Question 1:

Dear Cheap Astronomy – Oh, come on, is that really the whole space junk story?

Cheap Astronomy recently covered some questions on space junk – concluding there's there so much stuff up there at all different altitudes and different trajectories that any plans for chase-and-grab solutions or passive-net solutions might work on a small scale, but aren't likely to make any serious dent in the current global problem. Then we said that what everyone should focus on is to stop making more space junk – although we also said that would create an expensive impost on every new space mission, so there's no way one country's going to do it if all the other countries aren't going to do it as well. And then we said, well maybe we didn't say it, but we certainly thought it –if you could solve this problem, there's something called climate change you could help us with as well.

But, it's true that there is an important part of the space junk story that we glossed over. The previous answers we've gave were focused on space junk in low Earth orbit – which covers everything up to 2,000 kilometres altitude, But it's important to appreciate that there's a whole different story about all the stuff way up there around geosynchronous orbit, at about 35,000 kilometres altitude. At that altitude, things may not naturally deorbit for thousands, if not millions, of years and actively deorbiting any of those things would just mean you're sending more material down into the smaller diameter lower orbits which are already congested with existing space junk – so all you'd really be doing is increasing the risk of the whole nightmarish Kessler Syndrome space junk apocalypse.

Furthermore, deorbiting such high altitude satellites would require burning substantial amounts of fuel – which means we'd need to launch everything we launch now with much bigger fuel reserves so we'd need to launch everything on much bigger rockets – all of which would be more polluting, more complex and much more expensive. So, no-one is going to do this, at least not with the technology currently available to us today – and this isn't a Cheap Astronomy opinion, it would just be objectively stupid.

But, it's not as bad as it might sound. Despite all the doom and gloom about whether we can ever engender a coordinated global response to deal with low Earth orbit space junk, there is actually a globally-agreed, though non-binding, protocol whereby anyone launching a new geostationary satellite has to put it into a graveyard orbit near the end of its functional life. Putting a geosynchronous satellite into a graveyard orbit involves retaining just enough fuel to send it on a final flight up into an orbit that's just 230 kilometres higher than geosynchronous orbit. At that height, satellites should remain fstable or millennia or more, since the only things that can affect their orbit at that altitude are solar radiation pressure and the exceedingly gentle perturbations generated by the Moon orbiting around the Earth.

There is also a non-binding agreement whereby any satellites sent into such a graveyard orbit around Earth must also be passivated – meaning they should be defueled and depressurized – and have their batteries and any explosive bolts discharged to minimise the likelihood of a shrapnel-generating explosion happening, either incidentally or in the event of a collision.

These agreed protocols are overseen by the Inter-Agency Space Debris Coordination Committee whose 13 members include NASA, Roscosmos and even the Chinese National Space Agency. Indeed, some countries have established regulations, which require that all geostationary satellites launched after March 2002, must commit to moving to a graveyard orbit at the end of their functional life.

The fuel needed for a lift of 235 kilometres from a geosynchronous orbit up to higher graveyard orbit is equivalent to about 3 months of fuel that would otherwise have been used for what's called station-keeping – that is, the tiny readjustments required to maintain a satellite's altitude and attitude. And that is just 3 months out of decade-or-more long missions, so it's not such a terrible economic impost really.

So, yep, way up there in that enormously economically-valuable region where we fly TV satellites and internet satellites and weather satellites – space junk regulation has really taken off – small astronomy joke there. And slowly, over time, these ideas may filter down to the wild-west of low Earth orbit. And, with that hopeful conclusion, we once again say, good luck.

Question 2:

Dear Cheap Astronomy – Could electrodynamic tethers solve the space junk problem and even provide cheap propulsion?

Imagine you dangle a tether, which is essentially a long wire, from a satellite. The whole system is in orbit around Earth and angular momentum is always conserved, but the end of the tether at high altitude will experience less gravitational pull than the end of the tether at low altitude. So the higher altitude end has a greater tendency to be flung outwards away from the planet. We could also talk about centrifugal forces, or tidal forces or even spacetime dilation – but the point is when you have a length of tether in orbit, it will naturally arrange itself to lie straight along an axial line that's drawn out from the centre of the Earth. For much the same reason, a space elevator cable will also stay straight along an axial line that's drawn out from the centre of the Earth.

Anyhow, an electrodynamic tether is able to conduct electricity and if it's deployed in Earth orbit, you will have yourself a conducting wire that's moving rapidly through the Earth's magnetic field. That action will create a current along that wire – that is, a flow of electrons. So, essentially you are converting the tether's kinetic energy into electrical energy. As a consequence, the orbiting system will lose kinetic energy – that is, it will slow down, which means the satellite's orbit will start to decay.

So, through this process an orbiting electrodynamic tether can generate electrical power, either for battery storage or for immediate use. However, this does have limited practical value since the consequence of generating electrical power is that you lose altitude. What's a more interesting idea is that you launch all your satellites with furled up tethers – and as they approach the end of their functional life, you unfurl the tether, which should then deorbit the satellite – and so, no more space junk.

There have been some successful small-scale proof-of-concept tests of this principle, but for now it remains just an interesting idea. To bring about a really substantial effect on slowing a satellite down, you will need a tether that's about five kilometres long, so even if you're using carbon nanotubes, or whatever, you're still looking at a lot of redundant payload mass that you have to get into orbit – and there's some non-trivial engineering challenges involved in both furling and unfurling a five kilometre space tether. So, at the end of the day, you'll need to demonstrate that this system is more economical than just launching a bit of extra rocket fuel sufficient to deorbit your satellite near the end of its functional life.

Where things get weirder is the proposal that you can reverse everything we just discussed and generate kinetic energy from your electrodynamic tether, so that it becomes a propellant-free thruster. There's some complex physics involved – look up Lorentz forces if you're keen. If you're not that keen just consider that on one hand we can use turbine motion and magnets to generate electricity – and on the other hand we can use electricity and magnets to create a rotary motor. In a nutshell, kinetic energy really can create electrical energy and electrical energy really can create kinetic energy.

So, while the motion of an electrodynamic tether through the Earth's magnetic field naturally generates a current that runs down the tether, you can expend electrical energy to drive current flow the 'wrong way' up the tether. You might draw that electrical energy from the satellite's solar panels – and it should result in the tether, and the satellite, generating a kinetic push against the Earth's magnetic field.

But, while this much seems reasonable, the question then becomes whether the Earth's magnetic field has enough Gaussian oomph to push back. Our magnetosphere does a reasonable job of deflecting charged sub-atomic particles in the solar wind, but it does get all bent out of shape in the process. The idea that our magnetic field could maintain its integrity sufficiently to push back on a powered-up electrodynamic tether in a way that could raise kilograms of mass against gravity does seem a little hard to swallow.

Still, one organisation claims it is building a prototype tether system that will be able to lift a 125 kilogram satellite from a 350 kilometre altitude orbit to a 700 kilometre altitude orbit in just 50 days. If it works, that will be a huge boon to the space industry – and be yet another hat for Cheap Astronomy to eat. Stay tuned.