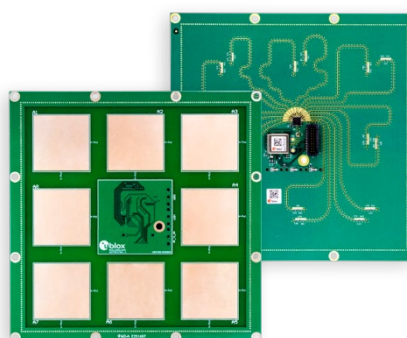
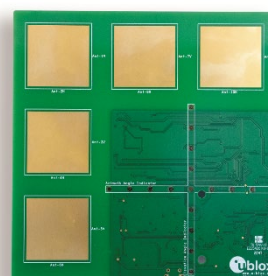


# Indoor positioning demo system

## Bluetooth indoor positioning User guide



### Abstract


This document describes the u-blox Local Positioning Engine and how it can be used with for example the u-blox XPLR-AOA-2 and XPLR-AOA-3 kits for indoor positioning. It also describes how the local positioning engine is used with floor plans and integrated into Traxmate platforms. The document is aimed for any developers involved in the development of applications using AoA technology.

# Document information

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This document applies to the following products:

Product name
NINA-B4
XPLR-AOA-2
XPLR-AOA-3

 Local Positioning Engine v3.0 is only compatible with u-locateEmbed v3.0 and above. Be sure to upgrade all anchor points.

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# 1 Introduction


This document describes the u-blox XPLR-AOA-2 and XPLR-AOA-3 kits and explains how to use them for indoor positioning. The kits build on the Bluetooth indoor direction-finding technology from u-blox and include a positioning algorithm and web-based GUI for configuring the system and tracking beacons.

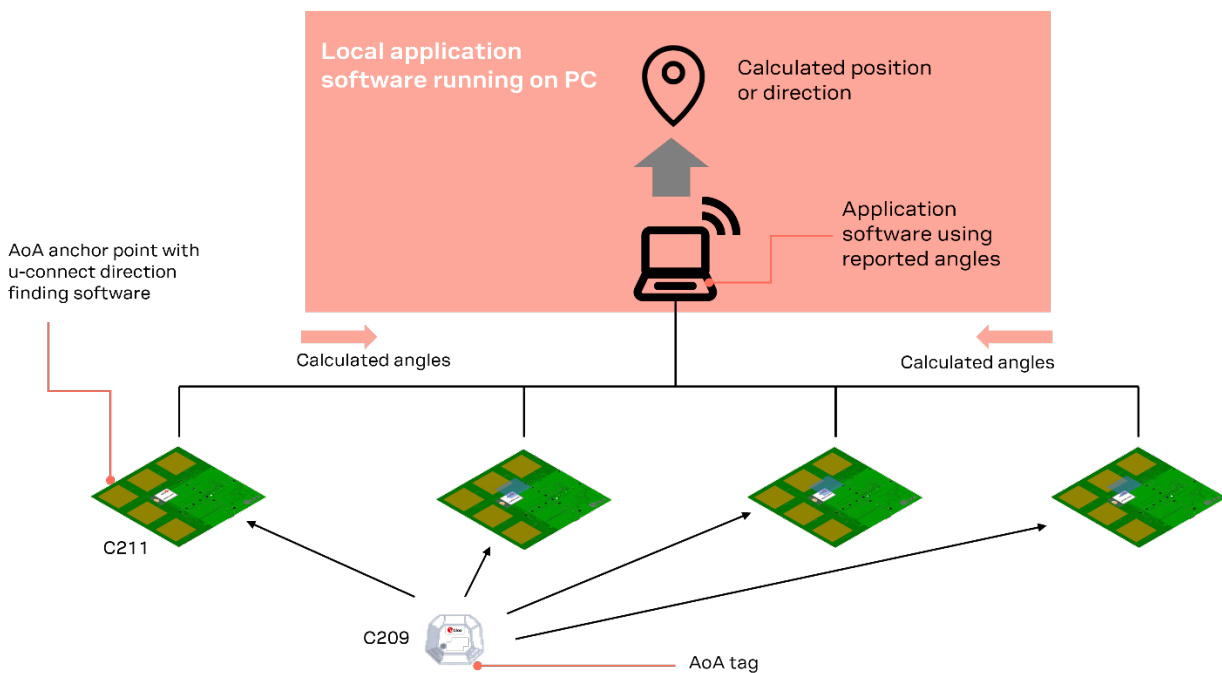
To understand the technology underlying direction-finding systems, refer to the Bluetooth Indoor Positioning product page [\[11\]](#).

## 2 System overview

The XPLR-AOA-2 kit consists of four u-blox anchor nodes that can be positioned in most room areas, while 4x XPLR-AOA-3 kits yield an equivalent setup based on ANT-B10. The kits are connected to the Local Positioning Engine running on a Windows PC using a Wi-Fi or an USB cable. An example setup of the demo system is shown in [Figure 2](#).

Out of the box, the system anchor nodes track u-blox C209 tags but can also be configured to track other tags that emit CTEs (Constant Tone Extension) and advertise Bluetooth content using Eddystone beacon messages. See also the user guides for the XPLR-AOA kits [\[7\]](#) [\[10\]](#).

 Although the figures shown in this document depict the C211 antenna board, you can safely assume the ANT-B10 antenna board included in XPLR-AOA-3 can be used with the same effect instead.



**Figure 1: u-blox local positioning demo system**

The position of the tracked tags can be visualized locally on the PC, using the system with a local floorplan, or integrated into the Traxmate® cloud-based tracking platform.

## 3 Installation of anchor points

### 3.1 Placement and configuration of anchors

Anchors can be connected through the UART interface using USB cables but can also connect over Wi-Fi/UDP. To connect anchors through the UART interface using USB cables, make sure the baud rate is configured to 115200bps. To connect anchors over UDP, the UDP server must be started in the “Utils” tab. To learn how the anchor nodes can be configured to connect to the Local Positioning Engine over UDP, see also the XPLR-AOA kits user guides [7] [10].



UDP is a connectionless protocol, which means that the delivery or ordering of sent packets cannot be guaranteed.



In the position engine implementation, the default baud rate for connecting anchors through UART interface is 115200bps.

The Local Positioning Engine provides best results when the anchors are placed in a rectangular shape, but it is also possible to place them in other geometrical shapes – on a straight line for example.

After having placed the anchors, it is important to keep note of which anchor (MAC address) is situated in each corner of the tracking area. The easiest way is to make a note of this and draw a map as they are placed in the area.

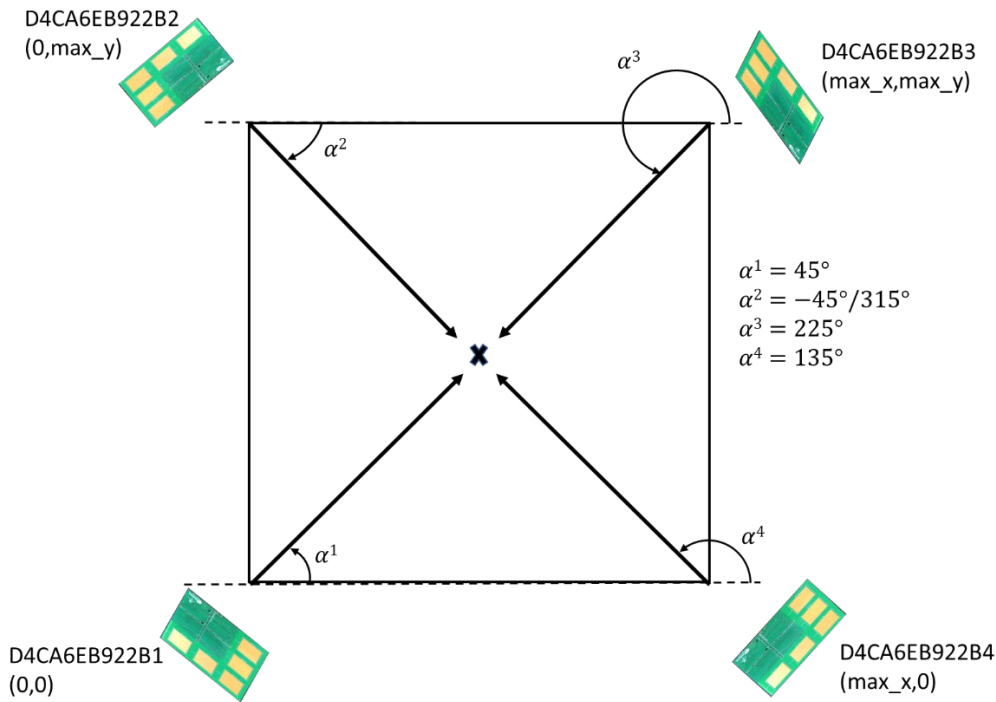
The MAC address of an anchor can be found in several ways:

- Scan the barcode situated on the module mounted on the anchor.
- Connect the anchor using USB and connect a terminal emulator to the COM and issue the command `AT+UMLA=1`.
- Connect just one anchor and check the `+UUDF` events for the MAC address in the `<anchor id>` field (one tag needs to be active).

Figure 2 shows an example of the anchor positioning with the appropriate 45° angles for a square layout. The angles should be calculated in accordance with a mathematical “unit circle”, where the angles are based on the positive x-axis.

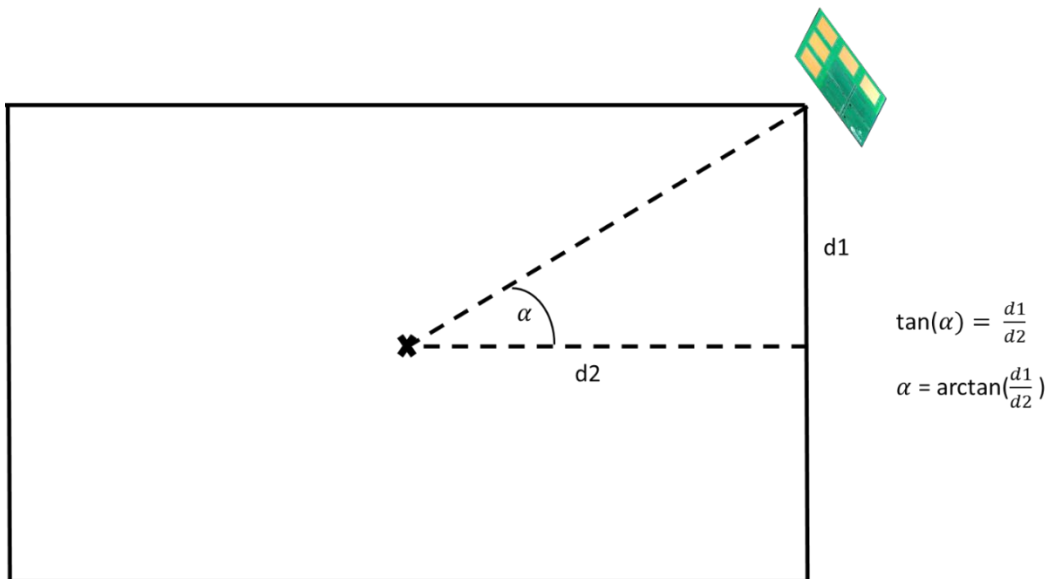


Although not strictly required from the positioning engine, it is good practice to point the normal of the anchors towards the center of the room.



**Figure 2: Anchor placement and angles in a square layout**

If your layout is not square but rectangular for example, you can calculate the angles using the normal trigonometry formulas. [Figure 3](#) shows the mathematical calculation of the angle, but you can also use a protractor to measure the angles if you prefer.



**Figure 3: Angle calculation**

It is also perfectly fine to just place the anchors in alignment with the corner with angles in multiples of  $45^\circ$ .

## 4 Setup and configuration

### 4.1 Installation

The positioning engine is delivered as a zip container file that includes:

- The server executable
- Some example floor plans

To install the engine, extract and then run the `server.exe` file.


To access the positioning engine, open a web browser tab with the address <http://localhost:5000>, where the user interface for configuration and running the local positioning engine can be found.

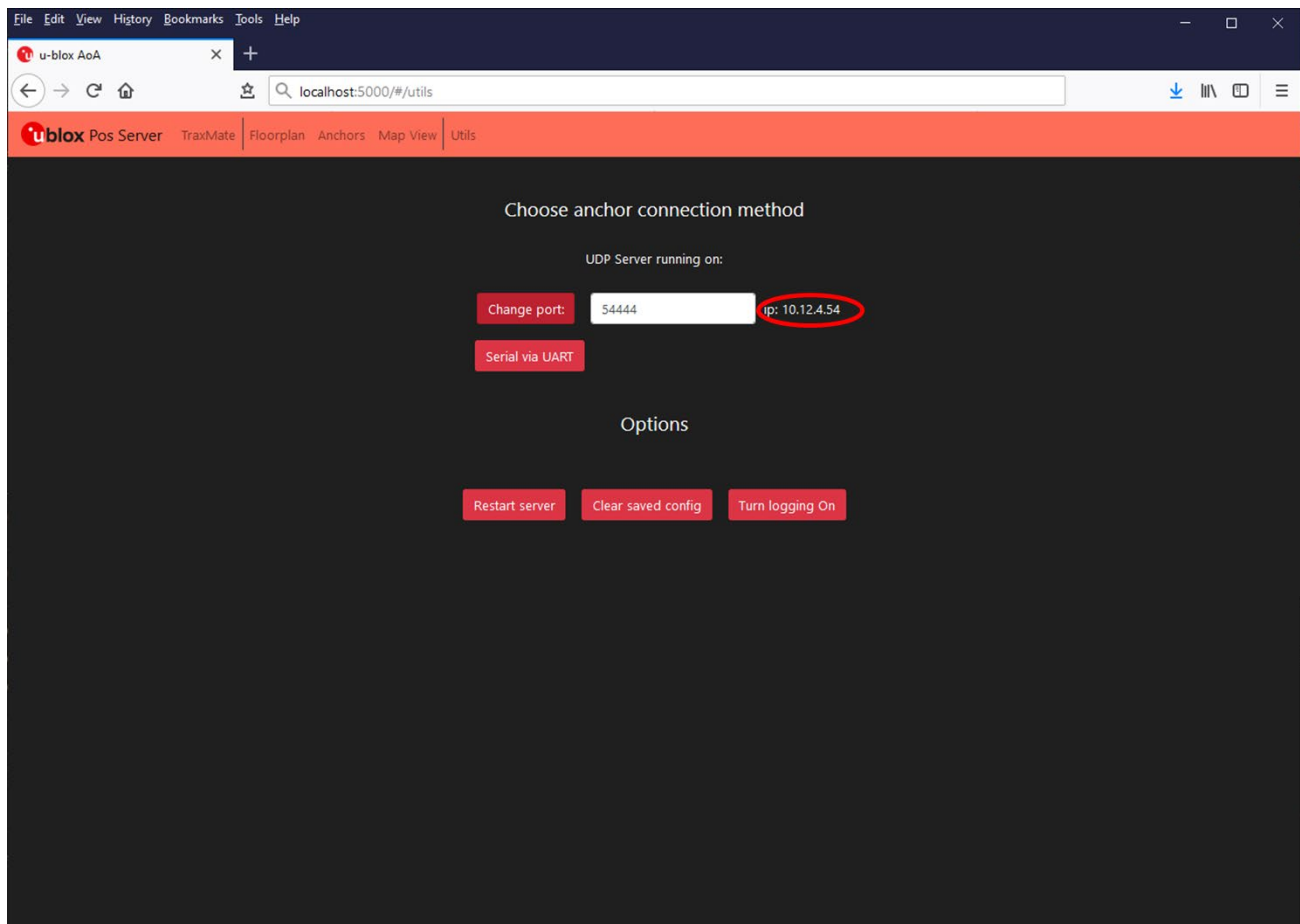
Google Chrome is the preferred browser for the web-based user interface.

### 4.2 Anchor connection

The anchor nodes can be connected to the PC using either a serial connection through the USB/UART interface or wireless connection over UDP.

If the anchors are connected over UDP it is necessary to start the UDP server from the “Utils” tab in the user interface. [Figure 4](#) shows the IP address and UDP port that is used.

 Your choice of connection method is saved between sessions, so the UDP server only needs to be started once.



**Figure 4: UDP server started. Note port and IP address for setting up the anchors**



The system confirms how many connected anchors have been detected in subsequent dialogs.

To detect anchors connected over UDP at least one tag needs to be active and transmitting.

### 4.3 Tracking in local UI or Traxmate cloud

Figure 5 shows a login prompt for the Traxmate cloud, where you can sign up for a Traxmate account. This is the first dialog that is shown when starting the system. To use the cloud, log in here and follow the procedures described in [Using the system with Traxmate integration](#).

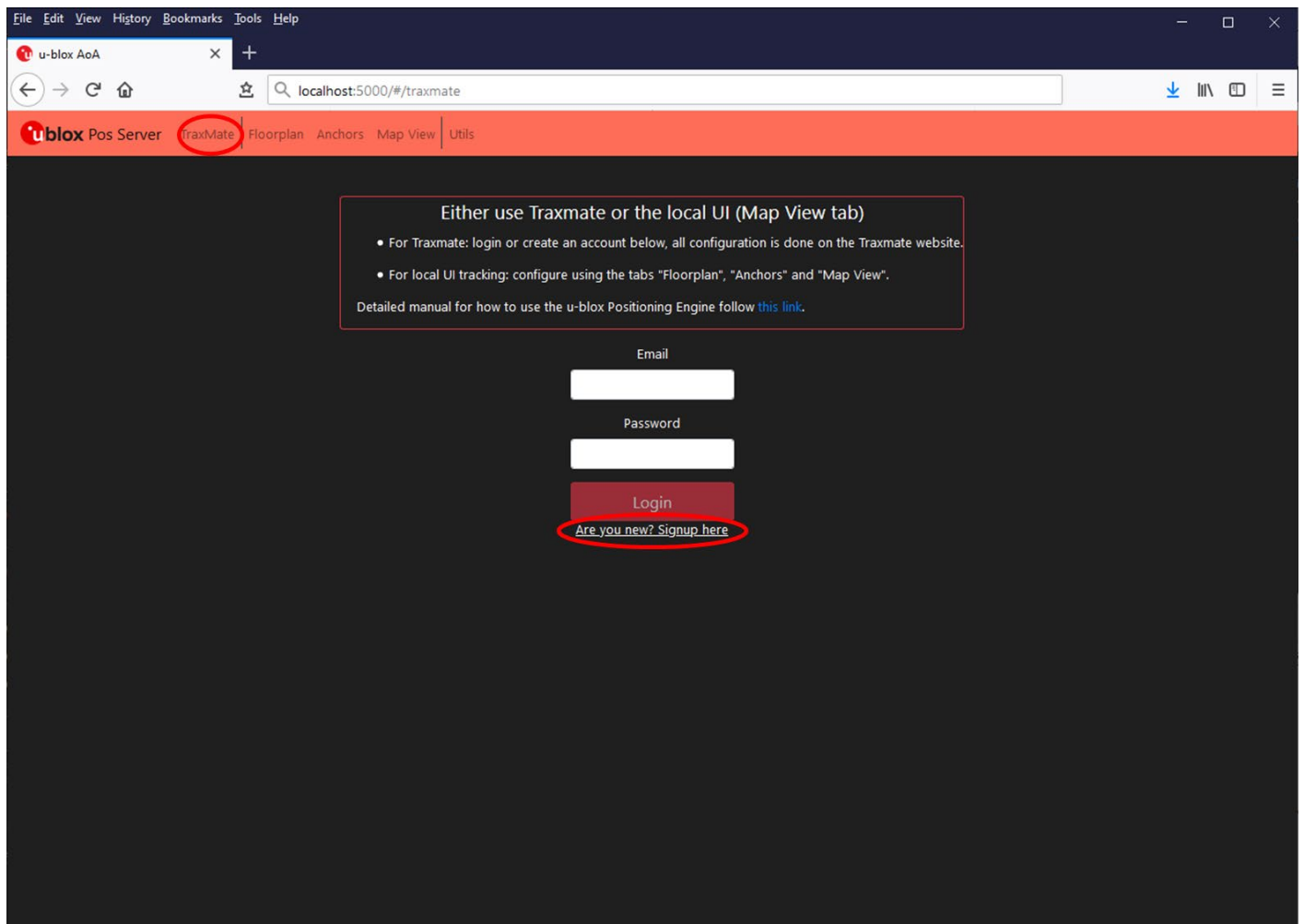



Figure 5: System start dialog

Password requirements apply for Traxmate account creation. The password needs to be of a minimum length and complexity.

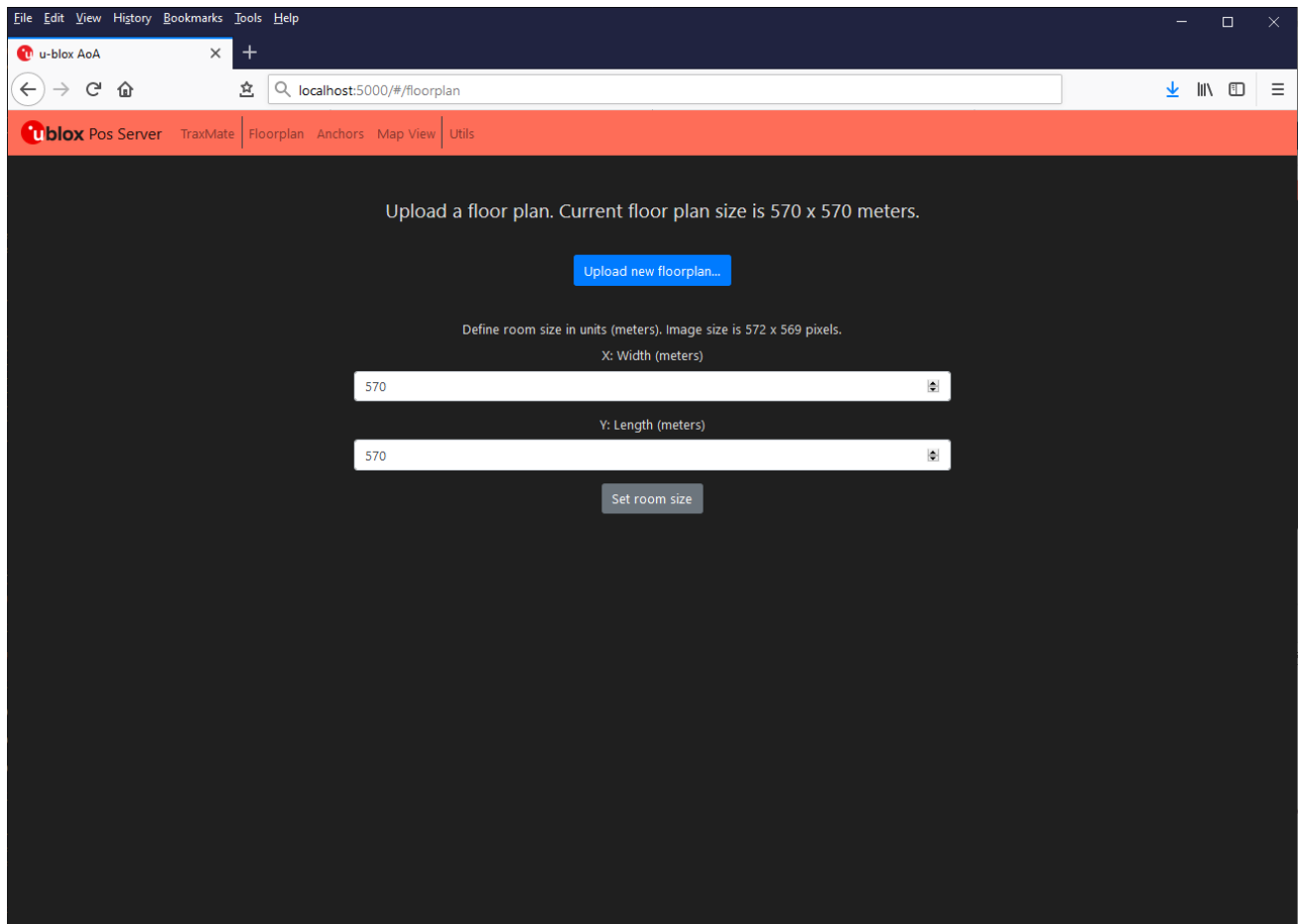
## 5 Using the system with a local floor plan

### 5.1 Floor plans

The package that includes the u-blox local positioning engine comes with several preconfigured floor plans, but other custom floor plans can also be added. The preconfigured floor plans are stored in the `floor_plans` folder of the installation.

 Your chosen demo area must be arranged in close accordance with the scale and dimensions of the current floor plan. It is necessary to set up the size of used area shown in the Floorplan tab. The size is configured using the metric system.

To upload a new floor plan, select “Upload new floorplan” in your browser, as shown in [Figure 6](#).



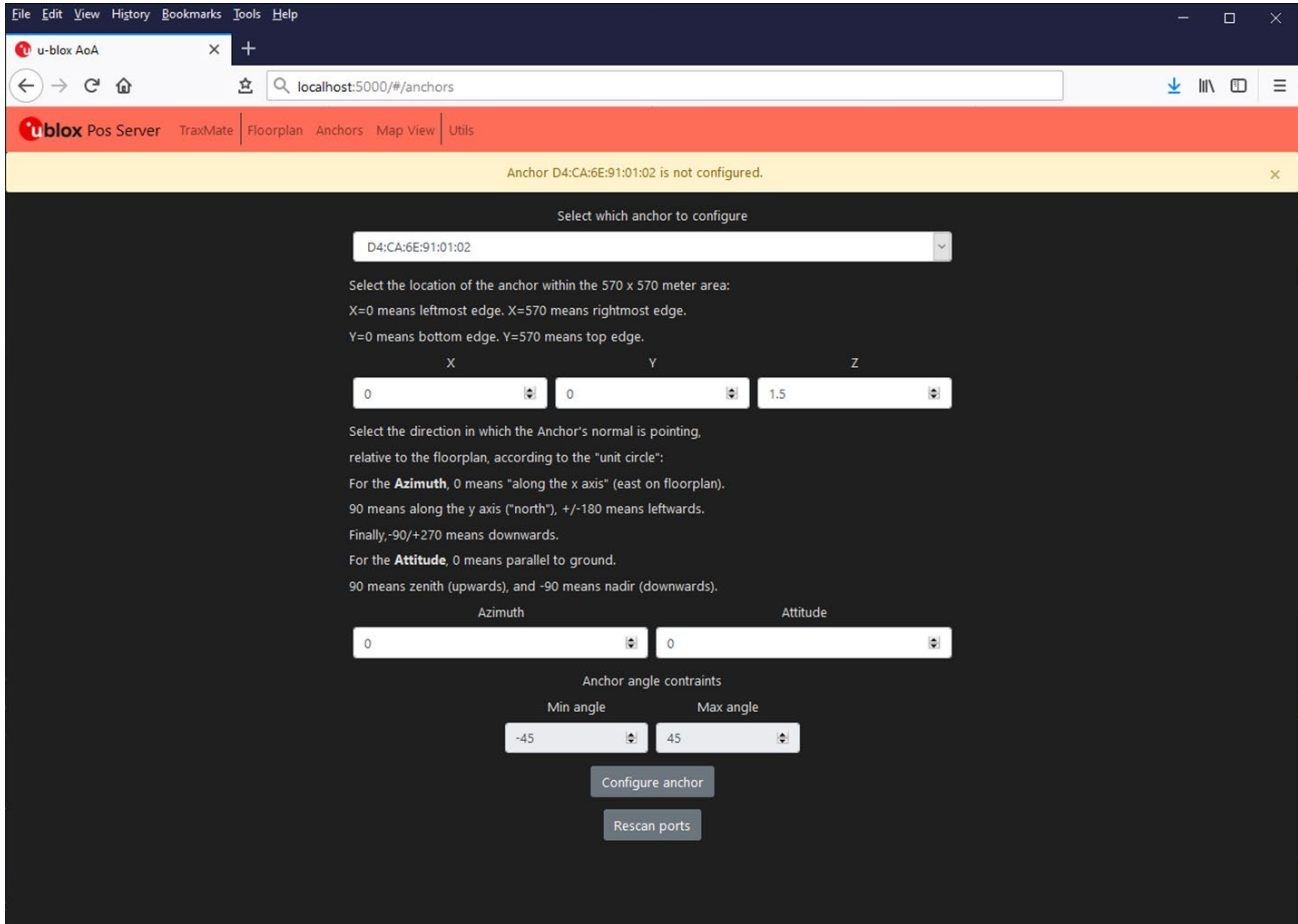
**Figure 6: Uploading a floor plan**

The floor plans can be in any of the following image formats:

- png
- jpg
- jpeg
- tiff
- tif
- bmp
- gif
- ppm

## 5.2 Anchor configuration

Having uploaded your floor plan, you must then place the anchors in the model. Follow the [placement and configuration of anchors](#) you chose earlier and configure the anchors one-by-one as, as shown in [Figure 7](#). The connected anchor points are automatically detected and listed in the drop-down list in the Anchor configuration view.



**Figure 7: Anchor configuration**

Set these parameters to place and configure the anchors:

- X: X coordinate of anchor, related to map. Set in meters.
- Y: Y coordinate of anchor. Set in meters.
- Z: Z coordinate, that is height of anchor over the floor. Set in meters.
- Azimuth: Angle of anchor relative the unit circle positive x-axis. See also [Placement and configuration of anchors](#).
- Attitude: The angle of the tilt of the anchor relative to the floor. Negative angle is downwards, positive angle upwards.
- Min angle, Max angle: The minimum and maximum angles set in [Figure 7](#) are used to restrict errors when the tags move close to the border of the surveyed area. These parameters provide the constraints for the reported angle. The surveyed area appears to be a cone shape. When min angle and max angle are set to -45 and 45°, the surveyed area is shown as in [Figure 8](#).

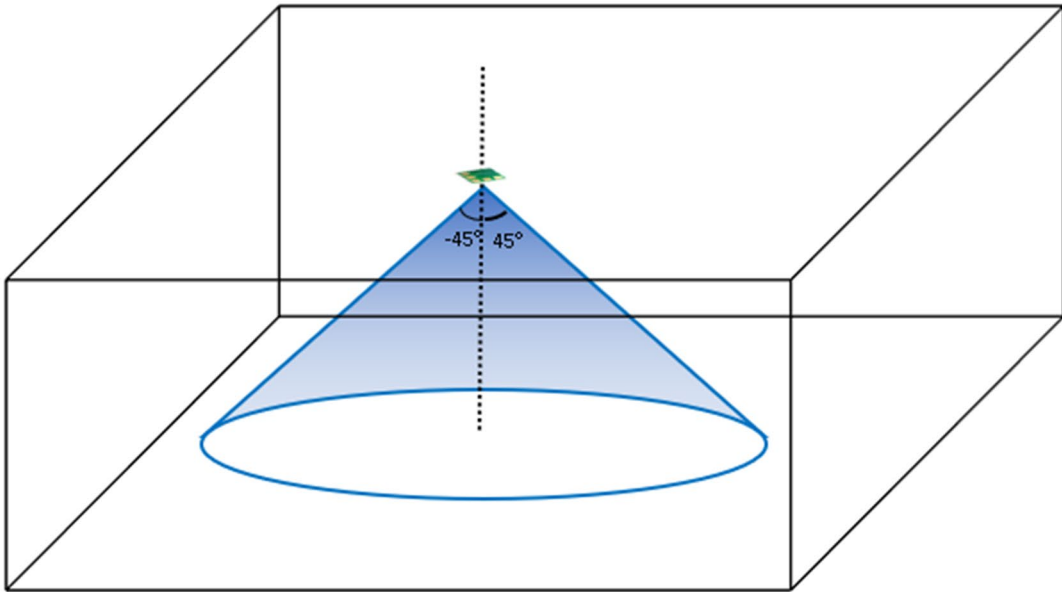


Figure 8: surveyed area when min angle and max angle are set to  $-45$  and  $45^\circ$

## 5.3 Running the system

After the floor plan is configured and the anchors have been set the system is ready to run. Press the Play button in the UI and verify that the floor plans and anchors are placed as expected.

The “Map view” shows three buttons in the UI footer, as shown in [Figure 9](#):

- Play – starts the tracking of the tags
- Down – for internal use only
- Tracing – adds a trace the tag movements

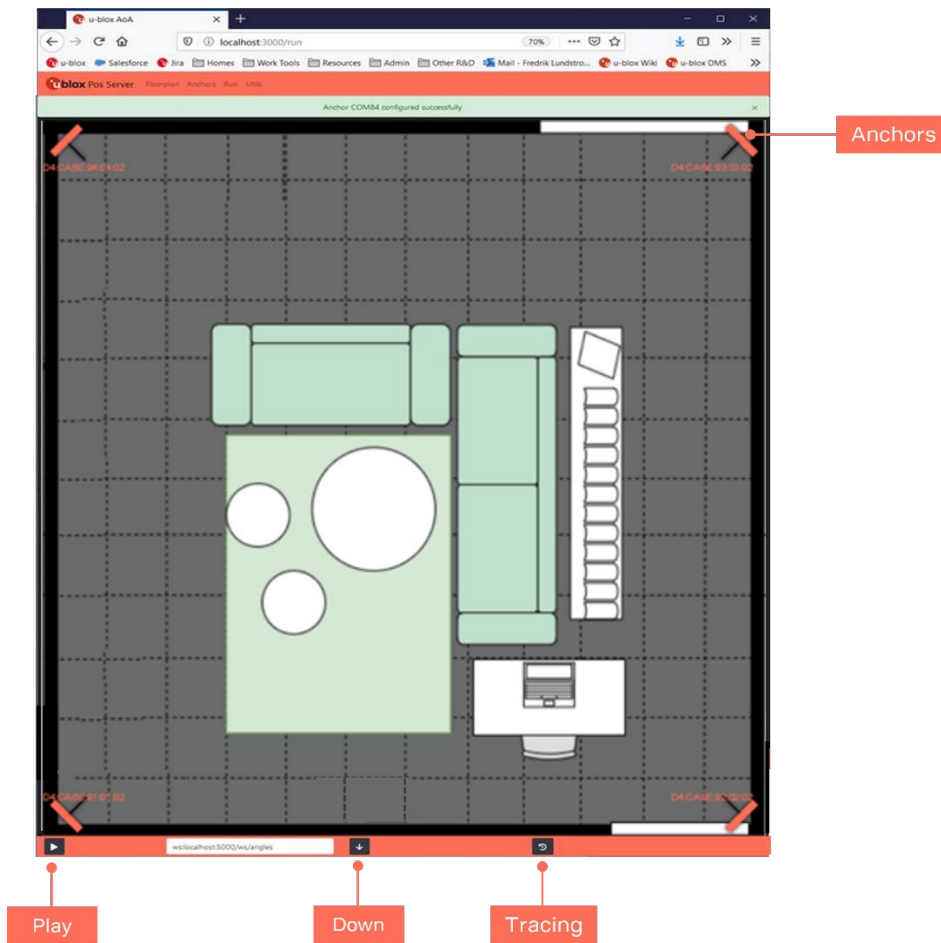


Figure 9: Floor plan with anchors placed

Clicking an anchor in the system displays an arrow to show its reported angle, as shown in [Figure 10](#).

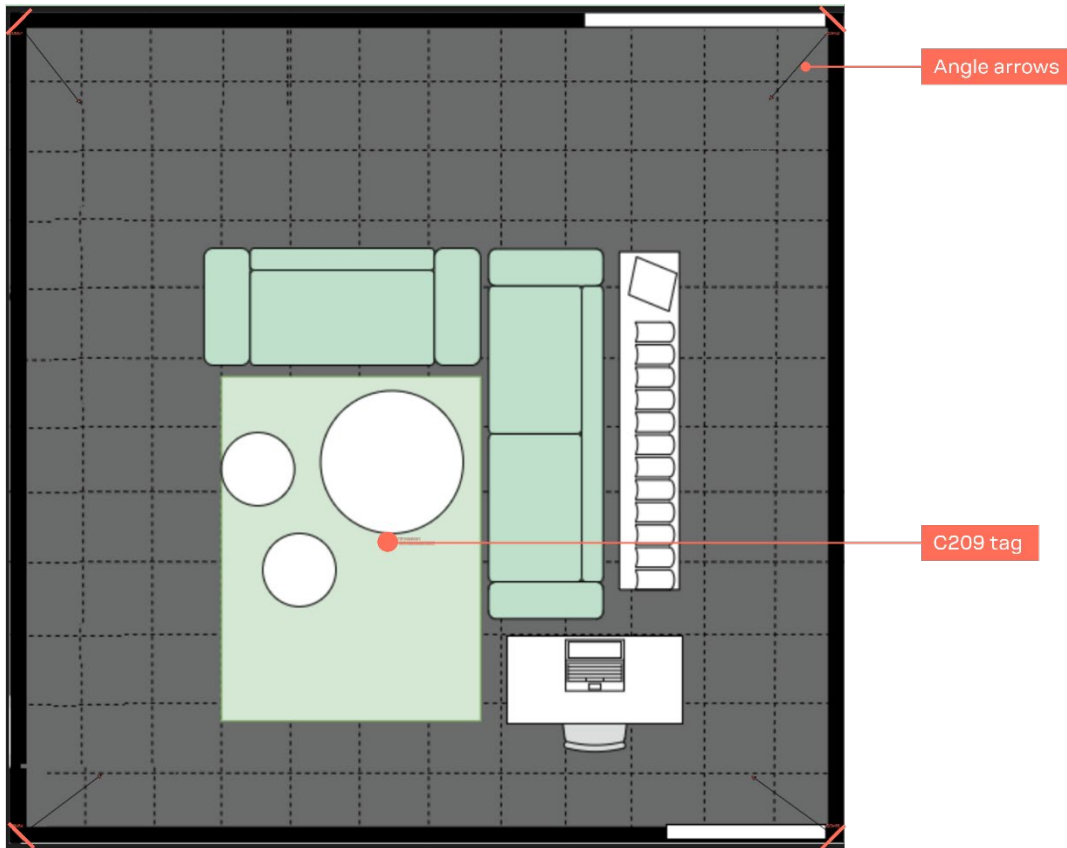


Figure 10: Floor plan with angle arrows activated for all anchors

## 6 Using the system with Traxmate integration

When using the u-blox indoor positioning solution together with Traxmate, the positions calculated by the u-blox local positioning engine are sent to the Traxmate system for analysis and display.

### 6.1 Setting up the Traxmate cloud

The workflow for using the u-blox indoor positioning solution with Traxmate requires:

- Adding a building. Use the building set up example in the Traxmate system or add a new one. See also [Adding a building in Traxmate](#).
- Adding a building model. The building model includes information about the anchors in the location, which can be automatically uploaded from this dialog.
- Configuring the Building model in Traxmate
- Publishing the building model

To setup the system in Traxmate:

1. Create an account in the Traxmate cloud. To get the correct account type this must be done from within the local positioning GUI. Select the Traxmate tab and then the sign-up link, as shown in [Figure 5](#).
2. After successful account creation and login, you are directed to the Traxmate setup dialog, as shown in [Figure 11](#).

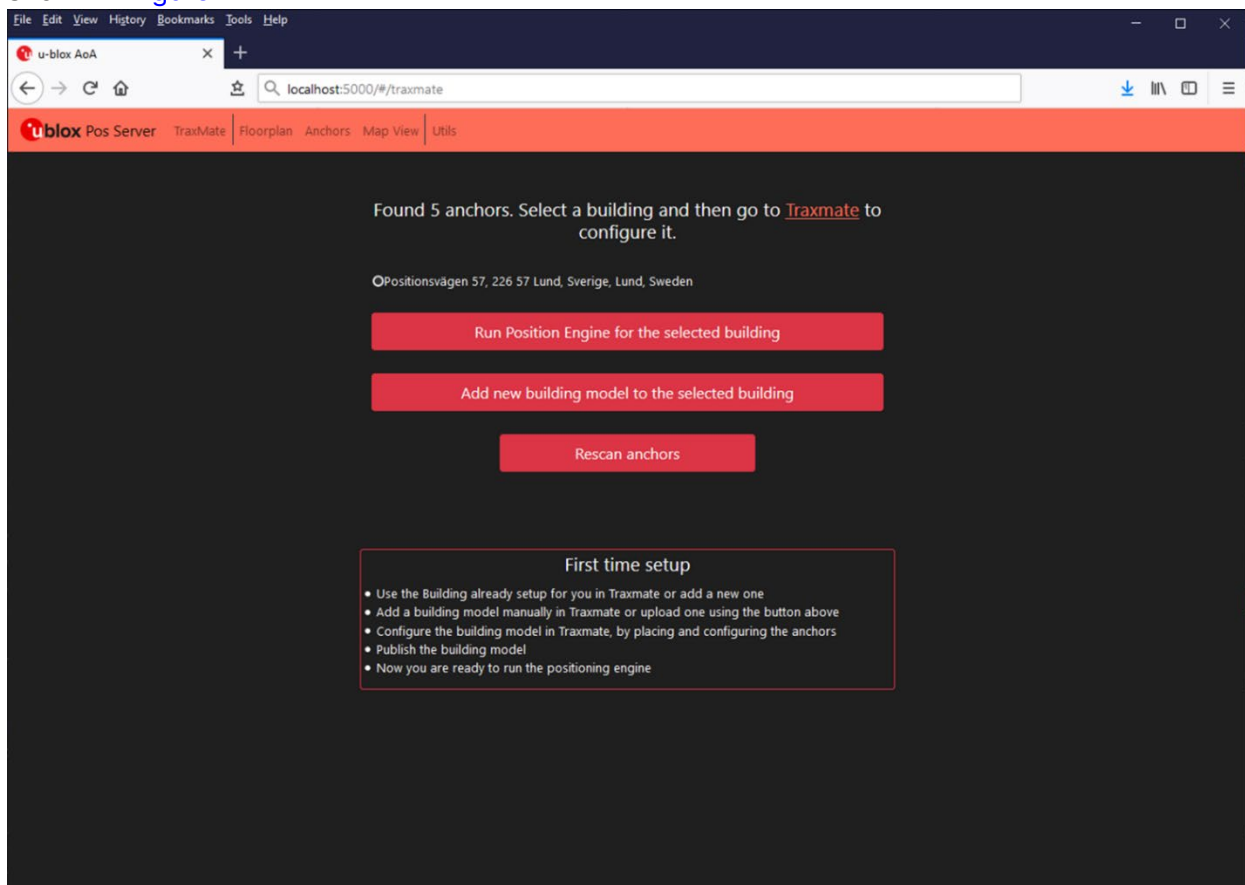

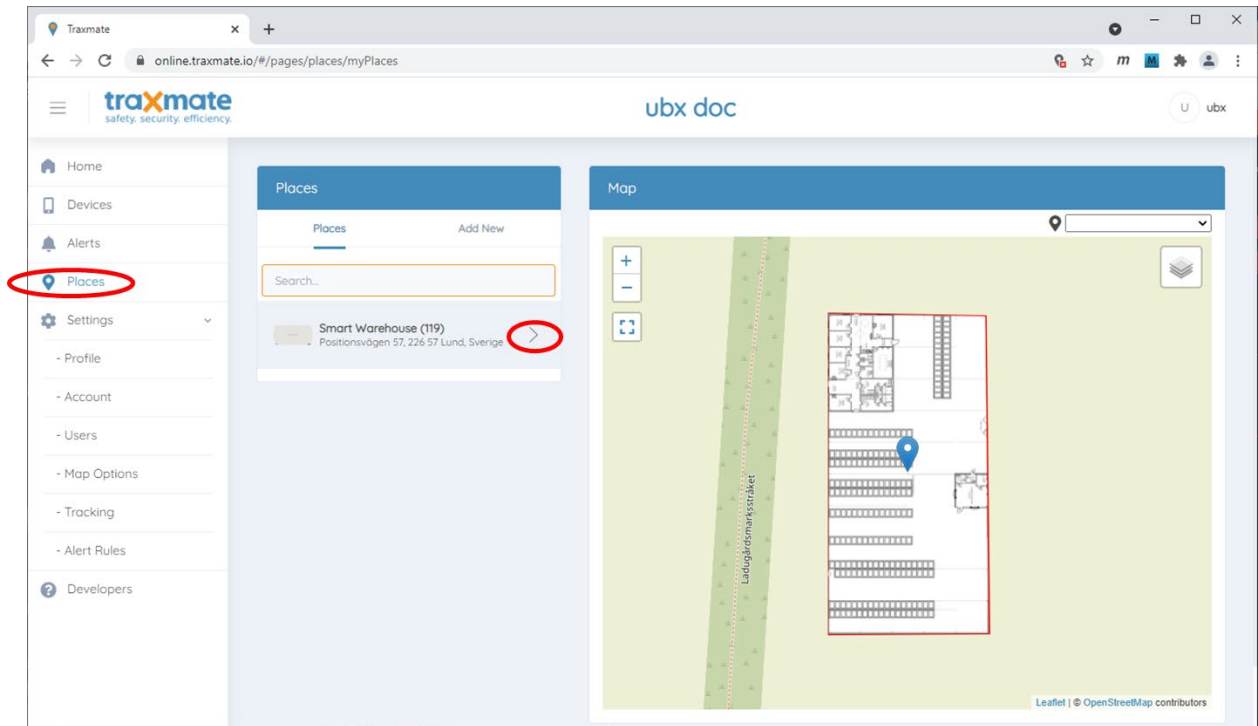


Figure 11: Traxmate panel in u-blox local positioning engine

Select “Add new building model...” to upload the building model for your model. Note that this step is also necessary for the default building.

 It may take some time (allow for a minute or two) before the uploaded building model is visible in Traxmate.

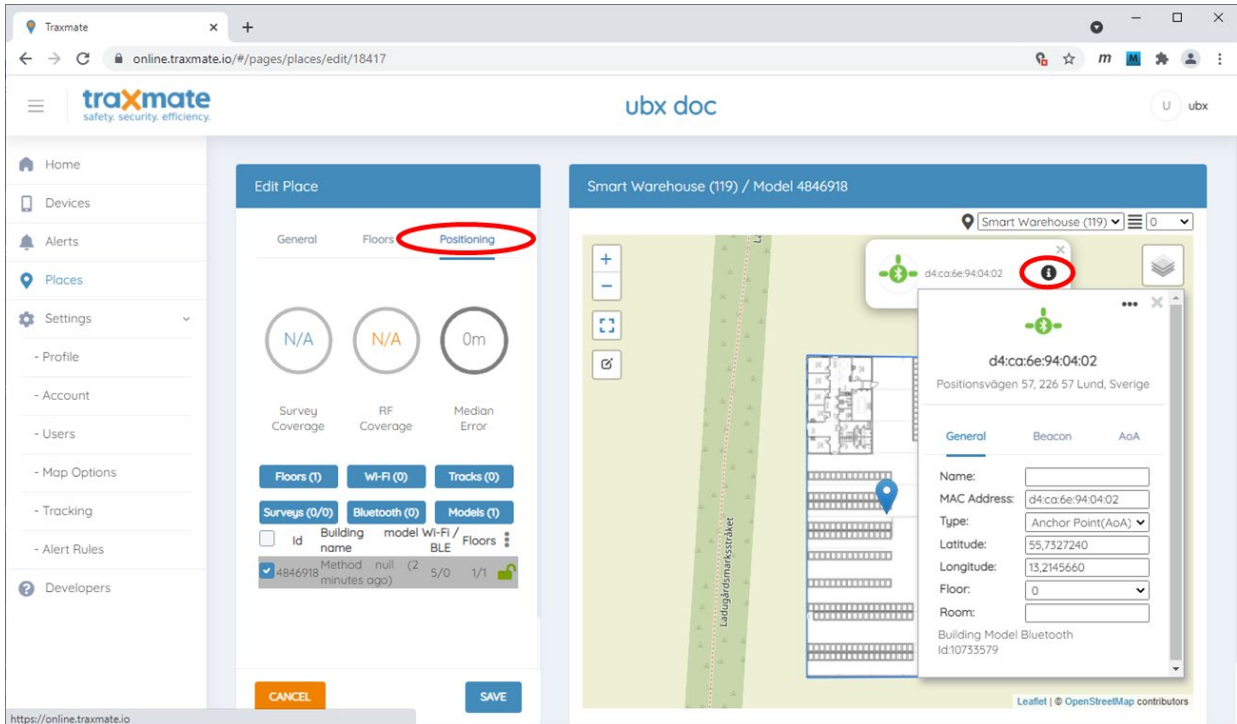
3. Press the Traxmate link in the setup dialog, and then log in to the Traxmate cloud using the credentials you provided in step 1.
4. Select “Places” and then your preconfigured building to configure your anchors. “Smart Warehouse” is the preconfigured building shown in [Figure 12](#).



**Figure 12: Traxmate places view**

5. From the chosen preconfigured building dialog, configure your anchors by dragging the anchors to the desired location.
6. Select the model and press the EDIT button to move your anchors to the desired position. As all anchors are initially placed on top of each other in one corner, you need to move the top anchor to see the others.
7. Set the properties of each anchor. Select the anchor and press the information symbol in the subsequent pop-up dialog, as shown in [Figure 13](#).





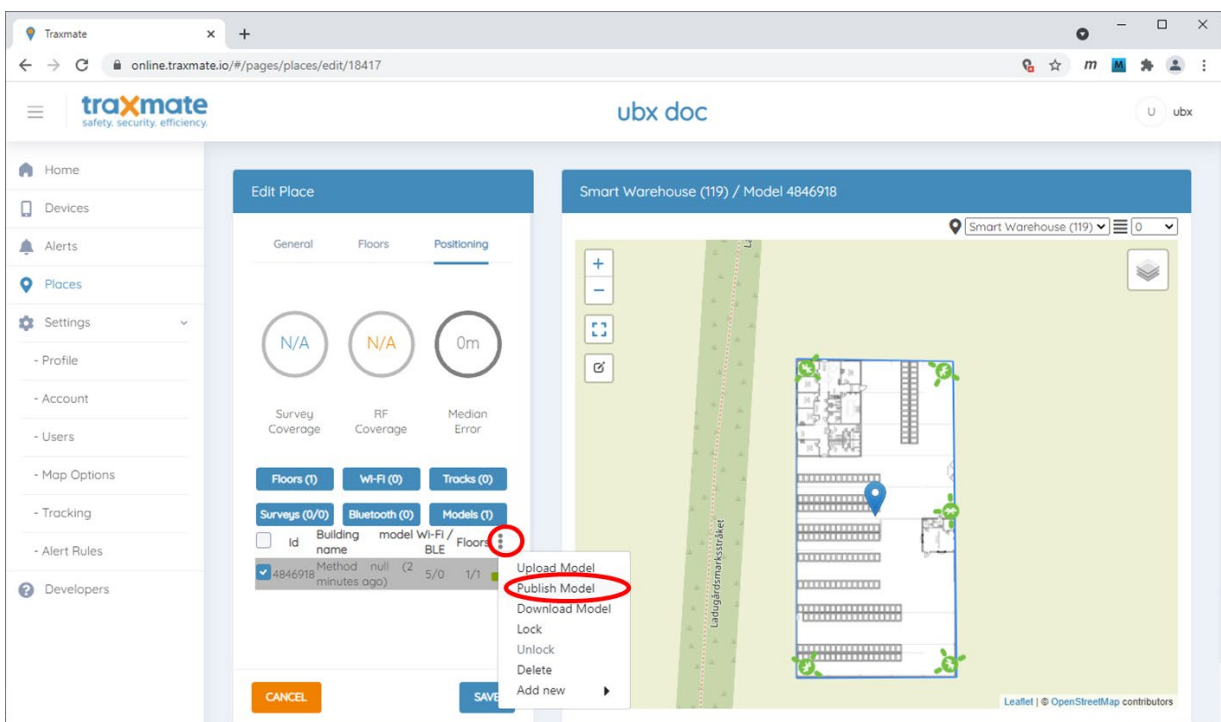
**Figure 13: Anchor configuration in Traxmate**

8. Set the Floor in the General tab
9. In the AoA tab, set the angles and height over the floor for the anchor.



All the anchors must be configured on the same floor.

10. When all anchor settings are complete, publish your building model, as shown in [Figure 14](#).



**Figure 14: Publishing configured building model**

11. The system is now ready. Select “Run Positioning Engine...” in the u-blox local positioning engine GUI and then start some tags to track the movements in the Traxmate cloud.

## 6.2 Adding a building in Traxmate

### 6.2.1 Preparation

Prepare floor plan images for the indoor spaces you want to track the C209 tags. The same images can be reused for several floors. The images must be rendered in png, jpg or gif format.

### 6.2.2 Adding a building

1. From the “Places” menu, look up an address in the Traxmate GUI and add the building you want to track as a “Place”. Search for the address or mark the place in the map, as shown in [Figure 15](#).

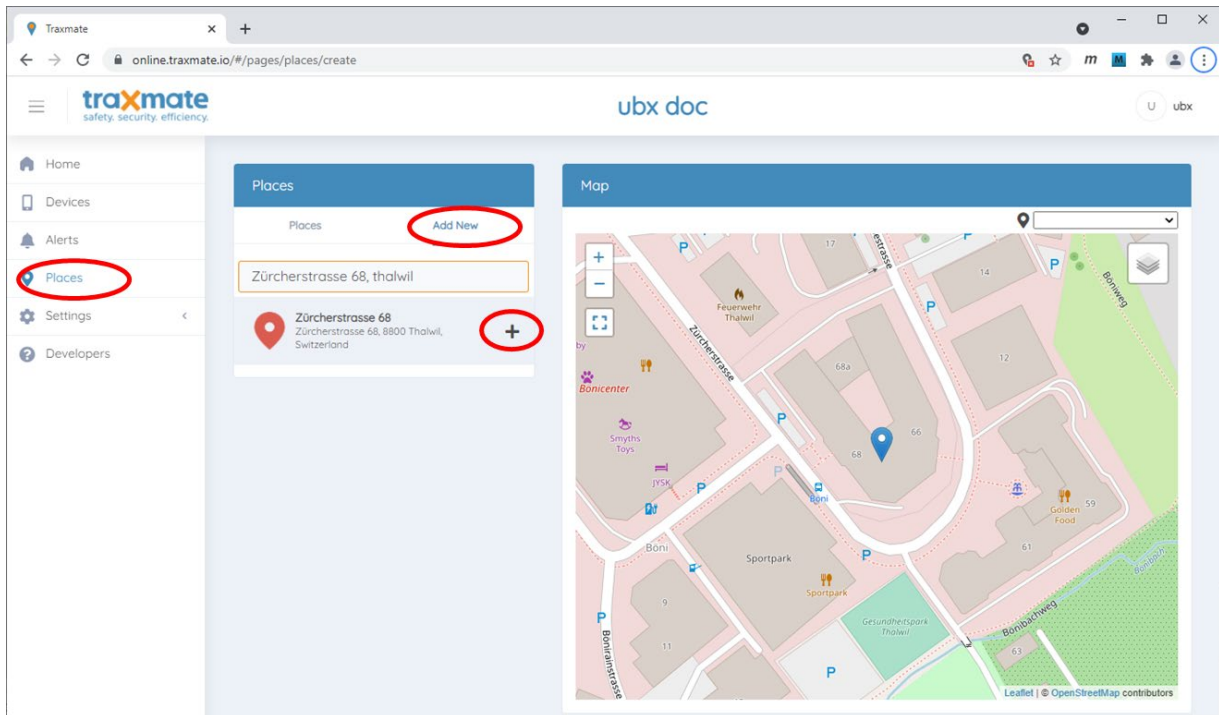


Figure 15: Adding a new place in Traxmate

- Use the polygon tool to draw the building shape and then **SAVE** the building.

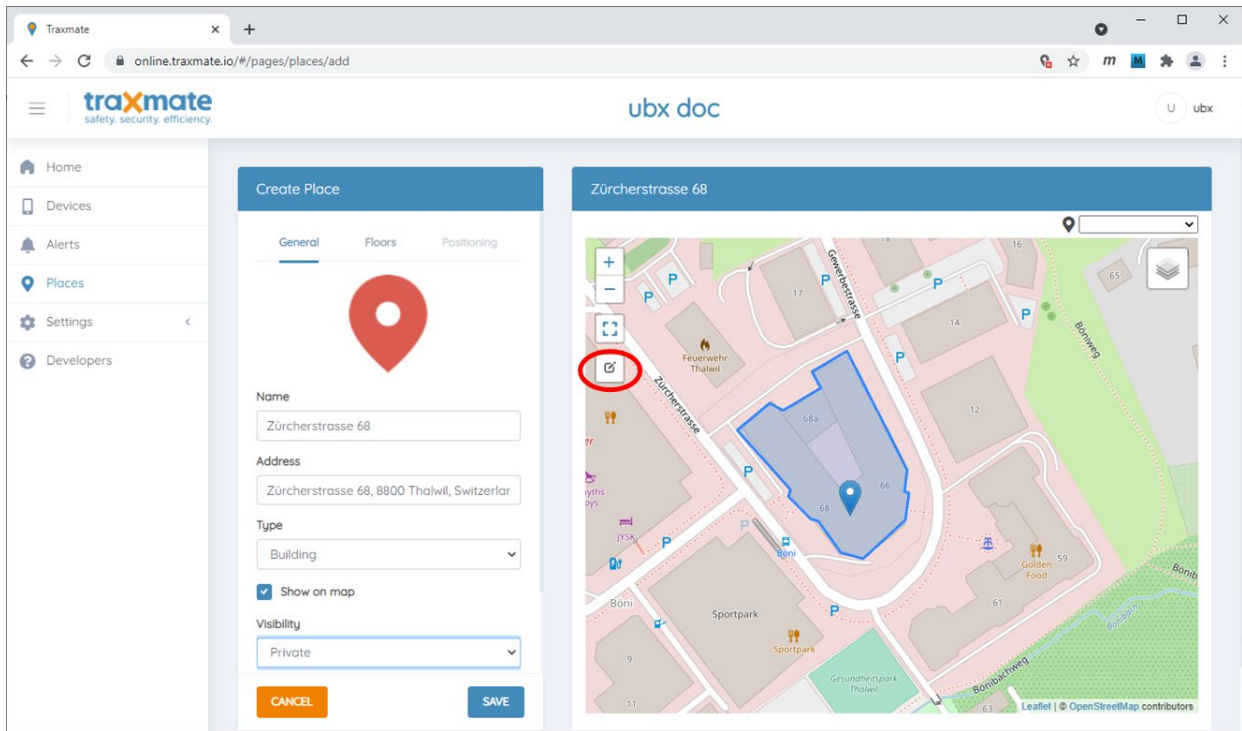


Figure 16: Using the polygon tool to draw building shape

- Enter the “Floors” tab and add your floors and floor plans for the building. Select the cloud icon for the chosen floor to upload your prepared floor plan.

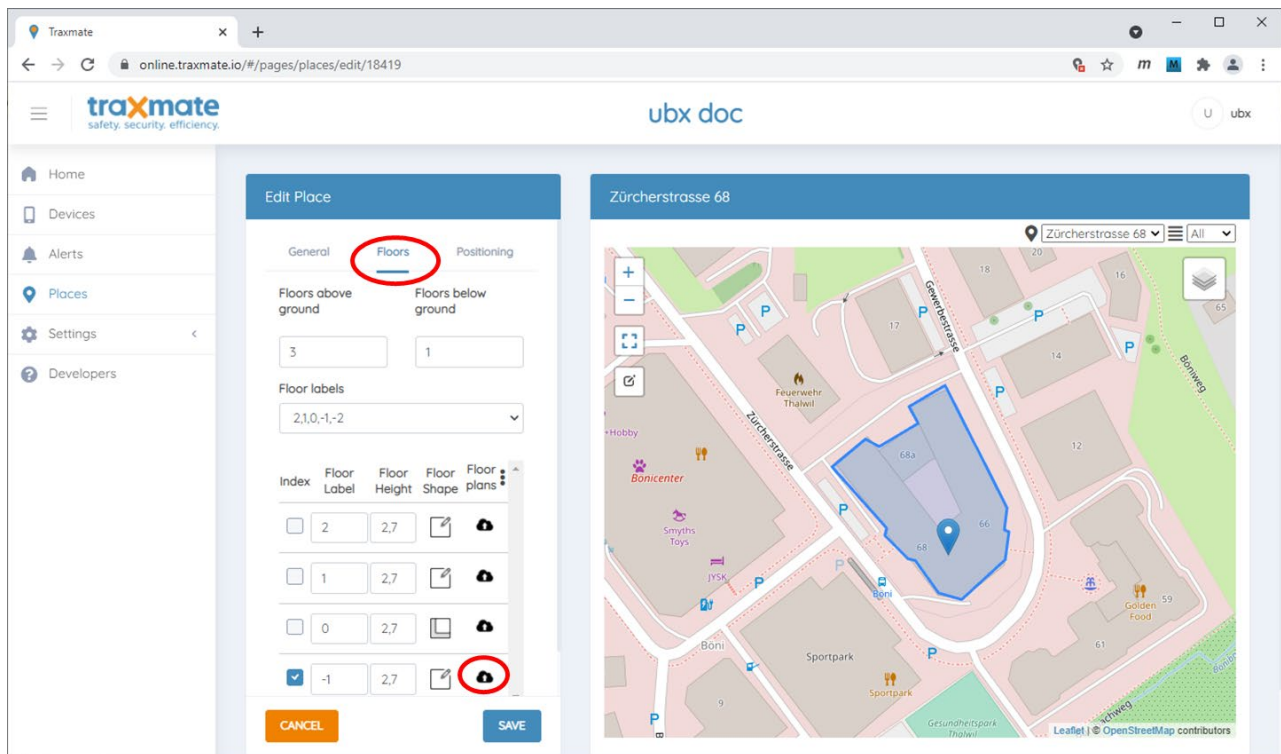


Figure 17: Adding floors and floor plans to a building

4. From the drop-down ellipsis menu, add the same floor plan to other floors – if needed.

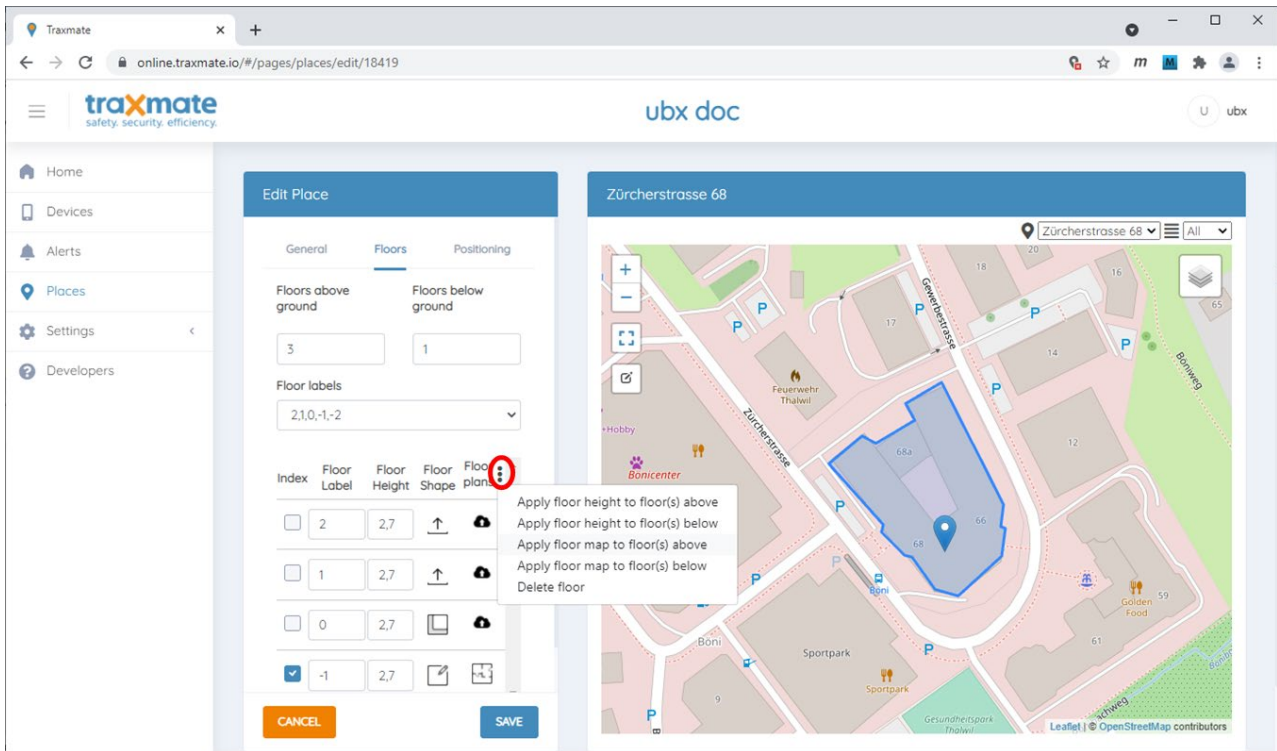


Figure 18: Reusing floor plan between floors

- When the floor plan for the “Place” is complete, select **SAVE**.
- Add a building model. Reload the view in the u-blox local positioning interface. The place saved in the previous step is now shown as an added place.

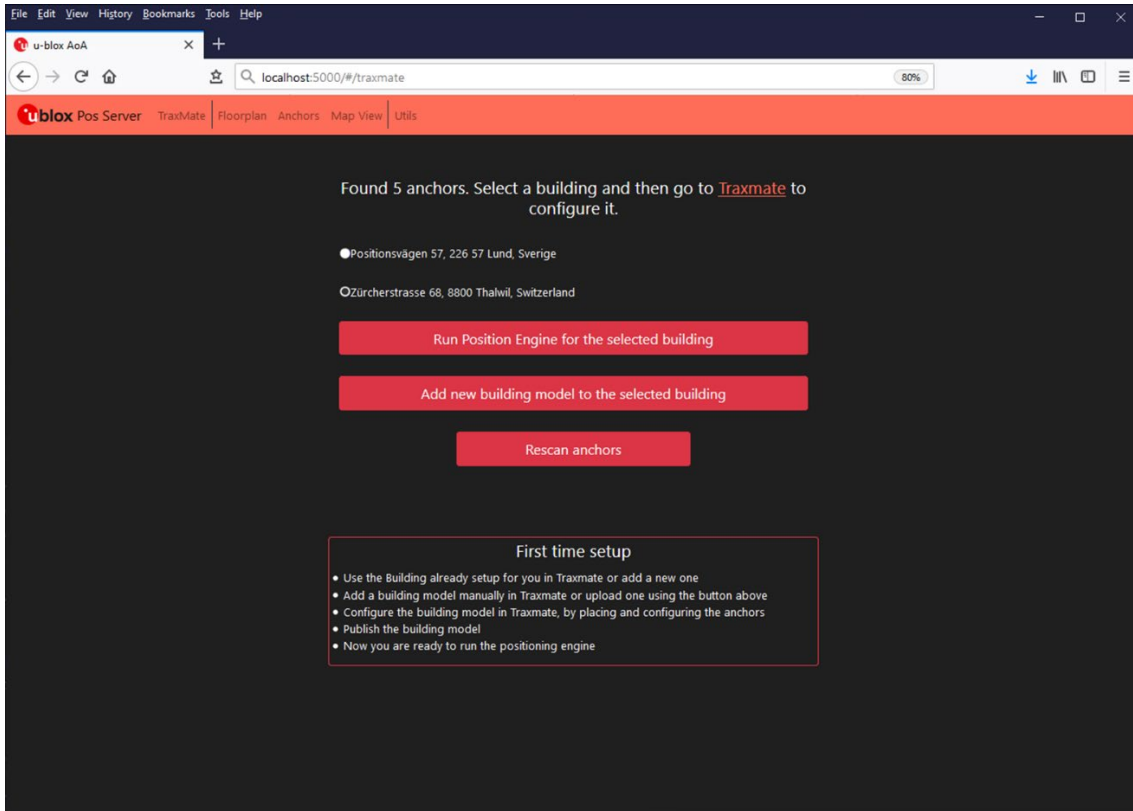


Figure 19: Adding a building model to new building in Traxmate

7. Select “**Add a new building model...**” The model can now be configured in the same way as it is in [Setting up the Traxmate cloud](#).



As an alternative to uploading the model from the u-blox local positioning engine a model can be created and the Bluetooth AoA anchors added in the Traxmate UI.

# Appendix

## A Glossary

Abbreviation	Definition
AoA	Angle of Arrival
AoD	Angle of Departure
CTE	Constant Tone Extension

**Table 1: Explanation of the abbreviations and terms used.**

## Related documentation

- [1] Bluetooth SIG white paper on direction finding: <https://www.bluetooth.com/bluetooth-resources/bluetooth-direction-finding/>
- [2] NINA-B41 product page, <https://www.u-blox.com/en/product/nina-b41-series-u-connect>
- [3] u-connectXpress AT commands manual, [UBX-14044127](#)
- [4] NINA-B4 system integration manual, [UBX-19052230](#)
- [5] s-center, <https://www.u-blox.com/en/product/s-center>
- [6] u-blox webinars, <https://www.u-blox.com/en/webinar>
- [7] XPLR-AOA-1 and XPLR-AOA-2 explorer kits, user guide, [UBX-21004616](#)
- [8] u-locateEmbed product page, <https://www.u-blox.com/en/product/u-locateembed>
- [9] Traxmate, <https://traxmate.io>
- [10] XPLR-AOA-3 kits user guide, [UBX-22006906](#)
- [11] Bluetooth Indoor Positioning technology, <https://www.u-blox.com/en/technologies/bluetooth-indoor-positioning>



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## Revision history

Revision	Date	Name	Comments
R01	1-Sep-2021	mapa	Initial release
R02	13-Sep-2021	mapa	Corrected port number in <a href="#">Setup and configuration</a> .
R03	01-Nov-2021	mapa	Included new section to describe <a href="#">using the system with Traxmate integration</a> , and added information about how to connect anchors with UDP.
R04	19-Jan-2022	mapa	Removed open-source licenses and moved to new document.
R05	20-Mar-2023	mapa	Updated document to include XPLR-AOA-3 kit. Added image file types in <a href="#">Floor plans</a> .
R06	20-Jul-2023	lliu	Specified anchor baud rate when connecting with PE through UART in <a href="#">Installation of anchor points</a> .
R07	02-Feb-2024	lliu	Specify min angle, max angle, two UI parameters, and compatibility with u-locateEmbed.

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