ExoMars: Russian part

ExoMars is a joint project of Mars exploration implemented under bilateral Agreement between European Space Agency (ESA) and Federal Space Agency (Roscosmos). The scope of cooperation is unprecedented in the history of both agencies. One of the crucial elements is joint Earth-based interplanetary mission operation and data control complex, which is planned to be built within the program. Russian and European experts are striving to consolidate their experience to develop new technologies for interplanetary missions. *ExoMars* is also one of the steps toward manned exploration of Mars.

Two missions are foreseen within the *ExoMars* programme: one consisting of an Orbiter plus an Entry, Descent and Landing Demonstrator Module, to be launched in 2016, and the other, featuring a rover, with a launch date of 2018. Both missions will be carried out in cooperation with Roscosmos.

Bilateral cooperation started in 2012, when Roscosmos became the main partner of ESA on the project (Declaration of Intent was signed by ESA and Roscosmos for cooperation on the *ExoMars* programme in April 2012) under the condition that Russia is a full participant of the mission's second stage. Russian part includes:

- launchers for both stages of the mission;

- scientific instruments for both stages of the mission;

- lander module for the second stage of the mission (2018), to be built by Lavochkin Space Association (Khimki, Moscow Region), part of the United Rocket and Space Corporation.

Space Research Institute of the Russian Academy of Sciences (IKI for short) is a head organisation for scientific payload of *ExoMars* project.

ExoMars is a part of the Russian Federal Space Program for 2006–2015 and the following for 2016–2025, currently under approval by the authorities.

ExoMars architecture is currently as follows:

1) The 2016 mission [ССЫЛКА НА ОТДЕЛЬНУЮ СТРАНИЦУ]:

- Trace Gas Orbiter (TGO) to detect and study atmospheric trace gases, such as methane, and water ice distribution in the upper layer of Martian surface.

- Entry, Descent and Landing Demonstrator Module (EDM), now dubbed Schiaparelly, to evaluate the lander’s performance as it descends, and additional sensors to study the environment at the landing site.

2) The 2018 mission [ССЫЛКА НА ОТДЕЛЬНУЮ СТРАНИЦУ];

- Pasteur rover with a number of equipment including a drill

- surface platform with a suite of instruments dedicated to study surface environment on the landing site.

Prepared with the help of ESA's web page for ExoMars program, courtesy http://exploration.esa.int/mars/ *For further details on the European part of the mission, please, refer to the relevant links.*

Russian web page for ExoMars project (IKI, in Russian) http://www.planetary-department-iki.ru/projects/current/exomars/exomars.html

[ОТДЕЛЬНЫЕ СТРАНИЦЫ]

ExoMars 2016 mission

The Orbiter and EDM will be launched together in January 2016 on a Proton rocket and will fly to Mars in a mated configuration. By taking advantage of the positioning of Earth and Mars the cruise phase can be limited to about 9 months. Three days before reaching the atmosphere of Mars, the EDM will be ejected from the Orbiter towards the Red Planet. The EDM capsule will then coast towards its destination, entering the Martian atmosphere and landing on the surface of the planet. The *ExoMars* Orbiter will be inserted into an elliptical orbit around Mars and then sweep through the atmosphere to finally settle into a circular, ~ 400-km altitude orbit ready to conduct its scientific mission.

IKI develops two instruments for TGO scientific payload:

1) *Atmospheric Chemistry Suite* (ACS) complex for spectrometry. It includes three spectrometers (echelle spectrometers for near- and mid-infrared range (ACS-NIR and ACS-MIR) and Fourier spectrometer(ACS-TIRVIM)) and data storing system (ACS-BE). Principal Investigator: Oleg Korablev, Space Research Institute (IKI), Moscow, Russia.

2) *Fine Resolution Epithermal Neutron Detector (*FREND) to register neutrons coming from Martian surface as a result of interactions with galactic and solar cosmic rays and to map water ice distribution with high spatial resolution. FREND includes a dosimetry module to estimate, how much of radiation dose on the orbit around Mars comes from neutrons. Principal Investigator: Igor Mitrofanov, Space Research Institute (IKI), Moscow, Russia.

Both instruments use a legacy of previous successful experiments onboard European (Mars Express, Venus Express) and American (Mars Odyssey, Lunar Reconnaissance Orbiter, Curiosity) missions.

ACS and FREND instruments are currently in the final stage of development and are getting ready for delivery to ESA.

[ИЛЛЮСТРАЦИИ]

Atmospheric Chemistry Suite (ACS) for *ExoMars* 2016 Trace Gas Orbiter (c) IKI

Atmospheric Chemistry Suite (ACS) for *ExoMars* 2016 Trace Gas Orbiter (c) IKI

Fine Resolution Epithermal Neutron Detector *(*FREND) for *ExoMars* 2016 Trace Gas Orbiter (c) IKI

2018 mission

The 2018 mission of the *ExoMars* programme will deliver a European rover and a Russian surface platform to the surface of Mars. A Proton rocket will be used to launch the mission.

During launch and cruise phase, a carrier module (provided by ESA with some contributions from Roscosmos) will transport the surface platform and the rover within a single aeroshell. A descent module (provided by Roscosmos with some contributions by ESA) will separate from the carrier shortly before reaching the Martian atmosphere.

Descent module consists of aeroshield and back shield to protect the spacecraft from heat, two parachutes to damp the speed down to subsonic, when landing module can be detached. The latter will perform soft landing using thrusters.

After landing, the rover will egress from the platform to start its science mission. The primary objective is to land the rover at a site with high potential for finding well-preserved organic material, particularly from the very early history of the planet. The rover will establish the physical and chemical properties of Martian samples, mainly from the subsurface. It is expected to travel several kilometres during its mission.

After the rover leaves the platform, the instruments onboard surface platform (provided by Roscosmos, developed by Lavochkin Space Association) will start scientific program. Its main target is to monitor regular processes, which have different temporal patterns, from diurnal to annual, for 1 martian year (1,8 Earth year).

IKI's contribution to the Pasteur rover is:

1) *Infrared Spectrometer for ExoMars* (ISEM) to be installed on the rover's beam. It will be used to assess the mineralogical composition of surface targets. Working with PanCam, ISEM will contribute to the selection of suitable samples for further analysis by the other instruments.

Principal Investigator: Oleg Korablev, Space Research Institute (IKI), Moscow, Russia

2) *Adron-RM* neutron detector To search for subsurface water and hydrated minerals. Adron will be used in combination with WISDOM to study the subsurface beneath the rover and to search for suitable areas for drilling and sample collection.

Principal Investigator: Igor Mitrofanov, Space Research Institute (IKI), Moscow, Russia.

IKI is also a head organization for scientific payload onboard surface platform. Its main objectives are:

1. long-term climate observations in the landing site;
2. study of Martian atmosphere composition;
3. study of surface-atmosphere interactions;
4. study surface composition;
5. study Mars's internal structure;
6. radiation environment monitoring as well as other factors.

Total mass of scientific payload for these goals is about 50 kg. Preliminary set of scientific instruments includes TV-system, soil sampler, meteorological suit, neutron spectrometer, Fourier spectrometer, mass spectrometer with laser ablation (to study surface's elemental composition), gas-analytical suit to study the dynamics of trace components of the Martian atmosphere near the surface, laser spectrometer for atmosphere composition studyies, seismometer, dust suit, soil radiometer, and an instrument to study electromagnetic emissions on the surface.

Final set of instruments will be defined after the results of international contest and the assessment of resources available.

[ИЛЛЮСТРАЦИИ]

Optical module of Infrared Spectrometer for *ExoMars* (ISEM) for Pasteur rover (*ExoMars* 2018 mission) (c) IKI

Adron-RM for Pasteur rover (*ExoMars* 2018 mission). General view (c) IKI