Question 1:

Dear Cheap Astronomy – Please tell us about satellite servicing

So, here's a new twist on the space junk story. Remember, there's two main populations of space junk, one in low earth orbit, which includes various rocket stages, decommissioned surveillance satellites and miscellaneous debris all of which will eventually undergo orbital decay in years, decades or centuries. Right now we don't have a workable technical solution other than waiting for orbital decay to happen and trying to minimize the addition of any new junk.

But there's another population of satellites in geostationary orbit – which is the most commercially valuable orbital real estate around Earth at the moment. Any satellites in geostationary orbit are unlikely to descend for millennia – indeed, many may be flung out of orbit due to various Sun, Moon, Earth interactions over millennia – but in the meantime we do need to get them out of the way. Once a geostationary satellite runs out of fuel it, it's out of control and becomes a danger to other commercially valuable geosynchronous satellites. So, current protocol is that just before a geostationary satellite runs out of fuel we raise their orbit by about 300 km, which we call a graveyard orbit, where they can just sit safely out of harm's way.

But it is a waste. All that most of our geostationary satellites have to do is capture a transmission from the ground and then rebroadcast back down, its altitude ensuring that broadcast reaches a much wider area of the Earth's surface than would be possible from a surface broadcast. There is some amplification and signal processing involved, but for the most part these satellites are just glorified mirrors. So wouldn't it be great if you could just refuel them, rather than replace them.

On the 9th of October 2019, MEV-1, Mission Extension Vehicle-1 was launched. It's a proof-of-concept mission and the plan is to dock it with the Intelsat 901 communications satellite, which is currently out of fuel and in a graveyard orbit. If all goes well, MEV-1 will clamp itself to Intelsat 901 and extend Intelsat 901's functional life by becoming a newly fueled engine for it – and will bring it back down into active service in geosynchronous orbit. And, because it is just a flying engine, after a five year trial MEV-1 might still have enough fuel to firstly return Intelsat 901 to the graveyard orbit, detach from it and then go on to extend the life of another glorified mirror.

So, that's the current state of satellite servicing science – and we still have to see this trial through to be sure it really works. There are major complexities involved in rendezvousing with a decommissioned satellite to a clamp a new engine onto it. Actual refueling is another step beyond, first you'd need to start launching satellites with a fuel cap and a docking mechanism.

Nonetheless, as is common in space technology, there's already lots of hugely sophisticated new missions being mapped out on paper. The next generation of MEVs might launch with a set of five or ten flying engine modules that will detach and extend the life of five or ten satellites and then return to the mothership for refueling. And after refueling becomes an established thing, we might also start flying maintenance spacecraft with 3d printers aboard, that can do in-orbit swap in and swap out repairs.

And if we now have the technology to clamp onto and extend the life of geostationary satellites, we might next move to consider extending the lives of our medium orbit GPS satellites that orbit the Earth once every two days in the second most valuable bit of Earth orbital real estate. After that, we might consider using the same technology to deorbit any low Earth orbiting objects – but there the economics get harder to work. Sure removing space junk might make the world a better place, but whose responsibility is it – which is really a question of who's going to pay for it and who do you blame if something goes wrong.

Question 2:

Dear Cheap Astronomy – What would a multi-generational spacecraft be like?

It would probably look like the human race's complete collection of moral dilemmas all packed into one sardine can. The premise here is that if we can't travel faster than light speed (or even close to it), the only way for people to reach other stellar systems is with a multi-generational spaceship. So you get on board with your spouse and have kids and then they have kids with other spouse's kids and so on. To get to something like another Earth orbiting a Sun-like star you're looking at a travel time thousand of years long and quite possibly tens or hundreds of thousands of years long. That's a lot of generations

So you'll need a drive system and fuel and you definitely need gravity, not just for adult health, but for safe child birth and child development. And you'll need space to grow food and etc. So, yes it'll be a whopping big spacecraft but let's focus on the people, the crew – in other words, the payload. For a generational spacecraft to work, you'll need a breeding population with genetic diversity. It's been proposed you could have sufficient genetic diversity with a crew of just eighty people. But if your ship only has carrying capacity for eighty people you'll need strict rules about how many kids anyone can have and an expectation that the old folks will all make noble sacrifices at a certain point.

Assuming everyone goes along with all that, the oldies won't be stepping out of the airlock, since that would be a loss of valuable water, not to mention… well, let's just say Soylent Green. But you'll need to be careful about how you manage that recycling. If you create a vector for microorganisms to move from dead individuals to live individuals you're in trouble. Indeed, just having lots of people crowded into an enclosed space and breathing the same air is trouble. You can't load 80 people on to a spaceship without a whole bunch of pathogens going with them. On top of all the maintenance, the teaching and the farming work, it's unlikely the crew will have the time or resources to run a pharmaceutical laboratory, let alone a production and testing facility. So once all your onboard pathogens develop resistance to the antibiotics you took off with, you're in trouble.

And then of course, there's the whole Lord of the Flies scenario. A bunch of isolated people with no alternate world views to draw upon are going to get a little introspective and the next generation who've never even viewed a world are going to get more introspective – and the next generation.

Of course, Earth will maintain a mission control and hence provide a little sanity, but when all the ship is doing is just going forward, on and on through empty space, there'll inevitably be staff cutbacks. And the farther out the ship is, the longer time delay for radio communications so there'll quickly come a point where Earth will be no help in an emergency. Indeed, whatever heart-felt promises might have been made at launch, the crew should probably anticipate becoming totally self-dependent within a few generations.

And all the while things will run down and need replacing – and sure you can launch with 3d printers, but you'll also need the raw materials to do the printing with and not everything can be recycled. And the personnel turn-over is problematic too – sure you can launch with a crew full of PhDs – and being PhDs they might be able to teach their kids some pretty sophisticated stuff. But those kids won't ever get PhDs themselves and they might not quite as good teachers for their kids and so on and so forth – meaning there'll be a loss of skills and innovation over the generations. You really do need a village to raise a child and 80 people is a pretty small village.

So, on the face of it, a generational star ship is about as good an idea as sending colonists one a one way mission to Mars. The alternative of sending frozen eggs and sperm that are mixed together and grown up by robots when the near their destination is its own nightmare. And of course once you mention robots – well, why don't we just send robots.