

Question 1:

Dear Cheap Astronomy – What's the latest with the James Webb Space Telescope

Alas the James Webb Space Telescope is becoming a tale of woe. There were high hopes of maintaining its 2018 launch date, up until around September 2017 – when the launch date was shifted to 2019, then it was shifted to 2020. An independent review board then went over current status and determined, in June 2018, that the launch couldn't happen before 30 March 2021 and to even to that, NASA would need to breach its already-revised budget cap of \$8 billion – requiring NASA to go back to the US congress and explain that it now needs \$8.8 billion just to get to launch.

But the tale of woe is not that JWST will get cancelled, too much has been invested for that to happen now. The woe is that it may now be harder for projects of this scale to ever get the go-ahead in the future. Big budget space telescope projects now carry a reputation for going way over budget and going way past their project deadlines. And no-one is interested in hearing that this is how the world works. If this is how the world works, then people should be planning for how the world works in their project proposals.

Given the money pit that James Webb has become, the rest of the space telescope community is crying poor, with WFIRST having come within a whisker of being cancelled in early 2018, although fortunately it wasn't. Nonetheless, the upcoming 2020 decadal survey for astrophysics has been directed by NASA to narrow the scope of any proposed flagship missions and cap their budgets at \$5 billion. This is presumably to ensure there's room to manoeuvre with James Webb and with WFIRST, since both are not only yet to launch, but they'll both need money for mission operations five to ten, or even more years, after launch. And sorry, if you don't already know, WFIRST is the Wide Field Infrared Survey Telescope. Given that, just like James Webb, WFIRST is an infrared telescope that, just like James Webb, is planned to be launched to the Sun-Earth L2 Lagrange point, it's lucky to still be a going concern and you'd also have to say that even if it's future is assured, the chances on it launching on time and in budget are at best hypothetical.

As to where things are with James Webb, the telescope is essentially built – indeed, NASA announced construction was complete way back in December 2016. Things have gone awry in the subsequent testing phases. For example, the mission-critical, but quite fragile sunshield was torn during a test deployment. The sunshield, not to mention the telescope's mirror has to be folded up into the nose cone of an Ariane 5 rocket for launch and then unfold origami-like once James Webb is in space. If that unfolding process doesn't work, it's pretty-much game over since we can't send anyone to fix it.

The tear was apparently what tennis commentators call an unforced error. Some of the cables which make the unfolding happen weren't tensioned right – so it was human error rather than a design error. There's also been an issue with a set of propulsion system valves that all had to be replaced because someone cleaned them with the wrong solvent. Also, some shake testing, meant to mimic the conditions of a launch, shook loose some screws and fasteners loose.

On the bright side though, the whole idea of pre-launch testing is to find problems and fix them. No-one really expects to get through pre-launch testing without finding something that needs fixing. But this is the thing, the independent review board produced a list of the

project's major problems, one of which was human error, but another was an excess of optimism – the message being that people should have been expecting the unexpected and made some contingencies for it.

Perhaps the main thing to reflect on here is that it's time to get a bit more real about those project proposals. Space is hard and for the most part not cheap. Gaining a reputation for submitting bogus funding bids is not going to help. Anyhow, ad astra James Webb, hopefully in 2021 - and best of luck WFIRST.

Question 2:

Dear Cheap Astronomy – Who will make it back to the Moon first?

So, which nation will land a human back on the Moon first? It's still looking like the US, since they really are building the Space Launch System and the Orion spacecraft – which have the right engineering to do the job, although a Moon landing is probably still more than a decade away since the hardware isn't operational yet and there's no firm commitment to going back to the Moon or anywhere else really.

Nonetheless, it probably will be the US, because once they've built the hardware, they're going to have to do something with it – and do something with it on a regular basis to justify maintaining all the infrastructure and to keeping lots of expert staff on. NASA has talked about asteroid missions, although it's not really clear why you need to send astronauts, unless it's to tele-operate robots in real-time – and those are asteroid-prospecting robots that no-one has built yet. And it's still the case that flying to Mars is just way too dangerous, notwithstanding you first need to build habitable modules to get there and a lander to land – and first you'd want to test that equipment pretty thoroughly – say by, you know, landing on the Moon.

But, all that said, it's still worth keeping an eye on what everyone else is doing. China and India are launching Moon missions in 2018 – unpersonned ones of course, but that is a step in the right direction.

India's Chandrayaan - 2 is scheduled for launch in October 2018 following the success of Chandrayaan-1, which orbited the Moon in 2008 and 2009. Chandrayaan-2 will aim to take things a step further by putting a lander on the surface and letting loose a rover. The rover will have 3D camera and various scientific instruments – none of which sounds like we should expect any dramatically new data. But, you never know – they might still find something that no-one has ever found before.

And by December 2018, we are expecting the launch of the Chinese Chang'e 4. The Chinese have already put a lander on the surface and let loose a rover with the Chang'e 3 mission in 2013. Chang'e 4 is going to put a lander on the far side of the Moon – which you might think is a little crazy because how will they relay the data back to Earth. But, in case you didn't notice, the Chinese also launched the Queqiao (kay key-yow) satellite in June 2018, which is now positioning itself into a halo orbit around the Earth-Moon Lagrange point 2 – meaning it will be ideally positioned to relay data from the far side of the Moon back to Earth. Chang'e 4 contains a curious scientific payload – a sealed canister with potato seeds

and silkworms. If the potato seeds germinate and grow they'll absorb CO₂ and produce O₂ and if the silk worms hatch and grow they'll absorb O₂ and produce CO₂. It's not quite this easy to create a self-perpetuating ecosystem, but it will be neat demonstration of what might be feasible sometime in the future. And hey, it's silk-worms and potatoes on the far side of the Moon. If we get wiped out by an asteroid the next day – well, at least we did that much.

The Chinese will take it yet a step further with Chang'e 5 sometime in 2019. This will be a sample return mission. The plan is to dig at least 2 metres into the Moon's near-side surface and collect samples that no-one has ever sampled before. There's a whole bunch of engineering challenges involved in accomplishing that task, but if the Chinese achieve that, you'd have to call it ground-breaking – small astronomy joke there – and you have to start asking what's next?

Well, there might be a few more Chang'e missions yet, but the Chinese are definitely planning to land Taikonauts on the Moon in the 2030s. That is a cautious and realistic deadline, which the US could easily beat if the US just commits itself to the same task sometime in the next 5 to 10 years – where committing itself to the task means it needs yet another five to ten years to actually do the task. Well, we'll see.

Oh and South Korea is also joining the club, with a lunar orbiter planned to launch in 2019 called the Korea Pathfinder Lunar Orbiter – the Pathfinder bit suggesting that South Korea also has long-term plans.