

## SLR station Sazhen-T (Shelkovo)



Telescope



Telescope dome



Operator workplace

| Ranging  | Angle measurements  | Photometry                              |
|--|---|---|
| Orbit height up to 36000 km<br>NP RMS 0,5 – 1 cm | Brightness $\leq 14^m$<br>RMS 1 – 2 arcsec<br>for angle velocity $\leq 40$ arcsec/sec | Brightness $\leq 13^m$<br>RMS $< 0,2^m$ |

## Altay Optical/Laser Center (AOLC)



## Telescope overview



Dome fold

Wide-field objective dia. 350  
мм FOV 6,25 sq.deg

Laser beam collimator dia.200  
mm

Main receive objective: dia.  
600mm, FOV 19x14 sq.min

Torque motor

Mount

## TRANSPORTABLE SLR STATION SAZHEN-TOS (Baikonur)

Receive objective dia. 60 cm



| Ranging                     | Angle measurements  | Photometry             |
|-----------------------------|---|------------------------|
| Orbit height up to 36000 km | Brightness $\leq 14^m$                                      | Brightness $\leq 13^m$ |
| NP RMS 0,5 – 1 cm           | RMS 1 – 2 arcsec<br>for angle velocity $\leq 40$ arcsec/sec | RMS $< 0,2^m$          |

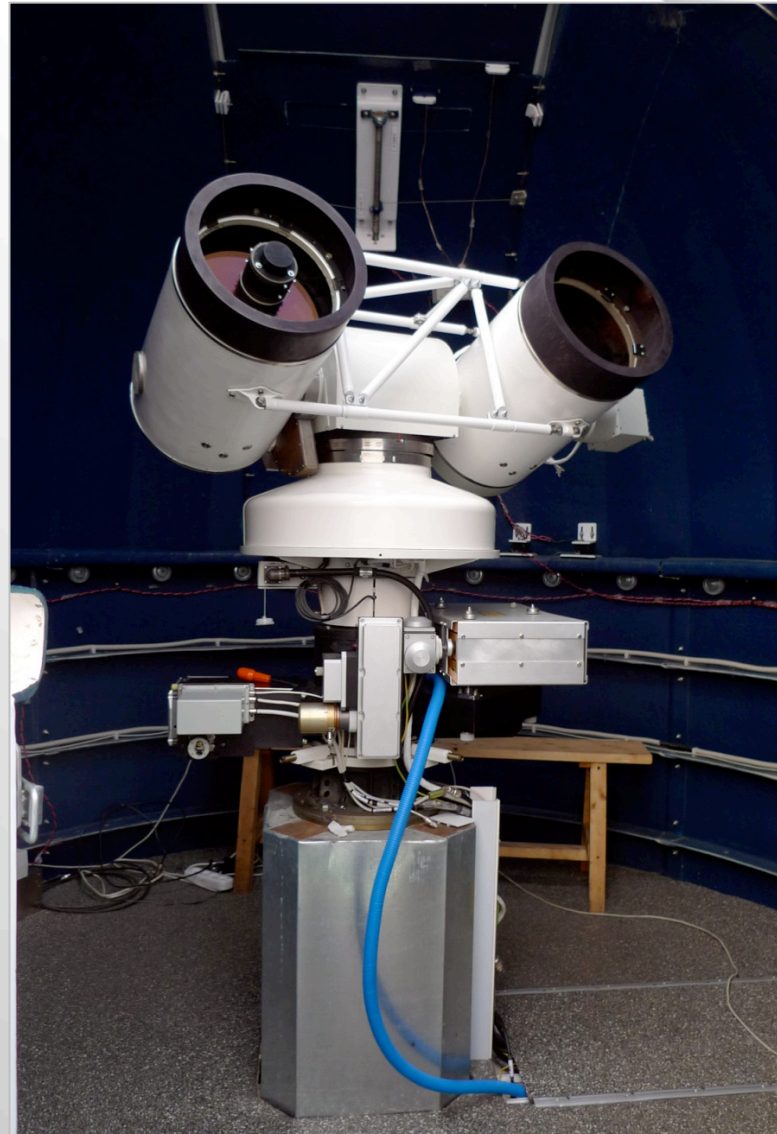
## Serially produced Sazhen-TM SLR station

Objective dia. 25 cm



| Ranging                     | Angle measurements  | Photometry             |
|-----------------------------|---|------------------------|
| Orbit height up to 23000 km | Brightness $\leq 12^m$                                      | Brightness $\leq 11^m$ |
| NP RMS 0,5 – 1 cm           | RMS 1 – 2 arcsec<br>for angle velocity $\leq 40$ arcsec/sec | RMS $< 0,2^m$          |

## Sazhen-TM in dome



## RUSSIAN SLR NETWORK (2011)



## Относительная эффективность ретрорефлекторных систем на КА ГЛОНАСС (по данным станций ILRS)

| Номер и название станции |                     | Среднее число ответов за 300 секунд |     |      |                                      |             | Средний выигрыш |
|--------------------------|---------------------|-------------------------------------|-----|------|--------------------------------------|-------------|-----------------|
|                          |                     | ГЛОНАСС-713, 716, 723               |     |      | Среднее для КА ГЛОНАСС-713, 716, 723 | ГЛОНАСС-729 |                 |
|                          |                     | 713                                 | 716 | 723  |                                      |             |                 |
| 1                        | 7839 Graz *         | 1585                                | 925 | 1085 | 1198                                 | 1740        | 1,45            |
| 2                        | 7840 Herstmonceux * | 242                                 | 251 | 232  | 242                                  | 354         | 1,46            |
| 3                        | 7825 Mt.Stromlo *   | 57                                  | 60  | 45   | 54                                   | 75,7        | 1,4             |
| 4                        | 7110 Monument Peak  | 108                                 | 140 | 131  | 126                                  | 172         | 1,36            |
| 5                        | 7090 Yarragadee     | 169                                 | 122 | 110  | 134                                  | 216         | 1,61            |
| 6                        | 7358 Tanegashima    | 778                                 | 791 | 375  | 648                                  | 852         | 1,31            |
| 7                        | 7810 Zimmerwald     | 529                                 | 576 | 552  | 552                                  | 573         | 1,04            |



## Terminal of Inter-Satellite Laser Navigation/Communication System for SC GLONAS-M



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## ISNCS Ground terminal

Image of this wide-field ( $2,5^{\circ} \times 2,5^{\circ}$ ) telescope at the Altay optical/laser center, with the ground station beacon laser on.

28.06.2009 22:10 ДМВ

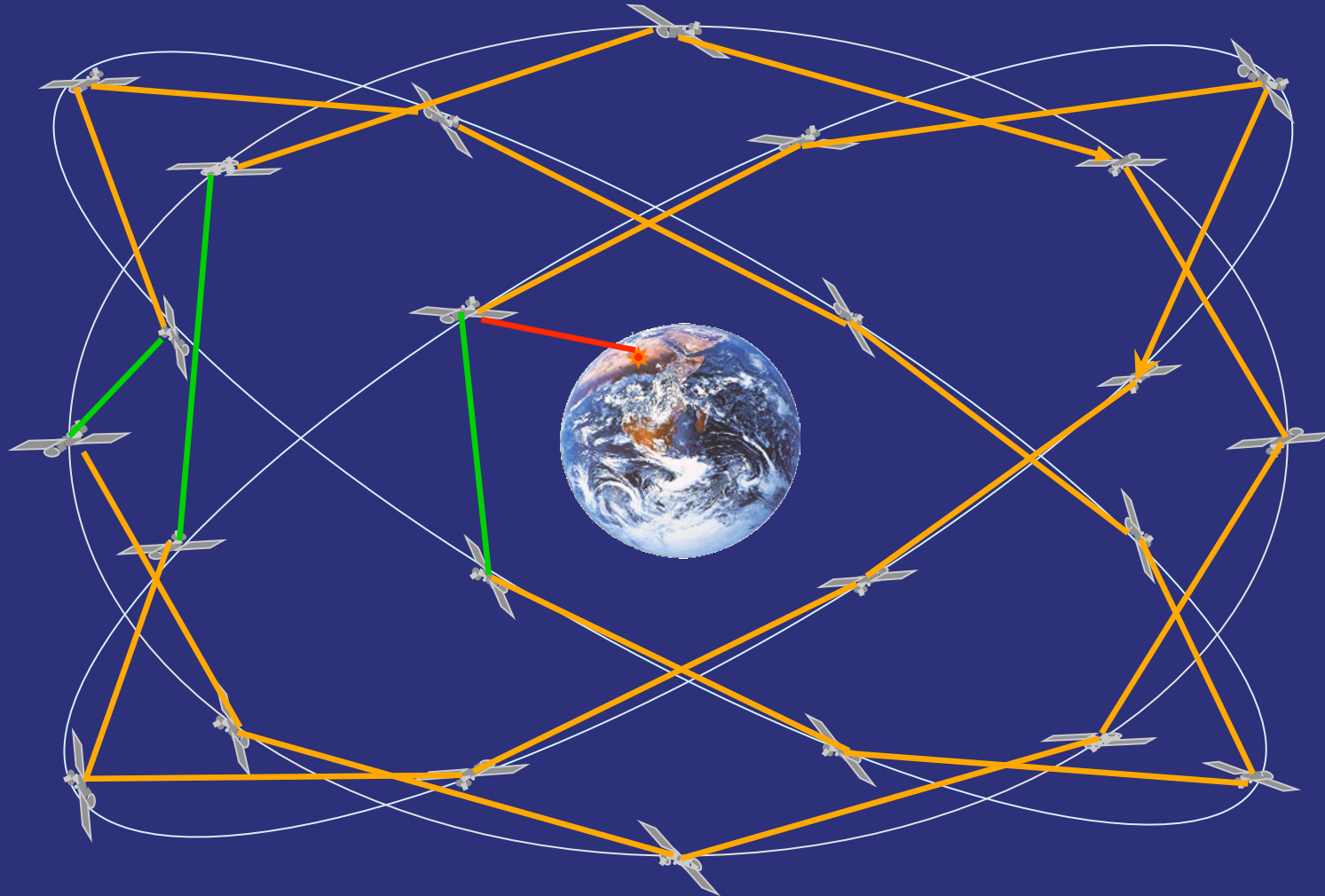
+

SC GLONASS



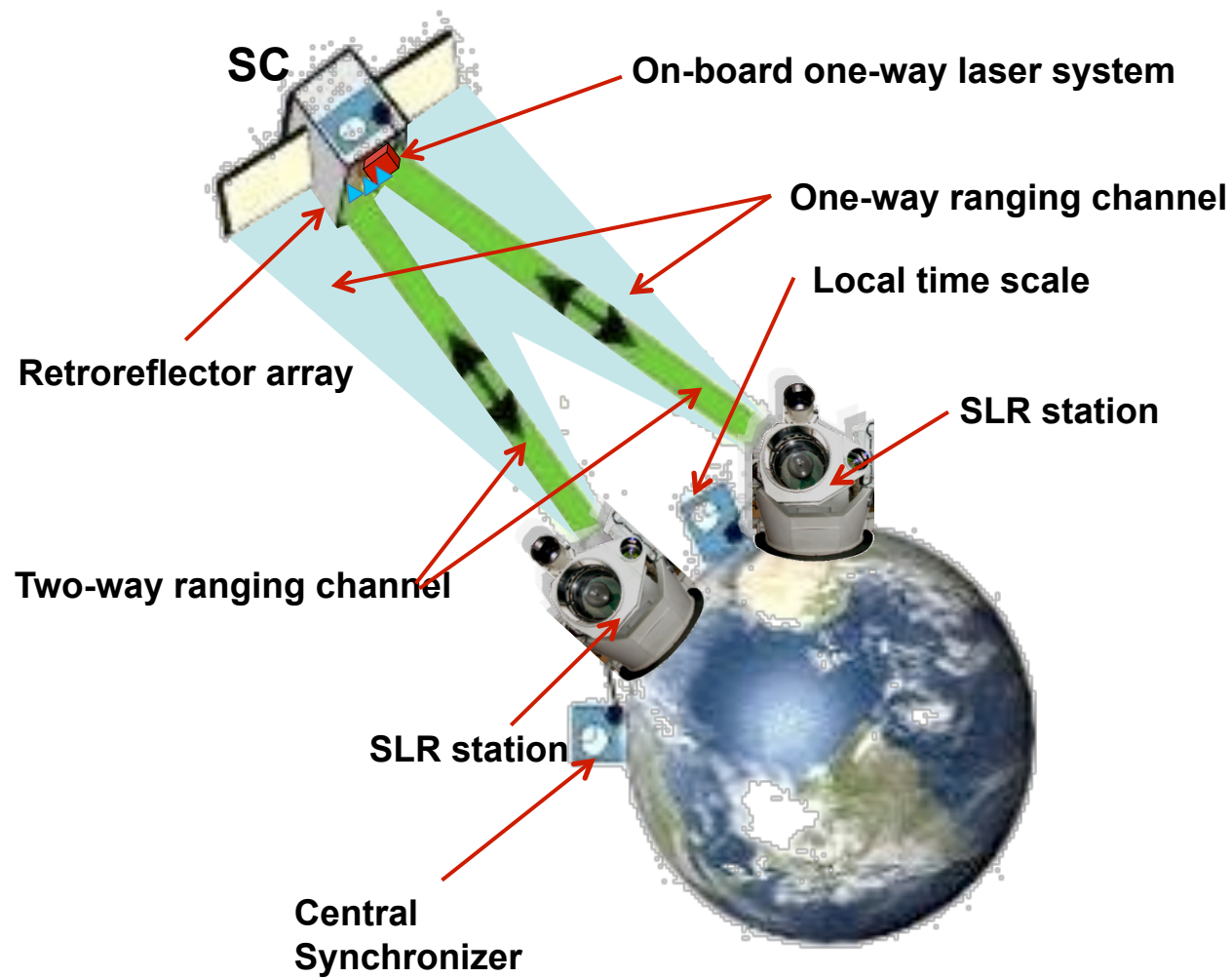
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## Topology of ISNCLS mutual measurements



Two-channel laser communication links will be established between all GLONASS spacecraft, providing in-plane and inter-plane data exchange. Time shifts in each link will be measured with an accuracy of 1 ns, as well as range with an accuracy of 10 cm. Two-way data exchange will be provided at a rate up to 50 kbps.

## One-way/two-way laser system



## Parameters of one-way/two-way laser system

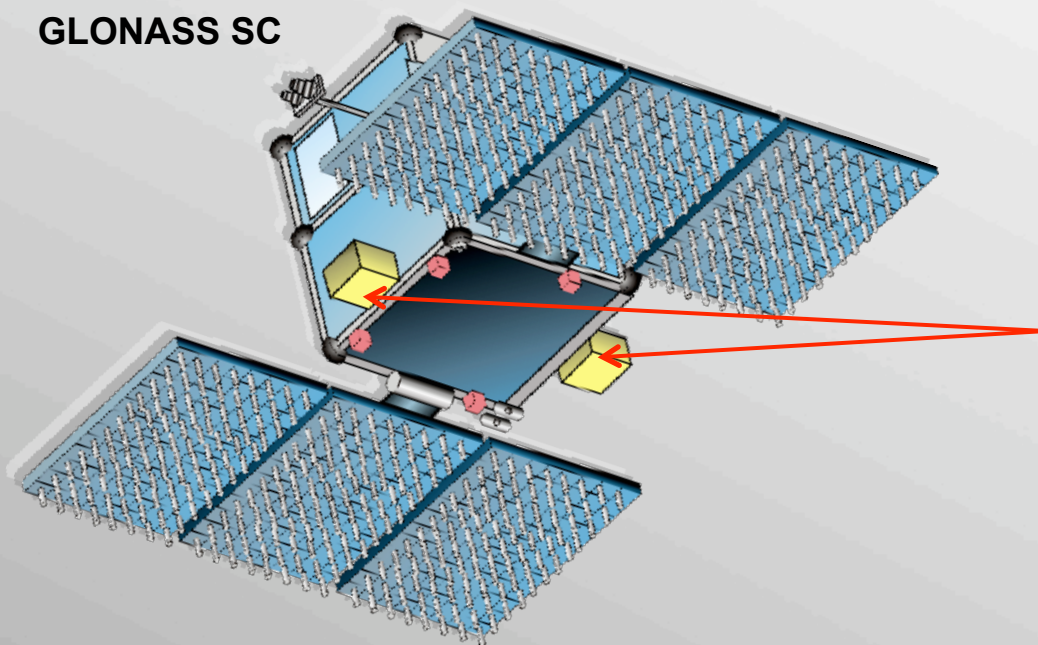


- One-way ranging (accuracy 15 mm);
- Two-way ranging (accuracy 15 mm);
- Measurement of SC time deviation from Central Synchronizer, with an accuracy of 0.1 ns
- Measurement of the remote ground station local time deviation relative to the Central Synchronizer, with an accuracy of 0.2 ns

## Parameters of ISNCS

| Parameter                               |                  |
|---|------------------|
| Range                                   | 300 to 55 000 km |
| Maximum ranging error ( $3\sigma$ )     | 10 cm            |
| Maximum timing error                    | 1 ns             |
| Spacecraft position error ( $2\sigma$ ) | 0,6 m            |
| Information bit rate                    | 50 kbps          |
| On-board equipment mass                 | $\leq 45$ kg     |

GLONASS SC



ISNCS terminal

