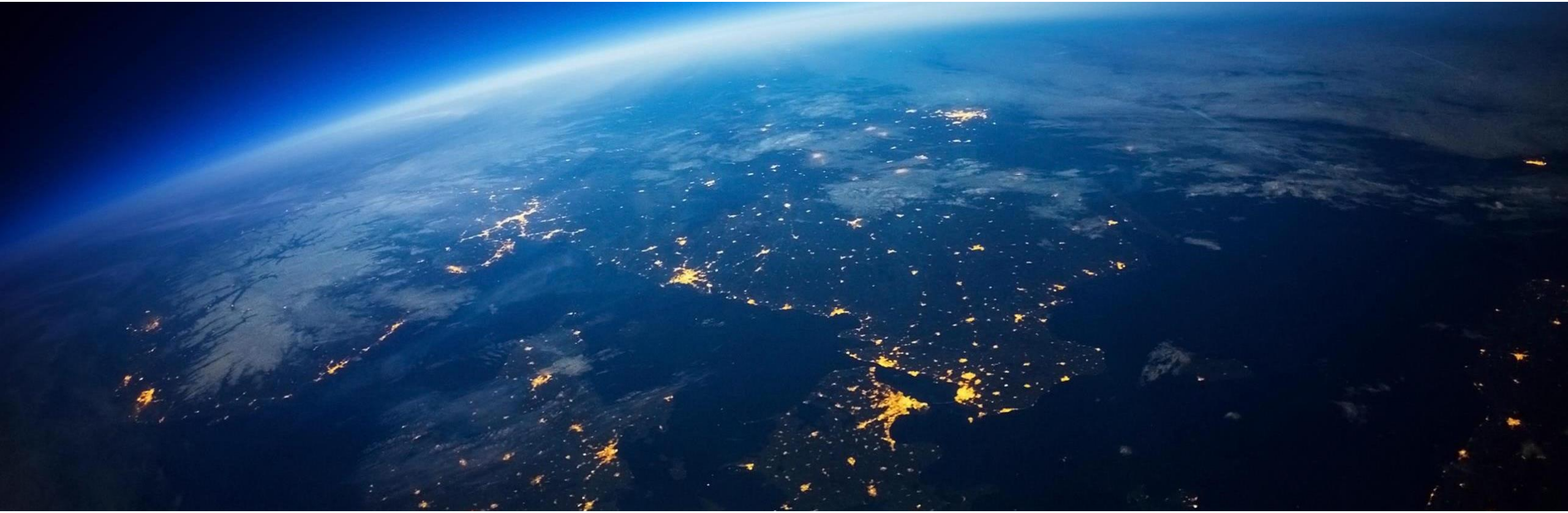
20/July/2023



SCRIPT Final Presentation Meeting
ESA Contract No. 4000133576/20/NL/CRS

SCRIPT
Agenda

1. Introduction
2. CD Design
3. Sprints #1, #2, #3
4. Lessons-Learnt
5. Conclusions and Future Work

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SCRIPT

SENER Concept Receiver for Indoor Positioning Techniques

UWB

Wi Fi

5G

Sprint#1

Baseline Configuration

Sprint#2

Baseline Configuration

Benchmark Configuration

Sprint#3

Baseline Configuration

Benchmark Configuration

SCRIPT
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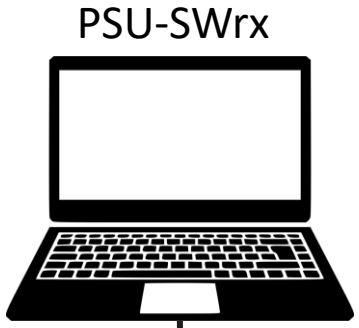
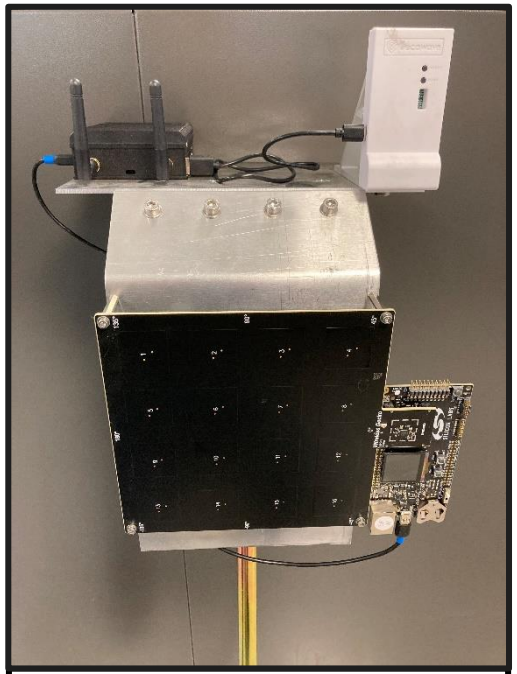
SCRIPT
Architecture



Network Switch



AP

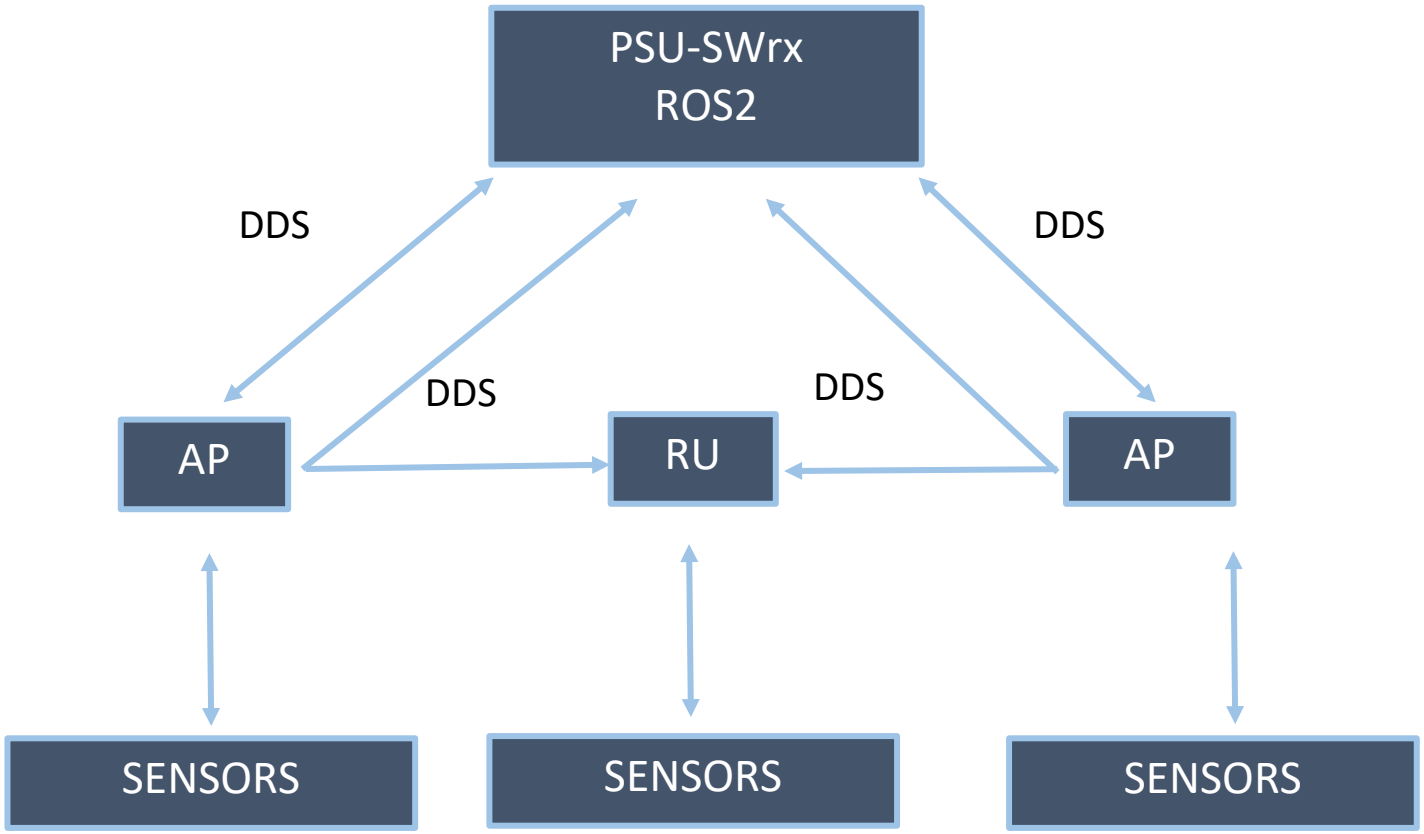
UWB	WiFi RTT
Bluetooth	5G

RU

UWB	WiFi RTT
Bluetooth	5G
GNSS	

sener

SCRIPT
Interface Design



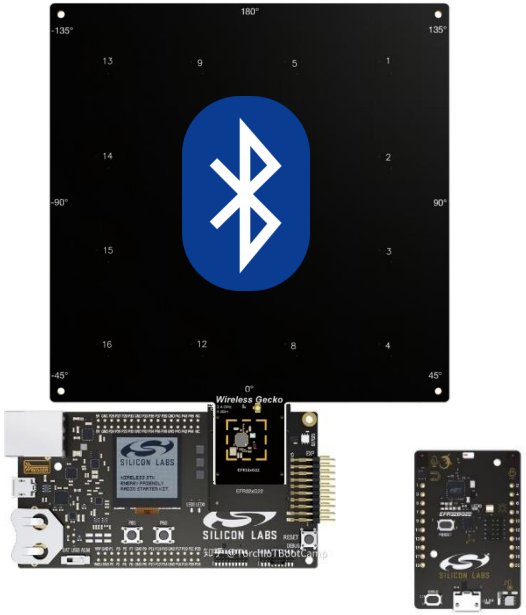
ROS 2

Cyclone DDS

ubuntu

SCRIPT
COTS

Compulab Wild



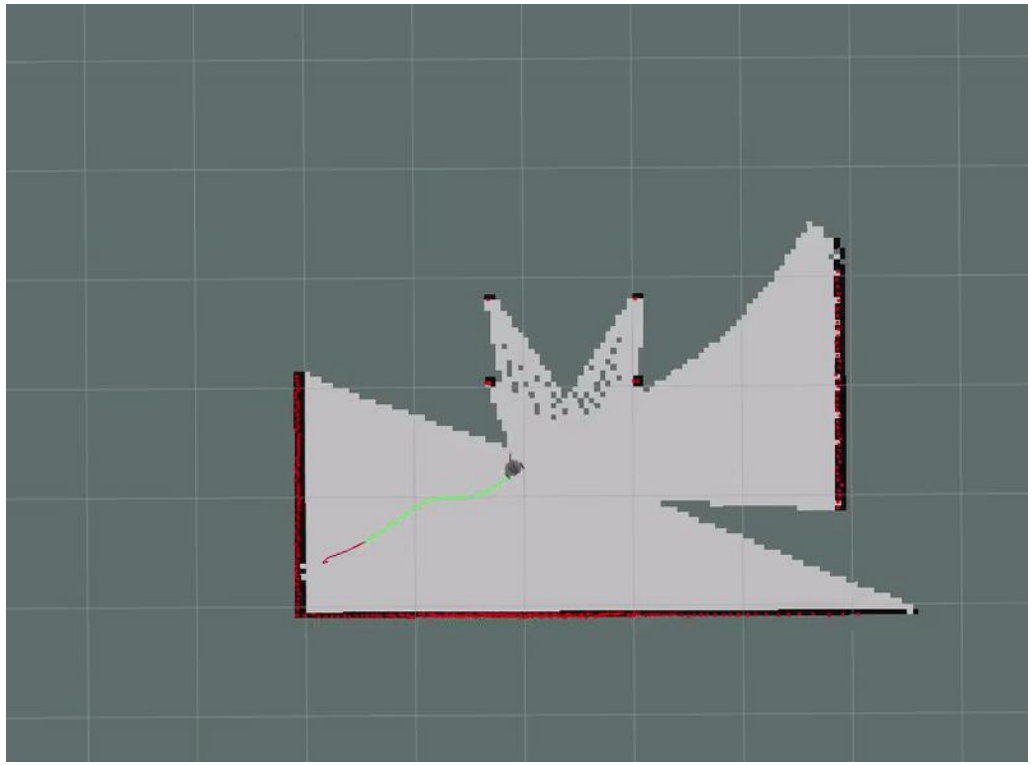
SLTB010A BT Tag
SLWRB4185A BT Antenna Array
SLWMB4001A BT Mainboard

Decawave DWM1001

SCRIPT
Validation

SENER SCRIPT Team

Indoor Mapped Scenario
(SENER's Facilities)



- SLAM - Simultaneous Localization and Mapping
- AMCL - Adaptive Monte Carlo Localization

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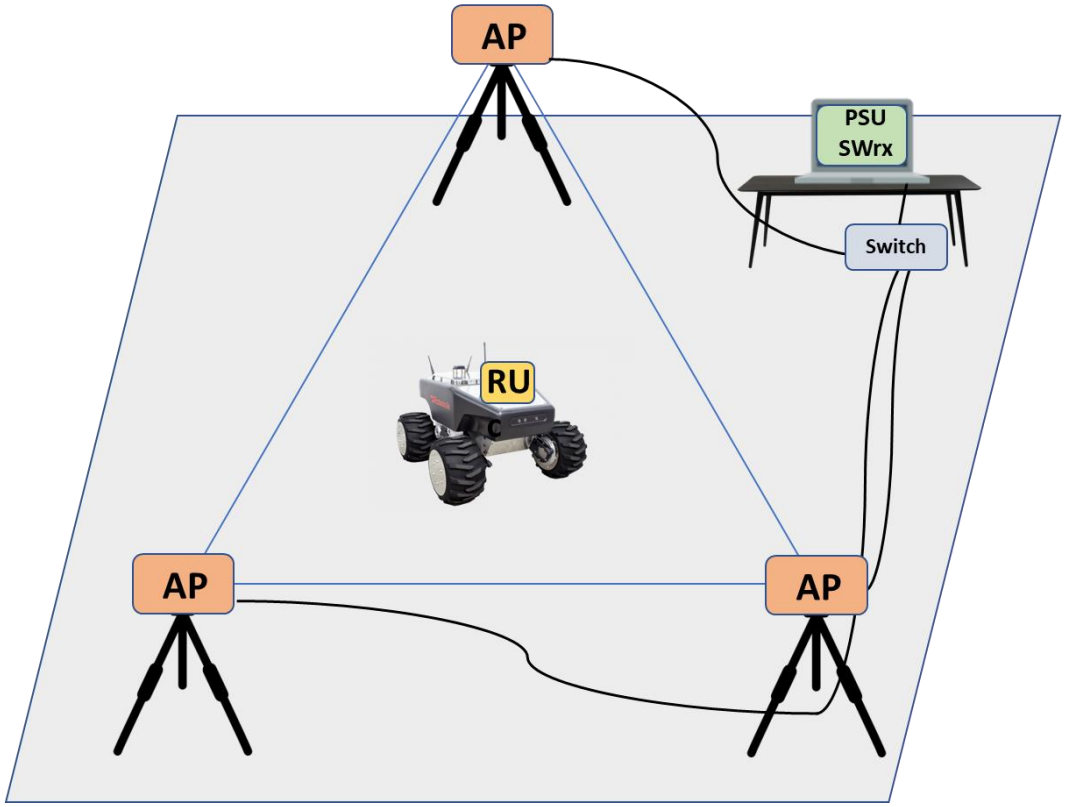
SCRIPT
Sprint #1

- Characterisation Tests
- Static Positioning Tests
- Dynamic Positioning Tests
  - Technologies:
    - UWB
    - Bluetooth
    - WiFi RTT
  - EKF Loose Coupling
  - Three Anchor Points
  - One Remote Unit
  - Indoor

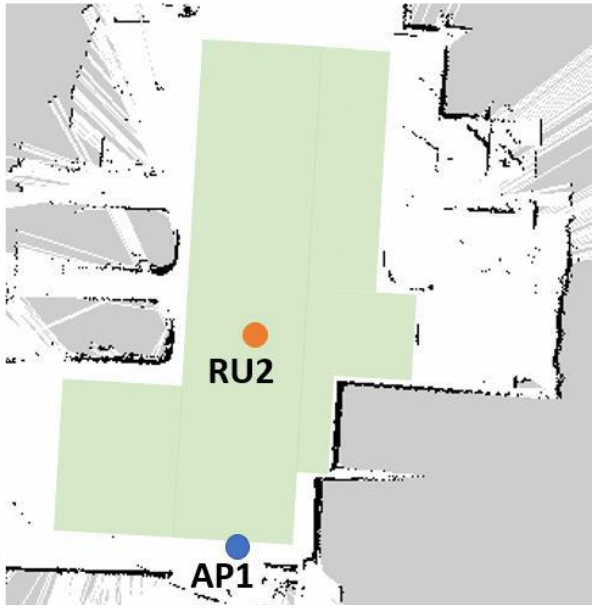


Sprint #1 Indoor Scenario

SCRIPT
Sprint #2

- Dynamic Positioning Tests
  - Technologies:
    - Sprint 1# Technologies
    - 5G
    - GNSS (Ublox receiver)
    - Collaborative data (2RUs in outdoor test)
  - ESEKF Tight Coupling
  - NLOS Detector
  - One Anchor Point (Sparse Infraestructure)
  - Two Remote Units
  - Indoor & Outdoor

Sprint #2 Indoor Scenario



Sprint #2 Outoor Scenario

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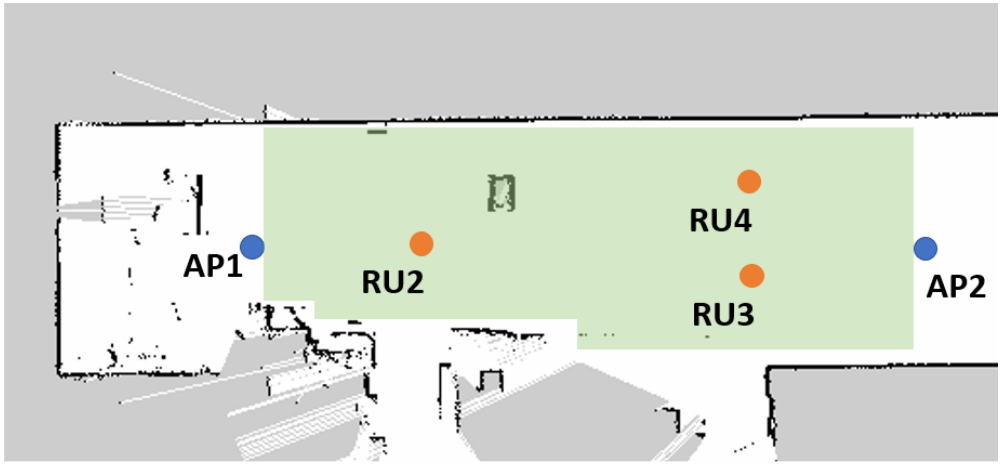
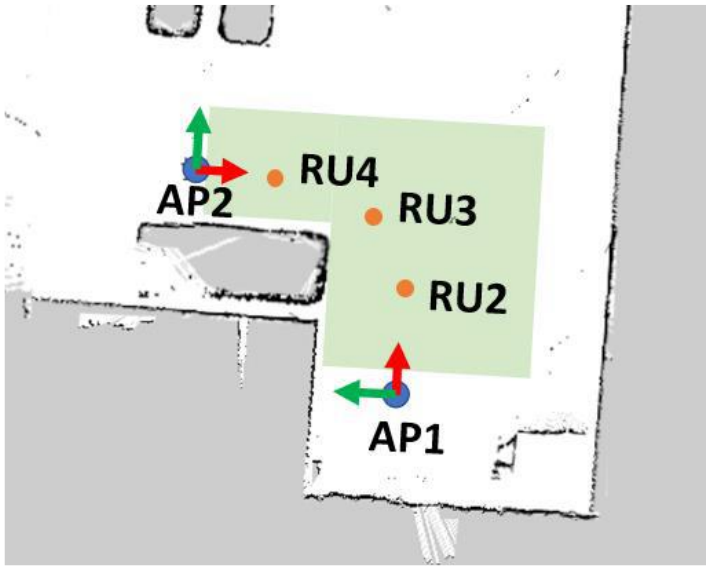
SCRIPT
Sprint #3

- Dynamic Positioning Tests
  - Technologies:
    - Sprint 1# Technologies
    - Sprint 2# Technologies
    - GNSS (CTTC receiver)
    - Collaborative data (4RUs)
  - ESEKF Tight Coupling
  - NLOS Detector
  - Dynamic Process Noise
  - One-Two Anchor Points
  - Four Remote Units
  - Indoor & Outdoor



Sprint #3 Indoor Scenario



Sprint #3 Outdoor Scenario

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Final Results

Indoor Frontal Setup	RU1 (Dynamic)		RU2 (Static)		RU3 (Static)		RU4 (Static)	
Route	RMS	CDF 95	RMS	CDF 95	RMS	CDF 95	RMS	CDF 95
1AP Ranging + AoA + Collaborative	2,55	5,61	1,74	2,83	3,74	8,15	5,62	11,19
2AP Ranging + Collaborative	1,66	3,40	0,52	0,98	1,51	2,49	2,46	4,40
2AP Ranging + AoA	1,26	2,27	0,60	0,84	0,36	0,46	0,19	0,36
2AP Ranging + AoA + Collaborative	1,19	2,24	0,68	1,13	0,43	0,70	0,85	0,79

Indoor test results. 2APs configuration with frontal APs arrangement

Outdoor Diagonal Setup	RU1 (Dynamic)		RU2 (Static)		RU3 (Static)		RU4 (Static)	
Route	RMS	CDF 95	RMS	CDF 95	RMS	CDF 95	RMS	CDF 95
1AP Ranging + AoA + GNSS(x4) + Collaborative	1,45	2,57	0,67	1,16	1,16	2,45	1,63	3,40
2AP Ranging + AoA + Collaborative	1,25	2,13	0,53	0,87	0,54	0,87	0,52	0,88
2AP Ranging + AoA + GNSS(x2)	1,28	2,17	0,53	0,89	0,56	0,88	0,53	0,87
2AP Ranging + AoA + GNSS(x2) + Collaborative	1,25	2,13	0,55	0,87	0,60	0,92	0,55	0,93
2AP Ranging + AoA + GNSS(x4)	1,27	2,19	0,54	0,91	0,57	0,89	0,54	0,87
2AP Ranging + AoA + GNSS(x4) + Collaborative	1,24	2,12	0,53	0,86	0,58	0,90	0,55	0,90

Outdoor test results. 2APs configuration with diagonal APs arrangement.

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SCRIPT
Lessons-Learnt

- Positioning results:
  - Static: RMS and CDF%95 <1m
  - Dynamic(pedestrian): RMS < 1.20m and CDF95% <2.25m
- Low anchor point coverage -> GNSS usage
- LOS impact
- UWB outperforms WiFi RTT and 5G ranging measurements
- Bluetooth brings low area coverage
- APs disposition (>1): 90º rotated and separated
- Collaborative data
  - Nominally improves performance
  - Could lead to a great instability

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Conclusions and Future Work

Conclusions

- Error State Kalman Filter
  - Ranging -> UWB, WiFi-RTT, emulated 5G ranging
  - Angle of arrival -> Bluetooth
  - Absolute positioning -> GNSS
- UWB error typically under 20-25cm
- Line-of-sight condition detector -> modify measurements weight
- Accurate positioning in areas well covered by the anchors.

Future Work

- COTS technological development (e.g., IEEE 801.11az standard)
- Include new sensors (e.g., RGB cameras)
- Expansion to populated networks
- Improve collaborative stability
- Potential applications: logistic warehouses, patients tracking or rescue missions

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THANK YOU

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