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Performance Assessment of the Formation Flying L-Band Aperture Synthesis Mission Concept

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1. Introduction

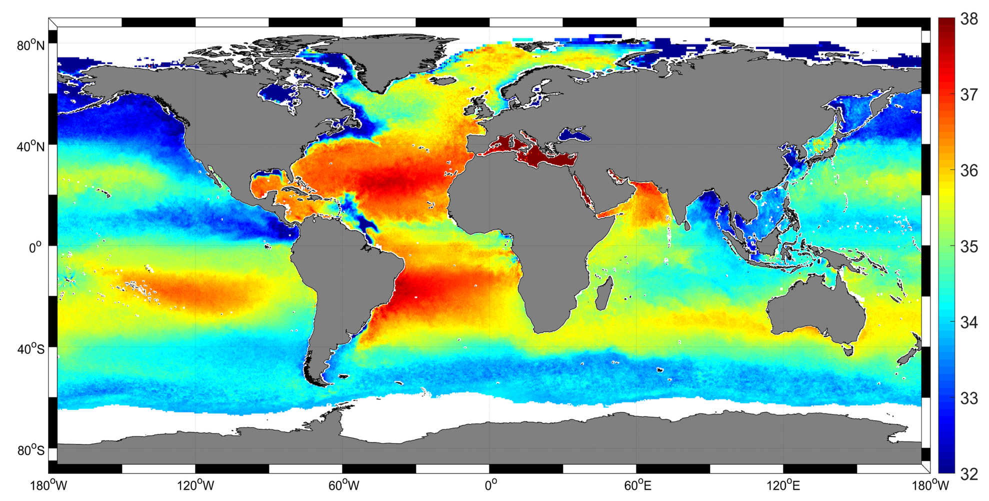
Figure 1: Global Sea Surface Salinity Map (©ESA–CCI)

The outcomes of the ESA's **Soil Moisture and Ocean Salinity (SMOS)** mission highlight the importance for **future applications** over land and oceans.

- Improve **spatial resolution** from 40 km, as SMOS, to **1-10 km**.
- High-resolution measurements are vital to improve the **scientific monitoring of geophysical parameters**.

The European Space Agency proposed the **Formation Flying L-band Aperture Synthesis (FFLAS)** study, carried out by **Airbus Defence and Space** and by **Politecnico di Milano**.

2. Research Question

- How to **improve the aperture size** and, **spatial resolution** up to 10 km?

This study focuses on the possibility to combine **multiple L-band antenna on different satellites**, working as nodes of a network of sensors. The resulting **combined interferometry** provides an improvement in the spatial resolution. Moreover, the **geometry of the antenna** influences the interferometry solution:

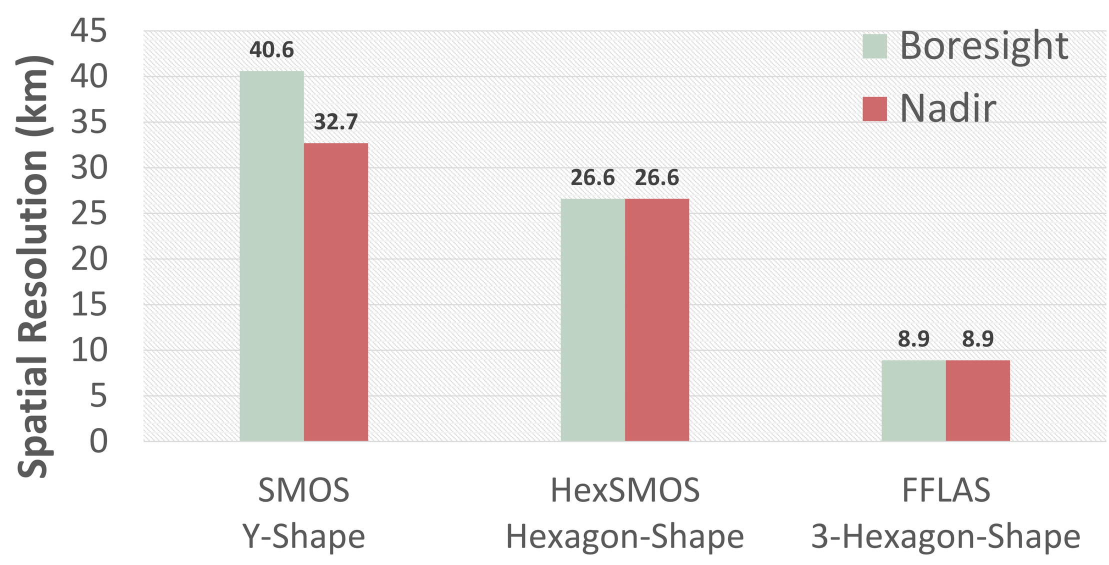

Figure 2: Spatial resolution for different paylaod shapes

3. Methodology

The FFLAS study proposes:

- A formation of **three** identical satellites, mounting **hexagonal L-band antenna** arrays, with a diameter of about 8 m.
- Nominal configuration: **equilateral triangle** of **12 m side.**

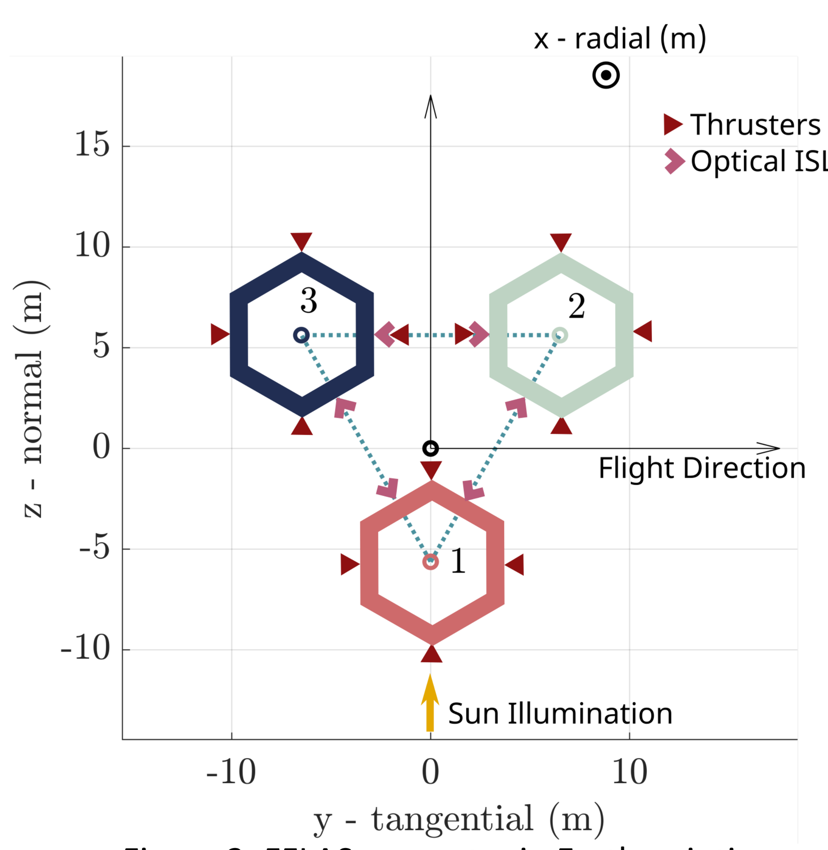

Figure 3: FFLAS geometry in Earth pointing

The nominal geometry is maintained rigid along the scientific phase by a **continuous control** thrust, to counteract external perturbations.

Moreover, the **manoeuvre** to reconfigure the satellites to **payload calibration** mode was designed, through **optimal delta-v** trajectories.

4. Results

A **high-fidelity simulator** to design an **accurate and precise** control and navigation systems **(GNC)**, considering the safety conditions among the satellites.

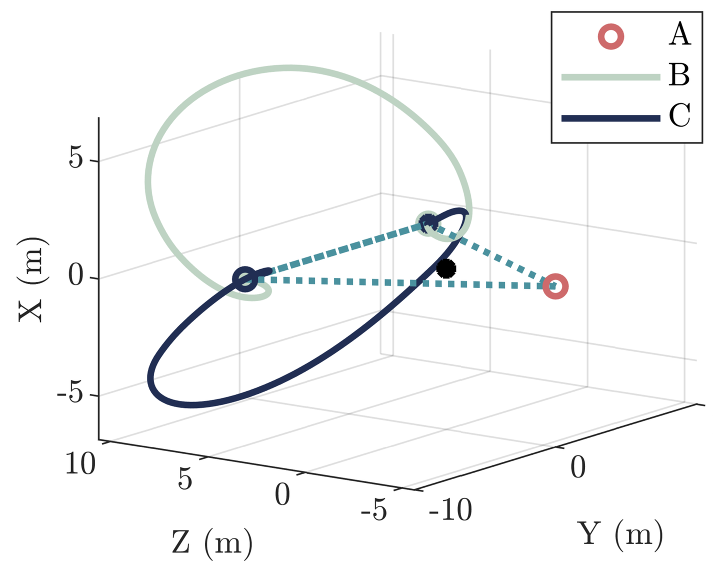

Figure 4: Maneuver from Earth pointing to calibration configuration

- **Gravitational potential** ($J_{160x160}$) and **Drag** pertubations
- Single-frequency **GNSS-based navigation** system
- **Linear Quadratic Regulator** controller
- **QinetiQ T5 engine** up to 25 mN constant thrust in (y-z)

The **main results** for the relative states of the formation are:

- Control accuracy: **2 to 10 cm** (1σ),
- On-board navigation accuracy: **1 to 2 cm** (1σ).

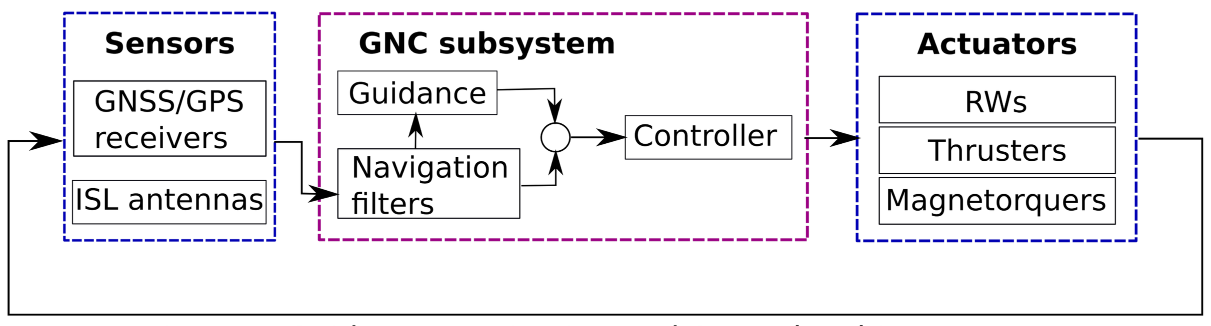

Figure 5: Guidance, Navigation and Control architecture

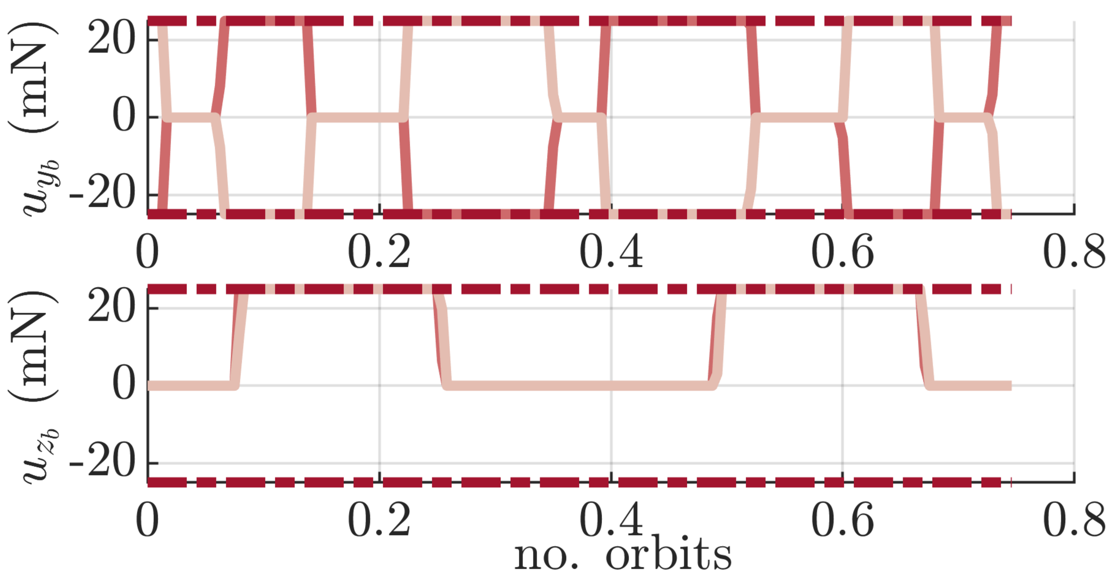

Figure 6: Control profile for calibration reconfiguration

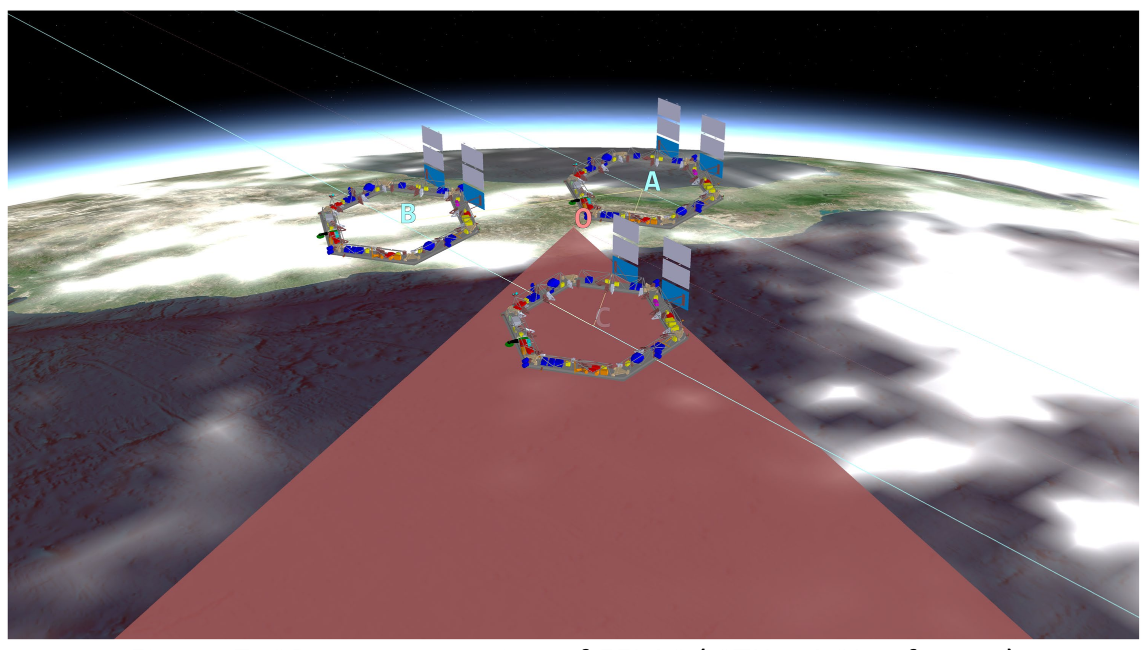
Figure 7: 3D representation of FFLAS (STK – AGI software)

5. Open Aspects

Several **follow-on studies** are envisioned:

- Improve spatial resolution by using **six satellites** (Figure 8),
- Improve the **navigation knowledge** with high-fidelity model of GNSS sensors,
- Improve **control accuracy** with different controllers.

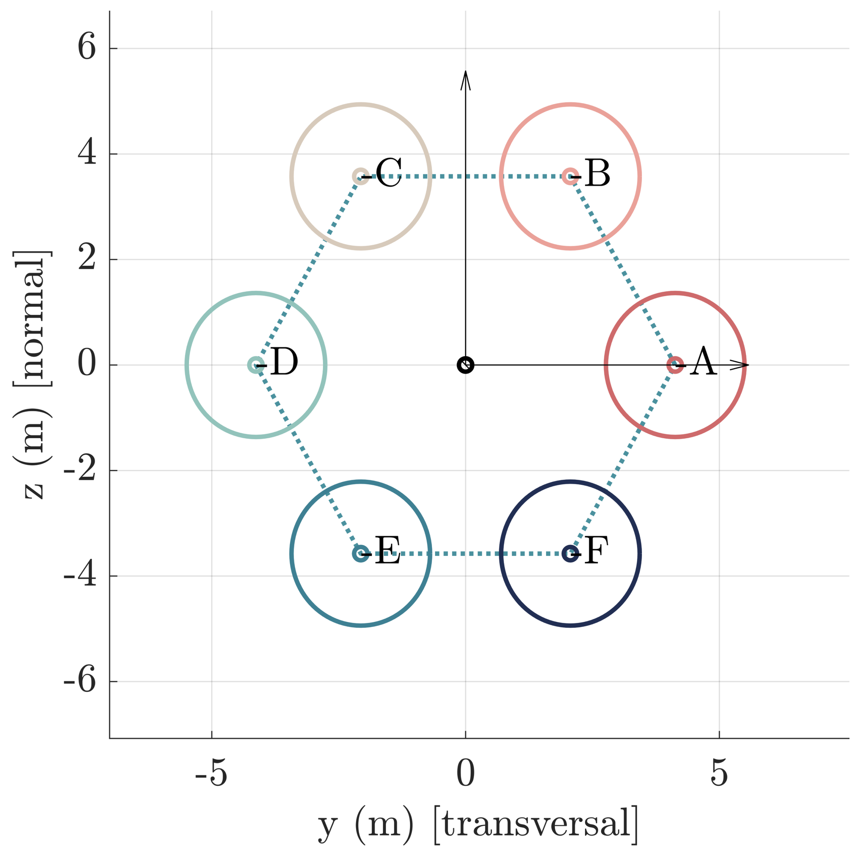

Figure 8: FFLAS follow-on geometry

6. Conclusions

A new path to achieve a **spatial resolution improvement** in L-band passive remote sensing has been explored, providing **future follow up** to ESA's SMOS mission. The analysis gives **confidence** on both **navigation knowledge** and **control accuracy**, ensuring at the necessary robustness to **avoid collisions**.

Acknowledgments

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