MGE-MSR-01 – Sensors and State Estimation

Introduction to Exercise 1
WS 2020/2021

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Learning objectives

Learning objectives:

- Inertial sensors (+, - , errors)
- Inertial Navigation (Strapdown Integration)

Literature:

- Lectures: Sensors, Inertial navigation
- Groves, P. D.: Navigation Using Inertial Sensors,
  University College London, UK, IEEE A&E Systems magazine, February 2015, Part II of II.

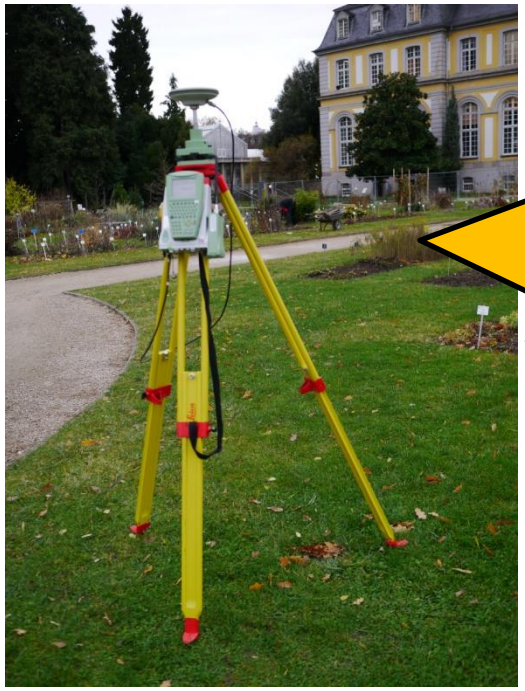
Exercise Description

- Measurements acquisition
- Estimating trajectory - self-implemented Strapdown (Python or Matlab)
- Analysis of the results & comparison to the reference solution

Description of the MSS (multi sensor system)

Kinematic MSS

Components:

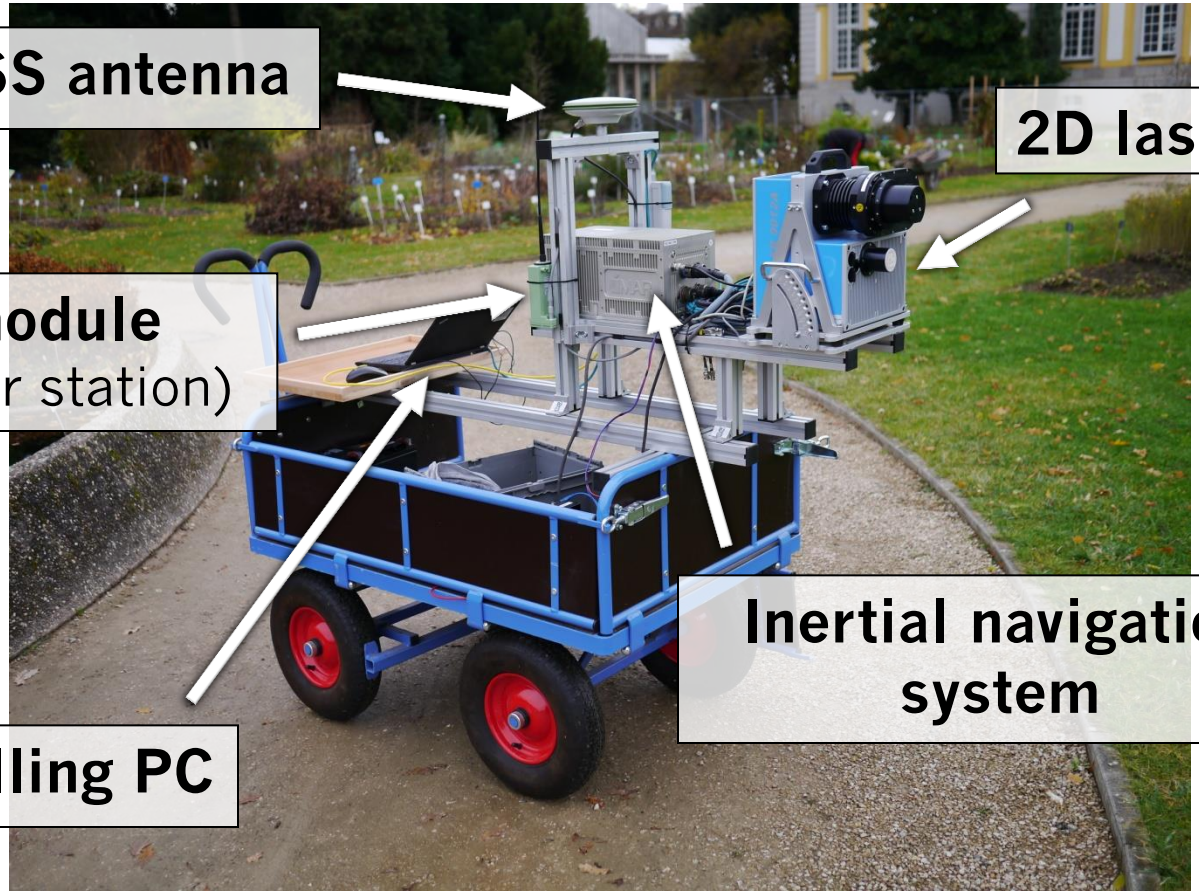


GNSS master station
(sending observations to MSS → RTK-GNSS)

Kinematic MSS
(laser scanning in motion)

Kinematic MSS

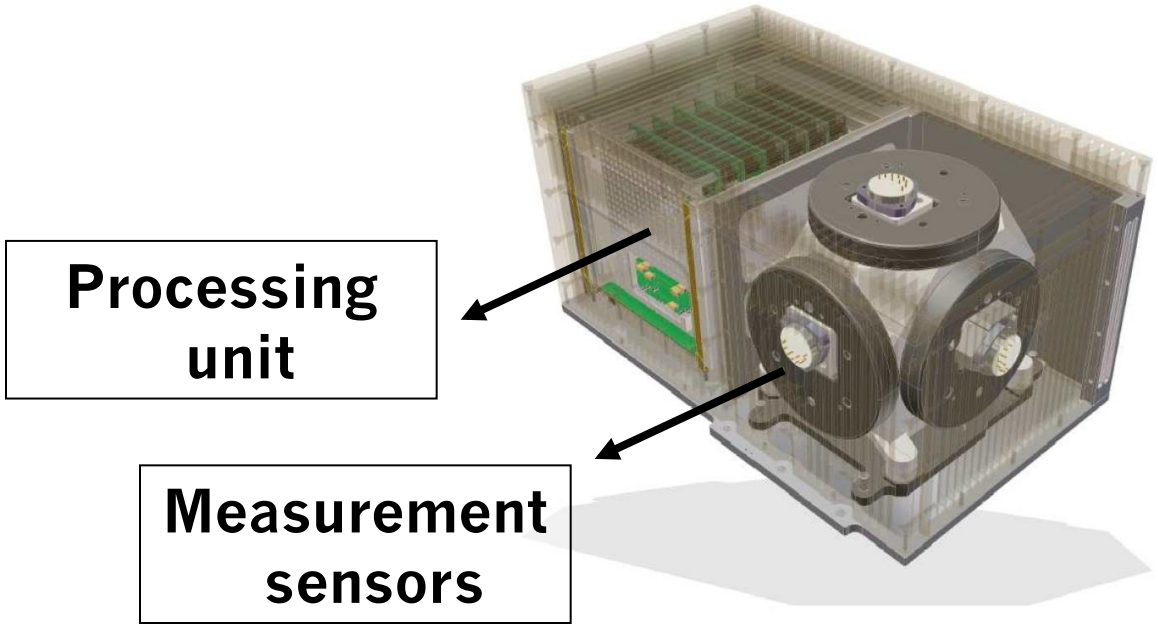
Components:



Inertial navigation system

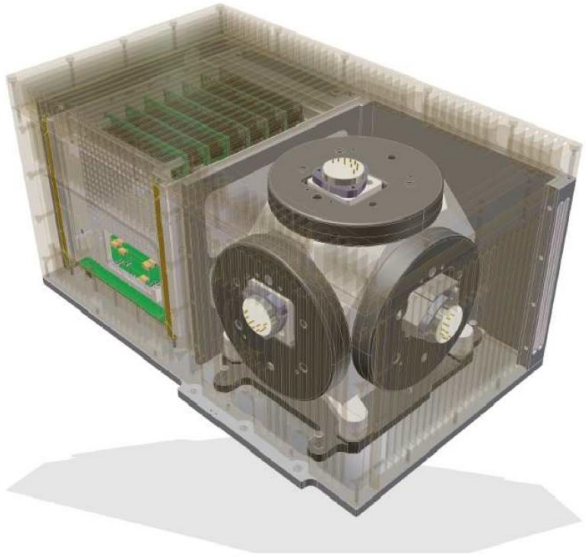
Components:

- GNSS receiver
- Gyroscopes
- Accelerometers
- Processing unit

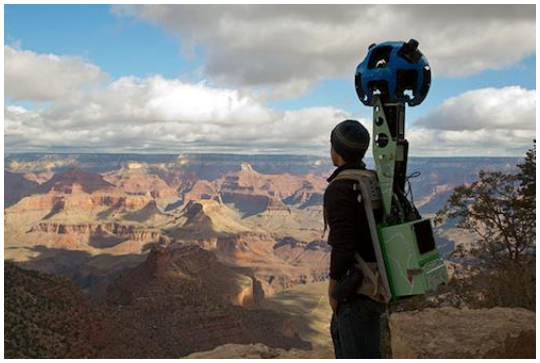


Inertial navigation system (GNSS/IMU unit)

- iMAR iNAV-FJI-LSURV (navigation-grade INS)
- multi-frequency GNSS, three fiber-optic gyroscopes and servo accelerometers (see documentation)
- trajectory determination ($\sigma_{Position}$ = ~ cm, $\sigma_{Attitude}$ < 0.025°)



Kinematic MSS



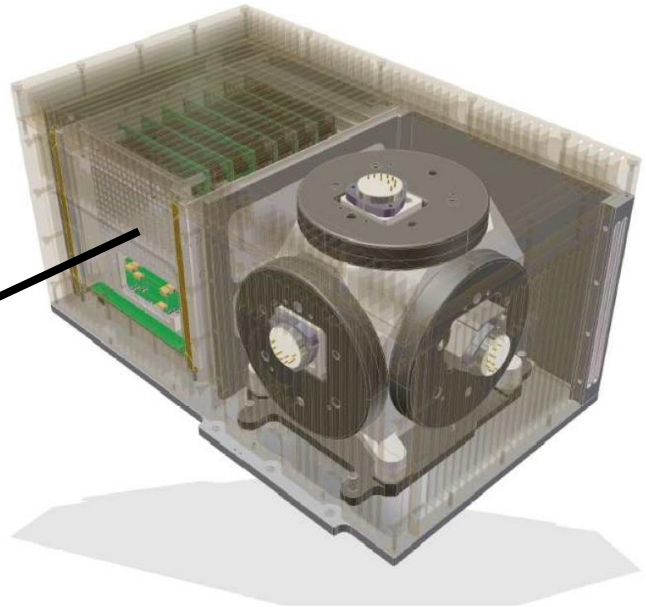
Inertial navigation system

Initial values:

- Position ?
- Velocity ?
- Attitude ?

Reference values ?

Processing unit

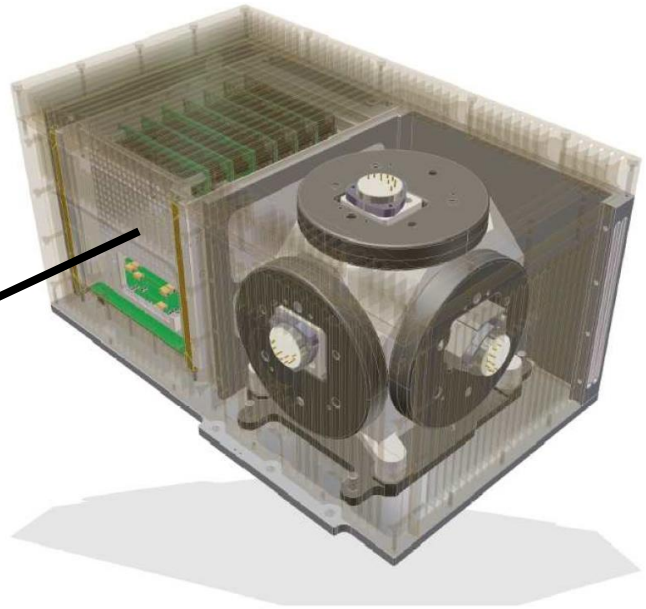


Inertial navigation system

Initial values:

- Position ?
- Velocity ?
- Attitude ?

Processing unit



Reference values

- GNSS trajectory
- On-board navigation solution
- Reference Strapdown code

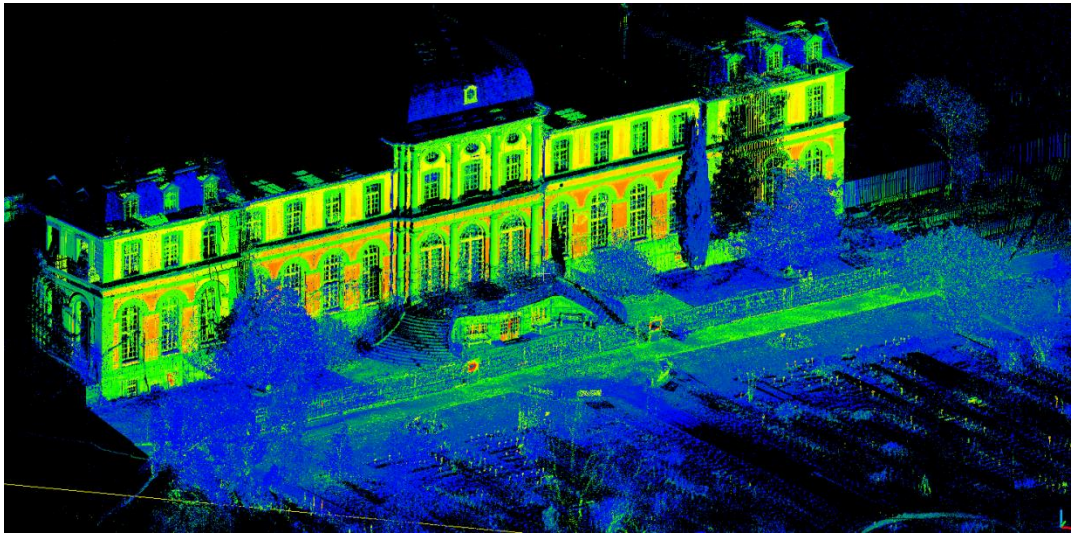
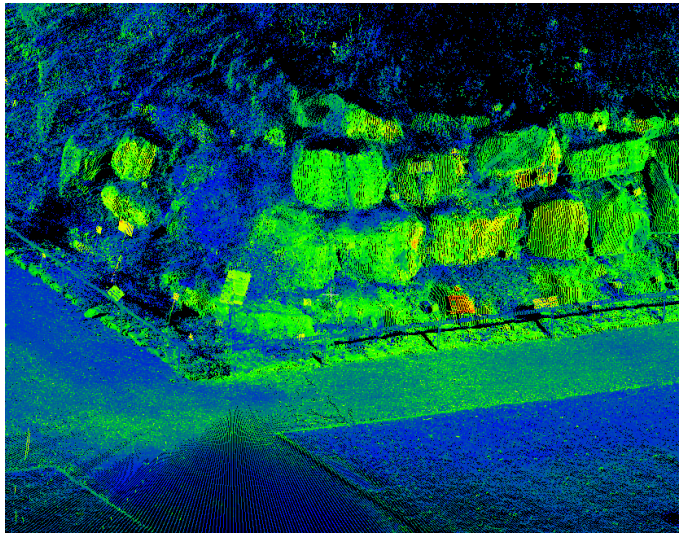
2D laser scanner

- Z+F Profiler 9012 A (phase-based distance measurement)
- measurement of 2D scan profiles with intensity (see documentation)
- single point accuracy ~ mm

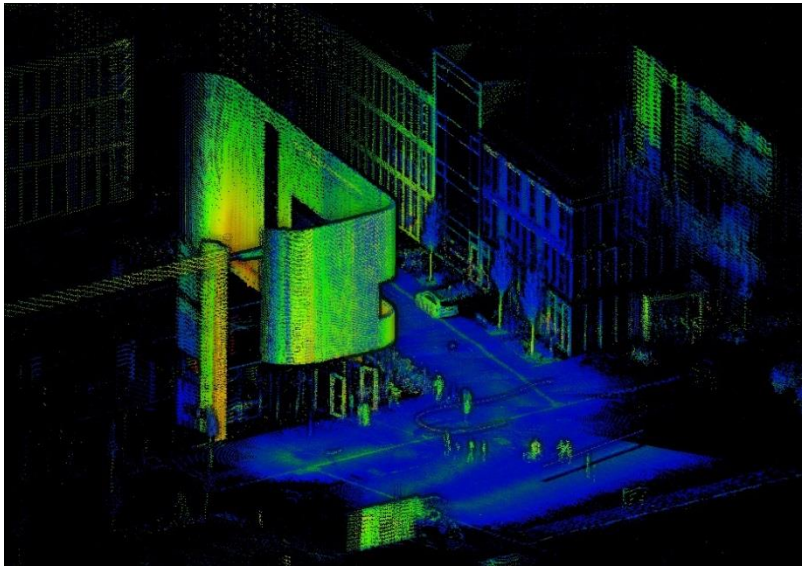
Kinematic laser scanning

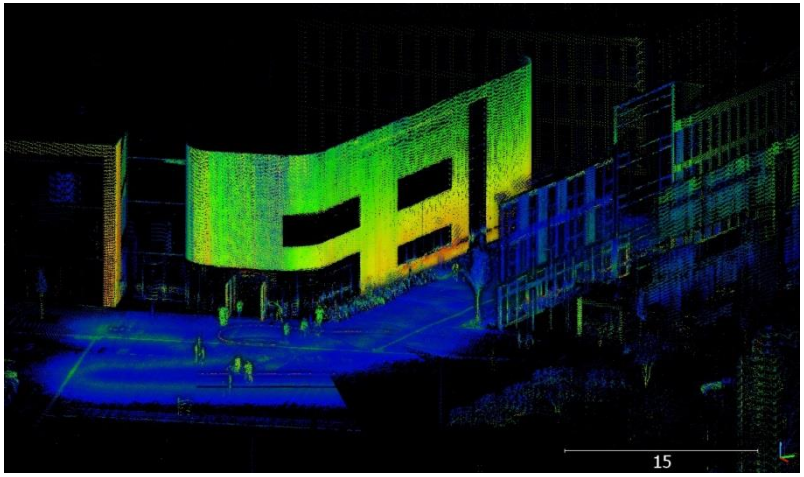
Generating 3D point clouds in motion



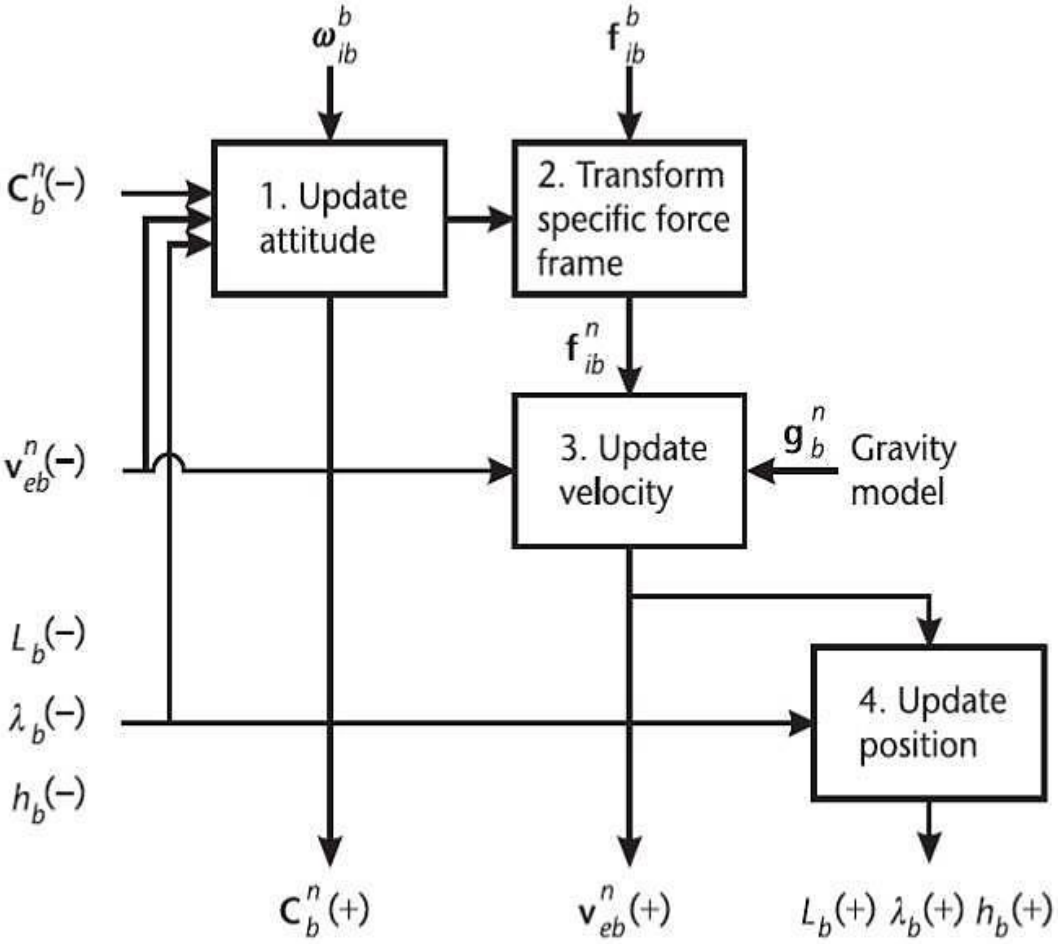
SSE – E1 (WS 2017/2018)





Strapdown integration (simplified)

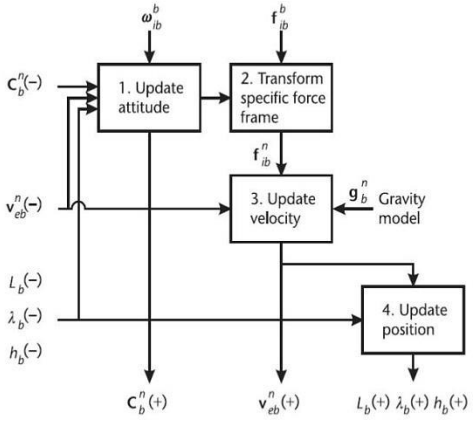
NED – Local Navigation Frame



- Describe
- Implement
- Use on data
- Compare
  - Reference
  - Grooves (more complex eq.)
- Supplementary

Strapdown integration (simplified)

Input: MSS measurements (accelerometers, gyros)



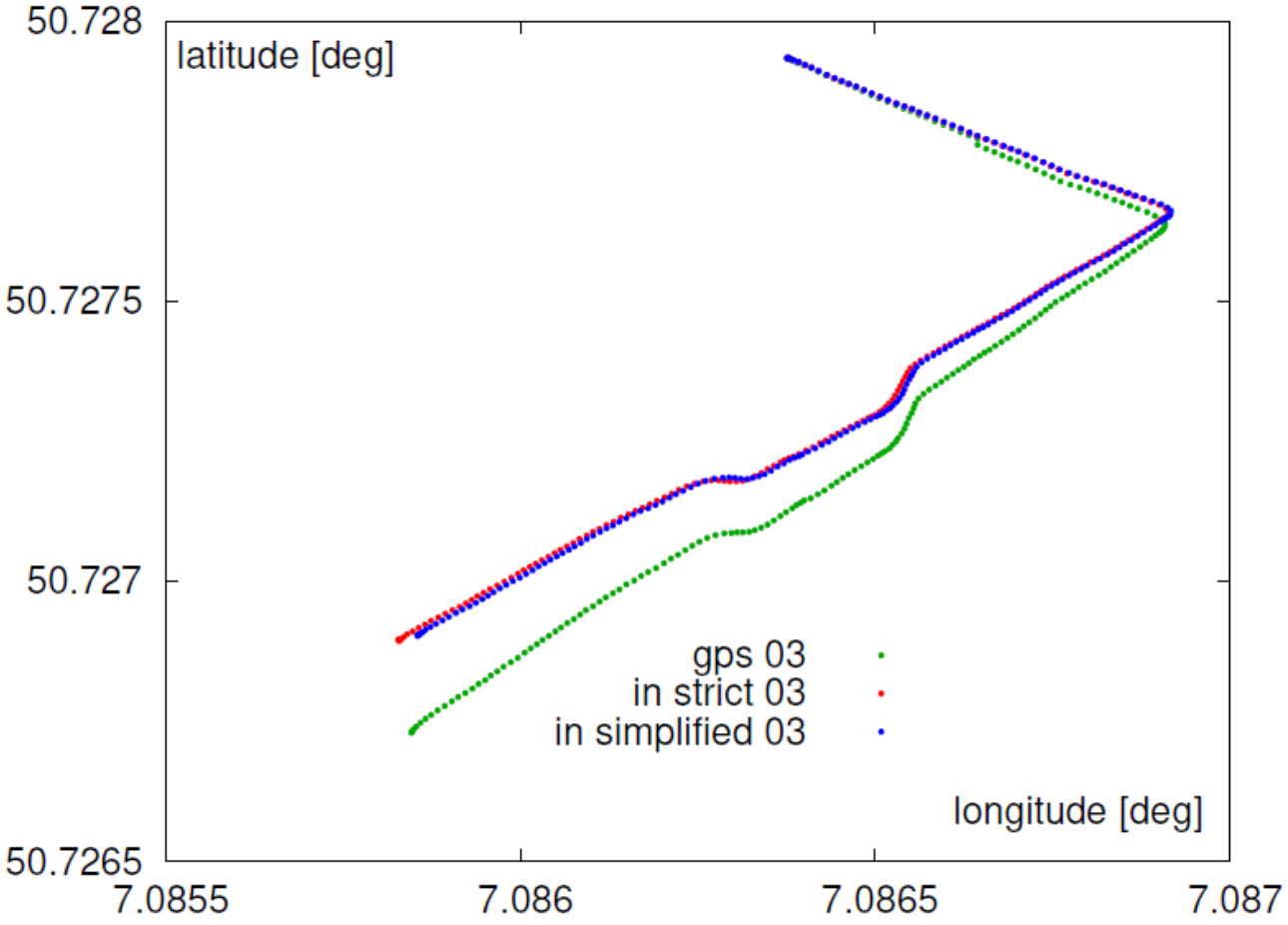
Output: navigation (motion or trajectory profile)

1. Time stamp
2. Position (lat, long, h)
3. Velocity (N, E, down)
4. Attitude (N, E, down)

- 10 values for every time increment

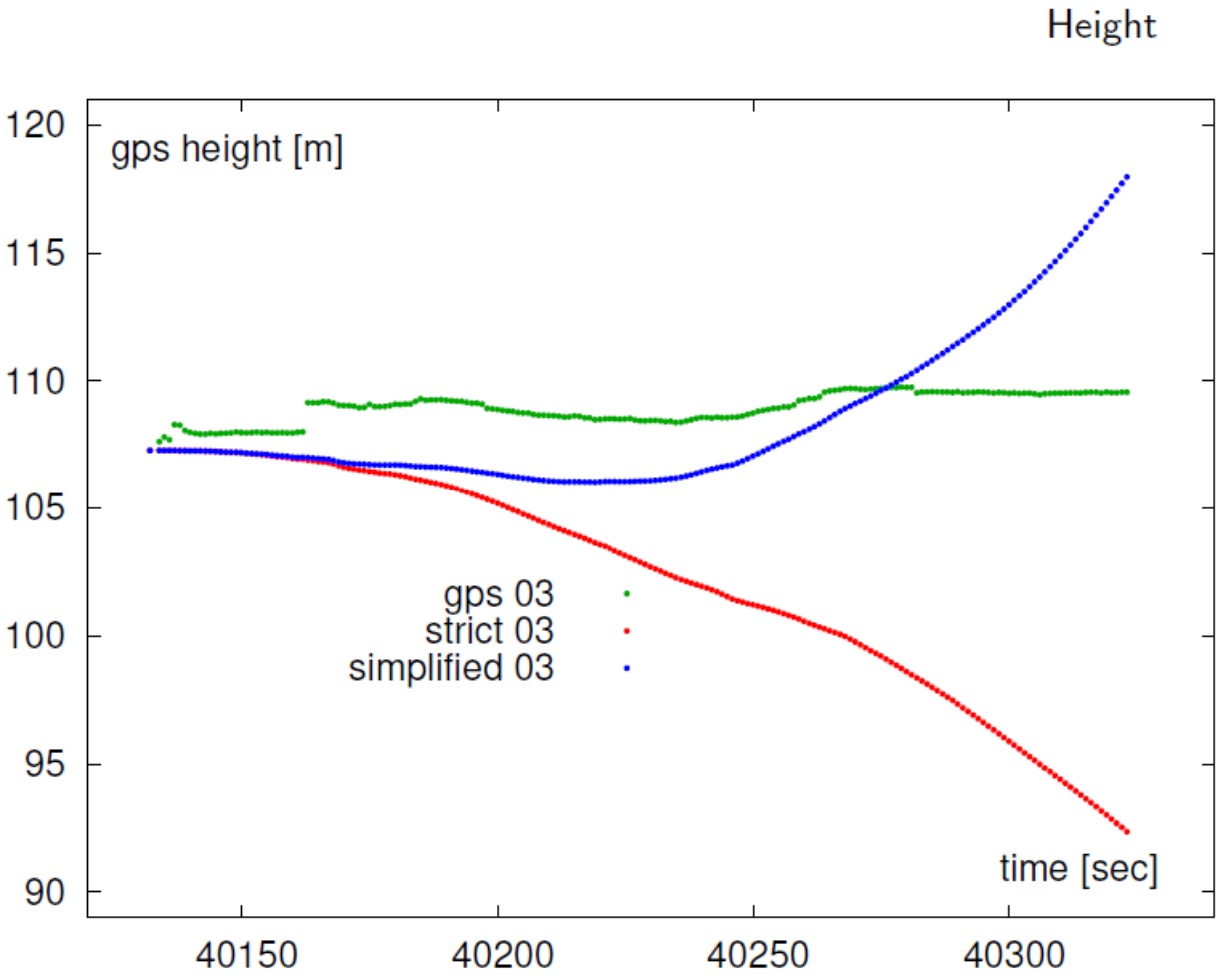
Results & Comparison

Analysing trajectory in 2D (position)



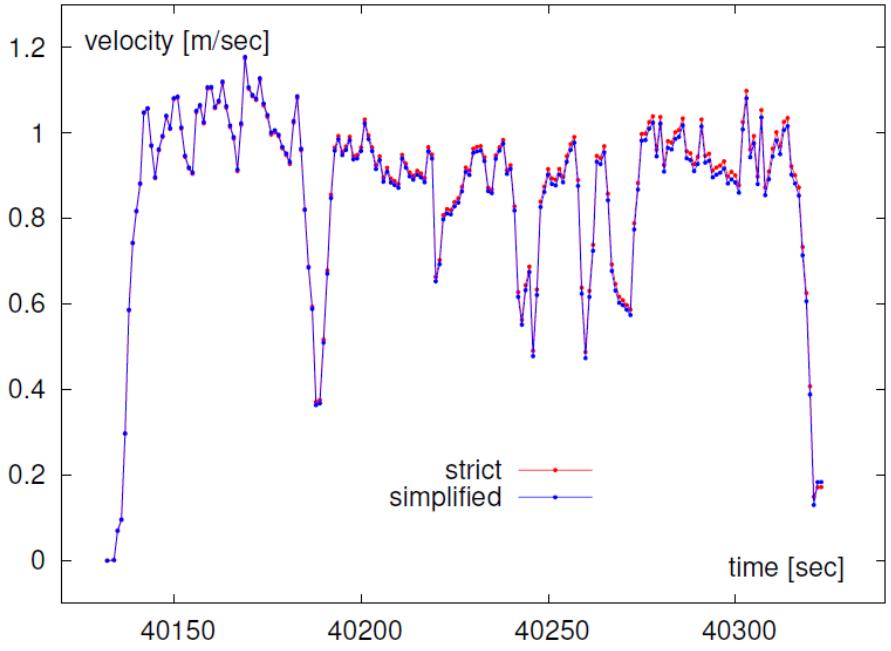
Results & Comparison

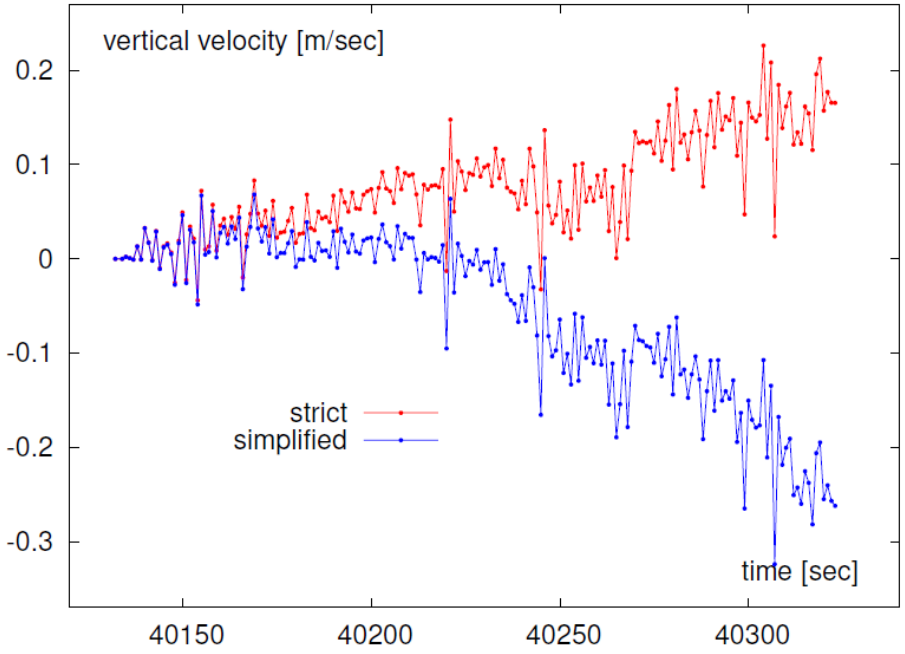
Analysing height



Results & Comparison

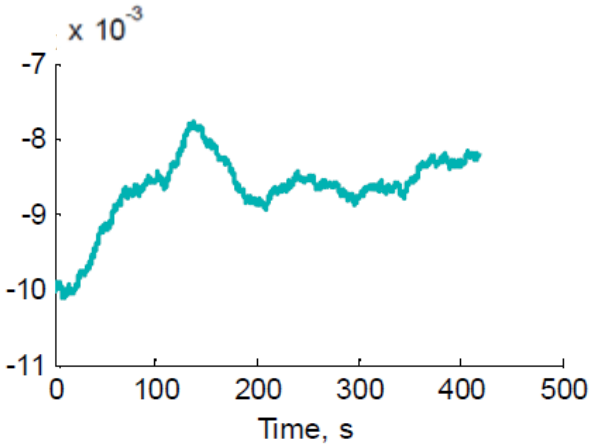
Analysing velocity

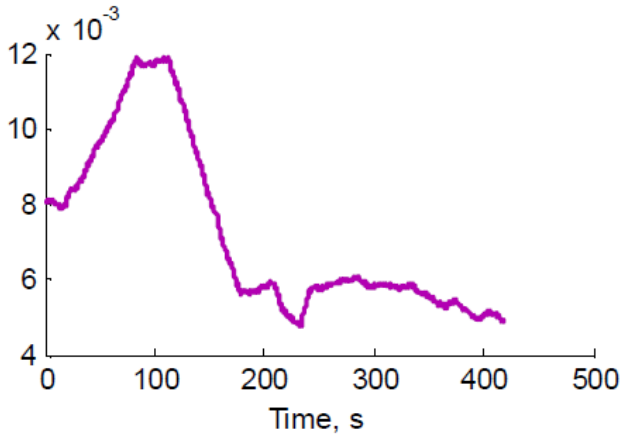


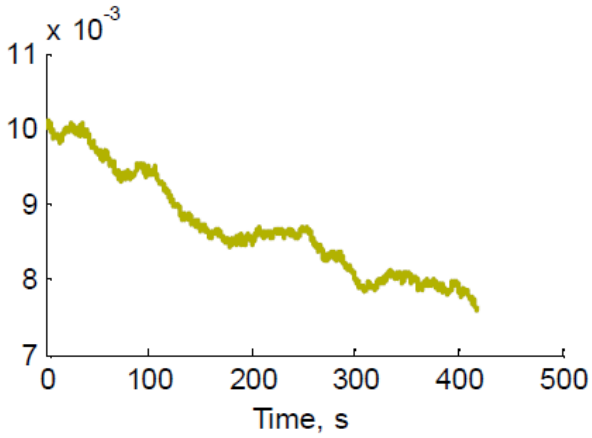


Results & Comparison

- **Roll, pitch, yaw (heading)**







Thank you for your attention
Questions or comments?