LASER GLONASS

Dr. Shargorodskiy Victor, dr. Kosenko Victor, dr. Chubykin Alexey,

dr. Pasynkov Vladimir, dr. Sadovnikov Mikhail

Open Joint-stock Company

«Research-and-Production Corporation «Precision Systems and Instruments»

Reshetnev company

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The biggest contribution in the balance of errors of GNSS user position determination is the error of the space segment consisting of navigation S/C constellation and S/C ground control system.

"Laser GLONASS" is a combination of methods and technology that will radically reduce that error.

Development of laser systems utilizing break-through information and measurement technologies is foreseen in 2012-2020 to achieve high accuracy characteristics of the GLONASS.

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Purpose of creation of laser technologies and systems

Achievement of GLONASS target characteristics

Component of error of position and time determination due to the space segment

- real time – up to 0.6 m and 0.1* m
  (base values – 2.8 m and 1.0 m)*
- in posterior mode – up to 0.03 m
  (base value 0.1 m)
- up to 1 ns *(base value – 5 ns)*
- calibration - up to 0,1 ns

* *using additional systems*

Obtaining measurement data to reduce:

- error of reference of Federal Geocentric Coordinate System (FGCS) to the center of gravity of the Earth – down to 0.01 m
  (base value – 0.5 m)
- FGCS error in GLONASS – down to 0.02 м
  (base value – 0.2 m)

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Laser GLONASS systems

- **Onboard systems**
  - ISLNCS
  - OOSLR
  - Array of CCR
- **Ground systems**
  - GOSLR
  - Network of SLR
    - *collocation*
      - SLR GMS
      - SLR GMS, VLBI
      - SLR GMS, VLBI DORIS
  - SVOEVP

ISLNCS - **I**nter **S**atellite **L**aser **N**avigation and **C**ommunication **S**ystem

OOSLR – **O**n-board **O**ne-way **SLR**

GOSLR – **G**round **O**ne-way **SLR**

CCR – **C**orner **C**ube **R**eflector

SVOEVP - System for high-accuracy determination of ephemeris and time corrections

GMS – **G**NSS **M**onitoring **S**ystem (radio)

VLBI – **V**ery **L**ong **B**aseline **I**nterferometry

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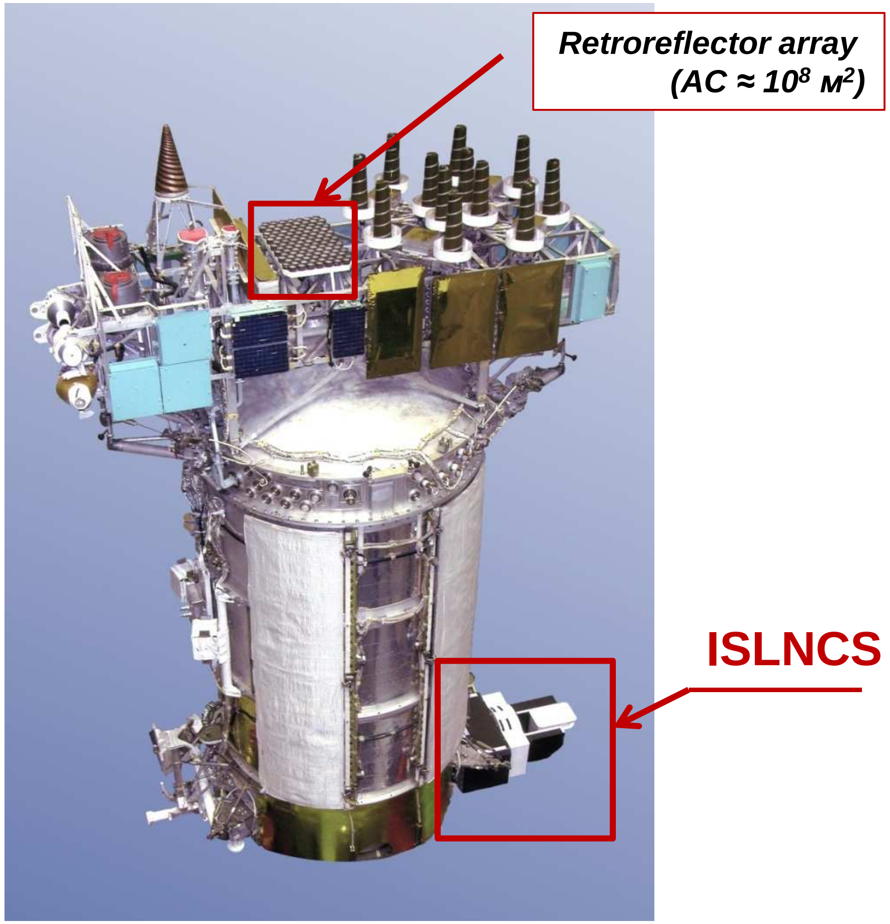
ISLNCS is designed for high-accuracy inter-satellite one-way measurements of pseudo-range

for:

- **repeated determination of deviation of a S/C time scale drift with sub-nanosecond accuracy at every orbit,**
- **integrity check of navigation field;**
- **provision for global coverage with placement of S/C time synching systems on Russian territory only.**



ISLNCS and retroreflector array onboard satellite "GLONASS-M"

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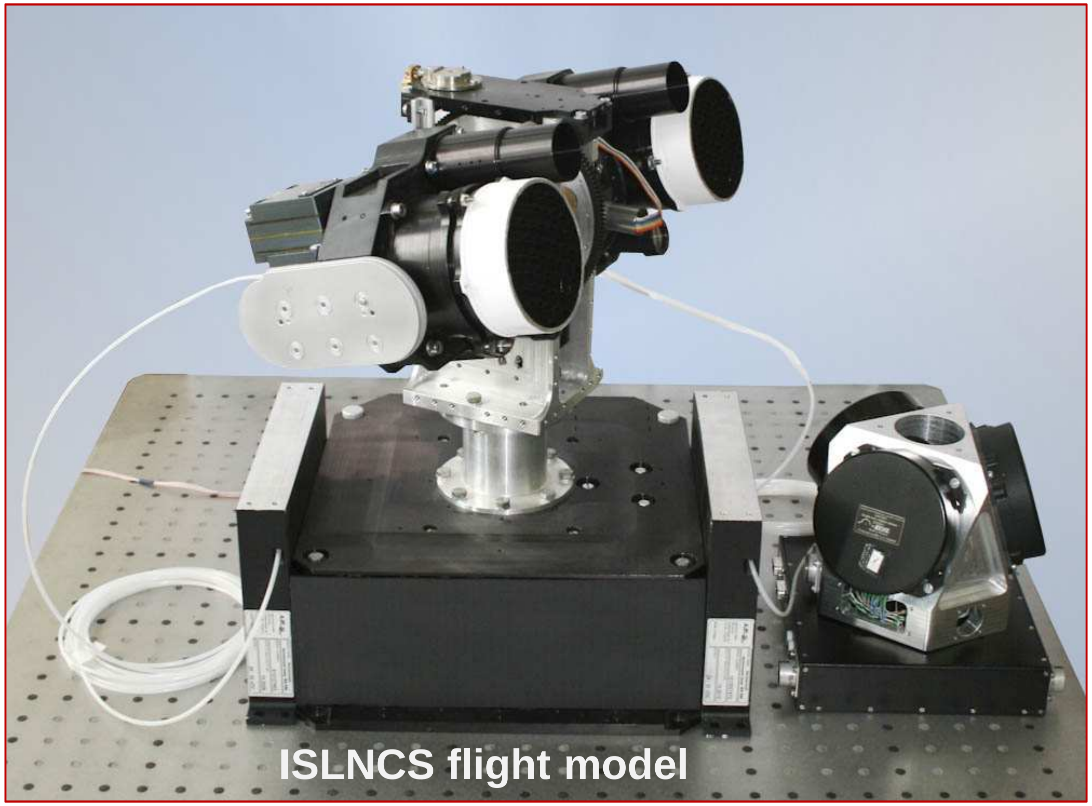
ISLNCS measurement tasks are solved using
high-accuracy counter-measurements of pseudo range between "GLONASS" navigation satellites
Measurement data exchange is done using laser signals with time-pulse modulation



ISLNCS flight model

Pseudo range differs from the range by difference between time scales multiplied by the speed of light.
In case of counter-measurements, this value will be included in pseudo-range measurements with different signs.

Half-sum of counter pseudo-ranges is true range, and their half-distance unambiguously determines the shift of time scales between two S/C.

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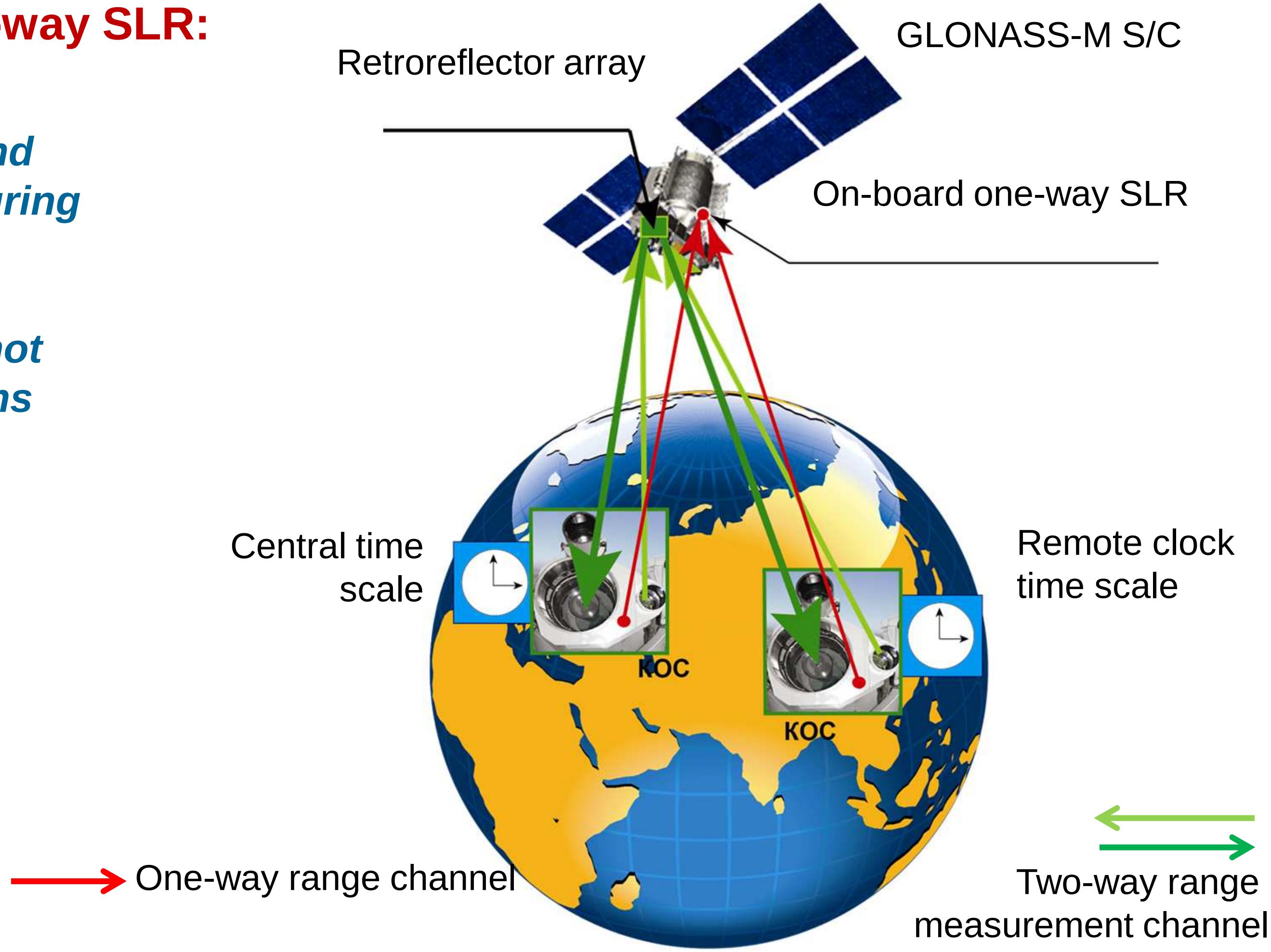
Problems solved by on-way SLR:

- calibration of on-board and ground GMS equipment during in-flight operations;
- synching remote ground clocks at accuracy levels not achievable by radio systems and mobile frequency standards



Schematics of synching of onboard time scale and ground time scale and transmission of time to a remote ground station using one-way SLR

Operating principle of the laser system for determination of difference between onboard and ground time scales

The method of determination of difference between onboard and ground time scales is based on comparison of one-way and two-way distances measured at sub-centimeter levels.

Half of a two-way range differs from the one-way pseudo range by shift between time scales multiplied by the speed of light. Determination of this shift is at the level of 10^{-10} s.

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SLR Network

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Problems solved by SLR network

- calibration of active radio systems during their flight operations with sub-centimeter accuracy;
- obtaining SLR, VLBI and GMS collocation data to provide GLONASS system with high-accuracy coordinate reference frame to ensure required accuracy of transfer of Federal Geocentric Coordinate System (FGCS) by GLONASS system;
- evaluation of errors of representation of FGCS by GLONASS navigation field by comparison of SLR coordinates obtained from laser measurements of LAGEOS satellites with SLR coordinates obtained from laser measurements of GLONASS satellites;
- check accuracy of calculation of high-accuracy ephemeris and time correction information SVOEVP.

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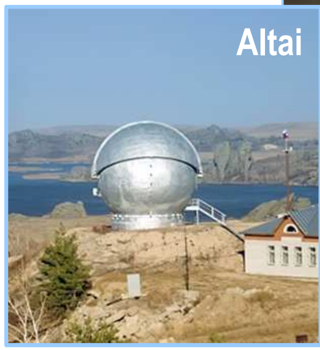
SLR

Shelkovo
(Moscow Region)

Svetloe

Komsomolsk-On-Amur

Baikonur



Altai

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System for high-accuracy determination of ephemeris and time corrections (SVOEVP)

Provision of real-time GLONASS ETS

- **calculation of SD for NFAF**
- **models support**
- **support of GCS GSD**

Calculation of high-accuracy posterior data for provision of global positioning

Solution of fundamental problems

- **FGCS support**
- **geodynamic data calculation**

ETS – Ephemeris and Time Support
FGCS – Federal Geocentric Coordinate System
GCS – Ground Control System
GSD – geodetic source data
NF – navigation field
NFAF – navigation frame accuracy factor
PETI – posterior ephemeris and time Information
RT – Real Time
SD – source data
UNE – user navigation equipment

Information

- **generalized evaluations of NF accuracy**
- **information bulletins**

RT navigation support

- **assisting technology**
- **remote calibration of UNE in the course of operation**

Navigation provision in posterior mode

- **PETI GLONASS (GPS)**
- **parameters of local models of stratosphere, ionosphere, etc.**
- **positioning in relative mode**

Support for navigation of dynamic users in FGCS

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SLR measurements are used in SVOEVP GLONASS for solution of the following problems:

- **check of transmission of the parameters of the Federal Geocentric Coordinate System (FGCS) to end users by GLONASS navigation signals;**
- **calculation of reference parameters and check of correspondence of parameters of the Federal Geocentric Coordinate System (FGCS) to the international reference frame (ITRF);**
- **check of posterior ephemeris information (PEI) of the SVOEVP using comparison of two-way laser measurement of slant ranges with ranges obtained from PEI;**
- **check of posterior time and frequency information using comparison of two-way SLR range with one –way range obtained by on-board one-way SLR (or GMS);**
- **use of SLR measurements for calculation of velocities of ground stations motion for refinement and support of initial geodetic data of GLONASS ground control system;**
- **refinement of location determination of phase centers of satellite antennae systems and analysis of spacecraft attitude system work quality using comparison of one-way SLR and GMS data;**
- **calculation of calibration corrections of GLONASS navigation equipment, evaluation of accuracy of user navigation equipment;**
- **calculation of calibration corrections and check of accuracy of two-way and one-way radio measurement systems;**
- **support of malfunctioning GLONASS satellites in the case of partial and complete failure of onboard radio systems, including daytime observations.**

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Conclusion:

Development of experimental and serial units of onboard and ground equipment is foreseen in the Federal Target Program “Support, development and operation of GLONASS system in 2012-2020.

Creation of “Laser GLONASS” and, therefore, achievement of parity and, perhaps, superiority to the world level of potential accuracy of ephemeris and time support is a real deal in the near future.

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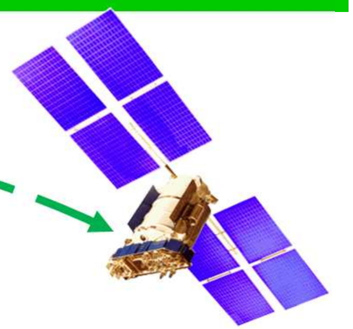

Thank you
for your attention!