



Considerations for Optimal Sensor Placement for Higher Accuracy Object Localization for Urban Air Mobility

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Outline

- Introduction: Dilution of Precision
- Considerations for Higher Accuracy
- Application Scenario
- Results
 - Sensitivity analysis of field test outline
 - Analysis for :
 - Default sensor characteristics
 - Sensor alignment errors
- Conclusions and Future Work

Alta X drone



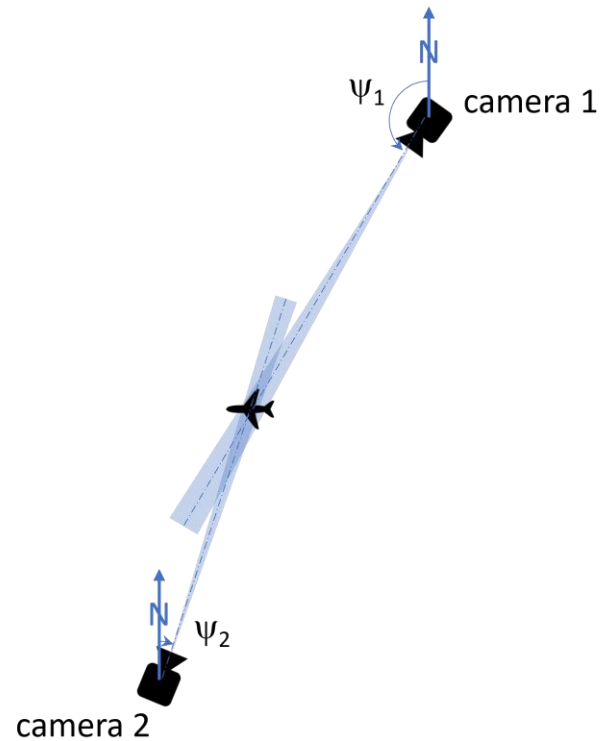
GoPro EO camera



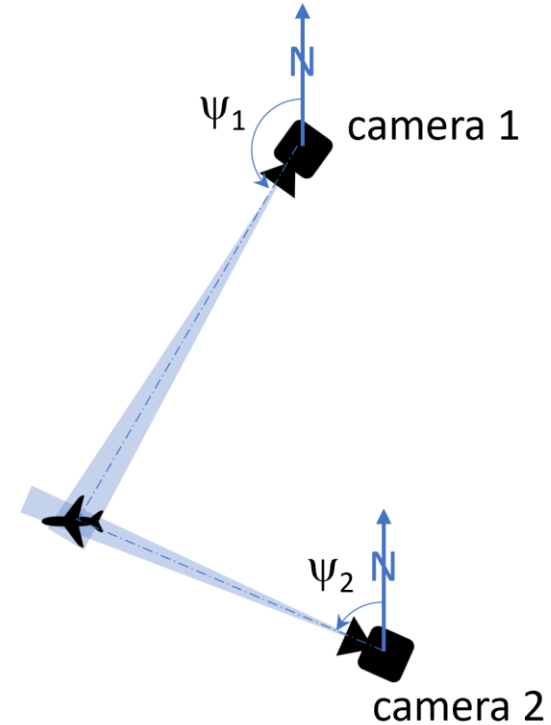
Skydio drone

Introduction: Dilution of precision

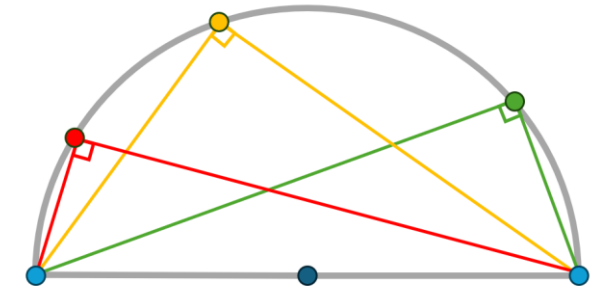
Ill posed geometry



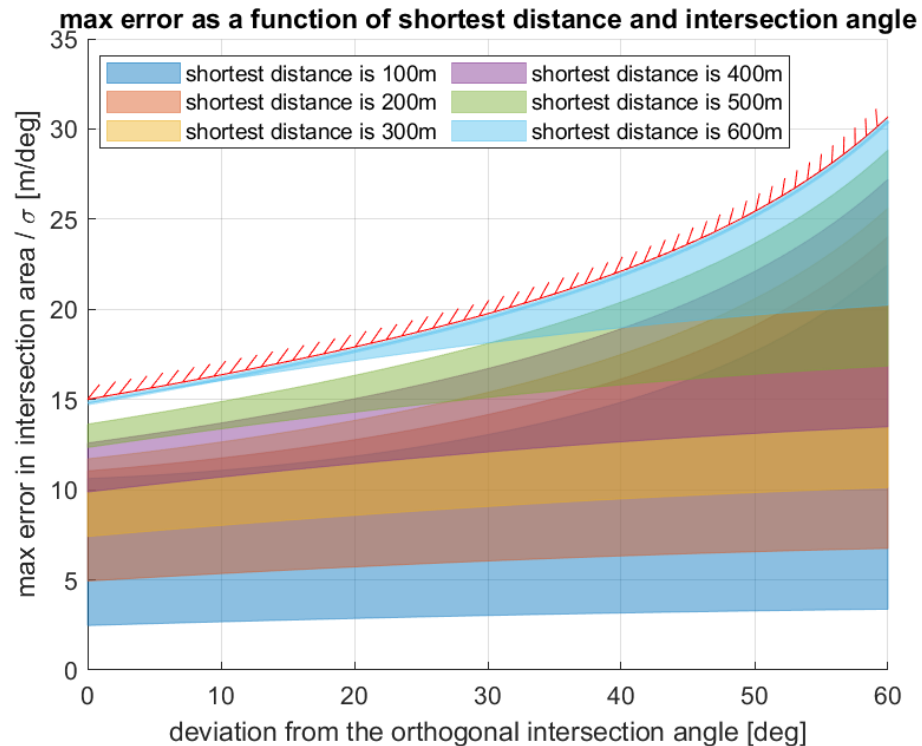
Well posed geometry



Considerations for Higher Accuracy

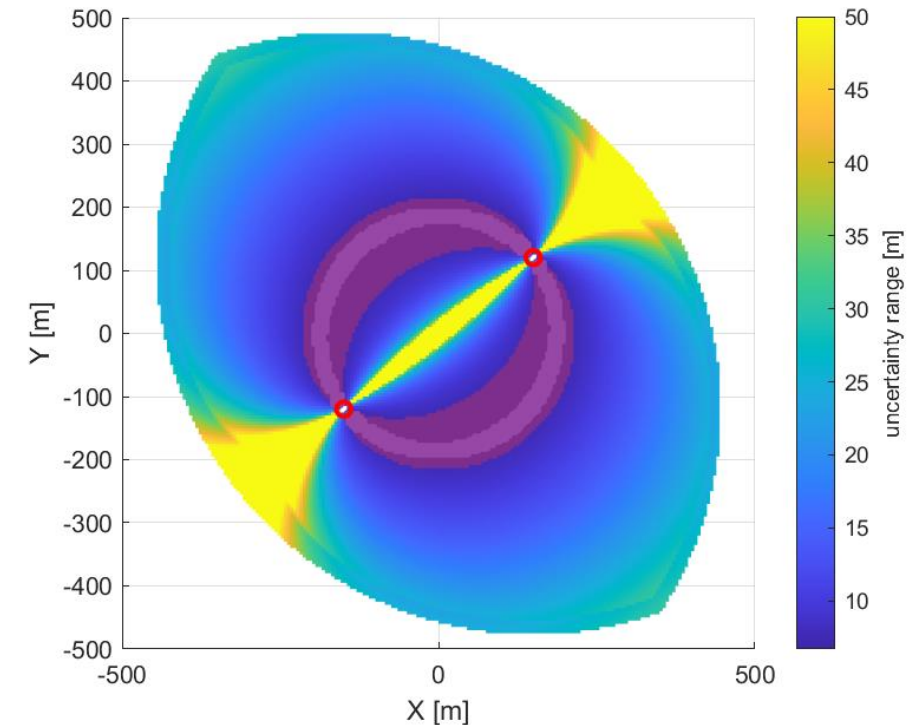


Sensitivity Analysis

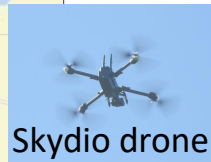
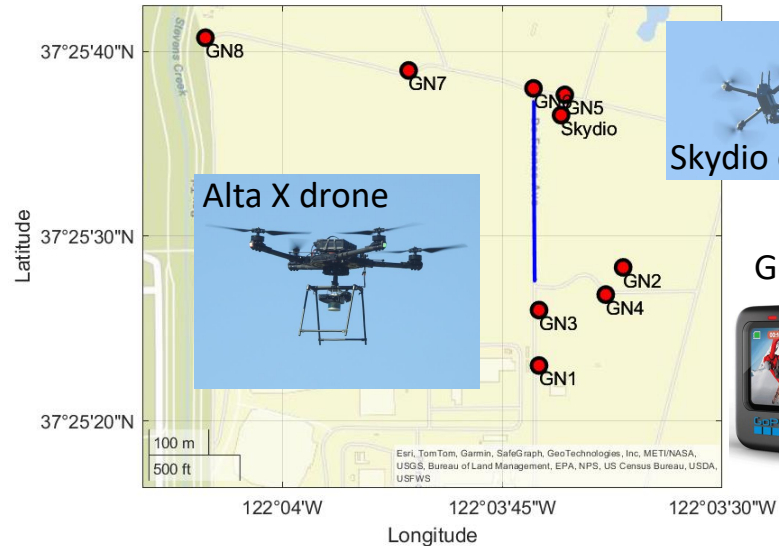


Max error for 2 ground nodes

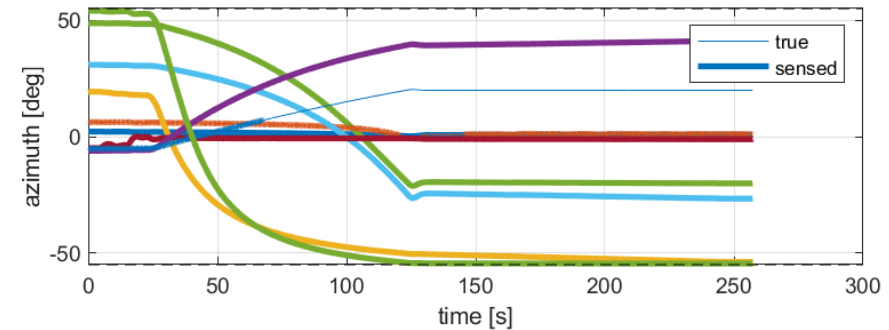
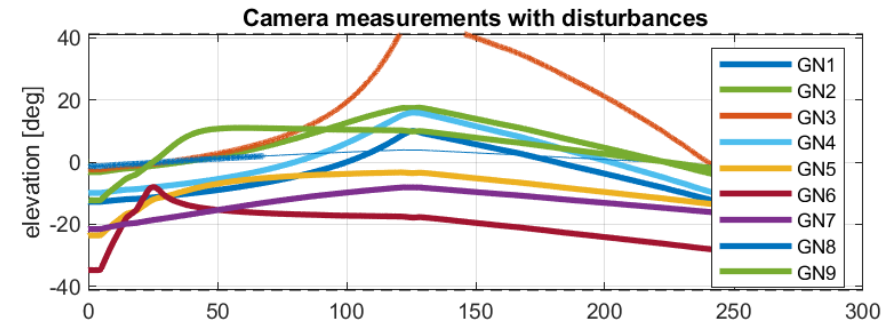
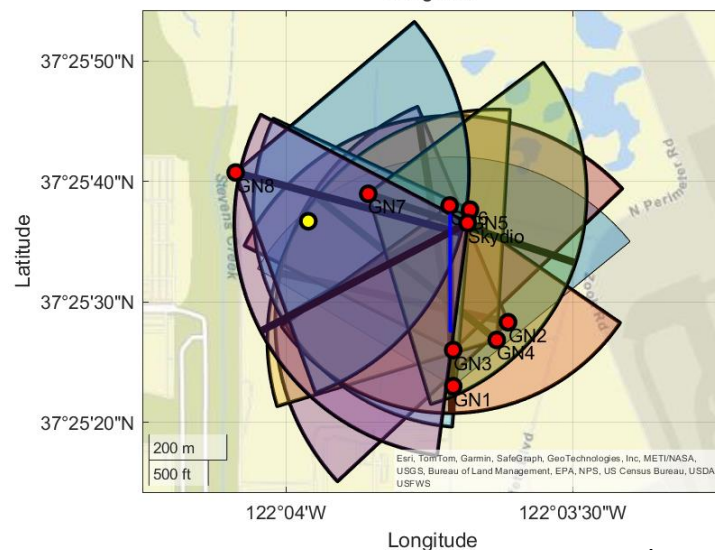
Assumption: 1 deg horizontal alignment error



Scenario description



GoPro EO camera

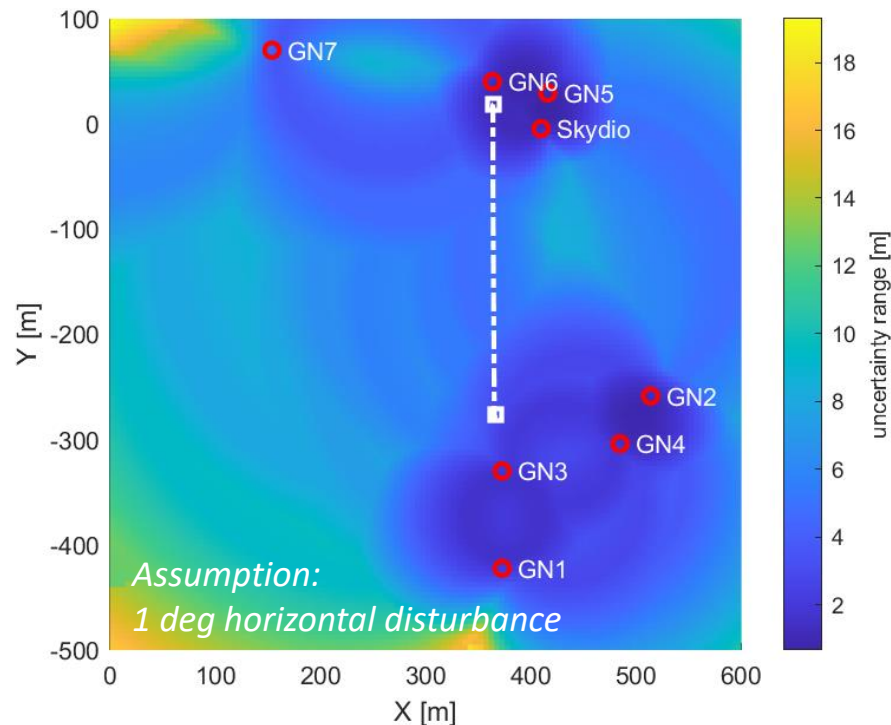


Observer	Lat (°)	Long (°)	Abs. Alt. (m)	Heading (°)	Elev. (°)	Range (m)
GN 1	37.4230556	-122.061803	1.27	-4.14	12.05	600
GN 2	37.4245310	-122.060209	1.51	-77.87	3.75	600
GN 3	37.4238889	-122.061803	0.83	-8.54	1.63	600
GN 4	37.4241220	-122.060538	1.51	-51.70	10.60	600
GN 5	37.4271260	-122.061314	1.52	-120.25	21.74	600
GN 6	37.4272230	-122.061907	1.75	179.40	27.67	600
GN 7	37.4274930	-122.064273	1.54	108.33	20.58	600
GN 8	37.4279850	-122.068125	1.71	105.02	0.57	600
Skydio	37.4268210	-122.061385	10.00	-114.75	0.00	600

Results:

Sensitivity Analysis for Field Test Outline

Max error for Field test outline



Observations

3 zones of varying precision:

- Takeoff area: highest precision ~2m
- En route: lowest precision ~6m
- Landing area: medium precision ~4m

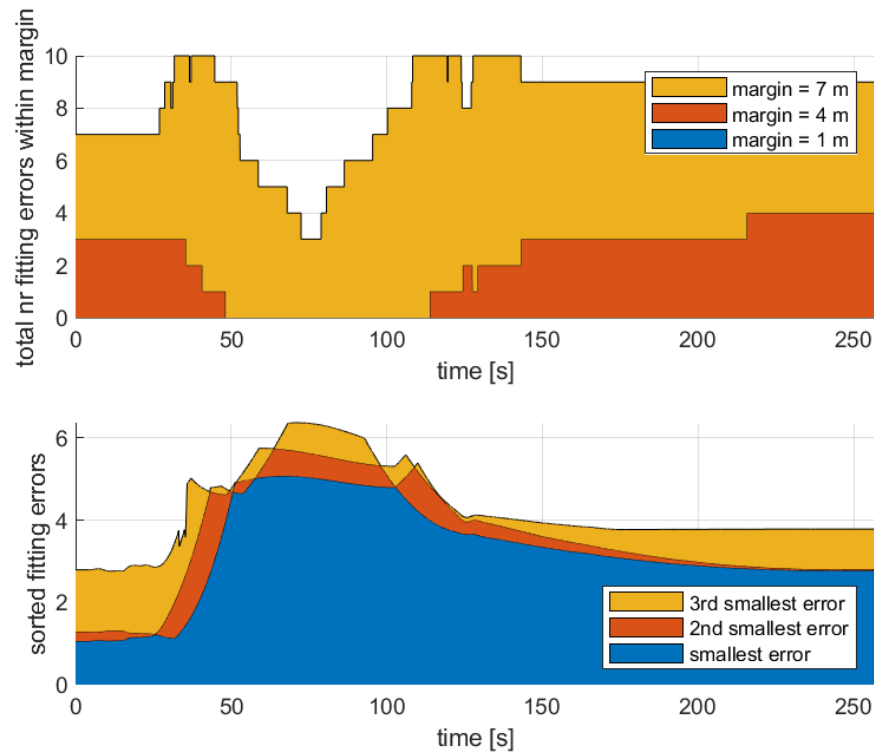
Max allowable disturbance for min required precision:

- 3m precision: 0.5 deg disturbance
- 1m precision: 0.16 deg disturbance

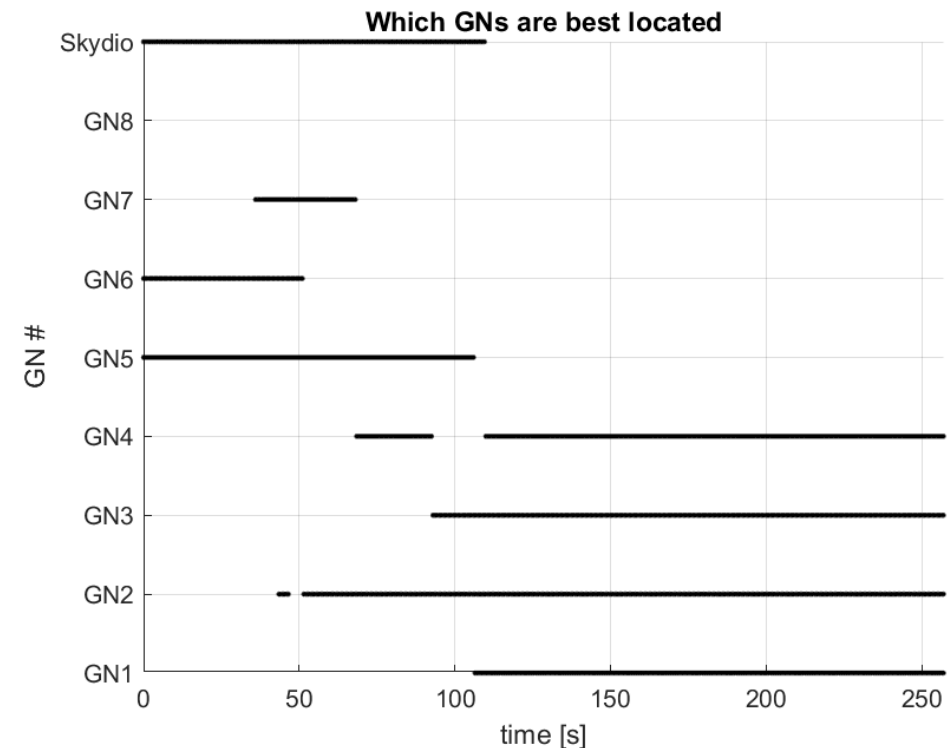
Results:

Sensitivity Analysis for Field Test Outline

Max error for Field test outline



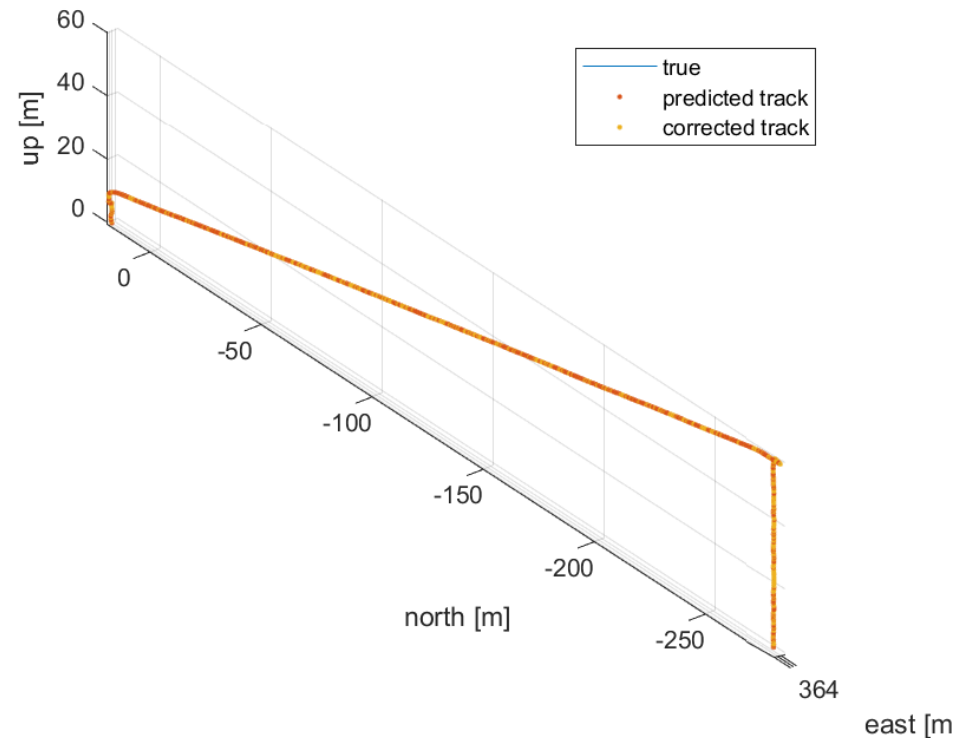
Which ground nodes contribute most



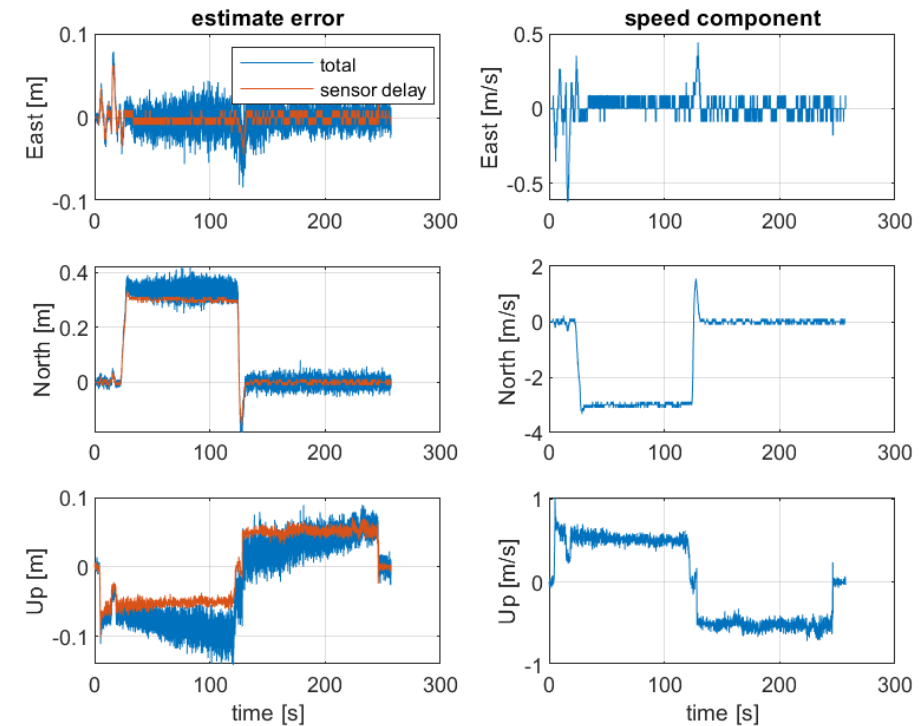
Results:

Analysis for default sensor characteristics

ENU estimate compared to true path

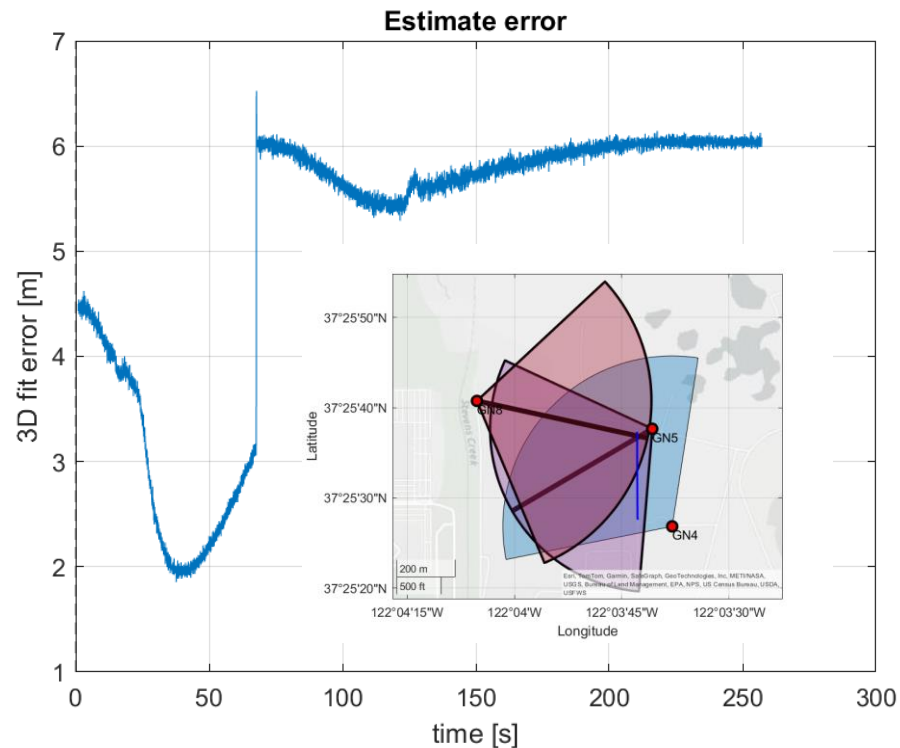


Components of the estimate error

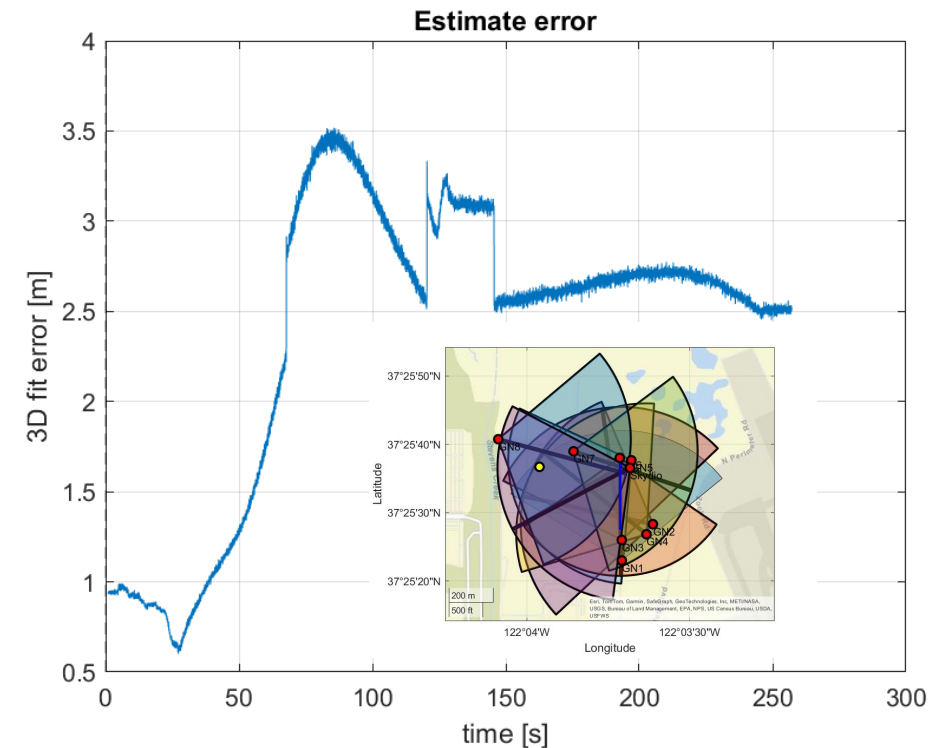


Results: Analysis for sensor misalignment

Only 3GN



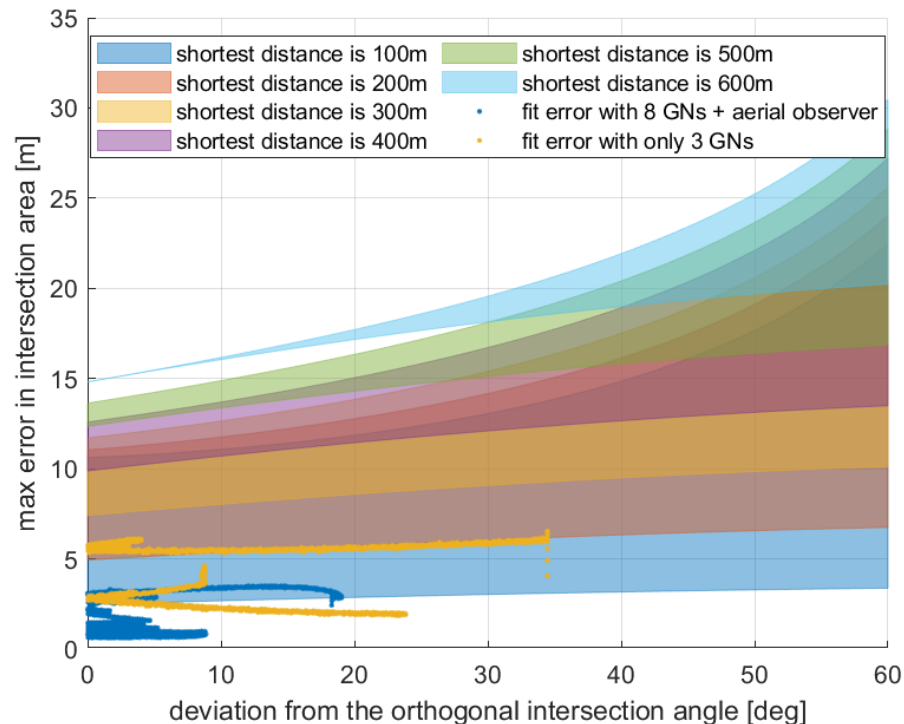
All GN + airborne observer



Results:

Analysis for sensor misalignment

Error traces over sensitivity analysis



Observations

- Only 3 GNs:
 - max 6 m fit error
 - Intersection angle deviations up to 35 deg
 - For max 1m fit error, only 0.16 deg misalignment allowed
- All GNs & airborne observer:
 - max 3.5m fit error
 - Intersection angle deviations up to 18 deg
 - For max 1m fit error, only 0.28 deg misalignment allowed

Conclusions and recommendations

- Precision of the estimated trajectory depends on:
 - Precision of location and viewing angles of observers
 - Field of view of the sensors
 - Sensor noise
 - Time delays in sensor, processing, communication
 - Density and positioning of the ground nodes and airborne observer
- Future work:
 - Continue analysis with real flight test measurement data



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