Colonizing Mars

No human being has set foot on an astronomical body other than Earth since 1972. One can argue that there's no pressing need to do so, going back to the Moon — or further, to Mars or some other planet — especially with actual people. Unmanned spacecraft can do an awful lot of useful science. It would be a waste of resources to send people, and we have enough other pressing problems. Right? NASA does have plans for Mars, but envisions human astronauts going there only sometime in the 2030s.

However, there is another perspective. Catastrophic events on Earth have previously wiped out many long-lived species, and there's a small but non-zero chance that Earth could, in any given year, get obliterated — by an undetected asteroid or comet, or a nearby supernovae. Or human life might get erased from the planet by our inaction in the face of the pressures we're putting on the biosphere, or by overaction in the form of an out-of-control engineered biological organism. Given enough time, human extinction might be a more or less certain prospect — unless we spread from the planet. From this perspective, efforts to spread our species to other astronomical objects seems rather more urgent.

It's this argument that lies behind the efforts of Elon Musk, who recently announced plans for his company SpaceX to work toward taking paying passengers to Mars by 2022. His vision is hugely ambitious, inspiring, and also admirably practical. It's motivated by the perception that human technical capabilities don't advance automatically, but only if we decide to focus our scientific, engineering and industrial effort on a specific goal. That said, the project does face some imposing and unsolved hurdles

Why Mars? First, it's not too far away, and far more hospitable than alternatives such as Venus or Mercury. The Martian day is 24 hours and 40 minutes, and temperatures range from –140 °C to 30 °C, compared to Earth's slightly warmer –88 °C to 58 °C. If we could warm Mars a little, it could be much like Earth, with a dense gaseous atmosphere and liquid oceans. Plentiful CO_2 in the atmosphere also means we could grow plants. There's decent sunlight given that Mars is only 50% further from the Sun than Earth.

Musk's path to getting lots of people to Mars — and making humanity a multiplanet species — rests on bringing the price of getting a human to Mars to a reasonable level so that many people who want to go can also afford to go. Musk estimates this to be about US$200,000 — roughly the median value of a house in the US. It's likely that lots of people would opt for the challenge, and there would be plenty of jobs on the newly inhabited planet. Presumably, many other visitors would be sponsored. Is this price achievable?

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This represents a price reduction of around four and a half orders of magnitude from what it cost to put astronauts on the Moon. As Musk reasons — based on discussions with technical experts — this is achievable if engineers pursue two strategies. First, we're going to need to make spacecraft and the boosters used to get them to Mars fully reusable and capable of multiple trips. That, he suggests, could provide a reduction of between two and two and a half orders of magnitude. The final two orders of magnitude would then come from the development of an industrial scale production of the right spacecraft fuel on Mars itself.

As Musk points out, reusability is what makes many transport technologies affordable. A trip on a modern commercial aircraft would cost roughly US$500,000 per person if planes could only be used once, but comes down to the order of US$100 due to reusability. The same applies to spacecraft for Mars, although the gain is limited somewhat by the fact that the Earth–Mars rendezvous only happens every 26 months, limiting how frequently a craft can be used. Also important, he argues, will be launching the spacecraft into orbit with fuel tanks essentially empty, and refilling them in orbit from a fleet of boosters that carry fuel to space. This way the craft can have very large tanks and carry large payloads. Musk has discussed these and other details of his plans in a recent article (*New Space* **5,** 46–61; 2017).

Another key would be extensive production of spacecraft propellant on Mars itself, so that ships sent to Mars could return to Earth. This should be possible, he suggests, given that the Martian atmosphere is predominantly CO_2, with water and ice present in the soil. Both methane (CH_4) and oxygen (O_2) can then be produced as a fuel source. In Musk's vision, this would fuel a fleet of spaceships that would in time come to number as many as 1,000. Each ship would carry about 100 people on a trip of 80 days, and would, of course, need to carry an incredibly wide range of cargo to support everything from manufacturing and oxygen production to farming and entertainment. Building up a sustainable population on Mars — of, say, one million people — would take many decades, possibly as long as a century.

Musk goes on to examine the kind of engine technology that might be used, based on the recent technological success of his company SpaceX. This part of the story seems quite believable, especially given the impressive progress SpaceX has had over the past decade or so. It's become the largest private producer of rocket engines in the world, and produces the engine giving the highest ever thrust to weight ratio. It's also mastered technology to have rocket boosters return to their launch sites and land carefully back on the pad.

One big stumbling block — one Musk doesn't mention in his essay — is radiation. Earth has a nice magnetosphere that largely protects us from the harsh solar wind and high-energy cosmic rays arriving from outer space. Travelling through space to Mars presents serious risks to astronauts; this remains the primary risk as viewed by analysts at NASA. There appear to be few technical solutions to shield astronauts, who may inevitably suffer serious radiation damage.

Yes, of course — going to Mars en masse is risky, the method unproven and uncertain, still awaiting invention. But historically, this is often how amazing scientific, technological or cultural accomplishments have come about. On occasion, as our capabilities advance, something that for so long seemed impossible suddenly becomes possible, given the right sustained effort. Musk's vision aims for just such a change. It may all end in disappointment and failure. But, even then, we're sure to learn many things along the way. ❐

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