**Space station on the Moon of flight to Mars?**

The question if humanity should build a space station on the moon or fly to Mars cannot be answered easily.

The Moon is Earth’s only permanent satellite and interestingly the largest planetary satellite in the solar system relative to the size of the planet it orbits. In comparison to Earth, the Moon’s mean radius is 1737.1 km which is 23.7% of the Earth’s and has only a sixth of the force of gravity. Since the last century humans have been on and near the Moon several times. The first ones to perform a soft landing on the lunar surface were the soviets with their Luna 9 mission. In 1966 Luna 12 was the first to take high resolution pictures of the Moon’s surface. On the other side of the global, the Americans aimed high by setting the task to be the first who set foot on the Moon. In 1969 they achieved their goal with Apollo 11 and Neil Armstrong and Buzz Aldrin became the first human beings to ever set foot on the Moon. Since then 6 successful missions in total were carried out until in 1972 the last spacecraft, Apollo 16, was launched towards the Earth’s only permanent satellite.

Today the far more interesting question is not how to get to the Moon but rather are we alone in the universe. In order to search for extra-terrestrial life, facilities and projects were brought to life which aim to receive or send messages from or in outer space. One of them is the search for extra-terrestrial intelligence (SETI) which is monitoring electromagnetic radiation as a sign of life on other planets by using huge antennas. One of these antennas is located in Effelsberg, Germany. Another institute is the Netherland’s Institute for Radio Astronomy which is forcing a breakthrough in sensitivity for astronomical observations at radio frequencies with Low Frequency Arrays (LOFAR). On the other hand, messaging extra-terrestrial intelligence (METI) sends, as its name implies, interstellar messages and tries to receive such.

When it comes to question where to place a space station on the Moon, the answer will most likely be in the quiet cone on the dark side of the Moon. Due to a phaenomenon which is called tidal locking the Moon spins in the same speed as it orbits the Earth. Therefore, the Moon is showing the observer on Earth always the same side. This leaves a cone on the averted side which is completely shielded against radar light, infrared radiation and other radiation coming from Earth. Thus, this distinguishes it as the perfect location for projects like SETI, a human research station or large optical telescopes.

Moreover, due to the low Moon gravity even more lightweight structures can be constructed and researches without disturbances are feasible.

Nevertheless, before erecting such a space station the material needs to be transported to the Moon increasing drastically the payload of rockets as well as the number of rockets starts. Following this idea even huge antennas raise the number and size of rockets distinctively. A possible solution for this problem would be the use of 3D printing technology which uses solids, dust or any material on the Moon’s surface to create hollowed closed cell structures by melting these components together. Another con for the location on the dark side of the Moon is the lack of power supply and sunlight. This makes the use of solar panels almost impossible. To solve the energy problem nuclear energy might be a solution. Nonetheless history showed us that nuclear energy is not easily handled and unsafe. A promising approach would be to plant the solar panels on a different spot on the moon, e.g. the Mount Malaput, a 2 km high mountain which is nearly permanently illuminated and always front facing Earth, and lay a long cable from the panels to the space station. Furthermore, in the quiet cone no radio connection with Earth is possible. Again, the Mount Malaput could help with antennas facing Earth.

Considering all the pros and cons of a space station on the Moon, the station could enhance the research for extra-terrestrial life, however, it takes a tremendous effort, is difficult and devours enormous sums.

More promising might be a flight to Mars.

But why should we fly to Mars? Reasons could be human curiosity, human progress in order to explore life on Mars or simply the point that a project like this could lead to an international cooperation like previously the ISS.

The constitution of Mars differs distinctively from Earth. The gravitation acceleration is less than half the one on Earth with 3.71 m/s^2, the atmosphere density is 0.02kg/m^3, the average temperature is near -55°C and water is abundant as ice and fluids. Although a year on the red planet takes about two earth years, a day on Mars is just about half an hour longer. And, last but not least, Mars has got two Moons, Phobos and Deimos.

The timeframe for a flight to Mars is a crucial problem. The most efficient way to fly to Mars is the Hohmann transfer which uses the least fuel and takes about 260 days from Earth to Mars. Once the red planet is close enough for landing a direct return is impossible due to the constellation of start and destination. The next date to start the way back is 460 days after arrival. This gives the astronauts a lot of time for exploring. Once the date of return has come it takes another 260 days until the astronauts are finally back on Earth. So, in total a flight to Mars and back eats up over 980 days, nearly 3 years, and 520 of them are spent in outer space.

This has a massive effect on humans. Since there is no gravity in outer space the muscle and bone mass of the pilots decrease rapidly. To encounter these effects a lot of hard training for the humans is necessary and the required training equipment increases the launch weight. So far, the longest time a human has spend in outer space is 437 days and prior missions showed that the astronauts could barely walk after the re-entry of Earths gravity. On Earth human beings are protected by Earth’s atmosphere and magnetic fields against radiation from sun and other cosmic radiation. As a consequence, protective shields are crucial. Nonetheless the risk of cancer is high which would favour middle aged persons. Another important problem is space and boredom for the astronauts. Until now, the biggest manned spaceship, the Orion, offered its travellers 20 m^3 of space. The ISS for comparison has got 400m^3 for six humans permanently living in it. To keep the astronaut’s busy experiments and other activities are required which result in even more payload.

Technical problems are important as well.

Because a direct return from Mars is impossible this eliminates the chance of aborting the mission if technical failures occur or one astronaut falls ill. Moreover, technical support from Earth is limited based on the time it takes signals to be received. Once the Mars is in sight a parachute landing is unfeasible since the Mars’ atmosphere is so thin. Once more alternative landing techniques conclude in a raise of payload. The same as with a space station on the Moon we have no experience in living on a different planet. The long duration of the flight maximizes the risk of technical failures. To tackle this problem redundant systems are necessary and the opportunity to fix them on flight.

All these technical issues can be solved but it takes a lot of time for testing and huge amounts of money.

A promising idea to approach the problem of the huge payload might be to build a colony some time before humans arrive on Mars. This could reduce the equipment and supplies the spaceship needs to transport. It does not matter which solution is the most promising larger spacecrafts are going to be needed. An enormous rocket that already exists for example is the falcon rocket which is intended to go to Mars and has a volume of an A380 jet.

To give an example of the weight distribution the curiosity rover weighed about 1 ton and the rocket had a launch mass of 540000kg of which 90 % are fuel and oxidizer.

The question ought not to be if those plans are feasible but rather if it is worth concentrating on discovering other planets instead of fixing the problems, we already face on our only home planet.