CGMS

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REPORT ON THE STATUS OF CURRENT AND FUTURE RUSSIAN SATELLITE SYSTEMS

This document addresses the current status of the Russian satellite systems: Meteor-M N2 polar-orbiting meteorological satellite (launched on 8 July, 2014) and Electro-L N1 geostationary meteorological satellite (launched on 20 January, 2011).

Future Russian geostationary meteorological constellation will consist of three Electro-L satellites. The location of Electro-L satellites in orbit will be 14,5W, 76E and 166E. The mission objectives, payload and ground segment matters are provided.

Working paper provides an overview of future Meteor-3M polar-orbiting satellite system, which will include three meteorological and one oceanographic satellites, and also forthcoming series of Meteor-MP and Ocean satellites.

Arctica-M constellation of highly elliptical orbit satellites is now under development. The system will include two spacecrafts. These satellites will provide continuous observations over the Arctic region. The launch is scheduled for 2017–2019. An overview of the mission objectives, payload and ground segment matters are presented.

STATUS OF CURRENT AND FUTURE RUSSIAN SATELLITE SYSTEMS

1 INTRODUCTION

According to the project of the Russian Federal Space Program and Strategy of the hydrometeorology and related fields for the period up to 2030 (including climate change issues) the space system for hydrometeorological and environmental monitoring will consist of three polar-orbiting meteorological and one oceanographic satellites, three geostationary meteorological satellites and two highly elliptical orbit satellites. Currently, two spacecrafts of Meteor-M series have been already launched – Meteor-M N1, N2 (2009 and 2014) and Electro-L N1 (2011).

Meteor-M N1 is not operational (end of lifetime). While some instruments are still functioning, the restricted exploitation of the satellite is planned to be continuous. Following the commissioning phase, Meteor-M N2 has become operational. Electro-L N1 operates in the degraded mode. Ground segment matters as well as data transmission details, projects and services are also presented.

Future Meteor-M series of polar-orbiting satellites and their payload, including oceanographic satellite Meteor-M N3, and forthcoming Meteor-MP and Ocean series satellites are provided.

A constellation of Electro-L geostationary satellites to be located at 14.5W, 76E and 166E is presented.

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

2 CURRENT SATELLITE SYSTEMS

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

Current GEO satellites contributing to the GOS

Sector	Satellite in orbit	Operator	Location	Launch date	Details on near real time access	Instrument payload
Indian Ocean (36°E-108°E)	Electro-L N1	Russian Federation /Roshydromet	76°E	20/01/2011	HRIT/LRIT specification	MSU-GS, HMS (GGAK), DCS, GeoSAR. Direct broadcast HRIT, LRIT

Current LEO satellites contributing to the GOS

Orbit type	Satellite in orbit	Operator	Equator Crossing Time	Mean Alti-tude	Launch date	Details on near real time access	Instrument payload
Sun-synchronous "Morning" orbit ECT between 19:00-24:00 and between 07:00-12:00	Meteor-M N2	Russian Federation /Roshydro met	09:30	820 km	08/07/2014	Signal structure	MSU-MR, MTVZA, IKFS-2, KMSS, Severjanin, GGAK-M. Dissemination: HRPT, LRPT

2.1 Status of current GEO satellite systems

According to the Russian Federal Space Program the Electro-L N1 geostationary meteorological satellite has been located at 76E. Due to technical issues onboard (instability of orientation of spacecraft) the satellite operates in the degraded mode.

2.1.1 Mission objectives, payload/instruments, products

Primary objectives of Electro-L N1 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 visible and infrared channels;
- The development and maintaining the national data collection system (DCS), collection of the hydrometeorlogical data from national and international platforms (DCPs);
- Retransmission of the data from Roshydromet regional centers;
- Heliogeophysical measurements at geostationary orbit altitudes;
- Data dissemination in HRIT/LRIT formats to national and foreign users.

Besides standard meteorological communication package (DCS and re-transmitters) the key payload consists of MSU-GS imager that provides data in three visible and seven IR channels. The spatial resolution at sub-satellite 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 the more frequent mode is 15 min. JSC "Russian Space Systems" is a developer of this instrument. The 7.5 GHz channel with data rate of 30,72 Mbps is used for transmitting raw MSU-GS data.

GGAK Heliogeophysical Measurements Suite provides monitoring of the electromagnetic solar radiation, corpuscular radiation and terrestrial magnetic fields. The 1.7 GHz channel (5 Kbps data rate) is used for 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 MSU-GS data dissemination in HRIT and LRIT formats;
- The transponder for the geostationary COSPAS-SARSAT Search & Rescue system.

2.1.2 Status of spacecraft

The current status of Electro-L N1:

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

2.1.3 Impact on spacecraft due to space weather

Impact on spacecraft due to space weather is not established.

2.1.4 Ground segment matters

Roshydromet ground segment consists of three SRC Planeta regional centers, responsible for receiving, processing, disseminating and archiving satellite data: European (Moscow-Obninsk-Dolgoprudny), Siberian (Novosibirsk) and Far-Eastern (Khabarovsk). These centers together give full coverage of the Russia and neighbouring territories.

Roshydromet ground segment for Electro-L satellite is based on SRC Planeta facility. The receiving and transmitting systems are located in European center (Moscow-Dolgoprudny), with the backup facility in Siberian center (Novosibirsk). The deployment of the receiving system in the Far-Eastern center (Khabarovsk) is underway. Satellite data is also received by 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

Electro-L N1 HRIT/LRIT channels are functional, but currently not in used due to instability of orientation of satellite. Additionally, the satellite is used for signal retransmission from COSPAS-SARSAT Search & Rescue system at 0.4/1.54 GHz.

When available the meteorological data in HRIT format is distributed to some users via SRC Planeta FTP server.

2.1.6 Projects, services

The list of services currently provided by Electro-L N1 satellite:

- Visible and IR imagery (not in a regular mode);
- DCS;

- COSPAS-SARSAT system.

2.1.7 User statistics

Electro-L N1 satellite data is used by Russian Hydrometeorological and Environmental Monitoring Service.

2.2 Status of current LEO satellite systems

The second spacecraft of Meteor-M series of new Russian polar-orbiting meteorological satellites, Meteor-M N2 was launched on 8 July, 2014. It is located in a sun-synchronous orbit (820 km, ascending, equator crossing time ~ 9h : 30min, inclination 98,79°). The satellite was designed and built by JSC "VNIIEM Corporation".

Following the commissioning phase, Meteor-M N2 has become operational.

2.2.1 Mission objectives, payload/instruments, products

The main objective of Meteor-M N2 mission is to provide global observations of the Earth's surface and the atmosphere. The data acquired by the satellite is used for the following purposes:

- Weather analysis and forecasting on global and regional scales;
- Global climate change monitoring;
- Sea water monitoring and forecasting;
- Space weather analysis and prediction (solar wind, ionosphere research, Earth's magnetic field, etc.).

Payload of Meteor-M N2 consists of:

- MSU-MR Scanning Radiometer (1 km spatial resolution multichannel scanning unit, 6 channels, VIS/IR);
- KMSS VIS Scanning Imager (6 channels implemented by 3 cameras, 50 m and 100 m spatial resolution);
- Severjanin X-band Synthetic Aperture Radar;
- MTVZA-GY Imaging/Sounding Microwave Radiometer (module for temperature and humidity sounding of the atmosphere, 26 channels, 10.6-183 GHz);
- IR Fourier-transform spectrometer (IR atmospheric sounder, spectral range 5-15 μm, spectral resolution ~ 0.5 cm^{-1});
- GGAK-M Heliogeophysical Measurements Suite;
- Data collection system (DCS).

Meteor-M N 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 in each channel;
- 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 data transmission rate (LRPT data transmission).

2.2.2 Status of spacecraft

The current status of the basic instruments:

- MSU-MR instrument is fully functional;
- MTVZA-GY instrument is fully functional (absolute calibration work is now underway);
- 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.

2.2.3 Impact on spacecraft due to space weather

Impact on spacecraft due to space weather is not established.

2.2.4 Ground segment matters

Roshydromet ground segment consists of three SRC Planeta regional centers, responsible for receiving, processing, disseminating and archiving satellite data: European (Moscow-Obninsk-Dolgoprudny), Siberian (Novosibirsk) and Far-Eastern (Khabarovsk). These centers together give full coverage of the Russia and neighbouring territories.

Roshydromet ground segment for Meteor-M N2 satellite is based on SRC Planeta facility. It also includes the network of DCS, LRPT and HRPT stations. Data acquisition and processing are also performed by Roscosmos operational facility in Moscow.

Meteor-M N2 ground segment has been developed by Roshydromet and Roscosmos.

2.2.5 Data transmission

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

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

2.2.6 Projects, services

The list of services currently provided by the Meteor-M N2 satellite:

- Visible and IR imagery (MSU-MR instrument);
- Moderate resolution visible imagery (KMSS instrument);
- MTVZA-GY (in the experimental mode);
- IKFS-2 (preparation phase).

Meteor-M N2 data is used for disaster monitoring such as floods and forest fires, as well as sea ice and water pollution monitoring, etc.

2.2.7 User statistics

Meteor-M N2 satellite data is currently used by Russian Hydrometeorological and Environmental Monitoring Service, and also provided to EMERCOM – Ministry of Civil Defence, Emergencies and Disaster Relief of the Russian Federation, Ministry of Natural Resources and Environment of the Russian Federation and other federal and regional institutions of Russia.

3 FUTURE SATELLITE SYSTEMS

Sector	Satellite in orbit	Operator	Location	Planned launch date	Instrument payload
Indian Ocean (37°E -109°E)	Electro-L N2	Russian Federation/ Roshydromet	77.8°E	2015	MSU-GS, HMS (GGAK), DCS, GeoSAR. Direct broadcast HRIT, LRIT
TBD	Electro-L N3	Russian Federation /Roshydromet	TBD	2016	MSU-GS, HMS, DCS, GeoSAR. Direct broadcast HRIT, LRIT
TBD	Electro-L N4	Russian Federation /Roshydromet	TBD	2019	MSU-GS, HMS, DCS, GeoSAR. Direct broadcast HRIT, LRIT
TBD	Electro-L N5	Russian Federation /Roshydromet	TBD	2021	MSU-GS, HMS, DCS, GeoSAR. Direct broadcast HRIT, LRIT
Indian Ocean (37°E -109°E)	Electro-M N1-1	Russian Federation /Roshydromet	TBD	2023	MSU-GSM, IRFS-GS, ERBR, LM, GGAK-E/M, BRTK-M
	Electro-M N1-2			2025	

Orbit type	Satellite in orbit	Operator	Orbit	Planned launch date	Instrument payload
Highly Elliptical Orbit (non-geo-stationary)	Arctica-M N1	Russian Federation /Roshydromet	Molnya Orbit	2017	MSU-GS, DCS, HMS(GGAK)
	Arctica-M N2	Russian Federation /Roshydromet	Molnya Orbit	2019	MSU-GS, DCS, HMS(GGAK)

Sun-synchronous "Morning" orbit ECT between 19:00-24:00 and between 07:00-12:00	Meteor-M N2-1	Russian Federation /Roshydromet	TBD	820 km	2016	MSU-MR, MTVZA, IRFS-2, KMCC, DCS. Dissemination: HRPT, LRPT
	Meteor-M N2-2	Russian Federation /Roshydromet	After-noon (Time TBD	820 km	2016	MSU-MR, MTVZA, IRFS-2, KMCC, DCS. Dissemination: HRPT, LRPT
	Meteor-M N2-3	Russian Federation /Roshydromet	TBD	820 km	2019	MSU-MR, MTVZA, IRFS-2, KMSS, MeteoSAR, GGAK-M2, DCS. Dissemination: HRPT, LRPT
	Meteor-M N2-4	Russian Federation /Roshydromet	TBD	820 km	2020	MSU-MR, MTVZA, IRFS-2, KMSS, MeteoSAR, GGAK-M2, DCS. Dissemination: HRPT, LRPT
	Meteor-M N2-5	Russian Federation /Roshydromet	TBD	820 km	2021	MSU-MR, MTVZA, IRFS-2, KMSS, MeteoSAR, GGAK-M2,

						DCS. Dissemination: HRPT, LRPT
	Meteor-M N3	Russian Federation /Roshydromet	TBD	650 km	2020	CZS, SCAT, OCS, Radiomet, SAR-X, Dissemination: LRPT

3.1 Status of future GEO satellite systems

According to the Russian Federal Space Program Electro-L constellation of the geostationary meteorological satellites should consist of three similar satellites.

The satellites are designed and built by Lavochkin Association and have a three-axis stabilized platform.

Electro-L N2 is scheduled to be placed at 77.8E in July 2015. The launch of Electro-L N3 is scheduled in 2016.

The payload of Electro-L constellation is similar to Electro-L N1 spacecraft but with improved instrument performance. The payload will consist of MSU-GS Imager, standard meteorological communication package (DCS and re-transmitters), data retransmission channel for hydrometeorological data exchange between Roshydromet centers, and GGAK Heliogeophysical Measurements Suite.

3.1.1 Mission objectives, spacecraft, payload/instruments, products

Primary objectives of Electro-L missions:

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

Besides standard meteorological communication package (DCS and re-transmitters) the key payload will consist of MSU-GS Imager which provides data in three visible and seven IR channels. The spatial resolution at the sub-satellite 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 mode is every 15 min. JSC "Russian Space Systems" is a developer of this instrument. The 7.5 GHz channel with data rate of 30,72 Mbps is used for transmitting raw MSU-GS data.

GGAK Heliogeophysical Measurements Suite provides monitoring of the electromagnetic solar radiation, corpuscular radiation and terrestrial magnetic fields. The 1.7 GHz channel (5 Kbps data rate) is used for 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 MSU-GS data dissemination in HRIT and LRIT formats;
- The transponder for the geostationary COSPAS-SARSAT Search & Rescue system.

3.1.2 Ground segment matters

Electro-L N2, N3, N4 & N5 ground segment will be developed by Roshydromet and Roscosmos. Roshydromet main ground segment for Electro-L satellites will be based on SRC Planeta facility. The ground segment will also include the network of DCP, LRIT and HRIT stations.

3.1.3 Data transmission

Electro-L N2, N3, N4 & N5 HRIT/LRIT channels will be used for the data transmission in L-band every 30 min. Additionally, the satellite will support COSPAS-SARSAT Search and Rescue system at 0.4/1.54 GHz.

3.2 Status of future LEO satellite systems

According to the project of the Russian Federal Space Program and Strategy of the hydrometeorology and related fields for the period up to 2030 (including climate change issues) the polar-orbiting satellites system should consist of three hydrometeorological and one oceanographic satellites.

Meteor-M N2-1 hydrometeorological satellite is scheduled to be launched in 2016. It is planned to launch five similar satellites with the same payload as Meteor-M N2, i.e. Meteor-M N2-1, Meteor-M N2-2, Meteor-M N2-3, Meteor-M N2-4, Meteor-M N2-5. The goal is to create a system of identical operational meteorological satellites in morning and afternoon orbits. These satellites will be designed by JSC "VNIIEM Corporation". The payload of Meteor N2-1 and Meteor N2-2 will be modified to exclude Severjanin X-band Side-Looking Radar and Heliogeophysical Measurements Suite. For Meteor N2-3, Meteor N2-4 and Meteor N2-5 there will be MeteoSAR and modified Heliogeophysical Measurements Suite GGAK-M2 instead.

Meteor-M N3 oceanographic satellite is currently under development. Its payload will consist 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; 25x25 km spatial resolution, swath 1800 km);

- Coastal Zone Scanner (4 channels, visible range, 80 m spatial resolution, swath 800 km);
- Ocean Color Scanner (8 channels, visible range, 1 km spatial resolution, swath 3000 km);
- Radio-occultation instrument (Radiomet).

Meteor-M N3 is scheduled for launch in 2020.

Ocean series satellites

Forthcoming Meteor-MP meteorological satellites' payload will be basically similar to Meteor-M series payload, but with improved instrument performance.

Meteor-MP payload will consist of:

- Scanning radiometer (low-resolution multichannel scanning unit);
- 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);
- Scatterometer;
- Side-looking radar system;
- Radio-occultation instrument;
- Data collection system;
- Heliogeophysical Measurements Suite;
- 137 MHz data downlink system;
- 1.7 GHz data downlink system;
- X- band data downlink system.

Meteor-MP N1 and N2 are scheduled for launch in 2021 and 2023.

According to the project of the Russian Federal Space Program the development of series of Ocean oceanographic satellites is planned. The payload of Ocean satellites will consist of:

- 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

The development of Ocean satellites will be started in 2020.

3.2.1 Mission objectives, spacecraft, payload/instruments, products

The main objective of Meteor-MP and Ocean missions is to provide global observations of the Earth’s surface, World Ocean and the atmosphere. The data acquired by the satellite can be used for the following purposes:

- Weather analysis and forecasting on global and regional scales;
- Global climate change monitoring;
- Sea water monitoring and forecasting;
- Space weather analysis and prediction (solar wind, ionosphere research, Earth's magnetic field, etc.).

3.2.2 Ground segment matters

The Meteor-MP and Ocean ground segment based on the existing facilities will be developed by Roshydromet and Roscosmos.

Roshydromet ground segment consists of three SRC Planeta regional centers, responsible for receiving, processing, disseminating and archiving satellite data: European (Moscow-Obninsk-Dolgoprudny), Siberian (Novosibirsk) and Far-Eastern (Khabarovsk). These centers together give full coverage of the Russian territory and neighboring states.

The ground segment also includes the network of DCSs, LRPT, and HRPT stations.

3.2.3 Data transmission

Global data X- and Ka-band downlink will be used for Roshydromet purposes only.

The direct broadcast will work in L-band in AHRPT and in a band of 137 MHz in format LRPT. The detailed format description will be updated and published at SRC Planeta website after the commissioning phase.

3.3 Status of future HEO [or other] satellite systems

At CGMS-43 it was reported on the Russian project of Arctic region monitoring from the “Molnya” highly elliptical orbit for the first time. Now this project evolved into mission of two HEO satellites called Arctica. The work has been started in 2011 and the first satellite is now being developed by Lavochkin Association.

3.3.1 Mission objectives, spacecraft, payload/instruments, products

The main purposes of the mission are meteorology, oceanography, including ice cover monitoring and disaster monitoring in the Arctic region. To perform operational monitoring of Polar Regions 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 are similar to Electro-L series.

The essential feature of Arctica system spacecraft is their mass and power reserves allowing to add different types of complementary instruments, including international ones if it is considered necessary. The launch of the first Arctica satellite is scheduled in 2017.

3.3.2 Ground segment matters

The ground segment for 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 coastal zone along the Northern Sea Route.

3.3.3 Data transmission

- Data transmission system of Arctica satellites will consist of:
- Downlink in X-band with data transmission rate of 30.72 Mbit/s;
- Downlink in L-band for the GGAK with data transmission rate of 5000 bit/s;
- DCS retransmission support at 401-403 MHz / 1.7 GHz;
- Meteorological data retransmission in L-band.

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

The geostationary Electro-L N1 satellite located over the Indian Ocean at 76°E has international DCS channels which may be used to collect the information from the remote areas located within its footprint. Electro-L N2 satellite will be located at 77.8°E to provide also the coverage of Indian Ocean. Thus, CGMS could recommend its members to use this opportunity.

As the second recommendation, it is suggested to make an additional effort into channels inter-calibration of the geostationary and polar-orbiting satellites, especially in the infrared and microwave channels.

5 CONCLUSION

Russian Federation is currently developing national constellation of meteorological satellites. It will be complemented by the satellites in highly elliptical “Molnya” type orbits. Two satellites in HEO, the first spacecraft is scheduled for launch in 2017, will provide the continuous monitoring of the atmosphere, ocean and land in the northern Polar Regions.