Status of current and future Roshydromet satellite programmes

State Research Center on Space Hydrometeorology PLANETA, Moscow, Russia
<table>
<thead>
<tr>
<th>Year</th>
<th>Russian Earth Observation Satellites Program 2006-2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td><strong>ELECTRO № 1 (76°E)</strong></td>
</tr>
<tr>
<td>2007</td>
<td><strong>ELECTRO № 2 (location TBD)</strong></td>
</tr>
<tr>
<td>2008</td>
<td><strong>ELECTRO № 3 (76°E)</strong></td>
</tr>
<tr>
<td>2009</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td></td>
</tr>
<tr>
<td>2013</td>
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<tr>
<td>2014</td>
<td></td>
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<tr>
<td>2015</td>
<td></td>
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<tr>
<td>2016</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
</tr>
</tbody>
</table>

**Geostationary meteorological system**

- ELECTRO № 1 (76°E)
- ELECTRO № 2 (location TBD)
- ELECTRO № 3 (76°E)

**Polar-orbiting meteorological system**

- METEOR № 1
- METEOR № 2
- METEOR № 3 (Oceanographical)
- METEOR № 4
- METEOR № 5
- METEOR № 6 (Oceanographical)

**R&D environmental satellites**

- KANOPUS-V № 1
- KANOPUS-V № 2
- RESURS-P № 1
- RESURS-P № 2
ELECTRO-L  General Design

- Three-axis high-precision stabilization
- In-orbit mass - 1500 kg
- Payload mass - 370 kg
- Lifetime - 10 years
- Longitude - 76E
- 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 Performance Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of channels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• VIS</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>• IR</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Spectral range at half maximum of spectral response function (μm)</td>
<td>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</td>
</tr>
<tr>
<td>3</td>
<td>Image frame (deg x deg)</td>
<td>20 ± 0.5 x 20 ± 0.5</td>
</tr>
<tr>
<td>4</td>
<td>HRIT ground resolution in subsatellite point (km)</td>
<td>1.0 (VIS); 4.0 (IR)</td>
</tr>
<tr>
<td>5</td>
<td>S/N ratio for VIS channels</td>
<td>≥ 200</td>
</tr>
<tr>
<td>6</td>
<td>NEΔT at 300K (K)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• in the band 3.5-4.0 μm</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>• in the band 5.7-7.0 μm</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>• in the band 7.5-12.5 μm</td>
<td>0.1-0.2</td>
</tr>
<tr>
<td>7</td>
<td>Power (W)</td>
<td>≤ 150</td>
</tr>
<tr>
<td>8</td>
<td>Weight (kg)</td>
<td>≤ 88</td>
</tr>
<tr>
<td>9</td>
<td>Lifetime of basic and reserve units (years)</td>
<td>10</td>
</tr>
</tbody>
</table>
**METEOR-M General Design**

- 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 Mission Objectives and Basic Instruments

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Application</th>
<th>Spectral Band</th>
<th>Swath-width (km)</th>
<th>Resolution (km)</th>
<th>Instruments for intercalibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSU-MR</td>
<td>Global and regional cloud cover mapping, SST, LST, ...</td>
<td>0.5 – 12.5 μm (6 channels)</td>
<td>3000</td>
<td>1 x 1</td>
<td>AVHRR/NOAA</td>
</tr>
<tr>
<td>KMSS multichannel scanning unit</td>
<td>Earth surface monitoring</td>
<td>0.4-0.9 μm (3 channels)</td>
<td>100</td>
<td>0.06/0.1</td>
<td></td>
</tr>
<tr>
<td>MTVZA imager/sounder</td>
<td>Atmospheric temperature and humidity profiles, sea surface wind</td>
<td>10.6-183.3 GHz (26 channels)</td>
<td>2600</td>
<td>12 – 75</td>
<td>SSMIS/DMSP AMSR/AIDS/AQUA AMSU/NOAA</td>
</tr>
<tr>
<td>IRFS-2 advanced IR sounder *</td>
<td>Atmospheric temperature and humidity profiles</td>
<td>5-15 μm</td>
<td>2000</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Severjanin (SAR)</td>
<td>Ice monitoring</td>
<td>9500-9700 MHz</td>
<td>600</td>
<td>0.4 x 0.5</td>
<td></td>
</tr>
<tr>
<td>Radiomet* (radio occultation unit)</td>
<td>Atmospheric temperature and pressure profiles.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* - to be launched on board METEOR-M №2
### Basic performance characteristics of IRFS-2

<table>
<thead>
<tr>
<th>№</th>
<th>Parameter</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Spectral range: wavelength wave number</td>
<td>μm, cm⁻¹</td>
<td>5-15 2000-665</td>
</tr>
<tr>
<td>2</td>
<td>Reference channel wavelength</td>
<td>μm</td>
<td>1.06</td>
</tr>
<tr>
<td>3</td>
<td>Maximum optical path difference (OPD)</td>
<td>mm</td>
<td>17</td>
</tr>
<tr>
<td>4</td>
<td>Angular size of FOV</td>
<td>mrad</td>
<td>40 x 40</td>
</tr>
<tr>
<td>5</td>
<td>Spatial resolution (at subsatellite point)</td>
<td>km</td>
<td>35</td>
</tr>
<tr>
<td>6</td>
<td>Swath Width and spatial sampling</td>
<td>km</td>
<td>2500, 110 2000, 100</td>
</tr>
<tr>
<td>7</td>
<td>Aperture angle of beams reaching the detector</td>
<td>degree</td>
<td>63</td>
</tr>
<tr>
<td>8</td>
<td>Duration of the interferogram measurement</td>
<td>s</td>
<td>0.5</td>
</tr>
<tr>
<td>9</td>
<td>Dynamic range</td>
<td></td>
<td>2¹⁶</td>
</tr>
<tr>
<td>10</td>
<td>Number of reference points in two-sided interferogram</td>
<td></td>
<td>2¹⁵</td>
</tr>
<tr>
<td>11</td>
<td>Frequency band of measuring channel</td>
<td>kHz</td>
<td>4.5-13.5</td>
</tr>
<tr>
<td>12</td>
<td>Reference signal frequency</td>
<td>kHz</td>
<td>65.5</td>
</tr>
<tr>
<td>13</td>
<td>Frequency band of reference channel</td>
<td>kHz</td>
<td>61-70</td>
</tr>
<tr>
<td>14</td>
<td>Weight</td>
<td>kg</td>
<td>45-50</td>
</tr>
<tr>
<td>15</td>
<td>Power</td>
<td>W</td>
<td>50</td>
</tr>
</tbody>
</table>
Roshydromet Satellite Ground Segment

3 Main centers:
Europe
(Moscow-Obninsk-Dolgoprudny)
Siberia
(Novosibirsk)
Far-East
(Khabarovsk)

- 68 Local centers
Status of Roshydromet Ground Segment

- Polar-orbital satellites:
  - NOAA
  - Terra
  - Aqua
  - MetOp
  - FY-1
  - SeaStar

- Geostationary satellites:
  - Meteor-M
  - MTSAT-1R
  - Elektro-L

- Retranslation satellites:
  - Eumetsat data transferring system

- SRC «Planeta» (Moscow, Obninsk, Dolgoprudny):
  - Elektro-L
  - Elektro-L, Meteor-M
  - Elektro-L, Meteor-M, Terra, Aqua
  - PK-9
  - PK-7 (SPDD)
  - PK-3,5

- Moscow:
  - NOAA, MetOp, SeaStar Terra, Aqua, FY-1
  - Eumetsat
  - Kongsberg MEOs Polar

- Obninsk:
  - Data processing, archiving and dissemination center

- Dolgoprudny:
  - Data processing, archiving and dissemination center

- Roshydromet organizations:
  - Ministries and departments:
    - Ministry of Defense, Emergency control Ministry, Ministry of transport, Roskosmos, Roskartografi and others.

- Regional consumers:
  - Federal regions: Privolzhsky region, Southern region.
  - Regional and city governments: Moscow, Moscow region, St. Petersburg region, Volgograd region, Archangelsk region, Tver region and others.

- Foreign partners:
  - WMO, EUMETSAT, CNES, ESA, NASA, DLR, NASDA and others.

- Roshydromet data processing facility:
  - Administrative data exchange (via satellite channels)

- Networks under technical guidance and management of SRC “Planeta”:
  - DCS network
  - ADRS Network
  - NOAA
  - Meteor-M
  - Scanex (22 stations)
  - ETS-1L and ADRS (70 stations)
  - Analog 3 kHz
  - (20 stations)
  - 100 bit/sec

- Khabarovsk:
  - Terra, Aqua
  - NOAA
  - Meteor-M, NOAA, Terra, Aqua
  - Scanex
  - EOScan
  - “Scanex”
  - Uniscan
  - UPPOI

- Novosibirsk:
  - Elektro-L
  - Terra, Aqua
  - Meteor-M, NOAA, Terra, Aqua
  - CKC 87
  - Uniscan
  - SPOI
  - TNA-57R + PRI-P

- Space and ground segments activity management center:
  - Western-Siberian Center (Novosibirsk)
  - Far-Eastern Center (Khabarovsk)
  - ADRS Network
  - Spacecraft control organizations: Flight control centers, scientific research organizations and others.
High-elliptical Orbits Satellite System "Arctica"
Earth observation by the international meteorological satellite system

Observation area of the Northern Hemisphere by the international and Russian meteorological geostationary satellites “ELECTRO-L(M)” since 2008.

Observation area of the Arctic region by the international meteorological low orbit satellites “METEOR-M” since 2008.

“GOES-12” USA 75°W

“ELECTRO-2 L” RUSSIA 14.5°E

“MTSAT-1R” JARAN 140°E

“METEOSAT № 5,7” EUROPE 63°E

“ELECTRO-1L” RUSSIA 76°E

“GOES-10” USA 135°E

“METEOSAT № 8,9” EUROPE 3,4/6,5°W

Observation area of the Arctic region by the international meteorological low orbit satellites

Frequency of data reception 15 minutes

Frequency of data reception 6-12 hours
Mission objectives

Monitoring of the Earth atmosphere and surface in Arctic region (inaccessible for observation from geostationary orbit) on the base of multispectral imaging with high temporal resolution (15 – 30 min).

Providing heliogeophysical information in polar areas.

Maintaining data collection system, telecommunication service for data exchange and retransmission.

Search & Rescue service (COSPAS-SARSAT).
Main Tasks and Applications

Utilization for analysis and forecasting:

- weather in the regional (Arctic) and global scales
- ice cover in Arctic
- flight conditions for aviation (cloudiness, wind, jet-streams etc.)
- snow cover
- heliogeophysical conditions in the near Earth Space

Monitoring of disasters (fires, floods, volcanic eruptions etc.)

Monitoring of climate changes

Data collection and relay from land-, sea- and air-based observing platforms

Exchange and dissemination of processed satellite, meteorological and heliogeophysical data
"Arctica" System General Design

Spacecraft No.2

Spacecraft No.1

Command program data

Hydro meteorological and helio-geophysical data

Service data

Ground control complex

Ground segment for satellite data receiving, processing and distribution
Ballistic configuration of the space system

Parameter of the spacecraft orbits:
- apogee altitude ($\alpha$) ~ 40,000 km;
- perigee altitude ($\pi$) ~ 1,000 km;
- inclination ($i$) ~ 63°;
- orbital period ~ 12 hours

Positional relationship of the spacecraft orbits:
coincidence of ascending node ($\Omega$) of the spacecraft No.1 orbit
and descending node ($\varpi$) of the spacecraft No.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 No.1 and spacecraft No.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
Advantages of the high-elliptic orbits (HEO) over geostationary orbits for Arctic observations

1. Providing the quasi-continuous observations for Arctic region (areas at latitudes higher than 60° N).

2. The quasi-continuous observations need no more than 2 satellites
Conclusions

1. To a great extent the progress of global and regional numerical weather forecasting, as well as providing safety navigation along Northern Sea Route together with many other Earth monitoring problems depends on the capabilities to provide hydrometeorological information for the Arctic region (at the latitudes higher than 60 deg. N) in quasi-continuous mode with high temporal resolution.

2. Geostationary meteorological satellites cannot provide such information and therefore the proposed "Arctica" system should supplement existing global satellite observation system.

3. Russia has great experience on design and exploitation HEO satellite systems, as well as the technical stock on the development of "Electro-L" and "Spectr-R" type spacecrafts. Based on this Roscosmos and Roshydromet (as responsible Russian governmental bodies) propose to realize "Arctica" project in the frame of wide international cooperation.
THANK YOU!