



Task 5: Final Review Presentation

FR

23rd June 2023

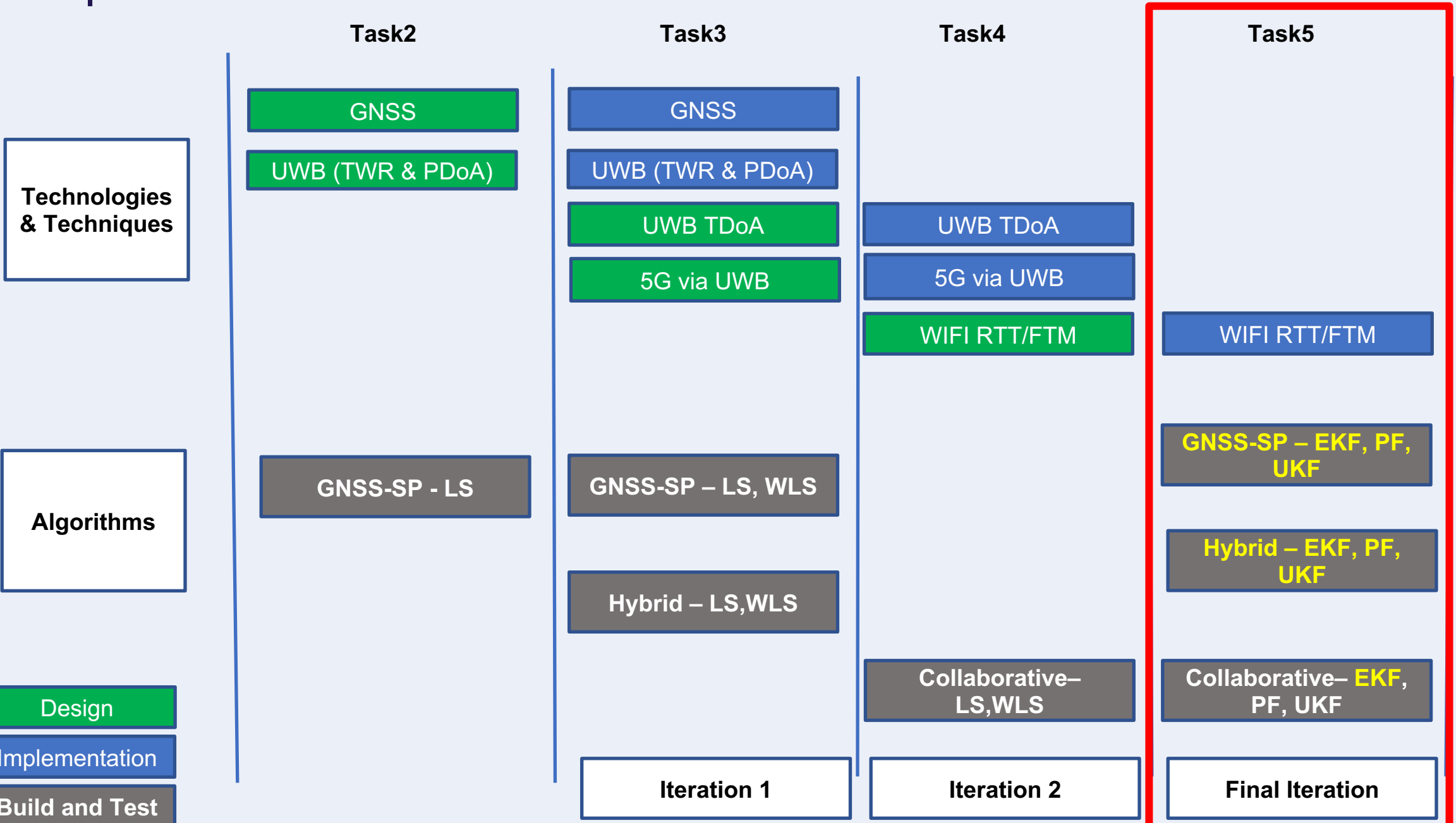
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14.7.2023

Agenda

- Implementation Plan – Scope of Task 5
- Deliverables – D2 V5.0, D3 V3.0 and SW/HW and User manual (v3.0) and Test data.xls summary
- CD Architecture and UI
- Test Results
- Outstanding Actions from the previous MoM and keypoints – treated in Annex 3 D2 deliverable
- Project Requirement Updates – Statement of Compliance
- Discussion of RIDs
- Conclusions and recommendations

Implementation Plan – Task 5



Technologies & Techniques

Algorithms

Design

Implementation

Build and Test

Task2

Task3

Task4

Task5

GNSS

UWB (TWR & PDoA)

GNSS

UWB (TWR & PDoA)

UWB TDoA

5G via UWB

UWB TDoA

5G via UWB

WIFI RTT/FTM

WIFI RTT/FTM

GNSS-SP - LS

GNSS-SP – LS, WLS

Hybrid – LS,WLS

Collaborative– LS,WLS

GNSS-SP – EKF, PF, UKF

Hybrid – EKF, PF, UKF

Collaborative– EKF, PF, UKF

Iteration 1

Iteration 2

Final Iteration

Objectives of Task 5

- Design
 - Mechanical Design
- Implementation & Testing
 - Mechanical Prototype
 - WIFI RTT/FTM
 - Inclusion of PDoA into algorithms
 - Algorithms – (**GNSS-SP – EKF, PF, UKF**), (**Hybrid – EKF, PF, UKF**), (**Collaborative - EKF, PF, UKF**)
- Outputs: D2(v5), D3 (v4) DS1(V3 Test Data), SW1 (SW Receiver)

Test plan- Task 5 -part 1

Task 5 CD tests including carry over from Task4					status
Test Name	Description	Pass/Fail Criteria	Test Info	Status	
Wi-Fi Functional Tests					
WIFI101	One AP with one STA device	Measure variation TWR distance measurements	95% of session successful		Done
WIFI102	4 Aps with one STA Device	Measure variation of arrival times of two CCPs	95% of session successful		Done
WIFI103	4APs with 2 RUs - static RU Location	Ensure all RU's run and no missed RTT sessions	95% of session successful		Done
WIFI103-b	2APs with 4 RUs - static RU Location	Ensure all RU's run and no missed RTT sessions	95% of session successful		Done
WIFI104	Reset of AP	AP returns to waiting for RTT requests	Pass/Fail		Done
WIFI105	Test RU with multiple APs static test (same as WIFI102)	Measure TWR of multiple Aps to determine position	95% of session successful		Done
WIFI106	Test RU with multiple APs walk test (Same as WIFI112 & WIFI113)	Measure TWR of multiple Aps to determine position	95% of session successful		Done
WIFI107	Determine effective weighting of Wifi RTT observable data	Gather Data from 4 APs - 2 with obstruction.	Characterisation		Done
Wi-Fi Performance Tests					
WIFI110	Test RU with multiple APs static test (outdoor)	Measure variation TWR distance measurements	Accuracy < 5 m (indoor)		Done
WIFI111	Test RU with multiple APs walk test (outdoor) (Same as WIFI112 & WIFI113)	Measure variation TWR distance measurements	Accuracy < 5 m		Done
WIFI110	Test RU with multiple APs static test (indoor) (same as WIFI102)	Measure variation TWR distance measurements	Accuracy < 5 m (indoor)		Done
WIFI111	Test RU with multiple APs walk test (indoor) (Same as WIFI112 & WIFI113)	Measure variation TWR distance measurements	Accuracy < 5 m		Done
WIFI112	Static tests at a series of locations, APs co-located (outdoors)	Measure variation TWR distance measurements	Accuracy < 5 m - show improvement in performance due to		Done
WIFI113	Static tests at a series of locations, APs co-located (indoors)	Measure variation TWR distance measurements	Characterisation		Done
CD Functional Tests					
CD1005	Test CD with Wi-Fi RTT operation selected	Positions are reported correctly	Pass/Fail		Done
CD1006	Replay data for WiFi with updated algorithm parameters	Positions are reported correctly	Pass/Fail		Done
CD1007	Test Collaborative Solver runs correctly at max input data data from RU's and AP's	System can solve as data arrives	Pass/Fail		Done
UseCase Tests					
U401	Use cases tests to be repeated with Wi-Fi RTT enabled	Same tests as previously U101 to U304	Characterisation		
U401a	Office Use case Walk Slow				Done Done
U401b	Warehouse Use case				Done
U401c	Outdoor to Indoor Transition				Done
U402	Test the system to determine the locations of the Aps using Collaborative Solver	Plot accuracy vs Integration time (30sec - 24 hrs)	Characterisation		Done

Test plan- Task 5 -part 2

Additional Tests - Note these were mostly completed in Task4 but in offline mode, to be tested in on-line (realtime) mode					
	Test Name	Description	Pass/Fail Criteria		
5G101	Test 5G model on MQTT broker feeding it sample data	Distribution matches Model	Pass/Fail		Done
5G104	Stop Start Service	5G model restarts correctly	Pass/Fail		Done
5G105	Replay of 5G input data from the database	Data can be rerun through the 5G model	Pass/Fail		Done
CD1002	Test CD with 5G operation selected	Positions are reported correctly	Pass/Fail		Done
CD1003	Replay data for 5G and UWB DL-TDOA with updated algorithm parameters	Updates in Algorithms are used	Pass/Fail		Done
CD1004	Test Collaborative Solver runs correctly at max input data rate/inputs(?) from RUs and APs (4 + 4)	System can solve as data arrives	Pass/Fail		Done
CD Demonstration Tests					
	Test Name	Description	Pass/Fail Criteria		
U403a	1 AP and 1 RU in indoor conditions , both ranging and DoA/DoD measurements available (GNSS exploitation optional);	Characterise the accuracy possible for indoor positioning	Characterisation	AP - 2, RU 4	Done
U403b	1 AP and 1 RU in light-indoor conditions , only ranging measurements available together with GNSS;	Characterise the accuracy possible for indoor positioning	Characterisation	AP - 0, RU 5	Done
U403c	1 AP and 1 RU in indoor conditions, 1 RU in light-indoor or outdoor conditions , only ranging measurements available (AP-RU/s, RU-RU) together with GNSS;	Characterise the accuracy possible for indoor positioning	Characterisation	AP 2, RU 4,5	Done
U403d	1 AP and 1 RU in indoor conditions, 1 RU in light-indoor or outdoor conditions , both ranging (AP-RU/s, RU-RU) and DoA/DoD (AP-RU/s) measurements available together with GNSS;	Show the benefits of using GNSS with sparse indoor infrastructure	Characterisation	AP 2, RU 4,5	Done
U403e	A scenario with the maximum number of RUs available in the CD (scenario to be consolidated during the activity).	Use of 4 Rus in collaborative positioning	Characterisation	AP 0,1 RU 2,3,4,5	Done
U404	2 APs and 1 RU in indoor conditions to enable TDoA values to be used	Show the benefits of using TDoA, which requires 2 or more Aps	Characterisation	AP - 0,2 RU - 5	D2
U405	Multiple Aps used to provide ground truth on walk tests	ground truth for walk tests	Characterisation		D2

Updated Project Plan

- Plan Overview (18months)

- Task1 KO+3months
- Task2 KO+7months
- Task3 KO+12months
- Task4 KO+15months
- Task5 KO+17months

- Task 5 plan

- Task kick off 20th Feb
- Task 4 duration 3months
- Completion 22nd May
- Keypoint review week of 3rd April

- Plan Schedule

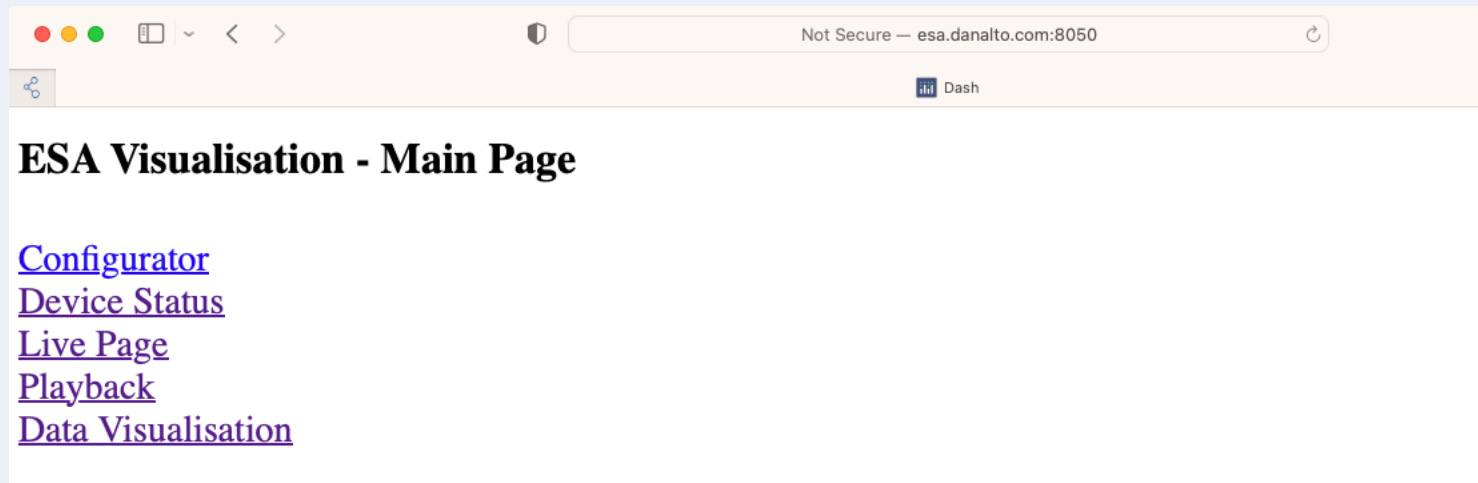
- Task1 Complete 16th Dec 2021
- Task2 Complete 21st April 2022 -> 27th May
- Task3 Complete 9th Sept 2022 -> 23rd September
- Task4 Complete 9th Dec 2022 -> 17th Feb
- Task5 Complete 17th March 2023 -> 22nd May (FDP 6th June; Estec presentation 21st June; demo in Dublin 23rd June; final close by 15th July)

Deliverables Update

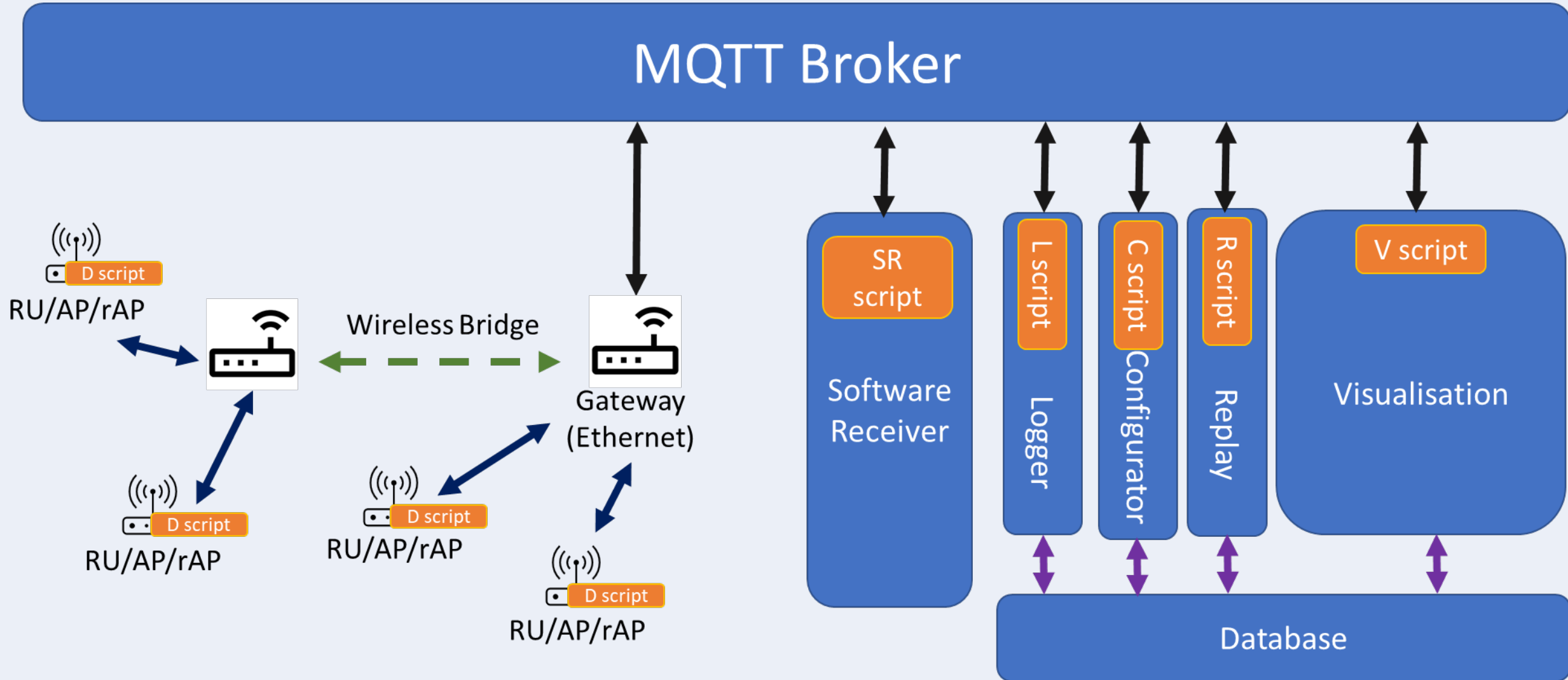
- Annex 3 D2 V5.0 - **D2 updated** with new Annex reference
- D3 V3.0 – **up revision with detailed tests**
- SW/HW – SW receiver and CD - **Software code update**
- User manual (v3.0) - **updated** with final CD/UI description operation
- Test data.xls summary - **updated** database reference
- Statement of Compliance V2.2 - **updated**
- Final Report – **part of FDP**
- Executive Report – **part of FDP**
- Final presentation (this file) – **part of Final FDP**

Concept Demonstrator - Architecture and User Interface

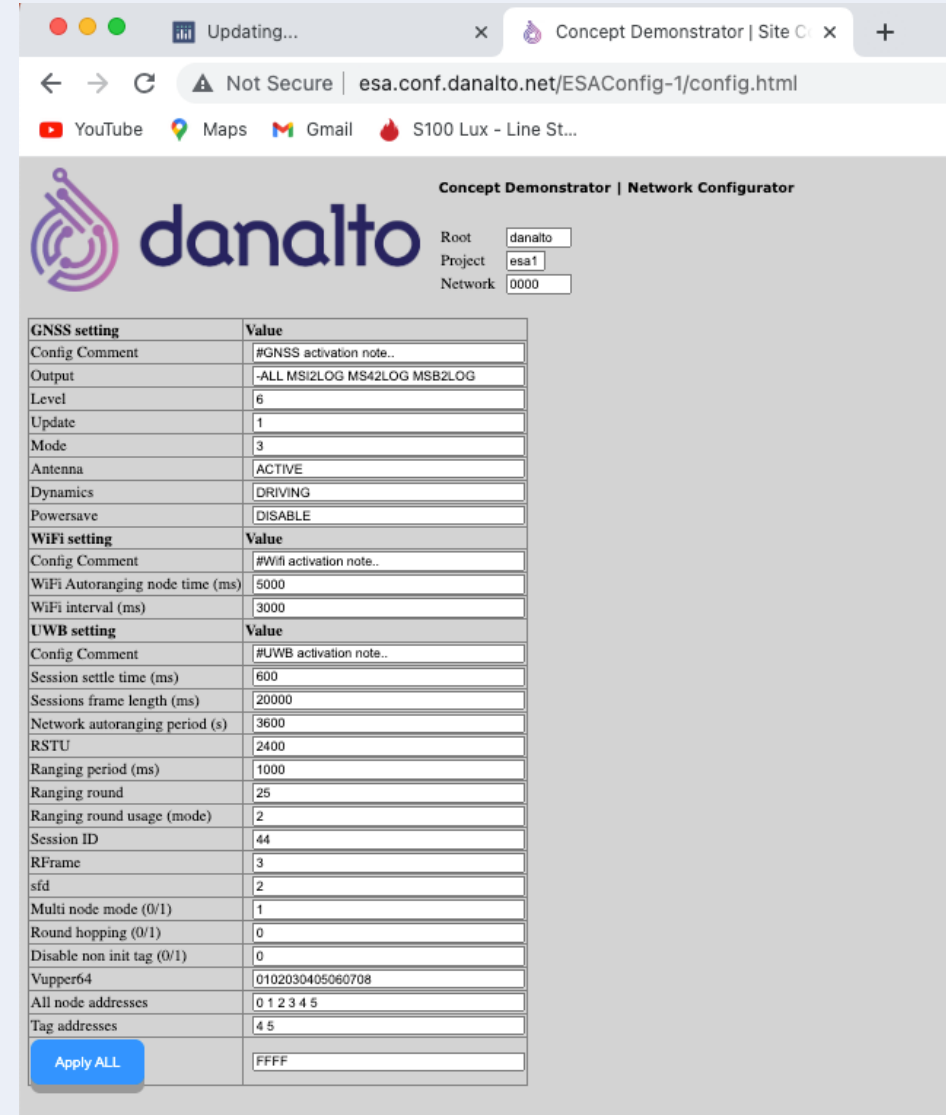
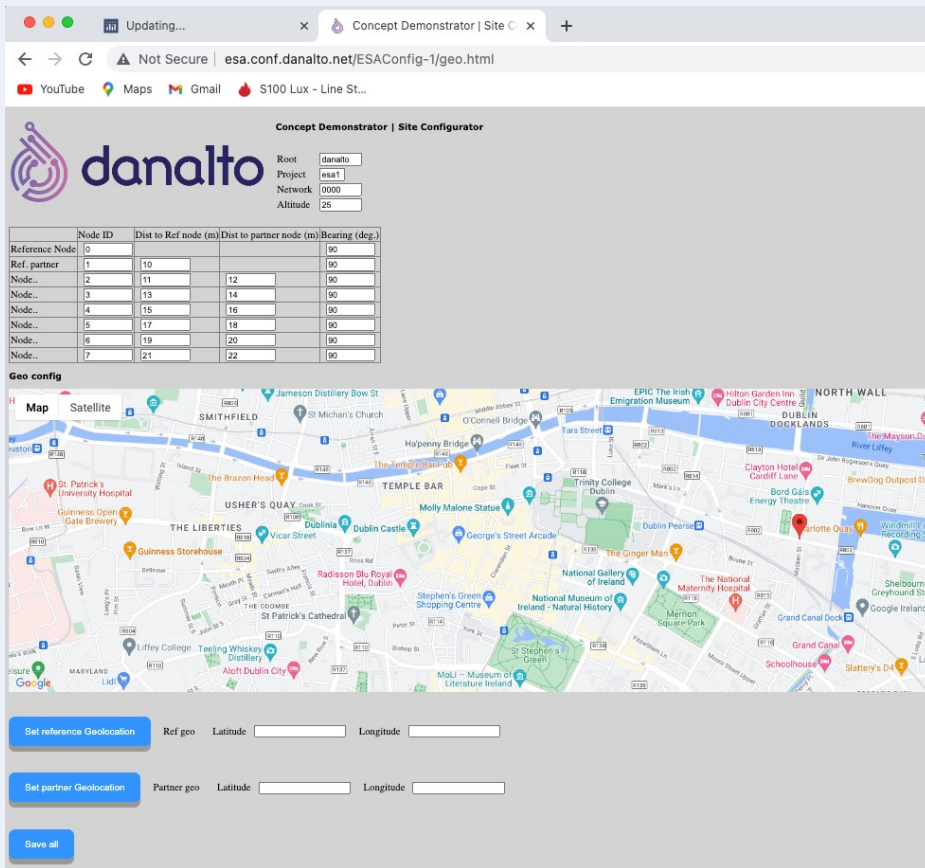
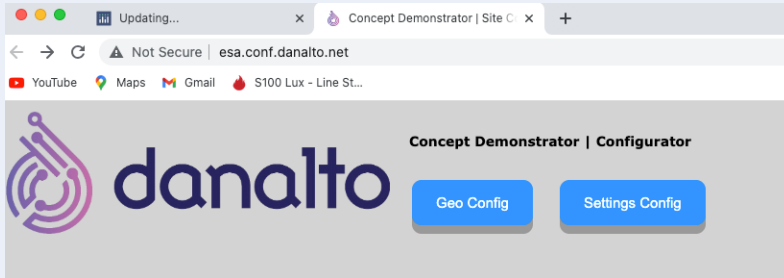
- Web Application server accessible via
 - <http://esa.danalto.com:8050>
 - Landing page:



CD underlying Architecture



CD Architecture and UI – Configurator



CD Architecture and UI – Device Status

[Device Status](#)

[Live Page](#)

[Playback](#)

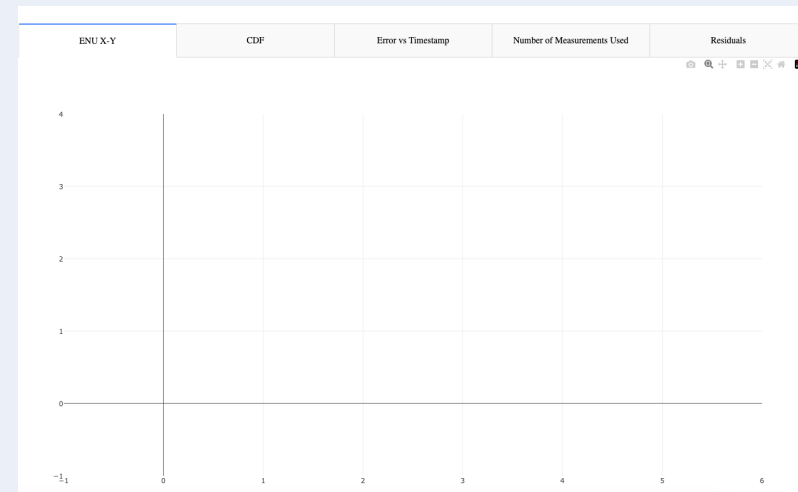
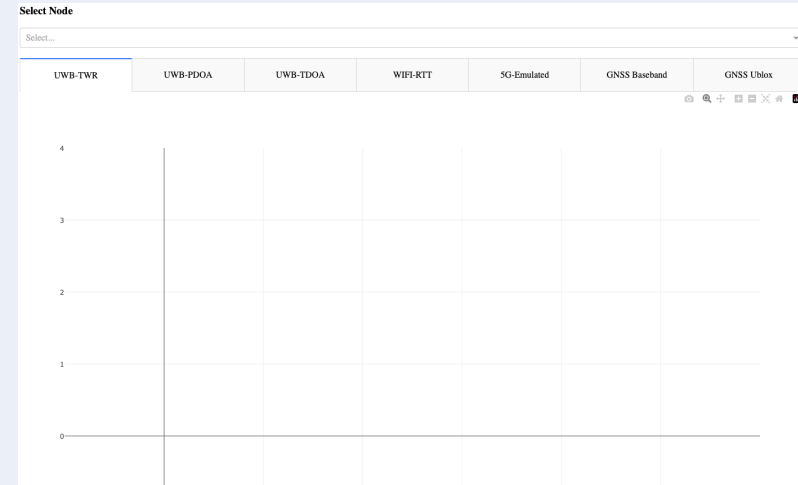
[Data Visualisation](#)

Node Status(Last 10 minutes)

node	Meas Type	Status - Since Last Active(S)	Created At	topic	testname	elapsed
0	GNSS Baseband	OK -- 9.979609	2023-05-31 21:51:34.063000	danalto/esal/node/0000/0/upli		9.979609
0	UWB TWR	OK -- 1.528372	2023-05-31 21:51:42.512000	danalto/esal/node/0000/0/upli		1.528372
1	GNSS Baseband	OK -- 1.739057	2023-05-31 21:51:42.311000	danalto/esal/node/0000/1/upli		1.739057
1	UWB TWR	OK -- 1.939773	2023-05-31 21:51:42.109000	danalto/esal/node/0000/1/upli		1.939773
2	GNSS Baseband	OK -- 9.191805	2023-05-31 21:51:34.868000	danalto/esal/node/0000/2/upli		9.191805
2	UWB TWR	OK -- 0.139446	2023-05-31 21:51:43.919000	danalto/esal/node/0000/2/upli		0.139446
3	GNSS Baseband	OK -- 12.21648	2023-05-31 21:51:31.851000	danalto/esal/node/0000/3/upli		12.21648
3	UWB TWR	OK -- 2.157151	2023-05-31 21:51:41.909000	danalto/esal/node/0000/3/upli		2.157151
4	5G	OK -- 2.572105	2023-05-31 21:51:41.506000	danalto/esal/node/0000/4/upli		2.572105
4	GNSS Baseband	OK -- 12.423093	2023-05-31 21:51:31.650000	danalto/esal/node/0000/4/upli		12.423093
4	GNSS Ublox	OK -- 14.636951	2023-05-31 21:51:29.440000	danalto/esal/node/0000/4/upli		14.636951
4	UWB TDOA	OK -- 3.372341	2023-05-31 21:51:40.702000	danalto/esal/node/0000/4/upli		3.372341
4	UWB TWR	OK -- 3.571702	2023-05-31 21:51:40.500000	danalto/esal/node/0000/4/upli		3.571702
4	WIFI RTT	OK -- 7.597629	2023-05-31 21:51:36.478000	danalto/esal/node/0000/4/upli		7.597629

CD Architecture and UI – Live Page

The screenshot shows a web browser window with the URL `esa.danalto.com:8050/live`. The page title is "ESA Visualisation - Main Page". Below the title are several navigation links: [Configurator](#), [Device Status](#), [Live Page](#), [Playback](#), and [Data Visualisation](#). The "Live Page" link is highlighted. Below the links is a section titled "Live Page" with a sub-header "Test Name". There is a text input field labeled "Enter Test name" and two buttons: "Start Test" and "Stop Test". Below this is a "System Config" section with a dashed border and a "Generate Config" button. The "Current System Configuration" section contains a text area with the text "Current Live Config Values are Displayed here" and a "Send Config" button at the bottom.



CD Architecture and UI – Playback



ESA Visualisation - Main Page

- [Configurator](#)
- [Device Status](#)
- [Live Page](#)
- [Playback](#)
- [Data Visualisation](#)

Playback Page

Start Date

08/06/2023, 12:30

End Date

08/06/2023, 12:30

Load Tests

Select Test

Select...

Load Data

Upload Playback Config

Drag and Drop Config or Select Files

Node: Software:

Select Node to Display Data

UWB-TWR	UWB-PDOA	UWB-TDOA	WiFi-RTT	5G Emulated	GNSS Baseband	GNSS UIMx
4						
3						
2						
1						
0						

ENU X,Y	CDP	Number of GNSS Measurements Used	Number of TWR Measurements Used	Number of TDOA Measurements Used
3				



CD Architecture and UI – Visualisation

The screenshot shows the main page of the ESA Visualisation tool. It includes a browser header with the URL `esa.danalto.com:8050/data`. The page title is "ESA Visualisation - Main Page". Below the title are several navigation links: [Configurator](#), [Device Status](#), [Live Page](#), [Playback](#), and [Data Visualisation](#). The "Data Viewer" section contains a "Start Date" field with a date-time picker, an "End Date" field with a date-time picker, a "Load Tests" button, a "Select Test" dropdown menu, a "Load Nodes" button, a "Select Node to Display" dropdown menu, and a "Retrieve Data" button.

This screenshot shows a dropdown menu titled "Select Node to Display". The menu is open, showing a "Retrieve Data" button and a "Download csv" button. Below these buttons is a table with seven columns: "UWB-TWR", "UWB-PDOA", "UWB-TDOA", "WiFi-RTT", "5G-Emulated", "GNSS Baseband", and "GNSS Ublox". The table is currently empty, with only the column headers visible.

This screenshot shows a data visualization table with a grid layout. The table has a header row with the following columns: "DU's", "Rate in dBm", "CDF", "Number of DNS Measurements Used", "Number of TWR Measurements Used", and "Number of TDOA Measurements Used". The table body is currently empty, with only the grid lines visible.

Test Results - Task 5 – Summary

- Summary test results focused on
 - additional of new radio technologies to the CD/UI since last iteration
 - plus addition of new filtering approaches.

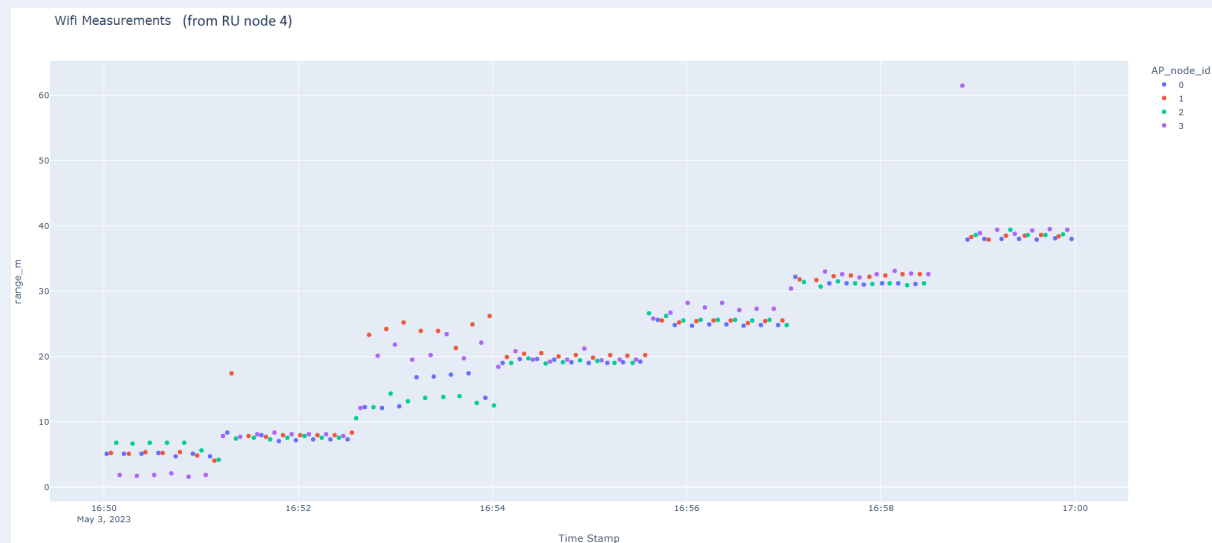
- Namely:
 - WiFi
 - GNSS-SP – EKF, PF, UKF
 - Hybrid – EKF, PF, UKF
 - Collaborative– EKF, PF, UKF

Summary tests presented

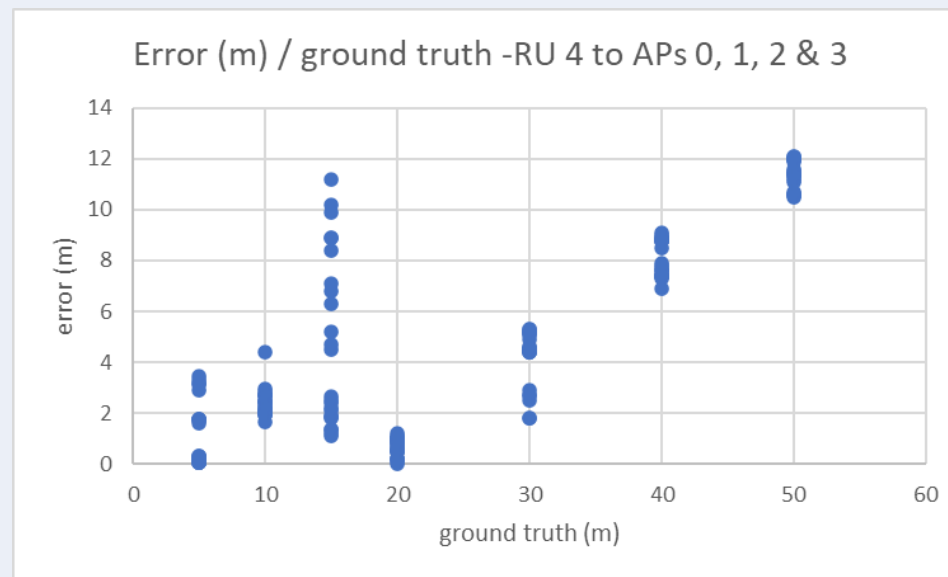
(full comprehensive set in D3 and key summary in Annex 3 D2 deliverables)

- WiFi112
- WiFi113
- U401a1 – office – static
- U401a2 – office - walk
- U401b
- U401c - Outdoor to indoor transition
- U403b

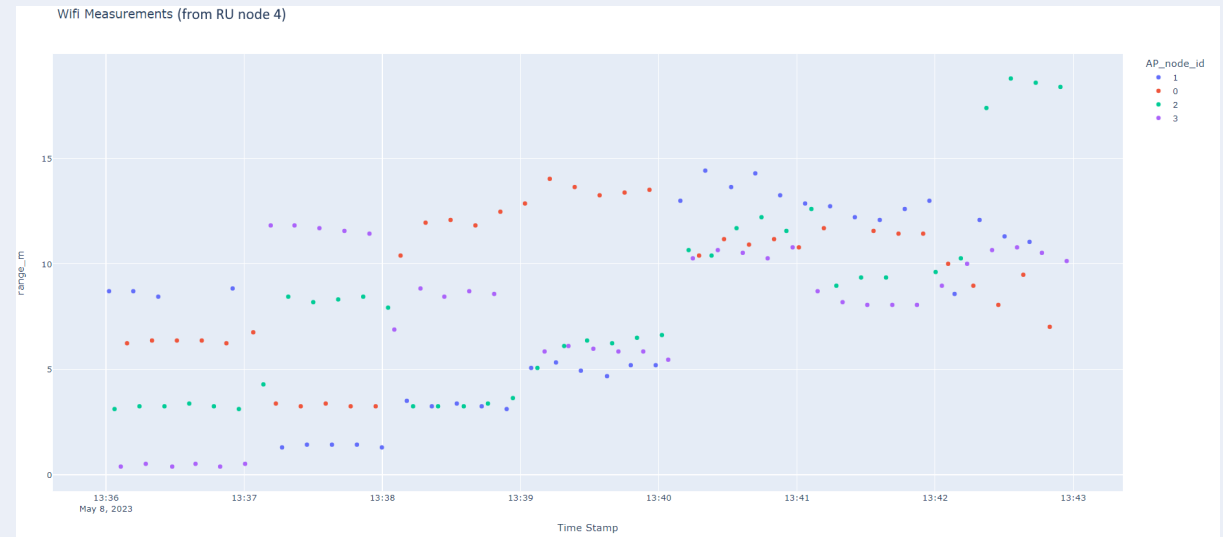
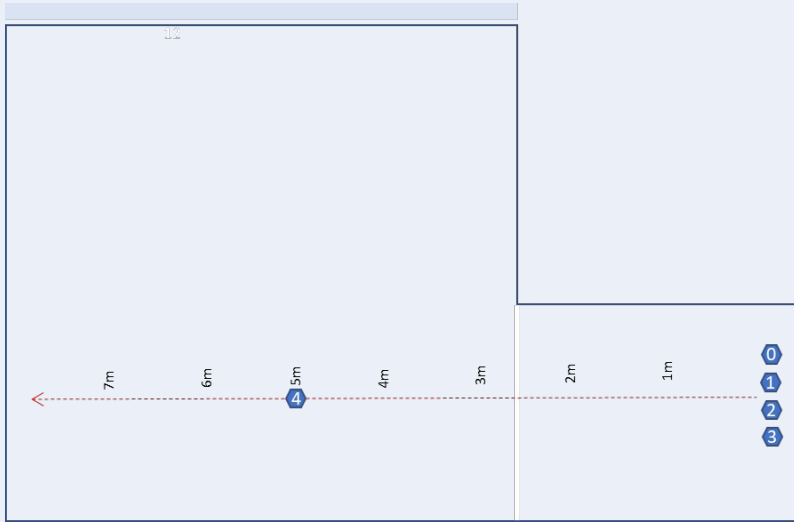
WiFi112 – 4 co-located APs with 1 RU device at intervals. Outdoors



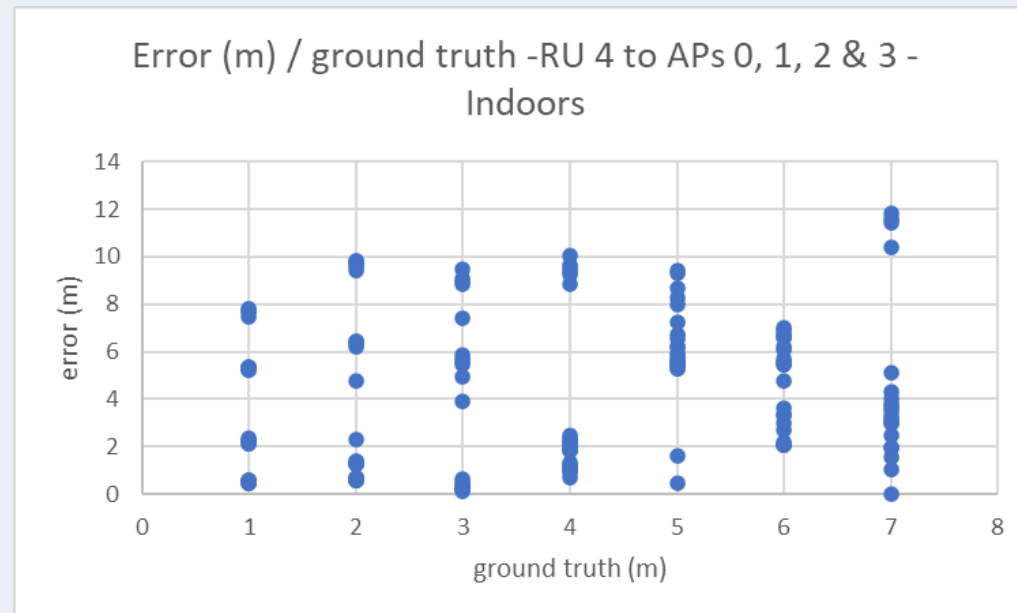
Wifi FTM histogram, Node 4 measurements to 4 APs @ 5, 10, 15, 20, 30, 40 & 50m



WiFi113 – 4 co-located APs with 1 RU device at intervals. Indoors.

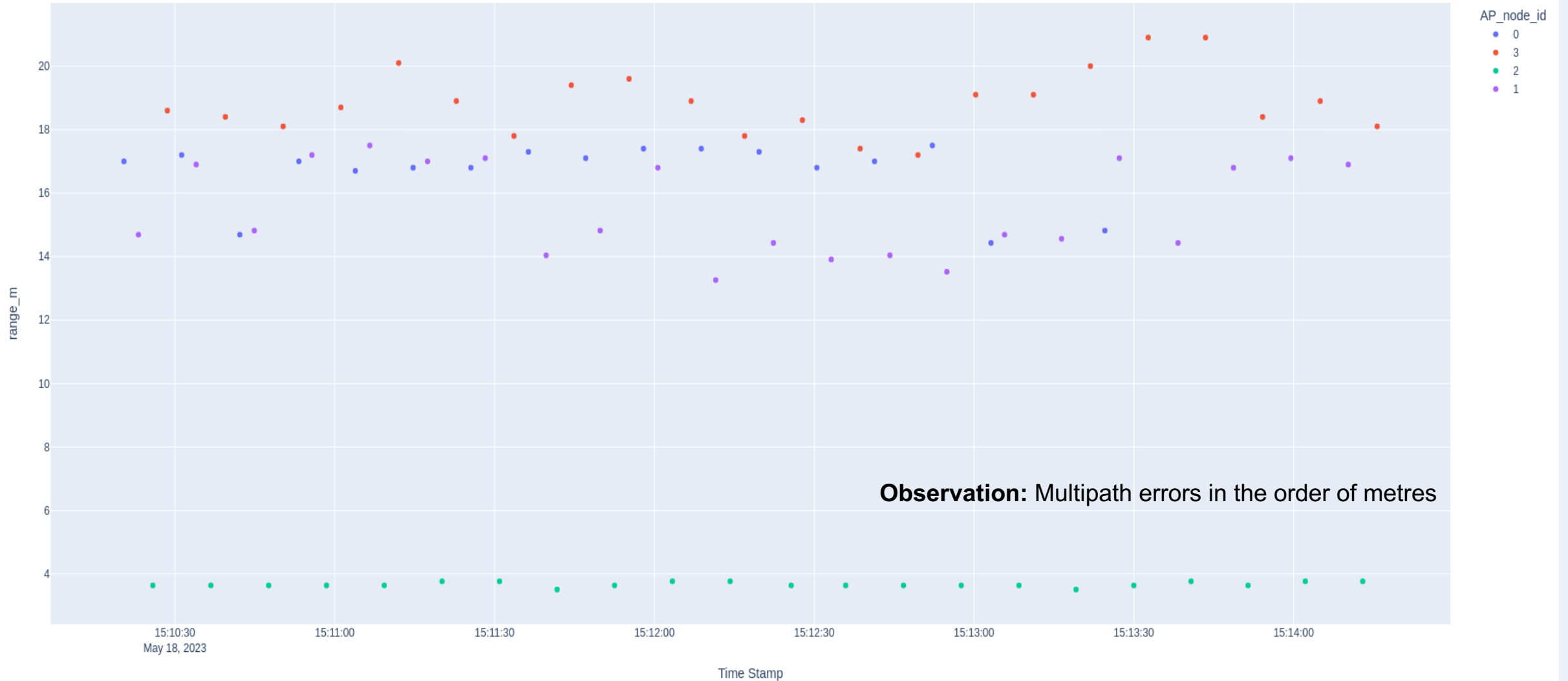


Wifi FTM histogram, Node 4 measurements to 4 APs @ 1, 2, 3, 4, 5, 6 & 7m - indoors



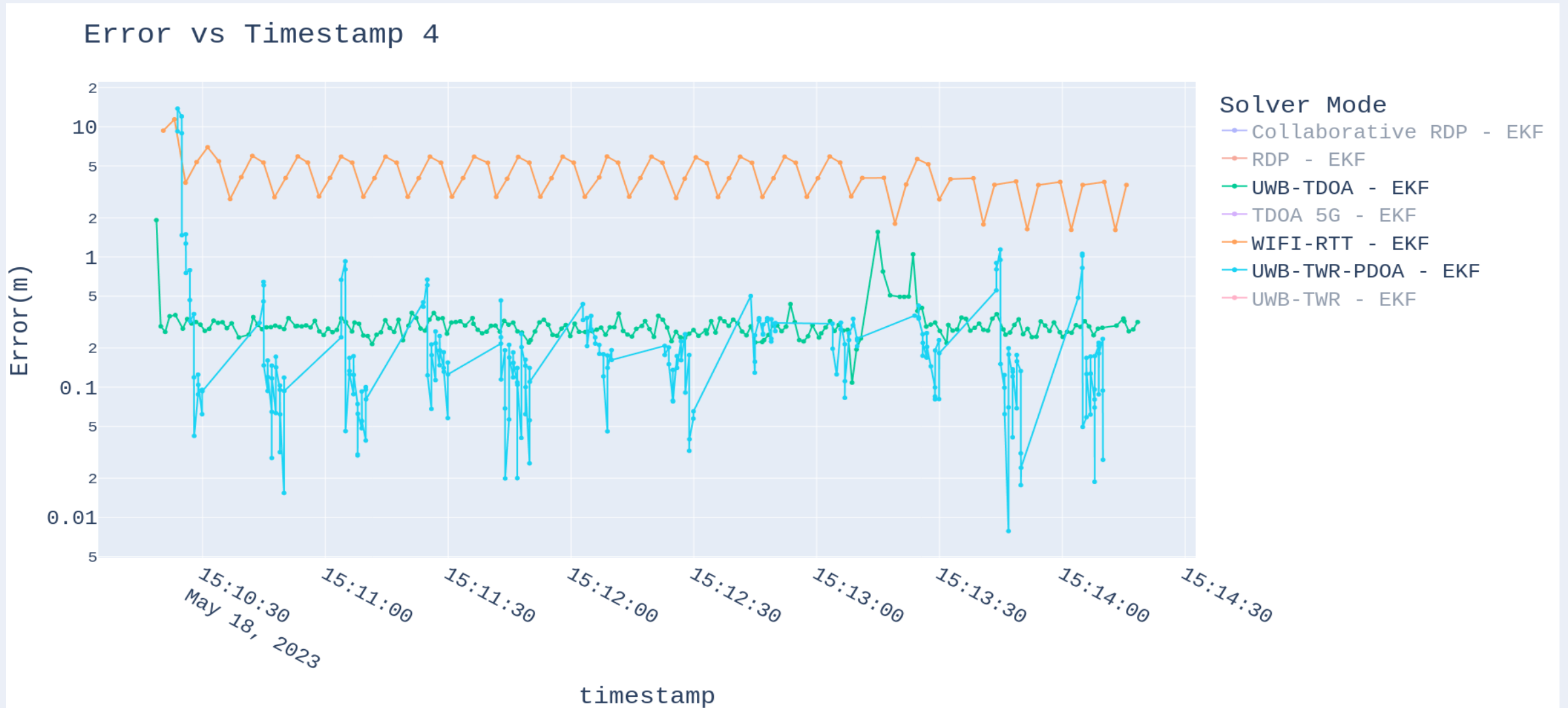
Wifi Raw Data – Node 4

Wifi Measurements

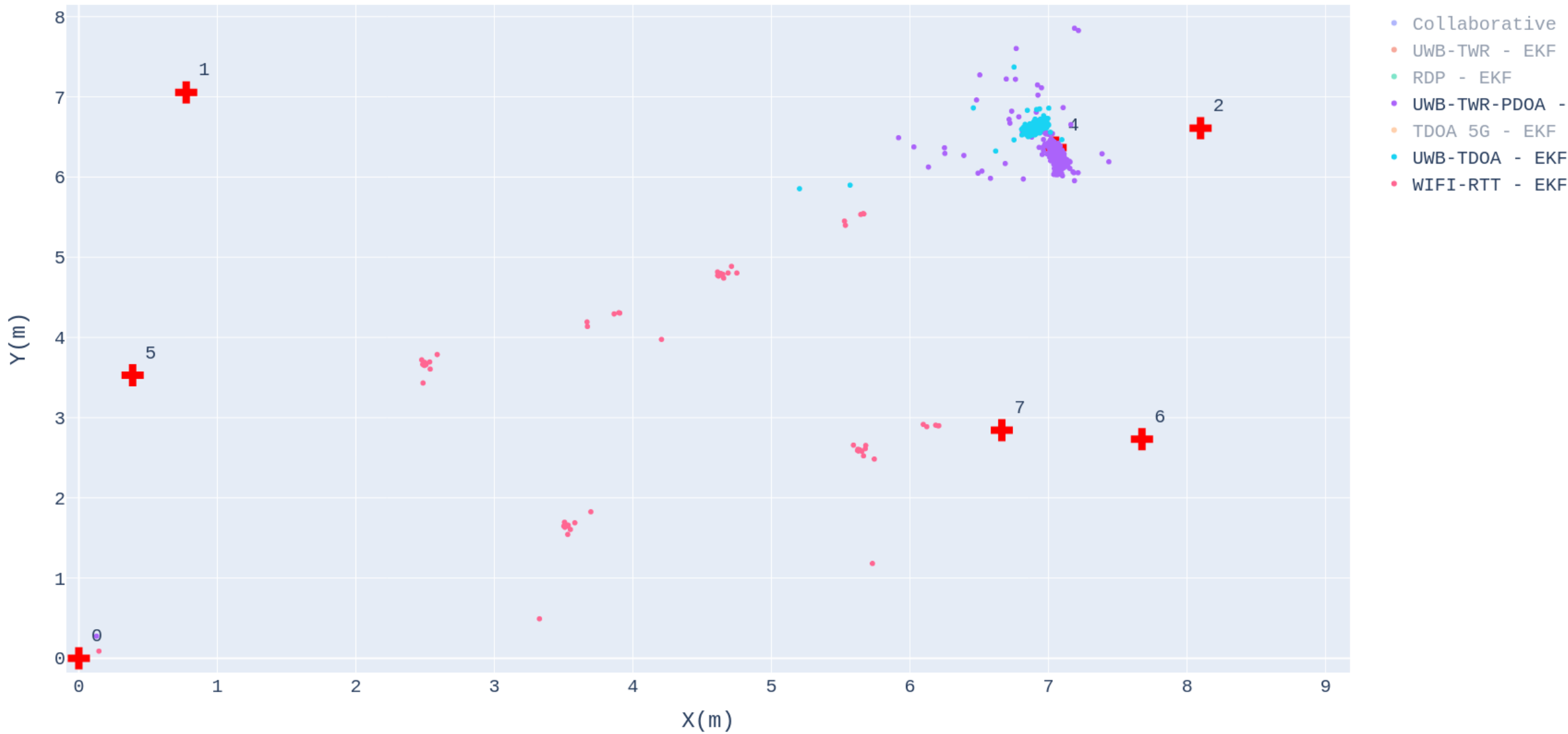


Observation: Multipath errors in the order of metres

Wifi RTT vs UWB-TDOA vs UWB-TWR-PDOA – Node 4



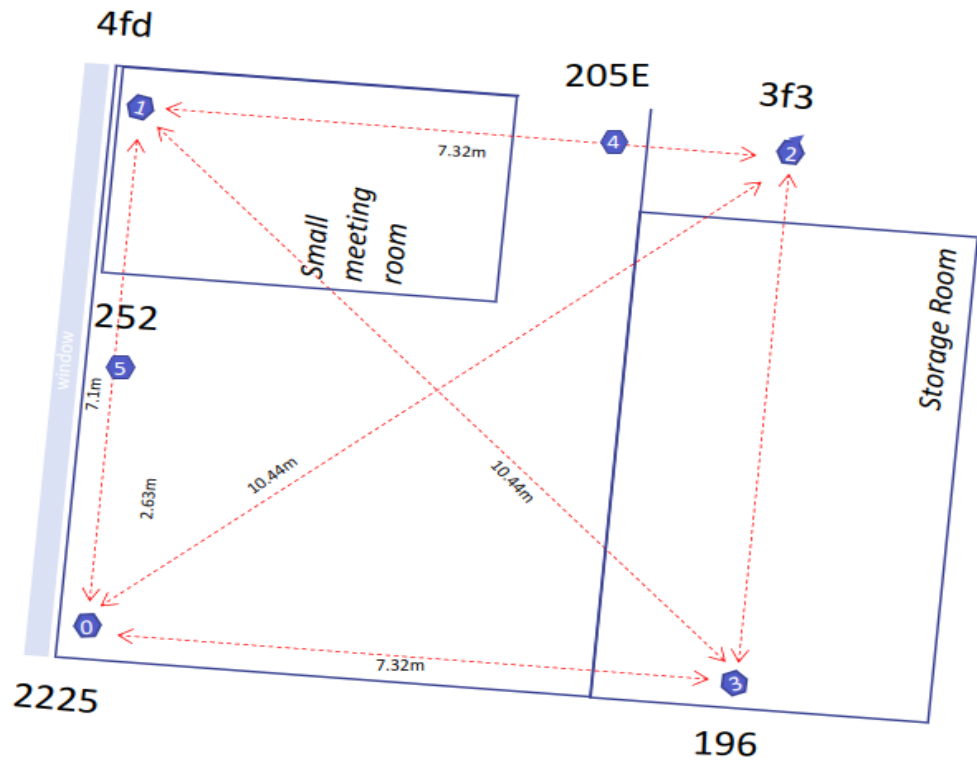
ENU location of Node 4



Summary: Multipath errors of Wi-Fi

- Limits use Wi-Fi as low accuracy positioning system 5-10m
- Hybrid approach with other technologies – Discard multipath measurements using UWB
- Bandwidth of only 20MHz available is the main limitation
 - For example, UWB uses bandwidth >500MHz
- Only supports TWR in standards (802.11mc)
- Future releases will also allow higher bandwidths (802.11az – 160MHz, 802.11bk – 320MHz) so performance should become more comparable to UWB (in bandwidth terms)

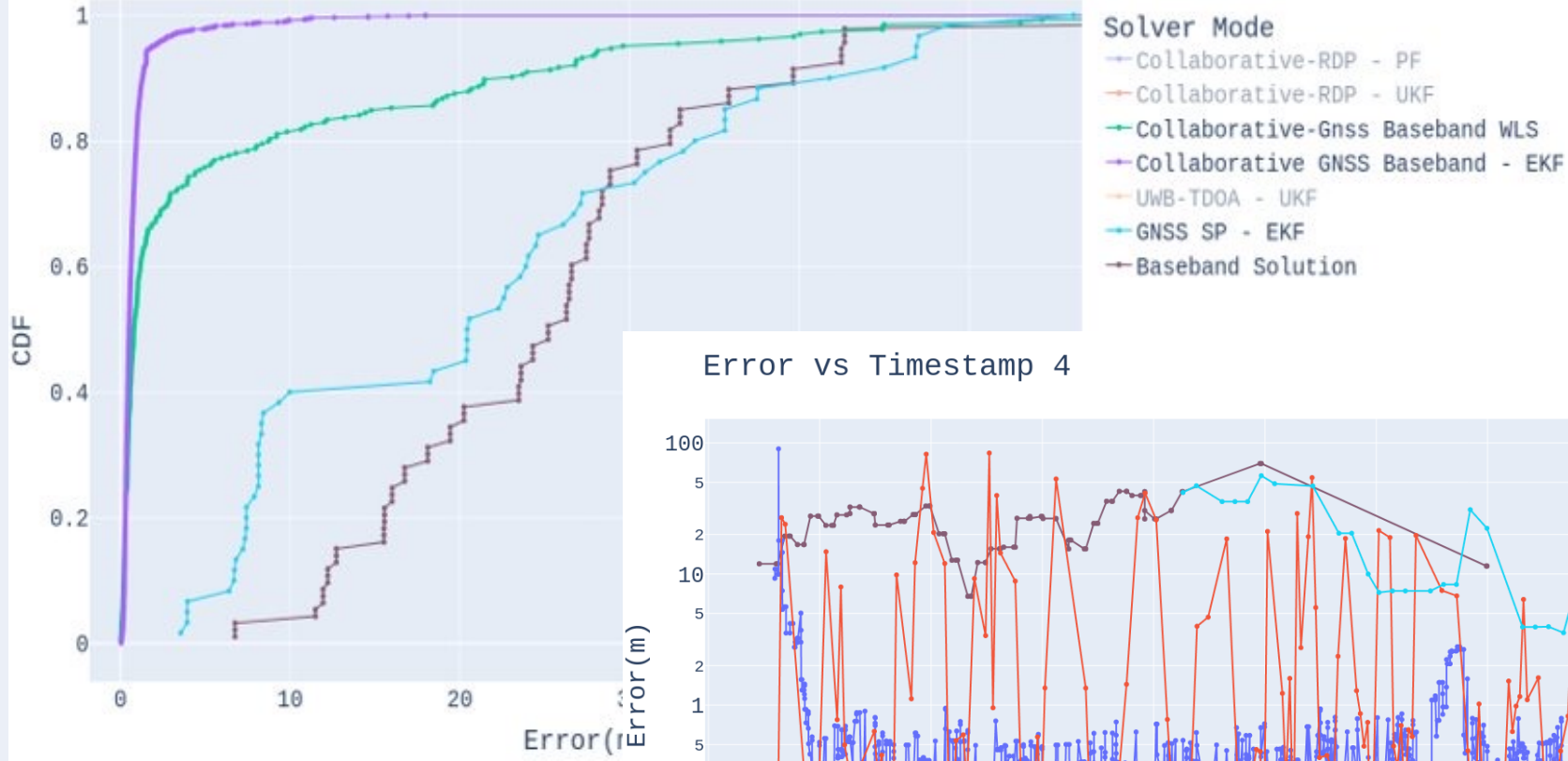
U401a1 - Office Test - Static



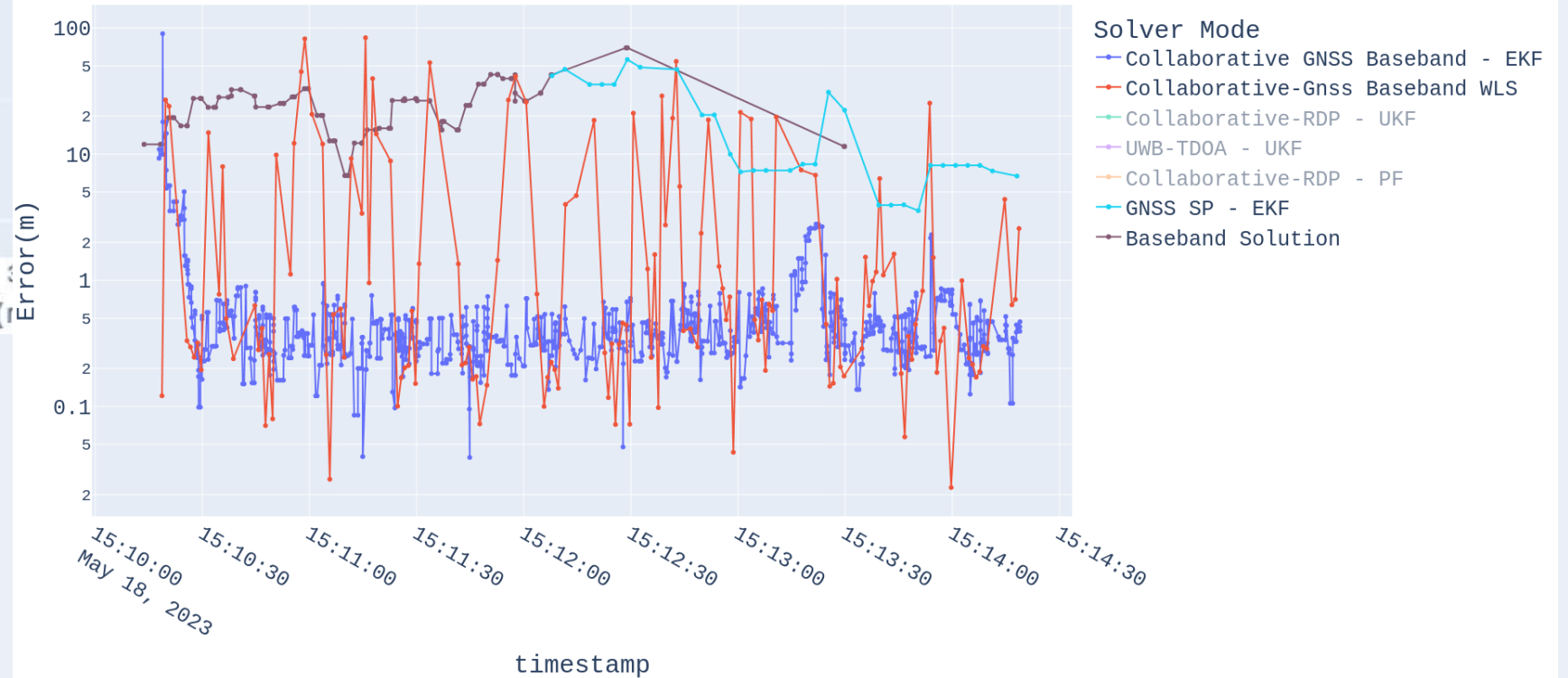
	Percentile-50	Percentile-80	Percentile-95
Collaborative GNSS and - EKF	0.35732	0.58237	1.48702
Collaborative-Gnss and WLS	0.49700	7.76736	28.70817
Collaborative-RDP - PF (No GNSS)	0.23454	0.58504	1.18788
Collaborative-RDP - UKF (No GNSS)	0.32797	0.53540	0.87225
GNSS SP - EKF	8.22524	35.61371	47.98223
UWB-TDOA - UKF	0.37661	0.43243	0.71977

GNSS variants only

CDF of All Nodes



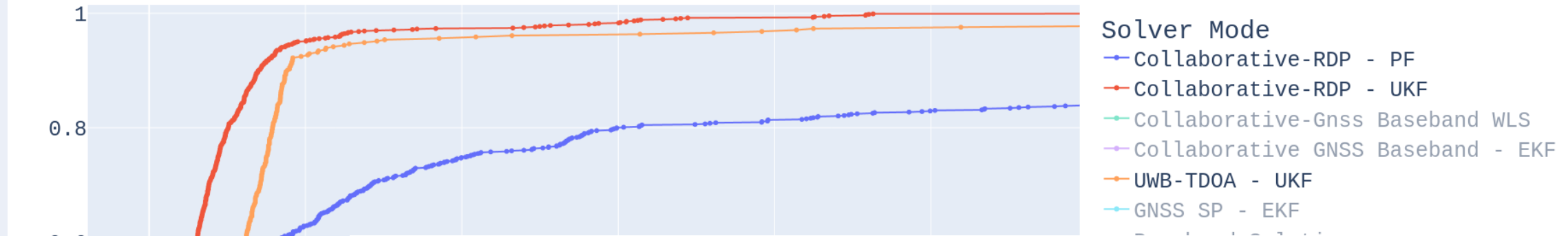
Error vs Timestamp 4



U401a1 - Office Test - Static

Non GNSS variants

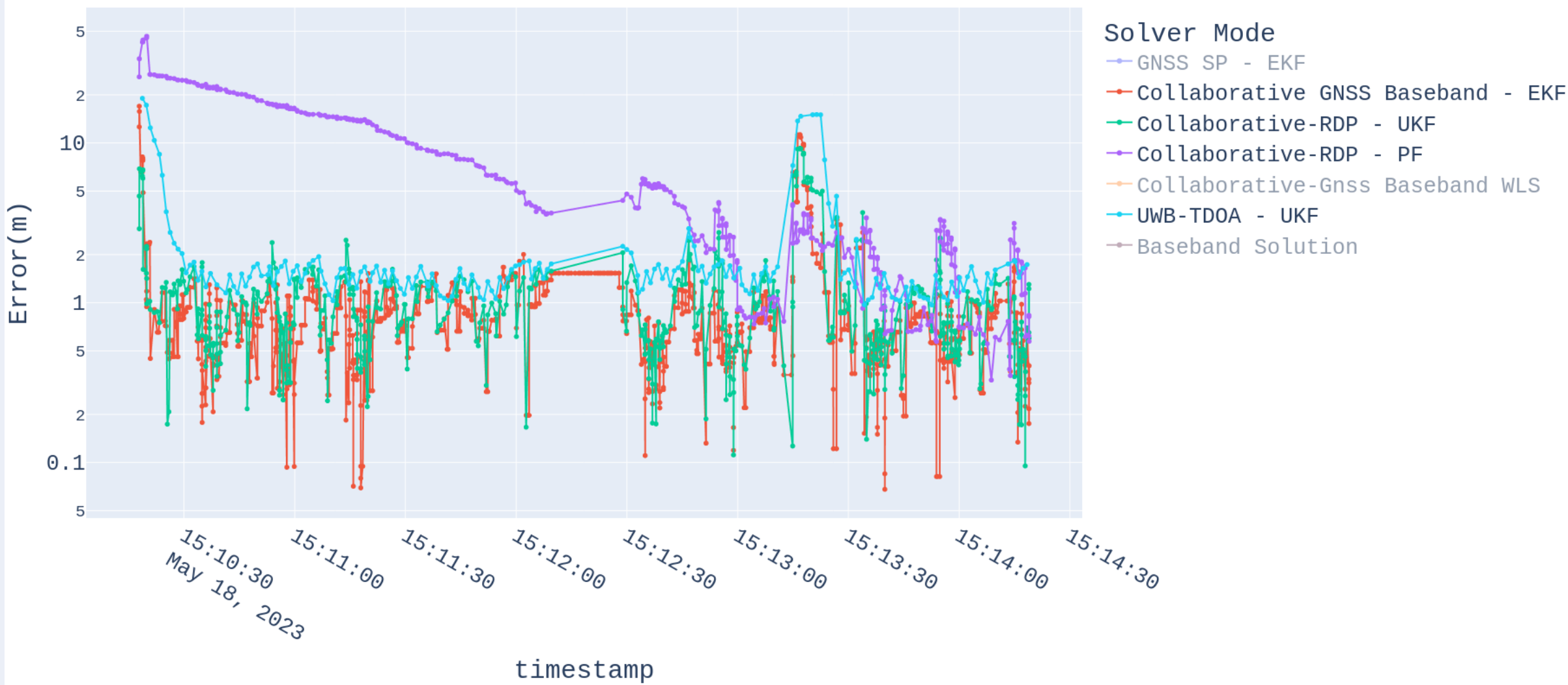
CDF of All Nodes



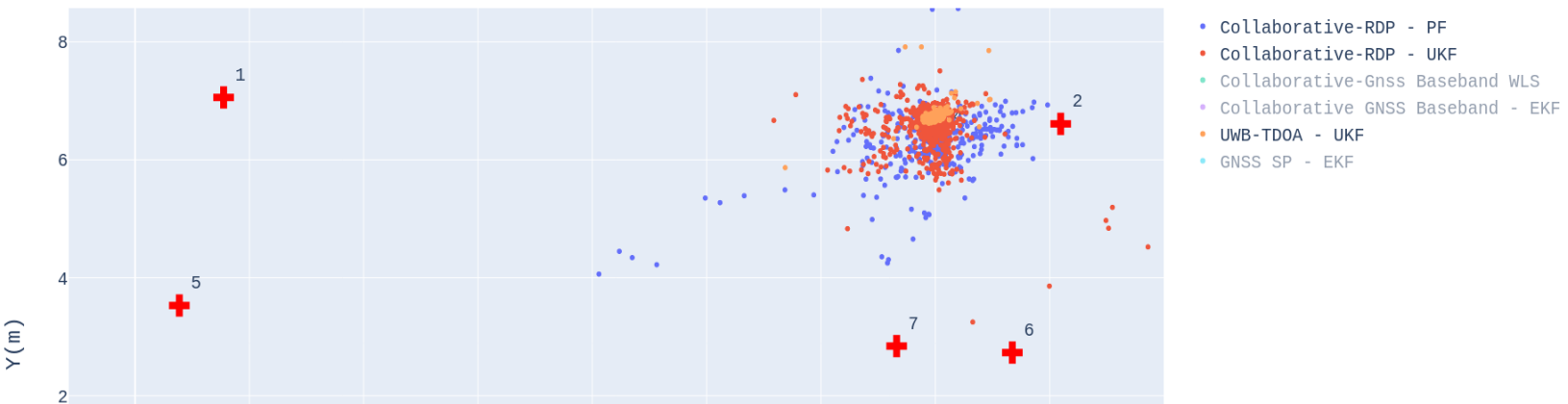
Error vs Timestamp 4



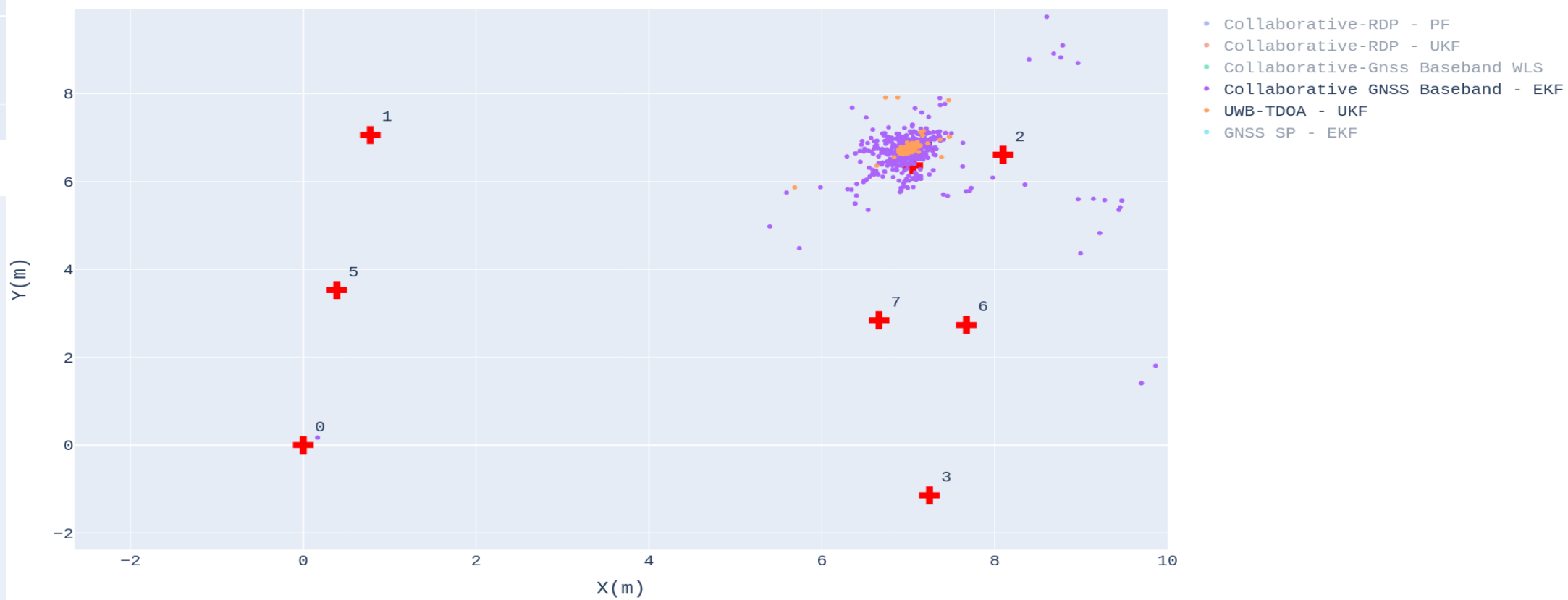
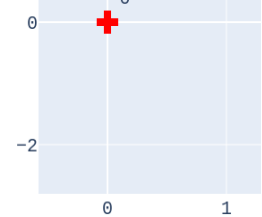
Error vs Timestamp 5



ENU location of Node 4

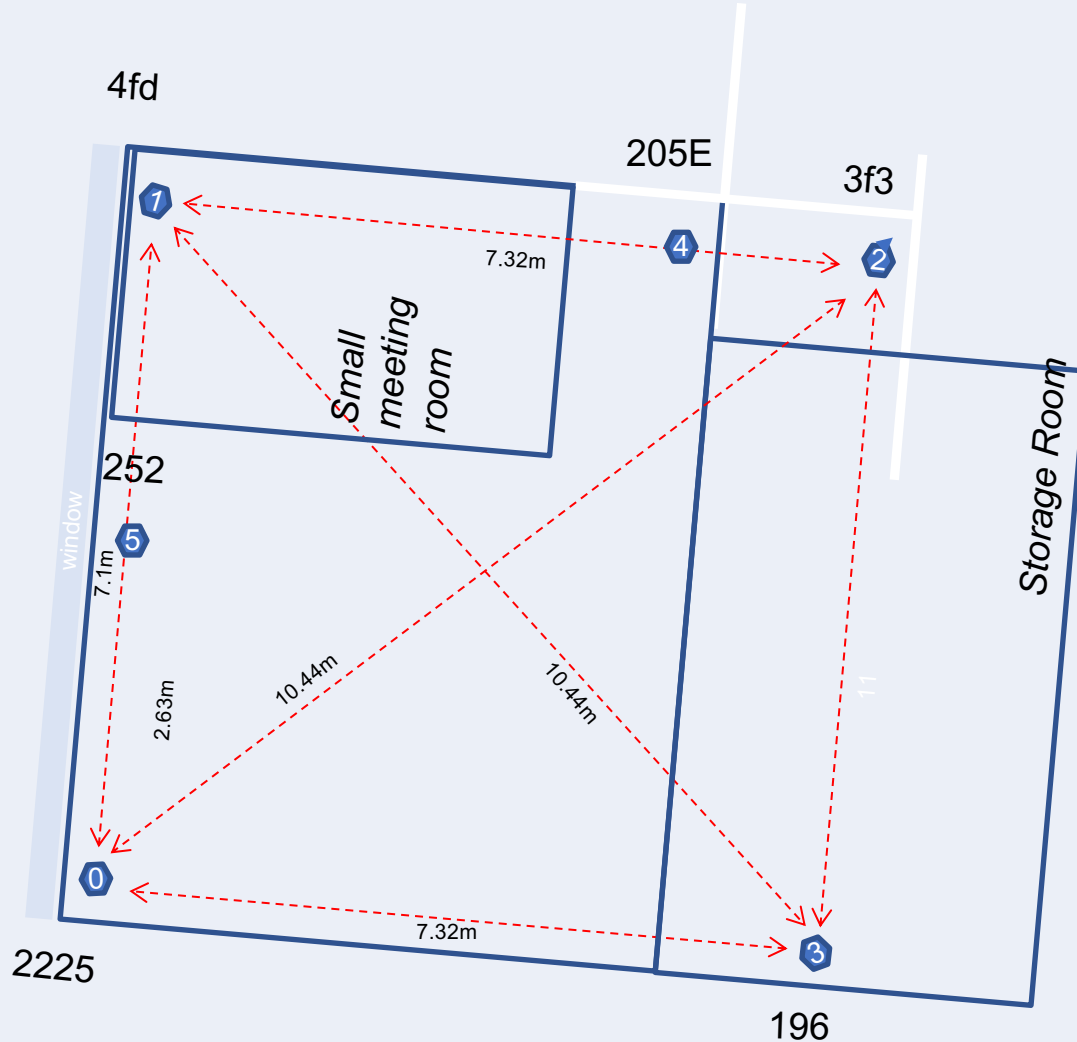


ENU location of Node 4



U401a2 - Static Test

18/05/23 15:10 – 15:15



Anchor Time databases:

NODE 0

```
007788 #idx, addr, #, stddev, age(s)
007788 0, 196, 1603, 7.518, 5, 0.014, 1.1
007788 1, 4fd, 1523, 7.143, 5, 0.014, 1.1
007788 2, 3f3, 2363, 11.083, 5, 0.112, 1.1
```

NODE 1

```
002473 compat> tdb list
003542 #idx, addr, tof, tof(m), #, stddev, age(s)
003542 0, 2225, 1536, 7.204, 3, 0.009, 4.4
003542 1, 196, 2280, 10.694, 3, 0.060, 4.4
003542 2, 3f3, 1633, 7.659, 2, 0.042, 13.0
```

NODE 2

```
03379 compat> tdb list
004182 #idx, addr, tof, tof(m), #, stddev, age(s)
004182 0, 2225, 2241, 10.511, 4, 0.028, 3.8
004182 1, 196, 1529, 7.171, 4, 0.004, 3.8
004182 2, 4fd, 1766, 8.283, 4, 0.393, 3.8
```

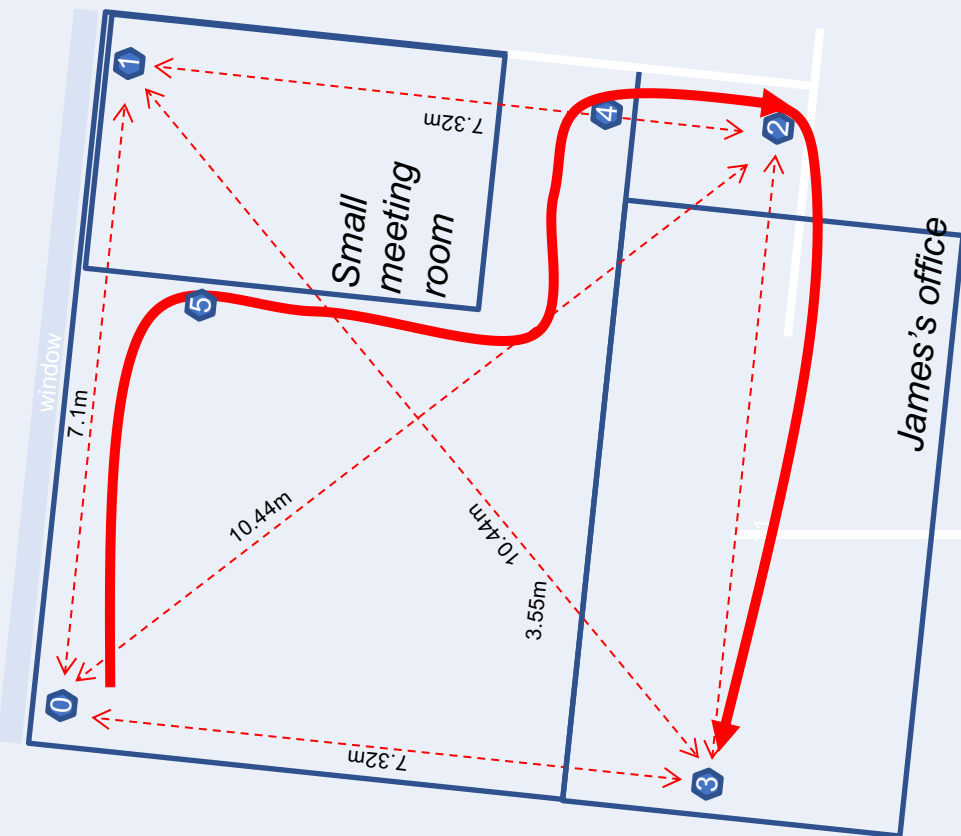
NODE 3

```
02106 compat> tdb list
002483 #idx, addr, tof, tof(m), #, stddev, age(s)
002483 0, 2225, 1620, 7.598, 3, 0.042, 0.1
002483 1, 4fd, 2253, 10.567, 3, 0.065, 0.1
002483 2, 3f3, 1513, 7.096, 3, 0.103, 0.1
```




node	lat	lon	bearing
0	53.34246049	-6.241043227	60
1	53.34252389	-6.241031589	150
2	53.34251988	-6.240921654	240
3	53.34245019	-6.240934447	330
4	53.3425177	-6.240937365	
5	53.34249219	-6.241037408	

U401a2 - Walk Test



← → ↻ Not secure | esa.conf.danalto.net/ESAConfig-1/geo.html

Concept Demonstrator | Site Configurator




Root:
 Project:
 Network:
 Altitude:

	Node ID	Dist to Ref node (m)	Dist to partner node (m)	Bearing (deg.)
Reference Node	0			80
Ref. partner	1	7.1		150
Node..	4	9.82	6.56	
Node..	2	10.44	7.32	240
Node..	3	7.32	10.44	330
Node..				
Node..				
Node..				

Geo config

Map Satellite



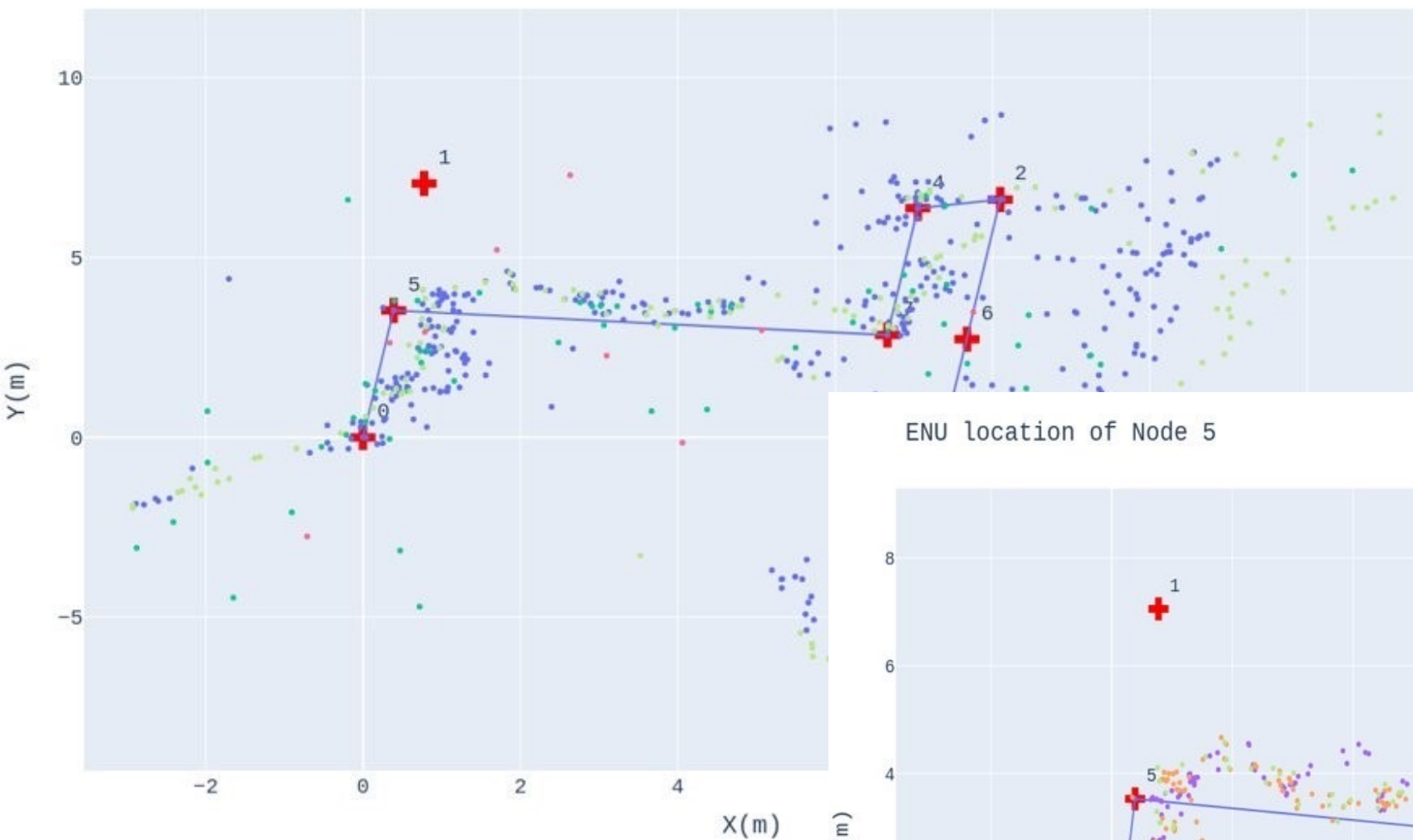
Google

Set reference Geolocation Ref geo Latitude Longitude

Set partner Geolocation Partner geo Latitude Longitude

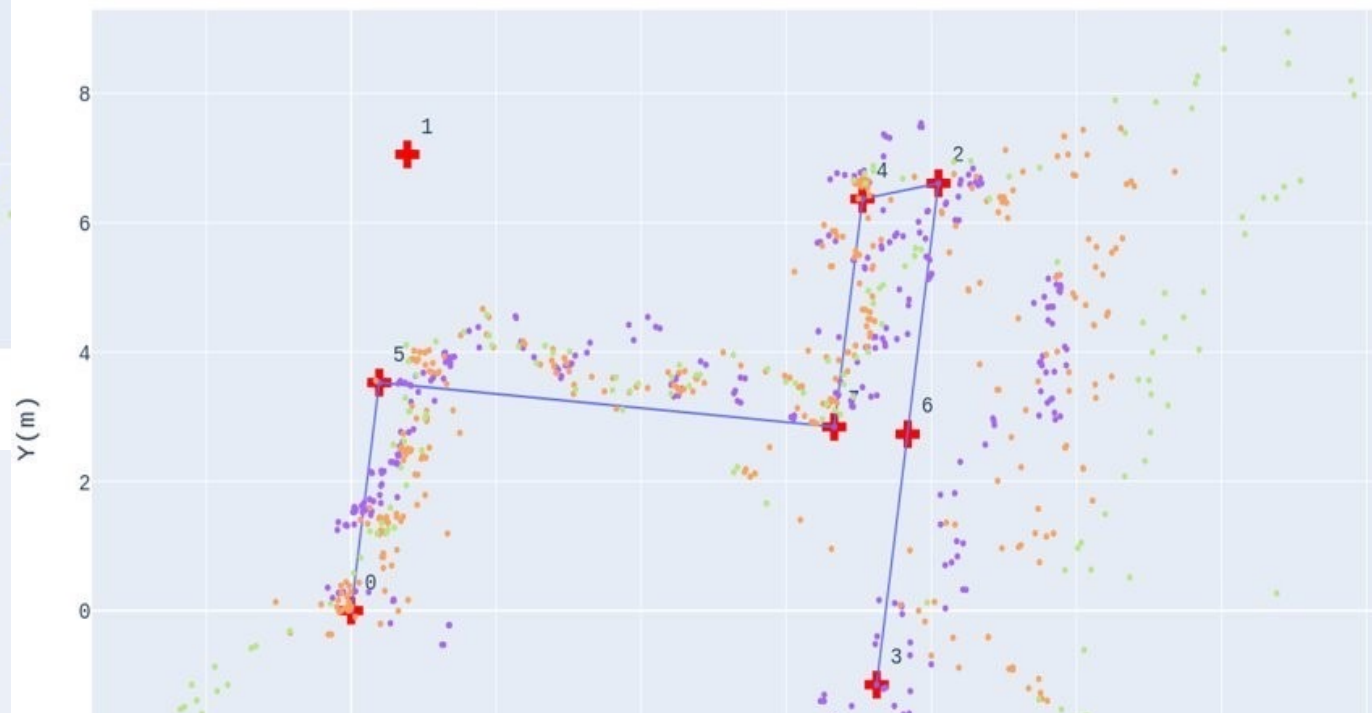
Save all

ENU location of Node 5



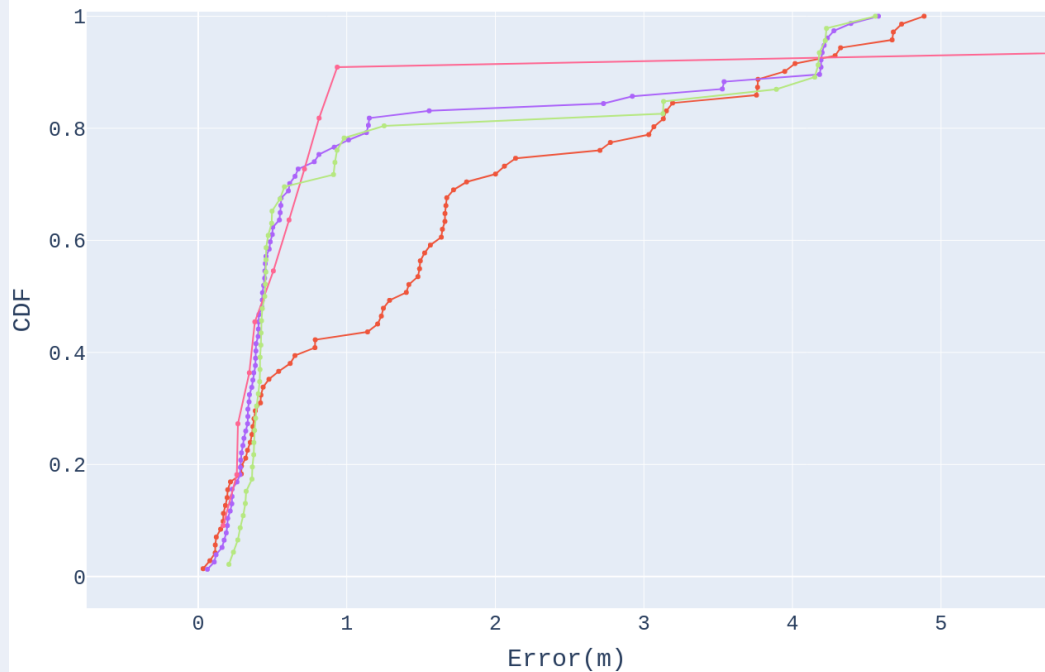
- Collaborative GNSS Baseband - EKF
- Collaborative RDP - EKF
- Collaborative-Gnss Baseband WLS
- Collaborative-RDP - PF
- Collaborative-RDP - UKF
- Collaborative-RDP WLS
- GNSS SP - EKF
- UWB-TDOA - UKF
- UWB-TWR-PDOA - UKF

ENU location of Node 5



- Collaborati
- Collaborati
- Collaborati
- Collaborati
- Collaborati
- Collaborati
- GNSS SP - E
- UWB-TDOA -
- UWB-TWR-PDO

CDF of Stationary Nodes

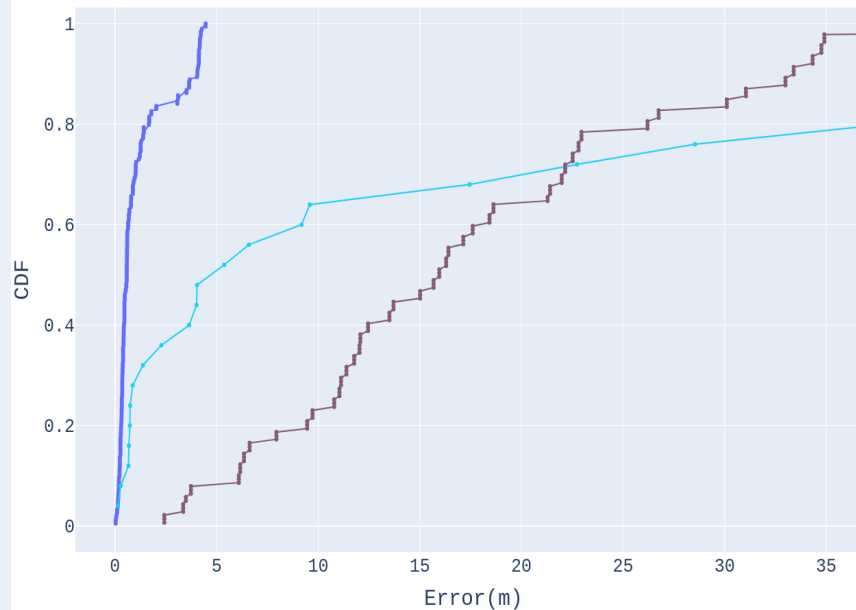


Solver Mode

- Collaborative GNSS Baseband - EKF
- Collaborative-RDP - PF
- Collaborative RDP - EKF
- Collaborative-RDP - UKF
- Collaborative-RDP WLS
- Collaborative-Gnss Baseband WLS
- UWB-TWR-PDOA - UKF
- UWB-TDOA - UKF
- GNSS SP - EKF
- Baseband Solution

RU - 4

CDF of Stationary Nodes

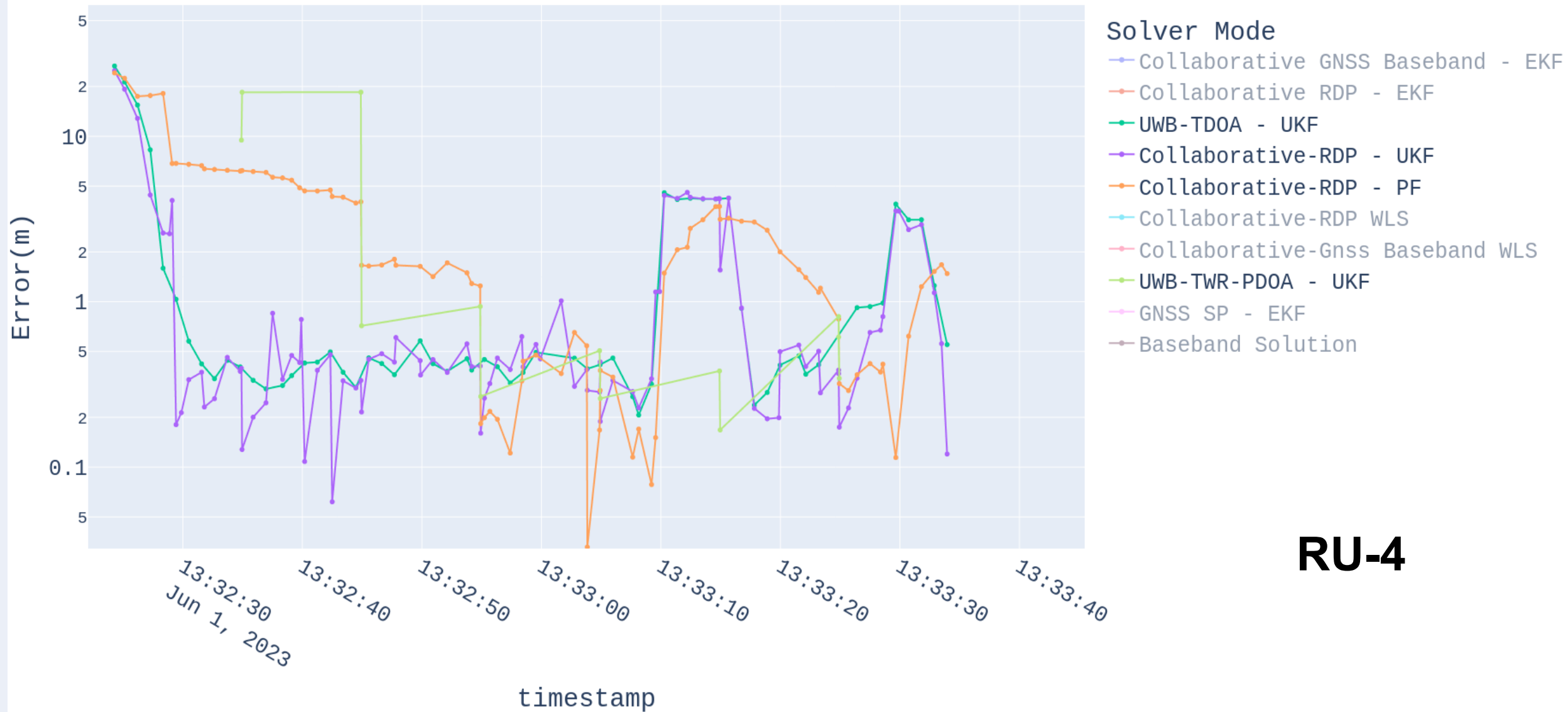


Solver Mode

- Collaborative GNSS Baseband - EKF
- Collaborative-RDP - PF
- Collaborative RDP - EKF
- Collaborative-RDP - UKF
- Collaborative-RDP WLS
- Collaborative-Gnss Baseband WLS
- UWB-TWR-PDOA - UKF
- UWB-TDOA - UKF
- GNSS SP - EKF
- Baseband Solution

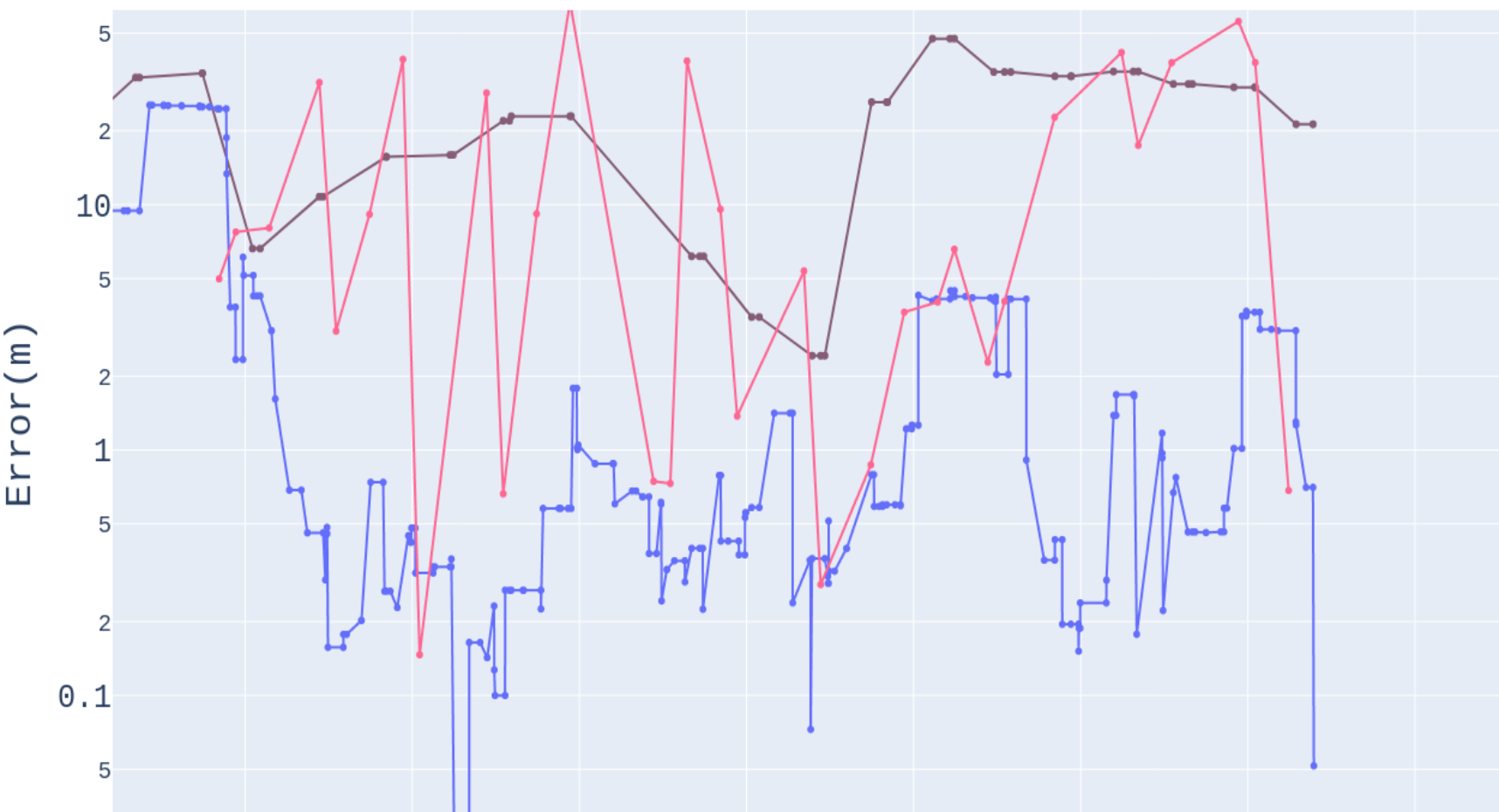
mode	Percentile-50	Percentile-80	Percentile-95
Collaborative GNSS Baseband - EKF	0.58	1.67	4.15
Collaborative RDP - EKF	0.33	1.12	4.18
Collaborative-Gnss Baseband WLS	5.37	37.94	53.06
Collaborative-RDP - PF	1.40	3.07	4.50
Collaborative-RDP - UKF	0.43	1.14	4.22
Collaborative-RDP WLS	0.55	2.42	4.27
GNSS SP - EKF	90.28	92.62	93.79
UWB-TDOA - UKF	0.45	1.25	4.21
UWB-TWR-PDOA - UKF	0.51	0.81	9.71

Error vs Timestamp 4



RU-4

Error vs Timestamp 4



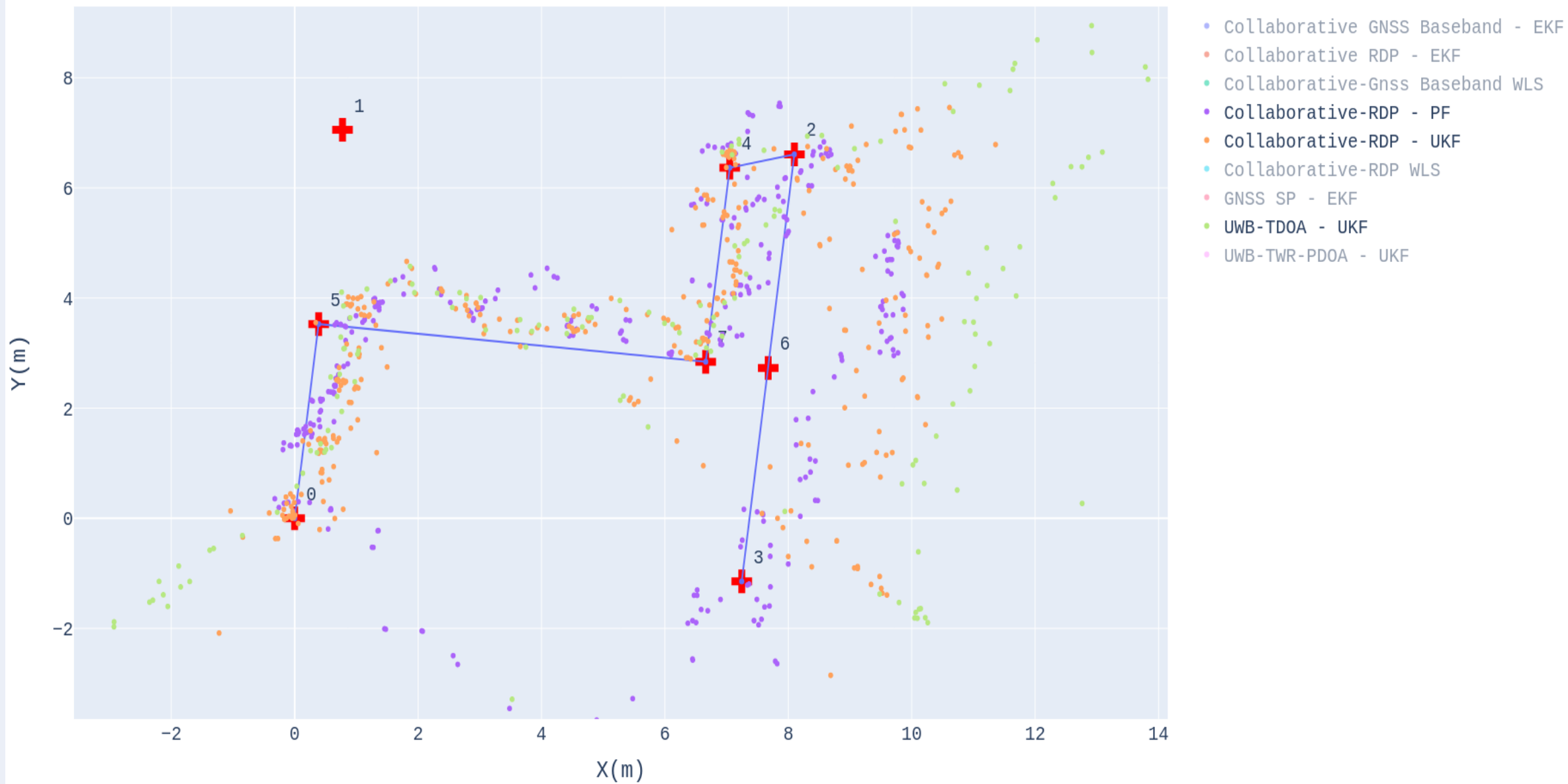
- ### Solver Mode
- Collaborative GNSS Baseband - EKF
 - Collaborative RDP - EKF
 - UWB-TDOA - UKF
 - Collaborative-RDP - UKF
 - Collaborative-RDP - PF
 - Collaborative-RDP WLS
 - Collaborative-GNSS Baseband WLS
 - UWB-TWR-PDOA - UKF
 - GNSS SP - EKF
 - Baseband Solution

GNSS solvers with Baseband GPS only data

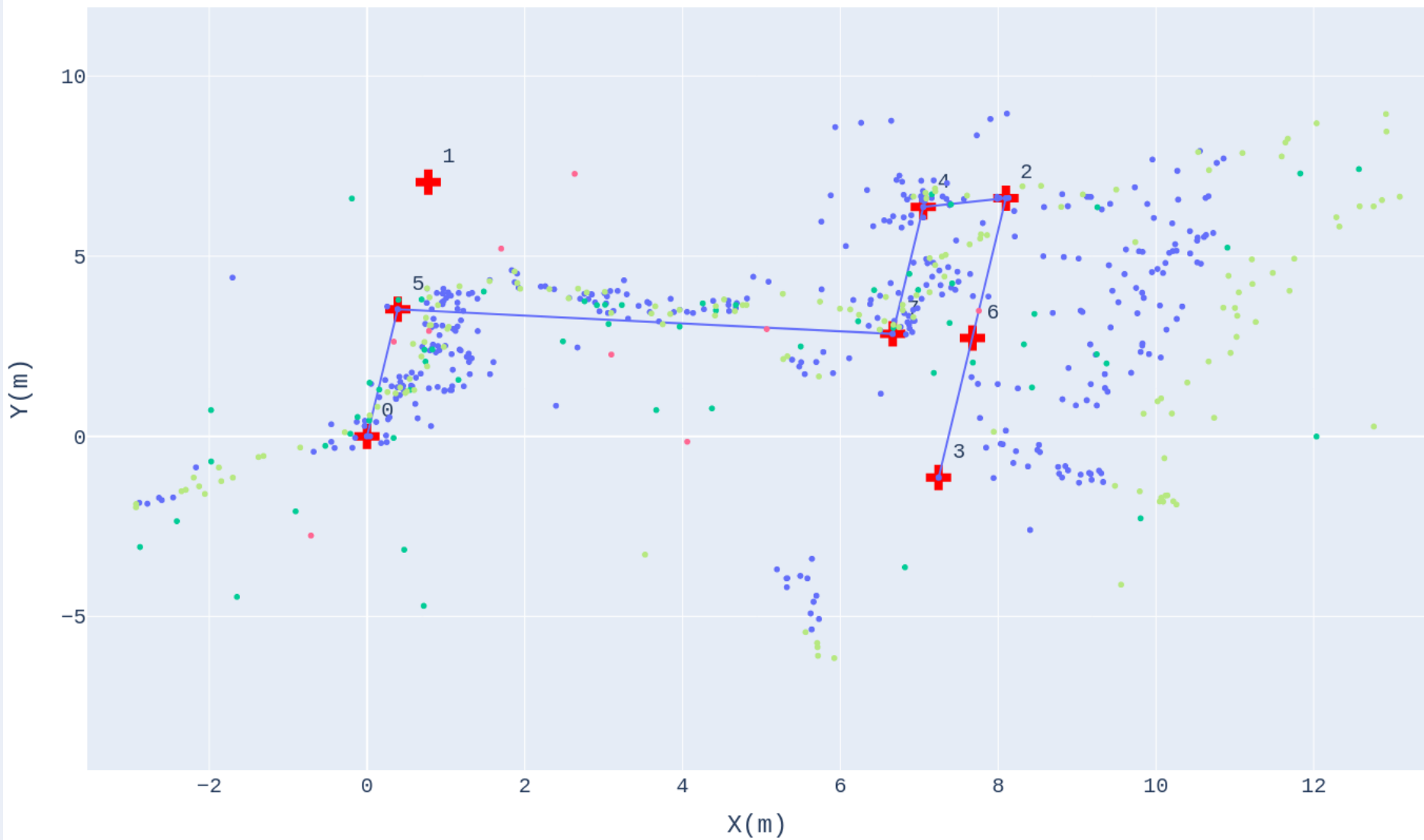
13:32:30
Jun 1, 2023

timestamp

ENU location of Node 5



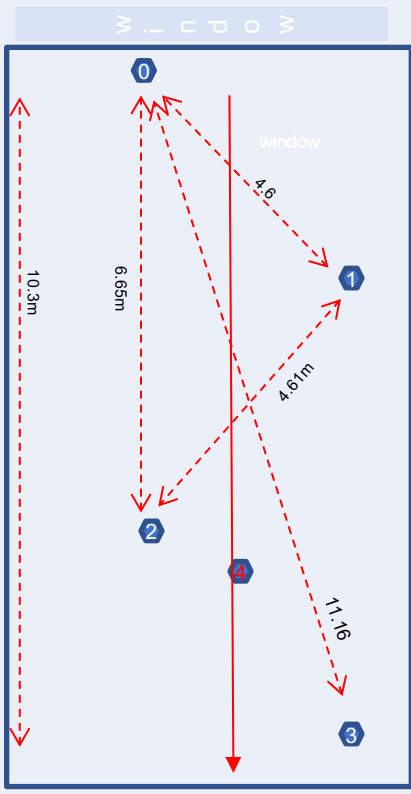
ENU location of Node 5



- Collaborative GNSS Baseband - EKF
- Collaborative RDP - EKF
- Collaborative-Gnss Baseband WLS
- Collaborative-RDP - PF
- Collaborative-RDP - UKF
- Collaborative-RDP WLS
- GNSS SP - EKF
- UWB-TDOA - UKF
- UWB-TWR-PDOA - UKF

U401b

010623-u405-test-1-slow
010623-u405-test-1-fast



← → ↻ Not secure | esa.conf.danalto.net/ESAConfig-1, Concept Demonstrator | Site

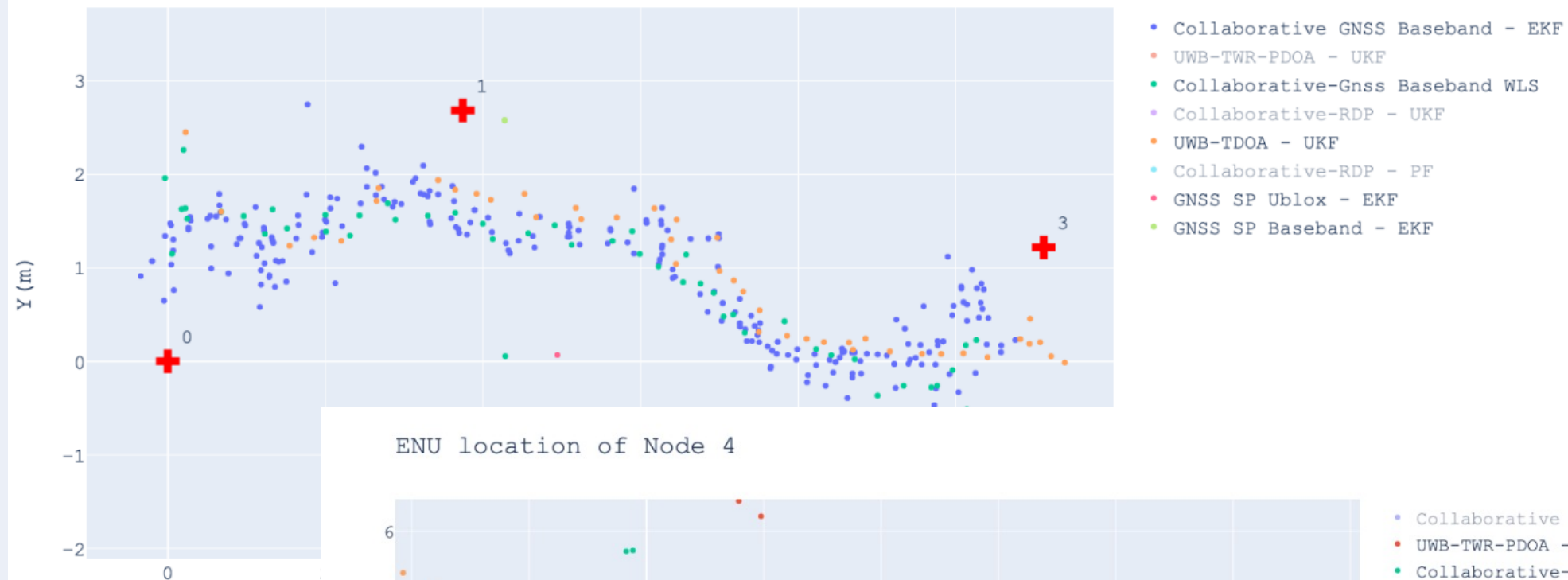
Root
Project
Network
Altitude

	Node ID	Dist to Ref node (m)	Dist to partner node (m)	Bearing (deg.)
Reference Node	0			15
Ref. partner	1	4.6		195
Node..	2	6.65	4.61	15
Node..	3	11.16	7.5	195
Node..				
Node..				
Node..				
Node..				

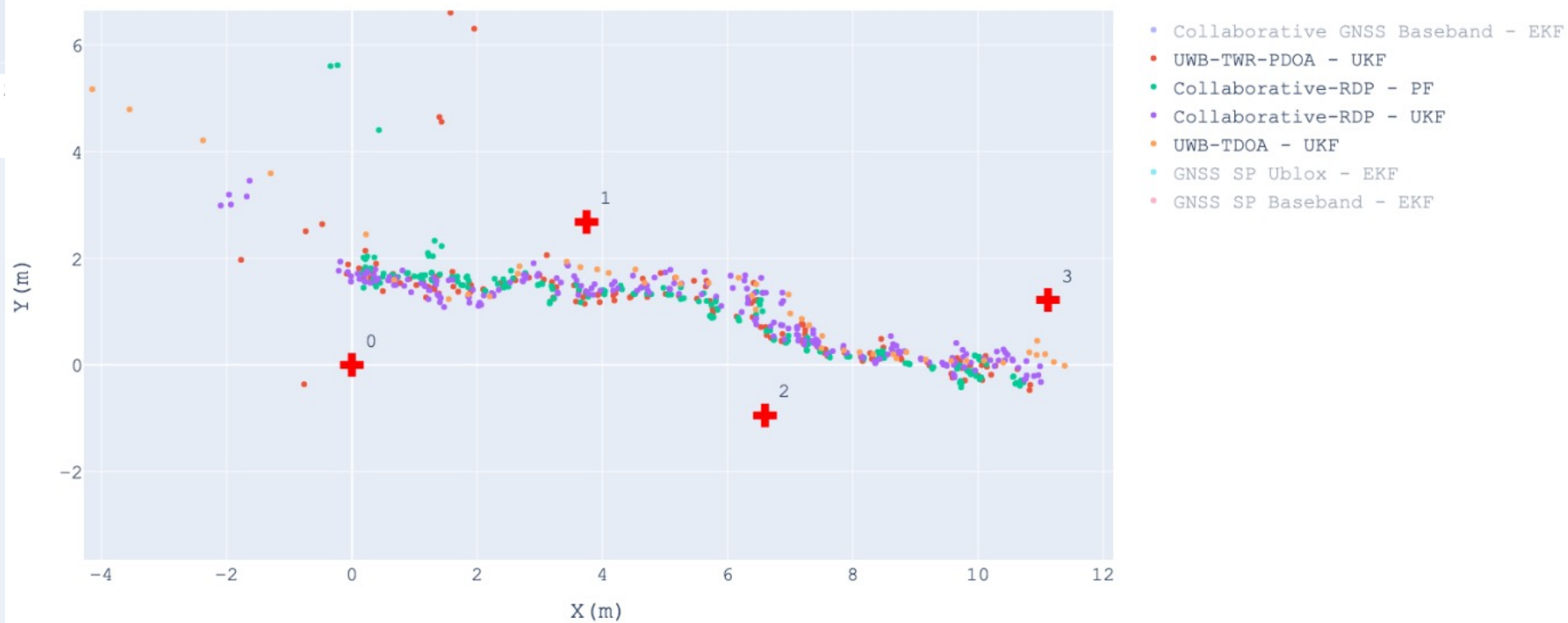
Geo config

Map Satellite Labels

ENU location of Node 4



ENU location of Node 4



U401c - Outdoor to Indoor test



31/5/23 15:00ish – 15:40ish
test names
SLOW WALK :
310523-out-to-in-test-6
Normal WALK :
310523-out-to-in-test-7-FAST



Concept Demonstrator | Site Config

Root:
Project:
Network:
Altitude:

	Node ID	Dist to Ref node (m)	Dist to partner node (m)	Bearing (deg.)
Reference Node	0			150
Ref. partner	1	4.57		240
Node..	2	8.76	8.24	330
Node..	3	8.24	8.76	60
Node..				
Node..				
Node..				
Node..				

Geo config

Map Satellite



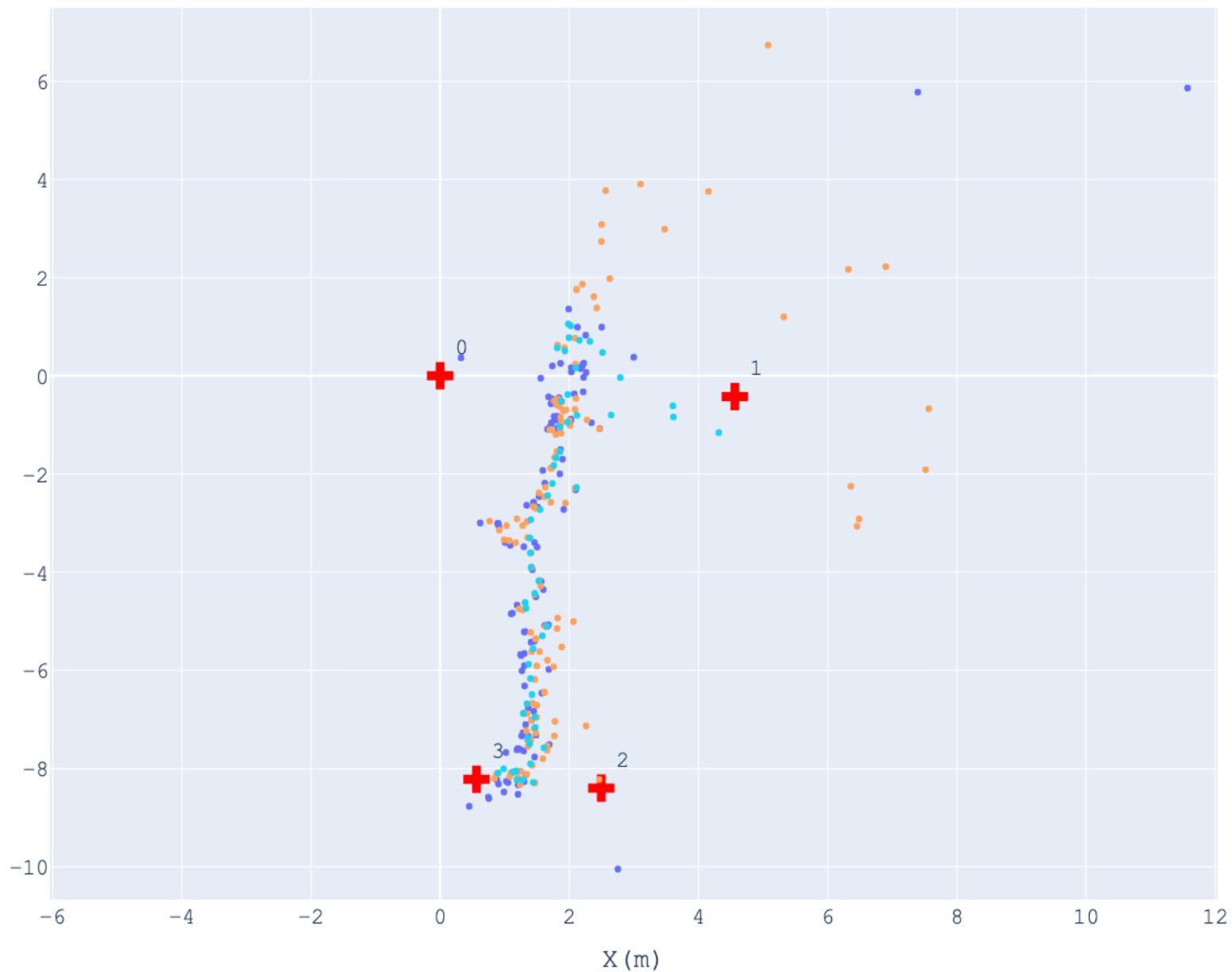
Set reference Geolocation Ref geo Latitude Longitude

Set partner Geolocation Partner geo Latitude Longitude

Save all



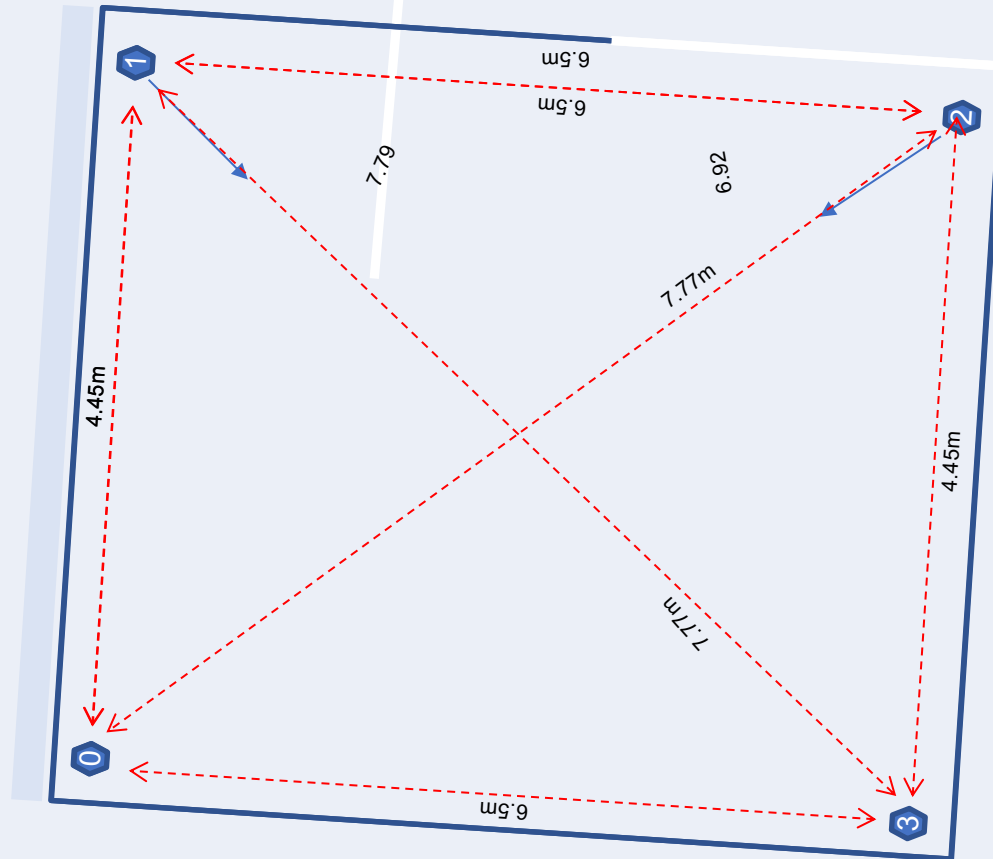
ENU location of Node 4



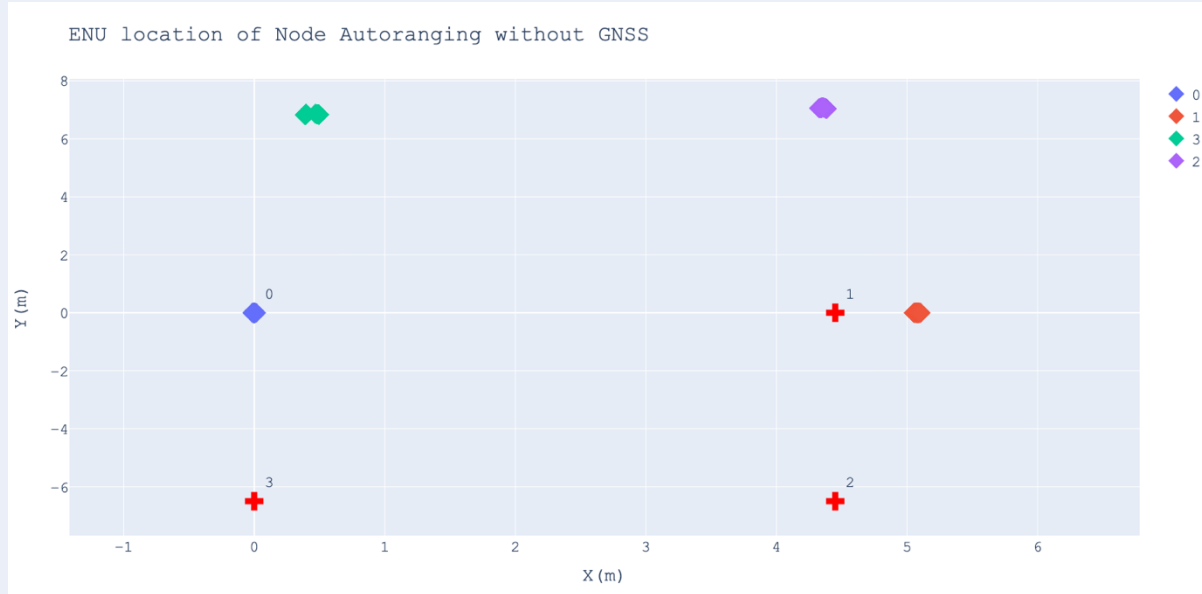
- Collaborative-RDP - UKF
- Collaborative GNSS Baseband(GPS Only) - EKF
- Collaborative-Gnss Baseband WLS
- Collaborative-RDP - PF
- Collaborative GNSS Ublox(Pseudorange-GPS+Gal) - EKF
- UWB-TDOA - EKF
- GNSS SP Baseband - EKF
- GNSS SP Ublox(Codephase-GPS+Gal) - EKF
- GNSS SP Ublox(Pseudorange-GPS+Gal) - EKF

U402 - Auto-ranging – self forming/referencing

18/05/23 15:10 – 15:15



U402 - Autoranging result of AP 0,1,2,3 with AP 0 & AP 3 fixed in x-axis



Mirrored results of auto ranging solver with Extended Kalman Filter after 5 minutes of data without additional information

AP - 3

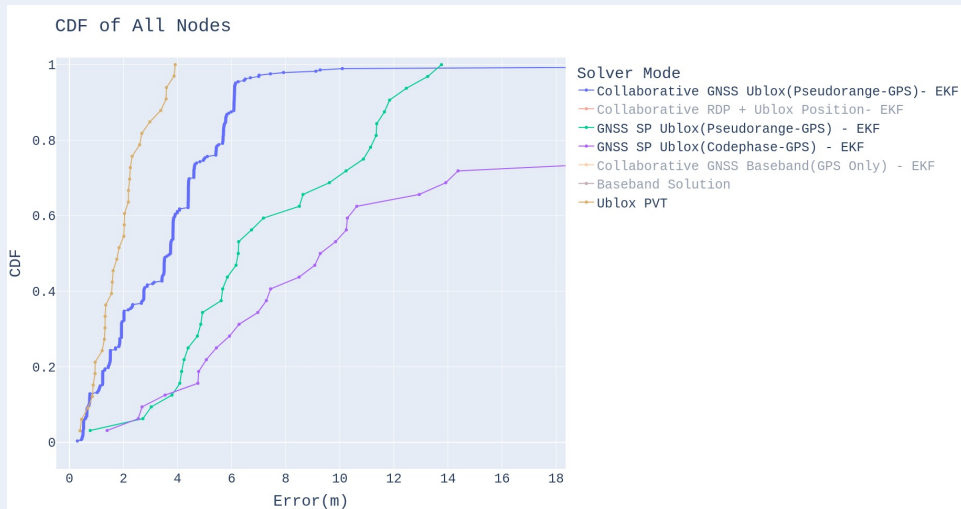


U403b - 1 AP and 1 RU in light-indoor conditions, only ranging measurements available together with GNSS;



U403b -1 AP and 1 RU in light-indoor conditions, only ranging measurements available together with GNSS

mode	Percentile-50	Percentile-80	Percentile-95
Collaborative GNSS Ublox(Pseudorange-GPS)- EKF	3.45	4.57	5.98
GNSS SP Ublox(Codephase-GPS) - EKF	9.59	47.99	64.99
GNSS SP Ublox(Pseudorange-GPS) - EKF	6.29	11.35	13.48
Ublox PVT	1.84	2.65	3.70



CDF of different solvers on RU 5

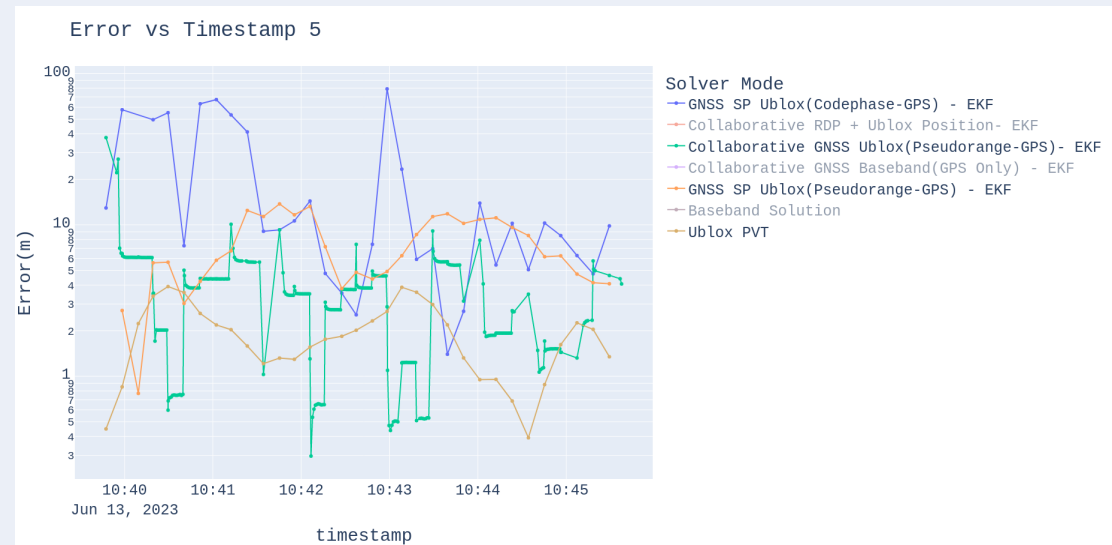


Figure 217 Error vs Timestamp of RU5

Project management items -

outstanding Action Items (AIs) from the previous MoM and keypoints.

Action ID	Action Description	Responsible	Due Date	Action Status
#A1-1	FM-02 - update status of filter implementation at key point 3. Particle filter results to be provided ahead of FR.	Danalto	14 th April	Open
#A1-6	FM – 12 – show different models when implementing the weighting models	danalto	FR	Open
#A1-8	FM-14 - To perform a test in which the GNSS receiver is moved from indoors to outdoors to assess the impact on the collaborative PVT solution.	danalto	FR	Open
#A1-9	FM-16 – Following follow-up questions: 1) It is shown that the number of Galileo satellites is > 10 in most cases, but still the performance of Galileo only indoors is much worse compared to GPS. Do you see this kind of behaviour consistently (in other words is this test representative)? How is the poor performance for galileo explained? 2) Clarification seems not to be added.	danalto	FR	Open
#A1-10	FM-17 – To add tests to assess the sensitivity of the 5G emulation settings onto the PVT accuracy.	danalto	FR	Open
#A1-10	FM-18 – Currently there are two reference lists in the document. Please combine them to a single list for the FR delivery	danalto	FR	Open
#A1-11	FM -19 – It seems not all colours are present in the plot (for instance Hybrid GNSS - 4 AP with Baseband). Also to improve how the figure can be interpreted, it may be better to separate the plots over 2 figures (for FR).	danalto	FR	Open
#A1-12	FM-21 – For new results, consider additional KPI's (as per REQ-047) when deemed useful.	danalto	FR	Open
#A1-13	FM-23 – Action to obtain new measurements for the updated quality factor which is in range 0-1 and to plot the results in the format of a distribution.	danalto	DKPT-3	Open
#A1-15	FM-25 –To improve how the figure can be interpreted, it may be better to separate the plots over 2 figures (for FR).	danalto	FR	Open
#A1-18	FM-01 - - For the final version of the document, please include a reference to the full D2 in the list of reference documents. Also share the main version of D2 with the reference to the annex. - Please also keep the change log updated.	danalto	DR	Open

outstanding Action Items (AIs) from the previous MoM and keypoints.

Action ID	Update at FR
#A1-1	Particle filter data has been share during KPT3
#A1-6	Added to D2 as part of this Task 5 activities
#A1-8	See U401c test results as part of D3 deliverable
#A1-9	Added to D2 as part part of the Galileo testing
#A1-10	There is no power/sensitivity control aspect of the the 5G emulator.
#A1-10	Single ref list as part of final deliverables
#A1-11	Improvements have been added as part of FR
#A1-12	Useful KPIs, such as number of measurement exploited, have been added to the CD/UI
#A1-13	Already closed as part of KPT-3 slide 19
#A1-15	Improvements have been added as part of FR
#A1-18	Reference list updated

Project management items -

- Project Requirement Updates – Statement of Compliance
 - Total number of requirements = 47
 - Compliant requirements = 40
 - Partial compliance = 4
 - Non compliance = 3 (Of these 3, 1 is optional, and the other two related to DPE which was agreed not to be included in the project.)
- Discussion of RIDs
 - TBD

Conclusions, lessons learnt and recommendations.

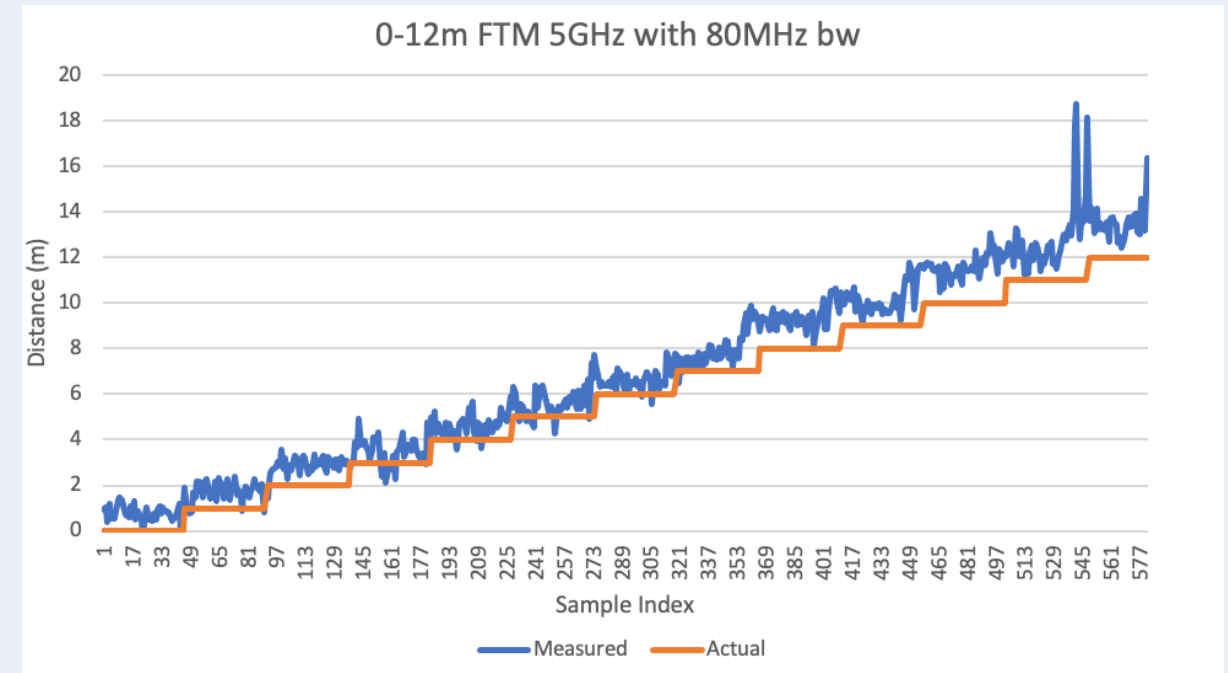
- A rigorous analysis trade-off, followed by a CD implementation, validation and Use Case testing has been realized during the current activity.
- A fully integrated collaborative solver has been implemented, across all the main radio technologies employed for inferring outdoor and indoor location
- Effective filtering methods are critical for overall system performance
- UltrawideBand, plus PDoA, is a critical element for realizing low infrastructure deployments
- WiFi location performance is poor, but shows significant upside, given new silicon developments underway
- Seamless transition out to indoor has been reliably realized

Conclusions, **lessons learnt** and recommendations.

- New Galileo services and feeds provide a significant enhancement to giving broader and better partial indoor coverage than other satellite GNSS systems to aid and support geo extension to the indoor environment
- Indoor location is “almost” there, but needs to be enabled within the broadband ecosystems of business and residences
- Short Snap-Shot GNSS receivers are not suitable for indoor use. Tracking receivers are needed – CNo limited.
- Automatic setup and auto-referencing of all indoor low infrastructure required, MUST be feasible
- TWR and AoA are best approaches for sparse infrastructure

Conclusions, lessons learnt and **recommendations**.

- Given the rapid advancement of WiFi, to further explore the alignment and synergies and interworking possibilities of GNSS to this ecosystem for service alignment and acceleration
- Continuation and productization of portions of this work through the NAVISP-EL-143 activity (ongoing)

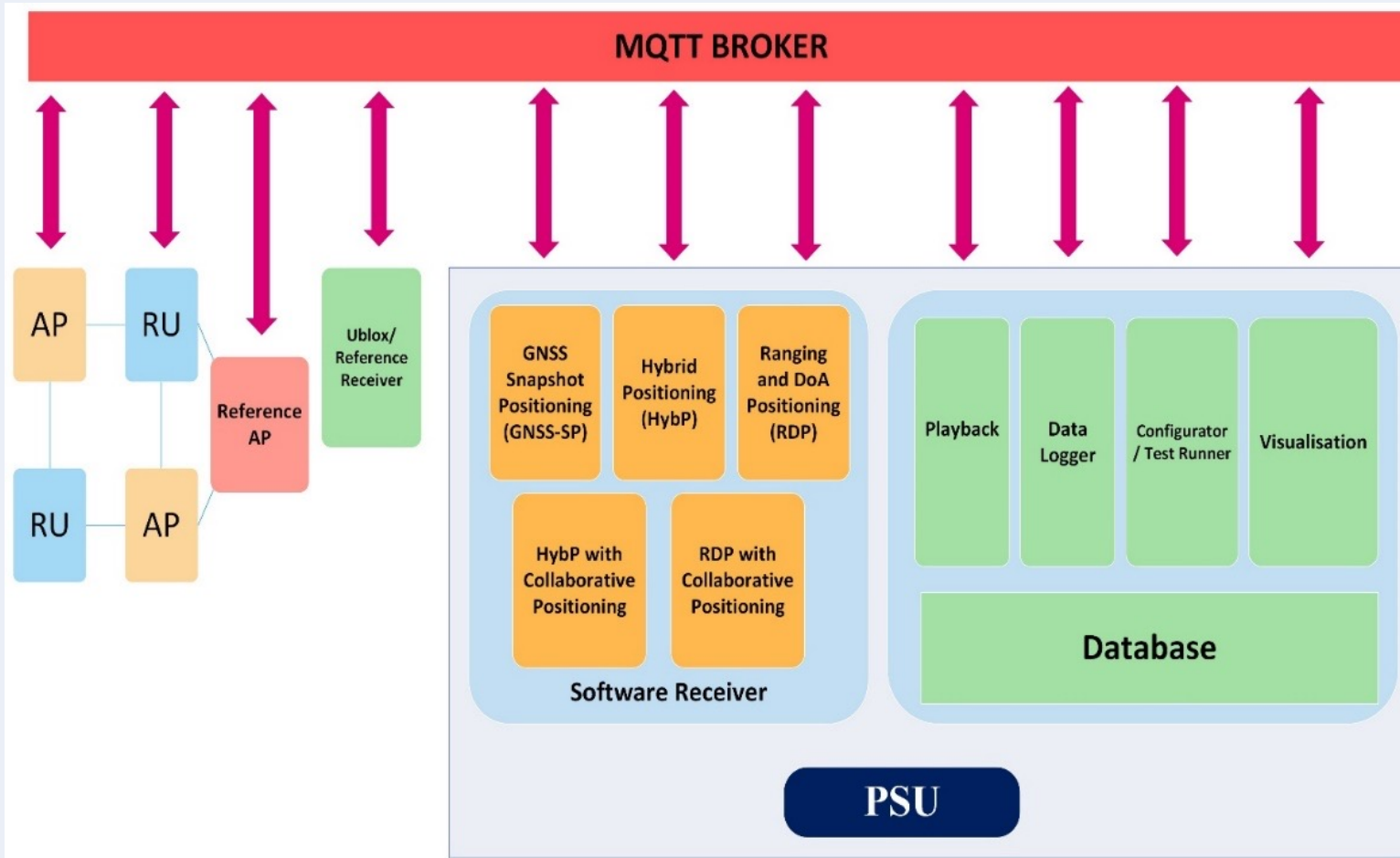




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Backup Slides

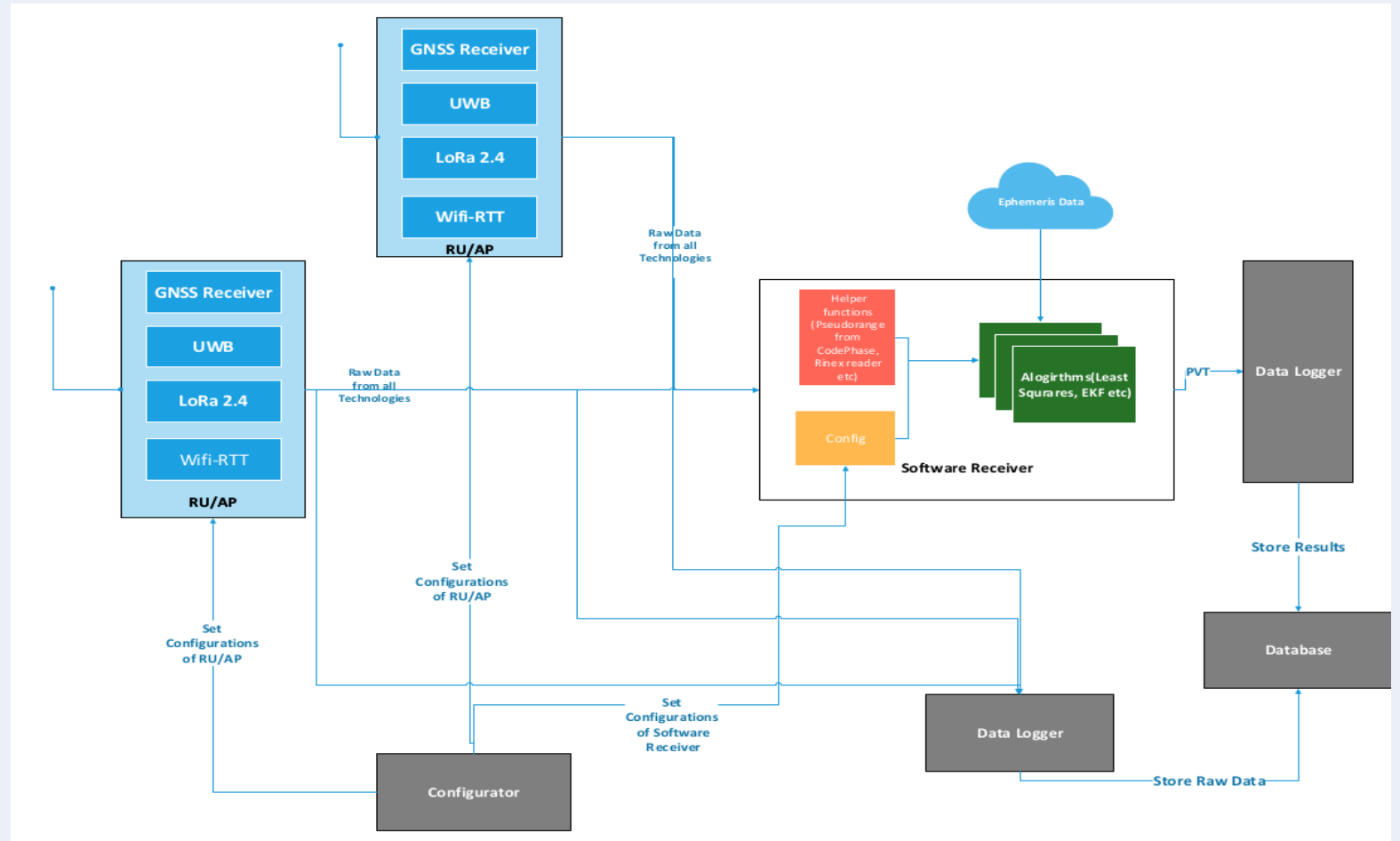
System Design and Architecture



- RUs, APs and rAPs
- MQTT Broker
- Processing and Storage Unit (PSU)
 - Software Receiver
 - Configurator
 - Visualisation
 - Data Logger
 - Playback
 - Database

Software Receiver Design

- Modular Architecture
- Two modes:
 - Realtime Mode
 - Test Mode
- Configurable
- Different Positioning modes and Algorithms.
 - LS, WLS, EKF, PF & UKF to be tested & implemented





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