Absolute Calibration of σ⁰ for European and Chinese Satellite Altimeters using Passive Corner Reflectors

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Abstract

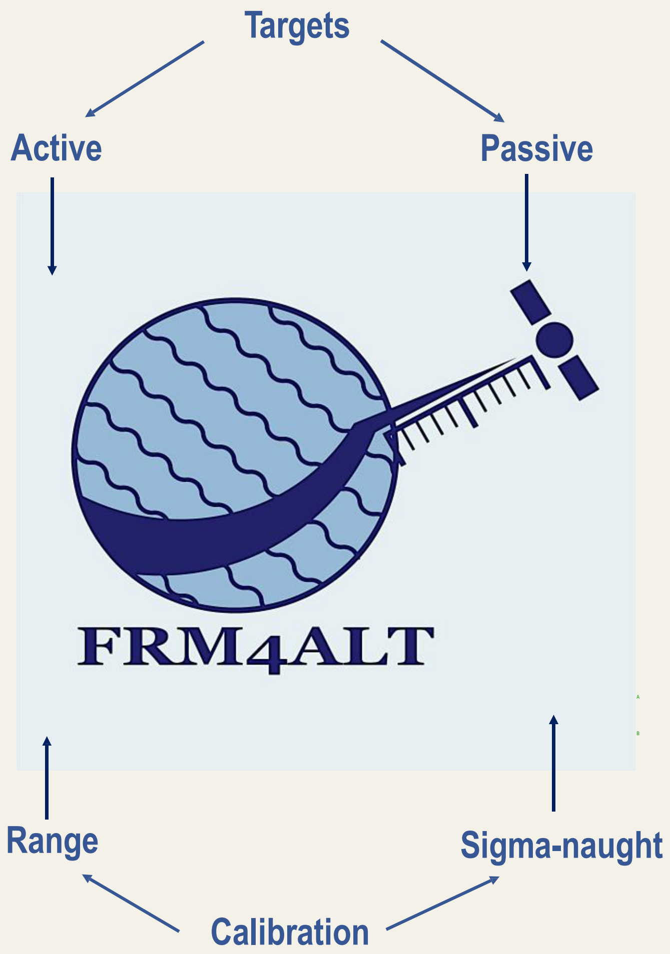
The main objective of the Dragon V project (ID 59198) is to standardize procedures for calibrating European and Chinese satellite altimeters. Calibration and Validation (Cal/Val) actions should follow the guidelines prescribed by the Fiducial Reference Measurements for Altimetry strategy, developed by the European Space Agency for standardizing procedures and results.

One of the fundamental quantities that needs to be calibrated in satellite altimetry is the backscatter coefficient (sigma-naught). This is a satellite measurement related to wind observations at sea and constitutes an important and indispensable parameter for climate change models. At the moment, there is no European or Chinese Cal/Val facility dedicated to sigma-naught calibration.

This work presents the progress made in the design, analysis and validation of corner reflectors for the absolute and direct calibration of the backscatter coefficient in satellite altimeters. Requirements and specifications (i.e., material, dimensions, etc.) for manufacturing such corner reflectors have been defined. These are tailored for calibrating Ku and Ka-band satellite altimeters. Finally, the ground location where these corner reflectors are to be installed has been selected because of its low clutter level and capability of calibrating multiple satellites.

Objectives

1. **Upgrade** Cal/Val services with sigma-naught (σ0).
2. **Increase** confidence of Cal/Val by combining diverse results (sea-surface, transponder, ground reference).
3. **Incorporate** corner reflectors (CR) along with transponders for range calibration.



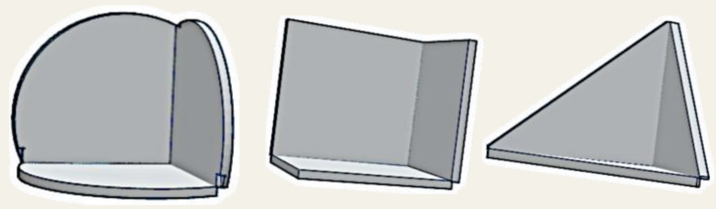
Workplan

- **Review** of previous works on radar Cal/Val using passive targets.
- **Design** and **construct** the optimal **CR** for altimetry Cal/Val.
- Identify **ideal location** for CR deployment.
- Analysis of **CR echo** on altimeter's records.
- **Comparison** against conventional sea-surface and transponder **Cal/Val**.

Corner Reflector versus Transponder

	Transponders	Corner Reflectors
Type	Active	Passive
SNR	High	Low
External Power Need	Yes	No
Applicable	σ⁰ & range	σ⁰ & range
Moveability	Low	High
Multi-Frequency	No	Yes
Stability Error Source	Electronic	Mechanical
Cost	High	Low

Performance Characteristics per CR type

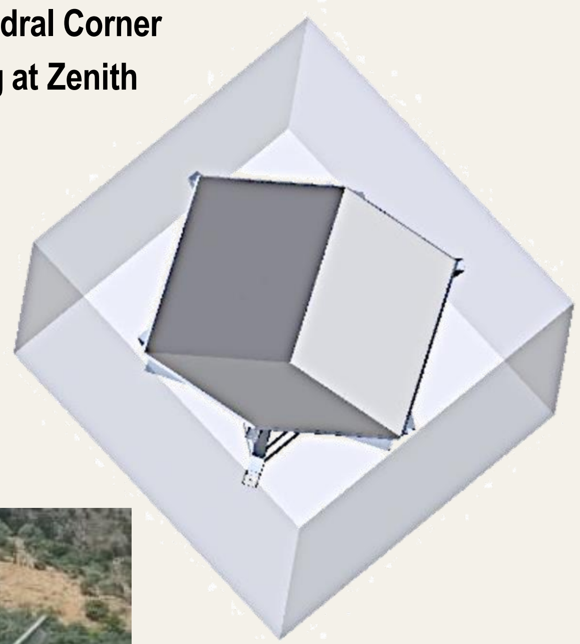


	Circular	Rectangular	Triangular
Max RCS	$\frac{15.6\pi l^4}{\lambda_0^2}$	$\frac{12\pi l^4}{\lambda_0^2}$	$\frac{4\pi l^4}{\lambda_0^2}$
Avg RCS	$\frac{0.47\pi l^4}{\lambda_0^2}$	$\frac{0.7\pi l^4}{\lambda_0^2}$	$\frac{0.17\pi l^4}{\lambda_0^2}$
Coverage around symmetry axis	32°	23°	40°

RCS= Radar Cross Section

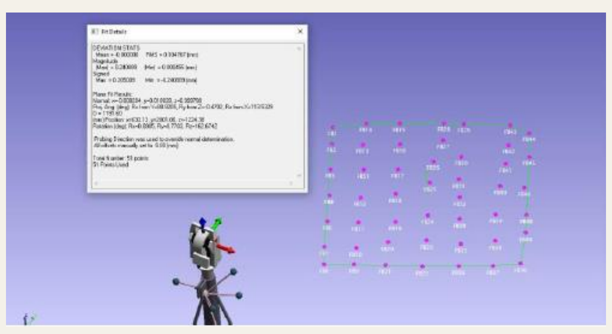
Corner Reflector Design Selected & Constructed

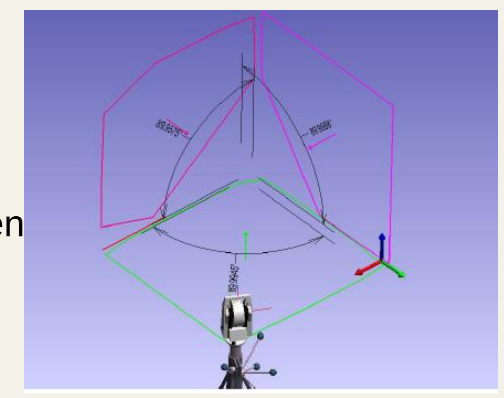
- ✓ Rectangular Trihedral Corner
- ✓ Reflector Looking at Zenith



Flatness and Perpendicularity Certification

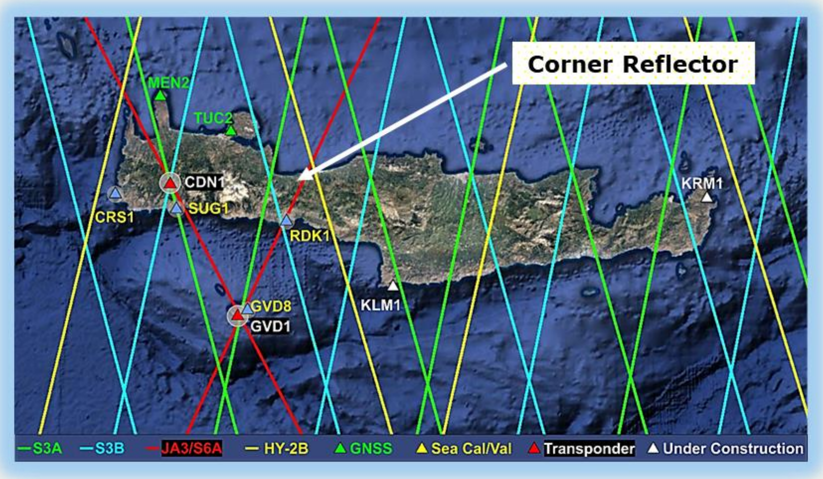
Flatness **< 0.1mm** on each side





Perpendicularity between each plane ± **0.5°**

Corner Reflector Deployment



Satellites supported from ALX1 Corner Reflector

Mission	Offset Distance
Sentinel-6A	6.7 km
Sentinel-3A	5.4 km
Sentinel-3B	3.3 km
HY-2B	15.8 km

Corner Reflector Installed July 2023

- GNSS survey for ALX1 coordinates' determination
- Local leveling with benchmarks

Conclusions & Future Plans

- Corner reflectors **complement** active transponders.
- Rectangular trihedral CR looking at zenith design to support **Ku- & Ka-** missions.
- Site selected to **maximize** return of investment: support of **satellite altimeters**.
- Corner Reflector **installed** on 29 July 2023.
- **Collaboration** with satellite missions' operators
- **Processing** of satellite altimetry products **on going**

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