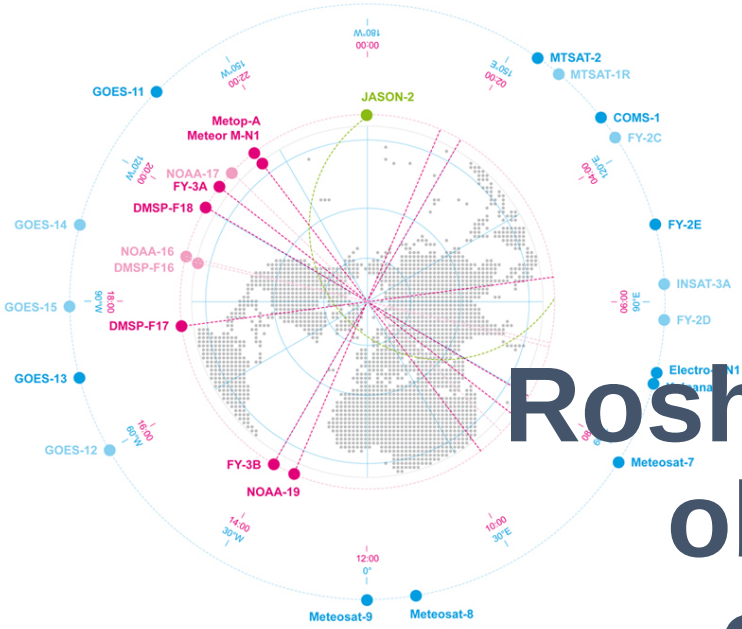


Roshydromet space-based observation system: current status and development perspectives

Presented to the Sixth Asia/Oceania Meteorological Satellite Users' Conference

Roshydromet Space Observation System Objectives

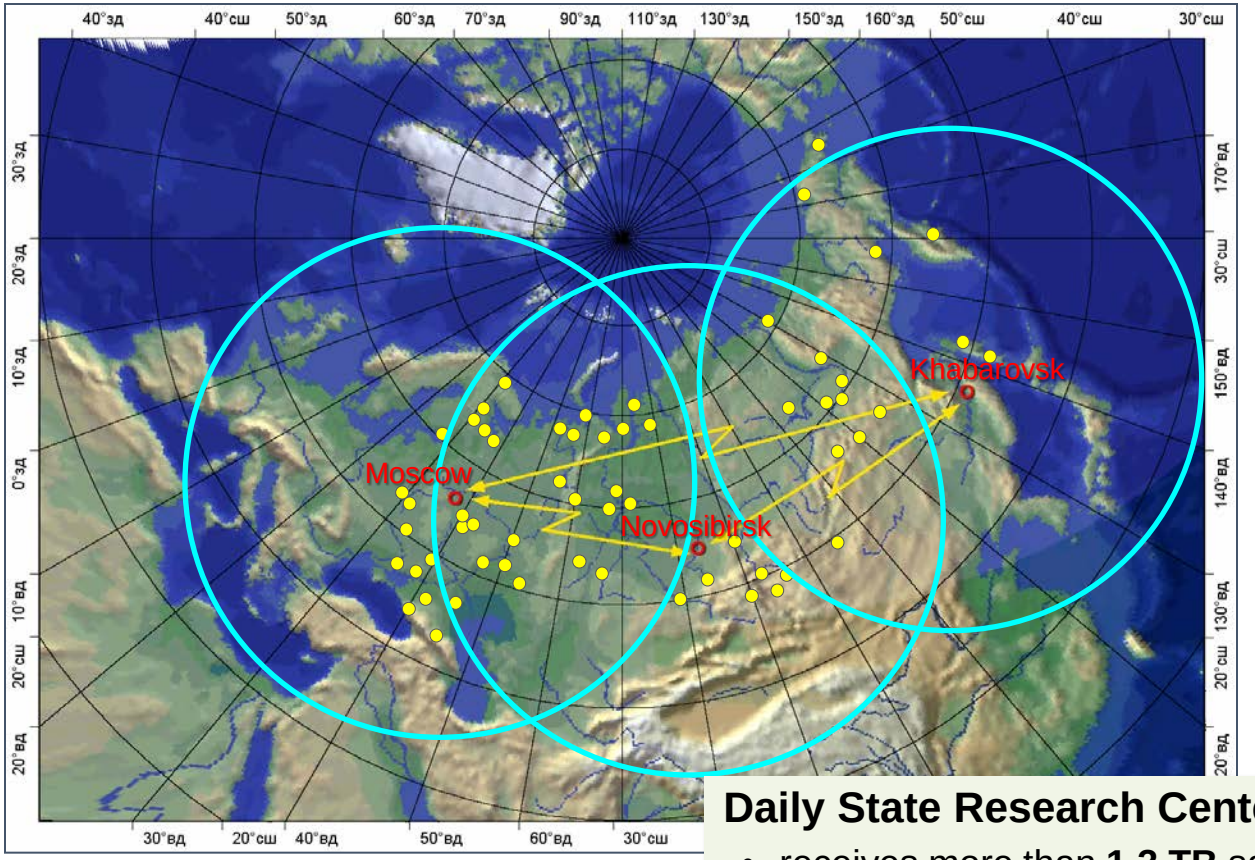
HYDROMETEOROLOGY AND GEOPHYSICAL MONITORING:
- atmosphere and ocean monitoring and forecasting;
- ice monitoring for navigation in Arctic and Antarctic regions;
- heliogeophysical information service;
- ground-based observation data collection and retransmission via satellite.

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

PLANET MONITORING AND GLOBAL CLIMATE CHANGES:
- climate, ocean and landscape change studies based on radiation balance, cloud cover, ozone layer, cryosphere, sea surface temperature and ocean color, vegetation cover data etc.;
- climate and climate affecting processes studies.

ENVIRONMENTAL POLLUTION MONITORING:
- environmental pollution mapping for atmosphere, land surface and ocean;
- assessment of risk zones for spreading contamination, including radioactive contamination.

Ground Segment of Earth Observation Satellite System



Regional Centers:

European
(SRC Planeta, Moscow - Obninsk - Dolgoprudny)

Siberian
(SRC Planeta, Novosibirsk)

Far-Eastern
(SRC Planeta, Khabarovsk)

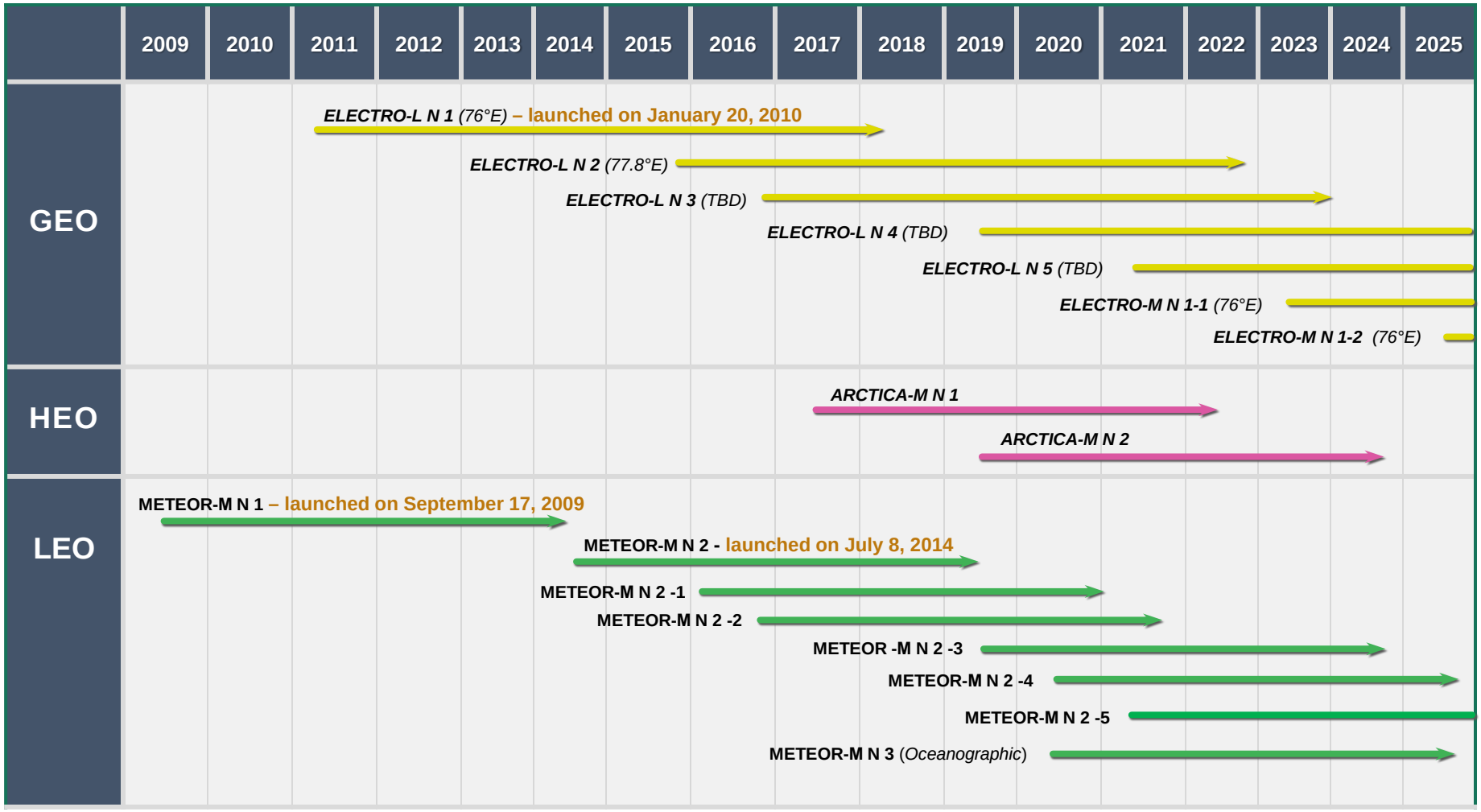
● - more than **70** local centers

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.

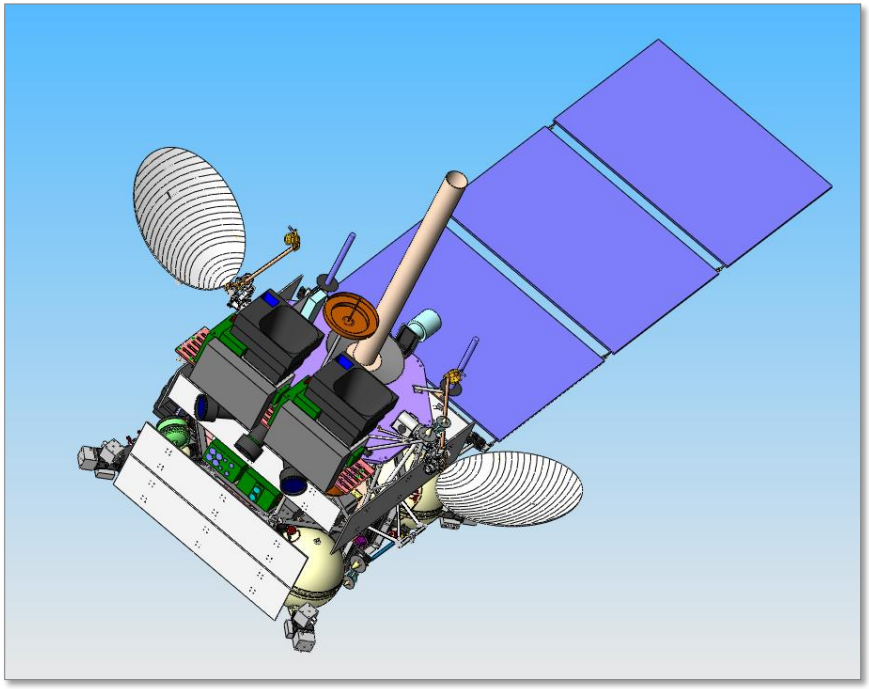
Russian Meteorological Satellite Systems

(Russian Federal Space Program for 2006-2015 and the forecast for 2016-2030)



Status of Current GEO Satellite Systems

ELECTRO-L General Design



Russian geostationary satellite ELECTRO-L N1 was launched on **January 20, 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 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	 0.8 0.4 0.1-0.2
Power (W)	≤ 150
Mass (kg)	≤ 88
Lifetime of basic and reserve units (years)	10

Status of Electro-L N1 Spacecraft

- **MSU-GS** instrument operates in the degraded mode due to technical issues onboard the spacecraft;
- **DCS** is fully functional (300 national channels and 33 international channels);
- **COSPAS-SARSAT** system is functional;
- **GGAK** instrument operates with significant limitations;
- **HRIT/LRIT** channels are functional, but currently not in use;
- When available, the data in HRIT format is distributed via SRC Planeta FTP server.

Roshydromet Ground Segment for Electro-L N1

Electro-L N1

0,4 GHz 0,1; 1,2 Kbit/s

1,693 GHz GGD

1,691 GHz LRIT

Data collection platforms (800 DCPs)

DCP network

APPI-M (80 DCPs)

APPI-G (3 DCPs)

LRPT stations network

7,5 GHz DD, MSU-GS

8,195 GHz HRIT, LRIT, DD

1,697 GHz 0,1; 1,2 Kbit/s

1,691 GHz HRIT

1,691 GHz LRIT

7,5 GHz DD, MSU-GS

8,195 GHz DD

1,697 GHz 0,1; 1,2 Kbit/s

1,691 GHz HRIT

1,691 GHz LRIT

7,5 GHz DD

8,195 GHz DD

1,691 GHz HRIT

1,691 GHz LRIT

SKS 8/7 Receiving and preprocessing station

SKS 8/7 Transmitting station

SPDP Receiving station

SPOI-E Control station

APPI-M Control station

SRC Planeta, Moscow

SRC Planeta, Dolgoprudny

SKS 8/7 Receiving and preprocessing station

SPDP Receiving station

SPOI-E Receiving station

APPI-M Control station

SRC Planeta, Novosibirsk

Siberian Center

SKS 8/7 Receiving and preprocessing station

SPOI-E Receiving station

APPI-M Control station

SRC Planeta, Khabarovsk

Far Eastern Center

Central data processing, archiving and dissemination node:

- *- 15 specialized data processing systems;*
- *- operational and long-term data archiving;*
- *- data distribution system.*

SRC Planeta, Moscow

Users

Federal Service for Hydrometeorology and Environmental Monitoring of Russia

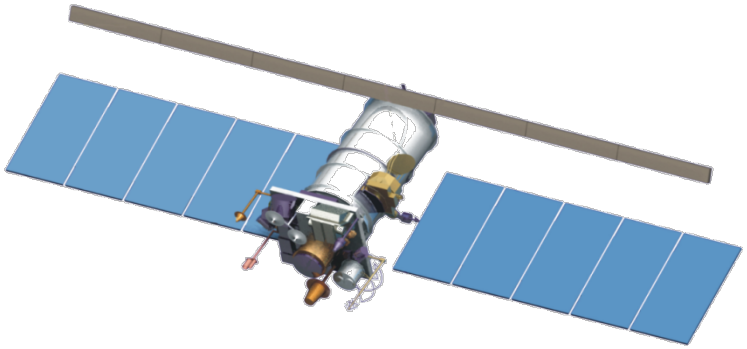
European Center

9 – 13 November 2015, Tokyo/Japan

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 – 830 km

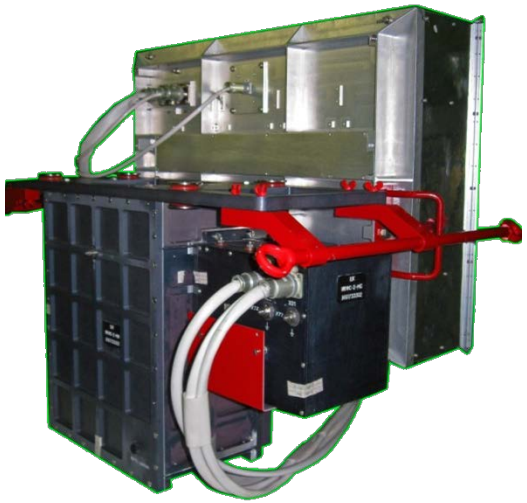
Data dissemination format – HRPT/LRPT

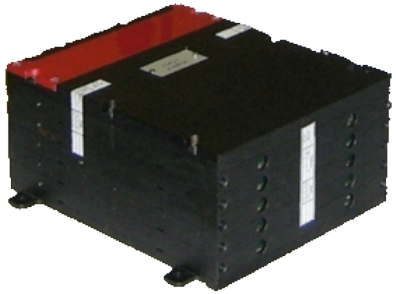
Meteor-M N 1, 2 Basic Instruments Specifications

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)	3000	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)	2600	12 – 75
IKFS-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	Data retransmission from DCPs			

* - installed on-board Meteor-M N2

Advanced IR Sounder IKFS-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
Dynamic range		2^{16}
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 (absolute calibration work is still ongoing);
- **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

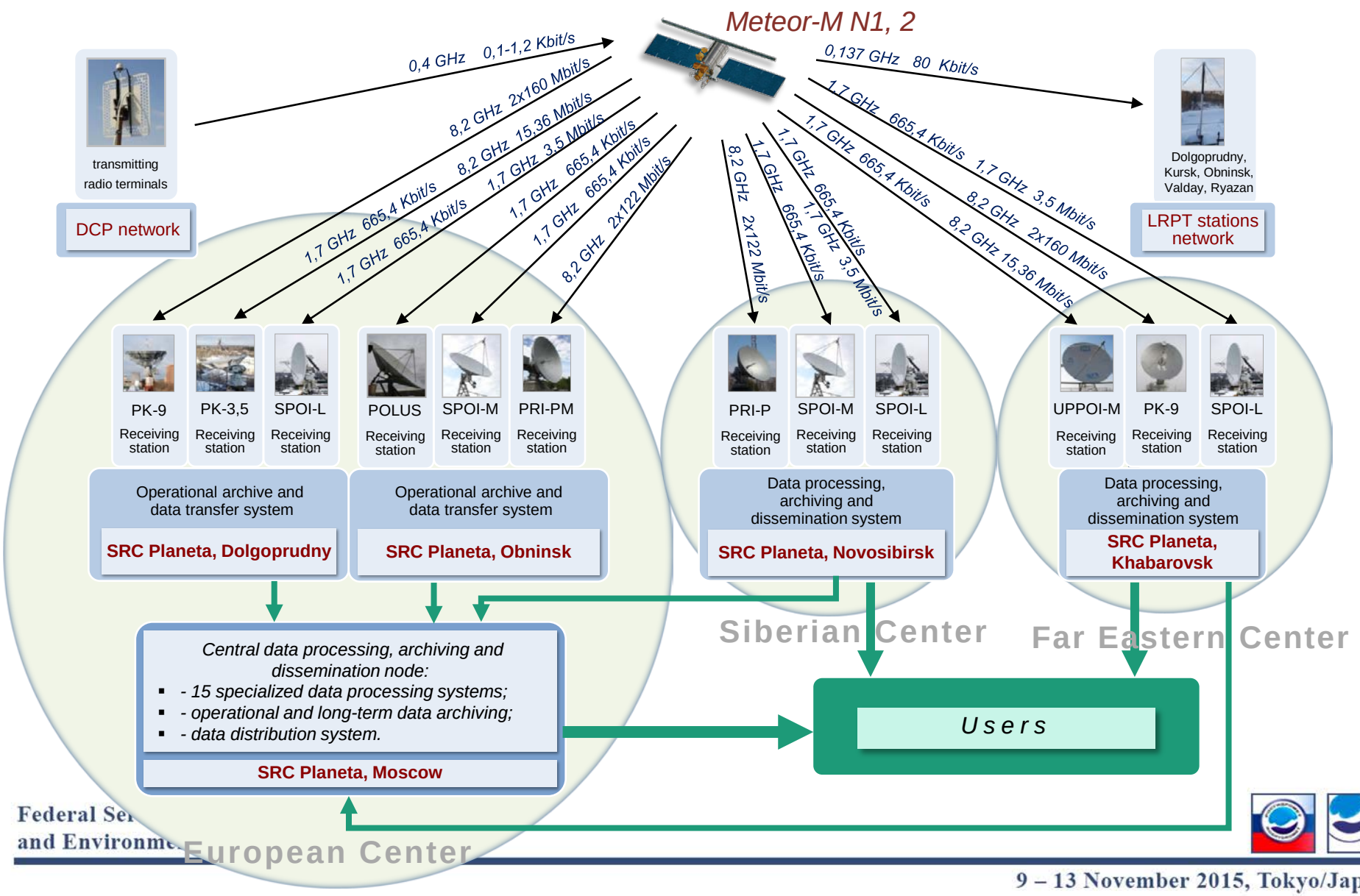
2. Global data access

Global data can be accessed on demand via FTP, e.g. for calibration/validation purposes. Operational data access is subject to further discussions.

3. L2 products access

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

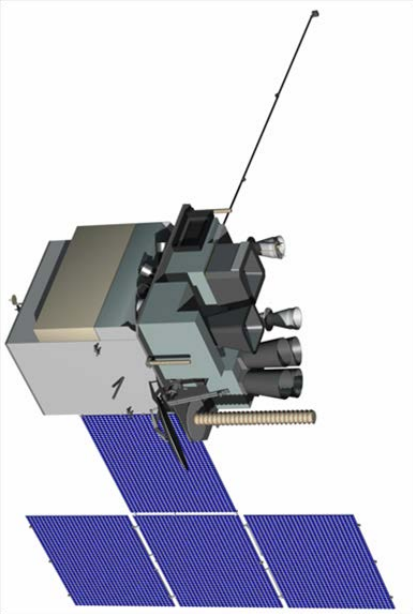
Roshydromet Ground Segment for Meteor-M N1, 2



Status of Future GEO Satellite Systems

- The launch dates for: Electro-L N2 – 2015; Electro-L N3 – 2016; Electro-L N4 – 2019; Electro-L N5 – 2021.
- The Electro-L N 2,3,4,5 payload is similar to the one of the Electro-L N1, but with improved instrument performance.
- Orbital positions: for Electro-L N2 – 77.8°E; for Electro-L N3, 4, 5 – TBD (14.5°W /166°E).

Electro-M



Parameter	*Value*
Electro-M N 1 longitude Electro-M N 2 longitude Electro-M N 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;

- 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;

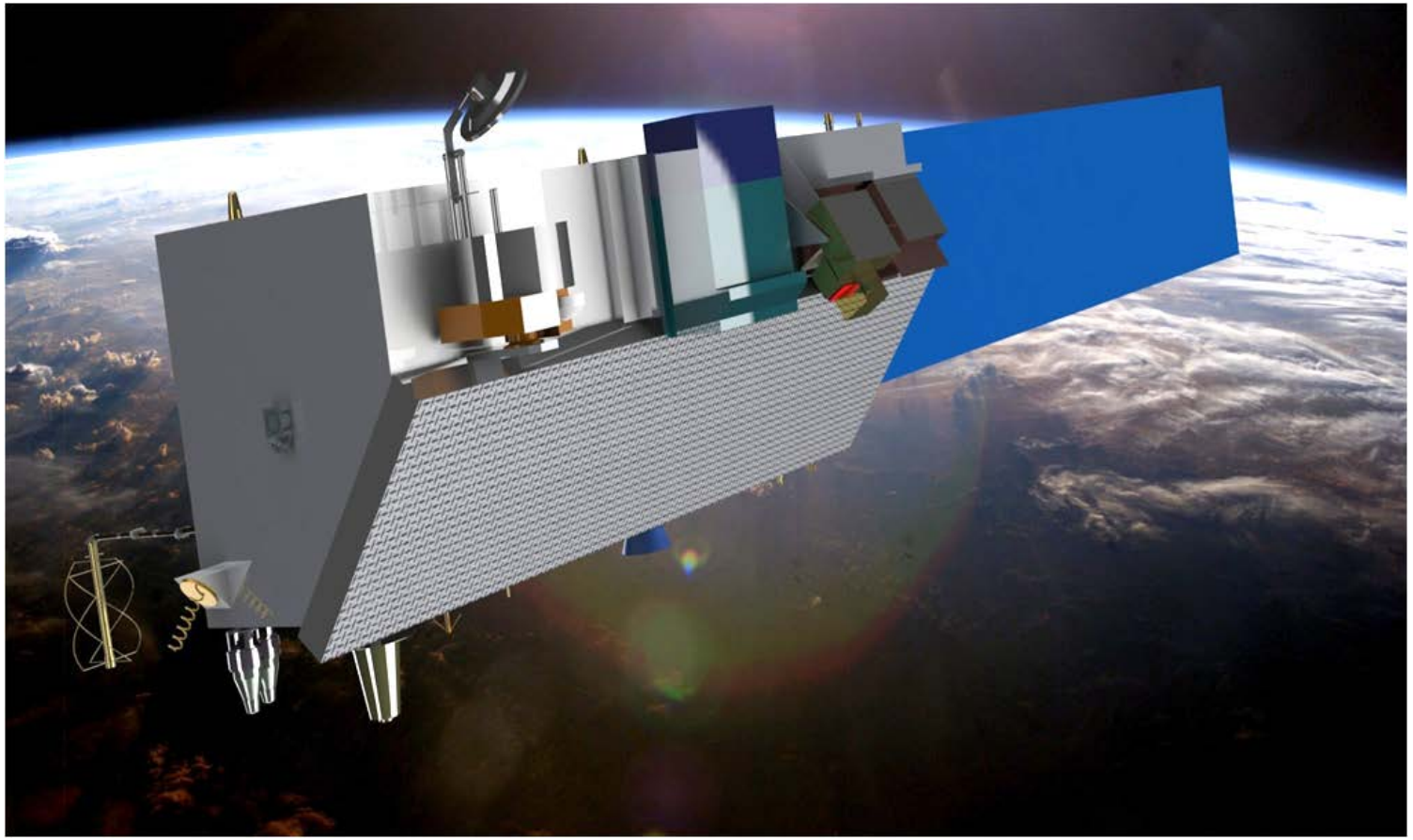
- BRTK-M on-board radio-retransmitting suite, providing data downlink in UHF and SHF bands.

Status of Future LEO Satellite Systems

Meteor-M N3 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
(Meteorological)

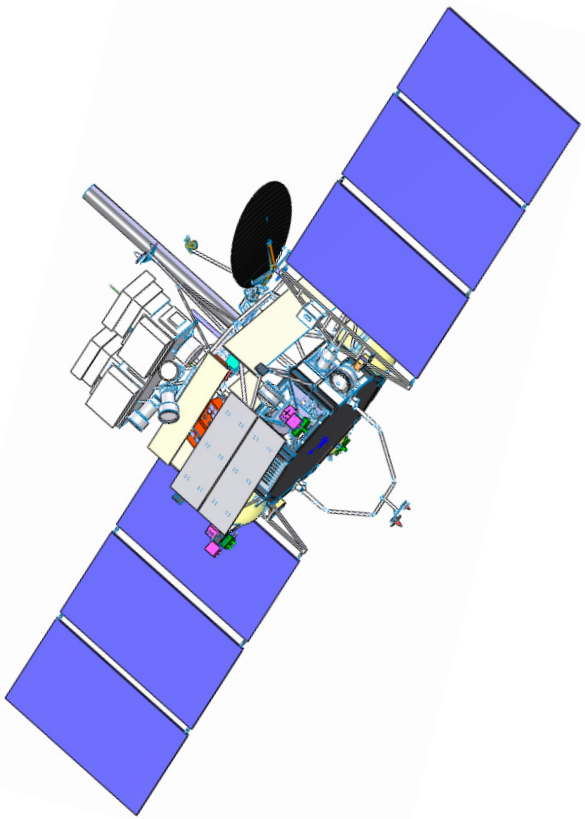
- Low-resolution multi-channel scanning radiometer;
- Visible spectrum scanning imager (moderate resolution multispectral imaging system);
- Infra-red Fourier-transform spectrometer;
- Moderate resolution multispectral infra-red scanner;
- Atmospheric composition spectrometer;
- Microwave imager-sounder
  (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- and Ka- band data downlink system.

OCEAN Basic Payload
(Oceanographic)

- Ocean color scanner;
- Coastal zone scanner;
- Scatterometer;
- Visible spectrum scanning imager (moderate resolution multispectral imaging system);
- Moderate resolution multispectral infra-red scanner;
- Multimode radar system based on active phased array antenna (APAA);
- Data collection system;
- 1.7 GHz data downlink system;
- X- and Ka- bands data downlink system.

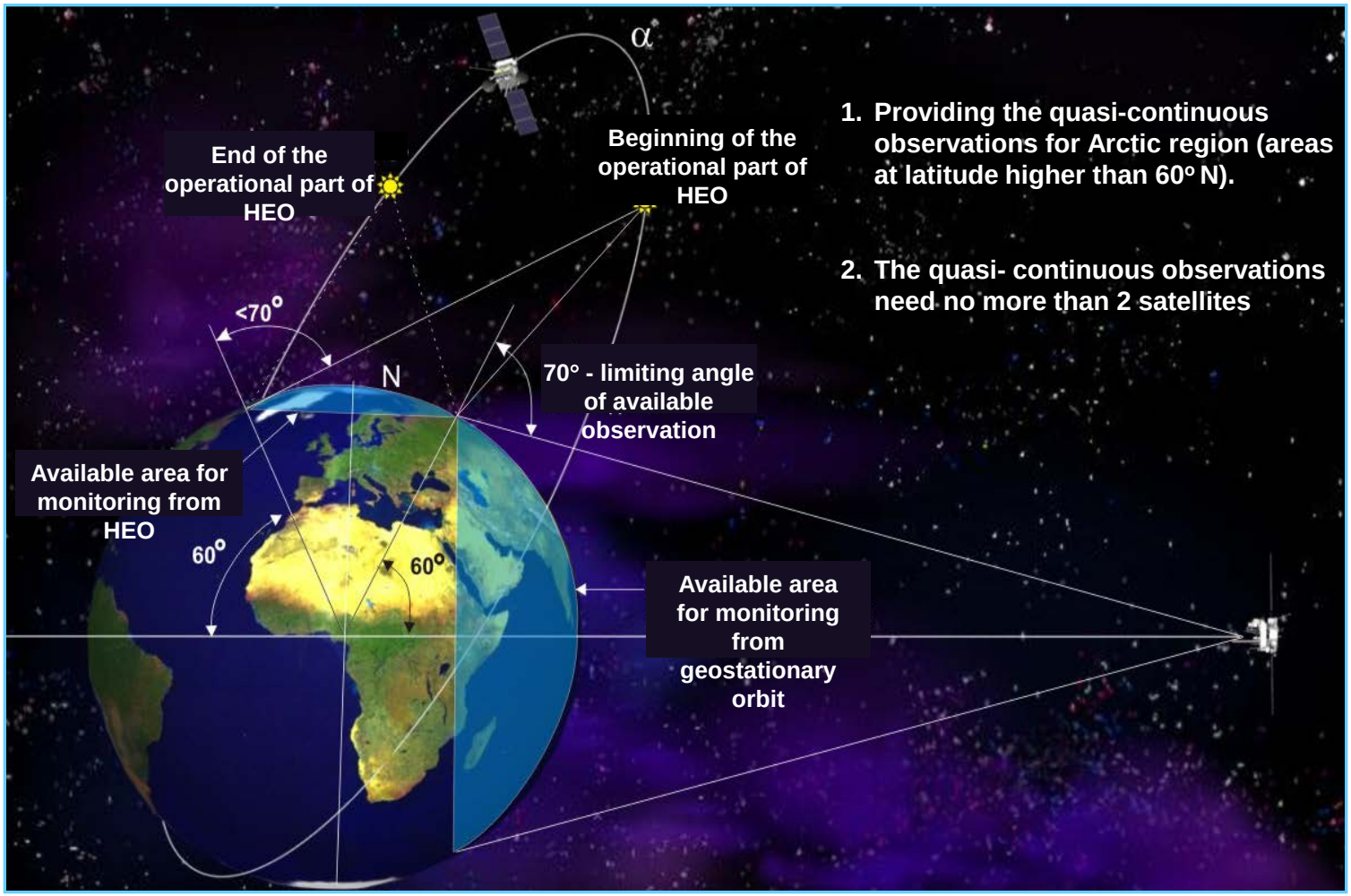
Status of Future HEO Satellite Systems

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**

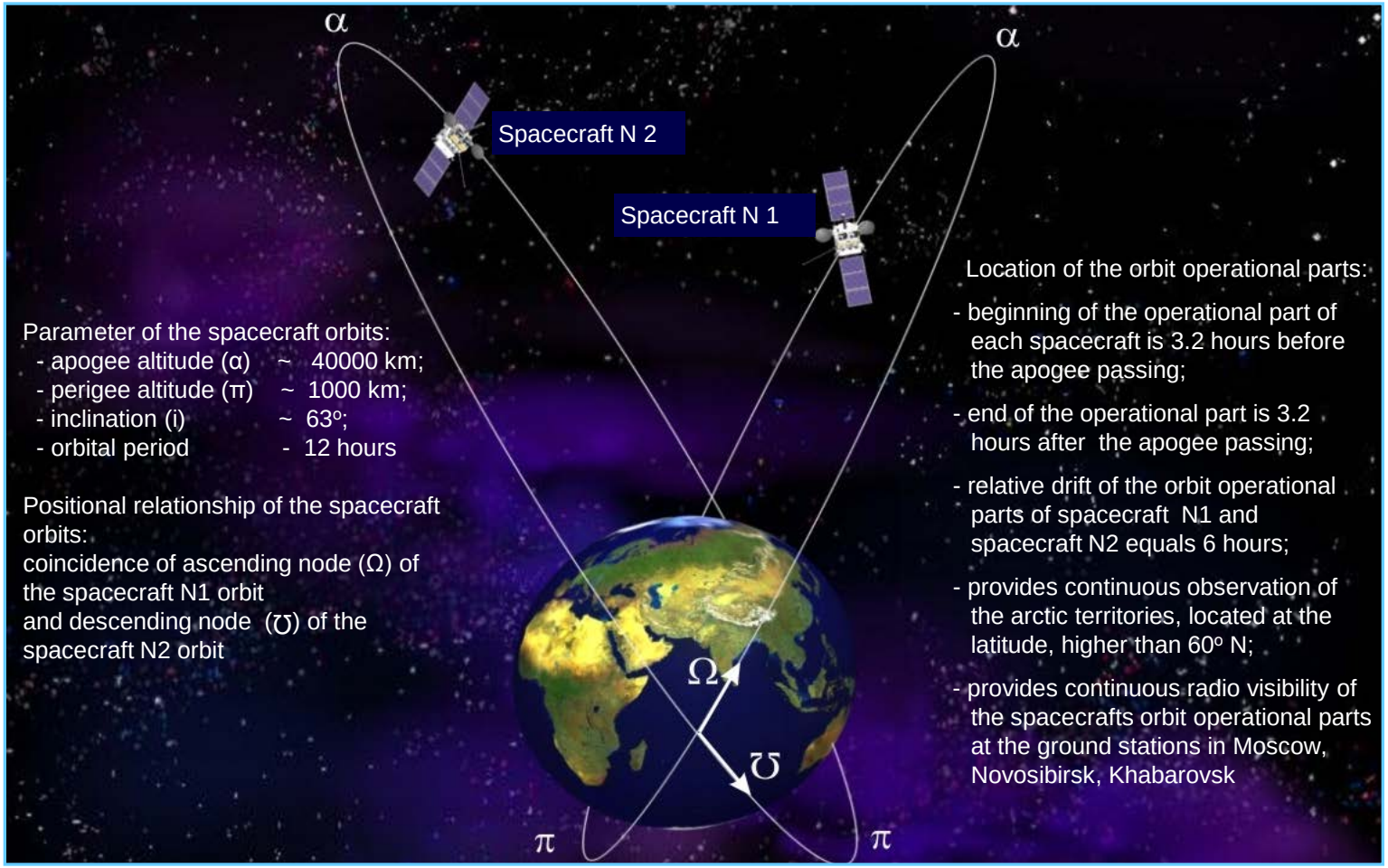
Advantages of the High-Elliptic Orbits (HEO) over Geostationary Orbits for Arctic Observations



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 2017.

ご清聴ありがとうございました

Thanks you for attention!