A permanent colony on Mars in the 21st century?

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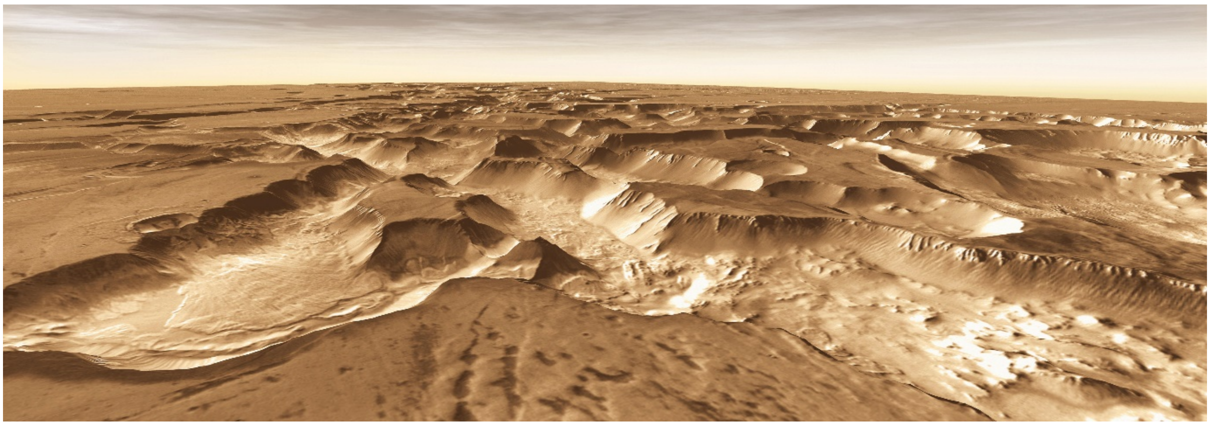


Noctis vista, courtesy NASA.

I'd hesitate to call a colony on Mars in the 21st century 'a Mars colony' for certainly it would be an Earth colony on Mars. There are modest advantages of going to a place with little or no life at all. You don't have to learn the native language, respect the native customs, fight for space, identify the poisonous plants or beware aggressive wildlife. The resources are yours, all yours. On Mars your conscience will be absolutely clear, for whatever you do you won't kill a single native animal, insect, bird, fish or plant. Yes, a few advantages sit on one side of the balance. On the other side of the balance sits the proverbial elephant in the room. There is nothing in the environment directly tailored to supporting life.

When the first homo species evolved a few million years ago they appeared over millennia in a self-sustaining, fully formed biosphere. There was an atmosphere to breath, a hydrological cycle provided rain to water an astonishing variety of vegetation and seas stocked with their own hierarchy of life. Each individual had a microbiome to digest their food of choice or necessity and an immune system to deal with injury and infection. Consciousness may create the sense of 'I' but no animal is an island, and neither are a family or a tribe. We are all interconnected in the web of life, a phrase I've used elsewhere.

Mars has a self-sustaining, fully formed environment too. It's likely been much the same for the past billion years or longer. The atmosphere is 96% carbon dioxide and there's very little atmosphere by our standards. Temperatures are well below freezing on most of the planet for most of the year. Cosmic rays and UV rain down from above, hardly checked. There are no seas, lakes, rivers or rain. The surface is 100% land, mainly dull rusty red, strewn with boulders, sharp rubble, craters, scarps, fine sand in places but no soil as such. Don't even think about going to the frozen polar wastes. The image above is courtesy NASA. No doubt the planet is subject to asteroids straying from the adjacent asteroid belt, cratering random spots, but that is a small inconvenience in the larger scheme of things. Most importantly of all for any prospective colony, there is no biosphere. ‘You’re on your own’ can seldom be said with more validity. I’ve read my share of SF novels set on Mars. In them human life continues much as before but on a different stage. It won’t be like that, at least not for thousands of years. Indeed, the average temperature on the summit of mount Everest is substantially more than the average temperature on Mars, and the air pressure on Everest’s summit is 50 times that typical on Mars. As far as breathing on Mars is concerned, one may as well be in space.

The problem of colonising Mars doesn’t begin on the planet. It begins on Earth. People want to go there now, not in a few centuries time but now. Maybe they want their names written into the history books as the Adams and Eves of Mars. I don’t know. They want to go there without first making the place habitable. I rate the chances of establishing a self-sustaining colony on Mars without serious biological preparation of the site as very slim. People make journeys of exploration that last months but they survive off the land, or the sea, or on a space station they are supplied from base. Supplying from base won’t happen for a Mars colony – it’s just too expensive to ferry the necessities of life from Earth on a regular basis. Of course the first of anything ambitious is expensive, as the enabling technology is developed. Taking the first half-a dozen humans to Mars in one spacecraft is a project estimated to cost over $400 billion as I write this in 2017. Ferrying supplies will be cheaper, but not cheap enough. I’ll come back to this shortly.

Society doesn’t want to send people to Mars without being able to bring them back, which multiplies the logistical problem many-fold. I’m sure it would be possible to stock a medium-sized city with volunteers willing to make a one-way trip to Mars but a one-way trip is not acceptable, at least for nationally funded projects. Changed days. The British government were quite happy to send people on a one-way trip to Australia a couple of centuries ago, never to return or see their families again. OK, even the Australian outback isn’t as inhospitable as Mars but the principle of a one-way trip is the same.

It’s time to look at some of the physical issues. The physics throws up irrefutable numbers and it’s the numbers that wash away aspirations better than an icy shower. Unlike the Moon, Mars is a variable distance from the Earth. It’s at its closest when the Earth overtakes it on the inside track around the Sun. Even then it’s 150 times as far as the Moon. It turns out that this particular distance is not hugely relevant even though people arriving then would experience minimum communication time with the Earth. What counts is leaving Earth so that the journey there is the shortest, when the Earth-Mars distance is naturally decreasing. That turns out to be a journey of more like 1000 times the distance to the Moon. It will take a good 200 days.

Why do we need the shortest time to get there? Comfort isn’t the issue. Health is. Many people could survive a 7-month journey, even in very cramped conditions. On a trip to Mars, radiation is your enemy. Away from the protective shield of the Earth’s atmosphere and the Earth’s magnetic field a spaceship is subject to the very variable effects of the solar wind and cosmic rays. Both are as good at destroying biological cells as radioactivity – in fact better. As ESA says “damage to the human body extends to the brain, heart and the central nervous system and sets the stage for degenerative diseases”. The ball-park figure is that for every day in space an astronaut will receive a year's radiation. On this count, radiation alone is a "showstopper" for the trip to Mars. Radiation is not good for electronics either. The spacecraft will include some shielding but not nearly as much as we have on Earth, provided by our atmosphere. This is as good as living behind four-metre-thick concrete. Life on Earth has evolved in a radiation shielded environment. Even at the Earth's surface you can switch on a small Geiger counter anywhere and hear the click-click-click of radiation that does reach us. In space the clicks will at times blur together into a continuous noise. It's now called 'space weather'. Space weather is very variable, even more so than ordinary weather. Just as you wouldn't sail to Australia in a sailing boat that takes months if the boat couldn't survive a storm, you wouldn't really want to travel to Mars in a capsule that couldn't survive a solar storm. It's likely people will have to, for spacecraft will not have the luxury of four metres of concrete between the occupants and the great outside.

Radiation has a handmaiden who will help quench your will to live. Even forgetting the psychological stress of being cooped up in a can for 200 days or more with probably no more than half-a-dozen colleagues, space (or more strictly microgravity) degrades human physiology. Bone loss in space is typically 1% per month, even with a more prolonged exercise regime than you'd want to do at home. Muscle wastes. Blood and other bodily fluids don't flow properly; astronauts lose the ability to stand up and walk properly. Induced hibernation may be a future option for the psychological stress but that won't solve the physiological issues. Our Mars colonists are likely to arrive mentally fragile and in poor physical shape. Some may be clinically ill. The gravity on Mars is 0.38 that on Earth, which should help but will do little to restore bone loss and muscle loss for a return to Earth. If the trip there doesn't kill them, having to survive on Mars for a year and a half likely will. Fate will have a third opportunity on any trip home.

The small can taking the astronauts to Mars has to provide air, food, water and energy for the crew for say 7 months. That's not an easy problem to solve. Then what? They can't spend just a few days there and, like the lunar astronauts, return by the reverse route. In the time taken to reach Mars, the Earth has travelled to the other side of the Sun from where the astronauts started. Mars has moved in its orbit too, but not as far round. The next opportunity for the reverse journey from Mars will be 500 days later. Life-support logistics are a big problem. 500 days is too little time to establish a food source derived from Mars' own resources. Remember there is no water, no oxygen, no soil as we find it on Earth. There is carbon dioxide for plant growth, in fact more carbon dioxide in the atmosphere than there is on Earth, but on Earth plants need help from the biosphere too, which comes from the soil and water impregnated with minerals, fungi and a pot-pouri of background organic life. 'In situ resource utilisation' is today's buzzword for using natural resources at the destination. It's a tall order for Mars.

One trouble with exploring the solar system is that a spacesuit is essential garb. We can't survive anywhere off-Earth without a spacesuit. Indeed, further than about 20 km off-Earth, a spacesuit must be used, yet you can't do very much in a spacesuit: it's bulky and restricts almost every aspect of mobility. Living in a spacesuit for even days on end would be unpleasant. Without a habitable capsule on hand, you can't change your spacesuit as you would change your clothes. The Earth's atmosphere is our shared spacesuit. It took about 4 billion years to evolve one that allows today's life on Earth to exist on this one planet in the solar system. Humanity is not going to reproduce the equivalent elsewhere in a few centuries.

At best we can build an enclosure that will allow life to exist elsewhere and explorers to take off their spacesuits. In fact, this has to happen if any place is to be colonised.

How big an enclosure is needed on Mars for, say, 8 people to survive, grow food, recycle waste, manage oxygen and water, make things, set up a laboratory, eat, sleep and live when it's on average -50ºC outside (due to comparatively weak sunlight) and there is no breathable air? 8 people couldn't do it on Earth under far less difficult conditions in the sealed enclosure Biosphere-2, which covered over a hectare. There's the additional problem that I've not seen discussed of providing air for an enclosure. Air is so plentiful on Earth that we just take it for granted in day-to-day life. On Earth an enclosure a hectare in area and 5 m high contains 50,000 cubic metres of air, mainly nitrogen and oxygen, of mass about 60 tonnes, of which over 10 tonnes is oxygen. Where exactly is a seed colony going to find 60 tonnes of air on Mars? They could probably get away with about 40 tonnes in that volume but scarcely less, and that's without any contingency for inevitable leakage. It seems to me there is no alternative if we want a Martian colony than to do the homework – establish the basic necessities for life robotically (no air needed, at least for building things) before future colonisers travel there. We certainly haven't the technology to do this at present.

After air, there is no basic necessity bigger than water. Not only is there no surface liquid water on Mars, there is virtually none in the Martian atmosphere either. This means that any melted subsurface ice must be totally contained. A puddle on Earth takes a while to evaporate even after rain has stopped because some water already in the atmosphere condenses into the puddle at the same time as energetic water molecules leave it. No reverse flow of water will exist on Mars unless a free water surface is totally enclosed. Enclosures eventually leak and with the leak water will escape into the planetary atmosphere.

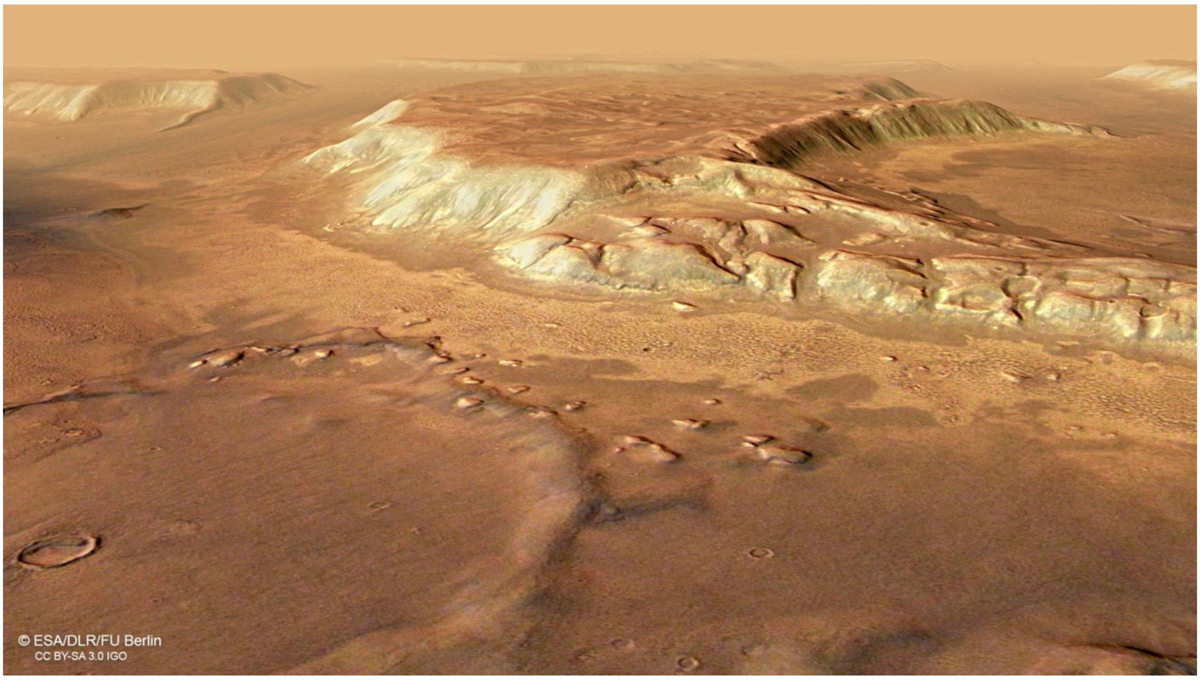
The saturated vapour pressure of water at 10° C is about twice the existing total atmospheric pressure on Mars. To create that pressure of water in the whole Martian atmosphere requires about 330 kg of water in the column of air above every square metre. If a few percent of the whole planet were at that temperature then over 10 billion tonnes of water would need to be released into the atmosphere. That's actually not a vast amount, for a cubic kilometre of water has a mass of a billion tonnes. That amount of water certainly can't be brought from Earth. In fact there is this amount of water sitting on the surface of Mars but it's rock hard and very cold. In the northern hemisphere, the Korolev crater contents alone would be enough if it were turned to water vapour but it sits within Mars' Arctic circle. In summer its surface temperature rises to -30° C and in winter falls below -100° C. Unfortunately for plants, the whole planet isn't at 10° C, for the average temperature is around -60° C. Only near the equator in summer does it get above freezing. Mining the Korolev crater for water is mainly going to spread its ice over the planet as any evaporation re-condenses as ice elsewhere. Red Mars morphing to green Mars? Only on the computer simulation screen in this century and probably still so in the next few centuries. Another 'blue marble' in the solar system in future? Mars will need surface liquid water to keep it green and enough water vapour in the atmosphere. On a timescale of centuries, Mars will stay too cold for either of these and human presence will do little to change that over the planet as a whole. In the long term, Mars gravity is too weak to hold water within the atmosphere, which is why there is virtually none there now.

You may say that because there is no oxygen in Mars' atmosphere, maintaining an oxygen environment is just as critical as maintaining water in the atmosphere. At least any oxygen put into the atmosphere won't condense out but more water is needed for life than oxygen. Averaged over a day a person may use about 1 litre of oxygen per minute, mass barely 1.5 g. Over a day that's about 2 kg of oxygen. 500 day's supply for 6 people adds up to 6 tonnes, too much to bring. In fact, a good bit more is needed, for people aren't going to be wearing space-suits all the time. Oxygen can be created by means such as the electrolysis of water or even in principle extracting it from atmospheric carbon dioxide or from Martian rocks. People also drink about 2 kg of water a day, though most of that is recoverable. The big problem is plants. Plants are needed for food and a colony needs plants for a balanced ecology. A large tree creates enough oxygen for several people to survive but a large tree consumes a few hundred litres of water a day. There is carbon dioxide in the atmosphere but plants in general need a lot of water. Algae are the best bet for carbon dioxide to oxygen converters but they live in water.

In short, I see water as the biggest problem to solve before any habitation worthy of the name 'colony' is established. Having said that, at least there is water on Mars, if it can be unlocked; likewise for oxygen. There is absolutely no food whatsoever, anywhere on the planet. Dehydrated survival rations (not exactly 'food, glorious food') for the round trip is going to come in at about 1 tonne of mass per person, assuming water is available. That's just too much extra mass, and you need the technology to make full use of urine and faeces, technology that we don't have at present. Growing food has to be part of the package but it's a hard way to create usable energy. Speculating that in the reduced gravity of Mars a person might need 2500 Calories per day, equivalent to about 10 MJ. Mars has haze but not much cloud so a solar panel of 4 m^2 could provide that energy on most days for a robotic explorer. Providing for a human explorer is a different matter altogether. Humans certainly will need a 'garden' very, very much larger than 4 m^2 to supply food, the problem made harder by the average temperature being many tens of degrees below freezing. Expose the garden by accident to one night of Martian temperatures or to winter temperatures and any transplanted food plants we know about on Earth will be frozen to death. Even getting a garden started will be a challenge. Planting seeds and sprinkling with a watering can won't work. Martian soil not only lacks the biological ingredients of Earth's soil but it is toxically impregnated with salts. A self-supporting base-camp on Mars without prior preparation – you have to be kidding.

The radiation problem experienced on the journey there doesn't disappear upon landing. Mars' tenuous atmosphere and lack of magnetic field mean that really significant effects of the solar wind and cosmic rays reach ground level. Without sheltered accommodation, astronauts would receive more than a century's worth of radiation in their 500 days there. That's on top of the radiation experienced in getting there, which will be more than this. The 4 metres of concrete, or the equivalent in Martian stone, will be needed. Living in a lava tube may appeal to our distant ancestral caving instincts but lava tubes are more like burrows and we really need a totally sealed enclosure where we can remove our spacesuits and at least see the outside world. I should also mention the all-pervasive fine dust. It's whipped up by the Martian winds on a small scale into 'dust devils', on a large scale it can at times envelope the planet for months. Forget the expansive vistas seen on all satellite photos. What can you explore in a sand storm, one that goes on week after week? With no rain to clean the atmosphere dust eventually gets into everything and coats solar panels. I suspect that, like moondust, it will be a potential hazard to health when brought inside living quarters on equipment and on environmental suits. It won't stop the show but dust will be a persistent irritant.

A real show stopper will be the accidents that on Earth might be almost brushed off but on Mars will be fatal. You may be on Mars for 50 million seconds before you can leave. A loss of concentration for a few seconds and you stumble and tear your space-suit through on a sharp rock or broken piece of metal. Within 2 minutes you will be a horrible, bloody, mess, as dead as you would be had your suit failed in space. What's the chance of that happening in any second? One in a million? If it's as big as that, you won't survive. If there was an environment on Earth truly like that on Mars, no-one would go there, or at least no-one would want to live there for any length of time.



Perspective view of Deuteronilus Mensae, a table feature left by former ice flows: courtesy ESA

There's another piece of physics that needs to be looked at, related to the cost. How much energy does it take to get from the surface of the Earth to the surface of Mars? Never minding the cost of making the hardware needed, every mission to Mars has to climb out of the gravitational well of the Earth and slow down as it gets into the gravitational well of Mars. Both exercises take fuel, lots of it. In fact it's a lot worse than that, for to get to Mars a craft also has to climb some way out of the much deeper gravitational well of the Sun. To climb out of the gravitational well of the Earth needs about 60 MJ per kg of mass. There is little escape from this requirement, though launching from near the equator at the right time of day gives a craft a start of about 0.4 km s^{-1}. This is about 3.6% of the escape speed, but only 0.13% of the escape energy required.

Mars is some distance higher up the Sun's potential well but is travelling slower than the Earth. The total energy of unit mass in Earth orbit is $-GM_S/2a$ = -445 MJ and in Mars orbit -293 MJ. The difference is 152 MJ kg^{-1}, which the thrusters have to provide. Suppose your craft is now effectively free of the Earth's local gravity, say 1 million km away cruising in a similar orbit around the Sun. It's in an analogous position to a satellite in low Earth orbit that needs to move to medium Earth orbit. In this case, think of the craft in low Sun orbit wanting to move to medium Sun orbit (Mars). The minimum energy solution is to initiate a Hohmann transfer orbit (see the piece on 'orbits'). Approximating Mars to be in a circular orbit 1.524 as large as the Earth's ($\rho = 1.524$ in the notation of the 'orbits' piece), then an ellipse of eccentricity $e = 0.208$ and $a = 1.89\times10^8$ km will get the craft into Mars orbit. Of course this by itself is not enough. The timing must be such that Mars is close by! The detail can be calculated from the 'orbits' information. Two Δv thrusts are needed, changing the speed of the craft. The first gives the craft a Δv of 2.93 km s^{-1}, taking an energy of 92 MJ kg^{-1} and the second a Δv of 2.64 km s^{-1}, taking an energy of 60 MJ kg^{-1}. The two bursts create the 152 MJ kg^{-1} needed. The transfer from Earth orbit to Mars orbit can be done in less time than the connecting Hohmann orbit but that will take more energy. In practice the eccentricity of both planets' orbits must the taken into account.

How much energy is 152 MJ kg^{-1}? Compare it with the energy of climbing uphill on Earth. Climbing 1000 m takes about 10 kJ per kg. 152 MJ per kg is equivalent to climbing a mountain 15,200 km high with gravity as strong as it is at the Earth's surface. That's not the end of the story, for having got say within 500,000 km of Mars the increasing pull of that planet speeds you up so that more fuel is needed to slow the spacecraft down. To appreciate the predicament of an approaching spacecraft, imagine standing on a giant tower on Mars and throwing yourself off. What next? You'll start heading for the ground, at ever increasing speed. Terminal velocity on Mars can be calculated as around a quarter of a kilometre per second for a falling person (not experimentally verified). Enough said. Unmanned probes have the luxury of being able to use aerobraking over months but since time is of the essence with a manned probe this isn't an option. Mars may not have much atmosphere but slamming into it at several km s^{-1} is not a survival option. Aerobraking needs an extended but gentle touch in the high atmosphere. A back-of-the-envelope calculation for the drag afforded by Mars atmosphere (ground level density about 0.02 kg m^{-3}) on a parachute is not good news. If you want to support a 10 tonne load at a landing speed of 1 m s^{-1} then you need a parachute at least 1 km across. That's not 'on'. Fuel needs to be carried for retro rocket firing, adding more weight to the Mars package.

Plenty of probes have been to Mars, so what's the problem? Unmanned probes are relatively small, about the mass of a small car including onboard manoeuvring rockets and fuel, batteries and solar panels, communications equipment and a modest number of remotely operated sensors and instruments. The most successful Mars lander to date has been the *Curiosity* rover, mass about 900 kg and cost of mission 2.5 billion dollars. It used retro rockets to land. Unmanned probes clearly have no life support systems, few emergency recovery and safety systems and if they do crash and fail like Beagle 2 then no-one dies. My first conclusion is that even sending equipment to Mars is expensive and the safety record for unmanned missions isn't great. Sending people is a 'different ball game'. NASA is developing its Orion Capsule, mass about 10 tonnes that should get astronauts to the Moon but is too small to get them to Mars. It will need the addition of a crews' quarters module, too big to be sent up in one go and needing assembled in space and, of course, the rocket engines and fuel to climb further out of the gravitational wells, the Sun's in particular. If I were planning the mission, I'd take a leaf out of Christopher Columbus's book and send two or three craft more or less together, for just as you need redundancy in mission computers and critical components, so a manned mission needs some redundancy in human expertise. Accidents and misfortune will happen. Guaranteed.

The scale of the enterprise needed is determined by the Tsiolkovsky rocket equation. It is this that dictates that most of the mass you launch is rocket fuel. The Saturn V rocket that took a crew of three and their equipment to the Moon and back about half a century ago had a laden mass of almost 3000 tonnes. It's true that the on-board computers were bulky and inefficient by today's standards but they were a tiny fraction of the mass. The Saturn V's engines were impressive. Today's as yet untried Falcon Heavy lift rocket, one of the current hopeful developments as I write, has half the mass of a Saturn V and less than half the thrust. Yet there is no way the Saturn V could have taken people to Mars, or even cargo. It didn't have enough fuel. NASA's Space Launch System, classed as a 'super heavy lifter', is the logical development of their decades of experience. It will match or exceed Saturn V's performance. If funding continues at the present rate of over one billion dollars per year, it still won't have taken people much beyond the Moon by 2025 and is unlikely to have sent a sizeable craft to Mars by 2030.

People talk about sending supplies to Mars as if it were as easy as putting goods on a lorry. The reality is very different. Considering size issues as much as energy, it is better not to start from the surface of the Earth. Assemble your large Mars transporter in orbit using many launches and then leave. The Moon's escape energy is only 4 MJ kg^{-1}, though you also need to expend this amount of energy to slow down to land your equipment on the Moon. Assembling on Moon therefore takes about 8 MJ kg^{-1} more than assembling in orbit, which is small compared with the overall energy costs. The convenience may be worth it and the starting point is most of the way out of the Earth's potential well.

Getting back from Mars will be perhaps an even worse nightmare for astronauts than getting there. After pages discussing the problems of sending people to Mars it's tempting to say just 'and there's the problem of getting back' and leave it at that. It hasn't been done yet for even the smallest rock-sample capsule. You might think that having climbed out of Mars' gravitational well (only 6.7 MJ per kg needed) it would be downhill all the way to Earth. It is. Basically you have to get rid of 152 MJ kg^{-1}. Even then, you will arrive like a meteor with the likely scenarios of either bouncing off the atmosphere like a stone skimmed over water or burning up if you haven't got your aerobraking exactly right. You need pretty well as much rocket fuel to slow up while coming back as you do to get there. That fuel is not likely to come from 'in situ resource utilisation' on Mars, at least not with only 500 days of minimal rations with minimal supplies at your disposal.

Prior preparation on Mars is essential for survival. I doubt if any explorers who reach the ground in my lifetime will survive long enough to return, or indeed have the means to return. They won't colonise.

One of the troubles with exploring the rest of the solar system is that there is a natural tendency to see places anthropocentrically. We look at the apparently familiar but sometimes weird landscape of Mars, think how it might have been formed by processes we understand on Earth and pigeon-hole it as like the Earth but a bit different. 'Different' doesn't faze us. Humans can live in icy wasteland or subtropical deserts, so it becomes a small step of imagination to see ourselves living on Mars. Maybe we can, but it's no small step.

Parachute in, fire your retro rockets to arrive safely, step out of the capsule but there will be no hunting, shooting or fishing to live off the land. We can’t live on Mars as it is, only on some of it as it might become. The word that must not be spoken among the conservation conscious is ‘terraforming’. Terraforming will mean not only modifying the land but creating surface water and changing the atmosphere. Objects fall a bit slower on Mars but nothing can truly fly, not even drones or balloons, at least nothing larger than tiny dust grains until atmospheric pressure is made a lot nearer to that on Earth. That won’t happen for centuries, if not millennia.

All the talk in the air as I write about sending people to Mars has come at a time when ‘robotic’ exploration can be very much more sophisticated than anything in the 20th century. That coupled with today’s and tomorrow’s more sophisticated instruments really knocks the bottom out of the argument that people can explore much better than machines. Even with ‘robots’, it’s not really the machines that are exploring but the designers and controllers at home base.

The scientific rationale for human presence is that human exploration is better than robotic exploration. On Earth that’s true. You can pick up the soil and run if through your fingers, smell the vegetation, hear the wildlife, compare the surroundings with decades of experience, discuss with companions and make instant decisions on what to do next or where to go. In a spacesuit, pretty well every sensory feeling is remote and movement of arms, legs and body is quite restricted. Standing on Mars in your spacesuit, are you really getting much more information than a robot could supply? Indeed a robot can be equipped with telephoto eyes, infrared and ultraviolet vision, ionising radiation detectors and a raft of quantitative sensors in place of a human’s qualitative sensors. Little atmosphere, no water, no food, too much radiation? No problem. The robot will cope. In short, human biology is great but it’s not the tool for front-line exploration off-Earth.

Another Earth related point is ‘how many people does it take to maintain a hi-tech community? A Mars community will necessarily be hi-tech. When the medicines run low will it have the facilities to make more, or send the injured and ill to medical scanners? When the micro-controllers in the environmental systems and 3D printers fail, will there be facilities to make replacements? A high-tech society is underpinned by hundreds of thousands of people, people we never meet doing their specialist jobs in facilities built by hundred of thousands of others. I’d be really surprised if a self-sustaining Mars community could be established in less than several centuries.

Given today’s technology as I write, the right people could probably explore better on the spot if they were magically transported there but, in the absence of magic, for the cost of sending half-a-dozen people to Mars whose first page of priorities will be simply keeping alive, a suite of amazingly complex robotic missions could be funded. There would be no need to bring them back and no-one would die. Such a suite won’t get funded in lieu, of course, but it highlights that the reason for people going to Mars has little to do with Science. It’s motivated by ambition in a broad sense that includes psychology, politics and sociology. It was more or less the same for the Moon landings, where Science was about 5% of the mission. As I mentioned at the beginning, people may be spared the moral dilemma of killing the local wildlife but colonists won’t be spared the dilemma of modifying the landscape and erasing evidence of some earlier solar system history that is inaccessible on Earth. It’s been argued that we should mine the knowledge Mars has been keeping for us, before we contemplate colonisation.

Mars is not just an exotic extension of the Earth. We take for granted, often too much for granted, the enormous diversity of life on Earth. This diversity is not matched by anywhere else we know about in the universe. Once the novelty of walking on Mars has passed, the boredom of landing on a sterile planet will take over. I suspect that every astronaut on the first trip to Mars will look back on Earth from 1000 km away, see the stunning white, blue and multicoloured ball of the Earth that has been a cradle of life for almost 4 billion years and think “I really must have lost my senses to be leaving Earth for dead and lifeless Mars”.

My conclusions are that a permanently manned colony on Mars in the 21st century is unlikely to happen, even with all the well-funded ambition now in evidence. The physical problems are too great. Unlike the Moon exploration, the most likely scenario is that a few will go to Mars and if they succeed in landing will likely end their lives there. Elon Musk, multi-billionaire CEO of the private spacecraft developer SpaceX is a Mars fanatic who would like to send thousands to Mars and has said he would like to die there. On the second count he of all people may get his wish. On the first count, I’d bet that he won’t. A ‘permanent’ colony on Mars in the 21st century? My guess is that tens of thousands will have the opportunity to explore Mars before the end of the century but it will be through the technology of virtual reality from the comfort of Earth. No lifting the rocks to see what’s underneath but with enough finely detailed images, anywhere can be explored. I don’t like being a naysayer but I think a Mars colony is pretty unlikely. It’s a good bet that someone will die on an early manned mission to Mars. After the first bodies are buried on Mars, the price will be seen as too great, adequate preparation won’t have been done and the public won’t be willing to fund it. As astronomer Martin Rees has said, going to Mars “*is a dangerous sport*”, not a tourist trip - probably not just ‘Formula 1’ dangerous but ‘Colosseum gladiator’ dangerous, in its own way. Almost half a century after the Moon landings we haven’t got a lunar colony and the cost of creating this is small compared with establishing a permanent colony on Mars. Will Mars ever be inhabited? I can look out of the windows of our house over a wide expanse of sea, stretching to the horizon and far beyond. I’m pretty sure it will be thousands of years before any human can say that on Mars. Will Mars ever be inhabited? Of course, but beginnings are always the hardest.

JSR