

Waging War on TNLA:

The Next Large Asteroid on its way to strike Earth

A Strategic Planetary Defense Policy Proposal

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"For all we know, a large asteroid may be heading this way right now, and you'll never get this [conversation] on the air. The danger of asteroid or comet impact is one of the best reasons for getting into space. I'm very fond of quoting my friend Larry Niven:

'The dinosaurs became extinct because they didn't have a space program.'

And if we become extinct because we don't have a space program, it'll serve us right!"

Arthur C. Clarke

Executive Summary

It has been ten years since geologists discovered the Chicxulub Crater proving that extinction by asteroid impact is a real possibility for mankind. Since that discovery The Next Large Asteroid on its way to strike Earth (TNLA) has come 4 billion miles closer to impact and scientists and academics are still thinking and talking and debating and conferencing... when for years this business has not really been their problem to solve. Are these highly intelligent and highly educated leaders in their respective academic communities smart enough to pass their insights onto those agencies best qualified to deal with this threat before we become nothing more than part of Earth's fossil history? After ten years we not only do not have a global authority dedicated to defending the planet but even the most scientifically advanced nation in the world does not have a qualified authority responsible for making the most basic strategic and tactical decisions in response to this threat. Time does not appear to be on our side in this issue.

This is not a failure of leadership or political will. The 'intelligent' community has simply failed to present this issue to those policy makers 'to whom this should concern' as one that clearly rises to the level of an imminent Clear and Present Danger. What we have here is a failure to communicate. When you consider just how little we can do to defend ourselves from this threat and how much luck would be required to even see this Rock coming before impact the prospect of a large asteroid impact warrants a great deal of fear. Perhaps it is the fear of fear itself that has compelled a more acceptable and benign view of this reality and perhaps at bottom what we have here is a failure of courage as well - a failure of *intellectual* will...

Sooner or Later some astronomer somewhere will detect The Next Large Asteroid on its way to strike Earth. Within a matter of days its detection along with the precise date of impact would be confirmed and sent to the Administrator of NASA who will take it to the Vice President who will walk it over to the Oval Office. Upon receiving a confirmed notification that a large asteroid is now incoming, no matter how far away it is, the first call any President of the United States is certain to make will be to his Department of Defense. And Later, Planetary Defense will become military business.

Planetary Defense as military business 'Later' would be a desperate and fearful thing, with much pointing of fingers and gnashing of teeth and real last-minute politicking about who did not intelligently connect the dots. And which desperate extemporaneous nuclear one-shot option the POTUS should choose to save mankind from Extinction by NEO. Plans for Solar Sails or Mass Drivers will not even make it into the Situation Room, although any prayers or good luck will certainly be welcome. On the other hand, Planetary Defense as military business 'Sooner' would involve much preparation, training and vigilance with far less faith in prayers or good luck and far more reliance in diligent strategic foresight... and Projecting Power to Mars. Mars may be an old cold dead red ball of rock that will kill you for just being there, and even though there is nothing on Mars worth going there to get, there is one good reason to go to Mars. Mars is the best strategic location to defend our planet from TNLA.

TNLA is closing at a million miles a day. This is not just another campaign issue but a new status quo for mankind requiring administration by an agency as autonomous and immune to the vagaries of economics and politics as possible - a global human martial authority. In this arena, the Mission must dictate Policy. Statecraft, Economics and even Science must take a backseat to the demands of building and maintaining a Strategic Planetary Defense. Even then, absolute security could never be guaranteed by any agency or at any price. The cost and resulting effectiveness of any planetary defense can only be approached from the perspective of whatever the market can bear. However we can surely afford far more than the yearly 3.5 million dollar next to nothing we are spending today and mitigate much of the threat. Every year 30 million people spend 400 billion dollars on Heroin and Cocaine. Certainly the other 5.97 billion of us can match that as a premium to ensure us all from going the way of the dinosaurs. Particularly, if that 400 billion dollars comes from reallocating worldwide military budgets it will ultimately only cost us the opportunity to kill each other over economic, political and religious principals.

The Sky is Falling Now! This battle has already begun! This is War... and we are losing.

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Waging War on TNLA:

The Next Large Asteroid on its way to strike Earth

This is not a drill! Once upon a time there was a Big Bang. Cause/Effect - Cause/Effect - Cause/Effect and 15 billion years later we have this chunk of cosmos weighing in at perhaps trillions of tons, screaming around our solar system, somewhere, hair on fire at fifty thousand miles an hour, on course to the subjective center of the universe. Game Over! No Joy! Restart Darwin's clock... again. On impact this Rock would release the equivalent of a 1.3 Hiroshima bomb for every man, woman and child on the planet and as things stand today we can only imagine a handful of dubious possibilities to defend ourselves with. There is nothing we have actually prepared to do in response to this event. The causes that have determined this future for us have already had their effect. The Next Large Asteroid on its way to strike Earth (TNLA) is out there, now - whether we ever actually see it coming or not. This die has been cast. All that is left for us to do is to find it and find a way to make sure it does not stop rolling here. This is a set-piece game, it is our move, and we do not even have a pawn on the board. As a threat, The Next Large Asteroid on its way to strike Earth has already arrived - this impact event has already started. Given the magnitude of the challenge in developing an effective response and preserve our species, choosing to wait any longer for any reason is simply inviting Suicide by NEO. We are engaged! The battle has begun! *The Sky Is Falling Now!*

Credible Imminent Threat

All the large asteroids in our Solar System, whether they are Near Earth Objects or Rogue or Main Belt asteroids, can only be perceived as a threat because collectively they constitute the candidate group for The Next Large Asteroid on its way to strike Earth. The rest are irrelevant. They will either never strike Earth at all or will impact sometime after TNLA. If we develop and deploy a standing capability for defending the planet and succeed in dealing with TNLA subsequent impactors will lose much of their character as catastrophic threats becoming only problematic - engineering challenges. If we fail to deal with The Next Large Asteroid on its way to strike Earth we may well become extinct. Again, the rest are irrelevant.

To determine the credibility of this threat we need only to consider the 200-kilometer hole in the Earth at Chicxulub. It is irrefutably a large asteroid impact crater and the implications are clear that the result of this impact brought the dinosaurs and most land-based life forms on Earth to a quick extinction. Then, if we look around our Solar System we find that there are nearly 2 million more asteroids out there large enough to at least destroy life on Earth as we know it and many of those easily large enough to bring *us* to a quick extinction. Given the relative fragility of the human requirements for 'life' and subsequently the low threshold for what would constitute a catastrophe today, even the impact of the smallest large asteroid, anywhere in the world, could bring down our cultural and economic house of cards. Taken together these two realities alone easily raise the aspect of large asteroid impact to the level of a credible threat. From a broader perspective, considering the likelihood of how common asteroids are, it may well be that asteroid impact is the single greatest instrument of extinction for life everywhere in the universe. We should be paying far more attention to this Cosmic WMD than we actually are. We are like ants that evolved and enjoy safe harbor in our little cosmic footprint. Yet like ants we fail to fully appreciate the prospect of feet.

As far as the immanence of this threat - TNLA is coming... period. Earth has been struck by thousands of large asteroids in its past and in that past the Solar System has had millions of large asteroids in it. Today the Solar System still has millions of large asteroids in it and it follows as a simple rational deduction, virtually to a degree of absolute certainty, that sooner or later Earth will be struck by a large asteroid again. Further, in that it is a characteristic in common to all asteroid impact events that they are discrete, unique aperiodic events free of any season or observable routine they can occur at any time. It follows then that from the subjective and strategic perspective of defending the planet until we have developed the surveillance capability to generate empirical evidence to the contrary we must always regard the rational probability for the next large asteroid impact event to always be 100%. TNLA is coming... forever!

That another large asteroid is out there on some course to strike Earth is seldom seriously contested... as such. Consider the rationale for the argument that it is not... It only becomes arguable when the question concerns when it might arrive. If we hold to a definition of the threat as *The Next Large Asteroid on its way to strike Earth*, as far as its impacting Earth the observable behavioral elements of all other asteroids are irrelevant. Also, the principal deterministic elements that generated TNLA go back to the formation of the solar system and are far beyond our ability to appreciate. Further, in that they are discrete, unique and aperiodic, past asteroid impact events cannot serve as even approximate appreciable deterministic elements

for crafting a credible probability for any when TNLA might or might not impact... There is nothing left to work with and we are simply going to have to wait and hope we see it coming before we can derive any valid mathematical probabilities for when it might or might not arrive. Chaos: unstable aperiodic behavior in deterministic nonlinear dynamical systems... asteroid impact events! How can anyone presume to derive a rational probability for a single event from something in a state of damn-near pure chaos?

Until we find TNLA crafting mathematical probabilities for 'when' it might or might not arrive results in little more than comfort food for thought - smoke and mirrors - statistical sophistry - straws. Still, scientists and academics do not always say 'I don't know' out loud and in public easily. So some kind of mathematical probability for when TNLA might arrive is calculated and without the benefit of a subjective and strategically qualified rigorous and diligent review, it is offered up to the altar of public consumption. But they fail to stop there. They go on to interpret and characterize this abstract and purely academic model of a probability and with a deft alchemic slight of hand transform a mathematical artifice into a fundamental strategic threat assessment: "The probability for large asteroid impact anytime in the next century is low". Consider the elements of this conclusion in detail beginning with the follow-up question that is seemingly never asked... In what century will the probability be high?

- In that the authors, proponents and adherents of this assessment do not actually know anything about 'the next century' specifically it is safe to assume that 'the next century' is little more than a non-mathematical user-friendly analogy for a given 100-year period... *any* 100-year period. As such, the probability for large asteroid impact in 'the next century' is no different than it was in the century 65 million years ago when some 10-km asteroid hit the Yucatan peninsula at Chicxulub... Statistically speaking, in that all 100-year probabilities will be the same mathematically, from the logic of this assessment all past large Earth/asteroid impacts can only have occurred in a century where the probability was 'low'...

- Unless you modify the baseline deterministic data, find more asteroids or increase the size of the target, one way to express a higher apparent probability would be to increase the interval of time mathematically. Then, any given millennial probability would appear to be 10 times greater than the probability for that of any given century. However, the probability of asteroid impact events cannot be perceived to culminate and increase towards the end of any given of time. Impact events may be seen to occur anytime during the period expressed and satisfy the probability. By simply increasing the period of time the ratio between any given period of time and its corresponding probability will always be the same. The actual probability does not change: just the size of the numbers expressing it. The difference between the probability expressed for a century and that of a millennium will not be higher or lower relative to each other. Consider the price eggs at 6 for \$1.00 and at two dollars a dozen... where is the price of a single egg 'low'? If the probability for a century is expressed as 5,000:1 and for a millennium is expressed 500:1 both can be resolved to the same absolute expression of 1:1 every half million years.

Further, if this were a valid method for the interpretation of statistics it would also follow that the more time that passes from the point of any given impact the greater the probability for the next impact to occur. As the Law of Greater Numbers this is a favorite perspective in Las Vegas... for The House: the longer you play your number the better the odds your number will come up. Since there is no causal relationship between successive impact events, anymore than the result of one flip of a coin effects the result of the next, in either case this line of reasoning would be false. The odds for 'heads' are always 1:2. TNLA - 1:1.

- The probability of 'low' is often also expressed when a comparison is implied between the occurrence of large asteroid impacts and something else suggesting that impact events are relatively rare and infrequent mitigating the perception of how much attention we should afford this issue. However, to be apt and useful any comparison should at least be made for the relevant characteristic that concerns us most. Here, that would only be something with the word catastrophe in it. National or regional catastrophes like earthquakes or tsunamis may rise to the level of the smallest asteroid able to strike Earth: 50 meters and 12 Mt - 1,000 Hiroshima bombs. But to get as close to comparing apples to apples: to be fair and the comparison relevant, we have to be comparing to some global catastrophe like Global Thermonuclear War! Then we would at least be in the effect range of the smallest 'large' asteroid: 1,000 meters and 100,000 Mt - 10 times the current world arsenal. If the assessment of the probability of large asteroid impact were made relative to the occurrence of Global Thermonuclear War we would have Large Asteroid Impacts in the thousands and Global Thermonuclear Wars... zero. Remember the attention, wealth and resources we dedicated to the prospect of Global Thermonuclear War... Remember MAD? So unless you are comfortable comparing asteroids to apples this manner of assessment finds little support in any comparative analysis as 'low' either.

- When expressed within given periods of time, these impact probabilities do not suggest impacts as occurring at the end of a given period but rather anytime throughout the entire period given. If you consider

an impact occurring in an instant anytime within any given 500,000-year period where the mathematical probability for impact is 1:1, you have to recognize that this impact would correspondingly be also occurring in some constituent millennia and century and decade and year as well. If at any given time we are simultaneously *within* one of each of these constituent periods we are therefore subject to all possible impact probabilities as they relate to their own discrete period of time. As a result we are free to promote whatever probability best serves our own short-term self-interest as long as we express it within the appropriate period of time. Take your pick. Here, probability itself becomes a very subjective commodity.

- The mathematical tools for calculating probabilities first require any base-line empirical data to be reordered into a relative frequency which will only generate an abstract modeled result. So instead of addressing when 'The Next Large Asteroid on its way to strike Earth' will arrive scientists and academics have reframed and redefined the nature of the threat itself by modeling and abstracting it in order to better-fit the demands of their tools. Then they can comfortably address the probability for 'a large asteroid impact' at anytime but only as modeled in the abstract - as a mathematical ideal. Strategically speaking, here is where all the wheels fall off the methodology wagon.

Consider that in promoting his company's FY/02 performance and stock value to potential investors on CNBC an executive of the Mattel Corporation stated that on average, every 3 seconds somewhere in the world someone buys a Barbie doll. It does not take an MBA to appreciate that in actuality 80% of all Barbie dolls are likely sold in November and December. The statistic of 1 Barbie every 3 seconds was not intended for use by the manufacturing and distribution elements of the Mattel Corporation in meeting their respective responsibilities. If so, depending on when they implemented this schedule, Mattel would either need to build warehousing for millions of Barbie dolls or millions of little girls worldwide would need to wait months for their ration of Barbie doll. Averaging to this degree would critically skew the data that manufacturing and distribution would normally rely upon to make the strategic decisions required to best do their jobs. However, even in context, the relative frequency of Barbie doll sales was irrelevant. No investor actually cared when the next Barbie doll was sold or what the probability of a Barbie being sold in the next second was. The per-second interpretation of Barbie doll sales had no strategic value for the investor at all. The Mattel executive was merely marketing the fact that Mattel sold 10 million Barbie dolls that year by spinning it in a less blunt more user-friendly manner.

The single most dire strategic characteristic of the threat of Earth/asteroid impacts is that they *are* aperiodic and that we will never be able to appreciate any of the deterministic elements of large asteroid impact events. Here, in the effort to calculate probabilities, the pro forma demands of analytical methodologies have not merely skewed the already estimated primary data, but have served to re-fabricate the only component relative to the end result of the process in order to better-fit the tools used to appreciate it! By averaging and establishing a relative frequency the perception of the threat itself is corrupted far beyond any rational strategic value... unless of course you *are* only trying to market something.

- In that the impact of TNLA will be a singular unique and specific event, to induce any characteristics of this event from a general statement of large asteroid impact events would only be valid when dealing with those specific characteristics in common to all large asteroid impact events. In that asteroid impact events are absolutely aperiodic, as such, when they have occurred in the past or will occur in the future cannot be a common characteristic. As their occasion is always unique and discrete to each event you cannot induce from the general to the specific for this characteristic with any integrity. TNLA is TNLA.

- The most egregious aspect of this misuse of probability is that its proponents have substituted chance for the magnitude of the loss as the principal strategically critical deterministic element in their assessment of the threat. Probability often contributes to assessment but it should never be of greater consideration than what is at risk. Go home tonight and tell your wife that you have bet the lives of her children and her children's children on the strength of a 'low probability'. Do you think she will want to hear the odds?

Yet the conclusion that 'the probability is low' is presently one held by many scientists who have been studying this issue. This conclusion serves the underlying rationale for their assessment of the threat and subsequent prescription for a strategy and scares us only enough to consider building a tactical response only after detection. If as a threat assessment this conclusion is false and misleading and it is understood that useful probabilities for TNLA can only be derived from direct observation then the only perspective, the only strategic probability we can afford is to regard the impact of TNLA as perpetually imminent. And respond accordingly. In our continued survival as a species we have learned to hope for the best but prepare for the worst. Preparing for the best while ignoring the worst has never been a reliable survival trait and only ever the result of a poverty of will or ability or both - or stupidity. Perhaps we are just too poor or too stupid to survive. Nonetheless, there is good reason to be far more afraid than we may want to be.

Perhaps the greatest obstacle we face in building a Planetary Defense stems from an innate lack of any racial memory or primal fear of Death by Rock from Sky. Aside from a 50-meter impactor striking Chicago tomorrow and providing us with an obvious observable lesson in the workings of the Cosmos, the only way to approach this problem would be to cultivate a fear of large asteroid impact rationally. Without fear to season our perspective and catalyze a response we will never martial the resolve or effect the allocation of resources adequate to the daunting task of dealing with this threat. After the fact, the fear of Death by Rock from Sky itself can be faced as mitigated with the justified confidence of having developed a standing capability to respond to TNLA. However, most people, when confronted with the logic underlining this threat perceive the justified fear that goes with it and find and embrace some comfortable form of denial and dissociation before ever looking at this issue head on. If the first principal of belief is the freedom to believe in whatever truth you want the truth to be, in order to just sleep at night, why would anyone choose to believe that the chance for a large asteroid impact - and extinction - is anything *but* low?

Whatever comfort we may find in probabilities is nothing more than a poorly negotiated peace with a Rock. Only fear ever defines necessity and it is time to become afraid. It is time to abandon the comfort of our beliefs and become very afraid. Once we have adopted the responsibility for building a Planetary Defense *personally* then the only peaceful sleep we deserve will be when we are prepared to meet the threat of TNLA with clearly superior force, not spurious probabilities and statistical sophistry. Before we can begin to prosecute this War with TNLA we must destroy the 'low probability' within our own minds and let slip our fears to foster and steel the resolve we will need to win. It is bad enough being held hostage by the Cosmos and its Rocks. Do we need to suffer being held hostage by the comfort of our own beliefs as well?

A Dire Clear and Present Danger

The magnitude of any threat can best be quantified by the ability to detect and defend against it. Even a veteran US Navy SEAL, blindfolded and bound to a chair, would have to regard an angry twelve-year old girl scout with a fingernail file as a potentially life-threatening situation. Our current capability for detecting TNLA and making mankind safer has been offered and often accepted as far greater than what it actually is. And any confidence in the effectiveness of any imaginable extemporaneous tactical response, when and if TNLA is finally detected, is probably little more than a result of connecting the wrong dots.

DETECTION: The DEFT scenarios for the Planetary Defense Conference have already given half the battle - detection, which is easily the difference between success and extinction. These scenarios are improbable not in their detail but individually as imaginable results reliably stemming from any real Planetary Defense policy capabilities in place at the given times of detection. Funded by the House Subcommittee on Space & Aeronautics (the highest US governmental authority involved in this issue) to verify their estimates for the population of large NEOs, the NASA Spaceguard Survey is the only agency in the world currently tasked with any aspect of Planetary Defense... To count some rocks in Space. In that the Spaceguard Survey talks about an ideal objective threshold of 30 years for detecting TNLA by no means rises to the level of a demonstrable capability to perform to that standard. Even then, to actually be determinable as *The Next Large Asteroid* on its way to strike Earth a candidate's orbital elements: position, mass and velocity, must be measurable to +/- 0.000003% (+/- 4,000 miles/ Earth's radius over 30 years/12 billion miles) in order to accurately calculate its point of impact. Or we run the risk that any response we might take may turn what was merely some poor rogue Rock that never was going to strike us *into* TNLA...

Any asteroid that ever will strike Earth is on course to do so now even if that course includes the occasional asteroid/asteroid collision or two and even if observed it is not clearly apparent as TNLA... yet. Eros, the only asteroid we have visited, has 100,000 impact craters evidencing 100,000 discrete orbital paths. If the recently detected 1,200-meter NEO QQ47 were struck by a 100-meter NEO, Rogue or Main Belt asteroid having only 0.1% of QQ47's mass and moving at a similar speed, after only one orbital cycle it could effect a displacement of 2 million miles in QQ47's orbital path. That would certainly be far enough to change its status from merely another safe NEO to incoming Death by Rock from Sky. Our present ability to observe the deterministic dynamics of the solar system in this regard is infinitesimal. We would have to detect and monitor all the tens of millions of asteroids of all sizes 24/7/52 throughout the entire trillion-trillion cubic mile Area of Interest they travel in to know if any asteroid detected and plotted to be safe yesterday was still safe today. With the Spaceguard Survey's present 'catch as catch can and release' strategy their capability to detect TNLA as incoming and in its terminal trajectory is currently far more a matter of chance, good luck and serendipity than any diligent strategic application of leading edge technology. Supporting the continued efforts of this earthbound effort alone will only serve to slightly increase already extremely low odds. Regarding NASA's Spaceguard Survey as anything other than the academic progenitor for a real Planetary Defense is little more than whistling past our own graveyard.

Some considerations and conditions for detecting TNLA:

- We can only search for it from Earth and then only at night.
- We can only search for it in an area of space away from the Sun outside Earth's orbit.
- As Earth revolves around the Sun the area of space we can actually search for it continually changes.
- As Earth rotates on its axis the portion of the area of space we can search for it in continually changes.
- Only a few modest observatories have been made available to search for TNLA in their spare time.
- The low resolution of available observatories limits how far away we can search for TNLA.
- At current technical levels military and astronomical radar cannot be effectively used to search for TNLA.
- At any given time TNLA may be anywhere in an overall area defined by a sphere with a radius from the Sun halfway to Jupiter: roughly one trillion-trillion cubic miles.
- Over the course of a year, we can only search for TNLA in less than 2% of the overall area it may be in.
- In searching on any given night we do not search more than 0.02% of the overall area TNLA may be in.
- In terms of real-time surveillance, we only search for TNLA in a few square degrees of the 1% of the available search area as observatories come to bear with Earth's rotation.
- TNLA can move a million miles in one day.
- TNLA must be passing through that region of the search area we are searching in and be at the same place within that region at the same time we are actually looking there.
- Sunlight reflecting from Earth's atmosphere at the horizons effectively restricts the arc of night sky dark we can search for TNLA in from any given observatory to 5 or 6 hours a night.
- Moonlight can reduce observational opportunities for finding TNLA to only 3 or 4 nights a month.
- Clouds generally obscure observations of space from Earth and make searching for TNLA impossible.
- TNLA must be reflective enough and/or close enough to Earth to even be detectable within the limits of the observatories we have available.
- TNLA must be reflective enough to be detectable as 'large' (over 1-km) to meet the current criteria of being investigated and catalogued as a NEO threat.
- TNLA can only be detected as an asteroid at all if it is moving at an oblique angle to an observer on Earth.
- Millions of asteroids of all sizes must be detected, sized, plotted, classified monitored to determine if they are Main Belt, Rogue, NEO or TNLA.
- TNLA will not become easier to detect nor necessarily gradually pass closer to the Earth in subsequent orbits approaching the time and point of impact.
- Due to perturbations and collisions in The Main Belt any asteroid there could become TNLA any time.
- All Rogues and NEOs cross thousands of other asteroid's orbital paths in every orbital cycle and could become TNLA as a result of a collision with another Rogue, NEO or Main Belt asteroid.
- Much of the initial observations in searching for TNLA are by amateurs and are irretrievably lost in the queue before they can be followed up on by the Principal Spaceguard Survey Observatories.
- Worldwide there is no one actually employed full-time to find TNLA.
- The world's total budget for searching for TNLA is less than 4 million dollars a year.

Given the impossibility of methodically searching for large NEOs and actually 'survey' the Solar System cubic grid by cubic grid, NASA's Spaceguard Survey has had to settle for looking for them when and where they can, approaching the problem more like a cosmic asteroid egg hunt. By any stretch of the imagination this is not 'surveillance' either. Once they have detected enough large NEOs to satisfy their initial estimates, demonstrating their hypothesis and justifying their audit - that mathematically, there are enough large NEO's to constitute a Clear and Present Danger - the Spaceguard Survey can declare victory and go home.

To date the Spaceguard Survey has detected half of the 1,000 large NEOs they initially estimated to exist and have determined that so far none of those detected appear to be on a collision course with Earth anytime in the next century and can be regarded as 'safe'. They then go on to make the strategic assessment that these results somehow serve to reduce the risk of large asteroid impact in the next century by half as well and have made mankind safer in the process. This interpretation can only be rational if the threat were defined as if all 1,000 of the large NEOs estimated were going to impact Earth sometime over the next century. As if there were 1,000 Barbarians at the gate, all individually dire and equal in their capability to rape, pillage and burn and in dispatching 500 of them you reduce the threat and thereby the risk by half.

However, the threat is clearly better understood to be the possibility of one large asteroid on course to strike Earth sometime in the next century... not 1,000. Instead of Barbarians there are 1,000 Pilgrims at the gate and one of them is a terrorist. After interrogating half and failing to find the terrorist you will not have reduced the risk by any measure. Risk is a constructive result of the terrorist/threat. From this perspective the size of the group is irrelevant. In any initial assessment of the risk, the majority of large NEOs would necessarily be regarded to be non-impactors in the first place and finding them would only go to verifying the initial risk assessment. The claim to derive some interim reduction of the overall risk by finding non-impactors stems substantially from a flawed definition of the threat, which as an abstract probabilistic construct expresses the threat as 'the risk of large asteroid impact'. From here and from now the threat can only be defined specifically as The Next Large Asteroid on its way to strike Earth and the error of claiming any interim reduction in the risk should resolve itself. Even when the period of risk expressed narrows the definition of the threat to the next century the challenge of detection remains the same: find TNLA.

It can be argued that in reducing the size of the remaining unknown candidate group the degree of difficulty in detecting TNLA is reduced and ultimately contributes to mitigating the threat. However, this advantage is always only potential and would be conditioned upon the intent and reasonable expectation of finding all the large asteroids there are which would first require that we be dealing with a static and closed system... as in the group of 1,000 Pilgrims. If you interrogate half of the Pilgrims the remaining candidate group will be reduced and with a reasonable expectation of interrogating the remaining Pilgrims you reduce the degree of difficulty in finding the terrorist by half as well. But if you fail to interrogate the remaining candidate group and open the gates of the city to all 1,000 Pilgrims, the advantage of interrogating a reduced group is lost and so is any reduction in overall risk. The overall risk for the entire group would then revert to its original uninterrogated level. Further, the size of the remaining portion of candidate group is irrelevant to this effect. If you interrogate 999 Pilgrims and let one uninterrogated Pilgrim into the city the risk for the total group reverts to its original level. As things stand and all things considered at the Spaceguard Survey today, any reasonable expectation for a complete audit of the large asteroid population is impossible and consequently no claim could ever be made for an interim reduction in the risk by detecting large asteroids that never will strike Earth. At best, reducing 'risk' here is little more than a feel-good academic actuarial exercise. The real task is to find The Next Large Asteroid on its way to strike Earth.

Either way you look at it, without the capability to determine which large asteroid is The Next Large Asteroid on its way to strike Earth detecting a large asteroid that will not strike Earth will have no bearing on the threat or the risk. To make matters worse, since all NEO and Rogue asteroids were perturbed from their once stable orbits in The Main Asteroid Belt, and this process is ongoing, there is no assurance that TNLA will necessarily come from the NEO population at all! Only after we have found the last large asteroid in the solar system: NEO, Rogue or Main Belt, will we be able to determine which one is TNLA and eliminate this risk... by escalating it to an incoming certainty. Without the capability to find TNLA all the Spaceguard Survey can mitigate is the perception of the threat. You don't get what you don't pay for. Then again, the Spaceguard Survey never asked for nearly enough money to build a program with a reasonable expectation of finding TNLA in the first place... just enough to count some rocks.

Even if the Spaceguard Survey's final results, or some other influence, ultimately indicate that the large asteroid population is greater or less than initial estimates these results can only be used to effect the math for calculating the risk in the abstract model. The only way to reduce the tangible risk and not merely its perception would be to mitigate the threat that fosters the risk in the first place. To this end finding TNLA is the only imaginable result that will effectively make us any safer.

An expected result of the Spaceguard Survey's sporadic and opportunistic approach is that early detections will be the easiest. Because early efforts have failed to detect TNLA, or detect it as such, and since the balance of the effort will not only be 'later' but more difficult, the likelihood of detecting TNLA in time to successfully respond to it has decreased. Since we know that TNLA is out there and that any increase in difficulty in detecting it negatively affects our ability to respond, then detecting half the large NEOs and failing to find TNLA can only be tactically interpreted as a net *increase* in the level of the threat. Even with a 100-year interval qualifying the risk, detecting TNLA still stands as the only result that will mitigate the threat and make us safer. It will just be a matter of determining whether or not TNLA will arrive in the next 100 years. The Spaceguard Survey makes us safer only because in the process of counting the rocks in Space they *are* Watching the Wall as well and they may stumble across TNLA. They mitigate the threat and reduce the risk by whatever small degree can be represented by whatever small piece of the wall they are watching at any given moment. As such, the Spaceguard Survey is the absolute least mankind can do to save itself from Extinction by NEO. Talk about a risk...

Speaking for everyone on the planet (Astronomers, Astrobiologists and Minor Planetologists aside) The Next Large Asteroid on its way to strike Earth is the only asteroid we give a damn about. The Spaceguard Survey or any Earth alone detection system can only ever afford us some small possibility of detecting TNLA before impact at all, and that possibility becomes extremely remote when 'long enough before impact to do something about it' is added. We can only know when TNLA will impact because we may see it coming. We do not have a capability even approximating the scope of surveillance that would be required to allow us to trust that at any given time TNLA is not about to impact because we do *not* see it coming. The Spaceguard Survey does not so much look like our Cosmic DEW Line as it does some Cosmic Punch Line. Perhaps at least the gods will get a laugh.

In that detection is only half the battle, in order to reduce the level of the threat by half we would need to be watching all the wall all the time. Even then any tangible reduction at all would be conditioned upon having a reliable standing capability to respond or any efforts in looking for TNLA would amount to little more than academic curiosity. We need a comprehensive surveillance of the total Area of Interest operating in conjunction with a tested capability to interdict The Next Large Asteroid on its way to strike Earth. To save ourselves from Extinction by NEO we need a program that affords us the ability to respond within a margin of days and not decades. Days may be all the heads-up we will get...

INTERDICTION: NASA can afford to regard the probability of large asteroid impact as low. If you call NASA today and ask for the person in charge of defending the planet from large asteroid impacts you would end up talking to NASA's director of Solar System Exploration. You would be informed that it is NASA's job to study and observe asteroids not to deflect or blow them up. Just because NASA has Space in their name does not make them responsible or qualified to respond to everything that happens there and dealing with impacting asteroids is simply not their job. Consequently, without the dedicated mission responsibilities or funding for interdiction, any strategy NASA has offered for interdiction naturally relates only to those efforts which have been allocated funding such as NASA's Spaceguard Survey, which has been tasked with auditing the population of large NEOs. There is no mission specifically dedicated to finding TNLA. The resulting strategy is that in the course of their studies and observations the Spaceguard Survey may incidentally find TNLA and do so decades before impact and only then, with hard data on its orbital elements and composition, will somebody begin to actually do something to Save the World.

Justified by this hopeful best case scenario, the free marketplace of ideas surrounding NASA has generated some imaginative tactics serving this post detection strategy. Most regard using any nuclear solution as a desperate last-ditch backup 'Plan-B'. These options occasionally work in accord with some of the laws of physics and some may even look good on paper. However, in considering the cost and time and reliability in executing some of these tactics in The Real there are notable and often critical flaws - real deal killers! Setting aside the doctrine that any strategy that proposes to defend will ultimately fail if it does not design against the worst case scenario, consider these tactics employed only against the recently detected QQ47. A scenario only 3 times worse (kinetic energy) than NASA's routine reference to typical 1-km asteroids which as examples are still only 0.1% of the magnitude and challenge of a 10-km Chicxulub level impactor.

Any engineering effort, even *with* the benefit of vast experience and expertise, necessarily affords some margin of error in its implementation. Here, we would first need to account for any empirical discrepancies that would be reflected in the math for calculating the projected impact of QQ47. With a 20-year or 12 billion-mile detection, to calculate impact point of +/- Earth's 4,000-mile radius, would require determining QQ47's orbital elements to an accuracy of +/- 0.00003%. Then we would have to allow for all the potential subsections of Murphy's Law inherent with an ad hoc unpracticed extemporaneous enterprise of this apparent magnitude. Finally, but most importantly, to recognize and reflect the magnitude of the loss should this endeavor fail. In order to account for these considerations we should afford any system's engineering design capability with a displacement objective margin of 20,000 miles - 5 times Earth's radius.

Given an interdiction point 10 years away from impact and generally taking advantage of orbital mechanics, to achieve this displacement target, a single pulse would need to result in accelerating QQ47 by 5 cm/sec along any axis. With a mass of 3 billion tons and velocity of 33,000 m/sec QQ47 manifests 15×10^{20} joules of kinetic energy. To accelerate this mass at this velocity and effect the 5 cm/sec needed to displace QQ47 in a single pulse requires a net 4.5×10^{15} joules as Work. Any gradual force over the course of the entire 10 year displacement period would need to be designed to achieve a final change in velocity of 10 cm/sec and generate 9×10^{15} joules as Work to effect the same 20,000-mile displacement. When QQ47 was first detected it was offered by authoritative sources that if it were on course to strike earth all that would be required to deflect it from impact would be to send a small spaceship to nudge it into a safe orbit. Let's see what the meaning of small is.

The Space Shuttle Main Engine (SSME) will combust and exhaust an External Tank (ET) of fuel (700 tons) at about 3,000 meters per second generating approximately 2.5×10^{12} joules KE. Over 10 years of gradual force it would require 600 ETs, and given a 7.5-hour continuous duty life between overhauls, as many as 50 fresh SSMEs to deflect QQ47 from impact. To get this mission to the target at would require a total mission mass in excess of 500,000 tons. Over 25,000 Titan 4 launches just to get it to LEO. This does not even consider the energy that would be required to de-spin this rock so it can be pushed. Then, do you think for a minute that this or any mission to Save Mankind would be unmanned? Again, you can ask your wife if she thinks it would be wise to bet the lives of her children on a robot. Like the man said, "What's Plan B?"

A Mass Driver, once QQ47 has been somehow stabilized for pitch, yaw and roll, would have to throw millions of tons of QQ47 at 1,000 m/sec for several years in order to generate the Work required. That is more than most strip mines on Earth produce annually and Mass Driver velocities of 1,000 m/sec at that scale are still only theoretical. Even then QQ47 itself must be composed of machineable ferromagnetic non-magnetizeable ore for the option to work at all. Shipping a large space tempered strip mining operation to QQ47 one Titan 4 launch at a time has to be way further down the line of options than Plan B.

The Massive Spaceship or Kinetic Impactor *<revised in addendum>* is fairly straightforward... If TNLA is not an aggregate and relatively 'soft' asteroid - as most are believed to be - crash a massive spaceship into QQ47 and slow it down or deflect it with a single pulse. This tactic has the advantage of requiring half the KE that would be needed over a 10-year gradual interdiction period. However, the prospect of crashing this ship into the asteroid along its -X axis would require a massively expensive retrograde orbit and launch from Earth. A prograde interception, parking a massive ship along QQ47's path at half its velocity, all things considered would still require an extended total mission mass in excess of 500,000 tons. Even if this mission is divided up into many smaller impactors the risk of catastrophic disruption and creating a cluster impactor is high. Up to some point, with mankind in the balance, this will also be a manned mission.

A 200 sq km Solar Sail would theoretically provide enough force to accelerate QQ47 by 10 cm/sec over 10 years and at 15 to 20 tons/sq km would seem to be a far lighter mission than rockets or massive spaceships. Except when you consider that the sail is not likely to last 10 years. Under constant bombardment by solar radiation and the stress of the reflected photons generating the kinetic energy transferred to QQ47 it may not effectively last 10 weeks! Solar Sails have never been tested in Space or even in LEO so there is no empirical data available for their average energy conversion efficiency over their useful life. There is even some question whether Solar Sailing works at all. However, if it does, as QQ47 orbits around the sun, the orientation of the asteroid would need to be constantly adjusted in order to reflect light. This would require the presence of 'solar sailors' not only for initially deploying the sail but also as crew for the duration to maintain and replace worn sail and tacking the Rock around the sun. The logistics of maintaining and relieving a crew on QQ47 for 10+ years along with the possibly of several/many/hundreds of complete sail replacements would likely make this tactic as massive as any other. Of course if the asteroid is not initially stabilized for pitch, yaw and roll all we will get is the solar system's largest ball of tinfoil. So some fairly large rocket engines and propulsion mass - and more crew - will be required for stabilization as well.

A Laser or Concave Mirror ablating and volatilizing the surface of the asteroid into a gas expanding at 1,000 m/sec as propulsion mass will need to move the same millions of tons of rock as a mass driver... but as gas. In order to ensure some control over the displacement result, like the mass driver and solar sail QQ47 may need to be stabilized for pitch, yaw and roll and the mission manned for deployment and crewed for its duration. Given all the thermal and mechanical inefficiencies in converting the unconfined surface of an asteroid varying in composition and topography, into an effective working fluid generating useful Work, in vacuum, at -250 degrees C the initial hourly energy requirements here would easily be many gigawatts... Hundreds of US military grade Rickovers for the Laser or for a Mirror tens of sq km. Then, if the principal of Solar Sailing does work and a Mirror is not tethered to QQ47 it would need its own station keeping rockets and fuel for 10 years just to keep it from 'Sailing' away in the course of reflecting light onto the surface of QQ47. Of course if it is tethered to QQ47 much of the Work generated by the volatilized gas would be offset by the pull of the Mirror functioning as a Solar Sail...

The Nuclear Nudge: *<revised in addendum>* With a standoff detonation in vacuum there is no concussion to 'nudge' QQ47 with so... Perhaps the radiation from a nuclear detonation would heat the surface of an asteroid and volatilize and forcefully expand some portion of that surface mass and generate work... to some small degree. But this is criminally sloppy engineering there are far too many unknowable variables that can only be accounted for by over-designing by several orders of magnitude. Even then this tactic would require a relatively precise placement of the device in orbit above QQ47 to even begin the process.

At one QQ47's radius distant only 6% of the radiation generated by the device would strike the asteroid. Roughly 50% (?) of the energy that strikes the surface would go to effecting any change of state. The rest would be reflected or merely serve to heat the rock. Then, only 20% (?) of the energy effecting any change of state would contribute to actually volatilizing any mass and be available to do Work with the balance lost to only liquefying the surface to a molten slag. At -250 degrees C any hot expanding gas would quickly condense and precipitate into ash. However, before it does, it would generate some Work. Although without atmospheric pressure and outside any form of containment the thermal conversion efficiency of this reaction could not possibly exceed 2% (?). With this entire process generally taking place on the surface of a sphere only 40% (?) of the useful Work generated would be directed against the asteroid and only 50% of that accountable in reaction against QQ47.

In a single pulse accelerating QQ47 5 m/sec would require a net 4.5×10^{15} joules or 1 Mt of TNT as kinetic energy. To do this much Work by ablation with a nuke would require a single device on the order of 40,000 Mt or four times the current world nuclear arsenal. The payload mass would only be around 20,000 tons (Cold War mass/yield) but since we would need to match QQ47's velocity of 33,000 m/sec in order to rendezvous and precisely place the device in orbit we could almost just as well crash the whole thing on the surface. Check that. At 33,000 m/sec we could generate the necessary KE with less than 10,000 tons. Even in this we will only get one shot, Failure is Not an Option, it must work the first time we will ever try anything like this... catastrophe, extinction, doom etc. - so again this will necessarily be a manned mission.

Blowing It Up With A Nuke would not be the same as merely blowing it apart and having the fragments continue on to strike earth separately. Blowing it up would mean changing the magnitude of the velocity and/or changing the direction of all the fragments so that they are no longer on the same course to strike Earth. For any fragment to go on to strike Earth as before, it would have to retain approximately both the original orbital trajectory and velocity. As QQ47, all the would-be fragments are already moving at 33,000 m/sec, the net KE required to 'blow it up' and add the same 5 cm/sec to their initial velocity would still be 4.5×10^{15} joules or a net 1 Mt as KE. As a single pulse at this level of acceleration this option would still require ten years from the point of execution to be effective and as unpredictable and criminally sloppy engineering, this will still require a lot of very good luck to achieve a satisfactory result.

In order to maximize the energy and derive Work from a nuclear device its detonation would necessarily have to occur hundreds of meters underground which would be far beyond the capability of any imaginable penetrating ordinance we could devise. So this would require landing on QQ47 and to ensure some degree of uniform distribution of the kinetic energy generated, strategically drilling hundreds of 'Willis' holes in order to evenly distribute the yield over hundreds of different locations. Using underground nuclear test results as a benchmark, a 1 Mt yield detonation would result in a cavity 200 meters in diameter. For our purposes, maximizing the yield of a 1 Mt nuclear device would require drilling a reinforced hole 1 meter in diameter and well over 100 meters into the asteroid. Even then there would be the concern that with the mass/energy ratio of volatilized gas to molten rock in a typical underground nuclear cavity there may not actually be enough of QQ47 to blow itself up with... at least, not without some very clever engineering.

In contrast to a standoff nuclear approach virtually all of the radiation will be absorbed by QQ47 however the same losses to merely heating rock and making glass will apply leaving only a small portion of the energy available to generate volatilized gas as a working fluid. Here, the potential for a high degree of thermal conversion efficiency is reduced by the high probability that most asteroids are aggregate balls of boulders and dust loosely held together only by their own collective gravitational attraction. For the most part any explosive expansion of volatilized gas would follow some path of least resistance exhausting through gaps between the denser elements and on into Space. Even in high-density portions of the asteroid the first fracture would still instantaneously vent the volatilized gas resulting in a low thermal conversion efficiency with little actual Work being directed against the fragments of QQ47. To get the net 1 Mt KE as Work required we would still be looking at something on the order of hundreds of Megatons to begin with just to blow it up. This is still a manned mission. Still looking to somehow get a payload of hundreds of tons of nukes, several Space Tempered to -250 degree C drilling and excavation systems, a Gigawatt power source to run them, a platoon of Astronaut/miner/NucWepSys operators and their habitat and consumables, off Earth to LEO. Then, out of LEO at just the right time to rendezvous with QQ47 at 3 times our current achievable velocity in space. Then, over hundreds of weeks or even hundreds of months drill hundreds of holes, plant hundreds of nuclear charges (whether they are Mt or Kt is virtually irrelevant), remove the shoring and refill the holes. Then simultaneously detonate hundreds of nukes and *pray* that this will at least work well enough, the first time anyone has ever done something like this, to at least save most everyone on Earth. All ten years before QQ47 impacts... Then consider what would be required to deal with a 10-km Chicxulub grade impactor at 333 times the KE of QQ47! This is our ace-in-the-hole Backup Plan?

Given the magnitude, cost and questionable effectiveness it is hard to imagine any of the above tactics as reliable elements of an extemporaneous ad hoc post-detection response strategy and certainly not what one could call a mission for a 'small spaceship'. However these are our options and 'Plan B' is probably something we have so far only imagined being able to actually do. Today we have no experience or expertise in doing anything like this. We have never attempted anything on this scale or dealt with this much energy and we have done next to nothing in working beyond Earth's orbit. We have no capability for defending the planet from large asteroid impact whatsoever and yet we will never have so much at stake as we will when we have to do just that. If we are actually going to do something that will actually work in time to actually save ourselves, and not just pump more feel-good funding into NASA's pork barrel we must actually build Plan-A before we detect TNLA! We can upgrade to a Plan B if and when we get one.

It is the *threat* of TNLA that rises to the level of a dire Clear and Present Danger. Dire, not just because of the potential magnitude of the loss or the completely unpredictable and aperiodic nature of impact events making them perpetually imminent but because we have no reliable means to mitigate this threat in even its smallest manifestation. It does not even appear that many of us fully appreciate the scale and scope of what will constitute an effective response. Until we have the standing capability to reliably detect and interdict TNLA how can we consider ourselves in anything less than Dire Clear and Present Danger. What will the next species to rise to sentience out of mankind's ashes conclude when they wonder why we did not bother to save ourselves from Extinction by NEO. "Couldn't we 'see it' coming?" The cockroaches will laugh: declare War on TNLA, build a space program, project a little power and defend *their* world... from Mars.

Pork Barrel Planetary Defender

In seeking only nominal funding for their limited efforts, NASA's Spaceguard Survey circumvented the potential for a broader Executive review and analysis of this issue avoiding any policy determination and the possibility for the overall responsibility of Planetary Defense being delegated to a more appropriate agency. As a result, the cornerstone of NASA's recommended strategy for defending the planet - and as such the de facto world strategy - is in the anticipation that someone will detect The Next Large Asteroid on its way to strike Earth decades before impact. Then, once it has been detected someone will be tasked by someone with the ad hoc mission to select, develop, design, build, test, train, deploy and somehow execute some global mission to deal with TNLA and the world will simply extemporaneously save itself... As if there is no other imaginable outcome - as if It Is Written - as if as a species we are somehow Chosen. In fact whatever response we kludge together will have to work the first time we try it, the first time we need it to. Otherwise there will be no one left to learn and take advantage of our mistakes after the fact. Anything less than detection decades before impact - a 'best' case scenario - and we are doomed.

Justification for this extemporaneous post-detection response strategy can only be that NASA has found comfort in the perception that the probability of large asteroid impact anytime in the next century is low. And with every large NEO the Spaceguard Survey discovers that does not appear to be on a collision course with Earth, they declare the risk of asteroid impact proportionally reduced. The world will be saved by astronomy alone and a standing Planetary Defense is unnecessary. Forget about hoping for the best and preparing for the worst. NASA's Planetary Defense policy fails to even prepare for the best!

A likely consequence of NASA's post-detection strategy would be that on the day TNLA is detected, and its exact point of impact determined, anything short of a whole-earth killing impactor will become someone's national or regional problem. Without standing space programs or aerospace industries and the specific human resources required, even if they wanted to help many nations would never be able to directly contribute to building any response. All they would be able to provide would be money and at a certain point, without the time to train personnel and build the necessary infrastructure, all the money in the world will not buy a Planetary Defense. After TNLA is detected it will likely be too late for just money, leaving substantial portions of the world's capability unavailable. With the prospect of this now irreparable human error revealed in hindsight once-friendly borders will be sealed to immigration, resources will be hoarded and priority given to any effort to ensure self-survival. If the US or anywhere in North America is to be Ground Zero, economies worldwide will rapidly begin to cascade into collapse. The world will become polarized into two camps: World-Savers and Self-Preservationists... Would this really be the best time to be putting together a Global Planetary Defense pact?

Consider the prospect of the Porthos scenario with its projected impact in the central United States less than 3 years from its detection. With only 32 months of lead-time any form of deflection or interdiction is out of the question. At 60,000 m/sec just hitting it would be beyond our current capabilities and a matter of very good luck let alone landing on it. An impact in the range of 400,000 Mt (40 times the current world nuclear

arsenal) is inevitable. Time to get out of Dodge but where do we go? Where on Earth, even under the best imaginable conditions, could 400 million North Americans seek refuge and find a suitable and willing host? The most likely exodus scenario would involve Carrier Battle Groups, Marine Expeditionary Units and B52s carpet bombing the front door of any 'host' selected. Keep in mind that the complete population any refugee nation would be leaving everything behind to be destroyed - every personal and national asset, infrastructure or resource they ever produced. In the case of North America this would amount to the ability to generate one fourth of the Gross World Product. Aside from the CVBGs, MEUs and B52s we would be arriving virtually empty-handed. What exactly would be the fate of the host? What nation on Earth has the natural resources or developed infrastructure to accommodate 400 million *more* people? Then, what if Ground Zero is China? Where would *we* put 1.2 billion people? How do we feed them even before TNLA's impact and the subsequent global climatic cataclysm? How will they even get here - the Million-Man Swim? The Rule du jour will have to be based on the luck of the draw. Survival of the Species will dictate that you stay where you are and take the hit! To enforce such a rule, if we are lucky, the world will maintain enough continuity to come under Global Martial Law. Politicians and policy-makers and world leaders will somehow have to keep all their people within their own borders and will do as they are told... or *they* will be shot! And surviving TNLA will have become military business... one way or the other.

Even with far more warning than what is given for the Porthos scenario it would take little more than some high school physics and some time on Google to figure out that given our current level of technological development any extemporaneous mission is not likely to meet with much success. This insight will quickly become part of the global public dialogue and will easily be supported by both sound logic and doing the math. Once the magnitude of the mission required and the unlikely prospect for its success has become public knowledge large portions of humanity will undoubtedly fall into a state of despair. In resigning themselves that the end is nigh we can then add a third camp - World Enders. With the imminent loss of the civilization and culture that we have come to draw our identity and purpose from, much of mankind will simply lose any will to fight or even to survive long enough to witness the results of TNLA's impact. Many will simply quit what remains of the status quo and often, as directed by the tenants of their faith, simply embrace the end of days. It is unlikely that many will continue paying their bills or showing up for work or performing any civic duties for a society and civilization that has failed them so completely. What portion of NASA and the aerospace industry will we lose to simply *finding* TNLA?

Make no mistake, there will be some measure of justice in mankind's final moments... sans any rule of law. We have developed a strong propensity for attributing the success or failure of our collective endeavors to our leaders and those far-looking authorities and experts who serve to guide our efforts and lives. Once it has become common knowledge to this despairing public (the media will surely be the last estate to quit) that for decades NASA has been studying this problem and that our political leaders have been paying them to do so... And that all they managed to accomplish was to count some rocks in Space... In the light of this apparent failure of specific performance to actually *do* anything to protect them from TNLA, images of launch gantries around the world bearing 'strange fruit' come to mind.

Without the high confidence and morale only imaginably afforded by having a prepared and trained force deployed with an effective and tested technological capability, merely detecting TNLA will unavoidably result in a crippling breakdown of our contemporary social order to some large degree. It will happen at NASA and at Vandenburg, at the Pentagon, in the halls of Congress and in the White House. It will happen in Riyadh, in Paris, in Deli, in Moscow, Cairo, Peking, London, Damascus and Berlin. It will happen everywhere. Much of what we are and can do: our vaunted industrial and technological evolution, has its foundation in the strength of our sociological constructs: consumer confidence, market forces, currency evaluations, credit, debt, economic and political faith. As such, against the natural forces of the Cosmos we are no longer a hardy and capable species. Finding TNLA is far more than enough to bring down this house of cards that we call our civilized world. By the time TNLA does finally arrive to kill us all it will only be serving to add grievous injury to cosmic insult. After all, *we have* been duly warned...

Mankind today may be made of sterner stuff, may not cave and crumble as easily as has been offered here but in this regard this generation is certainly not the greatest generation. Much of what has served to make us stronger in the past would certainly kill us today. Can we afford to wait and see how this plays out? It will not be the despair of the population in general as such, or even that portion of critical NASA personnel that may give up the ghost and decide to just stay home for the rest of their lives. It will be a failure of that relatively fragile and complex invisible infrastructure on which NASA and all the rest of us depend upon for our daily business as usual. It will just be some truck driver or office clerk failing to show up for work at some freight company in Boise that triggers a cascade of now ultimately catastrophic deterministic events that loses the bolt that fits in the post that holds up the house that Jack built. Turn the page...

With the mission to harbor and cultivate the dreams and aspirations of our nation in Space NASA has never needed to evolve the collective or individual strategic mindsets necessary to perform as anything but a discretionary agency. There have never been dire consequences if they should fail in their general mandate or mission statement. For decades job number one at NASA has effectively been the re-distribution of discretionary federal funds back to the States in direct proportion to their electoral votes. No one expects NASA to actually *do* anything. NASA is the Circus in our Bread and Circuses. So why is NASA making critical strategic threat assessments and fundamental decisions that will determine the survival and existence of our species? Particularly when in the course of little more than a year NASA's new mission statement has devolved from "Protect our Home Planet... as only NASA can" to their current battle cry of "Safety First"! Why would we ever look to this agency to defend the Earth from large asteroid impact and mankind from Extinction by NEO? We may as well bring in the clowns. The idea of entrusting the responsibility for this mission to NASA is as great a threat as TNLA itself.

Let's be real, NASA is about exploration, discovery and understanding - harboring our aspirations and our dreams. NASA can only "Protect our Home Planet" *only as* NASA can... in our dreams. Even though NASA could never leverage the funding necessary for building a Planetary Defense it would not have to be out of the loop. Even with a second perfectly viable US space program at Vandenberg, NASA could still find itself on the bloody leading technological edge of this effort and of Space. Its budget could even increase ten-fold! However, funding, along with their marching orders, would come through the DoD... Until we conquer Space, come to own it boots-on-the-ground, we will never be able to defeat TNLA. No matter how much treasure we pour into NASA, with its political will reflected in the battle cry 'Safety First' it has become crippled in its ability to take and hold Space. The conquest of Space will cost us far more than treasure it will cost us human lives and NASA will simply never be able to afford a line in their budget for dead astronauts. NASA is about science and this is no time for scientists to be playing soldier.

Sooner or Later

Sooner or Later - perhaps tomorrow - some astronomer somewhere in the world will detect TNLA. Within a matter of days his detection along with the precise date of its impact would be confirmed by the Spaceguard Survey and as such sent to the Administrator of NASA. He will take it over to the Vice President who will walk it over to the Oval Office. Upon receiving a confirmed notification that the next large asteroid impactor has been detected, no matter how far away it is, the first call any President of the United States is certain to make will be to his Department of Defense. Ostensibly, ion cannons and tweaking the gravitational constant aside, any effective interdiction will likely involve the use of some form of thermonuclear explosive device. A task reserved exclusively to militaries worldwide. And Later, Planetary Defense will have become military business. The second call The POTUS is likely to make will be to the Administrator of NASA, notifying him that in response to this threat he has declared a State of National Emergency. And that as a result, he, his agency and all of its facilities and personnel have been placed under the direct command and authority of the DoD and will remain so for the duration of this crisis.

Planetary Defense as military business 'later' would be a desperate and fearful thing with much pointing of fingers and gnashing of teeth and real last-minute politicking about who did not intelligently connect the right dots. This cacophony would be driven by concerns about the questionable efficacy of the few ad hoc extemporaneous nuclear options still only imaginably available. Which one-shot will the POTUS choose to take to Save the World? Plans for Solar Sails, Mass Drivers or crashing into it with massive spaceships will likely not even make it into the Situation Room. All prayers and any good luck will, however, be welcome. On the other hand, Planetary Defense as military business 'sooner' would involve much preparation, training and vigilance with far less faith in prayers or good luck and far more reliance in diligent strategic foresight. However, even solar sails and mass drivers would stand a better chance of success in military hands with military minds behind them. Because by design a military agency does its business only in Harm's Way, its perspective would easily include the necessity for a *manned* mission as the only option dictated by the magnitude of the loss should the mission fail. The lives of our children and grandchildren are in the balance. How can we justify 'Safety First' and sending computers and robots to Save the World when Failure is clearly Not an Option at any cost? The only rational logic that would ever justify an unmanned mission would have to proceed from the circumstances of a desperate act - and that will always only be the result of a lack of time! The time to make this choice and to build a Planetary Defense is now.

How much Preparation... Consider the generally sound (although unmanned) B612 proposal in a full-scale application. The proof of concept for this program is planned by its authors to weight 20 tons, cost 1 billion dollars and be capable of displacing a 200 meter diameter, 11 million ton, 15,000 m/sec asteroid by 0.2 cm/sec in its demonstration. Let's ramp up the B612 demonstration model to address the recently flagged

1,200-meter QQ47: at 3 billion tons and 33,000 m/sec, first by a factor of 5 for a full displacement of 1 cm/sec over 10 years. Second, by 5 again for a reasonable engineering margin of error to 5 cm/sec. Then third by 4 in order to afford a gradual interdiction strategy over the 10-year period of displacement and corresponding loss of any surgical orbital interdiction opportunities. Then finally, by 300 times for the greater mass of QQ47... we would need 30,000 B612 NEOTugs - 600,000 tons (6 Nimitz class aircraft carriers) - 30 trillion dollars! 30 trillion dollars is a lot of money. More to the point it is a proxy for a lot of global resources and the dedication of a tremendous amount of high-end human talent, energy... and time.

Far too much time to consider that beginning flatfooted from Earth after TNLA is detected is an approach affording mankind any rational degree of security. At 20 tons, merely the B612 proof of concept would be five times larger than any mission ever launched outside of Earth's orbit and at 15,000 m/sec, twenty times more massive than any mission at that velocity. The technology it proposes to demonstrate is at the bloody leading edge of propulsion, mission velocity and power generation in space. The autonomous astrogation and maneuver capabilities and systems required for the rendezvous, stabilization and displacement of the target asteroid are likely not even on anyone's drawing board yet. That said, the B612 project is typical and defines the size of the ballpark and may very well be the best game in town. Any displacement tactic would require a similar scope and scale and push the edge of our technical, economic and societal envelopes. If we expect to succeed in even thinking about this problem we are going to have to start thinking really big.

Really big: If we consider the magnitude of the effort required to deal with a Chicxulub scale impactor (10 million Tugs and 200 million tons) all we really need to appreciate is the cost of B-612 tactic as then ramped up from that of QQ47 by 333 times to 10,000 trillion dollars - 250 years of Gross World Product. In terms of value added human endeavor, what portion and for how long could we afford to dedicate our world production to a Planetary Defense and still be able to feed ourselves and maintain our civilization and culture? In any desperate 11th hour attempt to save ourselves from Extinction by NEO we may well lose everything we have just to save ourselves and in the end still run out of time and fail. How much of our current world production capability is actually qualified to contribute to such an effort... even 1%? This is not just a matter of money and of raising taxes. We can not just go to NEOShiva.Com and order up a Planetary Defense! This will have to be built, virtually from scratch, by the hand of man. It does not take a rocket scientist to recognize that any endeavor of this scope and scale is not something to be undertaken extemporaneously or On Demand or Just in Time if it is to have any real chance of success. The sooner we begin investing our global efforts into building a Planetary Defense the more planetary defense we will have when the time comes to use it. And it is worth saying again: Failure Is Not an Option - at any cost!

How much Training... Unlike scientists, soldiers understand that in 'just doing their job' they put their lives at risk every day. Any responsible mission to preserve our species: to preserve the lives of our children and our grandchildren, will necessarily be manned. As such, considering the magnitude of the loss should this mission fail, success At Any Cost will not only mean taxing the capacity of our GWP but that, from the relatively mundane duties of training and Watching the Wall to the execution of an interdiction, individual human lives are expendable. This is not a paradigm found to any degree at NASA or in any civilian or other governmental agency outside those dedicated to military service. It will not merely be a matter of sacrificing oneself to Save the World - any of us would do that. It is a matter of having the disposition and discipline and most of all the training, when with that sacrifice you achieve a successful result! Only training can afford us a reliable expectation of success beyond that of good luck. And beyond the time and money it will take training, in itself, will take its toll in lives far beyond any actual interdiction. So we begin with personnel that have already accepted this fundamental condition of their service and already accustomed to living and working in conditions that rise to the level of Harm's Way. It will be imperative that working in Space becomes second nature and every imaginable task that they may be called upon to do must be drilled to a point of reflex. Then they must practice what they have trained for until the day comes when they have to do it for real and in the process some will die... Space kills.

How much Vigilance... Far more than we can achieve from the surface of the Earth or from Low Earth Orbit. To be effective, vigilance requires a commensurate ready ability to respond. Without such an ability, vigilance is little more than science... Nor is it effective when Watching the Wall constitutes an annual one-eyed glimpse at a brick. In this case, responsible vigilance would ultimately demand the Projection of Power: manned NEOInterceptor/Tugs forward deployed to the orbit of Mars with the capability for surveillance of TNLA's complete trillion-trillion cubic mile Area of Interest. Here is where we will find the greatest risks and invariably suffer the greatest number of casualties. Implementing what you have been trained for will likely be less hazardous than just getting to the Wall and Watching it. Harm's Way for Planetary Defenders will be in the waiting and the watching. Vigilance alone will take its share of lives.

Making the detection and interdiction of TNLA reliable will require a highly trained, motivated and disciplined force deployed in Space on a prolonged basis. Schemes for simply shooting it down from Earth in the manner of some super-sized missile defense program are fundamentally irresponsible and highly unlikely to perform as advertised. Compelled by the prospect of the potential magnitude of the loss should they fail, there is no autonomous robotic technology imaginable that could ever replace the extemporaneous creative abilities or the driven firm resolve that any best of the best crew mankind has to offer would bring to this mission. The potential for mission failure would increase by an order of magnitude simply by making it unmanned. How do you program <failureisnotanoptionatanycost> into a computer?

Sooner or later dealing with TNLA will be military business and later has a very high likelihood of failure. Sooner would require the United States to take an executive leadership role in recognizing and publicly declaring this threat for no less than what it is and then instituting the first steps in creating a coalition of world military leaders tasked with building a Planetary Defense. The first challenge of this alliance would be to establish a consensus for a clear understanding and assessment of the threat, develop an Order of Battle and determine how to implement and deploy a strategic capability in response to this common threat. The second challenge would be in accepting that the best way to pay for this response would be by reallocating standing military budgets for offensive capability. It will be much easier to hold such an alliance together once the allies involved have stopped pointing their armies at each other. Then they can let the politicians and statesmen into the room and instruct *them* as to what policy has to be in this issue. We have more urgent things to spend our global resources and our human martial energies on now and in doing so it will not involve a catastrophic economic dislocation of military personnel or their supporting industries. It will just take a little re-training, retrofitting and some beating of swords into spaceships.

Any Global Strategic Planetary Defense Policy on this issue must be firmly anchored in a clear and unmitigated assessment of the threat, an acute awareness of our current collective inability to reliably deal with it and a full appreciation of the magnitude of the loss when we do not. Any rational policy must appreciate that until we have deployed an effective planetary defense and mitigated this threat, TNLA is a dire Clear and Present Danger for the whole world. That this is not just another partisan campaign issue but a new status quo for mankind requiring administration by an agency as autonomous and immune to the vagaries of economics and politics as is possible - a global human martial authority. In this arena the *Mission must dictate the Policy...* not the other way around. Statecraft, Economics and to some degree even Science must take a backseat to the demands of Planetary Defense.

We have to embrace the simple wisdom of preparing a response to this threat before we see it coming. And then deploying this response to where it will be able to get to wherever it has to be, whenever it has to be there, with enough force to do us any good! We have to appreciate that even responding to a moderate impact threat such as QQ47 may require the equivalent of one year's Gross World Product and take decades to execute. What has to be said and who has to say it to generate a justifiable demand for resources so far in advance of apparent observable need? What agency will be capable of actually leveraging this kind of money out of 'we the people of the world' in advance of detection? How could any agency imaginably establish the dramatic justification that would be required without using the logic of Credible Imminent Threat and Dire Clear and Present Danger and the rational fear these insights engender? Once these conclusions have been introduced it will become self-evident that only that element of our society already responsible for dealing with threats to our national lives and existence is also the only agency qualified to defend the planet. No matter who asks for the money, as long as they ask for enough to actually wage and win a War with TNLA, Planetary Defense will become Military Business.

Join the Navy and See the World... From Mars!

Today the best weapon we have in hand to deal with TNLA is time and as is always the case with this resource, if we fail to use it we lose it. Developing and building a tactical response in advance of detection is only part of the equation. Theoretically, we can do that anytime before we need to use it. The hope of early detection may help, however, the orbital path of TNLA along with the deadline to begin interdiction and the mass of the mission required would define what is early enough. From Earth the launch window for this mission may very well be a once in a lifetime event... Strategically, Earth is absolutely the worst place in our Solar System from which to detect and interdict The Next Large Asteroid on its way to strike Earth. From this single rotating point in space revolving around the sun we can never maintain any degree of continuous surveillance of any portion of the area of interest. More importantly, even if we could manage to build some *Nimitz* class NEOInterceptor and assemble it in LEO fast enough or even if we build and deployed it in LEO in advance of detection; we would still have to have a suitable launch window from there to intercept TNLA. The mass of any response we may offer, at the exact velocity and trajectory required for interception, and the limitations of even our most advanced propulsion systems will combine

with the location of TNLA to severely restrict the parameters: and as a consequence the availability of launch windows. Any defense, flatfooted from ground zero, may not even be executable unless TNLA is in precisely the right place at precisely the right time for precisely whatever solution we have available. In other words TNLA would have to pass directly before our guns. Interdiction deadline aside, there is no certainty that from Earth or even from LEO any opportunity to launch and deploy and execute such a mission would ever even present itself before impact at all! And with the limitations inherent in looking for TNLA only from Earth this would of course only be a problem if we detect it... at all!

Mars may be an old cold dead red ball of rock that will kill you for just being there yet many of us like the idea of going to Mars just because it would be cool... But there is really nothing on Mars worth going there to get: nothing that justifies the cost of sending humans there to get it. As for minerals: there is nothing on Mars we do not already have in abundance here on Earth - and certainly at a cost far below that of going to Mars for. Energy resources: it is virtually BYO all the way. What Science for Science is worth to those who are actually asked to pay for it can easily be done by robotics. Other motives tend to sound like some form of extreme sport or individual pioneering ambitions spun large as if they were driving societal compulsions when first and foremost our species loves its status in 'quo'. And don't hold your breath for mankind to be going to Mars any cheaper as a result of any 'natural' technological evolution. Serendipity aside, such enabling forces seldom develop in a vacuum absent demand. For Mars there is no imaginable return commensurate with the investment required and that discretionary pork barrel NASA works out of is just not nearly big enough. However, there is one dramatic justification that just may get us there.

From the perspective of Planetary Defense, Mars and its orbital path around the sun are the only strategic and tactical high ground we have for pre-positioning a forward deployed response to TNLA: Projecting Power. The orbit of Mars can be stationed at multiple points greatly increasing the probability of having an effective interception vector when we need one. Further, any interdiction effort should also consider the tactical advantage of mitigating the orbit of TNLA at its aphelion where the energy required for displacement would generally be half that required at the median of its orbit. From this perspective alone, pre-deployment further away from Earth may be the difference between mission success and our extinction. From multiple stations in the orbit of Mars early and precise detection also becomes merely a matter of cost: preparation, training and vigilance. Rather than trusting the dynamic spatial geometry of our Solar System to reveal TNLA in just the right place at just the right time for us to deal with it. From the orbit of Mars it is at least imaginable that we can deal with TNLA without relying only on very good luck.

Mars may not have those critical resources we have come to rely upon and value on Earth but whatever *is* on Mars is already *there!* Mastering Space is nothing if not a logistical problem: moving mass from point A to point B and the resources of Mars are already far closer to where we will have to be in order to deal with TNLA. We only need to adapt the in situ Martian resources to serve the various mission requirements of preserving and defending the Earth... living off the land, so to speak. Ultimately we must regard going to Mars as our best chance for defending the Earth and Martian resources as what we have on hand to do so. Dealing with asteroid impact will be a challenge beyond TNLA. TNLA-2.0 is out there as well and justifies some very long-term thinking. With its resources in a lower gravity well, it will be more economical to develop Mars as the principal provider of propulsion mass, consumables, technology and ultimately low-grav born personnel to Watch this Wall than it would be to do so from Earth. Perhaps, instead of making unqualified strategic threat assessments and economic assumptions scientists at NASA could be working on ways to pound regolith into spaceships and growing indigenous Martians to fly them. A Martian economy could easily be based on defending mankind from The Next Large Asteroid on its way to strike Earth! Besides, it's Mars! Doesn't everyone already want to go to Mars? For decades it has been a matter of finding some catalyst - a dramatic justification commensurate with the tremendous cost to foster the political will and send Man to Mars. Done right it would even serve as a Global Economic Stimulus!

No matter how we perceive doing this on paper we must keep in mind that we can never know where TNLA is or its orbital path or when it will impact before we see it coming. We cannot know exactly where in Space it will be when it must be dealt with. After we see it coming we may not be able buy a launch window from Earth at any price. All the money in the world will not alter the dynamic spatial geometry of our Solar System. All the money in the world will not buy us more time. Strategically, the key is to spend as much money as we can over as much time as possible in developing whatever Planetary Defense we can imagine and deploy it where will maximize the opportunity for its use *before* we detect TNLA. If applied with diligent strategic foresight, money can make a difference now and price should not be an object. The more time we take to build a Planetary Defense the more money we can pour into it and the better it will work as required and the greater the chance for victory over TNLA and mankind's continued survival. And the most effective place to spend that money is on Mars. Once the imminence and magnitude of this threat

has become clear at the highest level of world leadership and Planetary Defense has become Military Business, sound strategic and logistical doctrines will dictate the overall the mission design. The most effective strategic and logistical doctrine will always be forward deployed pre-positioning in support of force projection and that will take us far away from Earth. We can either Bring It to The Rock or sit back on our planetary ass and wait for The Rock to Bring It to us and if we are going to Bring It to The Rock we have to Bring It to Mars first... and at any cost.

This is not about exploring the solar system or mining asteroids or looking for life on other planets. This is not about Space. This is not about Science. This is about the security of mankind. This is about survival. This is about waging and winning an Unconditional War! No new scientific knowledge is required. Reliable detection is a matter of employing military grade surveillance in real-time 24/7/52 over the entire Area of Interest and interdiction a matter of engineering the application of some force far beyond anything man has ever attempted before. It would seem far more effective to train our world militaries for a mission in space, retaining their characteristics of discipline, endurance and resolve, than to teach NASA's Minor Planetologists, Astronomers and Astrobiologists how to succeed at any cost and to perform when failure is simply not an option. If we are to survive the chaos of the universe and the natural events of our own solar system tomorrow's recruiting posters will read "Join the Navy and Save the World... From Mars". If not, tomorrow becomes a somewhat questionable proposition.

The Cost and Benefits of Survival

It is not the act of building and deploying a Planetary Defense out to the orbit of Mars that is disagreeable here. When we consider dealing with TNLA there are no moral or ethical issues on the table. Most everyone agrees that going into Space and to Mars and the home planet industry that will go along with it in and of itself is a good thing. It is only a matter of the cost and the principal of Return on Investment. On that basis, if the day after we completed building and deploying a Planetary Defense we had to actually use it, and Saved the World and preserved mankind from extinction, *any* cost would then seem to be a bargain. What would seem disagreeable would be to build and maintain a Planetary Defense and then even after a thousand years not have an opportunity to actually use it: if after a thousand years of very good luck, hindsight could then make the whole thing look to be unnecessary. Good luck is hardly the basis for a good argument in foresight let alone the foundation for a good strategy. Good Luck is what blessings are made of and if in a thousand years we have not had to use our Planetary Defense, we can count them from Mars.

Absolute security from TNLA could never be guaranteed at any price. There is no potential here for ultimate victory, only some level of ease in managing this persistent and never-ending problem. If we begin building our Planetary Defense now and continue on forever we will only serve to increase our chance for success. So the sooner we begin the longer we can amortize the start-up costs and mitigate any perception of negative effects and financial hardship as well as enhance the front-end odds for defeating TNLA. Certainly by waiting until we find TNLA and actually see it coming, in the inevitable ensuing climate of panic and desperation, the effects of economic uncertainties would themselves be debilitating and likely catastrophic. TNLA will get here when it gets here. It will not wait for us to build an affordable response.

As a cost, the resulting effectiveness of any Planetary Defense can only be approached from the perspective of whatever the market can bear and how long it may take to build and deploy an initial effort with whatever technology we have available. However, we can surely afford far more than the \$3.5 million next to nothing we are spending on NASA's Spaceguard Survey. Last year 30 million people worldwide spent \$400 billion (1% of GWP) on Heroin and Cocaine. Certainly the other 5.97 billion of us can match that as a nominal premium to ensure us all from Extinction by NEO and in the process create a new industry complete with jobs and profits and taxes. Even though such an effort may initially be perceived as a hardship to some small degree there would be several immediate and short-term secondary benefits and social value to be realized in just *building* a Strategic Planetary Defense now.

• Unite the Nations of Earth in common cause

The idea of our species untied in common cause has always had great appeal at many idealistic sociological levels. Here we can consider the prospect as proceeding not from a fundamental unifying force of any one race, religion or economic principal but from the already common political characteristic of our national militaries. Modern military organizations worldwide are all pretty much the same. They are adversarial only because it is their job. Beyond motivating troops to die for god and country they do not actually harbor fundamental differences in their beliefs or principals. They all read from the same how-to-win-a-war book. The enemy of my enemy is my friend is not a very long leap... for soldiers. Once we get busy Waging War on TNLA there would not be much martial will or money left to wage war on each other and our own unique racial, religious and economic principals will be left to each his own. The appeal of our species

untied in common cause has at times been great enough to consider justifying the fabrication of some dire world threat merely in order to achieve this end. However, the truth here will do just fine: our species is at risk and so here we can rely on yet another common characteristic. The devil in this detail will be that without a universally credible Chicken Large, approaching some world leaders with the fear of Death by Rock from Sky will need to be accompanied by a great deal of diplomacy and statecraft... bribes. However, it may be enough that the combination of a consensus of First World Nations and sharing in the secondary benefits will encourage them to enlightenment in this issue. After all, if they want to go to Mars and run with the big dogs in Space they only have to pay their fair share of the ticket. For now, it *is* only money.

- Reduce military offensive postures worldwide

The current annual world military budget constitutes 2% (\$800 billion) of GWP. By tasking the collective world militaries with the mission of defending the planet perhaps 'financing option A' should be that they have to do so from their current budgets as well. Then, from the perspective of opportunity cost, with Planetary Defense as a first priority mission, we would lose much of our collective capability for killing each other without suffering the drastic economic dislocation 'peace dividends' have caused in the past. An initial objective would be to rededicate half of all military expenditures into building, deploying and maintaining a standing Strategic Planetary Defense. Ideally those components that constitute offensive capability would go first and in relative proportion without disrupting the current military balance between nations. Sanctions to the point of complete economic quarantine or even forced disarmament would be warranted to bring holdout nations into compliance. Finally, a way the United Nations can earn some keep.

- Craft a mission of peace for world militaries for millennia to come

This is will not be like your fathers Cold War. We can never finally win... This business will go on forever. No ultimate victory will be possible - there will always be another TNLA. The technology will improve to meet this demand and our expertise will evolve. Tractor beams, anti-matter bombs, photon torpedoes and tweaking the gravitational constant, combined with a century or two of practice and training to flatten the learning curve will ultimately mitigate the dire character this threat has for us today. But the likelihood of large asteroid impact and the potential magnitude of the loss will never go away. This wall must be watched forever and it will likely never be cheap. Although technology may make the job easier and safer it will never be a task we can entrust to anything but the best of the best of the right stuff of us. This mission will always be in Harm's Way and even a millennium from, now still military business. So you can join the Army and "Be, All That You Can Be"... on Mars!

- Generate global economic stimulus

If the politicians and policy-makers insist on maintaining our current level of capability for killing each other then creating an independent budget for Planetary Defense gradually, and not as a crash 11th hour act of desperation, would serve as a Global Economic Stimulus. Craft a new and discrete agency from the best and brightest personnel and elements of the militaries and space agencies of the world, and fund it (1% of every nation's GDP) right on top of everything else we are doing. Ok, yes, this is top-down economics writ large. But at a Global level it works! Its like hiring your kids to work in the store and charging them room and board when they get home! The *money* does not have anywhere to go. It all stays somewhere on Earth. From the global perspective it's-all-good. You tax people that are working in order to service the new top end jobs created by building a Planetary Defense. By creating work at the top, the successive vertical opportunity will result in job availability at the bottom as well. Then people who were not working before can afford to buy the things people that were working before are making, and people that were working before can make more money and *both* pay more taxes... plan. This effect could theoretically proliferate until either we run out of people with nothing to do or large asteroids in Space. Jobs and Profits and Taxes: Global Consumerism! We have only needed a rational global demand to catalyze something like this.

- Redeem NASA

To date, NASA has always been a discretionary item on the federal budget. No dire negative consequences would occur if NASA ever failed in their general mission statement. As such, the funding it has received over the last 40 years is logically accounted for in the annual budget deficits over that period and can fairly be recognized today, with 40 years accrued and compounded principal and interest, as constituting 15 to 20% of our current National Debt. With the FY/02 interest payment on that debt being \$333 billion, last year the Ghost of NASA Past may have cost us as much as \$66 billion more than the \$15 billion it received in new federal funding in the FY/03 budget. How can we get our money's worth from NASA? Let's take what we have learned about manned missions in Space (LEO) and use it as a foundation to Save the World from TNLA! And don't forget about those Moon Rocks. Before Apollo most astronomers believed the craters on the Moon were volcanic when they were in fact asteroid impact ejecta and the craters on the Moon 800,000 dots that can all be connected directly to TNLA... if we choose to follow the dots.

- Create an urgent demand for developing new technologies and sources of energy

Most of the technology that will be developed for Planetary Defense will be useable only for applications in Space and will have no demand or direct value as a return on investment for any Earth market. In an economic vacuum without a pressing and urgent demand for a Planetary Defense suitable technologies are unlikely to evolve on their own. In the final analysis there is nothing in Space worth going there to get or we would have surely been on our way to get it for 30 years by now. However, controlled fusion, as a propulsion system would be one of the first technological objectives in Projecting Power into Space. It has also been the next promise of science for (clean and abundant) Energy Too Cheap To Meter. However, as such its development would cause far too much disruption in the status quo of the world's energy industry as well as threaten world economies with catastrophic deflation. Any energy too cheap to meter, if actually implemented, would be just as economically devastating as light sweet crude at \$100 a barrel and may explain why we have been 10 years away from achieving controlled fusion for 30 years. That and how do you make money on anything 'too cheap to meter'... But from the perspective of paying for Saving the World: the global electrical consumption for 2010 is projected to be 25 trillion kilowatt/hrs and at \$0.10 per kilowatt/hr amounting to 2.5 trillion dollars per year. If controlled fusion can cut that cost in half it would afford a margin of 1.25 trillion dollars per year for a Global Planetary Defense Tax. The net ROI for this benefit, as a vehicle for financing Planetary Defense, would be the clean and abundant and the global warming parts. We will just have to train coal miners to be rocket scientists...

- Facilitate the colonization of Mars

Ok, in extension, there is nothing on Mars worth going there to get either - at least not for a Market Earth. But if we can otherwise justify Mankind in Space, that would be another market place altogether. Mars, as a developed source of raw materials, propulsion mass, manufactured goods and even more space-friendly human beings, is in an ideal location with the required resources for servicing a Market Space. Kick in the four decades of pent up Pioneering Spirit, Science for Science and Because It's There at NASA and all the Martian wannabes around the world and you have a ready constituency for the colonization of Mars. NASA, ESA, the RKA and even the Chinese already have file cabinets full of plans for this. Pick one.

- Install an infrastructure to put Mankind into Space permanently

There will always be another TNLA and we will always have to deal with it in Space. And you know Mankind - it will be hard to keep him down on the farm once he's seen the Earth from Olympus Mons. Then, from Mars, it won't take much more than a jury-rigged hair-brained pork barrel excuse to get us to Io, or the Kuniper Belt (got to watch *those* asteroids too) and then the Ort Cloud (Comet Watch). After that we will spread across the Universe like a plague of locusts. Next stop: some Galaxy far, far away. All this will keep industries on Earth and the Moon and Mars busy - jobs and profits and taxes oh my.

- Reduce the cost to LEO facilitating private enterprise in Space

Space Plane... how about a Space Elevator? Given the apparent demand for putting the mass equivalent of a Carrier Battle Group in Space in order to defend the planet, the prospect of tens of thousands of Titan or Proton or Space Shuttle launches - at \$10,000 per payload pound - will simply seem absurd. At this level of effort the idea of a permanent structure to lift material and personnel into LEO would pay for itself in a matter of decades... remember, we are still thinking *really* big now. At least for business in LEO the transportation cost for any satellite or low gravity enterprise will be drastically reduced. Then once we have colonized Mars in order to save the Earth and established a Market Space it would only be a matter of time before Made on Mars products found their way to Market Earth - Business. It would not be the first time in the history of our species that we have taken advantage our military endeavors to exploit commercial opportunities. The more things change...

- Saving Mankind from Extinction by NEO

... Priceless.

As Long As Those Who Have Adopted Responsibility For Defending The Planet

- Define and perceive this threat as an abstract and obscure possibility and not the clearly inevitable certainty of The Next Large Asteroid on its way to strike Earth...
- Find comfort in probabilities for 'when' TNLA will arrive when in fact we can not now, nor can we ever, calculate any probability of 'when' until we see it coming...
- Allow arcane mathematical artifacts to replace the potential magnitude of the loss for determining what constitutes an appropriate level of response...

- Contend that TNLA be detected by NASA's Spaceguard Survey decades before impact, and not that this could only imaginably occur as a result of anything but serendipity and very, very good luck...
- Persist in regarding NASA's tenuous foothold in LEO and the occasionally successful robotic probe to Mars as a 'Space' program and not something far short of the technological expression of human endeavor rising to a level envisioned by Niven and Clarke capable of dealing with TNLA...
- Cling to the straw that because TNLA comes from Space it is the business of NASA and not that with the survival of the species in the balance this is clearly the business of mankind's military agencies...
- Regard current levels of technological development adequate for extemporaneously dealing with TNLA and not merely a result of doing the wrong math and/or connecting the wrong dots...
- Hold to the notion that better technology will evolve as if a matter of some ordained technical destiny and not as only the conceivable result of a commensurate demand or clearly expressed dramatic justification...
- Accept the claim that we have somehow reduced the magnitude of the threat by finding large asteroids that are never going to strike Earth and do not recognize that all that has been accomplished by such claims is to mitigate the perception of the threat...
- Harbor a Cold War prejudice for putting the military in Space and fail to appreciate that in doing so you set aside the best tool we have for dealing with the greatest threat we have ever faced...
- Make only safe career-friendly and politically correct 'low probability' presentations of this issue to avoid being considered an alarmist and fail to see that in doing so you abandon fear, your greatest ally for leveraging the urgent attention of those 'to whom this should concern'...
- Tolerate the media's sound-bitten simplicities that regularly miss-represent, restate and occlude simple frightening truths in the name of calm and responsible journalism when in fact they serve only to mitigate what should by this stage in our evolution be a fundamental and paramount public concern...
- See planing to build a Planetary Defense and Save the World as no more than an opportunity to enhance grant-funding and not a constructive responsibility to actually do it...
- Think that just because this effects all of mankind that responsibly for the success or failure in building an effective Planetary Defense should not be taken personally...

... The Next Large Asteroid on its way to strike Earth will win this War!

There will always be many more ways to lose a war than there are to win one.

Victory is often achieved merely as a result of executing any of the options remaining after those that are sure to fail have been eliminated. If we continue blinding ourselves with short-term self-interests, dissociative logics and simple pedestrian cowardice, allowing such weaknesses to foster critically flawed strategic assumptions, we will only add to the already long list of ways to lose this war. If those who have adopted any responsibility for dealing with TNLA continue to perpetuate or fail to object to any of the misconceptions that have grown up around this issue they are only contributing to increasing the likelihood of our Extinction by NEO. Since only fear defines necessity it falls to us to engender a great deal of fear of The Next Large Asteroid on its way to strike Earth at the highest levels of our civilized leadership. If we expect to successfully prosecute this War to an acceptable outcome we cannot hesitate or retreat from making politicians and policy-makers afraid. We must make them very afraid... Now!

Another Small Step for Mankind

There is no rational argument to be made for a post-detection response strategy. Cost would simply be a matter of choosing between maintaining a standing opportunity to kill each other over religious, political and economic principals and for mankind to save itself from extinction. However, then we find that from assessment and detection to building, maintaining and executing an interdiction, the prospect of dealing with The Next Large Asteroid on its way to strike Earth is currently in the minds of the wrong people. What are we going to do with TNLA: blow it up or study it? Having identified this threat, as scientists, academics and intellectuals the challenge now is are we smart enough to see that this intelligence reach the minds of those best qualified to deal with it? Considering the magnitude of loss alone it would clearly be irresponsible to allow the development and execution of a Planetary Defense to be placed in the hands of anything less capable and resolute than a military agency. There cannot be anything wrong with turning half the world's military personnel and their technological efforts into astronauts and spaceships... and using their own budgets to do it. Where is the downside? As a discrete and unique aspect of civilizing our social structure the concept of a dedicated martial agency has evolved to address problems where Failure is Not an Option and At Any Cost includes the ultimate personal sacrifice. After millennia of cultivating this subset of human characteristics should we disregard this human facility just when we need it the most?

If those who have adopted a responsibility for framing this issue and influencing world policy-makers can at least reach a definitive consensus that this threat clearly requires the response of military leadership and military disciplines then the challenge of building a Planetary Defense becomes simple. Educate, convince and impress just one person with the truth. Bring the fear of The Next Large Asteroid on its way to strike Earth to the President of the United States. Once he sees this issue justified as a Credible Imminent Threat and a Dire Clear and Present Danger, through his executive capabilities he can declare a State of 'Global' Emergency. Then he can task his Department of Defense to take a leadership role in creating a worldwide military coalition to begin dealing with this threat - Step One! We will have a dedicated global executive authority qualified to wage and win this War on TNLA! Funding and the politics of reallocating military budgets will not be achieved quite so simply and can be more easily approached in relatively small annual increments. One percent of the current world military budget would be a 200-fold increase in the current allocation for defending the planet... eight B-612 NEOTug craft.

Once a strategy of establishing a substantial and permanent presence in Space and on Mars, and the development of all the new technology that will be required for this has been recognized and presented as necessary to defending the planet, invitations will not be required. World leaders will be standing in line to sign up. What nation could turn down a chance to simply buy-in to Man in Space, the colonization of the Moon and Mars, Saving the World from TNLA and doing their share of saving their little piece mankind from extinction? What nation could allow the United States to do this unilaterally, keeping Space, Moon and Mars and all that new technology as a proprietary (and military) benefit of Planetary Defense for itself when the opportunity to go along is simply lying on the table for them to sign. And all it would cost them would be half their ability to kill their neighbors. Big carrot! If they still don't bite, tell them the truth. Take them aside one at a time and put the fear of a Cosmic God into them. Talk about the extinction of their grandchildren. Make defending the planet from TNLA personal... Bigger stick!

It bears repeating that all the current space programs in the world combined do not rise to the level of a capability to effectively deal with TNLA even in its best case scenario. All we have today is a LEO program with the occasionally successful robotic reconnaissance mission to other planets in our solar system. Larry Niven's warning, amplified by AC Clarke still stands. "We will become extinct if we do not have a Space Program"... in *Space!* Every little pork barrel feel-good or nearly scientific mission does makes some contribution to the total knowledge and capability of a Planetary Defense. Particularly if it is manned or beyond Earth orbit. It's-all-good, it's just not nearly enough to save us from extinction ... yet. If you know you are going to a gunfight and have only *planned* to bring a knife you *deserve* to be shot.

Successful strategies are often found in merely choosing between the full measure of one risk and the full measure of another. We can risk 1% of GWP and build a Planetary Defense: uniting the world in a common cause, re-tasking martial energies, stimulating the global economy, colonizing the Moon and Mars and sooner or later Save the World. Or we can talk about it and think about it and do nothing to defend ourselves until we see it coming and risk extinction... How is this difficult? In hindsight this next step in our evolution could look to be no more than choosing a successful survival strategy to just grow *up*.

The Universe is a dangerous place it does not suffer dilettantes gladly. It does not run in service of our good fortune or wellbeing and ultimately we may very well fail to survive its chaos despite our best efforts. In this issue, our best efforts to date have been no more than the very least we can do, and far, far less than what will ultimately be required for our survival. Having become aware of TNLA and all its implications we can no longer afford the illusion that Earth is a safe place to live. Or that we are likely to survive the simple consequence of being part of this universe by waiting for TNLA to arrive before we respond to it. Foresight is the one advantage we have over the sightless cause and effect of the cosmos and in this we need only to open our minds to see our future and act accordingly. There is no security in counting rocks in space, or statistical sophistries, or plans that only look good on paper or anymore of these conferences. The Next Large Asteroid on its way to strike Earth is closing at a million miles a day. The Sky Is Falling Now! We must Militarize Planetary Defense develop an Order of Battle and Bring It to the Rock! This is War! This Is Not A Drill!

Addendum

NEONet

Two ways to defend the planet from The Next Large Asteroid on its way to strike Earth and its pesky little brothers and do so faster/better/cheaper.

The KENet: To Catch a Falling Star

The KENet (Kinetic Energy Net) would be a 'Green' approach to dealing with small 50 to 500 meter diameter) asteroid impactors. Consider an asteroid 200 m in diameter, 10×10^9 kg in mass and moving at 15,000 m/s (B612). To match the 0.002 m/s ΔV of the 20 ton Nuclear/VASIMR NEOTug performance you need only to deploy a concave 3 ton, 100,000 square meter Kevlar+ net in a prograde orbit directly along the X-axis of B612 at one half (7,500 m/s). The collision should be virtually inelastic and the momentum transfer from B612 to the KENet resulting in the same 0.002 m/s ΔV projected for the NEOTug. Even at this impact velocity the KENet should survive impact and serve to retard any disbursement of the asteroid due to the result of the elastic waves generated by the impact. In that at 10 years a 0.002 m/s ΔV would not effectively deflect the B612 from impact, subsequent KENets would be required (as would additional NEOTugs) which would impact at different points on B612 enveloping it as it tumbled along its X-axis.

Notes:

- The KENet technology will cost a small fraction of the technology of the NEOTug.
- Given the KENet requires only one half the asteroid's rendezvous velocity the mission mass (including fuel) at LEO would far less than the NEOTug and as such cost far less to get to its interception point.
- The KENet does not require the 'miracle' of de-spinning the asteroid to effect the ΔV along the X-axis.
- If the asteroid is chondritic and likely to be unstable, the first few KENets can be employed at a velocity closer to that of the asteroid to minimize the risk of disbursting it.
- KENets can be assembled from smaller hexagonal sections as it is spooled around a central spindle for a centrifugal style KENet deployment or tucked between the inside of a launch vehicle sized payload tube and a central core attached to the center of the KENet for a cannon style deployment.
- The simplicity of the KENet would allow the margin of for a human/mechanical error reflected in the target ΔV of the mission (as it is being designed 20 -30 years before impact) to be far less than half that of any tactic requiring de-spinning and coupling and pushing it over a period of months per NEOTug module.
- Once an asteroid has become enveloped in a number of nets the option presents itself to then start using either small dense impactors or a series of low yield nukes detonated on the surface of the asteroid to generate an impulse and the required ΔV ... politics permitting.

NukeNet: To Put a Falling Star in a Pocket

Consider a Chicxulub class impactor - 10,000 meters in diameter, 10×10^{14} kg in mass and moving at 20,000 m/s. Considering that: The ellipse of probability defining where this Rock may be in 20 - 30 years may be several Earth diameters in size. And that the mission will need to be designed to have the capability to displace the Rock the 'diameter' of the ellipse not the 'radius' of the Earth. And that the potential new precedents of Murphy's Law human and mechanical error will invite with a venture of this scale. And the magnitude of loss should we fail - a ΔV of 0.05 m/s at 10 years may even be low. Yet if you offer interdiction with the NEOTug, before you afford any capability to de-spin this Rock, you are looking at a mission mass in LEO consisting of 10 million NEOTug modules - 200 million tons. This mass would reflect both the loss of the tactic of deflection only at perigee (and the orbital mechanical ΔV multiplier that goes with it) and the necessity of having to deflect throughout the 10-year period of displacement instead of before it. Combining to effectively reduce the effectiveness of the concept by a factor of 4.

Using a series of nuclear devices to generate an impulse is a delicate dance between getting them close enough to generate a volatized propulsion mass from the asteroid's surface at a high enough temperature to explosively propel from the surface of the asteroid generating a reactive force without cratering and fracturing the asteroid creating a unmanageable cluster impactor. If you effectively deal with 99.9% of a 10-km asteroid you still have a 1-km asteroid left on course to strike Earth. Define success...

So wrap it in a Net and start whacking it with nukes that detonate right on the surface. Three - 5,000 ton, 300 square kilometer, 3 to 10 meter mesh, Kevlar+ NukeNets would contain any large fragments and keep them from drifting apart facilitating the continued deflection. For a 10-km Rock it may require 2000 Mt (100 - 20 Mt) of nuclear mines along its X-axis deployed hundreds of kilometers apart to avoid fratricide and to bring fresh asteroid surfaces to bear as the Rock rotates along its orbital path. Make this a manned mission (given that mankind is in the balance here) and with a total payload mass (15,000 tons of NukeNet, 2000 Mt nuclear mines, teleoperated nuclear mine layer, crew vehicle and consumables) of, call it 20,000 tons. With fuel enough to achieve rendezvous velocity - say a total mission mass of 200,000 tons.

Notes:

- At least three NukeNets should be considered: deployed along the asteroids X-axis at 100 m/s or so less than the asteroid's velocity; at intervals designed to wrap around the Rock as tightly as possible.
- The shape of the NukeNet might be configured with the center half as a concave hexagon with triangular points extending from each side to form a general star shape. From the points, tethered weights can serve to provide a 'bola' effect as the net impacts the asteroid and the star points whip around to envelop the Rock.
- The mesh of the NukeNet could easily be as large as 10 meters. As long as any fragments perturbed from the Rock are less than 50 meters in diameter they pose no hazard to Earth... fried in the atmosphere.
- The holes generated by the mines could become problematic. However if the mines are designed to penetrate a few meters into the asteroids surface (100 m/s) the intervening surface mass should mitigate the effect on the net. Striking a strand of the NukeNet is a low probability and can be mitigated by putting a fine point on the front of the mine.
- Again the simplicity of this tactic will reduce the margin of error by half and the reduction in scale would reduce that margin by an order of magnitude.
- Because once it is set up the actual deflection portion can take place over the course of hours, the option of executing this mission at apogee where the asteroid's velocity is at its lowest is available. There may even be some orbital mechanical mojo force multiplier to be taken into account?
- There is no reason (other than not being 'Green') that this tactic will not work on smaller asteroids. The US Military long ago developed small nuclear munitions (SADM) for artillery. They can even dial down from 1 Kt to 0.1 Kt to serve the needs of the job. Dial a Nuke.
- The B612 people project a cost of 1 billion dollars per module. If the above 10 km rock will require 5 million modules that would be 10^{16} dollars: 250 years GWP. However since less than one tenth of one percent of the world production capability is suitable or convertible to a purpose like this, it would take mankind 250,000 years just to build this mission. With NukeNet: We already have the Nukes and the net itself could be made with 3rd world labor. The fuel and mission vehicles would be a bush-league challenge for our chemical and aerospace industries. We could probably sub-contract the whole thing to the Chinese!