A conversation with Anders Sandberg on 28 February 2014

Participants

- Anders Sandberg—Research Fellow, Future of Humanity Institute
- Nick Beckstead—Research Fellow, Future of Humanity Institute

Summary

Purpose of the call: I contacted Anders to learn about the feasibility of space colonization and who the experts in the area were.

Why this person: Anders Sandberg has published a paper on the feasibility of space colonization and has a long-term interest of the subject.

Anders listed space debris (in Earth's orbit), space dust, large expenses, lack of interest in space colonization, lack of nitrogen, and space radiation as potential roadblocks to space colonization. In his view, space colonization is definitely possible for an advanced civilization with the appropriate motivations—none of these potential roadblocks is likely to reliably prevent it. It is physically possible given our current understanding of physics; a factor making it impossible must either be new physics or some universal socio-economic law that has a far more definite applicability across all societies than we have ever seen before. Space colonization is especially likely to be possible if advanced AGI and molecular manufacturing are possible—as Anders believes they are—though he also thinks it is possible if they are impossible.

I also asked Anders about concerns about energy requirements, replicator technology, terraforming, long-term data storage, human reproduction in space, and slowing down at the end of the trip. Anders felt that none of these posed a plausible in-principle roadblock to space colonization.

Anders was aware of no credible critic of the in-principle feasibility of space colonization. The closest he could think of was Charles Stross—a sophisticated science fiction author—who is skeptical of space colonization except under very favorable assumptions, but still believes that it is possible in principle.

Why might space colonization be impossible?

Anders identified multiple potential in-principle roadblocks to space colonization, but felt that none of them were very plausible. He felt they were especially implausible if advanced AGI and/or nanotechnology are possible, though these technologies would not be necessary for space colonization.

Survival in space

One potential obstacle to human survival in space is the effect of microgravity on health and reproduction. Microgravity causes bone decalcification and liquid redistribution in humans. In addition, attempts to breed mice and fish eggs in space have come out badly; the prevailing view is that microgravity is the source of the problem. However, this problem could be solved by rotating the station or vessel and thereby inducing artificial gravity.

There are many other obvious challenges--such as food and oxygen--but Anders believes these are solvable. Oxygen could be manufactured from moon rocks or ice, and food could be grown using hydroponics. Hydroponics would require nitrogen, which is discussed below.

Space debris in Earth's orbit

If there were too much debris in Earth's orbit, it could become impossible to get out into space. Donald Kessler, a NASA scientist, discussed a scenario of this kind (called "Kessler syndrome"). However, Anders said that debris of this kind would not be a permanent roadblock to space colonization because the debris would eventually clear, and the debris would not cover all orbits. In theory, a "laser broom" might clear the orbit, but Anders doesn't know whether creating one is feasible.

Space dust

There is interstellar dust. If objects are travelling at a high speed, hitting a very small piece of dust could do substantial damage. Travelling at a high speed is desirable for interstellar or intergalactic travel. The larger the vessel, the worse the problem. Intergalactic dust is less common, and would be much less of a problem.

This problem could be averted by creating adequate shielding. At a conservative end, we know that space dust does not prevent comet nuclei from doing interstellar travel at a few tens of km/s. A vessel could simply dig into a comet and use it as shielding (for a very slow trip). Anders believes that other shields could be constructed out of metal and graphene foils which would make interstellar and intergalactic space colonization possible with at higher speeds and with less mass.

Maybe it's too expensive

Right now it costs on the order of $10,000 per kg put in orbit. This makes it extremely expensive to try out new things in space. The price may need to go down by a couple of orders of magnitude before it becomes feasible to do much in space without enormous costs. However, this is just a high initial threshold - once crossed prices of space hardware would go down.

Maybe the benefits would be too low for anyone to ever do it

Charles Stross has argued that it would be unattractive to be part of the first colonization wave—it would take a long time to get there, and there wouldn't be a cluster of people like there is back on Earth. Anders can see various reasons people might want to do this eventually: diversity of preferences, desire to do research, desire to continue civilization. Arguments from high discount rates making investments into the far future not worth enough to do have been proposed, but long-term projects not benefiting the originators are occasionally undertaken anyway, and certain

project may have payoffs so large that they overwhelm the discount rate.

Nitrogen

If space colonization were attempted with organic beings, nitrogen is necessary. But it may be scarce in comparison with other necessary elements and molecules (such as water) in the inner solar system. But there are enough places that have nitrogen that it wouldn't be a show-stopper in Anders's opinion.

Radiation

Space radiation would damage both humans and electronic equipment left in space for a long time. This problem gets more severe for very long-distance travel at relativistic speeds.

It would be possible to prevent the negative consequences of radiation with sufficiently thick shielding on the space vessel, though this increases the mass of the vessel and the amount of resources required to travel. Error-correcting codes and other measures like shielded electronics could prevent fatal damage to computers. It's not that we have the engineering solutions ready to hand, just that Anders believes solutions would be possible.

Someone might question whether it's possible to create electronic devices that would work for very long periods of time in the presence of radiation, as would be necessary for space colonization. Anders believes this is a solvable engineering problem.

Miscellaneous questions

Is it possible to get enough energy for space colonization?

In Anders' view, building a Dyson shell should work or using fission should work. Beam power might also work as a method of transmission. Chemical power probably wouldn't work. Even if we ran out of oil, it would be possible to brew rocket fuel using other resources.

Do people who say otherwise not know about Dyson shells, or do they think they're impossible?

It's hard to say because it's hard to get these people to engage seriously with the question. Anders would guess that the people who object haven't considered the issue or don't think that Dyson shells are possible. As Anders uses the term, a Dyson shell is just a large collection of solar collectors orbiting the sun, with the capacity to transmit energy.

How plausible is it that the necessary replicators are impossible?

Robert Freitas has a reasonably well-worked out replicator that could be built on the moon. The idea seems feasible to Anders, though he emphasized that it would be good to see a more up to date version of the idea. Acorns are a "proof of concept" that very small objects can be replicators when combined with the right environment.

How plausible is it that necessary terraforming is impossible?

Not likely. In Anders's view, building a base on Mars appears possible with current technology. Terraforming the entire planet is a tall order, though.

Could human reproduction be impossible in space for some reason?

You can mimic the effects of gravity with rotation. Radiation is bad for babies, but appropriate shielding would solve the problem.

Could data storage make space colonization impossible?

We don't currently have the technology for sufficiently reliable data storage for multi-millennia spaceflight, but redundant code and other engineering solutions should exist.

Is slowing down at the end of the trip a problem?

Magnetic sails/solar sails could probably solve this problem, and it would also be possible to carry enough fuel in the vessel to use the fuel to slow down. A possible challenge for nuclear power is that the isotopes would decay by the time they would need to be used. In Anders's view, this could probably be solved through induced fission.

Could there be in-principle roadblocks to space colonization which we can't think of?

This would be very surprising to Anders. In his view, it would probably require learning new physics for us to learn that space colonization is in principle infeasible for some reason not listed here.

People to talk to/references

Anders felt that most of the people who have expertise on the in principle feasibility of space colonization believe that that, in principle, it's feasible. The people who have downplayed space colonization tend not to be saying that it's impossible, but instead that it would be costly/people wouldn't want to do it (e.g. Charles Stross).

Anders identified as authorities:

- Robert Zubrin—Founder and President of the Mars Society.
- Geoffrey Landis—NASA Scientist, hard science fiction author.
- Charles Stross—Hard science fiction author, possibly the most credible critic of the feasibility of space colonization (though he falls short of saying that it's impossible in principle).
    - Critique of feasibility: http://www.antipope.org/charlie/blog-static/2007/06/the_high_frontier_redux.html
    - Argument for in-principle feasibility: http://www.antipope.org/charlie/blog-static/2009/11/the_myth_of_the_starship.html
- Robert Freitas—Senior Research Fellow at the Institute for Molecular Manufacturing.
- Elon Musk—Founder and CEO of SpaceX.
- Eric Drexler—father of nanotechnology, has thought about these issues thoroughly.

- Stephen Baxter—UK SETI network, science fiction author.

Anders also suggested that a space elevator expert might have insight into these issues.

Appendix: Questions discussed

1. Why might space colonization be impossible? (Alternate framing: Imagine you learned that space colonization wasn't technologically possible for us, even in principle. In your mind, what are the most plausible reasons that could be true?)
2. At what other stages have other people said—or would they say—that space colonization is impossible?
3. Who could speak with authority on these questions?
4. Who are the most credible/authoritative people saying that it's impossible (or something in that vicinity)? (Looking for both citations and people we could speak with.)
5. Who are the most credible/authoritative people saying that it's possible? (Looking for both citations and people we could speak with.)