
RTLS TECHNICAL INSTALLATION PLAN

LOCUS/PrecisionSense

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List of Acronyms

App	Application
BLE	Bluetooth Low-Energy
CSV	Comma-Separated Values
DL	DownLink
EU	European Union
GW	GateWay
HW	HardWare
ID	IDentification
LED	Light-Emitting Diode
LoRaWAN	Long-Range Wide-Area Network
MAC	Media Access Control
NS	Network Server
PSR	Packet Success Rate
RSSI	Received Signal Strength INdicator
RTLS	Real-Time Location Solution
Rx	Receive, receiver, etc.
SNR	Signal-to-Noise Ratio
SW	SoftWare
TIP	Technical Installation Plan
Tx	Transmit, Transmitter, etc.
UL	UpLink

1 Overview

NOTE: DO NOT activate the Beacons or Trackers until the specified procedure steps. It is important to provision these LoRaWAN devices on the NS and Application in the correct order before activation to both save battery life and ensure that the proper configuration settings are applied

1.1 Introduction

This document provides the list of components and procedural steps for the installation of the *Real-Time Location Solution (RTLS)* at a new site.

The RTLS is a system that uses multilateration techniques to resolve the location of assets and display them on a dashboard. The RTLS is comprised of the component entities listed in Table 1-1. The components fit into the system architecture as shown in Figure 1-1.

Table 1-1: Components of the RTLS system

Component	Description
Beacons	A network infrastructure of fixed BLE Beacons, each of which transmit advertising packets with regular periodicity and Tx power. These can either be LoRaWAN-managed Beacons or not.
Trackers	One or more <i>Gen2 Enterprise Asset Tracker</i> devices that are mobile within the Beacon network. The Trackers scan for the Beacon packets with regular periodicity and scan parameters, then send the scan results in a LoRaWAN UL to the NS.
Gateways	LoRaWAN NS access points that relay data from the Trackers to the NS and vice versa. Usually a few Gateways (GWs) are enough to provide coverage to many Trackers and Beacons.
Network Server	A LoRaWAN Network Server (NS) layer enables connectivity and management of the Trackers (and Beacons, if applicable), and receives all of the UL data.
RTLS Application	<ul style="list-style-type: none">○ Analyzes the data passed from the NS by applying a multilateration algorithm to resolve the Trackers' locations.○ Initiates commands to configure the Trackers' settings.○ Retrieves and represents current and historical data in a graphical way. The RTLS application can be accessed as either a mobile application or a platform-free web application.

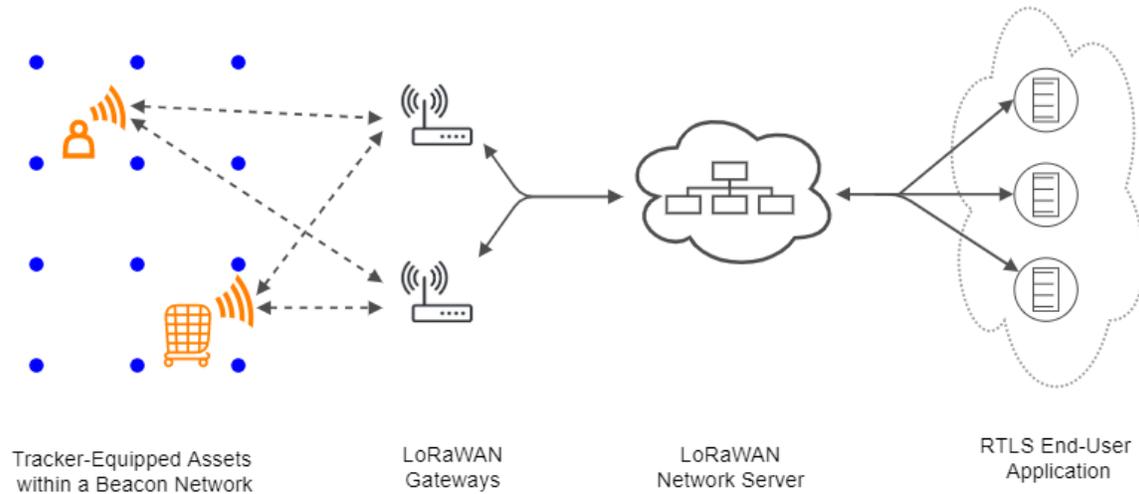


Figure 1-1: RTLS system architecture

1.2 Scope

This document covers the LoRaWAN Network Server (NS) set up, LoRaWAN network component integration, the installation and provisioning instructions for the Beacons and Trackers, verification of the RF environment, and asset pairing on the RTLS Application.

A high-level summary of the installation steps are as follows and will be expanded upon in the following relevant sections.

1. The Network Server needs to be set up to manage all LoRaWAN devices. This includes provisioning the GW(s), Beacons (if applicable), and Trackers in a NS application with the proper network settings. This application must have an integration linking it to LOCUS/PrecisionSense.
2. The HW infrastructure including the Beacons and GW(s) must be installed. The Beacons must be activated with the magnetic activation pattern and placed in the proper positions as shown on the floor plan. The GW must be installed in a recommended position and connected to the local network.
3. The LoRaWAN RF Environment is verified to be reliable and covering the whole production area by analyzing the RSSI, SNR, and PSR from the beacons over a period of time.
4. After provisioning, the Trackers can be activated with the magnet as well. Once online, they can be paired to assets through the RTLS Application interface. The Trackers will also need to be configured to user specifications through the RTLS Application.

Following these steps will result in an end-to-end system with the capability of tracking assets in real-time.

2 Installation Prerequisites

2.1 Hardware and Equipment Components

Table 2-1: List of Physical Components for Installation

Component	Quantity	Description	Procedure Section
TEKTELIC Gateway(s) for permanent installation	Per site basis	LoRaWAN network access point. Antenna, DC power supply cable, and ethernet cable included for each GW.	3.1
TEKTELIC Micro Gateway(s) for RF mapping	At least 1	Portable GWs to move to various test locations to measure LoRaWAN signal coverage and determine the best permanent GW locations. Cellular backhaul is preferred.	3.3
Floor plans	1 per floor	Images including recommended Beacon placements. Must include a digital version for use as the application floor plan image.	3.2
BLE Beacons*	Per site basis	Nodes in the fixed Beacon network infrastructure. Depending on deployment, there are 3 options: <ul style="list-style-type: none"> • TEKTELIC LoRaWAN-managed Beacons, for ATEX or non-ATEX environments • Minew i3 Beacons, for non-ATEX environments • Loc-Ex 01 Beacons, for non-ATEX environments 	3.2
Enterprise Asset Trackers*	Per site basis	For pairing to and tracking assets within the Beacon network	3.4, 3.5
Batteries	<ul style="list-style-type: none"> • 1 LTC per device (TEKTELIC) 2 alkaline per device (3rd-party Beacons) 	To power the Trackers and Beacons (included).	3.2, 3.4
Magnet	1 (minimum)	To activate the Trackers and Beacons	3.2, 3.4
Adeunis Field Test Device	1 (minimum)	For immediate feedback on LoRaWAN signal strength in particular areas of production.	3.3

* DO NOT activate the LoRaWAN Beacons Trackers until the specified procedure step in Section 3.3. It is important to provision the Trackers on the NS and Application in the correct order before activation to both save battery life and ensure that the proper configuration settings are applied.

3 Installation Procedure

3.1 LoRaWAN Network and Integration Setup

The LoRaWAN NS enables the connectivity and management of the Trackers and GW(s) (and Beacons, if they are LoRaWAN-managed). This section describes how to set up the LoRaWAN network such that all components can intercommunicate. The detailed instructions for setting up and provisioning the NS application, devices, and network settings is described here. Detailed instructions for setting up and provisioning the GW(s) are not included here.

NOTE: Some or all of these steps may have already been completed. If they have already been completed, move on to the next section.

1. Login to the TEKTELIC NS using the credentials for your account. Navigate to the *Gateways* section and add the GW(s). Both the permanent GW(s) and portable test Micro GW(s) can be added at once, or the permanent GWs can be added later, after installation.
2. Wait a few minutes for the status of the GW(s) to be “Online” in the NS.
3. Create a NS application (distinct from the RTLS Application; a NS application is like a grouping of devices in the NS) by navigating to the *Applications* tab on the left side bar, then by clicking the + icon as shown in Figure 3-1. In the pop-up window, enter a name of your choice for the NS application and click *Add*.

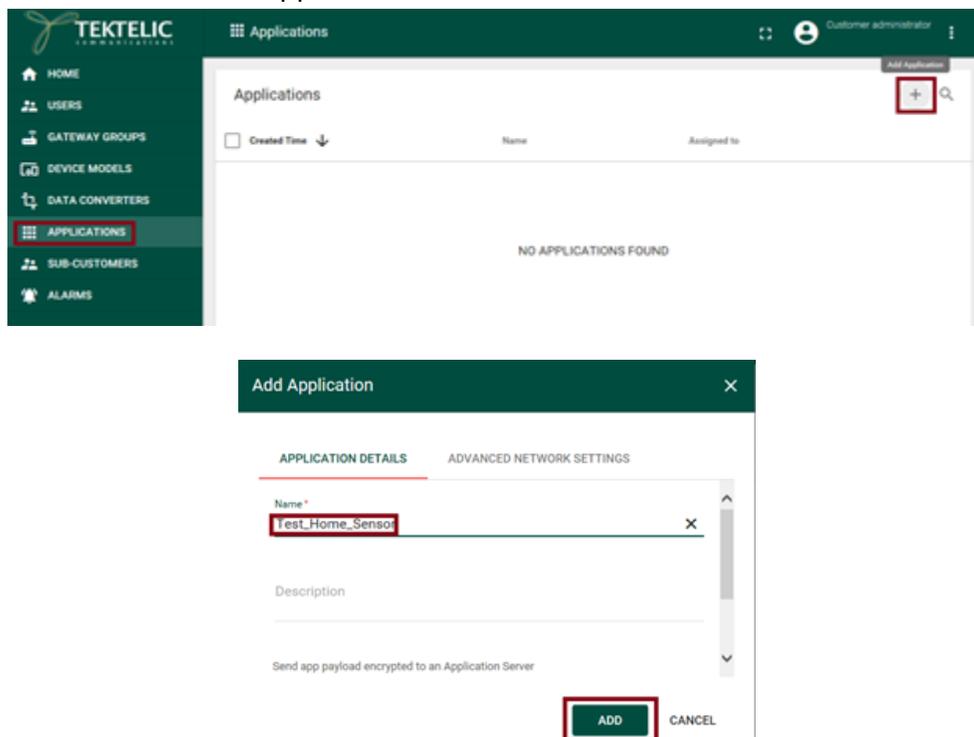


Figure 3-1: Adding a New NS Application

4. Now, click on the newly-created NS application and navigate to the *Advanced Network Settings* tab as shown in Figure 3-2. Click the pencil icon to be able to edit, then apply the following settings:
 - a. Un-check the enable ADR checkbox to disable the ADR.
 - b. Set the appropriate channel frequency plan for your LoRaWAN region. For example, in the EU region, in the channel frequency list enter the frequencies 867.1, 867.3, 867.5, 867.7, and 867.9 [MHz].
 - c. Set the appropriate channel mask to match what is supported by the GW(s). If the GW(s) do not support 64 channels, ensure the proper channel mask setting is applied. Please contact TEKTELIC for support on this if this is not known.

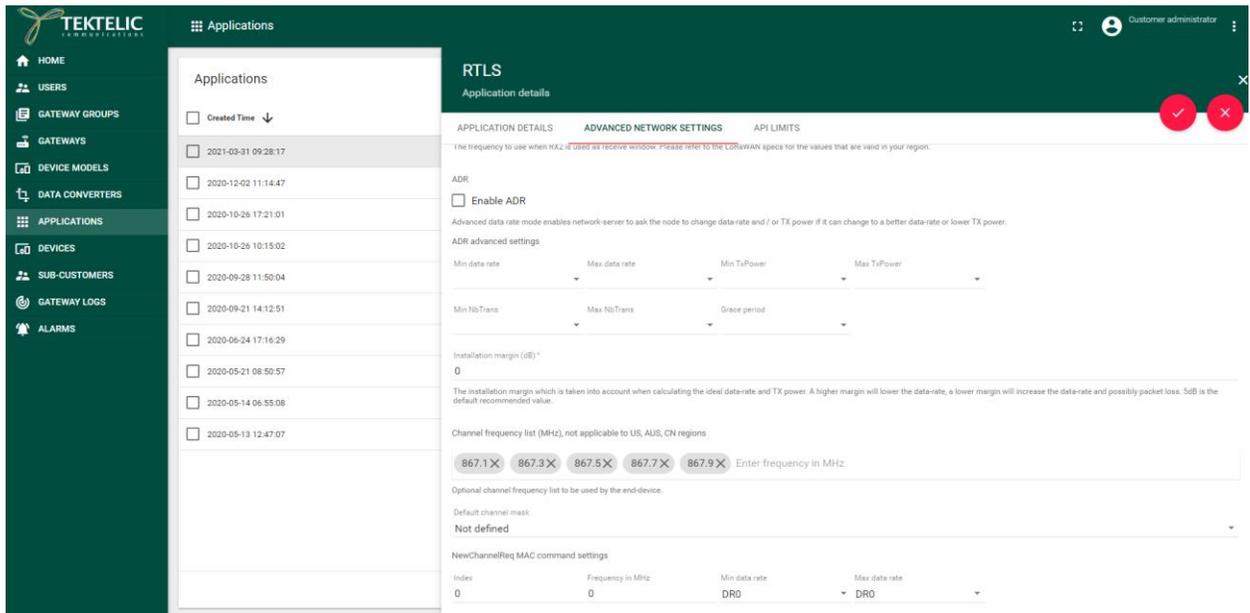


Figure 3-2: Advanced Network Settings

5. An integration between the NS and RTLS Application is necessary for the data to be pushed between the two, and should already be setup. If support is required for setting up another integration, please contact TEKTELIC Communications Inc.

3.2 Beacon Deployment

For TEKTELIC LoRaWAN-managed Beacons, follow the steps in Section 3.2.1. For 3rd-party Beacons, follow the steps in Section 3.2.3 for non-ATEX environments or the steps in Section 3.2.3 for ATEX environments.

3.2.1 TEKTELIC LoRaWAN-Managed Beacons for ATEX or Non-ATEX Environments

For the RTLS system to be able to localize the Trackers and display their positions accurately, each Beacon must be placed in a precise position which is accurately reflected in the SW.

1. Provision the Beacons on the NS by navigating back to your NS application and clicking the *Manage Devices* button. To provision the devices, either do so by bulk importing the commissioning info via csv file or individually by clicking the + icon and entering the commissioning information manually. The commissioning info should have been provided by TEKTELIC. If this information is lost or for more details on how to provision devices, please contact TEKTELIC for support.

NOTE 1: It is recommended that the Device Model is chosen such that in the NS, Beacons can be easily distinguished from Trackers, which will be added later to the same NS application. For example, a user can create separate Device Models and name them “Enterprise Asset Trackers” and “TEKTELIC Beacons,” respectively.

NOTE 2: Regardless of the method of provisioning, ensure the Device Model specified is one that is of device class “Class A.” If not, go to the *Device Models* tab and edit the device model to reflect Class A as shown in Figure 3-3.

NOTE 3: Regardless of the method of provisioning, ensure the *Use application setting* checkbox is selected before adding the device(s).

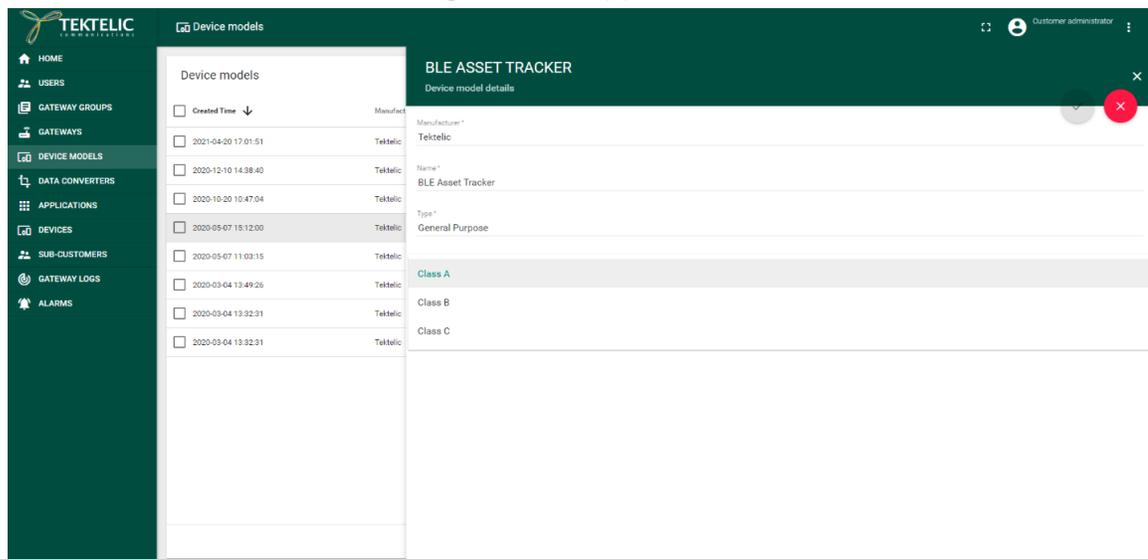


Figure 3-3: Ensuring the Device Model is Class A

2. Provision the Beacons in the RTLS Application by using the *Site setup* dashboard. In the *Device List* widget, click the *New Device* button. In the pop-up window, fill out the following fields if adding a single device (see Figure 3-4), or upload a csv for bulk upload:
 - a. **How do you want to create the device?:** “By device”
 - b. **Name:** name of your choice
 - c. **EUI:** The DevEUI of the device as shown in the network server. E.g.:
“647FDA0000001234”
Alternatively, the QR code on the device label can be scanned.
 - d. **Decoder:** To match your device. E.g.: “BLE Beacon”
 - e. **Frequency Management:** update interval of your choice in minutes. E.g.: “5”

NOTE: Steps 1 and 2 MUST be done before activating the Beacons and letting them try to join. If the Beacons are activated before these steps are complete, they will lose battery capacity attempting to join.

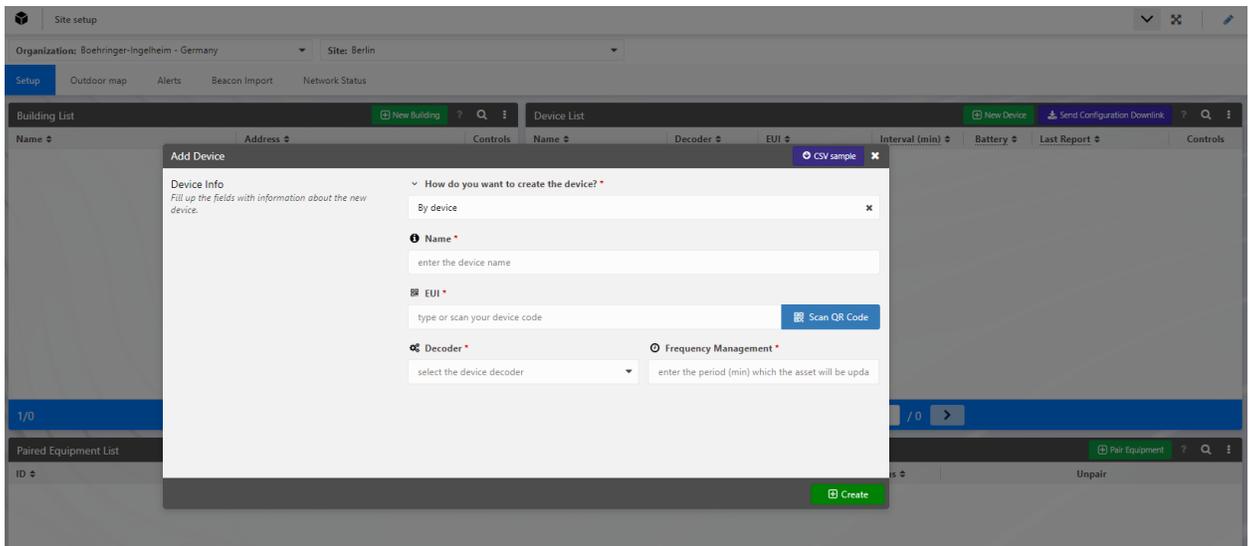


Figure 3-4: Provisioning Devices on the RTLS Web Application

3. The Beacons are shipped in a state of Deep Sleep to conserve battery life (in place of a battery tab). AFTER the Beacons have been provisioned in the NS, the *magnetic activation pattern* may be applied using the magnet provided (or another sufficiently strong magnet). The magnetic pattern in this application is illustrated in Figure 3-5. A “magnet presence” is achieved by placing the magnet against the enclosure at the magnet symbol. A “magnet absence” is achieved by taking the magnet away from the enclosure. Figure 3-5 shows that the pattern involves sustaining a “magnet presence” continuously for at least 3 s but less than 10 s.

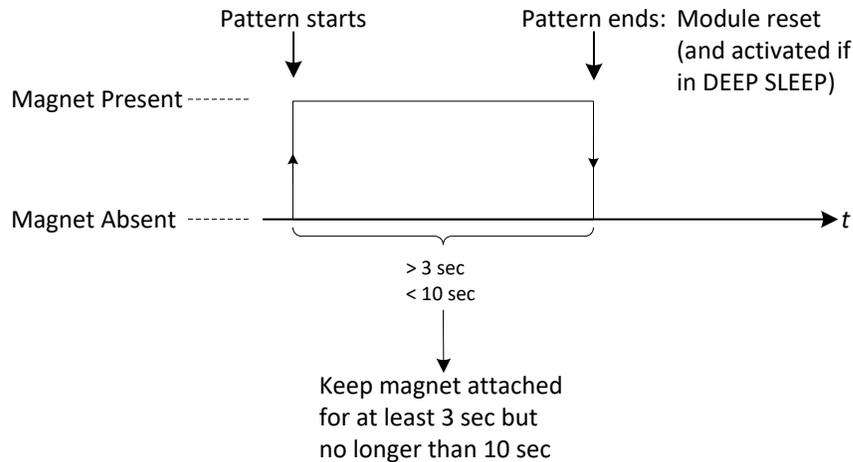


Figure 3-5: The Magnetic Activation Pattern.

Activate the Beacons by applying the magnetic activation pattern to each one. If the Beacons are programmed for a LoRaWAN region that is restricted by duty cycle limitations (e.g. EU), it is recommended that they are activated and joined one at a time to expedite the join process.

4. Within 5 seconds of correctly activating, the Beacon displays an LED pattern consisting of 3 consecutive flashes of the green LED, each 500 ms long. The device will then begin attempting to join the network, which is indicated by:
 - a. The green LED blinking rapidly and continuously.
 - b. The red LED blinking occasionally (approximately every 5 seconds).
5. As soon as all the Beacons' statuses in the NS are displayed as "Online," they are ready for installation and normal operation.
6. A *Key User* must set up the site in the RTLS Application by first importing all of the floor maps. For each map, the Key User must set the origin and scale. The origin should be set to some meaningful reference point that one can physically measure from, like a corner of the building. The scale must be set by selecting a length in the image that is of some known actual length in metres. This scale will be used to convert the image units to meters.
7. The *Installer* should then install the Beacons in the physical locations as recommended by TEKTELIC.
 - a. The Beacons should all be installed at approximately the same height.

- b. The Beacons can either be installed with the included mounting bracket and screws, or by other means such as adhesive.
 - c. Ensure that it is recorded which Beacon is placed in which location. This can be indexed by the MAC address (located on the Beacon's label).
 8. After the Beacons have been installed, the Installer must enter the locations into the app. Alternatively, this step can be done before installing the Beacons if it facilitates installation.
 - a. In the *Site setup* dashboard, navigate to the *Beacon Import* tab. Upload a CSV file containing the list of Beacon MAC addresses and corresponding names.
 - b. Navigate back to the Setup tab and select the building in which the Beacons are being installed. Navigate to the *Beacon setup* tab and click on the *edit* icon of the floorplan widget.
 - c. Click on the *Add Beacon* icon and center the cursor crosshairs on the position on the floorplan that corresponds to the Beacon. Click to place the Beacon, then select the name of the Beacon that is at this position.
 - d. Repeat step (c) for all other Beacons installed on this floor.
 - e. Repeat as necessary for other floors, buildings, or sites.

3.2.2 Minew i3 Beacons for Non-ATEX Environments

For the RTLS system to be able to localize the Trackers and display their positions accurately, each Beacon must be placed in a precise position which is accurately reflected in the SW.

1. The Beacons should already be powered-on from the manufacturer; there is no need to activate them in any way. However, their default settings need to be changed. This can be done before or after physical installation, but before installation is recommended to minimize time.
 - a. Open the BeaconSET mobile app on a smartphone equipped with Bluetooth. The screen should look like that shown in Figure 3-6.

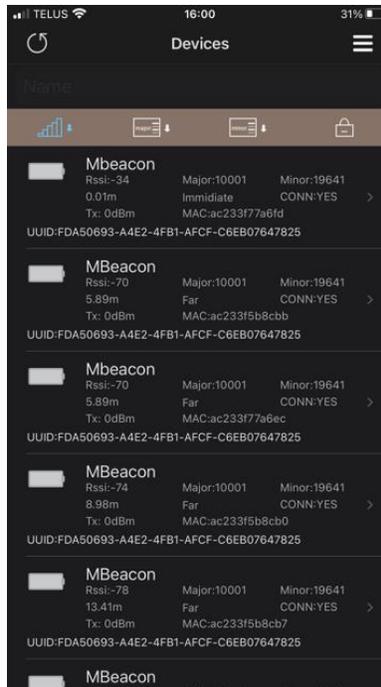


Figure 3-6: BeaconSET Mobile App for Managing Beacon Settings

- b. While standing in close proximity to a Beacon, select it on the app by clicking on the Beacon which has the matching MAC address. Select *Settings*.
- c. The list of beacon settings should now be displayed. Ensure that the *Transmission Power* setting is 6 (it should be by default). Click on the *Broadcasting Interval* setting and you will be brought to a screen that looks like that shown in Figure 3-7.

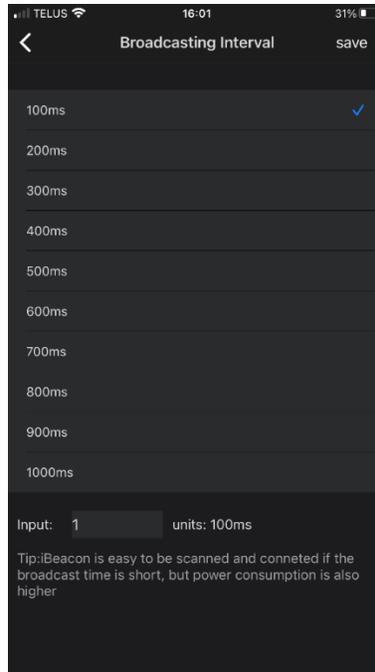


Figure 3-7: The BeaconSET Mobile App Broadcasting Interval Setting

- d. Select 100 ms as the setting, then click *save*. If prompted for a password, enter “minew123” which is the default password for all Beacons. This should only need to be entered for the first Beacon connected; the app should save it for all other Beacons.
 - e. Repeat for all Beacons to ensure their *Transmission Power* setting is 6 (0 dBm, 50m) and their *Broadcasting Interval* setting is 1 (100 ms).
 2. A *Key User* must set up the site in the RTLS Application by first importing all of the floor maps. For each map, the Key User must set the origin and scale. The origin should be set to some meaningful reference point that one can physically measure from, like a corner of the building. The scale must be set by selecting a length in the image that is of some known actual length in metres. This scale will be used to convert the image units to meters.
 3. The *Installer* should then install the Beacons in the physical locations as recommended by TEKTELIC.
 - a. The Beacons should all be installed at approximately the same height.
 - b. The Beacons can either be installed with the double-sided adhesive pad or with 2 screws to fasten the mounting.

- c. Ensure that it is recorded which Beacon is placed in which location. This can be indexed by the MAC address (located on the Beacon's label).
4. After the Beacons have been installed, the Installer must enter the locations into the app. Alternatively, this step can be done before installing the Beacons if it facilitates installation.
 - a. In the *Site setup* dashboard, navigate to the *Beacon Import* tab. Upload a CSV file containing the list of Beacon MAC addresses and corresponding names.
 - b. Navigate back to the Setup tab and select the building in which the Beacons are being installed. Navigate to the *Beacon setup* tab and click on the *edit* icon of the floorplan widget.
 - c. Click on the *Add Beacon* icon and center the cursor crosshairs on the position on the floorplan that corresponds to the Beacon. Click to place the Beacon, then select the name of the Beacon that is at this position.
 - d. Repeat step (c) for all other Beacons installed on this floor.
 - e. Repeat as necessary for other floors, buildings, or sites.

3.2.3 Loc-Ex 01 Beacons for ATEX Environments

For the RTLS system to be able to localize the Trackers and display their positions accurately, each Beacon must be placed in a precise position which is accurately reflected in the SW.

1. The Beacons should already be powered-on from the manufacturer; there is no need to activate them in any way. However, their default settings need to be changed. This can be done before or after physical installation.
 - a. Download and open the *ecom*[®] *ecommander* mobile app on a smartphone equipped with Bluetooth. The landing screen should look like that shown in Figure 3-8. Ensure that the activation key file from *ecom* is saved in the smartphone's files.



Figure 3-8: ecom commander Mobile App for Managing ATEX Beacon Settings

- b. While standing in close proximity to a Beacon, select it on the app by refreshing the page and clicking on the Beacon which has the matching MAC address. Select *Settings*.
 - c. The list of beacon settings should now be displayed. Change the *Transmission Power* setting to 0 dBm and the *Broadcasting Interval* setting to 100 ms. Click *save*.
 - d. Repeat for all Beacons to ensure their *Transmission Power* setting is 0 dBm and their *Broadcasting Interval* setting is 100 ms.

2. A *Key User* must set up the site in the RTLS Application by first importing all of the floor maps. For each map, the Key User must set the origin and scale. The origin should be set to some meaningful reference point that one can physically measure from, like a corner of the building. The scale must be set by selecting a length in the image that is of some known actual length in metres. This scale will be used to convert the image units to meters.

3. The *Installer* should then install the Beacons in the physical locations as recommended by TEKTELIC.
 - a. The Beacons should all be installed at approximately the same height.
 - b. The Beacons can either be installed with the double-sided adhesive pad or with 2 screws to fasten the mounting.
 - c. Ensure that it is recorded which Beacon is placed in which location. This can be indexed by the MAC address (located on the Beacon's label).

4. After the Beacons have been installed, the Installer must enter the locations into the app. Alternatively, this step can be done before installing the Beacons if it facilitates installation.
 - a. In the *Site setup* dashboard, navigate to the *Beacon Import* tab. Upload a CSV file containing the list of Beacon MAC addresses and corresponding names.
 - b. Navigate back to the Setup tab and select the building in which the Beacons are being installed. Navigate to the *Beacon setup* tab and click on the *edit* icon of the floorplan widget.
 - c. Click on the *Add Beacon* icon and center the cursor crosshairs on the position on the floorplan that corresponds to the Beacon. Click to place the Beacon, then select the name of the Beacon that is at this position.
 - d. Repeat step (c) for all other Beacons installed on this floor.
 - e. Repeat as necessary for other floors, buildings, or sites.

3.3 RF Environment Verification

This subsection describes the procedure for determining the quality of the LoRaWAN RF signal coverage throughout the production area (the area in which the Beacons are installed). This procedure should only be completed by a TEKTELIC technician or by someone experienced with the NS and Beacon configuration.

3.3.1 Test with No Beacon Network or Partial Beacon Network

NOTE: This test is applicable to sites in which the TEKTELIC LoRaWAN-managed Beacon network has not been fully installed. This test also assumes that the Beacon positions have been recommended by TEKTELIC and floor plans with these locations is available.

The goals of this test are to:

- Use the Adeunis field test tool to empirically assess where potential areas of weak LoRaWAN connection may be.
- Use these results to determine the best locations and positions of the Beacons/remaining Beacons.

1. Take the Adeunis Field Test Tool around to one of the recommended Beacon installation points as shown on the floor plan.
2. Use the tool to send a few confirmed ULs at that location. Ensure the UL RSSI is above -100 dBm. If there is a reading below -100 dBm,
 - a. Record 5-10 RSSI values to calculate the average value.
 - b. Place the signal test device at one or more other vertical positions and repeat step 2a to observe if a difference in height affects signal strength.
3. Repeat steps 1-2 until all recommended Beacon locations has been evaluated.
4. If some Beacons have been installed or are available to be left in positions for testing, they can be used to supplement the field test tool by following the procedure in Section 3.3.2.
5. Highlight the potential weak RF locations on the floor plan to help determine whether Beacon or GW installation points may need to be modified.

3.3.2 Test With Full Beacon Network

NOTE: This test is only applicable to sites in which TEKTELIC LoRaWAN-managed Beacons are fully installed.

The goals of this test are to:

- Empirically measure the RSSI, SNR, and PSR values throughout the production area,
 - Determine where potential areas of weak LoRaWAN connection may be,
 - Use the measured data to determine the best location(s) for permanent GW installation points.
1. For the Beacons in the area(s) of interest, queue a DL containing the command **0x A0 00 00 00 14 A1 00 01** on **LoRaWAN port 100**. This configures the Beacons to send a battery report every 20 s. Wait for all of these DLs to be sent and these settings applied to all Beacons. This can be expedited by forcing ULs using the magnet for each Beacon.
 2. Place the portable test Micro GW(s) in a fixed location(s) that is a possible permanent GW installation point(s). Record this location on a floor plan.
 3. Allow the Beacons to UL periodically for ~1 hour or more. Export the *real-time packet* info and use this data to determine the average RSSI, average SNR, and overall PSR for each beacon location. Use this information to map out the LoRaWAN RF environment for that GW position.

4. Move the GW(s) to different location(s) and repeat step 3. Repeat as many times as desired.
5. Use the results to determine the best GW installation point(s).
6. Queue a DL for each of the Beacons to change their battery reporting interval back to normal.

3.4 Tracker Activation

After the LoRaWAN network is online, the Trackers can be activated and begin normal operation.

1. Provision the Trackers in the NS using the commissioning information provided with the devices. This can be done one at a time or by CSV bulk import. More detailed steps for provisioning devices can be found in the *Network Server Quickstart Guide – Creating Your First Network* document available on the TEKTELIC support portal.
2. Provision the Trackers in the RTLS Application by using the *Site setup* dashboard. In the *Device List* widget, click the *New Device* button. In the pop-up window, fill out the following fields if adding a single device (see Figure 3-4), or upload a csv for bulk upload:
 - a. **How do you want to create the device?:** “By device”
 - b. **Name:** name of your choice
 - c. **EUI:** The DevEUI of the device as shown in the network server. E.g.:
“647FDA0000001234”
Alternatively, the QR code on the device label can be scanned.
 - d. **Decoder:** To match your device. E.g.: “BLE Beacon”
 - e. **Frequency Management:** update interval of your choice in minutes. E.g.: “5”

NOTE: Steps 1 and 2 MUST be done before activating the Trackers and letting them try to join. If the Beacons are activated before these steps are complete, they will lose battery capacity attempting to join.

3. The Trackers are shipped in a state of *Deep Sleep* to preserve battery life (in place of a battery tab). Using the magnet provided with the Trackers (or another sufficiently strong magnet), apply the *magnetic activation pattern*. The magnetic pattern in this application is illustrated in Figure 3-9. A “magnet presence” is achieved by placing the magnet against the enclosure at the magnet symbol. A “magnet absence” is achieved by taking the magnet away from the enclosure. Figure 3-9 shows that the pattern involves sustaining a “magnet presence” continuously for at least 3 s but less than 10 s.

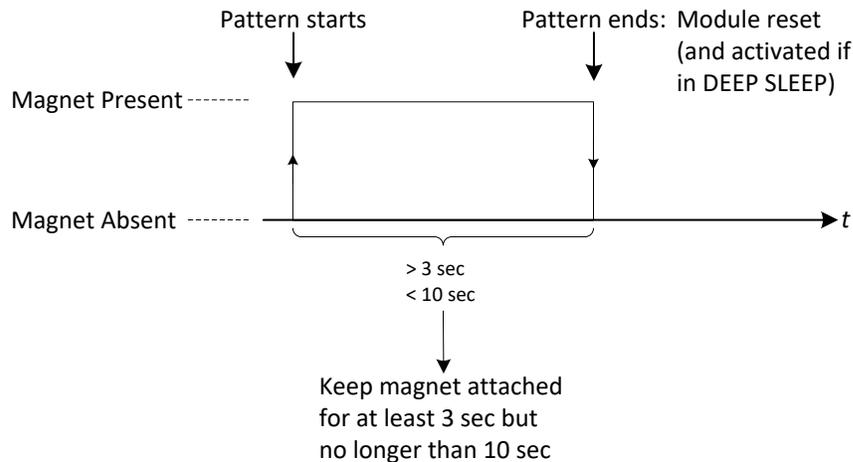


Figure 3-9: The magnetic activation pattern.

4. Apply the magnetic activation pattern to each of the Trackers. If the Trackers are programmed for a LoRaWAN region that is restricted by duty cycle limitations (e.g. EU), it is recommended that the Trackers are activated one at a time to expedite the join process.
5. Within 5 seconds of correctly activating, the Tracker displays an LED pattern consisting of 3 consecutive flashes of the green LED, each 500 ms long. The device will then begin attempting to join the network, which is indicated by:
 - c. The green LED blinking rapidly and continuously.
 - d. The red LED blinking occasionally (approximately every 5 seconds).
6. As soon as all the Trackers' statuses in the NS are displayed as "Online," they are ready for normal operation.

3.5 Tracker Configuration

The TEKTELIC Enterprise Asset Trackers have been designed to be configurable for multiple use cases. As such, their settings must be properly reconfigured to work for an RTLS use-case. The desired refresh interval is also configured at this time.

1. The RTLS Application will automatically encode and send a LoRaWAN DL with the payload: **0x 91 00 00 92 05 00 A0 00 00 00 3C A5 00 01 D0 FF D1 03 03 D2 01 F4 D3 00**

96 F0 60 00. This will configure the Tracker to the required settings as described in Section 2.1 of the *Configuration Specification* document and save the settings to flash.

3.6 Asset Pairing

Once the Trackers have been activated and configured, they are then ready to be paired with equipment and used for normal operation.

1. Once each Tracker has joined the network, it should appear in the *Device List* widget in the *Site setup* dashboard in the RTLS Application.
2. To then pair a device to an asset, do one of the following options:
 - a. Use the web application to click *Pair Equipment* and type in the IDs of the device and equipment that you wish to pair in the corresponding fields. Click the *Pair* button.
 - b. Use the mobile application to click *Pair Equipment* and scan the QR codes of the device and equipment that you wish to pair. Click the *Pair* button.