Question 1:

Dear Cheap Astronomy – What do you make of the space taxi announcement?

The space taxi announcement occurred in September 2014 when the US government awarded contracts to Boeing and Space X, to fly astronauts up from Earth to the International Space Station, the ISS, starting in 2017.

That time frame is pretty ambitious as neither spacecraft, the Boeing CST-100 or the Space X Dragon V2, have been built yet and you'd think that each might need at least one unmanned launch test before people start flying in them.

The CST of Boeing CST-100 stands for crew space transportation and the 100 is meant to symbolise the 100 kilometre altitude beyond which most of the atmosphere stops and people become astronauts. In 2012, a mock-up of the CST-100 capsule was dropped from a helicopter at four kilometres altitude to test its main parachute system, which apparently worked quite well. When it does launch properly, the CST-100 will be atop an Atlas V (which is a jointly-built Lockheed-Martin and Boeing rocket), but will also be compatible with a Delta IV rocket (which is built by Boeing) and a Falcon 9 rocket (which is built by Space X).

A mock-up of the Dragon V2 spacecraft was put on display in 2014 for a media event, but that's about all it's done so far. A launch pad test (which is not actually a launch) is scheduled for later in 2014. Once fully built, the V2 will probably launch atop the Space X Falcon 9, but could presumably be adapted to other rocket types if required.

Although Boeing is a bigger company with a longer track record, Space X has the advantage of already having flown its unmanned Dragon cargo vessel on several successful rendezvous with the ISS. Boeing doesn't have any current spacecraft that can do this, with the only other currently-flying US cargo vessel being Orbital Science's Cygnus spacecraft, which only started flying to the ISS in 2014. Space X has been flying there since 2012.

Both the CST-100 and the Dragon V2 will be able to launch up to seven crew, but are expected to mostly fly with four crew plus cargo and the first manned launch tests will probably fly with only two crew, just in case. Again, it will be a bit extraordinary if either craft manages to launch to the ISS with a crew aboard by 2017, but if not by then, they will soon after.

And if you hear someone saying that these latest spacecraft designs are a backward step because they all look like Apollo capsules – you should explain that no, in fact they all look like something that is designed to fly beyond Earth orbit and then return safely back to Earth again, which is what the Apollo spacecraft were designed to do.

A spacecraft that can achieve a speed sufficient to leave orbit, will usually also return to Earth at about the same speed – and there's no point wasting fuel to slow down when you can just aerobrake on the Earth's atmosphere.

Space shuttle orbiters re-entered the atmosphere at velocities of around 25,000 kilometres an hour, while Apollo capsules re-entered the atmosphere at about 40,000 kilometres an hour. A space shuttle re-entering the atmosphere at such a speed would risk having its wings ripped off. If you want to do high-velocity aerobraking, you use a round, flattened heat shield and a conical fuselage behind it. There's nothing old fashioned about this design, it's how you build these things.

This choice of design doesn't mean that the CST-100 or the Dragon V2 will ever leave Earth orbit, but perhaps both manufacturers want to be seen to be setting a course down that path.

It makes sense for a NASA contractor to keep abreast of NASA's own Orion spacecraft design, which is also Apollo-like and which really will be leaving Earth in the next five or six years – perhaps to the Moon or to an asteroid, although probably not to Mars. A Mars mission will need next generation designs, next generation program management and probably next generation governments.

Anyway, there you go, this is what we make of the space taxi announcement – and like most predictions of the future, this will probably turn out to be wrong in most important respects.

Question 2:

Dear Cheap Astronomy - How did the lunar rovers work?

Everyone loves rovers. The Americans, the Russians and the Chinese have all roved the Moon now. India is planning to be next, as are a number of private enterprise outfits.

The current distance record for a rover on a celestial body is held by Opportunity, which after 10 years on Mars has covered over 40 kilometers – way ahead of Curiosity's 9 kilometers to date, although it seems likely that Curiosity will eventually take that title – at least for a while.

But anyway, that's the robots' story. The human-driven lunar rovers were also remarkable – seeming, as some conspiracy theorists have proposed, to have appeared out of nowhere during the course of the Apollo landings.

However, not all the Apollo landings were the same. Apollo 15, 16 and 17, also known as the J missions, landed with upgraded extended mission lunar modules. The descent engines' size and power were increased to allow them to soft-land with more payload. In total, the extended mission modules were an extra metric ton in mass over the earlier versions and about 200 kg of that extra mass was a lunar rover, folded and flat-packed onto one side of the square body of an extended mission modules' descent stage.

Other enhancements to the extended mission modules allowed two astronauts to stay on the Moon's surface for over 3 days – something that the modules on Apollo missions 11 to 14 could never have managed. Those enhancements included a waste drain that went from the cabin to a holding bay in the descent stage – and the less said about that the better.

The ascent engines of the extended mission modules didn't have to be enhanced, since all the extra mass that was soft-landed, including the rover, was just left behind at the end of the mission. And, for the record, the waste drain's contents were also left behind.

Anyhow, the lunar roving vehicles or LRVs were pretty nifty, even if they weren't that fast. Gene Cernan holds the extra-terrestrial land-speed record, of 18 kilometres an hour, achieved while driving Apollo 17's rover.

Each rover was controlled by a T-shaped hand controller situated between the two seats. Pushing it forward moved the rover forward and a forward pivot movement provided throttle control – that is, making it go slow or go fast. Moving the controller left or right steered the rover left or right. You could also put the rover in reverse, by flicking a switch before pulling the controller back. And when you arrived at your destination, pulling the controller all the way back activated the parking brake.

As with any powered vehicles, particularly ones that operate in a vacuum, cooling was a big issue for the LRVs. The batteries and electronics were passively cooled, using thermal capacitors and radiating surfaces. While driving, those radiators were covered with mylar blankets to minimize dust accumulation. The blankets wouldn't blow away, since, you know… no atmosphere. Then, after stopping, the astronauts would open the blankets and carefully remove excess dust from the radiating surfaces with hand brushes. Cooling really was a big issue.

The rovers had an onboard computer which was fed data from a directional gyro and an odometer, so the astronauts could find their way back to the lunar module. In the event of a total systems failure, there was also a kind of sundial that would help point them in the right direction back. Since the Sun only shifts in the Moon's sky as the Moon turns once in its 27 day orbit of Earth, the Sun's shadow would hardly move at all over the course of 12 to 24 hours.

Incidentally, while the rovers did covered large distances, those distances were mostly concentric circles around the location of the lunar module. The astronauts were never allowed to drive further away from the lunar module than the distance over which they could conceivably walk back, in event of a breakdown.

The Apollo 17 crew managed to stretch this out to 7.6 kilometers. That's sounds like a long way to walk in bulky space suit, but in one sixth gravity it wouldn't have been so bad.