

# **GLONASS modernization: initial characterization of the first K2 spacecraft**

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# GLONASS-K2



- Launched in August 2023
- 2.5 m x 6.0 m x 1.4 m
- Solar panels: 34 m<sup>2</sup>
- 1645 kg
- Signals:

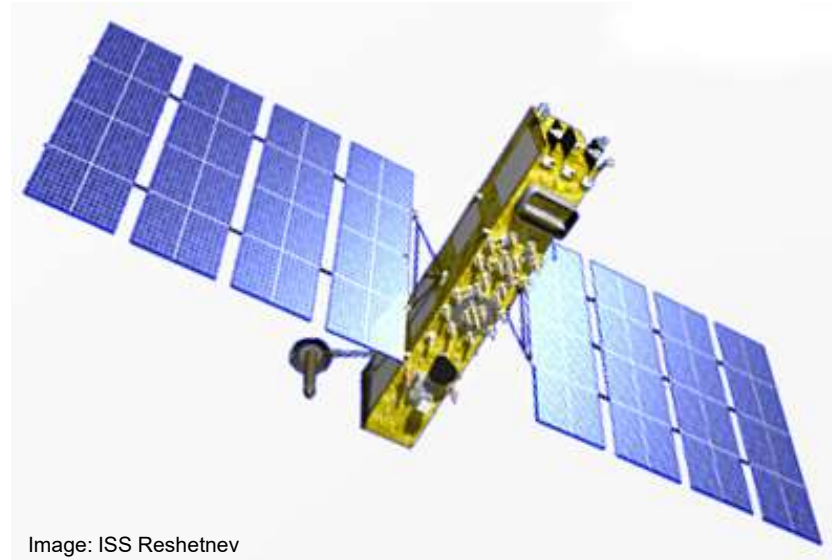


Image: ISS Reshetnev

## 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)

# GLONASS-K2

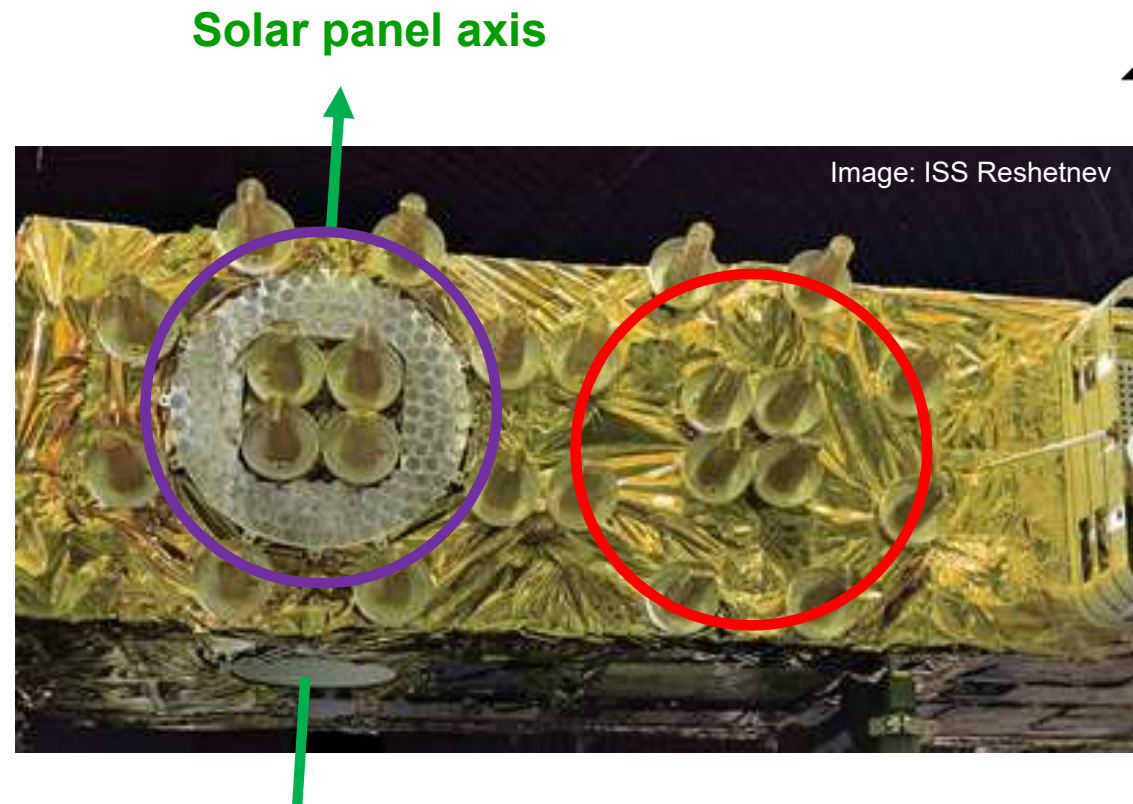
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## Frequency Division Multiple Access

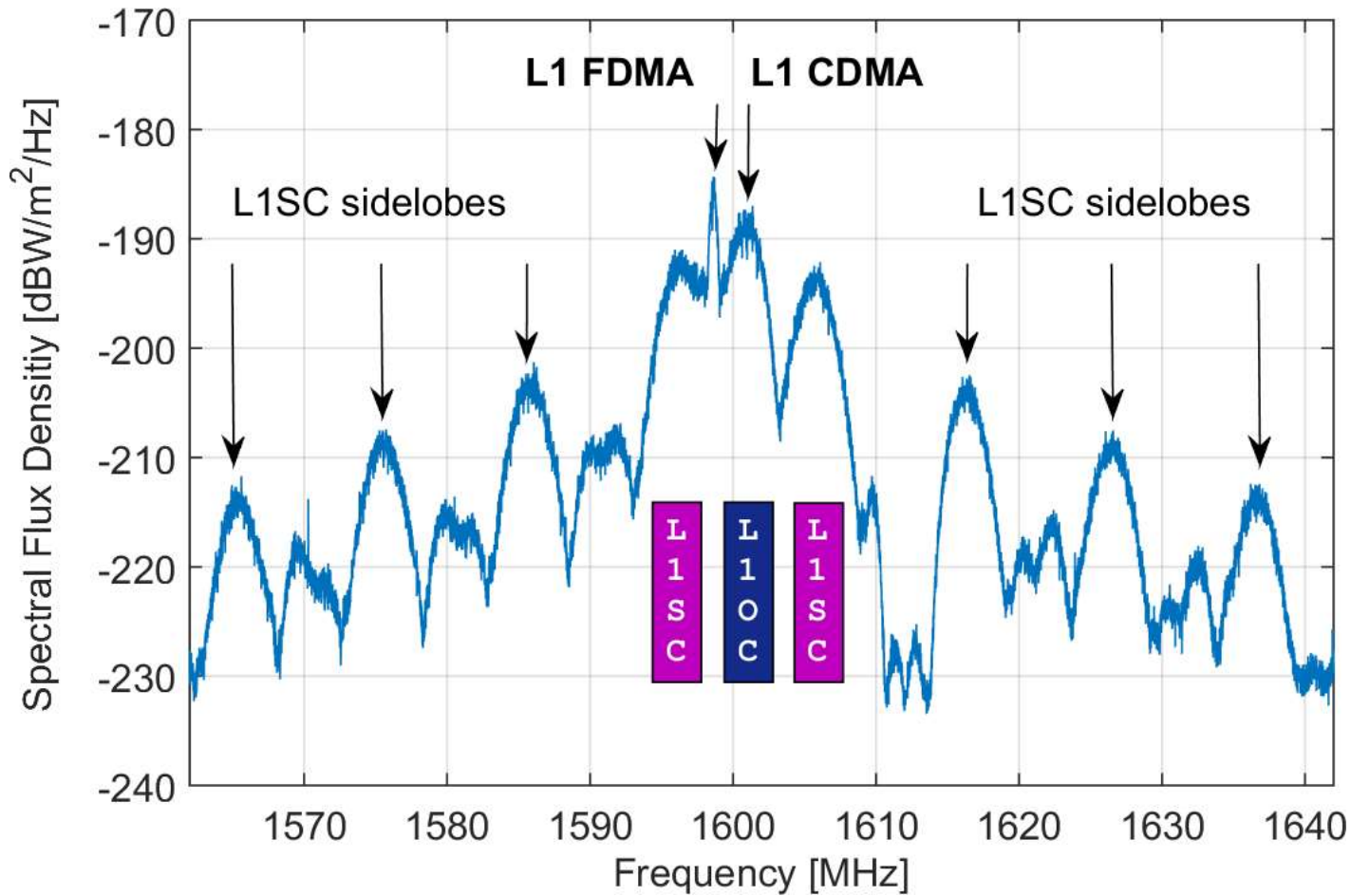
- L1 FDMA (legacy)
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## Code Division Multiple Access

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



# L1 Frequency Spectrum



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

## L1SC

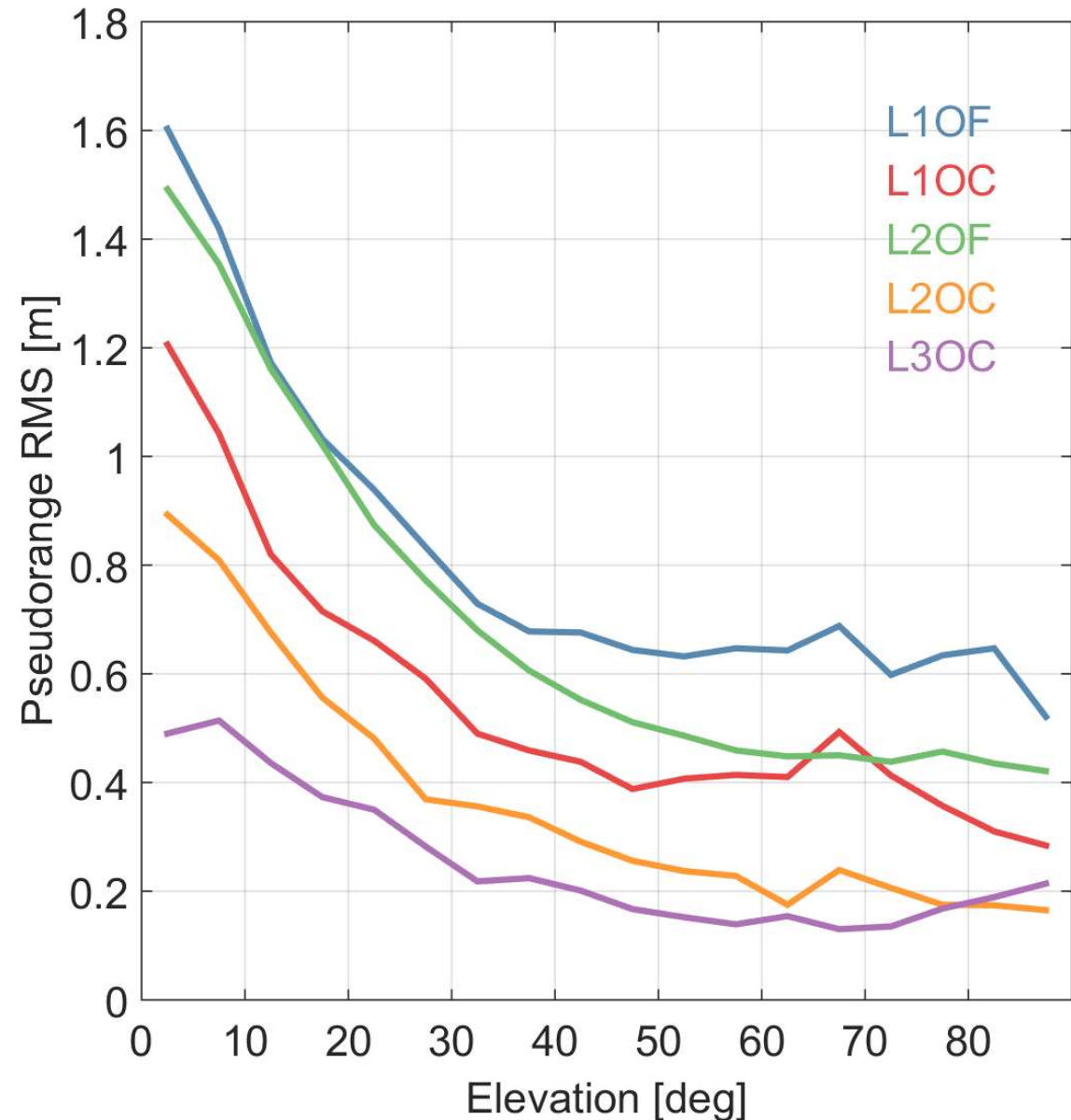
- L1 Secure Service CDMA
  - Binary Offset
  - Carrier: BOC(5,2.5)

## L1OC

- L1 Open Service CDMA
  - data component
  - pilot component

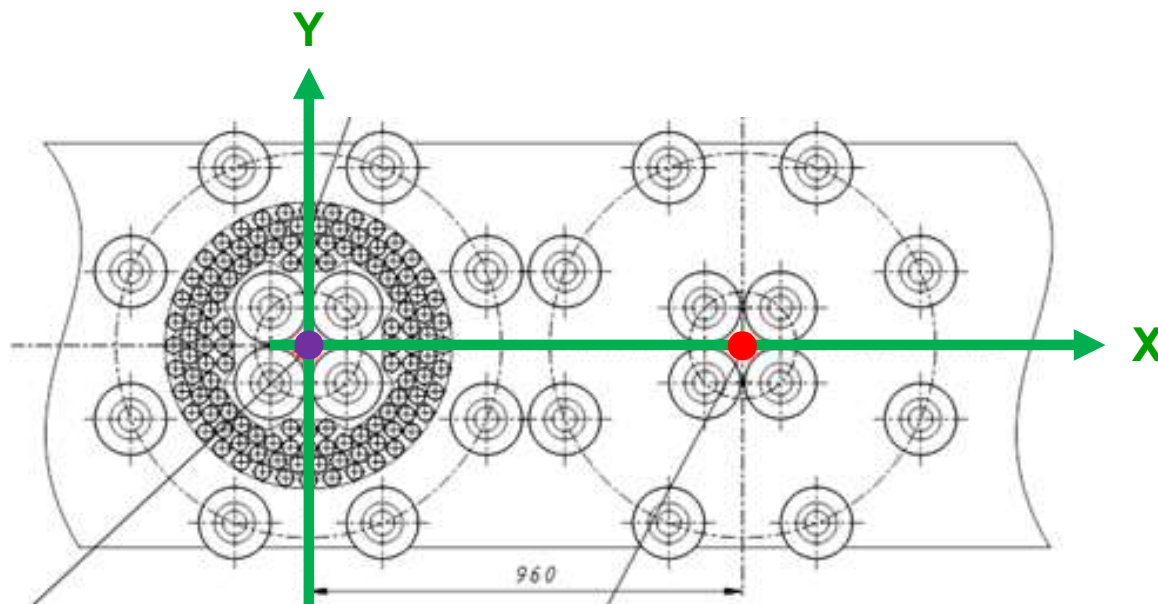
# Receiver Tracking

- 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

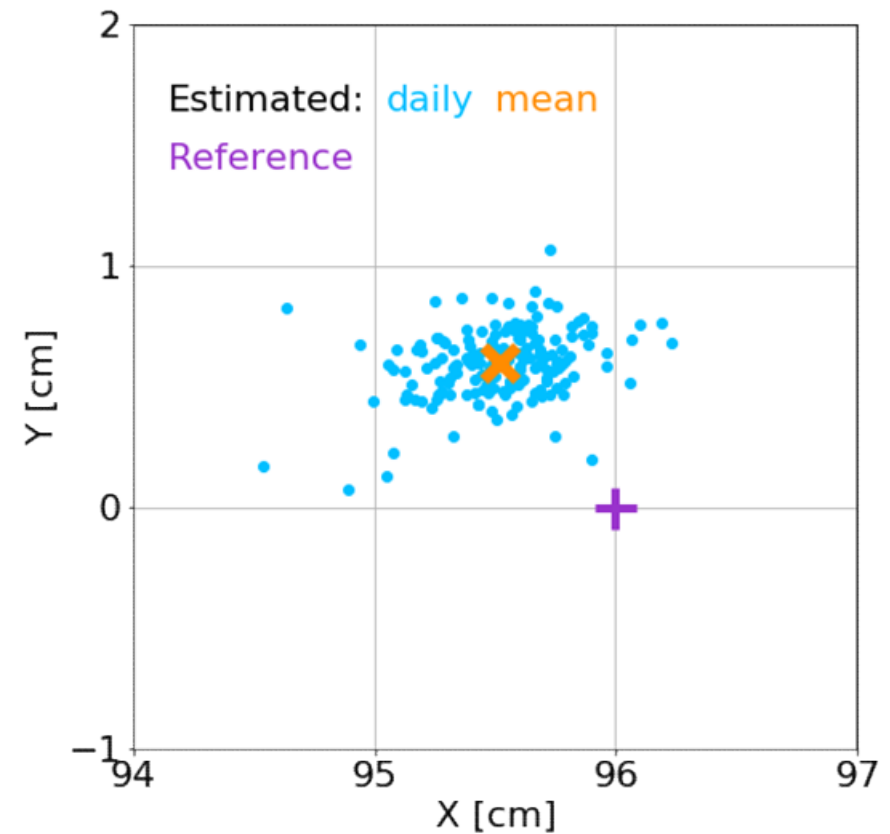


# FMDA/CDMA Antenna Baseline Estimation

- 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

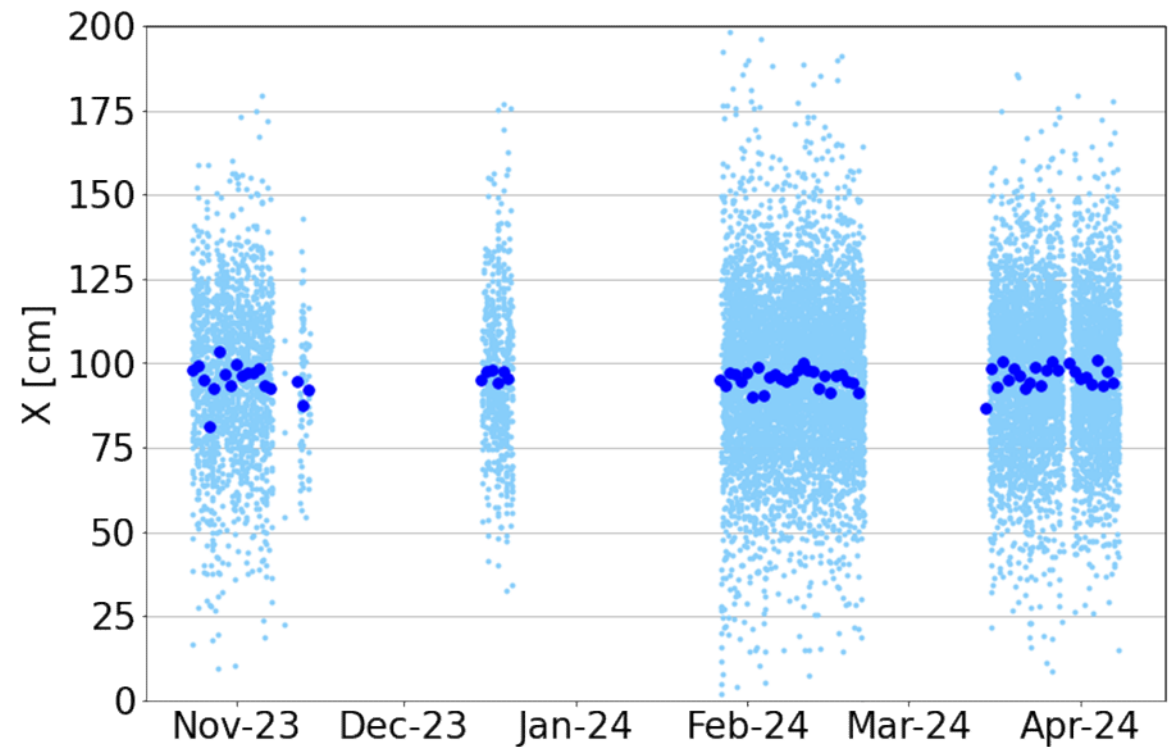
$$PCO_{FDMA} =$$

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

Transformation Earth-fixed into spacecraft body frame

5 min:  $95.9 \pm 23.7$  cm

Daily:  $95.7 \pm 3.5$  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

