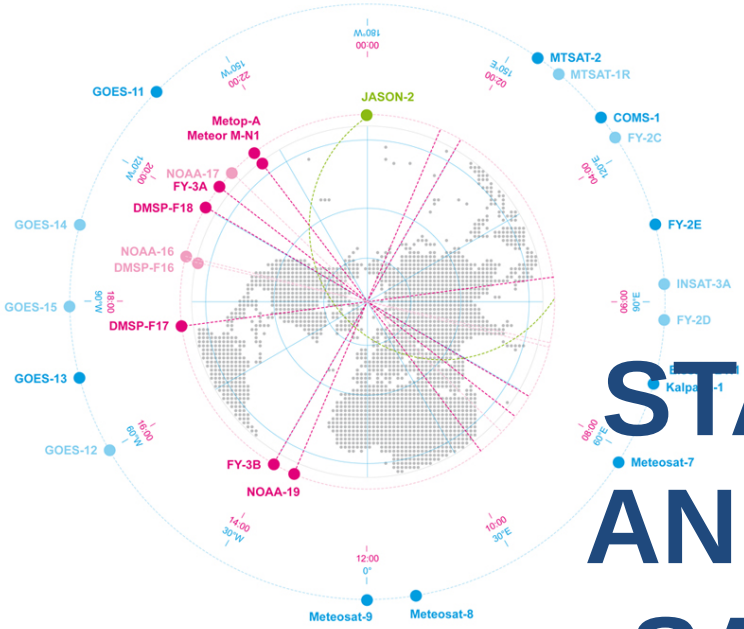


STATUS OF CURRENT AND FUTURE RUSSIAN SATELLITE SYSTEMS

by Roscosmos / Roshydromet

Presented to CGMS-45 plenary session

Coordination Group for Meteorological Satellites

CGMS

2017

Objectives: Hydrometeorological Satellite Observation System

HYDROMETEOROLOGY AND GEOPHYSICAL MONITORING

- atmosphere and ocean monitoring and forecasting;
- ice monitoring for navigation in Arctic and Antarctic regions;
- heliogeophysical information service;
- ground-based observation data collection and retransmission via satellite.

DISASTER MONITORING

- disaster features detection;
- disaster impact /damage assessment;
- risk areas examination, including an assessment of probability and scale of disaster.

CLIMATE MONITORING

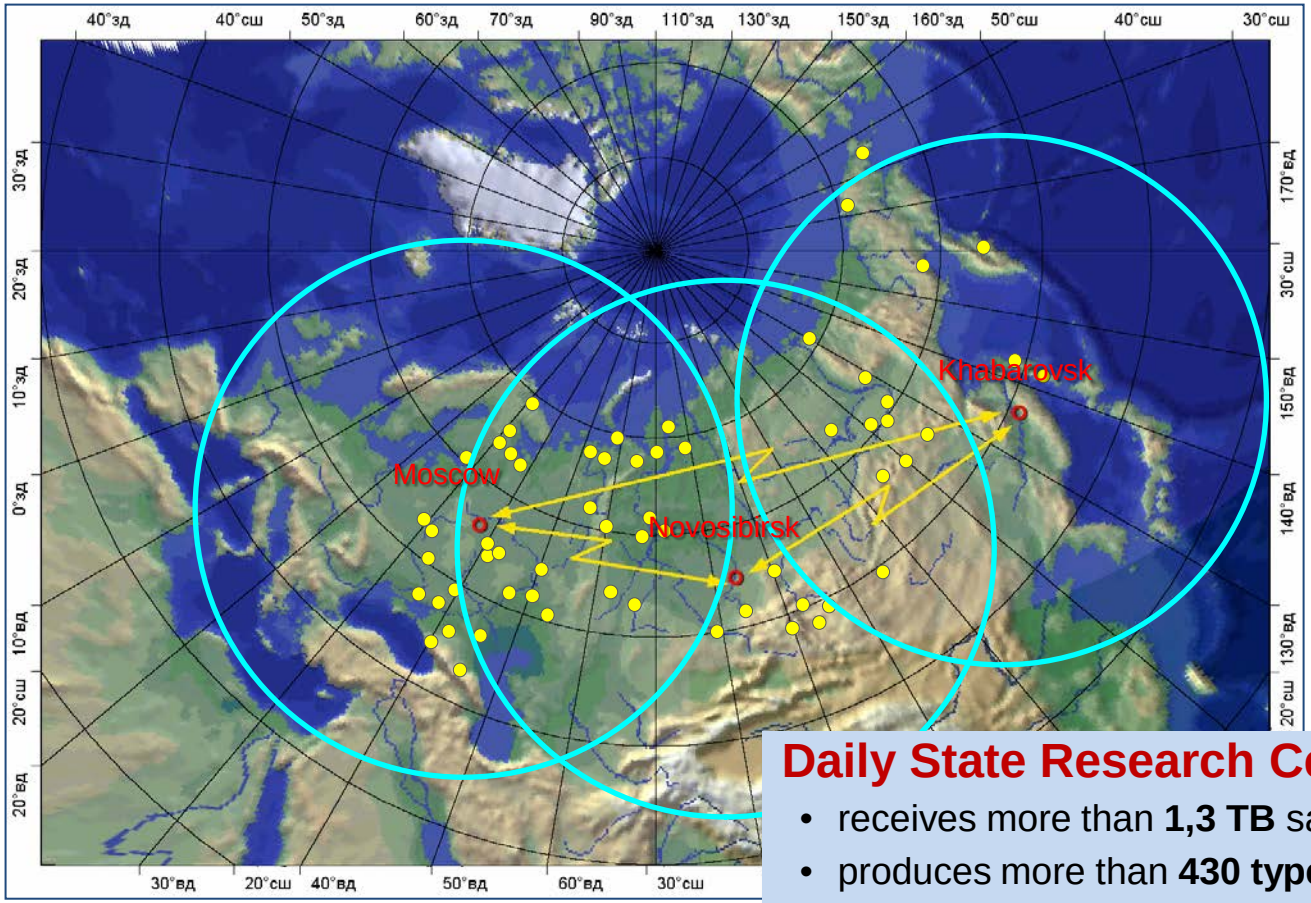
- climate, ocean and landscape studies based on radiation balance, cloud cover, ozone layer, cryosphere, sea surface temperature and ocean color, vegetation cover data, etc.

ENVIRONMENTAL POLLUTION MONITORING

- environmental pollution mapping for atmosphere, land surface and ocean;
- assessment of risk areas for spreading contamination, including radioactive contamination.

Ground Segment of Earth Observation Satellite System

Core Centers of the Integrated Geographically Distributed Information System of Earth Remote Sensing (IGDIS ERS)



Satellite Data Receiving Centers:

European
(SRC Planeta, Moscow - Obninsk - Dolgoprudny)

Siberian
(SRC Planeta, Novosibirsk)

Far-Eastern
(SRC Planeta, Khabarovsk)

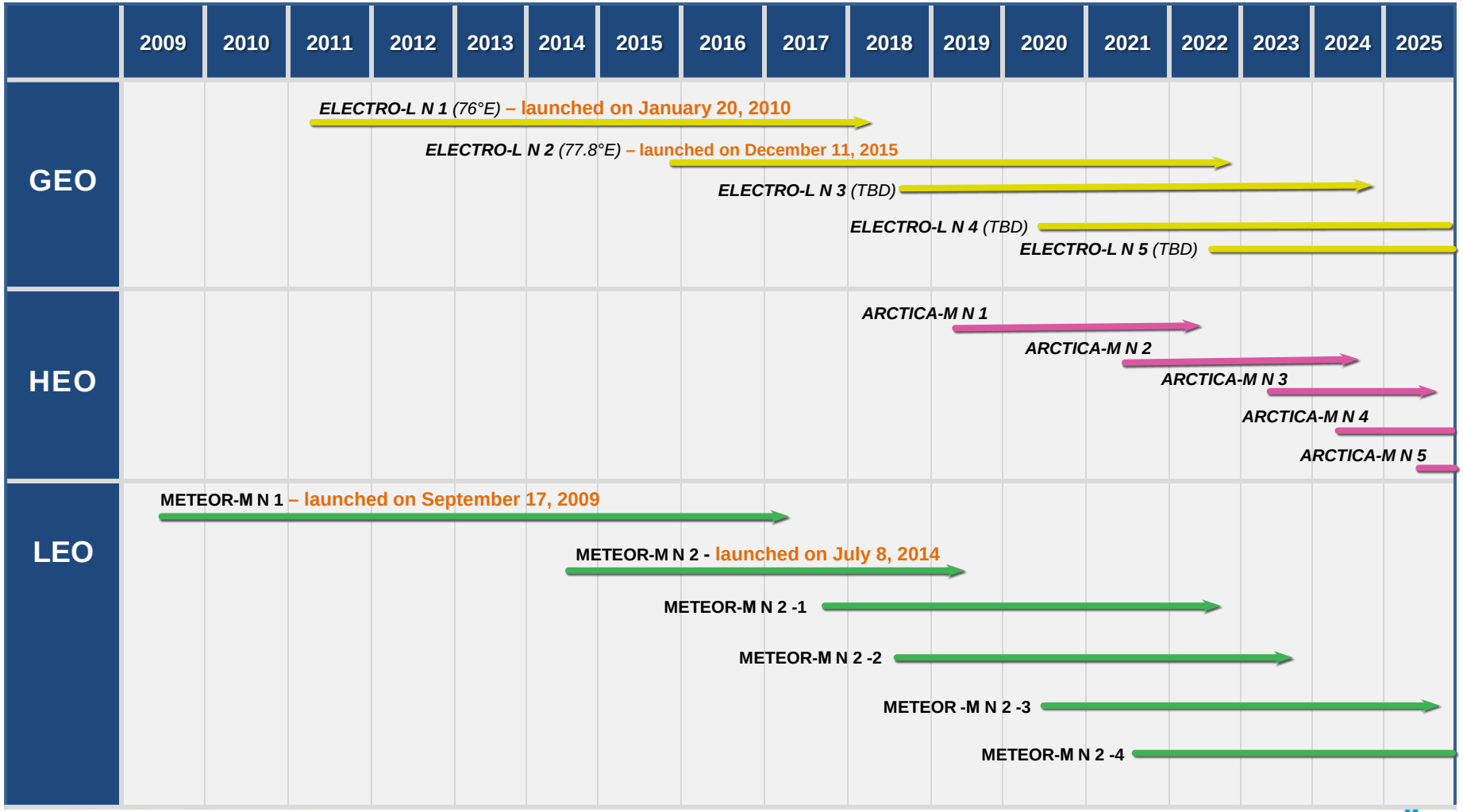
● - more than **70** local points

Daily State Research Center "Planeta":

- receives more than **1,3 TB** satellite data;
- produces more than **430 types** of satellite-based products;
- provides data for more than **540** federal and regional users.

Russian Meteorological Satellite Systems

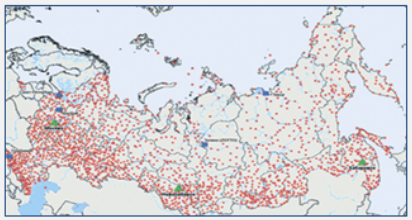
(Federal Space Program for 2016-2025)



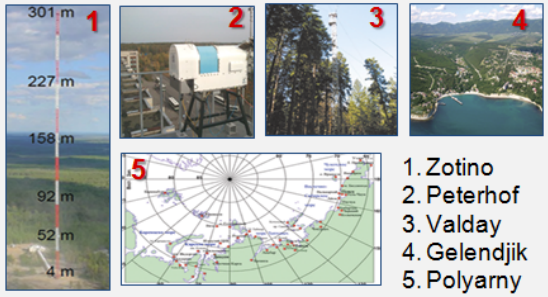
CAL/VAL System for Satellite Data and Products

Standard measurements

Roshydromet' observation sites

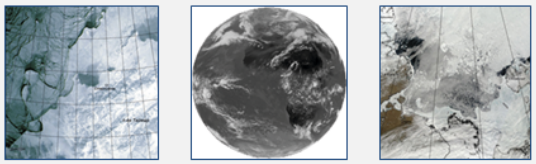


Test sites



1. Zotino
2. Peterhof
3. Valday
4. Gelendjik
5. Polyarny

Foreign satellite data



NOAA/AVHRR | Meteosat/SEVIRI | Terra/MODIS

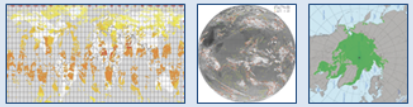
Russian meteorological satellites of Electro-L and Meteor-M series data

Data calibration
Data intercalibration

Thematic processing

Validation

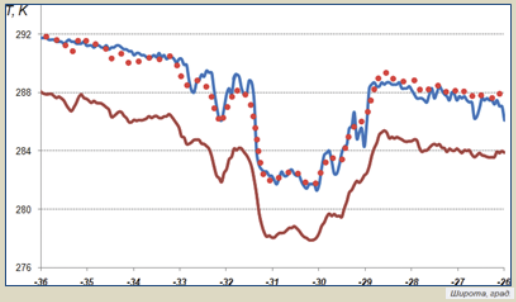
Satellite products



Numerical weather prediction

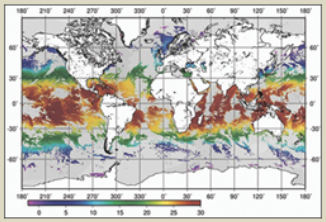
Cal/val examples

Data intercalibration for channel 10.2-11.2 μm over sea surface

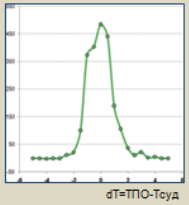


- Meteosat-10/SEVIRI data
- Electro-L/MSU-GS data
- Electro-L/MSU-GS data (after intercalibration)

Sea surface temperature validation *vs* ship measurements



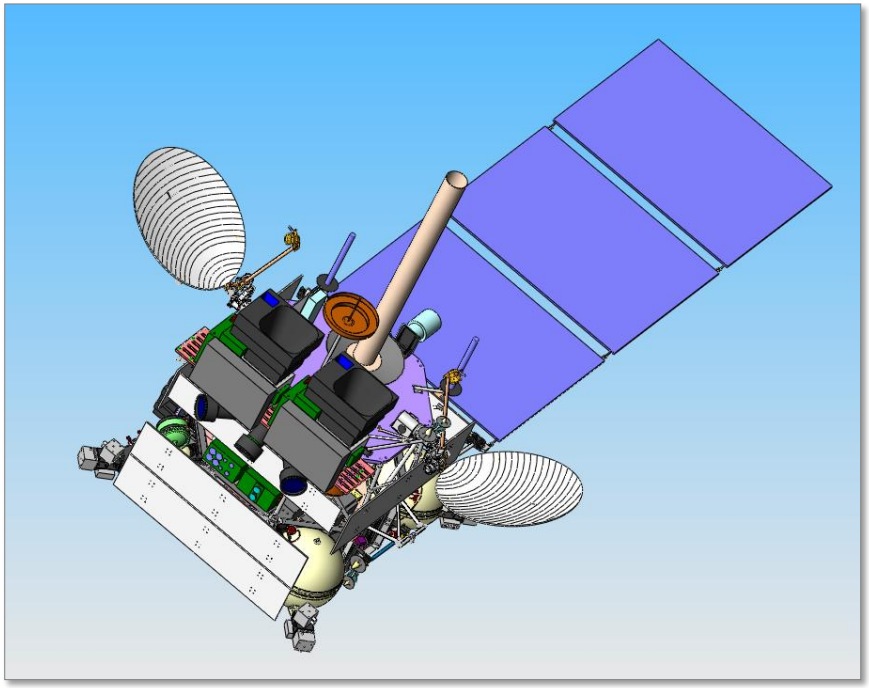
SST derived from Meteor-M/MSU-MR



Bias = -0,01° K
RMSE = 0,9° K

Status of Current GEO Satellite Systems

ELECTRO-L General Design



Russian geostationary satellite
Electro-L N2 — on **11 December 2015**

Three-axis high-precision stabilization

In-orbit mass — 1500 kg

Payload mass — 370 kg

Lifetime — 10 years

Longitude — 76°E, 14.5°E, 165.8°E

Data dissemination format — HRIT/LRIT

Image repeat cycle — 30/15 min

Mission objectives

- Operational observation of the atmosphere and the Earth surface
- Heliogeophysical measurements
- Maintaining Data Collection System and COSPAS/SARSAT Service

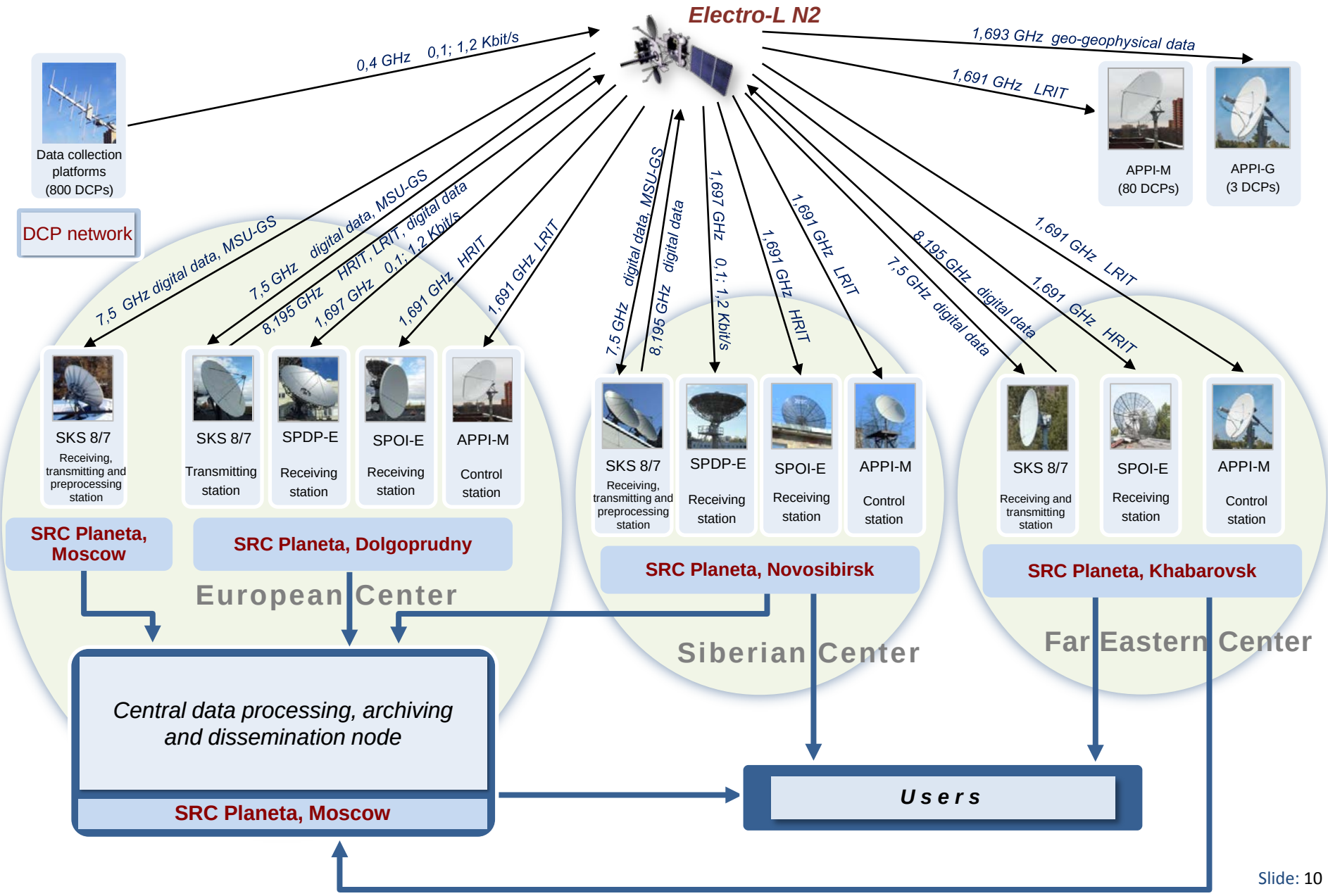
MSU-GS Basic Characteristics

Parameter	*Value*
Number of channels VIS IR	10 3 7
Spectral channels (μm)	0.5-0.65; 0.65-0.80; 0.8-0.9; 3.5-4.0; 5.7-7.0; 7.5-8.5; 8.2-9.2; 9.2-10.2; 10.2-11.2; 11.2-12.5
Image frame (deg x deg)	20 ± 0.5 x 20 ± 0.5
HRIT spatial resolution at sub-satellite point (km)	1.0 (VIS); 4.0 (IR)
S/N ratio for VIS channels	≥ 200
NEΔT at 300K (K) • in the band 3.5-4.0 μm • in the band 5.7-7.0 μm • in the band 7.5-12.5 μm	 0.2 0.1 0.1
Power (W)	≤ 150
Mass (kg)	≤ 88
Lifetime of basic and reserve units (years)	10

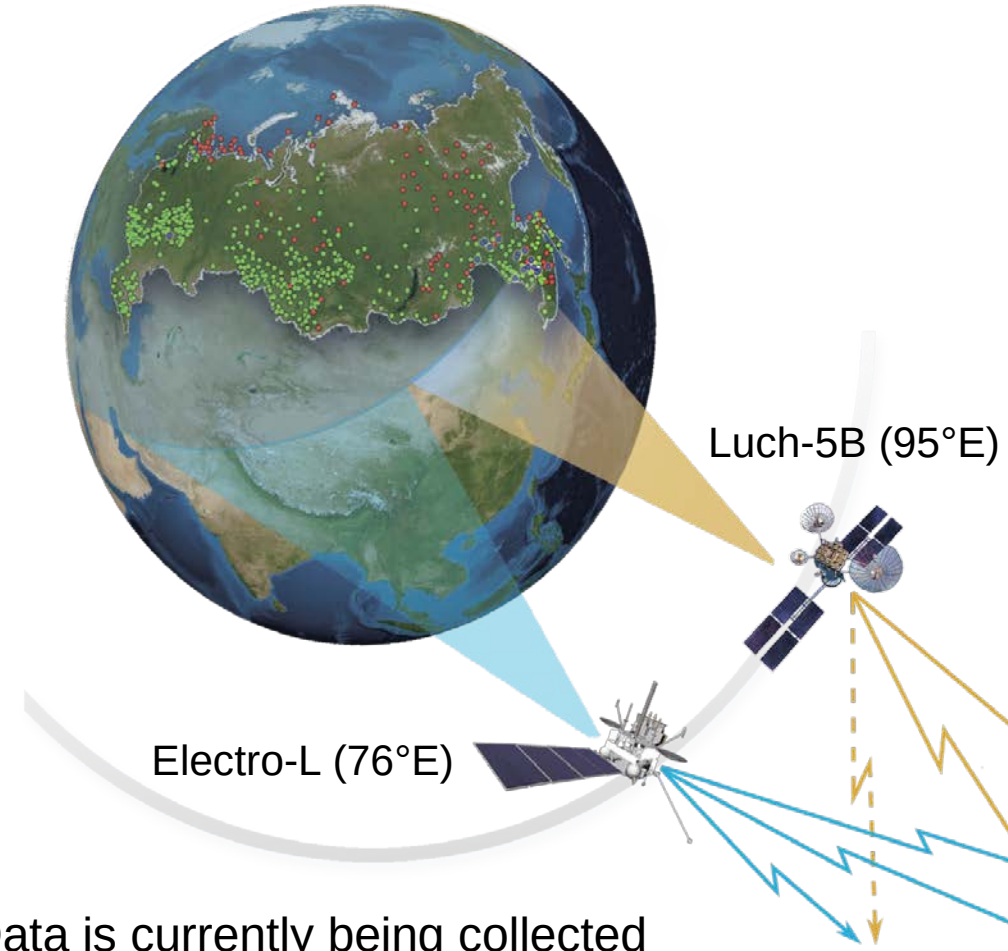
Status of Electro-L N2

- **MSU-MR** is functional with limitations (12 mkm channel is out-of-order).
  Absolute calibration work is currently ongoing;
- **DCS** is functional;
- **COSPAS-SARSAT** system is functional;
- **GGAK** instrument is functional;
- **HRIT/LRIT** data is being distributed via the land channels, including Internet channels.

Core Ground Segment for Electro-L



Russian Data Collection System based on geostationary satellites



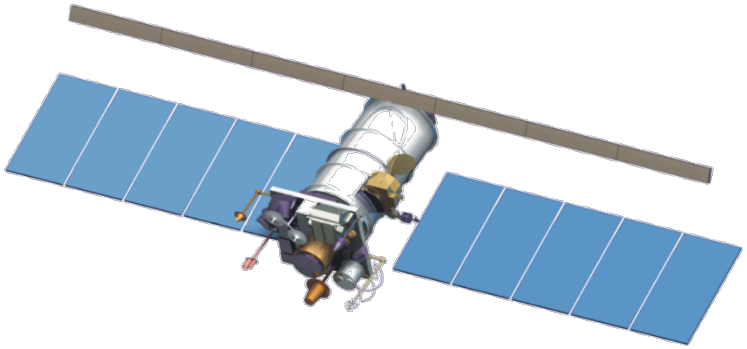
DCS comprises of the network of DCPs at Roshydromet observation sites, relay transponders at Russian geostationary satellites of Electro and Luch series, and ground reception stations at SRC Planeta centers.
The system will be further complemented with the launch of high-elliptical orbit satellites of Arctica series.

Data is currently being collected from over 600 Roshydromet observation network, including difficult to access stations (114), and hydrological sites (over 20).

Status of Current LEO Satellite Systems

METEOR-M General Design

Russian meteorological satellite Meteor-M N2 was launched on **July 8, 2014**



In-orbit mass – 2700 kg

Payload mass – 1200 kg

Lifetime – 5 years

Orbit – Sun-synchronous

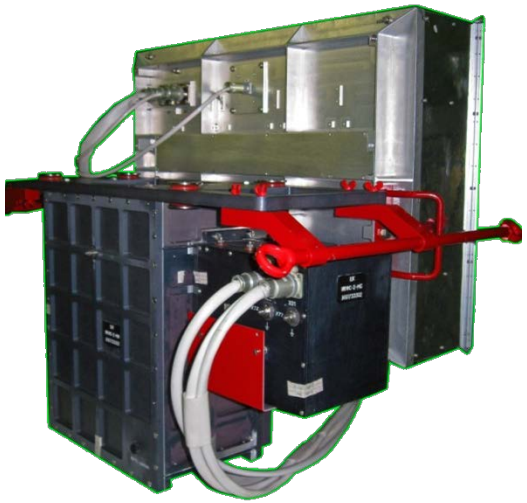
Altitude – 820 km

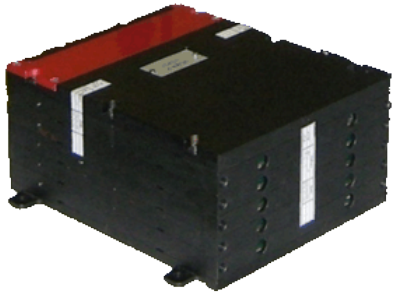
Data dissemination format – HRPT/LRPT

Meteor-M N 2 Basic Instruments Specifications

Instrument	*Application*	*Spectral band*	*Swath-width (km)*	*Resolution (km)*
MSU-MR Low-resolution multi-channel scanning radiometer	Global and regional cloud cover mapping, ice and snow cover observation, forest fire monitoring	0,5 – 12,5μm (6 channels)	2900	1 x 1
KMSS Visible spectrum scanning imager	Earth surface monitoring for various applications (floods, soil and vegetation cover, ice cover)	0,4-0,9 μm (3+3 channels)	450/900	0,05/0,1
MTVZA-GY Imager-sounder (module for temperature and humidity sounding of the atmosphere)	Atmospheric temperature and humidity profiles, SST, sea level wind, etc.	10,6-183,3 GHz (26 channels)	1500	16 – 90
IRFS-2 Advanced IR sounder (infrared Fourier-spectrometer)	Atmospheric temperature and humidity profiles	5-15 μm	2000	35
“Severjanin-M” X-band synthetic aperture radar	All-weather Ice coverage monitoring	9500-9700 MHz	600	0,5/1
GGAK-M Heliogeophysical measurements suite	Heliogeophysical data			
BRK SSPD Data collection system (DCS)	Data retransmission from DCPs			

Advanced IR Sounder IRFS-2





Parameter	*Units*	*Value*
Spectral range: wavelength wave number	μm cm^{-1}	5-15 2000-665
Reference channel wavelength	μm	1.06
Maximum optical path difference (OPD)	mm	17
Angular size of FOV	mrad	40 x 40
Spatial resolution (at sub-satellite point)	km	35
Swath width and spatial sampling	km	2500, 110 2000, 100
Duration of the interferogram measurement	s	0.5
Mass	kg	45-50
Power	W	50

Spectral range	*Absorption band*	*Application*
665 to 780 cm^{-1}	CO_2	Temperature profile
790 to 980 cm^{-1}	Atmospheric window	Surface parameters (T_s, ε_ν), cloud properties
1000 to 1070 cm^{-1}	O_3	Ozone sounding
1080 to 1150 cm^{-1}	Atmospheric window	T_s, ε_ν,; cloud properties
1210 to 1650 cm^{-1}	H_2O, N_2O, CH_4	Moisture profile, CH_4, N_2O, column amounts

Status of Meteor-M N2 Spacecraft

- **MSU-MR** instrument is fully functional;
- **MTVZA-GY** instrument is fully functional;
- **KMSS** instrument is fully functional;
- **IKFS-2** instrument is fully functional;
- **Severjanin** instrument is functional with limitations (due to low signal/noise ratio);
- **DCS** is functional;
- **LRPT** transmission is functional;
- **GGAK-M** is functional.

Meteor-M N2 Data Dissemination

1. Direct broadcast

MSU-MR and MTVZA-GY data are currently being disseminated at 1.7 GHz band in direct broadcast mode (HRPT-like).
Data format description is available at SRC Planeta WEB-site
http://planet.iitp.ru/english/spacecraft/meteor_m_n2_structure_eng.htm

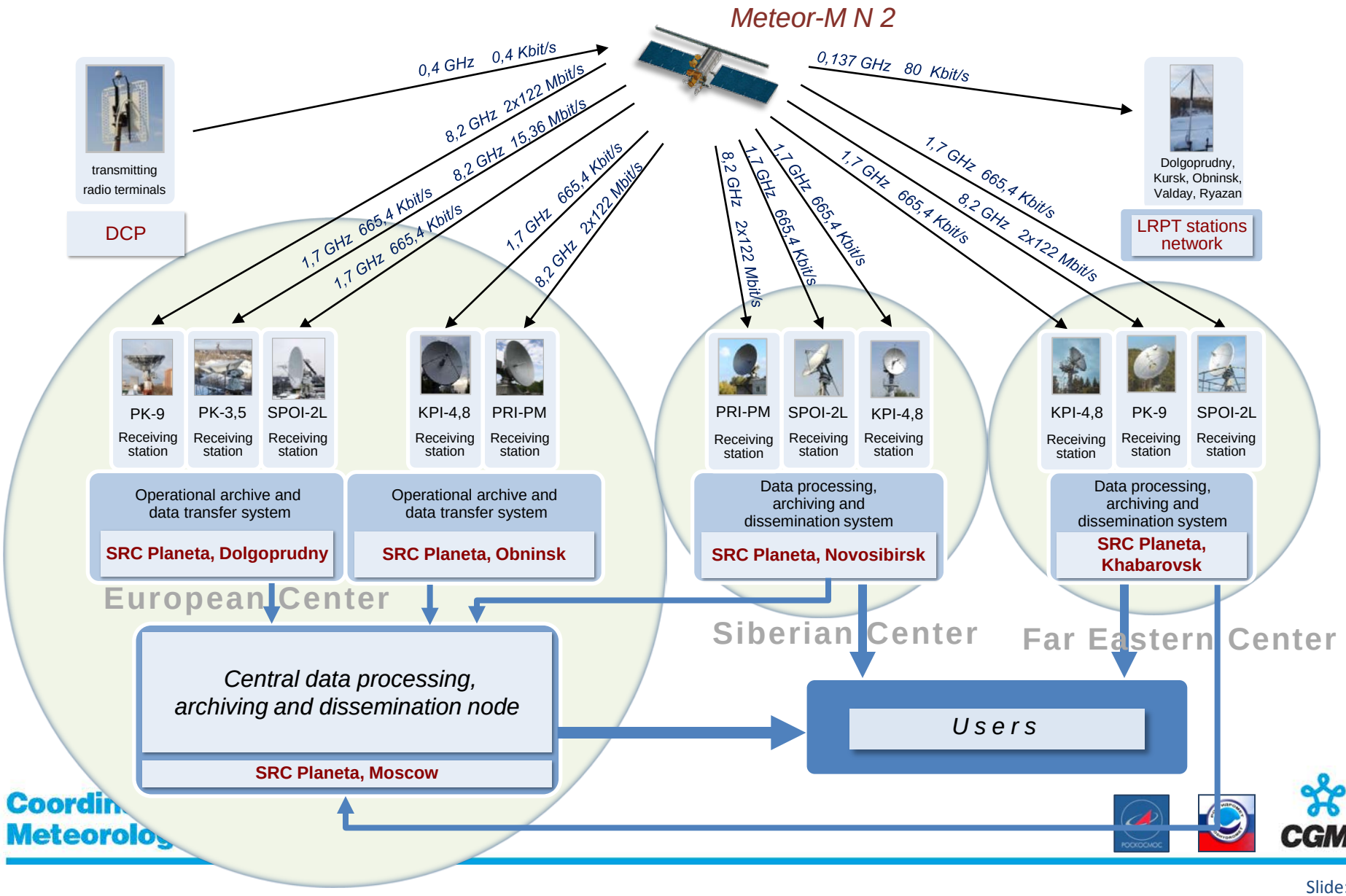
2. Global data access

MTVZA instrument data, declared as Essential according to Roshydromet-EUMETSAT bilateral Agreement, is available in HDF format to EUMETSAT third party service in near-real time via FTP channel, free to be redistributed to all interested parties. Test distribution of preprocessed IRFS-2 data has been started.

3. L2 products access

Some L2 products are regularly generated by SRC Planeta and can be accessed via SRC Planeta WEB-site.

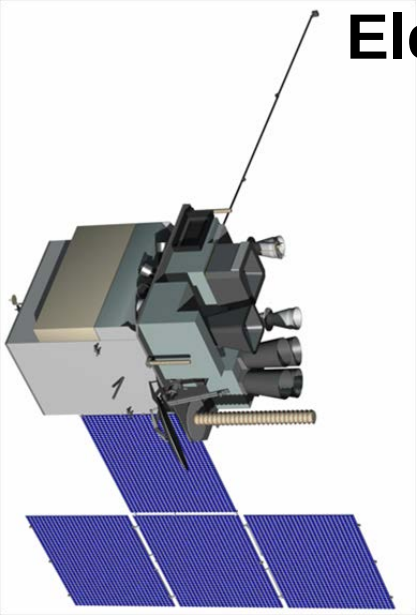
Core Ground Segment for Meteor-M N 2



Status of Future GEO Satellite Systems

- The launch dates for: Electro-L N3 – 2018; Electro-L N4 – 2020; Electro-L N5 – 2022.
- The Electro-L N 3,4,5 payload is similar to the Electro-L N 2, but with improved instrument performance.
- Orbital positions: for Electro-L N3, 4, 5 – TBD.

Electro-M (3-rd generation)



Parameter	*Value*
Electro-M N 1 longitude Electro-M N 2 longitude Electro-M N 3 longitude	**14,5º E** **76º E** **165,8º E**
MSU-GS-M channels	**20**
MSU-GSM spatial resolution at sub-satellite point, km - VIS and NIR - IR	 **0,5** **2**
MSU-GSM scan period, min - regular mode (full Earth disk) - frequent mode (fragments of the Earth disk)	 **15** **5**
Mass, kg	**1870**
Expected lifetime, years	**10**

Mission objectives

- Operational observation of the atmosphere and the Earth surface (MSU-GSM, IRFS-GS, ERBR, LM, GGAK-E/M)
- Heliogeophysical measurements
- Maintaining Data Collection System and COSPAS/SARSAT Service

Electro-M Basic Payload

- MSU-GSM (Multichannel scanning unit – Geostationary-M) instrument, providing full Earth disk measurements in 20 channels (VIS, NIR, IR) with 10 min period between scanning sessions and spatial resolution about 0,5 km for VIS and 2,0 km for IR channels at sub-satellite point;

- IKFS-GS (Infrared Fourier-transform Spectrometer - Geostationary) instrument providing measurements in 3.7 - 6 μm and 8.3 - 15.4 μm spectral bands with 4 km spatial resolution (at sub-satellite point).
- The spectral resolution is about 0,625 cm^{-1}. Repeat cycle is 1 hour.

- ERBR (Earth Radiation Budget Radiometer) instrument, providing measurements in 0.32 …4.0 and 0.32 …30.0 μm spectral bands with spatial resolution ≤ 50 km every 5 min.

- LM (Lightning Mapper) instrument, providing continuous detection at 777,4 μm.

- GGAK-E/M (Geliogeophysical instrument suite) – modernized GGAK-E.

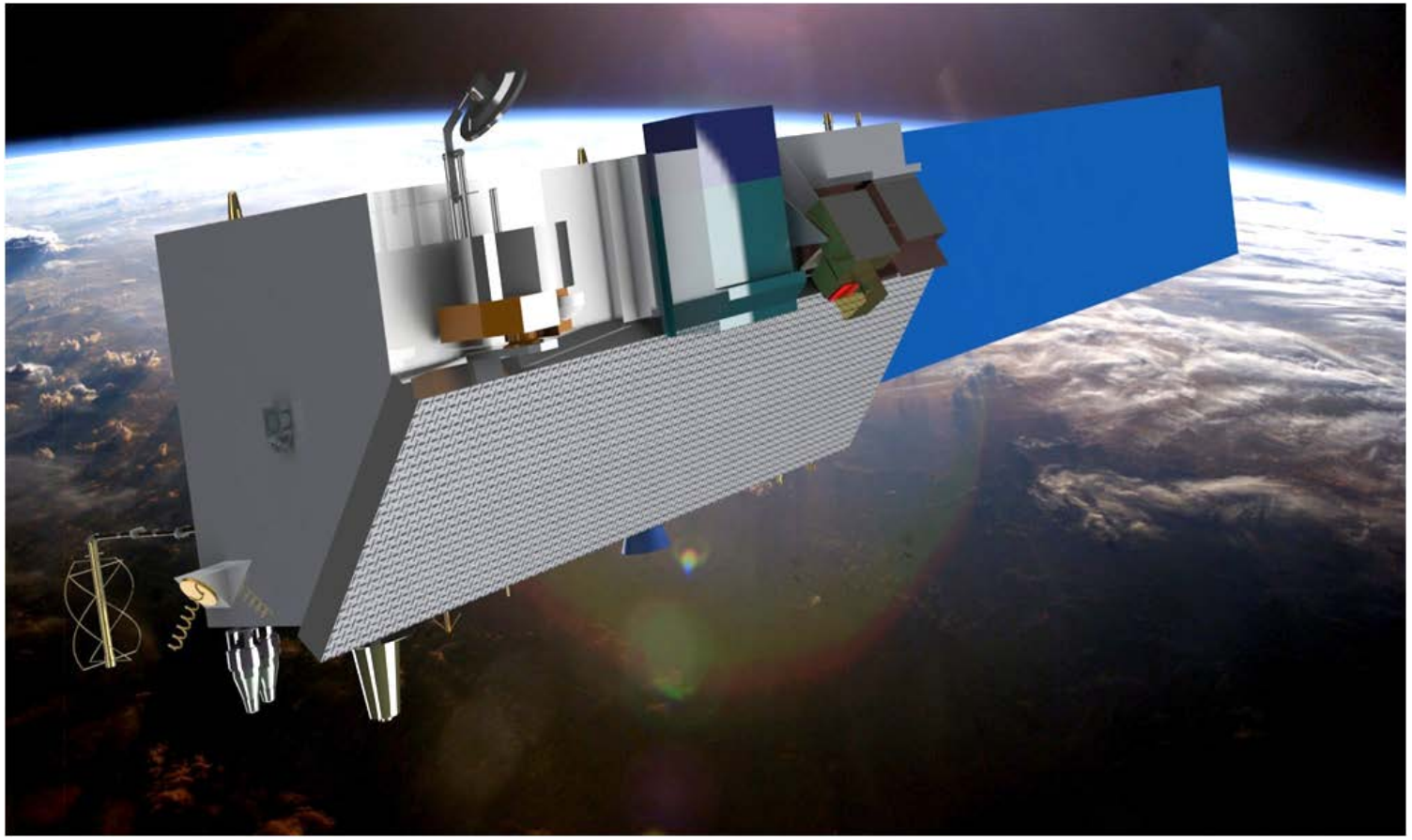
- BRTK-M on-board radio-retransmitting suite, providing data downlink in UHF and SHF bands.

Status of Future LEO Satellite Systems

Future LEO Satellite Orbit

Orbit	*Satellite*	*Operator*	*Time, ETC*	*Height*	*Launch data*	*Instrument*
SSO	METEOR-M N2-1	ROSH	15.09 ↑	816,4 km	2017	MSU-MR, MTVZA, IRFS-2, KMSS, DCS, COSPAS-SARSAR Dissemination: HRPT, LRPT
SSO	METEOR-M N2-2	ROSH	09.00 ↓	815,2 km	2018	
SSO	METEOR-M N2-3	ROSH	15.09 ↑	820,7 km	2020	MSU-MR, MTVZA, IRFS-2, KMSS, DCS, COSPAS-SARSAR, METEOSAR, GGAK-M2 Dissemination: HRPT, LRPT
SSO	METEOR-M N2-4	ROSH	09.00 ↓	820,7 km	2021	

Meteor-MP (4-th generation)



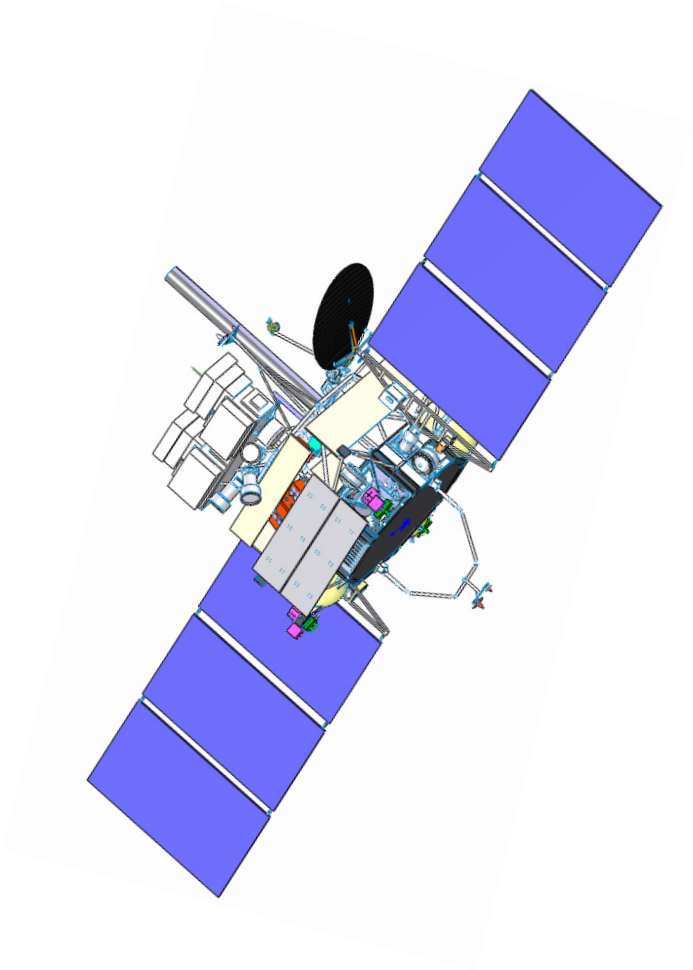
Spacecraft mass: 3300 kg, deployed size: 21,5×3,2×4,4 m

METEOR-MP Basic Payload
(Meteorological)

- Low-resolution multi-channel scanning radiometer;
- Visible spectrum scanning imager (moderate resolution multispectral imaging system);
- Infra-red Fourier-transform spectrometer;
- Atmospheric composition spectrometer;
- Microwave imager-sounder
  (module for temperature and humidity sounding of the atmosphere);
- Side-looking radar system;
- Radio-occultation instrument;
- Data collection system;
- Heliogeophysical instruments suite;
- 137MHz data downlink system;
- 1.7GHz data downlink system;
- X-band data downlink system.

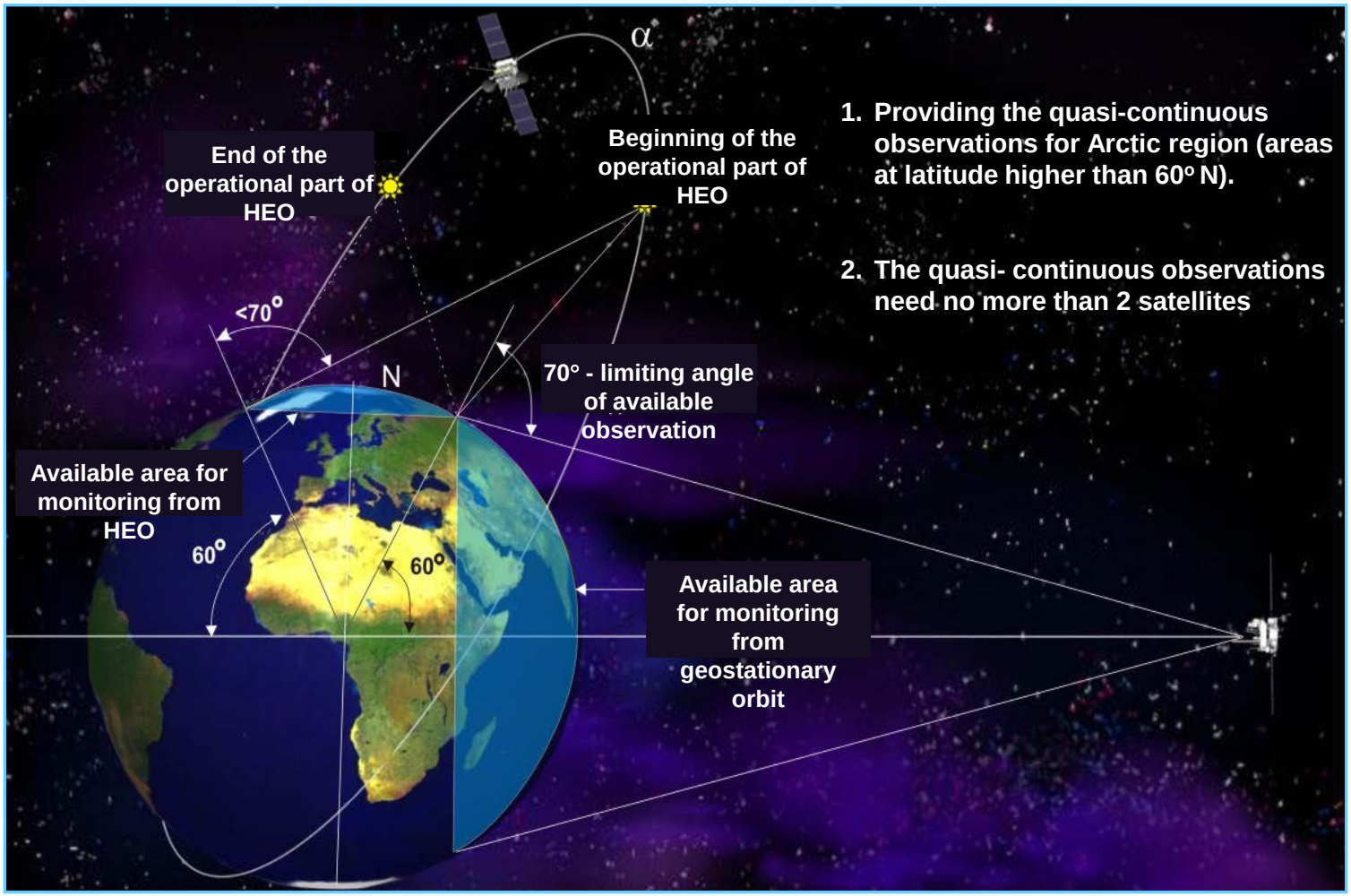
Status of Future HEO Satellite Systems

Arctica-M



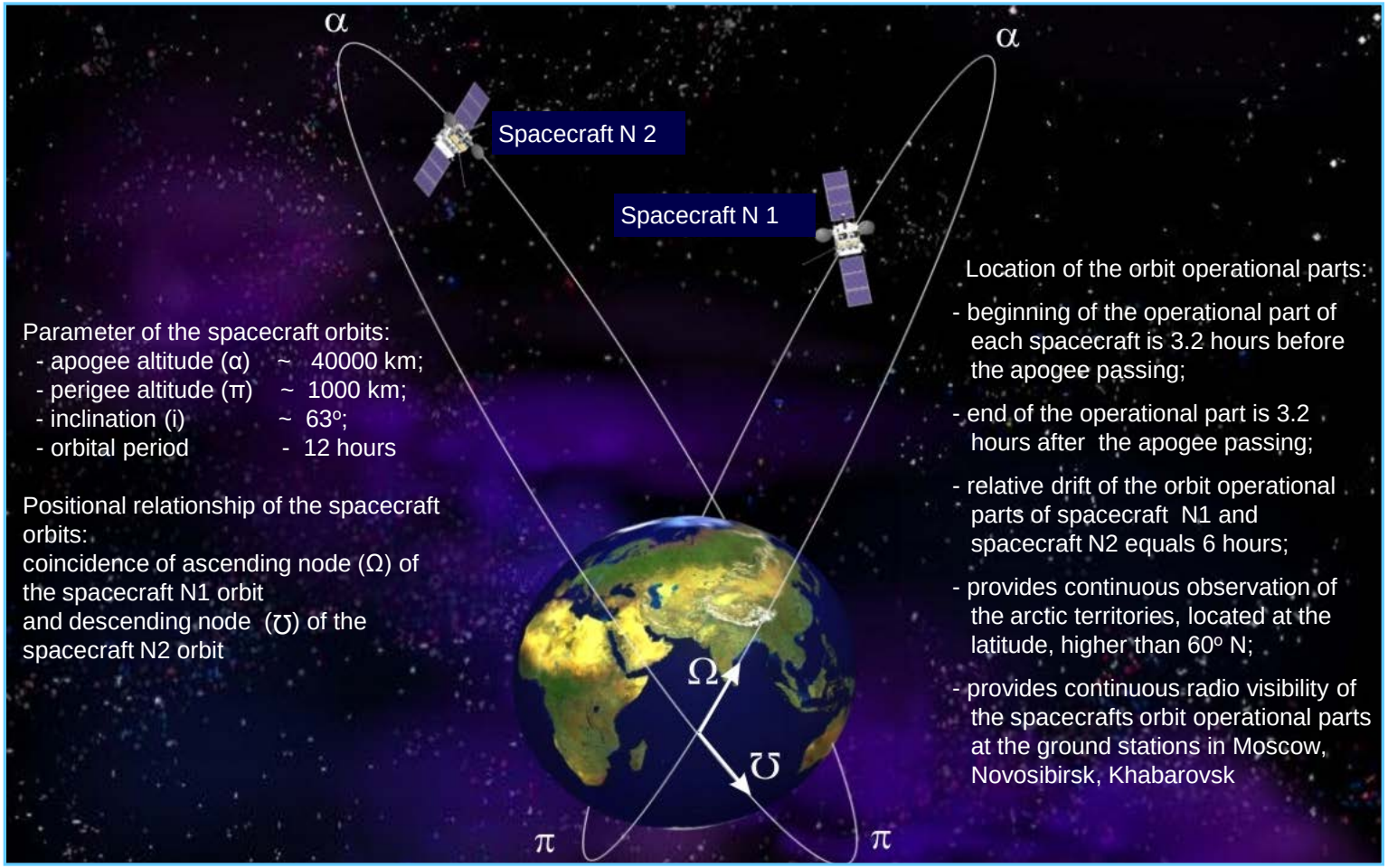
Parameter	*Value*
Orbit:	
Apogee, km	**40000**
Perigee, km	**1000**
Inclination, deg	**63,4**
Period, h	**12**
Full number of MSU-A spectral channel	**10**
Spectral range, μm	from **0,5** to **12,5**
Resolution (at nadir):	
- VIS-channel, km	**1**
- IR-channel, km	**4**
Frequency of full Earth disk observation, min:	
- regular mode	**30**
- frequent mode	**15**
Spacecraft mass, kg	**2000**

Advantages of the High-Elliptic Orbits (HEO) over Geostationary Orbits for Arctic Observations



1. Providing the quasi-continuous observations for Arctic region (areas at latitude higher than 60° N).
2. The quasi- continuous observations need no more than 2 satellites

Space System Ballistic Configuration



Parameter of the spacecraft orbits:
- apogee altitude (α) ~ 40000 km;
- perigee altitude (π) ~ 1000 km;
- inclination (i) ~ 63°;
- orbital period - 12 hours

Positional relationship of the spacecraft orbits:
coincidence of ascending node (Ω) of the spacecraft N1 orbit
and descending node (℧) of the spacecraft N2 orbit

Location of the orbit operational parts:

- beginning of the operational part of each spacecraft is 3.2 hours before the apogee passing;
- end of the operational part is 3.2 hours after the apogee passing;
- relative drift of the orbit operational parts of spacecraft N1 and spacecraft N2 equals 6 hours;
- provides continuous observation of the arctic territories, located at the latitude, higher than 60° N;
- provides continuous radio visibility of the spacecrafts orbit operational parts at the ground stations in Moscow, Novosibirsk, Khabarovsk

Arctica-M Basic Payload

- The multichannel scanning unit MSU-A, 10 spectral channels (3 VIS and 7 IR channels).
- The heliogeophysical instruments suite GGAK-A, providing the heliogeophysical measurements at the “Molnia” orbit.
- The on-board radio-retransmitting complex BRTK-A, providing data downlink in UHF and SHF bands.

The launch of the first satellite of Arctica series is scheduled for 2019.

Thanks for attention!