Space Navigation in Russia:
History of Development

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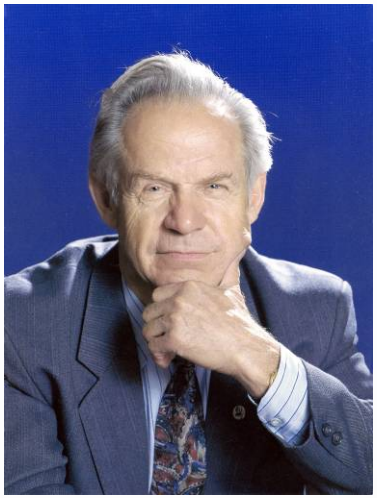
General Director

JSC “Academician M.F.Reshetnev “INFORMATION SATELLITE SYSTEMS”

START OF SPACE NAVIGATION IN RUSSIA



RESHETNEV
Mikhail

Hero of Socialist Labor, Laureate of the Lenin Prize and the State Prize, Academician of USSR Academy of Science (Russian Academy of Sciences)

Development of space activity in Siberia started on June 4, 1959 with the affiliated company of Design Bureau No.1 established in the city of Krasnoyarsk–26 (today, city of Zheleznogorsk).

The first practical implementation of the company was the 11К65 launch vehicle (“Cosmos”) and three small satellites of the “Cosmos” series (No. 38,39,40) launched on 18 August, 1964 which successfully continues today .

1 August 1977 - NPO PM was established.

1997 - NPO PM was renamed as “Academician M.F. Reshetnev NPO PM”.

3 March 2008 - rearranged as JSC «Academician M.F. Reshetnev “Information Satellite Systems”.

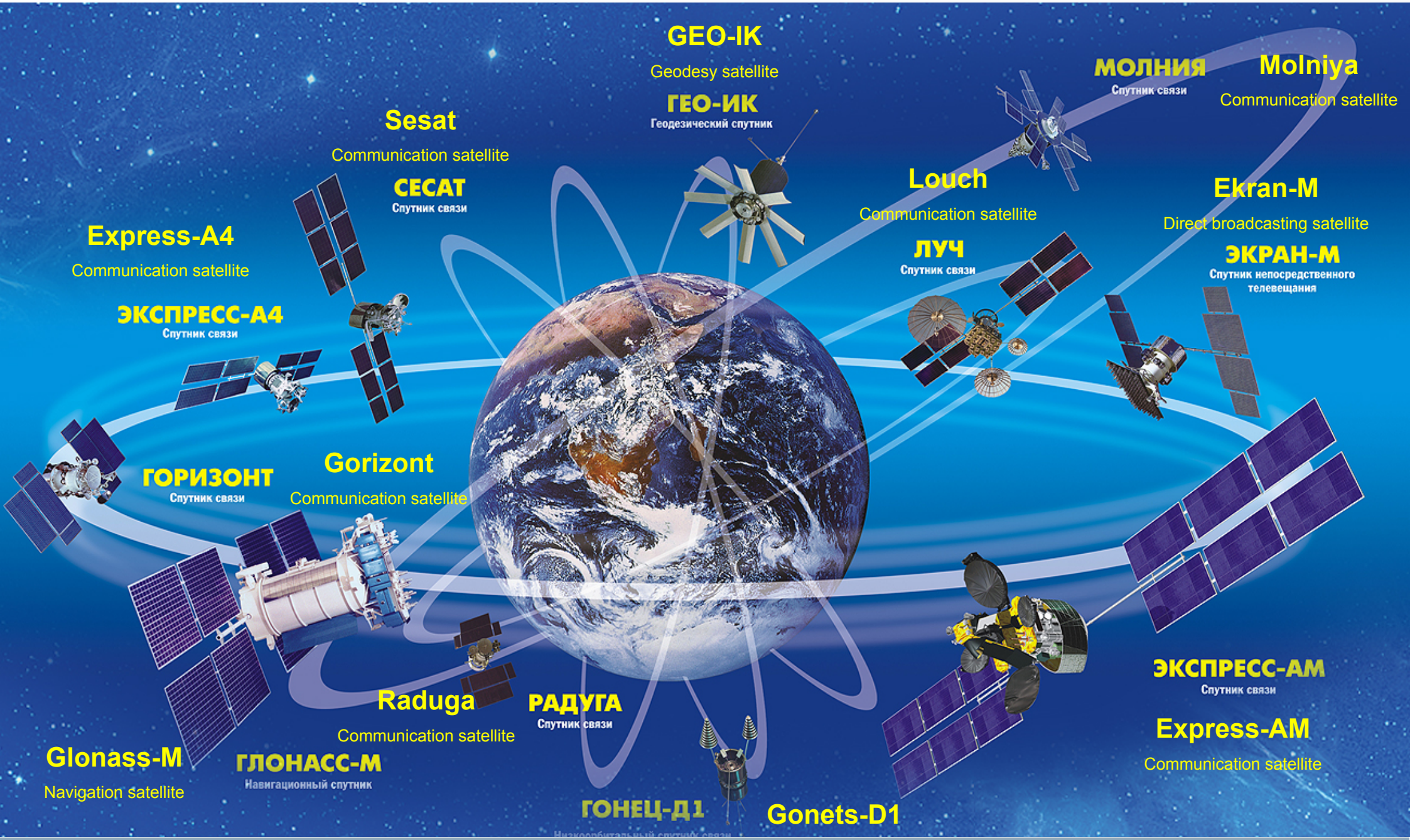
SATELLITE PRODUCTION CYCLE

- Development
- Manufacture
- Testing
- Maintenance

of satellites and systems designed for communication, TV-broadcasting, data relay, navigation, and geodesy for the benefit of national security, social and economic development, and cultural evolution of the country and international links

SATELLITES FOR ALL ORBIT TYPES

РЕШЕТНЕВ
АО «ИСС»

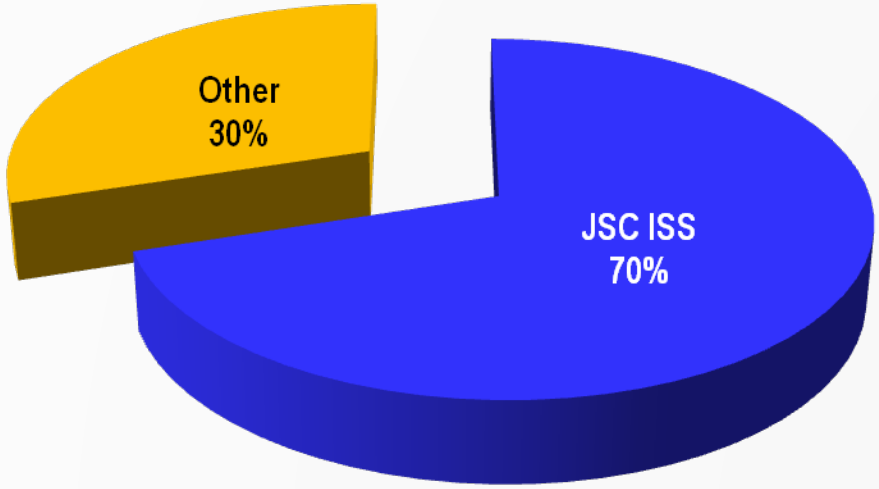


STATUS OF THE RUSSIAN ORBITAL FLEET AS OF MAY 18, 2015

Satellite Fleet of Russian Federation in total:
134 satellites

94 satellites were developed and manufactured by JSC ISS

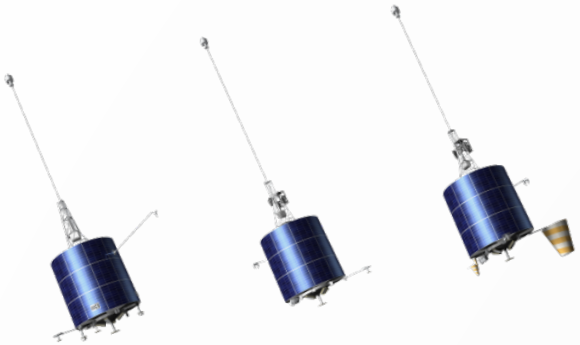
40 satellites were developed and manufactured by other enterprises



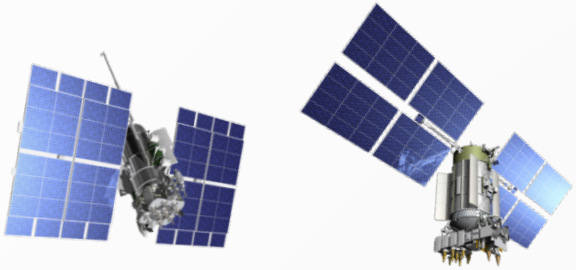
JSC «ACADEMICIAN M.F. RESHETNEV « INFORMATION SATELLITE SYSTEMS» (ZHELEZNOGORSK) IS THE PIONEER OF SATELLITE NAVIGATION IN RUSSIA

SPACE NAVIGATION

NAVIGATION SATELLITE EVOLUTION



Tsiklon Tsikada Nadezhda



Glonass GLONASS-M

Glonass-K1 Glonass-K2

1967 1st Generation of SNS

1982 2nd Generation of SNS

2011 3d Generation of SNS

Directive No. 823-247 of the CPSU Central Committee and the Council of Ministers of the USSR Dated of August 29,1979

"Global Navigation System" Federal Program 2002 – 2011

GLONASS Sustainment, Development and Use for 2012 – 2020" Federal Program.

FIRST GENERATION OF THE SPACE NAVIGATION SYSTEM

Satellite navigation started with creation of space navigation systems based on Doppler navigation approach. With a Doppler frequency increment for one fast-moving satellite, an user defines his own position on the ground surface (which is especially for benefit of maritime users) with intervals of ~ 1.5 hours and accuracy of 100 meters.

These parameters determined the orbit type selected (circular subpolar orbit with altitude of ~ 1000 km) and number of satellites (~ 6).

SNS based Tsiklon S/C

The first launch of Tsiklon No. 11F (Cosmos-192) – November 23,1967

Total **25** Tsiklons

SNS based Tsiklon-B S/C (the Parus (Sail) System)

The first launch of Tsiklon-B No.11F (Cosmos -700) – December 26, 1974

Total **93** Tsiklons-B

SNS based Tsikada S/C (the Tsikada (Cicada) System)

The first launch of Tsikada No. 11F (Cosmos -883) – December 15, 1976

Total **21** Tsikadas

SNS based Nadezhda S/C (COSPAS-SARSAT):

The first launch of Nadezhda No.11F (Cosmos-1383) – June 30, 1982

Total **10** Nadezhdas

GLONASS SYSTEM SPACE COMPLEX

GLONASS SPACE COMPLEX ARCHITECTURE

GLONASS CONSTELLATION

Generation and transmission of navigation signals
Orbit: circular, H=19140 km, I=64.8 degrees
Constellation: 24 operational satellites in 3 planes (8 satellites per plane)

Glonass
1982

Glonass-M
2003

Glonass-K
2011

Glonass-K2
2018

LAUNCH VEHICLES

S/C launches, development and replenishment of the nominal orbital constellation

Plesetsk

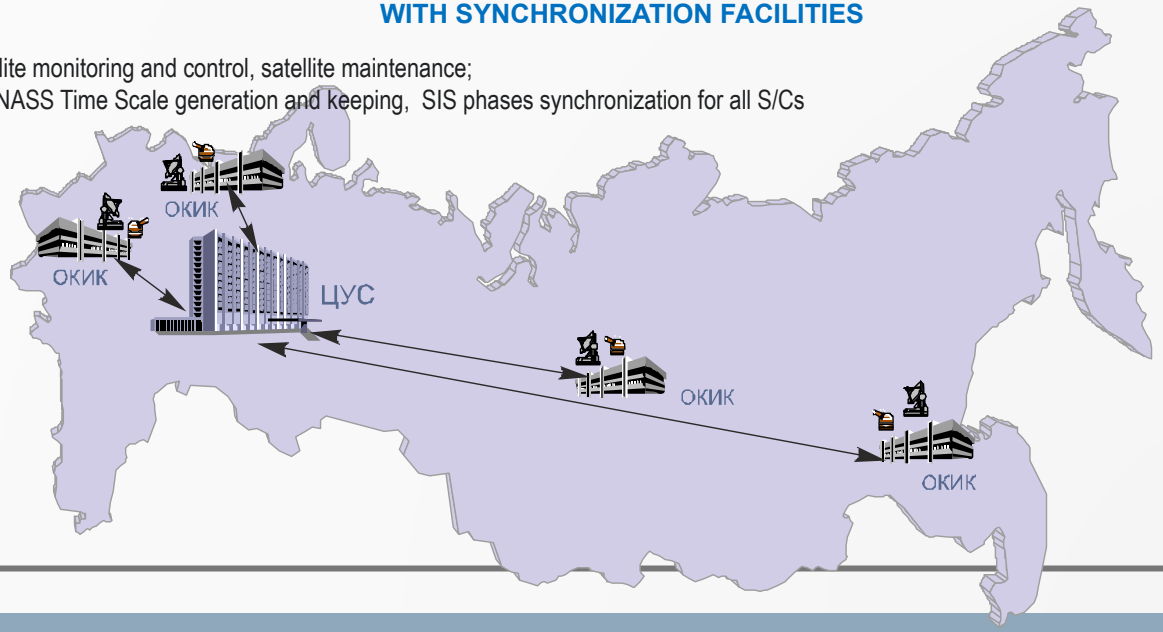
Soyuz-2 LV
Fregat Booster
Glonass S/C

Baikonur

Proton-M LV
eze-M Booster
3 Glonass S/C

MODERNIZED GROUND COUND CONTROL SEGMENT WITH SYNCHRONIZATION FACILITIES

Satellite monitoring and control, satellite maintenance;
GLONASS Time Scale generation and keeping, SIS phases synchronization for all S/Cs



SECOND GENERATION OF THE SPACE NAVIGATION SYSTEM

РЕШЕТНЕВ
АО «ИСС»

Glonass

Design life	- 3 years;
Mass	- 1413 kg;
Power consumption	- 1000 W;
Accuracy of S/C Earth orientation	- ± 0,5 deg.;
Accuracy of S/C Sun orientation	- ± 2 deg;
Stability of onboard frequency generator	- 1×10^{-13};
Navigation signals:	
Frequency Division Multiple Access	- L1OF; L1SF; L2OF; L2SF;
Launched	- 88 S/Cs

Glonass-M

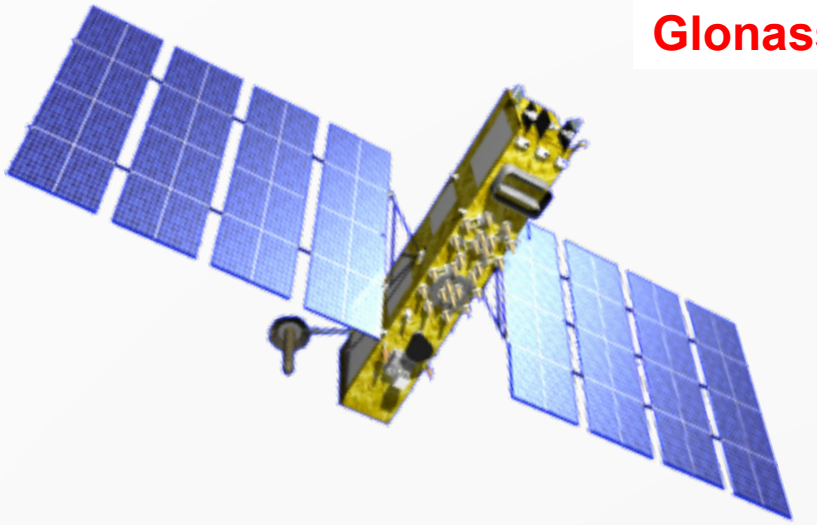
Design life	- 7 years;
Mass	- 1415 kg;
Power consumption	- 1250 W;
Accuracy of S/C Earth orientation	- ± 0,5 deg;
Accuracy of S/C Sun orientation	- ± 2 deg.;
Stability of onboard frequency generator	- 1×10^{-13};
Navigation signals:	
Frequency Division Multiple Access	- L1OF; L1SF; L2OF; L2SF;
Launched	- 42 S/Cs

THIRD GENERATION OF THE SPACE NAVIGATION SYSTEM

Glonass-K1

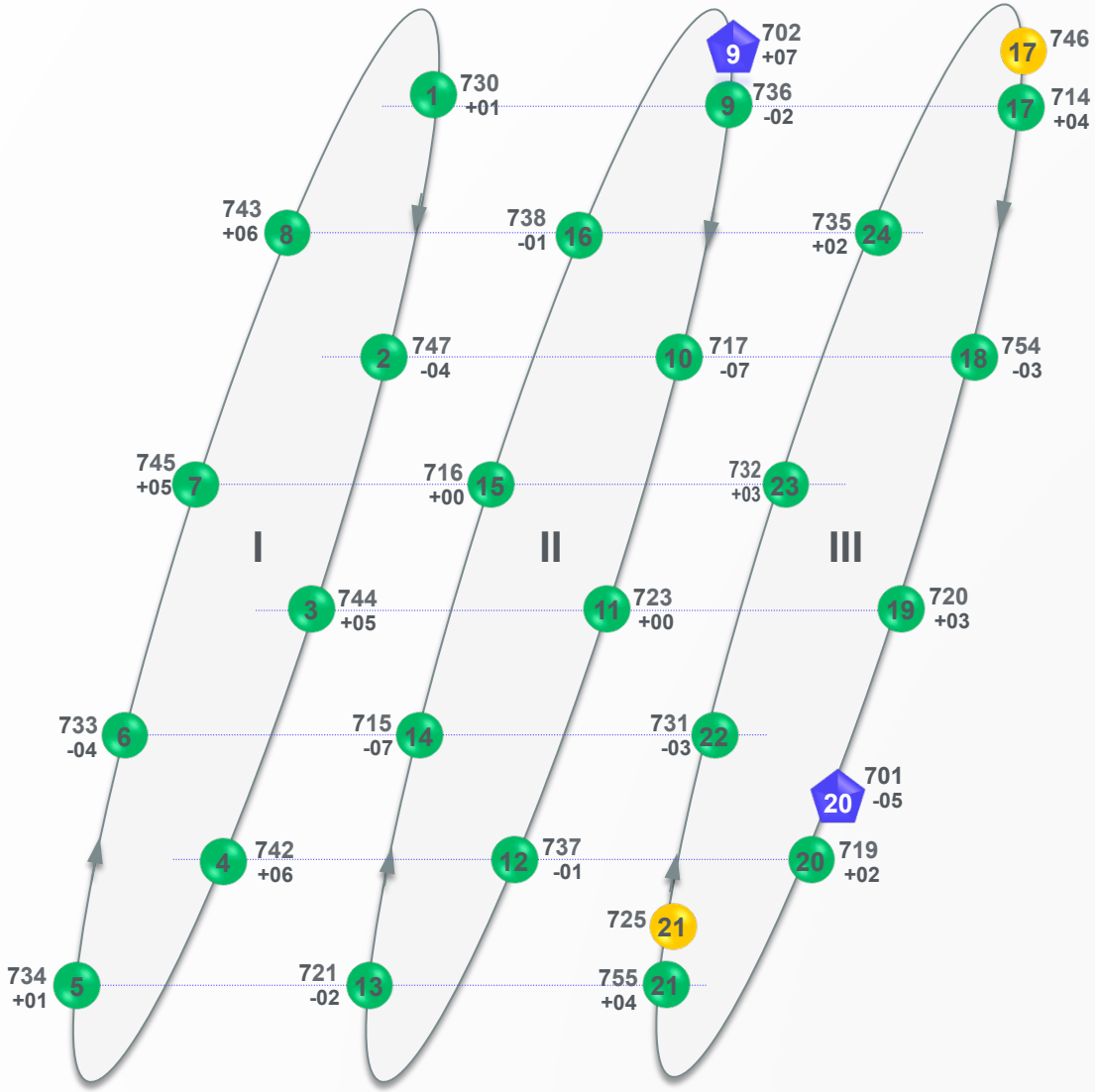
Design life	- 10 years;
Mass	- 962 kg;
Power consumption	- 1600 W;
Accuracy of S/C attitude control	- ± 0,5 deg.;
Stability of onboard frequency generator	- 5×10^{-14};
Navigation signals:	
- FDMA	- L1OF; L1SF; L2OF; L2SF;
- CDMA	- L3OC;
Launched	- 2 S/Ca

Glonass-K2



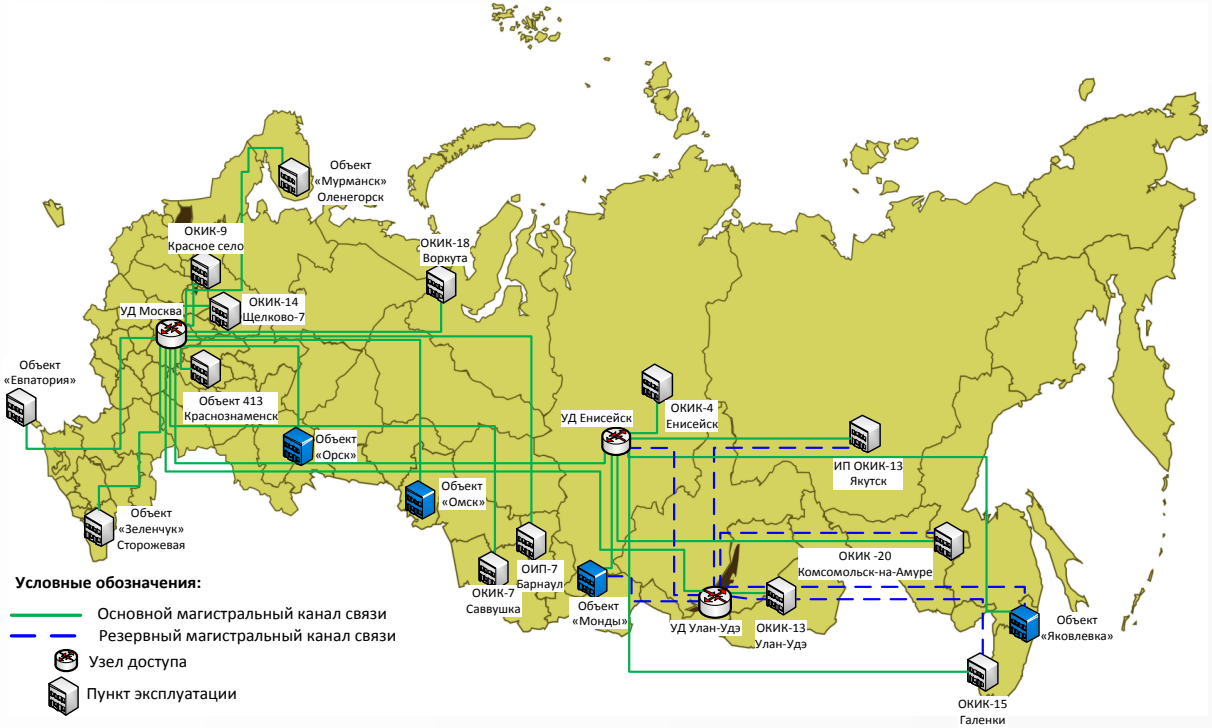
Design life	- 10 years;
Mass	- 1645 kg;
Power consumption	- 4370 W;
Accuracy of S/C attitude control	- ± 0,25 deg;
Stability of onboard frequency generator	- $5\times10^{-14} \div 5\times10^{-15}$;
Additional PL equipment	- 6
Navigation signals:	
- FDMA	- L1OF; L1SF; L2OF; L2SF;
- CDMA	- L1OC; L1SC; L2SC; L3OC;
Launch	- since 2018

GLONASS CONSTELLATION



Status as of May 18, 2015.	
Total	28 S/Cs
Operational	24 S/Cs
Under flight test	2 S/Cs
Under investigation	2 S/Cs

GROUND CONTROL SEGMENT



The Ground Control Segment (GCS) serves for automated control of GLONASS satellites

Within the management process GCS resolves the following tasks:

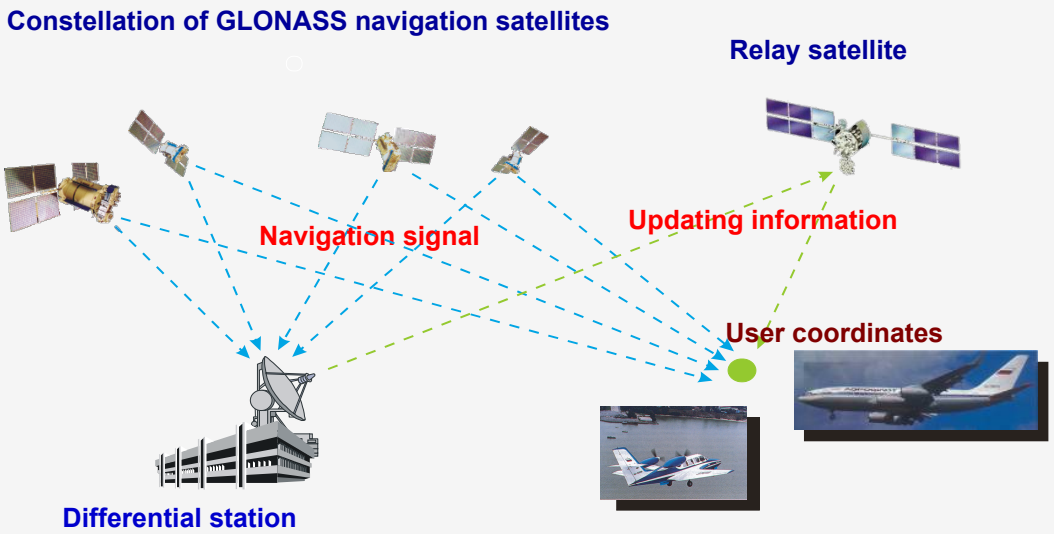
- **Planning of work with satellites for GCS means, control of satellite injected into orbit;**
- **Control and analysis of satellite operation and status;**
- **Determination and prediction of satellite orbit parameters and calculation of ephemeris, clock, and almanac data;**
- **Upload and control of mission data (ephemeris, clock data, etc.) with the purpose of navigation frame generation;**
- **Check, phasing, and correction of Onboard Time Scale;**
- **Control of navigation data downloaded;**
- **Control of SIS performances.**

PROGRAM OF THE GLONASS CONSTELLATION DEVELOPMENT AND SUSTAINMENT

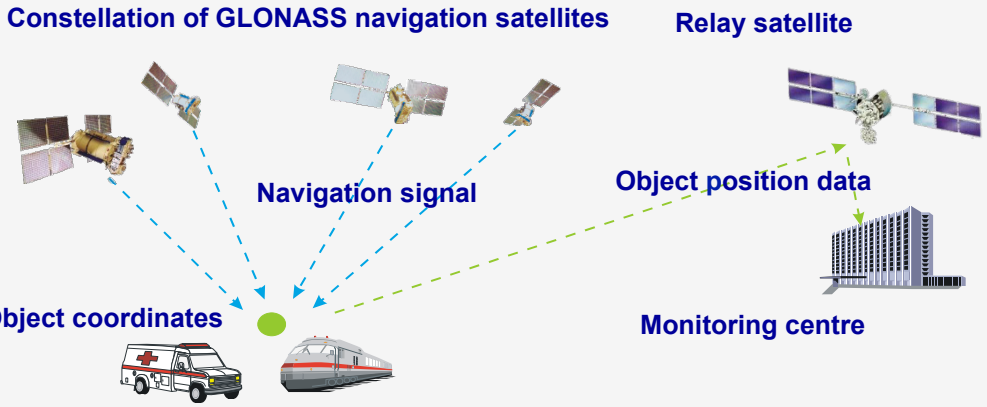
2014				2015				2016				2017				2018				2019				2020			
I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
54	55		K12		51	52 53 56	57	58		59	60			61	$K_2$13	K13 K14	K15	K16 K17 K18	$K_2$14	K19 K20 K21		K22		K23			$K_2$15
																										
48c	49c		K2c		50c	51	52c	53c		54c	55c			56c	K3c	K4c K5c	K6c	K7	K8c	K9		K10c		K11c			K12c

HIGH PRECISION INFORMATION PROVISION

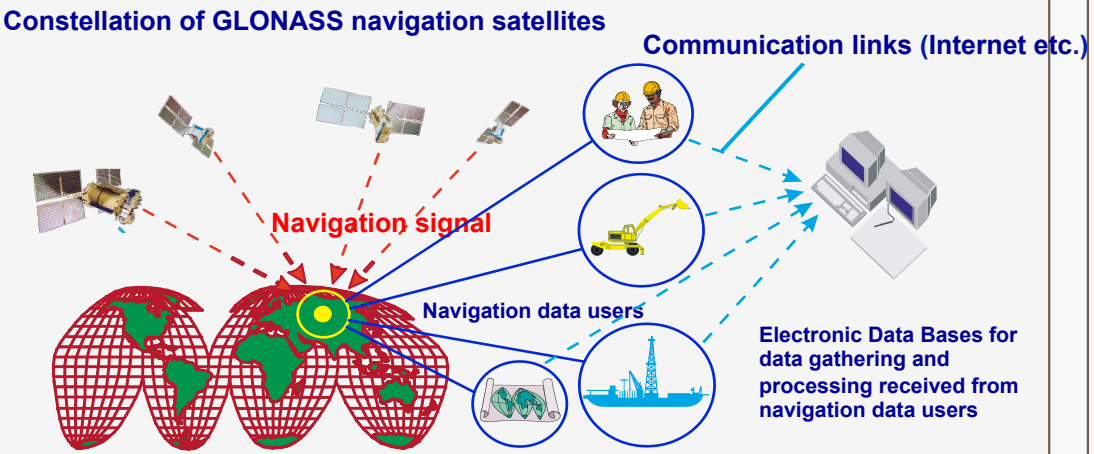
HIGH-PRECISION COORDINATE DETERMINATION



MONITORING OF OBJECTS



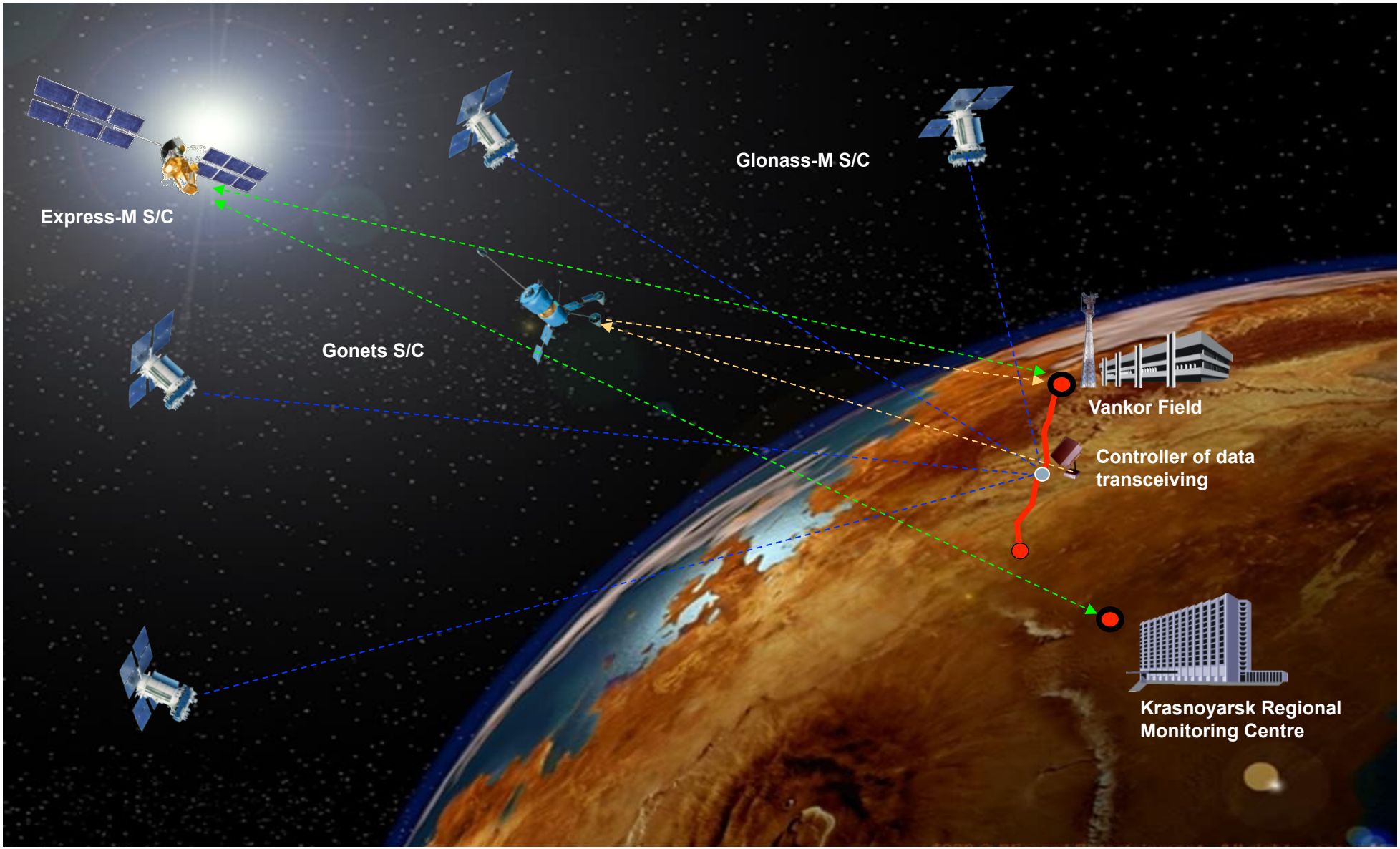
Cartography and Land Use



Monitoring of Extended Objects Condition

The project of the motorway bridge structural monitoring for M-53 federal highway near Krasnoyarsk was designed and is in use currently.
Technology of bridge member control using GLONASS technology was proven under real-time testing.
Accuracy characteristics for relative motion of bridge reference points: 1-3 mm

SPACE SYSTEM FOR AUTOMATED OIL PIPELINE MONITORING USING GLONASS GNSS
(one of the prospective projects)

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