Question 1:

Dear Cheap Astronomy – How will we exploit the Solar System?

Hey, we're the human race. Exploiting natural resources is what we do. What guides the way we do it is consumer demand, access and cost. For aesthetic reasons we adore gold and diamonds, which aren't that easy to find, so their cost is high. There was a time when shiny aluminium was considered more valuable than gold or silver, but then someone figured out a low cost way of extracting it from bauxite ore, which suddenly made it readily accessible to everyone and so the price plummeted – and we now mostly use aluminium for building material and for making soft drink cans. These days aluminium is a key component of a whole range of infrastructure and materials technologies, so it has enormous economic vale, but it is in no way treasured by individual humans, apart from people chasing recycling refunds – they just love the stuff.

These considerations are key to understanding the economics of exploiting the solar system. If we want to take over the solar system with astronauts, the most valuable commodity will probably be water – since we won't get far without it. But, if we want to take over the solar system with robots, then water becomes mostly irrelevant, unless we task the robots with stockpiling water for later human arrivals. Otherwise the robots will be focused on collecting economically-valuable materials, particularly rare Earth metals which are rare here, but might not be out there. The robots almost certainly won't be tasked with finding gold and silver, which do have some role in electronics, but mostly retain their value because they look nice and they're relatively rare on Earth. The moment they're not rare, we'll start making soft drink cans out of them.

Anyhow, as we've discussed previously on Cheap Astronomy, extraterrestrial mining requires not only finding a rock full of the stuff you want, but you also need to extract the desired stuff from that rock. To do this effectively, you'll need factory and processing infrastructure and you'll almost certainly need gravity, since most extraction techniques involve separating dense heavy stuff from fluffy light stuff. So, Cheap Astronomy has suggested a sensible strategy would be CSOTM, crash sh%$ on the Moon and then transport the ore-rich rubble over to your lunar-based factory refinery. After you've isolated the desired metals, you might still have to lift them off the Moon again, but you've only got 0.16g to fly against and you are flying a much-smaller, concentrated and refined mass.

If you were going to write a science fiction about a civilisation making bold economic steps into space – you would give their planet a Moon with no atmosphere and just enough gravity to make it easy for them. Honestly, the Moon is the best step stepping stone into space that we could have asked for. So we should build a frontier mining town there, with maybe some primitive accommodation for adventurous tourists and meanwhile start gathering building materials from space so you can build a proper space hotel and start a booming business. Meanwhile the mining that you're doing should start a lucrative delivery stream of refined rare metals back to Earth. Even if we're not all still using smart phones in the 22nd century there'll be some hand-held device that will contain rare-earth metals. So, you've got a commercial basis for resource exploitation and you're also making megabucks hosting tourists in safe and comfortable accommodation that's in space, but still only 3 days from home.

The formula for Mars doesn't work out so well. Sure you're closer to the asteroid belt but the planet has more gravity and it has an atmosphere that you can't breathe but which does create resistance to both landings and launches – and you are very isolated from Earth. It's much more problematic.

So, if we can't take control of a celestial body that's three days away with one sixth G, no atmosphere, some potential water sources and an abundance of solar energy – well, let's just give up now. The idea that we can just wait around until someone invents warp speed and then we zip off to colonise Earth 2.0 is a pipe dream. The way forward will be long, hard, slow and hugely-dependent on technology. So, like we always say at Cheap Astronomy, if you want Homo sapiens to be a space-faring species, finish school, work hard, be good and pay your taxes. If you happen get a job at NASA, Roscosmos, ESA, ISRO, CNSA, JAXA – or even the Israel, New Zealand, Canada or Australian space agencies – well, that's great. But if you don't, please still work hard, be good and pay your taxes – that's what will really make the difference.

Question 2:

Dear Cheap Astronomy – Small Astronomy Joke, Apophis will fly-by Earth on Friday the 13th 2029

Yep, it's true, the big bad, the monster of near-earth Objects 99942 Apophis will do its long awaited next fly-by less than 10 years from now in 2029 and yes in April and yes on April the 13th which is a Friday. No doubt this concordance with humanity's obsession with extracting meaning from arbitrary numbers will be remarked upon for many years to come. But it does usefully draws everyone's attention to the fact that there are some very big rocks out there that move very fast and sometimes come very close and yes, let's pause to remember what happened to the poor, old dinosaurs.

It is reassuring to know that we are now totally confident that Apophis will skim the outer perimeters of the space occupied by our geostationary satellites around Earth and it will then just keep on going. There really is no chance whatsoever of an impact. This absolute knowledge of a future event shows how we really are taking the whole asteroid impact thing pretty seriously. All we have to do now is start taking the whole climate change thing pretty seriously and get the plastic out of the oceans and save the last rhinos and polar bears and pangolins – as well as the last kiwis and numbats, for that matter.

But anyway, there was a genuine concern back in 2004, just fifteen years ago, that 99942 Apophis was on a trajectory with enough variance in that trajectory that there was a 3% chance that it might impact with Earth in 2029. Astronomers then went to work big-time on nailing down with exacting precision what the trajectory of Apophis really was and no, we now absolutely know there's totally zero chance it will strike Earth in 2029. If you're interested, it should be visible to the naked eye for anyone on the night side of Earth as it passes over, but it really will just pass over.

As we've previously said on Cheap Astronomy, its fly-by past Earth will introduce new uncertainties about its future orbit, which will bring it back towards Earth in 2036. But we're already pretty confident that it will only have a one in 45,000 chances of intercepting Earth in

2036 and it’s likely that will hold true. Of course try and model Apophis’ trajectory centuries or millennia in advance and more and more uncertainties are introduced.

So, how bad is the risk, really? Well, it’s unlikely Apophis would have wiped out all the dinosaurs. It probably would have killed a lot of them, at least in Mexico but Apophis a bit less than a kilometer wide, while the Chixculub impact object was probably around 10 kilometers wide. The size, or more importantly the mass, of something that means a lot when you’re about to be hit in the face by that something – and when you are dealing with biggish asteroids, the difference between one kilometre a ten kilometres in diameter is a lot more than just one order of magnitude.

At the these massive scales, gravity becomes a significant factor. So, while a kilometer wide asteroid might be a closely packed rubble pile a ten kilometer wide asteroid will be a dense, mean, solid and nasty block of mass-extinction badness. Of course we don’t really know for sure what the Chixculub impactor that killed the dinosaurs was –estimates vary from 10 kilometres in diameter to 80 kilometres in diameter. We know the mass of Apophis is 27 billion kilograms, which about 3 times 10 to the 12th kilograms, we think the Chixculub impactor was something like 3 times 10 to the 16th kilograms. So its diameter might have been ten times as big, but its mass might have been ten thousand times as big. We really just don’t know. The devastation caused by a boloid, that might be an asteroid or it might be a comet, depends on its angle of deflection, its composition – which might be ice, carbon or metal and where it actually hits – which might be land, ice or water. Different dynamics and different chemistries will come into play with each of those variant possibilities.

Of course, a totally unexpected object, something orders of magnitude bigger than Oumamamma might suddenly appear out of the interstellar nowhere on a direct trajectory with Earth. But, really nothing can just appear out of nowhere these days – we are scanning the skies pretty intently and interstellar object can only move so fast, so we’ll likely have months if not years to prepare. And it’s likely, we will prepare, not with some half-baked Bruce Willis option, but with a fully-fledged scientifically-plausible option. That probably means that we’ll end up doing something like sending a robot up to fire paint balls at it and then wait six months for the Yarkovsky effect to kick in, but that’s the sort of solution you’re going to get if you put science geeks in charge.