Accurate Passive Targets for Radiometric and Polarimetric SAR System Calibration

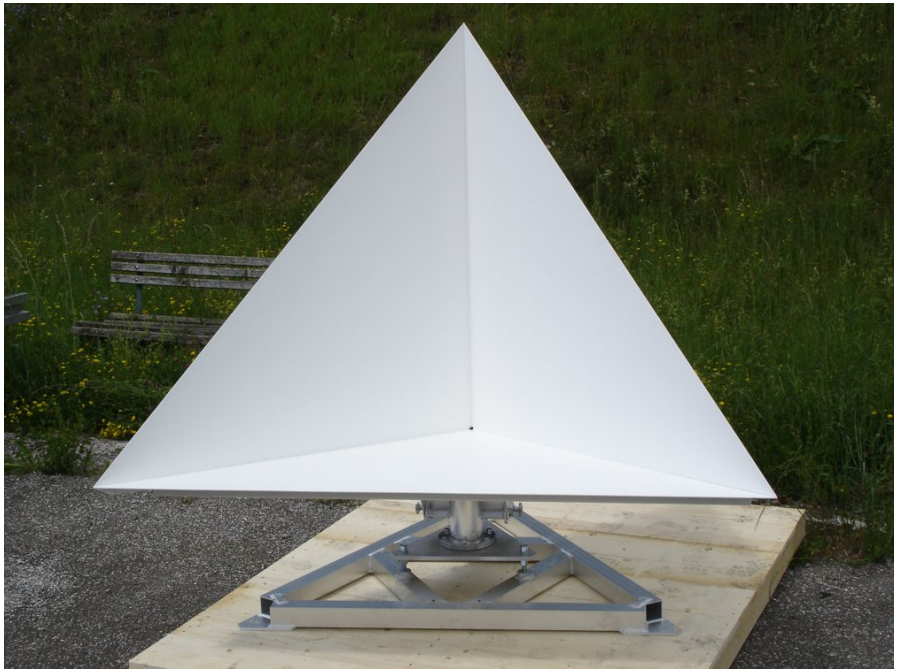
Jens Reimann, Marco Schwerdt

German Aerospace Center - DLR

Microwaves and Radar Institute

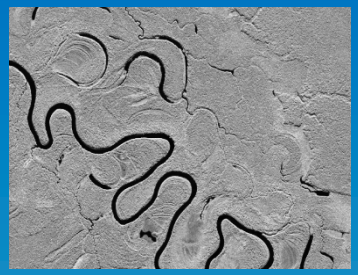
What's the RCS of this Trihedral Corner Reflector at X-band?

$$\sigma = \frac{4}{3}\frac{\pi l^4}{\lambda^2} ?$$



DLR

Why do we care?



SAR Image

Increasing

Trihedral CRs form the Radiometric Reference for (all) our SAR Satellites!

Transponder

Trihedral Corner Reflector

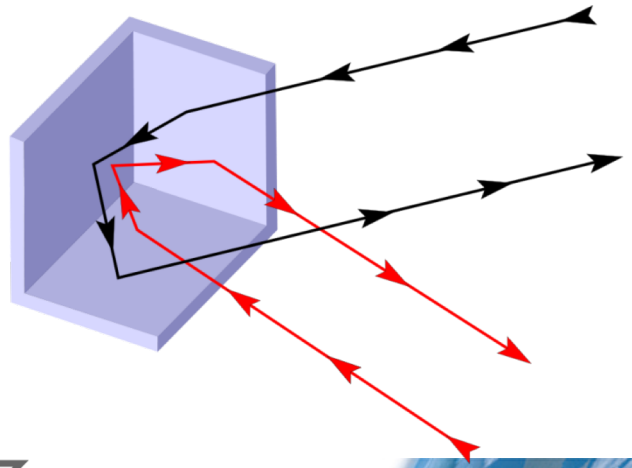
What's wrong with this Equation?

$$\sigma = \frac{4}{3}\frac{\pi l^4}{\lambda^2}$$

GO Simplification

Geometrical Optics assumes

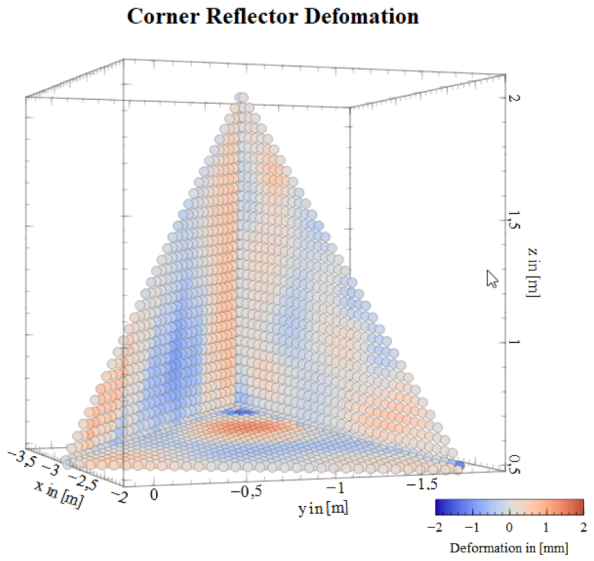
- Radar Wave as a Ray
- Infinite Large Plates
- No Edges
- Corner Large w.r.t. Wavelength



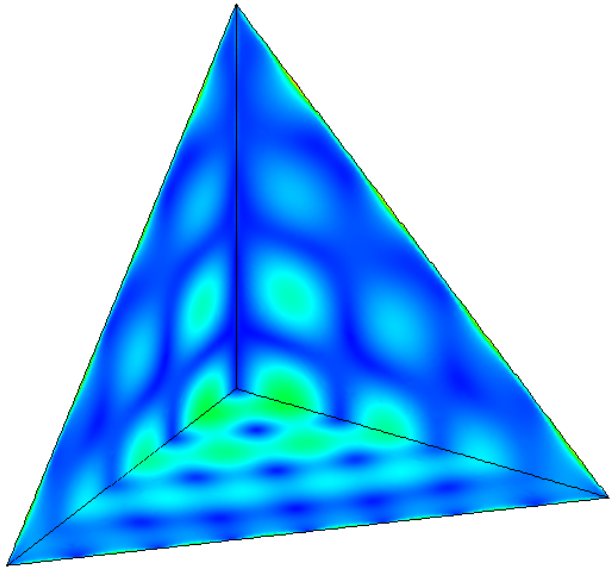
Deformation

Corner Reflector is never ideal

- Plates are not orthogonal
- Plate Deformation

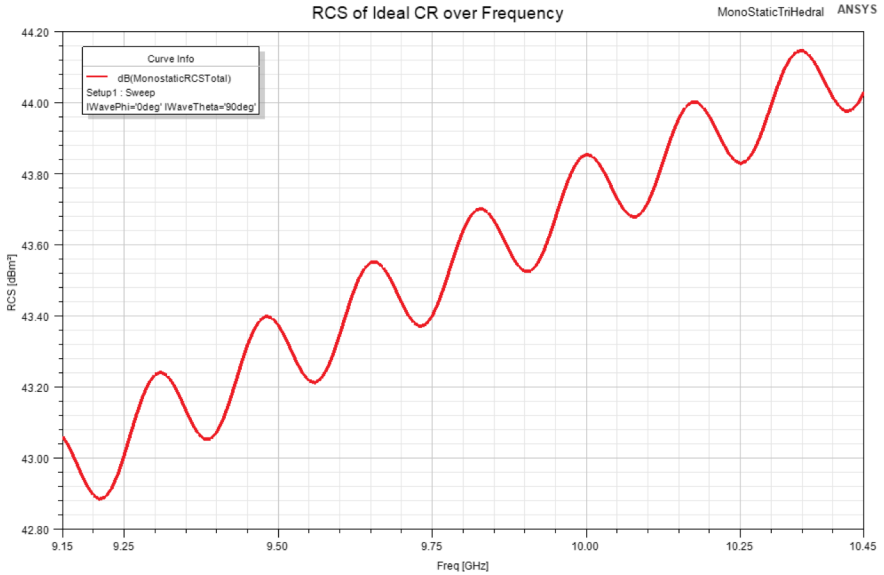


How to Overcome GO Simplification?



Corner Reflector has to be simulated

- Shoot & Bouncing Rays (SBR): based on Physical Optics -> not precise enough
- Finite Element Method (FEM): extreme Memory consumption -> not feasible
- Multilevel Fast Multipole Method (MLFMM): based on Method of Moments -> precise and fast

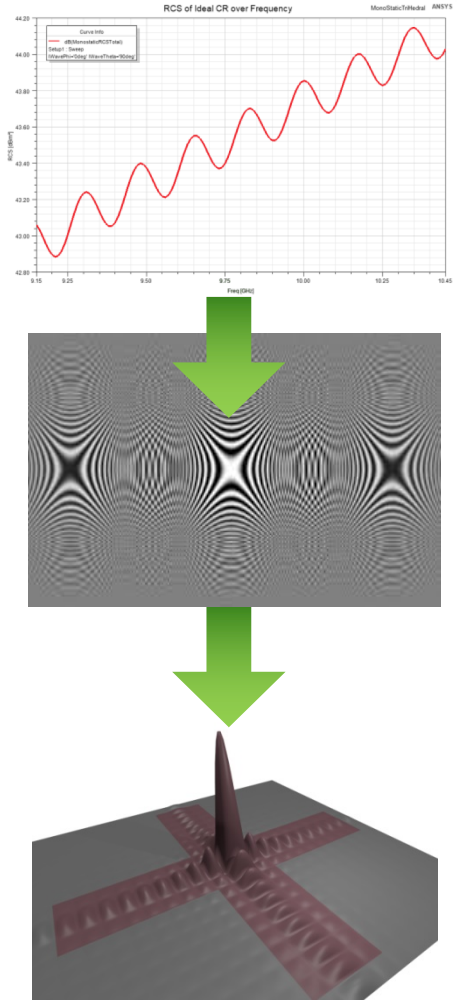


Surface Currents and Edges causing oscillation for RCS

Oscillation Amplitude depends of relative Size (1.5 m CR @ X-band: ±0.2 dB)

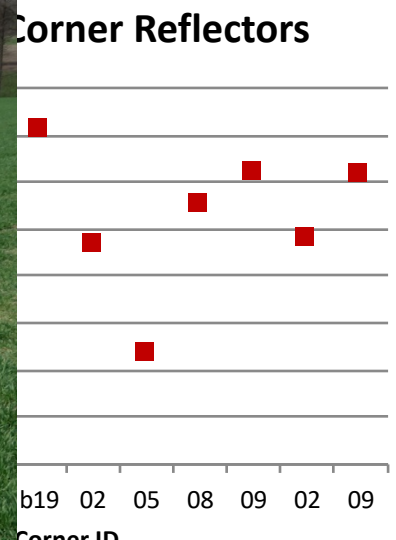
Point Target Simulation

- SAR Processing is a filtering
  - over Frequency in Range Direction
  - over Synthetic Aperture Angle in Azimuth Direction
- Point Target Simulation calculates the Impulse Response Function (IRF) considering the SAR parameters like
  - Range Bandwidth
  - Doppler Bandwidth
  - Windowing Filter



Corner Reflector Deformation

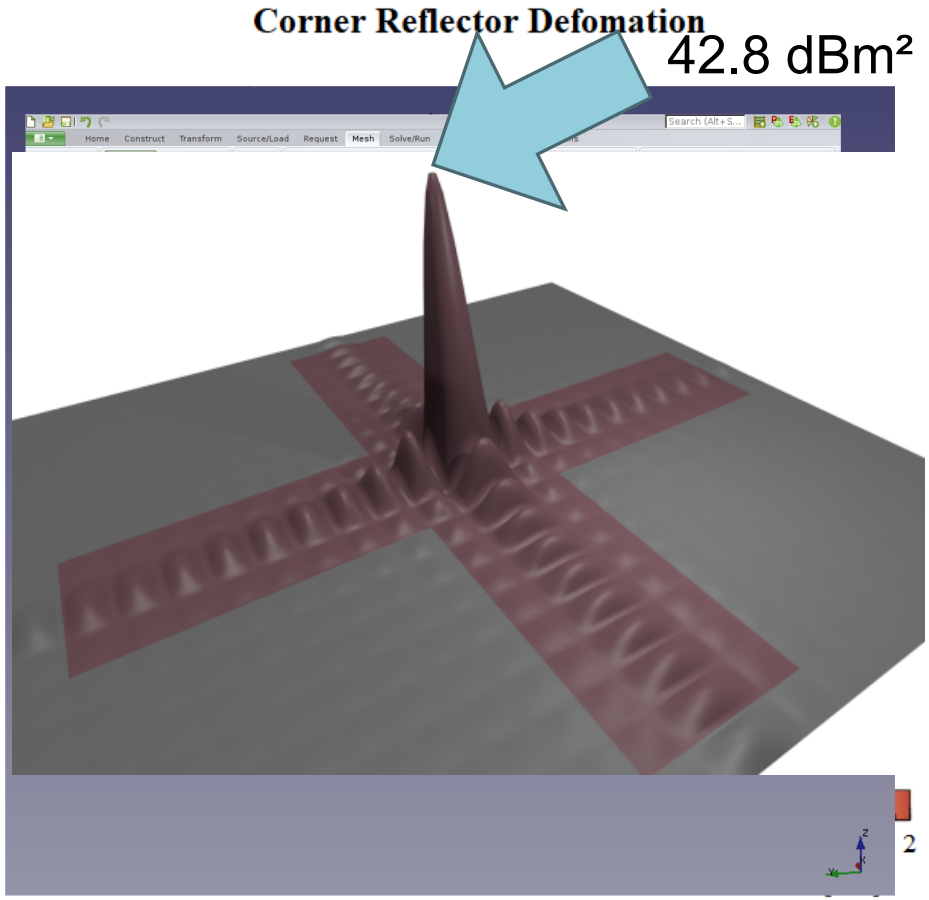
- Mechanical build
- Environmental deformation
  - Relocation
  - Hails
  - Beer
  - Farm
- These Def



SAR-X during Transponder
2019

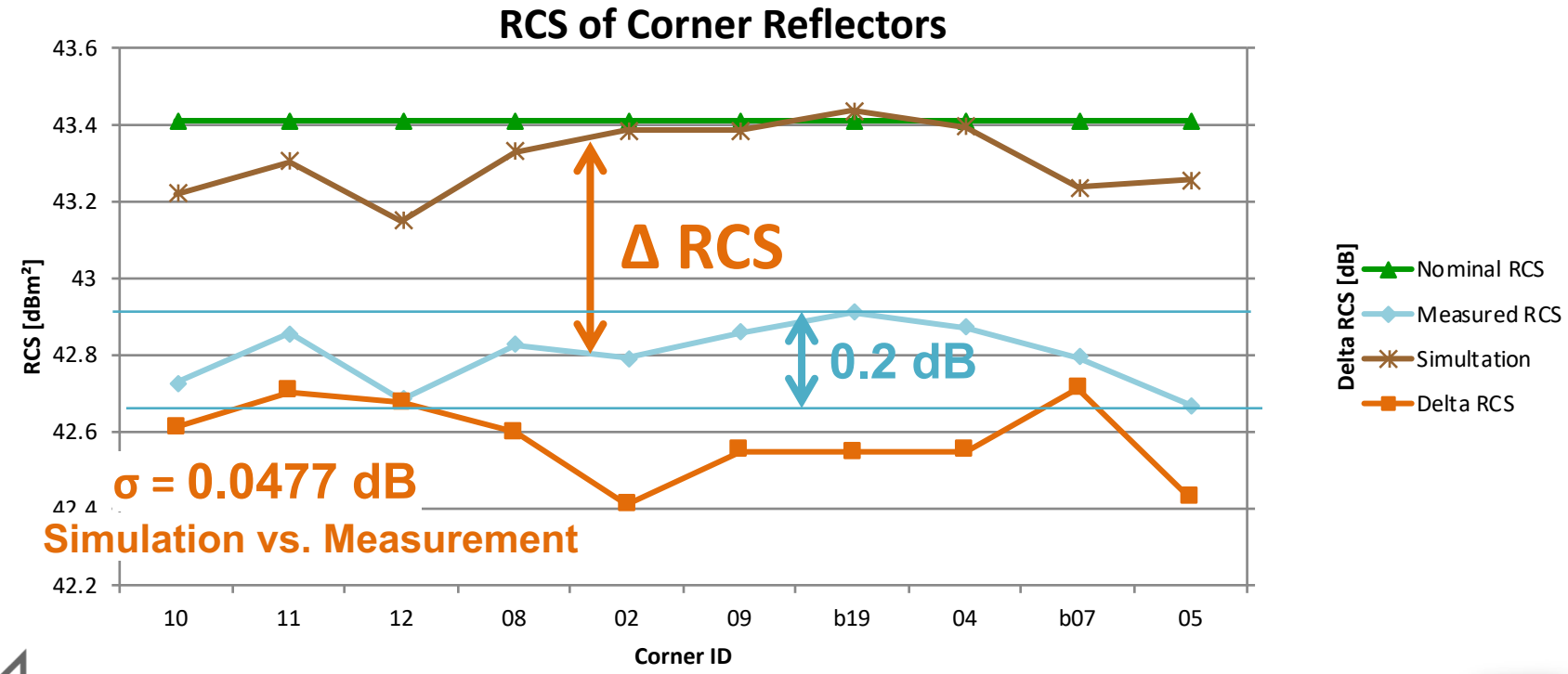
How to retrieve a good RCS Estimation?

- Measurement of Geometry for all Corner Reflectors individually
- Retrieve the Geometry & Estimate Errors (Deformation, Orthogonality)
- Generating a Mesh
- Simulating the Mesh
- Running a Point Target Simulation
- Determining (E)RCS



Uncertainty Estimation: Relative Error

- Relative RCS between Corner Reflectors as measured by TerraSAR-X
- Standard-Deviation: ~0.15 dB, Standard Error: ~0.031 dB



Uncertainty Estimation: Absolute Error

What absolute reference to use if the CR is already our best RCS reference?

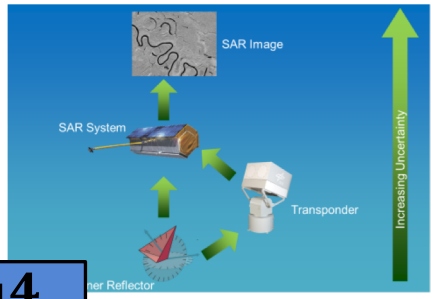
RCS of Trihedral Corner Reflectors can be estimated much better than 0.1 dB (1σ)

- Solution of HFSS and FEKO slightly differ (Analysis is on-going)

➢ 3-Transponder-Method can estimate RCS without a Reference (Measurement is on-going)

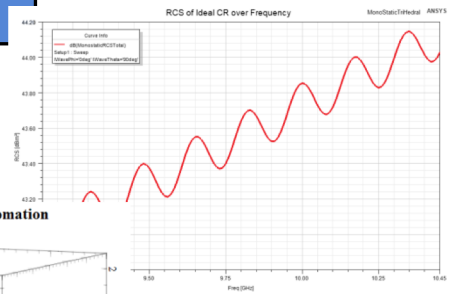
Conclusion

- Trihedral Corner Reflectors are the most commonly used Reference for Absolute Radiometric Calibration

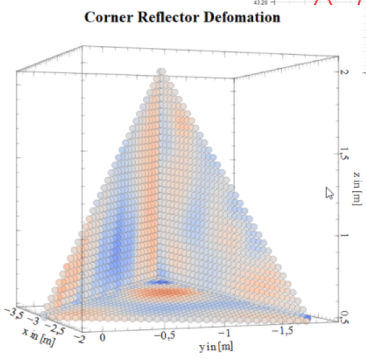


- Closed-form RCS equation is inaccurate for real Corner Reflectors

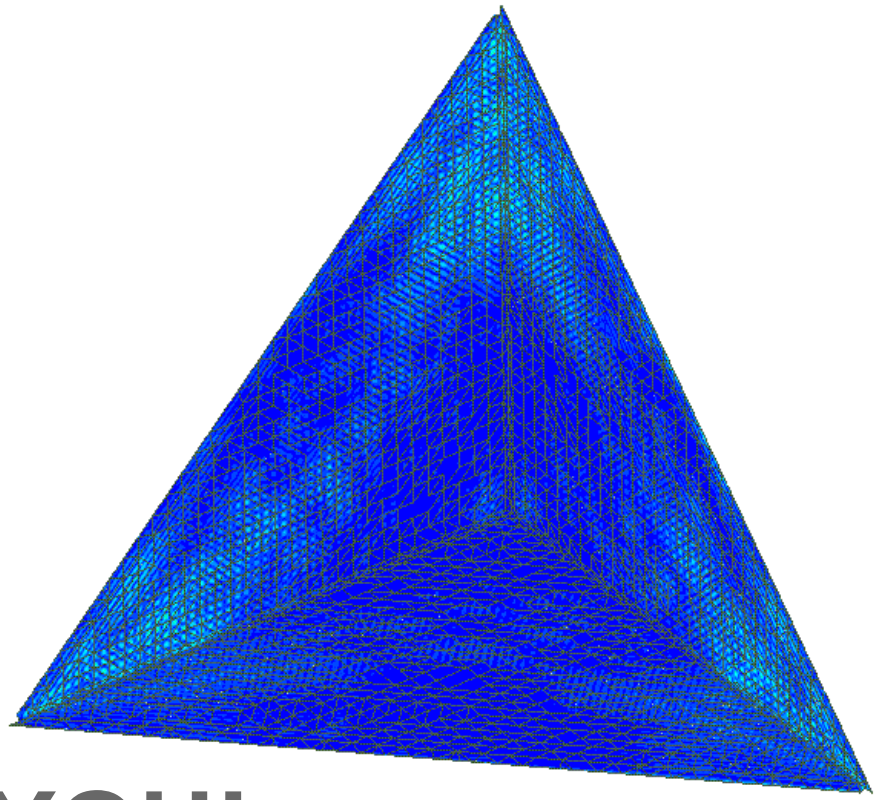
$$\sigma = \frac{4\pi l^4}{3\lambda^2}$$



- Full-wave Simulation of Trihedral Corner Reflectors has become feasible



- Individual Deformation has to be considered resulting in a RCS uncertainty < 0.1 dB



THANK YOU!

Dr.-Ing. Jens Reimann | Senior Scientist | Calibration
Tel: +49 8153-28-3595 | Fax: +49 8153-28-1449 | jens.reimann@dlr.de

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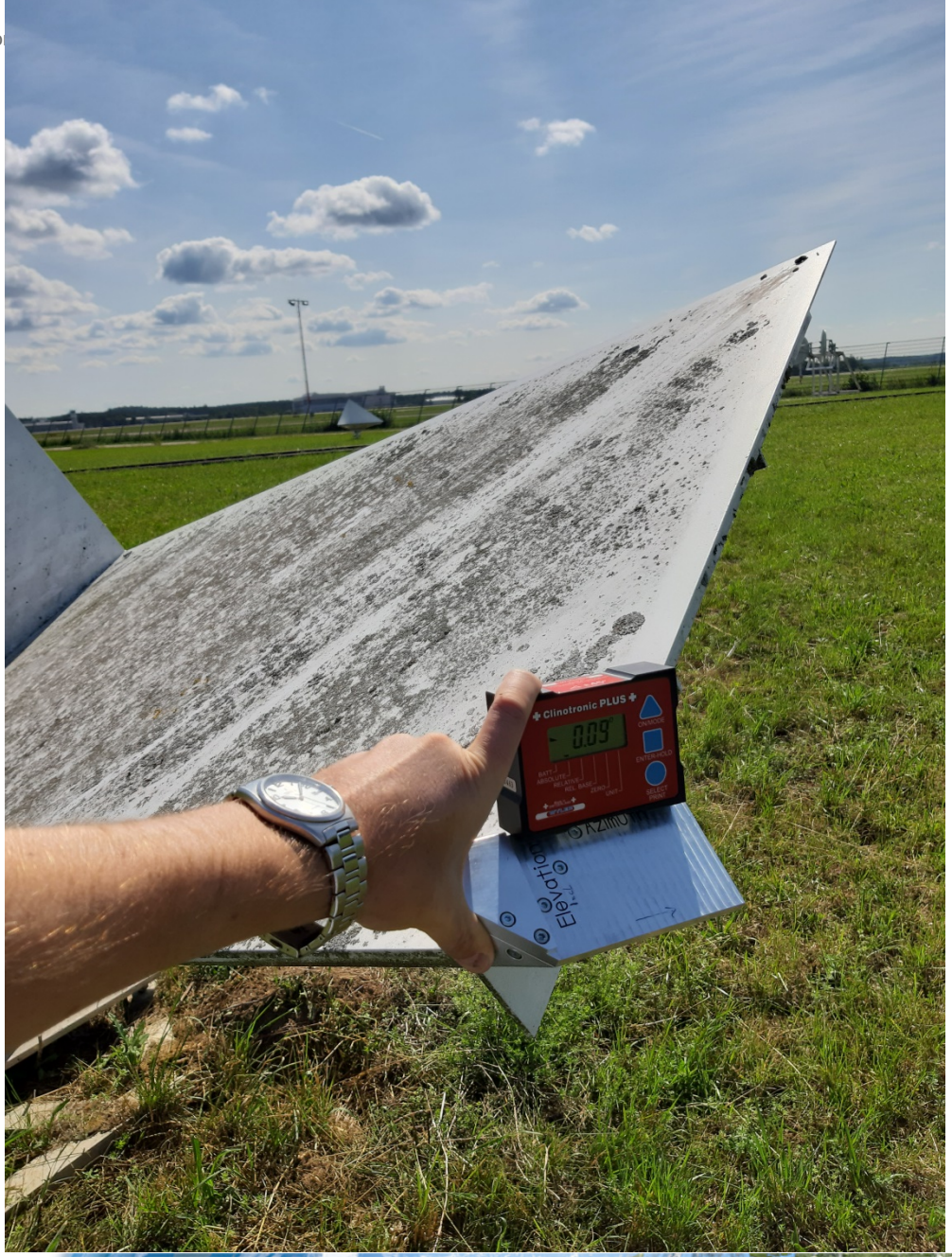
BACKUP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