

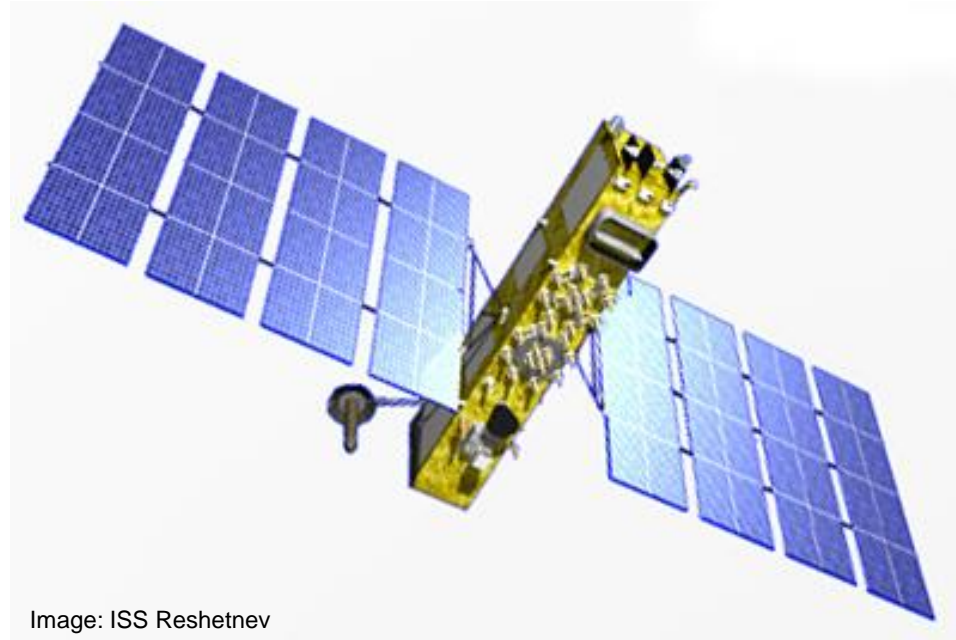
GLONASS modernization: initial characterization of the first K2 spacecraft

Peter Steigenberger, Steffen Thaelert, Oliver Montenbruck



GLONASS-K2

- Launched in August 2023
- 2.5 m x 6.0 m x 1.4 m
- Solar panels: 34 m²
- 1645 kg
- Signals:



Frequency **D**ivision **M**ultiple **A**ccess

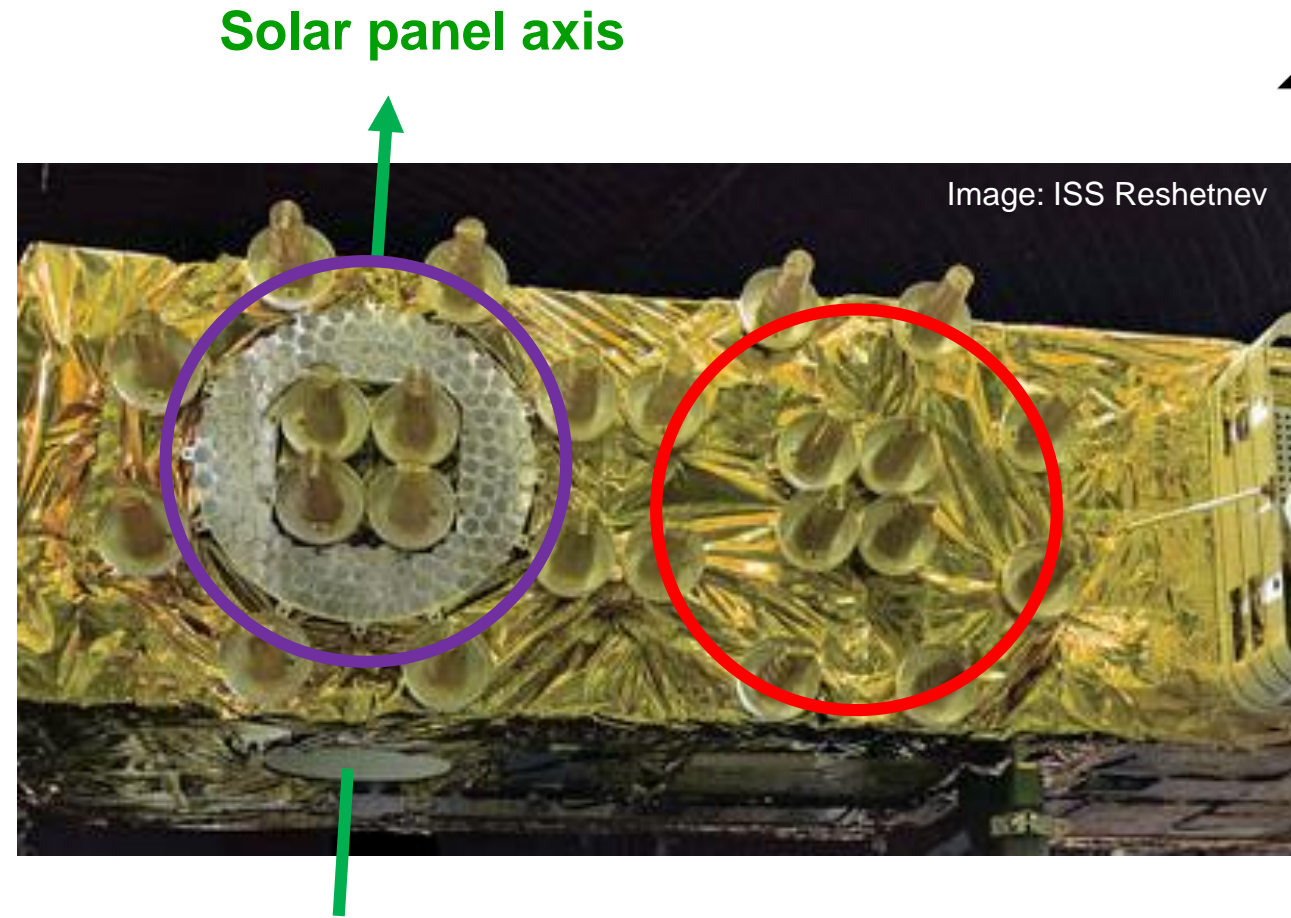
- L1 FDMA (legacy)
- L2 FDMA (legacy)

Code **D**ivision **M**ultiple **A**ccess

- L1 CDMA (new)
- L2 CDMA (new)
- L3 CDMA (M+, K1)

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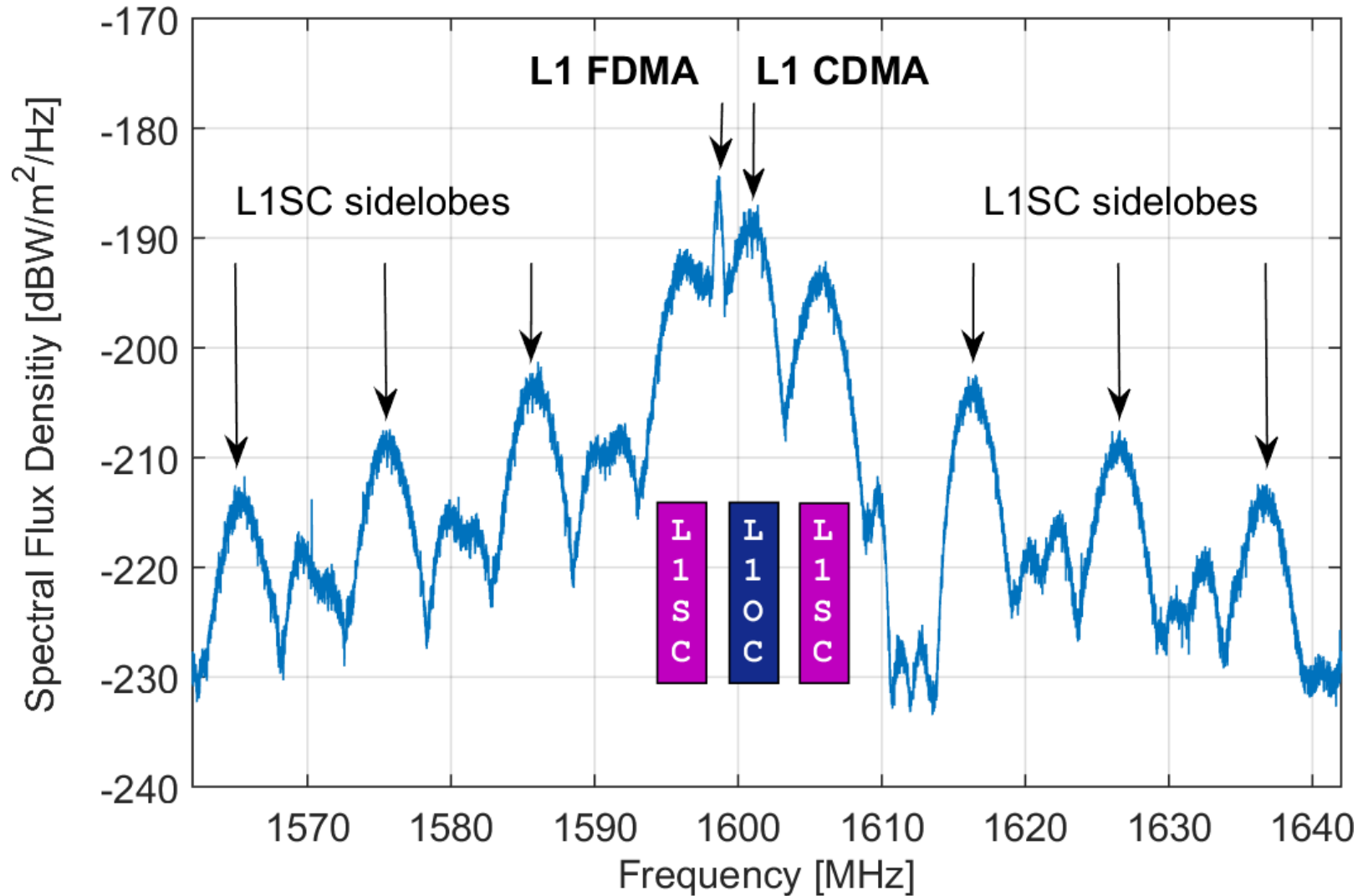
Frequency Division Multiple Access

- L1 FDMA (legacy)
- L2 FDMA (legacy)

Code Division Multiple Access

- L1 CDMA (new)
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L1 Frequency Spectrum



- Measured with 30 m high-gain antenna in Weilheim, Germany

L1SC

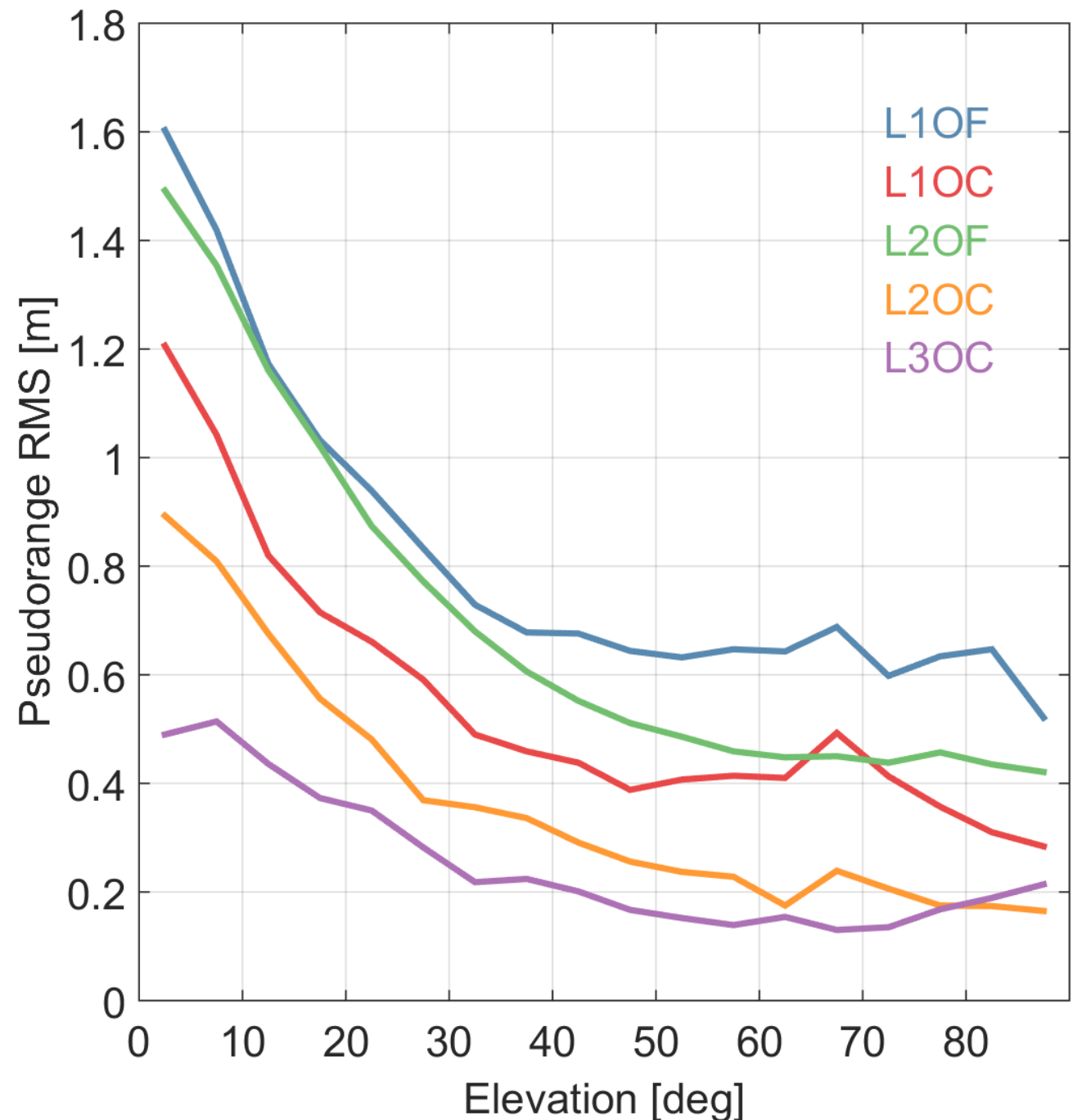
- L1 Secure Service CDMA
 - Binary Offset
 - Carrier: BOC(5,2.5)

L1OC

- L1 Open Service CDMA
 - data component
 - pilot component

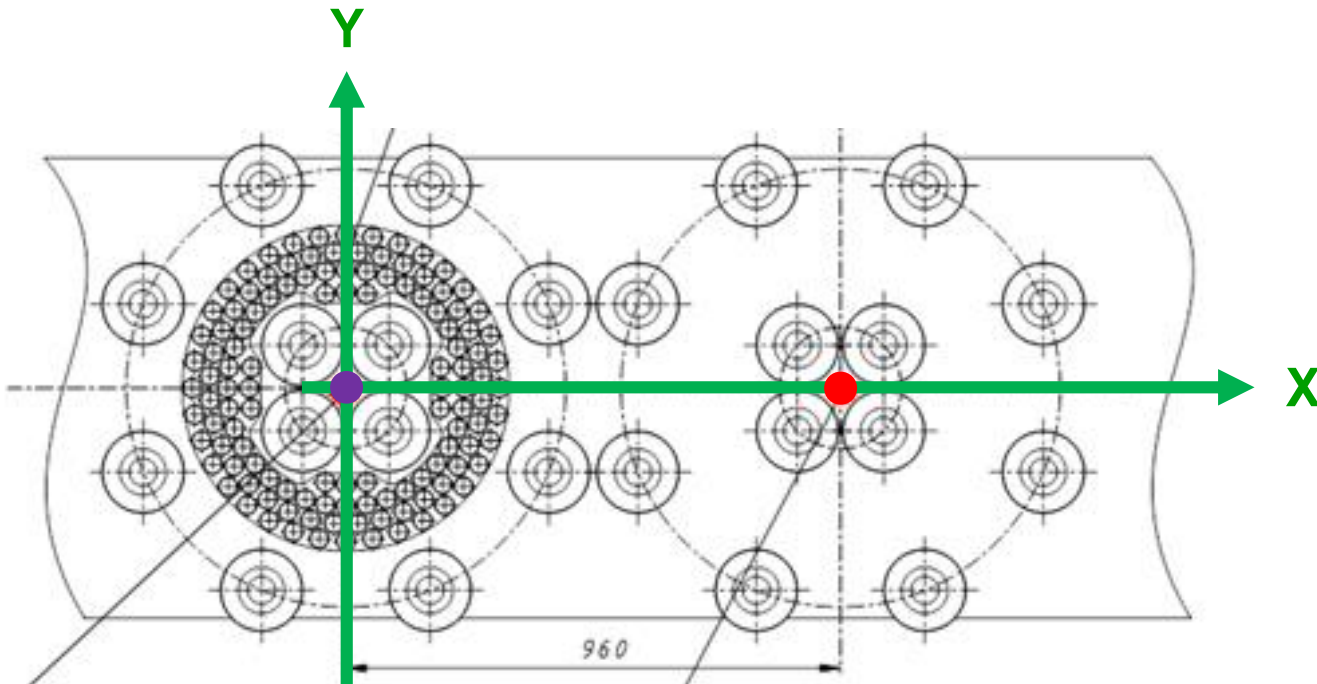
Receiver Tracking

- Javad TRE_3S with prototype firmware
- Dual-frequency pseudorange noise and multipath linear combination
 - **L1OF**: L1 Open Service FDMA
 - **L2OF**: L2 Open Service FDMA
 - **L1OC**: L1 Open Service CDMA
 - **L2OC**: L2 Open Service CDMA
 - **L3OC**: L3 Open Service CDMA

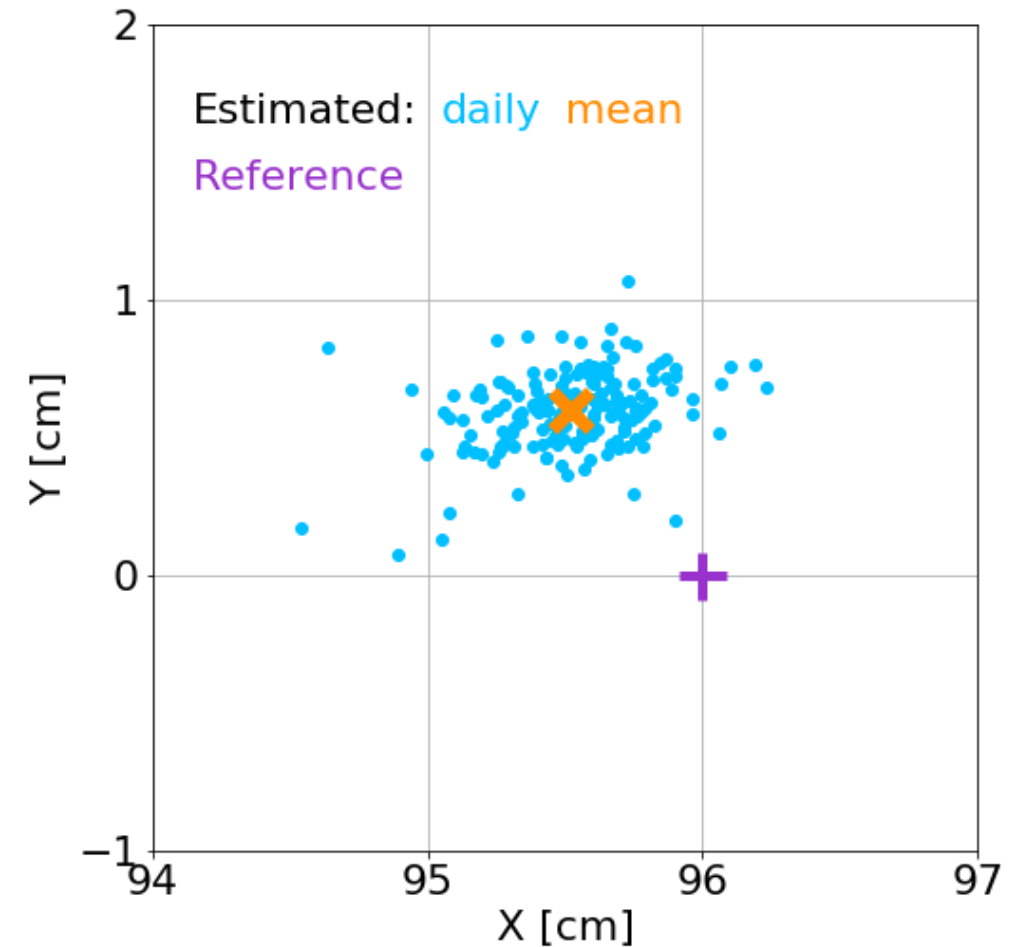


FMDA/CDMA Antenna Baseline Estimation

- Ionosphere- and geometry-free triple-frequency linear combination
 - L3 **CDMA**, L1 and L2 **FDMA**
 - Estimation of periodic line bias variations



Solar panel axis



Satellite Antenna Phase Center Offsets



Broadcast ephemerides

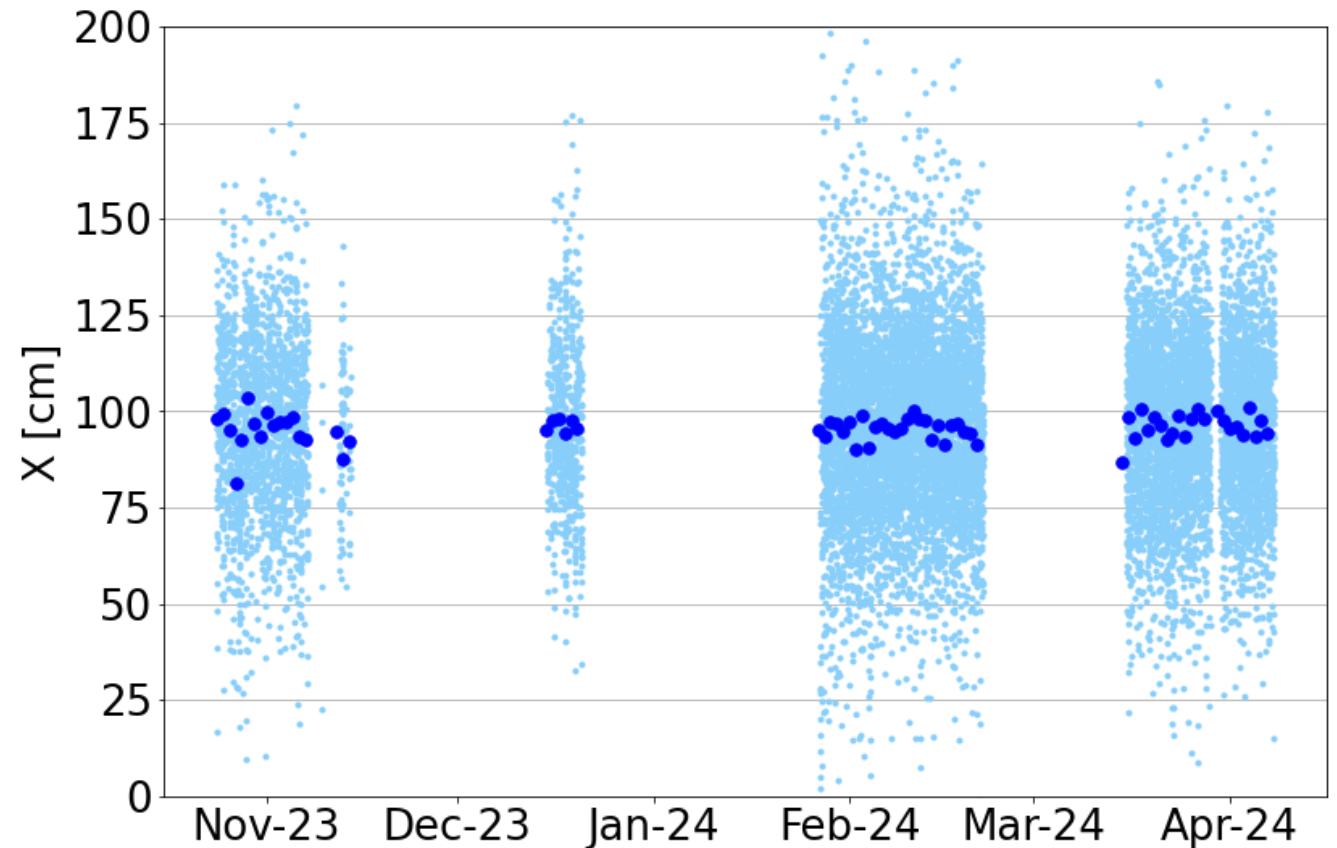
- FDMA: antenna phase center
- CDMA: center of mass

$$\text{PCO}_{\text{FDMA}} = \mathbf{T} (\mathbf{r}_{\text{FDMA}} - \mathbf{r}_{\text{CDMA}})$$

Transformation Earth-fixed into spacecraft body frame

5 min: 95.9 ± 23.7 cm

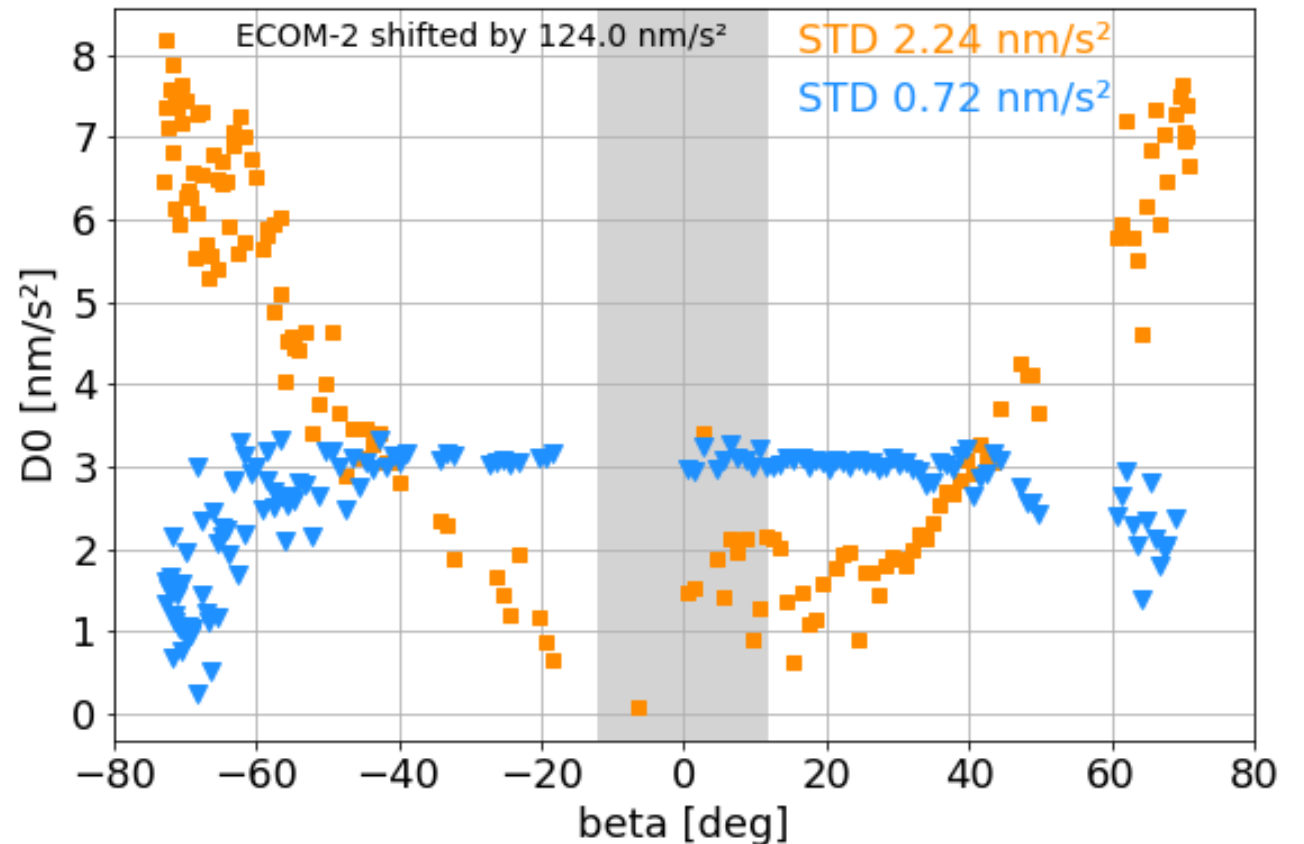
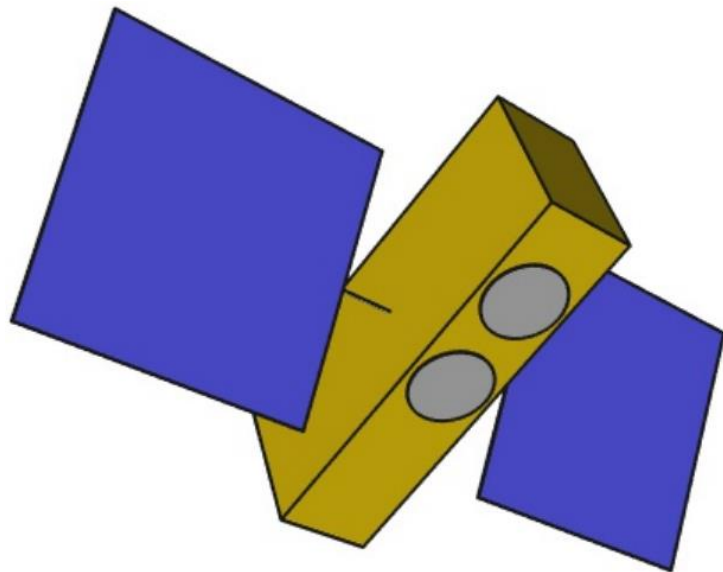
Daily: 95.7 ± 3.5 cm



Solar Radiation Pressure Modeling

Box-wing model from approximate dimensions and default optical properties

- ECOM-2 (7 parameters)
- Box-wing model + estimation of 5 empirical ECOM parameters



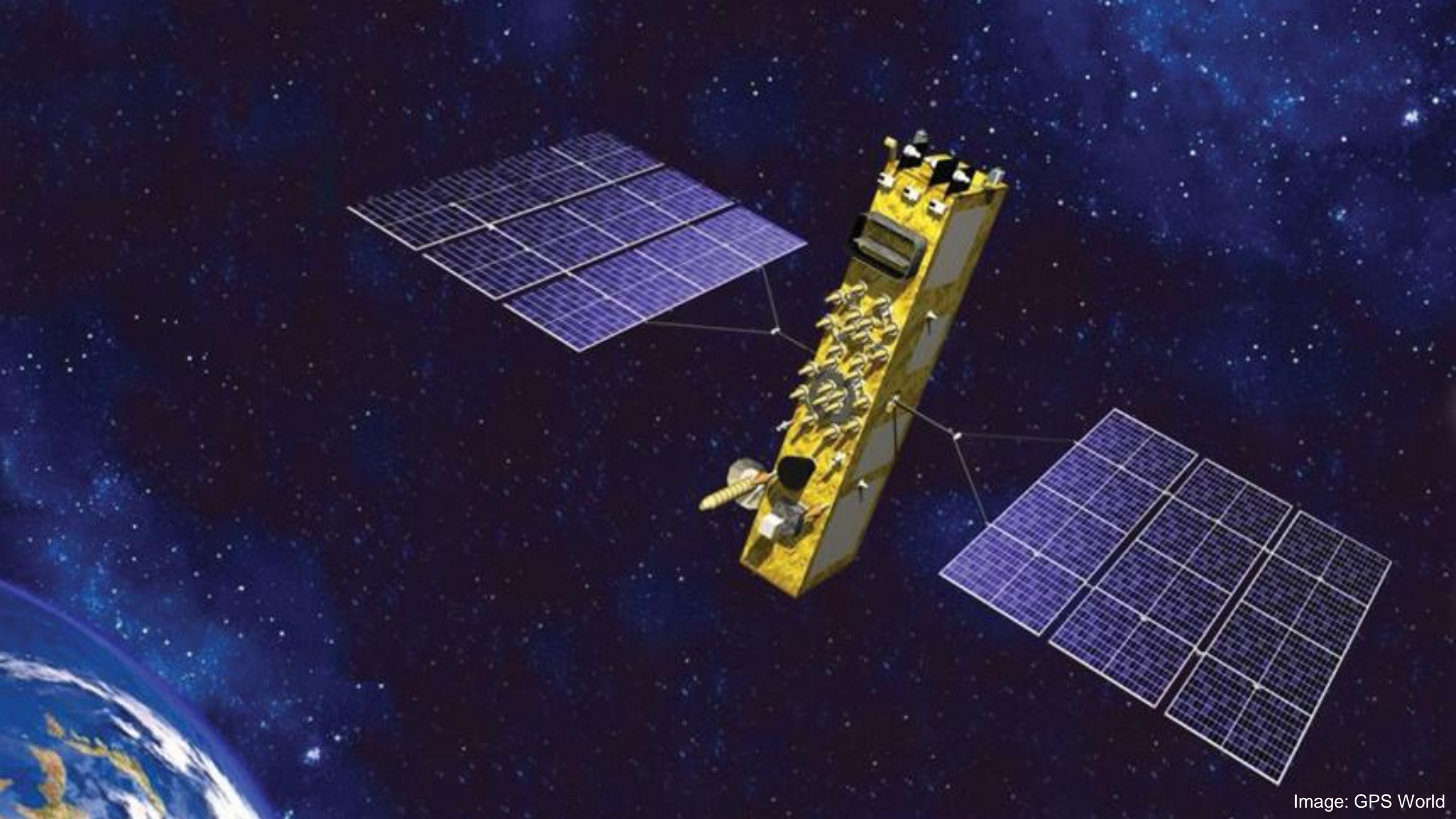


Image: GPS World