Relativistic Navigation Satellite System

(part 2)

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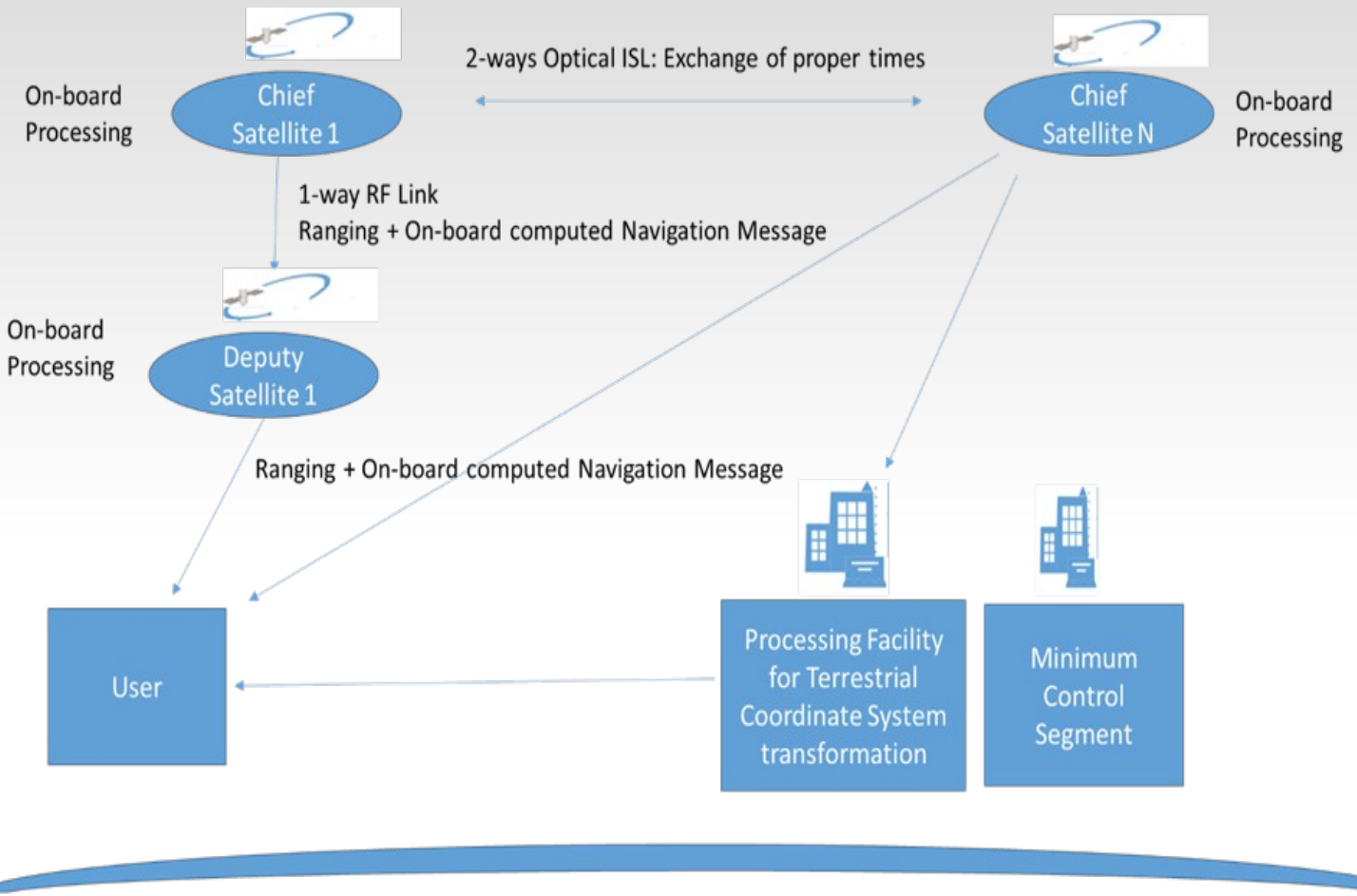
This presentation is based on LIFELINE Project and
RPS Experiment project results.
Both projects are European Space Agency funded projects.

AaltaLab

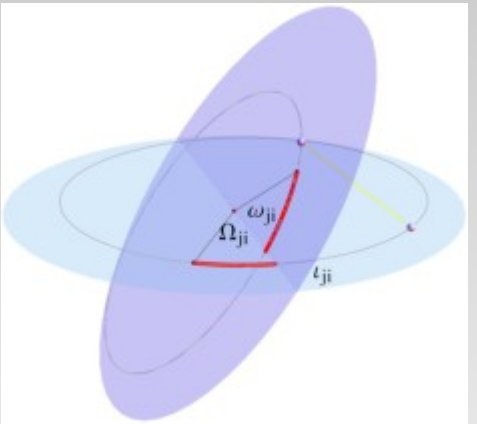
gmv INNOVATING SOLUTIONS

esa European Space Agency

System concept and architecture



Relative orbit determination



Chief constellation

ISL

Modules 1&2

Modules 3&4

Data reduction
+
Clock correction

Modules 3&4

Orbital Elements

Module 5

Coordinate transformation

QMC (t_o, x_o, y_o, z_o)

Modules 2&5

ABC – Autonomous Basis of Coordinates

Module 5

EC $(\tau_1, \tau_2, \tau_3, \tau_4)$

Deputy constellation

Deputy constellation

Modules 1&2

Modules 2&5

Ground user

EC $(\tau_1, \tau_2, \tau_3, \tau_4)$

Module 5

Orbital Elements

Module 5

Coordinate transformation

QMC (t_o, x_o, y_o, z_o)

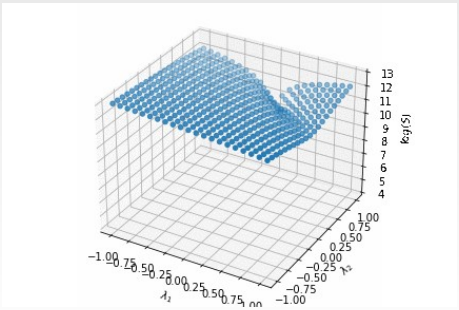
Simulations

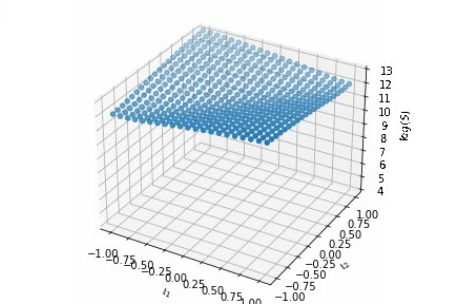
Chief constellation

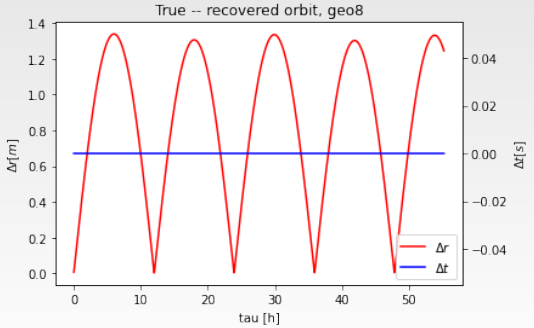
Chief #8 & #18

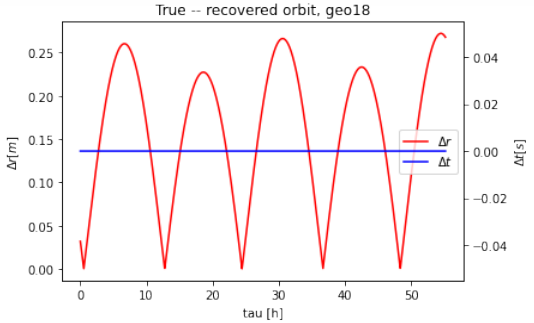
$\Delta\iota = 100^O$

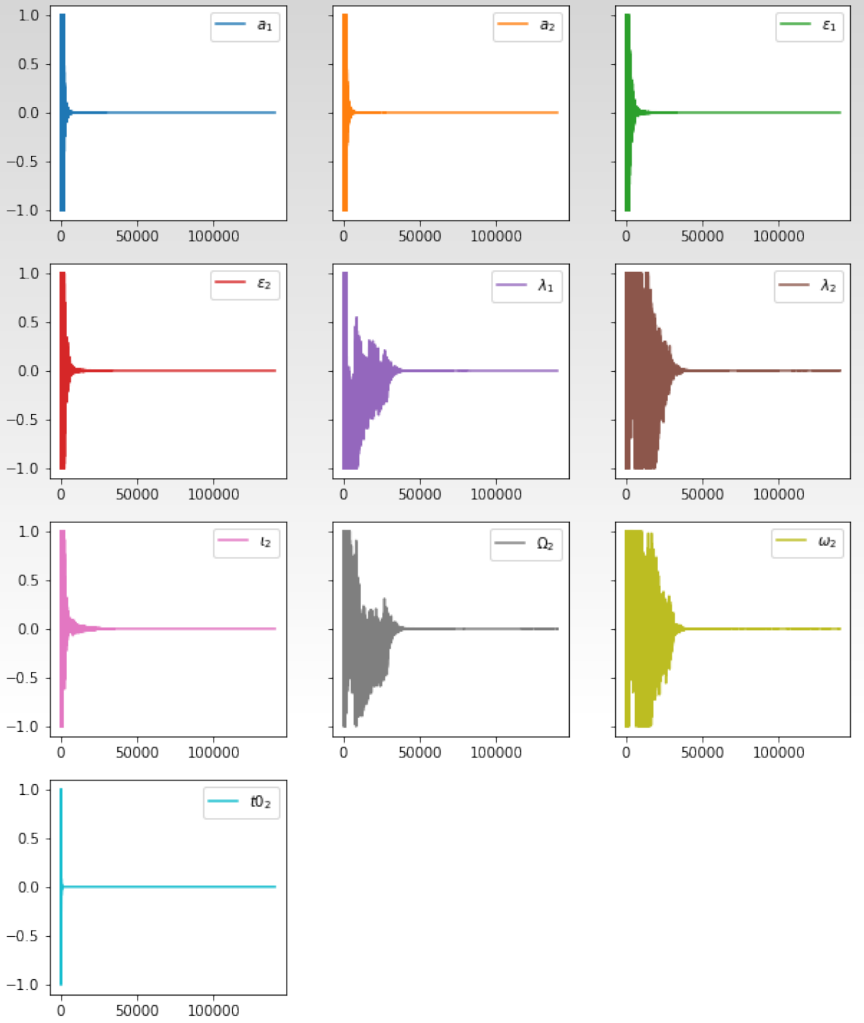
$\Delta\lambda = 170^O$











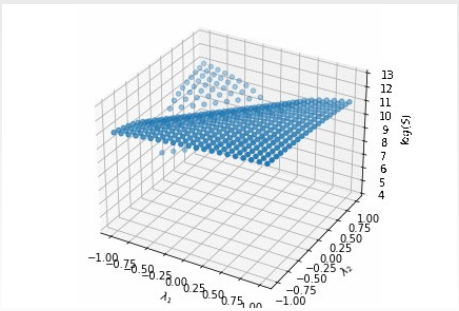
Simulations

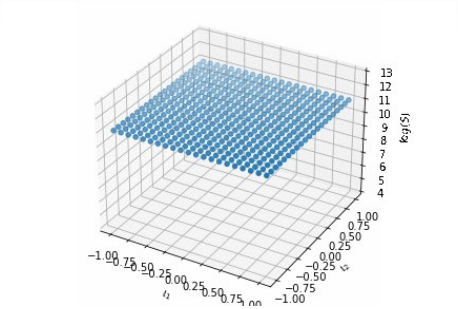
Chief constellation

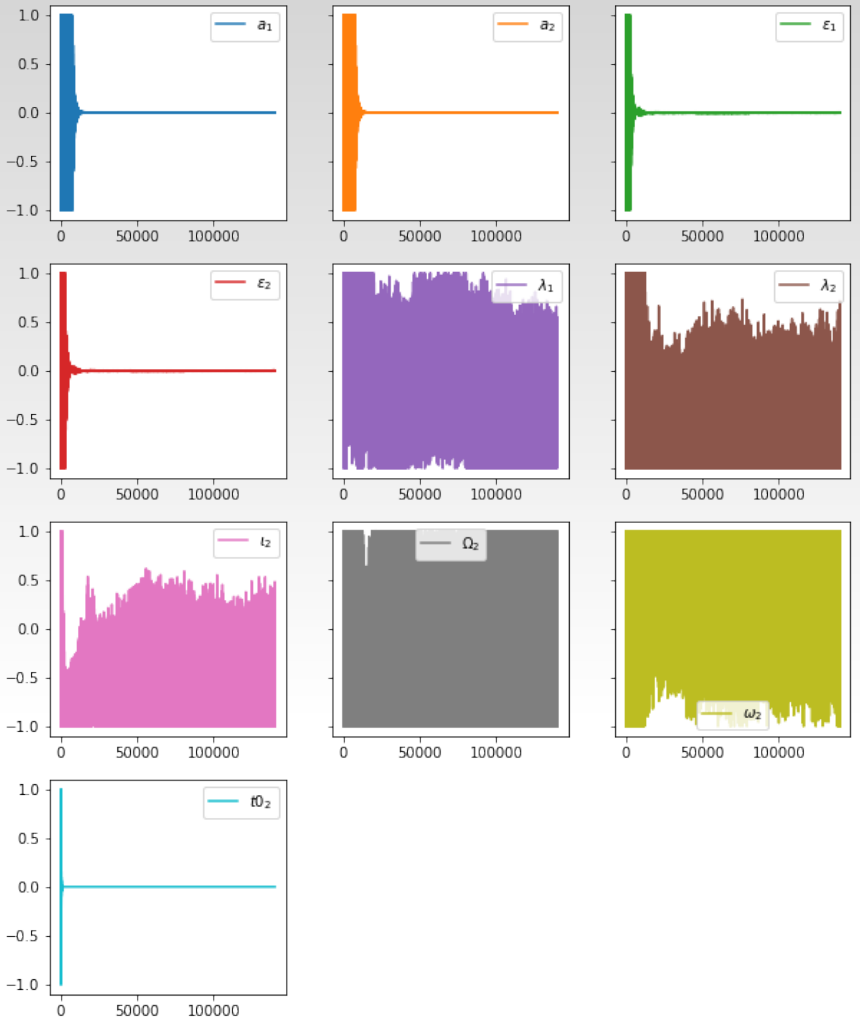
Chief #18 & #20

$\Delta\iota = 0^O$

$\Delta\lambda = 170^O$





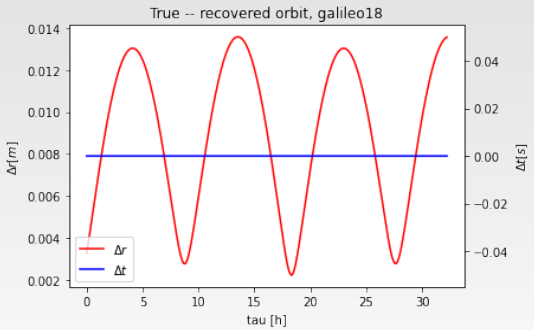


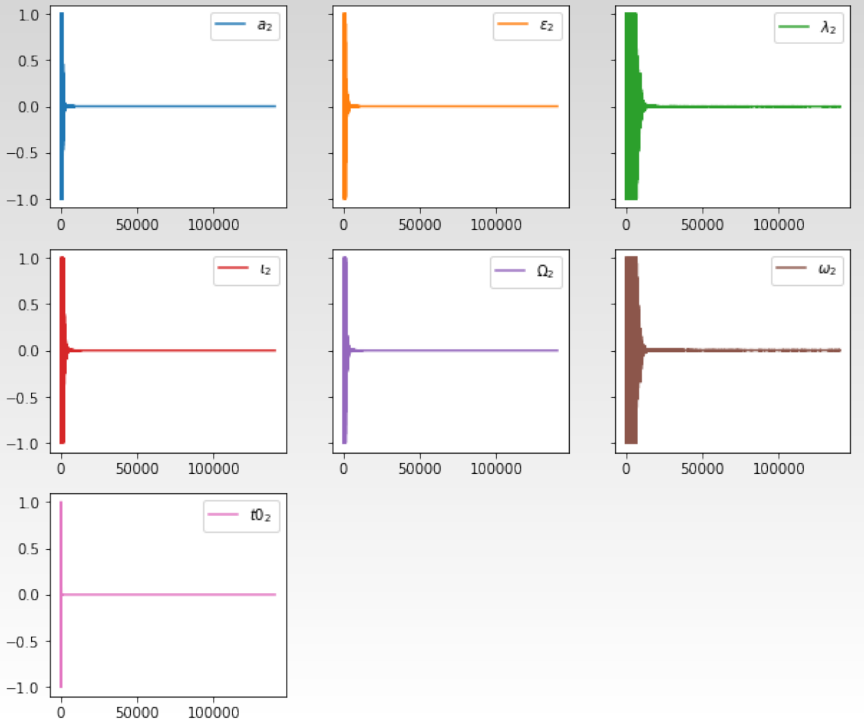
Simulations

Deputy constellation

- minimization approach

Chief #18 & Deputy #18



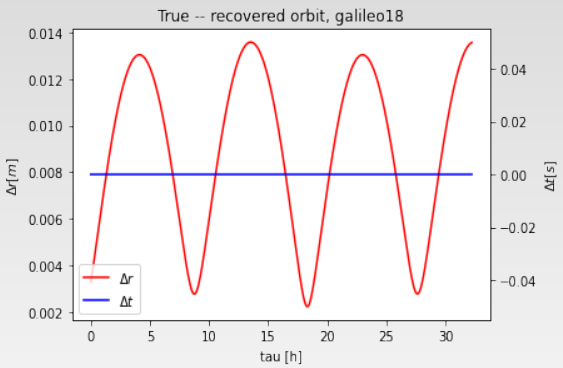


Simulations

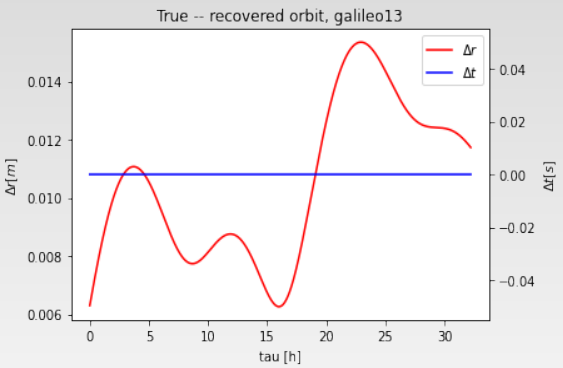
Deputy constellation

- minimization approach

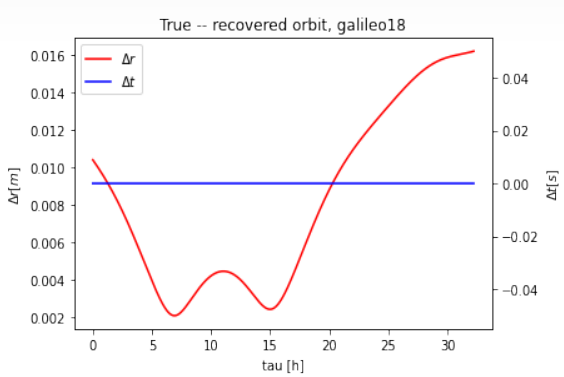
Chief #18 & Deputy #18



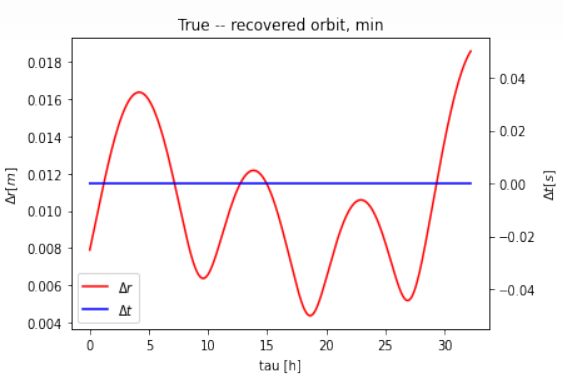
Chief #8 & Deputy #13



Chief #8 & Deputy #18



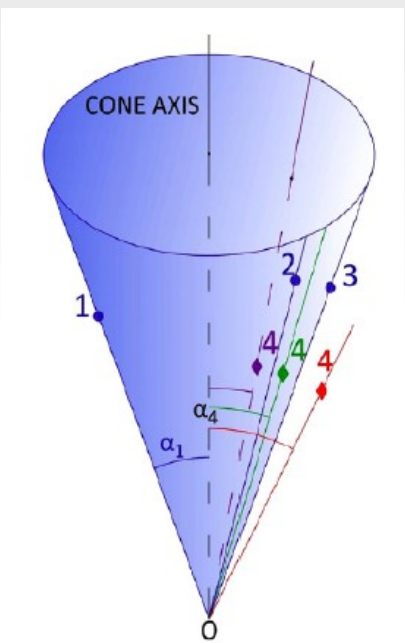
Chief #8 (min) & Deputy #13



Simulations

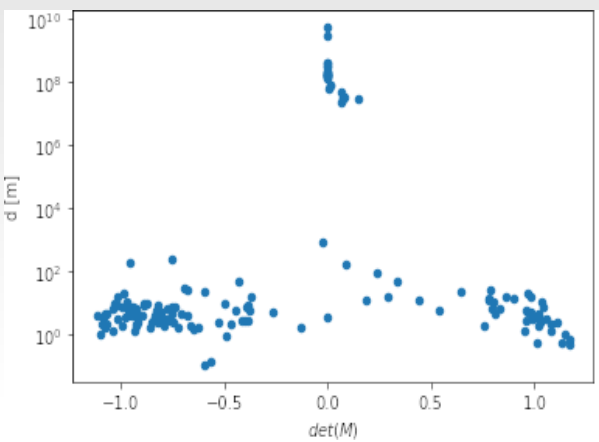
Deputy constellation

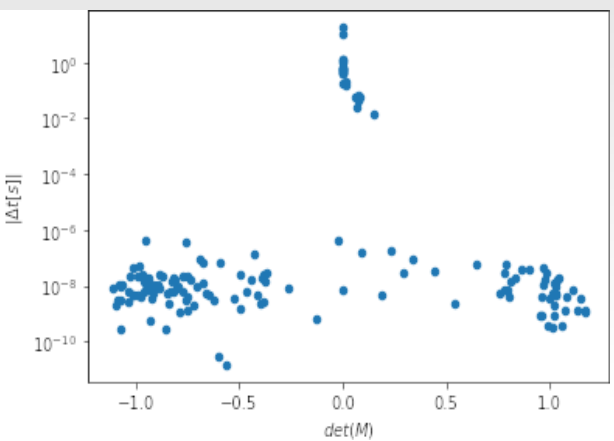
- positioning approach



Chiefs: #7, #8, #17, #18

Deputy: #13





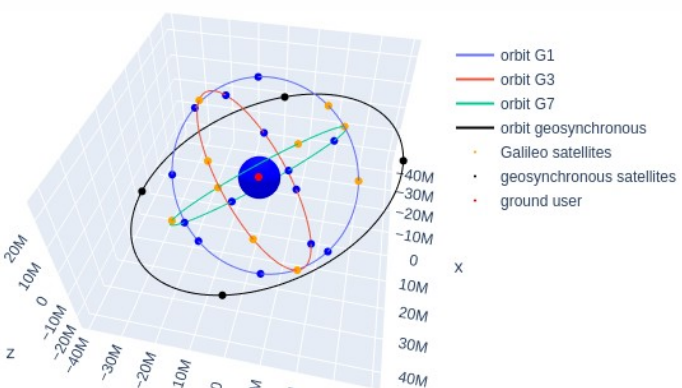
Simulations

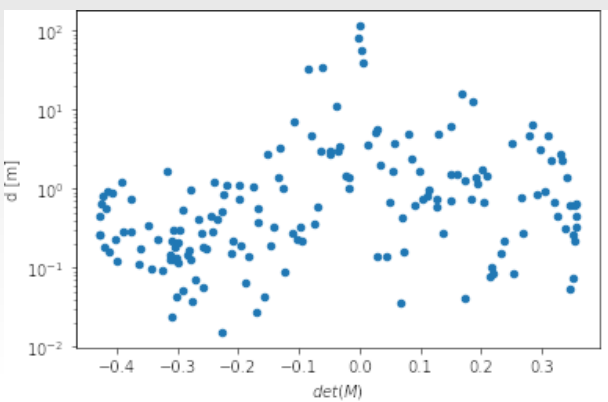
Ground user

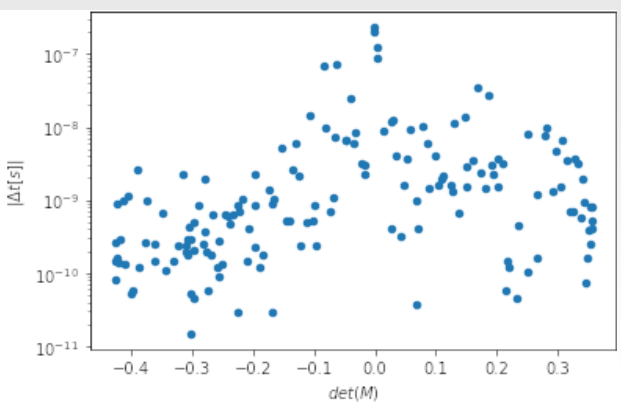
- positioning approach

Deputies: #8, #13, #14, #18

Ground user: La Palma



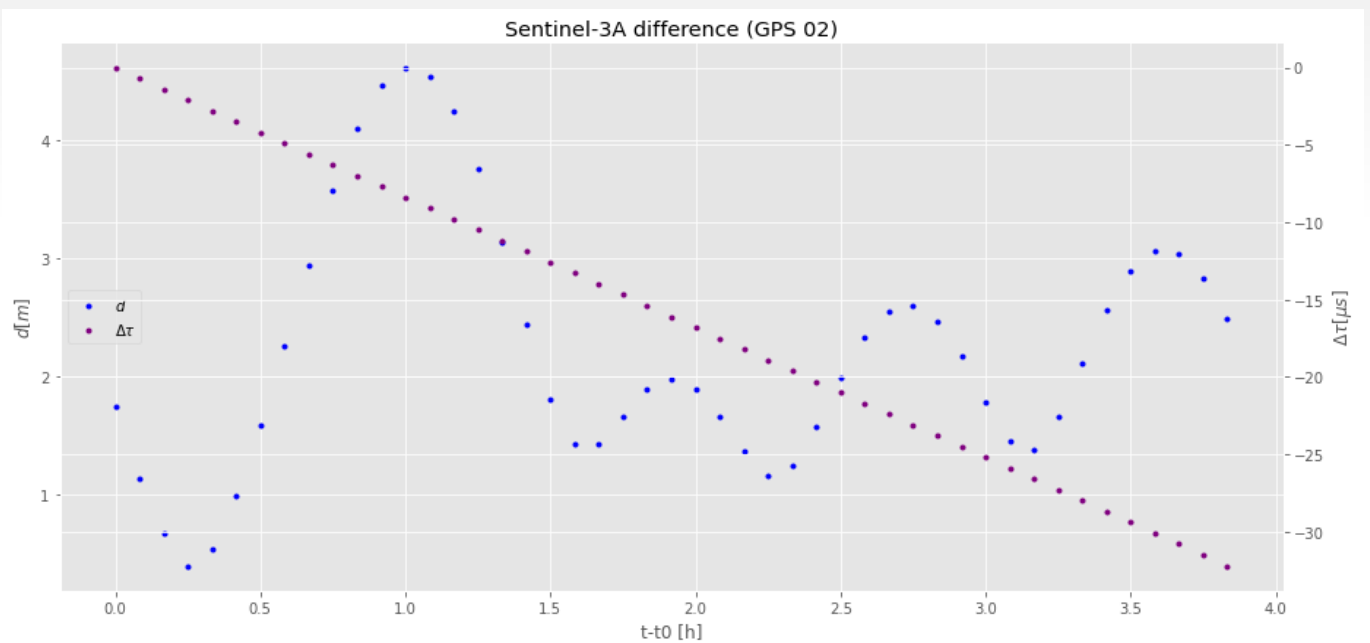




Experiments

GPS → Sentinel 3A (chief → deputy)

- orbit of the GPS satellite is known
- Minimize GPS clock bias and drift, S-3 orbital elements
- Initial deviation (or search box): 10 km
- Final deviation: **~4.5 m**



Experiments

GPS → Sentinel 3A

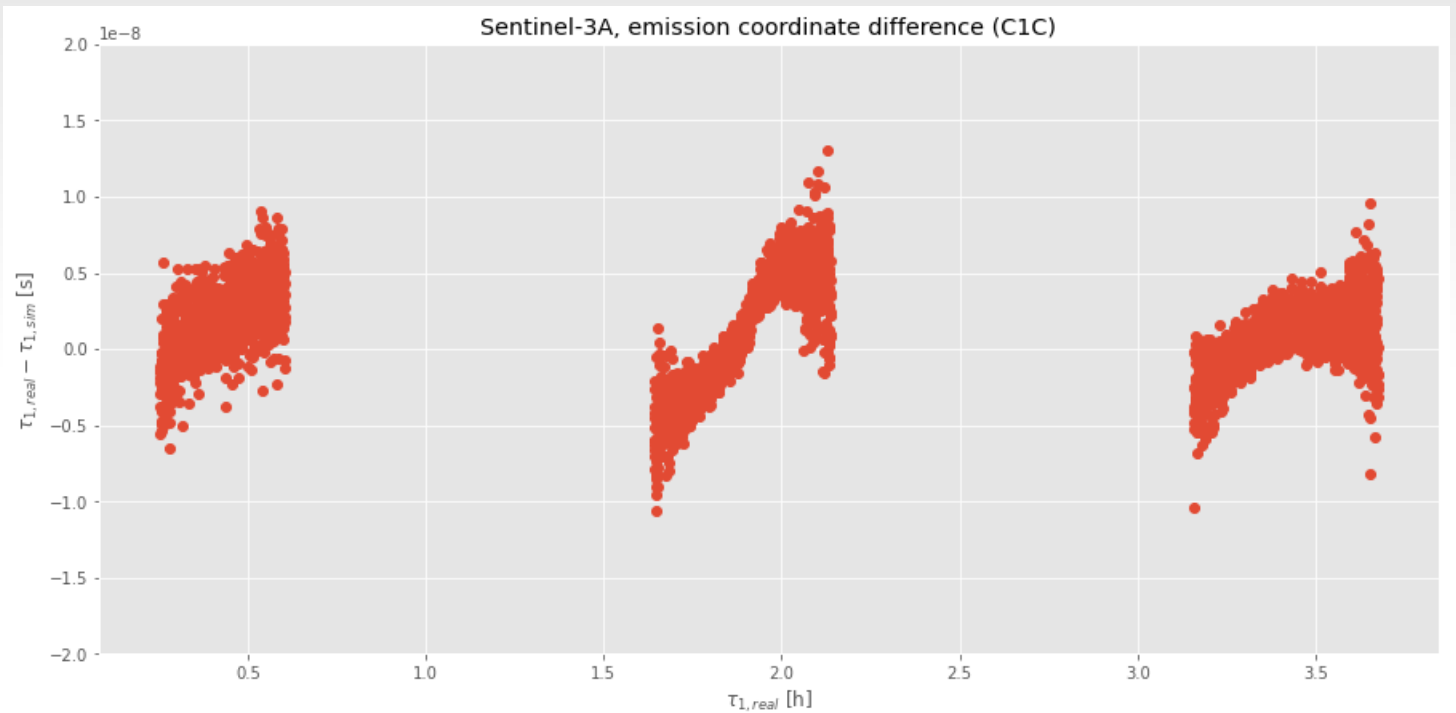
GPS	*d* [m]
G13	8
G16	26
G19	4500
G20	10
G21	**3.5**

G19: only 10% of orbit covered with comm. pairs

Experiments

GPS → Sentinel 3A

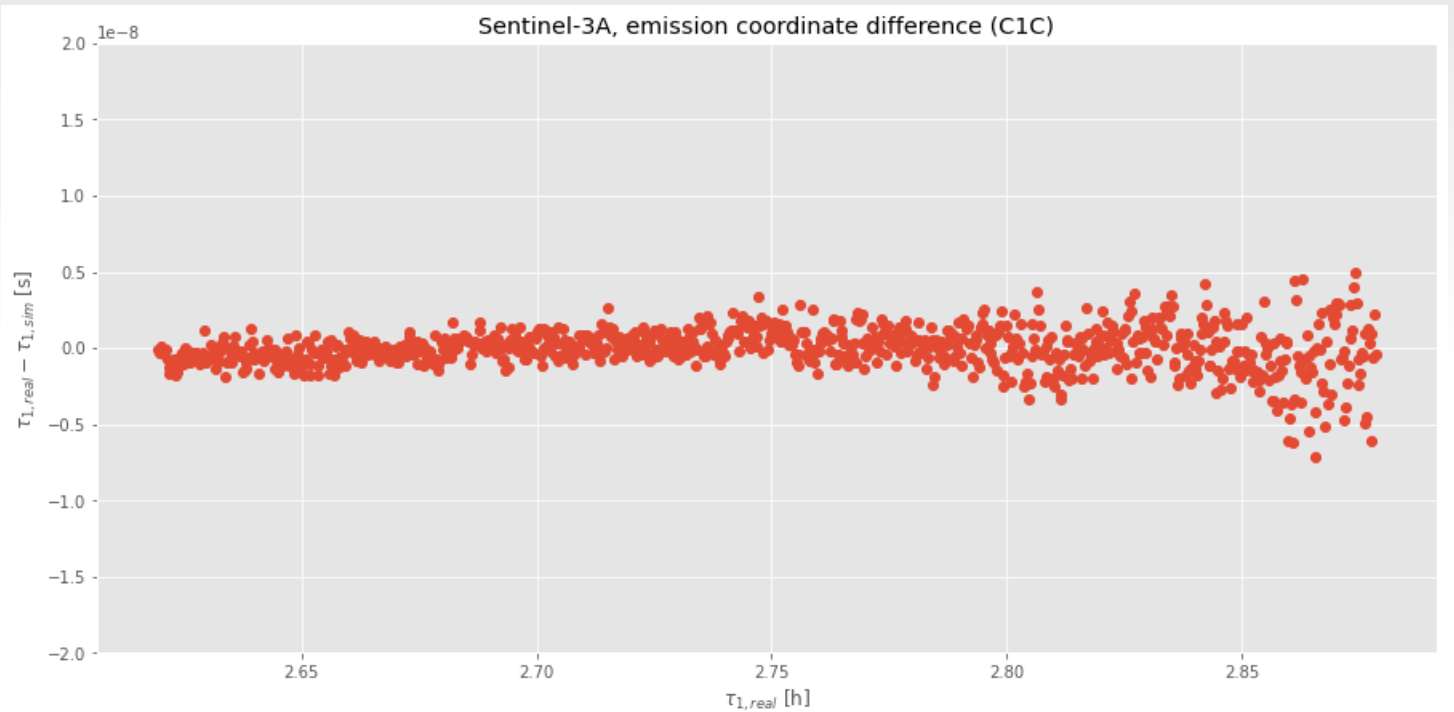
G21 communication pairs
(drift and bias removed)



Experiments

GPS → Sentinel 3A

G19 communication pairs
(drift and bias removed)



Conclusions

- RPS would be independent of terrestrial frames and could provide an independent, robust and self-consistent navigation solution,
- Potential improvement on the accuracy level of satellite orbits
- Autonomy and simplicity: Idea behind RPS is to give the constellation of satellites the possibility to constitute by itself a primary and autonomous positioning system, without any a priori realization of a terrestrial reference frame
- Reduction in the Ground Segment infrastructure, transferring capabilities to the space segment could be achieved, which could also imply improvements in the Security of the system.
- Provide a high enough number of communication pairs in case of noisy data
- It can help the convergence if the clock drift and bias are known in advance
- Satellites should have comparable orbital periods to get the same coverage with the communication pairs to facilitate the convergence