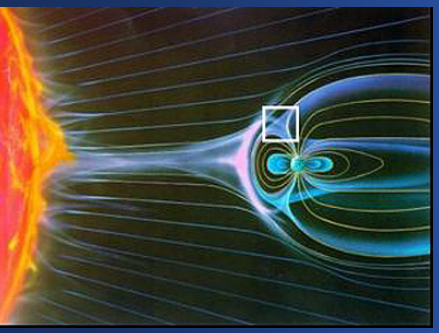
Current Russian Activity in Space Science

VERY SHORT OVERVIEW

Lev ZELENYI

IKI RAS

MAIN FIELDS OF FUNDAMENTAL SPACE RESEARCH
IN RUSSIA



Space plasma and Solar physics:

- Studying of an internal heliosphere and the Sun from close distances;
- Studies of resonance interaction between electromagnetic radiation and charged particles in the Earth's magnetosphere;
- Studies of earthquakes' forerunners.

Out of-atmosphere astronomy and CR:

- High-accuracy astrometric measurements and precise definition of fundamental coordinate system;
- Astronomic objects observation in radio, ultraviolet, gamma, X-ray, millimeter and submillimeter ranges of spectrum.

Luna, planets and small bodies of the Solar System:

- Studies of atmospheres, magnetosphere and surfaces of the Solar System planets;
- Expansion of the Solar System's small bodies research, including studies of Phobos soil samples.

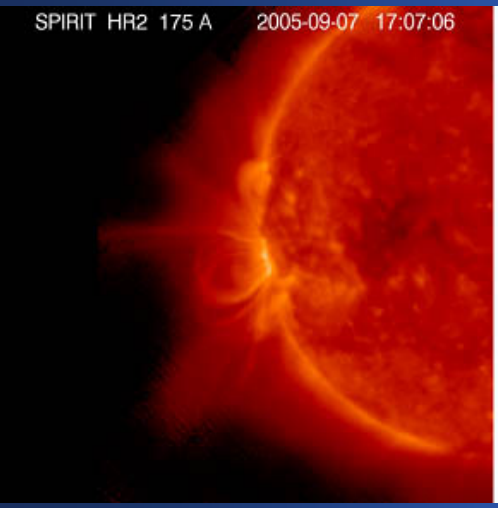
Basic problems of space biology, physiology and medicine:

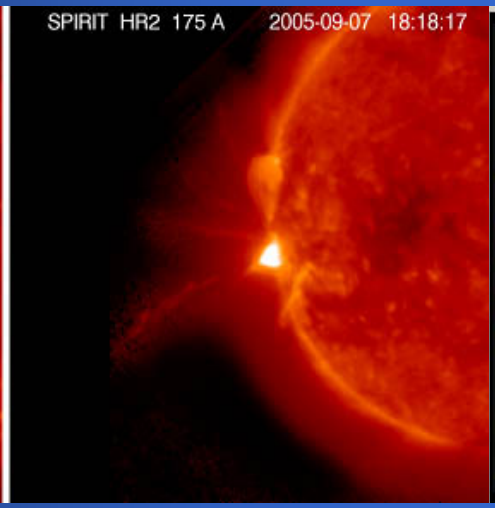
- Research programs on study of microgravity and other spaceflight factors influence on processes of biological objects adaptation.

CORONAS-F

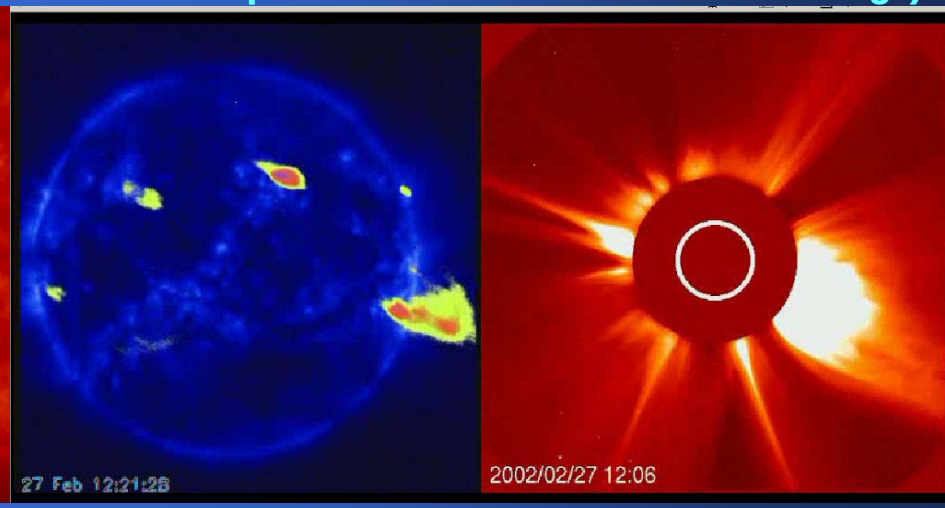
July 31, 2001 – December 6, 2005

Extreme Solar Events, September, 2005





Hot flare plasma in the corona 20 m.deg.)

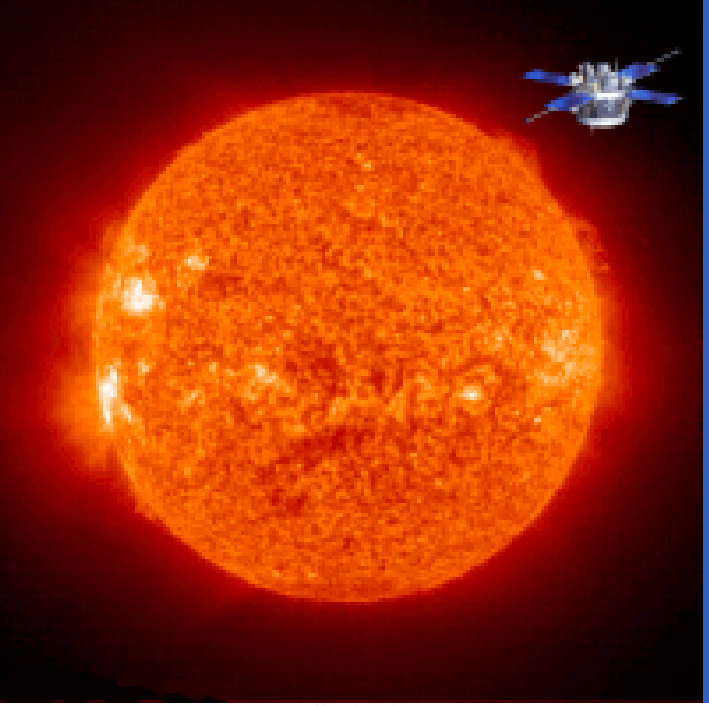


CORONAS-PHOTON

Investigation of solar flare's hard emissions

- Energy storage and its transformation into energy of accelerated particles
- Mechanisms of acceleration and propagation of energetic particles
- Correlations of physical-chemical processes in upper Earth atmosphere with solar activity

Launched January, 30, 2009

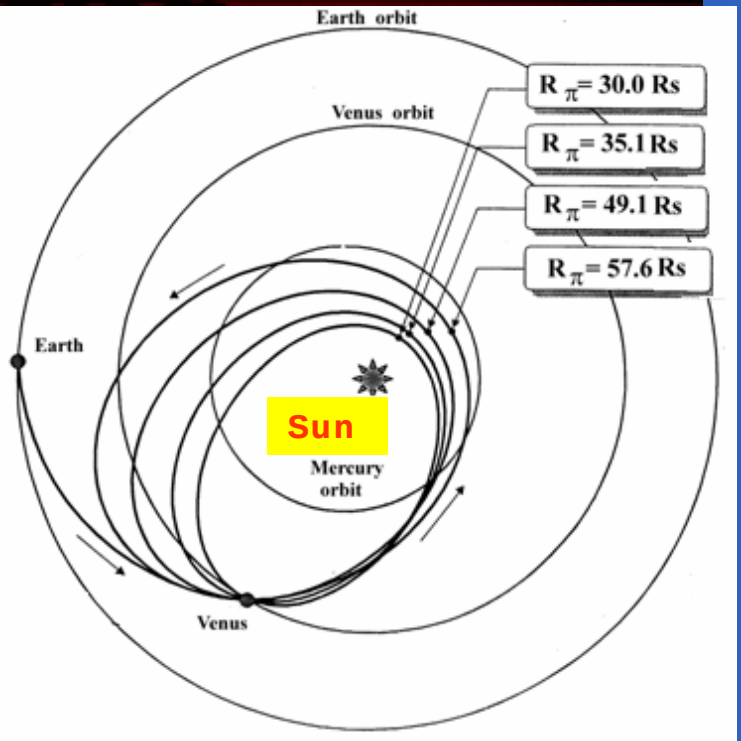


INTERHELIOPROBE

Investigation of Inner Heliosphere and the Sun from close distances

MAIN SCIENTIFIC GOALS

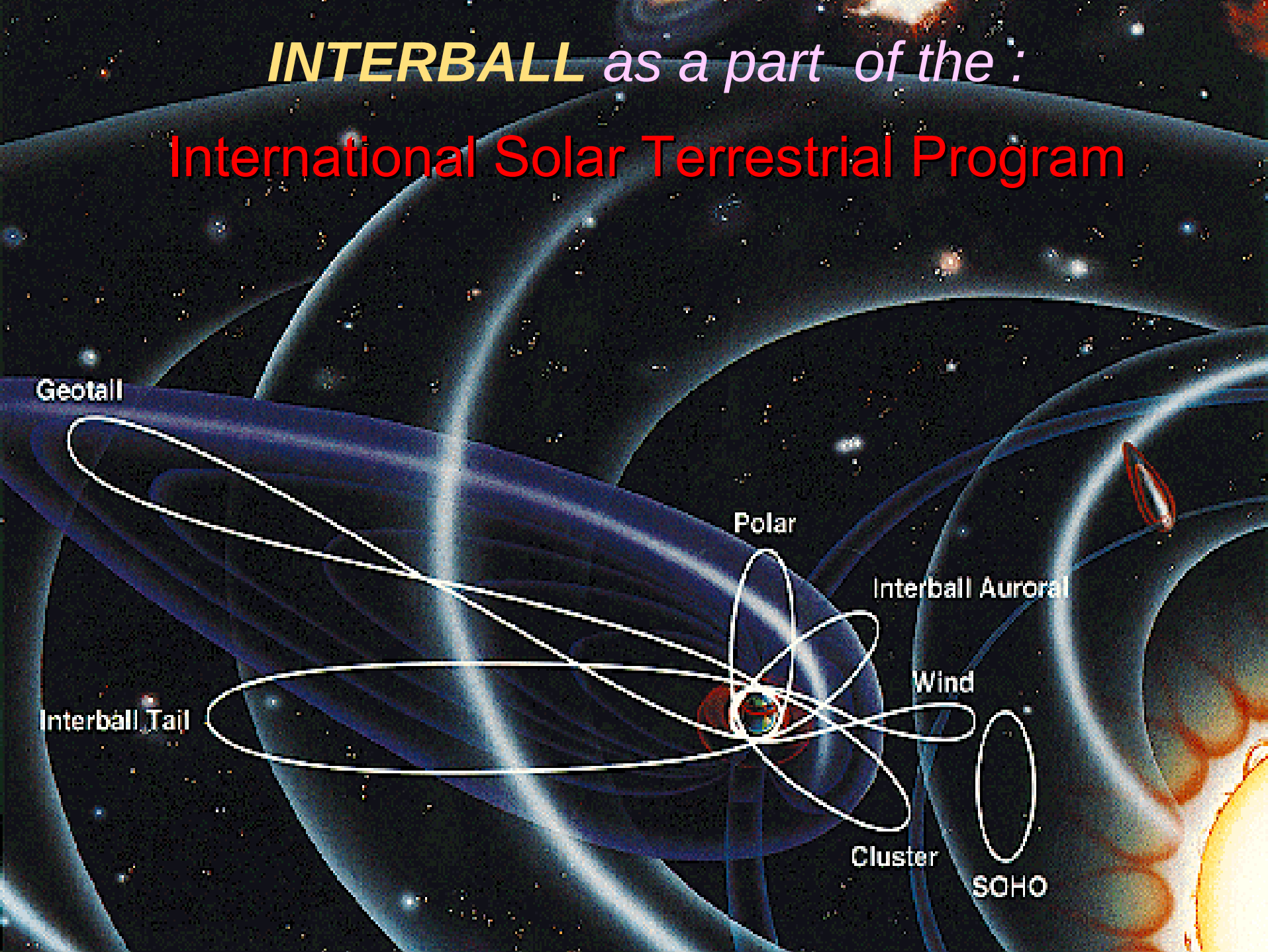
- to identify mechanisms of the coronal heating and the solar wind
- to investigate fine structures and dynamics of the solar atmosphere
- to determine the origin and study the global dynamics of the most powerful solar activity phenomena - solar flares and their influence on the heliosphere and space weather
- to investigate generation and propagation of solar energetic particles
- to determine the mechanism of the solar dynamo and solar cycles



Inclination of the orbit

INTERBALL as a part of the :

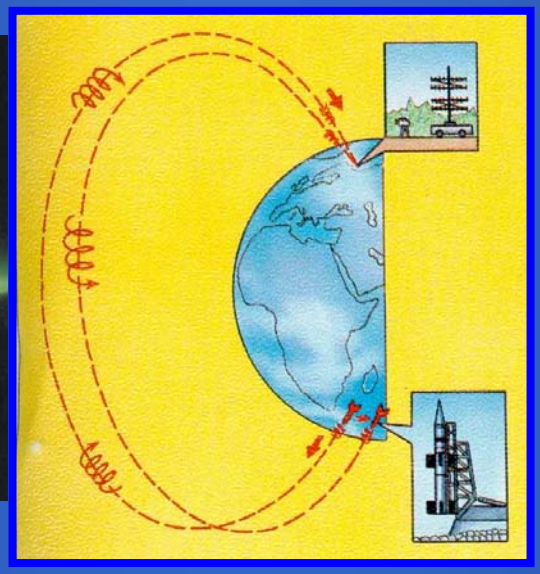
International Solar Terrestrial Program



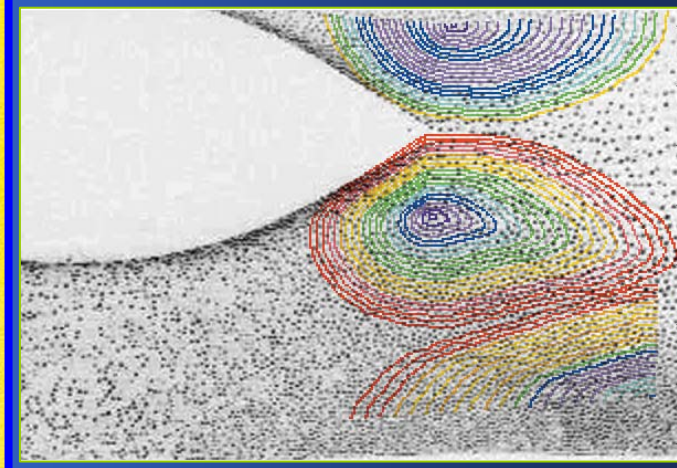
SPACE AS LABORATORY AND WORKSHOP

Space plasma: from phenomenology to physics

NEW PHYSICAL PHENOMENA IN PLASMA NEAR PLANETS



ACTIVE EXPERIMENTS



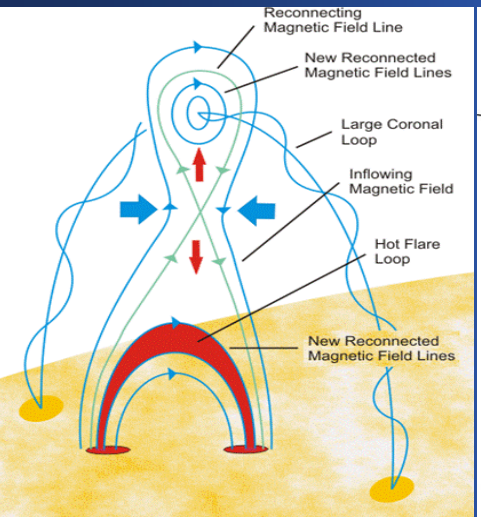
- MICROGRAVITY
- DUSTY PLASMA CRYSTALS
- Materials in space

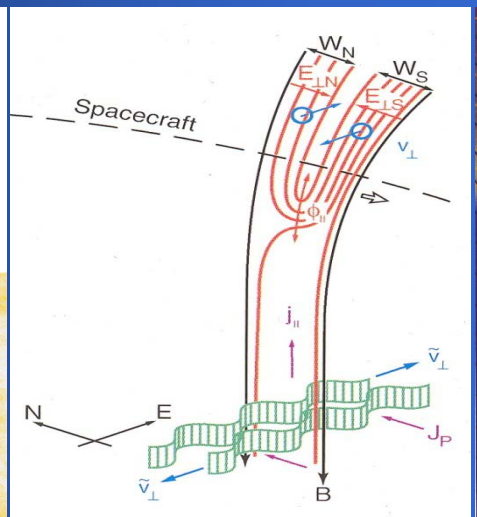
Magnetic reconnection

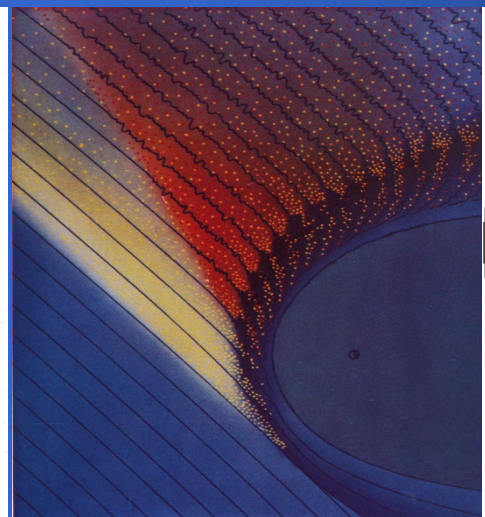
The Earth as a source of radio emissions

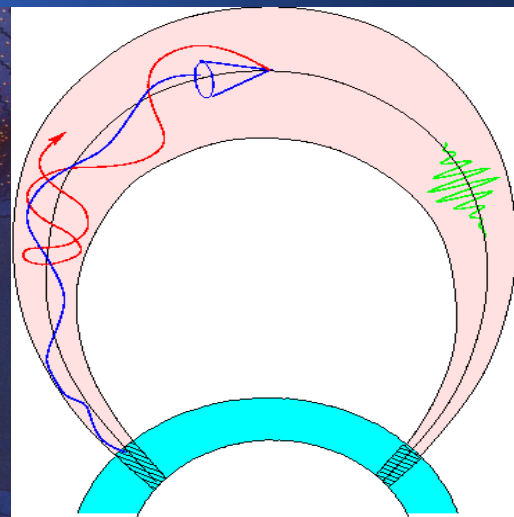
Collisionless shocks

Cyclotron masers & acceleration









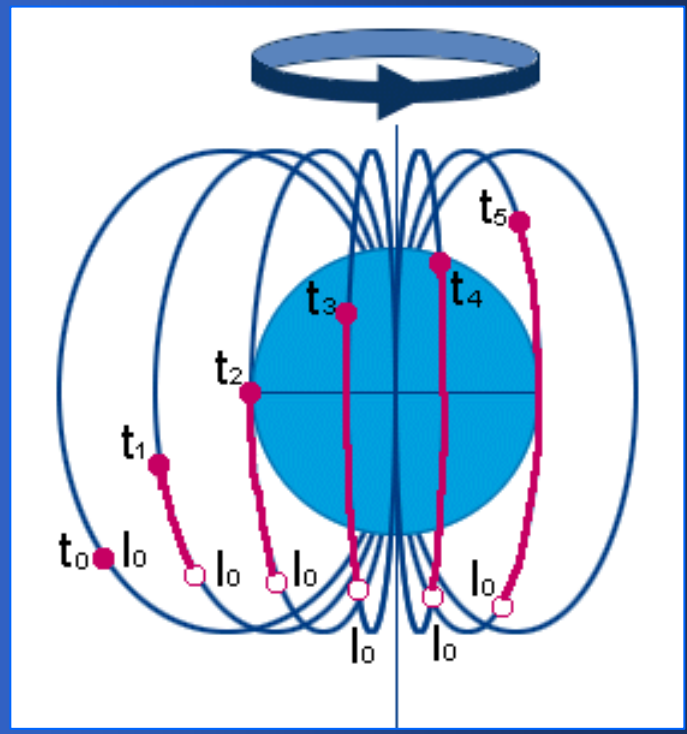
RESONANCE -4 s/c mission

Study of wave-particle interactions and plasma dynamics in the inner magnetosphere

1. *Long term observation of the natural phenomena:*
   - *Dynamics of cyclotron maser in magnetospheres,*
   - *Ring current formation,*
   - *Refilling of plasmosphere after magnetic storms.*
2. *Auroral region*
   - *Global phenomena in auroral region,*
   - *The role of the small-scale phenomena in the global plasma dynamics*

Magnetosynchronous orbit

Scheme of the RESONANCE satellite motion along the magnetic flux tube.



Two pairs of satellites will be launched in the magneto-synchronous orbit.

Orbit parameters:

T = 8 h

h_{ap} = 28 000 km

h_{per} = 500 km

i = +/- 63,4°

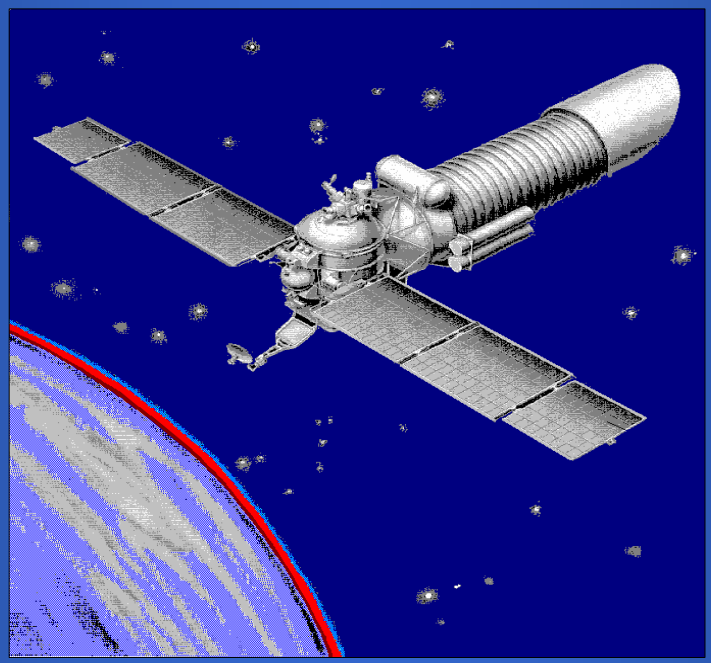
Out of-atmosphere astronomy - astrophysics:

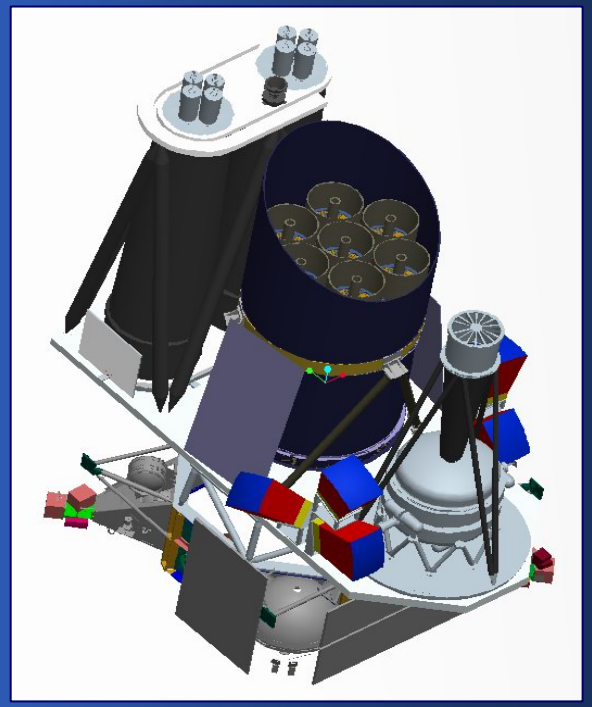
Missions under preparation

«RADIOASTRON»
2009

«WORLD SPACE OBSERVATORY – ULTRAVIOLET»
2010

«SPECTR RENTGEN GAMMA»
2011

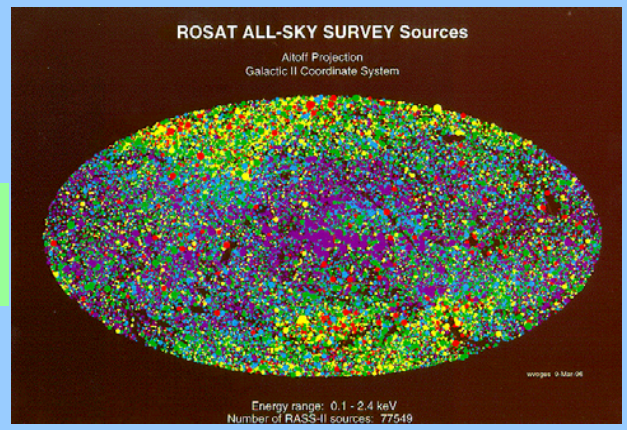




Spektr-RG : from thousands to millions of AGN

4-year all-sky survey

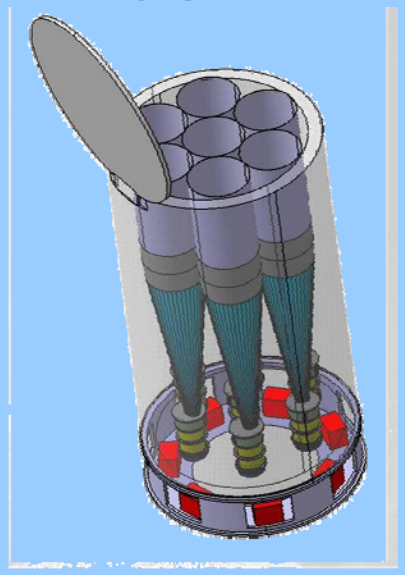
(0.5-10 keV)



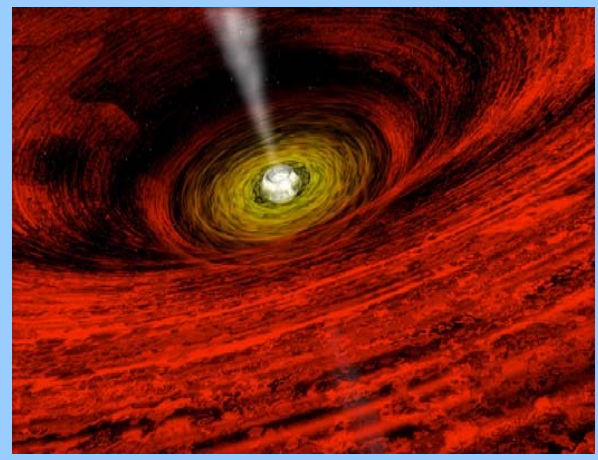
eROSITA - **e**xtended **RO**entgen **S**urvey with an **I**maging **T**elescope **A**rray

eROSITA

MPE-DLR (Germany)



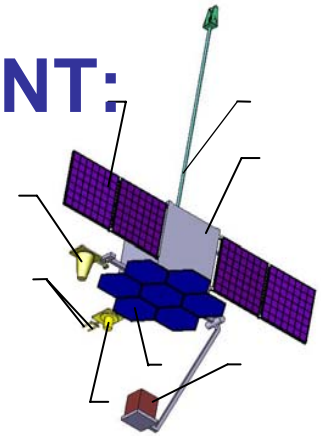
2 orders of magnitude more sensitive than previous all-sky surveys (*ROSAT, RXTE*)



Expected: 3 000 000 AGN (0.5-10 keV)

- *accreting supermassive black holes with masses 10^7 – 10^9 Msun*

COSMIC RAYS EXPERIMENT: TUS



TUS 2010

Satellite

Primary particle 10^{20} eV

UV collector

View angle

Atmosphere

Secondary electrons

Fluorescent emission

N_{max}

Cherenkov emission

Ground level

Luna, planets and small bodies of the Solar System:

Future missions

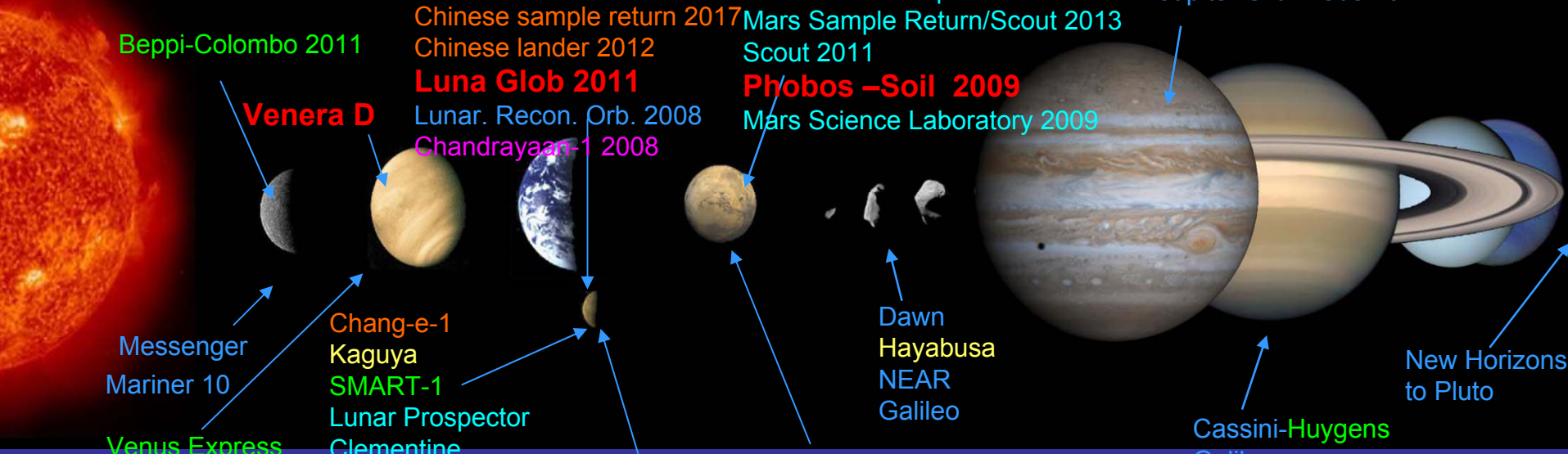
Japan manned 2025
US Moon Base 2020
Chinese sample return 2017
Chinese lander 2012
Luna Glob 2011
Lunar. Recon. Orb. 2008
Chandrayaan-1 2008

Mars 2018, 2020
Scout/Mars Sample Return 2016
Mars Sample Return/Scout 2013
Scout 2011
Phobos –Soil 2009
Mars Science Laboratory 2009

Jupiter Orb Probe 2011

Beppi-Colombo 2011

Venera D



Messenger
Mariner 10

Venus Express
Cassini
Galileo
Magellan
Vega 1,2
Venera 15,16
Venera 13,14
Venera 11,12
Pioneer12,13
Venera 9,10
Mariner 10
Venera 7,8
Venera5, 6
Mariner 5
Venera 4
Mariner 2

Chang-e-1
Kaguya
SMART-1
Lunar Prospector
Clementine
Galileo
Luna 21,22,24
Luna 17,19,20
Zond 8
Luna 16
Zond 5,6,7
Luna 14
Surveyor 5,6,7
Lunar Orbiter 4,5
Surveyor 3
Lunar Orbiter 3
Lunar Orbiter 1,2
Luna 11,12,13
Surveyor 1
Zond 3, Luna 9,10
Ranger 7,8,9
Luna 1,2,3

Apollo 17
Apollo 16
Apollo 15
Apollo 14
Apo;;o 12
Apo;;o 11
Apollo 10
Apollo 8

Phoenix 2007
Mars Recon. Orb.
Opportunity, Spirit
Mars Express
Mars Odyssey
Mars Pathfinder
Mars Global Surveyor
Phobos 2
Viking 1,2
Mars 4,5
Mariner 9
Mars 3
Mariner 4,6,7

Dawn
Hayabusa
NEAR
Galileo

Cassini-Huygens
Galileo
Voyager 1,2
Pioneer 10,11

New Horizons
to Pluto

Comet sample return 2010?

Rosetta 2004-2011
Deep Impact
Stardust 2004-2008
Deep Space 1
Giotto
Suisei, Sakigake
Vega 1,2
ICE

Past and current missions
(successful only)

Космический аппарат "Фобос-Грунт"
"Phobos Sample Return" spacecraft

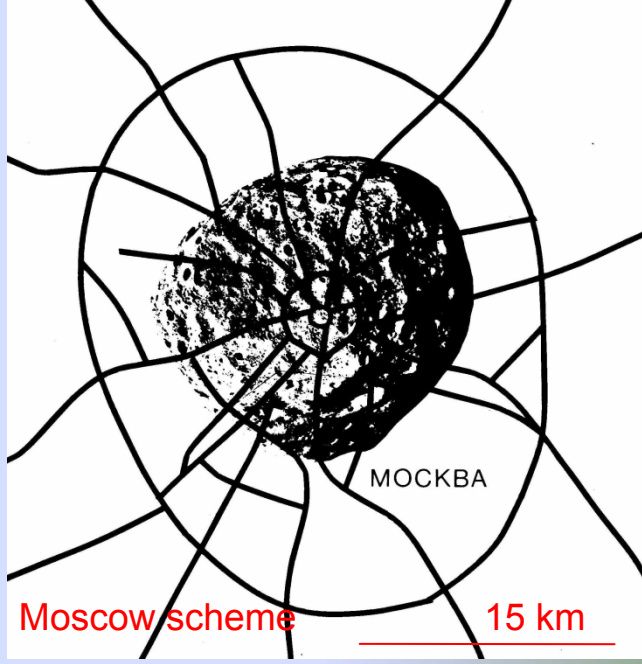
Phobos Sample Return Project

(C) IKI
PHOBOS — FREGAT
28:02:09

PHOBOS SAMPLE RETURN

GOALS OF THE MISSION

- Phobos regolith sample return,
- Phobos in situ study and remote sensing,
- Martian environment study
- Mars monitoring



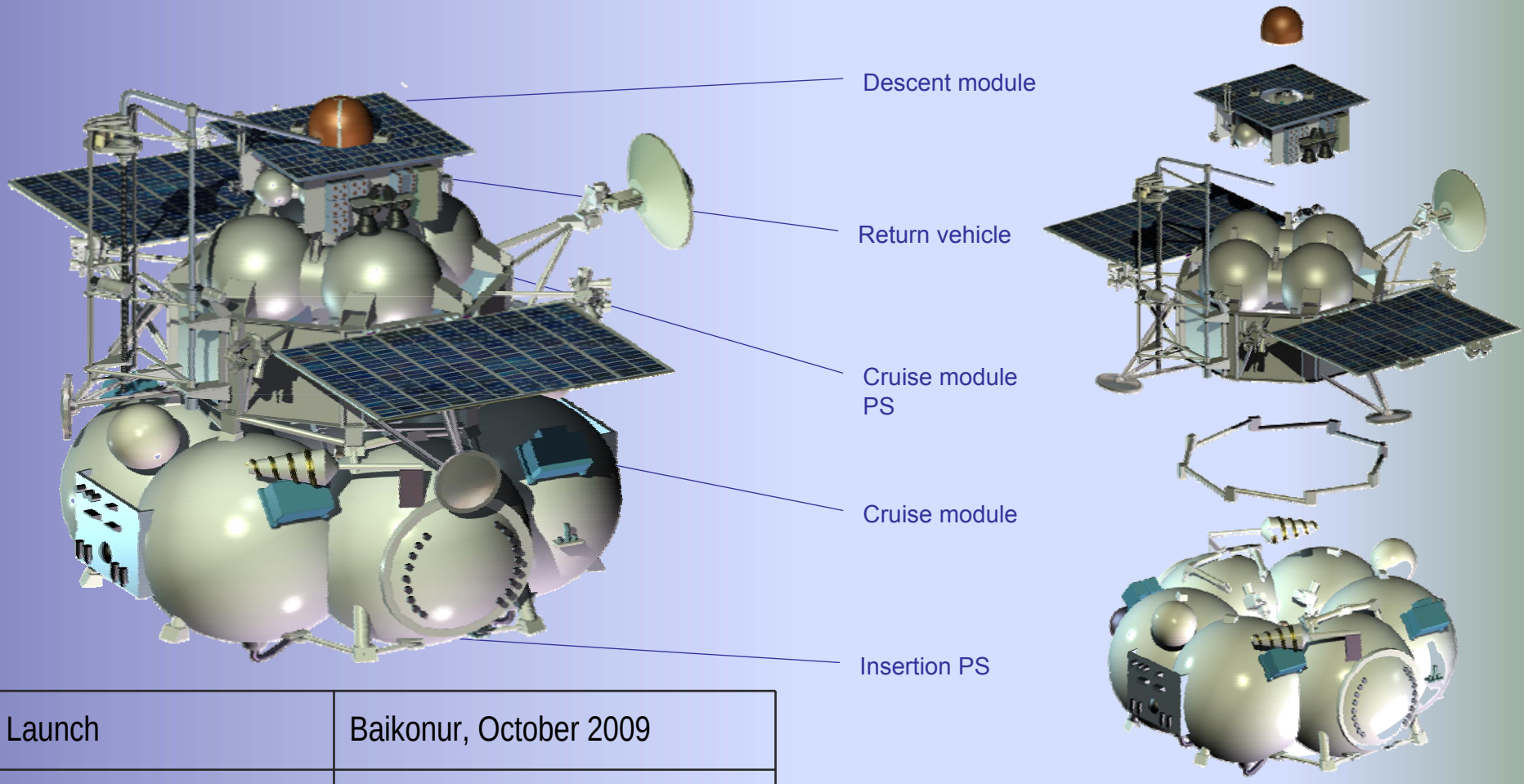
Pecularities of the mission:

1. Samples return
2. Mars system science:
   - **Martian moon** (regolith, internal structure, origin, evolution),
   - **Martian environment** (dust, plasma, fields),
   - **Mars** (surface and atmosphere global dynamics)

Martian satellites, Problems:

- origin of the Martian satellites,
- nature and characteristics,
- difference in characteristics,
- low density,
- internal structure,
- peculiarity of the motion,
- dust tori ?

SC MARS ORBIT INSERTION CONFIGURATION



Launch	Baikonur, October 2009
Total mission duration	~ 33-34 months
Mass returned samples	0.2 kg

PAYLOAD

Instruments for sc navigation and sampling

TV-system

Mechanical device for sampling

Instruments for study of Phobos regolith and internal structure

Panoramic camera

Gas-chromatograph

Messabuer spectrometer

Gamma-spectrometer

Neutron spectrometer

Laser TOF spectrometer

IR spectrometer

Thermodetector

Long wave radar

Seismometer

Instruments for Martian environment study

Plasma, waves and magnetic field detectors

Dust particles detector

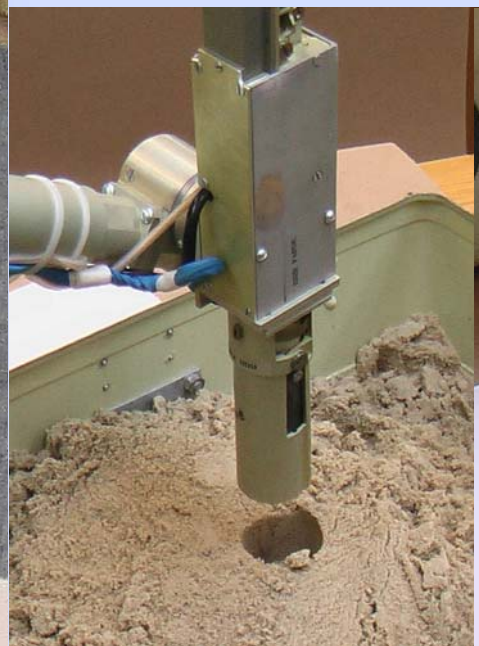
Returned experiment

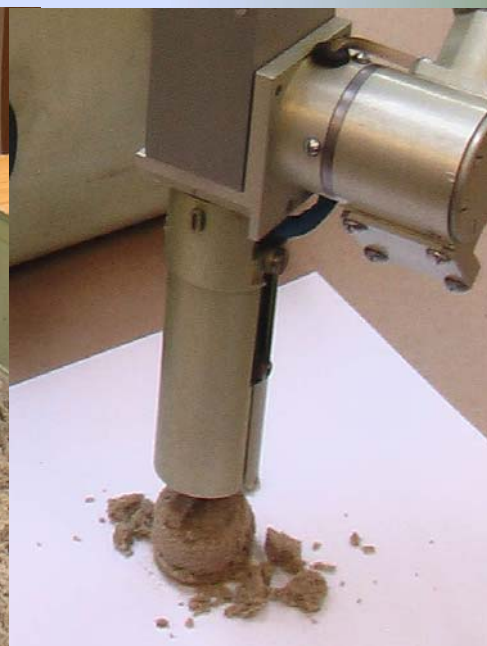
LIFE

PHOBOS SAMPLE RETURN

ROBOTIC ARM

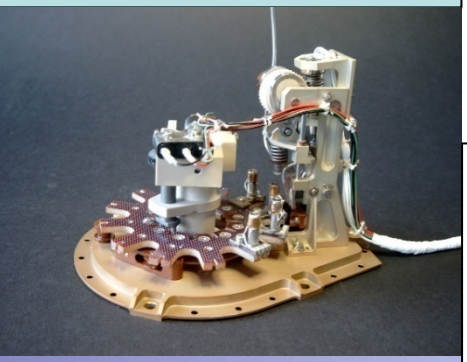
• Precision	± 5 mm
• Velocity	10 ± 3 mm/s
• Length	1000 mm
• Pressure	till 1,5 H
• Volume of a sample	0,5–1,5 cm^3
• Number of samples	min 15
• Mass, total	3,5 кг





Gas-Chromatograph Complex

Device for delivery and handling of samples

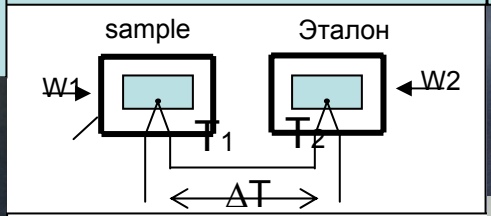


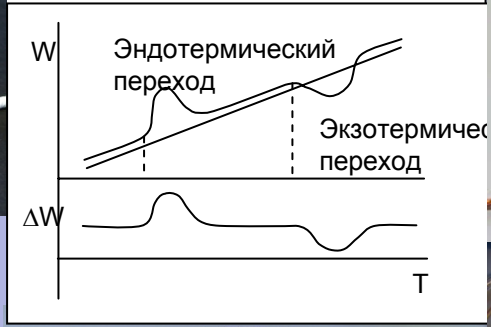
PI: Dr. M. Gerasimov

Cooperation:

IKI, GEOHI, Chromatec, Germany,
France
Hong Kong Polytech. Univ

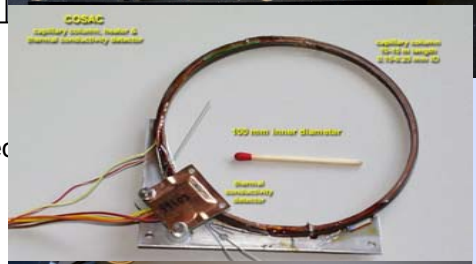
Therm.-Differenc.Analyzer TDA (pyrolytic cells)





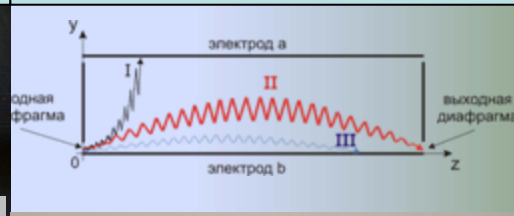
Mass 0,5 kg
T till 1000^0

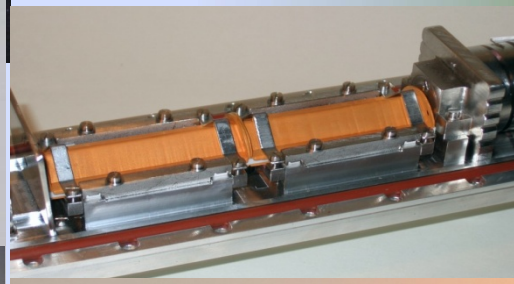
Chromatograph ChMS-1

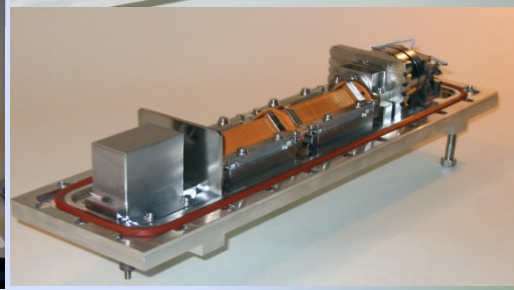


Mass 4,5 kg
Sensitivity > 10^{-9}

Mass-spectrometer MAL-1







Mass 3,5 kg
Mass range 1-150 a.e.м.

Objectives

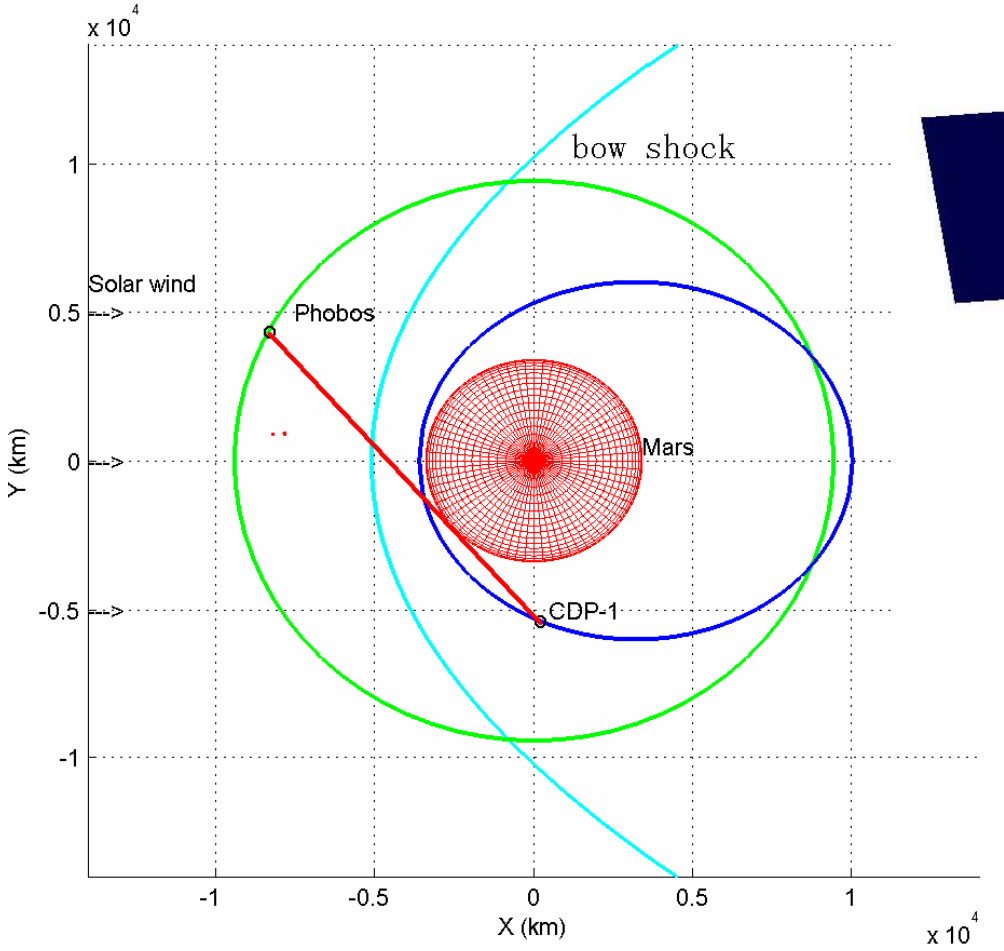
Investigation of the ability and chemical composition of volatile components in the soil of Phobos (bound water, organics, noble gases, etc.)

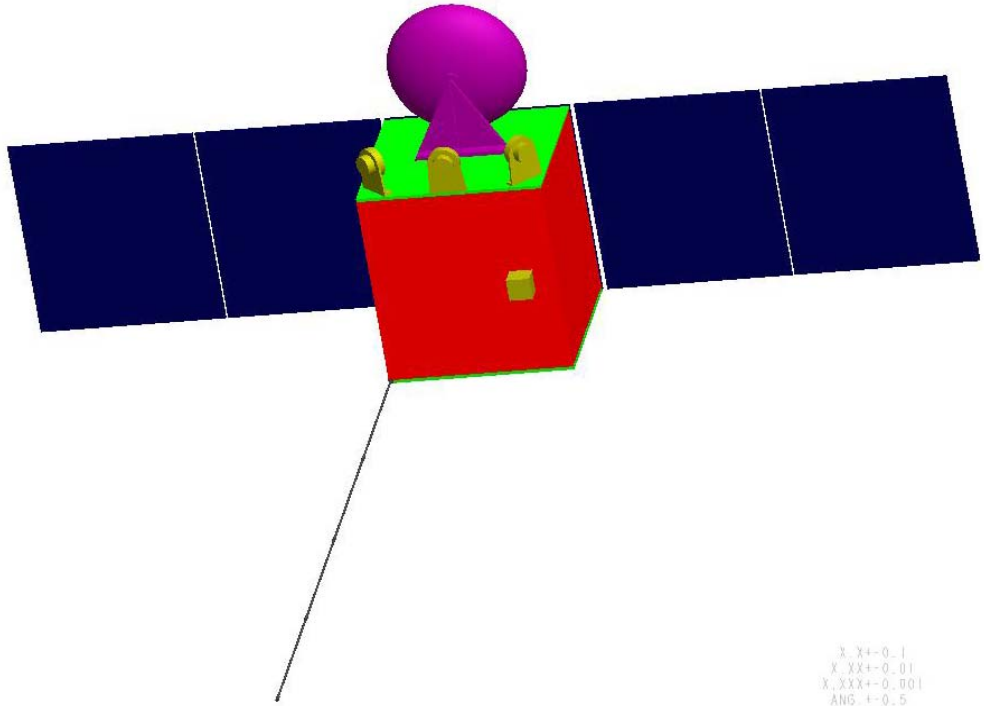
- to measure of the quantity of individual gas components in a complex gas mixture, which is evolved from the soil sample by pyrolysis, due to their separation by the time of retention in a chromatographic columns and detection by TCD sensor.
- to identifiy chemical composition of gas components by their calibrated time of retention and by spectroscopy of specific absorption lines for H_2O, CO_2, and CH_4 gases.
- to measure isotopic composition of C, H, and O elements by spectroscopy of specific absorption lines for H_2O and CO2 gases.

Chinese Mars Micro-satellite, Yinghuo-1

Investigation of the interaction of the solar wind with Mars

- bow shock
- ions escaping,
- ionosphere

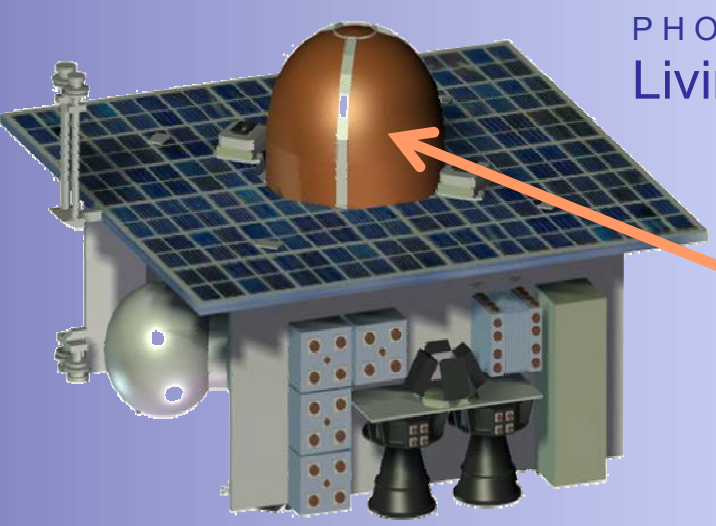


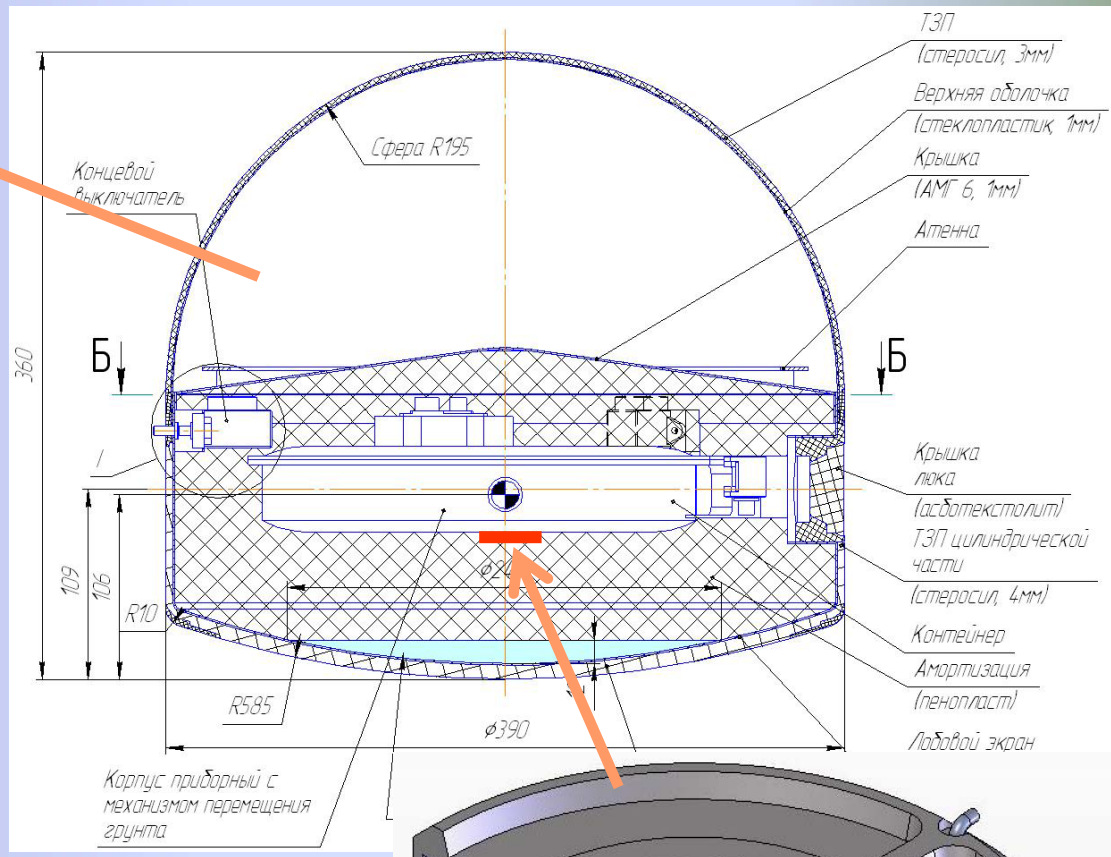


- Microsatellite, total mass, 112Kg,
- Power comsumption:75W, 195W
- 3-axis stabilized platform
- Rigid boom for FGM

P H O B O S SAMPLE RETURN

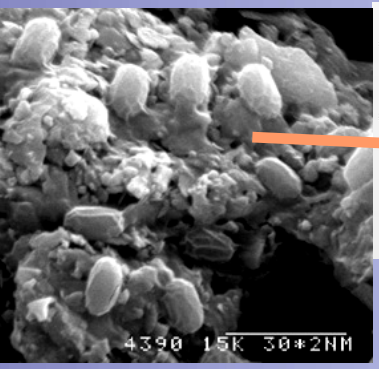
Living Interplanetary Flight Experiment, **LIFE** (returned)

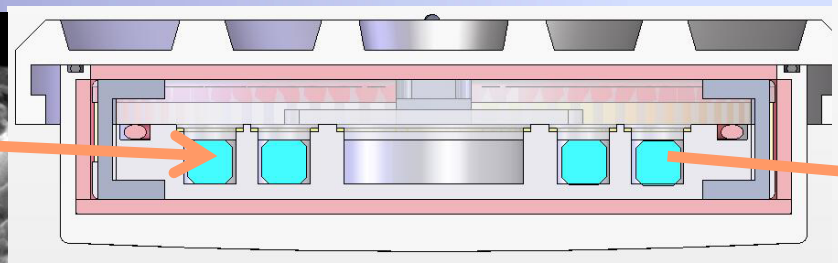


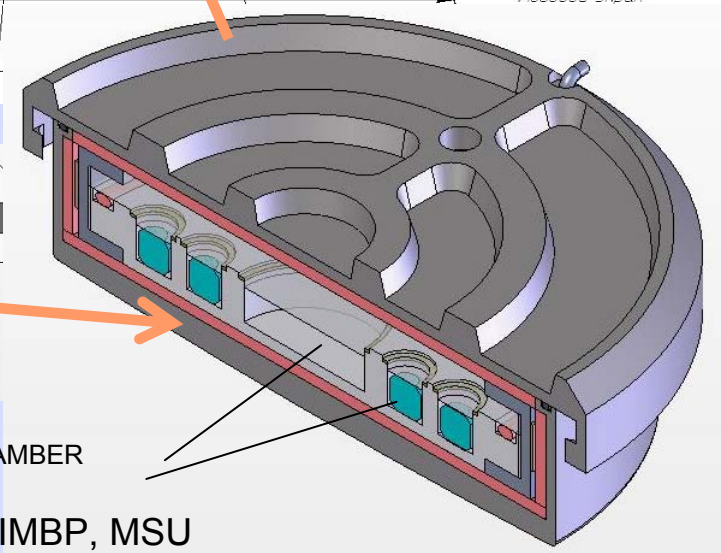


Goals: Study of the survivability of microorganisms during interplanetary transfer

- BIO-CARRIER IS SHOCK MOUNTED
- TRIPLE VACUUM SEALED
- DOUBLE LOCKED
- PLANETARY STERILE







MICROBE COLONY CHAMBER

Participants: USA, IKI, IMBP, MSU

Passengers

- **LIFE would test the survival of approximately ten species selected from among Bacterial, Archaeal, and Eukaryotic domains**
- **Organisms could be tagged with specific genetic sequences**
- **Species have not been finalized, but examples are given here:**

- Bacterial Domain
  - Sporulating
    - B. subtilis (flown on previous missions and standard assay organism for planetary protection)
    - B. pumilus (radiation and desiccation resistant)
  - Non-sporulating
    - Deinococcus radiodurans (extremely radiation and desiccation resistant)
    - Thermus aquaticus (thermophilic)
    - Micrococcus (very thick cell wall, stable in γ-radiation)
- Eukaryotic Domain
  - Yeasts (Cryptococcus?)
  - Plant seeds (*Arabidopsis thaliana*)
- Archaea Domain
  - Halobacterium (survives extended **periods of time salt deposits)**
- **Soil community**

Организмы

- Бактерии
- Дрожжи
- Грибы
- Водоросли
- Высшие растения
- Животные

ГРУППЫ: ЭКСТРЕМОФИЛЫ, АЭРОБНЫЕ ХЕМОЛИТОТРОФЫ, CYANOPHYTA (ГР-), СПОРОВЫЕ БАКТЕРИИ (Гр+), СИМБИОТРОФЫ, АКТИНОМИЦЕТЫ*

Rhodotorula*, Cryptococcus*

Aspergillus sydowi (Bainier et Sartory 1913) Thom et Church 1926;
Aspergillius phoenicis (Corda 1840) Thom 1926;
Aspergillus versicolor (Vuillemin 1903) Tiraboshi 1926;
Penicillium aurantiogresium Dierckx 1901;
Penicillium expansum Link 1809 ex Gray 1821;
Сем. Dematiaceae*

споры *Pediastrum species* (Chlorophyta)
споры *Eunotia species* (Bacillariophyta)

Семена арабидопсиса *Arabidopsis thaliana*
Семена горчицы *Brassica rapa*

эфиппии Daphnia magna (Crustacea)
цисты Streptocephalus torvicornis (Crustacea)
цисты Artemia salina (Crustacea)

покоящиеся яйца Eucypris species (Crustacea)
Покоящиеся личинки Polypedilum vanderplanki (Insecta)

Tests to be Done After Sample Return

- Viability/Capability of Self-propagation
- Culture each organism in their optimal culture conditions, and compare the growing cell number with the negative controls.
- Spore regeneration
- Culture the spores and count the vegetative cell forms, compare with negative controls
- PCR before and after the mission?
- Morphological characteristics before and after the mission (EM analysis)
- Biochemical activities before and after the mission
- Contamination control
- Environmental organisms in the landing area for showing that there is no contamination in the samples

LIFE Design Overview

- Not-to-exceed mass limit of 100 grams
- All passive experiment, no active control nor actuators
- Accommodates diverse samples
- 30 individual sample holders, nominally for 10 triplicate samples
- Single “colony” soil sample (optionally divided)
- Includes passive radiation detectors inside bio-module

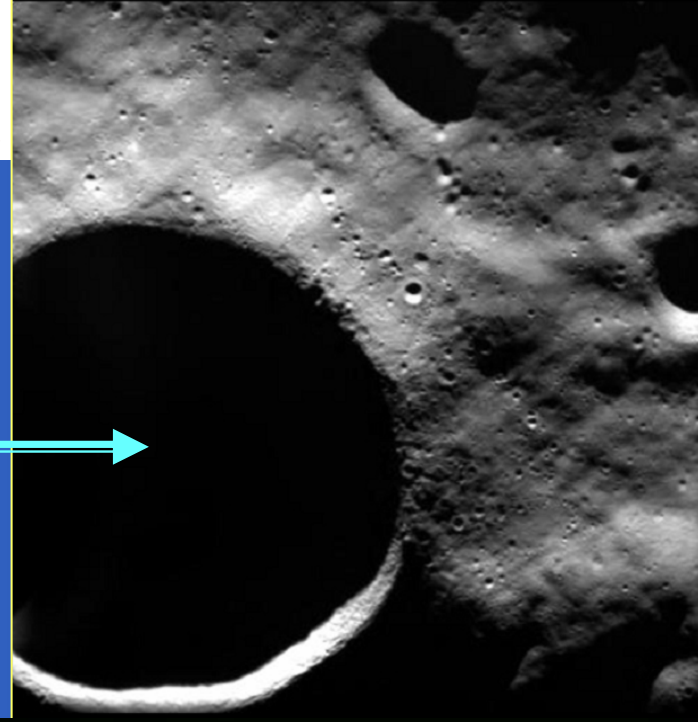

PHOBOS SAMPLE RETURN SPACECRAFT

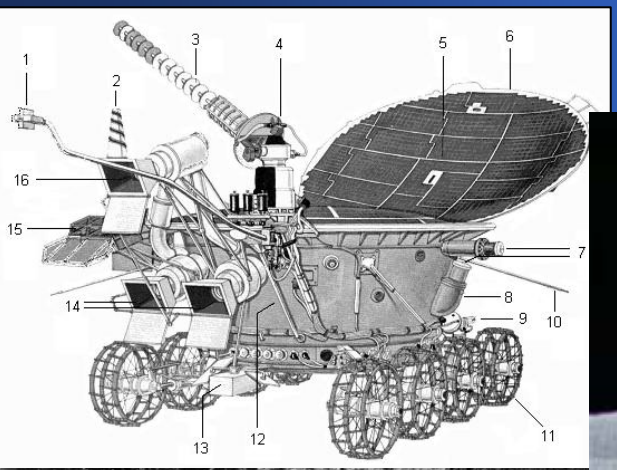
Moon

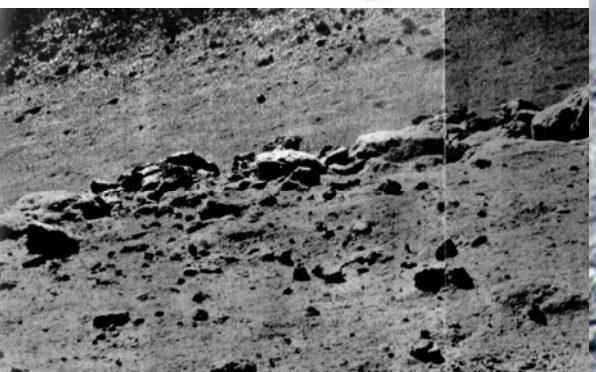
Moon is dusty window to the Earth past

Geologically dead ?

Cold traps near south pole







Apollo epopee

"LUNA-GLOB" PROJECT

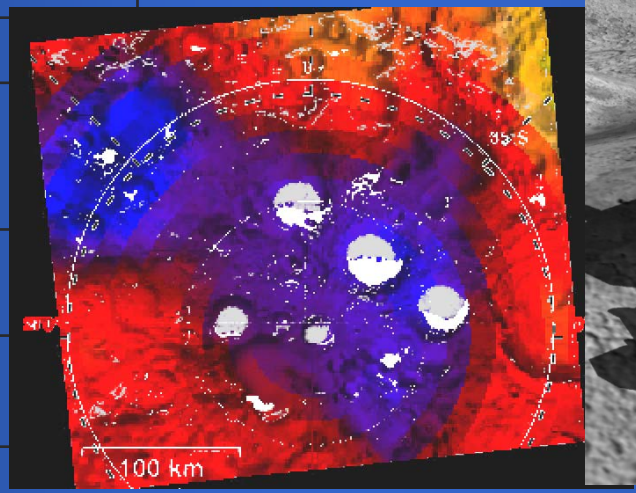
(1-st phase: orbital mission)

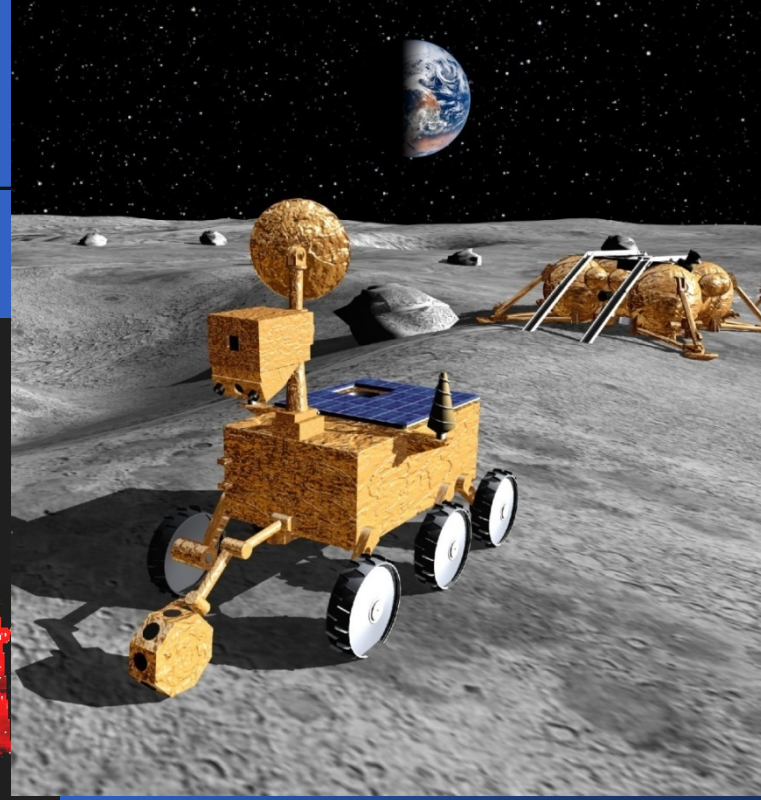
Scientific tasks	Study of the Moon internal structure and prospecting of natural resources
Launch year	2012
Launcher	Soyuz-2
Spacecraft composition	– Orbiter – Penetrators at the Moon surface (net)
Spacecraft mass: – at launch – on Lunar Transfer Trajectory	 7120 kg 2050 kg
Orbiter payload mass	120 kg

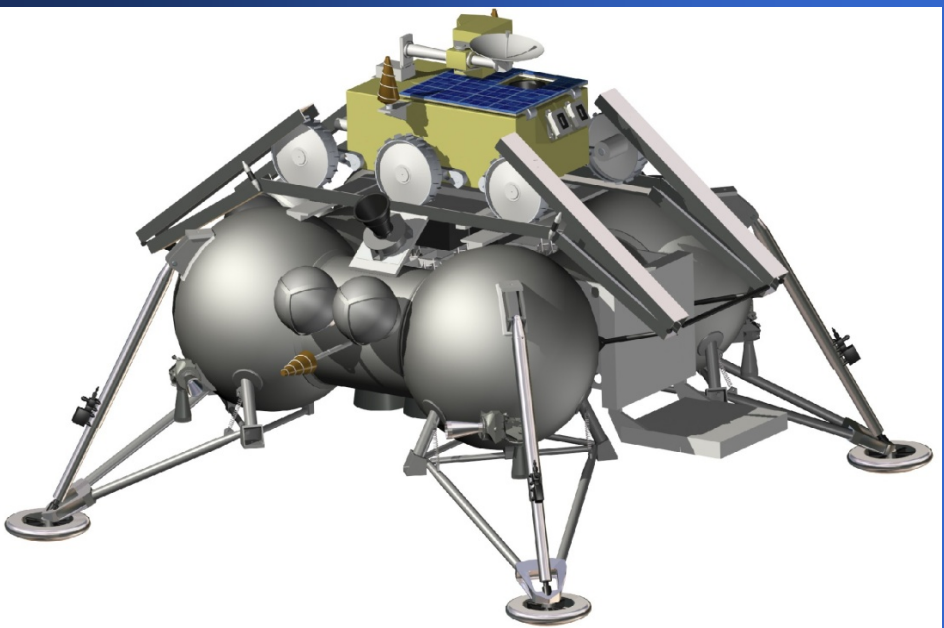
“LUNA-RESOURCE” PROJECT

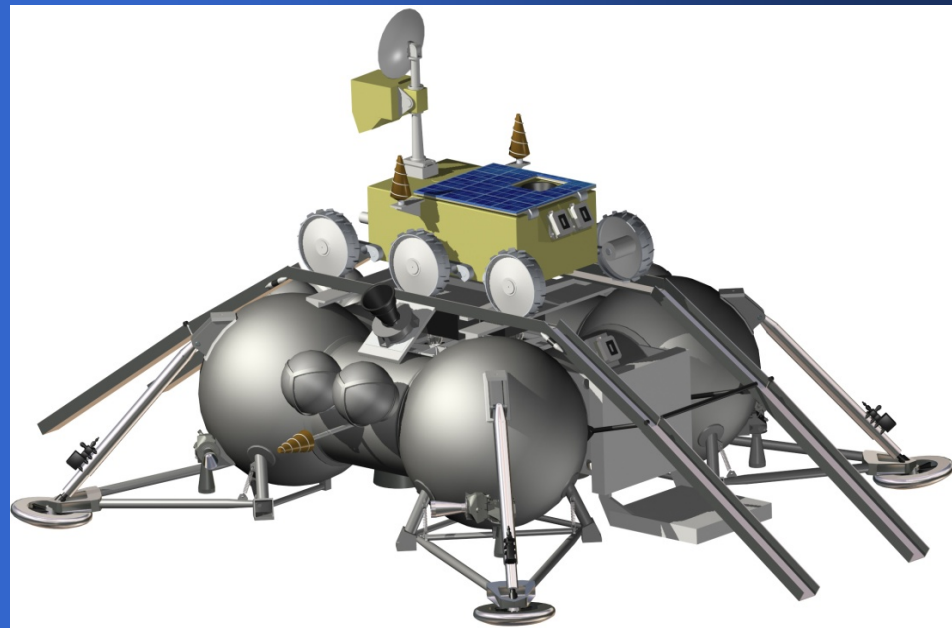
(2-d phase: rover mission)

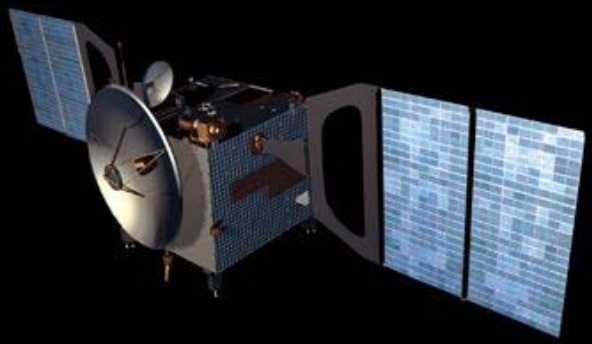
Scientific tasks	investigations in the near-Pole region of the Moon
Launch year	2013 (TBC)
Spacecraft composition	– Landing Module – Moon Rover
Spacecraft mass	1200 kg
Rover mass	>50 kg











Venus – a sister planet with Earth-like size, composition and structure, but very different climate

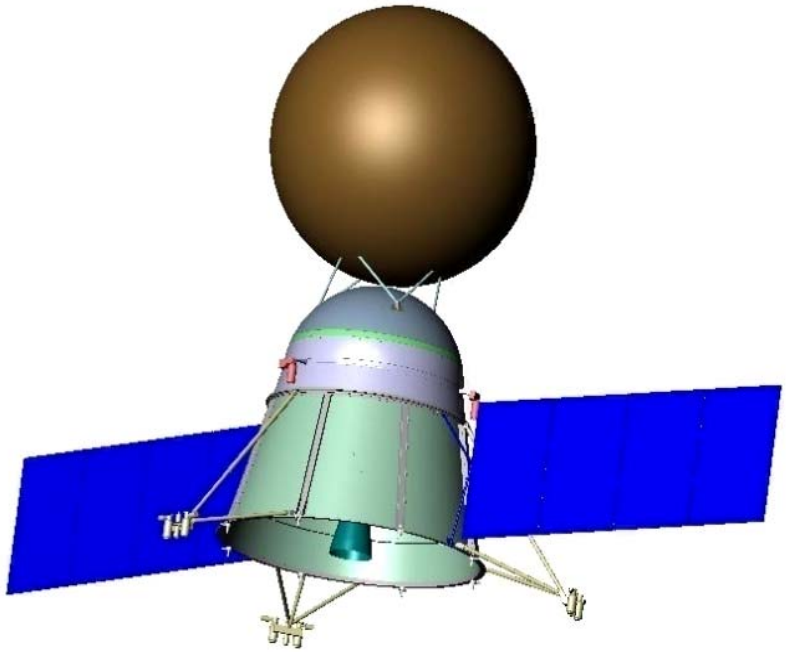
- atmospheric pressure 90 at,
- high temp. 735K , greenhouse
- deficit of water
- absence of magnetic field

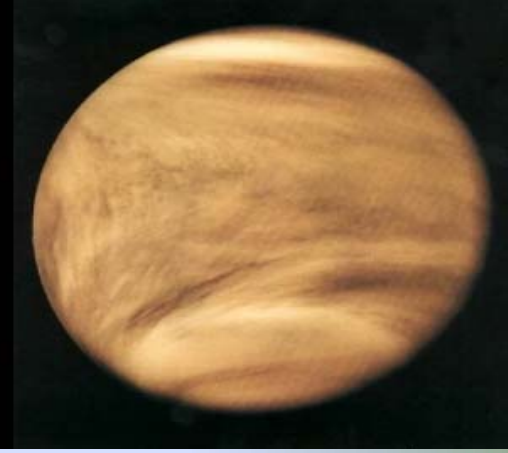
different surface environment and geologic history-

Absence of plate tectonics

Superrotation of atmosphere

Runaway greenhouse effect on Venus !





VENERA-D

Launch 2016

Orbiter

- temperature and wind field in the middle atmosphere
- Investigations of the thermal tides;
- Nature, composition and optical properties of the clouds;
- Nature of “unknown” UV absorber;
- Dynamics and nature of superrotation
- Chemical composition of the atmosphere;
- Plasma environment.

Balloons in the atmosphere

- Dynamics of the atmosphere;
- Meteorology (pressure, temperature density);
- Chemical composition of the atmosphere and clouds;
- Imaging of the surface;
- Radiative balance and greenhouse effect;
- Possible volcanic activity
-

Lander at the surface

(Dewar conception)

- Chemical composition of the atmosphere
- Abundance of noble gases and isotopic composition;
- Clouds composition and optical properties;
- Radiative balance and greenhouse effect;
- Surface temperature, mineralogy;
- Possible volcanic and seismic activity

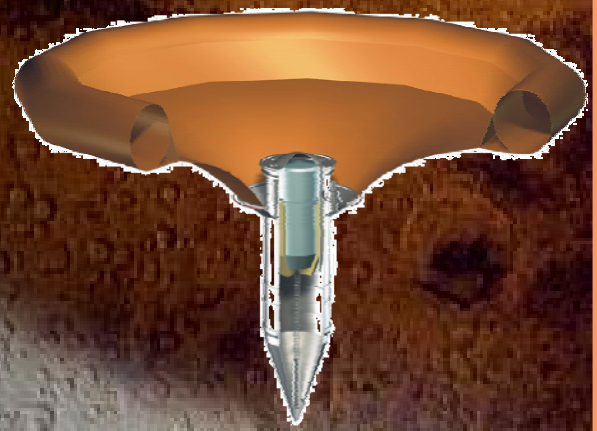
Mars exploration program

Main goals to study Mars:

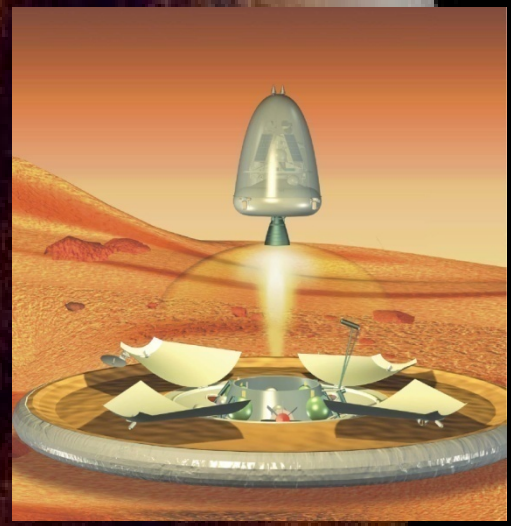
- Internal structure, core
- Water
- Life
- Mars is a spare planet for the Humanity ?

Phobos sample return mission 2009

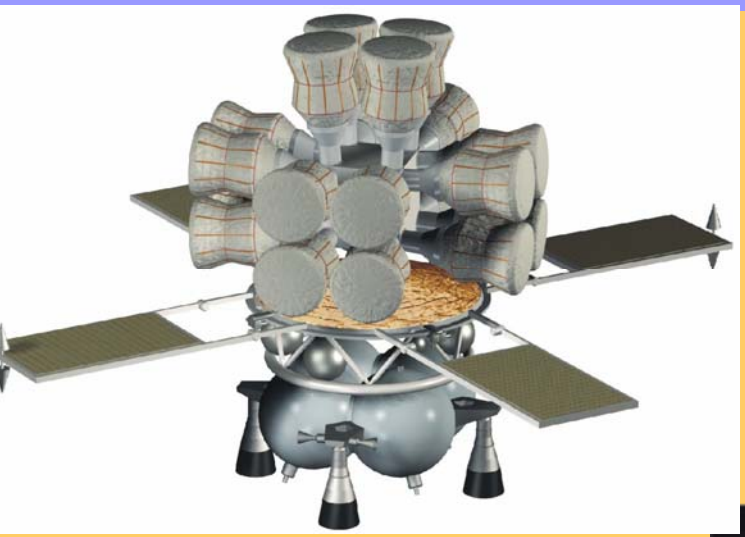
MarsNet mission (together with ExoMars ESA mission) 2016



Mars sample return mission (?) 2019-2022



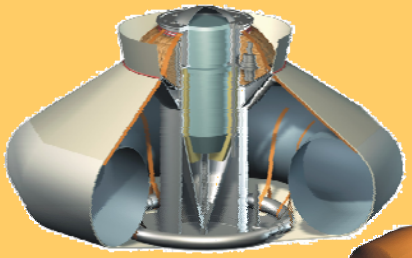
Mars MetNet – net of small stations at the Martian surface



Scientific objectives:

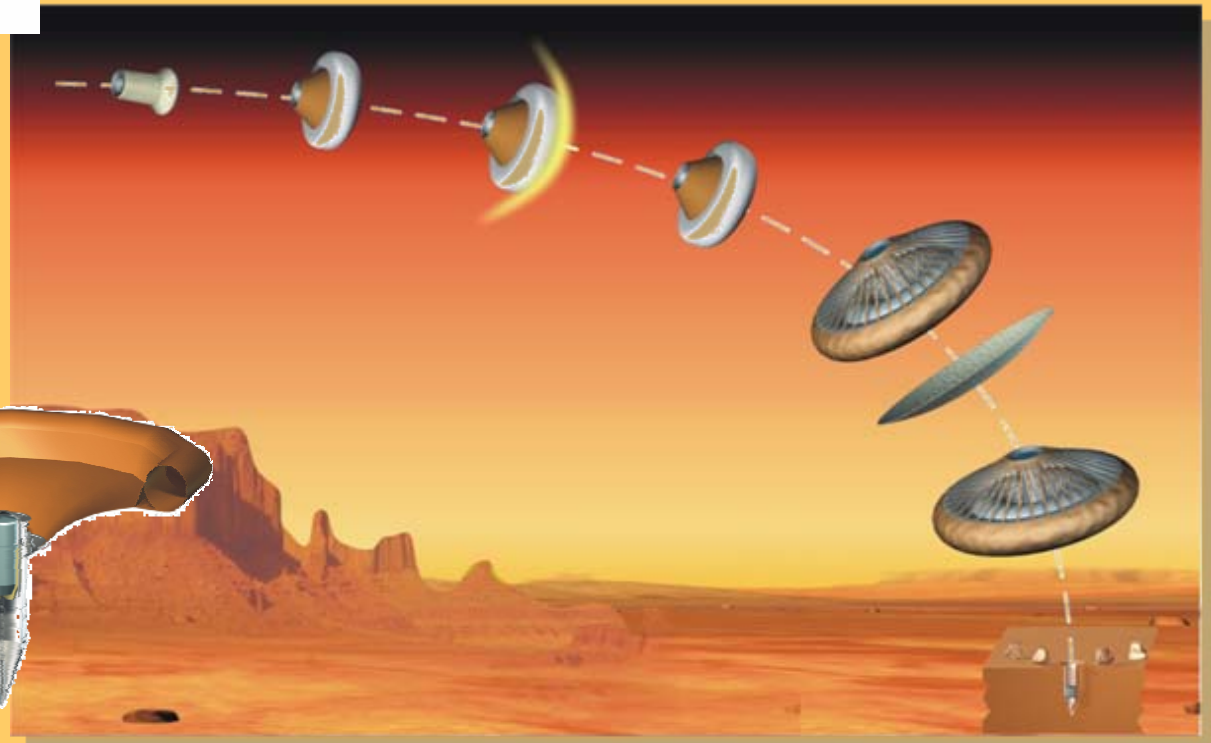
- Vertical structure of the atmosphere at several latitude and longitude;
- Global meteorological monitoring;
- Net of seismic-stations

Launch configuration



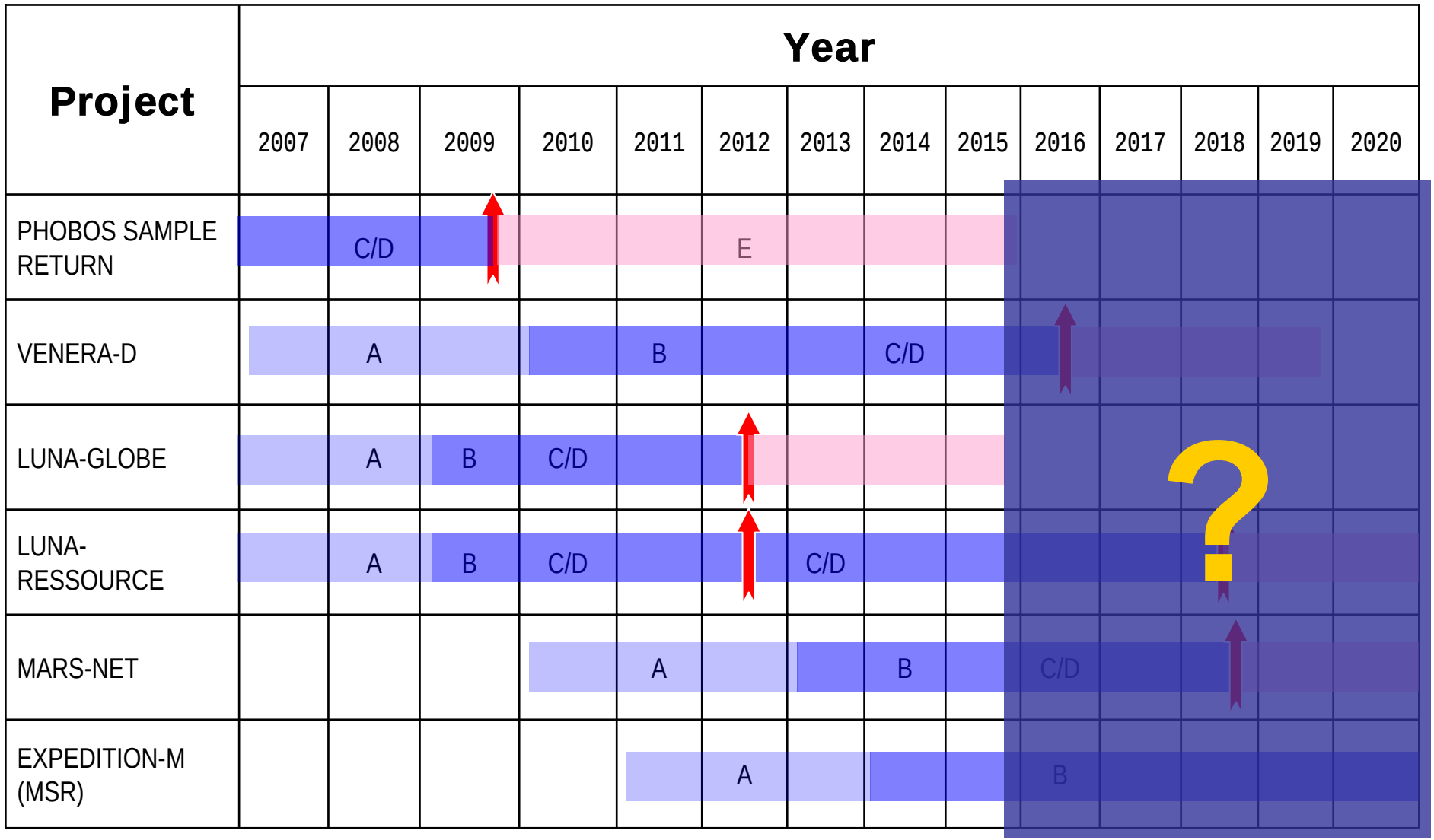
Enter into the atmosphere configuration

Landing configuration



Russia, Finland collaboration

Planets in Federal Space Programme as in 2008



MANNED MISSION TO MARS?

Research & / or Exploration

Outstanding task - Challenging project:

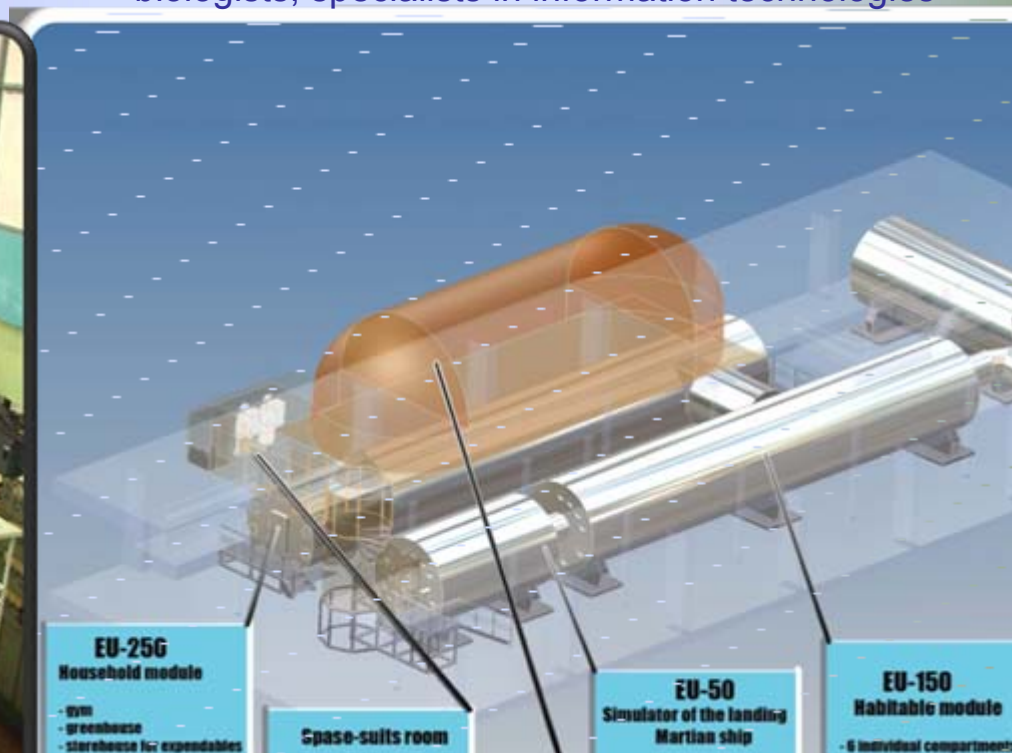
- Development of international collaboration
- Drive for development of new technology
- Snazzy targets for young people

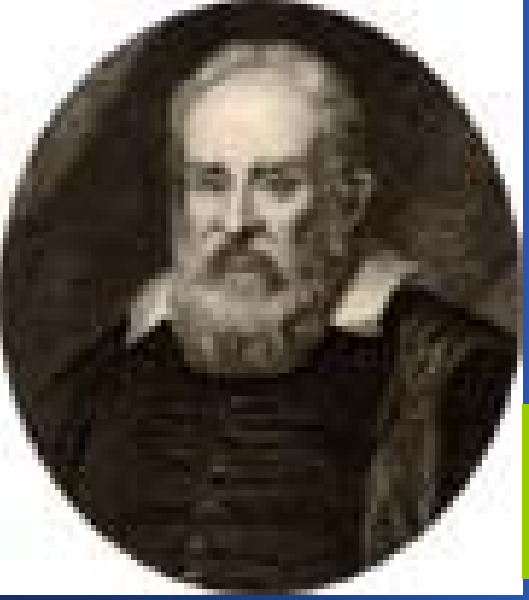
MARS – 500. Manned Martian mission

(ground based simulation in the IMBP fasilityes)

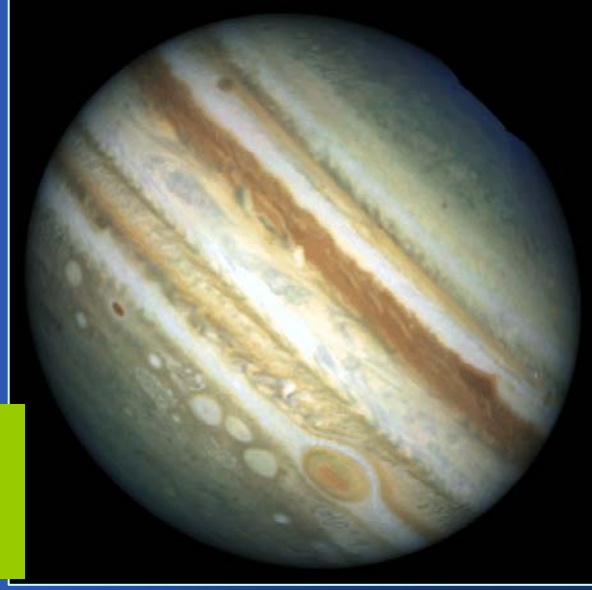
- **GRAVITY** – long (up to 2 years) influence of microgravity
- **RADIATION** – high level of ionizing radiation
- **ISOLATION** – long staying in artificial atmosphere of a small group of people

- Total Mission duration - 500 - 700 days
- Number: 6 members of the crew
- Simulation of peculiar features of the mission
- Simulation of landing and work on Martian surface:
  - 3 subjects spend 7- 30 days on “the Martian surface”,
  - 3 subjects stay in “the orbiter”
- National composition: international
- Age: from 25 to 50
- Preferable occupation: engineers, medical doctors, biologists, specialists in information technologies





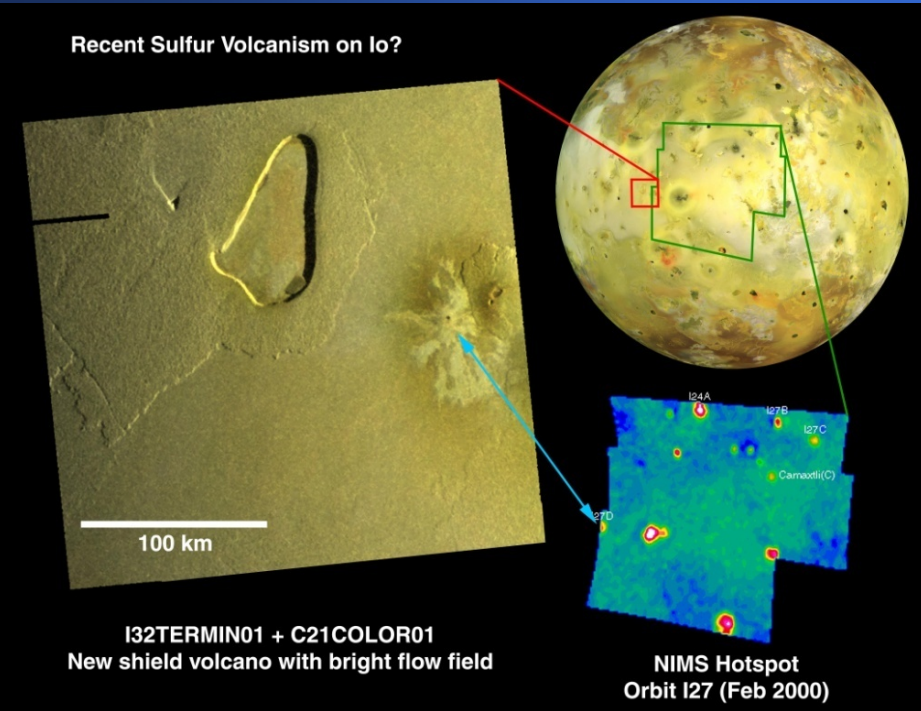
Jupiter's Galilean satellites

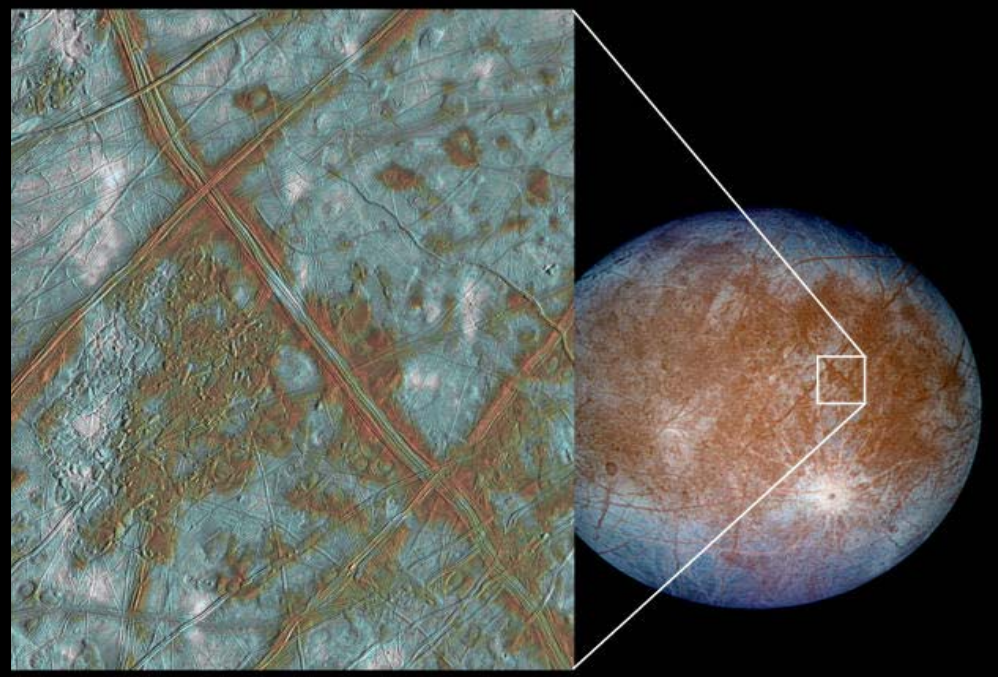


Scientific question:
IS EUROPA HABITABLE?

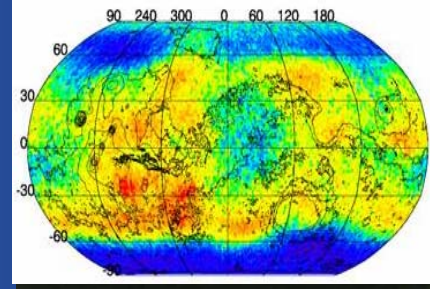
Io: tidal volcanism
eccentricity maintained by resonance

Europa: a mantle of liquid water?
ICE SHELL >10 km



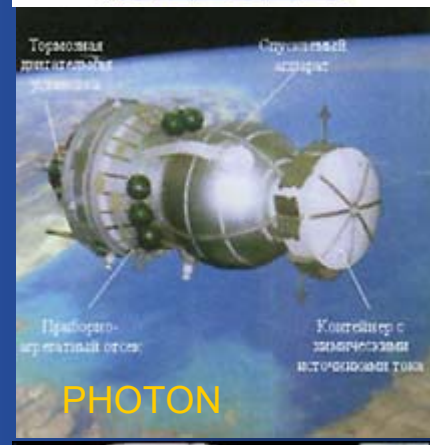


Other space activities



Experiments onboard NASA and ESA space missions

- Mars Odyssey (HEND)
- Mars Express
- Venus Express



The study of physics of weightlessness

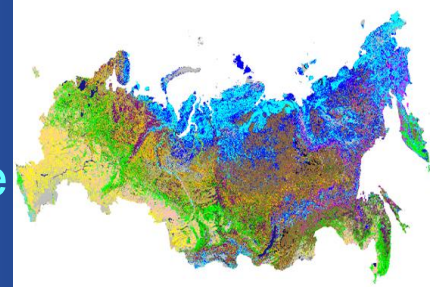
for space technology and biotechnology

Scientific studies on board the ISS Russian segment

- studies of the biomedical problems of space flight,
- experiments in the field of physics of weightlessness and space biology.

Study of the Earth from space

- remote sensing system (projects "Resource- P", "Meteor-M") for the observations of land, water area and atmosphere
- experimental system of monitoring the parameters of near-earth outer space (project "volcano") for registering the foreshocks (which appear in the ionosphere under the action of tectonic processes).



BION-M

Biological studies

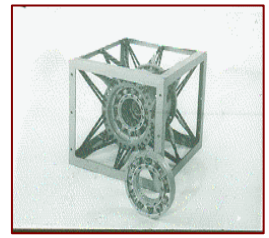
Launches in 2010, 2013, and 2016

Space biology and medicine, radiation-physical and radiation-biological experiments in favor of manned spaceflights

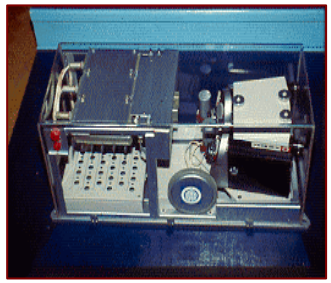
"BION-M" MISSIONS: OBJECTS UNDER STUDY AND FACILITIES

- Rats

- Eggs of birds



- Plants

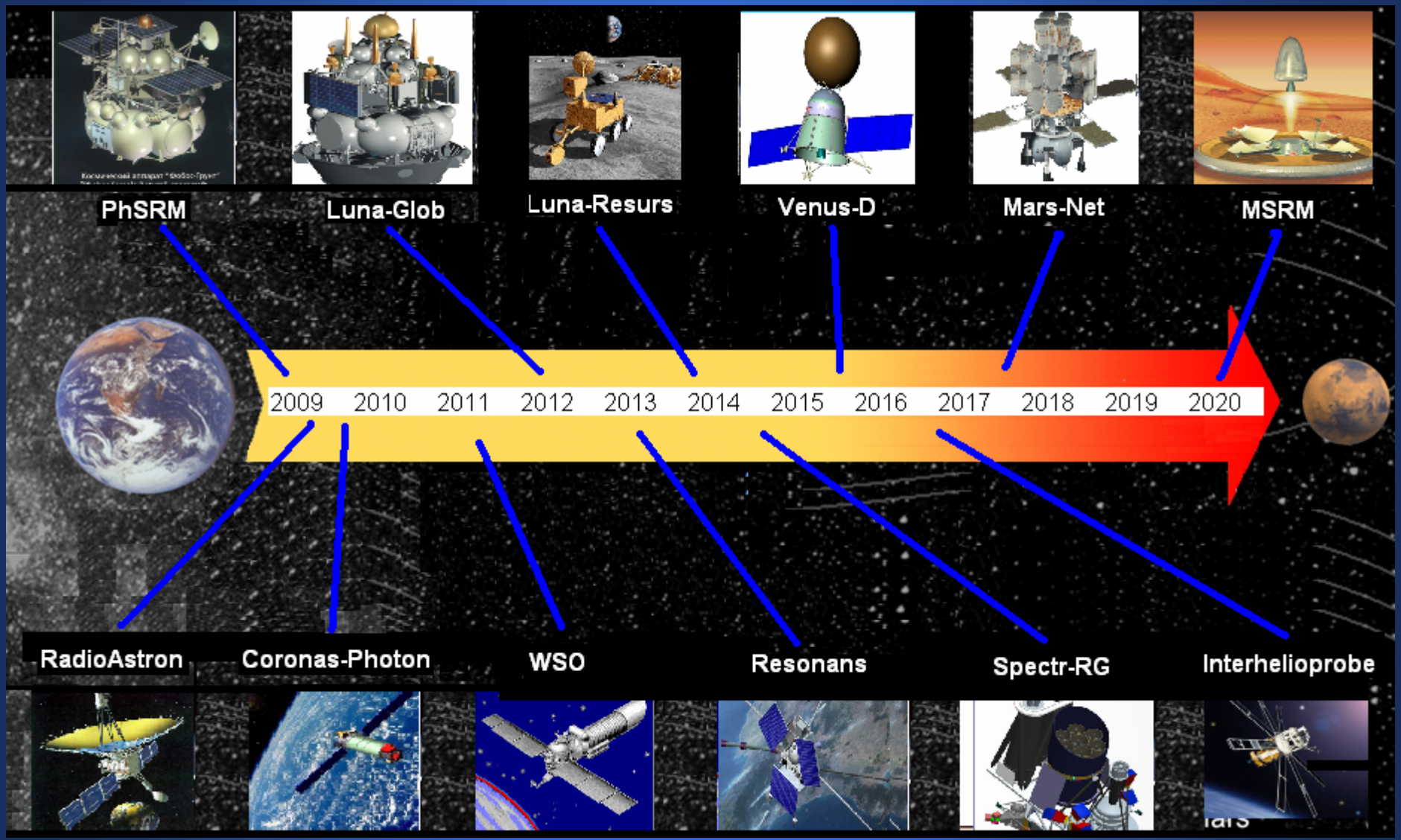


- Reptiles
- Amphibia

- Fishes

- Microorganisms
- Insects
- Worms
- Cultures of cells and tissues

RUSSIAN SPACE PROGRAM on SCIENCE



source: http://www.esa.int

RUSSIAN SPACE PROGRAM on SCIENCE

source: http://www.esa.int