CGMS

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STATUS OF CURRENT AND FUTURE RUSSIAN SATELLITE SYSTEMS

Current status of polar-orbiting meteorological satellite Meteor-M №1 (launched in 2009) and geostationary meteorological satellite Electro-L №1 (launched in 2011) is presented.

Technical information about future Meteor-M polar-orbiting satellite system is given. By the year 2015, there should be three meteorological and one oceanographical satellites launched. The forthcoming Meteor-MP series satellites are presented.

Future Russian geostationary constellation should consist of three Electro-L series satellites by the year 2015. Orbital positions of these satellites will be 14,5W, 76E and 166E. The mission objectives together with payload and ground segment description are provided.

A constellation of high-elliptical orbit satellites Arctica-M is now under development. These two satellites will provide continuous observations over the Arctic region. The launch is planned for the years 2015 and 2016. An overview of the mission objectives, payload and ground segment description is given.

STATUS OF CURRENT AND FUTURE RUSSIAN SATELLITE SYSTEMS

1 INTRODUCTION

According to the Russian Federal Space Program (2006-2015) the weather monitoring space system should consist of three meteorological and one oceanographical satellites on the polar orbit and three satellites on geostationary orbit by the end of 2015. Currently, one satellite of each series is already launched - Meteor-M №1 (2009) and Electro-L №1 (2011).

Both Meteor-M №1 and Electro-L №1 are now considered as experimental due to some limitations. More detailed description is given below. Ground segment issues as well as details of data transmission, projects and services are also presented.

Future polar-orbiting satellites of Meteor-M series and their payload are described, together with oceanographical satellite Meteor-M №3 and forthcoming Meteor-MP series satellites.

A constellation of Russian geostationary satellites of Electro-L series to be placed at 14,5W, 76E and 166E orbital positions are presented.

Arctica-M project of two high-elliptical orbit satellites is outlined. It will provide observations similar to those of geostationary satellites but over the Arctic region. The payload of Arctica-M satellites will be similar to those of Electro-L series.

2 CURRENT SATELLITE SYSTEMS

There are two meteorological satellites currently on orbit: one polar-orbiting and one geostationary. The satellite statuses in the WMO tables are updated below.

Current geostationary satellites contributing to the GOS

Indian Ocean (36°E-108°E)	Electro-L N1 (L)	Russian Federation /Roshydromet-Roscosmos	76°E	20/01/2011	HRIT/LRIT specification	In commissioning MSU-GS, HMS (GGAK), DCS, GeoSAR. Direct broadcast HRIT, LRIT

Current LEO satellites contributing to the GOS

Sun-							

synchronous "Morning" orbit ECT between 19:00-24:00 and between 07:00-12:00	METEOR-MN1(L)	Russian Federation /Roshydromet-Roscosmos		830 km		Signal structure	MSU-MR, MTVZA, KMSS, Severjanin, GGAK-M. Dissemination: HRPT, LRPT

2.1 Status of current GEO satellite systems

According to Russian Federal Space Program 2006-2015 the geostationary meteorological satellite “Electro-L” №1 has been placed on 76E orbital position..

The satellite was manufactured by Lavochkin Association and has a three-axis stabilized platform.

2.1.1 Mission objectives, payload/instruments, products

Primary objectives of the “Electro-L” №1 mission:

- Continuous observation of the Earth within a radius of 55-60 degrees centred at the sub-satellite point;
- Simultaneous images of cloud cover and the Earth's surface in 10 spectral channels of visible and infrared range;
- The development and maintaining of national data collection system (DCS), collection of the hydrometeorlogical data from national and international platforms (DCPs);
- Retransmission of the data from ROSHYROMET regional centers;
- Heliogeophysical measurements at geostationary orbital altitude;
- Data dissemination in HRIT/LRIT formats to national and foreign users.

Besides standard meteorological communication package (the DCS and the re-transmitters) the key payload consists of imager MSU-GS that provides image data in three visible and seven IR channels. The spatial resolution in subsatellite point is 1 km for visible and 4 km for IR channels. The period between scanning sessions for all channels is 30 min and in more frequent regime every 15 min. JSC "Russians Space Systems" is a developer of this instrument. The 7.5 GHz channel with data rate of 30,72 Mbps is used for transmitting the raw MSU-GS data.

The heliogeophysical complex GGAK provides monitoring of the electromagnetic solar radiation variations, corpuscular radiation fields and variations of the Terrestrial magnetic field. The 1.7 GHz channel (1.2 Kbps data rate) is used for the GGAK data transmitting.

Subsystem for data retransmission consists of:

- The channel for collecting and transmitting data from DCP network to the ROSHYDROMET centers;

- The channel for hydrometeorological data exchange between ROSHYDROMET centers;
- The channels for dissemination the MSU-GS data in HRIT and LRIT formats;
- The transponder for the geostationary Search & Rescue service of the COSPAS/SARSAT.

SRC PLANETA produces various products such as cloud cover etc., and provides satellite informational products to number of users.

2.1.2 Status of spacecraft

The current status is as follows:

- The three-axis stabilized space platform “Navigator” and Ground Segment flight tests are completed;
- 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.

Cannel No	Range, mkm	**Application**
1	0,5 – 0,65	**Static and animated cloud maps, snow, ice and vegetation detecion (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

- The DCS is fully functional (300 national channels and 30 international channels);
- The data exchange between ROSHYDROMET centers is now established;
- The COSPAS-SARSAT system is working;
- The GGAK instrument operates with significant limitations;
- The HRIT/LRIT channels are now used for the regular data transmission;
- The data in HRIT format is distributed on demand via SRC Planeta FTP site.

2.1.3 Impact on spacecraft due to space weather

2.1.4 Ground segment matters

The Roshydromet main ground segment facility for the Electro-L satellite is supported by SRC Planeta. Its receiving and transmitting facilities are located in Moscow and Dolgoprudny, with the backup facility in Novosibirsk. Satellite data is also received at a Roscosmos facility in Moscow for the quality control purposes.
The ground segment of Roshydromet also includes the network of DCP, LRIT and HRIT stations.

2.1.5 Data transmission

The Electro-L N1 HRIT/LRIT channels are now used for the data distribution at 1.7 GHz. The data is currently transmitted once in three hours. Additionally, the satellite is used for signal retransmission from COSPAS-SARSAT emergency rescue systems at 0.4/1.54 GHz frequency band.
The meteorological data in HRIT format is distributed to some users via SRC Planeta FTP site.

2.1.6 Projects, services

The list of services currently provided by the Electro-L N1 satellite is as follows:

Visible and IR imagery;
DCS;
The data exchange between ROSHYDROMET centers;
COSPAS-SARSAT service.

2.1.7 User statistics

The data from the Electro-L N1 satellite is currently used by the Russian Hydrometeorological service.

2.2 Status of current LEO satellite systems

The first one in Meteor-M series of new Russian polar-orbiting meteorological satellites, Meteor-M №1 was launched in 2009. It is placed on a sun-synchronous orbit (820 km, ascending, equator crossing time ~ 9h:30min, inclination 98,79). The satellite was manufactured by JSC “VNIIEM Corporation”.

The satellite is considered as experimental due to a limited functionality of the main payload.

2.2.1 Mission objectives, payload/instruments, products

The main objective of the Meteor-M-1 mission is to provide global observations of the Earth surface and the atmosphere. The data acquired from the satellite is being used for the following purposes:

• Regional and global weather analysis and prediction, including climate and global change monitoring
• Analysis and prediction of ocean surface-water states
• Analysis and prediction of the space weather (solar wind, ionospheric interaction, Earth's magnetic field, etc.).

Payload of Meteor-M №1 is described below:

Scaning radiometer MSU-MR(1 km spatial resolution multichannel scanning unit, 6 channels, VIS & IR).

Visible spectrum scanning imager KMSS (3 cameras with 3 channels each, spatial resolution 50 and 100m);

X-band side looking radar Severjanin (500 m and 1000 m resolution);

Microwave imager-sounder MTVZA-GY (module for temperature and humidity sounding of the atmosphere, 26 channels, 10.6-183 GHz)

Heliogeophysical instrument collection GGAK-M;

Data collection system.

Meteor-M №1 has three downlink radio lines:

2-channel X-band radio link (8.192 GHz and 8.320 GHz) with 122.88 Mbps data transmission rate;

L-band radio link (1.7 GHz) with 665.4 Kbps data transmission rate (HRPT data transmission);

VHF-band radio link (137 MHz) with 80 Kbps transmission rate (LRPT data transmission).

2.2.2 Status of spacecraft

Meteor-M №1 data is now used by Roshydromet with limitations due to some instrument's failures. The satellite is considered as experimental.

The current status of basic instruments is as follows:

- 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 operational with significant limitations.

Channel No	Range, mkm	**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.

operarional

operational with limitations

not operational

2.2.3 Impact on spacecraft due to space weather

2.2.4 Ground segment matters

The major components of the Roshydromet's ground segment are three Main Regional satellite data receiving and processing Centers of SRC Planeta: European (Moscow-Obninsk-Dolgoprudny), Siberian (Novosibirsk) and Far-Eastern (Khabarovsk). These Centers together give full coverage of the territory of Russia and surrounding states. Data acquisition and processing is also performed by the Roscosmos operational facility in Moscow. Roshydromet ground segment also includes the network of DCP, LRPT,and HRPT stations.
The Meteor-M N1 ground segment has been developed by Roshydromet and Roskosmos.

2.2.5 Data transmission

Global data downlink at X-band is used for Roshydromet purposes only.

The direct broadcast is operational at L-band in HRPT format. A detailed format description is published at SRC Planeta web site.

2.2.6 Projects, services

The list of services currently provided by the Meteor-M N1 satellite is as follows:

- Visible and IR imagery (MSU-MR instrument);
- Medium resolution visible imagery (KMSS instrument).

The Meteor-M N1 data is used in emergency monitoring systems such as floods and forest fires detection, sea ice mapping, water pollution tracking etc.

2.2.7 User statistics

The data from Meteor-M N1 satellite is currently used with limitations by Russian Hydrometeorological service, and also provided to EMERCOM – Russian Emergency Control Ministry, Ministry of Natural Resources and Environment of Russian Federation and other regional and federal institutions of Russia.

3 FUTURE SATELLITE SYSTEMS

East Atlantic (36°W -36°E)	Electro-L N2	Russian Federation/Roshydromet-Roscosmos	14.5°W	2013	MSU-GS, HMS (GGAK), DCS, GeoSAR., ~~-~~GGAK Direct broadcast HRIT, LRIT

Indian Ocean (36°E-108°E)	Electro-M N1	Russian Federation/ Roshydromet-Roscosmos	76°E	2018

West Pacific (108°E-180°E)	Electro-L N3	Russian Federation /Roshydromet-Roscosmos	166°E	2015	MSU-GS, HMS, DCS, GeoSAR. Direct broadcast HRIT, LRIT
Highly Elliptical Orbit (non-geo-stationary)	Arctica-M N1	Russian Federation /Roshydromet-Roscosmos"	Molnya Orbit	2015	MSU-GS, ~~Space Weather Instruments~~, DCS, HMS(GGAK)
	Arctica-M N2	Russian Federation /Roshydromet-Roscosmos	Molnya Orbit	2016	MSU-GS, ~~Space Weather Instruments~~, DCS, HMS(GGAK)

METEOR-M N2-2	Russian Federation /Roshydromet-Roscosmos	Afternoon (Time TBD)	820 km	2015	MSU-MR, MTVZA, , KMSS, Severjanin, GGAK-M,IRFS-2, DCS. Dissemination: HRPT, LRPT

Sun-synchronous "Morning" orbit ECT between 19:00-24:00 and between 07:00-12:00	METEOR-M N2	Russian Federation /Roshydromet-Roscosmos	9:30	836 km	March 2013	MSU-MR, MTVZA, IRFS-2, KMSS, Severjanin, GGAK-M, DCS. Dissemination: HRPT, LRPT
	METEOR-M N2-1	Russian Federation /Roshydromet-Roscosmos	TBD	820 km	2014	MSU-MR, MTVZA, IRFS-2, KMSS, Severjanin, GGAK-M, DCS. Dissemination: HRPT, LRPT

METEOR-M N3	Russian Federation /Roshydromet-Roscosmos	TBD	835 km	2015	CAS, SCAT, OCS, Radiomet, MultRadar, Dissemination: HRPT, LRPT

3.1 Status of future GEO satellite systems

According to the Russian Federal Space Program 2006-2015 the geostationary meteorological constellation Electro-L should consist of three similar satellites.
The satellites are being manufactured by Lavochkin Association and have a three-axis stabilized platform.
The "Electro-L" №2 is now in the development stage and is scheduled for launch to 14,5W in 2013. The "Electro-L" №3 (166E) is to be launched in 2015.
The payload of all planned satellites is similar to the first "Electro-L" №1 but with improved performance characteristics. It consists of imager MSU-GS, standard meteorological communication package (the DCS and the re-transmitters), data retransmission channel for hydrometeorological data exchange between ROSHYDROMET centers, and heliogeophysical complex GGAK.

3.1.1 Mission objectives, spacecraft, payload/instruments, products

Primary objectives of the "Electro-L" №2 & N3 missions:

- Continuous observation of the Earth within a radius of 55-60 degrees centred at the sub-satellite point;
- Simultaneous images of cloud cover and the Earth's surface in 10 spectral channels of visible and infrared range;
- The development and maintaining of national data collection system (DCS), collection of the hydrometeorlogical data from national and international platforms (DCPs);
- Retransmission of the data from ROSHYROMET regional centers;
- Heliogeophysical measurements at geostationary orbital altitude;
- Data dissemination in HRIT/LRIT formats to national and foreign users.

Besides standard meteorological communication package (the DCS and the re-transmitters) the key payload consists of imager MSU-GS that provides image data in three visible and seven IR channels. The spatial resolution in subsatellite point is 1 km for visible and 4 km for IR channels. The period between scanning sessions for all channels is 30 min and in more frequent regime every 15 min. JSC "Russians Space Systems" is a developer of this instrument. The 7.5 GHz channel with data rate of 30,72 Mbps is used for transmitting the raw MSU-GS data.

The heliogeophysical instrument suite GGAK provides monitoring of the electromagnetic solar radiation variations, corpuscular radiation fields and variations of the Terrestrial magnetic field. The 1.7 GHz channel (1.2 Kbps data rate) is used for the GGAK data transmitting.

Subsystem for data retransmission consists of:

- The channel for collecting and transmitting data from DCP network to the ROSHYDROMET centers;
- The channel for hydrometeorological data exchange between ROSHYDROMET centers;
- The channels for dissemination the MSU-GS data in HRIT and LRIT formats;
- The transponder for the geostationary Search & Rescue service of the COSPAS/SARSAT.

3.1.2 Ground segment matters

The Electro-L N2 & N3 ground segment will be developed by Roshydromet and Roskosmos on the base of existing facilities. The Roshydromet main ground segment for the Electro-L N2, Electro-L N3 satellites will be supported by SRC Planeta. Roshydromet receiving facilities for the Electro-L N2 satellite will be located in Moscow and Dolgoprudny, for the Electro-L N3 satellite – in Khabarovsk. The ground segment will also include the network of DCP, LRIT and HRIT stations

3.1.3 Data transmission

The Electro-L N2 & N3 HRIT/LRIT channels will be used for the data transmission in L-band with a rate once in 30 min. Additionally, the satellite will support COSPAS-SARSAT emergency rescue systems at a frequency of 0.4/1.54 GHz.

3.2 Status of future LEO satellite systems

According to Russian Federal Space Program 2006-2015 the polar-orbiting satellite system should consist of three hydrometeorological and one oceanographical satellites.

The Meteor-M №2 is about to be launched in 2013. The oceanographical satellite Meteor-M №3 is scheduled for 2015.

These satellites will be manufactured by JSC “VNIIEM Corporation”.

Payload of Meteor-M №2 is described below:

Scaning radiometer MSU-MR(low-resolution multichannel scanning unit, 6 channels, VIS & IR);

Visible spectrum scanning imager KMSS (3 cameras with 3 channels each, spatial resolution 50 and 100m);

X-band side looking radar Severjanin (with 500 and 1000 m resolution);

Microwave imager-sounder MTVZA-GY (module for temperature and humidity sounding of the atmosphere, 26 channels, 10.6-183 GHz);

Infra-red Fourier-transform spectrometer IKFS-2 (IR atmospheric sounder, spectral range 5-15 m, spectral resolution ~ 0.5 cm^{-1});

Heliogeophysical instrument suite GGAK-M;

Data collection system.

Meteor-M №2 has three downlink radio lines:

2-channel X-band radio link (8.192 GHz and 8.320 GHz) with 122.88 Mbps data transmission rate;

L-band radio link (1.7 GHz) with 665.4 Kbps data transmission rate;

VHF-band radio link (137 MHz) with 80 Kbps transmission rate (LRPT data transmission).

All instruments for Meteor-M №2 mission are now produced and installed onboard the spacecraft. The satellite is to be launched on a sun-synchronous orbit (820 km, equator crossing time ~ 9h:30min, inclination 98,79) in 2013.

It is planned to launch two similar satellites with the same payload as Meteor-M №2, i.e. Meteor-M №2-1 (launch due 2014) and Meteor-M №2-2 (launch due 2015). The goal is to create a system of identical operational meteorological satellites on morning and afternoon orbits.

Oceanographical satellite Meteor-M №3 is currently at the development stage. Its payload consists of:

Multimode radar based on Active Phased Array Antenna (APAA) technology (X-band, spatial resolution from 1 to 500 m, swath 10 - 750 km);

Scatterometer (Ku-band; spatial resolution 25x25 km, swath 1800 km);

Coastal Area Scanner (4 channels, visible range, spatial resolution 80 m, swath 800 km);

Ocean Color Scanner (8 channels, visible range, spatial resolution 1 km, swath 3000 km);

Radio-occultation instrument (Radiomet).

Meteor-M №3 is scheduled for launch in 2015.

According to the Federal Space Program, the development of New Generation Satellite Constellation Meteor-MP has been started in 2011.

Meteor-MP satellite constellation will comprise of 3 satellites: two meteorological and one oceanographical satellite. Meteor-MP payload will be basically similar to Meteor-M series payload, but with improved performance characteristics.

Meteor-MP payload will consists of:

	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	+	+	-
Medium resolution multispectral infra-red scanner	-	-	+
Atmospheric composition spectrometer	+	+	-
Microwave imager-sounder (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	+	+	-
1.7GHz data downlink system	+	+	-
X- and Ku- band data downlink system	+	+	+

The launch of the first Meteor-MP series satellite is scheduled for 2016.

3.2.1 Mission objectives, spacecraft, payload/instruments, products

The main objective of the Meteor-MP mission is to provide global observations of the Earth surface and the atmosphere. The data acquired from the satellite is being used for the following purposes:

• Regional and global weather analysis and prediction, including climate and global change monitoring
• Analysis and prediction of ocean surface-water states
• Analysis and prediction of the space weather (solar wind, ionospheric interaction, Earth's magnetic field, etc.).

3.2.2 Ground segment matters

The Meteor-MP ground segment will be developed by Roshydromet and Roskosmos on the base of existing facilities.
The major components of the Roshydromet's ground segment are three Main Regional satellite data receiving and processing Centers of SRC Planeta: European (Moscow-Obninsk-Dolgoprudny), Siberian (Novosibirsk) and Far-Eastern (Khabarovsk). These Centers together covers the whole territory of Russia. Roscosmos will also use its Moscow facility to receive and process data from Meteor-MP satellites.
The ground segment also includes the network of DCP, LRPT, and HRPT stations.

3.2.3 Data transmission

Global data downlink at X-band will be used for Roshydromet purposes only.
The direct broadcast will operate at L-band in HRPT format. A detailed format description will be updated and published at SRC Planeta web site after the commissioning phase.

3.3 Status of future HEO [or other] satellite systems

At the CGMS 34 it was firstly reported about the Russian project of Arctic region monitoring from the "Molnya" high elliptical orbit. Now this project evolved into mission of two HEO satellites called Arctica. The work have been started in 2011 and the first satellite is now being produced by Lavochkin Association.

3.3.1 Mission objectives, spacecraft, payload/instruments, products

Main purposes of the mission are meteorology, oceanography, including ice cover monitoring and disaster monitoring in the Arctic region. To perform operational monitoring of the region of interest 24 hours a day each of two satellites will be covering the area for 6,4 hours and then step back for the next one. The cycle time for each satellite is exactly 12 hours.
The payload and design of the satellites is similar to the ones in the Electro-L series.
An essential feature of the spacecrafts of the Arctica system is their mass and power reserves allowing us to add different types of complementary payload and instruments, including international ones if considered necessary.
The first Arctica satellite launch is scheduled for 2015

3.3.2 Ground segment matters

The ground segment for the Arctica constellation will be based on SRC Planeta/ROSHYDROMET facilities in Moscow, Novosibirsk and Khabarovsk. Also it is planned to deploy the network of small data acquisition centers in the costal area along Northern Sea Route.

3.3.3 Data transmission

Data transmission system of the Arctica satellites will comprise of:

- downlink at X-band with data transmission rate of 30.72 Mbit/s;
- downlink at L-band for the GGAK data with transmission rate of 5000 bit/s;
- DCS retransmission support at 401-403 MHz / 1.7 GHz;
- meteorological data retransmission at L-band.

4 ACTIONS AND/OR RECOMMENDATIONS FOR CONSIDERATION BY CGMS PLENARY SESSION

The geostationary Electro-L satellite located over the Indian Ocean at 76° longitude has international DCP channels which may be used to gain information from remote meteorological sites or sensors located within its footprint. Thus, CGMS could recommend its members to use this possibility.

Also it is worth mentioning that geostationary satellite Electro-L N1 data is distributed via FTP site as well as via direct HRIT/LRIT broadcast. An access to FTP site can be granted to CGMS members by SRC Planeta/Roshydromet.

As a second recommendation, it is suggested to direct additional effort into channel inter-calibration of the geostationary and polar orbiting satellites, especially in the infrared and microwave spectrum range.

5 CONCLUSION

In order to solve various problems, mainly related to the use of information concerning condition of the atmosphere and underlying surface, Russia is currently creating a strong constellation of meteorological satellites. Its essential distinction from similar constellation of other countries is in the use of highly elliptical orbits of the “Molnya” type. Two satellites on such orbits, the first of which is scheduled for launch in 2015, will allow for continuous monitoring of the atmosphere, ground and ocean condition in the northern polar regions.