Question 1:

Dear Cheap Astronomy – If things don't go according to plan with the James Webb Space Telescope, could we fix it?

So, here we imagine the James Webb launches in 2018, gets to its destination, but maybe its reverse-origami unfolding process doesn't work, or – and here we'd really like to think this couldn't possibly happen again – it turns out the mirror geometry is wrong. Well, it's already cost $8 billion and a lot of NASA and national pride is at stake, so at that point it's likely that people would start asking whether we shouldn't go out and fix it – like we did with the Hubble Space Telescope.

So, there are two issues here: one is whether we could actually fly astronauts out there to do the job and two is whether it can actually be repaired. A quick answer to the second point is no, which leaves the first point somewhat moot.

The Hubble Space Telescope was designed from scratch with the intention that it would be serviced several times over its life. It's full of detachable panels to enable access to its innards and most of its innards are modular in nature to allow things to be swapped in and out. The Hubble Space Telescope is beyond servicing right now, because we've lost the Space Shuttle. But, for now, the telescope is performing just fine and its orbit will not begin to substantially decay until well-into the 2020s. So, it's not out of the question that we may yet launch something robotic, which can dock with Hubble and lift it up to a higher orbit, which will then give us more breathing space to think about how we could service it again with an astronaut crew at some point in the future.

But anyway, the James Webb is a whole different story. It's an infrared telescope built to take advantage of the Earth-Sun Lagrange point 2 – where it can be in a solar orbit, so it can permanently face away from the Sun – but, by remaining around L2, it can stay in close proximity to the Earth.

The whole James Webb mission concept was to create a space telescope that could be folded up into the nose cone of a rocket and then launched to L2, 1.5 million kilometres from Earth, along with enough fuel to allow it to maintain a halo orbit around L2, for about ten years. So, as soon as we start adding modifications to make it serviceable, that's going to make it harder to fold up and would also make it a lot heavier, so it would need more fuel, which means the launch rocket would need more fuel ,and so on and so forth. All these kind of parameters are calculated and balanced, way back when a space mission is still on the drawing board. So, from the get-go the Hubble was always meant to be serviceable and from the get-go the James Webb was never meant to be serviceable.

So, if it turns out James Webb doesn't work after it arrives at L2 – that will probably be that. At this point in our technological history, It would actually be cheaper and quicker to build a new James Webb Space Telescope from scratch, rather than trying to fast-track a piloted rescue mission.

But of course, if James Webb does work – and it very likely will –after it's been delivering great science for ten years and we realise it's running low on fuel and that the end is nigh, then we might start exploring some options.

Interestingly, it was decided fairly late in the game to give the James Webb a docking ring. The docking ring is described as a just-in-case contingency – which means it's there just in case someone can think of something useful to do with it. Given James Webb's servicing limitations, probably the only thing worth considering is a refuelling mission - which might keep it going a bit longer until something substantial breaks down. Any docking procedure poses a significant risk to the telescope, so we'd only consider a refuelling attempt at the very end of the telescope's functional life and even then it's not like the James Webb has a fuel cap you can unscrew. So, maybe there's a way to do it, but it would be risky and expensive, because of course the James Webb really was never meant to be serviced. That was the plan, not an oversight.

Question 2:

Dear Cheap Astronomy – So what do you think of the BFR?

Space X's BFR may have started life as the Big Falcon Rocket until people realised the F could stand for so much more. But, despite the name, the BFR isn't actually all that big size-wise. As a fully stacked launch vehicle, the Saturn V was 111 metres tall, while the planned BFR stack will be 106 metres tall. And although the BFR is always depicted with lots of windows, as though all the passengers will get a view from their master bedroom, the diameter of the BFR is actually only 9m metres, while the diameter of the Saturn V was 10 metres. Admittedly, that is the diameter of the unmanned first stage of the Saturn V. The width of the command module, that housed the crew was less than 4 metres in diameter. So, OK the BFR has a wider average diameter and a wider cabin diameter – but, it's still just 9 metres.

Of course though, it's not all about size. What really matters in the rocket business is payload, that is how much mass a rocket can get into space. The Saturn V could launch a payload of around 120 metric tons to Earth orbit– although the whole Apollo spacecraft, fully-fuelled and on its way to the Moon along with its various modules, including the lunar module was more like 50 metric tons. The return mass of the Apollo command module and its three astronauts, was just 13 metric tons.

The payload of the BFR is claimed to be around 150 metric tons, although that is essentially the whole second stage of the BFR, which encompasses crew and cargo compartments as well as its own fuel tank and its own set of rockets. Its return payload, in terms of crew and cargo, will be 50 metric tons, which will be soft-landed on dry land when it's rockets retro-burn its last bit of fuel still aboard.

So, comparisons between the BFR and the Saturn V-Apollo solutions are complex. The Saturn V-Apollo solution got three astronauts to the Moon, two of them landed and took off again and then all three astronauts returned safely to the Earth. The BFR can launch its much larger spaceship into Earth orbit. But about all the spaceship can do from there, is land back down on the surface again. To do anything more interesting, it needs to be refuelled.

To make that possible, there are actually two BFR configurations. One is the spaceship atop the launch booster, the other is a tanker atop the launch booster. The tanker is pretty-much just a fuel tank, but with enough infrastructure smarts to enable the BFR spaceship to dock with it in orbit and refuel. The spaceship is then ready to go the Moon, or to Mars or whatever.

And it’s that refuelling step that changes the whole ballgame. The completely self-contained Saturn V assembly, fully-fuelled and with Apollo modules and astronauts aboard was 2,950 metric tons on the launch pad. The BFR spaceship assembly, fully-fuelled on the launch pad would be 8,650 metric tons, including a proposed 100 passengers who would make up less than 10 metric tons of that total mass.

So really, that’s why it’s called a big $%&#ing rocket – and is why its launch booster needs 31 engines. It might not be big in size, but it’s $%&#ing big in terms of mass that’s not just fuel. It’s important to appreciate that the primary purpose of a rocket is to launch a &%$#-load of rocket fuel off the ground, which is then steadily burnt up so as to get a very small proportion of the rocket’s launch mass into orbit and beyond.

The BFR concept with its tanker-mediated refuelling step, messes with the fundamental math of rockets. The BFR spaceship configuration launches an initially-useless fuel-expended spaceship into orbit, but then the refuelling step makes that spaceship useful again. This is certainly not an original idea, but making that idea a reality really would be a big $%&# deal.

For this plan to not only become a reality in the near future, but also get us to Mars by 2024, SpaceX has some work ahead of it – not only to deliver the hardware, but also to convince everyone it can deliver on its promise.