SSC RF Institute of Biomedical Problems RAS

# MARS 500

## «MARS-500» project

## 520-day isolation

# Landing of the surface of Mars

Moscow
February, 2011

## What is “Mars-500” project?

“Mars-500” project is a series of experiments, simulating ones or another aspects of a manned flight to Mars.

The project is being conducted under the auspices of Roscosmos and the Russian Academy of Sciences at IBMP’s premises with wide participation of Russian and international organizations.

The objective of the project is studying of the system “humans – environment” and obtaining of experimental data about the state of health and working capacity of the crew, staying for a long time in conditions of isolation in confined pressurized environment during simulation of the main peculiarities of a manned flight to Mars (over-duration, autonomy, changed conditions of communication with Earth – signal passage delay, limitation of the expendables).

The main part of “Mars-500” project includes series of experiments on long-term isolation of the crew in conditions of a specially designed ground-based experimental facility. By the present day two from three planned experiments have been conducted – 14-day isolation (finished in November 2007) and 105-day isolation (finished in July 2009). The third experiment with 520-day isolation at the present time is being conducted.

## Experiment with 520-day isolation

Beginning –June 3, 2010. Finishing – November 5, 2011.

**The crew:**


**Sitev Alexey** – the commander of the crew (Russia)
**Kamolov Sukhrob** – the physician of the crew (Russia)
**Smoleevskiy Alexandr** – researcher (Russia)
**Romain Charles** – flight engineer (ESA, France)
**Diego Urbina** – researcher (ESA, Italy)
**Van Yue** – researcher (CCTC, China)

## The structure of the scientific investigations, conducted during 520-day isolation:

| Direction of investigation | The number of projects | | | In total |
|---|---|---|---|---|
| | Russian projects | Foreign projects | | |
| | | ESA | Other countries | |
| Physiological investigations | 17 | 3 | 6 | **26** |
| Psychological and psycho-physiological investigations | 16 | 7 | 3 | **26** |
| Clinical and laboratory-diagnostic investigations | 24 | 3 | 7 | **34** |
| Microbiological and sanitary-hygienic investigations | 7 | 1 | - | **8** |
| Operational-technological experiments | 10 | 1 | - | **11** |
| **In total** | **74** | **15** | **16** | **105** |

## Mars planet: the objectives and aims of the real manned expedition

With what is such great interest to Mars as compared to other planets of the Solar system connected? Why does Mars attract us so much that is planned to perform people's landing on this planet?

1. The central objective of planetary investigations is to create a scientific theory of formation and evolution of the bodies of the Solar system – planets, their satellites, small bodies (comets, asteroids). It is necessary to single out the problem of the theory creation of Earth formation and evolution, that is able to forecast its further development. Mars belongs to the family of planets of the Earth group, i. e. similar in many aspects to Earth, and it was formed, apparently, from the same initial material, that is why exploration of Mars is important for clarification of origin and evolution of planets in the Solar system (comparative planetology).

2. Mars has enough adequate characteristics, so that its climate can admit existence of water and organic compounds or bacteria, i. e. 'life" on this planet. It is interesting to compare it with Earth life and get closer to understanding of its still unknown origin.

3. Climatic and physic conditions on Mars allow to hope on possible colonization of this planet, as the most suitable object of the Solar system.

## General characteristics of Mars

Above the Martian surface there is atmosphere wich is in 100 times thinner than the Earth atmosphere. However, it is enough to support existence of seasons, system of winds, clouds, i. e. climate.

Mars is much farther from the Sun (in 1.5 times), while its average radius is in 2.107 times smaller than the Earth radius. Earth is in 10 times more massive, than Mars, that has density on about 70% less than Earth. As a result a man on Mars would feel as if his weight decreased on 60%, and if this man dropped something of the surface, this thing would fly to the surface much more slowly than on Earth.

Like Earth, Mars rotates around its axis from West to East, and the Martian day lasts for 24 hours 39 min. 35 sec., that is, it is close to the Earth day.

The distance from Earth to Mars changes in line with rotation of both planets on their orbits around the Sun, and it can change from about 50 mln. km to 400 mln. km.

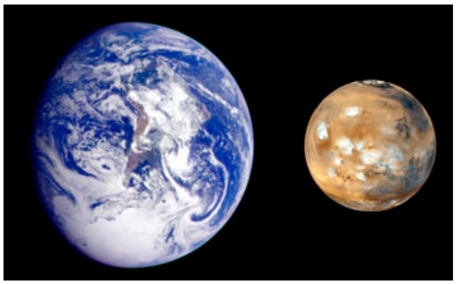


**Fig. 1.** Comparative sizes of Earth and Mars.

*Credit: JPL/NASA*

## Comparative characteristics of Earth and Mars:

| | Earth | | | Mars | | |
|---|---|---|---|---|---|---|
| **Orbital characteristics** | | | | | | |
| Average distance from the Sun | 149 597 890 km (1,0 a.u.) | | | 227 936 637 km (1.523 a.u.) | | |
| Period of rotation on the orbit (duration of the year) | 365.24 Earth days | | | 686.96 Earth days | | |
| Satellites | 1 (Moon) | | | 2 (Phobos, Deimos) | | |
| **Physical characteristics** | | | | | | |
| Equatorial radius | 6378.14 km | | | 3402.5 km | | |
| Polar radius | 6356.78 km | | | 3377.4 km | | |
| Mass | $5.9737 \times 10^{24}$ kg | | | $6.4185 \times 10^{23}$ kg | | |
| Density | 5.515 g/cm³ | | | 3.934 g/cm³ | | |
| Gravity in the equator zone | 9.766 m/s² or 1 g | | | 3.69 m/s² or 0.376 g | | |
| Second space speed | 11 180 m/s | | | 5 072 m/s | | |
| Rotation period around its axis | 23.93 h | | | 24.62 h | | |
| Temperature of the surface | min | aver | max | min | aver | max |
| | 185°K | 287°K | 331°K | 133°K | 210°K | 280°K |
| Atmospheric pressure | 101,325 kPa | | | 0,7—0,9 kPa | | |
| **Composition of the atmosphere (%)** | | | | | | |
| Oxygen | 21 | | | 0.13 | | |
| Carbon dioxide | 0.03 | | | 95.32 | | |
| Nitrogen | 77 | | | 2.7 | | |
| Argon and other mixtures | 1.97 | | | 1.85 | | |

## Some peculiarities of the Martian surface

The North and the South hemispheres of Mars differ significantly on topographical characteristics, that is seen well in fig. 2. In the South hemisphere there is highland with a big number of craters (red-orange colour), whereas the North hemisphere consists mainly of more smooth plains and lowlands (blue and light-green colour). On the edge of the red area on Mars dichotomy border is established, that points to different characteristics of the Martian crust in both hemispheres.

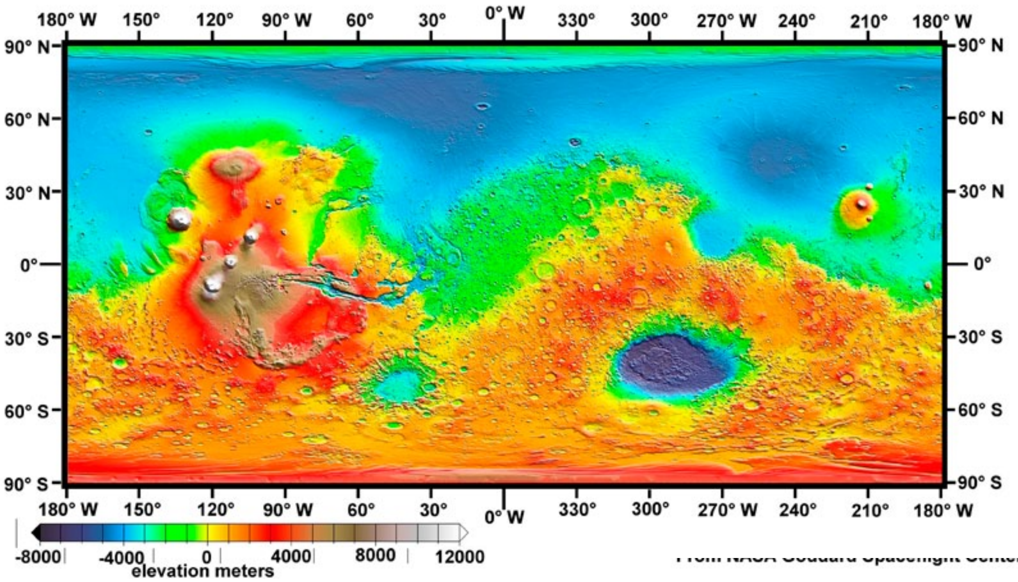



**Fig. 2.** Topography of Mars according to the data of laser altimeter MOLA, placed on the American satellite Mars Global Surveyor.
*Credit: MOLA/NASA*

There are very deep lowlands (dark-blue areas) in both hemispheres. Unlike Earth, the whole planet is covered with numerous impact craters, originated from meteorites impact on the surface, badly protected by thin atmosphere. There is a hypothesis that ancient Mars suffered from asteroid impact, that crumpled and shifted its surface in the southern direction.

**Fig. 3.** The system of canyons the Valley Marineris on Mars.
*Credit: NASA*

**Plains,** as it has already been said, are mainly in the northern hemisphere. Some of them are the flattest and lowest areas as compared to similar phenomena on the surface of other planets of the solar system. They, apparently, are filled with sedimentary rocks, that are interpreted by some investigators as proofs in favour of existing of an ocean in the far past of the planet.

**The system of canyons,** situated along the equator, is called Valley Marineris in favour of Mariner 9 apparatus, that discovered them in 1971. The surface of the plateau with the canyons has the height of about 10 km (above the conditional zero level of the planet), its length is 1/5 from the circumference of the planet (4000 km). The depth of the canyons is about 6-10 km.

For comparison the Grand Canyon in the USA has the length of 500 km and the maximum depth of 1.6 km. A lot of specialists consider that canyons originated in splits in the Martian crust during its compression due to cooling, and then they were subjects to erosion. However, big erosion valleys go from the eastern part of the canyons, and they point, that possibly the canyons were filled with water. Valleys and cloughs exist in many parts of the Martian surface, pointing to the fact that water activity led to noticeable erosion of the surface of many regions of the planet and edges of the craters. As result, a net of minor valleys appeared, from dozens, hundreds meters to several kilometers – in width and to thousands kilometers – in length. These formations externally resemble the Earth system of rivers and brooks, and, as a rule, end in local depressions or inside big impact craters.

**Polar areas.** In polar areas of Mars there are formations, that have thin layered structure, formed due to layering of ice deposits with deposits of the dust material. These deposits go from the pole to 80° in both hemispheres. They could be formed as result of season changes and continuing variations of the Martian climate. On the top of these deposits there are layers of polar caps from water ice, that never melts. Together with the low layered deposits these formations have thickness of several kilometers. During winters on Mars polar caps are supplemented with a layer of “dry ice” – condensate of carbon dioxide $CO_2$ from atmospheric gases. In such seasons polar caps go to the half of distance to the equator, i. e. to the latitude of 55°.

**Magnetic field of Mars.** It turned out that Mars does not have its own dipole magnetic field like Earth and some other planets, however it is not completely like Venice, that does not have magnetic field either. The Martian dynamo, that is responsible for creation of its own magnetic field in all the planets, stopped working several milliard years ago. At the temperature in the area of the Martian nucleus (presumable 1500

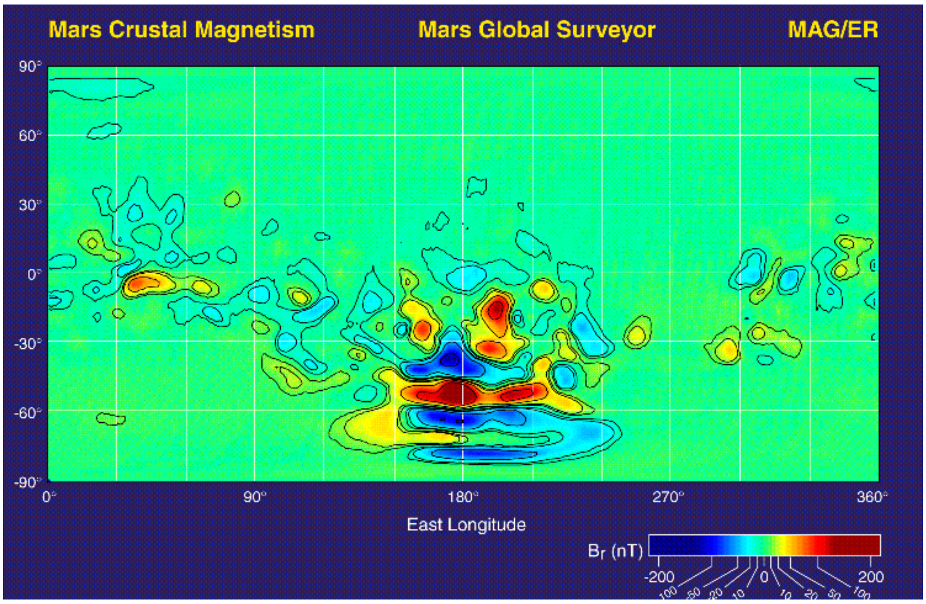



**Fig. 4.** A map of magnetic anomalies on Mars on the data of changes by magnetometer on the apparatus Mars Global Surveyor.
*Credit: Connerny et al., Geophys.Res. Lett., 28, 4015-4018, 2001*

degrees Kelvin) the mixture of ferrum, nickel and sulphur, from which it consists, must be in a liquid form. On the external part of the nucleus, however it can harden somehow, but it will happen, only if the content of sulphur in this region does not increase 10.6%. It explains the situation when Mars stopped having magnetic field, and Earth has it till the present day. It is considered that it is originated on Earth due to hardening of the internal part of the nucleus. It, due to dragging on the external part, consisted of melted ferrum, works on the principle of dynamo machine.

After finishing of the dynamo activity some craterial bays appeared, where there is not magnetic field, for example, Ellada and Argir, and according to the age of these not young formations it is possible to make conclusions about the fact that the magnetic field of Mars remained only in some regions of its crust – anomalies.

Magnetic field on the surface of the planet is 0.5 nT in the nights and 1 nT at any other time. On the daytime side it is about 30-50 nT at the surface in the areas beyond magnetic anomalies.

Magnetic field of the anomalies on Mars, assessed on measurements of a satellite at the height from 80 to 400 km, can achieve from +200 nT to -200 nT, and they contribute to forming of “efficiency” of dipole (fig. 10), that regulates such important large-scale processes, as interaction with the solar wind – with magnetic flows of charged particles (of plasma), forming Martian magnetic sphere and its dynamics.

**The atmosphere of Mars** contains much less oxygen ($O_2$) than the Earth atmosphere, only 0.13% (in the Earth atmosphere the content of $O_2$ is 21%). The main component of the atmosphere of the planet is carbon dioxide ($CO_2$) – 95.3%. The rest gases include nitrogen ($N_2$) = 2.7%, argon (Ar) – 1.6%, CO – 0.07% and water evaporation ($H_2O$) – 0.03%.

In the atmosphere at big heights there can be clouds of frozen carbon dioxide $CO_2$, and also fog, that is formed by condensed evaporations of water $H_2O$, in particular, in the mornings, when the temperature is very low.

On Mars like on Earth there is a global picture of winds, accompanied sometimes even with typhoons, but they are less strong than on Earth due to less thickness of the atmosphere. On average the wind speed is about 10 km per hour.

**Radiation situation on Mars.**

From fig. 5 it is evident that the safest from the point of view of radiation situation are the lowest areas of Mars (dark-green and brown colors on the map fig. 5). It happens because Mars has the atmosphere that is in 100 times thinner than the Earth atmosphere, and the column of atmospheric gases, where space rays penetrate, is thicker in lowlands that in other areas. The green areas on the map are areas of moderate risk, whereas the red areas mark the areas of increased risk to suffer from radiation.

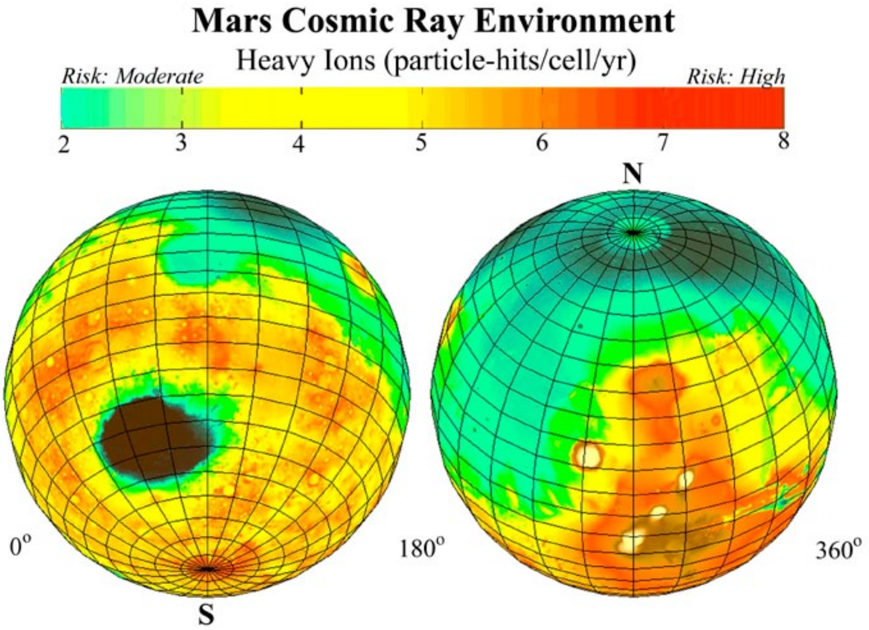



**Fig. 5.** Distribution of the intensity o space rays in both hemispheres of Mars.
*Credit: NASA/Jet Propulsion Laboratory/JSC*

## Dust on the surface of Mars Water on Mars

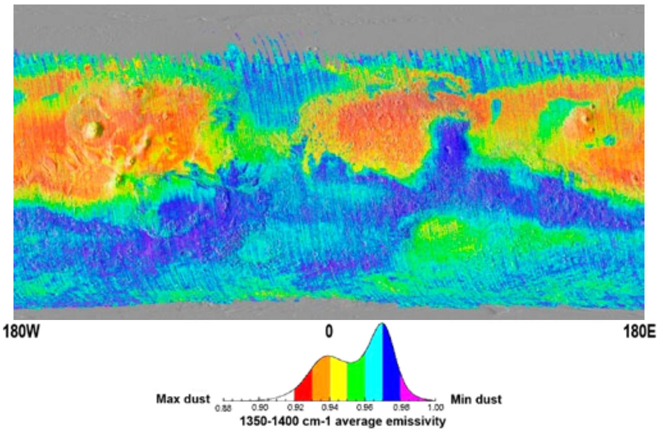



**Fig. 6.** A map of dustiness of the surface of Mars, built from observations of spectrometer TES on the basis of mapping of spectral index of dust (*S. Ruff, P. Christensen, 2002)*.
*Credit: NASA/JPL/Goddard*

The most impressive phenomenon on Mars are dust storms (fig. 7). During short intervals of time whirling of winds raises dust into the atmosphere, forming so-called "dust devils", looking like small tornadoes.

From fig. 6 it is seen that the most dusty areas on Mars (red-orange colour) dominate mainly in the northern hemisphere, where the thickness of the dust level can reach up to 1-2 m. In the southern hemisphere the dustiest area is connected with the area of depression Ellada.

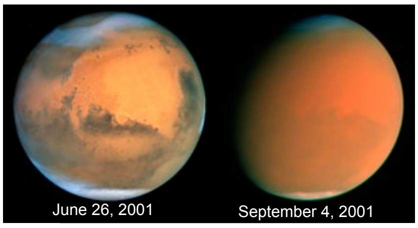



**Fig. 7.** Dust storm on Mars.
*Credit: NASA, James Bell (Cornell Univ.), Michael Wolff (Space Science Inst.), and the Hubble Heritage Team (STScI/AURA)*

## Temperature on Mars

On Mars it is much colder than on Earth (fig. 8). The temperature on the surface of the planet changes from -125° near the poles in winter to, sometimes, +20° at midday on the equator in summer. The average temperature, however, does not increase -60°C.

## Water on Mars

A series of peculiarities of the modern surface of the planet point to the fact that there were epochs, when water still played a great role: branchy valleys, looking very much like the bed of dried rivers (wady) are the most vivid example.

If this interpretation is right, then, water, apparently, still exists in splits, snaps and pores of under-surface rocks. Space apparatus discovered significant amount of ice under the surface, in particular, near southern pole.

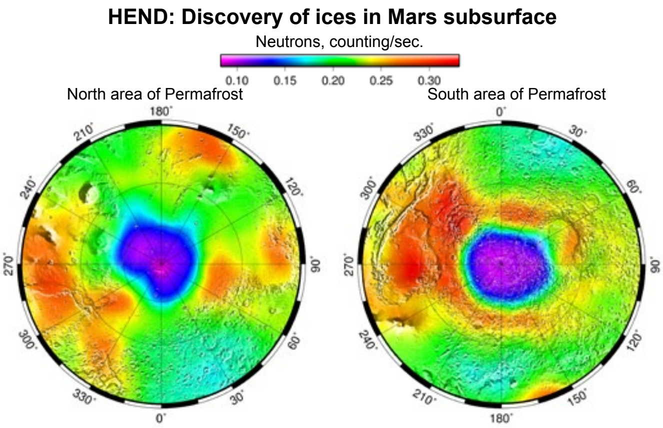



**Fig. 9.** HEND device developed by Roscosmos and Space Research Institute of RAS for the gamma-spectrometer project of NASA "Mars-Odyssey" has revealed the water ice layers in the subsurface of the Mars circumpolar areas above 50°-60° north and south latitude. The permafrost areas with water ice in the soil are indicated by blue colour at the maps of neutron radiation.
*Credit: Roscosmos*

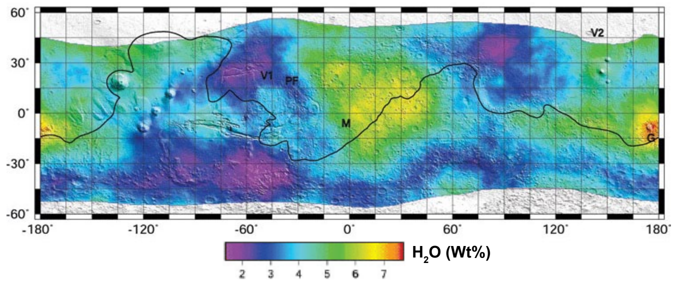
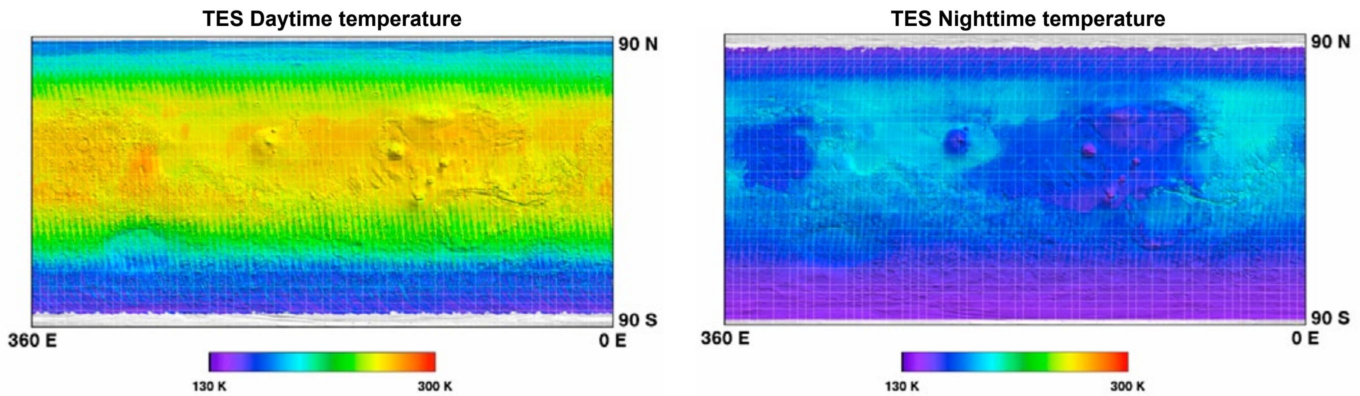



**Fig. 10.** Content of water in the area of average latitudes in surface areas of Mars according to the data of American SA Mars-Odyssey. The black curve is the border of dichotomy of the surface between the northern and southern hemispheres.
*Credit: NASA/JPL/University of Arizona*

**Fig. 8.** Maps of day and night temperature of the surface of Mars at the end of summer in northern hemisphere (Ls=180°), obtained on the data of observation of thermo-emission spectrometer TES from board SA Mars Global Surveyor.
*Credit: TES Team/MGS/JPL/NASA*



## Where shall we send manned expeditions to Mars?

Investigations of Mars with the help of devices on space apparatus and robotic-technical apparatus on the surface began in 1960. The first landing on the surface of the planet was performed by landing modules of the apparatus Viking 1 and 2 in 1976. In 1997 successful expedition on the surface of the planet was performed with the help of the rover Mars Pathfinder. The photographs of the Martian surface from these apparatus have been shown in the whole world.

In 2001 Mars-Odysseys was launched, that was equipped with the equipment for investigation of the chemical composition of the Martian surface and under-surface water from the orbit of the IS. Huge deposits of under-surface water ice were found at the latitudes higher than 60° in both hemispheres of Mars. This ice is in 1 m of the under-surface soil and its volume is comparable with the two volumes of the water in the lake Michigan in the USA ( Steven W. “Mars” World Book online reference Center. 2004. (http//www.worldbookonline.com/wb/Article?id=ar346000)

In 2004 rover Spirit landed in Gusev’s crater on Mars, and in a month Opportunity rover landed in a small crater of the area, named Meridiani Planum. Both rovers investigated the surface of Mars during several Martian years and passed the distance of up to 3 km. They found out that the Martian surface in the place of their work have compounds and chemical compounds, pointing to significant interaction of the water on significant regeneration of water on Mars rocks? Many found by the rovers evidence of existing in the rocks and soils hydrated phases of minerals persuade us that in the past of Mars such processes as hydrothermal activity and salty water reservoirs were widely developed on the surface of the planet.

It is evident that on Mars three conditions are met, that, as specialists consider are necessary for appearance and preservation of life: 1) there are chemical elements, such as hydrogen, carbon, oxygen, nitrogen, i. e. those blocks from which organic compounds are formed; 2) sources of energy necessary to maintain life (solar energy); 3) liquid water. Water, no doubt, was present on the significant part of the planet during its whole evolution, and it exists under the surface at the present time, remaining in a liquid phase (on big depths) due to warming of the internal sources of warmth of Mars. Searches for water and life became the key tasks of many Martian expeditions, performed with the help of automatic stations.

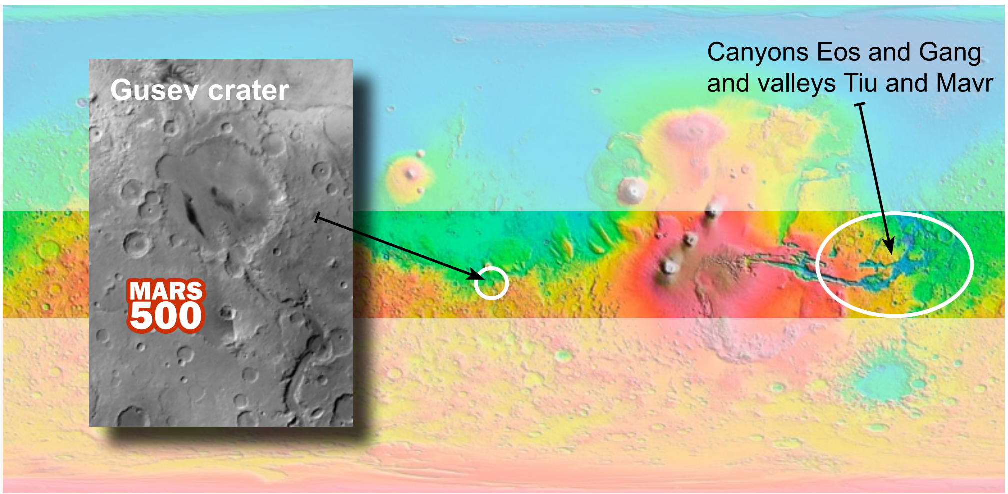
It is evident that during choosing the place of landing for the manned expedition it is necessary to take into account all the peculiarities of the Martian surface, that were described above, and also to determine and range the tasks of the expedition according to the already accumulated information, obtained by automats.

First of all, in the aims of the biggest safety for the landing site it is necessary to choose low enough regions, with possibly thicker layer of the atmosphere above them, protecting from radiation (see fig. 5). This choice shall also take into account existence of extremely cold regions (fig. 8), very dusty open regions (fig. 6), it is necessary to take into account existing of Martian magnetic anomalies (fig. 4), steep slopes and crossed areas. Taking into account all these circumstances, the landing site is chosen, ranging the tasks of the expedition - search for Martian water and evidence of possible life, i. e. organics, or, for example, nature and strange lying of magnetic anomalies. That is why it is necessary to select regions, that have already been investigated by robots and artificial satellites, that performed preliminary speaking and found evidence of existing of water and chemical components, potentially possible for synthesis of organics and existing material.

The most perspective spheres for choosing the landing site are in the latitude belt ±15° with the heights of the surface from 3 to 4 km and below the average zero average level of the planet, corresponding with the pressure of ≈6.1 millibar.

For the virtual landing in the framework of the project “Mars-500” Gusev’s crater has been chosen, named after Russian scientist M. M. Gusev (1826-1866), one of the pioneers of astrophysics.

**Fig. 11.** Areas of the Martian surface, potentially suitable and interesting from the point of view of landing of a manned expedition to the planet. *Credit: NASA/MOLA/GRS*



## The purpose of the stage of Mars landing

Simulation of the crew activity on provision of landing and work on the Mars surface with use of robotic tools as well as computer technologies and virtual reality technologies.

## Main tasks:

- Learning of the equipment of EU-50 module, transfer and distribution of the loads from the reserve storehouse;
- Simulating of the dynamic operations on the docking and undocking the landing module with interplanetary space facility;
- Crew members training with use of virtual and computerized models of crew activity on the Mars surface;
- Simulation of the body liquids redistribution under microgravity before the crew landing on the Martian surface;
- Performance of the permanent crew training using the 3D virtual model of the crew activity on the Mars surface;
- Support and implementation of 3 exits to the Mars surface of the landing part of the crew;
- Remote exploration of the Mars surface with use of real robotic tools;
- Provision of the medical control and program of scientific researches during the activities on the Mars surface.

## Scientific program

4 projects are realized during the work of the crew on the Mars orbit and in the Mars surface simulator:

1.”Investigation of the effects of cranial redistribution of liquids on the state of working capacity and orthostatic tolerance of humans during the work in a space suit on the simulated Martian surface in the ground-based experiment with long-term isolation, simulating a manned flight to Mars”.

2. “Performing of 3 goings out to the Martian surface and its exploration with the help of robotic-technical means (“Gulliver” rover)”.

3. Investigations with the use of the technology of virtual reality (VIRTU).

4. “Approbation of PRET (Performance Readiness Evaluation and Training Tool)” in the framework of “Mars-500” project.

## The crewmembers of the “Martian” landing group

**Alexander Smoleevskiy** (Russia). The landing group commander and the pilot of the lander.

**Diego Urbina** (ESA)

**Van Yue** (CCTC).

**Project №1**

Investigation of the effects of cranial redistribution of liquids on the state of working capacity and orthostatic tolerance of humans during the work in a space suit on the simulated Martian surface in the ground-based experiment with long-term isolation, simulating a manned flight to Mars.

**The purpose of the experiment:**

The objective is to study possibility of human work in a space suit on the surface of the planet after simulation of a previous long-term interplanetary space flight, the last phase of which will be accompanied with combination of the factors of isolation and decrease of locomotor activity with the effects of redistribution of liquids in the cranial direction.

**Tasks:**

– simulation of the effects of redistribution of liquids in the cranial direction and decrease of locomotor activity;

– investigation of the peculiarities of the central hemodynamics and the state of liquids during the combined influence of the factors of isolation with the factors of cranial redistribution of liquids;

– investigation of dynamics of the indices of neurohumoral regulation of metabolism in conditions of the combined simulation of effects of microgravity;

– investigation of the functional state and hemodynamic changes of the abdominal organs in conditions of combined simulation of microgravity effects;

– investigation of the state of the immune system in conditions of combined simulation of microgravity effects;

– investigation of the state of working capacity and orthostatic tolerance during the work in a space suit on the simulated surface of the planet after combined influence of the factors of isolation and cranial redistribution of liquids.

The main influencing factor of the investigations is staying in conditions of antiorthostatic position (ANOP) with the angle of inclination of the body in reference to the horizon of -12°.

For maintenance of liquids redistribution in the cranial direction during daytime activities used modified anti-G suit «Kentavr».

3 crew members, who will land on the surface of Mars, participate in the investigations.

Head down tilt position (HDTP). Baseline data collection before the Mars-500 project launch

Modified anti-G suit «Kentavr». Used in the experiment for maintenance of liquids redistribution in the cranial direction during daytime activities.

**Project №2**

Performing of 3 goings out to the Martian surface and its exploration with the help of robotic-technical means (“Gulliver” rover).

Two landing group members perform going out to the simulator of the Martian surface in space suits “Orlan-E”, developed in Scientific-production enterprise “Zvezda”, that include:

– two space suits “Orlan-E”;

– autonomous system of pressurizing and ventilation of space suits;

– communication device.

As the basic model “Orlan-DMA” space suit has been chosen with conduction of definite improvements, the main objective of which was maximal lightening of the space suit construction.

“Orlan-E” includes:

– the space suit itself with the system of internal ventilation, device for excessive pressure regulation, wire system for the conduction of speech communication;

– aan autonomous system of pressurizing and ventilation for ventilation support and creation of excessive pressure in the space suit (compressor, gas expenditure control, interfaces) are outside the space suit;

– additional equipment, including place for putting on the space suit (cart-training device) and specially equipped place for having a rest;

– individual items (underwear, communication helmet, gloves).

The cover of “Orlan-E” space suit includes:

– hard part (the case and the bag);

– soft parts (legs and sleeves);

– gloves.

The weight of the space suits is 32 kg.

The soft parts of the cover have regulating straps, allowing to adjust the space suit according to the anthropometric data of the investigator.

The bag is the entrance hatch at the same time.

For regulation of the pressure in the space suit there is a regulator of excessive pressure, and for the pressure control there is a manometer.

The standard size of the space suit with individual regulation of the soft cover allows to support the work of the investigators, whose height in standing position is in the interval from 165 to 180 cm.

Regulation of ventilation air expenditure is performed in the range of 0-280 nl/min.

Investigators in “Orlan-E” space suit under excessive pressure of 0,2 atm can move independently on the horizontal surface, perform movements, simulating working operations during EVA: bending, turning, squatting, movements with hands.

The time of work in a space suit during moderate physical loading is up to 2 hours, at this periodical rest is necessary.

*Above:* the subjects are putting on the spacesuits.

*Below:* work with instrumentation in the simulator of the Mars surface

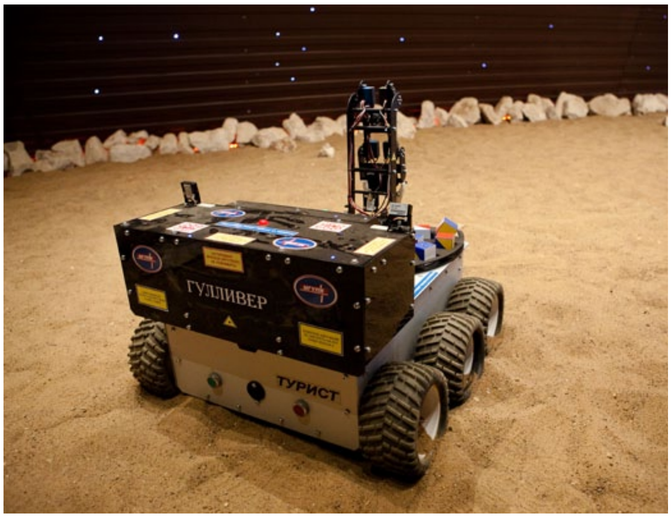
The investigators are resting in the special armchairs.


The investigators are in the simulator of the Mars surface.

The rover is in the simulator of the Mars surface. Development of MGUPI (Moscow State University Of Instrument Engineering And Computer Sciences).


Rover with open manipulator.


View of the program window for the rover control.




Rover "Gulliver", back view. The inscription «Tourist» stands for «remotely operated robotic explorer for land areas».

**Project №3**

Investigations with the use of the technology of virtual reality (VIRTU).

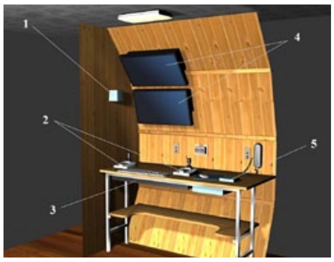
The use of virtual reality for simulation of work on new, not available so far for humans territories is a very promising sphere of investigations. With absence at the present moment of samples of specific equipment, with the help of which landing and exploration of other planets will be performed, virtual reality allows to simulate both well-known specific parameters of the environment of other planets (gravity, lightening, dustiness, etc.) and also psychological structure of activity in new conditions, key operations, that will be performed by the members of expeditions (landing, taking off, works on the surface of the planet, etc.). At this, the person working in the frameworks of the given model will experience real psycho-physical tension, connected with performance of responsible activity, newness effect from working in unusual parameters of the environment, negative psycho-physiological effects of these conditions (lightening, dustiness, changing of circadian rhythm) on perception in general, and simulated off-nominal situations, like losing of one of the crew members in conditions of dust-storm, etc.

**Content of the trainings according to the points of the menu of the program "Virtual reality":**

- Automatic landing on the surface of Mars.
- Examination of the landing site by the cosmonaut.
- Investigation of the surface of the planet with the help of a big Martian rover.
- Investigation of the surface of the planet with the help of a small Martian rover.
- Conduction of drilling operations for searching a source of water.
- Medical operation of help providing for the injured cosmonaut.
- Emergency leaving the investigation site in conditions of meteorites rain.
- Investigation of the surface of the planet in conditions of sand-storm.
- Automatic taking off from the surface of the planet.

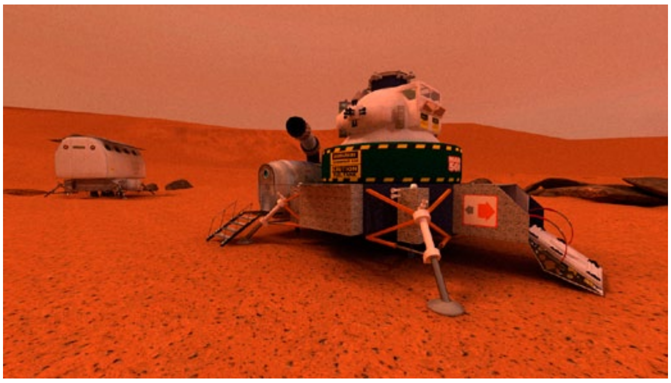
Joint trainings in pair foresee interaction in a group, work of one cosmonaut on the surface in the 3D-mode under observation of the second cosmonaut, directing activities of the operator and giving advice from the landing module of EU-50 (LM) with the use of information from the monitors.

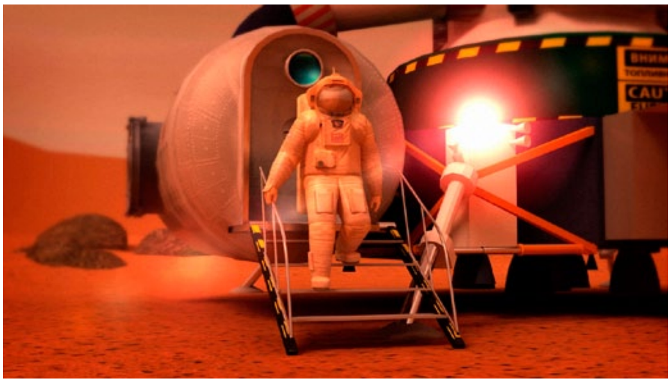
During implementation of the experimental sessions the sensor of registration of physical parameters is put on.



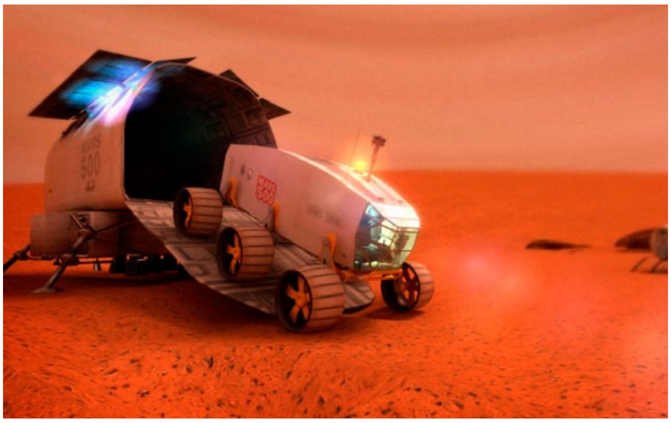
The workplace of the operator for training in the virtual reality inside the landing module EU-50 (development of JC Group).

1 – element of the system for tracking the head movements
2 – joysticks for interactive control of the objects
3 – graphic station
4 – 26" monitors
5 – helmet display system.



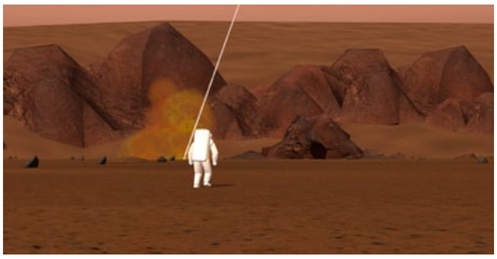


Automatic Mars landing at the site chosen beforehand.
The astronaut performs external examination of the runway facility (performed in 3D-mode with use of special glasses) after landing.



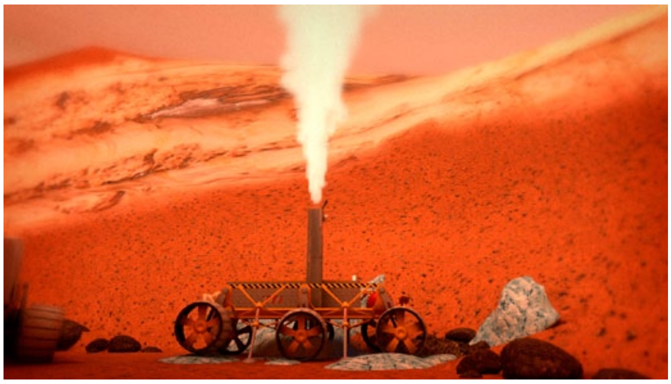
Exploration of the planet surface with use of big rover. Trainings foresee the activity of one of the astronauts as a rover pilot and of another astronaut as a navigator.

The instrumentation panel of the transport rover



Emergency leaving of the research site under meteorite rain conditions.

*On the left* – view of the site for the operator. *On the right* – view of the site through the subject's eyes (blue indicator light shows the degree of proximity to the place of meteorite falling)




**The use of telemedicine technologies**

During the drilling operation the astronaut gets an injury (fracture of arm). Then he falls down to the surface. The second landed astronaut helps him to rise and brings him to the runway facility at the big rover.

Then the diagnostics is performed in the module by mean of the teleconference with the physician of the orbital module with use of 3D laptops including nVidia 3D Vision technology. After diagnosis establishing the medical care is provided, at this a communication session with the Earth (taking into account the time delay of the signal) is performed with use of the telemedicine technologies.

**Project №4**

Approbation of PRET (Performance Readiness Evaluation and Training Tool)" in the framework of "Mars-500" project.

**The purpose of the experiment:**

With the help of computer simulation of exploration trip of the rover on the surface of Mars to perform performance readiness of the crew of "Mars-500" on the basis of the selected indices of performance quality, that is:

• Activity on the rover driving (quality of driving, smoothness of maneuvering, time of the expedition, status of performance of the tasks);

• Results of the cognitive tests, that are implicitly installed into the tasks of the expedition and connected on sense with the scenario of the exploration mission.


Above and below – pictures of the program screen during the performance of the simulating tasks.


**Tasks:**

Simulation expedition PRET consists of 4 main tasks:

1) driving of the rover,

2) control over the energy expenditure on the rover and calculation of the passes time,

3) manipulation with the mechanical "arm" of the rover/ collection of the soil samples,

4) analysis of information and data transfer in nominal and off-nominal situations.

**The next stage of 520-day isolation is the «flight» to the Earth, to the home**

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## «Mars-500» project

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