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RADIATION RISKS –

THE REALITY AND THE HYSTERIA

Owen Louis David *examines what are the radiation risks of a Mars Mission. Will Mars pioneers be risking their lives or do we know how to protect them and ensure they remain healthy?*

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FLIGHT 7 – THE LOWDOWN

Good news and bad news. How bad? What will be the impact for the Mars Mission? Find out in our update on Starship's Flight 7.

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MARSWORLD –

THE CULTURE OF MARS

OK, we may think we've got the technology right but what sort of society will be created on Mars? *A fascinating article that looks at the arts, architecture, interior design, sports and festivals we can expect to see in a colony on Mars.*

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LATEST WEATHER AND IN THE NEWS

Check out the latest weather on Mars (in Gale Crater) and hear what was new in the world of tech and electronics at the CES show in Las Vegas that might be relevant to Mars.

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MARSWORLD – THE CULTURE OF MARS

Owen Louis David gives an overview of Chapter 5 in his book Marsworld which is focussed on the culture of a Mars colony. This is a wide-ranging chapter focusing on language, arts, architecture, festivals, and sports.

Let's start with that most conspicuous of home sapien attributes – our ability to communicate through speech. What language or languages plural will be spoken on Mars?

English is almost certainly going to be the principal (and official) language of the colony. There are many reasons why. Firstly it looks very likely that the colony is going to be established by an American company with US citizens as the main component of pioneers and early colonists. But, in addition to that foundational fact, English is already well established on the home planet as the language of science, of academia, of the artworld, of medicine and of business. Moreover, it is the first choice as a second language for those who do not speak it as a first language – it is Earth's "lingua franca".

Of course, it will be American English that will be Mars's language but just as American English was an offshoot of British English, so we can expect a distinct Mars English to grow out of its American English roots. There is already a Mars lexicon e.g. *sol* to refer to what we call a day on Earth. That will expand hugely once colonisation gets under way.

We have come to associate science and technology – rockets, rovers and robots – very closely with Mars and the idea of creating a second home for humans on Mars. It is certainly true that in the early years, the emphasis will have to be on material technology since that is what is going to be keeping humans alive in what would otherwise be a fatally hostile environment. But in this Chapter in my book I make the case that art has, throughout the history of our species, been absolutely vital to our individual and social development.

Looking back at our evolutionary path, we can see that the quite sudden development of the symbolic world of language can be interpreted as creating a kind of chaos. Whereas before, as part of the animal kingdom, there was a direct and unself-conscious connection to the physical world now we had to make sense of this limitless symbolic reality around us. We can think of art as an answer to, an ordering of, that chaos. Perhaps it began with communal dancing – the stamping of feet before a hunt , a kind of "team talk". Then there must have been beguiling narratives told around the campfire, which were passed on from one generation to the next, being elaborated upon along the way. Meanwhile, in caves and on rock faces, ochre and other pigments would be carefully applied to create representations of the world they experienced – the animals and the landscape.

Music and song would have been central: shaking of gourds, drumming on tree stumps, bone flutes making eerie sounds. People would have danced to the music and song. Still today we understand from rock concerts how that can create a euphoric feeling of great solidarity as we move together to the same rhythm.

So art was born. Once human society learned how to pursue agriculture and domesticate animals (the neolithic revolution) art then became a vital element in social solidarity in the huge empires (Sumer, Egypt and so on) with their millions of people that soon followed the creation of large food surpluses. Now we were in a new era of huge disparities in wealth and power within societies and war between empires. Putting your life on the line in some far-away place doesn't come naturally to the average person. Empires needed to manipulate their populaces, in order to support the governing elites. Martial drumming, praise songs, vivid wall paintings and reliefs and commanding architecture were all pressed into the service of these empires.

Art in all its many forms (we are not talking just high art here of course but also the art of TV soaps and dramas, advertising billboards and magazines) is vital to social functioning. Since the Dada movement of the early 20th century art (high art at least) has misleadingly become identified with the rebellious spirit and the cult of innovation. That perhaps blinds us to the fact that art in all its many manifestations still remains something that glues society together rather than renting it apart. I suggest we can safely assume that art on Mars will be not be fundamentally different from art on Earth but it will be fundamentally important.

Art will have an especially vital role to play in humanising the Mars colony. In the absence of the sort of direct contact we have with the "outdoors" on Earth, the indoors becomes even more important. I argue that the interiors of the Mars city need to be high spec, using natural materials like wood, bamboo and polished stone. There needs to be lots of visual stimulation – paintings and sculptures, mobiles, photographs, mosaics. Within the city with its connected habitats there needs to be a distinctive character to our journey as we walk through the settlement. For instance there might be sound galleries offering different acoustic experiences: birdsong, abstract noise, gentle music, water sounds and so on.

Through the thick glass windows of the Mars city we will be able to glimpse the Mars landscape. These outdoor spaces can be made aesthetically pleasing. Perhaps you can have a Japanese gravel garden in one location or a lush greenhouse at another or there might be a sculpture park. In the distance, on a hillside perhaps we can see a huge figure – something along the lines of the Uffington Horse or something like the Hollywood sign. There need to be icons everywhere!

Culture includes sport as well as art. What sort of sports will people play and watch on Mars? I argue in the book that non-contact sports will be favoured over contact sports. With a chronic labour shortage on Mars (for the foreseeable future, after the first landing, there will be more things for people to do than the people to do them), it will make no sense to see people being hospitalised or unable to work after engaging in sports such as boxing, rugby, or American football. Another constraint will be that large stadia will not be feasible, at least for several decades.

Taking these factors into account, it seems highly likely (given the likely American roots of the colony) that basketball will be the most

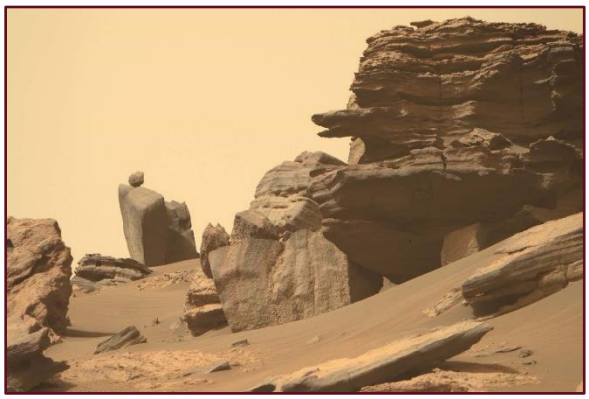
favoured sport though the hoop may need to be higher and the ball might need to be heavier. Others sports such as tennis and badminton could also thrive. Swimming and rock climbing will probably be highly popular as competitive sports. I think aqualung diving could be very important – the ability to explore an artificial coral reef, perhaps with robo fish in the early stages. It will be a good substitute for "an outdoors" – a distinctly different world, the underwater environment. One can imagine underwater treasure hunts being organised on a competitive basis.

In this Chapter I also look at what a calendar for Mars's year (which comprises roughly 670 sols and 687 Earth days) might look like. It seems reasonable to assume there will be festivals that mark the passage of time but that they will not have a religious character. After all, the colony will include people from numerous different faith group background. It would be invidious to choose one religion over another and impractical to attempt to give recognition to what might be 100 religious festivals. There is also the difficulty of synchronizing the Mars year with that of Earth's. You would often end up with two Christmases (and even three Ramadans on occasion) in the same year.

So I suggest that the community will likely choose the winter and summer solstice and the two equinoxes for major festivals. The winter solstice period would also mark the New Year, No doubt other festival days would be chosen to mark events such as the first landing of humans on the planet, the foundation of the big city, celebration of the arts on Mars, perhaps a Pioneers Sol to celebrate those who laid the foundations for the colony and so on.

Speculating about Mars's cultural future is fascinating, I feel. I would encourage others to do so. It helps us build up a realistic concept of how the city will function and I think it brings to the fore some key requirements, such as the need for high quality interior environment with many leisure activities on offer.

PICK OF THE PICS



Credit: NASA

This is a great image from Jezero crater taken by the Perseverance Rover. Who wouldn't want to go exploring there? Thanks Emile G for sending this in.

Do send us your favourite Mars pics!

Radiation: realities v hysteria

By Owen Louis David

When debating the risks of Mars colonisation online, you quickly discover that the people opposed to Mars colonisation, the ones I call the Stay-Putters often seem to think that radiation is their trump card. ***"You won't be able to live there. You'll die from the radiation. Your gonads will get fried. You'll become a mutant."*** **That sort of thing!**

Given how weak the arguments of the Stay Putters are – often little better than conspiracy theory prattle aimed at Elon Musk who has become their bête noire – you can see why they feel this is their ace to play. It sounds like a rational concern. So from their point of view, this is their winning card.

But is it?

How serious are the risks really? Are the opponents of Mars colonisation playing fair with the evidence?

Before we get into the meat of the subject, a bit of disambiguation as they say on Wikipedia. Whether deliberately or out of carelessness on their part the anti-Mars crowd frequently elide facts that should be kept carefully separated. For instance, you'll often find that colonisation opponents fail to distinguish between radiation experienced by humans during transit (travelling in a space rocket to the Red Planet from Earth) and radiation on the surface of Mars itself. They like to bandy around the figure for transit because it's higher without making it clear that this doesn't apply on the surface of Mars. So, beware! = bear in mind we always have those two radiation realities, one for the time spent in transit and one for living on the surface of Mars.

Further confusion arises because the Stay-Put community don't acknowledge the effect of protective measures when discussing radiation risks What you get more often than not is the raw no-protection figure. They much prefer to talk

as if you will be running around the surface of Mars naked (rather than spending most of your time in a well-protected hab, possibly with a further, non-cumbersome, protective suit on). To listen to their dire predictions and prognostications, it's as if the makers of the Starship are somehow going to forget to integrate any anti-radiation protection into their design! Really, if they want to engage in sensible discussion about the radiation risk, they should be using *net* figures ie taking account of radiation protection.

Next, they like to talk up the frequency of solar events such as coronal mass ejections and solar flares and use that as a kind of benchmark. Such events should be seen as very much the exception, something for which we can plan and put in place emergency arrangements (radiation "storm shelters).

So with those distinctions in mind, let's look at what the radiation risk really is. For some baseline information: the average level of radiation on Earth is something like 2.6 millisieverts (mSv) per annum – there are varying estimates but this one seems to be quite widely quoted. By contrast the average for Mars is around 230 mSv per annum.

What about transit? NASA used the transit to Mars of the Curiosity Rover to assess radiation levels. They calculated the total dose - solely for the cruise phases to and from Mars (ie no surface exposure) - to be 660mSv. [(6)]

The safety limit for astronauts, used by NASA, is 1000 mSv. So, if the crew were entirely unprotected, a Mars mission might send them over the limit. However, really that's only the beginning of the story.

Let's look more closely at what we can say about the realities of the radiation risk in relation to travel to and living on Mars.

Firstly, I'd like to begin by mentioning a rather remarkable city in Iran called Ramsar. It's a sizeable settlement made up of 35,000 people. Lying on the southern shore of the Caspian Sea it's a favoured tourist destination. Anything else? Oh yes, natural radiation levels of up to 260 mSv per annum have been recorded in one part of the city and the average measurement is over 200 mSv (including the impact of radon gas), far in excess of Earth's average. In other words, the radiation levels are very like the surface of Mars. The people of Ramsar however seem to live quite happily with this elevated amount of radiation. To what extent this might be the result of adaptation to the environment is unclear but there is no evidence of incomers to the city suffering significant ill health. It does suggest we should perhaps rein back the hysteria and stop thinking of radiation levels above the Earth average as a death sentence (which seems to be the easy

assumption of many of those hostile to Mars colonisation).

Assessing radiation risk is a complex business. For instance, if you zap larger particles with primary radiation protection you get secondary radiation e.g. X-rays which as we all know can be a risk to our health. However there are a number of key points regarding protection of humans on a Mars Mission that the layperson needs to understand. Let's begin with regolith.

A one metre thick layer of regolith can reduce primary radiation by some 41%. [(1)] That's a one metre barrier but of course we might be thinking in terms of a *two* metre layer above the roof of a hab and at the sides to give all-round protection. Remembering that gravity on Mars is at 0.38G and structures can bear mass more easily, the regolith might be applied directly to the hab. Alternatively a steel structure designed to take the regolith might be erected over the hab. Two metre regolith protection could maybe reduce the radiation received in the hab down to 24% of normal radiation levels on the Mars surface.

Clearly exterior application of regolith is going to be pretty effective. What about inside though? What sort of materials should we use in habs, human passenger rovers and spacecraft to protect crew members from radiation? Well simple plastics are a good candidates. Experiments conducted with the Lunar Reconnaisance Orbiter showed that plastic shielding could protect astronauts from Cosmic Rays (among the most harmful form of radiation). [(2)]

Detailed research has been undertaken with respect to the properties of polyurethane foam. [(3)] Doping of polyutherane with other materials at nano-particle levels can enhance absorption of particular types of radiation. For instance, lead oxide nanoparticle doping was found to have excellent properties for shielding from gamma rays.

NASA's Human Research Program (HRP) has been examining in detail the most effective ways to protect humans from accumulating harmful radiation while in space habitats. The broad conclusion is that a hybrid approach is best, since different materials are more effective with different types of radiation. [(5)] When designing habitats, the type of radiation exposure needs to be assessed (Earth orbital, the Moon, in-space transit and the Mars surface will all have different radiation profiles). That assessment will then inform the nature of the protection to be used.

What we have been discussing so far have been different types of *passive* shielding – but in the absence of a magnetosphere to protect humans either in transit or on Mars, we can also look to *active* shielding – deflecting particles before they hit the

protected area. This is a technology that is in its infancy but nevertheless it is has potential as the following assessment shows: *"Active shielding methods, which use electromagnetic fields to deflect charged particles, have the potential to be a solution that can be used along with passive shielding to make deep-space travel safer and more feasible."* [5] Initially such systems might prove more effect in deflecting solar energy particles as opposed to gamma rays which are more penetrating.

One final point, of particular relevance during transit: it's noticeable that ISS crew members do not wear protective suits even though they experience raised radiation levels as they are beyond the protection of the atmosphere. Such suits do not need to be cumbersome or restrictive but they could add another layer of protection and might well be advisable while in transit to Mars.

So these are my conclusions:

1. The levels of radiation to be experienced on a Mars Mission are *not* going to be fatal or even harmful. Deploying all the latest protective materials will ensure the levels are more than acceptable. They will be far less than the lifetime limit for an astronaut.
2. Radiation levels on Earth vary considerably. We should not assume the average is a meaningful safety limit.
3. Using both passive (preferably hybrid, layered protection) and active (electro-magnetic) shielding will ultimately reduce radiation exposure to trivial levels.

Sources:

(1) **Effectiveness of Martian regolith as a radiation shield.** By Harry J. Llamas, Karen L. Aplin, Lucy Berthoud. Published in *Planetary and Space Science* Volume 218, 2022.

(2) **Architectural approach for evaluation of radiation shielding integration in space habitats.** By Olga Bannova, Eszter Gulacsi. Published in *Acta Astronautica.* Volume 220, 2024

(3) ***Investigating polyurethane foam loaded with high-z nanoparticles for gamma radiation shielding compared to Monte Carlo simulations*** By Mokhtari Dorostkar et al. Published in *Scientific Reports* Volume 14 2024.

(4) ***Plastic Could Protect Astronauts from Deep-Space Radiation.*** By Mike Wall. Published in *Space.Com*, 14 June 2013

(5) ***Hybrid methods of radiation shielding against deep-space radiation*** By Rajarshi Pal Chowdhury et al. Published in *Life Sciences in Space Research*, Volume 38, 2023

(6) **Rover radiation data poses manned Mars mission dilemma.** By Jonathan Amos, BBC Website. Published on 30 May 2013

Flight 7 – No sugar-coating it…it's a setback.

By Victor Samuels and Mary Khan

We all had high hopes of Flight 7 – we were going to see an evolved version of Starship (a "Block 2" version) with new heat tile patterns and a neat little Starlink satellite deployment system letting loose some dummy satellites. Joy of Joys - we were also going to be treated to a second catch of a Booster by those chopsticks – a modern marvel, for sure. So how did it go?

The good news is, firstly, that the launch itself was a textbook affair. Later there was one misfire on a Booster engine as it began the return manouevre but it subsequently relit for the next stage in what was a dramatic descent (purposely faster than previous descents). The chopsticks capture took place with something close to perfection.

Meanwhile at the other end things were going badly wrong…

SpaceX lost contact with the upper stage Ship just after 8 minutes into flight. This indicated a serious anomaly had taken place.

Space X reported that all six of the Ship's Raptor engines fired up during the ascent burn, but towards the end of the ascent burn, communication was lost with the engines and then the whole Ship. There were a series of engine failures and then the Ship exploded and fiery debris was filmed descending (rather prettily against the sunset) towards the ocean…but some debris also fell on the Turks and Caicos Islands rather than in the sea. It is reported there was damage to a car.

During the ascent, keen-eyed observers noted a piece of material flapping in the air. Was that something to do with the explosion? It appears not – the flapping material was a more or less cosmetic covering for what was believed to be a future catch fin fixing point for a chopsticks capture (not planned for the Ship on this flight).

There had been significant modifications to this latest "Block 2" version of the Starship. Space X indicated that the vehicle's forward flaps have been reduced in size and shifted towards the vehicle tip and away from the heat shield, significantly reducing their

exposure to reentry heating while simplifying the underlying mechanisms and protective tiling.

Redesigns to the propulsion system, including a 25% increase in propellant volume, the vacuum jacketing of feedlines, a new fuel feedline system for the vehicle's Raptor vacuum engines, and an improved propulsion avionics module controlling vehicle valves and reading sensors, all add additional vehicle performance and the ability to fly longer missions.

These modifications added about 6.5 feet to the vehicle's length, according to SpaceX. The Ship was carrying an additional 300 tons of fuel. That is perhaps significant.

After the Flight Musk tweeted as follows: *"Preliminary indication is that we had an oxygen/fuel leak in the cavity above the ship engine firewall that was large enough to build pressure in excess of the vent capacity. Apart from obviously double-checking for leaks, we will add fire suppression to that volume and probably increase vent area. Nothing so far suggests pushing next launch past next month."*

So, it seems that Musk does not expect this to seriously impact the Mars mission programme. However, the FAA have instructed Space X to undertake a "mishap" investigation and will be unlikely to approve Flight 8 until they are satisfied that investigation has identified how to rectify the fault. It was lucky no one was injured by debris but you can't rely on luck in the space business.

Space X remain focussed on a quick follow-up Flight 8 (the latest touted date is now in the second week of March). We'll see if the FAA is happy with that. However, Musk's previous highly optimistic statement that humans could be on Mars by 2028 looks like it should now be considered defunct, since that assumed a very compressed, near-enough snag-free programme. A more comfortable, but still very impressive date for humans on Mars might be 2030.

THE LATEST WEATHER ON MARS

Here's your update for the weather on Mars provided by the Curiosity Rover in Gale Crater.

For the nearest Sol to **6 January 2025** we have a *high* of **minus 24 degrees Celsius** (minus 11 degrees Fahrenheit), which was 3 degrees colder than last month. The low for the same date, at **minus 74 Celsius** (or minus 101 degrees Fahrenheit) is the same temperature as recorded last month. As we noted last time, the record low on Earth (minus 89.2 Celsius) was registered at Vostok on Antarctica in 1983. We haven't got down to that temperature yet at Gale Crater since we've been covering the weather there. However, Gale Crater is in the Southern Hemisphere and so it's early Autumn – it's going to get colder! Remember that Mars's year is much longer than Earth's as it is further away from the Sun, meaning it takes longer to complete an orbit. Autumn lasts nearly twice the same season on Earth.

IN THE NEWS - CES

The annual CES show in Las Vegas unveiled some very interesting technologies that could prove more than useful on Mars.

Here are some examples.

Lithium-sulphur batteries which can be 50%-75% lighter than nickel and other lithium batteries and clocks in at 320 Wh per Kg. These could be useful in the early stages of colonisation when batteries are being imported to Mars from Earth and we want the Starship payload to be as mass-effecient as possible.

Plantaform offers automated plant growing systems in attractive units, using "fogponics" (ultra-fine mists) to carry nutrients to the plants. These could be used by Aresians to grow food at home or to decorate public spaces and offices with self-managing house plants. The system uses up to 50% less water than hydroponic systems. Just plug in the seed pod like you do a coffee pod and the rest happens and watch it grow!

Hydrific offered a simple and inexpensive water monitoring device that clips on to pipes and can monitor water flow as well as identifying leaks. Could be very useful on Mars where water leaks would be very unwelcome.

SEE YOU NEXT MONTH