# Heaven Can’t Wait: A Critique of Current Planetary Defence Policy

PRE-PUBLICATION DRAFT

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Joel Marks

*University of New Haven, USA*

‘This is not an issue that we should worry about in the near term.’

– NASA Administrator Charles Bolden testifying about the threat of catastrophic impact by an asteroid or a comet (House Science Committee 2013, minute 104:50)

It is now generally recognised that Earth is at risk of a collision with an asteroid or a comet that could be devastating to human civilisation. Impressive strides in our understanding of this threat have been made in recent decades, and various efforts to deal with it have been undertaken. Intuitively the problem seems suited for governmental direction because of both the magnitude of the risk and the magnitude of the required response to that risk. However, the pace of government action hasn’t kept up with the advance of our knowledge. This is certainly not an unusual situation, given the indirect connection between real hazards to the populace and the way governments function. A gap has therefore opened up for non-governmental initiative to fill. Despite the daunting dimensions of planetary defence, one intrepid NGO in particular has stepped up to the plate: The B612 Foundation has embarked on a half-billion-dollar project, called Sentinel, to map the estimated one million near-Earth objects (NEOs) that could wipe out a city or worse (B612 Foundation [B612] n.d.a).[[1]](#footnote-1) This chapter will offer an explanation of how we have arrived at this curious state of affairs, where private citizens have assumed what is arguably government’s primary mandate to ‘provide for the common defence’ (quoting the preamble to the U.S. Constitution), and examine some of the practical – or, if you will, ethical – risks that may be attendant on such a shift of responsibility. Finally, a new policy emphasis will be proposed.

Humanity’s interaction with space rocks has a long history and no doubt prehistory, but the last half-century has been especially noteworthy. The period is aptly bookended by the 1963 publication of planetary geologist Eugene Shoemaker’s paper proving the meteoritic origin of Barringer Crater in Arizona (Shoemaker 1963), and the explosion of a meteor over Chelyabinsk, Russia, in 2013, which indirectly injured a thousand people and narrowly missed killing a million (Durda 2013). In between we have seen – to give just a partial list of highlights – the discovery of a likely meteoritic (that is, asteroidal or cometary) cause of the extinction of the dinosaurs (Alvarez 1980 and Schulte 2010); the collision of a comet with the planet Jupiter (Jet Propulsion Laboratory [JPL] 2000) – perhaps the most titanic event ever witnessed in the solar system by human eyes, including my eyes (Marks 1994); the initiation of a dedicated survey of near-Earth objects that could threaten humanity (Morrison 1992); and the realisation that our planet is immersed in a sea of such objects (Morrison 2005).

Yet these have been both the best of times and the worst of times for planetary defence. For hand in hand with these impressive revelations and undertakings has been an odd complacency. To slightly mix metaphors: Despite any number of wake-up calls, humanity keeps hitting the snooze button. Why is this? No doubt the answer is complex, with economic, political, and other contingent factors in play; but as a philosopher with an interest in this issue, I have been particularly attuned to the role of various fallacies of reasoning in bringing us to this pass.

The logical crux of the matter is the nature of risk. The standard formula for assessing risk is to multiply the (negative) value of a prospect by the probability of its occurring. Thus, suppose you were on your way to an important meeting and came to a fork in the road. You had been intending to take the left branch, but now a sign warns you of possible flooding after the last few days of heavy rainfall. The right branch also leads to your destination, but, although high and dry, is a longer route. Your choice is therefore whether to take a small chance of missing the meeting entirely or almost certainly to arrive late. Given the importance of your presence at the meeting, you take the route on the right. To have ignored either of the two sorts of consideration – the relative costs of your missing all or part of the meeting and the respective likelihoods thereof – would have led to an unsound decision.

The risk of impact by space rock presents a similar crisis. On the one hand we will want to consider the severity of the feared outcome: the destruction of a city, the disruption of a region, the wrecking of human civilisation, even the extinction of our species. On the other hand we will want to consider the probability of these eventualities.[[2]](#footnote-2) My diagnosis of the current state of affairs is that the relative lack of urgency in humanity’s response to this threat has in large part been due to the failure to carry out this analysis properly.

How could this be? Are not the components of the formula straightforward? What is peculiar about the case, however, is twofold: The value of the outcome seems virtually infinite, while its probability seems virtually infinitesimal. The former is so because the end of humanity would be the ultimate catastrophe (for humanity), not only killing billions of human beings but also aborting all future human beings and in the process stripping the lives of those who had lived of a great deal of their meaning (in progeny, reputation, and survival of projects and institutions to which people had contributed or for which they had sacrificed or with which they had identified or about which they simply cared). But the latter is so because such events take place in geologic time and not in the short span of a human generation or even a culture.

So what do you get when you multiply infinity times infinitesimal? The answer is not really mathematical since both of these quantities are only virtual or suggestive. The actual numbers to be assigned are very large or small but not genuinely infinite. But who is to say what those precise numbers are?[[3]](#footnote-3) The best we can do is compare relative magnitudes in an intuitive way; but this could be enough for practical purposes. Thus for example: A tiny chance of annihilation by space rock could be compared to the near-certainty of global disruption from climate change, leading to the conclusion that the latter be given priority.

But in reaching such a conclusion, fallacious reasoning has already been employed, I submit. I see the chief mistake in the way probability has been utilised. This is a deep problem, not just an error of calculation. It turns out that there are many ways to misunderstand the implications of minuscule probabilities when taking decisions based on them, and, indeed, in the process sometimes to misunderstand the nature of probability itself.

The relevant fact about asteroids and comets is that the larger they are, the fewer of them there are. This is known as a power law, and it has been empirically arrived at through extrapolation from observations. Furthermore, it is obvious that the smaller objects are less dangerous; the vast majority of them burn up in the atmosphere before they can cause any damage at Earth’s surface. In addition, even larger objects that can penetrate the atmosphere, or descend far enough to cause surface damage if they exploded, can be mostly discounted because most of Earth’s surface is uninhabited – in particular, the oceans that cover 71 per cent of the globe.

A critical point is reached only when a space rock is a kilometre or more in diameter, at which point the consequence of colliding with it would be regional or global no matter where it hit; for example, even plummeting into an ocean could result in a tsunami that devastated an entire coastline. And a true extinction event would require an object ten times that size. Now it is true that the Spaceguard survey mandated by Congress has already shown that there are roughly 1,000 kilometre-plus objects in Earth’s immediate neighbourhood (JPL 2013b). However, every one that has been tracked shows no risk of impact on Earth for at least the next century; and this only confirms the independent geologic evidence that mass extinctions on Earth have been exceedingly rare, regardless of extraterrestrial cause.

Is all of this cause for reassurance? Only, I shall argue, if one were to commit one or another of the following fallacies, which could lead someone to conclude that planetary defence is not an urgent matter or is even entirely unnecessary.

## The Fallacies

*Argument from ignorance*

While it is true that no object yet discovered poses an imminent risk to humanity, and also true that most (over 90 per cent) of the extinction-size objects that are estimated to exist in Earth’s vicinity have already been discovered, it does not follow that there is no such object. Yet we have this remark from Phil Plait (2012), a popular expert on astronomy:

We know there are no rocks that big [that is, extinction-size] headed our way anytime soon, at least not for centuries.

It is even more scary when the Near-Earth Object Program Executive at NASA says the same thing:

We know everything out there that is that big, and there is just nothing right now that's in an orbit that's any threat toward the Earth (Lindley Johnson as quoted by Wall 2012a).

These statements are simply false; we *know* no such thing. Not knowing that there are any is not the same as knowing that there aren’t any. To think otherwise is to commit the fallacy of arguing from ignorance. Indeed, Phil Plait (2013) was obliged to chew (if not eat) his words a year later when he reported:

Three new near-Earth asteroids[[4]](#footnote-4) have been discovered, one of which can actually get pretty close to Earth, close enough to categorize it as “potentially hazardous”. Now, don’t flip out about that. … this new one … only gets to about 5.5 million kilometers (3.4 million miles) form [sic] Earth. … so in real-world terms, this rock isn’t too big a worry. Which is nice, because it’s about two kilometers across, so we really don’t want it hitting us! … The other two asteroids never get near the Earth, which really is good news, since they’re both roughly 20 km (12 miles) across! … So really, none of these three new asteroids is a threat. However they underscore the need for more survey observatories to go sniffing around the sky. I don’t like that objects that big can still hide from us.

*Fallacy of composition*

But let us suppose that we do have or will shortly have a comprehensive inventory of the objects near Earth that would wreak havoc were we to collide, and sufficient prognostication to assure us that we won’t any time soon. It still would not follow that we are not at risk of a catastrophic collision in the near future. Why not? Because such objects, which are predominantly asteroids, do not constitute the only relevant category. Our planet is also vulnerable to collision with comets, and in particular, long-period comets (Chapman, Durda & Gold 2001). What is distinctive about the latter is that they are approaching from such a great distance that their speed would be tremendous by the time they reached the inner solar system. The result is that, at the point that a long-period comet targeting Earth were actually near Earth, it would almost certainly be too late for humanity to launch an effective defence against it. According to planetary scientist Donald Yeomans (2013, p. 120), the time-to-Earth-impact after detection of a long-period comet at the distance of Jupiter – typical for this kind of apparition – could be as short as nine months. Meanwhile, in his testimony before the House Science Committee on April 10, 2013 (at minute 68:00), astronomer and NASA principal investigator Michael A’Hearn explained that, under present circumstances, two to four years would be needed to launch a payload to deflect such an object. And A’Hearn’s comment pertains only to time-to-launch and perhaps time-to-intercept; the actual *deflection* of an *extinction-size* object with present technology could take from decades to a century.[[5]](#footnote-5)

Yet the term ‘asteroid’ dominates the present discussion of the space-rock threat, carrying with it the unspoken implication that comets are safely ignored. Thus, the name of recent Congressional hearings on planetary defence was ‘Threats from Space: A Review of Efforts to Track and Mitigate Asteroids and Meteors’; the name of a new United Nations plan for planetary defence is the ‘International Asteroid Warning Network’, and of the press conference announcing it, ‘Defending Earth from Asteroids’; the name of a recent White House/ NASA Grand Challenge on planetary defence was the ‘Asteroid Initiative’; the slogan accompanying the logo of B612, the premier NGO on planetary defence, is ‘Defending Earth Against Asteroids’[[6]](#footnote-6); and, taking their cue from the experts, just about any news report on planetary defence you are likely to come across will highlight asteroids usually to the total exclusion of comets, for example, Moscowitz 2013, in which ‘asteroid’ appears 16 times and ‘comet’ not once, being utterly typical in this regard.[[7]](#footnote-7)

That this is not just a matter of nomenclature is borne out by the plans currently under way to implement planetary defence. The most notable of these is B612’s Sentinel telescope. As their website explains, ‘Our mission is concerned with objects that are orbiting within the inner solar system’ (B612 n.d.b). Dealing with the threat of long-period comets is explicitly ruled out. As Ed Lu, physicist, former astronaut, and current B612 CEO, put it to me in a recent conference call (9 August 2013), ‘we would have to come up with something fundamentally different’ to meet it. To my knowledge, there are no plans by B612 or anyone else to do that. My point now is that the incentive to mount such an effort is being systematically dismantled by the drumbeat of fallacious asteroid/space-rock equations in the public discussion of the overall threat, and perhaps even in the minds of some of the experts. This is an example of the Fallacy of Composition, by which a feature of a part, in this case the manageability of asteroids, is attributed to the whole, in this case, the population of potential impactors.

What is particularly amazing and dismaying to me is that, with all the recent talk of the Chelyabinsk meteor explosion (plus the near-simultaneous buzzing of Earth by the even larger object DA14) being a wake-up call to the threat of impact by an asteroid, the far more ominous discovery of Comet Siding Spring the previous month elicited only exclamations of joy at the potential spectacle (Beatty 2013). At that time, C/2013 A1 (the comet’s technical name) was estimated to be of dinosaur-killer size or larger, and predicted possibly to collide with Mars in October of 2014 (a mere 20 months after discovery). It turned out to be smaller and a near-miss. But had such a comet as originally characterised been headed towards us instead, we would be toast.

*The clockwork fallacy*

Another fallacy in the thinking about and public discussion of the impact threat has been spawned, apparently, by a locution, namely, ‘once per’ or ‘once in’ or ‘once every’ (or just ‘every’). Consider the following wholly representative instances of its use:

… the frequency of NEO collisions where kinetic impact cannot accomplish deflection is low: approximately *once every* 100,000 years. (Schweickart 2008; my emphasis)

The first thing to appreciate is that although Earth has been and will get clobbered, it doesn't happen very often. Impacts from objects 10 km across, energetic enough to sterilize Earth, or nearly so, are *once-per*-100-million-year events – a good thing! (Beatty 2011; my emphasis)

Fortunately, the risk of The Really Big One – 10 kilometers (6 miles) across or bigger – is rare. Near Earth Objects (NEOs) that hit the Earth and do what the one 65 million years ago did to the dinosaurs and most other life on the surface – wiped them out – occur on the order of *once every* hundred million years or so. (Ropeik 2011; my emphasis)

The phrase is commonly used to express statistical facts, as in, ‘You can expect a three to come up once every six throws of the die.’ This is not meant literally, of course, since there could well be seven or thirty or even, I suppose, one hundred throws of a fair die before a three came up again. And even more to the point of planetary defence, you could get two in a row. As Arizona Congressman David Schweikert put it at a hearing on planetary defence: ‘It’s a 500-year flood except we had three of them in the last ten years’ (House Science Committee 2013, minute 79:14). The point is that ‘once every’ is a manner of speaking and should not be taken to imply regular periodicity.

Yet such mental slippage is a definite possibility, and can have very real-world consequences. This could not be more perfectly illustrated than by the following remark by Russian Emergency Minister Vladimir Puchkov regarding the lack of preparedness for what took place in Chelyabinsk:

We thought that humanity would not have to face such an attack for another couple of thousand years, but the opposite happened and Russia was hit with a large-scale natural emergency. (RT News 2013)

In addition to the basic fallacy, I would point out two concomitant temptations. First is that the specific numbers given appear to be made out of whole cloth. Obviously they are all rounded, and each must be based on something arbitrary or assumed. My strong suspicion is that the hundred-million-year figure in particular is an extrapolation from a single event, namely, the Chicxulub impact at the Cretaceous–Paleogene boundary. Second, even taking the numerical assertions at face value, they are typically employed in an absurd manner; it is as if there were a resetting of the cosmic clock every time one of these timespans is cited. Thus, when I hear someone say that a catastrophic impact occurs ‘once every’ umpteen million years, and reflect that it has been umpteen million years since the last one, I think, ‘Then perhaps we are due for another!’ But the clear intent of the speaker is, ‘Therefore it will be umpteen million years before there is another.’ Here is a possible example:

It turns out that [a large] asteroid … only comes along every 10 million years or so, but there are plenty of lesser asteroids that could make life unpleasant for you or someone you know *much sooner*. (Huebert 2006; my emphasis)

The essential fallacy remains that a regularity is sometimes presumed where only randomness reigns. The next Big One could come in a hundred million years or next year. We simply have no idea.

*The actuarial fallacy*

A close cousin to the ‘once every’ fallacy is the actuarial fallacy. As that ‘bad’ astronomer (his nickname) Phil Plait put it:

Allowing for the number of Earth-crossing asteroids – the kind that can hit us because their orbits around the Sun intersect ours – as well as how much damage they can do (which depends on their size), [astronomer Alan Harris] calculated that any person’s lifetime odds of being killed by an asteroid impact are about 1 in 700,000. … As a comparison, you’re more likely to die in a fireworks accident. (Plait 2008)

This may be true, but what follows? Although Plait is definitely a supporter of redoubled efforts on behalf of planetary defence, he nonetheless echoes Bolden (in the epigraph) by inferring that:

One out of seven hundred thousand! That’s still pretty low… and certainly not enough to lie awake at night worrying about it. (ibid.)

Ditto[[8]](#footnote-8) for Yeomans:

No one should be losing sleep over this issue …. We’ve got much bigger problems, such as global warming or firearm safety. (quoted by Boyle 2013)

The fallacy, indeed absurdity, of this inference is that it ignores the unique significance of an extinction event. An actuarial calculation makes sense for an insurance policy, where premiums and compensations for loss need to be mutually adjusted, and for other kinds of cost/benefit situations. But there can be no compensation for the loss of our entire species. One does not want an insurance policy to cover such a loss; one wants only to prevent it.

*False analogy*

A similar criticism applies to yet another variation on the same theme, this time by analogy to a lottery (and also being killed by a terrorist). In the same column quoted above, Plait notes that:

Despite propaganda to the contrary, the odds of any given person being killed by a terrorist attack are incredibly low. While terrorist attacks in the long run are a near certainty, the odds of you getting killed are very low. It’s like the lottery: someone wins every time (eventually), but chances are it won’t be you.

Ergo: It’s stupid to play the lottery. Just so, there will be annihilation by space rock, but the chance of your being a victim is minuscule. But what does this show? *Don’t worry – be happy?* I don’t think so! To conclude thus is fallacious, and in more than one way. For one thing, it is a kind of *ignoratio elenchi*, which is to say, beside the point. For the dreaded outcome is not necessarily one’s own death but rather the end of human civilisation. The second problem is that it leads to an irrational policy recommendation. This can be demonstrated by means of a *reductio ad absurdum*, as follows:

Suppose it were true that the vanishingly small probability of annihilation by space rock in the near future made it irrational to strive to make adequate preparations to prevent it (since there will always be more pressing priorities).

Then there would never be a good reason to make adequate preparations to prevent annihilation by space rock.

But there is certainly a good reason to make adequate preparations to prevent annihilation by space rock (since it will occur someday unless we prevent it).

Ergo: It is not true that the vanishingly small probability of annihilation by space rock in the near future makes it irrational to strive to make adequate preparations to prevent it.

*Fallacy of division*

Another way to diagnose the above mistake in reasoning is as an instance of the Fallacy of Division, by which a feature of a type is attributed to each instance of the type. Consider that somewhere out there is an asteroid or a comet that will be the next large object to hit Earth unless we stop it. In particular there is an object of diameter 10 or more kilometres (> 6 miles), which is large enough to wipe us out. Call this object NEPI, for Next Extinction-size Potential Impactor. What we want to know, therefore, is when NEPI will be at our doorstep, which is to say, close enough to be of real concern and yet far enough away to allow us enough time to prepare an effective defence against it.

Since NEPI has not yet been identified, we have minimal information to go by in answering our question. Currently all estimates are made on the basis of the relative frequency of extraterrestrial objects of various sizes. The fallacy is to suppose that the latter knowledge gives us knowledge about NEPI, or about NeLO – the Next Large Object to be discovered. This manifests a confusion about the nature of probability. It often seems to be treated as if it were an objective quality of an object or an event. Thus, when we ponder the likelihood that NeLO will be none other than NEPI, we seem to be attributing a particular probability to that hypothetical object.

Suppose, for example, that the Minor Planet Center in Cambridge, Massachusetts, announced that a new object had been discovered. Based on the orbital and other characteristics known or estimated to that date, the Center might also specify a probability that the object would hit Earth. However, as the object’s properties became better known, that probability could be considerably downgraded. This is in fact what happened after the asteroid Apophis was discovered in 2004 (JPL 2013a). It was at first given a small but real chance of impacting Earth in 2029; but over time that likelihood was reduced to negligibility. So, did Apophis’s physical properties change in the interim? Not at all. Therefore its probability of impacting us is not one of its properties. Rather, probability is a function of our knowledge of something, not a property of the thing itself.

That is, with two exceptions. For in reality – whether we know it or not – Apophis has either a zero or a one-hundred per cent probability of hitting us (unless we destroy or divert it). In other words, by the deterministic laws of the universe, a given object either will or will not hit Earth (unless we stop it). We now believe Apophis won’t. Meanwhile, ex hypothesi, NEPI has a probability of hitting us of one-hundred per cent (unless we stop it). The problem is: We don’t know when this will happen (or, more to the point of our real concern, when this would happen if we didn’t prevent it).

But there is a much more immediate problem. The confusion about probability makes it seem as if we *do* know when this *won’t* happen, namely, in the near future. For by interpreting the probability that NeLO will be NEPI as a quality of NeLO itself, we lull ourselves into a dangerous complacency about the prospect of extinction. We are lulled because the probability in question is exceedingly small, given the size class to which NEPI belongs. So why is the resultant complacency dangerous? Because the next large object to come down the cosmic turnpike does not itself have an exceedingly small probability of wiping us out. It has either a zero per cent or a one-hundred per cent probability of wiping us out, and we don’t know which.

The classic case of the Fallacy of Division is that the average American family has 2.6 children. Does this tell us that the next American family we encounter will have 2.6 children? Of course not. Indeed, no American family has 2.6 children, even though the ‘average one’ does. Just so, there is not a single asteroid or comet in the solar system that has a .000001 probability of being NEPI. There is only NEPI and then there are all the others that are not NEPI. And no statistical or frequency probability will tell us if the next large object to show up at our doorstep will be it. In fact, if NEPI were to surprise us and then wipe us out because we had been insufficiently prepared, the statistical probability of such an event would *still* be vanishingly small – ‘once per’ umpteen million years. But it would be little consolation when the doomsday rock is bearing down upon us to be able to exclaim, ‘This is highly unlikely!’

*Begging the question*

Yet another way to conceive the same error of reasoning is as an instance of question begging. For when the inference is made from a frequency probability (‘once every hundred million years’) to an assessment of risk (‘exceedingly low probability’), it is really only a change of language that is taking place, rather than a production of knowledge. The ‘conclusion’ is just a redescription of the premise (which has itself been misleadingly described), but appears to be telling us something new. We seem to know something about the next object to be discovered, but in fact all we know is the relative frequency in a population of objects of a certain size. Yet on this basis we go on to make predictions and decisions of great moment.

*Improper transposition*

A distinct error of reasoning that bears on the impact threat is the formal fallacy of improper transposition. A pessimist might cite a famous assertion by Socrates as an example. For when the snub-nosed sage proclaimed that the unexamined life is not worth living, it is commonly assumed that he meant to be making the much stronger claim that the *examined* life *is* worth living. This, however, would not follow. The mistake is to take a necessary condition (for life to be worthwhile, it must involve critical reflection) as a sufficient condition (habitually engaging in critical reflection will make life worthwhile). But, even granting the truth of the premise (that reflection is needed for the good life), additional conditions may need to be met before a life could be deemed a good one, for example, that you have friends.

This fallacy is hovering in the vicinity whenever someone says, ‘You can’t stop a rock you haven’t found.’ This has become a mantra of the planetary defence movement; for example, it is the cornerstone of B612’s Sentinel mission:

We have the technology to deflect asteroids, but we cannot do anything about the objects we don’t know exist. To date, less than 1% of asteroids larger than the one that leveled Tunguska in 1908 have been tracked. (Lu 2013)

The problem is to rely on detection as *sufficient* for planetary defence. Yet this is the natural, albeit fallacious, inference to draw. Our human tendency to do so is exploited, for example, in promotions of lotteries, as in the slogan, ‘You can’t win if you don’t play.’ But of course, if you *do* play the lottery, this surely does not mean that you *will* win the jackpot. Just so, we could have a highly developed monitoring capacity for space rocks, and yet, it would do us little good if, as noted earlier, what we discovered were a 10-kilometre comet speeding right toward us from the vicinity of Jupiter.

*Contradiction*

Finally there is outright contradiction or inconsistency with respect to another mantra of the movement:

Although the annual probability of the Earth being struck by a large asteroid or comet is extremely small, the consequences of such a collision are so catastrophic that it is prudent to assess the nature of the threat and to prepare to deal with it. (Morrison 1992)

This is of course an application of the standard formula for risk, which considers not only probability but also the value of the outcome. However, in the current climate, it tends to be invoked to spur action to ward off rogue asteroids but not long-period comets, and even so, the city-busters rather than the dinosaur-killers. The reason given? In direct contradiction to the mantra: Because the latter are so unlikely! *But they are also more calamitous*![[9]](#footnote-9)

Policy Errors

My concern, then, is not to be a logical nit-picker, but to show the dire practical consequences of widespread illogical thinking about the impact threat. For it is clear to me that policy issues about the danger of extinction by space rock are being decided in part on the basis of logical miscues, and that as a result, despite impressive achievements to define and meet the threat, humanity is leaving itself unnecessarily vulnerable. The specific policy mistakes I see are these:

To focus on smaller rocks to the almost complete neglect of extinction-size ones.

To focus on asteroids to the almost complete neglect of comets, and in particular, long-period comets.

To focus on detection to the relative neglect of deflection.

To focus on deflection of small objects with long advance-warning times to the almost complete neglect of deflection of extinction-size objects with short advance-warning times.

## Other Factors

There are certainly other factors supporting these policies besides fallacious reasoning. This is obvious because, as I have already indicated, the planetary defence community *has* shown an awareness of at least some of these logical pitfalls, and, more generally, the problematic nature of our epistemic situation.[[10]](#footnote-10) But that awareness has apparently been blunted by considerations such as the following.

*Cognitive bias*

There is a cottage industry of social scientists who have isolated various irrational biases that are inherent in human psycho-logic. The most obvious one relevant to the present question is the human tendency to exaggerate the risk of certain types of outcomes, despite their low or relatively low probability. This is why human beings are much more prone to dread flying than driving, even though the former is far safer. So it is commonplace to come upon items such as a column by science writer Jeff Wise in *Time* magazine, which places ‘Asteroids’ in the What We Fear [but is] Not Dangerous quadrant because ‘Astronomers already have a track on everything big enough to destroy civilisation’ (Wise 2012). Besides the outright falsity and illogic of this premise – the main theme of my chapter – I would also argue that the implied analysis is flawed. For the flying/driving example takes the relevant outcome to be death as such, in which case driving is surely more risky than flying. But would it not be more apt to conceive the outcomes as contrasting, say, instantaneous death from crashing through a windshield on the one hand, and, on the other, minutes-seeming-like-an-eternity of terror in a plummeting airplane and then death? If so, then the higher risk attributed to the less likely event might be quite legitimately based on a much more dreaded outcome. And, of course, what could be more dreadful than the end of our entire species?[[11]](#footnote-11)

*Anti-nuclear resistance*

There is also a popular movement to eliminate nuclear weapons, and to keep them out of outer space in particular. Consider this statement from a report co-signed by former U.S. Senator Chuck Hagel just before he became Secretary of Defence:

No sensible argument has been put forward for using nuclear weapons to solve any of the major 21st century problems we face …. (Global Zero 2012, p. 2).

But this flatly contradicts the finding of the most comprehensive and authoritative report on the impact threat to date:

Unless a large flotilla (100 or more) of massive spacecraft was sent as impactors, nuclear explosions are the only current, practical means for changing the orbit of large NEOs (diameters greater than about 1 km). They also remain as a backup strategy for somewhat smaller objects if other methods have failed. They may be the only method for dealing with smaller objects when warning time is short …. (National Research Council 2010, p. 84)

The current state of this controversy is admirably reported by Birch (2013).

*Budgetary resistance*

There is also abroad in the land (of the U.S.in particular) a very budgetary-minded antipathy to creating new government programs. The satirical newspaper *The Onion* captured the sentiment perfectly in an article titled:

Republicans Vote to Repeal Obama-Backed Bill that Would Destroy Asteroid Headed for Earth (http://www.theonion.com/articles/republicans-vote-to-repeal-obamabacked-bill-that-w,19025/)

Nor is this mere satire; the situation characterised in the following quotation from 2007 remains unchanged today:

NASA officials say the space agency is capable of finding nearly all the asteroids that might pose a devastating hit to Earth, but there isn't enough money to pay for the task so it won't get done. (Borenstein 2007)

And during the government shutdown in October 2013, NASA, the agency that is de-facto in charge of American planetary defence efforts, turned out to have the largest percentage of ‘nonessential’ employees of any large government agency who were sent home – 97 per cent (Borenstein 2013)!

Yet the simple fact is that the tremendous progress made to date has been done on the cheap – mere millions, not billions of dollars of federal moneys. And even if the cost of a comprehensive planetary defence were significantly higher, it might still be comparable to portions of the budget that we take for granted, such as national defence and health care. Consider how much the money spent on the Iraq War could have furthered the protection of our species! The issue, therefore, I would maintain, is not one of affordability but of priorities.[[12]](#footnote-12)

Furthermore, it is not really an either/or proposition for a wealthy nation, for example, defending against terrorists or defending against space rocks, or defending against city-busters or defending against dinosaur-killers – no more than is providing *both* food and shelter for an average American family. The cost argument could therefore be considered another fallacy of reasoning: *false dichotomy*. For example:

… most people continue to drive their automobiles regardless [of there being ‘31 million accidents … per year, at an annual cost of almost $100 billion’]. For the same reason, that we can't live our lives paralyzed by the fear that something bad may happen, we shouldn't let the remote possibility of being struck by a meteor or asteroid rule our lives. (NASA 1998)

This makes it sound like the situation is that either we go crazy with worry and go broke funding feverish efforts to avert a very unlikely catastrophe, or else we live a sane existence with no sense of urgency whatever. But of course there is plenty of room between these extremes for a rational but still urgent effort to address the possibility of a catastrophic impact.

The Private Sector Response

All of these factors[[13]](#footnote-13) have come together to inspire the B612 Foundation’s initiative to build and launch its own space telescope (B612 Foundation [B612] n.d.a). The aptly named Sentinel will be placed in a Venus-like orbit, which will allow for continuous scanning of the near-Earth vicinity while looking away from the Sun. In addition, the outer-space vantage will avoid the water vapour in Earth’s atmosphere, which impedes the infrared radiation that emanates from charcoal-black asteroids. Sentinel’s sole purpose is to fill the existing gaps in our knowledge of which objects orbiting near Earth pose a potential impact threat. It is expected to complete the inventory of the estimated one million such objects that would be large enough to destroy a city (or worse).

I personally am astounded that a nongovernmental organisation has the wherewithal – or at least the chutzpah – to take this near-definitive step to save the world. There is no question in my mind that people like Rusty Schweickart and Ed Lu are heroes of the highest order for seeing what needed to be done, and could be done, and then doing it. (Full disclosure: I am a proud contributor to their organisation.)

But I am equally astounded that humanity has come to this pass, that an NGO wholly dependent on donations from private citizens needs to take such an initiative; for it represents a colossal failure of government to carry out one of its fundamental charges. In addition, I am dismayed by the further hardening of policy positions that I have characterised as irrational, which seems to be an inevitable result of the privatisation of this governmental function. For consider that B612, which must quite properly focus on a project that is do-able by private means, may consequently be obliged to withdraw from, if not outright discourage, public discussion of the broader conception of planetary defence, lest that divert interest and funds away from its own herculean enterprise. This leaves it to outliers like myself[[14]](#footnote-14) to perform this educative and political function – to play Chicken Little (or Don Quixote?) to an unknowing and sceptical world, and to a government that would be only too happy to discount the larger threat so as to focus on more local and electable concerns. The problem with relying on the private sector to conduct planetary defence, therefore, is that the fallacies I have highlighted in this chapter become not so much mistakes of reasoning as business and practical imperatives.[[15]](#footnote-15)

Conclusion

I therefore propose as a principle of planetary defence that we act on the assumption that the next extinction-size object targeting Earth will be discovered the day after we have prepared an adequate defence against it were we to begin to prepare with all deliberate speed today. This further implies, I submit, that we cannot wait until we detect a specific threat to prepare to deflect it, but must have a deflection infrastructure in place prior to detection.[[16]](#footnote-16) Further, the scope of detection efforts must also be increased, specifically, beyond the orbit of Jupiter and outside the ecliptic plane, in order to provide the advance warning we would need to deflect a long-period comet with our name on it. Any less robust planetary defence policy strikes me as irrational and potentially fatal to the human race.

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1. The technical, and confusing, definition of “near-Earth object” encompasses even objects that may now be vastly distant from Earth, so long as at perihelion they would be closer than 1.3 AU to the Sun (where 1 AU is the mean distance of Earth from the Sun). In this chapter I will be using the term more intuitively, as others have done, to refer to objects whose orbits are within the inner solar system. Cf. also B612 Foundation n.d.b. [↑](#footnote-ref-1)
2. Strictly speaking one’s deliberations would not be complete until one had also tallied up for comparison the likely net costs, including opportunity costs, of *attempting to avoid* the various possible outcomes. [↑](#footnote-ref-2)
3. Goodin (1995, chapter 17) deals with the same sort of problem in a discussion of nuclear disarmament, where he proposes a “shift from probabilistic to possibilistic reasoning” to resolve it. I cannot help but wonder if Goodin’s defence of disarmament would have withstood factoring in the impact threat. See also my discussion of anti-nuclear resistance in the sequel. [↑](#footnote-ref-3)
4. Plait updated this to report that one of these asteroids has been reclassified as a comet, which could help to explain why it had never been observed before. But this is small consolation, as I explain in the sequel. [↑](#footnote-ref-4)
5. Cf. this typical statement regarding even the smaller asteroids: ‘The B612 Foundation Sentinel Space Telescope … will give humanity *the decades of warning needed* to prevent asteroid impacts with existing technology’ (Lu 2013; my emphasis). [↑](#footnote-ref-5)
6. The B612 Foundation’s website does, however, discuss the cometary threat (B612 n.d.b). [↑](#footnote-ref-6)
7. This particular article is noteworthy for its neglect since two of the speakers at the press conference it was covering (American Museum of Natural History 2013) actually did mention, indeed highlighted the comet threat (and in a way that could be interpreted as critical of their colleagues): astrophysicist Neil DeGrasse Tyson (at minute 42:53) and former astronaut Thomas Jones (at minute 57:08). [↑](#footnote-ref-7)
8. I find it deliciously ironic that both Yeomans’ statement and this more specific claim by a reporter writing about the actuarial aspect of asteroid impacts – ‘With another asteroid scare coming up later this month (spoiler alert: we won't die), it's time to put the danger of "impact events"– when comets and asteroids crash into Earth – in perspective’ (Nerney 2013) – came just weeks before the meteor explosion over Chelyabinsk, which narrowly missed killing one million people. Director of the White House Office of Science and Technology Policy John Holdren skewered the actuarial fallacy in his Congressional testimony after Chelyabinsk (House Science Committee 2013, minute 105:30). [↑](#footnote-ref-8)
9. I will admit that there may be a reasonable limit of concern in terms of what is technologically feasible. Consider for example the recent surmise that there are billions of planets in our galaxy not orbiting any star (Wall 2012b). This would then suggest the possibility of a *When Worlds Collide* scenario, against which we would, presumably, be truly helpless. Yet I note with mixed feelings the White House’s tongue-in-cheek dismissal of a recent popular petition to build a Death Star (https://petitions.whitehouse.gov/petition/secure-resources-and-funding-and-begin-construction-death-star-2016/wlfKzFkN). [↑](#footnote-ref-9)
10. For example: ‘It is this juxtaposition of the small probability of occurrence balanced against the enormous consequences if it does happen that makes the impact hazard such a difficult and controversial topic’ (NASA 1998). [↑](#footnote-ref-10)
11. That is, dreadful to us; for certain other species might send up a cheer at the prospect of our, albeit not their, demise. [↑](#footnote-ref-11)
12. See Gerrard (2000) for an exploration of how such priorities are set. [↑](#footnote-ref-12)
13. Easterbrook (2008) offers yet another hypothesis:

    NASA’s institutional instinct is not to ask, “What can we do in space that makes sense?” Rather, it is to ask, “What can we do in space that requires lots of astronauts?” [↑](#footnote-ref-13)
14. And gaiashield.com [↑](#footnote-ref-14)
15. But perhaps the same could be said as well about government, mutatis mutandis. Hence the perennial need for the role I have assumed in writing this chapter – the philosopher as gadfly. It does not take a rocket scientist to observe that it is better to be safe than sorry or that, while hoping for the best, it is wise to prepare for the worst. [↑](#footnote-ref-15)
16. Compare Chapman, Durda & Gold (2001, p. 13):

    Instead of waiting to characterize threatening objects only after they are discovered, consideration should be given to the advantages to building a capability in advance. [↑](#footnote-ref-16)