POLITECNICO
MILANO 1863

DIPARTIMENTO DI ELETTRONICA
INFORMAZIONE E BIOINGEGNERIA

DEIB

LOCALIZATION, NAVIGATION AND SMART MOBILITY

Project presentation A.Y. 2023/2024

General rules

- Project mark
  - July 2024 up to **+4 points**
  - September 2024 up to **+4 points**
  - January 2025 up to **+3 points**

- The project is valid only for the 23/24 academic year.

- The project can be done individually or in group (up to 4 members). All group members will get the same score (unless disparities or issues are motivated by group members).
  The project data are available in WeBeep.

- Evaluation strategy: **presentation** of the results (please also deliver the matlab code and the slides/ppt), a report is optional.

- There will be one day for presenting the project at the end of Jul24, one at the end of Sep24, and one at the end of Jan25. The exact day of presentation will be provided.

Group composition

Please organize yourselves in groups by writing the members in this file:

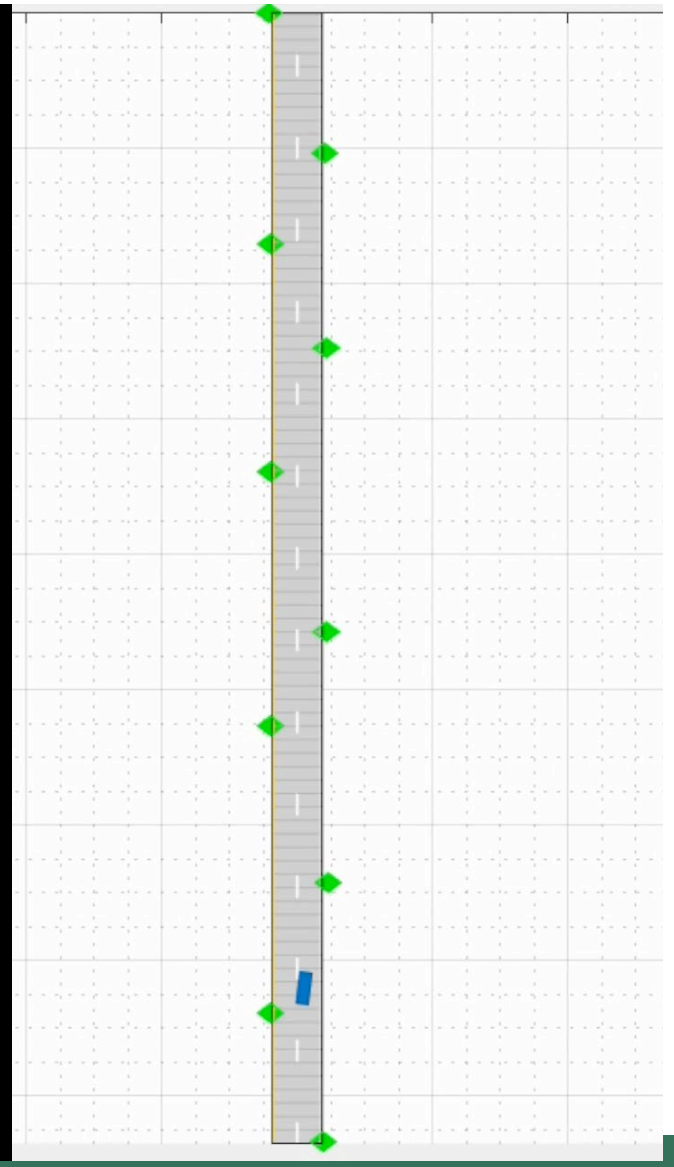
Groups.xlsx

Deadline: 31 May 2024
The sooner you organize, the sooner you can start (even tomorrow).

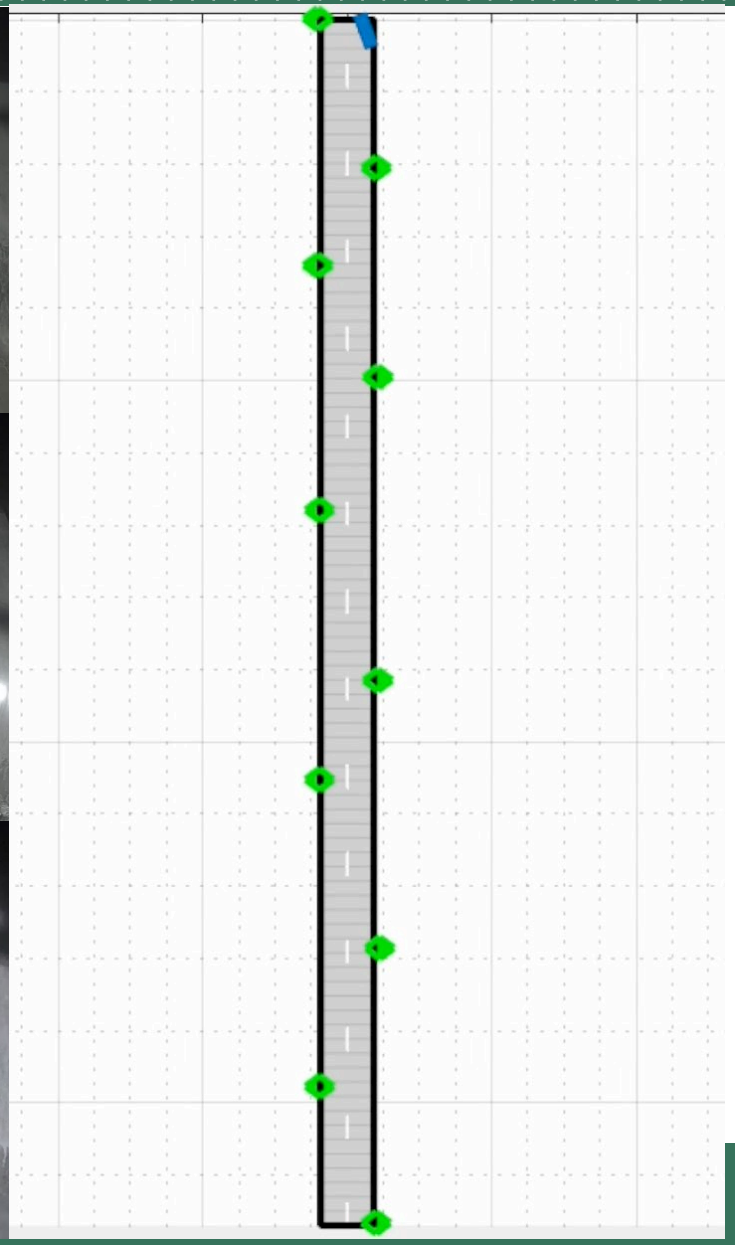
Vehicle localization

Vehicle localization with UWB

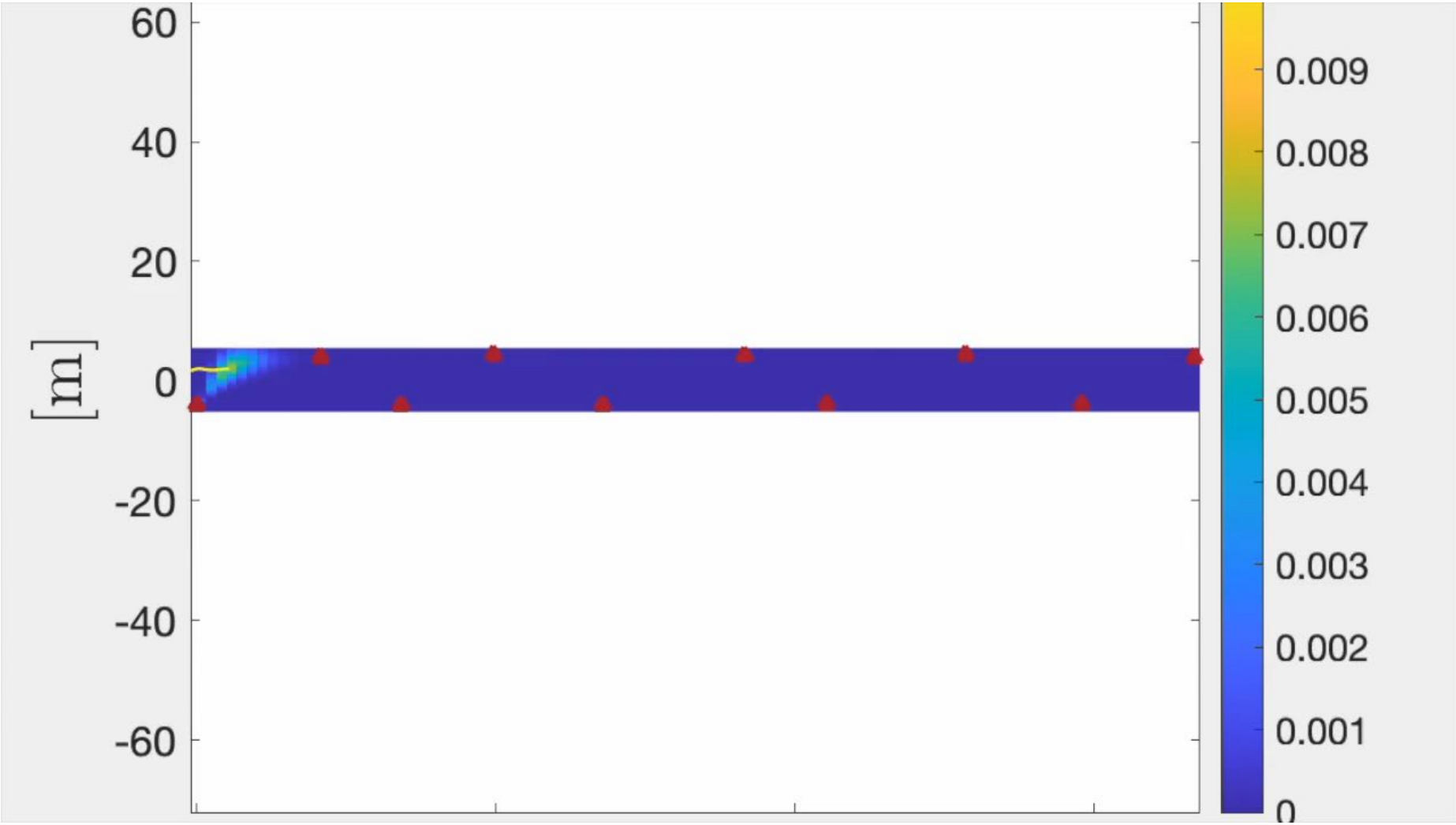
Video Slalom test



Video of one experiment



Likelihood AOA video evolution



Data

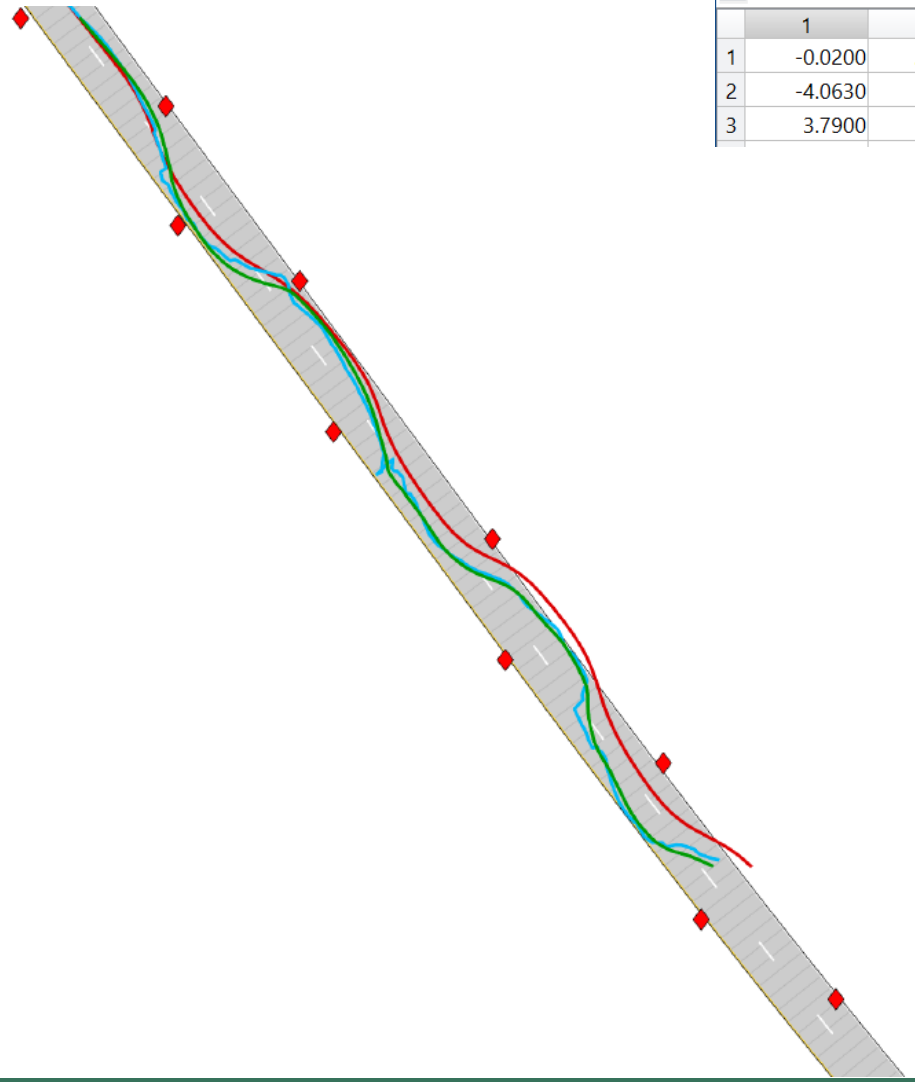
3 tests, 3 datasets, same data structure (next slides)

1 tunnel_experiment_70kmh

2 tunnel_experiment_100kmh

3 tunnel_experiment_slalom

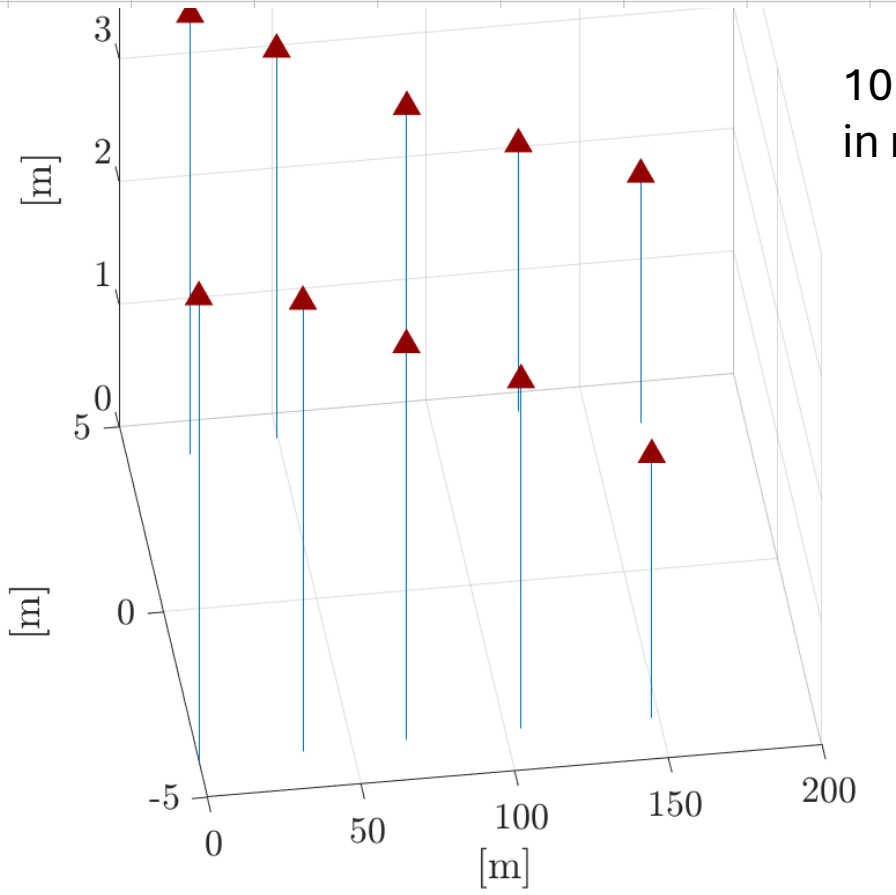
Data structure – AP positions



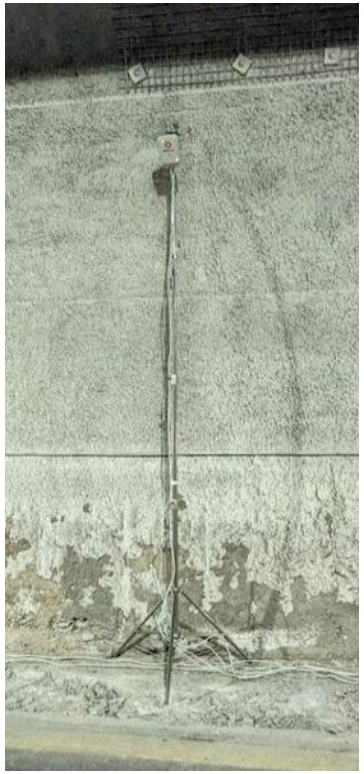
AP

3x10 double

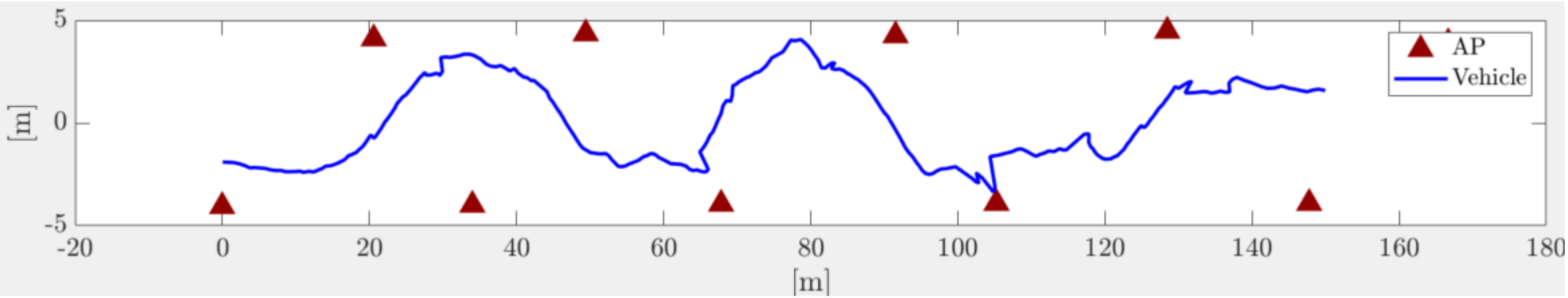
	1	2	3	4	5	6	7	8	9	10
1	-0.0200	20.5890	33.9980	49.4150	67.8140	91.5300	105.2440	128.4680	147.7640	166.6640
2	-4.0630	4.1130	-3.9990	4.3570	-3.9510	4.2650	-3.9090	4.4840	-3.9110	3.9220
3	3.7900	3.5800	3.6600	3.1600	3.2200	2.6300	2.8400	2.1800	2.1400	2.0200



10 APs, with *xyz* coordinates in meters



Data structure – vehicle trajectory



ground_truth

4x336 double

	1	2	3	4	5	6	7	
1	0.1466	0.5585	0.9039	1.6047	1.7959	2.4842	3.1174	
2	1.3372	1.2729	1.2064	0.9834	0.8982	0.8653	0.9210	
3	1.1488	1.1666	1.1639	1.0966	0.9531	0.9448	0.9693	
4	1.6693e+09	1.6693e+09	1.6693e+09	1.6693e+09	1.6693e+09	1.6693e+09	1.6693e+09	1.6

X [m]
Y [m]
Z [m]
Time (sec)

To be used only for performance benchmark!

Data structure – TDOA measurement

meas_tdoa

double

26	27	28	29	30	31	32	33
-3.9411	-4.8245	-5.6409	6.4293	7.7936	8.6770	9.4542	10.3097
9.7237	NaN	7.9177	13.3964	13.3964	13.3964	13.2622	13.2622
NaN	23.4361	NaN	28.0594	28.1265	28.0594	27.9811	27.9531
NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1	1	1	2	2	2	2	2

10 APs -> 9 TDOA meas., expressed in meters

The master AP m is indicated in row 10 (last row)

d_i: distance of the i-th AP

d_m: distance of the master AP

TDOA meas: $\rho_i = d_i - d_m$

TDOA indexes are incremental, and the master is excluded from the count (see next slide)

TDOA explanation

$\rho_2 = d_2 - d_1$

$\rho_3 = d_3 - d_1$

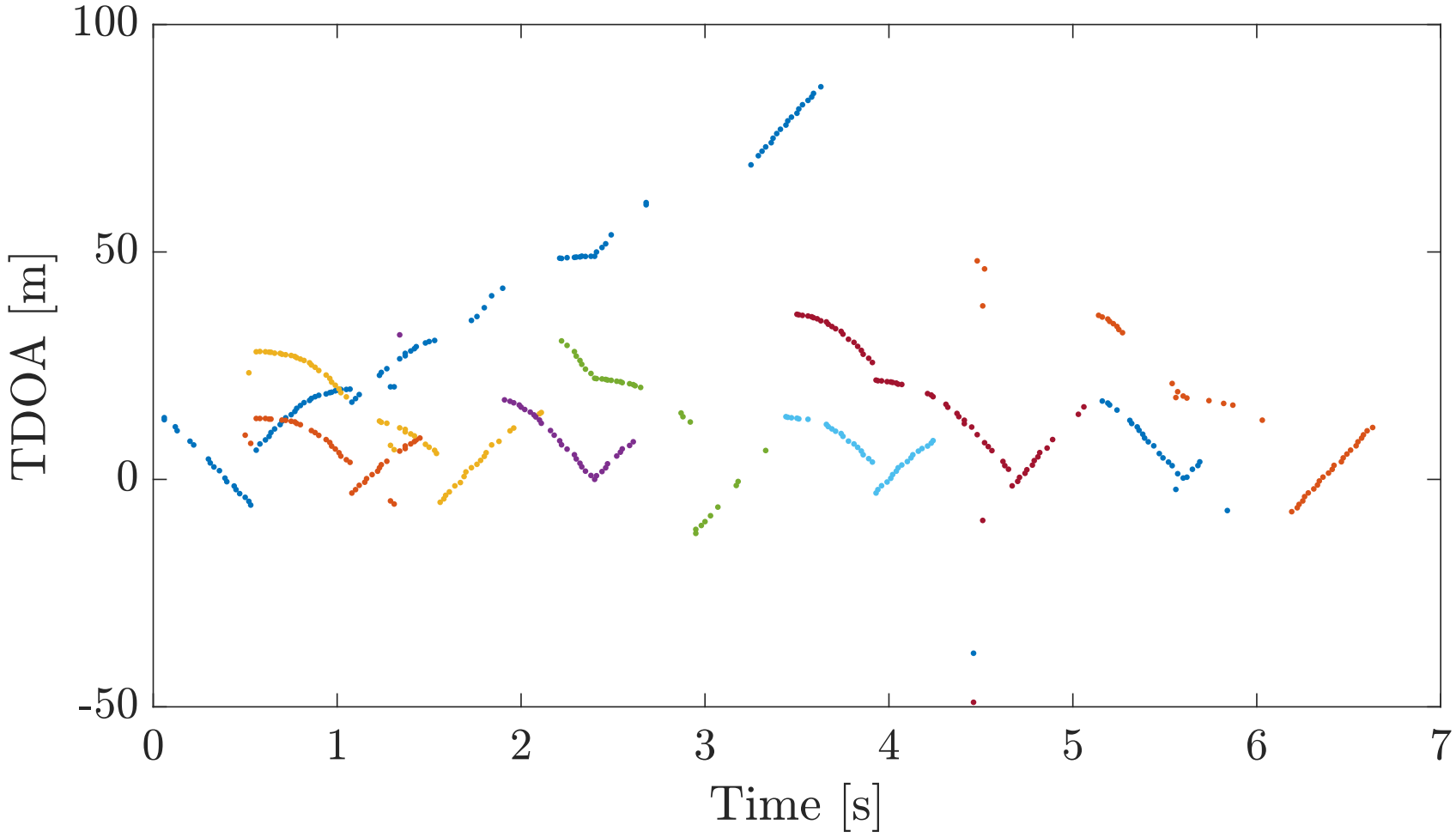
28	29
-5.6409	6.4293
7.9177	13.3964
NaN	28.0594
NaN	NaN
NaN	NaN
NaN	NaN
NaN	NaN
NaN	NaN
NaN	NaN
NaN	NaN
1	2

$\rho_1 = d_1 - d_2$

$\rho_3 = d_3 - d_2$

$\rho_4 = d_4 - d_2$

TDOA visualization



Data structure – AOA measurement

meas_aoa

20x286 double

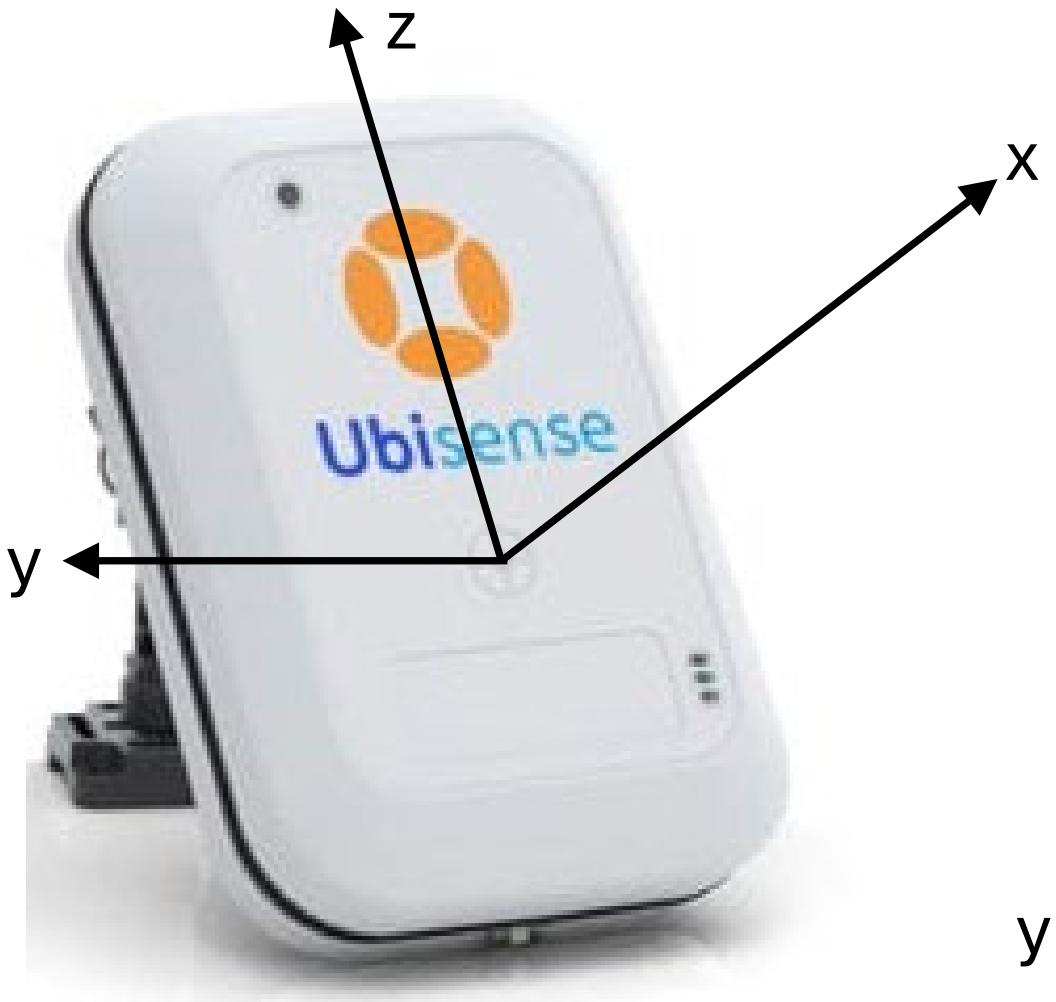
azimuth

elevation

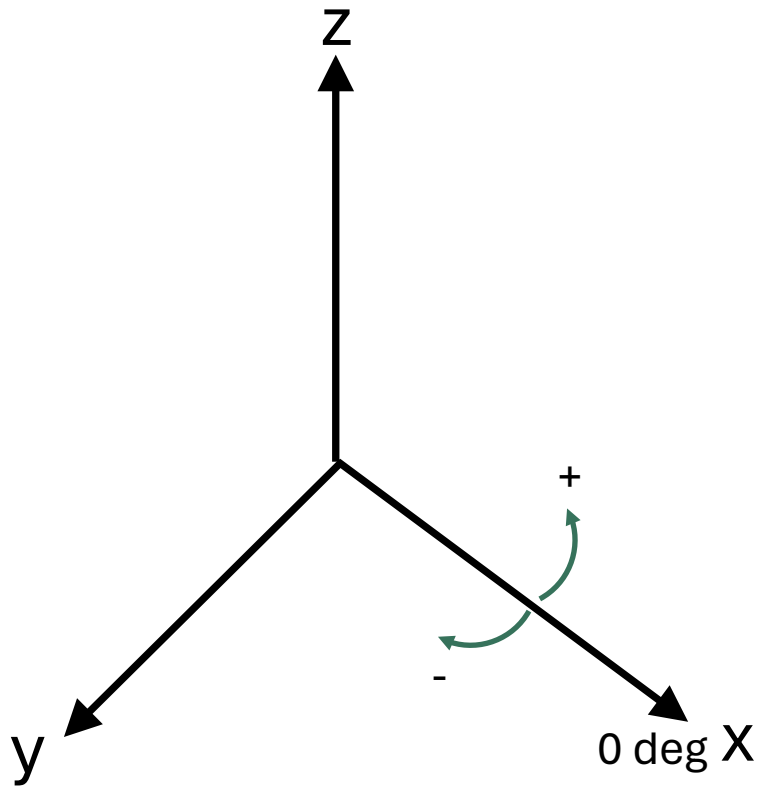
	1	2	3	4	5	6	7	8	9	10	11
1	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
3	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
4	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
5	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
6	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
7	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
8	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
9	-55.8600	-50.5400	-41.9500	-34.4400	-27.9100	NaN	-16.6600	NaN	-4.9100	-0.8000	3.6100
10	-20.6300	-25.9300	-24.9300	-21.5500	-24.9800	-26.7400	-30.2500	-27.9300	-21.2700	-20.6600	-26.3500
11	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
12	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
13	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
14	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
15	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
16	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
17	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
18	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
19	2.5600	5.3200	7.6400	11.4100	15.1400	NaN	21.2600	NaN	26.2200	27.0400	27.2000
20	27.7300	27.4900	24.0400	25.6900	29.3500	29.6900	27.8400	24.6900	24.6500	28.9900	34.5800
21											

degrees

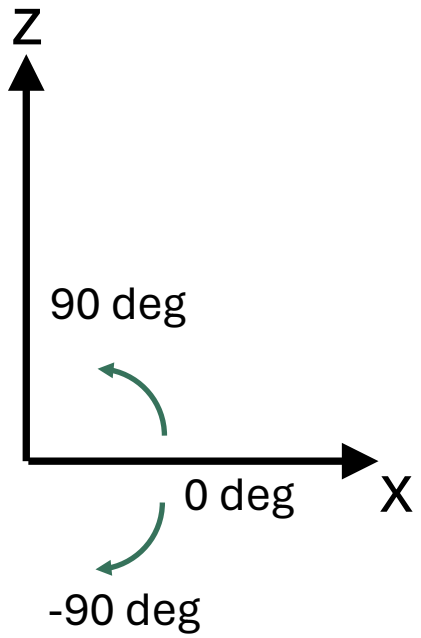
AOA measurements



AZIMUTH

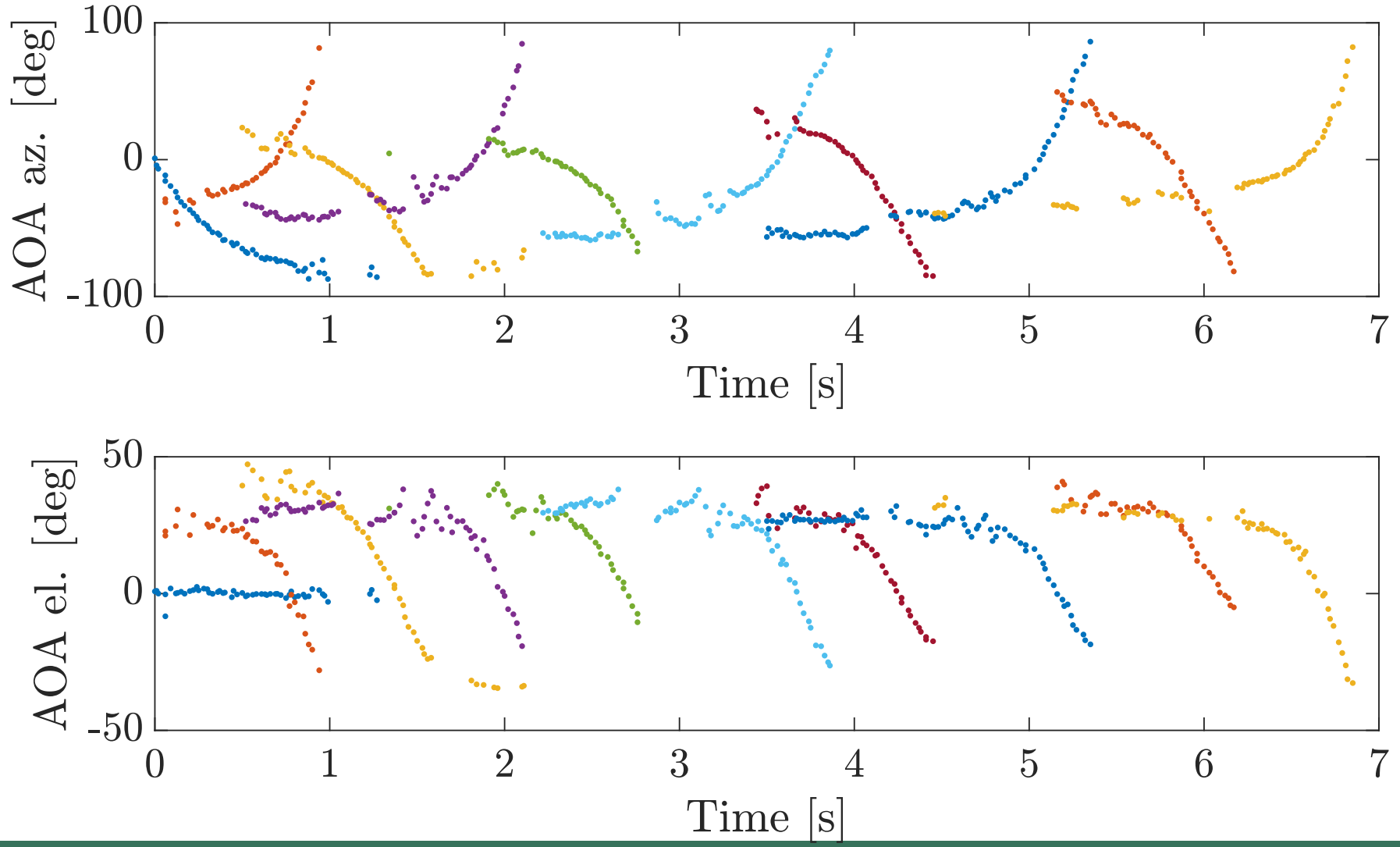


ELEVATION



AOA are local (w.r.t. the antenna reference system).
To convert from local to global, a correction by pitch and yaw must be applied.

AOA raw measurement



AOA adjustment

Raw meas.

Post-conversion into global coordinates

APpitch

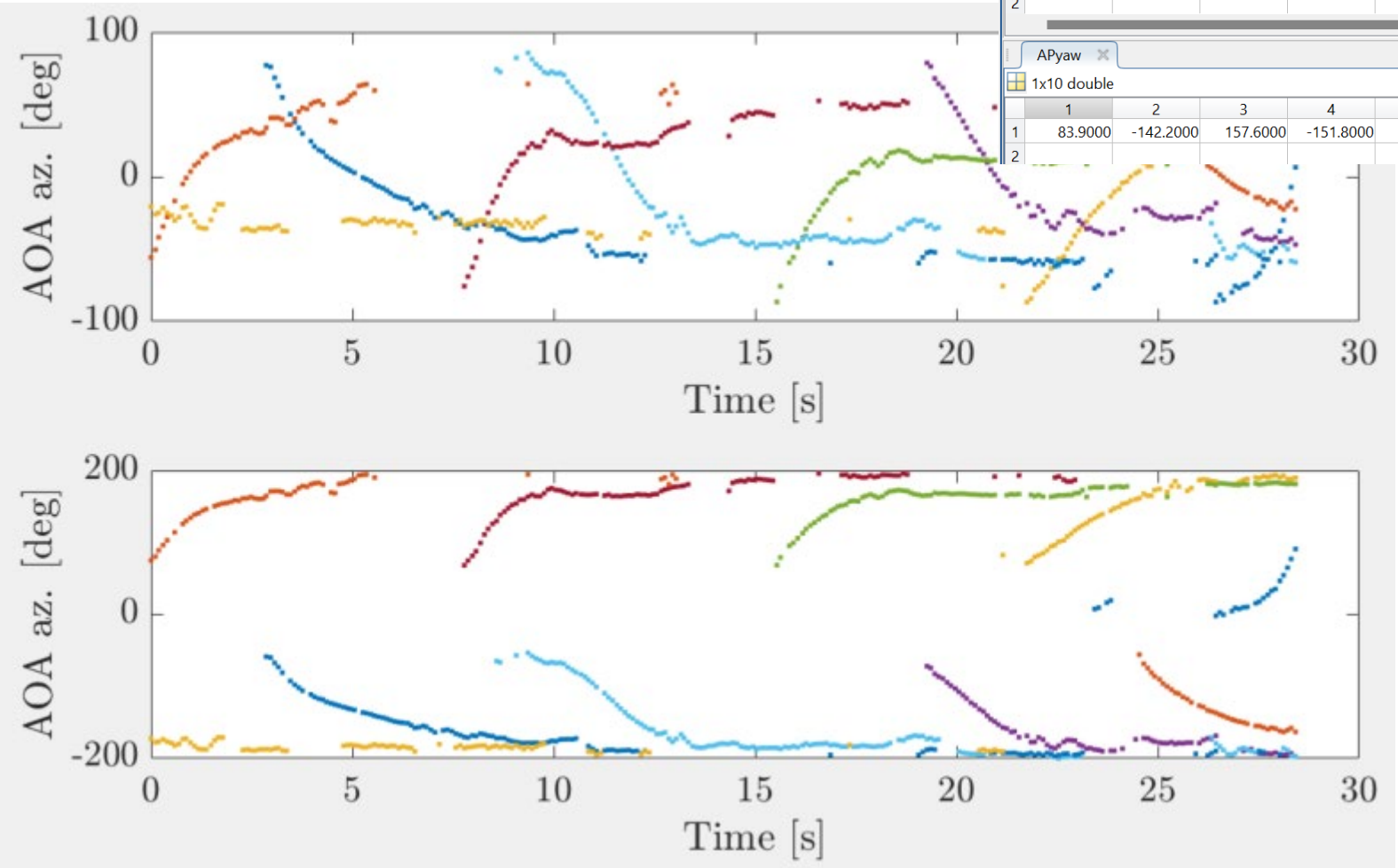
1x10 double

	1	2	3	4	5	6	7	8	9	10
1	-26	-40.3000	-47.7000	-50.7000	-43.8000	-42.9000	-45	-40.3000	-52.5000	-37
2										

APyaw

1x10 double

	1	2	3	4	5	6	7	8	9	10
1	83.9000	-142.2000	157.6000	-151.8000	154.5000	-140.1000	143.4000	-136.9000	130.5000	-153.4000
2										



What to do

1. Load, analyze, understand and visualize data

2. Localize the vehicle **(2D only)**
   Implement at least one localization/tracking algorithm for localizing the vehicle with
   - TDOA
   - AOA
   - TDOA+AOA
   measurements. **The choice is up to you (choose correctly ☺)**. Compare and analyze the results.

3. Play and tune the algorithm
   Compare the performance for different configurations of the algorithm over the 3 datasets, optimizing the localization accuracy.

NOTE: CAREFULLY SELECT THE WAY TO PRESENT THE RESULTS, THE TYPES OF ANALYSIS AND GRAPH. MOTIVATE YOUR CHOICES AND PROVIDE CRITICAL ANALYSES.