Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *Go up and turn right.*

Like most things in life, flying to Mars looks easy on paper. But in reality, it is almost insanely risky, technologically fanciful (at least by 2009 standards) and of course horrendously expensive. Here at Cheap Astronomy, we like doing things on paper.

Planning a spaceflight is all about reducing weight and finding fuel efficiencies. One of the heaviest things you are going to have to lift off the Earth is your fuel, so you need to make your spacecraft as light as it can be and try and limit how much fuel you need for the trip – because you have to take it all with you. For every bit of extra fuel you think you'll need, you'll have to take extra fuel to lift that extra fuel – which means even more extra fuel and so on.

Some of the other heavy stuff you are going to need to get to Mars includes enough consumables, like oxygen, food and water, to last you for about two years. You'll also need some kind of heaving shielding to protect you from the intense radiation out past Earth's magnetosphere – including the surface of Mars itself.

You are almost certainly going to need a whole separate spacecraft as well, like the Apollo lunar module, so you can undock and land when you achieve Mars orbit – and take off again after you've had a bit of a walk around. Otherwise you would have to land all the consumables and the fuel needed for your return trip and launch them off the surface again when you have finished your Mars mission – which wouldn't be very fuel efficient.

Apparently landing on Mars also carries its own complications. The atmosphere is too thin for aero-braking to have much effect on a big spacecraft carrying humans. This means you will have to slow your spacecraft down with retrofire. And guess what that means? Yep, you are going to have to carry more fuel, which means your spacecraft will have more mass and more momentum, so it will need even more fuel to slow itself down and land on the surface – and you already know this story.

Mars' gravity is only 40% of Earth's, but remember that the Moon's gravity is only 17% of Earth's. So your Mars module will need to be a lot bigger than the lunar module was – or at least its fuel tank will need to be.

In a nutshell, if you want to fly to Mars, start inventing now. As well as your light weight, but lead-shielded spacecraft – you will need to lift probably several oil tankers worth of fuel. And of course it will take more tankers of fuel just to get the first lot of tankers into orbit.

Of course instead of oil, we are talking large amounts of liquid hydrogen/oxygen and some hypergolics. Alternatively, we could just plan ahead in anticipation of someone discovering an incredibly light weight and ultra-efficient *Inventi-fuel* along with some lightweight-but-lead-dense *Inventi-shields* needed for the spacecraft. As long as all that happens, this whole thing will be a piece of cake.

Otherwise, it seems reasonable to assume that a mission to Mars will need to engage a workforce in the hundreds of thousands over a decade or more and during this intense period there may not be enough extra money or infrastructure around for people to fight wars and stuff – so yeah, all that is going to happen real soon.

But hey, apart from all those fiddly practicalities, the flight plan to Mars is a piece of cake. You just go up and turn right. We've done the go up thing plenty of times now. The smart thing is to launch your rocket from near the equator, which is moving much faster than any other part of the globe – and then let your rocket lean over to the east in flight, since the Earth is spinning towards the east so you get that bit of a leg up into orbit.

Once in a direct orbit (that is an orbit in the same direction the Earth is spinning) you can consider your next step – and the first thing to consider is that although you may be technically in orbit around the Earth – really both you and the Earth are in orbit around the Sun – and both moving at about 30 kilometres per second relative to the Sun.

If you can imagine looking down on the solar system from above the Earth's north pole, then you would see the Earth rotating on its axis in an anti-clockwise direction – as well as orbiting the Sun in an anti-clockwise direction. Indeed all the planets will also be orbiting the Sun in an anti-clockwise direction. So from Earth you'll need to turn right to go to Mars or turn left to go to Venus.

The most fuel efficient kind of interplanetary mission – at least to Mars or Venus – involves initiating a Hohmann interplanetary transfer orbit. This involves firing your rockets in one burst to put you on an elliptical trajectory that transfers you from one solar orbit to another. The trajectory is always going to be elliptical because you are still deep within the Sun's gravity well. Firing your rockets in a quick burst will move you up or down the gravity well, but as soon as you stop firing, the curvature of space-time will determine your subsequent trajectory.

Anyway, when I say you turn right to go to Mars – all you really have to do is fire your rockets to propel you ahead of the direction the Earth is travelling around the Sun – meaning you are increasing your velocity relative to the Sun. This gets you that bit closer to the escape velocity from the Sun, so you move up the gravity well towards Mars' orbit – that is, right. If you wanted to go to Venus you would actually have to do a retrofire, reducing your velocity relative to the Sun, making you move down the gravity well towards Venus's orbit – that is, left.

But of course there's more to this than just getting to Mars' orbit. If Mars' orbit is at the far end of your elliptical trajectory you are going to have to fire your rockets again to stay there, otherwise you will just keeping following your ellipse and fall back towards Earth's orbit again. Also, you really want to time this whole manoeuvre so that you arrive at Mars orbit just as Mars is passing by. Then all you have to do is get captured in its gravity well and commence your landing.

With today's rocket technologies and the whole fuel-equals-weight-equals-more-fuel issue it turns out that the most fuel-efficient Hohmann orbit from Earth to Mars will take you about 259 days – or about 9 months. And of course there's a limited launch window to ensure that when you leave Earth and follow your 9 month Hohmann orbit Mars is there waiting for you when you arrive.

This timing is actually determined by the aptly named porkchop plot – try Wikipedia for more information there. The plot demonstrates that a launch window from Earth to Mars is available every 25 and a half months. This opportunity just passed us by in late 2009 – and we'll have to wait until February 2012 for another shot – but somehow I don't think we're going to be ready.

So look, I know everyone's keen to go to Mars, but just in case all of humanity gets wiped out in the next asteroid impact – how about we build that planetary defence system people have been talking about first. Maybe clean up the atmosphere a bit too? Then we've got plenty of time on our hands to plan the trip properly – not to mention inventing all that stuff we'll need to make it happen.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where thought experiments don't need research grants. No ads, no profit, just good science. Bye.