Question 1:

Dear Cheap Astronomy – How would you design a spacecraft.

Here at Cheap Astronomy we'd use recycled materials, outsourced labour and lots of cut corners. Seriously though… if we're talking about a crewed spacecraft one of the first things to think about is gravity. Most science fiction spacecraft have approximately 1G of gravity in all crewed areas, which is rarely explained. Discovery 1 from 2001 a Space Odyssey had a rotating crewed compartment, as did the Hermes from the Martian. This may be the best solution, although a cheaper solution would be having an onboard centrifuge that you could hop into for a couple of hours a day, watching movies or something while the centrifuge readjusts your body fluid distribution as well as toning your muscles and skeleton. Whatever method you go with, the cabin floors of your spacecraft would be perpendicular to the starship's main direction of travel, so that acceleration generates some useful artificial gravity rather than pressing the crew against a wall.

Another thing with science fiction spacecraft is that they are pressurized form nose to tail so that humans can access every part of the ship. In reality, to minimize the risk of decompression and also minimize mass you would limit pressurized crewed areas to a small number of cabins with sealable doors. Maintaining those pressurized areas needs pumps and filters which have mass and the gas itself also has mass, so you wouldn't bother with pressurized hang bays or even pressurized Jeffries tubes to access other areas of the ship. If there's maintenance required you either put on a space suit or you send a robot. Indeed part of good spacecraft design will be to have good robots. They could be telepresence units, which you would drive with a headset and hand controls or they'd be autonomous units that do standard tasks – or they could be both.

Science fiction spacecraft also maneuver implausibly in a vacuum. If you just have one main drive engine at the rear of your spacecraft, it's unclear what controls the pilot could be fiddling with to manage all those sharp turns you see in the movies. You need lateral thrusters, probably in the nose of your craft to balance the work of the main engine at the rear, a bit like the Space Shuttle orbiters. But, the aerodynamic form of the space shuttle orbiters with delta wings and a vertical tail fin are totally pointless features in a vacuum, they're just there so the orbiter can land aerodynamically on Earth. If a spacecraft is built for deep space travel, streamlining is unnecessary, but the craft would probably still be long and thin to maximize the distance between the crewed section and the main drive which would be generating a lot of heat and probably radiation. Its structural framework would need to be both strong and flexible, to manage forces of acceleration and as well as temperature changes that occur when flying within stellar systems.

Beyond all that you might think it's a long way down the road to the chemist's, but that's just peanuts to space, so if you want to get anywhere you need speed and lots of it. So you need to minimize mass and maximize your ability to increase speed, which in rocket terminology means maximising your delta V. If we assume warp drive is out of the question (and yes, it is out of the question), then you have to fly through real space. If you had a main engine that could maintain a constant 1 G of acceleration, that would be great for generating artificial gravity and you could theoretically get to Mars in a bit over a day. If you kept on going, you would start approach light speed in around about a year, but at that speed you'd also risk destroying your ship by colliding with a dust grain en-route.

But with an imaginary drive system that could generate a sustained 1G acceleration, the good ship Cheapastro would accelerate to up to a speed that was as fast as was safe, then coast at that constant speed - then, as the destination approached, the ship would turn around and fire its main engine to decelerate. So you get two periods of artificial gravity – and you can either rotate the cabins or use those personal centrifuges during the cruise phase. Piece of cake really.

Question 2:

Dear Cheap Astronomy – Are everything-you-launch-is-it spacecraft now old technology.

So, this is really a question about whether the Apollo mission concept – of launching everything in one go is the way of the future or will we move to an approach of where you launch components separately and then assemble them in orbit – and maybe fly to your destination where the various pre-launched modules are already positioned there awaiting your arrival – like say a Mars lander?

The latter case sounds compelling if not inevitable, but we should acknowledge the former case is pretty much all we've done so far. The Apollo mission concept was a launch-everything-in-one-go spacecraft, but it was also a kind of a hybrid – where, although everything was launched in one go – after the command and service modules detached from third stage of the Saturn V, they turned around to dock with the lunar module that was housed with the upper section of that third stage, hence creating a whole new spacecraft.

Probably the best-known example of a modular spacecraft that's been assembled from components that have been launched on different launch vehicles is the International Space Station, although it's never left Earth orbit.

So, all we can really say at this point is that it seems like a great idea to assemble purpose-built deep space exploration vehicles from separately launched composite parts, even though we've never actually done this. It does seem likely that whatever spacecraft does fly people to Mars it will be such a composite assembled vehicle, if only because of the mass we anticipate that vehicle will need, most of which will be in its fuel and propellant.

As well as flying to Mars in a composite deep space vehicle, we may then dock with a Mars waystation before transferring over to a Mars lander spacecraft – but again while it sounds like a good idea we've never done it before. NASA's current robotic lander solution is to use aerobraking – that is, the vehicle pretty-much flies at full speed into the atmosphere, using the atmosphere to slow down, hence saving on fuel that would otherwise be burnt by retrorockets. So just because we can land robots on Mars doesn't mean we have a solution to landing people on Mars, we just have a few ideas about how it might be done.

If you adopt the approach of flying to Mars to dock with something in orbit then you'll need extra fuel to enable you to slow down for an orbital injection and you'll need extra fuel to do all the fine maneuvering required to dock with another orbiting vehicle. All that may be possible, but remote docking with a 24 minute radio delay with Earth means it has to be either done with AI or by a human crew.

Beyond that, pretty much the only plan for a crewed mission to Mars is that we land and then launch again using locally-sourced fuel. Space X is running with this plan for its Starship super-heavy lift vehicle, which is still has prototypes exploding in 2021. Of course, this is how you get the job done, learning through failure. But when you have exploding prototypes in 2021 and the plan is to test fly an uncrewed mission to Mars in 2024 followed by a crewed mission in 2026, it all sounds a bit ambitious.

While it's feasible to produce oxygen from the CO2 atmosphere, the other required fuel component will be methane CH4, which needs water as a hydrogen source where the plan is to source from large sub-surface deposits. Again, this is feasible, but at this time we don't know where such large subsurface deposits are, we just think they exist. It's also the case that the first large scale Mars fuel plant will be delivered in parts and the first crew or crews to land will have to construct and also make that plant work so they can get home again. So, having launched different components on different launches just to get to Mars, you then have to assemble those parts on Mars to get home again. It is all feasible, but in 2026? Come on…