

STATUS OF CURRENT AND PLANNED RUSSIAN METEOROLOGICAL SATELLITE SYSTEMS

**Presented to 4th Asia-Oceania Meteorological Satellite Users
Conference**

**on behalf of Dr. Vasily V. Asmus,
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Roshydromet Space Observation System Objectives

HYDROMETEOROLOGY AND GEOPHYSICAL MONITORING:

- atmosphere and ocean monitoring and forecast;
- sea ice monitoring for navigation in Arctic and Antarctic regions and seas;
- data providing for heliogeophysical service;
- DCP data retransmission via satellite.

DISASTER MONITORING:

- disaster events features detection;
- disaster monitoring;
- disaster impact /damage assessment;
- potentially dangerous areas survey, with an assessment of probability and impact of a disaster.

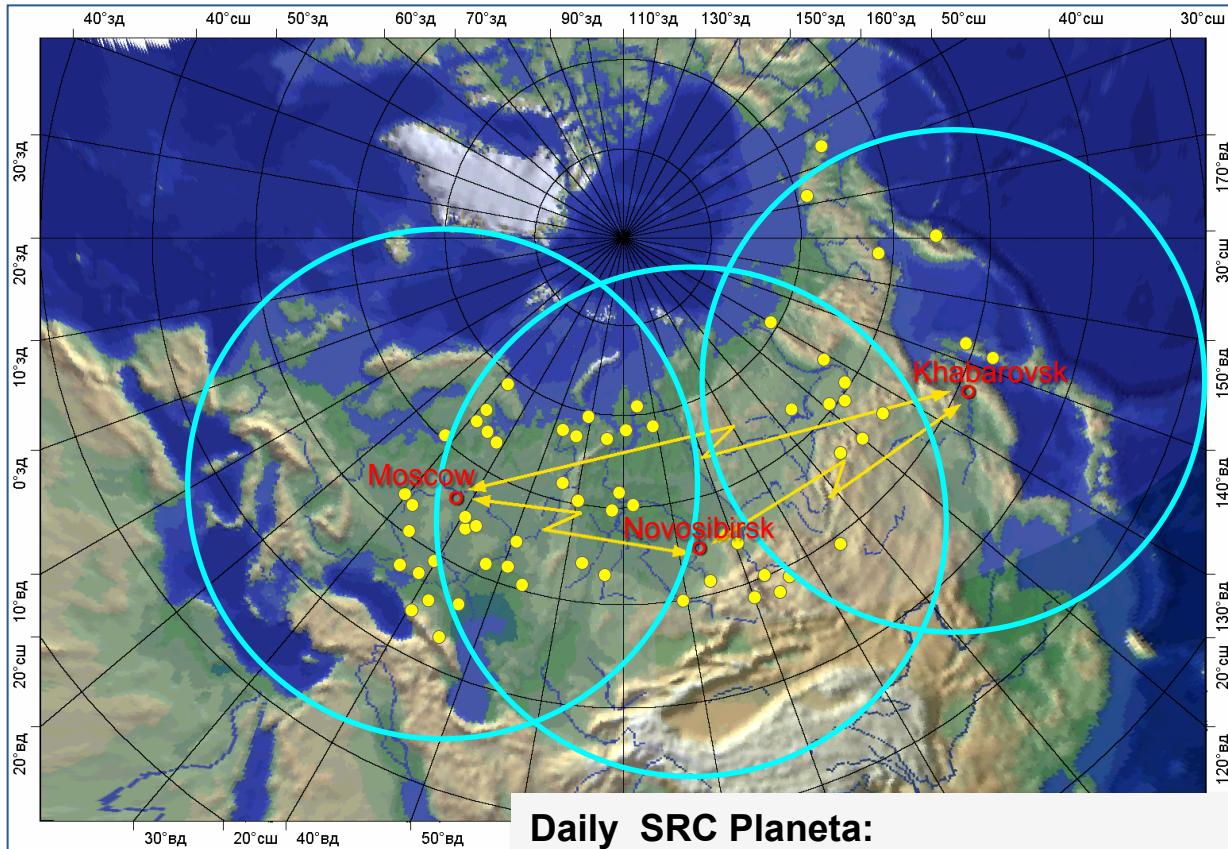
GLOBAL CLIMATE CHANGES AND EARTH MONITORING:

- climate, ocean and landscape change studies based on radiation balance, cloud cover, ozone layer, cryosphere, SST and ocean color, vegetation cover data etc.;
- climate and climate affecting processes studies.

POLLUTION MONITORING:

- pollution characteristics mapping for atmosphere, land surface and ocean;
- assessment of potentially dangerous zones for pollution propagation, including radioactive pollution.

Ground Segment of Satellite Earth Observation System



Daily SRC Planeta:

- receives more than **360** GB satellite data;
- produces more than **350** types of informational products;
- provides data to more than **510** federal and regional users.

Regional Centers:

European

(SRC Planeta, Moscow-Obninsk-Dolgoprudny)

Siberian

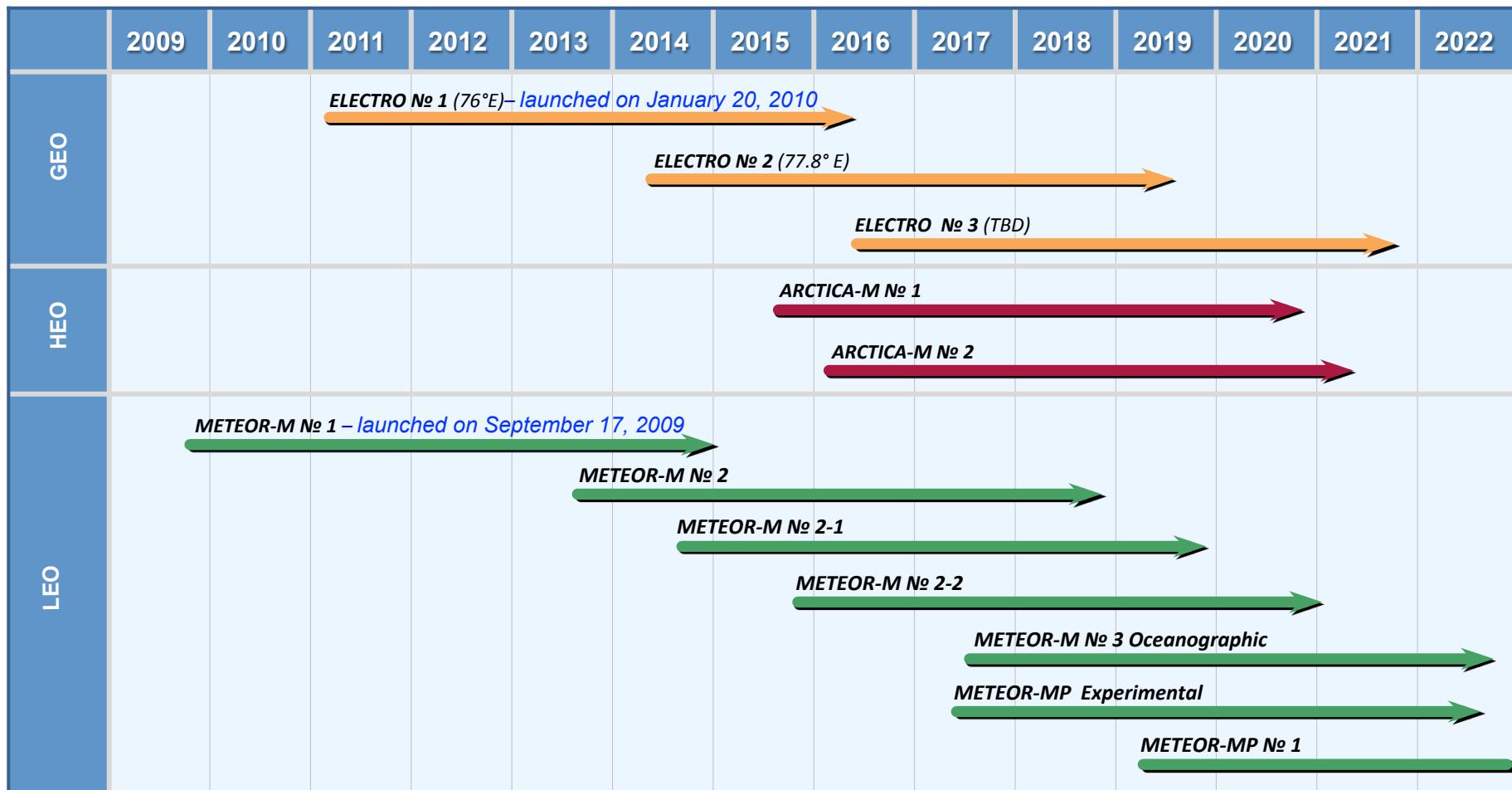
(SRC Planeta, Novosibirsk)

Far-Eastern

(SRC Planeta, Khabarovsk)

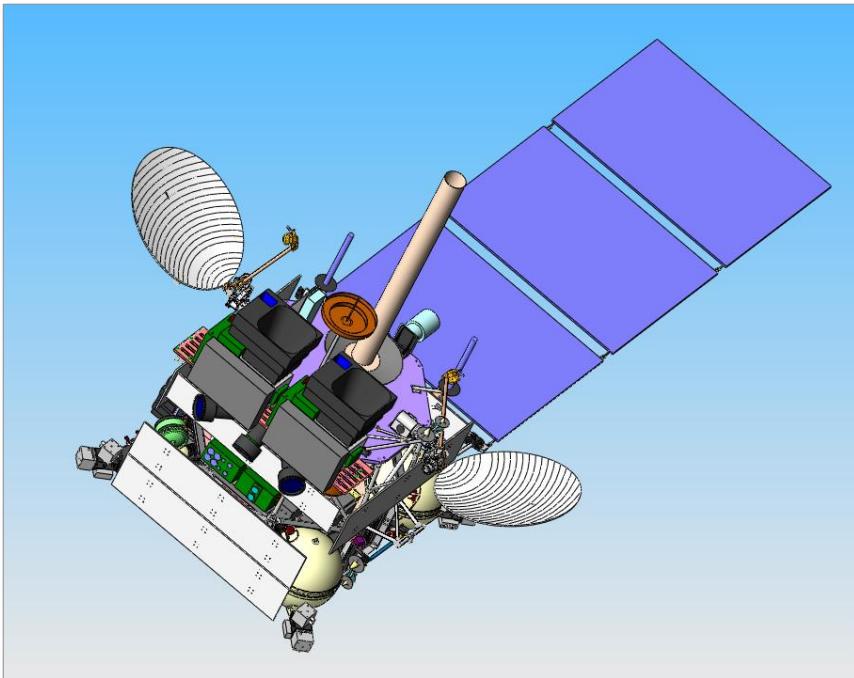
● - 68 local centers

Planning of Russian Meteorological Satellite Systems



Status of Current GEO Satellite Systems

ELECTRO-L General Design



Russian geostationary satellite ELECTRO-L №1
was launched on **January, 20th 2011**

Three-axis high-precision stabilization

In-orbit mass - 1500 kg

Payload mass - 370 kg

Lifetime - 10 years

Longitude – 76°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

<i>Parameter</i>	<i>Value</i>
Number of channels	10
• VIS	3
• IR	7
Spectral range at half maximum of spectral response function (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)	$20 \pm 0.5 \times 20 \pm 0.5$
HRIT spatial resolution at sub-satellite point (km)	1.0 (VIS); 4.0 (IR)
S/N ratio for VIS channels	≥ 200
NE Δ T at 300K (K)	
• in the band 3.5-4.0 μm	0.8
• in the band 5.7-7.0 μm	0.4
• in the band 7.5-12.5 μm	0.1-0.2
Power (W)	≤ 150
Mass (kg)	≤ 88
Lifetime of basic and reserve units (years)	10

Heliogeophysical Measurements Suite (GGAK-E)

The GGAK-E suite includes 7 sensors:

SKIF-6 – spectrometer of the corpuscular emission with particle energy in the following ranges 0,05...20,0 keV; 0,03...1,5 MeV; 0,5...30,0 MeV;

SKL-E – spectrometer of the solar cosmic rays with particle energy in the following ranges 1...12 MeV, 30,0... 300,0 MeV, > 350,0 MeV;

GALS-E – detector of the galaxy cosmic rays with particles energy in the range > 600 MeV;

ISP-2M – measurements of the solar constant in the range 0,2-100 microns;

DIR-E - measurements of the solar X-rays with energy in the range 3-10 keV;

VUSS-E - measurements of the solar UV radiation at the Hydrogen resonant line H_α (121,6 nm);

FM-E – magnetometer for the magnetic field intensity measurement in the range ±300 nanotesla.

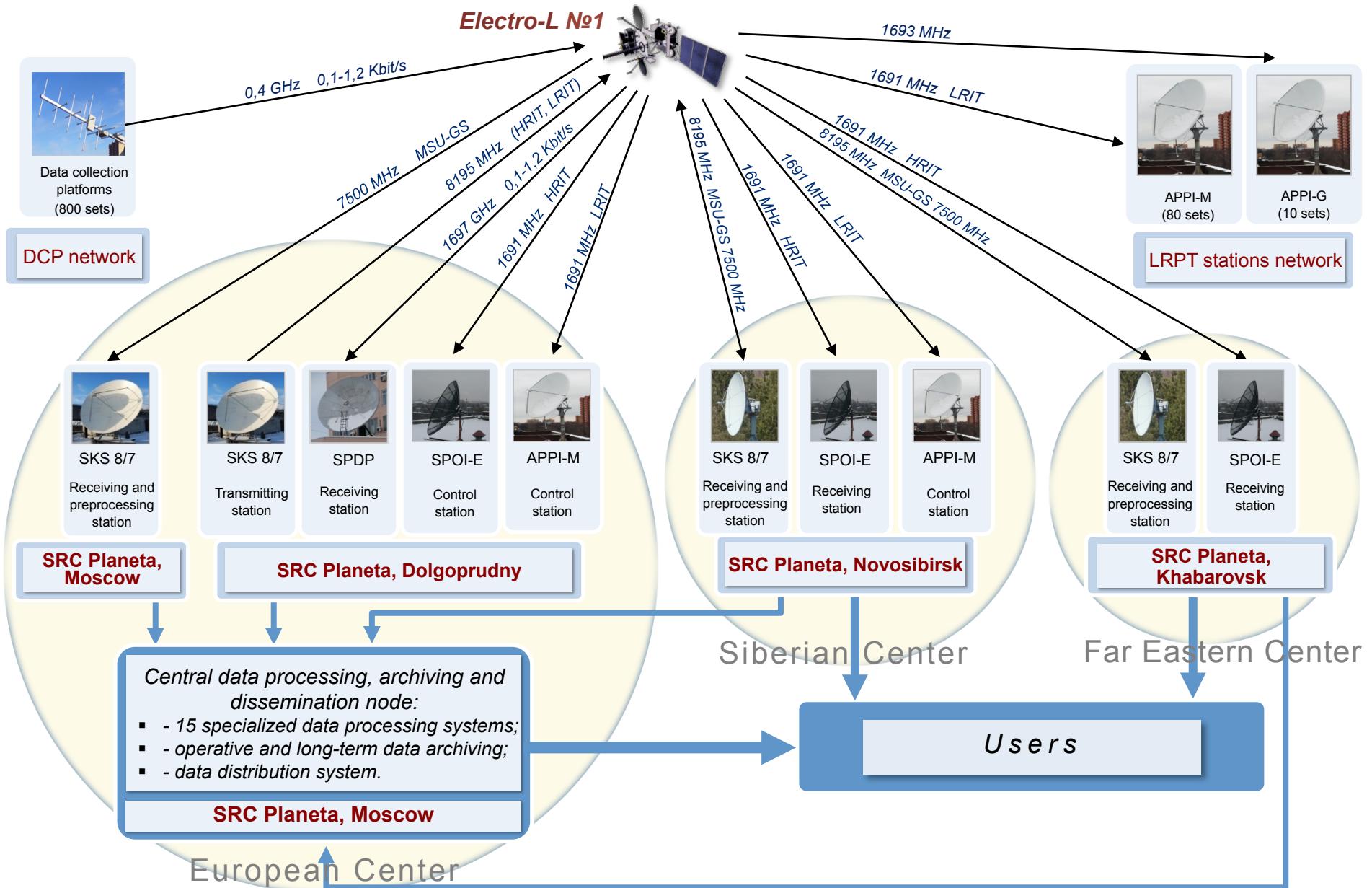
Status of Electro-L №1 Spacecraft

The MSU-GS instrument has some problems with calibration and excessive noise level in IR channels. The WV channel is not functional because of excessive noise. All visible channels are fully functional. Application of the MSU-GS channels and their functional limitations are shown below. GGAK-E instrument suite is functioning with significant limitations, DCS as well as COSPAS/SARSAT retransmission service are fully functional.

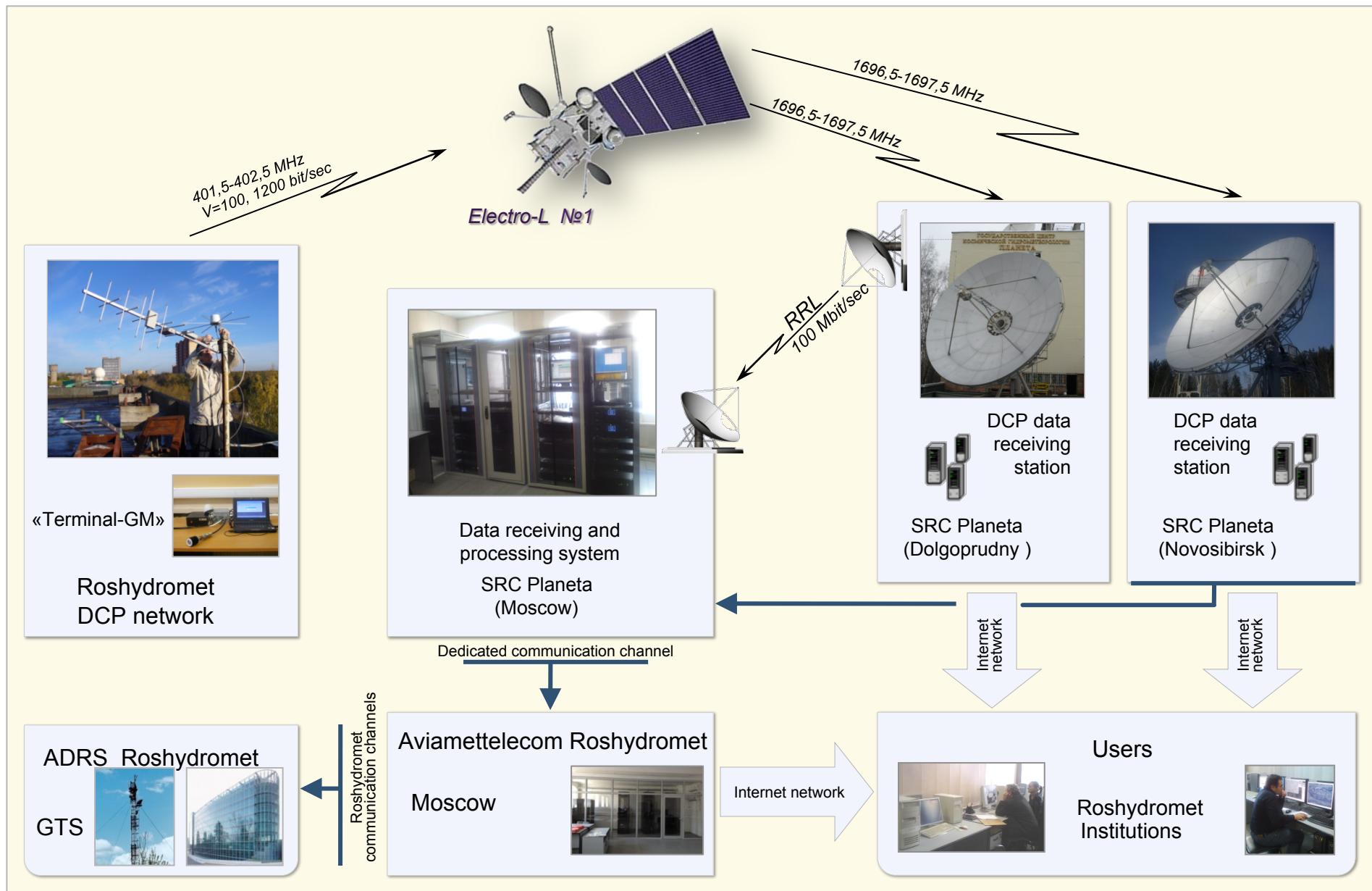
Channel No	Range, μm	Application
1	0,5 – 0,65	Animated cloud imagery, snow, ice and vegetation detection (daytime)
2	0,65 – 0,8	
3	0,8 – 0,9	
4	3,5 – 4,0	Fires, SST (nighttime)
5	5,7 – 7,0	Water vapor, wind, semi-transparent clouds
6	7,5 – 8,5	Semi-transparent stratus clouds
7	8,2 – 9,2	
8	9,2 – 10,2	Ozone (total column)
9	10,2 – 11,2	Animated cloud imagery, wind, SST and LST, precipitation, cloud top height, fires etc.
10	11,2 – 12,5	

— - operational — - operational with limitations — - non-operational

Roshydromet Ground Segment for Electro-L №1



Electro-L Data Collection System



MSU-GS/Electro-L №1 Data Dissemination

1. Direct broadcast

MSU-GS HRIT/LRIT data dissemination is performed every 3 hours.

Data format description for MSU-GS HRIT/LRIT is published at SRC Planeta WEB-site http://planet.iitp.ru/english/index_eng.htm and provided to WMO in January, 2012.

2. Data access via Internet

HRIT data dissemination via Internet is organized via SRC Planeta FTP server. This data become available for the EUMETSAT in September, 2012.

3. MSU-GS products access

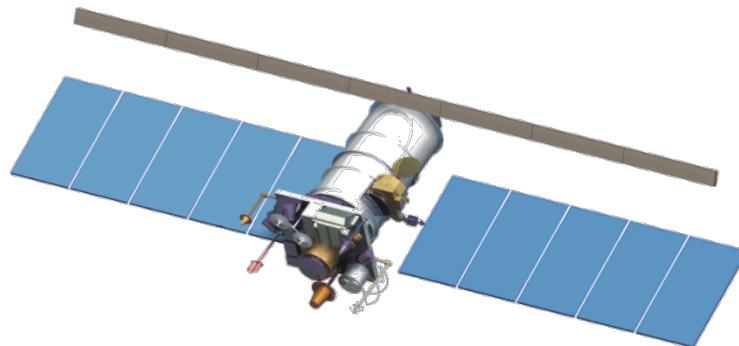
Some products that are regularly generated by SRC Planeta from MSU-GS data can be accessed via SRC Planeta WEB site.

Status of Current LEO Satellite Systems

METEOR-M №1 General Design



Russian meteorological satellite
Meteor-M №1 was launched on
September, 17th 2009



In-orbit mass – 2700 kg

Payload mass – 1200 kg

Lifetime – 5 years

Orbit – Sun-synchronous

Altitude – 830 km

Data dissemination format – HRPT/LRPT

Meteor-M №1 Basic Instruments Specifications

<i>Instrument</i>	<i>Application</i>	<i>Spectral band</i>	<i>Swath-width (km)</i>	<i>Resolution (km)</i>
MSU-MR Low-resolution multi-channel scanning unit	Global and regional cloud cover mapping, ice and snow cover observation, forest fire monitoring	0,5 – 12,5 μ m (6 channels)	3000	1 x 1
KMSS Visible spectrum scanning imager	Earth surface monitoring for various tasks (floods, soil and vegetation cover state, ice cover)	0,4-0,9 μ m (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, sea surface wind	10,6-183,3 GHz (26 channels)	2600	12 – 75
“Severjanin-M” Synthetic aperture radar	All-weather Ice coverage monitoring	9500-9700 MHz	600	0,4 x 0,5
GGAK-M Heliogeophysical instrument suite	Heliogeophysical data providing			
BRK SSPD Data Collection System	Data retransmission from DCP			

Low-resolution Multi-channel Scanning Unit MSU-MR (Meteor-M №1)



MSU-MR

Parameter	Value
Number of channels	6
Spectral bands, μm	0.5-0.7 0.7-1.1 1.6-1.8 3.5-4.1 10.5-11.5 11.5-12.5
Swath width, km ($H=835$ km)	2800
Spatial resolution, m ($H=835$ km)	1000
Data rate, Mbit per second	0.66
Number of bits	10
NEDT for 300K - 3.5-4.1 μm - 10.5-12.5 μm	0.5 0.12
Mass, kg	106 (two units)

Visible Spectrum Scanning Imager KMSS (Meteor-M №1)



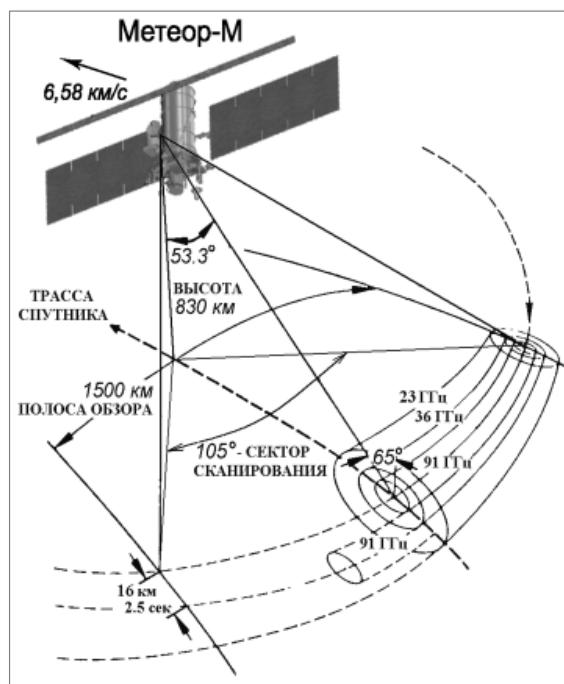
KMSS consists of three cameras. Two of them have a 100mm focal distance, the third one has a 50mm focal distance. Characteristics of both camera types are given below:

Parameter	Value
Swath width, km	450, 900
Viewing angle, degrees	31, 62
Spatial resolution, m	50, 100
Number of spectral channels	6
Spectral channel range at half-maximum of spectral response function, μm	
50 m resolution	0.535 – 0.575
	0.630 – 0.680
	0.760 – 0.900
100 m resolution	0.37 – 0.45
	0.45 – 0.51
	0.58 – 0.69
Number of bits	8
Signal/noise ratio	200

Microwave Imager/Sounder MTVZA-GY (Meteor-M №1)



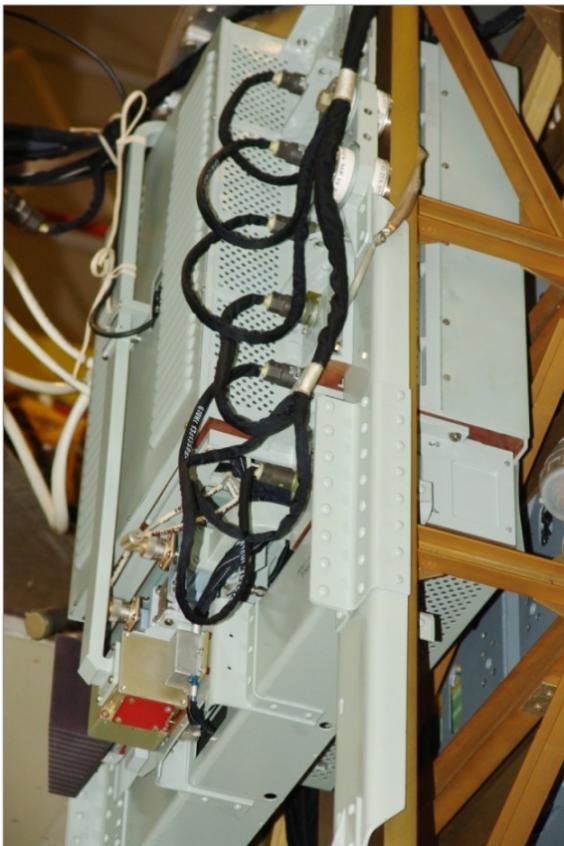
Instrument MTVZA-GY



Scheme of scanning

Parameter	Value
Frequencies, GHz	10.6, 18.7, 23.8, 36.5, 52-57, 91, 183.31
Channels	29
Antenna Aperture, cm	65
Spatial Resolution, km	16-198
Sensitivity, K/pixel	0.3-1.7
Calibration Accuracy, K	< 1
Swath Width, km	1800
Conical Scanning Period, s	2.5
Data Rate, Kbit/s	35
Mass, kg	94
Power , W	80

BRLK «Severyanin-M» (Meteor-M №1)



Parameter	Value
Swath width (km)	≥ 600
Spatial resolution (m) - low resolution mode - moderate resolution mode	800-1300 400-650
Radiometric resolution (dB) - low resolution mode - moderate resolution mode	$\leq 1,5$ $\leq 1,9$
Noise equivalent of the backscattering coefficient (dB)	≤ -20
Dynamic range of measured backscattering coefficients (dB)	≥ 28 (from -25 to +3)

Status of Meteor-M №1 Spacecraft

- MSU-MR instrument is functional with limitations (calibration issues and high noise level in the IR channels);
- MTVZA instrument is non-operational due to onboard memory failure and temperature sounding channels malfunction;
- KMSS instrument is fully functional;
- Severjanin instrument is non-operational;
- DCS is non-operational;
- LRPT transmission is non-operational;
- GGAK-M is functional with significant limitations.

<i>MSU-MR Channel No</i>	<i>Range, μm</i>	<i>Application</i>
1	0.50-0.70	
2	0.70-1.10	
3	1.60-1.80	Cloud cover, snow, ice, surface types, vegetation (daytime)
4	3.50-4.10	Fires, SST (nighttime)
5	10.5-11.5	Global and local cloud maps, SST and LST, precipitation, cloud top height, cloud fraction, water content, etc.
6	11.5-12.5	

— green - operational — blue - operational with limitations — red - non-operational

MSU-MR/Meteor-M №1 Data Dissemination

1. Direct broadcast

MSU-MR instrument data is currently disseminated at 1.7 GHz band in direct broadcast mode (HRPT).

MSU-MR HRPT data format description is available at SRC Planeta WEB-site
http://planet.iitp.ru/english/spacecraft/meteor_m_n1_structure_eng.htm

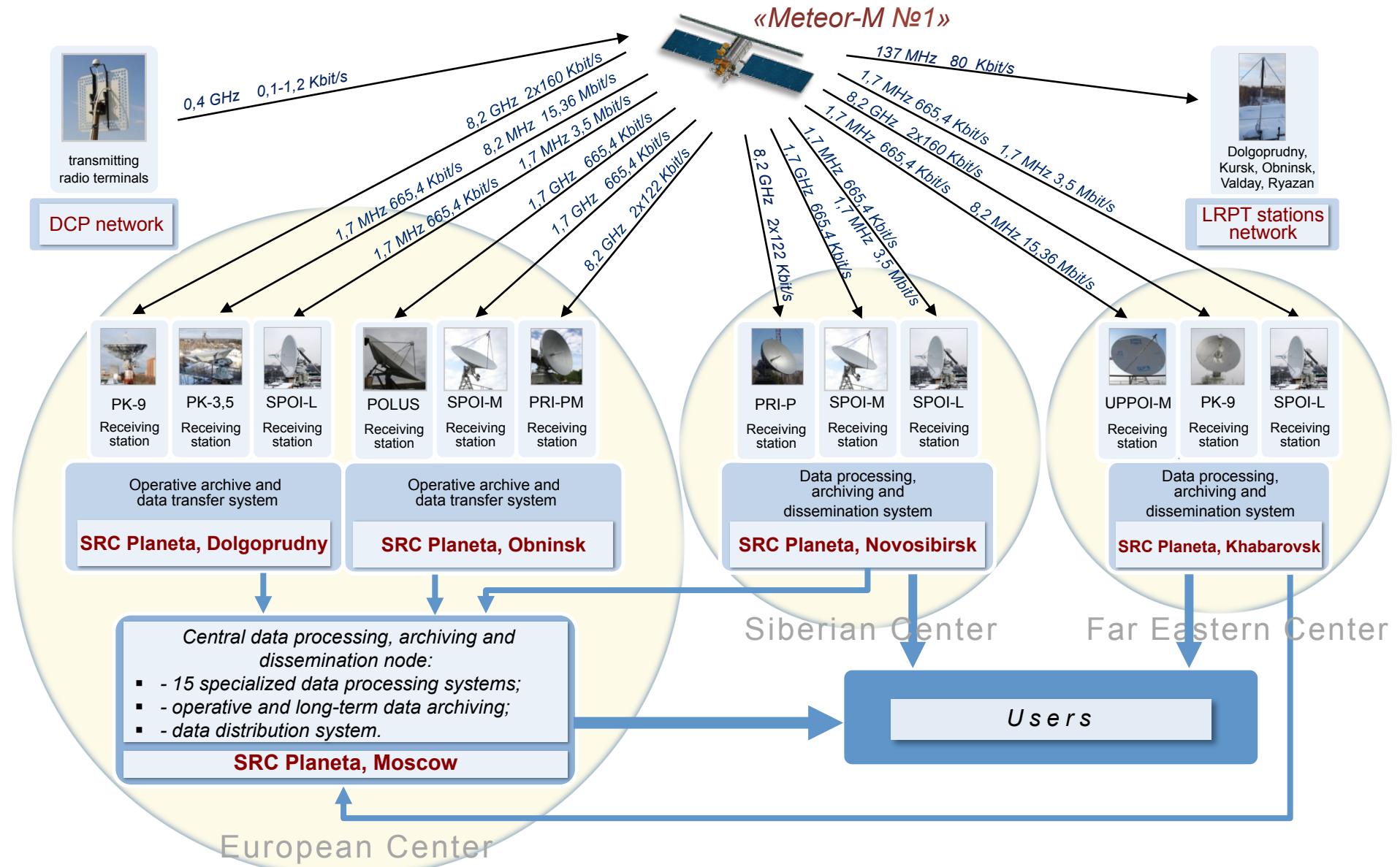
2. Global data access

Global MSU-MR data can be accessed on demand via FTP, e.g. for calibration/validation purposes.

3. MSU-MR products access

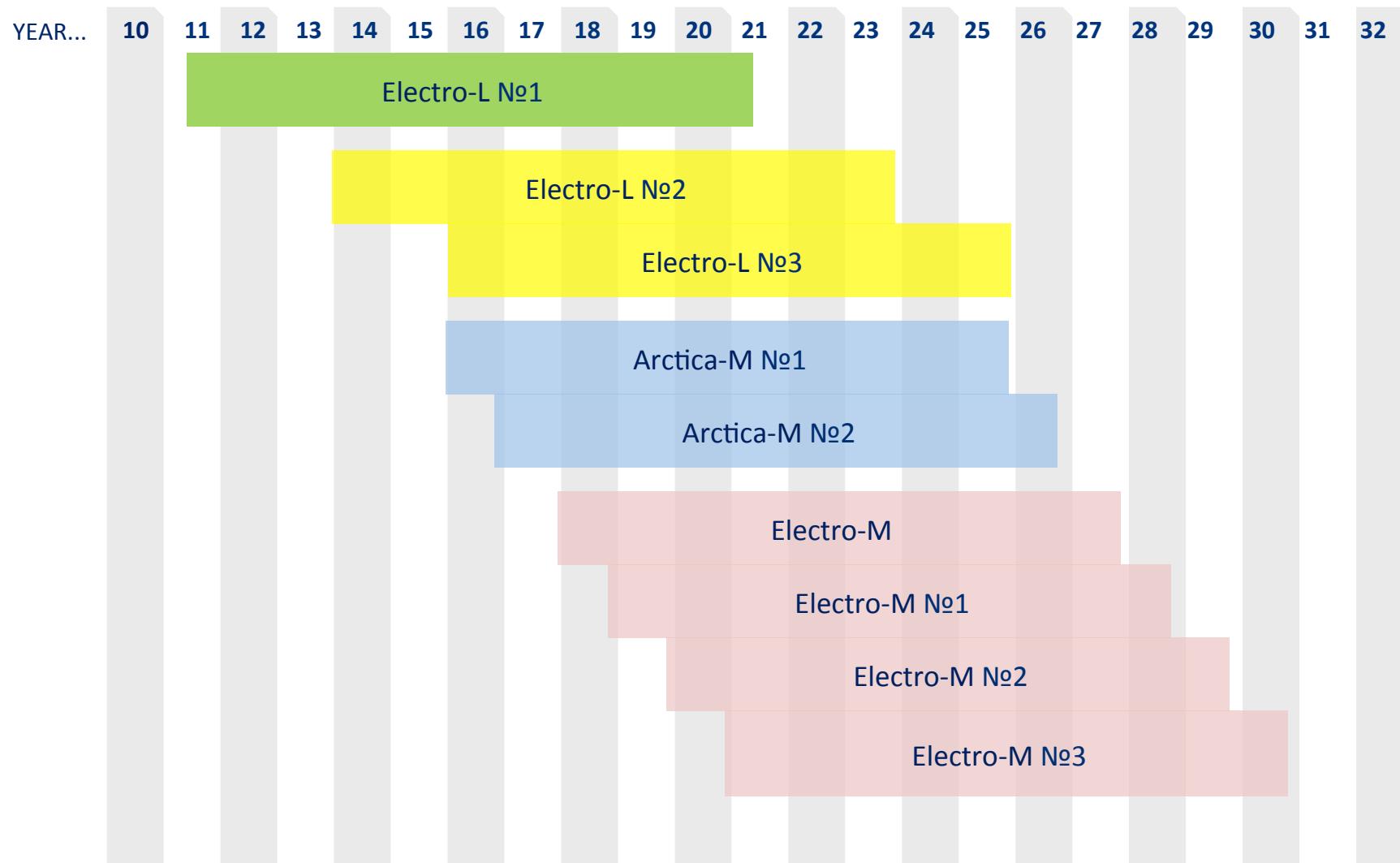
Some products that are regularly generated by SRC Planeta from MSU-MR data can be accessed via SRC Planeta WEB-site.

Roshydromet Ground Segment for Meteor-M №1



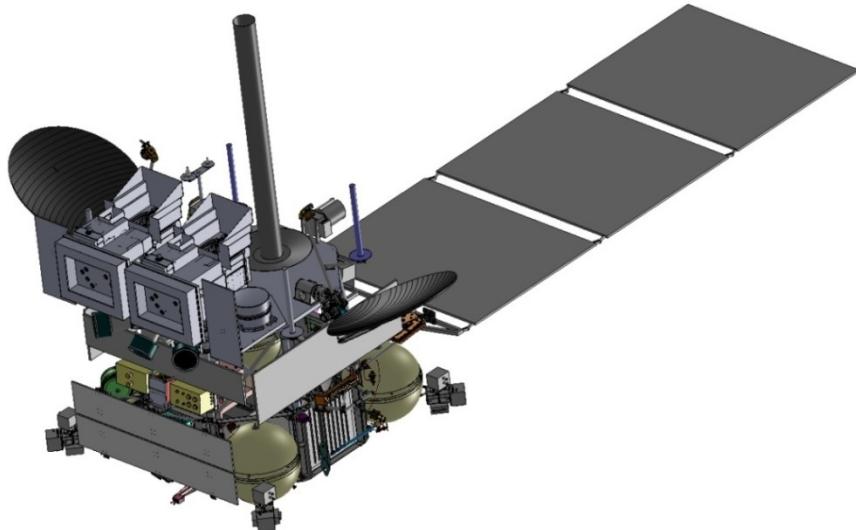
Status of Future GEO Satellite Systems

Electro-L/Arctica-M/Electro-M



- The Electro-L № 2,3 payload is similar to the one of the Electro-L №1, but with improved instrument performance.
- Orbital positions: for Electro-L №2 – 77.8°E; for Electro-L №3 – TBD (14.5°W or 166°E).
- The launch dates: for Electro-L №2 – 2014; for Electro-L №3 – 2016.

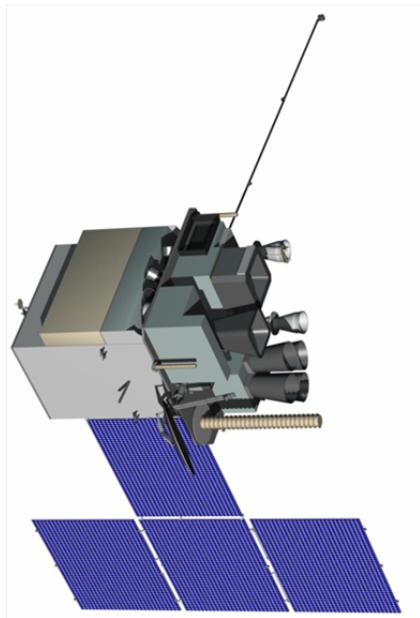
Electro-L №2, №3



Mission objectives

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

Parameter	Value
Electro-L № 2 longitude Electro-L № 3 longitude	77.8° E TBD (14.5°W or 166°E)
MSU-GS channels	10
Wavelength range	0,5 - 12,5 μm
Spatial resolution at sub-satellite point: - VIS and NIR - IR	1 km 4 km
MSU-GS scan period: - regular mode (full Earth disk) - frequent mode (fragments of the Earth disk)	30 min 15 min
Mass, kg	1870



Electro-M

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

Parameter	Value
Electro-M № 1 longitude	76° E
Electro-M № 2 longitude	77.8° E
Electro-M № 3 longitude	TBD (14.5°W or 166°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

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;
- IRFS-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 \leq 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

Meteor-M №№ 2, 2-1, 2-2 Basic Instruments Specifications

<i>Instrument</i>	<i>Application</i>	<i>Spectral band</i>	<i>Swath-width (km)</i>	<i>Resolution (km)</i>
MSU-MR Low-resolution multi-channel scanning unit	Global and regional cloud cover mapping, ice and snow cover observation, forest fire monitoring, ...	0,5 – 12,5 μ m (6 channels)	3000	1 x 1
KMSS Visible spectrum scanning imager	Earth surface monitoring for various tasks (floods, soil and vegetation cover state, ice cover)	0,4-0,9 μ m (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, sea surface wind	10,6-183,3 GHz (26 channels)	2600	12 – 75
IRFS-2 Advanced IR sounder (infrared Fourier-spectrometer)	Atmospheric temperature and humidity profiles	5-15 μ m	2000	35
“Severjanin-M” Synthetic aperture radar	All-weather Ice coverage monitoring	9500-9700 MHz	600	0,4 x 0,5
GGAK-M Heliogeophysical instrument suite	Heliogeophysical data providing			
BRK SSPD Data Collection System	Data retransmission from DCP			

IRFS-2 Basic Performance Characteristics



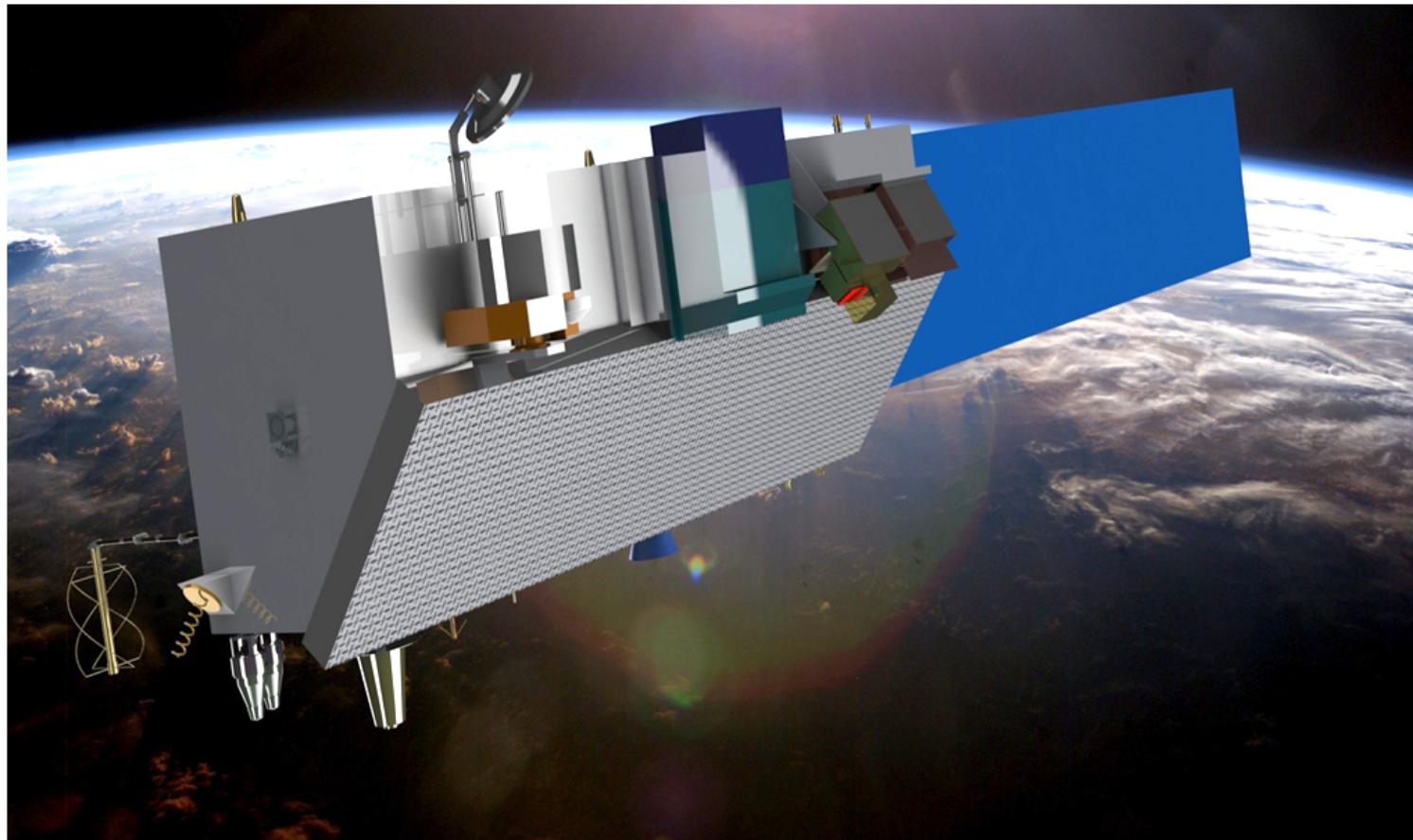
Parameter	Units	Value
Spectral range: wavelength wave number	μm cm^{-1}	5-15 2000-665
Reference channel wavelength	μm	1.06
Maximum optical path difference (OPD)	mm	17
Angular size of FOV	mrad	40 x 40
Spatial resolution (at sub-satellite point)	km	35
Swath Width and spatial sampling	km	2500, 110 2000, 100
Duration of the interferogram measurement	s	0.5
Dynamic range		2^{16}
Mass	kg	45-50
Power	W	50

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

Meteor-M №3 Basic Instrument Specifications

<i>Instrument</i>	<i>Spectral band</i>	<i>Resolution</i>	<i>Swath width(km)</i>
SAR Synthetic aperture radar	X - band	1, 5 - 500 m	10 - 750
Scatterometer	Ku - band	25×25 km	1800
OCS Ocean color scanner	13 channels 0.407 – 0.875 μm	1 km	1800
CZS Coastal zone scanner	6 channels 0.433 - 0.885 μm	80 m	800
Radiomet Radio-occultation sounder	1160 – 1600 MHz	Vertical resolution – 150 m Horizontal resolution – 300 km	

Meteor-MP №1, 2



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

METEOR-MP Basic Payload Instruments

Instruments	Meteor-MP		
	№1	№2	№3
Scanning radiometer (low-resolution multichannel scanning unit)	+	+	-
Ocean colour scanner	-	-	+
Visible spectrum scanning imager (Medium resolution multispectral imaging system)	+	+	-
Coastal area scanner	-	-	+
Infra-red Fourier-transform spectrometer (IRFS-3)	+	+	-
Medium resolution multispectral infra-red scanner	-	-	+
Atmospheric composition spectrometer	+	+	-
Microwave imager-sounder MTVZA-GY-M (module for temperature and humidity sounding of the atmosphere)	+	+	-
Scatterometer	-	-	+
Side-looking radar system	+	+	-
Multimode radar system based on Active Phased Array Antenna (APAA)	-	-	+
Radio-occultation instrument	+	+	-
Data collection system	+	+	+
Heliogeophysical instruments suite	+	+	-
137MHz data downlink system	+	+	+
1.7GHz data downlink system	+	+	-
X- and Ka- band data downlink system	+	+	+

Low-resolution Multi-channel Scanning Unit MSU-MR (Meteor-MP №1,2)

<i>Parameter</i>	<i>Value</i>
Number of channels	17
Spectral bands, μm	0.4-12.5
Swath width ($H=835 \text{ km}$), km	3000
Spatial resolution ($H=835 \text{ km}$), m	0.25 – 0.5
Data rate, Mbit per second	7.5
Number of bits	10
NEDT for 300K	0.1 – 0.2
Mass, kg	160-180

IRFS-3 Basic Performance Characteristics (Meteor-MP №1,2)

<i>Parameter</i>		<i>Value</i>
Spectral range		645...2760 cm ⁻¹ (3.6-15.5 μm)
	LW	645...1200 cm ⁻¹
	MW	1200...2000 cm ⁻¹
	SW	2000...2760 cm ⁻¹
Spectral resolution		0.25 cm ⁻¹
Swath width		2200 km(±48), 30 scans
Field of view	Full	2×2 +1, 48×48 km ²
	Instant	Ø14 km

Atmospheric Composition Spectrometer (Meteor-MP №1,2)

<i>Parameter</i>	<i>Value</i>
Spectral resolution, nm UV1 - 214 – 334	0,5
UV2 - 320 – 452	0,5
VIS - 430 – 800	1,5
NIR1 - 755 – 910	0,9
NIR2 - 900 – 1210	0,9
SWIR1 - 1200 – 1770	2,0
SWIR2 - 1934 – 2044	0,5
SWIR3 - 2259 – 2386	0,5
Observation modes	Nadir Limb Sun
Spatial resolution for nadir observations (H = 800 km)	8 - 14
Swath width for nadir observations, km	1000
Spatial resolution for limb observations, $\delta L \times \delta H$, km	35 x 3

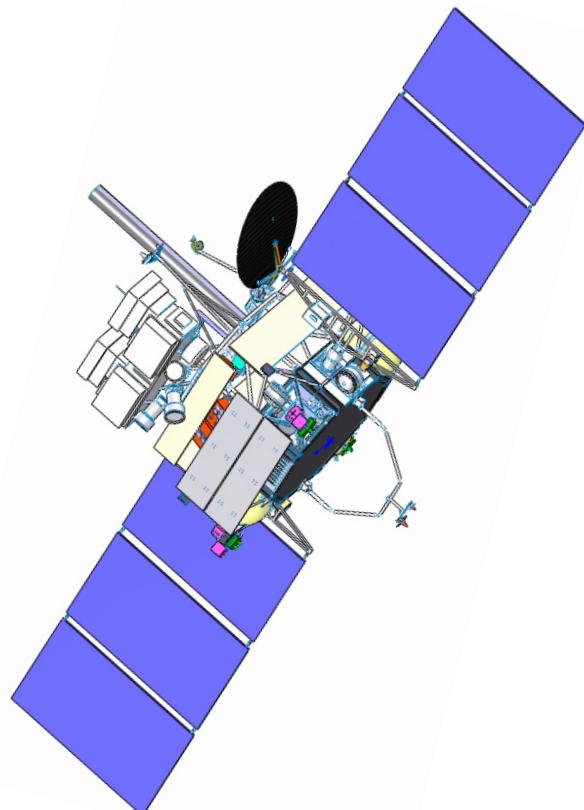
MTVZA-GY-M

(Meteor-MP №1,2)

<i>Parameter</i>	<i>Value</i>
Frequencies, GHz	6.9 10.6 18.7 23.8 36.5 52.3-57.0 91 183.31
Channels	29
Swath width, km	1500
Spatial resolution, km: - horizontal - vertical	12-250 1.5-5
Scanning type	conical
Onboard memory, GB	1
Mass, kg	100

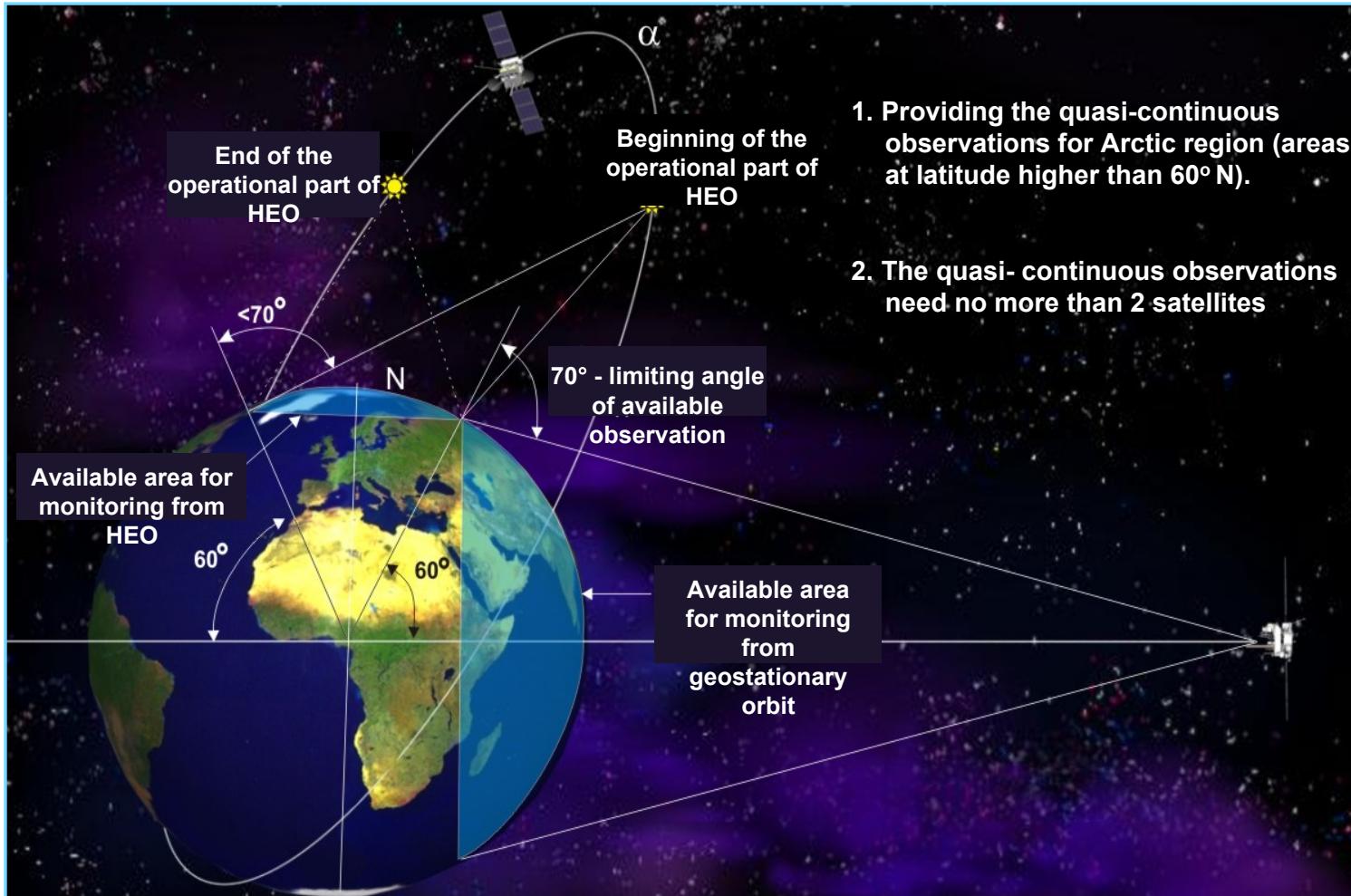
Status of Future HEO Satellite Systems

Arctica-M

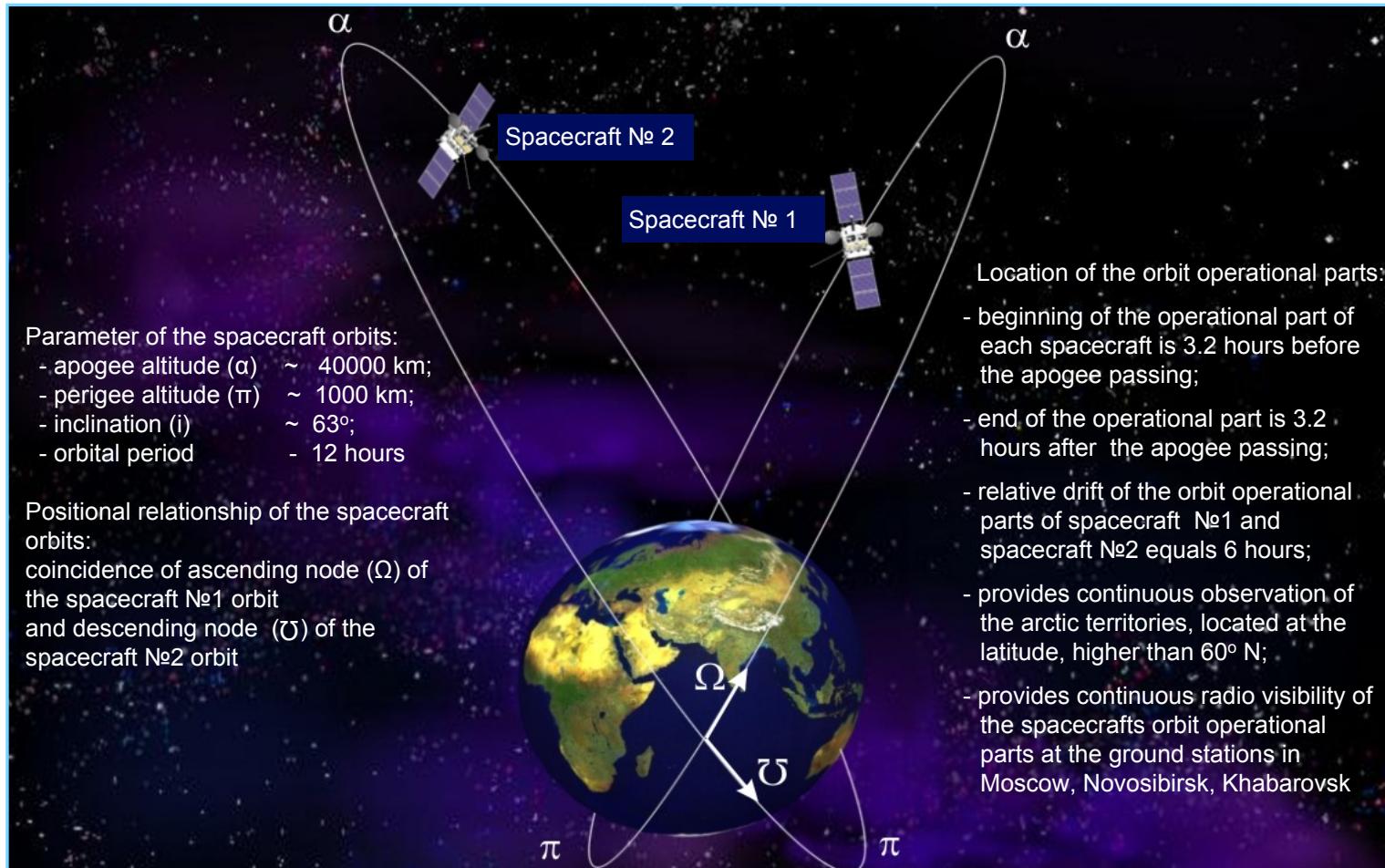


Parameter	Value
<i>Orbit:</i>	
Apogee, km	40000
Perigee, km	1000
Inclination, deg	63,4
Period, h	12
Full number of MSU-A spectral channel	10
Spectral range, μm	from 0,5 to 12,5
<i>Resolution (at nadir):</i>	
- VIS-channel, km	1
- IR-channel, km	4
<i>Frequency of full Earth disk observation, min:</i>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

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



Space System Ballistic Configuration



Arctica-M Basic Payload

- The multichannel scanning unit MSU-A, 10 spectral channels (3 VIS and 7 IR channels).
- The heliogeophysical instrument 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.

Arctica preliminary design is now completed. The launch of the first satellite in Arctica series is scheduled for 2015.

Thanks for attention!