5G-4iCity: Enhancing Smart City Localization with 5G and Omlox

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HFT Stuttgart iCity

iCity

Ein Projekt der Hochschule für Technik Stuttgart

Plan

1. Context of the work
2. Overview of the 5G
3. Overview of the Omlox
4. Benefits of combining 5G and Omlox
5. Omlox Lab + Potential Activities

Context of this Work: iCity Project

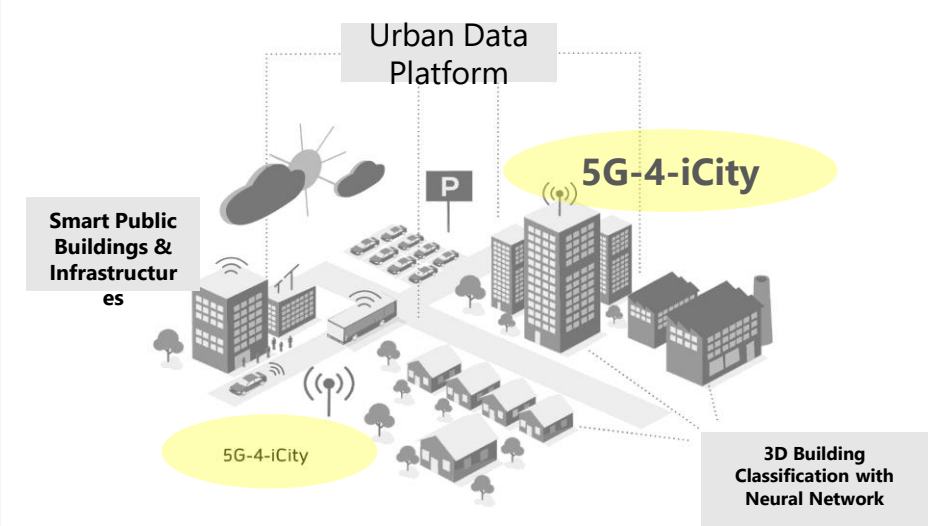
2017-2021
Start-up Phase (iCity 1)

2022-2024
Build-up Phase (iCity 2)

From 2025
Maintenance and Evaluation Phase

kick-off Project
Smart Public Building

Kick-start and Boost Project
Smart Public Buildings & Infrastructures, 3D Building classification with neural network, 5G4iCity



5G-4-iCity: work packages

- iCity Use Cases refer to the use of IoT technologies to improve the efficiency and sustainability of urban living. These Use Cases include traffic management systems, public safety and security systems, waste management, energy management, and more.
- 5G-4iCity:
  - Research study to investigate 5G as a mobile communication network to improve iCity Use Cases implementation
  - The potential of 5G features as a technical basis for more accurate indoor and outdoor localization
  - Identification of 5G enabled Use cases and the corresponding key performance indicators
  - Selection of 5G-4-iCity Use Cases, in cooperation with Solingen Technical Works (TBS: Technische Betriebe Solingen)

5G Based Mechanic’s Workshop App: A Case Study of the CityCat V20 E

- The 5G-Based mechanic's workshop is a technological solution designed to provide efficient and improved servicing of dedicated vehicles.
- TBS has selected the CityCat V20e as a main focus. CityCat V20e plays an important role in smart city implementation, to help reduce costs, increase vehicle availability and reliability, and contribute to a cleaner, more sustainable urban environment.
- This project proposes solutions which integrate: the 5G network, AR-enhanced repair procedures, real-time monitoring and localization, as well as real-time reporting of road conditions, to be implemented.

Outlines: Objectives, Needs, and Solutions

Infrastructure: 5G mobile network is adopted. the integration of a 5G network in the workshop and city provides faster, constant, and more reliable connectivity, enabling mechanics to access repair and maintenance information in real-time, even in remote locations.

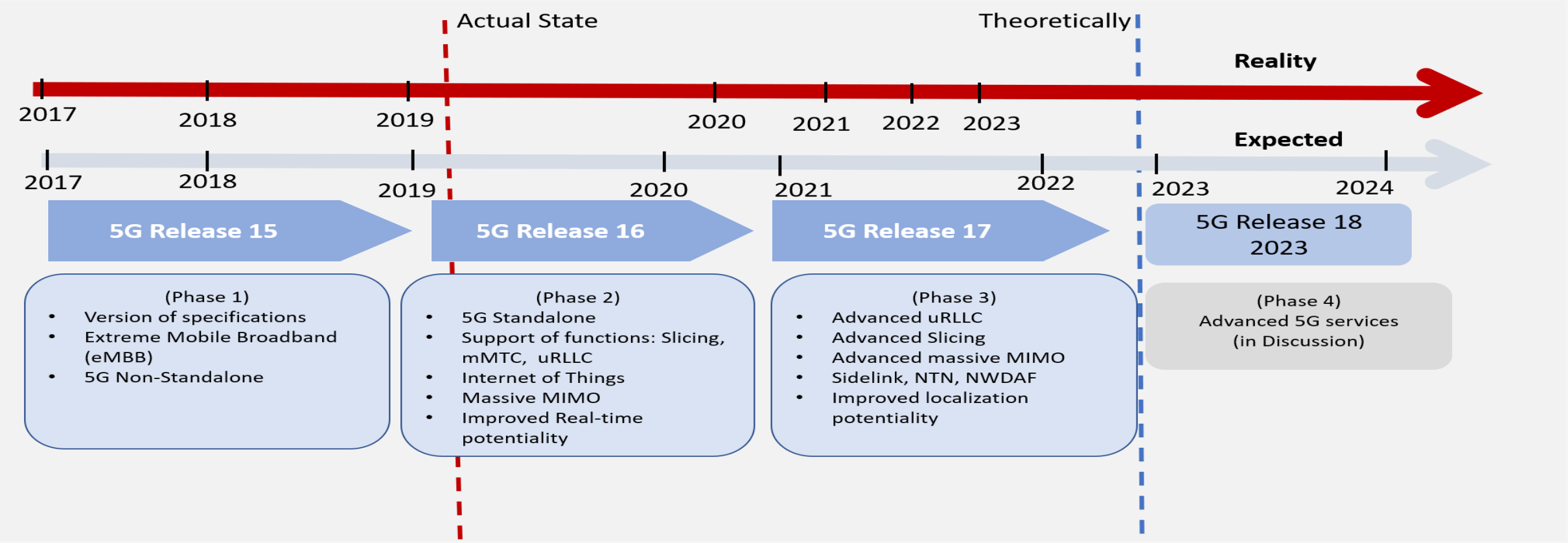
AR-Enhanced Repair procedures: The solution will use AR technology to create customized repair procedures for the CityCat V20e vehicle. This will involve creating a digital twin of the vehicle, which can be used to overlay AR graphics on top of the real-world vehicle, as well as detailed information on which parts and components to check and how to repair them, and videos/training courses to ensure that mechanics are able to effectively use the AR-enhanced repair procedures.

Real-time Monitoring and Localization: 5G connectivity can enable real-time monitoring of the car's performance and condition, providing mechanics with real-time data on critical parameters by connecting to the digital platform of the vehicle.

Real-time Reporting of Road Conditions: The integration of real-time reporting and analysis of road conditions provides valuable information about road conditions and traffic patterns, such as potholes or debris, in real-time. This enhances road safety by providing, through the 5G network and technology, localized updates on road conditions to track users efficiently and to have information about accidents or road closures in the area. This is achieved through mobile sensor data, such as IMUs sensors, GPS, LiDAR, etc.

Overview of the 5G

- The 5G standard is developed by the 3rd Generation Partnership Project (3GPP), it is the fifth generation of cellular network technology, succeeding 4G/LTE. It is designed to provide faster data transfer rates, lower latency, and more reliable connections than its predecessors. 5G networks use higher frequency bands, larger channel bandwidths, and advanced antenna technologies to achieve these improvements. The technology is expected to enable new applications and services, such as augmented and virtual reality, autonomous vehicles, and the Internet of Things (IoT).
- 5G is standardized in form of Releases (3GPP): Each release builds upon the previous one and adds new features, capabilities, and improvements.



Unlocking the Potential of 5G: Utilizing Omlox for Accurate Localization

- While 5G networks are already available in various parts of the world, their coverage is still limited and adoption is not yet widespread.
- The true potential of 5G technology is expected to be realized as it continues to evolve and more devices and applications are developed to take advantage of its capabilities.
- However, many of the advanced features promised by 5G, such as improved localization capabilities, enhancement of IoT applications, or AR applications, may not be possible with current infrastructure and devices. It may take several months or even years for dedicated 5G modules to become widely available to support these functionalities.
- Therefore, in the context of the 5G-based mechanics workshop, to enable more precise and accurate localization of devices and objects, we will use the Omlox real-time localization system to achieve this goal.

Overview of Omlox

- Omlox is an established and accepted standard, that involves a set of technical specifications and requirements allowing the possibility to provide real-time location data independently of technology and manufacturers. The standard consists of two key components: Omlox Core Zone and Omlox Hub.

  - The Omlox Core Zone is the heart of the standard. It is an open real-time location system whose specifications respect the Omlox standard. It is based on ultra-wide-band technology (UWB) to provide a common data format that allows sharing of location data.

  - The Omlox Hub is the central component of the standard, acting as a tracking middleware for processing location data collected from different devices and technologies by the mean of the Core Zone part, to the business application layer allowing for easy management and monitoring of location data.

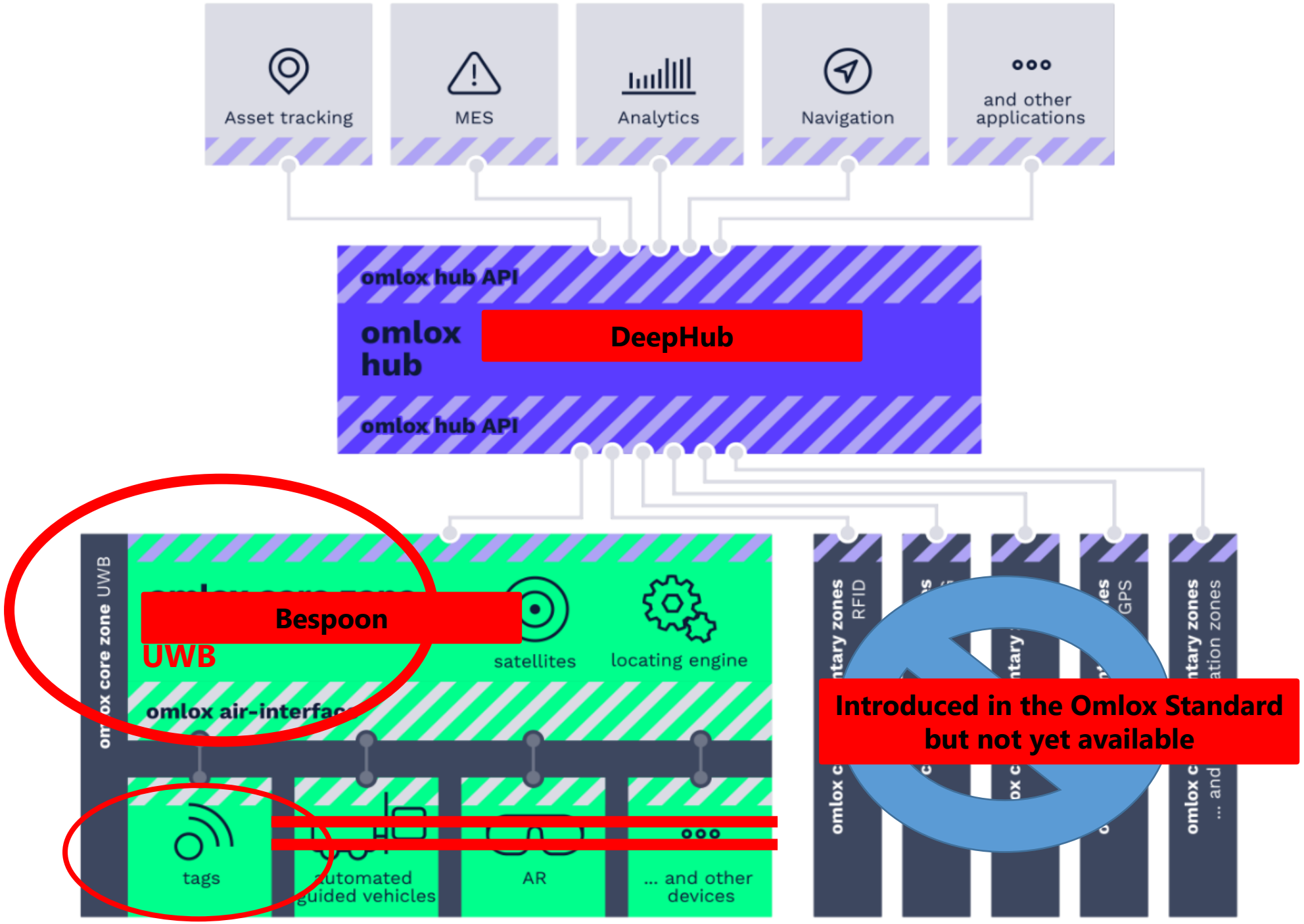
- The Omlox aggregates also a complementary part, named complementary Zone that includes other technologies that can be added to be used in the future to calculate the location of assets, such as RFID, WIFI, and 5G, … but actually the standard is based on UWB to locate assets.

Benefits of combining Omlox and 5G

Performance of Indicators	Omlox	5G	Results
Localization Accuracy	Provides high-precision positioning information using standardized interfaces and protocols	Enables high-speed, low-latency data transfer and communication between devices and networks	Improved localization accuracy through faster and more reliable communication of positioning data
Real-Time Data Processing	Provides standardized interfaces for data exchange and synchronization across different positioning technologies and systems	Enables real-time data processing and analytics at the edge of the network, closer to the data source	Real-time data processing and analysis for better decision-making and more efficient resource allocation

Scalability, Energy Efficiency, Data Transfer Speed, …

The software architecture of Omlox


Asset tracking
MES
Analytics
Navigation
and other applications
omlox hub API
omlox hub
DeepHub
omlox hub API
Bespoon
UWB
satellites
locating engine
tags
automated guided vehicles
AR
... and other devices
Introduced in the Omlox Standard but not yet available

Auto-Calibration

Progression : 0%

Start Measures

Start Solver

Start Topology

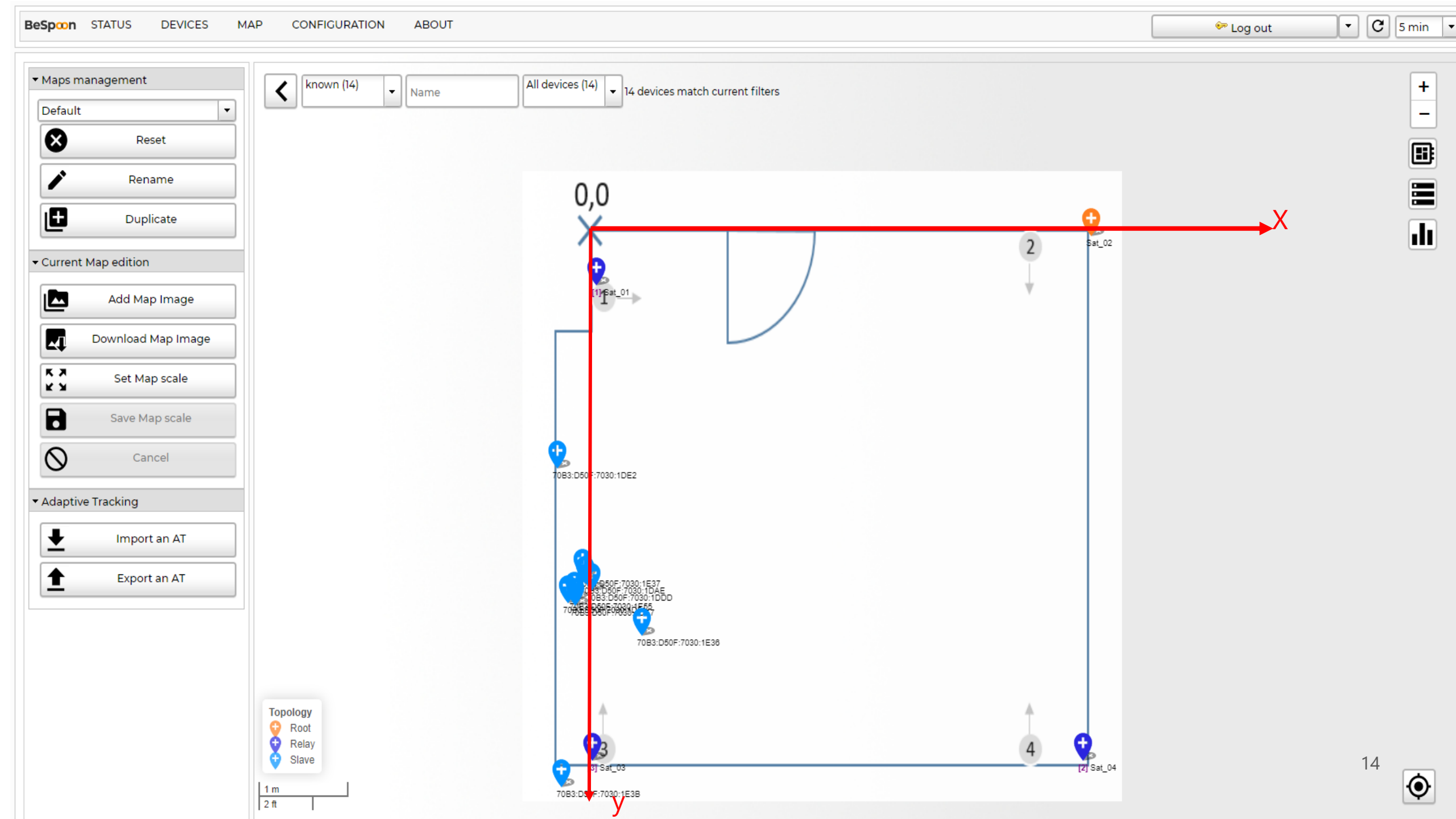
Devices management

Import devices list

Export devices list

known (16) | Name | All devices (16) | 16 devices match current filters | Revert Modification(s) | Save Modification(s)

Model	Activated	Tracking Mode	State	Bat. Level	Name	UWB MAC	Device Id	x (m)	y (m)	z (m)	Type	Beacon Id	Target Ref Anchor	Sync Quality (%)	NRJ Check (%)	Ref Dist. Check (m)	Refresh
		None			70B3:D50F:7010:1997	70B3:D50F:7010:1997	4020	-	-	-	-	-	-	-	-	0.00	Default (Best
		None			70B3:D50F:7010:19EF	70B3:D50F:7010:19EF	2384	-	-	-	-	-	-	-	-	0.00	Default (Best
		Multi-Tag			70B3:D50F:7030:1D51	70B3:D50F:7030:1D51	4037	6.12	2.93	0.67	-	-	-	-	-	0.00	Default (Best
		Multi-Tag			70B3:D50F:7030:1DAE	70B3:D50F:7030:1DAE	586	-0.07	3.6	0.42	-	-	-	-	-	0.00	Default (Best
		Multi-Tag			70B3:D50F:7030:1DDD	70B3:D50F:7030:1DDD	2365	0	3.67	1.26	-	-	-	-	-	0.00	Default (Best
		Multi-Tag			70B3:D50F:7030:1DE2	70B3:D50F:7030:1DE2	551	-0.38	2.42	2.74	-	-	-	-	-	0.00	Default (Best
		Multi-Tag			70B3:D50F:7030:1DE7	70B3:D50F:7030:1DE7	2831	-0.18	3.82	0.11	-	-	-	-	-	0.00	Default (Best
		Multi-Tag			70B3:D50F:7030:1E36	70B3:D50F:7030:1E36	3644	0.56	4.13	4.88	-	-	-	-	-	0.00	Default (Best
		Multi-Tag			70B3:D50F:7030:1E37	70B3:D50F:7030:1E37	2462	-0.1	3.53	0.47	-	-	-	-	-	0.00	Default (Best
		Multi-Tag			70B3:D50F:7030:1E3A	70B3:D50F:7030:1E3A	3011	-0.06	6.48	0.74	-	-	-	-	-	0.00	Default (Best
		Multi-Tag			70B3:D50F:7030:1E3B	70B3:D50F:7030:1E3B	1829	-0.33	5.67	0.33	-	-	-	-	-	0.00	Default (Best
		Multi-Tag			70B3:D50F:7030:1E55	70B3:D50F:7030:1E55	3859	-0.19	3.76	0.38	-	-	-	-	-	0.00	Default (Best
		None			Sat_01	70B3:D50F:7010:04C3	3884	0.05	0.56	2.72	beacon	1	Sat_04	88	73	0.04	Default (Best
		None			Sat_02	70B3:D50F:7010:2185	271	5.52	0.05	2.74	root	-	-	-	-	0.00	Default (Best
		None			Sat_03	70B3:D50F:7010:219A	20	0.01	5.4	2.73	beacon	3	Sat_02	61	88	0.57	Default (Best
		None			Sat_04	70B3:D50F:7010:092A	2720	5.43	5.4	2.71	beacon	2	Sat_02	95	94	0.15	Default (Best

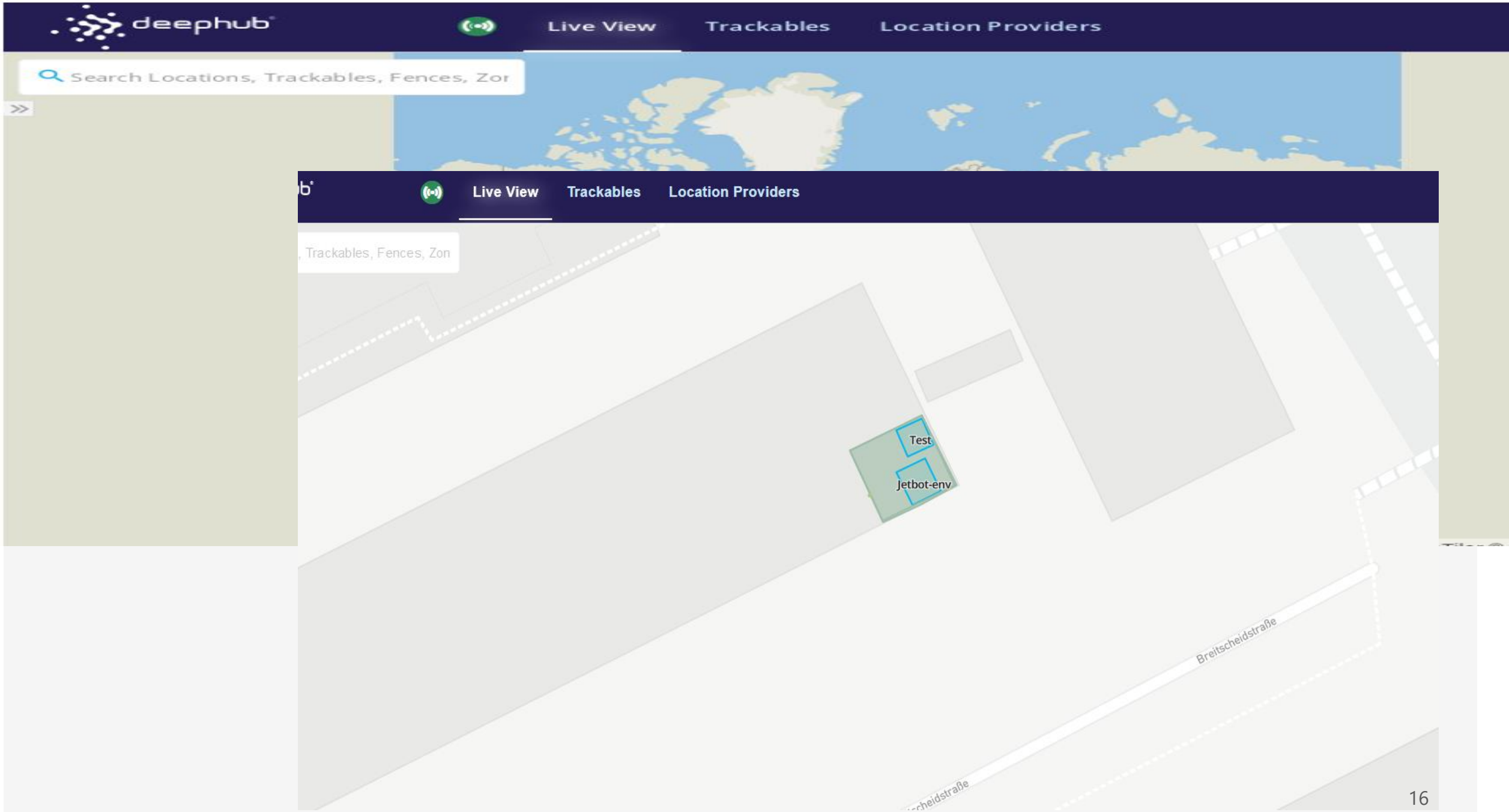

BeSpoon
STATUS
DEVICES
MAP
CONFIGURATION
ABOUT
Log out
5 min
Maps management
Default
Reset
Rename
Duplicate
Current Map edition
Add Map Image
Download Map Image
Set Map scale
Save Map scale
Cancel
Adaptive Tracking
Import an AT
Export an AT
known (14)
Name
All devices (14)
14 devices match current filters
0,0
X
y
1
2
3
4
Sat_01
Sat_02
Sat_03
Sat_04
70B3:D50F:7030:1DE2
70B3:D50F:7030:1E36
Topology
Root
Relay
Slave
1 m
2 ft
14

Example of data Output: JSON Format

[{"accuracy":4.110143501263543,"associated":false,"crs":"local","elevation_ref":"floor","floor":0,"position":{"coordinates":[-0.19606381527920494,4.598342768654683,0.30038324223445845],"type":"Point"},"properties":{"uncert":{"x":2.9685226260927737,"y":2.8427368888720963,"z":2.801411896327111},"uwb_time":"712810403"},"provider_id":"70B3:D50F:7030:1E37","provider_type":"uwb","source":"{2ba8cf8e-09ca-4b52-bbbf-8d6118fabc28}","timestamp_generated":"2023-03-15T11:05:43.016Z","timestamp_sent":"2023-03-15T11:05:43.390Z"}]

[{"accuracy":0.7258342159870115,"associated":false,"crs":"local","elevation_ref":"floor","floor":0,"position":{"coordinates":[-0.30836518264088286,4.598342768654683,0.31335037755167705],"type":"Point"},"properties":{"uncert":{"x":0.5998038357924942,"y":0.40874278913038975,"z":0.3734227967133349},"uwb_time":"712810467"},"provider_id":"70B3:D50F:7030:1E37","provider_type":"uwb","source":"{2ba8cf8e-09ca-4b52-bbbf-8d6118fabc28}","timestamp_generated":"2023-03-15T11:05:43.140Z","timestamp_sent":"2023-03-15T11:05:43.515Z"}]

[{"accuracy":0.4319107588572464,"associated":false,"crs":"local","elevation_ref":"floor","floor":0,"position":{"coordinates":[-0.30836518264088286,4.539090090549471,0.31335037755167705],"type":"Point"},"properties":{"uncert":{"x":0.36014817627304585,"y":0.2384118175423389,"z":0.19640465391975848},"uwb_time":"712810531"},"provider_id":"70B3:D50F:7030:1E37","provider_type":"uwb","source":"{2ba8cf8e-09ca-4b52-bbbf-8d6118fabc28}","timestamp_generated":"2023-03-15T11:05:43.266Z","timestamp_sent":"2023-03-15T11:05:43.640Z"}]


deephub
Live View
Trackables
Location Providers
Search Locations, Trackables, Fences, Zor
Live View
Trackables
Location Providers
Trackables, Fences, Zon
Test
Jetbot-env
Breitscheidstraße


Test
HFT Raum 0.64
Jetbot-env

HFT Omlox Lab

1. Introduce the Omlox Sytem
2. Mark a position in space (with a tape measure).
3. Place a tag on the mark and compare the coordinates from the Omlox system with the measured one.
4. Create a Test Environment in the predefined Zone, and interact with it: Boundaries, Coordinates, …
5. Projects:
    1. Project 1: Create a User Interface to Get the location data from Omlox Core Zone via WebSocket, to show only the related data of the activated Tags.
    2. Project 2: Create a scavenger hunt game to showcase the benefits of combining 5G and Omlox for indoor navigation and tracking. For example, it can be executed by attaching QR codes to each tag that, when scanned, provide information or clues for the game.

Project 1: Create a User Interface to Get the location data from Omlox Core Zone

- Goal: to showcase the benefits of Omlox for indoor navigation and tracking
- 3 Tags will be used
- WebSocket Client: Javascript
  - Index.html
- WebSocket Server
  - Nodejs
- Collect the data location in an output file (txt, csv)
  - Parsing (to get only the data of specified Tags)
  - Output of the data (UI, Console)!
  - Changing the place of Tags
  - Latency (timestamp->time that we need to take to display the new location)

Example of Code

index.js > ...

```
1   const WebSocket = require('ws');
2   var wss = new WebSocket('ws://IP-Ad/json/device/all/position');
3   const fs =require('fs');
4
5
6
7   wskh.onopen = function() {
8     console.log('WebSocket connection opened');
9   };
10
11  wss.onmessage = function(event) {
12    const data = JSON.parse(event.data);
13    fs.appendFile('output.txt', JSON.stringify(data)+'\n\n', function (err) {
14      if (err) throw err;
15      console.log('Parsed JSON data written to output.txt');
16    });
17
18
19  };
20
21  wss.onclose = function(event) {
22    console.log(`WebSocket connection closed with code ${event.code} and reason ${event.reason}`);
23  };
24
25  wss.onerror = function(error) {
```

javascript > index.html > html

```
1   <!DOCTYPE html>
2   <html lang="en">
3   <head>
4       <meta charset="UTF-8">
5       <meta http-equiv="X-UA-Compatible" content="IE=edge">
6       <meta name="viewport" content="width=device-width, initial-scale=1.0">
7       <title>WebSocket Client</title>
8   </head>
9   <body>
10      <script src="./websocket.js"></script>
11  </body>
12  </html>
```

Project 2: Scavenger hunt game + QR Code

1. Goal: Create a scavenger hunt game to showcase the benefits of combining 5G and Omlox for indoor navigation and tracking
2. Attach QR codes to each tag that, when scanned, provide Clues/challenges for the game, and correspond to various locations in the room. (use online QR code generator to create these codes)
3. Create clues or hints that lead your players to each location. These clues could be written or presented in a multimedia format, such as a video or audio clip. The QR codes would then be placed at each location, and players would need to scan the code using a smartphone to reveal the next clue or task.
4. Collect your Information / Clues: Software Architecture of Omlox, Localization in Omlox is based on which technology , What is the Role of Deephub? , Omlox works without Deephub? Enabled applications, …
5. Example:
   - Tag1: Clue: This technology is used to track the location of objects or people in real-time.
     Challenge: Find a piece of equipment in the room and use the Omlox technology to track its location.
   - Tag2: Clue: QR codes are a type of two-dimensional barcode that can be scanned using a mobile device.
     Challenge: Scan a QR code using a mobile device and identify what information is contained within the code.
   - Tag3: Clue: The deployment of 5G networks in smart cities can bring significant benefits for localization.
     Challenge: do you know some potential benefits for the 5G-enabled smart traffic management ?
6. Set a time for the Game, the game continues until all the tags have been found.

Questions!