Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *Powering deep space missions.*

If you want to send a spacecraft mission out past the asteroid belt, at the moment you'll need a chunk of plutonium-238 to generate electric power – just like we've done for Pioneers 10 and 11, Voyagers 1 and 2, Galileo, Cassini, even Ulysses which just did a big loop out and back to get a new angle on the Sun – and now there's New Horizons on its way to Pluto.

The reason for the plutonium of course is there's just not enough sunlight that far out to have any hope of running solar panels to produce electrical power, so all these missions have to have a radioisotope thermoelectric generator (or RTG).

That is of course until the Juno mission to Jupiter. Juno will be launched in 2011 – and then follow a trajectory to increase the diameter of its solar orbit by some conservative fuel burns, including a gravity assist fly-by of Earth in 2013 until it is able to rendezvous and go into orbit around Jupiter in 2016. Its electric power will be delivered by 3 giant solar arrays contributing a total of 60 square meters of solar panels which would allegedly produce over 18 kilowatts in Earth orbit, but only manage 400 watts in Jupiter orbit. Juno will also do the closest pass of any spacecraft so far, coming within 5000 kilometres of Jupiter's cloud tops.

But before we go there – what is exactly is an RTG and why isn't Juno using one of them? Maintaining electric power to spacecraft is vital if you want them to do anything, like take scientific measurements or take photos – and then transmit all that data back to Earth. Electric power can also support attitude control systems, like reaction wheels (or other gyroscopic mechanisms), which orientate the spacecraft – all of which is separate to a spacecraft's propulsion system, which needs rocket fuel.

Well, OK one exception to that rule are ion drive spacecraft – which use electrical power to charge the electromagnet that accelerates the ions out the back of the spacecraft to create thrust.

But anyway, it's time we answered the question of what is an RTG? They aren't nuclear reactors, but just take advantage of the heat generated by a chunk of radioactive material (generally plutonium-238, which is a plutonium isotope). If you sit a chunk of this material on a bench, it will glow red hot as a result of steady radioactive decay which may persist for a half-life of 90 years. Within the RTG, solid state thermoelectric converters, or thermocouples, use this heat to generate an electric current. Hence, the name radioisotope thermoelectric generator.

The Russians have actually used RTGs on Earth to power remote lighthouses – though this practice may have been discontinued following stories of lone trekkers sheltering up to an RTG for warmth – and then later being hospitalised with radiation burns. However, if you do just keep a bit of distance, they become quite safe. Small RTG's were used on the Apollo missions 12 to 17 to power the ALSEPs - standing for Apollo lunar surface experiment package – including the one on Apollo 13 – which was returned to Earth and underwent atmospheric re-entry along with the lunar module Aquarius – which had been the crew's life boat up until then.

Allegedly, NASA tested the waters where the remains of Aquarius were thought to have ended up and found no trace of plutonium contamination - probably because the plutonium container was built withstand re-entry temperatures and otherwise guaranteed to last at least 10 plutonium half-lives anyway – which is about 900 years.

There was a degree of hoo ha surrounding the launch of Cassini to Saturn which carried the largest amount of plutonium-238 ever launched from Earth - and was accompanied by the alarmist factoid that if that amount of plutonium was evenly dispersed across Earth then it would give every human being on the planet lung cancer. Well… let's remember that plutonium is a naturally occurring element and all the plutonium we've ever launched from Earth has been obtained from Earth.

Really, the most dangerous thing you can do with plutoium-238 is to concentrate it into a single pellet that is used in an RTG. Once that pellet is broken up and dispersed again, what danger there is pretty much goes away.

And even then, if you are planning to give everyone on the planet lung cancer, you need to come up with some plausible mechanism whereby the plutonium can be transported as an aerosol – which, given that it’s got one of the heaviest atomic weights of any naturally-occurring known element, isn't going to be easy.

So, all this suggests that RTGs are a reliable low risk interplanetary deep space mission power source - even if they may not be the best option for running terrestrial lighthouses. At least for now, if we want to send robotic spacecraft out past Jupiter's orbit to do exploration and science stuff - we need RTGs.

But, isn't it great that that you can now go to Jupiter with solar - made possible by the fact that we are building more efficient solar cells in the 21st century. Indeed, the main reason we decided to send Juno to Jupiter with solar panels is because we can. Space exploration is all about pushing our technology to its limits - which will certainly be the case with this hazardous mission.

After its 2011 launch, the little spacecraft with its huge solar panel wings will arrive at Jupiter in 2016 and be placed in a polar orbit of Jupiter, primarily to try and keep it alive.

The polar orbit will limit Juno's exposure to radiation - since like the way Earth's van Allen belts channel most of the Sun's high energy solar wind particles around the Earth's equatorial regions. Jupiter's magnetic field concentrates most of its high energy particles in a around its equatorial regions - and, again like Earth, around the polar regions Jupiter's magnetic field peters out – meaning it’s much safer to bring a spacecraft close in to the planet around the poles – and much more dangerous to bring it in around the equator.

And, once again just like Earth, Jupiter has polar aurorae, where high energy particles come into contact with Jupiter’s atmosphere - causing spectacular lighted circles around Jupiter’s north and south poles. Of course, within the perimeter of those circles, there are no high energy particles at all. So, the plan is to bring Juno close in to the planet near the poles within the perimeter of those aurorae, where it will manage to avoid most of Jupiter's powerful radiation.

Just in case though - the nerve centre of the Juno spacecraft, which is about the size of an SUV, has been enclosed within a titanium radiation shield. It's estimated that for the 15 months mission duration, Juno will have to withstand radiation that is the equivalent of more than 100 million dental X-rays.

And if you didn't understand that other analogy, SUV stands for sports utility vehicle, which is what we call a four wheel drive in Australia - and if that doesn't work for you, an SUV is about the size of the Scooby Doo Mystery Machine - being a 1966 Chevrolet Sportvan 108.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where you can feel good about being the member of a species that puts things the size of a 1966 Chevrolet Sportvan 108 in orbit around other planets. No ads, no profit, just good science. Bye.