Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *A planetary defence system.*

A good working definition for a planetary defence system is 'something that the dinosaurs never built'. Calculating the risk of a devastating impact with a large asteroid or comet is a kind of 'zero times infinity' problem. While there is almost zero chance of being struck in the next hundred years or so by a 10 kilometre meteor of the type that killed the dinosaurs, the effect of such an unlikely event would be unthinkably catastrophic.

But, unlike the poor old dinosaurs, in the 21st century we have options. All we need to do is be alert and not alarmed and maybe print the following handy survival tips on a fridge magnet.

1. Immediate action: Fund sky surveys.
This is about knowing your enemy. The Spaceguard Survey is currently underway aiming to identify 90% of near Earth objects (or NEOs) down to the size of 140 metres in diameter.

We still could get caught out by long period comets which aren't normally NEOs and can appear out of nowhere with maybe only a few years warning and they do tend to be dangerously large side. But still, knowing where 90% of NEOs are is an awful lot better than not knowing anything. Currently there's over 6,000 NEOs that we know about, with more yet to be found as the current sky surveys won't be finished for another ten or fifteen years.

One of the best available facilities for near Earth object tracking is the 300 metre Arecibo radio telescope – better known for its role in searching for aliens. The Arecibo dish can use radar up to a range equivalent to one tenth of the distance from the Earth to the Sun (that is, 0.1 of an astronomical unit). Trouble is, the Arecibo dish is fixed into the ground so it really needs help from the Goldstone Deep Space Communications Complex with dishes up to 70 metres in diameter – which can be manoeuvred around to cover the whole sky. However, currently Goldstone isn't really doing much of this and Arecibo is starting look a bit old and under-funded.

Objects can always be tracked with optical telescopes and this is your main option for objects more distant than 0.1AU – but radar provides the best method for accurate orbit and trajectory determination, as well as determining the size, shape and surface features of the object being tracked.

2. Medium term action (5 to 10 years warning): Civil defence
A strange term introduced by the 2010 National Academy of Science (NAS) *Defending Planet Earth* report, civil defence really means run for your life - or (*alarm*) please evacuate the anticipated impact site in an orderly fashion.

The NAS report considered various civil defence options depending on the size, frequency and destructive power of different objects. For example an object in the order of 25 metres in diameter might explode before it hits the ground with an energy release of perhaps 1 megaton. These might be expected every 100 years or so – an example being the 1908 Tunguska event – which was (ahem) 102 years ago.

Potential city destroyers in the 140 metre range may only hit Earth every 30,000 years, but with an energy release of 300 megatons. Objects around 1 kilometre in diameter have an estimated impact frequency of once every 700,000 years with blast forces in the 100,000 megaton range. These objects may have global effect, perhaps an 'asteroid winter' where impact debris and smoke blocks out sunlight for months or even years, but still falls short of a full on mass extinction. Mass extinction objects are in the ten kilometre range and may

only come every 100 million years or so, but then deliver impact energies of 100 million megatons.

If it's one of these taking us by surprise with less than 10 years warning, well, them's the breaks. Kiss your children, have a big party and wish the dolphins better luck than we had. Or maybe we could all go and live in an underground network of coalmines, led by a scientist with a certain visionary genius, like (*Dr Strangelove*).

Or what the heck, why not get ready to kick some asteroid butt. Whether the big bad comes in the next ten years or the next ten thousand years being prepared means you do end up saving all of humanity – not to mention the pandas and the polar bears and well, most of the megafauna really…probably the dolphins too.

3. Long-term action (more than 10 years warning): Engage

If we do have more than 10 years warning, there's maybe just enough time to develop and implement some nifty technology solutions, ideally managed by crack teams of steely-eyed folk in colourful uniforms, carrying things that go (*tricorder*)

Various asteroid deflection techniques have been suggested over the years – few of them involving (*phaser blast*), instead they tend to be clever and sciencey strategies like painting them bright colours to increase their albedo and allow light pressure to nudge them of course.

Gravity tractors represent a slightly more exciting and engaging solution. These are robotic spacecraft – maybe with cool sounding ion drives and gravitometric monitoring devices. Even if such a plucky little space tug is dwarfed by the mass of its nearby rocky or icy nemesis, Newton's inverse square law works to enable the tug to gently manoeuvre the larger object onto a different course.

The Planetary Society has recently advocated the use of mirror bees which would be a swarm of small robotic spacecraft carrying mirrors that concentrate sunlight onto the surface of an object, heating it and producing an outgassing of volatiles. So the object essentially blows itself off course.

However, any of these gentle push or pull options require decades to be effective and even then may only be effective on objects up to 100 metres in diameter. You really need to shift an object on intercept course by about 15,000 km (a distance slightly larger than the Earth's diameter). This requires either small forces exerted over long time periods or larger forces exerted over short time periods. Yeah.

If the large object is already on collision course, it's time for 'instantaneous force' (IF) options, which include crashing something into the object (kinetic impact) or, as a last resort, just nuking the darn thing – although the NAS report notes a 500% uncertainty about the outcome of such interventions. Ideally, a 'full deflection campaign' involves a primary IF deflection followed by some subsequent shepherding of the one or more remaining fragments with robotic gravity tractors.

To summarise, the rules of engagement are that slow push/pull options will only be adequate on under one kilometre objects and where we have decades to achieve an outcome. With objects of a kilometre or more we'll go for the kinetic impact option – although you still need a good decade ahead of it potentially impacting you, to have any real effect on it. So, with less time or with bigger objects – we'll just fire a nuclear weapon at them and hope for the best.

In the end - it is all about being prepared. Detailed surveillance of the skies will give us the advanced warning we need. From there, whatever we can do to cut down the time required to turn what's a good idea on paper into something we can actually launch could make all the difference.

We've taken quite a pounding over the last 4.5 billion years. Isn't it time the Earth learnt how to fight back?

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website helping you to save all of humanity on a tight budget. No ads, no profit, just good science. Bye.

Recommended reading:

National Research Council report (2010). *Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies.*

The Association of Space Explorers' International Panel (chaired by Russell 'Rusty' Schweickart) report (2008). *Asteroid Threats: A Call For Global Response.*