Cosmic Promise

Logic and Arguments Justifying a National Planetary Defense Policy

Watching The Wall

If you are Watching the Wall
And look for the Greater Harm,
See first to your False All Clears
And not to your False All Arms.

See: Priam at the gates of Troy, Smith on the bridge of the Titanic,
Chamberlain at The Battle of Britain, Kimmel at Pearl Harbor, or Clark on 9/11...

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Governmental policy is justified and becomes manifest only in response to some perceived Risk. The clarity and accuracy of the perception of that Risk is fundamentally deterministic and foundational to the accuracy and relevance of any policy. Further, until a policy defines and establishes an objective we cannot think strategically: determine what is essential to the conduct of implementing a successful response. Consequently, if the perception of a Risk is flawed so will be the resulting policy and any subsequent strategic designs. Even further, should the perception of a Risk be flawed in the direction of understating the threat, either in terms of the probability of the event or the magnitude of the loss, the potential for dire consequences becomes far *more* likely. Effectively, the existential Risk becomes compounded through incompetence. Should we fail to get *this* Risk *right* our very survival as a species may be forfeit...

Yet it seems to be a settled academic consensus, at least to the level of administration of NASA (defining the context for its recent Near Earth Object Workshop), that the results and product of the Spaceguard Survey can be interpreted as somehow reducing the Risk of large asteroid impact. Their claim is that by 2008 in discovering 90% of the estimated categorically large earth-orbit-crossing asteroid population and further finding these asteroids not to be 100 year threats they will as well have effectively reduced the 100 year Risk of large asteroid impact by 90%. A predictable consequence of this projected assessment is that policy makers, and those who may influence them, are now no longer considering the need for an effective tactic or comprehensive strategy, let alone determine and codify any policy, in response the threat of asteroid impact.

Rather, now the focus is to address the categorically *small* asteroid population. Presuming to reduce the level of that Risk in the same dubious manner. Then, by the completion of this mission, claims can be made to have retired the Risk of asteroid impact altogether. How can the failure to determine which large asteroid is "The Next Large Asteroid on its way to strike Earth" and if it will impact in the next 100 years or not, rise to the level of reducing the Risk?

Deterministic, rational logic would insist that conditionally, all that would be required for the unmitigated Risk of one large asteroid impact event (and the potential for our extinction) in the next 100 years would be the mere *possibility* of one and only one undiscovered large asteroid. However, Risk is probability of loss so perhaps they are using some probability theory...

Today the objective averaged relative frequency for large asteroid impact events is considered to be roughly one event every 500 thousand years. From this, a daily random-chance (statistical) probability for a large asteroid impact can be derived and be roughly expressed as 1 in 180 million. This means that the random-chance probability for a large asteroid impact today is 1 in 180 million. It means that on any given day 1,000 years from now the daily probability for large asteroid impact would be 1 in 180 million. And it means that on that day 65 million years ago when a 10 km large asteroid struck the Yucatan Peninsula the daily probability for large asteroid impact was 1 in 180 million. It means that on any day in the life of Earth that a large asteroid has struck our planet the daily random-chance probability for large asteroid impact was 1 in 180 million. It also means that if you look out your window and see a categorically large asteroid 10 seconds away from impact the averaged relative frequency derived random-chance daily "statistical" probability for large asteroid impact would be... 1 in 180 million (roughly).

If observing the specific expression of an event interpreted by random-chance probability does not alter the random-chance probability for the expression of the event then conversely, neither does observing the absence of the expression of such an event. The effect of either event would be a characteristic exclusive to the province of an empiric-conditional probability. Random-

chance (i.e. frequency, stochastic, statistical) probabilities are a metric of chance. Empiric-conditional (i.e. deterministic, epistemic, subjective) probabilities are a metric of certainty. The discrete methodologies and relevant elements that constitute to these two types of probability are unique and noninterchangeable and consequently these two probabilistic perspectives are wholly incompatible and nonconstructive to each other in application. In and of itself, discovering and observing the condition of asteroids has no effect on their random-chance probability for impact.

It should be enough to dismiss the Spaceguard Survey's assessment as strategically irrelevant on the basis that it is founded on random-chance probabilities and any such perspective can not be deterministic, accurate, testable or predictive (also the exclusive province of empiric-conditional probability). Rather, as an artifact, any random-chance probability is an abstraction and as such wholly a-rational: nonconstructive to sound prescriptive decision making. Conclusions or logics drawn or proceeding from random-chance probabilities can be no more than rationalizations...

Taken together, the Spaceguard Survey's assessment for the strategic effect and value of their results can be doubly dismissed as being a flawed interpretation of a intrinsically irrelevant perspective. On balance, strategically speaking, the product of the Spaceguard Survey threatens to do far more harm than good. Not for what they expressly have or have not done but for what they claim to have done and have not!

This business is not about Man in Space. This is about the Survival of Mankind. The prospect of large asteroid impact and the potential for our extinction is not merely a Risk. It is not merely a threat - it is a Cosmic Promise. How can we afford the Risk of abstract and academic thinking of strategic dilettantes *here*? How can tasking this most dire of all human endeavors to anyone less than the best strategic minds on the planet possibly be considered wise?

Strategic Context:

From a dynamical analysis of the solar system we understand that the prospect of Earth/asteroid impact is an ongoing process and a cosmic status quo that will never change. From objective averaged relative frequency estimates it can be extrapolated that over the next 500 million years Earth will be struck by 100,000 asteroids. By a large margin most will be categorically small: 50 to 1,000 meters in diameter. However 1,000 of these will be large: 1,000 meters or greater in diameter. Of these large asteroids at least 10 will be greater than 10,000 meters in diameter and on impact convey the potential for a human extinction level event. There are two things all these asteroids have in common that are relevant to defining the strategic Risk a) all of these asteroids are out there right now and b) their impacts will all be random and aperiodic events. So, here and now we are somewhere between the last large asteroid extinction level impact event and the next. We will not/can not know exactly where until we see it coming... *if* we see it coming.

That said, the number and frequency of small or large asteroid impact events or total human extinction level impact events in mankind's future is strategically irrelevant. The number of small or large asteroids does not help to meter or predict the occasion or magnitude of the existential Risk: Probability of Loss, or consequently the level of our response. As impact threats these asteroids are individually unique and discrete from each other and must be confronted and dealt with, without fail, one at a time in the order of their occasion. There may be no opportunity to learn from our mistakes here. Simply put, how many extinction level events can we afford?

There is one asteroid that constitutes a rationally manifest and existential first-order definition for the threat of asteroid impact: “The Next Large Asteroid on its way to strike Earth” (TNLA).

Therefore, tactically speaking, the Risk of asteroid impact for any given increment of our future would be the impact of TNLA in that increment. If the most critically relevant strategic increment can be narrowly defined as the next "evergreen" 100 years, it would follow that the expression of the Risk of asteroid impact in its most critical and likely rational postulate would be for one and only one large asteroid to be on course to strike Earth in the next 100 years... by default: The Next Large Asteroid on its way to strike Earth.

Further, which large asteroid is TNLA or if there is or is not one large asteroid on course to strike Earth in the next 100 years, are both binary problems that cannot be resolved proportionally or in any way probabilistically. Both are problems that are not likely to be resolved in any manner other than by detection a few decades before Earth impact... and then only with very good luck.

Strategically speaking, the question of which large asteroid in our Solar System is TNLA alone rises to the level of the most important thing mankind will *always* need to know. As a binary problem that can only be approached and resolved in the absolute and in the affirmative, not finding TNLA is worth nothing. The strategic Risk here is that we may fail to determine exactly which asteroid is TNLA in time to successfully deflect it: the most important thing mankind will always need to *do*. How much time will be required for a successful deflection can only be reduced by Preparation and Training. How much time we will have to successfully deflect it once we do know which one it is can only be increased by Vigilance. The only relevant metric for reducing Risk here is in the degree of effectiveness reflected in whatever program of perpetual Preparation, Training and Vigilance we chose to implement. But knowing which asteroids are not TNLA is nothing... strategically speaking.

The Logic in First Principals:

The Spaceguard Survey et al claim that by finding 90% of the rogue, Earth-orbit-crossing large asteroids estimated and in also finding this discovered 90% to be "safe" (not 100 year threats) they will have reduced the 100 year Risk of large asteroid impact by 90%. Clearly they have done little that can go to actually deflecting asteroids. They have not built a fleet of Galactic Class Asteroid Interceptors and any level of early-warning they may represent can not be afforded value independent of a standing, tested deflection capability. They are expressly addressing only the probabilistic element of this Risk and not the loss inherent in its occasion.

If we consider that given a constant mind and a constant perspective then in the absence of new, relevant information, any interpretation or understanding of an event or condition will remain constant as well. This would seem to be a First Principal of Logic, if not a comprehensive definition for its inherent mechanical process and essential nature.

From observations and analysis of the dynamics and geometry of this rogue asteroid population we understand that the orbital elements of these objects are all unique and discrete to each other. From this we can safely extrapolate that Earth/asteroid impacts will all be random and aperiodic events. Further, that an averaged distribution of these events would show us a relative frequency of categorically large asteroid impacts to be one event every 500,000 years. From this we can derive a random-chance 100 year probability for such an event to be 1:5,000.

Within any 500,000 year interval it would be a reasonable expectation that one large asteroid would impact Earth and it would consequentially necessarily impact in some 100 year increment. Therefore, in any 100 year increment of the 500,000 year absolute interval it would be 5,000 times more likely that no large asteroid would impact Earth in that increment than it would be for

one large asteroid impact event. The prospect of two such events occurring within an absolute interval of 500,000 years and within the same 100 year increment (1:25,000,000) would be considered anomalous. The prospect of three or four events, perhaps only extremely anomalous and five to ten events... absurd. The prospect of all 1,100 large Earth-orbit-crossing asteroids impacting Earth in the same 100 year increment would have to be considered simply insane.

If we are to be strategically rational and consider relevant only what is essential to the conduct of implementing a response, then whether we face the most likely prospect of no large asteroid event in the next 100 years or whether we face the next most likely prospect and Risk of one large asteroid impact event in the next 100 years it rises to the level of virtual absolute certainty that 1,099 of the estimated 1,100 large asteroids will not strike Earth in the next 100 years. How then can finding 1,000 large asteroids not to be 100-year impact threats possibly be considered new information? How can our understanding or our interpretation of this Risk be considered changed? If it has not changed then it can not be claimed to be reduced.

Towards a defense against the rationale that we *know* that 1,099 large asteroids will not be found to be 100-year threats it could be offered that a strict and rigorous adherence to empirical scientific method would insist that we do not *know* or understand that 1,099 large asteroids will not strike Earth in the next 100 years until after they have been *observed* to be so. If this is the case offered in defense, then we could freely infer that the Risk postulate the Spaceguard Survey has claimed to reduce would be the theoretical/abstract and wholly *academic* Risk of 1,100 large asteroid impacts in the next 100 years and not the most rational and only strategically relevant Risk postulate of one and only one large asteroid impact in the next 100 years.

If such arcane abstract methodological empirical qualifications lie undisclosed at the core of the Spaceguard Survey's logic, such a defense would serve to foster the single best argument that scientists should not be tolerated in dire and critical strategic roles. How can we possibly expect to ever save ourselves if we cannot resist fooling ourselves so easily into thinking we are safe? The only remedy to such a blatant failure to communicate would be a dramatic change of minds.

Barbarians At The Gate:

The Spaceguard Survey must be seeing this problem as if there were 1,000 Barbarians at the Gate. All individually dire and equal in their capacity and intent to rape, pillage and burn. And in dispatching 500 of them you reduce the threat and thereby the Risk by half. However, the Risk that fosters the analogy here is clearly understood as the potential for one and only one large asteroid to be on course to strike Earth in the next 100 years… not 1,000. So instead of 1,000 Barbarians, all equal in their imminence and dire intent, the analogy would be far more apt with 1,000 Pilgrims at the Gate and *one* of them *may* be a Terrorist... with a nuke. By interrogating half of the Pilgrims and not finding a Terrorist how have you reduced the Risk?

It should be clear that the conditional probability of whether or not a Terrorist is in this group is not in any way reflected by the number of Pilgrims at the gate. The probability of whether a Terrorist is in the group or not lies somewhere else. There either is a Terrorist in the group before the Gate or not. Even if the probability could somehow be expressed statistically, as a product of previously recorded Pilgrim/Terrorist relative behavior, merely interrogating and watching the Pilgrims would not effect that probability even if you found a Terrorist! The only way you can effectively reduce a random-chance 'statistical' probability here would be to start shooting the Pilgrims and reduce the number of Pilgrims at the Gate... not just look at them.

If the Spaceguard Survey were in fact dispatching these Earth-orbit-crossing asteroids as they discovered them: beaming them to a galaxy far, far away, then they would indeed be reducing the statistical probabilistic Risk... for whatever that would be worth in the abstract. Because even then, the unimpeachable conditional logic would still stand that all that would be required for the unmitigated Risk of one large asteroid impact event in the next 100 years would be the mere *possibility* of one and only one undiscovered large asteroid. There either is a large asteroid on course to strike Earth in the next 100 years or not. We either face reality here... or not.

A Million Miles A Day...

The mere fact that The Next Large Asteroid on its way to strike Earth is out there somewhere and closing at a million miles a day clearly warrants a comprehensive national Planetary Defense policy in response. A policy that clearly states that we will in fact endeavor to successfully deflect it from impacting our planet. Further, the condition that asteroid impacts are random and aperiodic events and as things stand we will likely never know which large asteroid is TNLA until we 'see it coming', begs a policy of rigorous Preparation, Training and Vigilance to the level of the worst case scenario to which we can imaginably respond... at any cost.

A strategic appraisal of the Spaceguard Survey's capabilities and objectives would conclude that their developed expertise is in defending us only from all the asteroids that will *not* strike Earth... not the next one that *will*. The legislative body that authorized and funded the Spaceguard Survey has subsequently crafted legislation approaching policy on this issue: new subsection 'g' of the Space Act of 2005. Unfortunately this legislation fails to respond to the full potential scope and magnitude or even the existential conditions of the manifest Risk. Instead this policy-like notion reflects those economically comfortable objectives and capabilities currently manifest in the Spaceguard Survey. Somehow, this problem has become redefined to suit the tools at hand. As policy “new subsection g” is fine as long as we never need to actually deflect an asteroid. As Planetary Defense it is little more than a placebo. A remedy, that if it is to work, must be accompanied by a very large dose of Hope... and Hope has never been a reliable survival trait.

Academics and scientists have mitigated only the perception here and are proceeding to dismiss and retire this threat without due cause. It is one thing to see mankind someday becoming extinct as a result of a large asteroid impact stemming from the sheer chaos and serendipity of the Cosmos. But on that day to understand that We The Species will know we could have prevented it will just add grievous insult to terminal injury. It is past time to put this business into the hands, and more importantly the minds, of those better qualified to deal with matters that have dire negative consequences should they fail. In that this issue is International in scope and a dire National Security concern, the attention and executive policy making abilities of the President of the United States are required here... Constitutionally.

It is not enough to assess a Risk simply from the perspective of loss or probability. Strategically speaking, any assessment must also encompass the ability to respond to that Risk. Spaceguard Survey's abstract and critically flawed assessment of the Risk has deflected our attention and retarded the development of a rational policy or strategy or tactic for successfully dealing with The Next Large Asteroid on its way to strike Earth. Consequentially they have effectively served to *increase* the Risk of large asteroid impact. And as long as their notions persist, corrupting any effort towards a comprehensive policy in response to this threat, the Risk of our extinction by large asteroid impact will continue to increase at the rate of A Million Miles A Day...

Addendums:

At this point any sound strategic thinker would see this question settled: the efforts and work product of the Spaceguard Survey et al have had no substantive effect on the Risk of asteroid impact, and they can proceed to the enclosure “To Whom This Should Concern: Arguments Towards a National Planetary Defense Authority: NASA vs. DoD”

For the rest, examples of the Spaceguard Survey's assessment and the curious notions these first-time strategic thinkers have offered in the direction of any logical proofs supporting their claim of reducing this Risk are included here in Addendum A. Addendum B will continue with arguments in response and proceed to dismantle and dispatch these notions in detail as well as offer a broad challenge to the wisdom of tolerating scientists and academics as strategists.

Enclosure:

“To Whom This Should Concern: Arguments Towards a National Planetary Defense Authority: NASA vs. DoD” (previously published) has either been been included or can be referenced at <http://Gaiashield.Com/NPDA/> as a logical extension and conclusion for the arguments presented in “Cosmic Promise”.

If The Rock That Hit Chicxulub Had Been Traveling
5 mph Faster or 5 mph Slower Dinosaurs
Would Have Colonized Mars 10 Million Years Ago...

Addendum A: Beyond Here Thar be Monsters...

Excerpts of Spaceguard Survey et al Risk interpretations.

Dr. Clark Chapman/Dan Durda: NEO White Paper (2001)
Once 90% of large NEAs have been cataloged and found to be "safe" for the foreseeable future (as is very likely but not assured), then the risk to civilization will be known to be a factor of several (perhaps approaching an order-of-magnitude) lower than it was a decade ago when few NEAs had been found.

Dr. David Morrison: testimony before Congress (2002)
Ten years ago there was very little recognition or support outside this committee for dealing with the asteroid impact hazard. I could not have predicted then that by 2002 we would already be past the halfway mark in discovering these large Earth approaching asteroids. Thanks to the Spaceguard Survey, we can now assert that we have reduced the risk from an unforeseen catastrophic impact by more than a factor of two. This is a notable achievement in an effort to protect humanity from the worst known class of natural disasters. <SNIP> We are finding these at a rate that will allow us to retire that risk within a few more years (unless we find that one of these objects is on a collision course with Earth). As discovery techniques improve, we can shift our search toward smaller NEAs.

Dr. David Morrison: interview Space.Com (2002)
DM: We are efficiently finding the NEOs 1 kilometer [0.62 miles] or larger in size, which is a range that includes anything that is a global threat; that is, that could produce a global environmental catastrophe. We're more than halfway there. In fact, we have reduced the risk from an unexpected asteroid strike by about a factor of two. We reduced this risk without actually having to move anything.

Dr. Michael Griffin: testimony before Senate (2004)
At the current rate of discovery, the group of observatories that are finding and cataloging NEOs will come close to achieving their goal of identifying 90% of the greater than 1-km diameter NEO population by 2008. More than 50% of the expected population has already been discovered and discoveries continue to be made each month. While this effort will retire most of the risk of a global catastrophe,

Dr. Clark Chapman: interview Discover Magazine (March 2006)
The way I think about it is that there is a natural threat—things are out there flying around, and some of them are going to eventually hit us. Others will crash into the sun, others will be flung out of the solar system, others will hit Venus, and so on. Suppose we find them all and calculate their orbits accurately and discover that within the next 100 years, none of them are going to hit Earth? That doesn't change the natural statistics for the far-distant future or what it has been in the past, but it seems to me that if you know you've found them all and you know they aren't going to hit, you are perfectly safe. If we find 90 percent of them and know that none will strike, we are down to being 10 percent in harm's way.

Dr Benny Peiser: CCNet (February 2007)
Killer asteroids will essentially cease to be a threat within the next 30 years. Scientists are discovering near-earth asteroids (NEAs) so fast that the chances of one hitting the Earth with no warning is likely to become minute.

NEO News (01/15/04) Risk Reduction

David Morrison
HAS THE SPACEGUARD SURVEY MADE US ANY SAFER?

Proponents of the Spaceguard Survey have, since the idea was first advocated more than a decade ago, stressed the practical value of this survey. Our purpose is not to improve our scientific understanding of NEAs and the impact frequency, although these are legitimate byproducts of the survey. Rather, we are trying to find and examine NEAs, one at a time, to determine if any will collide with the Earth during the next century. We do this so that we will have sufficient warning of a future impact to avert it, thereby protecting the planet and its inhabitants from this particular cosmic hazard. The implication is, therefore, that as we carry out this survey we are contributing to the safety of the world and reducing the risk of an impact catastrophe.

Is it correct, however, that the Spaceguard Survey is reducing risk and making us safer? Are we really any better off than we would have been without the survey? Or, to carry the argument to its logical conclusion, if we ultimately find every NEA larger than 1 km and show that none will hit the Earth in the next century, have we effectively retired or eliminated this risk? And if so, does it also follow that when we have discovered half the population and shown that their orbits are safe (as is the case today), we can claim that we have removed half the risk?

Several persons have questioned this logic, leading to an interesting dialogue about the nature of the impact hazard. David Tholen of the University of Hawaii wrote (in CCNet for January 14, 2004) that the impact risk does not change, only our knowledge of it. "The risk to Earth is the same now as it was five years ago, and is the same as it will be five years from now. What will change is our knowledge of the risk. If, for example, we were to find that there are no objects larger than 1 km on an impact trajectory with Earth, then the risk is zero and has been zero all along; we simply didn't know that. As far as I am concerned, the only way to change the risk is to change the orbits of the NEOs. We can reduce the risk by moving an object on a collision course such that it will not collide. Or we can increase the risk by moving an object such that it will collide. In the absence of such changes, the risk remains the same. To use another example, back in 1990 we thought there were 2000 objects larger than 1 km in diameter in near-Earth orbits. Now we think the real number is closer to 1000. The risk posed by the actual population didn't change. Our knowledge of the population did change."

A similar question was raised by Rusty Schweickart of the B612 Foundation, who wrote "Reducing risk, it seems to me, could only result from changing the environment for the better... not simply knowing more about it. The risk can't have changed since we haven't done anything to reduce the incidence of asteroids hitting the Earth. What we have done is determined that the risk we actually have is lower than what probability would have led us to believe before we discovered the NEAs that we now know about. Our actual risk didn't change... only the accuracy of our knowledge of it." One possible way to clarify this issue is to note that what is being reduced is the risk of impact by an unknown NEA. For a known NEA with a well-determined orbit, the concept of risk (as a probability) is meaningless. The Spaceguard Survey steadily reduces the unknown population by moving NEAs from the unknown category, where we can associate a risk with them, to the known category, where they either pose zero risk or, at the opposite extreme, are predicted to collide with the Earth during the next century.
Alan Harris of the Space Science Institute notes, "With asteroids, the situation is completely

deterministic. Any single object either is, or is not, on an impact course in the next century. If we find one and certify that it isn't going to hit, then our estimate of impact probability for the next century is reduced by one over the number of remaining undiscovered objects. The per-object probability of impact is a constant. As we find more objects and certify that those particular objects are not going to hit, then our risk -- the per object probability times the number of remaining undiscovered objects -- goes down. Discovering NEAs does not reduce the per-object probability of impact, but it does reduce the number of undiscovered objects you have to multiply that probability by to get the remaining risk."

Journalist Oliver Morton puts it this way: "Spaceguard has reduced the risk of impact by a previously unknown body. At the same time, it has not increased any risks. Imagine the universe of risks as a set of non-overlapping categories such as "impact risk due to a previously unknown object." Reducing one category while not enlarging another reduces the universe of risk and makes us safer. However, there's a corollary to this. Spaceguard clearly *could* increase the risks in another category -- "impact risk due to a known object", and such a discovery would make us less safe. But it's certainly something that it's better to know than not to know; becoming less safe would not be a failure. My conclusion is that yes, we are safer today because of Spaceguard's results so far (and in all likelihood we'll be safer still at the end). But that that's not the point. Spaceguard is not meant to make us safe. It's meant to give us an accurate assessment of how safe we are."

Clark Chapman of SWRI in Boulder makes the following point: "If nothing else had changed, and if we actually found 90 percent of large objects -- which dominate the mortality -- then the chance of dying would indeed become a factor of 10 smaller, provided that none of those 90 percent are on an impact course in the next century. I used to show a slide that said that it was more likely that a mile-wide asteroid would hit Earth "next year" than that the next poker hand you would get would be a Royal Flush. More recently, I have had to amend that slide because Spaceguard has resulted in the chances being somewhat smaller of such an impact than being dealt the Royal Flush."

If we accept this logic, then it is reasonable to ask how the asteroid impact risk today compares with that estimated in 1992, when the Spaceguard Survey Report was completed (see also the paper by Chapman and Morison in Nature, 1994, on assessing the impact hazard). There are two components to the changes in our assessment of this risk, one from a revised estimate of the NEA population and associated impact frequency, and one from the actual discoveries of the Spaceguard Survey.

Even if we do not count the identification during the last decade of specific NEAs as non-threatening, we would evaluate the risk as lower today as a consequence of a better understanding of the NEA population and its orbital dynamics. Perhaps the simplest way to think of this is in terms of number of NEAs larger than 1 km, for which our best estimate has dropped a factor of two. The average interval between impacts increases by a factor of two, and the a priori lifetime risk of death from an impact (in the terms of the Chapman and Morrison paper) drops from about 1 in 20,000 to 1 in 40,000. It is probably also prudent to gain another factor of two by taking a diameter of 2 km rather than 1.5 km as the threshold for a global catastrophe. The net result of these two shifts is to change the average interval between civilization-threatening impacts from 0.5 million years to about 2 million years.

Of course, the uncertainties in these numbers are actually much greater, since in fact we know rather little about just what would trigger a collapse of civilization or what the probable fatalities would be in the aftermath of such an event. The actual values are therefore dependent on other poorly-known factors.

The recent report of the NASA NEO Science Definition Team (August 22, 2003) presents detailed models of the impact risk across a very broad range of impactor sizes. They determined what size impactors pose the greatest risk in various categories, and hence what mitigation remedies would be required to retire 90 percent (or any other fraction) of the remaining impact hazard. Figures 3.10 and 3.11 of the NASA SDT report show the overall hazard and the residual hazard, respectively, as a function of impactor size. The residual hazard is that hazard that will remain after five more years of the LINEAR survey (continuing at its present level and not counting any of the other survey telescopes). For nominal cases, this residual hazard is equivalent to annual fatalities of approximately 300, with the risk divided between the remaining undiscovered NEAs larger than 1 km and the large population of sub-km NEAs. This anticipated 2008 residual risk is about an order of magnitude lower than that suggested in the 1992 Spaceguard Report, partly as a result of the above discussed revisions in impact frequencies and partly as a result of the assumed 75 percent completion of the Spaceguard Survey in 2008. I emphasize, however, that these conclusions depend on the concept that risk really is retired by the discovery of NEAs and consequent reduction in the unknown population.

Addendum B: Sancho, my lance!

Initial Risk Postulates:

It should be noted that so far the Spaceguard Survey et al have never expressed a clear and succinct 'working' definition of the threat or subsequently any conditionally reducible initial postulate of the Risk. Nor, in the light of their strategic interpretation of the survey's results, any cogent and explicit expression of what the post-survey Risk will be.

● All or Nothing: From these notions one logic, constructive to the academic Risk interpretation, has been introduced:

"With asteroids, the situation is completely deterministic. Any single object either is, or is not, on an impact course in the next century. If we find one and certify that it isn't going to hit, then our estimate of impact probability for the next century is reduced by one over the number of remaining undiscovered objects."

If we restrict our understanding of the dynamics of this population to only the individual characteristic of "is or is not" a 100 year threat, then at the onset of the empirical survey, where essentially all objects were 'undiscovered', then collectively the random-chance probability that all 1,100 large asteroids estimated would be 100 year threats would be equal to the random-chance probability that they would not! From the beginning we have always understood clearly that this not the case... and by a astronomically large probabilistic margin. We understand that if the estimates are correct and there are 1,100 large asteroids then it rises to a level of virtual absolute certainty that 1,099 will not strike Earth in the next 100 years. The narrow and restricted analytical perspective expressed above serves only an initial Risk postulate wherein all 1,100 large asteroids impact in the next 100 years.

The above analytical perspective does however, describe the empirical mechanics and process for resolving the fundamental binary problem of whether one large asteroid 'is or is not' on course to strike Earth in the next 100 years. It could be seen that a binary problem: 'is or is not', expresses a simplistic 50/50 chance proposition. However, it would always be a simple 50/50 proposition whether there were 1,100 undiscovered asteroids or if there were one undiscovered asteroid... This also demonstrates that neither the size of the asteroid population or whether or not individual asteroids are undiscovered is in any way deterministic or conditionally relevant to the express event of any asteroid impact. Size of the candidate population would only be relevant to a random-chance probability and discovery only relevant to ultimately resolving the absolute binary problem... one way or the other.

● Complete Ignorance Equals Absolute Certainty: Another challenge to the above perspective would be to consider the equation of discovery-as-safe with reducing Risk as a valid collective result. If discovering 90% of large asteroids not to be 100 year threats reduces the probability to 10% then it would follow that initially, when all large asteroids were undiscovered, the Risk: probability of loss, would necessarily have to be expressed as 100%. How is this rational?

Again, all that is required for the unmitigated probability of one large asteroid impact event in the next 100 years to persist is the mere *possibility* of one and only one undiscovered large asteroid. Risk is probability of loss. Reducing the Risk by manipulating the perception of the *probability* apparently requires no more than a little academic slight-of-mind. The only way we will actually reduce the manifest Risk would be to manage the *loss*: Build a Planetary Defense... How is this difficult?

● We Don't Know: There are two levels of empirical assessments. First, strategically: from our observations of the Moon and Earth coupled with our understanding of the general dynamics of the asteroid population in our Solar System, the Risk can be expressed as *random and aperiodic events that can occur without warning at anytime that include the potential for our extinction*. Certainly this expression is unsatisfying. It is unquantifiable and fails to service the question of “which one” or “when” in any way. However, “we don't know” *is* strategically relevant information and unsatisfying or not it is the only rational and deterministic information we will ever have on The Next Large Asteroid on its way to strike Earth... until we see it coming.

● Zero Risk: Second, tactically: in the absence of any observed evidence that we will be struck by any large asteroid anytime in the next 100 years, the Risk can only be empirically expressed as Zero. Keeping in mind our observational capabilities must be qualified as being very, very far from empirically comprehensive or conclusive to any degree.

● What If: The security minded would cede the logic of Zero Risk. Yet even if our observational capabilities were several several orders of magnitude better than what they are, they would nonetheless insist that such information can never be absolute. And that given the potential dire magnitude of the loss we can only afford to err on the side of caution and that we must proceed with the postulate that there *is* one large asteroid on course to strike Earth in the next 100 years and respond accordingly. Anything else would be gambling with the survival of the species...

● Random Chance: AKA... Gambling. The random-chance probability for large asteroid impact anytime in the next 100 years would be 1:5,000. But then the random chance probability for large asteroid impact in any 100 year increment in the life of Earth pretty much always was, is today and will always be 1:5,000... Even in those 100 year increments when large asteroid impact events occur. And other than finding there are more or less large asteroids than what the

Spaceguard Survey initially estimated estimated, which does not appear to be either the case or contention, how can a Risk based on a random-chance probability possibly be reduced by determining the specific behavior or characteristics of individual elements within such a small increment of the general probabilistic condition?

Note that within the general strategic Risk of "We Don't Know" we are driven to empirically verify both the "Zero Risk" and the "What If" tactical postulates and that both present binary problems that can only be resolved in the absolute. We can wait until we see TNLA coming (if we see it coming) or since all that is required to constitute the Risk of one large asteroid impact is the possibility of one undiscovered large asteroid we can somehow determine which large asteroid is the last large asteroid in the Solar System. From here and now this threat presents itself as a textbook candidate for the Precautionary Principal which "*requires governments to take action to prevent harm even when it is uncertain if, when or where the harm will occur*." However, in this case the *if* and the *where* are clearly known and it is only the *when* that is not...

Observing The Risk:

Risk, as probability of loss, can only be reduced by a) doing something that contributes to implementing a successful response to the threat and either eliminating or mitigating the loss or b) learning that something is different from what it was or from what any reasonable mind would expect to find and project as probable and altering the probability. Theoretically, observation can reduce the strategically rational Risk of a asteroid impact threat in only four ways:

● Determine there are fewer large asteroids than estimated: Although this would reduce only the random-chance probability and not any manifest existential expression of the threat: TNLA, it is likely to late for such a possibility. There is more than sufficient reason to believe that if they are in error, the Spaceguard Survey's estimates of the large asteroid population may in fact be extremely low. However this can not be demonstrated by the the success of their current mission which will only establish the minimum population boundary estimate.

● Find the last large asteroid: Given the current technical capabilities of the Spaceguard Survey knowing we have detected the last large asteroid, even if we have, would not be possible. It would require demonstrating there are no undiscovered large asteroids anywhere else in the solar system. With the next generation of detection technology we will still be able to demonstrate only where an asteroid *is*... not where any are not. Even with a comprehensive real-time full spectrum 24/7/52 surveillance of the entire area of interest, at best, such a result would always still only be probabilistic. Couple that with the fact that the rogue asteroid population is dynamic: new asteroids randomly becoming Earth-orbit-crossing asteroids all the time. In any real sense over any tactically relevant increment of time, the idea of "the last large asteroid" can be seen as little more than a myth and any endeavor or expectation to actually find it, a fool's errand.

● Find that the laws of physics are somehow different: Since our understanding of the asteroid impact dynamic appears to be what we understood it to be before the survey effort began... No Joy here either... yet.

● Detect a threat in order to either deflect it or evacuate the point of impact. Here, in terms of forecasting the occasion of an event, detecting a impending impactor will abrogate either form of probability and therefore Risk in favor of certainty. We can then appreciate that Risk becomes operational: tactical, and may better be defined as probability of failure.

Given their current capability, there is little reason to regard the Spaceguard Survey as affording us with any degree of surveillance or to rely upon them to provide us with any "early-warning" for responding to the impact of TNLA at all! If it did, what would constitute "early-enough" for us to deal with it successfully, falls more into the category of Hope and would necessarily need to be accompanied by a great deal of very good luck. Even then, the value of any early-warning capability in terms of reducing the tactical Risk of successfully responding to an impending impact event cannot exceed the value of a standing tested capability to deflect it.

Given our current strategy, once we see it coming we will need to select, design, develop, build, test, train personnel, launch, stage, deploy, rendezvous and execute a deflection mission that may mass hundreds of millions of tons in LEO, we can only count our percentile for expectation of mission success in single digits. Which would then reflect a current corresponding value for any degree of early-warning as insignificant as well. In order for early-warning or detection to contribute to reducing the Risk of the impact of TNLA by 90% we would need to already have a reliable 90% probability that we would be capable of successfully deflecting it.

Reducing the tactical Risk inherent in successfully detecting the next large asteroid impactor in sufficient time to deflect it can only be achieved by some proportionate real-time surveillance of the area of interest The Next Large Asteroid on its way to strike Earth is in. Monitoring the known, safe population of the impact candidate group would not mitigate the risk of the expression of one large asteroid 100 year impact threat from any unknown population of the impact candidate group regardless of the size of that unknown population group...

Further, reducing the tactical Risk inherent in successfully deflecting TNLA, even given the good luck of sufficient early-warning, will always be a matter of the tens of thousands of things that can go wrong with any mission in space not doing so as a result of Preparation and Training. Here, thinking the Risk of large asteroid impact has been reduced simply by having failed to find an impending impactor has retarded any serious discussion for funding the identification and development of a comprehensive tactic suitable to deflecting this threat.

Ultimately, the only rational way to mitigate the perpetual strategic Risk, and the only way to actually make us any safer as a result, would be to address the threat itself: develop a perpetual standing capability to deflect a large asteroid impact before probability becomes certainty. The only way to afford any real value to detection would be within an overall comprehensive context that recognizes deflection as its single objective. Then, the value in detection can be seen in its constructive contribution to such a capability and together the tactics of detection and deflection can be metered strategically as one: Response. In short, you don't get what you don't pay for.

That said, the Spaceguard Survey *has* so far earned its keep and demonstrated some strategic value. The detection of Apophis alone, whether it proves to be an Earth impactor or not, has justified their entire survey budget. They detected the potential threat. What more can you ask of surveillance? Even the occasional detection that resolves itself to a low conditional impact probability incidentally serves to increase public awareness of the threat and affords some small extemporaneous value in the direction of preparation, training and continued vigilance...

However, tactically, as a comprehensive full spectrum 24/7/52 surveillance of the entire area of interest TNLA is in, they are in fact little more than a very small drop in a very large bucket. In terms of their strategic value, if they are not successfully detecting potential near-term impact threats then they are doing nothing more than counting rocks in space.

Rethinking *Thinking Odds*:

● Shall We Play a Game: To establish a logical intuition, consider two standard decks of cards and one joker. Replace one card in one deck with the joker, shuffle and then with the deck face down begin turning over cards. With the first card the random-chance probability that it will be a joker is 1:52 or 1 chance in 52 possibilities. As you proceed through the deck and do not find the joker the probability is re-expressed with each card. When you have turned over half the cards the relative probability that the next card will be a joker have increased to 1:26 or 1 chance in 26 possibilities. Note that whether or not the joker is in the deck is not probabilistic.

However, if you then shuffle the second deck into the deck with the joker and then divide this greater deck in half, the random-chance probability that the joker is in either deck is 1:2 or 52 chances in 104 possibilities. Selecting one of the decks, and having turned over half the cards and not finding the joker, have you changed the probability that the joker is in the deck? Even if you do find the joker have you changed the probability that the joker is in the deck? Note that merely turning over half the cards and looking at them is *not* cutting the deck in half a second time which would reduce the probability that the joker is in the deck to 1:4. There are still 52 chances in the deck whether we have looked at them or not or whether they are the joker or not.

The only way to reduce the 1:2 random-chance probability that the joker is in any given deck would be to cut the greater deck into decks smaller than 1/2 decks... In turning over the cards we are resolving a simple binary problem. Is the joker in the deck: yes/no? We are no longer dealing with random-chance but empirical certainty. A correlative and reciprocal probabilistic expression of the same problem would be the 1:2 probability that all the cards in the deck are not jokers. Demonstrating that in turning over and looking at the cards resolves nothing until we either turn over the last card or first find the joker. After all, whether the joker is in the deck or not we do know that 51 cards are not jokers. The only valid probabilistic perspective defining the expression of the joker in the deck was determined by dividing the greater deck into two decks. No matter what they are or are not, looking at the cards is nothing... probabilistically speaking.

In an attempt to seemingly assess the binary problem probabilistically, it could be offered that there are 52 “chances” or opportunities for the joker to be in either deck and that in revealing a number of cards in one of them not to be the joker reduces the number of chances remaining. But clearly the number of chances, as such, is fixed at 52 and remains the same whether we turn over the cards and look at them or not (quantum mechanical principals aside) or even whether we find one of them to be the joker or not. All that has been reduced is the time and effort – the work, required to turn over the remaining cards...

In translating this logic to the problem of asteroid impact we can recognize that reducing the probability of a joker by cutting the deck in half would be the equivalent of merely re expressing the 100 year probability of asteroid impact in terms of a 50 year increment. Unless we are relying on Heisenberg's Principal writ large, as with the cards no matter what they are or are not, looking at the asteroids, observing them, is nothing... random-chance probabilistically speaking.

● Chance vs. Condition: The prospect of the impact of Apophis demonstrates the two discrete forms of probabilistic thinking. Before its detection Apophis was a undiscovered member of the categorically small asteroid group. In terms of random-chance probability, collectively this group has a 1:5,000 probability of expressing one impact event in any given year. Individually, the categorically small asteroid soon-to-be-known-as Apophis had a 1:500,000,000 random-chance probability of striking Earth in any given year.

However, once Apophis was discovered our appreciation of the orbital elements of this asteroid resulted in an approximation that this asteroid may strike Earth. In expressing their empirical estimates to reflect a degree of certainty this potential was expressed as having a 1:6,500 empiric-conditional probability of impacting in 2036. However, the random-chance probability for a small asteroid impact did not *become* an empiric-conditional probability but rather the random-chance probability was simply abandoned completely. The random-chance probability can not in any way contribute to appreciating the orbital elements deterministic to the empiric-conditional probability for the impact of Apophis. Further, regardless of the fate of Apophis and whether it will go on to impact Earth (expressing an empiric-conditional probability of 1:1), until and unless it does then as a single, discrete earth-orbit-crossing-asteroid the random-chance probability for Apophis to impact Earth in any given year will be unaffected: 1:500,000,000.

With the detection of Apophis the random-chance probability is abandoned simply because it is arational. It is not deterministic, causal, accurate, testable or predictive and fails to afford any information that can be essential to the conduct of implementing a response. It is strategically irrelevant. The random-chance probability did not somehow constructively *become* arational and strategically irrelevant with the discovery of Apophis and the opportunity to employ empiric-conditional probabilistic assessments. Rather, it is because the random-chance probability has been arational and strategically irrelevant all along. In that before detection random-chance probability was the only perspective at hand affording an appearance of quantitative precision does not in itself justify its utility. Here, random-chance probabilities amount to little more than the pro forma side-step for avoiding the worst fear of every academic and scientist: uttering the anathema of “I don't know”. Which in fact *would* be rational and strategically relevant!

Random-chance (i.e. frequency, stochastic aleatorical, statistical) probability is a metric of chance. Empiric-conditional (i.e. deterministic, epistemic, subjective, positional) probability is a metric of certainty. The methodologies and relevant elements that constitute to these two types of probability are unique to and noninterchangeable with each other and as a result these two perceptions are wholly incompatible and nonconstructive to each other in application. In the decision making process we rely on the assessment of empiric-conditional probabilities as a matter of course. In that they are both expressed as probabilities it is easy to see how random-chance probabilities can be misused in the same process... a case of mistaken identity?

As a consequence of their fundamental design, random-chance probabilities are arational. Even though observed evidence may be random and aperiodic, the process of averaging perfectly sound empirical evidence corrupts the integrity of such evidence. As a consequence of that process the probabilities derived can not be deterministic, causal, accurate, testable or predictive in any way. They are no more than academic artifacts and conclusions drawn from these probabilities are at best abstract rationalizations. Which would therefore make any Risk postulate crafted from such a probability both tactically and strategically irrelevant.

Treating random-chance probabilities as rational seems to be a currently popular affectation of academia. Let this intellectual holiday stay in academia. Merely because you can express a Risk as a random-chance probability does not mean it is rational to base any decisions upon such a perspective. To do so leaves you with only one tool to manage a desirable outcome: Hope. And despite our highly evolved technological state, the primal wisdom still stands: if our species is to continue to survive we can only afford to Hope for the best after we have prepared for the worst. Not the other way around. That would only be gambling.

Academic Strategists...

Risk is probability of loss. In The Real we never actually use random-chance probabilities in our decision making... not even in Vegas. At their best the odds are often offered as a poor excuse after the fact: “but the probability of large asteroid impact was *low*!”. At their worst, they only tell us how hard we should pray. And as a sound-bite the odds can save a reporter from any need to understand the relevant conditions of a subject and the trouble of then having to actually well inform his audience. Consider the prospect of our elected officials or business leaders or the generals of our military flipping a coin or casting dice to make decisions in the performance of their duties. If we would expect a desirable outcome, we would not decide whether or not to respond to the potential threat of Apophis on the basis of its individual annual random-chance probability for striking Earth of 1:500,000,000. Rather our response will be determined by whatever conditional probability we generate from our empirical observations. How can we approach the collective threat of the asteroid population differently?

In The Real, in the absence of empirical evidence to foster a conditional probability, we rely solely on the magnitude of the loss to judge the rationality of our decisions and to meter the value and determine the scale of our response. And when faced with random-chance probabilities we have learned to never bet any more than we can afford to lose... especially in Vegas.

To use abstract and arational perceptions in assessing the Risk expressed by the prospect of an event that rises to the level of the extinction of our species is at best naive... at worst, intellectual negligence. Then to academically manipulate and construe that perception in favor of their own efforts... and do it wrong. In some cultures authors of such a blatant corruption of reason resulting in such a gross dereliction of vigilance would simply be taken out and shot! Here, we can only relieve these of any position of responsibility or credible authority they currently have in this issue. Although you can take their astronomy to the bank, at the least we should take their strategic Risk assessments with a very large grain of salt... They are, after all, *only* astronomers. What can they possibly know about Risk?

It should be clear to even a bush-league strategic thinker that the Spaceguard Survey has failed to rationally address those elements of this Risk that are essential to the conduct of implementing a successful response. If we are going to deal with the prospect of asteroid impact successfully we must first begin to think about it better or find the wisdom to promote it into the minds of those who will. And here, it will be far easier to task a soldier with a mission in space than it would ever be to teach a scientist to think like a soldier. How could anything else be wise?

The Sky Is Falling... NOW!

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