Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *Don Quijote*.

The original Don Quijote, convinced he was not your average Joe, set himself a mission to save the village from marauding giants, which today gives us the phrase 'tilting at windmills' to describe a romantic urge to assail entirely imaginary foes with great bluster and bravado.

The save-the-Earth rehearsal mission Don Quijote, commissioned by the European Space Agency, is planned to test the potential of a real life-or-death mission to deflect a mass-extinction-inducing asteroid from a collision course with Earth. The mission aims to fire a high speed 500 kilogram projectile at an asteroid, which is several hundred metres in diameter and several hundred billion kilograms in mass - and this is just a test run. The ultimate aim is to develop the capacity to deflect an asteroid like the one that wiped out the dinosaurs (apart from the birds). At 10 kilometres in diameter, this really would be a giant and does make the whole exercise sound a bit like tilting at windmills.

But in reality space is really big and for every action there is an equal and opposite reaction. There will probably be several years lead time from the point you observe that an asteroid is on a collision course until the time of impact. So, just a tiny nudge in the asteroid's orbit should produce a substantial cumulative effect, enough so that will it miss Earth entirely. It's all about science and math - and a bit about billiards.

Currently only at the 'concept' stage, the Don Quijote Near Earth Asteroid Impact Mitigation Mission may, all things going well, launch by 2015. Various target asteroids have been proposed, one of which is the slightly worrying 99942 Apophis which does carry a marginal risk of Earth impact in 2036, although the risk (1 in 250,000) is pretty marginal. There was a more substantial concern about Apophis a few years ago, when the risk looked more like 1 in 300, because it was looking like it might pass through a gravitational keyhole in 2029. Such a gravitational keyhole is a point in space where Apophis might be influenced by the Earth's gravitational proximity shifting Apophis' orbit into line with Earth on its next close pass. But fortunately subsequent measurements have since indicated that it won't go near the keyhole in 2029 - or at least it almost certainly won't.

In any case, Apophis is instructive if you want to know more about near Earth objects. Apophis orbits the Sun once every 324 days - and its orbital speed is just over 30 kilometres a second, where the Earth takes 365 days at a speed of 29.8 kilometres a second. Apophis' slightly faster orbital period is consistent with its orbit's slightly smaller semi-major axis of 0.92 of an astronomical unit - where the Earth's is of course 1 astronomical unit. Also, Apophis' orbit is tilted by 3.3 degrees to the ecliptic, where Earth's orbit represents zero tilt.

This all means that there is a certainly a statistical possibility for the two objects to collide. But what keeps that probability low is that space is really big - or to be more specific, the Earth's orbit has a total circumference of nearly a billion kilometres. The probability of the Earth colliding with an object 300 metres in diameter that also orbits a circumference of slightly less than a billion kilometres and which doesn't move in exactly the same orbital plane really is a pretty tiny probability – even the 1 chance in 250,000 collision risk only holds for its close pass in 2036.

But hypothetically, if that remote chance was realised, the 300 metre Apophis could easily wipe out a city with the loss of millions of lives, there might be tsunamis, destruction of agricultural land, indeed all kinds of bad things - and this still draws short of the effect of a genuine mass extinction object – which would be about thirty times bigger in size and at least that in impact. If we are hit by something that big – humanity really might not survive.

So, hooray for Don Quijote – even if this is just a trial run.

Whether or not Apophis is chosen as the final target for the mission, it's proposed that there will be a dual launch of two spacecraft – being the Impactor called Hidalgo (which was a mock title given to the original Don Quijote) and an Orbiter called Sancho (who was the Don's faithful companion).

While the Impactor's role is self-explanatory, the Orbiter plays a key role in interpreting the test impact – the idea being to collect impact momentum and trajectory change data that would then inform future missions, in which the fate of the Earth may really be at stake.

The extent of transfer of momentum from Impactor to asteroid depends on the Impactor's mass (about 500 kilograms) and its velocity (about 10 kilometres a second), as well as the composition and density of the asteroid.

The Impactor would achieve the greatest momentum change if the impact throws up ejecta that achieve escape velocity from the asteroid. This means the ejecta will act as thrust to push the asteroid in the other direction. If instead the Impactor just buries itself within the asteroid, not that much will be achieved, since the Impactor's mass is quite tiny in comparison with the asteroid.

So before the impact, the Orbiter will make a detailed analysis of the target asteroid's overall mass and its near-surface density and granularity. This will then assist future targeting and impact velocity calculations. Also, after the impact, the Orbiter will assess the speed and distribution of the collision ejecta blown out by the impact via its Impact Camera.

So, this all sounds fine in principle, but accurately measuring the tiny degree of deflection that will be achieved by the impact represents a substantial challenge for the mission. We will need to collect exceedingly precise data about the target asteroid's trajectory before and after the collision.

So, a precise determination of the Orbiter's distance from the asteroid will be achieved by its Laser Altimeter, while a Radio Science Experiment will precisely determine the Orbiter's position (and hence the asteroid's position) relative to the Earth.

Having established the Orbiter as a reference point in this way, the effect of the collision of the Impactor can be effectively assessed. However, a significant confounding factor is the Yarkovsky effect – the effect of solar heating of the asteroid, which induces the emission of thermal photons which itself generates a tiny amount of thrust.

And of course, given the importance of the Orbiter as a reference point, the effect of solar radiation on it must also be determined. Indeed, we will also need to factor in that this effect

will change as the shiny new spacecraft's highly-reflective surfaces lose their sheen over the duration of the mission. Highly reflective surfaces will emit radiation, almost immediately, at energy levels almost equivalent to the incident radiation that hits it. However, low albedo surfaces may only produce low energy thermal radiation due to heating - which has a lower momentum.

To put it another way, a mirror surface makes a much better solar sail than a dark surface.

So to sum all this up, the Don Quijote impact mitigation mission will require an Impactor spacecraft with a Targeting Camera – and an Orbiter spacecraft with an Impact Observation Camera – and also a Laser Altimeter to monitor its distance from the asteroid, a Radio Science Experiment to monitor its distance from Earth and a Thermal Infrared Spectrometer to check for the Yarkovsky effect – and you should make sure to remember to measure the Yarkovsky effect on the spacecraft early in the mission, when it's shiny – and later on, when it's not.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where saving the Earth is actually rocket science. No ads, no profit, just good science. Bye.