MOON EXPLORATION

27 launches were performed.

For the first time in the world:

- The soft moonfall was performed (“Luna-9”),
- The Moon satellite was developed (“Luna-10”)
- Lunar soil samples were delivered to Earth (“Luna-16”)
- The moon rover “Lunokhod-1” was designed and developed

Moon rovers:
“Lunokhod-1,-2”
(“Luna-17,-21”)

Landers
(“Luna-9,-13,-15,-16,-17, -18,-20,-21,-23,-24”)
11 launches were performed
For the first time in the world
- Mars landing was performed (“Mars – 3”)

Fly-by spacecraft (“Mars-2,-3,-6,-7”)

Landers (“Mars-2,-3,-6,-7”)

Orbiters (“Mars-4,-5”)

LAVOCHKIN ASSOCIATION HERITAGE

MARS EXPLORATION
VENUS EXPLORATION

18 launches were performed

For the first time in the world:
- Venus soft landing was performed (“Venera-7”),
- First image of Venus surface was received (“Venera-9”)
- Venus colored panoramic sight was received and Venus soil samples were studied (“Venera-13”)
- Balloon-borne probe was launched in Venus atmosphere (Vega-1”)

Landers (“Venera-4,5,6,7,8, 9,10,11,12,13,14”)
Orbiters (“Venera-15,16”)
Fly-by spacecraft (“Venera-11,12,13,14”)

“Vega-1” and “Vega-2”
LAVOCHKIN ASSOCIATION ACTIVITIES

MAIN AREAS OF ACTIVITIES

Lines of activities

Information systems

Astrophysical research

Planetary explorations

Small spacecraft

Launch vehicles

Unmanned aerial vehicles
PLANEARY MISSIONS

- Mars exploration
- Moon exploration
- Venus exploration
- Jupiter system exploration
- Sun exploration
- Mercury exploration
ROBOTIC MOON EXPLORATION PROGRAM

**Luna-Glob:**
- Remote sensing from lunar orbit;
- In-situ studies in the near-polar area of the Moon;
- Natural resources survey;
- Study of influence of incoming corpuscular fluxes and e-field radiation on the Moon (one-launch mission)

**Luna-Resource1:**
- In-situ studies in the near-polar area using stationary surface station in the framework of Russian-Indian joint project (one launch mission)

**Luna-Resource2: (Moon Sample Return):**
- Studies in the near-polar area by multi-functional lunar rover, soil samples collection and delivery to the Earth (two-launches mission)

**Lunar polygon:**
- Creation on the lunar surface of the scientific-research base
### PLANETARY MISSIONS

#### ROBOTIC MARS EXPLORATION PROGRAM

<table>
<thead>
<tr>
<th>PHOBOS-GRUNT</th>
<th>MARS-NET</th>
<th>MARS-GRUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Phobos-Grunt" /></td>
<td><img src="image2" alt="Mars-Net" /></td>
<td><img src="image3" alt="Mars-Grunt" /></td>
</tr>
<tr>
<td>Phobos samples return; Investigation of Phobos and Mars monitoring from the lander; Investigation of Phobos and ambient space from the orbiter.</td>
<td>Long-term investigations of Mars by contact and remote methods</td>
<td>Delivery of the Martian soil samples to the Earth</td>
</tr>
</tbody>
</table>
"MARS-GRUNT" MISSION (MARS SAMPLE (RETURN))

**Purpose**: Mars sample return

**Launch vehicle**: “Angara-5”/”Breeze-M”

**Mission concept**: Single –launch scheme with docking on the Mars orbit

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC mass</td>
<td>6 040 kg</td>
</tr>
<tr>
<td>PL mass on the Orbiter</td>
<td>50 kg</td>
</tr>
<tr>
<td>PL mass on the Lander</td>
<td>20 kg</td>
</tr>
<tr>
<td>Mass of delivered samples</td>
<td>0.2 kg</td>
</tr>
</tbody>
</table>
"MARS-GRUNT" MISSION PROFILE

1-st ignition of the upper stage. Injection into near-earth intermediate orbit

Launch

Mars-Earth transfer

Return capsule separation

1-st ignition of the upper stage. Injection into near-earth intermediate orbit

Return vehicle separation

Start of the Return vehicle to the Earth

To the Earth

Injection of the ascent vehicle orbital module into the orbit $H_{or}=500$ km

Rendezvous with orbiter

Docking and soil reloading into Return vehicle

DV separation

Sustainer propulsion separation

Braking. Transfer into 3-days near Mars orbit

Transfer into circular orbit $H=500$ km

Correction

Correction

Correction

Correction

Correction

Correction

Earth-Mars transfer

Separation of electrical propulsion transport module

Electrical propulsion module ignition. Введение траекторию Injection into Mars transfer trajectory

"MARS-GRUNT" MISSION PROFILE
"VENERA-D" MISSION

**Purpose**
Exploration of the Venus by contact and remote methods

**Launch year**
2016 (TBC)

**Launch vehicle**
“Soyuz-2"

**SC composition**
- Injection Propulsion Module
- Orbiter
- Lander

**SC mass**
8 120 kg

**Lander mass**
170 kg
"VENERA-D" MISSION
MISSION PROFILE

- Injection on to escape orbit to Venus
- Orbit correction
- Orbit correction
- Launch
- MPS separation
- Vehicle injection into Earth orbit
- Separation of Balloon probes
- Descent vehicle Reentry
- Descent injection into Venus orbit
- Atmopheric probes
- Lander
- Orbiter
- Atmospheric probes
**"INTERHELIO-ZOND" MISSION**

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Sun exploration from 30-40 its radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch year</td>
<td>2014</td>
</tr>
<tr>
<td>Launch vehicle</td>
<td>“Soyuz-2”</td>
</tr>
<tr>
<td>SC mass</td>
<td>8 120 kg</td>
</tr>
<tr>
<td>Payload module mass</td>
<td>&gt; 300 kg</td>
</tr>
<tr>
<td>Flight to</td>
<td></td>
</tr>
<tr>
<td>- 47 RS</td>
<td>1.9 years</td>
</tr>
<tr>
<td>- 34 RS</td>
<td>3.7 years</td>
</tr>
<tr>
<td>- inclination 30 deg</td>
<td>4.9 years</td>
</tr>
</tbody>
</table>
"MERCURY-P" MISSION

**Purpose**
Exploration of Mercury by contact and remote methods

**Launch vehicle**
“Soyuz-2"

**SC mass**
8 120 kg

**Lander mass**
710 kg

**Surface Station mass**
40 kg

**PL mass on Orbiter**
50 kg
"SOKOL-LAPLAS" MISSION

**Purpose**
Exploration of Jupiter system by contact and remote methods

<table>
<thead>
<tr>
<th>Mass Category</th>
<th>Mass</th>
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<tbody>
<tr>
<td>SC mass</td>
<td>6360 kg</td>
</tr>
<tr>
<td>Europe Lander mass</td>
<td>1210 kg</td>
</tr>
<tr>
<td>Orbiter mass</td>
<td>395 kg</td>
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</table>
PLANETARY MISSIONS

"SOKOL-LAPLAS" MISSION PROFILE

- **Earth departure** (C3=1 km²/s²)
- **Earth gravity assisted maneuver**
- **EPM separation**
- **Insertion into jovian orbit using CPM**

Orbital tour with gravity assist maneuvers
Injection into initial orbit
De-orbiting and landing
Injection into Europe orbit
Perigee increasing
Lander/Orbiter separation
SMALL SPACECRAFT

SPACECRAFT BASED ON “KARAT” UNIFIED PLATFORM

- RESONANCE
- ZOND-PP
- MONIKA-RELEK
- STRANNIK
- KONUS
ASTROPHYSICAL PROGRAM CONCEPT

SPEKTR-UF → SPEKTR-RG → SPEKTR-R → SPEKTR-M → GAMMA-400
<table>
<thead>
<tr>
<th>Year</th>
<th>Karat</th>
<th>Navigator</th>
<th>Flagman</th>
<th>Dvina-TM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Zond-PP</td>
<td>Spektr-R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>Monika-Relek</td>
<td>Spektr-UF</td>
<td>Phobos-Grunt</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Resonance</td>
<td>Spektr-RG</td>
<td>Luna-Resource</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Konus</td>
<td>Gamma-400</td>
<td>Luna-Glob</td>
<td>Interheliozond</td>
</tr>
<tr>
<td>2014</td>
<td>Strannik</td>
<td>Arctica-R</td>
<td>Luna-Grunt</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>MKA-FKI #5</td>
<td>Spektr-M</td>
<td>Venera-D</td>
<td>Mirror</td>
</tr>
<tr>
<td>2016</td>
<td>Arctica-R</td>
<td>Arctica-M</td>
<td>Mars-NET</td>
<td>Mercury-P</td>
</tr>
<tr>
<td>2017</td>
<td>ROY</td>
<td>Arctica-M</td>
<td></td>
<td></td>
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<tr>
<td>2018</td>
<td>Arktica-R</td>
<td>Arctica-M</td>
<td>Mars-Grunt</td>
<td>Sokol-Laplace</td>
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<tr>
<td>2019</td>
<td>ROY</td>
<td>Arktica-M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
<td>Astrometria</td>
<td>Mars-NET</td>
</tr>
</tbody>
</table>
The following frequency ranges are used in the advanced and present missions:

- **S – range** – for A-category spacecraft (small spacecraft in the near-Earth orbits);
- **C – range** – for A-category spacecraft (Electro, Spektr-R);
- **X – range** – for both A and B category spacecraft (Phobos-Grunt, Spektr-RG, Spektr-RG, Moon missions, Interheliozond).
Objectives of ground control segment are as follows:

Issue of command-program data to the SC board:
   bit rate – 2 kilobit/sec;
Telemetry downloading from SC:
   Bit rate – up to 4 Mb/sec;
Navigation measurements, including:
   one way Doppler;
   two way Doppler:
   VLBI (is not implemented in ground segment).
Automated data exchange via telecommunications in the ground segment structure and with external objects.
Currently in the Russian Federation for the abovementioned missions the following ground stations are involved:

- Ussuriysk (Ø – 70m) (X and C ranges);
- Medvezhi Ozera (Ø – 64m) (X and C ranges);
  - Medvezhi Ozera (Ø – 12m) (X range);
  - Medvezhi Ozera (Ø – 9m) (S and C ranges);
  - Kaliningrad (Ø – 12m) (X range);
  - Baikonur (Ø – 12m) (X range);
  - Khabarovsk (Ø – 12m) (X range);
  - Krasnoyarsk (Ø – 6m) (C range).

In addition the following ESA ground stations are involved:

- Cebreros (Ø – 35m) (X range);
- New Norcia (Ø – 35m) (X range);
- Maspalomas, Perth, Kuru (Ø – 15m) (X range).
Involvement of NASA ground stations

There are sufficient reasons for NASA ground stations involvement in order to provide the following activities in frame of “Venera-D”, “Laplace”, “Interheliozond”, “Mercury”, and Lunar missions:

Navigation measurements, including:
  one way Doppler;
  two way Doppler:
    VLBI.

Measurements accuracy with the following errors:
  - ranging error – no more than 10 m;
  - range rate error – no more than 0.5 mm/sec.

Telemetry data reception (data receive rate – up to 4 Mb/sec).