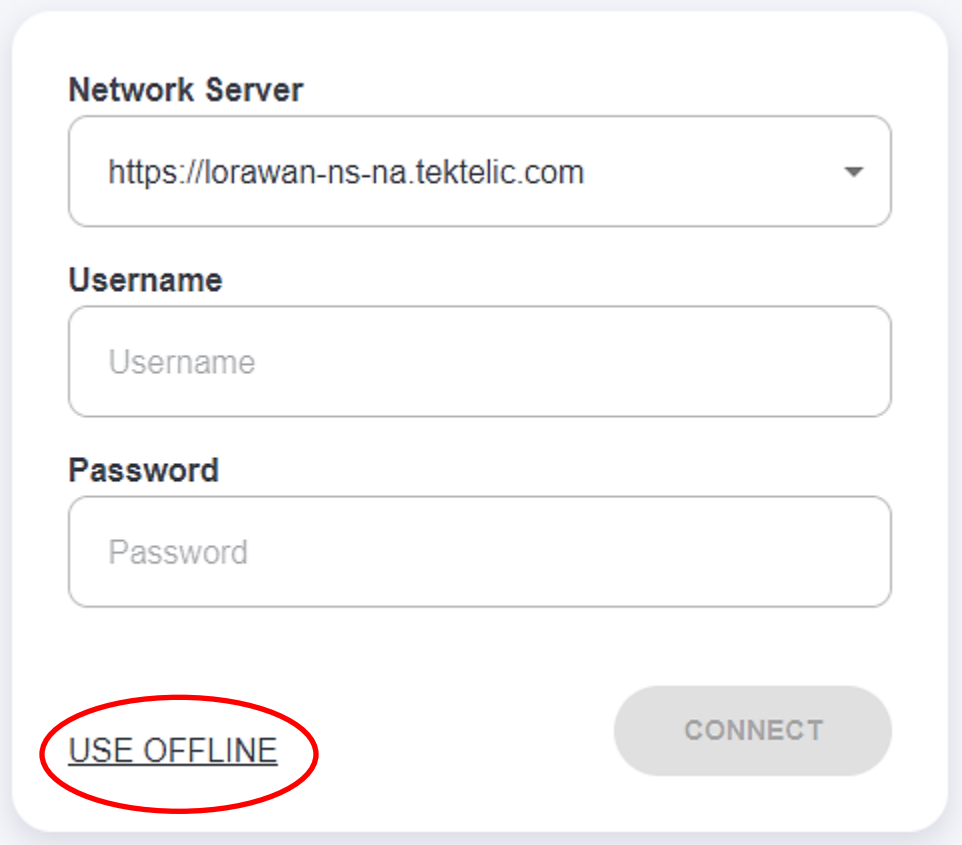


Figure 5-1: Login as offline mode

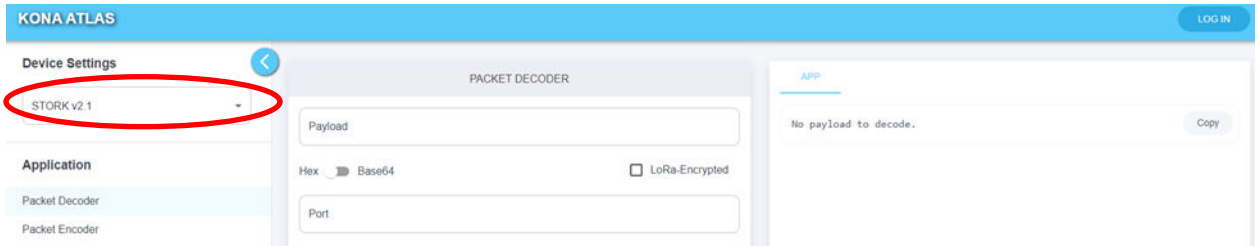


Figure 5-2: Select STORK decoder

2) with your TEKTELIC Network Server Credentials

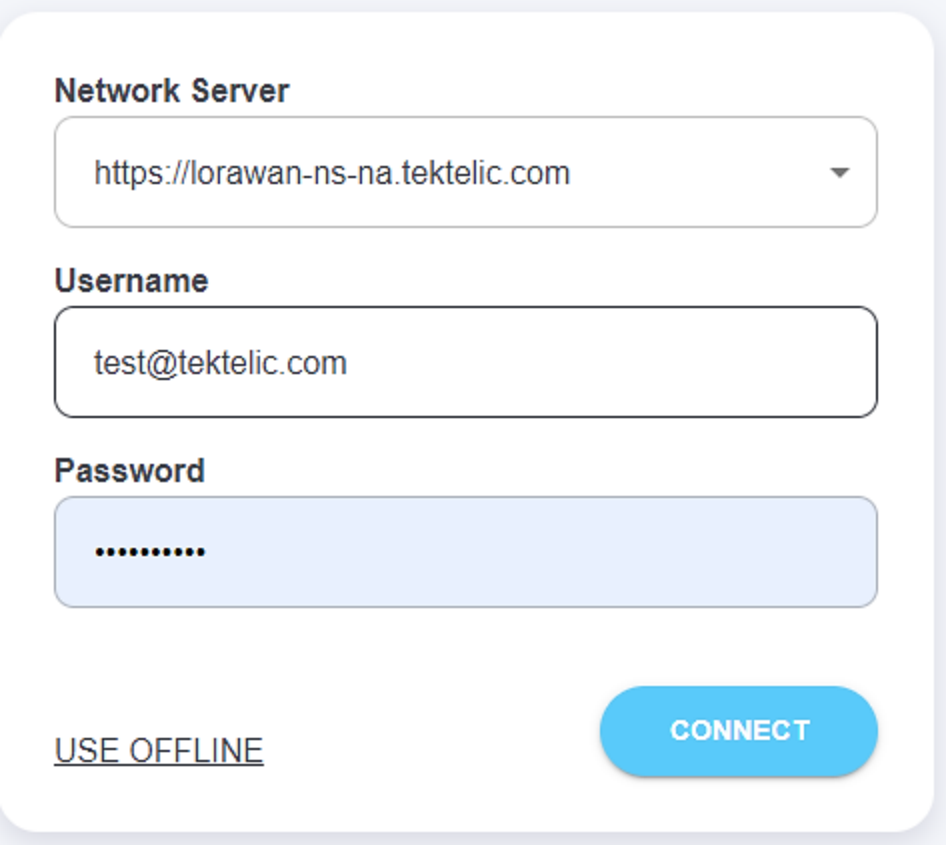


Figure 5-3: Login with Network server credentials

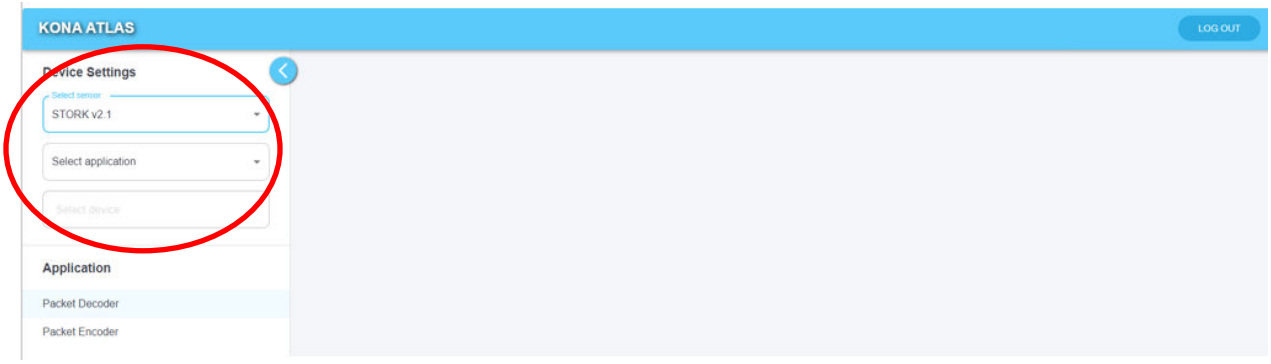


Figure 5-4: Select STORK Decoder, application and the device

For more information follow this link https://knowledgehub.tektelic.com/kona-atlas

6 LOCUS Application

6.1 Description

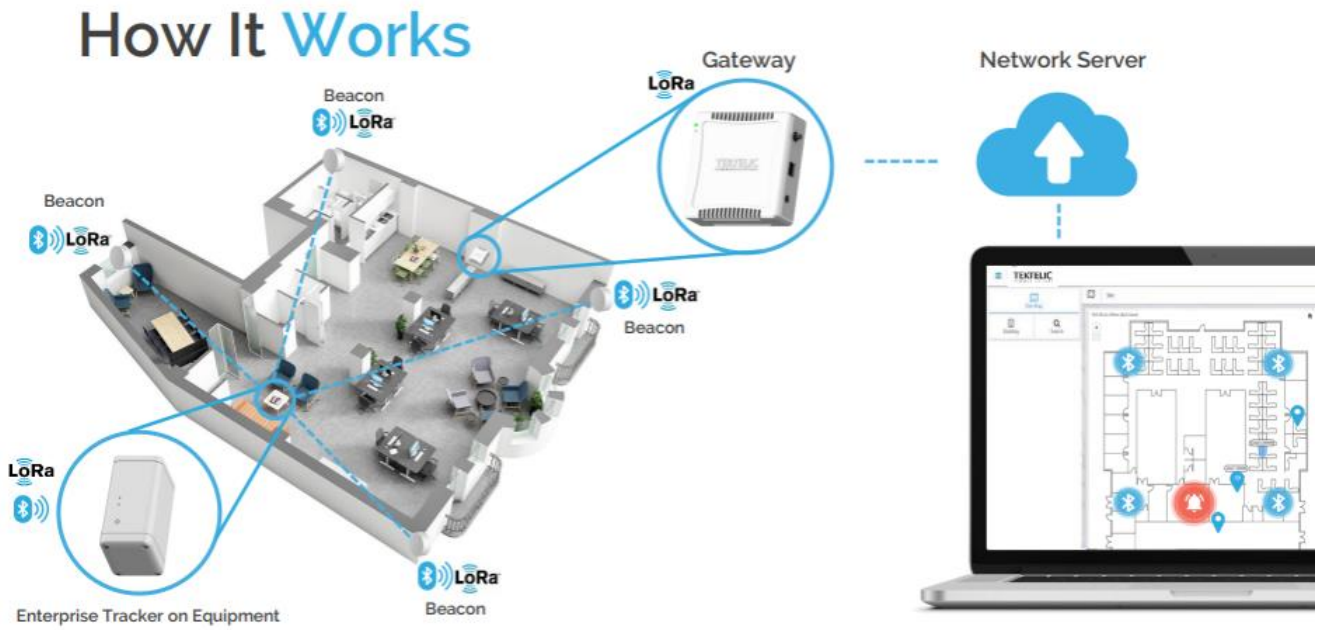
Locus is an application to track and monitor all assets in your network, including indoor, outdoor, and hazardous location asset tracking. Assets can be tracked across entire campuses, multiple buildings, and floors. For more detail about Locus please visit [Locus Application Documentation]

Application capabilities:

- Self managed floor plan/map loading
- User management – permission levels
- Geofencing & alerts
- API to customer database integration
- Support of multiple campuses, buildings & floors
- Device management/battery status
- Integrated to enterprise SAP

6.2 Operation principle

Asset tag localization uses RSSI multilateration. The location is determined by the signal strength reported by the BLE beacon in relation to the asset tag, providing precise location accuracy (2-5m).



7 Data converters

Please follow this link: https://github.com/TektelicCommunications/data-converters/tree/master for the data converters that are to be used on TEKTELIC & other Network Server for TEKTELIC Sensors. These data converters can be used as a reference for other platforms.

TEKTELIC's data converters conform to the LoRa Alliance Payload Codec Specification and can be used with any 3rd party Network Server / Application Server that supports this specification.

https://resources.lora-alliance.org/technical-specifications/ts013-1-0-0-payload-codec-api

8 Compliance Statements and Safety Precautions

8.1 Compliance Statements

Federal Communications Commission:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

To comply with FCC exposure limits for general population / uncontrolled exposure, this device should be installed at a distance of 20 cm from all persons and must not be co-located or operating in conjunction with any other transmitter.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in an industrial installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Innovation, Science and Economic Development Canada (Industry Canada):

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

i. This device may not cause interference, and

ii. This device must accept any interference, including interference that may cause undesired operation of the device.

This device should be installed and operated with minimum distance 0.2 m from human body.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

(1) L'appareil ne doit pas produire de brouillage.

(2) L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Cet appareil doit être installé et utilise à une distance minimale de 0.2 m du corps humain.

California Proposition 65:

⚠ **WARNING:** This product can expose you to chemicals including lead, nickel, and carbon black, which are known to the State of California to cause cancer, birth defects or other reproductive harm. For more information, go to www.P65Warnings.ca.gov.

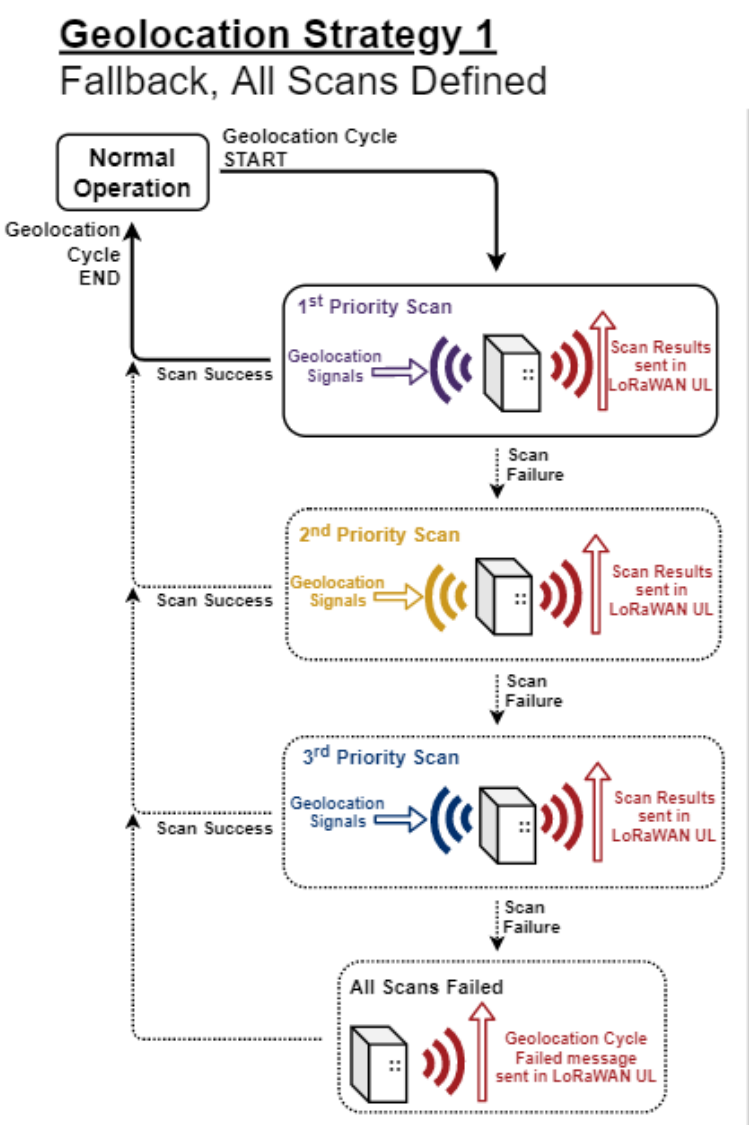
8.2 Safety Precautions

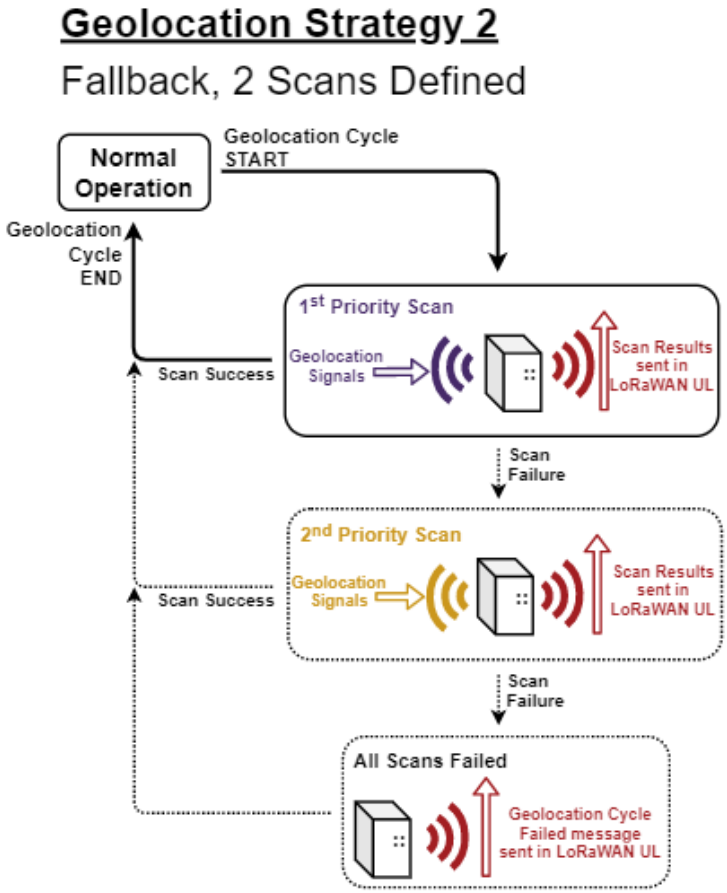
The following safety precautions should be observed for all STORK variants:

- All installation practices must be in accordance with the local and national electrical codes.
- Replace battery only with approved type (see Section 2.10).
- The sensor contains a single LTC C-cell battery. When used correctly, lithium batteries provide a safe and dependable source of power. However, if they are misused or abused, leakage, venting, explosion, and/or fire can occur. The following are recommended safety precautions for battery usage.
  - **Keep batteries out of the reach of children.**
  - **Do not allow children to replace batteries without adult supervision.**
  - **Do not insert batteries in reverse.**
  - **Do not short-circuit batteries.**
  - **Do not charge batteries.**
  - **Do not force discharge batteries.**
  - **Do not mix batteries.**
  - **Do not leave discharged batteries in equipment.**
  - **Do not overheat batteries.**
  - **Do not weld or solder directly to batteries.**
  - **Do not open batteries.**
  - **Do not deform batteries.**
  - **Do not dispose of batteries in fire.**
  - **Do not expose contents to water.**
  - **Do not encapsulate and/or modify batteries.**
  - **Store unused batteries in their original packaging away from metal objects.**
  - **Do not mix or jumble batteries.**

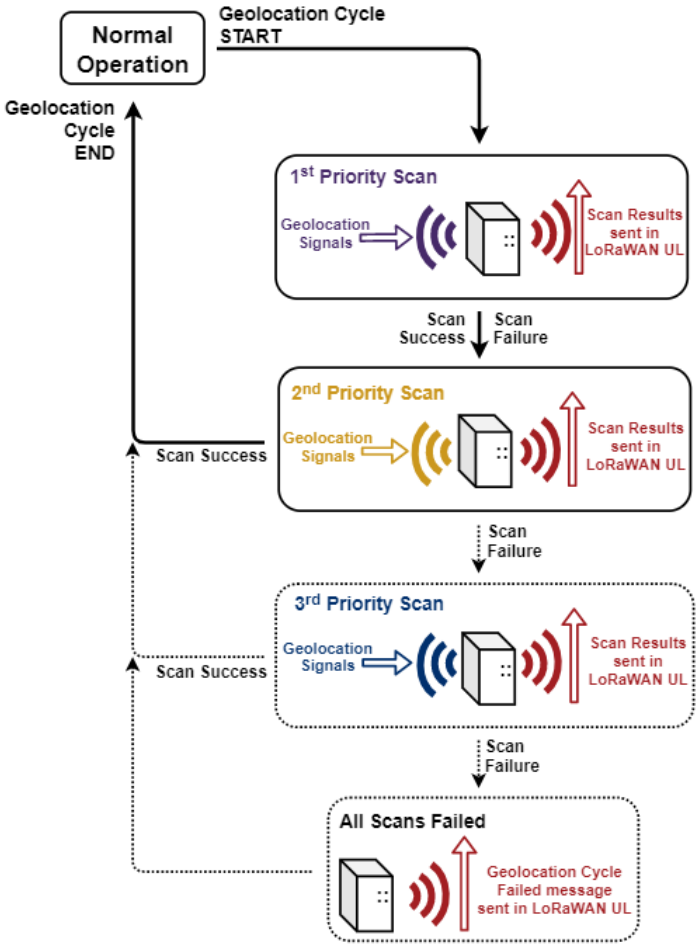
Appendix 1 - List of Geolocation Strategies

Solid lines: process always done. Dotted lines: process done under certain conditions.

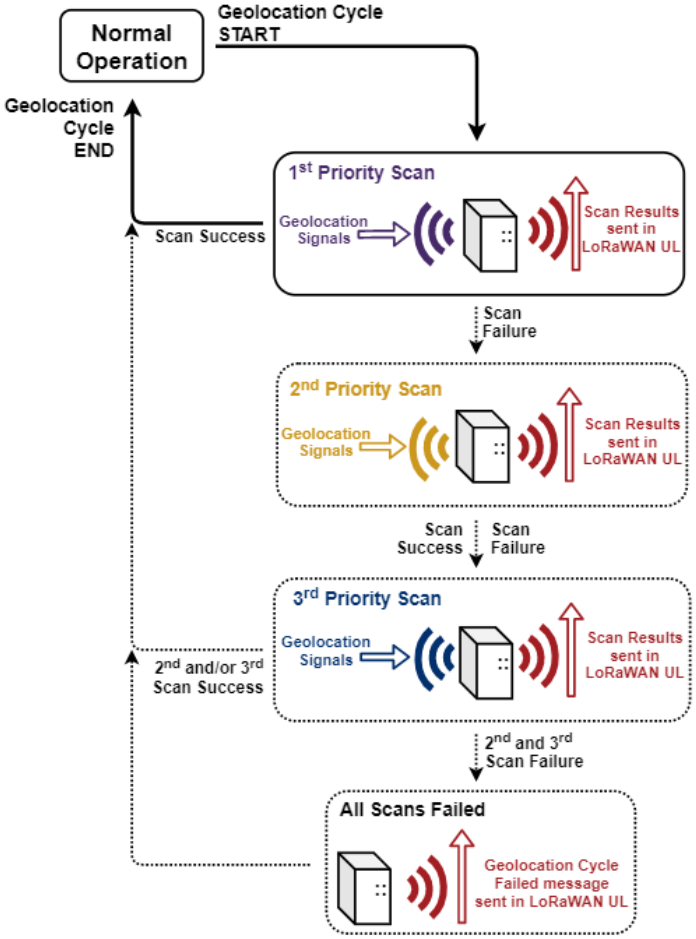




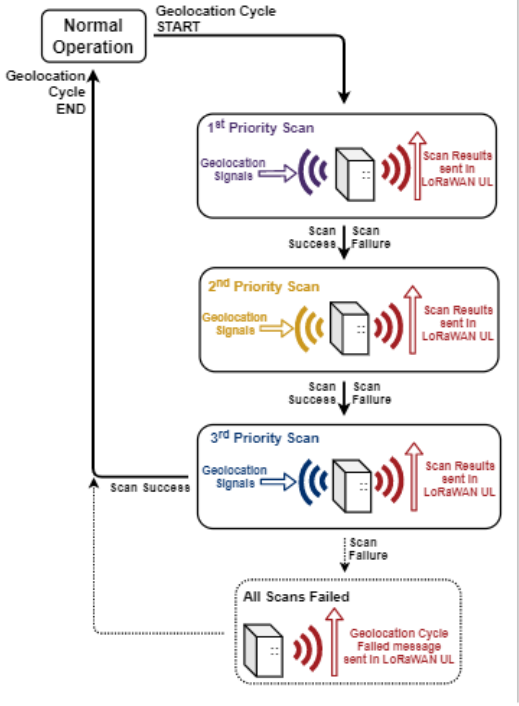
Geolocation Strategy 3
1 Backup, All Scans Defined



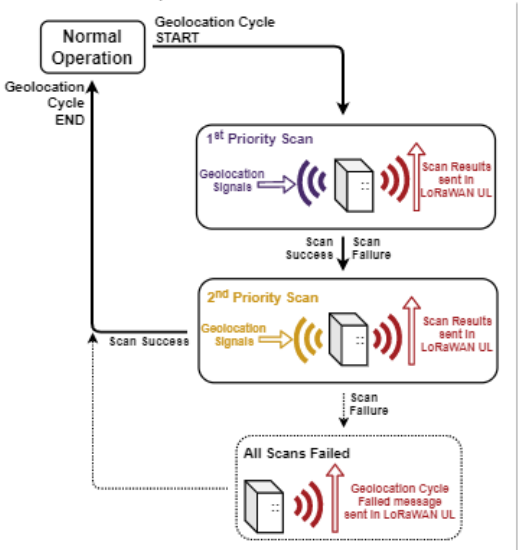
Geolocation Strategy 4
2 Backups, All Scans Defined



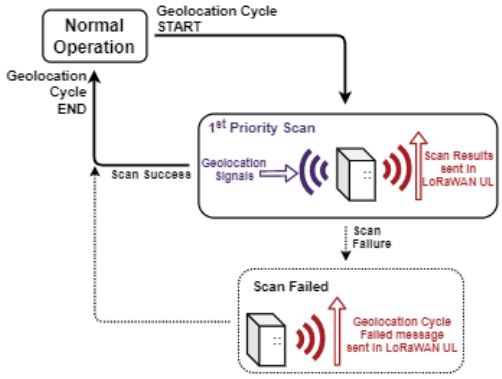
Geolocation Strategy 5
All Scans, All Scans Defined



Geolocation Strategy 6
All Scans, 2 Scans Defined



Geolocation Strategy 7
All Scans, 1 Scan Defined



List of Acronyms

BER .... Bit Error Rate
BLE .... Bluetooth Low-Energy
CNR .... Cahiers des charges sur les Normes Radioélectriques (RSS)
DL..... ..... DownLink
EGNOS ..... Wuropean Geostationary Navigation Overlay Service
EOS .... End Of Service
EU .... European Union
FCC..... ..... Federal Communications Commission
FSK..... ..... Frequency Shift Keying
FW .... FirmWare
GEO.... ..... GEOstationary Orbit
GFSK .. .. Gaussian FSK
GNSS.. ..... Global Navigation Satellite System
GPS .... Global Positioning System
GRB.... ..... Geolocation Resolver Backend
GW..... ..... GateWay
HW..... ..... HardWare
ID .... IDentifier
IGSO... ..... Inclined GeoSynchronous Orbit
IoT..... ..... Internet of Things
IP..... ..... Ingress Protection
ISM .... Industrial, Scientific, and Medical
LED..... ..... Light-Emitting Diode
LoRa... ..... Long-Range
LoRaWAN..... LoRa Wide-Area Network
LoS .... Line-of-Sight
LTC..... ..... Lithium-Thionyl Chloride
MAC... ..... Media Access Control
MCU... ..... MicroController Unit
NA..... ..... North America
NLOS .. .. Near LoS
NS..... ..... Network Server
OTA.... ..... Over The Air
PCB..... ..... Printed Circuit Board
PCBA .. .. PCB Assembly
Rev..... ..... Revision
RF..... ..... Radio Frequency
RH .... Relative Humidity
RSS..... ..... Radio Standards Specifications (CNR)
RSSI.... ..... Received Signal Strength Indicator
Rx..... ..... Receive, receiver, etc.
SBAS... .....Satellite Based Augmentation System
SW..... ..... SoftWare
TLM.... ..... TeLeMetry
TRM ... . Technical Reference Manual
Tx .... Transmit, Transmitter, etc.
UG..... ..... User Guide
UID..... ..... Unique ID
UL..... ..... UpLink
US..... ..... United States
v .... version
WAAS. ..... Wide Area Augmentation System
Wi-Fi .. .. Wireless-Fidelity

Document Revision History

Revision	Issue Date	Editor	Comments
0.1	September 06, 2023	Ade Adegboye	First draft (based on T0008710_TRM_v0.1_Draft and T0006940_UG_ver1.1)
1.0	December 12 2023	Carter Mudryk	• Updated based on review feedback. • Corrected product codes. • Minor grammatical and formatting changes.
1.1	February 28, 2024	Carter Mudryk	• Added additional T-codes for EU variants. • Changed name of “base” variants to “battery power.”
2	July 29, 2024	Marharyta Yuzefovych	• User friendly format
2.1	August 19, 2024	Marharyta Yuzefovych	• Added T code for AS-923
2.2	July 21, 2025	Marharyta Yuzefovych	• Updates to GNSS scanning process description