STATUS OF CURRENT AND FUTURE RUSSIAN SATELLITE SYSTEMS

by Roskosmos/Roshydromet

Presented to CGMS-40 plenary session

Roshydromet Space Observation System objectives

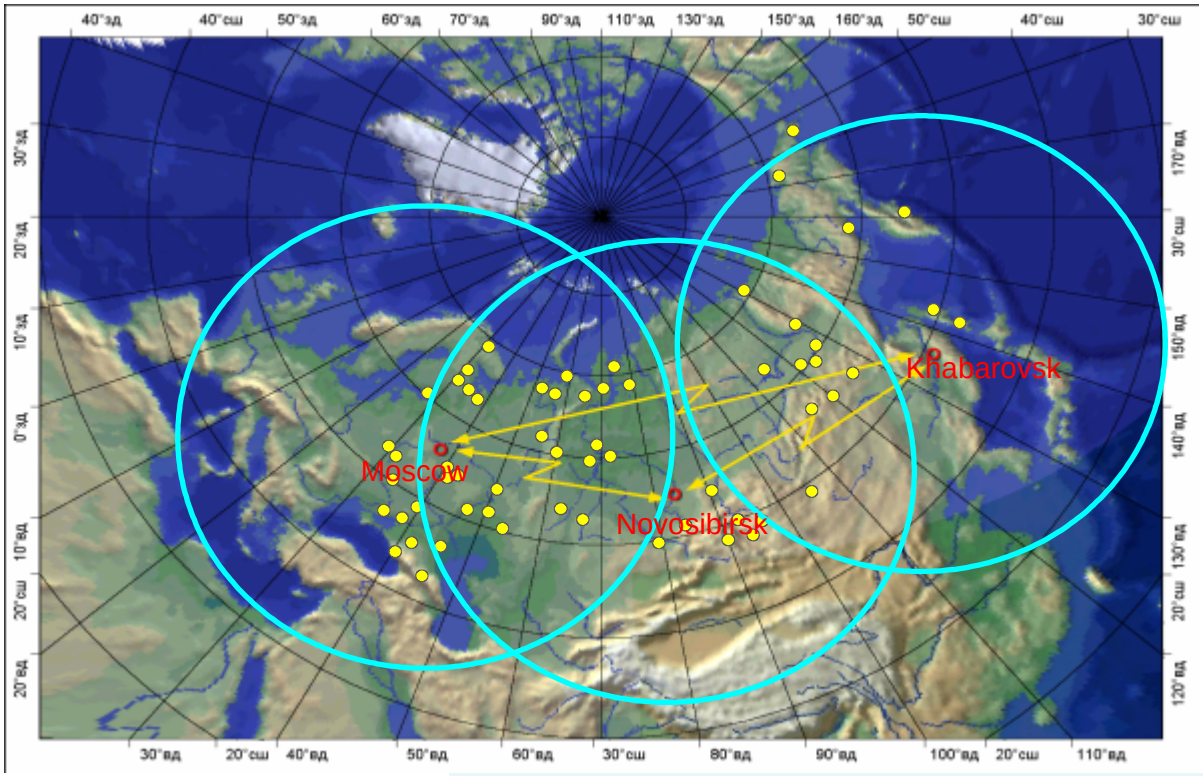
HYDROMETEOROLOGY AND GEOPHYSICAL MONITORING:
- atmosphere and ocean monitoring and forecast;
- sea ice monitoring for navigation in Arctic and Antarctic regions and seas;
- data providing for heliogeophysical service;
- DCP data retransmission via satellite.

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)

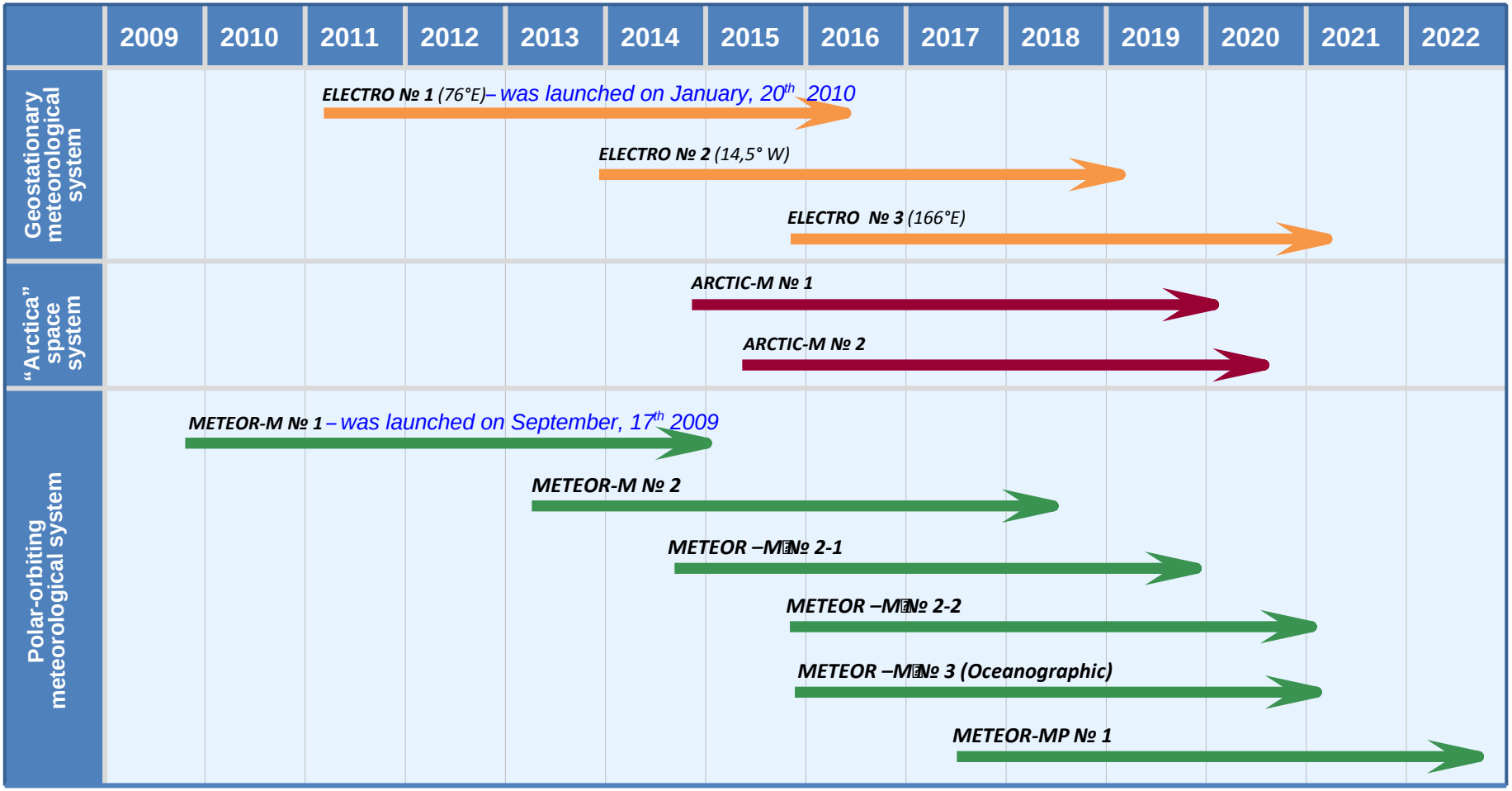
Far-Easten
(SRC Planeta, Khabarovsk)

● - 68 local centers

Daily "SRC" Planeta ":

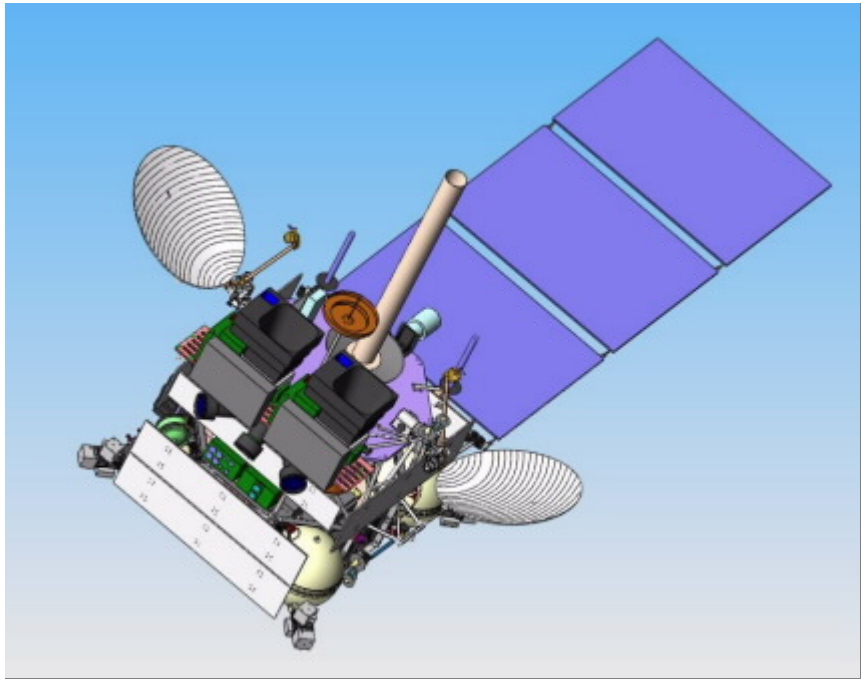
- receives more than **280** GB satellite data;
- produces more than **150** types of informational products;
- provides data to more than **460** federal and regional users

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 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 (MSU-GS)
- Heliogeophysical measurements
- Maintaining Data Collection System and COSPAS/SARSAT Service

MSU-GS Basic Characteristics

Number of channels • VIS • IR	10 3 7
Spectral range at half maximum of spectral response function (m)	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 ground resolution in subsatellite point (km)	1.0 (VIS); 4.0 (IR)
S/N ratio for VIS channels	200
NE T at 300K (K) • in the band 3.5-4.0 m • in the band 5.7-7.0 m • in the band 7.5-12.5 m	 0.8 0.4 0.1-0.2
Power (W)	150
Weight (kg)	88
Lifetime of basic and reserve units (years)	10

Heliogeophysical Measurements Complex (GGAK-E)

The GGAK-E set 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.

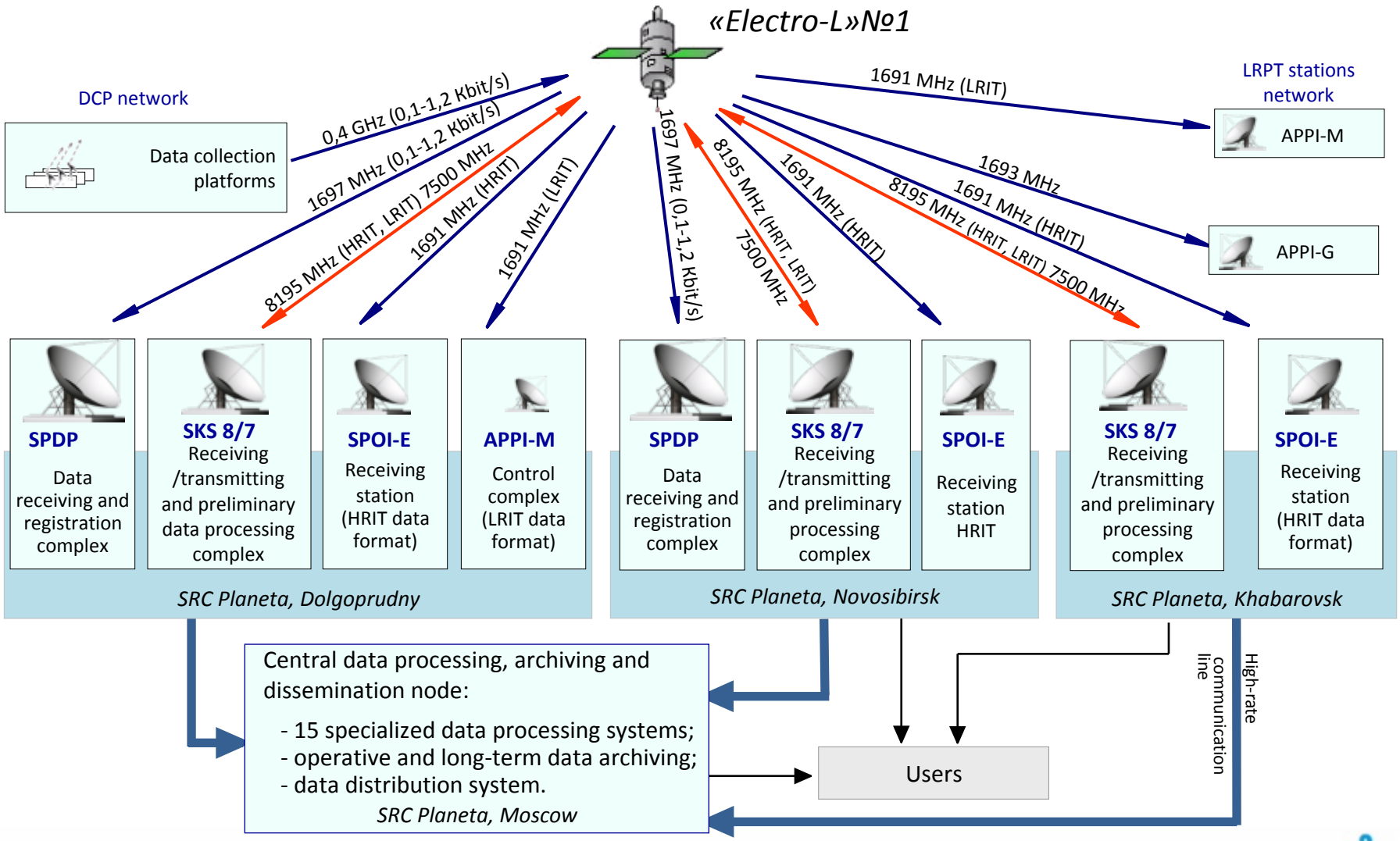
Status of Electro-L №1 spacecraft

The MSU-GS instrument has some problems with calibration and excessive noise level in some of 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 constraints 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, m	Application
1	0,5 – 0,65	Static and animated cloud maps, 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, winds, translucent clouds
6	7,5 – 8,5	Semi-transparent clouds
7	8,2 – 9,2	
8	9,2 – 10,2	O_3
9	10,2 – 11,2	Static and animated cloud maps, wind, SST and LST, precipitation, cloud top height, fires etc.
10	11,2 – 12,5	

- operational - operational with limitations - not operational

Roshydromet Ground Segment Overview for Electro-L №1 Satellite



MSU-GS/Electro-L №1 data dissemination

1. Direct broadcast

MSU-GS HRIT/LRIT data dissemination in now performed each 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 on SRC Planeta FTP server. This data become available for the EUMETSAT in September, 2012.

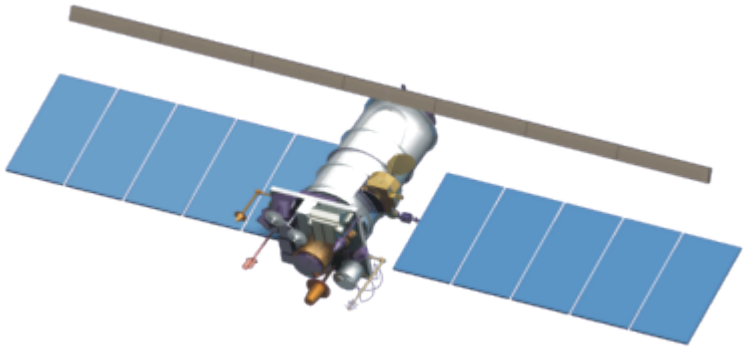
3. MSU-GS products access

Some products that are regularly generated by SRC Planeta from MSU-GS data can be accessed on 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 – 12,5 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 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 Helio-geophysical instrument suite	Helio-geophysical data providing			
BRK SSPD Data Collection System	Data retransmission from DCP			

Low-resolution multi-channel scanning unit MSU-MR (Meteor-M №1)

MSU-M R

Name	Value
Number of channels	6
Spectral bands, m	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 dimension, 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 m - 10.5-12.5 m	 0.5 0.12
Weight, kg	106 (two units)

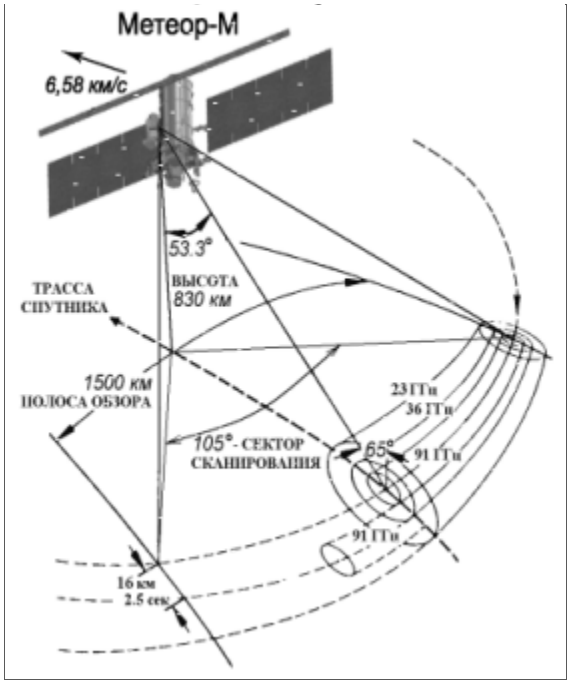
Visible spectrum scanning imager KMSS (Meteor-M №1)

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:

Swath, 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)

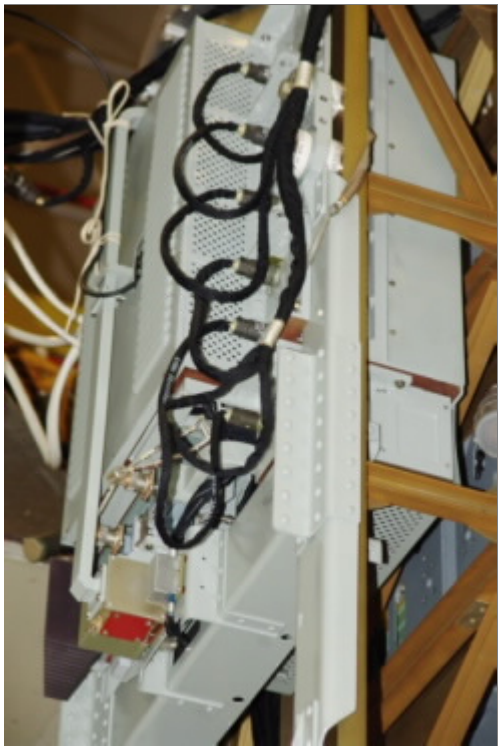
Instrument MTVZA-GY



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 Consumed, W	80

BRLK «Severyanin-M» (Meteor-M №1)



Swath width (km)	≥600
Spatial resolution (m) - low resolution mode - medium resolution mode	 800-1300 400-650
Radiometric resolution (dB) - low resolution mode - medium 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 higher 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.

Channel No	Range, m	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 - not 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 published at SRC Planeta WEB-site
http://planet.iitp.ru/english/spacecraft/meteor_m_n1_structure_eng.htm

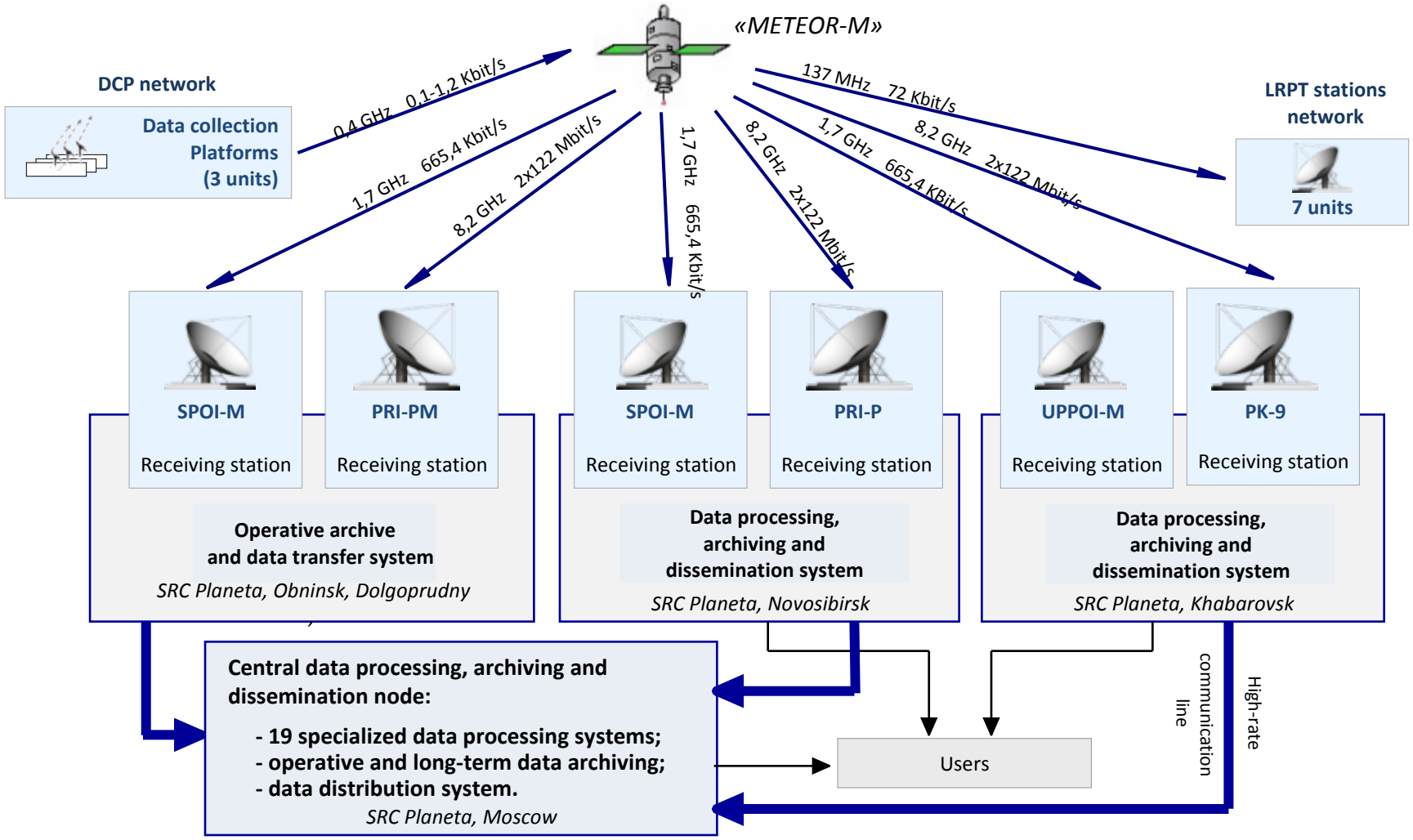
2. Global data access

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

3. MSU-MR products access

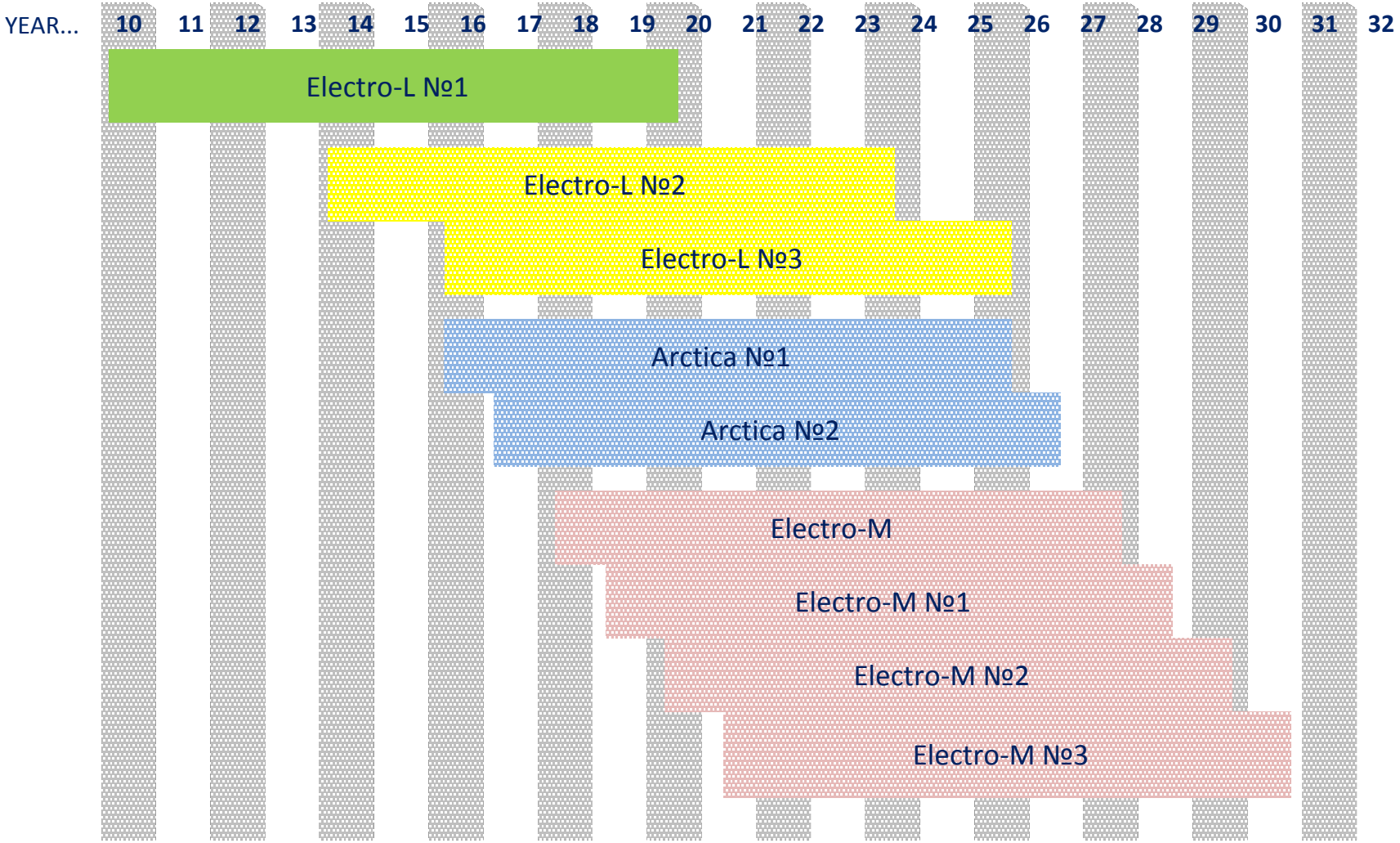
Some products that are regularly generated by SRC Planeta from MSU-MR data can be accessed at SRC Planeta WEB-site.

Roshydromet Ground Segment Overview for Meteor-M №1 Satellite



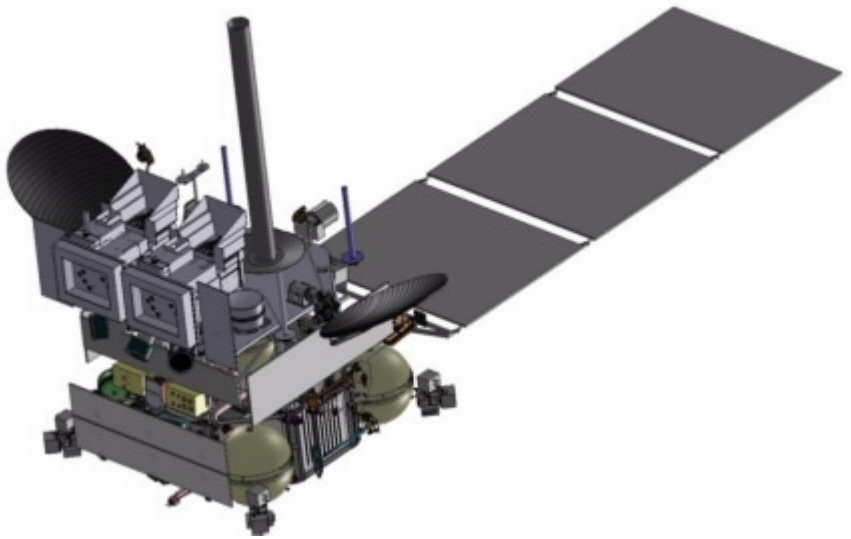
Status of future GEO satellite systems

Electro-L/Electro-M/Arctica



- 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 and Electro-L №3 satellites are 14,5 W and 166 E respectively.
- The launch dates for Electro-L №2 and Electro-L №3 satellites are scheduled for 2013 and 2015.

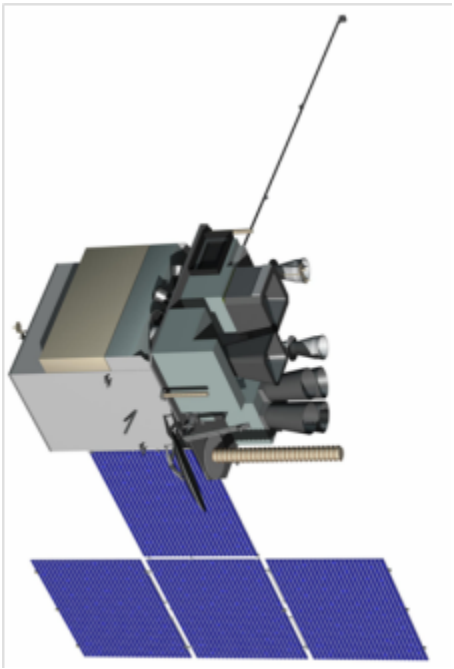
«Electro-L» №2, №3



Mission objectives

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

Name	Value
Electro-L № 2 longitude Electro-L № 3 longitude	14,5º W 165,8º E
MSU-GS channels	10
Wavelength range	0,5 - 12,5 mkm
Spatial resolution in subsatellite 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»

Name	Value
Electro-M № 1 longitude Electro-M № 2 longitude Electro-M № 3 longitude	76º E 14,5º W 165,8º E
MSU-GS-M channels	20
MSU-GSM spatial resolution in subsatellite 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

The “Electro-M” basic payload:

- MSU-GSM (Multichannel scanning unit – Geostationary-M) instrument, providing full Earth disk measurements in 17 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 in subsatellite point;

- The IRFS-GS (Infrared Fourier-transform Spectrometer - Geostationary) instrument providing measurements in 3.7 - 6 mm and 8.3 - 15.4 mm spectral bands with 4 km spatial resolution (in subsatellite point).
  The spectral resolution is about 0,625 cm^{-1}. The repetition rate is 1 hour.

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

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

- Geliogeophysical instrument suite GGAK-E/M – modernized GGAK-E

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

Status of future LEO satellite systems

Meteor-M №№ 2, 2-1, 2-2 basic instruments

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 – 12,5 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 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 m	2000	35
“Severjanin-M” Synthetic aperture radar	All-weather Ice coverage monitoring	9500-9700 MHz	600	0,4 x 0,5
GGAK-M Helio-geophysical instrument suite	Helio-geophysical data providing			
BRK SSPD Data Collection System	Data retransmission from DCP			

Basic performance characteristics of IRFS-2

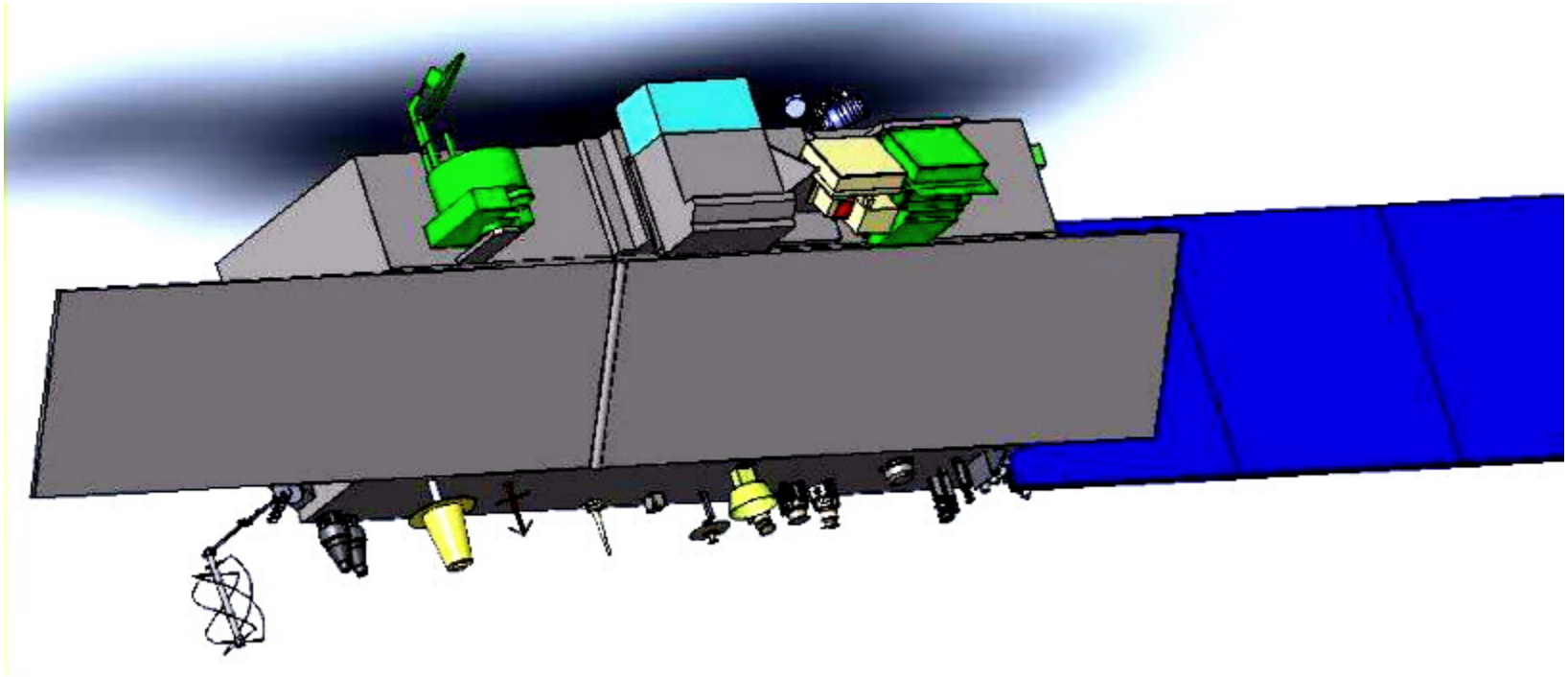
Parameter	Units	Value
Spectral range: wavelength wave number	m cm^{-1}	5-15 2000-665
Reference channel wavelength	m	1.06
Maximum optical path difference (OPD)	mm	17
Angular size of FOV	mrad	40 x 40
Spatial resolution (at subsatellite point)	km	35
Swath Width and spatial sampling	km	2500, 110 2000, 100
Duration of the interferogram measurement	s	0.5
Dynamic range		2^{16}
Weight	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,), cloud properties
1000 to 1070 cm^{-1}	O_3	Ozone sounding
1080 to 1150 cm^{-1}	Atmospheric window	T_s, ,; 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 m	1 km	1800
С ZS Coastal zone scanner	6 channels 0.433 - 0.885 m	80 m	800
“Radiomet” Set of devices for radiooccultation measurements	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

	Meteor-MP №1	Meteor-MP №2	Meteor-MP №3
Scaning 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 instrument collection	+	+	-
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)

Parameters	MSU-M R
Number of channels	17
Spectral bands, m	0.4-12.5
Swath dimension (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
Weight, kg	160-180

Basic performance characteristics of IRFS-3 (Meteor-MP №1,2)

Spectral range		645…2760 cm^{-1} (3.6-15.5 m)
	LW	645…1200 cm^{-1}
	MW	1200…2000 cm^{-1}
	SW	2000…2760 cm^{-1}
Spectral resolution		0.25 cm^{-1}
Swath		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)

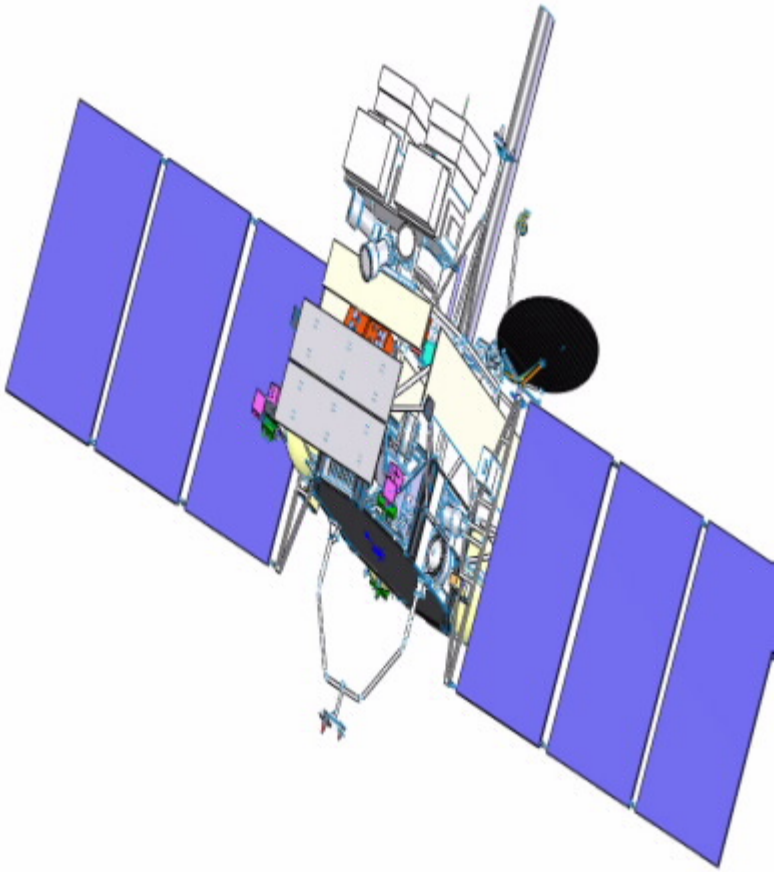
Name	Value
Spectral resolution, nm UV1 - 214 – 334	0,5
UV2 - 320 – 452	0,5
VIS - 430 – 800	1,5
NIR1 - 755 – 910	0,9
NIR2 - 900 – 1210	0,9
SWIR1 - 1200 – 1770	2,0
SWIR2 - 1934 – 2044	0,5
SWIR3 - 2259 – 2386	0,5
Observation modes	Nadir Limb Sun
Spatial resolution for nadir observations (H = 800 km)	8 - 14
Swath for nadir observations, km	1000
Spatial resolution for limb observations, δL x δH, km	35 x 3
Swath for limb observations, L x H, km	3000 x 100

MTVZA-GY-M (Meteor-MP №1,2)

Name	
Frequencies, GHz	6.9 10.6 18.7 23.8 36.5 52.3-57.0 91 183.31
Channels	29
Swath, km	1500
Spatial resolution, km: - horizontal - vertical	 12-250 1.5-5
Scan type	conical
Onboard memory, GB	1 GB
Mass, kg	100

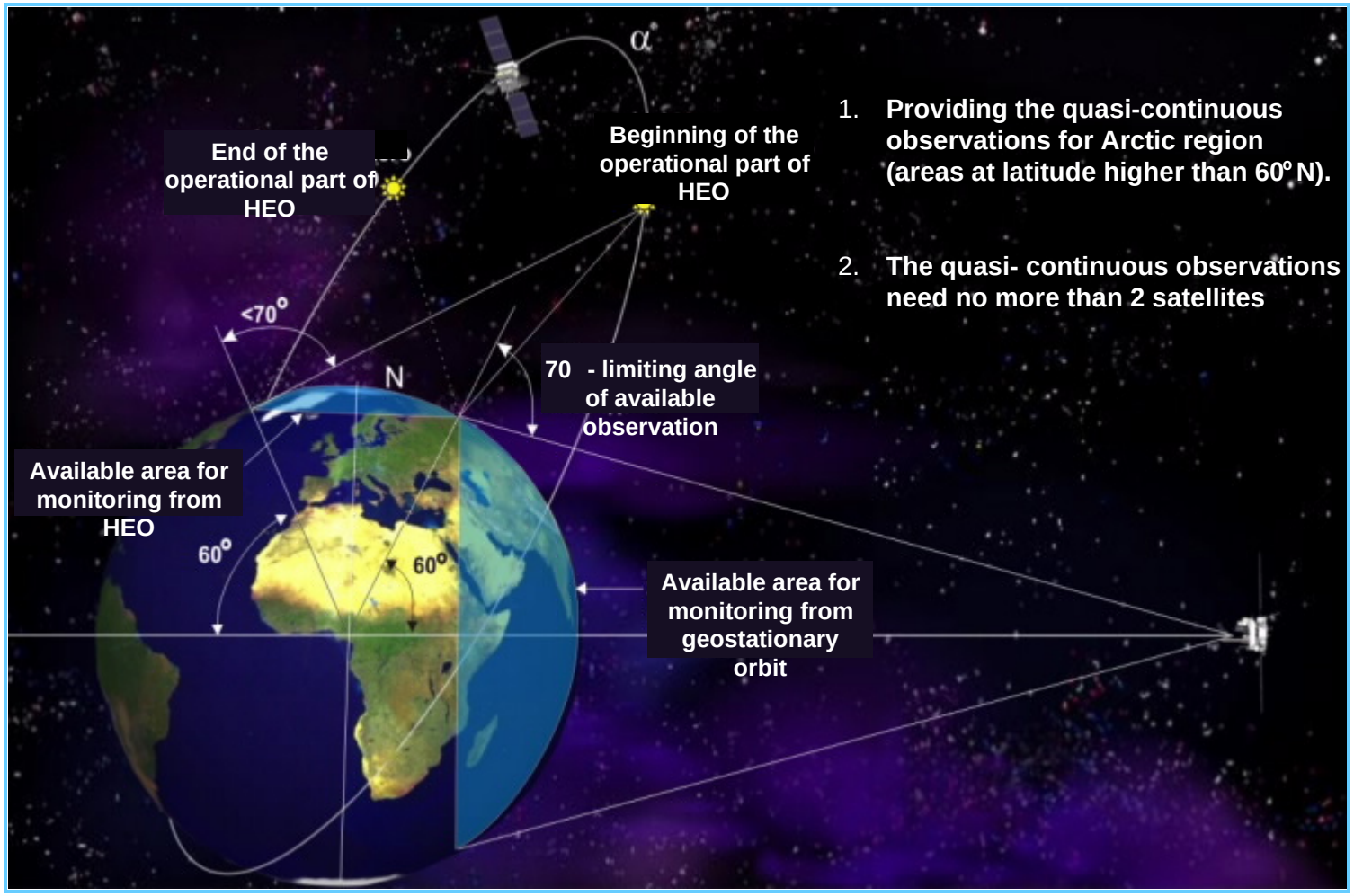
Status of future HEO satellite systems

Arctica



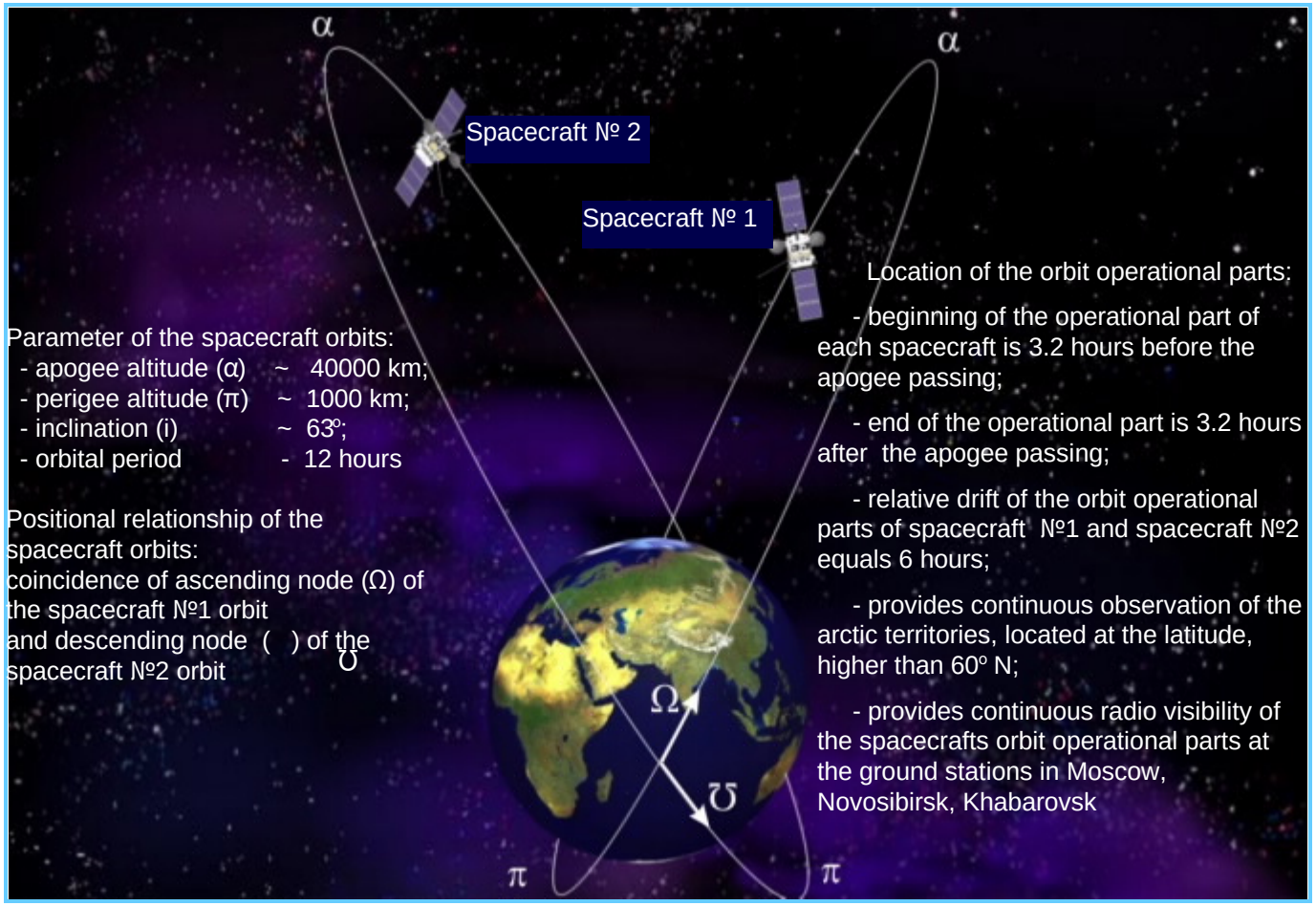
Parameter	Value
Orbit: Apogee, km Perigee, km Inclination, deg Period, h	 40000 1000 63,4 12
Full number of MSU-A spectral channel	10
Spectral range, m	from 0,5 to 12,5
Resolution (at nadir): - VIS-channel, km - IR-channel, km	 1 4
Frequency of full Earth disk observation, min: - regular mode - frequent mode	 30 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 ( ) of the spacecraft №2 orbit
υ

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

The Arctica 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.

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


MTSAT-2
MTSAT-1R
GOES-11
JASON-2
COMS-1
FY-2C
Metop-A
Meteor M-N1
NOAA-17
FY-3A
DMSP-F18
FY-2E
GOES-14
NOAA-16
DMSP-F16
INSAT-3A
GOES-15
FY-2D
DMSP-F17
Electro-L N1
Kalpana-1
GOES-13
GOES-12
Meteosat-7
FY-3B
NOAA-19
Meteosat-9
Meteosat-8

Thank you !