STATUS OF CURRENT AND FUTURE RUSSIAN SATELLITE SYSTEMS

by Roscosmos/Roshydromet

Presented to CGMS-42 plenary session

Roshydromet Space Observation System Objectives

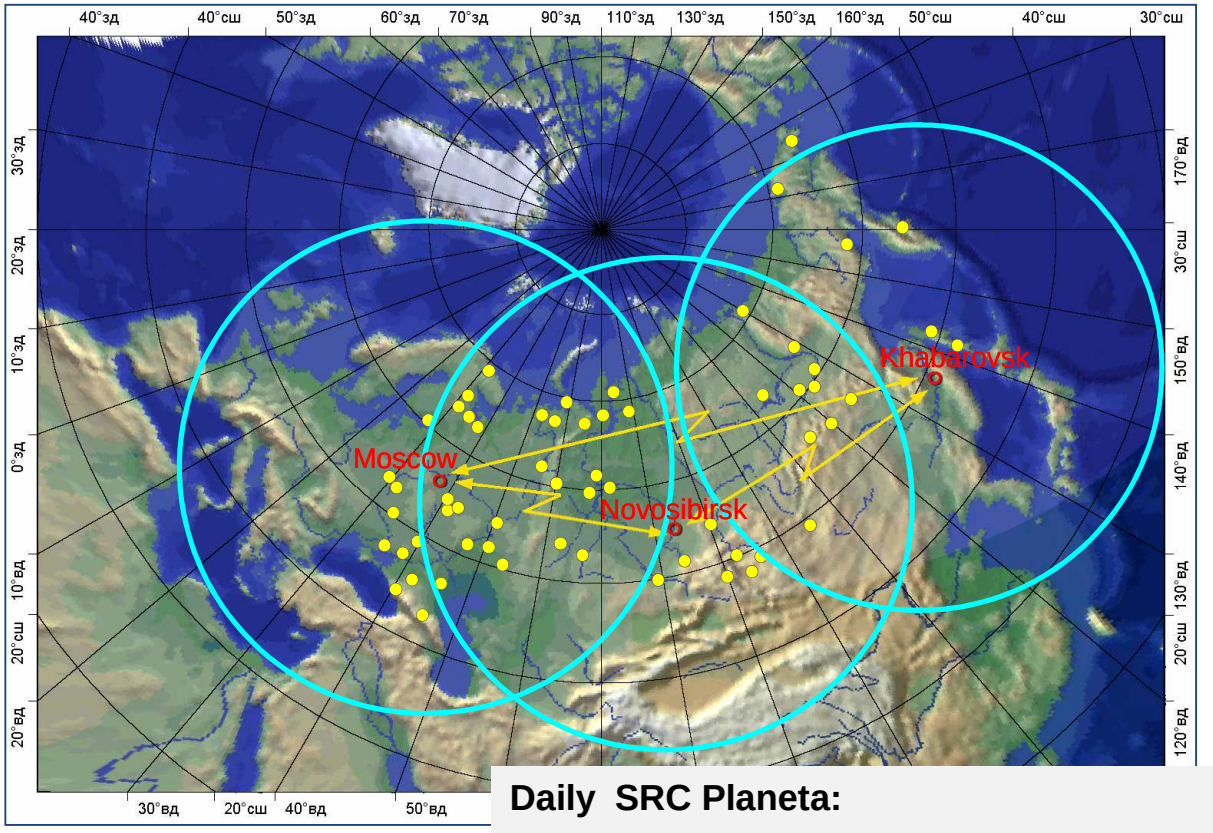
HYDROMETEOROLOGY AND GEOPHYSICAL MONITORING:
- atmosphere and ocean monitoring and forecast;
- sea ice monitoring for navigation in Arctic and Antarctic regions and seas;
- data providing for heliogeophysical service;
- DCP data retransmission via satellite.

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



Regional Centers:

European
(SRC Planeta, Moscow-Obninsk-Dolgoprudny)

Siberian
(SRC Planeta, Novosibirsk)

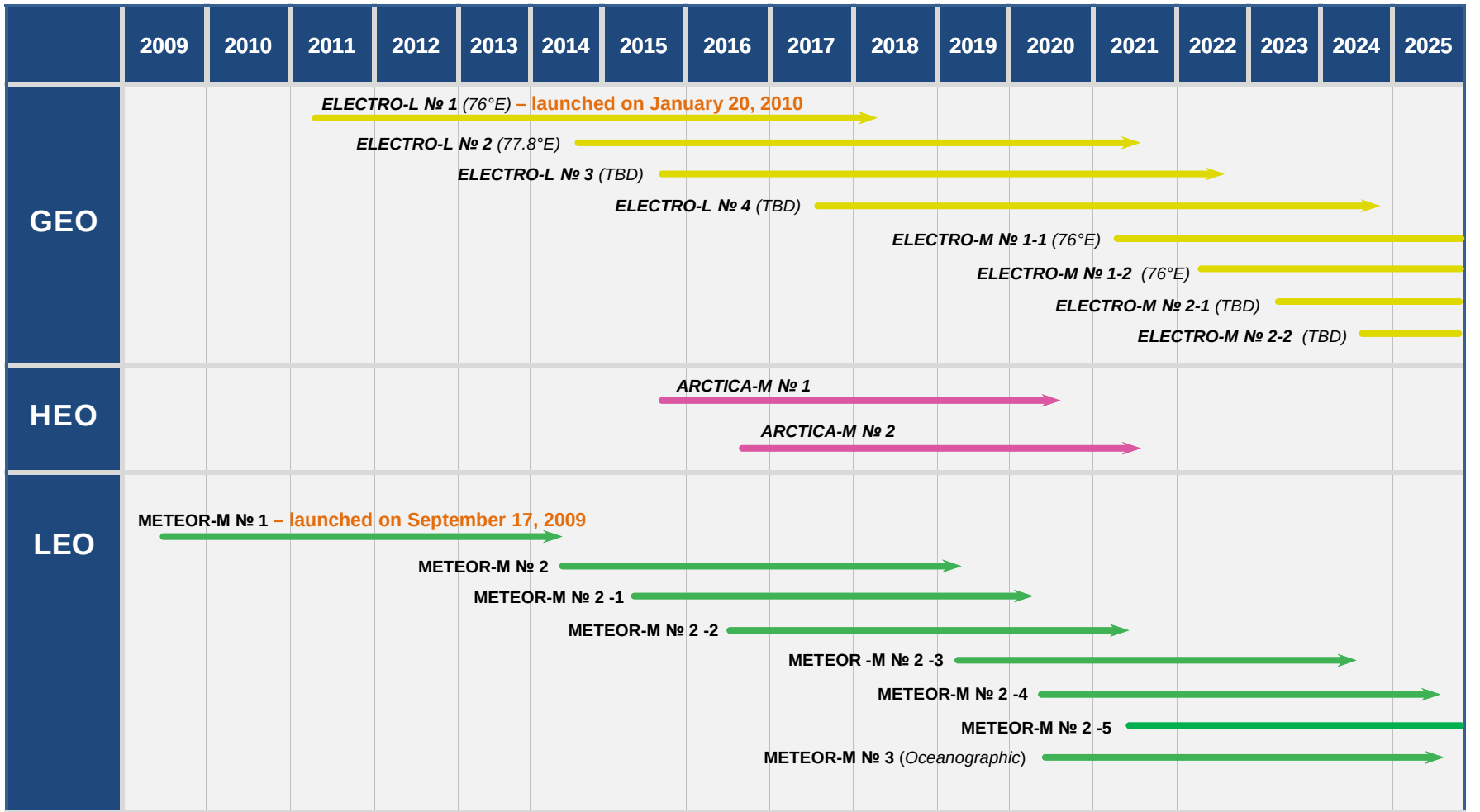
Far-Eastern
(SRC Planeta, Khabarovsk)

● - 68 local centers

Daily SRC Planeta:

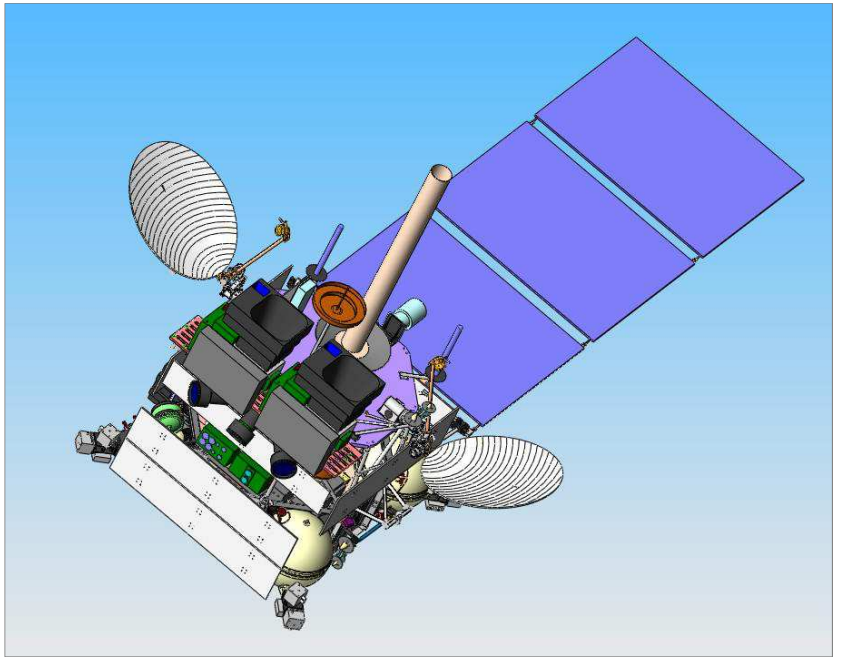
- receives more than **420** GB satellite data;
- produces more than **350** types of informational products;
- provides data to more than **530** federal and regional users.

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 ***20 January, 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

Parameter	*Value*
Number of channels • VIS • IR	**10** **3** **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 ± 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	 **0.8** **0.4** **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 HLa (121,6 nm);

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

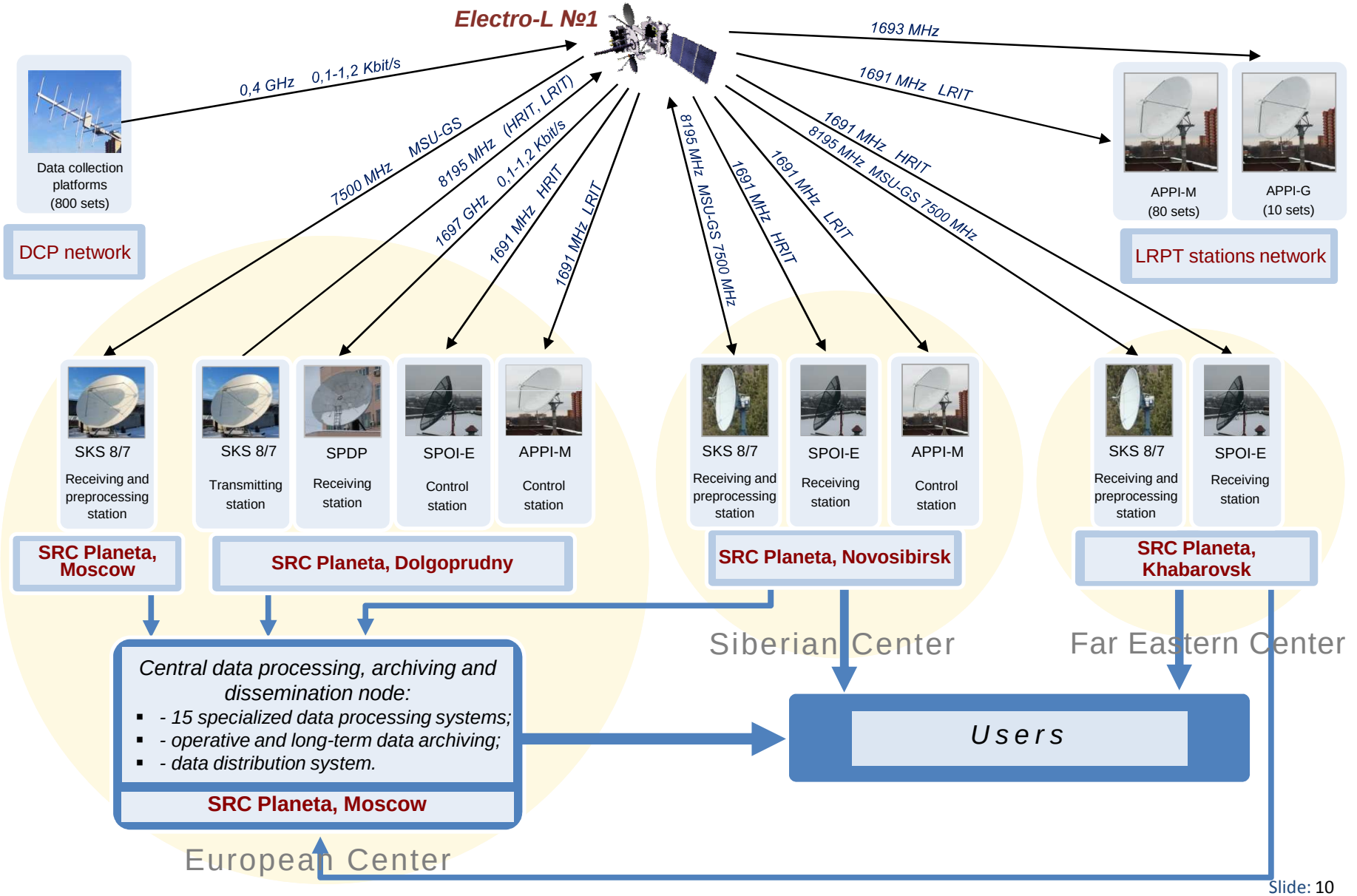
Status of Electro-L №1 Spacecraft

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.

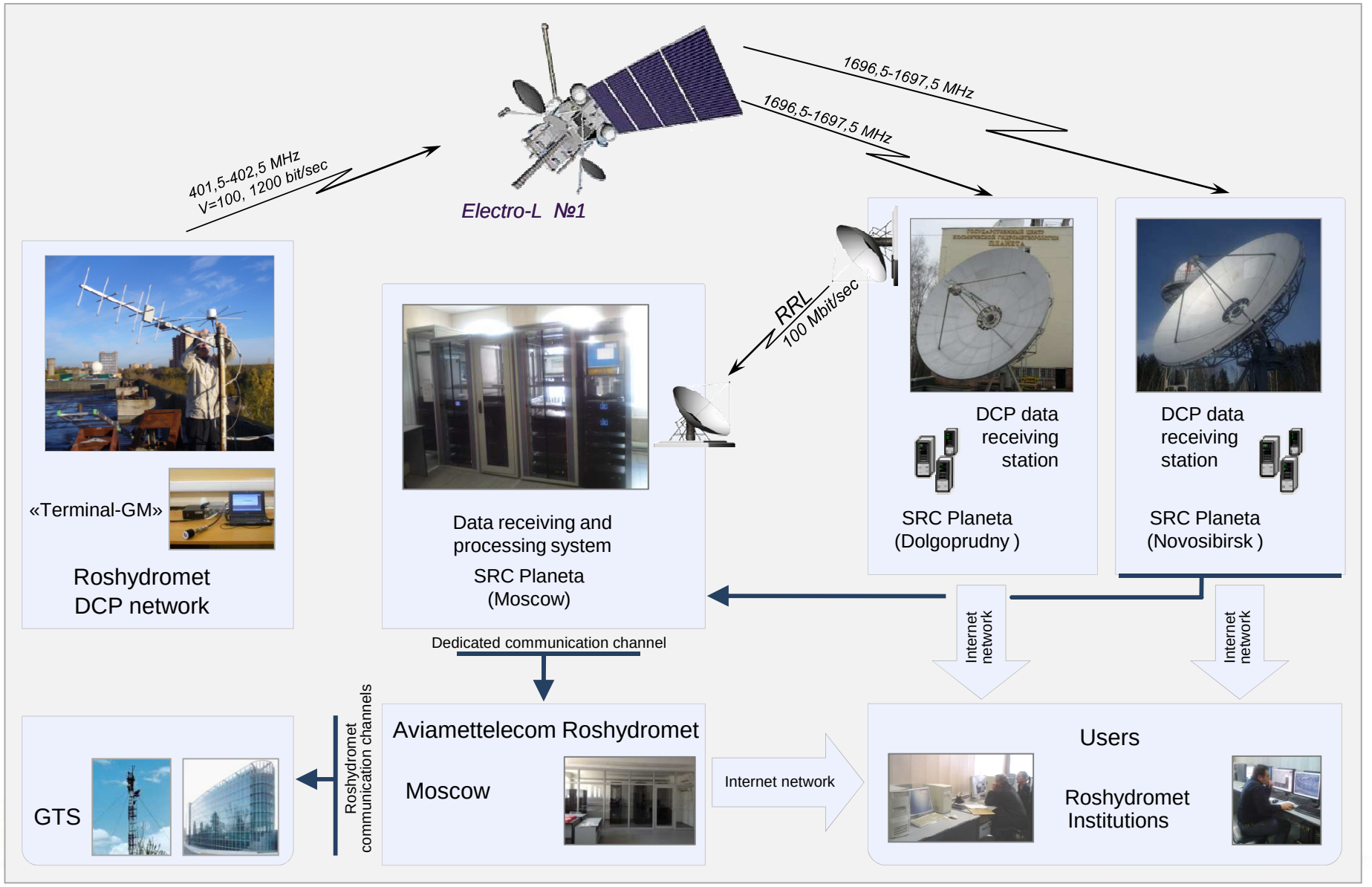
Cannel No	*Range, μm*	*Application*
1	0,5 – 0,65	**Animated cloud imagery, snow, ice and vegetation detection (daytime)**
2	0,65 – 0,8	
3	0,8 – 0,9	
4	3,5 – 4,0	**Fires, SST (nighttime)**
5	5,7 – 7,0	**Water vapor, wind, semi-transparent clouds**
6	7,5 – 8,5	**Semi-transparent stratus clouds**
7	8,2 – 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.

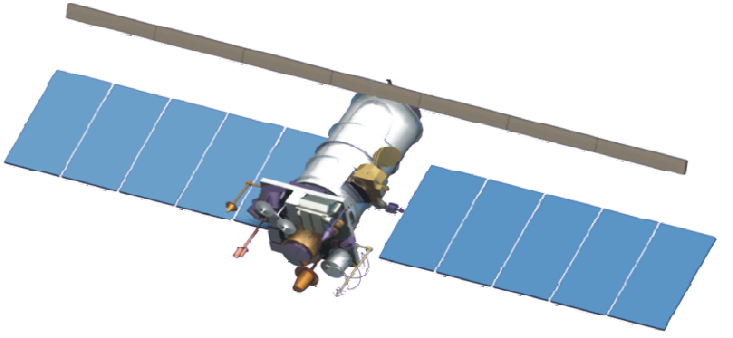
3. MSU-GS products access

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

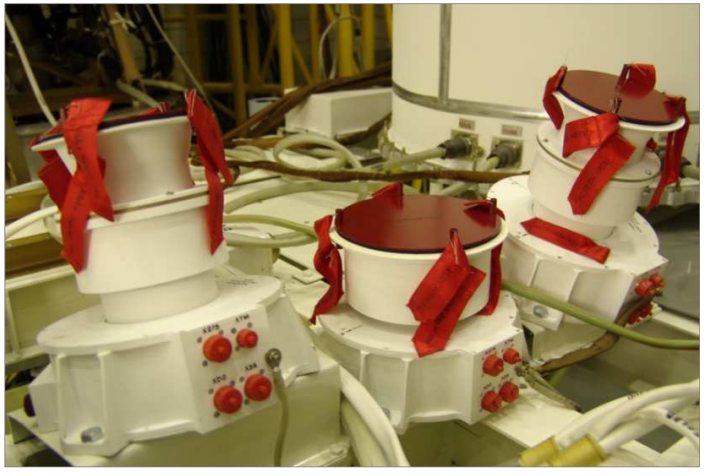
Instrument	*Application*	*Spectral band*	*Swath-width (km)*	*Resolution (km)*
MSU-MR Low-resolution multi-channel scanning unit	Global and regional cloud cover mapping, ice and snow cover observation, forest fire monitoring	0,5 – 12,5μm (6 channels)	3000	1 x 1
KMSS Visible spectrum scanning imager	Earth surface monitoring for various tasks (floods, soil and vegetation cover state, ice cover)	0,4-0,9 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, 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)

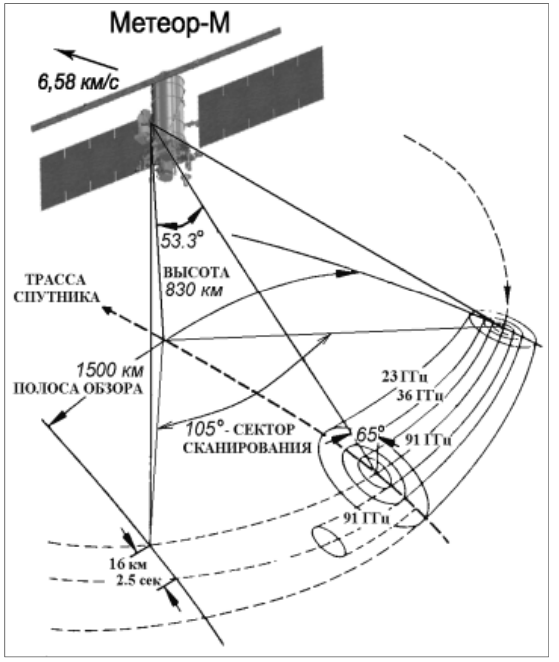


KMSS consists of three cameras. Two of them have a 100mm focal distance, the third one has a 50mm focal distance. Characteristics of both camera types are given below:

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)

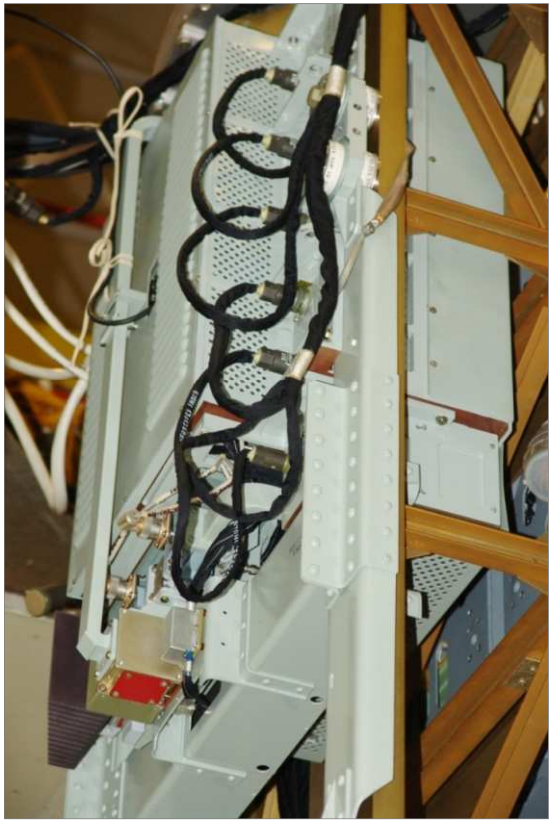
Instrument MTVZA-GY



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	 **≤ 1,5** **≤ 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 large noise level in the IR channels);
- MTVZA instrument is functional with limitations due to onboard memory failure and temperature sounding channels malfunction;
- KMSS instrument is fully functional;
- Severjanin instrument is non-operational;
- DCS is functional with limitations due to interferences to signals from ground sources;
- LRPT transmission is functional with limitations due to information compression errors;
- GGAK-M is functional with significant limitations.

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

- operational - operational with limitations - 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

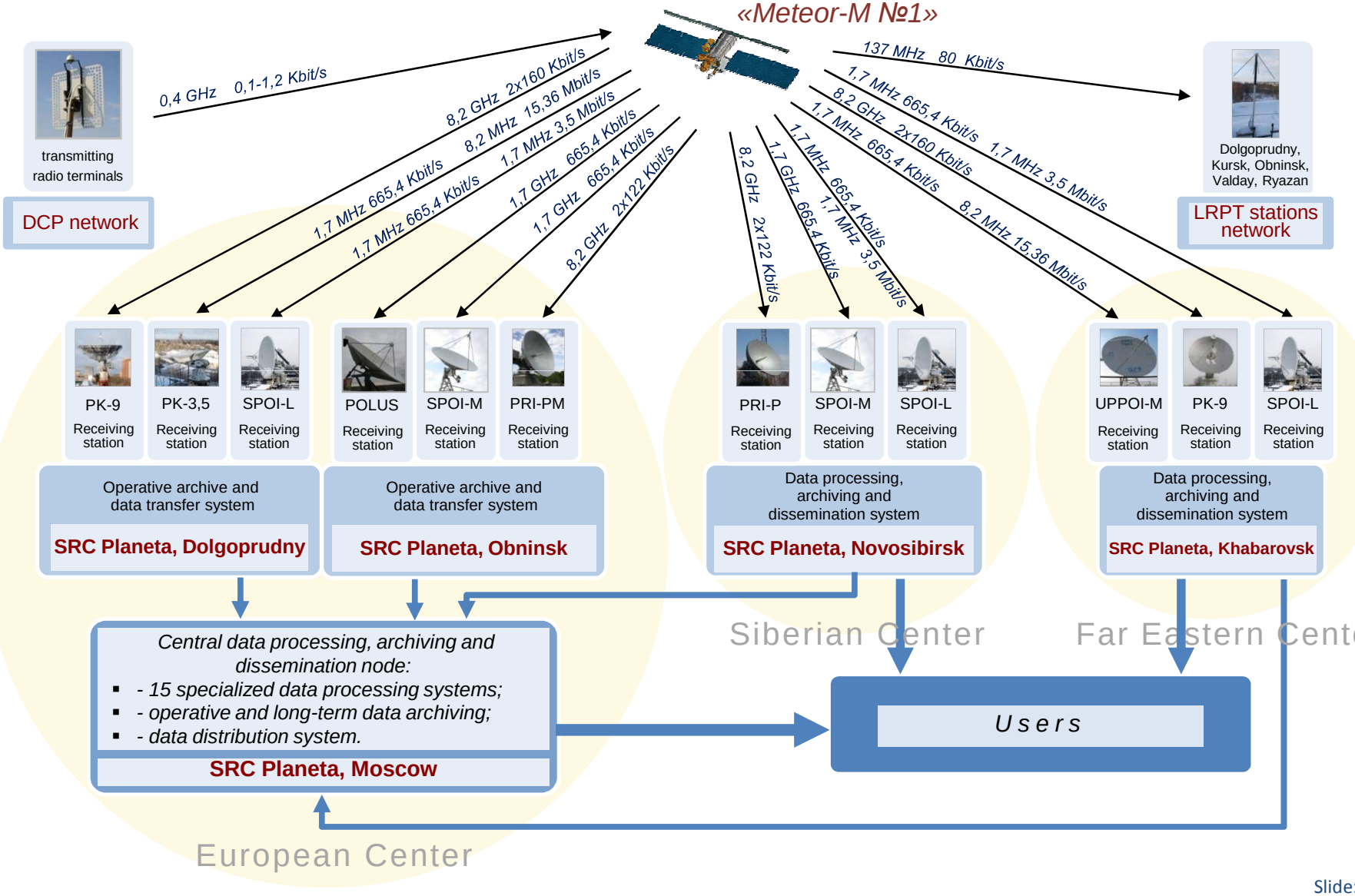
2. Global data access

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

3. MSU-MR products access

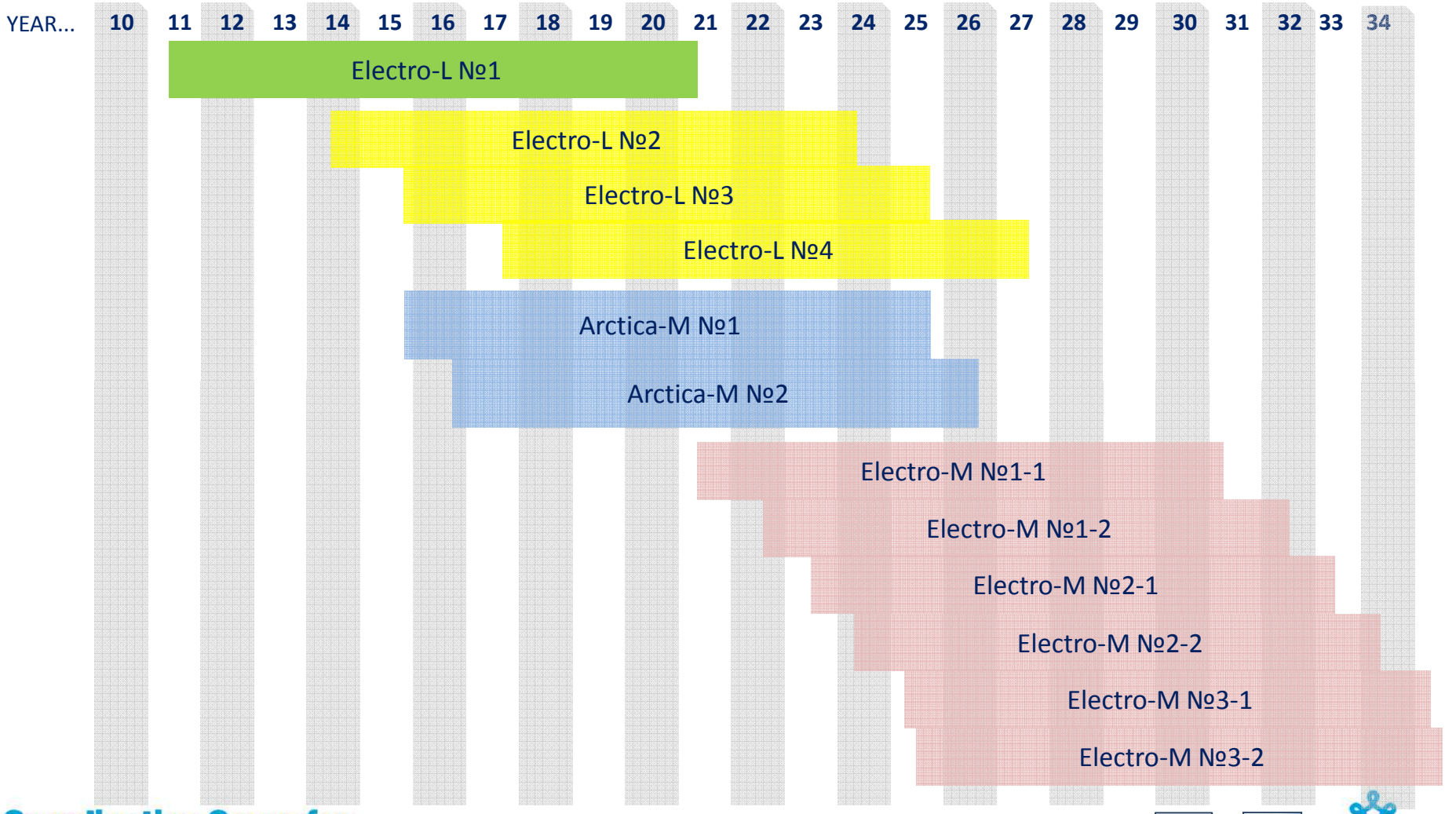
Some products that are regularly generated by SRC Planeta from MSU-MR data can be accessed via SRC Planeta WEB-site.

Roshydromet Ground Segment for Meteor-M №1



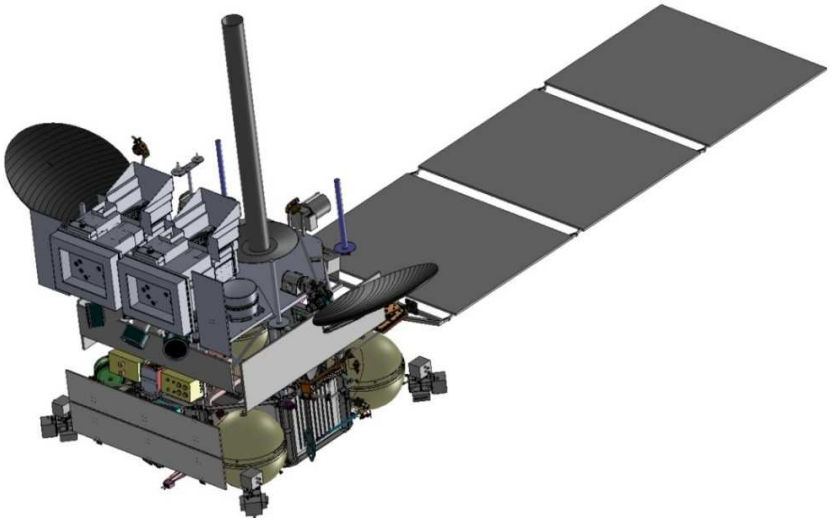
Status of Future GEO Satellite Systems

Electro-L/Arctica-M/Electro-M



- The Electro-L № 2,3,4 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 №3,4 – TBD (14.5°W /166°E).
- The launch dates: for Electro-L №2 – 2014; for Electro-L №3 – 2015; for Electro-L №3 – 2017.

Electro-L №2, №3, №4

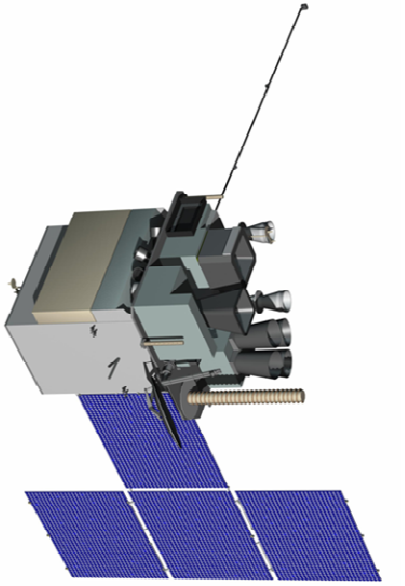


Mission objectives

- 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 Electro-L № 4 longitude	**77.8º E** **TBD** **TBD** **(14.5ºW / 166ºE)**
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



Parameter	*Value*
Electro-M № 1 longitude Electro-M № 2 longitude Electro-M № 3 longitude	**76º E** **TBD** **TBD** **(14.5ºW / 166ºE)**
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;

- 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 ≤ 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.

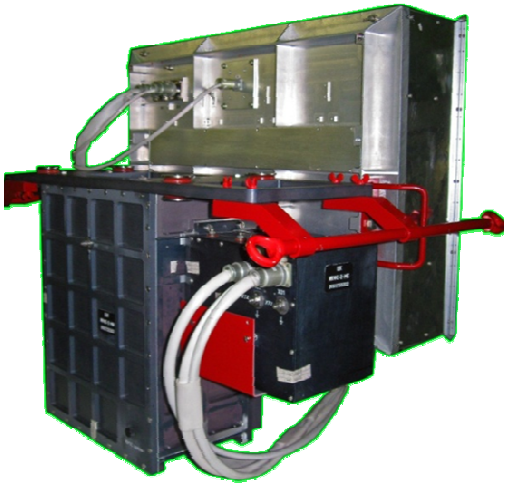
- BRTK-M on-board radio-rentransmitting suite, providing data downlink in UHF and SHF bands.

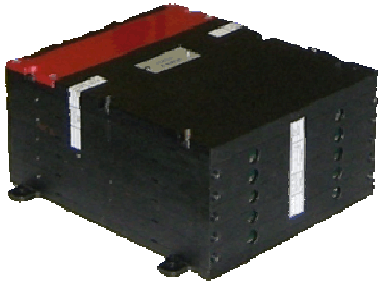
Status of Future LEO Satellite Systems

Meteor-M № 2, 2-1, 2-2, 2-3, 2-4, 2-5
Basic Instruments Specifications

Instrument	*Application*	*Spectral band*	*Swath-width (km)*	*Resolution (km)*
MSU-MR Low-resolution multi-channel scanning unit	Global and regional cloud cover mapping, ice and snow cover observation, forest fire monitoring, …	0,5 – 12,5μm (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 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, 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 μm	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





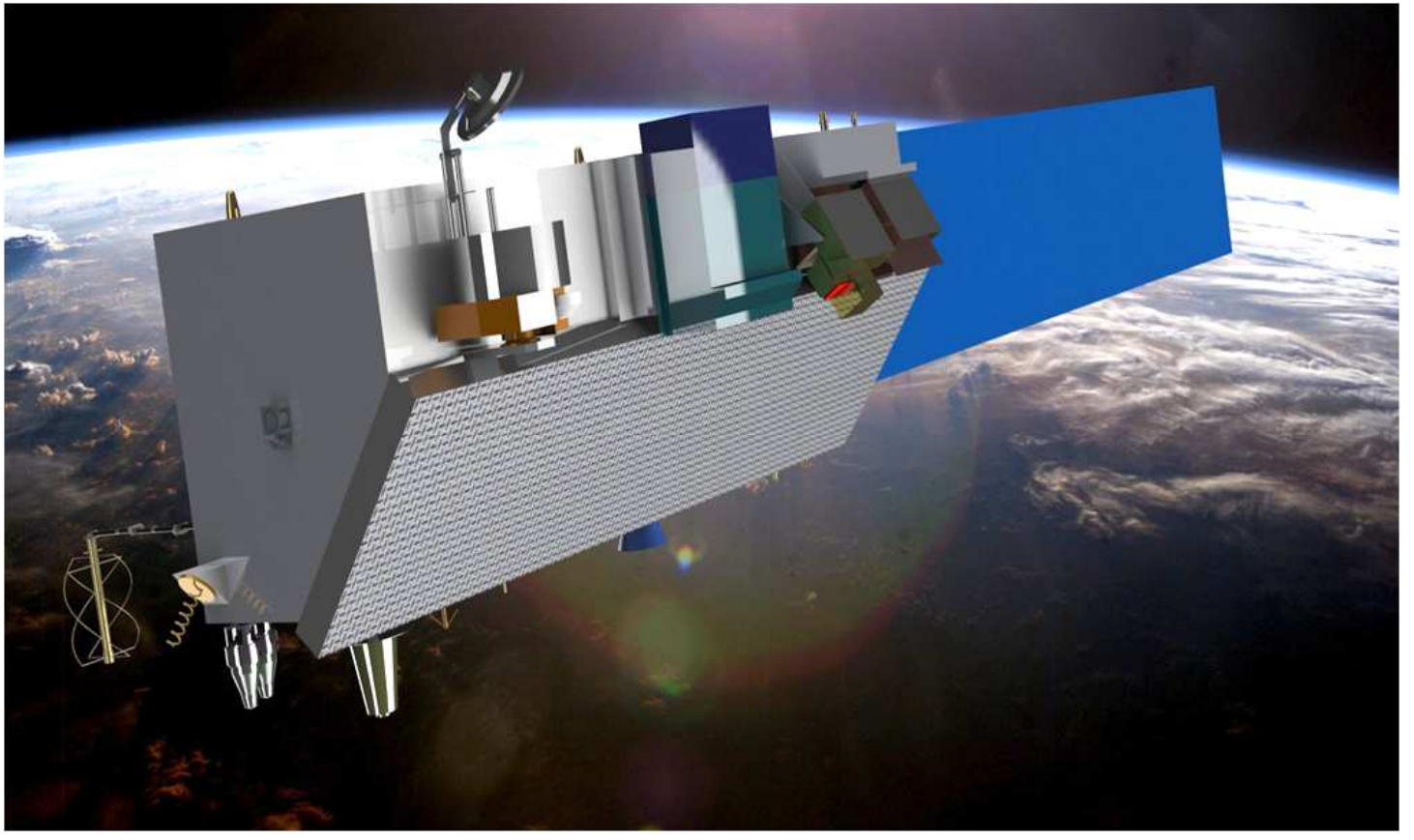
Parameter	*Units*	*Value*
Spectral range: wavelength wave number	μm cm^{-1}	**5-15** **2000-665**
Reference channel wavelength	μm	**1.06**
Maximum optical path difference (OPD)	mm	**17**
Angular size of FOV	mrad	**40 x 40**
Spatial resolution (at sub-satellite point)	km	**35**
Swath Width and spatial 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_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

Meteor-M №3 Basic Instrument Specifications

Instrument	*Spectral band*	*Resolution*	*Swath width(km)*
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



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

METEOR-MP Basic Payload Instruments

Instruments	*Meteor-MP*	
	Meteorological	***Oceanographic***
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 meteorological)

Parameter	*Value*
Number of channels	**17**
Spectral bands, μm	**0.4-12.5**
Swath width (H=835 km), km	**3000**
Spatial resolution (H=835 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 meteorological)

Parameter		*Value*
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 meteorological)

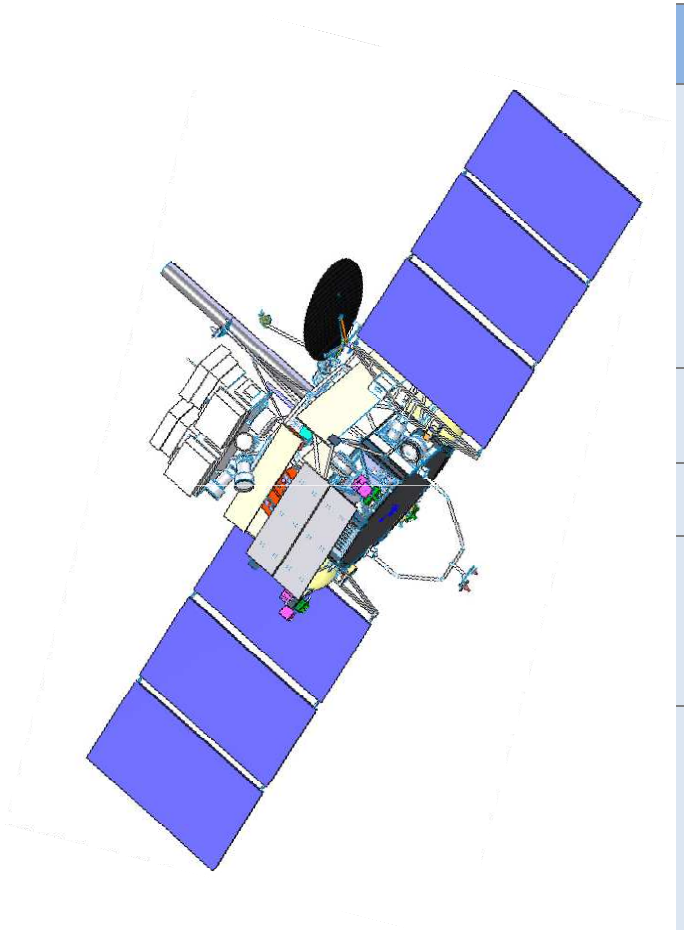
Parameter	*Value*
Spectral resolution, nm UV1 - 214 – 334	**0,5**
UV2 - 320 – 452	**0,5**
VIS - 430 – 800	**1,5**
NIR1 - 755 – 910	**0,9**
NIR2 - 900 – 1210	**0,9**
SWIR1 - 1200 – 1770	**2,0**
SWIR2 - 1934 – 2044	**0,5**
SWIR3 - 2259 – 2386	**0,5**
Observation modes	**Nadir Limb Sun**
Spatial resolution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

MTVZA-GY-M
(Meteor-MP meteorological)

Parameter	*Value*
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**

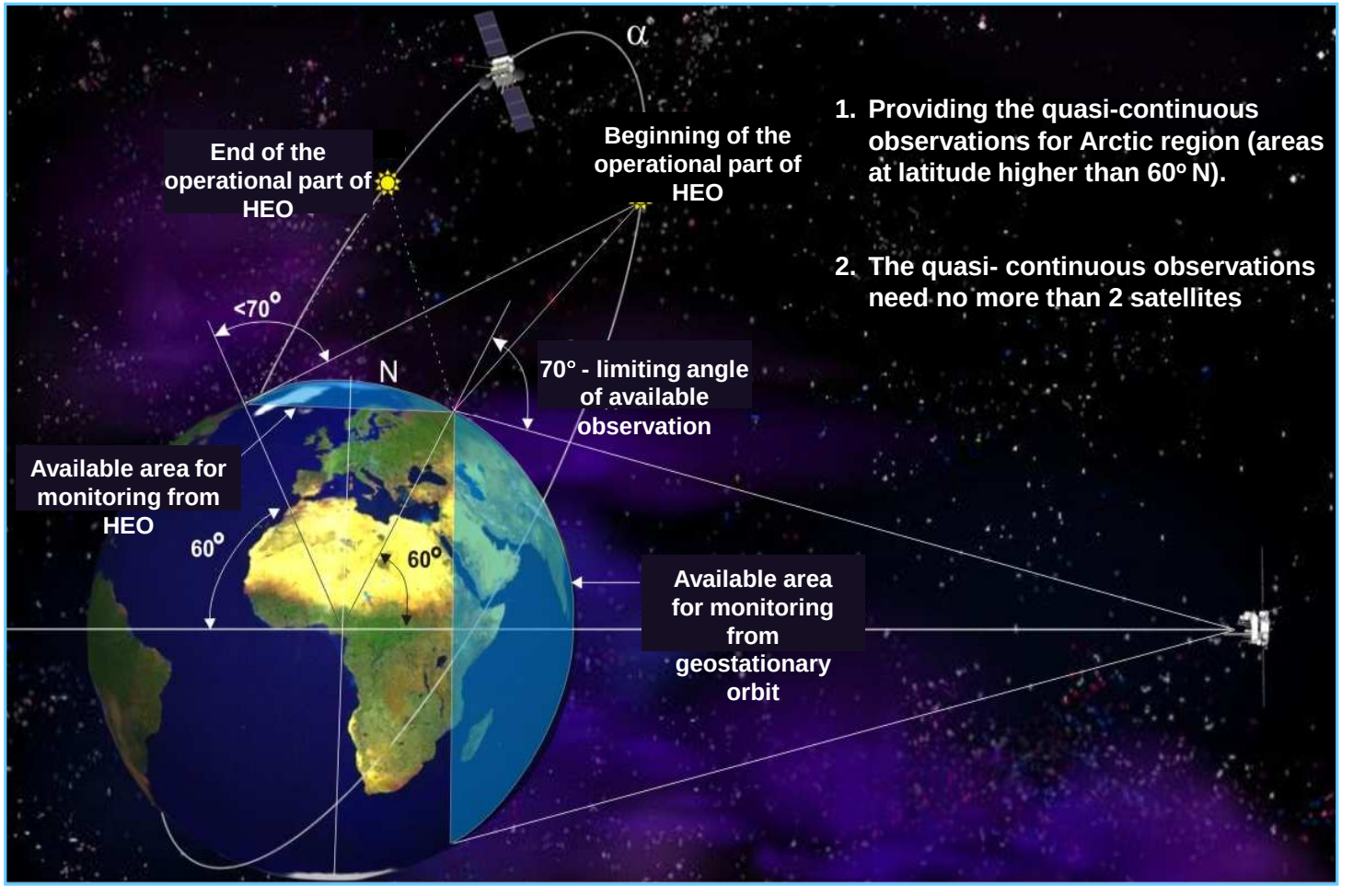
Status of Future HEO Satellite Systems

Arctica-M



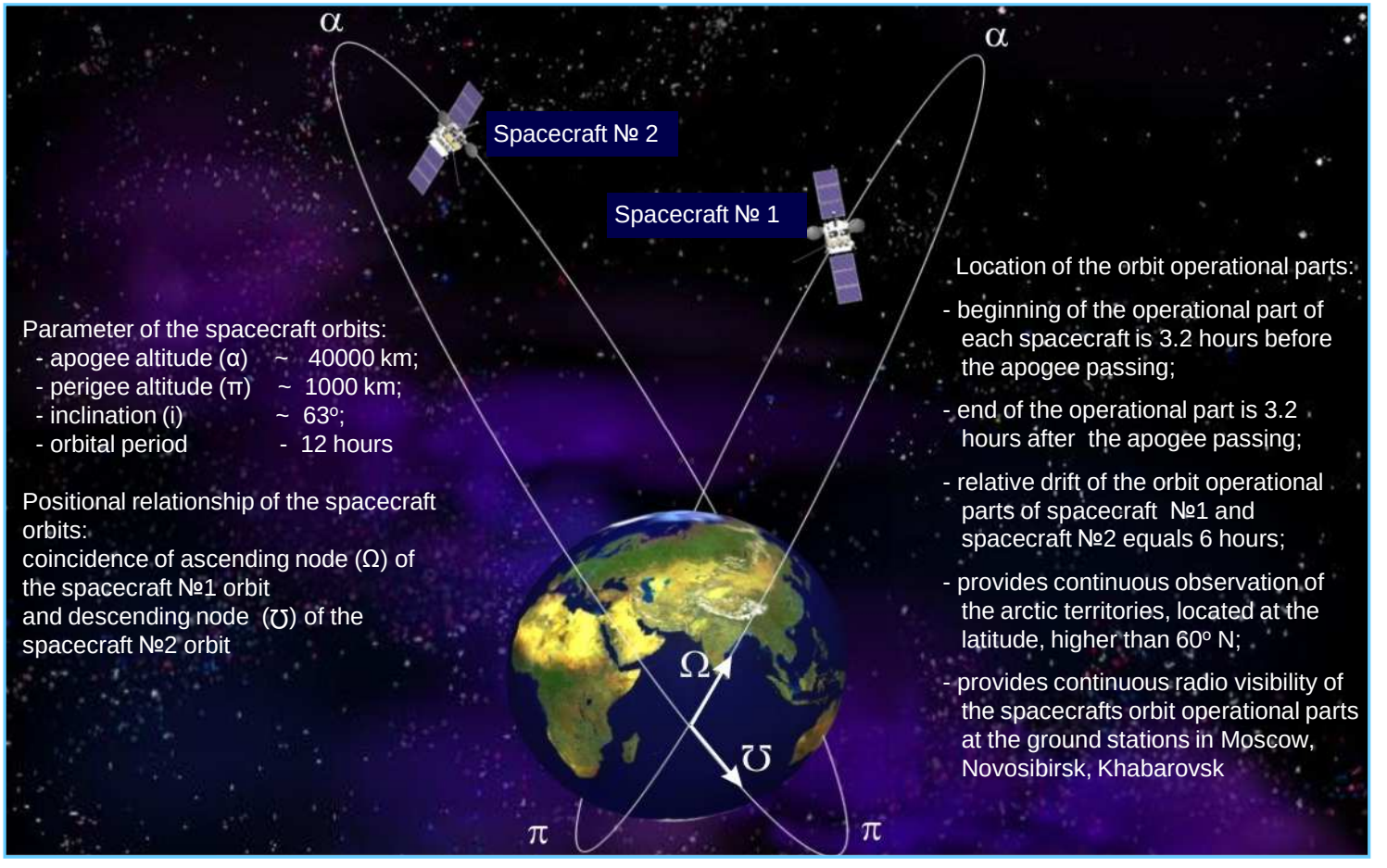
Parameter	*Value*
Orbit:	
Apogee, km	**40000**
Perigee, km	**1000**
Inclination, deg	**63,4**
Period, h	**12**
Full number of MSU-A spectral channel	**10**
Spectral range, μm	from **0,5** to **12,5**
Resolution (at nadir):	
- VIS-channel, km	**1**
- IR-channel, km	**4**
Frequency of full Earth disk observation, 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 №1 orbit
and descending node (ʊ) of the spacecraft №2 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 №1 and spacecraft №2 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 instrument suite GGAK-A, providing the heliogeophysical measurements at the “Molnia” orbit.
- The on-board radio-rentransmitting 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!