Question 1:

Dear Cheap Astronomy – So, no more lunar gateway?

NASA's Artemis program, which is totally committed to landing people on the Moon by 2024 unless it doesn't, is still looking a bit like like a space program on paper. For a long time the Artemis program ran with the idea that we would put a modular ISS-like space station in lunar orbit – in a roughly polar orbit that would ensure it stayed in constant radio contact with Earth. The idea was that it would be a way station for lunar astronauts and potentially for Mars astronauts. There is some logic to the waystation idea. The spacecraft that you need to launch from the surface of Earth, isn't really the spacecraft that you need to land on the Moon or to fly to Mars. You could do all those different things with Apollo-like modular designed spacecraft, but there's growing interest in having one type of reusable spacecraft that gets people and cargo into space – and once in space those people and cargo are loaded onto another reusable vehicle that works brilliantly in space, even though it would have no hope launching from the Earth's surface. Those space-going spacecraft could be built by launching components from Earth, along with people and cargo, as long as you have a way station where you can put all those things together

Trouble is, to justify the trouble and expense of building and sustaining such a waystation in space you need a reasonable amount of space-going traffic, both to and fro. And if you want a way station in space, putting it in Earth orbit has some clear advantages over putting it in lunar orbit. First, it's closer – so you'd just need a reusable spacecraft that gets you from Earth's surface to the way station in a matter of hours rather than a matter of days. And it would still be in Earth's magnetosphere – so the crew are protected from cosmic rays. And in the face of some kind of catastrophic emergency all they would need is a life boat with a heat shield that will let them drop back down to the Earth's surface.

The main advantages of a lunar orbiting way station are scientific in nature – you get more scrutiny of the Moon's surface and the opportunity to overcome a range of engineering and maintenance issues we've never had to deal with from the Earth-orbiting ISS. But it's hard to argue for a multibillion dollar operating budget if your main argument is that we should do this and the other things, not because they are easy, but because they are hard.

Anyway, the lunar gateway is still viable. Inded NASA has given Space X a contract to deliver supplies to the gateway when it's built. But there also statements that the Gateway is no longer critical to the 2024 mission return to the mission and what's being planned now is just a propulsion module and 'minimum habitation module' to be established further down the track. This is alsop puzzling since part of the justification for the Gateway was that that the Orion spacecraft wasn't well set up to act as a lunar lander plateform the way the Apollo command module had bee.

So Artemis is still mostly a space program on paper and 2024 isn't that far away. So, anything is possible, but you know… In a nutshell, a space going way station, essentially a Deep Space 9, is a great idea if you have a lot of back and forth traffic so you can generate lots of economies of scale. But after a 50 year hiatus of anyone landing on the Moon, starting your return to the Moon program by first building Deep Space 9 does seem a bit like putting the cart before the horse. The bean counters would also argue that we shouldn't invest the scarce funding available in a lunar gateway when you could instead establish a

Moon base. Cheap Astronomy's message to the bean counters who say it would be better to have a Moon base than a lunar gateway is – well, OK &%$#ing do it then!

Question 2:

Dear Cheap Astronomy – How will we get back to the Moon?

Continuing last week's theme of the planned return to the Moon mission in 2024. The actual mission that will do it is Artemis 3. The component architecture for the mission has the crew in the Orion spacecraft to be launched on the Space Launch System. The Orion spacecraft will play a similar role to the Apollo command module, so it will need to be joined up to a service module – which is now the European Service Module – a modification of the European Space Agency's Automated Transfer Vehicle, or ATV, which has a main engine and also fuel for that engine – and it will use solar panels for electrical power, rather than trouble-prone hydrogen-oxygen fuel cells (think Apollo 13). The ESM will fly the Orion crew capsule to the Moon and back again before being uncoupled just prior to the crew capsule re-entering the Earth's atmosphere.

And what about an equivalent to the Apollo lunar module you ask. The plan was always to have that – currently referred to as to as the Human Landing System (HLS) – waiting in lunar orbit for the Orion to arrive. Initially the Orion was to dock with the lunar gateway and the two members of the crew destined for the lunar landing (one almost certainly being female) would transfer over to the HLS lunar lander which had already been autonomously flown to lunar orbit and docked with the gateway. Now with the gateway out of the equation the plan is still that we'll autonomously fly the HLS to lunar orbit and the Orion will just dock with it directly.

As we said in the last episode, Artemis does still mostly look like a space mission on paper and the way you do missions on paper is all about the physics. So you look at the various mission components and calculate if their capabilities are sufficient for your payload – which in this case, is largely the crew and their life support requirements.

As much as the Cheap Astronomy's research department has been able to gather, the physics won't allow us to fly the HLS lunar lander from all the way from Earth, along with the Orion and its European service module. Both the Orion and the HLS are substantially bigger than their Apollo equivalents – so it's too just much mass to fly all the way to the Moon on the one engine, given the current technology we have available to us.

Anyway, it's good to know there is a plan and it all sounds feasible on paper. But landing a crew on the Moon in 2024? That is, to say the least, ambitious. Consider the mission timetables. Artemis 1 is scheduled for launch in April 2021 – which is, you know, next year on what maybe the maiden flight of the SLS. The plan is to fly an uncrewed Orion to the Moon and do an orbital insertion and a few orbits before returning to Earth. Artemis 2 will launch in late 2022, to fly a crew around the Moon, although it will just follow a figure 8 trajectory to go around the back of the Moon and then straight back again, so it won't actually go into lunar orbit. Then Artemis 3 is the real deal, flying a crew of four into lunar

orbit. Two of the crew will then transfer to the HLS lunar lander and then land – to stay for maybe a week, somewhere near the south pole so they can sample some of those permanently shadowed craters for water.

So, ambitious? Ah, yeah. Perhaps the most immediate issue is that the SLS rocket remains trouble prone and yet to do any kind of a proper test launch, let alone launch Artemis 1 next year. Various armchair commentators suggest we should switch to Space X's Falcon Heavy, which does have proven launch capability. That's not out of the question, but the Falcon's lift capability is about 64 metric tons, versus the SLS's 70 metric tons and every rocket has different dimensions and performance parameters, so you'd have to reconfigure the whole payload and how it's loaded on the rocket. so you'd lose a year or two anyway just working all that out. Less problematic is the Orion, where a prototype capsule was successfully test flown way back in 2014 and presuming the European service module is just a slight modification of the existing ATV, then that's already-proven hardware. At this time, the HLS lunar lander is not much more than an idea on-paper, but we still have until 2024 before it's needed.

So, we will get back to the Moon – absolutely. Will we get back there in 2024? Well…