UG514: Using the *Bluetooth*® Direction Finding Tool Suite

A Real Time Locating System (RTLS) consists of many locators that pick up the signals of asset tags to locate them in 3D space. To calculate the positions of the asset tags, one must know each locator's position, orientation, and configuration (such as antenna array type, switching pattern, and so on). The Silicon Labs' Real Time Locating (RTL) library also needs some configuration parameters, such as estimation mode, azimuth, elevation constraints, and so on, to provide the best estimation for a given environment. The Bluetooth Direction Finding Tool Suite is meant to ease development with the Silicon Labs' RTL library. It provides multiple tools to configure the system, and also helps development with analyzer tools that calculate many output parameters from the observed IQ samples.

KEY POINTS

- Direction Finding project generation
- AoA Configurator
- AoA Analyzer
- AoA Positioning Tool

1 Introduction

Beginning with Bluetooth SDK v3.1, Silicon Labs' Bluetooth stack supports CTE transmitting and receiving features and can take phase measurements on the incoming signal as specified by the Bluetooth standard. Note, however, that the determination of the angle of incidence from the phase measurements is outside of the scope of the standard and must be implemented in the application. To reduce the Time to Market for its customers, Silicon Labs also offers a reference implementation of a Bluetooth-based Real Time Locating System (RTLS), which provides both an out-of-box experience to evaluate the solution and a flexible framework that makes it possible for everyone to create their own RTLS. To get started with the reference implementation, refer to *AN1296: Application Development with Silicon Labs' RTL Library*.

The implementation described in AN1296 requires you to configure and build both individual locators and a locator host application in order to test the system. While the SDK examples provide the openness to customize and add new features to your direction finding project using RTL library APIs directly, the manual configuration of the locators and their topologies may not be a trivial task. It is simpler to configure a single locator and multi-locator setup through interactive graphical interfaces available through the Direction Finding Tools Suite.

AoA Analyzer can:

* Create a locator configuration file without the need to manually edit the .json file, to ease the configurations process.
* Apply the configuration for a single locator board and run the RTL library to estimate angles from the incoming data (without the need to build and run any host sample application).

AoA Analyzer is available through Simplicity Studio's Tools menu, as described next.

While it is easy to configure a single locator and get angle information of asset tags, configuring and running a multi-locator setup to get position information can be rather complicated. To calculate position, the RTL needs to know the coordinates and orientation of the locator so that it can translate the angle feeds from each one of them with respect to the coordinate system of a given topology. Simplicity Studio provides the Positioning tool, which makes the configuration and testing of a multi-locator setup easy and quick.

Positioning Tool can:

* Create a multi-locator topology without the need to manually edit the configuration .json file.
* Add locators to the topology and configure their positioning RTL parameters (such coordinates and orientation) easily.
* Apply the configuration and locate asset tags in 3D.
* Import/Export a topology from/to a configuration .json file.

Positioning Tool is available through Simplicity Studio's Tools menu as described next.

2 AoA Analyzer

The AoA Analyzer tool can be used to demonstrate the capabilities of the RTL library with regard to the Angle of Arrival (AoA) estimation from Constant Tone Extension (CTE) signals using one locator device. The tool can be used to configure and connect to a locator, define estimation mode, and evaluate the performance of the RTL library in real-time.

AoA Analyzer aggregates a set of user-friendly tools that are used for configuring, visualizing, analyzing, recording, and post-processing direction finding using a single locator. These are:

3D VIEW: Used for connecting, configuring antenna boards, and visualizing the direction of assets with respect to a locator in 3D.

ANALYZER: Used for creating charts using the real-time data stream from asset tags.

ASSETS: Used for visualizing the list of asset tags, hide/reveal tags in the 3d view mode, start/stop IQ sample recording to postprocess and replay back later.

AoA Viewer: A standalone tool used for replaying and post-processing IQ sample recordings.

To launch AoA Analyzer:

1. From Simplicity Studio 5's Launcher perspective, click **Tools**.
2. In the Tools Dialog, select **AoA Analyzer.**
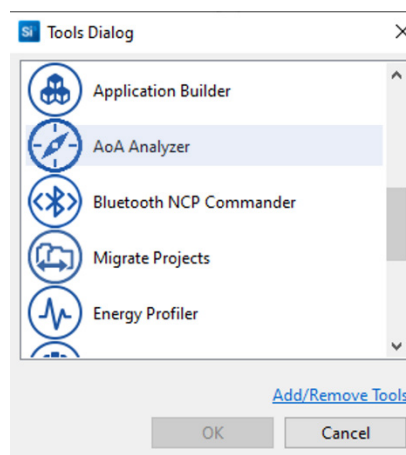
3. Click **OK**. AoA Analyzer opens in the Simplicity IDE perspective.

Note: AoA Analyzer works together with Antenna Array boards that were previously programmed with **Bluetooth - NCP AoA Locator** firmware. To test the device you will also need a tag, programmed with **Bluetooth - AoA Asset Tag** firmware. For details, see *QSG175: Getting Started with Silicon Labs' Direction Finding Solution*.

## 2.1   3D View

By default the AoA analyzer opens in 3D VIEW.
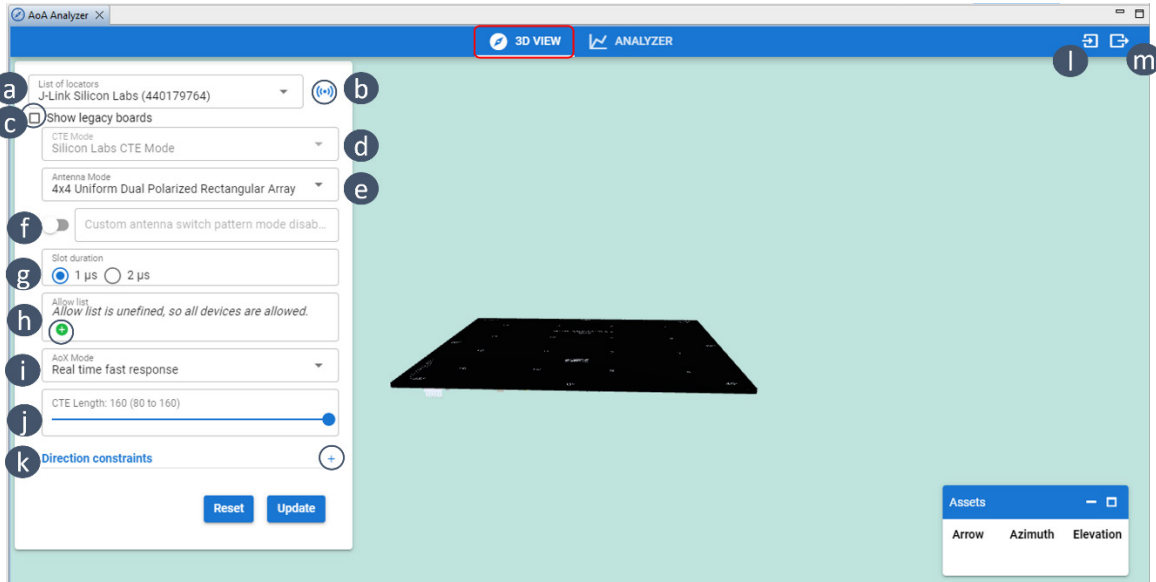

Figure 2-1. AoA Analyzer 3D VIEW

Use the 3D VIEW tool to:

a) Select your locator from a list of J-Link devices.
b) Connect your locator.
c) Enable to display legacy antenna boards (i.e BRD4185A).
d) Choose the CTE mode.
e) Select the antenna type: Dual polarized 4x4 URA, 4x4 URA, 3x3 URA or 1x4 ULA
f) Enable custom switching pattern. Default is 0 to 15.

Select (1) to generate a random switching pattern, or (2) to manually configure the switching pattern using a GUI, as shown in the following figure. .
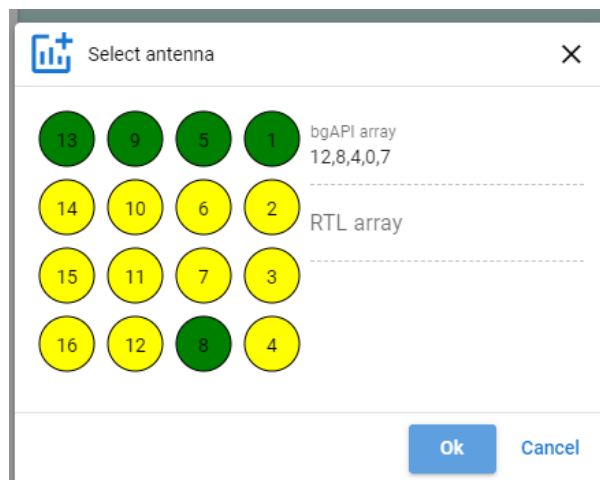
g) Select the switch slot duration: 1 µS, 2 µS.
h) Add the allowed list of tags.
i) Select the AoX mode.
j) Set the CTE length.
k) Insert direction (angle) constraints. Note that you can add as many azimuth and elevation angle constraints as you want. Simply click add azimuth / elevation button to add new direction constraints.
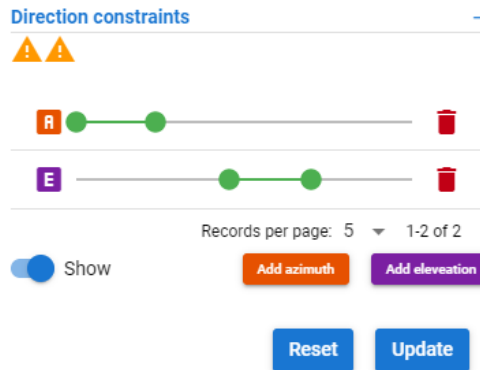
l) import a JSON configuration file of a locator.
m) export a locator's configuration to a JSON file.

Once the locator is connected through step b, the AoA analyzer generates arrows that emanate from the locator device pointing towards the direction of the asset tags that it finds in its vicinity. It also displays the azimuth and elevation angle values of the tags in the Assets window (see Figure 2-2. AoA Analyzer Displaying the Direction of an Asset Tag in 3D VIEW).

2.2 Assets

Use the maximize button in the **Assets** window to see the Detailed info panel of the asset tags (button a in the following figure), and the minimize button to hide the info panel (button b in the following figure). Use button c to hide a specific tag from the 3D VIEW.
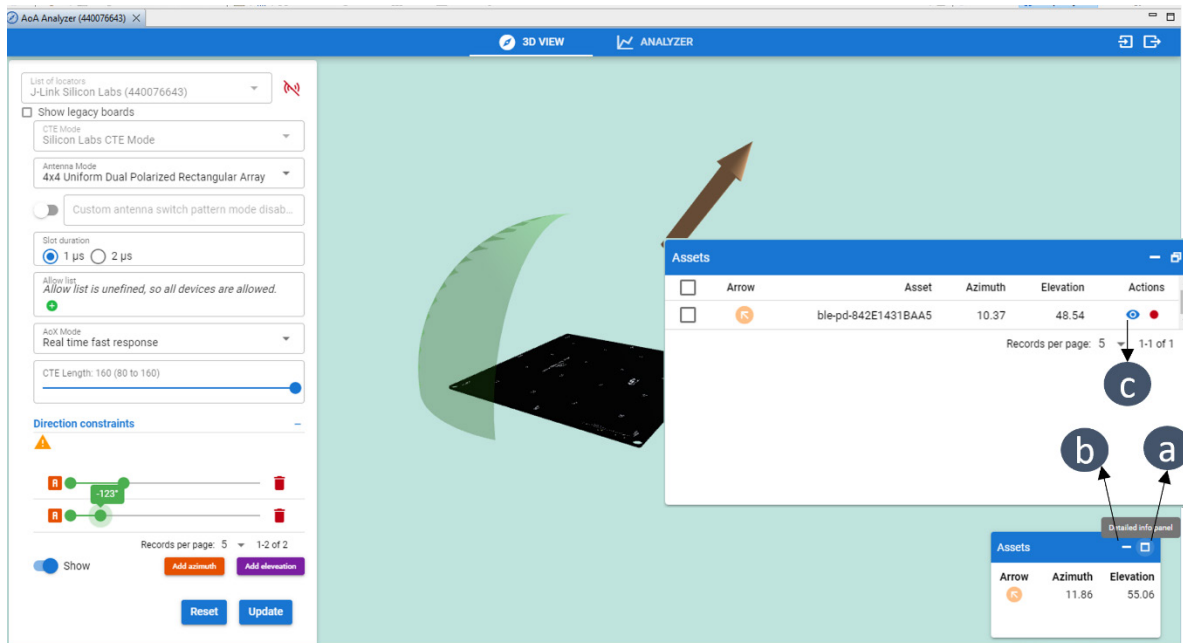
Figure 2-2. AoA Analyzer Displaying the Direction of an Asset Tag in 3D VIEW

After you make a configuration change click Update to see the effect in real time. Or Reset to return to the default values.

2.3   Analyzer

Use the ANALYZER tool to visualize different parameters of an asset tag measured by a locator device in real time using charts. You can create up to 20 charts in one step by combining asset tags, estimators, and the chart types.

To create charts using the ANALYZER tool:

1.   Click **Charts**.
2.   Select the number of charts and how they will be displayed in rows and columns.
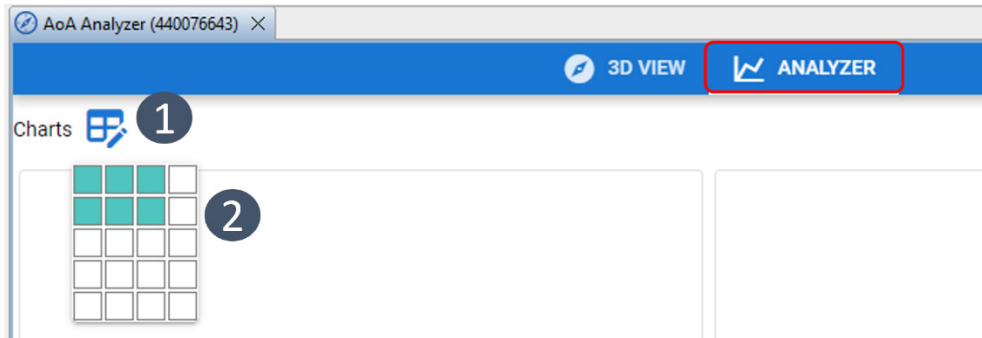
3.   A corresponding grid of chart placeholders is displayed.
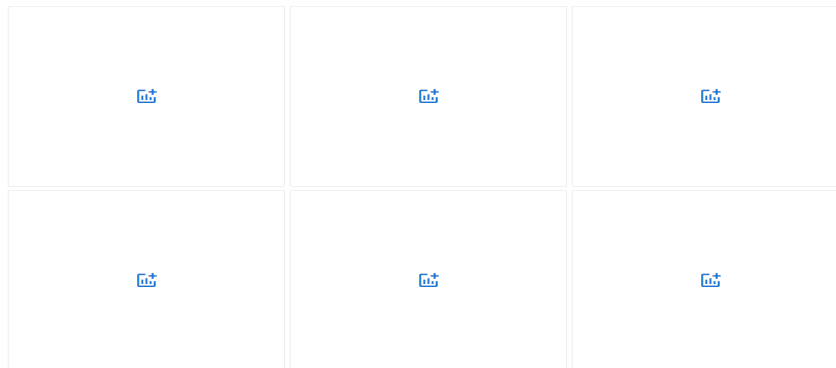
4.   Click the symbol in the middle of a placeholder. The **Add new chart** dialog opens. Here you can select the asset tag and chart type. Click **OK**.
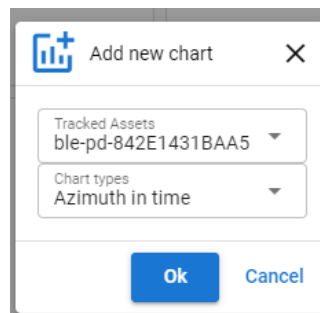
5. Repeat for each chart placeholder to populate the Charts display with real-time graphs. For each chart, you can (a) zoom X, (b) zoom Y, (c) go to full screen, or (d) delete the chart.
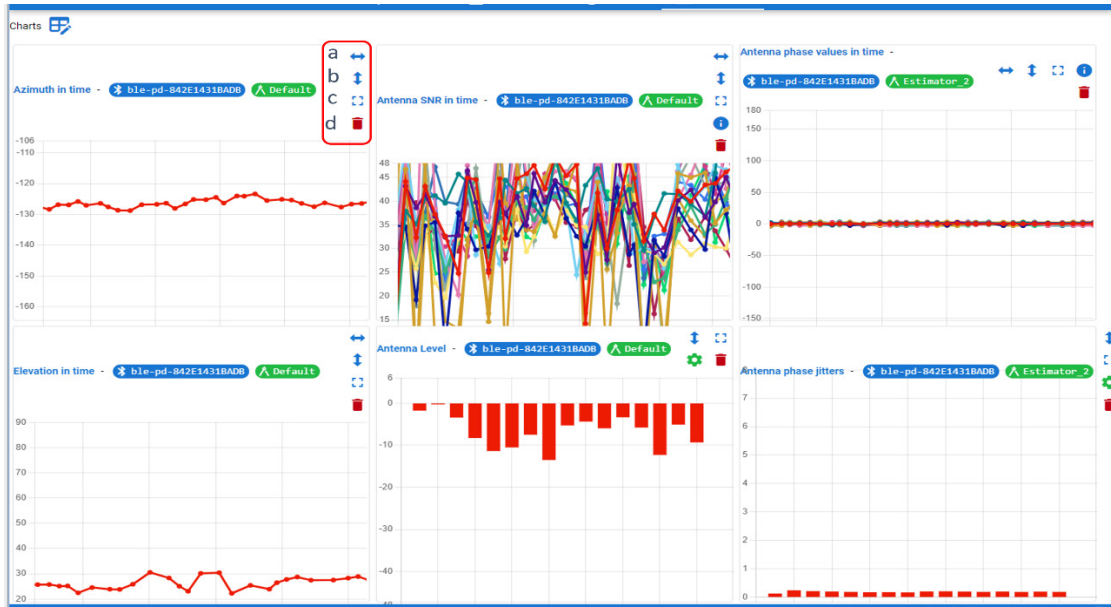
2.4 Recording and Playback

In the Assets window of the 3D VIEW tool, use the recording button to start recording IQ samples.
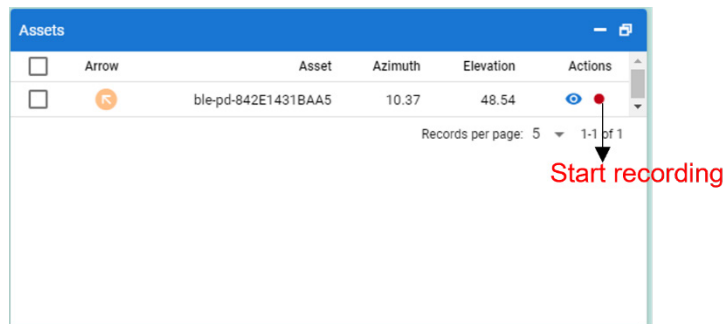
When prompted, save the file to a preferred location. By default the recordings files are saved using the tag's public BLE device ID in the filename: *ble-pd-xxxxxxxxxxxx.aoarec*.

Stop the recording using the Stop record button.
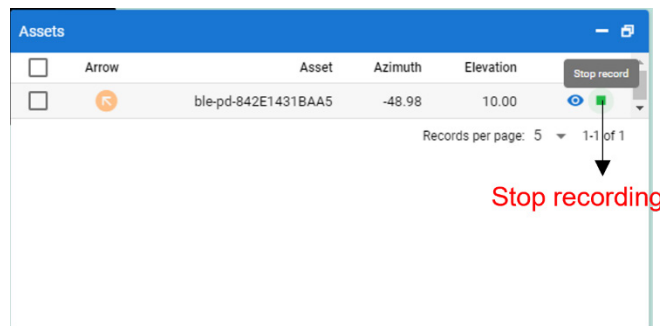
To play back or postprocess the recording, simply drag and drop the *.aoarec* file into Simplicity Studio's Simplicity IDE perspective. Alternatively, go to **File > Open file**, and browse to the location where you saved the recording.
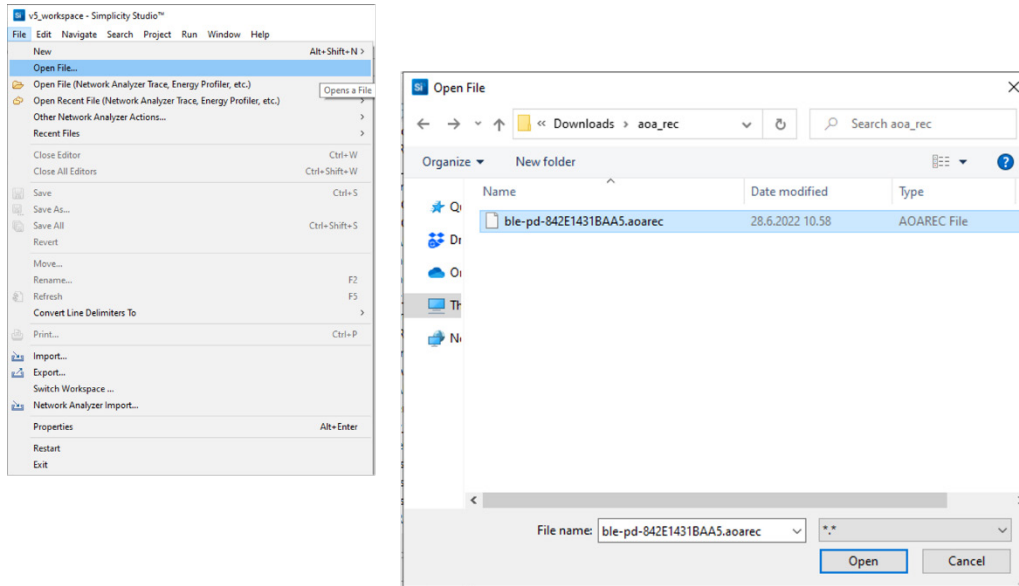
Select and **Open** the file. Then the recording opens using the **AoA Viewer**.

The AoA Viewer provides a 3D View, an Analyzer, and Export functions, accessed through tabs on the toolbar. The Overview tab's functions are annotated in the following figure.
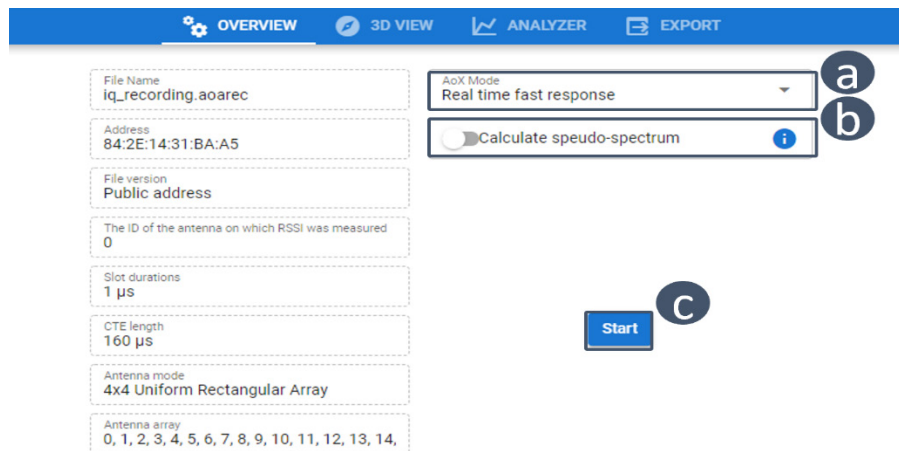
Figure 2-3. AoA Viewer

(a) Choose the AoX Mode

(b) Enable pseudo-spectrum calculation (requires huge computational resources and can be slow)

(c) Start the IQ sample processing

Use the **3D VIEW** tool ((a) in the following figure) to start the playback. Click/move inside the scroll bar (b) to view the azimuth (A), and Elevation (E) angles for each corresponding event counter value (C).
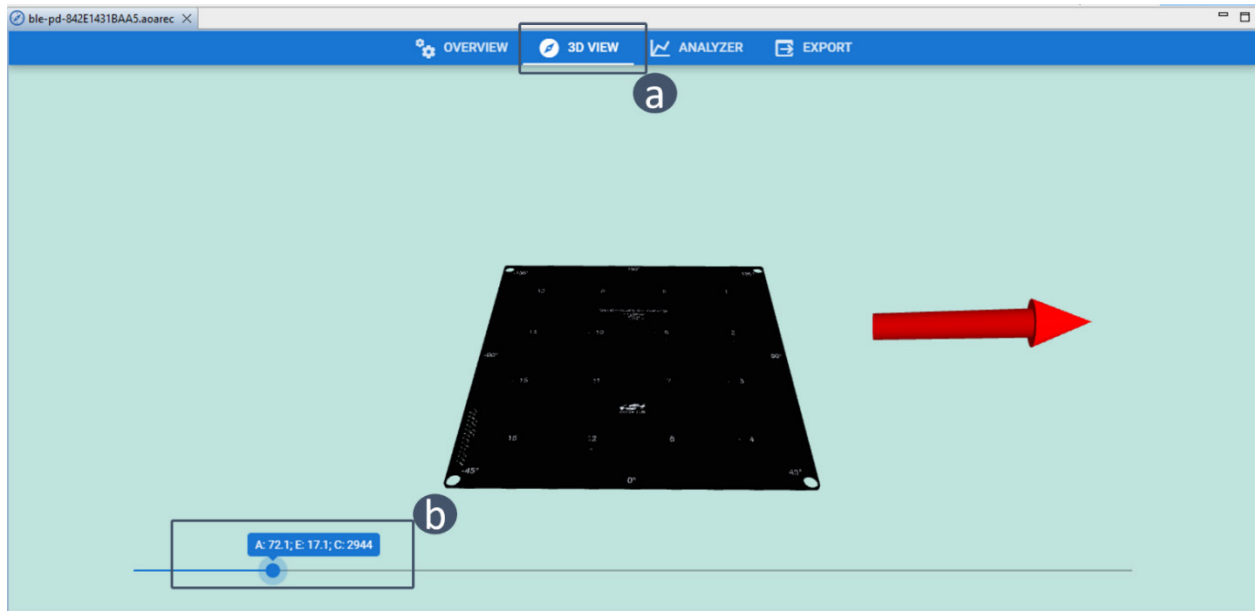
Figure 2-4. 3D VIEW of the Playback

Use the ANALYZER tool to draw line charts and histograms. If you enabled the pseudo-spectrum calculation, you can also graph a heat map to visualize the pseudo-spectra computation.
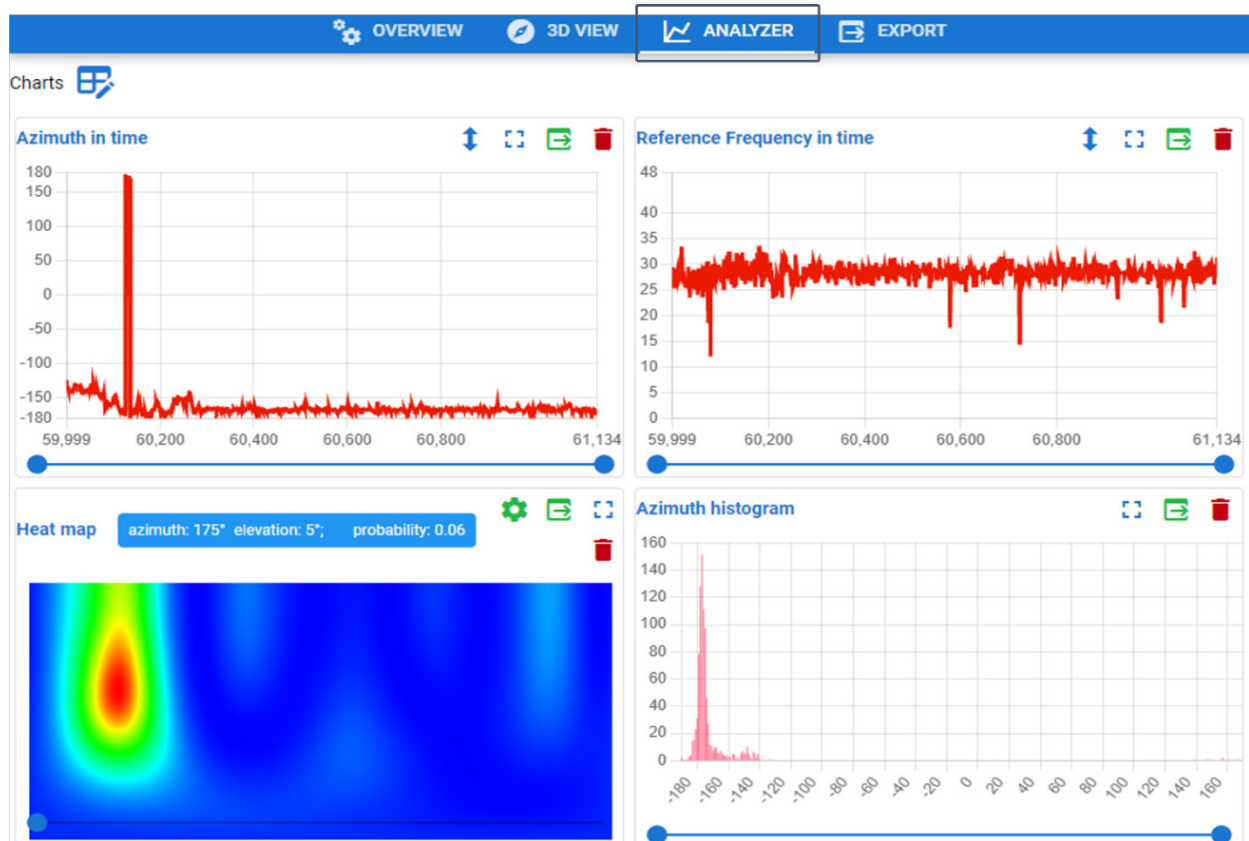
Figure 2-5. Drawing Line Charts Using the ANALYZER Tool

Use the **EXPORT** tool to export the postprocessing results of your IQ sample recordings in either JSON or CSV format.

3 Positioning Tool

While it is easy to configure a single locator and get angle information of asset tags, configuring and running a multi-locator setup to get position information can be rather complicated. To calculate position, the RTL needs to know the coordinates and orientation of the locator so that it can translate the angle feeds from each one of them with respect to the coordinate system of a given topology. Simplicity Studio provides the Positioning tool, which makes the configuration and testing of a multi-locator setup easy and quick.

To launch Positioning Tool:

1. From Simplicity Studio 5's Launcher perspective, click **Tools**.
2. In the Tools Dialog, select **Positioning Tool**.
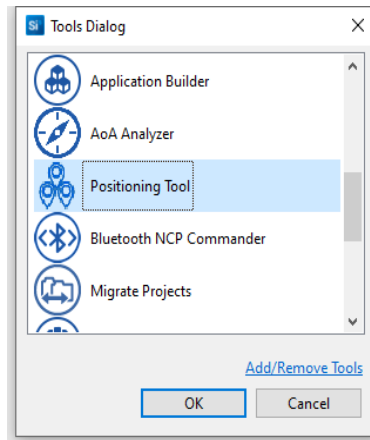
3. Click **OK**. Positioning tool opens in the Simplicity IDE perspective.

Figure 3-1. Positioning Tool

Here you can:

(a) Add a locator to topology.

(b) Import existing topology config JSON file, for instance from your GSDK directory: *example_host/bt_host_positioning/config/positioning_config.json*).

(c) Export the existing topology into a config JSON file.

(d) See the orientation of the topology's coordinate system.

(e) Change the settings of the positioning parameters of the RTL.

(f) Expand/collapse the sidebar menu.

3.1   Adding Locators

To test the position tool, you need to add two or more locator devices to your topology. To add a locator to a topology:

1.   Click the **Add locator** button (a in Figure 3-1. Positioning Tool Launch Window (or Opening Positioning Tool?)), and a Devices window opens.
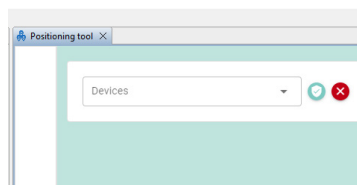
2.   Click the drop-down menu and select your locator by its J-Link serial number.
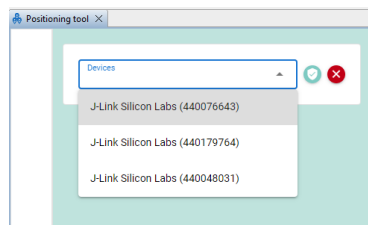
3.   Then, **Validate** your device. During the validation process the positioning tool (behind the scenes) connects with the chosen J-Link device in the previous step over serial (or IP), and executes a BGAPI command asking for the Bluetooth device ID. This is an important step since the RTL uses the Bluetooth device ID of the locator, and not the J-Link ID. Note: The board must be preprogrammed with **Bluetooth – NCP AoA Locator** firmware.
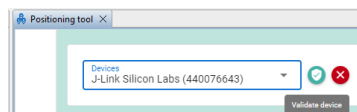
4. After the validation procedure is completed, the positioning configuration window for the locator opens (see the following figure). Use this window to

(a) Check the locator's Bluetooth device ID.

(b) Set the locator's x,y,z coordinates.

(c) Set the locator's orientation (rotation) using the sliding bars.

(d) Configure the RTL parameters used in angle calculation, add allow list and angle constraints (see Section 2.1 3D View).
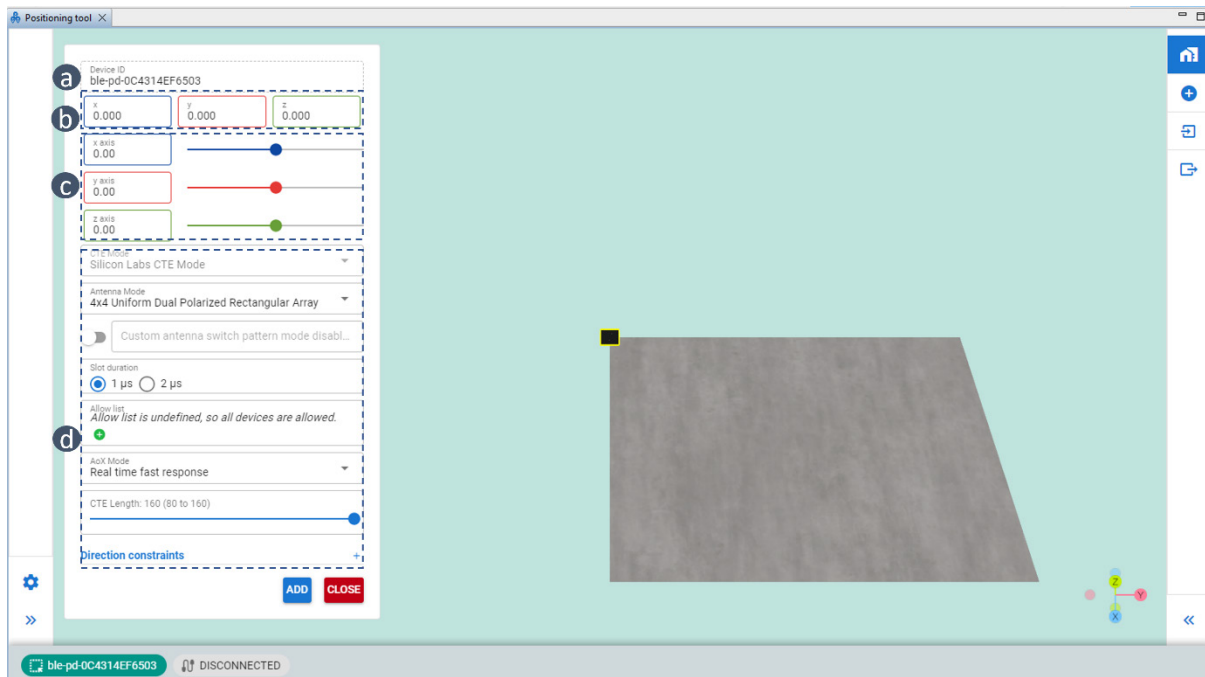
5. When finished click **ADD** and the locator will be added to the topology. Add as many locators as you want the same way.

3.2   Locating Asset Tags

The Positioning tool will locate the tags (if any) immediately after the second locator is added. Expand the sidebar menu on the left side and click on the plus sign next to the tag address ((a) in the following figure) and you will be able to see the tag's x,y,z positional values in real time at (b) in the following figure.
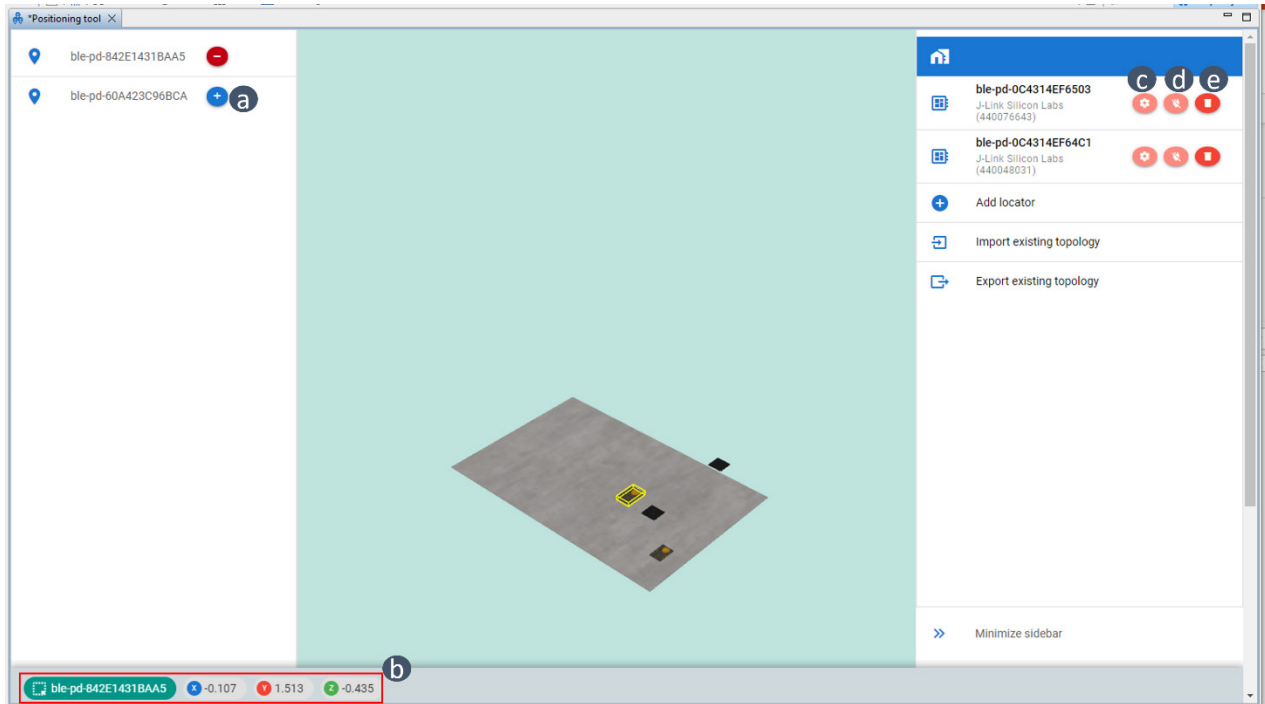
Figure 3-2. Tracking Asset Tags Using Positioning Tool

In the sidebar menu on the right side of the figure above you can (c) make changes to a locator's settings, (d) connect/disconnect a locator, or (e) delete a locator.

3.3   Setting Positioning Parameters

Use the settings control to change the RTL's positioning parameters, such as estimation mode, validation method, and so on. Through this control you can also enable/disable line vectors showing the direction of the asset tags as seen pointed by each locator device.

To change positioning settings:

1.   Click **Settings** on the left sidebar menu.
2.   Make changes to the parameters.
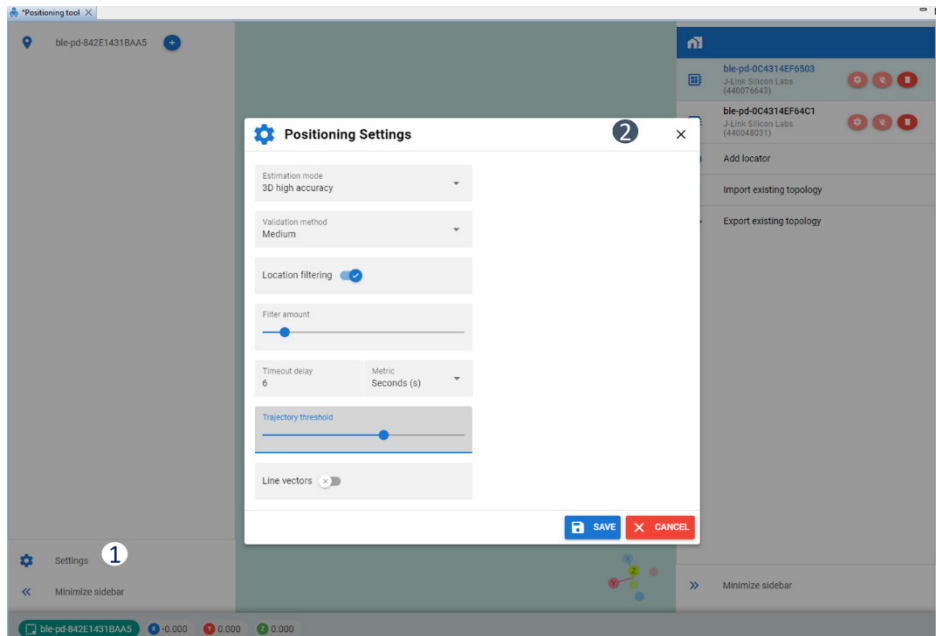
3.   Click **Save**. The changes will take effect automatically.

3.4   Importing a Topology

Use the **Import** feature to use your existing topology config file, for instance the one in your GSDK directory: $GSDK/app/Bluetooth/example_host/bt_host_positioning/config/positioning_config.json.

To import a topology, first launch the Positioning Tool following the steps in Section 3 Positioning Tool. Then,

1.   Click **Import Existing Topology**.
2.   Browse to the topology file and click **Open**.
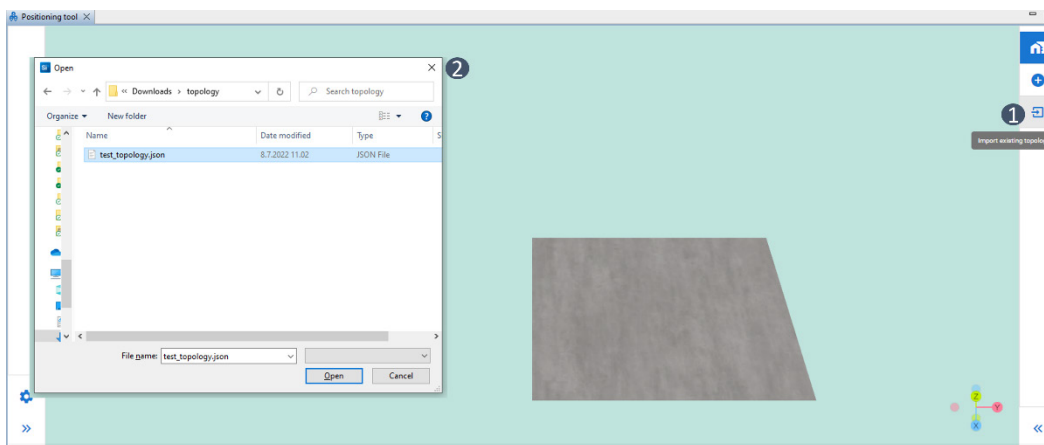
3.   Another window opens to connect and sync with a list of locator device IDs found in the topology file.
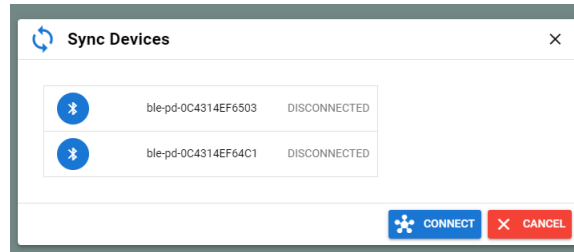
4. Click Connect and importing will be completed. The connect procedure is the reverse operation of the validation process discussed in step 3 of Section 3.1 Adding Locators. During this procedure the positioning tool scans through all the J-Link devices that it finds through Simplicity Studio and tries to connect and communicate with them using BGAPI commands asking for their Bluetooth device address. It syncs with those J-Link devices whose Bluetooth device address matches with the list of locator IDs in the imported topology file. After it completes synching, it immediately starts locating the assets in real time.
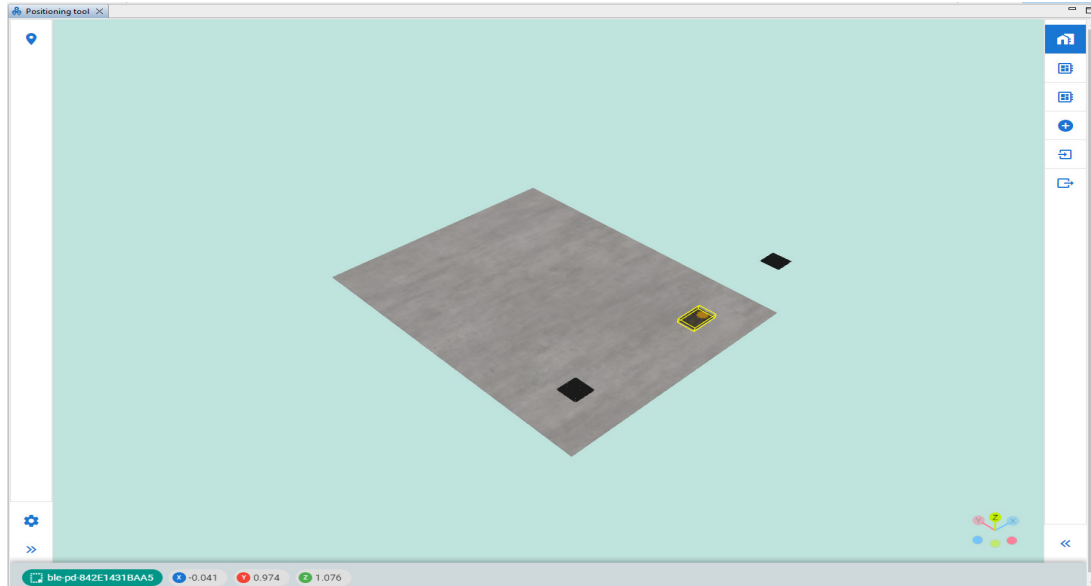
3.5   Exporting a Topology

Use the **Export** feature to export a topology configuration in the Positioning tool, for instance to re-use it in the GSDK host sample project: $GSDK/app/Bluetooth/example_host/bt_host_positioning/config/.

To export a topology:

1.   Click **Export existing topology**.
2.   Browse to the destination folder.
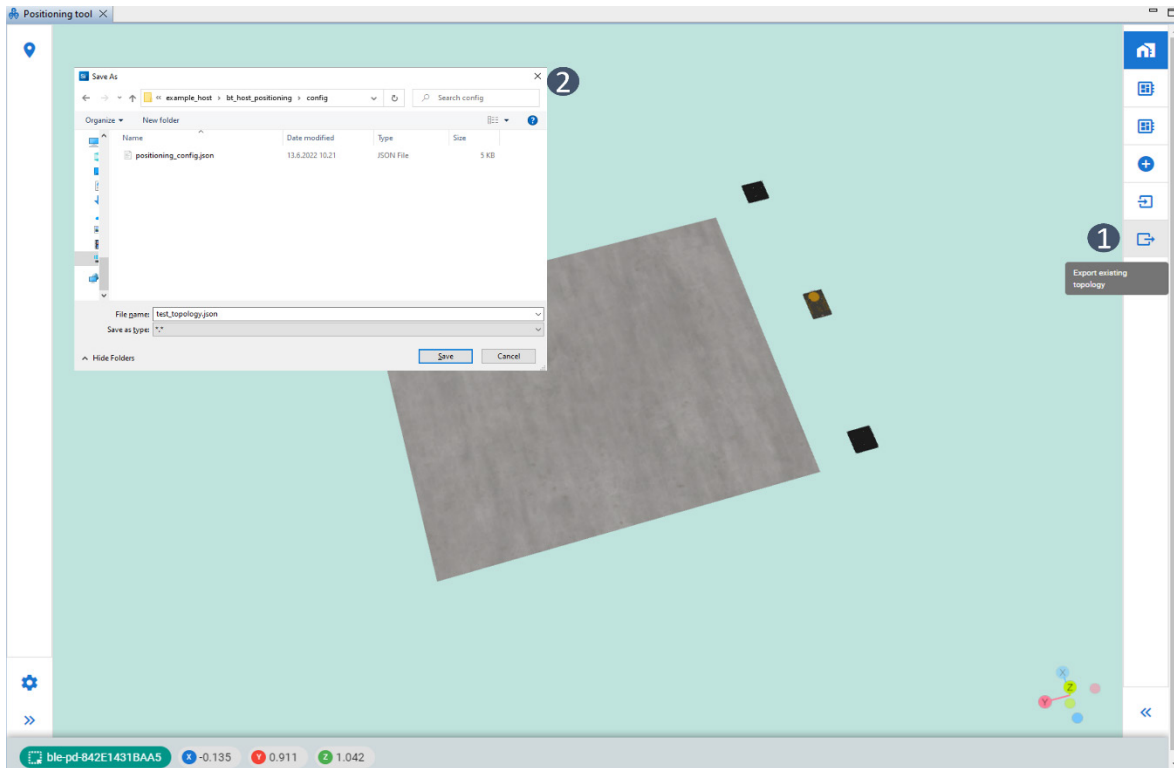
3.   Name the configuration file and click **Save** to finish exporting.

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