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Unacceptable Risk

Tasked by the House Subcommittee on Space & Aeronautics to study the threat of large asteroid impact the NASA Spaceguard Survey has, by default, become the world's only agency dedicated to Planetary Defense. The cornerstone of NASA's recommended strategy for defending the planet is 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, and with 30 or 40 years to prepare, someone will be tasked by someone with the ad hoc mission to select, develop, design, build, test, train, deploy and execute some way of dealing with it in time to Save the World. Anything less than detection decades before impact - the 'best' case scenario - and we are likely doomed…

The logical foundation for believing that the long lead-time tolerated in this strategy is proportional to the threat, and what makes the risk of doing next to nothing now seem acceptable, is NASA's fundamental assessment that 'the probability for a large asteroid impact anytime in the next century is low'. Unless NASA has some special knowledge of the 'next century' or of The Next Large Asteroid on its way to strike Earth, this assessment lacks rational integrity in its conclusion. Is questionable in its choice of perspective. Does not reflect the random nature of impact events in its methodology. And as justification for the risk inherent in their recommended strategy, fails to appropriately consider the potential magnitude of loss.

First: To calculate probability for large asteroid impacts, prior events must first be averaged. Then, the expressed probability for a large asteroid impact is found to be 1:1 in any 100,000-year period and in reduction, is 1:1000 in any 100-year period. The 'next century', as a 100-year period, would then have a probability of averaged large asteroid impact event of 1:1000… as would any century in the history or future of the planet. Therefore the probability for an impact event in the 'next century' can not be low in comparison to any other centuries. A comparison of the 'next century' to a greater period of time - 1000 years at 1:100 - is a tautological extension of the same probability to a greater interval and as such irrelevant. As would be any comparison to threats in any other context like lighting or earthquakes that do not carry the same degree of catastrophic consequence. In defense of this assessment it has been offered that among 'scientists who have studied this problem' this probability is simply 'seen' as 'low' - not the result of any diligent and rigorous comparative analysis, that outside any context 1:1000 is self-evident as low. The biased logic of these Astronomers, Astrobiologists and Minor Planetologists induces a conclusion from nothing more than a narrow consensus of unqualified opinion - a collective value judgement for 'low' that, as an assessment of a critically subjective strategic threat, can only be seen as arbitrary and empirically unsupportable. Consensus of opinion alone may serve peer reviewed requirements for funding academic research grants but it does not meet the standard for justifying strategic threat assessments that argue against preparedness. The probability for any large asteroid impact in the 'next century' cannot rationally be assessed as 'low'. This, in itself, seems to make NASA's post-detection strategy dubious at best.

Further: The logical perspective for interpreting the modeled results would either be that: the probability for a given interval would be constant throughout that interval or that the probability is progressive and appreciates to express itself in the final moment of that interval. In the second case, by extension of the logic and applied to impact events, the following 100-year interval would begin with a probability of 1:1000 and proceed to express an appreciated probability of 2:1000 over its next 100 years. This process would necessarily have had to be bounded initially with the last known large asteroid impact event and terminate eventually with the next. If we adopt this perspective the averaged relative frequency of one large asteroid impact event every 100,000 years would indicate that we have certainly passed the point of a 1:1 probability millions of years ago. If we adopt the first perspective we are always in some discrete 100-year interval and the probability throughout is always 1:1000 (and 'seen as low'). However, we are simultaneously, always in some discrete 100,000-year period as well, wherein the probability throughout is always 1:1 (and without the necessity of relying on opinion, at its 'highest')! It would seem that when we begin using increments of an absolute probability as the basis for assessing this threat we have our choice of probabilities that depend proportionally on nothing more than our choice of intervals. When a choice of perceptions is a variable in any analysis we must regard the subjective interests served by the perspective from which a risk is qualified. Why have the 'scientists who have studied this problem' chosen to think in the short term - to think in small intervals? Why even offer the ambiguous statistical sophistry inherent in any statement of Probability when "I don't know" is the only rational answer to 'When'?

Then: To express the occurrence of any event as a mathematical probability that event must first exhibit a relative frequency: an observable pattern of occurrence over similar periods of time. When a given event fails to exhibit this attribute and when its aperiodic nature is not relevant to the objectives of the analysis, averaging can afford a general picture of many events over a large period of time. However, models of averaged events can not serve as a tool for determining when a specific 'next' event will occur. Additionally, with impact events, their aperiodic nature is their most dire characteristic, raising them to the level of a wholly unpredictable Clear and Present Danger. 'When' the next large asteroid impact event will occur is the single most crucial element in defining a response to this threat. Replacing this event's aperiodic characteristic with averaged periodic behavior not only compromises and corrupts the integrity of any threat assessment but creates in its stead an imaginary Ideal Threat to deal with. It is impossible to assess the 'When' of asteroid impact events with any mathematical models of probability and leave this threat with its most subjectively relevant characteristic intact.

Finally: Risk is simply defined as exposure to loss. Even if there were an appropriate and reliable methodology for determining the probability of Earth's exposure to a large asteroid impact event in the 'next century' a responsible assessment of the risk would still stem principally from the potential whole-earth killing magnitude of the loss. It's not the odds - it's the size of the bet! With our children and our children's children in the balance how can we accept this risk at any probability? Loss should be the principal determinate for the proportion of our response. In terms of either loss or probability, how can the exposure in NASA's strategy be seen as acceptable? How does waiting until we see it coming (if we see it coming), before we develop a capability for dealing with this cosmic routine act of nature, rise to the level of a responsible defense? To see just how acceptable this risk is in your Real World, go home tonight and tell your wife "Honey I bet the kids". Tell her you bet the lives of her children on the wait-and-see recommendations of NASA. Do you think she will want to hear the odds?

The thousands of large asteroids that have ever struck Earth did so in one century or another. In advance of detection, there is no way to determine if the 'next century' will become one of them or not. That sooner or later we will be struck by another large asteroid is virtually an absolute certainty. 'When' is irrelevant to that probability. We must prepare to defend the planet from the very real likelihood that detection may only be a matter of days and not decades. We have learned that to survive even favorable odds and low probabilities, we prepare to deal with any threat in its 'worst' not its 'best' case scenario. We must evolve into space and deal with this threat as a rational, determined, not so simple act of self-preservation. That we can foresee our own extinction and are doing nothing to prevent it makes us… what?

This Is Not A Drill!
The Sky Is Falling Now!
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Detection

All the large asteroids in our Solar System, whether they are NEOs (Near Earth Objects) or Rogue or Main Belt asteroids, as a group, can only be perceived as a threat because one of them is The Next Large Asteroid on its way to strike Earth (TNLA). And we don't know which one it is. The rest are irrelevant. They will either never strike Earth at all or will impact sometime after TNLA. If we succeed in dealing with TNLA - develop and deploy a standing capability for defending the planet - any subsequent impactor will loose much of its dire character as a catastrophic Clear and Present Danger becoming only problematic. If we fail to deal with The Next Large Asteroid on its way to strike Earth we become extinct… and the rest are irrelevant!

To just detect TNLA consider the following challenges:

- We can only search for TNLA from Earth.
- We can only search for TNLA in a general area of space away from the Sun and outside Earth's orbit.
- As Earth revolves around the Sun the area of space we can actually search for TNLA continually changes.
- As Earth rotates on its axis the portion of night sky we can search for TNLA in is continually changing.
- There are only a few major observatories that have been made available for searching for TNLA.
- The observatories that are available can only be used to search for TNLA in their spare or part time.
- Most of the major observatories that are available use only moderate resolution making searching for it harder if not impossible if TNLA has a very low albedo.
- The resolution of these telescopes contributes to limiting how far away we can search for TNLA.
- TNLA can not be effectively searched for by military or astronomical radars at their current technical level.
- TNLA travels in an Area of Interest that can be defined as a sphere with a radius from the Sun to halfway to Jupiter of roughly 625x10^23 cubic miles.
- Over the course of a year, we can only look for TNLA in a torus shaped Survey Area around and extending from Earth's orbit out to the near edge of The Main Asteroid Belt - roughly 11x10^23 cubic miles - less than 2% of the overall Area of Interest.
- In looking for TNLA on any given night overall, we do not search more than 1% of the Survey Area - less than 0.02% of the overall Area of Interest.
- As real-time surveillance, we can search for TNLA in only a few square degrees of the 1% of the Survey Area as observatories come to bear with Earth's rotation.
- TNLA must be passing through a region of the Survey Area on a night that we can look in that region, and be at the same place within that region at the same time we are actually looking there.
- TNLA moves a million miles in one day.
- We can only search for TNLA at night.
- Sunlight reflecting from Earth's atmosphere at the horizons restricts the arc of night sky dark enough to effectively search for TNLA at any given time from any given observatory to 5 to 6 hours a night.
- Moonlight reduces the effectiveness of our telescopes to searching for TNLA to 3 or 4 nights a month.
- Clouds occasionally obscure observations of space from Earth and make searching for TNLA impossible.
- On its terminal trajectory TNLA will not become any more apparent than it is now… until only days away.
- The orbital path of TNLA will be estimated initially only by repeated observations over several orbital cycles and as a result, even after detection, a terminal trajectory and not be recognized as such for decades.
- The size of TNLA is only derived from its brightness.
- TNLA must be reflective enough and/or large enough and/or close enough 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 cataloged as a NEO threat.
- To determine its size by its brightness it is assumed TNLA has a 'standard' composition to determine how well it reflects sunlight.
- The distance TNLA is from Earth is determined by estimating how far it travels at an assumed

standard velocity over close subsequent observations.
- TNLA can only be detected as an asteroid at all if it is moving at an oblique angle to the observer apparent as a streak or smear or in a new location with successive photographic recordings.
- TNLA is only one of the millions of asteroids in the Solar System that must be detected, sized, plotted, classified and monitored to determine if they are Main Belt, Rogue, NEO or Imminent Impactors.
- TNLA can have recently become an imminent impactor in that perturbations and collisions in The Main Belt are continually creating Rogues and NEOs.
- TNLA can have recently become an imminent impactor in that all Rogues and NEOs cross thousands of other asteroid orbital paths in every cycle and in colliding Rogues can become NEOs and previously 'safe' NEOs can become imminent impactors.
- Much of the initial asteroid detection looking for TNLA is being done by amateurs whose work is largely lost in the queue before it can be followed up on by the Principal Spaceguard Survey observatories.
- Finding TNLA is in the hands of a small eclectic group of dedicated unpaid volunteers, all of which have their own day-jobs and wives and kids and lives to live effecting the diligence and rigor they bring to the task.
- Worldwide there is no one employed full-time to find TNLA and save the planet from asteroid impact.
- The world's total budget for searching for TNLA is less than 4 million dollars a year.
- Even if we do detect an imminent impactor there is no way to determine if it is actually TNLA until it is only seventeen seconds away from impact with Earth.
- With NASA's post-detection strategy we will need to detect TNLA 30 to 40 years before impact before we select, develop, design, build, test, train, deploy and execute some way of dealing with it to Save the World. Anything less and we are doomed…

Given the impossibility of methodically searching for large NEOs by actually 'surveying' the Solar System cubic grid by cubic grid, NASA's Spaceguard Survey has had to settle for looking for them where they can. Approaching the problem like some cosmic Asteroid Egg hunt, by any stretch of the imagination, is not 'surveillance' either. Once they detect enough large NEOs to satisfy their initial estimates; demonstrating their hypothesis and justifying their survey - that there are enough large NEO's to constitute a Clear and Present Danger - they can declare victory and go home.

To date they have detected half of what they have estimated, determined that none of them appear to be on a collision course with Earth anytime soon and are 'safe'. However, they go on to draw the conclusion that these results serve to mitigate the threat of large asteroid impact by half as well… Without detecting The Next Large Asteroid on its way to strike Earth how can detecting asteroids that will never strike Earth have any effect on the level of the actual threat? If detecting any NEOs as safe mitigates any threat it would have to be one proceeding from an initial perception where all large NEOs were imminent impactors not merely the candidate group for TNLA. Finding asteroids that will never strike Earth will not mitigate the threat posed by TNLA to any degree. In fact, in that early detections have been the easiest, and these efforts have failed to detect TNLA, the likelihood of detecting it at all has decreased. Since any increase in difficulty in detecting TNLA directly affects our ability to respond, these results can only be tactically interpreted as an overall net increase in the level of the threat as such.

We need a Plan B. A comprehensive surveillance of the total Area of Interest operating in conjunction with a standing tested capability to interdict The Next Large Asteroid on its way to strike Earth. To save ourselves from Extinction by NEO we need a plan that affords us the ability to respond within a margin of days and not decades. Days may be all the heads-up we get…

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Interdiction

Once upon a time there was a Big Bang. Then Cause/Effect - Cause/Effect - Cause/Effect and 15 billion years later we have this chunk of cosmos weighing in at trillions of tons, screaming around the solar system somewhere - hair on fire at 50,000 mph on course to the subjective center of the universe.

At NASA they have somehow managed to perceive the probability of a large asteroid impact event in the next century as low. As a result, the strategy they offer for interdiction is to hope someone sees it coming and if they do - and if we have decades before impact - we will select, develop, design, build, train personnel, test, deploy and execute some effort to Save the World. In this best case scenario, NASA and scientists who are studying this problem have offered some imaginative schemes for interdiction and regard most Nuclear solutions as a desperate last ditch backup option to be avoided if at all possible. These options work according to the laws of physics and may look good on paper…

Any strategy that proposes to defend will ultimately fail if it does not design against the worst case scenario. So here we have considered deflecting a 10-km asteroid. They come much bigger so this is only a compromise to NASA's routine reference to 1 and 2-km asteroids which, as examples, are ostensibly more manageable. Any engineering effort, even with the benefit of vast experience and expertise, affords some margin of error in implementation. So to allow for all the potential subsections of Murphy's Law inherent with an enterprise of this magnitude - going against the nature and status quo of the cosmos - we must afford the system's design a deflection target of at least 20,000 miles. NASA's 4,000-mile deflection baseline (1/2 Earth radius) may work in theory and on paper but this rock is out here in the Real and out here, stuff happens.

Given: 10 years after its detection - a stone asteroid, 10-km in diameter, traveling at 50,000 mph (23,000 m/s), weighing 1.5 trillion tons, now 10 years (4 billion miles) from Earth impact with a kinetic energy (KE) of 3.6x10^23 Joules (86 million Megatons of TNT). To deflect this rock with a single pulse would require a Delta-V (velocity change) of 0.1 m/s. At 23,000 m/s this would require 3x10^18j KE. A gradual deflection of 0.2 m/s over 10 years would require 6x10^18j.

A) The Massive Spaceship - To achieve the 3x10^18j KE required to deflect it in a single pulse, we crash 50,000,000 tons into the asteroid at 25,000 mph (top speed of current chemical rocket technology). That would require 2 million Shuttle launches just to get the impact mass to LEO and escape velocity. Then you have to figure in the mass of all the fuel to get it up to ramming speed and… well you know the drill. Not a long-term manned mission - just hit it the first time at a closing speed 75,000-mph. No fly bys. No second tries.

B) Rocketize It - Gradually deflect the asteroid by attaching or pushing it with rocket engines. In terms of a Space Shuttle's external fuel tank (ET) with 700 tons of propellant mass at the Space Shuttle Main Engine (SSME) exhaust velocity of 4,000 m/s it would take 1.25 million ETs to generate the 6x10^18j KE required for deflection. In that the SSME requires a general overhaul every 7.5 hours, at 15 ETs per SSME, it would be necessary to provide 85,000 fresh SSMEs over the 10-year course of the interdiction. This is obviously a manned mission - crewed for the duration.

C) The Solar Sail - At 9 Newtons of force per square kilometer, the size of the Solar Sail required can be roughly derived by comparing it to a SSME at 2.1 million Newtons or 233,333 sq/km per SSME. In that it will take the equivalence of 7.5 SSMEs operating continuously over 10 years it will take a 1.75 million sq/km Solar Sail to effect the same deflection. At 15 tons per sq/km (including rigging) this 25 million ton sail alone would require 1 million Shuttle launches without factoring in crew and life support for 10 years. Or thrusters and fuel to control the asteroid's pitch, yaw and roll. Then, from LEO, it would be necessary to somehow get all this up to 50,000 mph in order to land on the asteroid. At that velocity it would be more efficient to simply crash the whole thing on the surface than bothering to deploy the sail.

D) Ablation - Detonate a nuke 5 km from a 10-km asteroid and the radiation will volatize its surface into an expanding gas generating force. To generate a net 3x10^18j KE as a single pulse you would first need to allow that only 6% of the radiation will strike the asteroid. Then, given the variable composition and topography of the asteroid's surface, some degree of reflection and absorption short of volatilization could leave no more than 2/3 of that for volatilizing the surface. Then the thermal efficiency of deriving work from the expanding gas, at absolute zero, before it instantly precipitates into ash, could not be more than 5%. Finally, less than 40% of the resulting work would be bounded by the asteroid's convex surface and being uncontained at zero pressure evenly divided between the gas and the asteroid. So initially we will need 7.5x10^21j KE or a 1,800,000 Mt bomb at 450,000 tons - 180 times the current world nuclear arsenal. Given the stakes this is still a manned mission.

E) Mass Drivers - Shoot chunks of asteroid off its surface using an electromagnetic coil - Gauss/Rail gun. This may work for asteroids composed of machineable ferromagnetic non-magnetizeable ore… We can send up a foundry to shape the chunks into projectiles or billions of buckets to put the ore in. It has been proposed using a 100 m/s solar powered mass driver to deflect a 1-km asteroid 20,000 miles over 10 years. However to generate the 6x10^15j KE required it would need to throw 4 tons of asteroid per second 24/7/52/10 (10-km asteroid - 4,000 tons/second). One year more and it would run out of asteroid.

F) Nuke It - Blow it up with a nuclear bomb - NASA's fallback strategy. To just 'drop' a nuclear bomb on it won't work. A bomb would first have to create a volatized medium (atmosphere) to generate any concussion. Any bombs would need to be placed subsurface maximizing the conversion of radiative energy into a superheated rapidly expanding gas and containing it to do work. To blow it 'up' we must use sufficient force that all the fragments reach the escape velocity of the asteroid and do not reform around its center of gravity. And do so far enough away that the fragments do not merely become a slowly expanding formation of smaller asteroids still on a impact course to Earth. This escape velocity requires a Delta-V of roughly 2 m/s. The 'ideal' energy required to accelerate 1.5 trillion tons from 23,000 m/s to 23,002 m/s is 6.27x10^19j KE or 15,000 Mt. Even multiple charges placed subsurface over the entire asteroid this 'ideal' would need to be adjusted for engineering variables by a factor of at least 3 to 45,000 Mt or 4 times the current world arsenal. This is NASA's fallback Plan-B?

It is hard to imagine any of these tactics as a reliable post-detection response strategy. Here, we have no experience or expertise whatsoever. We have never attempted anything on the scale that will be required or dealt with this much energy and we have done next to nothing in working beyond LEO. And we will never have as much at stake as we will when we do undertake this endeavor. If we are actually going to do something that will actually work in time to save ourselves, and not just pump more pork barrel funding into NASA, we must actually build a Plan-A 'before' we detect The Next Large Asteroid on its way to strike Earth!

If it makes it easier to sleep at night just think in terms of NASA's 1-km best case scenario and you can reduce everything offered here by 3 orders of magnitude... But by day you will still be left with the cold reality that NASA's post-detection response strategy, as Planetary Defense, is little more than Suicide by NEO.

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USS Chicxulub

Sooner or later - perhaps tomorrow - some astronomer somewhere in the world will detect The Next Large Asteroid on its way to strike Earth. Within a matter of days his detection along with the precise date of its impact would be confirmed 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 a large asteroid impact is imminent, 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, because this will seem to be a mission requiring some form of thermonuclear solution in Space the President will order an emergency meeting of his Joint Chiefs of Staff looking for a way to defend ourselves from this imminent global catastrophe. Then, because it does come from space, he will contact the Administrator of NASA to inform him that due to this National Emergency that he, his agency and all NASA facilities and personnel are under the direct command of the DoD for the duration of the crisis. And later, Planetary Defense will have 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 concerns about the questionable efficacy of the few ad hoc extemporaneous thermonuclear options imaginable. Plans for Solar Sails, Mass Drivers and crashing into it with multi million ton spaceships will 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.

Point Defense: Despite any great degree of preparation and vigilance any effort for defending Earth flatfooted from ground zero may not even be executable unless the incoming asteroid is in precisely the right place at precisely the right time. The mass of any solution at the exact velocity required for manned interception and the limitations of even our most advanced propulsion systems combine to severely restrict the frequency and parameters of any launch windows. The Next Large Asteroid on its way to strike Earth would have to pass directly before our guns, and do so soon enough, before we could save the world from its impact. Even with decades of warning there is no certainty that from Earth (or LEO) any opportunity to launch such a mission would even present itself before impact at all! Further, with the limitations inherent in looking for it only from Earth, this assumes we will even detect it… at all!

Manned Mission: Making any asteroid's detection and interdiction reliable will require a highly trained and disciplined force deployed in Space on a prolonged basis. Schemes for simply shooting it down from Earth in the manner of some extension of a NMD program are fundamentally irresponsible and most unlikely to perform as advertised. We must take into account the necessity that even in executing any nuclear solutions we will have to land on the asteroid to place those charges subsurface in order to just 'blow it up'! Further, there is no guidance system or robotic technology imaginable that can replace the efforts and abilities and resolve of a crew compelled by the magnitude of the loss if they should fail and failure here is not an option.

Military Business: Any effective interdiction will likely involve some use of a thermonuclear explosive device; traditionally a task reserved exclusively to militaries worldwide. More importantly, in a worst case scenario, with the survival of our species on the line, success At Any Cost will not mean only taxing the capacity of Gross World Product. It will also mean that from the relatively mundane duties of training and Watching the Wall to the execution of an interdiction, individual lives are expendable. This is not a paradigm found to any degree at NASA or in any civilian or government agency outside those dedicated to military service. It is not merely a matter of being willing to sacrifice oneself to Save the World. It is a matter of having the training and discipline and most of all, the disposition, when with that sacrifice you do achieve a successful result. 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. If asteroids could think we would call this War!

Strategic Analysis: NASA is not the first name that comes to mind when you think of strategic acuity. Yet NASA has provided us with the only plan for dealing with this threat - do nothing until you see it coming. This issue redefines Global Security. Its resolution will ultimately manifest in an expert capability for applying a great amount of physical force far away from Earth. In its fundamentals this is similar to the challenge that has been successfully addressed by the U.S. Navy for decades. Yet the greatest authority for projecting power this world has ever seen - responsible for the strategic disposition of resources simultaneously on the sea below it, on the ground, in the air, in space and in the halls of Congress - is not even in the loop. In assessment, a principal strategic difference in the threat of the Cold War and that of asteroid impact is that ultimately asteroid impact is an absolute certainty.

Projecting Power: Since the first man floated across a river on a log to attack his neighbor, naval strategy has been about Projecting Power. The U.S. Navy has evolved to become the most effective force in history for bringing it to the other guy. This success is in large part the direct result of having become the world's most expert and experienced logistical authority and going into Space is nothing if not a dangerous precision logistical problem. However, it does not take a strategic war college study to see the advantage in deploying any capabilities we can develop in multiple locations as a picket line around and far enough away from Earth to be tactically effective. Get off of and away from Ground Zero not only to better observe the total Area of Interest but also to be pre-positioned to respond in a matter of days and not decades. A force, deployed to the orbit of Mars would give us both the strategic and tactical advantages we need to deal with this threat.

Personnel: From selecting for tolerating long term deployments to training in navigation, independent command, logistics and many technical skills - the U.S. Navy is the best place to start building a professional space force. Selected and trained to live and work in close quarters in a hostile environment with nuclear weapons and nuclear propulsion systems make the submarine service a particularly likely candidate group.

Global Leadership: For this we will need something new; a coalition of the world's militaries. Politicians will be needed for the distribution and portioning of the Global Economic Stimulus. However, at its core, a subjective goal-oriented hierarchical military mindset must prevail if we are to succeed. Here, the most likely candidate for leadership, the most duly respected military mindset in the world is the U.S. Navy.

Dealing with this threat is no longer a scientific issue. No new scientific knowledge is required. Detection is a matter of employing military grade 24/7 surveillance in real-time and interdiction is a matter of engineering the application of some force far beyond anything man has ever attempted before. It would seem far more rational to train the Navy for a mission in space, retaining their characteristics of discipline, endurance and resolve, than trying to teach NASA to think outside the pork barrel and succeed 'At any Cost' - to think subjectively and that failure is not an option! If we are to survive the natural events of our own solar system recruiting posters for tomorrow's Navy will read 'Join The Navy and See The World… From Mars!' If not, tomorrow becomes a somewhat questionable proposition.

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Mars: Tunguska Base

Mars is 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 there just because it would be cool… But there is nothing on Mars worth going there to get - at least 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's 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 'quo'. However there is a good reason for us to go to Mars. Mars and its orbit are the best strategic location to deal with TNLA: The Next Large Asteroid on its way to strike Earth!

Where we defend the Earth from will not just mean the difference between success and failure but success and any reasonable effort at all. The academics assuming the mantle of authority in this issue seem to fail to appreciate just how massive any effort for dealing with TNLA will be and have often drastically overstated our current capability to deliver any solution at all - let alone in time to save the world. If we wait until we actually see it coming we may know exactly what we need to do to deal with it. However we may not be able to actually do what we need to do, or be in the right place to do it from in the time we have left to do it in. The key, strategically speaking, is to make a serious effort (spend money) in developing whatever solution we can - deploying it somewhere that will maximize the opportunity for its use - before we detect TNLA.

Zone 1 - Earth/LEO: What we can do with TNLA combined with the degree of certainty we will expect from any deployment dictates where we must execute an interdiction from. "Blow it up with a Nuke" is the current Maginot Line of Planetary Defense at NASA. The difficulty in executing this solution lies in the mass of the bomb that would be required. To 'blow it up' would mean exploding the asteroid with enough force that all the fragments would be accelerated to the escape velocity of its center of gravity. Without an atmosphere to work in, nuclear devices would need to be placed sub-surface in order to have any substantive effect at all. Then, to insure an even distribution of the effect, the placement of these charges would have to be precisely engineered in multiple locations on the job making this necessarily a manned mission. Even then, the net kinetic energy required to deal with a worst case impactor would require tens of thousands of tons of nuclear bombs. With all the components pre-staged on Earth, and with our current heavy lift capability in the 100 ton range, the payload alone would take hundreds of launches just up to LEO (Low Earth Orbit) where it must then be assembled into a single mission. Then there would be the crew and all its equipment and the engines and the fuel to accelerate from LEO to escape velocity and the on-board fuel to accommodate both a rapid and accurate interception and the lower velocity required to land on it... Even pre-staged in LEO, given the overall mass of the mission and the unknowable and unique elements of its trajectory there may not even be an effective Launch Window before impact. With all our current technological limitations there might not even be an effective Launch Window from Earth… ever. Any interdiction strategy pre-positioned on the surface of the Earth or in LEO will likely never have the opportunity to be of any use when we actually need it. Any Launch Window may be so narrow that TNLA would need to pass directly before our guns in order for us to even engage it.

Zone 2 - Earth Orbit/L2: With any pre-positioned manned deployment in or near Earth's orbit around the Sun, we gain the tactical advantage of having already escaped most of Earth's gravity, which will save us both some time and energy after TNLA is detected. At Earth/Sun LaGrange Point 2 (L2), we would be one million miles directly outside Earth orbit and travelling at a velocity slightly greater than that of Earth (faster than most asteroids). At other LaGrange Points where station keeping may be more stable, or anywhere else along Earth's orbital path, we loose the advantage of being somewhat shielded by Earth from Solar radiation which is far greater than in LEO and 2.5 times greater than at Mars orbit. Also, at L2 surveillance of virtually that entire portion of our Solar System where asteroids travel falls into line of sight in real-time. Further, with Earth blocking the Sun, both infrared and optical detection technologies are enabled or enhanced in every direction 24/7/52. However, being only one point in Space and traveling with Earth in its orbit around the Sun, L2 still suffers most of the same spatial geometric disadvantages as LEO in terms of affording reliable Launch Window elements before impact. L2 is better than Earth/LEO but not as good as the orbit of Mars.

Zone 3 - Mars/Mars Orbit: This is the only strategic and tactical high ground we have for defending Earth. The orbit of Mars can be stationed in relative safety at multiple points - greatly increasing the probability of having an effective Launch Window. Any interdiction must also consider the tactical advantage of mitigating the orbit of TNLA at its aphelion - usually a region between the orbits of Mars and Jupiter. There, at half its average orbital velocity, the energy required would be one fourth that required at the median of its orbit. From this perspective alone, deployment closer to this region may be the difference between success and extinction. From multiple stations in the orbit of Mars early and precise detection become more a matter of cost, preparation and diligence rather than trusting the dynamic spatial geometry of our Solar System to reveal TNLA in time for us to deal with it from Earth. From the orbit of Mars it is at least imaginable that we can deal with TNLA without relying on some good luck Launch Window. Together with L2 and LEO we would have Defense in Depth and through many operational synergies enhance the net effectiveness of each Zone. Since dealing with asteroid impact will be a challenge beyond TNLA - forever - some very long-term thinking is justified. With its resources in a lower gravity well, it should be more economical to develop Mars as the principal provider of propulsion mass, consumables, technology and ultimately low-grav born personnel to Watch The Wall than it would be to do so from 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 to send Mankind to Mars. Done right it should 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 but after we see it coming we may not be able buy an effective Launch Window at any price. Before we see it coming we can improve the odds that we will have one that will work. After its detection, all the money in the world will not alter the dynamic spatial geometry of our Solar System or may not be enough to ransom our fate from extinction by TNLA. If applied with diligent strategic foresight, money can make a difference now and price should not be an object. The universe is a dangerous place. It does not suffer dilettantes gladly.

TNLA has been coming for 15 billion years and once we do 'see' it, this will become a desperate set-piece game with all the advantage going to The Rock. The game has begun. We must play - and play well - or die! It is our move and we do not even have a piece on the board. We either get off our planetary ass and Bring It to The Rock or The Rock is going to Bring It to us!

This Is Not A Drill!
The Sky Is Falling Now!
Militarize Planetary Defense Now!

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