Jamie Woodward, JP

Could humanity become an interplanetary species?

Introduction

As pioneers, humans have always pushed the boundaries of knowledge and exploration. Christopher Columbus sailed across the Atlantic to find the new world; the Romans travelled through the Sahara to find the source of the Nile, and the Greeks marched under the rule of Alexander the Great far into Asia and the Middle East. NASA's goal is to expand our knowledge in the world of astrophysics, to explore space and the potential for human presence throughout the solar system, including on Mars. Mars is still out of reach for humans, but NASA has already sent landers and probes which have taken rock samples and analysed them. In this essay I will discuss the aspects and challenges of travelling to Mars and settling there.

Why humans want to go to Mars

The volcanoes, craters from meteoroid impacts, signs of atmospheric effects and geophysical processes all provide evidence regarding Mars' history. Investigations conducted by ESA (European Space Agency) conclude that Mars once had an Earth-like atmosphere, a warmer climate which leads to the theory that Mars was once hospitable. There is evidence of underground water pockets suggesting that, like Earth, it once was covered in water [2]. NASA have spent the last 4 decades preparing by studying the topography of Mars and searching for a place for the Mars base.

Initial goal: travelling to Mars

Effect on the human body

With the current propulsion technology, today the journey would take 7 to 12 months to arrive at Mars. A major problem with spending this much time in zero gravity is that astronauts' bones would lose density and therefore strength; missions to the ISS (International Space Station) are limited to 6 months. One solution would be to introduce artificial gravity by making the shuttle spin; this would work because Newton discovered that a body would keep moving unless a force acts upon it, such as friction. An alternative is to have the astronauts exercise frequently. On the ISS astronauts are required to exercise 1-2 hours a day. Load-bearing exercises such as weightlifting would be ideal. However, this is not practical in space due to the size and weight of the equipment required as well as the lack of gravity. Scientists have invented a lightweight torsion device that could enable a lot of different exercises such as squats [14].

Scientific breakthroughs are often achieved by studying nature; lemurs are a primate closely related to humans. They hibernate when resources are scarce and the temperature is cold; in this state they do not exhibit muscle deterioration and bone loss. Scientists are studying microRNA and its abilities to control gene expression in a rapid, reversible manner that could aid hibernation in humans [7].

Astronauts are operating in a demanding environment; they need to be alert and able to foresee problems. Multiple factors can lead to mental health problems; one of the leading

contributors is sleep disruption [8] caused by the lack of a twenty-four-hour cycle and exposure to artificial light, especially blue light which inhibits melatonin production [9].

Hostile/enclosed environment

Managing the hostility of the environment is key to a successful Mars mission. In an enclosed ecosystem, illnesses can spread easily between astronauts and make them even more vulnerable to allergies and other viruses and diseases. Astronauts aboard the ISS have observed that bacteria have adapted to become more virulent and are able to withstand both antibiotics and cleaning solutions. This risks the perfect storm of weakened immune systems combined with strengthened bacteria and limited access to medical facilities. Scientists are working on antimicrobial coating, AGXX, which contains both silver and ruthenium and in tests has shown to stop bacteria living on surfaces treated with the coating [10].

Cosmic radiation

The most dangerous thing about travelling to Mars is that there is the possibility that the shuttle could pass through a wave of solar radiation emitted from the sun. Astronauts in space experience ten times the radiation we feel on Earth. The same radiation can cause problems with the electronics on the spaceship. The reason people on earth feel less radiation than people in space is because Earth has a strong magnetic field covering it. NASA are devising ways to check the health and radiation absorption of astronauts living on the Martian surface. Recently NASA has discovered a way to make a radiation suit, but the downside is they would have to wear the suit all the time, including while they slept [5].

A person on the surface of Mars feels 50% more radiation than a person on Earth because the magnetic field around Mars is considerably smaller and weaker than Earth's. Therefore, more radiation can penetrate through it. Within 3 years of an astronaut living on Mars they would hit the limit of the radiation exposure allowed for by NASA astronaut for their entire career due to the risk of cancer. A way to get around this is to cover the Mars base in a layer of frozen CO2 then a layer of dirt [3]. This would block the radiation, but the Mars base could not have any windows so the astronauts would be living without natural light. Although it would protect the astronauts in the base, it would do nothing if the astronauts ventured outside.

Planetary orbits

Mars and Earth's orbits are elliptical, but Mars' orbit is slightly tilted and more elliptical than Earth. This, combined with the fact that the period of orbit differs (Earth 365.25 and Mars 687 days), means that the distance between them is not constant. However, approximately every 2 years the planets are at their closest [11]. Radio waves travel at the speed of light so the one-way latency for a message sent from Earth to Mars or vice vera can take between 3 and 22 minutes [1]. It also creates a narrow optimal launch window when expeditions and supply missions can take place.

The three phases of Mars exploration

Earth reliant

Earth reliance is a stage of Mars exploration where NASA is doing research primarily on the ISS. This includes researching human health and behaviour, advanced communication systems, material flammability, extravehicular operations, life support systems and 3-D printing. NASA has sent 14 probes to land on Mars. The Mars Observer was the first of these,

launched in 1992 to study the atmosphere, climate, orbital rotations and the ground on Mars. Subsequent probes have found underground water pockets, a suitable home for life, organic carbon in the rocks, active methane in the atmosphere and evidence of a thicker atmosphere and more water in the past [12].

Proving the ground

During this phase, NASA will be learning to achieve successful long term, deep space missions and validating the resources they would need to take to Mars. A quote from Elon Musk said that it would take 1000 missions to set up a civilisation on Mars. Some pre-requisites include:

- a series of Exploration Missions (EMs), starting with EM-1, the first integrated test of SLS and Orion
- the Asteroid Redirect Robotic Mission that will collect a large boulder from a near-Earth asteroid, then ferry it to the proving ground Redirect which will allow astronauts to investigate and sample the asteroid boulder
- an initial deep-space habitation facility for long-duration systems testing autonomous operations, including rendezvous and docking and state of the art information technology solutions.
- concepts to minimize resupply needs through reduction, reuse, and recycling of consumables, packaging, and materials
- other key operational capabilities required to become Earth Independent [2].

Earth independent

Earth independence is defined as when a Mars or Moon colony can survive without frequent help from Earth. This would require creating a long-term civilisation on the Martian surface that could run for a long time without people or provisions from Earth.

NASA's journey forward

NASA and partners are already at Mars exploring the planet with probes and landers. NASA has been thoroughly researching the ground through the 14 Mars missions so far. They are developing a plan for the future landing of humans. Their research has concluded that the Martian atmosphere can support microbial life. Huge advancements have been made since the time of the Apollo missions. A quote from a NASA official said, 'this has immense potential for not only science, but for the future of humankind as well.' [2] While exploring Mars scientists have been developing improved rovers that could not only drive themselves but can extract and study the soil.

In the Mars base

Aquaponics

Aquaponics is a way of growing food by using plants to breed fish and their manure could make good fertiliser for the plants. When this is stable, the astronauts could have a fish and salad-based diet while on the space station. However, the ground lacks the vital nitrogen compounds needed to grow plants. Plants also need light and warmth to grow and the temperature on Mars is around –50C too cold for any plants to grow. Due to this we would have to use aquaponics to grow plants. To use aquaponics, we would need artificial lights and heat simulators to breed fish and their dung could supply soil for plants to feed them and the

astronauts. When the fish population is large enough, humans could start eating fish as well. The astronauts would then have a continuous and stable diet [3].

Electrical power

Electrical power is required for communication, lighting, heat and computers. Solar power alone could not sustain a Mars colony because even the weak sunlight that reaches Mars is sometimes hidden by huge dust storms. Geothermal power is not feasible as it requires a huge amount of equipment to bore into the core, and the core of Mars is colder than the Earth's. Wind power is not an option as there is almost no atmosphere and hence no wind. The only viable power source, therefore, is nuclear power which has been proven reliable by the 40 satellites that currently use it.

The dust on Mars

Mars' dust is poisonous to humans because of the chlorine-based compounds such as calcium perchlorate it holds. The levels detected in the Martian soil are around 0.5%, which is a level considered toxic to humans. The dust on Mars is finer than the dust on Earth and electrostatically charged so it would get inside the machines and cause them to malfunction. There are two solutions; the first one is to make better machines that do not let dust inside them, or humans could do the maintenance. The Mars dust would also stick to the astronauts suits and when they enter the Mars base. The solution is to have the space suits that stay outside the Mars base. Each different astronaut would need have their own space suit as all people have varied sizes and to avoid transmission of disease. Rovers would attach directly to the modules so that astronauts could transfer directly to the vehicles without going outside [4].

The Mars base

One idea that has been proposed is that the Mars base needs to be cylindrical because of the artificial atmosphere and the different air compounds in and outside the base and that would put pressure on the walls of the base [3][4]. In consideration of the dirt and frozen CO2 the Mars base would have no windows and would be lit by artificial light. The astronauts would lack the vital vitamin D humans need to survive so they would have to take pills to stay alive. The astronauts would have to have a constant source of food and water inside their base so they can minimise the radiation they receive from the sun. This is one concept for a Martian human base. It includes logistics modules, an astrobiology lab, a science module and a habitat module. In case there was a problem in the base there should be two bases where they have the exact same design so they can live through a disaster.

Conclusion

Mars holds many opportunities for mankind, and it could provide a fresh start. There are still many challenges to overcome, however a trip to Mars is becoming more feasible with each mission and discovery. Once we set up a Mars base, the possibilities are unlimited, we could build a sky hook centred on the Martian moons. We could mine asteroids for their resources. Although there are many challenges yet to solve, I think that a Mars base could be a feasible way to expand our horizons outside our planet [13].

There still lies the question of should we even do this. It will take billions of dollars in resources and the best scientists on the planet to achieve it. The opportunity cost is that those same people are not working to capture carbon dioxide, develop greener transport and other inventions that could help save our planet from climate change. However, space exploration has brought us many advances. Numerous technologies that help us to track climate change

either wouldn't exist or wouldn't be possible without it; notably GPS which is used to track animal migration and satellites which can measure the change in ocean levels.

Given the existential threat of climate change to our planet I struggle to justify that exploring Mars is of a higher priority than saving our own planet.

[1] www.Mars-one.com
[2] https://www.NASA.gov/sites/default/files/atoms/files/journey-to-Mars-next-steps-20151008_508.pdf
[3] https://www.youtube.com/watch?v=uqKGREZs6-w
[4] https://www.space.com/33123-NASA-human-Mars-base-concept-images.html
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[6] https://www.kickstarter.com/projects/oyo/oyo-nova-gym
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[13] https://www.youtube.com/watch?v=pP44EPBMb8A&list=PLFs4vir_WsTwEd-nJgVJCZPNL3HALHHpF&index=13