

# *Gaiashield Group*



## **A Million Miles A Day...** *Speaking For The Worst Case Scenario*

### ***The Existential Threat***

**Once Upon a Time:** There was a Big Bang... Cause/Effect - Cause/Effect - Cause/Effect and fifteen billion years later we have this chunk of cosmos weighing in at a couple trillion tons, screaming around our solar system, somewhere, hair on fire at a million miles a day, on course to the subjective center of the universe. Left to its own fate, on impact, this Rock would release the kinetic energy equivalent of one Hiroshima bomb for every man, woman and child on the planet. Game Over... No Joy. Restart Darwin's clock - again. No happy ever after. No Better Luck Next Times... Subjectively speaking, all there is, forever... gone.

There is simply no empirical logic or any rational argument that this could not be the *next* asteroid to strike Earth or that the next impact event could not happen tomorrow. That would be a product of luck. Even though we have long been aware of this threat and had the technological ability, we can only imagine a handful of dubious undeveloped and untested tactics we could use in response. There is nothing we could remotely consider to be an effective capability to defend ourselves. Nothing we have actually prepared to do in response to this threat.

From an empirical analysis of the dynamics and geometry of our solar system, we have come to understand that the prospect of an Earth/asteroid collision is a primal and ongoing process: a solar systemic status quo that is unlikely to ever change. The problem here is that the distribution of these events is completely aperiodic and random both in their occasion and magnitude. From abstract averaged relative frequency estimates we can fairly project that over the course of the next 500 million years in the life of Earth we will be struck by approximately 100,000 asteroids large enough to warrant our consideration. Most will be relatively small, 100 to 1,000 meters in diameter, millions of tons: only major city to nation killers. 1,000 or so will be over 1,000 meters, billions of tons and large enough to do catastrophic and potentially irrecoverable damage to the entire planet: call them global civilization killers. Of those, 10 will be over 10,000 meters, trillions of tons and on impact massive enough to bring our species to extinction. It bears repeating: these events are aperiodic and random in both their occasion and magnitude.

All these asteroids are out there, orbiting the sun... now. Nothing more needs to happen for them to go on to eventually strike Earth. As individual and discrete impact events, they are all, already events in progress. By any definition, an existential threat. Fortunately, our current technological potential has evolved to a point that if we choose to do so we can deflect all these impact events. Given a correspondingly evolved political will, we can effectively manage this threat to the continued survival of our species. But since these events are aperiodic and random we can not simply trust that an enlightened political consensus will somehow, spontaneously develop before we are faced with responding to this reality. If we would expect to deflect the *next* impact event a deliberate, rational, punctuated equilibrium of our sociopolitical will is required *now*.

The averaged relative frequency analysis described above, or any derived random-chance statistical probabilistic assessment, in itself, would be strategically meaningless and irrelevant (after all just how many extinction level events can we afford?). However, they can be indirectly constructive in illuminating the existential and perpetually responsible nature of the threat. Given that the most critically relevant strategic increment can be narrowly defined as the next “evergreen” 100 years, it would follow that the strategic expression of the existential risk of asteroid impact in its most likely rational postulate would be for one and only one large asteroid to be on course to strike Earth in the next 100 years...

If we do eventually choose to respond to this threat, clearly there is no way we can address the dynamics or geometry of the Solar System so there is no systemic objective we can respond to here. We can not address 'The Threat of Asteroid Impact' as such. We can only respond to this threat as these objects present themselves as discrete impending impactors: one Rock at a time. This leaves us with the only aspect of this threat we *can* effectively respond to - a rationally manifest first-order and evergreen tactical definition of this threat:

### **The Next Large Asteroid on its way to strike Earth.**

Which unfortunately, as a product of random-chance, includes the prospect for our extinction. Asteroid impact is a randomly occurring existential condition. Therefore the next large asteroid impact event is inevitable and expectable, and that inevitable expectability begins... *now*.

**The Probability is Low:** As a risk assessment, “The probability for large asteroid impact in the next century is low”... is at best irrelevant if not false. Even though it may be something we really *want* to be true and relevant. Say the daily random-chance (statistical) probability for large asteroid impact is one in a billion. Only because in any given increment of time the chance that an impact will not happen is far greater than it will, the chance it will happen is characterized as *low*. But if we look out the window and see a large asteroid 10 seconds away from impact the daily random-chance probability for large asteroid impact will still be one in a billion. We must therefore still characterize the chance of impact as *low*... When the characterization of the probability can be seen to be tested and be in contradiction with the manifest empirical fact of the event it must also then be seen to be empirically false. Worse: true only in the abstract. Abstract not in terms of a summary as in a conditional-empiric probability but rather in its first definition: apart from concrete existence... as in a Picasso. Therefore, as *information*, arational and false. If we expect to respond to these events, then when it counts the most, this method of assessment will not be relevant/true. If information can be seen to be irrelevant/false ex post it must also be seen to be irrelevant/false ex ante. Strategically, this assessment is meaningless.

Consider the current threat of the asteroid Apophis. With its discovery we abandon the average relative frequency derived annual random-chance probability for a rational conditional-empiric probabilistic threat assessment derived from observing its speed, vector and position relative to Earth. The collective result is expressed in probabilistic terms due only to our inability to meter these characteristics accurately enough to be precise to the point of potential impact. As Apophis approaches this point the observations and resulting metrics become increasingly accurate and the conditional-empiric probability will process to resolve into a certainty of either zero or one. Whereas the random-chance probability is unaffected by whether Apophis strikes Earth or not.

These two probabilistic perspectives are inherently incompatible, as well as unique, discrete and nonconstructive to each other. The only thing these two methodologies have in common is a nomenclature: probability/likelihood/chance. This lack of appropriate dedicated semantics has unfortunately served only to obfuscate and confuse the respective ideas these two perspectives represent and meter. Effectively allowing one to be seen rational and relevant when it can never be so: any conclusion or inference drawn from any random-chance 'statistical' probability will always be a non sequitur.

However, merely because they are non rational does not make averaged relative frequency derived random-chance probabilities worthless. They do have some psychological merit and enable some intuitive/emotional 'old-woman' grade wisdom. When we consider the occasion of some unpredictable event that may cause us harm and there is nothing tangible we can do to deflect or forestall or stop it from happening, we still want to know just how much we should worry about it. We need to quantify chance not only in case we can prepare or safeguard or indemnify against potentially recoverable consequences after the fact, but to also meter how much *hope* we should invest against the occasion of such events. Hope mitigates fear. And when there is nothing else we can do about it, only then is it wise to mitigate fear...

“The probability for large asteroid impact in the next century is low” does serve that purpose. It is a metric for hope. Fifty years ago, before we began to master space and\_ responding to this threat of asteroid impact became a real course of action, hope was all we could do. Today we can do much more. Today we can hold our hope for when the time comes to successfully deflect The Next Large Asteroid on its way to strike Earth. And then, after we have done everything we can possibly do to deflect it, there will still be of room for hope... and good luck. But until then, the the notion that probability for large asteroid impact or Extinction by NEO is *low* affords us with nothing more than a metric for hope. Not rational information constructive to metering a response or making a rational decision to do so or not. Here, the probability is in service only to illusion and nothing more than comfort-food-for-thought. And we still need such probabilistic comfort-food-for-thought for things like Rogue Black Holes and Gamma Bursts where we are still imaginably defenseless. But if we expect to punctuate the political equilibrium and develop the capability to effectively respond to the existential threat of asteroid impact, we must allow a rational and warranted fear of extinction by asteroid impact to drive a rational and warranted response to this threat forward. Forward into the hands and minds of those who have the aptitude and training and experience in *using* fear to handle fearful things. Fear focuses the mind... Fear reminds us that there are dire negative consequences if we fail...

### **Fear Defines Necessity.**

If we are going to concern ourselves with mounting a response and deflecting these objects and no longer tolerate and suffer this threat, would it not be far more relevant to know in which century the probability for large asteroid impact is *high*? But the random-chance probabilistic perspective can not even pretend to approach providing us with that kind of information. It can never be strategically relevant: contribute to the conduct of implementing a successful response. The same can be said to apply when such abstract reasoning is used to justify the notion that the next asteroid to strike Earth will likely be small... which leads us to little more than a hope based Planetary Defense. Chance/likelihood/probability derived from the averaged relative frequency of random events is at best always irrelevant... if not arguably always false. If we are ever to respond to this threat *well* then we must begin thinking about this threat *better*!

### **Large asteroid impacts are random events. Expect the next one to occur at any time.**

We have to adopt a hard, rational, security-mindedness: orient our thinking from when it *will not* happen to when it *will*. The feel-good mantras that help us sleep at night will never deflect any asteroids. Strategically speaking, this means being at DefCon 3: locked, cocked and ready to rock, prepared to defend the planet and mankind from the Worst Case Scenario, 24/7/52... forever. Doing anything less by design would be like *planning* to bring a knife to a gunfight.

If we expect our relevant technological abilities to continue to develop and continue to shape our nascent and still politically tacit will to respond to this threat: if we are ever to build an effective Planetary Defense, we must first abandon the debilitating sophistry of “The probability for large asteroid impact in the next century is low” in favor of a rational random inevitable expectation... and its attendant fear. And then the *only* thing we can ever allow to reduce that fear is a standing, tested Planetary Defense: Preparation Training Vigilance! No comfort-food-for-thought allowed.

**False Hope... The Academic Threat:** Now that we are looking for these objects to some degree, the principal strategically relevant question - what is essential to the conduct of implementing a response - becomes 'Is there *one* large asteroid on its way to strike Earth anytime in the next 100 years or not?' A simple, absolute, binary problem. On/Off, Zero/One... Yes/No. The strategically relevant answer will necessarily also be absolute. There is no room for any random-chance probabilistic response. This is not about deflecting probabilities.

Yet NASA's Spaceguard Survey and its apologists have claimed that by finding 80% of the 1,100 estimated large asteroids and in also finding this discovered 80% to be safe (not 100 year threats) they think they have somehow reduced the probability and thereby somehow reduced the 100 year risk of large asteroid impact by 80% as well. Superficially this does *seem* to have some intuitive merit. Clearly, if their initial perception of the risk were that all 1,100 candidate objects could be on course to strike Earth in the next 100 years, then they have indeed reduced *that* risk...

However, the subjective and rational existential threat here is just one Rock: The Next Large Asteroid on its way to strike Earth. Therefore

**all that is required for the risk of one asteroid impact in the next 100 years to persist unmitigated is the mere possibility of one undiscovered asteroid.**

The dice have already been cast. Time to forget about the odds... Look at the result! Either show us the Last Large NEO or just say "we still don't know"! Anything else is little more than statistical sophistry and/or poorly crafted abstract rationalizations. It may seem counter intuitive but "We don't/can't know" is as strategically relevant as "There it is". Since our interest is now strategic and no longer abstract or academic, the relevant question now is not what the 100-year probability for large asteroid impact is but rather is there or is there not one large asteroid on its way to strike Earth in the next 100 years *in fact!* This business has become empirical.

In the direction of establishing a more rationally insightful and appropriate intuition consider that this problem is not as if there are 1,000 Barbarians at the Gate: all equally dire in their prospect to rape, pillage and burn. And in dispatching 500 of them we would clearly be reducing the risk by half. Rather this problem is as if there are 1,000 Pilgrims at the Gate and one of them may be a Terrorist... with a Nuke. If we randomly select, search and rigorously interrogate half and fail to find any Terrorist with a Nuke, have we reduced the risk? Does the number of Pilgrims at the Gate have any constructive or implicative bearing on the threat or risk of a Terrorist at the Gate? The number of Pilgrims, and/or that they *are* Pilgrims, is irrelevant. The problem, the threat, the risk, is complete in the fact that there may be *one* Terrorist at the Gate... with a Nuke. We can only resolve the problem by finding a Terrorist or finding all, to the *last* Pilgrim, to be a Pilgrim.

Further, the Spaceguard Survey does not physically change anything: they are not beaming these objects to a galaxy far, far away as they find them. Which *would* reduce the random-chance probability but not the conditional-empiric risk. Nor are they finding anything different than they expected to find. So in terms of basic logic, at the onset of their survey the most rational understanding and initial perception of the threat and risk would be for one and only one large impact event in the next 100 years. Therefore, given their estimate at the time of 1,100 candidate objects, a reasonable mind would expect that in the next 100 years that if there were in fact either no impending impact event or if there were only one, a complete empirical assessment of the candidate population would reveal 1,099 objects not to be on course to strike Earth in the next 100 years. How then can they change any initial understanding or rational perception of the risk when they have found only what they expected to find? The fundamental and singularly relevant question here is "is there or is there not one large asteroid on its way to strike Earth in the next 100 years". To this question, finding 1099 large asteroids not on course to strike Earth in the next 100 years can not be considered new information. In the absence of new, relevant information understanding can not change. Therefore, logically, the initial perception the risk can *not* change.

If there are 1,000 Pilgrims at the Gate and you have an understanding that one of them may be a Terrorist with a Nuke, then through interrogation you should expect to find 999 of them to be Pilgrims. Therefore, finding 800 Pilgrims to be Pilgrims in fact can not in any way be taken as new information. How can it in any way change your understanding? Show me the last Pilgrim!

Yet these scientists and academics have already accepted the accolade that they have effectively “Saved the World”! They hold to the claim that, taken together with all their small asteroid discoveries, they have reduced the risk by 90% and as such, amounts to virtually eliminating the risk altogether. Therefore, there is little reason to continue looking for asteroids for anything other than “scientific purposes”. It is apparently enough to *seem* to be deflecting the abstract *probability* of asteroid impact and the question of whether The Next Large Asteroid on its way to strike Earth will do so in the next 100 years or not is simply not scientifically interesting.

By effectively retarding a sociopolitical response to this threat, the rationalizations and critically flawed logics and interpretations of these 'experts' have come to pose a greater strategic threat to mankind than the ignorance of the threat of asteroid impact in the first place. They look for the threat and in the name of fear of fear itself dismiss it with academic slights-of-mind. Only a rational fear ever defines necessity and what we have here is simply an

### **Irrational Absence of Fear.**

No fear, no funding. No funding, no Planetary Defense... Despite all their good intentions, in their assessment of their efforts they have so far labored to produce little more than an equation for Suicide by NEO.

These *are* academics... the same people who brought us the notion that “The probability for large asteroid impact in the next century is low”. But now it's time to *do* something. Now it's time to put the responsibility for addressing this threat into the hands of more strategic minded 'experts'.

### ***Two First-Order Executive Decisions:***

**Decision One:** Should we endeavor to deflect asteroid impacts?

If no, perhaps you would believe we are somehow a Chosen Species or perhaps you just like the odds and would choose for us to continue this cosmic gamble. Then, the only tool at our disposal to achieve a desirable outcome would be hope. But hope alone is hardly a reliable survival tactic. We can only ever afford to hope for the best *after* we have prepared for the worst. Except for fun we only ever willingly suffer the designs of chance once we have done all that we can to fix the race, stack the deck, load the dice... *cheat*. We The Species game the system... It's what we do.

If yes, then consider that this issue has been merely talked about for far too long and we seem to have lost sight of the fact that ultimately we must deliberately *do* something here. And this something will be a wholly new way for mankind to address a threat of Nature: an imposition of human will before the fact. If we are going to presume to overthrow and supplant the tyranny of the random-chance and seeming chaos of Nature and assume for ourselves the responsibility for the fate of our species in this, we must first come to the clear and unequivocal decision to do so. And if we would expect to succeed our decision must manifest and elicit the enthusiastic will of our species. The expression of our intent must be formal and bold... as if going to War. We can not sneak up on this like a thief in the night or afford to trust our will to somehow eventually evolve to meet the challenge ad hoc and extemporaneously... we simply may not have the time!

What is required then, is a codified expression of a Global Human Demand in response to this newly emergent Primal Fear of Death by Rock from Sky. A Global Executive Decision. A manifest Global Declaration of Intent, Global Policy Determination... A Global Resolution that:

**“We the people of Earth will endeavor to deflect asteroids and comets as they are discovered to be impending Earth impact threats’.”**

We simply can not leave this notion as a tacit assumption. It is both the conclusive expression of our collective resolve and the first fundamental political determinant compelling agency delegation, funding appropriation, strategy creation and ultimately executing an effective response. Such a declaration is critically essential to affording this threat the 21<sup>st</sup> Century grade credibility and perpetual imminence it clearly warrants. Without such a declaration we can never be on course to successfully defend ourselves from this threat.

Without a codified declaration of the political will of mankind in this, we will likely continue to only labor in some cheap and easy academic and abstract context... more plans and conferences and working groups and talk. It may not be certain that, as a matter of course, *with* such a declaration all else will follow, but it is surely unlikely anything else will follow *without* it.

Consider that if you took a poll of every man woman and child on the planet and asked them if we should deflect The Next Large Asteroid on its way to strike Earth you would expect to get a virtually unanimous affirmative response. Such an expression of unity and consensus would be a great place to start any venture. This is a relatively easy but critical first step to save us all from Extinction by Asteroid Impact. The question then would follow: What human agency is best able to effectively respond to this threat? How?... then a product of their determination.

If yes, then also consider that since all asteroid impact events are aperiodic and random both in their occasion and magnitude then from here and now we simply cannot derive any kind of rational certainty for either when the next event will occur or for how large it will be until we see it coming. And with good luck, that may be no more than decades before impact. Therefore...

**Decision Two:** Should we develop and build a means to successfully deflect The Next Large Asteroid on its way to strike Earth *before* we see it coming... or *after*?

If *after*, then consider that when that day comes, not all the money - not all the hubris, not all the resolve, not all the hope, not all the genius, not all the 11<sup>th</sup> hour road-to-hell-paving political good intentions mankind can bring to bear, altogether in the world, will buy us more time. Time to select, design, develop, test, train personnel, build and stage an effective response that may mass of millions of tons in Low Earth Orbit.

And once you think this all the way through, and think it through *well*... it gets worse! We not only do not know when the next asteroid will impact, we also do not know when we will see it coming or how large the detection-to-impact window will be if we do, or if impact-dictated deflection mission launch schedules will somehow coincide with relative orbital launch window opportunities - *if* any. We also do not know how large the asteroid will be: the larger the threat the larger the mission, the more launch windows and the less likely the coincidence. To afford a 1 km threat 10 cm/sec of deflection would require 10,000 Deep Impact kinetic type missions. Not counting all the sociopolitical and technological subsections of Murphy's Law that can come to apply, from here and now that sounds like a plan counting on a whole lot of very good luck... *After* makes Decision One look like a crap shoot either way we choose.

If we choose to develop and build a means to deflect asteroids *before*, then *before* begins... *now*! And we have all the time left in the world... And all luck great and small considered, we should not only be building a Planetary Defense before we see it coming but we should be deploying it to circumstellar orbit as well and be projecting power to the orbit of Mars.

Given that undeflected, the next large asteroid on its way to strike Earth may well result in an extinction level event, we need to do all that we can imagine we can do *before* we see it coming regardless of cost. A rational and comprehensive response to this threat should not only be on mankind's list of things-to-do, it should be at the very top:

**BUILD A PLANETARY DEFENSE!!**

## ***The Tactical Flexibility and Strategic Advantages of Nuclear Ablation***

**Nuclear Ablation:** In a nutshell, the Nuclear Ablation approach to deflecting asteroids would be to cross the orbit of a target asteroid with a nuclear explosive device and at the exact point it crosses the asteroid's path detonate the device at some predetermined proximity to the surface of the asteroid. The radiation generated from the device would explosively volatilize a thin layer of the asteroid's surface generating a high velocity thrust distributed over some large portion of the asteroid's surface effectively altering its speed. Over time, this change in speed would effectively displace the asteroid from a collision point with Earth.

If we were in a position to observe this process, if the light were just right we might see the streak of the device approaching ahead of the asteroid. Then, at the point where the device would cross the asteroid's path we would see an extremely brief but extremely bright flash of light. Then, if we don't blink, we may be able to just barely discern a nearly simultaneous puff of dust and gas from the asteroid's surface and... that's it. Asteroid deflected. Not even any sound effects! Certainly not the stuff Space Operas are made of.

In March of 2007, NASA's PA&E released the results of their Congressionally ordered study to provide alternatives to divert impending impact threats. Their finding concluded that the use of a Nuclear Explosive Device (NED), in an ablation approach would be ~100 times more effective than the Second Best Alternative. Effectiveness here is principally a product of the mission mass of a NED relative to the Second Best Alternative. The lighter the mission the faster we can respond. The faster/earlier we can respond the less force it will take and/or the more force we can respond with to ensure mission success... Then, in comparison, if we afford Nuclear Ablation the same level of Best Case Assumptions as we have to do in order to even consider using the entire class of Second Best Alternatives, we not only find Nuclear Ablation to be ~10,000 times more effective but the only tactic suitable for responding to any Worst Case Scenario.

In the direction of considering this differential, since there was no discrete appropriation of funding by Congress for this study, the PA&E was justified in limiting the scope of testing its considerations to categorically small asteroid threats under 1,000 meters which was the dedicated scope of The Brown Act conveying the request. When you extend the scope of the consideration to the categorically large asteroid threat (over 1,000 meters) we can see that in contrast to the conservative one asteroid radius proximity used by the PA&E, the greater mass and cohesion of larger asteroids would tolerate a near surface detonation (tens of meters) increasing the yield to work ratio by as much as a factor of ten. And a NED becomes ~1,000 times more effective.

Further, if we then speculate where the PA&E can not, we can contrast the off-the-shelf example of using a 30 year old Cold War designed B-83 tactical nuclear device with a 1 ton mass to 1 Mt yield as the specific NED referenced in their analysis, with a conceptual modern ad hoc design. Removing the superfluous variable yield and penetrator capabilities and setting aside the Cold War 'clean yield' restrictions and affording a 21<sup>st</sup> Century device design and upgrade yield efficiency, we could fairly expect to see an increase of the mass-to-yield ratio of the device by another factor of ten as well. Effectively compounding the optimal mission effectiveness of a NED over the Second Best Alternative to ~10,000 times.

A thumbnail for the relative differential between tactically optimized missions for a 10,000 meter Chicxulub class impactor would require one million tons of payload delivered on target for the Second Best Alternative as a kinetic impactor tactic for each centimeter of deflection. Whereas for the same effect, with Nuclear Ablation the optimized mission mass would be only 100 tons. Or, in real world terms: 1,000,000 Deep Impact missions vs 100 Deep Impact missions. Money is proxy for human endeavor so at At \$333m each... let's take a moment and do the math.

However, when the time comes to deflect the next large asteroid on its way to strike Earth the real metric will not be in dollars or human endeavor. When that day comes success will be determined by just how much good luck mankind has left: Launch Windows... Then, which is more likely to be available when we are likely to need them: 100 launch windows for a Nuclear Ablation mission or 1,000,000 launch windows for a Second Best Alternative kinetic impactor mission? A product not of quantitative economic industrial capability but rather random-chance. Note that these deflection capabilities have been for only 1 cm/sec and based on Best Case Assumptions for a 10 year interdiction. In rational real world terms and all things-of-chance considered, projecting applications that accommodate margins of error and ensure a reasonable expectation of mission success we should multiply everything here by a factor of ten.

**vs Second Best Alternatives:** Even in a Nuclear Ablation approach, aside from being seen as Politically Incorrect, critics of the application of 'Nukes' to deflect asteroids hold that such an approach would incur a high risk of inadvertently 'Blowing It Up'. That may indeed be possible if we narrowly see this process manifest as using One Big Fat Super Nuke ten inches from the surface of the object... if we do it stupid/wrong. Easy fix. Don't actually *do* it stupid/wrong...

The conceptual risk of disrupting the integrity of an asteroid presents itself in their argument not so much with monolithic and highly cohesive asteroids but rather in loosely bound/rubble pile threats. However, regardless of their cohesion, even if you want to, it is difficult to actually blow up anything from the outside-in... particularly in Space where you lose the transmission value of having an atmosphere to generate an initial shock that would strike the asteroid. And by blowing it up we must understand that to mean to impart sufficient velocity to the fragments to bring them all to escape velocity in order to overcome the extant center of gravity of the now disrupted asteroid. Absent a sufficient velocity, given time the fragments will simply fall back together.

If it were our intention to Blow It Up (apart), it would be far more effective to in fact use the Second Best Alternative nominated by the PA&E of employing a high relative velocity kinetic impactor! Note here that such a result, where all the fragments were dispersed, albeit randomly, beyond the initial escape velocity of the object, it is highly unlikely that with the random change in speed and/or vector that any of the disbursed fragments would remain on their previous unique 'collective' collision course with Earth. The problem with such an approach would be that the net energy requirements for such a distributed deflection would be orders of magnitude greater than merely deflecting the asteroid in the whole.

To some degree, in Nuclear Ablation the tactical risk of disrupting the integrity of a loosely bound/rubble pile threat is real. However, inherent in the approach there are several ways to augment the One Big Fat Super Nuke approach suggested by the critics that combine to mitigate and likely eliminate this risk and still maintain a substantial margin of effectiveness in this tactic over any Second Best Alternative.

**A) Multiple devices:** For many reasons, it would be strategically and tactically sound to design a response to any task as modular to afford flexibility, accommodate some margin of error and proportional success in response to the many manifestations of Murphy's Law. If we calculate we need 10 Mt of yield to achieve a desired effect we would design its implementation in 10 discrete 1 Mt devices. Since even Cold War designs vary in yield down to fractions of a kiloton there is no realistic minimum yield and therefore no obstacle to a modular application for categorically small asteroid threats. And both strategically and tactically speaking, when you have a choice, it can only be considered sound and wise to bring a gun to a knife fight. The application of multiple devices would decrease the mass-to-yield ratio by a factor of something on the order of two and from a modern designed device reduce optimal mission effectiveness relative to the Second Best Alternative from ~10,000 down to ~5,000 times.

**B) Incremental execution:** To avoid fratricide, and in the same direction of addressing the vagaries of device failure, we would address the problems of Murphy's Law in execution by delivering our devices over some reasonable short period of time: minutes/hours. This inherent aspect of implementation, by distributing the total force required for deflection over time, in and of itself would serve to decrease the potential for threatening the disruption threshold of any target asteroid with no effect to the net effectiveness relative to the Second Best Alternative.

**C) Increase altitude:** In the case of loosely bound/rubble pile threats, the proximity and therefore yield-to-work ratio can be varied to suit the tolerance characteristics of the target. Going from near surface (meters) to one radius would reduce the net effectiveness relative to the Second Best Alternative by a factor of approximately ten from the optimal multiple device approach of ~5,000 times to ~500 times.

**D) Incremental increase:** Further, in the case of loosely bound/rubble pile threats, since there is virtually no chance of actually disrupting the asteroid to the point of dispersal (Blowing It Up) as long as we avoid doing it stupid/wrong and vary the size of the individual device/yield employed as well as the proximity of its detonation, there is still the near certainty of some small degree of short term disruption of the asteroid if only in millimeters. To mitigate this effect in terms of being relevant to the objective of the mission, we need only to afford the target some period to settle and restore integrity by increasing the interval of the device delivery: weeks/months. Perhaps the term Gravity Bag would suit the effect here? And the greater the mass of the object the stronger the gravity, the stronger the force of the bag, the faster the fall-back and the shorter the restorative interval required. This variable would also have little if any effect on mission mass and therefore no bearing on the net effectiveness relative to the Second Best Alternative.

**E) NEONet A:** If we step outside-the-box, and if the target were large enough where the total available inventory of NEDs became problematic (for example) it may even be far more effective to employ a Net to contain any possible dispersal of a loosely bound/rubble pile threat and then abandon the optimal proximity for a maximal subsurface detonation and employ penetrator technology. Here we may see a trade off in mission mass between the increase of the yield-to-work ratio by perhaps yet another factor of ten with a subsurface detonation (effectively ~100,000 times greater than the Second Best Alternative) with the employment of the Net and in terms of overall mission mass still be equal if not favorable compared to a optimal Nuclear Ablation mission. However, added mission complexity would beg whole new sections of Murphy's Law so some degree of preparation and training would be required... as in any tactic.

**F) NEONet D:** The concept of Nuclear Ablation relies upon the advantage of distributing of the reactive force of the volatilized gas over the surface of the asteroid. So stepping outside-the-box again, another means to achieve this effect could be to distribute many low yield NEDs over a portion of the leading surface of the asteroid by means of a Net. Detonated simultaneously such an approach would disperse the potentially disruptive reactive force while at the same time dramatically increasing the effective yield-to-work ratio to that of a surface detonation.

The inherent flexibility of Nuclear Ablation, seen in a potential light of experience and expertise, would afford this tactic an optional ad hoc surgical character. Even tested by what may be the most difficult of deflection challenges: loosely bound/rubble piles, the margin of effectiveness of Nuclear Ablation over Second Best Alternates remains in the range of orders of magnitude. Given that Nuclear Ablation appears to be an effective response to any conditional manifestation of this threat, taken in conjunction with the strategic infeasibility of any of the proffered Second Best Alternatives to be effective in addressing any asteroid threat over 500 meters,

**the only reasonable course and commitment for any serious research and funding would be in support of developing reliable variations on the theme of Nuclear Ablation.**

Conveniently, the advocates of Second Best Alternatives (unsurprisingly the principal critics of Nuclear Ablation) have instead convinced at least themselves that the greater threat is somehow probabilistically no greater than 500 meters... Perhaps we should also be considering a response to defend against the threat of statistical probabilities? However, once a demand for deflection tactics has been established with Nuclear Ablation in the public sector, then research and development working against the mission mass differential effectiveness of Second Best Alternates can be relegated to a private sector entrepreneurial opportunity. So they can hope...

**Modern Design:** If we are going to employ NEDs in order to defend the planet from asteroid and comet impact we will need to develop, test and deploy a modern design upgraded to maximize its mass-to-yield ratio in the form of space capable Earth-Safe NEO Mines dedicated to this purpose. Starfish Prime was not even close to a test of the requirements here. Such devices must be the product of a dedicated design and tested to be consistently reliable in Zero G, absolute vacuum, at -240'C and in ambient radiation outside Earth's magnetosphere for long periods of time after being accelerated to circumstellar orbital velocities for deployment. We are far from having a standing tested NED capability that could be considered reliable to this degree.

The above notions describing the variations on the application of NEDs are offered here only as back-of-the-envelope and require the formal attention of a dedicated Planetary Defense agency for any precision. But, as is, these notions are clearly not rocket science nor do they require the insight of a strategic genius. They are basic rudimentary principals of doing things. Common sense. What may be at work in the minds of the opponents of 'Nukes' may simply be an absence of political courage to see and make the hard Real World decisions when the clearly best course of action is merely potentially politically incorrect. The result is a convenient ignorance of what should be obvious to even the harshest of critics.

However, to directly address this nagging 'Politically Incorrect' argument against the use of Nukes: We should not allow our completely rational and warranted fear of global thermonuclear war to be used to coerce a completely unwarranted and irrational fear of employing nuclear energy to defend us from our Extinction by Asteroid Impact. After all, sooner or later, when The Time comes, and you and your children and grandchildren are at Ground Zero, will you settle for whatever powers-that-be using any Alternative that is Second Best by a factor of 10,000 times or even 100 times? How about Second Best even by a factor of 2?

**The Silver Bullet/One Tactic Fits All Size Threats:** From an imaginative buffet of Second Best Alternatives: Solar Collectors, Mass Drivers, Lasers, Gravity Tractors, Kinetic Impactors... soft critics of using nukes would offer a conciliatory 'basket of tactics' approach commensurate with all the conceivable variations manifest in this threat. It is said that a Good Strategist is a strategic genius while a Great Strategist is a logistical genius... as well. That said, strategically speaking, a Great Strategist never wants to *have to* have more than one tactic to employ to achieve the results he is responsible for. He understands that: if he needs only one tool to do the job, regardless how the challenge may present itself, it will be far more likely he will be able to have and even deploy that tool *before* he needs to use it; be able to rely on the tool being cheaper and afford some potential for a reserve beyond what he may exactly require to achieve his mission; be able to trust that, by volume and redundancy of production, this tool will become refined and tested to a higher degree of inherent reliability; and better prepare and train personnel in its effective use.

### **Great Strategists *like* Silver Bullets...**

**Tactical imperative:** Even a strategic genius understands that to be able to craft any strategy: determine what is essential to the conduct of implementing a response, let alone manifest it, it is imperative that first their must be a dedicated tactic to *respond* with... The notion of having a 'basket of strategies' in support of some 'basket of tactics', with all their attendant economic, industrial and political infrastructures, would then insist on having a strategy of strategies. A formula for failure by complexity. All Strategists, Good or Great, love to keep it simple/stupid.

It makes their success easier to come to. It is only the engineers of the tactics and the industries they service that like the idea of a 'basket of tactics'. The notion saves them from making the hard determination as to which is in fact the *best* tactic and in the process alienating the advocates and proponents of everything else. But ultimately, these engineers will not be the ones to be actually tasked with the responsibility for successfully deflecting these threats. It would seem that what is at work here may be a fundamental difference between a scientist and a soldier. Whereas, in the face of a threat, a soldier may wait until he sees 'the whites of their eyes' before he fires his gun a scientist would wait until he sees the 'whites of their eyes' before he invents the gun.

Further, and critically, a 'basket of tactics' approach is directly constructive to ensuring that we will/can never effectively build and deploy any means to deflect an asteroid *before* 'we see it coming'. Even further, without exception, all Second Best Alternatives are ridiculously massive and unreasonable for addressing threats over 500 meters. As such, if we are lucky (the 'odds' *are* in our favor), it would be a waste of opportunity to prepare and train for the next large asteroid impact to employ anything other than Nuclear Ablation in response to any interim small asteroid threat. From a general perspective, responding to small asteroid threats should be seen as no more than 'live-fire' drills. Strategically speaking, the application of Nuclear Ablation in response to the threat of asteroid impact appears to be a universal hammer that does, in fact, turn all our asteroid impact problems into nails. The one tactical response with which to build a sound and effective Planetary Defense strategy around. KISS... it.

### ***Agency/Funding***

**NASA v DOD:** In the direction of *finally* moving to respond to the threat of asteroid impact and The Next Large Asteroid on its way to strike Earth, after 40 years of academic awareness of this threat amounting to little more than lip service and counting rocks in space, buried deep within H. R. 6063: the NASA Authorization Act of 2008, is some small indication that the United States government to the Executive level is considering thinking about delegating or creating a dedicated National Planetary Defense Agency. Since DoD arguably has the second largest space program in the world the choices are clear: NASA or DoD.

However, NASA is all about science: specifically, discovery and the exploration of Space. Administrator Griffin has testified before Congress that "NASA does not have the tools to protect our home planet." and "NASA is not a protection agency". Which its history clearly demonstrates. NASA has never defended anyone from anything. Whereas DoD, against all comers, has defended the territory and peoples and interests of this nation for over 200 years.

By 'tools' this can be understood to refer not only to Nuclear Explosive Devices, recently determined by NASA to be the most effective means of asteroid deflection, but to the inherent suitability of NASA's culture and mindset as well. Beyond its reputation, employees and budgets there have never been dire negative consequences if any mission at NASA failed or even if NASA fails in its general charter and mission statement. And this can be further demonstrated by what may come to define 'at any cost'. Even though there are doubtless thousands of people at NASA who would soldier-up and sacrifice their lives to save mankind you would be hard put to find even one administrator or director or manager that would ever *order* them to do so. Whereas at DoD that would be SOP and why Generals get the big money. A product of a long evolved culture effectively addressing threats to our society's strategic security and our national survival imperatives. And make no mistake, this business may well come to a matter of personal sacrifice just in training for the event. Romantic notions and astronomical pipe dreams aside, Space is an old cold dead dark place that will kill you for just being there. And with the survival of the species in the balance, to plan for an unmanned response to this threat would be nothing short of criminally negligent and little more than gambling on the lowest bid with the fate of our species.

When The Time comes to successfully deflect The Next Large Asteroid on its way to strike Earth it will be the product of far, far more human endeavor that we have been led to believe by the academics. Whereas NASA's annual budget is less than 20 billion dollars DoD commands 25 times that. And when necessary, has far greater ability to get more. And this is a case where the more money we can throw at this problem *before* the fact the better our chance for success.

NASA's recent NEO Workshop report definitively indicated that Nuclear Explosive Devices in a Nuclear Ablation tactic, will be 100 times more effective than the next best alternative for deflecting impending impact threats. By that, consider that when The Time comes to deflect the next 10 km extinction level asteroid we could be looking at executing an extemporaneous ad hoc a mission requiring thousands of Ares IV heavy launch vehicles... just for a nuclear response! Make that hundreds of thousands of Ares IV launches for the Second Best Alternative. The problem is not just building such a massive response in whatever time the detection-to-impact window allows, but whether or not we will even have launch windows suitable to the demands of the mission... or will it rain on the day we have to Save the World. The only strategic alternative to suffering this risk would be pre deployment to some circumstellar orbit: Projecting Power. A challenge of logistics and systems management expertise that DoD has overcome and excelled at for generations. A skill that NASA only assumes in its sub-contractors.

From here and now, barring any new and improved laws of physics, given their dramatic margin of effectiveness, it will surely be Nukes at the tactical bloody tip of our response. Therefore you can be certain that the discretionary authority for the tactical disposition of Nuclear Explosive Devices will only be taken from the cold dead hands of DoD... politically speaking.

The prospect of Extinction by Asteroid Impact is forever. This is not something that will ever go away or can be eliminated. It must therefore be addressed and responded to... forever. In a sense this is not so much a threat as a newly discovered element of our existential condition. And our response, a cosmic cost of living. This is not about Science but Security. Not about Man in Space but rather the Survival of Mankind. Do we task the militaries of the world to start thinking about a new kind of mission in Space or do we task our scientists and academics to start thinking like soldiers? Which would give us the greatest expectation of success?

That said, it can never be taken that the skills and resources and experience of NASA should not be utilized. They do have a substantial tactical role to play in responding to this threat and would likely be the recipient of most of the funding. What we can not afford here would be delegation of the strategic responsibility for safeguarding the planet to a 40 year old academic culture that has never been responsible for safeguarding anything. Here, the best result should be seen as a hybrid agency of both DoD and NASA with DoD in overall strategic command. Responsibility only ever *works* when it is apportioned to or taken by those with the ability to respond.

***This is not a drill:*** A 10,000 m asteroid is one million times the mass of a 100 m asteroid and therefore one million times more work to deflect. If the magnitude of the threat were no greater than 500 m then we could probably just let NASA handle this with some fancy basket of Second Best Green Alternatives. Even if they fail, odds are we lose a city once every five million years or so. We can afford that. But since the magnitude of this threat rises to and includes the very real prospect of a 10,000 meter Chicxulub Class extinction level event, such an endeavor would make deflecting small asteroids little more than preparation and training for The Real Thing.

Get this problem out of academia. Let NASA be NASA. Put the principal strategic responsibility for Planetary Defense into the hands and minds of those best qualified to respond to dire and fearful things. This is not some super-sized science fair project. In this, we succeed... or we die. As the man once said: Failure is not an option... and yet, apparently, at NASA, it was.

**Inverse Opportunity Cost:** We The Species have already evolved and developed a dedicated human agency for addressing our Survival and Security problems. And since Planetary Defense is truly a global responsibility consider that, whereas only a handful of nations on the planet have any space program, every nation on Earth has its military. How much easier would it be to task the militaries of the world with a mission in Space than it would be to try and teach our scientists and academics to think like soldiers? And the best part, at a trillion dollars a year or more, is that our world militaries come with their own budgets already dedicated to Survival and Security!

If we delegate this mission to the militaries of the world, with DoD in an appropriate leadership and precedent setting role, and direct the funding of building a Planetary Defense pro rata from standing military budgets maintaining current global balances of power, it would effectively be at the cost of reducing the opportunity for us to kill each other over political, economic and religious principals. Win/Win... When you do the math and find that it would take only 5% of the world's military budget to generate a fifty billion dollar annual war chest for Planetary Defense, given the side benefits, you want to ask for more... yes? To do this right, and address the threat of the Worst Case Scenario, we would need to relocate the world's nuclear arsenal - reconfigured to Earth-Safe NEO Mines - six months away to the orbit of Mars. It should then be far easier to sell mankind on the notion of going to Mars in order to defend the planet from asteroid impact at the expense of our collective global ability to wage thermonuclear war on each other than it would be to go to Mars just 'Because It's There' and at the expense of our ability to feed our children...

### **Win/Win/Win!**

Science and technology have advantaged the evolution of our understanding of our place in the cosmos. One product of this emergent awareness is the recognition of an inherent vulnerability to some concurrent and seemingly exigent and existential threats. Since the clearly credible and perpetually imminent threat of asteroid impact is a threat we can conceivably manage, and since it will always include the prospect for our extinction, which asteroid is The Next Large Asteroid on its way to strike Earth will always be the most important thing mankind will ever know. And deflecting it will always be the most important thing mankind will ever do.

The Universe is a dangerous place. It does not suffer dilettantes gladly. At the very least we should be capable of defending ourselves from the bits of cosmic stuff left over from the creation of our own Solar System. The question here and now is, even though our science and technology have evolved to the point that we can, in fact, do this: Are We The Species *smart* enough, are We *bold* enough, are We *wise* enough, are *We The Species* in fact evolved enough to actually do this? Will We assume this small measure of responsibility for the continued existence of our own species? Because, if so or not, The Next Large Asteroid on its way to strike Earth is coming... at

### **A Million Miles A Day...**

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