Implausible Engineering – Episode 4a: Space mining

Most of the contents of the periodic table are available in atomic or molecular form across the solar system. After all, the Earth accreted out of the same circumsolar dust cloud that all the other planets accreted out of, not to mention the dwarf planets, asteroids, comets and other bits. However, while that accretion was taking place the solar wind changed the mix of things by pushing light volatiles, notably hydrogen and water, outwards and leaving all rocky stuff in a more concentrated form behind

Since there's a lot more light volatiles than anything else, the outer solar system planets are giants, with giant gravities, giant storms and giant magnetic fields, all of which makes extracting materials from them quite difficult. But this isn't necessarily a problem, since if it's hydrogen you want you want you are better off just collecting water. Unlike hydrogen , water freezes solid at relatively high temperatures, making it easy to transport through space in big rocky chunks without needing to keep it in sealed containers. And when you're ready to hydrolyse that water to get the hydrogen, you also get oxygen as a byproduct and if you don't hydrolyse that water, you still have water – which, like oxygen, is very useful in keeping people alive.

Keeping people alive will be an important part of the space mining story, since mining needs miners. Maybe once a routine industrial scale process is established you can replace all the people with robots, but those first experimental steps in space mining will start with people. Keeping them alive will be easier and cheaper if you source the water they'll need from off Earth, but it will still be a very expensive business, so those miners will need to be mining something that generates a profit – that is, something that sells for more than it costs.

Getting to that point will be a slow, iterative process. Firstly, it's unrealistic to think you can transport mined ores to Earth in their raw form. Large scale gold mining involves refining ore deposits, where one metric ton of ore holds about one gram of gold. Other metals like aluminium are less extreme – around 25% of the mass of good quality bauxite ore may be aluminium, but even then it's not worth flying the ore down to Earth, which has plenty of aluminium anyway. So you can't just mine in space you have to refine too – and that needs infrastructure. It will almost certainly need gravity too – which enables you to separate heavy stuff from light stuff. Furthermore, prospecting across far-flung asteroids to find lucrative bits to chip off would be enormously time-consuming and expensive.

Regular listeners will know that this is the basis of CA's CSOTM proposal – that is, crash %$#@ on the Moon. So, rather than doing meticulous scan and capture missions of every asteroid out there, just do a quick sweep to identify likely candidates – say, big rocks with shiny bits; then attach rocket engines to them which direct them to crash on the Moon (with the reusable rocket engines detaching before impact). Then a lunar team would come in to sift through the rubble. In the early days, teams might just look for nuggets of precious metals that could be shipped back to Earth in robotic landers – the Moon's low gravity would make it easy to launch these, which would then just undergo a controlled fall back to Earth. By volume, it wouldn't be much so you wouldn't flood the market and drop the unit price – indeed the first few shipments of space gold, silver or whatever would presumably sell way over their usual market value.

Assuming this much activity is lucrative, things could then proceed to the next stage, which involves building ore refineries on the Moon. Once you can extract specific materials from ore, you might switch from precious metals to rare earth elements and perhaps uranium since it is likely that Earth will start running low on these essential materials in the not-too-distant future. Establishing such refineries might also represent the transition point from mining stuff to sell back on Earth towards mining stuff that supports a permanent human presence off-world. So there'd be more focus on finding water and building materials, like aluminium, iron, titanium, as well as silicon for glass and solar panels and vitrified lunar regolith for good old-fashioned bricks.

So, this is not-an-altogether implausible path to both space mining and space colonies. There's just that bit at the start that's hard to envision – that is, the initial step into profit-making. There's a considerable leap of faith and probably a good deal of legislation required before anyone crashes %$#@ on the Moon and there's some element of luck that we will find something worthwhile in those first debris piles. And when we say leap of faith, what we really mean venture capital – that is, investment up front with the expectation of profit down the track. This is likely to be how it starts, but this can only go so far, without some kind of financial return. Stay tuned.

Implausible Engineering – Episode 4b: Time machine (or not)

In a previous episode of Implausible Engineering we discussed how you could shift yourself into the future by sitting within a very, very fast moving cabin where relativistic time dilation would come into play. But arguably this is not really about time travel, it's just about you slowing your personal time relative to everyone else – so that after spending a few hours in your relativistic cabin you disembark and find that thousands of years have passed outside.

You can do similar things with gravity, For example, dipping into a black hole's intense gravitational field would slow your personal time down relative to people outside – and departing Earth's gravitational field might see your personal time speed up very, very slightly relative to those down on the surface. But in none of these situations do you ever jump from one time to another time – both you and the people back on Earth keep on moving through time just like you always did – it's just a case of you expending more or less heart beats compared with someone back on Earth. So really, we all travel in time and we all expend about the same number of heartbeats getting from one day to the next – it's just when you compare your heartbeats in relation to someone else's day that you can find variations.

Another aspect of relativistic physics which raises possibilities for time travel is spacetime curvature. So, if you imagine yourself moving on a spacetime manifold which is kind-of-like a surface – and let's say that surface is kind-of-like a sheet of paper then you could curl that sheet paper around into a cylinder so that you could progress along the manifold to a point that sits earlier in your own timeline – and so voila time travel. But while this can be made to look feasible with computer graphics, you're really just playing with two dimensional representations of four dimensional spacetime. In reality a spacetime manifold isn't really a surface and it's unlikely you could curl it back on itself anyway. You can curve a spacetime manifold into a gravity well, but only up to the point where it reaches an apparent singularity.

It makes no sense to think you can somehow curl the manifold further once it has already converged into a single point.

Similarly, you can generate lots of extraordinary scenarios with field equation mathematics, but the physical translation of that mathematics requires appealing to phenomenon like negative masses and negative energies, whatever the heck they are. And whatever twisting tunnels you might create from imaginary wormholes would require the existence of white holes, whatever the heck they are. So, this all looks a bit like smoke and mirrors – or at least highly-theoretical speculations that can't be confirmed by anything that looks remotely like evidence.

And there's still more cause for doubts. Putting aside the problems with trying to build a time machine, you also have to consider whether there is anywhere for such a machine could take you to. There are reasonable grounds to assume that all the energy available in the Universe in one instant gets used up in taking the Universe through to the next instant. On this basis, how can the past exist as a separate place you can travel to if you live in the only instant that contains the energy required to sustain a Universe – and of course how can you travel to a future that the energy of the present hasn't been passed on to yet. That said though you can certainly travel to the future in the same way that everyone else does, slowly and steadily, instant by freshly-generated instant.

And putting all the practicalities aside, travelling into the far future is dangerous and travelling back into the past is just plain irresponsible. Going to the far future is dangerous since you'll be exposed to all sorts of new pathogens that everyone else is immune to, plus you'll have no knowledge of how undertake basic transactions of daily living and so will become entirely dependent on the kindness of strangers – which sometimes works out OK and sometimes it doesn't. Going back to the past is irresponsible, not only because you could kill your grandparents but also you could take back pathogens that no-one has the immunity or the medical technology to fight – meaning you not only kill your grandparents but a whole bunch of other people's grandparents.

Perhaps the most common reason anyone has to want travel back into the past is to fix up something you bollicksed up in your earlier life, but that's fraught with risk since you may just set up a new course of events that leads you to bollicksing-up something else altogether. Surely it's much better just to use the time you have to learn from past events so as to avoid bollicksing something up in the future. Heck, why not get rich and put whole teams of researchers onto this - learning from the past in order to change the future. So, not only will you travel through time but manipulate the very fabric of it to create a whole new future to travel into – after all, people do this every day.

Hello Steve

Oh hi Bridget

Didn't you to a different podcast on why it's a stupid idea to attach a rocket engine to an asteroid

Well yes, it is actually a stupid idea. I'm just making the point that most of other ideas for space mining are pretty stupid too.

So you don't think space mining will ever happen.

No I think it will happen after someone's willing to do something stupid.

Like attaching a rocket engine to an asteroid?

Precisely.

So you actually do think you could attach a rocket engine to an asteroid?

No, no – that would be stupid.

Implausible?

Hey you're really getting the hang of this Bridget.

I'm not sure I really want to Steve, but thank you. I suppose the next part of this episode is also going stupid?

Yes, although the next part is actually just plain stupid. No intriguing perhapses about, it's just dumb.

You mean it's even more implausible than just being implausible.

Yeah, it's really implausible.

This is quite a podcast Steve

Hey, you really mean that Bridget?

Steve – don't be stupid.

Hello Steve

Didn’t you do a podcast on why it’s a stupid idea to attach a rocket engine to an asteroid.

So you don’t think space mining will ever happen.

Like attaching a rocket engine to an asteroid.

So you actually think it's possible? A rocket engine, on an asteroid.

Implausible?

I’m not sure I want to get the hang of this. I suppose the next part of this episode is going to be stupid too.

You mean it’s even more implausible than just being implausible.

This is quite a podcast

Steve. Don't be stupid