Hi, this is Janet for Cheap Astronomy, www.cheapastro.com. This is SISS, Science on the ISS – and today's episode is *The people factor*.

You've probably heard about the Orion capsule that is NASA's best bet to get astronauts back to the Moon – and maybe also to an asteroid and *eventually* to Mars. The pressurised and habitable volume of the Orion capsule is around eleven square metres – a lot bigger than an Apollo capsule, which had a habitable volume of only six square metres. But, while eleven square meters might sound luxurious in comparison, the main purpose of this larger volume is to get more astronauts on board. An Orion mission to the Moon may pack in six astronauts, none of whom are going to mind bumping elbows over a three day flight – after all, they are going to *the freaking Moon*.

But, imagine a crew of four astronauts agreeing to be locked in that same eleven square metre room to fly to Mars. It's true that these astronauts will be looking forward to eventually walking around on *freaking Mars* and then returning home again to do more talk show spots than anyone could ever hope for. But, these four people are going to have to live and work together for seven whole months on the way to Mars and then do it again on the way back. Over that period, crew members are going to have to trim their toenails, not to mention a range of other bodily functions, while their crew mates are in close proximity.

And it's not just seven months there and seven months back again. Earth and Mars are in constant motion around the Sun. While Earth completes a solar orbit in one year – Mars takes nearly three years. So, in the time that it takes a spacecraft to follow a trans-orbital trajectory from Earth's orbit out to Mars' orbit, the Earth will have already moved on ahead – meaning the spacecraft's crew will have to wait at Mars until the Earth comes back around again. In fact, NASA's Mars Mission Design Reference Architecture version 5.0 requires that astronauts take a 16 month stopover on Mars until Mars and Earth are both in the right positions to allow a safe return. So, the *entire* mission of seven months there, 16 months on Mars and another seven months back again is a total of 30 months – or two and a half years – and, at times, that will seem like an eternity. But, as the mission proceeds, it won't be the two and a half years that will drive everyone to want to throttle each other, it will be all the intervening days, hours and minutes that will.

Of course, our Mars-bound astronauts will be made of sterner stuff and of course the ever-present threat of dying – cold and alone, millions of kilometres from Earth and with utterly no hope of rescue – should effectively distract them from any petty personality conflicts. Nonetheless, extensive research is being undertaken into *the people factor* that could underlie the success (or failure) of a long-duration space mission.

Boredom is unlikely to be a huge issue. No-one expects that the first crew to Mars will be bouncing baseballs against a wall to pass the time. The first crew to cross such a vast expanse of interplanetary space in a self-contained vehicle will have a hefty workload to manage – operating, adjusting, checking and rechecking a suite of vital on-board systems – as well as running practice drills for key mission events, like course corrections and the eventual Mars orbital entry, descent and landing procedures. Most of the *people factor* research to date has focused on the nexus of *habitability*, *workload* and *performance*. The concern is not so much about the astronauts throttling each other – as keeping them working at maximum efficiency during the long flight, as well as ensuring they are physically and mentally able to deal with the stresses of the journey, the landing and the exploration of an alien world.

So, to ensure the crew's performance will be optimal, we need to know just how much workload they can manage without a break, as well as some idea of what personal space and facilities they will need to ensure those breaks are genuinely rejuvenating. We already know that if they are really going to do the whole return trip in microgravity each crew member will need to do around two hours of exercise a day, just to maintain a reasonable degree of muscular strength and minimise osteoporosis.

Sleep will also be a key issue. Chronic insomnia can turn any hardened professional into a nervous wreck within a matter of days. Sleeping on a Mars transit flight will be challenging, since one thing spacecraft never do is run quiet – and there will be times when the crew will need to work in shifts so someone will be up and around at all times. There is perhaps *one* small blessing to be had – people rarely snore in microgravity, because their soft palates don't slump back in their throat while they're asleep.

In the quest to ensure the sound physical and mental health of our future Mars-bound astronauts, a lot has already been learned from research bases in Antarctica – where small teams shelter from a hostile external environment within cramped quarters – separated from family, friends and civilisation at large, but rarely separated from the company of their teammates – and all with no chance of escape until a relief crew arrives in nine months.

Space mission analogue environments have also been established to help in *people factor* research. HERA– the Human Exploration Research Analogue – locks a team of four people up in an enclosed module at the Johnson Space Centre in Houston for a month or more. HiSEAS, the Hawaii Space Exploration Analog and Simulation, hosts missions for anything up to a year on the side of a volcano – where the crew can do simulation Mars walks outside in a desolate rocky landscape. And of course there's NEEMO, for NASA Extreme Environment Mission Operations, which is a fully underwater facility off the coast of Florida.

NEEMO has hosted a lot of big name astronauts like Chris Hadfield, Scott Kelly, Sunita Williams and Peggy Whitson, to name a few. It is arguably one of the best space environment analogues on Earth, since in the event of a hull breach or a suit malfunction you really could die and you have to be constantly mindful of the artificial atmosphere you are breathing and the effects that sudden pressure changes could have on your body – effects which could include killing you. And when the aquanauts go outside to do an aqua-walk, it's also an opportunity to simulate working in a low gravity environment, since the relative buoyancy you can experience underwater, in full scuba gear, is *a bit* like weightlessness.

But of course, the best Mars mission analogue of all is the ISS. We've already learned a lot from the ISS about how the human body copes with prolonged microgravity and with the higher radiation levels found in low Earth orbit. This includes data gained from Scott Kelly's recent year-long stay on the ISS, while his identical twin brother Mark stayed on Earth. Scott Kelly and other ISS astronauts have also been collecting data on the *psychological* effects of living and working in space using iSHORT – the iPad-based Space Habitability Observation Reporting Tool.

Originally developed in NEEMO, iSHORT allows the ISS crew to capture text, audio, video and photographs within a single interface. Astronauts can carry out their daily tasks as normal, but if they find something is impeding their daily tasks – perhaps they keep bumping into protruding

bulkhead or they snag their clothes on something sticking out from an instrument panel – they can document the experience and suggest some improvements.

The ultimate goal of this data collection is to better define the minimum habitable volume needed for a long-duration crew to operate effectively – along with planning the best layout for all the equipment needed on a long-duration spaceflight.

People factor research may also influence the selection of a long-duration crew. We know that long-duration astronauts will need to be good sleepers and we think the ideal personality type will be someone who is at their happiest when they are being productive – and apparently a good indicator of that is someone who is not only a workaholic, but also has a hobby to occupy them in their spare time.

It's also becoming clear that there is no way we are going to keep four Mars astronauts healthy and sane for seven long months in the eleven square metres of an Orion capsule. At the very least the Mars crew will have be one of those Bigelow-type inflatable modules attached – so that crew members can take turns bouncing around in it for a bit of 'alone time'.

But, as we increasingly engage with the reality of long duration space flight, it's looking more likely that we will build a proper Mars habitation module in orbit. This module could be generously spacious since, much like the ISS, it will only ever fly in a vacuum. It might even be set spinning to create a degree of artificial gravity for the astronauts.

So, the Orion spacecraft will still go to Mars, but its primary role will be to launch the astronauts from the Earth's surface and later return them safely down again. This makes sense, since its external design specifications are *entirely* constrained by aerodynamic considerations, as it will have to both leave and later re-enter Earth's dense atmosphere at very high speed. Although of course, that final re-entry won't be happening fast enough for anyone that's on board.

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