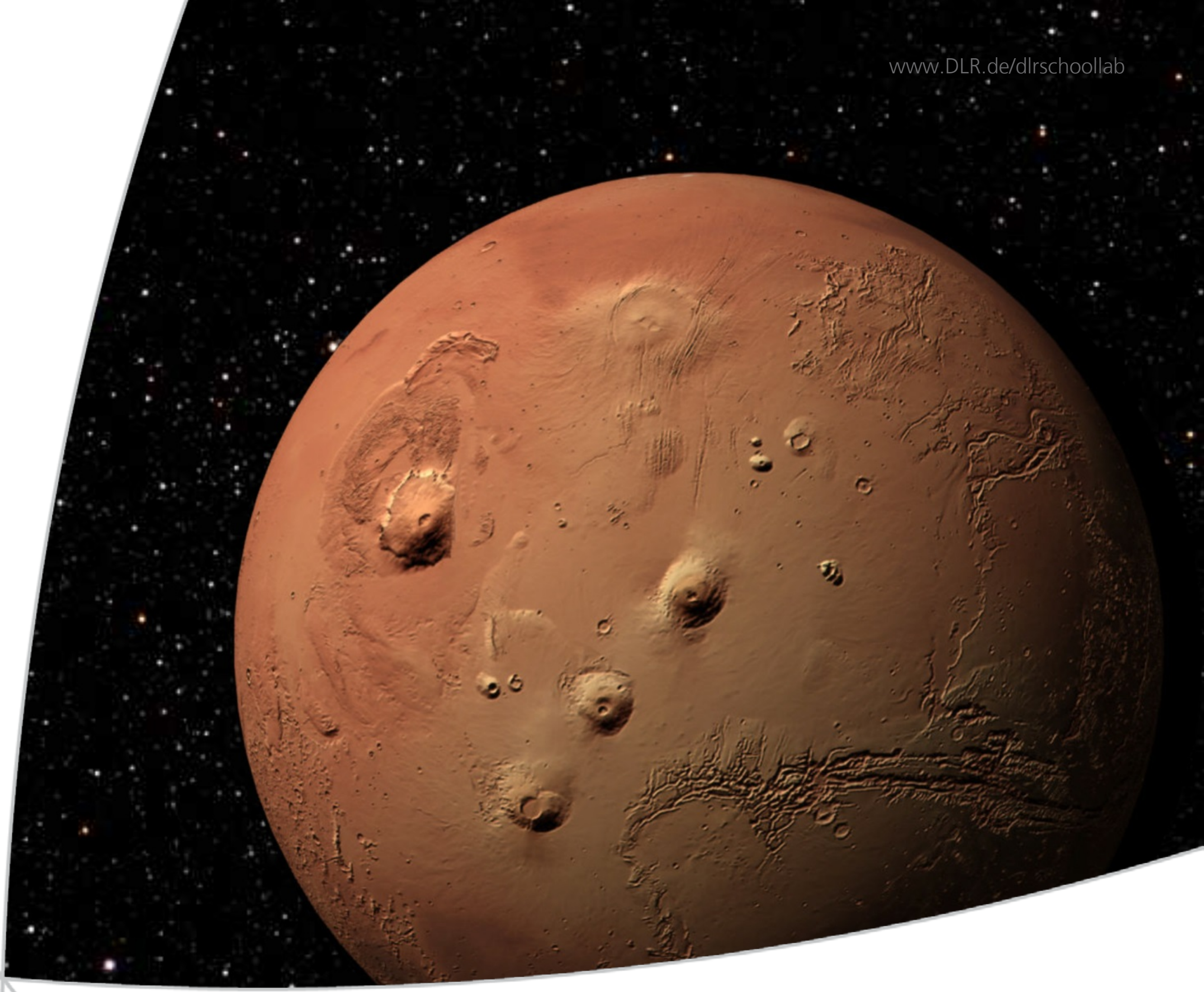
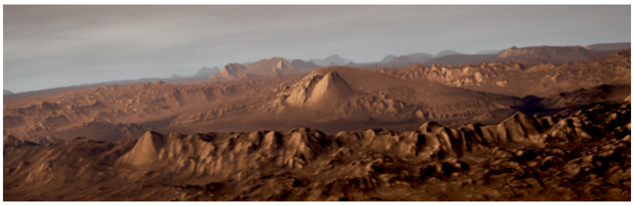


Mission to Mars

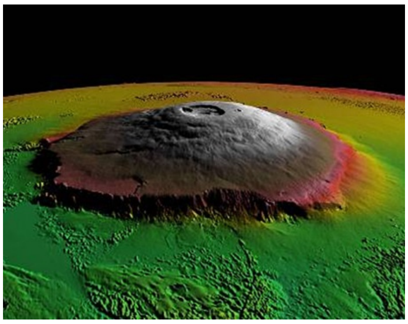
It is the year 2046. Eight months after leaving its moon base and 75 million km later, AQVILA M1, the International Space Agency's space craft, is readying for landing on Mars. In a few short hours, the first human will set foot on an extraterrestrial planet…

Whether there will be a manned Mars mission in 35 years or not…. We shall see. From a technological point of view, it might be possible. But even without having been there, we already have a good idea of what it looks like on Mars. Since Mariner IV flew past the red planet at an altitude of around 10,000 km in 1964, the first probe to pass Mars, a further 23 satellites have sent us thousands of pictures of Mars's surface. Robots have been deployed on Mars successfully five times – each new rover being bigger than the last. The most recent robot to land on Mars was "Curiosity" in August 2012.



The Gale crater, Curiosity's landing site in August 2012 (Photo: NASA)

The surface structure on Mars is much more rugged than on Earth. It has been shaped by a large number of meteorites. Strong storms swirl the reddish brown, rusty dust around. The differences in height are particularly pronounced: because Mars has less mass compared to Earth (less than 1/9 of the Earth's mass), it also has less gravity – only 0.38 g[1]. This means that volcanos were able to build up much higher (and therefore heavier) layers of ash and lava before the ground gave way beneath them. Mars's highest mountain (and an inactive volcano), Olympus Mons, stands at 26,400m – making it three times higher than Mount Everest.



Olympus Mons is the highest mountain in our solar system (the colors in the pictures are false – they are used to show corresponding altitudes.)

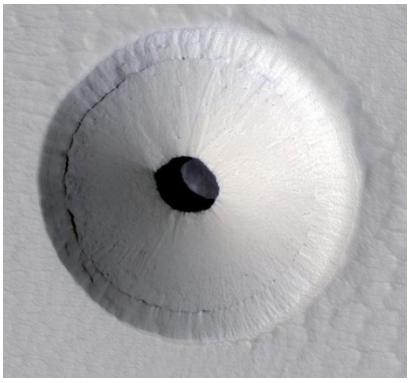
Why fly to Mars?

The planet closest to earth is Venus. Yet Venus is not suitable for a manned space mission. Surface temperatures of around 450°C and atmospheric pressure of 92bar, along with active volcanoes make Venus seem like hell.

Technological circumstances permitting, humans would be able to survive on Mars: Temperatures range between -130°C and +30°C and the atmospheric pressure on Mars is 6mbar. The thin atmosphere consists almost entirely of carbon dioxide. Future astronauts would therefore have to take oxygen with them or produce it through the electrolysis of water. Ice was discovered at the poles e.g. and the marks on the surface suggest that millions of years ago, water flowed across Mars. Most of the northern hemisphere might even have been completely covered by an ocean.

Are there inhabitants on Mars?

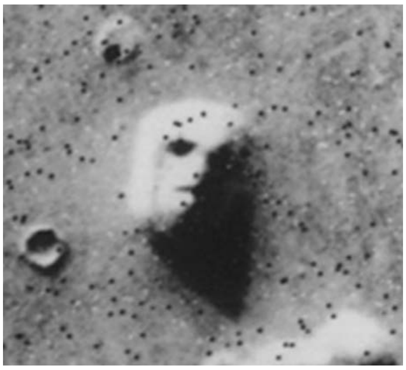
Liquid water is a condition for life – at least for life as we know it. Did living organisms ever exist on Mars or are they perhaps still alive today? Single cell organisms might have survived in crevices or caves that were the results of caved-in volcanic vents. These would offer protection from the cosmic radiation that hit the surface.



"Hole" near Pavonis Mons. The top of a thin layer of lava has broken away and made a cave (Photo: NASA)

In order to explore Mars's surface, we need to land on the planet. Several robots have analysed rock samples.

In 2007, the Phoenix probe searched for organic material near Mars's North Pole – unsuccessfully. We are therefore very curious to see the results that Curiosity will bring us. However, we are not expecting to find complex life-forms. The "Face on Mars" that was discovered on pictures taken by the Viking I probe in 1976 turned out to be an optical illusion.



The famous "Face on Mars" is actually the flat-topped mountain Cydonia mensa. The direction of the light causes shadows to fall that our brains interpret as a face. (Photo: NASA)

Your mission

In the DLR_School_Lab, you will steer a simple Mars robot. The robot is equipped with a camera, lights and various sensors. It will explore the surface of our Mars model. First, get used to the steering. Then, try to find the entrance to the lower level of our model.

Your mission is to draw a map of our Mars "cave" – as accurately as possible. You will be competing against the other groups. As in a real mission, you will only be successful if you work together as a team. Tasks will need to be delegated: Who will be the navigator and steer? Who will become the cartographer and draw the map? And who will take responsibility for the mission and be the commander? One of the commander's most important jobs is making sure the cartographers can keep up with what the navigator is doing. You will see that orientating yourself and drawing a map is not so easy when your visibility is limited.

The model of Mars in Cologne's DLR_School_Lab (Photo: DLR_School_Lab)

[1] in this context, the (unofficial) unit of measurement g denotes Earth's apparent gravity: 1g ≈ 9.81 m/s^2

Comparing the sizes of three generations of Mars robots: In the front Sojourner (1997), on the left Mars Exploration Rover (2003) and on the right Curiosity (2012). (NASA's Mars testing ground; Photo: NASA)

Mars in Dortmund

If you're lucky, then a team in our "remote Mars Station" in the DLR_School_Lab in Dortmund will be doing the same experiment as you are. In this case, you can contact the other students via video conferencing and steer the robot in Dortmund.

Long distance

Dortmund is about 90km away from Cologne. Mars is at least 56 million km away. You will not notice a delay in sending your signal to Dortmund, however sending a signal to Mars will always include a delay of at least 3 minutes for both directions (there and back). Try adding a delay of a few seconds to the programme that controls the robot and compare its navigation to before.

Autonomous systems

You will see that it is not possible to control a robot on Mars in real time. That is why the robot is equipped with programmes that ensure that it carries out tasks autonomously, using data that is gathered through different kinds of sensors. Engineers in the rover control centre on Earth can determine the sequence in which tasks are performed or devise ways in which existing programmes can be adapted to given circumstances. Which commands should be programmed into our robot, if we want it to explore our Mars model without getting stuck somewhere. We also want it to be able to find darker areas on the model's surface and for it to stop above such an area.

How far to Mars?

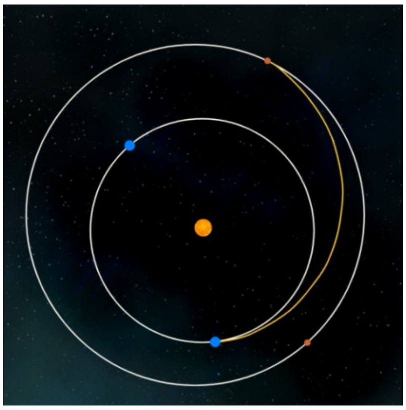
The Moon orbits the Earth at a distance of between 363,000 km and 405,000 km. Because the variation in distance is so small, lunar missions can be planned at almost any time. Mars missions, however, require a lot of foresight.

In the 16^{th} century, Johannes Kepler discovered that planets' orbits are ellipses with the sun at one of both foci. The Earth's orbit is close to being a circle rather than ellipsis, which is not true of Mars' orbit. The distance between the two orbits, therefore, varies enormously. As the two planets also orbit the Sun at different speeds (the Earth orbits the Sun in 365.25 Earth days, Mars orbits the Sun in 687 Earth days), the distance between them ranges from 56 million and 401 million km. So it is important to wait for an opportune moment when travelling to Mars.

Observe the variations in distance in our simulation programme. Mars missions can start about every 25 months. Mars and Earth will be particularly close in April 2018. But we will not be ready to send humans to Mars by then.

Apart from the distance, there are many other things that have to be considered when planning a manned Mars mission in order for the astronauts to be able to return. Read up on the subject here:

http://www.bernd-leitenberger.de/flug-zum-mars1.html
(German only)



The trajectory from Earth to Mars, as demonstrated by the "Mars Reconnaissance Orbiter" (a satellite that orbits and explores Mars). The mission began on 12.08.2005, long before Earth and Mars were closest to each other (19.10.2005). The satellite reached Mars on 10.03.2006, by which time the Earth was about 240 million km away. Over this distance, signals are transmitted with a delay of about 13 minutes.
In this illustration, only the orbits of the planets are true to scale, the size of the planets themselves are not. If they were, you would not be able to see them. (Illustration: DLR)

Links

DLR Institute of Planetary Research:
http://www.dlr.de/pf/

NASA Mars exploration programme:
http://mars.jpl.nasa.gov/

DLR next:
http://www.dlr.de/next/desktopdefault.aspx/tabid-6121/query=mars/
(German only)

DLR at a glance

DLR is the national aeronautics and space research centre of the Federal Republic of Germany. Its extensive research and development work in aeronautics, space, energy, transport, digitalisation and security is integrated into national and international cooperative ventures. In addition to its own research, as Germany's space agency, DLR has been given responsibility by the federal government for the planning and implementation of the German space programme. DLR is also the umbrella organisation for the nation's largest project management agency.

DLR has approximately 8000 employees at 20 locations in Germany: Cologne (headquarters), Augsburg, Berlin, Bonn, Braunschweig, Bremen, Bremerhaven, Dresden, Goettingen, Hamburg, Jena, Juelich, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Oldenburg, Stade, Stuttgart, Trauen, and Weilheim. DLR also has offices in Brussels, Paris, Tokyo and Washington D.C.

DLR Cologne

Aviation, space travel, transportation, energy and safety are the research areas pursued in the nine research facilities at DLR Cologne. The basis of the research and development carried out on site are the large testing facilities such as wind tunnels, turbine and materials test benches and a high-flux density solar furnace. The 55 hectare/ 136 acre site is home not only to the research and administrative facilities of the DLR, but also to the European Space Agency's (ESA) European Astronaut Centre (EAC). The DLR has around 1400 employees in Cologne.

About the experiment:

Recommended for grade(s): 4 to 10
Group size: 5 to 6
Duration: 50 minutes
Subject matter:
- **Robotic**
- **Astronomy**
- **Geography**
- **Physics**

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