

# *Gaiashield Group*

1400 Kra-Nur Drive, Burton, Michigan 48509



11/01/10

Gen. Charles Bolden, Administrator NASA

Re: Ad Hoc Task Force on Planetary Defense Final Report

General Bolden, Sir:

Enclosed are comments challenging the details and foundational conclusions of the Ad Hoc Task Force on Planetary Defense Final Report.

To be clear, my enclosed comments aside, the general recommendations, and in particular the notion of a Planetary Defense Coordination Office at NASA, all things political considered, are a necessary first step... albeit a very small one. However, with my comments I would endeavor to ensure that at least this first step come down in the right direction.

As in most things, once such an effort goes beyond the abstract, success will depend largely upon the person in charge of implementing its codified authority and mandate. Here, even with explicit Executive authorities and a crystal clear mandate, the prospect of NASA actually coordinating the efforts and performance of DoD and DHS in fact, warrants a great deal of skepticism.

As circumstances change and our understanding and wisdom in this arena evolve, the idea of a Planetary Defense Coordination Office will evolve. Given the relative masses of the agencies involved, it will likely become the Planetary Defense Liaison Office. However, for now, should the responsibility for actually creating this office fall to your watch, choose your people well and get the clear and unequivocal Executive authority for the tail to wag this dog.

Since the threat of asteroid impact is one that we understand we can manage to its worst case manifestation and that it will always include the random prospect for our extinction. Then the most important thing Mankind can ever *know* will always be which asteroid is The Next Large Asteroid on its way to strike Earth and deflecting it will always be the most important thing Mankind can ever *do*. At any cost. By any means... Failure will *never* be an option.

No pressure...

A Million Miles A Day

R. Dale Brownfield  
Gaiashield Group

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## **Strategic Comments and Response to the**

### **Final Report of the NASA Advisory Council Ad Hoc Task Force on Planetary Defense**

***Recommendation 1: Organize for Effective Action on Planetary Defense***

***Recommendation 2: Acquire Essential Search, Track, and Warning Capabilities.***

***Recommendation 3: Investigate the Nature of the Impact Threat.***

***Recommendation 4: Prepare to Respond to Impact Threats.***

***Recommendation 5: Lead U.S. Planetary Defense Efforts in National and International Forums.***

GS: Although in total this is a less than half measure, these are all necessary and valid objectives. However, they would be the explicit responsibility of a legally delegated Agency empowered with the authority to achieve them. The natural consequence of a codified National Policy to in fact respond to this threat. We can not leave such an expression of Political Will as tacit...

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*The space agency has broad expertise in scientific exploration and characterization of near-Earth asteroids (NEAs) and comets (NECs), and NASA's deep space operations experience could enable the development of deflection technologies to be used to divert a NEO threatening an impact.*

GS: True... relatively. In absolute terms, as defined by the requirements of responding to this threat, NASA's experience and capability here is still nascent and emergent. Further, NASA has no experience or expertise whatsoever in dealing with or in any way managing strategic risks or threats to the United States or its interests. No mission of NASA has ever had dire National consequences if it failed. Including the general mission statement and very existence of NASA... For such a mind-set and organic culture, go to DoD.

*The Task Force anticipates that the executive branch, in its current consideration of appropriate agency roles regarding the NEO impact hazard, will assign NASA a lead role for the U.S. government's activities for Planetary Defense. The recommendations herein reflect this assumption. If NASA is not assigned the leadership role for Planetary Defense, certain Task Force recommendations will apply instead to the responsible federal agency.*

GS: In that the Executive Office has failed in its 10/15 2010 reply to Congress to respond to the spirit, letter or substance of their request to definitively recommend a qualified agency for meeting this responsibility, Task Force anticipations have been unmet even in the alternative. However, the request for a National Planetary Defense Agency has been reiterated in the 2010 NASA Authorization Act with a new deadline of 09/30/2012...

The OSTP's letters to Congress did seem to 'coincidentally' prepare the ground for the Task Force's recommendation herein for a Planetary Defense Coordination Office... An unauthorized and toothless de facto PD Agency subject to the whipsawing whims and vagaries of Congress.

*The Task Force recognizes that other entities have conducted substantial work addressing Planetary Defense challenges. The Task Force relied on this, other primary sources, and new information developed during its deliberations to inform its recommendations. In citing this work, the Task Force has minimized, for brevity, the repetition of supporting material for its recommendations. This material can be found in the References section.*

GS: They never contacted me... or by their references any of those that have been modeling and/or sponsoring nuclear deflection options, or promoting DoD as principal or co agency, or in any way advocating the building of a standing means to respond to this threat in its worst case scenario before we see it coming. True to form, just as Rusty hand-stacked the Task Force with members agreeable to his positions, he has controlled the information and therefore the logic that shaped the conclusions of the Task Force to fit his personal objectives.

Worse, as has been the case for all the academics and scientists in this issue to date, the Task Force failed to solicit the interest and advice of anyone trained and experienced in the arts of Risk Management, Strategic Thinking or Decision Making... those non academic, non scientific disciplines that, in terms of responding to this threat, apply to this issue far more critically than Astronomy or any Science... anymore. It's past time for the engineers of technology and method: Generals, Businessmen and even Politicians...

### **Synergies from Planetary Defense**

GS: All NASA Pork Barrel idealistic Space Cadet pipe dream pap... Done right, addressing this to the scope of the worst case extinction level scenario, we would need our response to be pre deployed to the orbit of Mars (L3, 4 & 5) and serviced and maintained from a forward outpost on Mars. The true Real World synergy here would be in deferring the cost. If we task the principal strategic responsibility for this mission to the militaries of the world, to be funded by perhaps a perpetual 5% retasking of the current world military budget, the resulting reduction of the world military budget by \$50 billion/year would correspondingly reduce the ability of our species to kill each other for economic, political and religious principals by 5% as well... This way, spending money on Planetary Defense Saves the World twice... Win/Win! Kinda makes you want that allocation to be 10%.

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*1. NASA's search for near-Earth objects has discovered at least 87% of the large asteroids whose impacts could pose a global threat to our civilization.*

GS: Which can not, in any way, be taken as any reduction in the Risk of *one* large asteroid impact any time soon and specifically, is 87% of only an *estimate*. Which has been challenged by NASA's PA&E (x2 or 3 for the application of power law distribution methodology), the ESA (x2 for high albedo assumptions) and astronomers in the UK (x4 for medium period Dark Comets).

In terms of basic logic, if we began this empirical Survey with an estimation of 1,000 large asteroids, whether we held either an expectation of no asteroid impact in the next 100 years or a Risk postulate of one asteroid impact in the next 100 years, we should also hold the reciprocal expectation that, empirically, we would find 999 large asteroids *not* on their way to strike Earth in the next 100 years. Finding 870 large asteroids not on course to strike Earth in the next 100 years only conforms to our initial reciprocal expectation. It does not afford a logic or rationale or argument for any change in either an initial expectation of no asteroid impact in the next 100 years or a Risk postulate of one asteroid impact in the next 100 years.

Here, we can either we find a large asteroid on its way to strike Earth in the next 100 years and confirm the Risk postulate of one asteroid impact in the next 100 years or find the Last Large NEO and confirm our expectation of no asteroid impact in the next 100 years... Period.

The problem then, is that in order to find the Last Large NEO and confirm our expectation of no asteroid impact in the next 100 years requires proving that there are no more large asteroids to be discovered anywhere in our solar system, and that no new NEOs will be generated in the next 100 years. For this, the Survey methodology is wholly inadequate. Finding the Last Large NEO *estimated* does not count. Here, what would be required is a space-based full spectrum, real-time Surveillance of the entire Area of Interest 24/7/52... forever. What we are doing now is nothing more than counting rocks in space with some remote chance of seeing the next one coming.

Since all that is required for *one* large asteroid impact event is only *one* large asteroid then it follows that all that is required for the Risk/Threat of *one* large asteroid impact event to be complete and persist unmitigated is the mere possibility of *one* undiscovered large asteroid.

This threat presents itself as an absolute and binary problem: Is there or is there not one large asteroid on its way to strike Earth in the next 100 years... zero/one, up/down, on/off, yes/no. Strategically, finding large asteroids that are not on course to strike Earth in the next 100 years is nothing unless it is demonstrably the Last Large NEO. There is no end to this threat... ever.

*None pose a credible threat of a collision with Earth for the foreseeable future.*

GS: Only does not *appear* to be a threat for the foreseeable future... these things randomly bump into each other all the time. Those with elliptical orbits that orbit close to the ecliptic may spend as much as a third of their time traversing The Main Asteroid Belt giving them a relatively high random-chance probability for asteroid/asteroid impact. The one asteroid we have visited (Eros) had over 100,000 visible impact craters on its surface and every impact generated some level of Delta Vee. If an asteroid collides with only 0.1% of its mass it could be perturbed in its orbit by as much as a million miles in as little as 3 years...

*2. The National Research Council's (NRC) 2010 report, "Defending Planet Earth," presents a thorough collection of background information describing the hazard of NEO impacts and NASA's current search, impact analysis, and warning programs.*

GS: Which was strategically irrelevant... academic: without apparent use. Nothing in it NASA did not already know even though, at the mandate of Congress, NASA asked and paid for the study. Basically, the NRC failed to answer the three questions in the mandate: Find the Optimal Approach to maintain Arecibo, the Optimal Approach to implement the Brown Act and the Optimal Approach to developing a Planetary Defense capability because, as they they explicitly stated, they did not understand the meaning of the term 'Optimal Approach'... Academics!

*The NRC report authors examined several search options for detecting asteroids down to the 140-meter size target specified by the George E. Brown NEO Survey legislation. The Task Force recommendations are largely based on the conclusions of the NRC report.*

GS: No surprise there since the NRC Report was clearly shaped and informed principally by Schweickart and Chapman and Johnson and Jones and Yeomans with the support of selected associated and clearly biased and subjectively sympathetic 'experts'...

*3. However, the NRC report authors had very limited time to examine emerging capabilities to discover, track, and provide warning for near-term impact of the smallest objects with damage potential (ten to several tens of meters in size).*

GS: Which was not in their Congressionally mandated and NASA paid mission. Perhaps if they had not spent so much time arguing about the meaning of Optimal Approach...

*The Task Force supplemented the NRC's work to recognize that short-term warning could enable effective evacuation of affected areas.*

GS: Hard to imagine that a 10 meter object (or even larger) is going to conform to any predicted Ground Zero once it crashes into Earth's atmosphere and is randomly bounced/deflected or otherwise redirected to what could easily be 2 or 3 States away. Another probability ellipse? Where to run to where to hide... Particularly at ~1,000 meters where an impact in Kansas could flatten this country from sea to sea. Far better to not fail to deflect these rocks: at any cost and by any means necessary.

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*The population of long-period comets, with orbits originating in the outer solar system, represents a small part of the total comet threat, and thus an even smaller part of the total impact hazard. Because the tasks of effectively detecting and deflecting objects of this size and velocity are beyond our present technology, the Task Force report does not address long-period comets.*

GS: At least until we have embraced the inherent wisdom of responding to this threat in its worst case manifestation determined by the magnitude of the loss not by Random-Chance Statistical likelihood and for the development and proliferation of space capable thermonuclear NEOMines and pre deployed our Planetary Defense to the orbit of Mars.

*5. The driving philosophy behind the national and international defense against NEOs should be, "Find them early."*

GS: That would be the driving philosophy and battle cry of the Astronomers who do not have to deflect them. The Engineers over in the corner are all chanting "Build It Now". After all, it will be the efforts of the engineers ex post that should determine what will be early *enough* ex ante.

*Early detection of NEOs (especially those larger than 140 meters in size) is key to mounting an effective--and cost-effective--Planetary Defense effort.*

GS: 'Early' here is relative to the mission mass of our response. When NEOPucker Time comes the notion of Cost in dollars will simply not be relevant. Then, the Cost in terms of skilled human endeavor... Time, will be. Then, the lighter the mission the faster we can send it. The faster we can send it the less we have to send or the more we can send to ensure success. And at this point, in terms of mission mass, nuclear ablation is currently modeled at 2,000 times more effective than any "Second Best Alternative"... And that would be before speculation on modern designs increasing yield-to-mass ratios over our current 30 year old Cold War designs. If the Task Force had included some of the nuclear advocates in their research they would have known that.

*An adequate search, detection, and tracking capability could find hazardous objects several years or decades before they threaten impact. Early detection and follow up tracking of hazardous NEOs eliminates any need for a standing defense capability*

GS: Enter the Task Force's "Hope Based Planetary Defense" plan. The Task Force believes that the next asteroid on its way to strike Earth will always be small. Even with Nukes a mission to a 1,000 m threat at 10 years and affording a x10 margin of error (for technology confidence, probability ellipse and mass uncertainty) would require 10 Mt of yield at 10 tons of payload and effectively 10 Delta II missions. Are we going to have the launch windows for something like this when we need them? For a "Second Best Alternative" a Kinetic Impactor mission's payload would range from 20,000 tons to an optimized 2,000 tons (given that the momentum multiplier ejecta effect works as advertised and a high relative impact velocity). And times 1,000 for a 10 km Chicxulub Class problem. For even an Apophis size threat the KI mission would range from 500 to 50 tons or 500 to 50 Delta II launches.

For this plan to work they Hope the asteroid is small, Hope to see it early enough, Hope they have the launch windows, Hope its orbital elements and structure will be suitable for a KI approach, Hope that its composition and density will generate momentum multiplying ejecta, Hope that they know its precise mass, Hope that the boys at JPL got the math right and have a precise position for the object in 10 years and Hope that all that ad hoc technology supplied extemporaneously in the 11<sup>th</sup> hour by the lowest bidder works as advertised.

Hope is not method. Hope has never been a reliable survival tactic. Better to call in the engineers of method and technology and build and deploy something that will Leave Nothing to Chance.

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*11. Physical characteristics of NEOs pertinent to Planetary Defense include size, mass, density, porosity, composition, rotation, interior structure, binary nature, and the properties of the surface.*

GS: Principally, only for the “Second Best Alternatives”. For Nukes... not so much. Particularly if it is a manned response. There is a tremendous flexibility and range of options in the tactical application of the nuclear approach. Particularly in terms of Over Kill to ensure success. If you want to send twice what the engineers are recommending as Rocket Surgery, then where with Nukes it may be a matter of sending one more Delta II mission, with the KI approach it would be a matter of sending as much as 2,000 more Delta II missions.

*Our present knowledge is insufficient to understand the typical range of characteristics for NEOs comprising the potentially hazardous population.*

GS: False. We already understand the 'range' of possible characteristics. What we do not/can not know until we see it coming are the characteristics of The Next Large Asteroid on its way to strike Earth. Nothing else matters... strategically speaking.

*12. The Task Force strongly recommends that the cost of NASA Planetary Defense activities be explicitly budgeted by the administration and funded by the Congress as a separate agency budget line, not diverted from existing NASA science, exploration, or other mission budgets.*

GS: Politically, that approach takes the dire priority edge off this. Better to say that we/you think this business needs to be done even at the expense of any other thing NASA is currently tasked to do... Note that such an approach would not sound nearly so painful if we were asking DoD, and by extension the militaries of the world, to retask 5% of their current \$1 trillion budget to save the world at the expense of the ability to kill each other. Call it Inverse Opportunity Cost.

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*Task Force findings (anticipating the release by the OSTP of recommendations pursuant to Public Law 110-422) indicate that a focal point within the NASA Headquarters staff should be established to plan, coordinate, and oversee implementation of Planetary Defense (PD) related activities.*

GS: Subject to the Strategic designs of DoD. NASA simply does not have the mind-set or culture to go into Harm's Way. NASA, as only a Tactical facilitating element, would effectively then be performing in its traditional role. NASA has always been a National strategic *resource*. It has never been a National strategic *Agency*. It will always be far easier and far more effective to task a Soldier with a mission in Space that it would ever be to teach a Scientist to think like a Soldier.

At NASA, there are surely many that would knowingly sacrifice their lives to save Mankind. However, present company excluded, there is virtually no one in NASA's administration or management that would *order* them to do so. *That's* why the Generals get the big money...

More arguments in this direction available on request...

**1.1. Planetary Defense Coordination Office (PDCO).** *NASA should name an officer, responsible directly to the NASA Administrator,*

GS: A soldier... Battlefield Class... no Beltway Shrubs. *Not* a current 'expert' on this issue and definitely no double damned Academic. He can learn the strategically relevant asteroid bits on the job in a matter of days or weeks. A good fresh mind. Start with the right man... stuff (sorry).

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*In the out years, the PDCO should plan and budget for longterm, continuous monitoring of the NEO population, beyond the interval required for reaching the near-term discovery goals.*

GS: Forever... This threat will never go away.

*NEO orbits evolve over time, both episodically (due to gravitational encounters) and gradually (due to non-gravitational perturbations)*

GS: And dramatically due to constant asteroid/asteroid and asteroid/comet collisions.

*the NEO database will require periodic updates following the initial, intensive search and discovery period. New arrivals joining the NEO population from the main belt will also require discovery*

GS: Forever... And the same, or greater, effort that will be required to discover the currently estimated 1,000 large NEOs randomly distributed throughout the 100 trillion, trillion cubic mile Area of Interest will be required to discover the random creation of just one new large NEO... Clearly a Target Poor Environment.

*Once the catalog is substantially complete, existing ground-based elements will likely be sufficient for such follow-on monitoring.*

GS: In that all that is required for the near term Risk of one large asteroid impact to persist complete and unmitigated is the mere possibility of one undiscovered asteroid, there is no degree of *substantive* discovery and cataloging that would warrant standing down or in any way reducing the fullest possible space based, full spectrum 24/7/52 real-time surveillance of the entire area of interest we can manifest. In that this Risk will *always* include the random prospect for our extinction, then at any cost and by any means necessary is *always* warranted.

*Therefore, Planetary Defense funding requirements for detection, early warning, and mitigation/deflection demonstrations are substantially front-loaded.*

GS: False. If this is to ever work in anything other than a Best Case Scenario then this element of our response should be approached by a perpetual funding allowance affording a constant evolution in our technological capabilities... Forever.

And does 'mitigation' here refer to blowing them up/destruction... Deflection in Detail, in order to reduce the severity of the impact???

*The Task Force finds that the Planetary Defense program plan is likely to require an annual budget of approximately \$250 million to \$300 million per year during the next decade*

GS: Such a budget may meet the demands of a Hope based Planetary Defense on paper however, any engineering approach, leaving nothing to chance to the best of our ability, would look more like a Global \$50 billion/year... Forever. And even then, with Battle Star Class NEO Interceptors armed with Gigatons of Nuclear NEOMines deployed to the orbit of Mars, we are still human. Shit Happens. There is always Murphy's Law. No amount of funding can be said to be too much. Extinction: all there is, forever... gone.

*Given the global nature of the hazard and the need for a coordinated response from the space-faring nations, it is both desirable and cost-effective for the US to seek international partners in demonstrating deflection capability.*

GS: As long as the path to such cooperation is not seen as through the UN. No point in *planning* to take a knife to a gunfight. Think along the lines of a NEONATO. An Agency of Agencies.

*The PDCO should lead NASA efforts, in cooperation with Department of State and other agencies as appropriate, to proactively challenge the international community to join in the analytical, operational, and decision-making aspects of Planetary Defense.*

GS: Since only a handful of nations have any space capability such a challenge would better be facilitated by DoD to the respective militaries of the world. The Space capable nations will be included as a matter of course. Every nation on the planet has a military. This is, after all, a matter of Security not Science. A matter of the Survival of Mankind and not Man in Space.

*Substantial efforts have been underway for over five years in the U.N. Committee on the Peaceful Uses of Outer Space (COPUOS) and other space-related forums, to encourage international participation in NEO detection efforts.*

GS: We can trust the UN to be a place where nations can go to wage war by other means (sorry Carl). It is not, however, a place we can ever trust to actually *do* something. Let any regulating bureaucracy form only after we have established at least the model for an effective Agency for this and determined what it is we will have to do to make this work well. After all, this is War.

*For example, a particular NEO may have a 2 percent chance of impacting Earth on a particular day decades in the future. Waiting until ground-based observations improve the impact prediction to, say, 50 percent confidence will make an attempted deflection far more costly, if not physically impossible.*

GS: As things stand, this is a misleading underestimate. A 0.2% probability at 20 years (standard modeled launch point) and respectively a 5% probability at 10 years (standard modeled point of execution) are well within the range of likelihood. Particularly in the case of an asteroid that would, in fact, be on course to strike Earth. After all, for those that will miss, the margin of error in the math does not need to be as small the +/- 4,000 mile radius of Earth.

*Reducing the number of such “worrisome probability of impact” situations via better NEO search and track technologies (producing observations that prove the more likely case that the asteroid will miss Earth) will be far less expensive than launching transponder missions or an actual deflection campaign.*

> Again with the Hope based logic. The Task Force assumes and addresses only mitigating the “worrisome probability” of impact and not the inevitable certainty of an impact in fact. They addresses only the Fear and not the Fearful Thing itself.

But yes, develop remote surveillance and characterization capabilities to the highest possible level of our technological capability... But even then, assume that at some point and frequency, with either an impact in fact or a very near miss, we will look to a precursor reconnaissance mission. Consider then, that at this point, if the asteroid is small: 500 meters or less, we instead send a couple Megatons of Nukes and just blow it up. At this point it will clearly be known to be a Earth-orbit Crossing Object and random-chance would dictate that sooner or later it will indeed strike Earth. Given enough yield for the fragments to reach escape velocity, even as close as a year away from impact, few if any fragments would go on to strike Earth. Stop thinking in terms Rocket Surgery. Nukes are both cheap and light. Think Over Kill...



Consider that if we are ever going to do this, and do it *well*, it will be a product of Preparation, Training, Vigilance: Practice/Practice/Practice. We really should be blowing up some poor ECA once a year... or at least practicing our nuclear ablation deflection techniques once a year.

*Parallel efforts to demonstrate cost-effective deflection technologies would help deal with those few objects with impact probabilities that remain too worrisome to ignore. The Task Force recommends that NASA choose search and deflection capabilities that minimize the total combined cost of confronting future impact threats.*

GS: That means Nukes: Nukes in the morning, Nukes at night, Nukes all day long. The thing about Nukes is that not only are they clearly the *only* option for larger threats but that they ramp *down* very well. Whereas the Second Best Alternatives, in terms of cost in human endeavor... Time, they do not ramp *up* beyond a couple hundred meters, at all. Nukes are a strategic Silver Bullet. One-Tactic-Fits-All-Size-Threats. A fighter/bomber/tank/boat kinda thang. And cheap...

**2.1. NEO Search:** *To implement this recommendation, the Task Force recommends that NASA immediately initiate a space-based infrared telescopic NEO search project as the primary means of meeting the congressionally mandated George E. Brown NEO Survey goal.*

GS: And several more deployed throughout the inner solar system, to be maintained and replaced forever, to effectively address the actual strategic detection and early warning requirements and demands for successfully responding to this threat.

*NASA was tasked to discover 90 percent of the NEOs larger than 140 meters by the end of 2020 as part of the NASA Authorization Act of 2005 (Public Law No. 109-155).*

GS: Do not, for a minute, think that Congress got the strategic assessment and recommendation for successfully responding to this threat *right*. Counting Rocks in Space is nothing.

*Although some NEOs are potentially hazardous, their periodic close approaches to Earth also make them among the most accessible objects in the solar system for robotic and human exploration.*

GS: As well as candidates for annual Target Practice/Practice/Practice... Particularly as it applies to the Nuclear Ablation approach. We can drive them into the Sun once in a while... 10 points!

*NASA should plan and budget for the incremental costs of maintaining the Arecibo and Goldstone planetary radars to facilitate rapid orbit refinement and detailed physical NEO characterization.*

GS: Better: Build a dedicated NEO Radar characterization facility... or four. Arecibo is far to limited in its range and underpowered (1 MW) compared to even the current US Military capabilities (4MW?) found in its Aegis class systems.

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*For a newly discovered object within range, groundbased radars can measure position and velocity accurately enough to predict Earth encounters several hundred years in advance,*

GS: Current speed, vector and position relative to Earth would be only one of many data sets relevant to where any given asteroid will be in 'several hundred years'. The rest are generally poorly understood and/or random and predictable only if and when they come under direct observation... which even with an improved capability will be a matter of Good Luck. See the consistent theme of Hope underpinning the epistemology of this Task Force? Optimists... they always believe everything will work out. Which only leaves the heavy lifting to the Pessimists. Then, in the end, they point to how everything 'worked out'.

**2.3. Short-term Warning:** *NASA should investigate development of low cost, short-term impact warning systems and encourage widespread deployment, certainly by the international space agencies, and possibly by amateur and academic astronomical communities.*

GS: Involving 'amateurs and academics' would require a massive expansion in the scope and scale of the Minor Planet Center for processing such a flood of civilian information. Further, such observations would all necessarily need to be confirmed 'officially' in order to resolve any frauds, redundancies and false positives. It would be like notifying the public that there is a terrorist loose in their community and if you see anything suspicious please call...

*The NEO size-frequency distribution with many more small than large asteroids indicates that the most likely near-term damaging impact would be expected from an object 20 to 30 meters in size*

GS: Herein lies the flaw in logic that fosters the Hope based Planetary Defense. By extension, this is the thinking that stands between our developing a rational response and our extinction by asteroid impact... an appeal to Random-Chance with an expectation of Good Luck. You could bet a hundred bucks on such a likelihood just because you can afford to lose a hundred bucks. But would you chose to bet the lives of your children and grandchildren on such a likelihood?

If we test this logic in the context of the recommendations of this report, we see that the rationale of the Task Force would be that since there are more small asteroids than there are large, then the next asteroid in its way to strike Earth will 'most likely' be small. Therefore we only need to be prepared to defend against the event of a small asteroid impact. However, since there will *always* be more small asteroids than there are large, then the next asteroid in its way to strike Earth will *always* 'most likely' be small. Therefore we would *always* only need to be prepared to defend against the event of a small asteroid impact. With this logic, there will never be a 'most likely' condition for any large asteroid impact and sooner-or-later a small asteroid Planetary Defense simply won't work. The *likely* here is a statistical/Frequentist abstraction and as such, irrelevant.

The appeal to the differential in the size of asteroid populations is an indirect appeal to the fundamental element of statistical probability. Conditionally, the greater number of small asteroids than large indicates only that in any given large period of time there will be more small asteroid impacts than large. To foster an expectation based on relative population size in any short/near term or in terms of the next event, is nothing more than a commission of the Gamblers Fallacy. An appeal to the flawed Law of Averages and suitable only for doing business in Vegas.

All asteroid impact events are aperiodic and random: without recursive pattern, both in their occasion and magnitude. Other than by a real time direct observation of the entire Area of Interest the next large asteroid on its way to strike Earth may be in, no likelihood or expectation as to when or how large can be said to be rational... or therefore, strategically relevant. The first executive decision we have to make here is: Are we going to Manage this Risk or are we going to Take this Risk? Should we choose to engineer a Response or trust in good luck and Gamble?

When we appeal to random-chance/statistical probabilistic likelihoods with an expectation of Good Luck then the only tool at our disposal for a desirable outcome is Hope. Instead we must summarily condemn any such perspective in favor of metering our response to the worst case and the greatest magnitude of loss and build an effective Planetary Defense commensurate to *that* expression of the threat. At first, we may be seen to be wrong... then again, and again, until sooner-or-later we are not, and Save the World. However, if we chose to follow the logic of the Task Force and prepare to only respond to the most statistically likely expression of the threat, then at first, we may be seen to be right... then again, and again, until sooner-or-later we are not, and go extinct. The one thing we have to understand about Random-Chance is its certainty. The more you trust it to win the more certain you can be that sooner-or-later you lose.

If you and your's live in the forest there will always be far more wolves than there are Grizzly bears and always be far more mosquitoes than there are wolves. And at any given time it would always be more likely that at random you or your's would be bitten by a mosquito than eaten by a Grizzly bear. However, would you consider it to be well defended being armed only with such a likelihood and a can of Off? Or, likelihoods aside, would the magnitude of the potential loss of you or 'your's' to a Grizzly demand your being perpetually lock-cocked and loaded for bear?

*(In the event that even a small object, say a few meters in size, is discovered with a precise date and place of impact, it might be prudent to evacuate people or warn them to seek shelter).*

GS: It bears repeating that we consider the random net effect on where Ground Zero will be when such an object (or larger) hits Earth's atmosphere. We will be lucky to call the strike zone to anything more accurate than +/- a State or two. And at ~1,000 meters, an impact in Kansas may flatten the country from sea to sea. Best to deflect these beasts at any size. Nuke 'em all.

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*A key element in any defense strategy is to "know thine enemy."*

GS: If, one way or the other, we are going to Nuke It, we only really need to know where our enemy is... Composition, density are irrelevant. Even mass, since there is no such thing as deflecting it too far, will become irrelevant when NEOPucker Time comes. Cost will cease to be an issue (along with many other things) and our response will be to send just as much force down range as we can send. No Rocket Surgery required... so Over Kill will work just fine. If a thing can be seen to be irrelevant ex facto or ex post it must also be seen to be irrelevant ex ante.

*Objects classified as "potentially hazardous" should receive priority for follow-up physical observations from ground-based facilities.*

GS: Better: As Earth-orbit Crossing Objects, Nuclear Deflection in Detail. At about the same cost or at least as long as we need to go there... blow it up! Preemptive Disposition.

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*NASA's science, exploration, and survey missions aimed at NEOs should include determination of the physical characteristics most directly related to Planetary Defense. These include size, mass, density, porosity, composition, rotation period, interior structure, binary nature, surface heterogeneity, and near-surface mechanical and thermal properties.*

GS: These would only be relevant to the Second Best Alternatives. If we are going to use Nukes in either Ablation or Deflection in Detail, all we need is Location/Location/Location. Particularly if we come to see the wisdom and security of a Manned Response where we can choose between the two options of Ablation and Destruction post rendezvous.

*useful for Planetary Defense planning are science and exploration mission objectives aimed at determining NEO internal structure and evaluating methods for coupling directly to its surface.*

GS: How to reliably couple a Nuke to the surface of an asteroid would expand the tactical flexibility of a nuclear response. Handy as a hacksaw.

*NASA should perform the necessary research and development to perform an in-space test of a deflection campaign, with the goal of modifying, in a controlled manner, the trajectory of a NEO. Such a demonstration program should include both a powerful impulse technique (e.g. kinetic impact) and a gradual, precise (e.g. gravity tractor) deflection capability.*

GS: To establish a relative baseline, *first* we need to determine and corroborate the modeling and conclusions for the application of Nukes for both Ablation and Deflection in Detail. Confirm the apparent “First Best Alternative”. It would be a critical error in judgment to trust either the mathematical or computer generated simulations in the absence of any empirical in situ test.

However, since in 2007 NASA's PA&E has determined that in terms of mission mass Nuclear Ablation will be 100 times more effective than the Second Best Alternatives. And in 2009 the ADRC enhanced that differential to 1,000 times by determining a 'sweet spot' in closer proximity to a target object. And in the same year David Dearborn from LLNL doubled that differential to 2,000 times by reducing device mass to half... Why are we looking at a Kinetic Impactor approach currently at 2,000 times less effective than Nukes? And what are we going to test in Space... momentum transfer? High school physics... what's to test?

This 2,000 times differential is before considering the yield-to-mass ratio of a nuclear device once this challenge is presented to the boys at Lawrence Livermore and Los Alamos for a high efficiency modern ad hoc design. Speculation for a 10,000 times differential is not unwarranted.

As for the Gravity Tractor as a primary means to deflect asteroids, it is still a pipe dream that if it were developed, would be as even less effective than a Kinetic Impactor. However, employed as a VASIMR driven rapid delivery system and platform for carrying thermonuclear explosive devices we could use a dozen or so in the Terawatt Class. So here, test on!

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*With sufficient warning, existing technologies are likely adequate for NEO deflection but it is critical for both public and government confidence to physically demonstrate them prior to employment in an impact threat scenario.*

GS: Again, only if the next asteroid on its way to strike Earth will always be small. And all the mathematical and computer modeling is accurate. And if Random-Chance gives us a suitable launch window. Just a matter of Hope upon Hope upon Hope... again.

For a 1,000 meter threat at 10 years, even with Nukes (which have never been tested in Space at -240C/Hard Vacuum/Zero G/outside Earth's magnetosphere), accounting for reasonable Margins of Error in technological confidence, probability ellipse and target mass (x10 total), then if the simulations are correct it would require 10 Mt of yield at 10 tons of payload and 10 Delta II launches... Launch Windows permitting. For a KI mission it would take anywhere from 20,000 tons and 20,000 Delta II launches down to 2,000 tons and 2,000 Delta II launches (given optimal relative impact velocity and every thing was 'Just Right' for the ejecta/Beta effect). And for a 10,000 meter Extinction level impact threat multiply everything by 1,000.

Unless we assume the asteroid will be small we have to do far more than simply 'demonstrate' a means to deflect asteroids prior to executing any real mission and hold a reasonable expectation of success. Some level of predeployment will certainly be required. To the orbit of Mars?

*Although nuclear explosives are considered a rarely needed and last-resort deflection option,*

GS: 'Rarely needed' and 'last-resort' only in that community harboring an irrational, unwarranted fear of Nukes. In engineering terms: currently Nukes are considered (theoretically) to be 2,000 times faster/cheaper therefore *better* than the Second Best Alternative in any weight class of this threat. With a low relative impact velocity and no Beta effect conditions but still maintaining a x10 Margin of Error to warrant a reasonable expectation of success a KI mission to deflect a 100 meter asteroid at 10 years would still need to deliver 20 tons of payload... 20 Delta II launches.

Hope feeds on Best Case Assumptions.

*it is prudent that NASA should collaborate with the Department of Energy and Department of Defense to develop an analytic research program to explore the applicability, utilization, and design of nuclear explosion technology for NEO deflection.*

GS: Collaborate... As if DoD would ever let NASA play with its thermonuclear toys without complete strategic mission command and control. With the PDCO what we have is the flawed presumption that a 40 pound monkey can tell the 800-pound-gorilla-in-the-room what to do.

***Until non-nuclear techniques of comparable capability are proven, NASA should collaborate in nuclear deflection technique analysis and simulation.***

GS: Finally! A piece of rational strategic wisdom. Let's take this to the bank. Carve this in stone. But why are the rest of the implications, conclusions and recommendations in this report in such stark contradiction to this logic?

The problem here is that the only way 'non-nuclear techniques' can ever be proven comparable would be if Nukes fail to perform as advertised by a factor of 2,000 times. Then, since we can not engineer the principal of momentum transfer to improve the KI model or tweak the law of gravity for the Gravity Tractor model we better all *Hope* that the next asteroid on its way to strike Earth will *always* be small. Otherwise... we're screwed.

*computer hydrocode impact simulations, laboratory gas gun tests, and other appropriate experiments aimed at better understanding the momentum transferred to a target by a kinetic impactor.*

GS: This can be done simply and cheaply in the Lab. No Space mission required. And the margin of feasible application in the Real will likely be determined to be so rare as to be completely impractical. Elegant in engineering terms, but academic: without apparent use in the Real. Then we can dismiss this notion once and for all. However, before we even consider spending any money in the Lab, consider the limitations and unique variables inherent in a Kinetic Impactor mission.

### **The Goldilocks Approach:**

A) Clearly the threat must always be small. Even with the potential for a secondary Beta/ejecta effect it doesn't take much more than something over 100 meters before the greenest of the Greens start thinking Nukes: 2,000 times more effective than the KI approach.

B) The orbital elements relative to launch conditions on Earth must be such that the angle of the interception of the KI with the asteroid's path affords a high relative impact velocity.

C) We have to hit it... likely several times. We are shooting a bullet A in front of a bullet B so as bullet B runs into bullet A... and both bullets are traveling at ~20,000 m/sec. OkOkOk, we hit Comet Temple II, once. But Temple II, at 6,000 meters, would be almost 1,000 times larger than a 200 meter target. Which, in terms of mission mass, would be at the upper end of the effective KI mission range and likely not proportionally but exponentially more difficult to hit.

D) The KI is only ever feasible when deceleration is most effective. As a matter of chance half the threats will present themselves as having an advantage in our response if they are accelerated. Within the probability ellipse the asteroid will most likely be seen to be on either one side of the Earth or the other. Therefore, half the time deceleration would need to bring it across Earth and *then* away from the other side costing several multiples of that of an acceleration mission.

E) For a Rubble Pile a KI approach would simply be useless. It would strike one large element and deflect that part but leaving the balance only disrupted. Or the KI may simply pass through a void of dust and gravel and have little desirable effect whatsoever.

F) For a solid monolithic target a KI could easily expend the energy that may have gone into ejecta and the Beta effect into fracturing the asteroid in the main and effectively creating a Rubble Pile condition making effective subsequent impact efforts impossible.

G) In terms of net impact efficiency, due to the co-orbital angle of interception, the slower the KI the greater the relative velocity and therefore the greater the effect in terms of Delta Vee. Which as an objective, may present itself as problematic to orbital engineers who want to intercept the target ASAP and also find the higher KI velocity to be an advantage to accurate interception.

H) In terms of the Beta effect, a comprehensive qualifying precursor mission would always be required and most likely manned. Costing not only human endeavor but Time which will always count against the target Delta Vee and the total mass of the mission.

I) Then consider the shocked acceleration effect. The conditions required for an effective Beta result are similar to those of a 120mm APFSDS cannon round on a Main Battle Tank. The net effect would serve to explosively volatilize the surface of the target in close proximity to the blast and generate an unintended potentially disruptive inelastic shock to the entire asteroid.

J) If the target asteroid is soft or simply loosely bound, there will be little, if any, Beta effect. It has to be hard. But not so hard that the compound effects of the impact fragment the asteroid.

K) If you want to take advantage of a deflection at perihelion where the target's velocity is highest, then the optimal position of the asteroid in its orbit relative to Earth would be conditioned upon having a precisely suitable launch window.

L) If we accidentally strike and accelerate the asteroid along its Y or Z axis instead of along its X axis we would unpredictably disrupt the vector of the asteroid in its orbit over the short term and effectively make any subsequent incoming targeting solutions useless and likely impossible to redetermine or reconfigure accurately on the fly.

M) High velocity interceptions may be determined to problematic and rendezvous the more reliable if not the only possible option. For a Kinetic Impactor mission the orbital elements of the target relative to a launch window from Earth in its orbit may not be suitable for such a mission.

All things considered the Kinetic Impactor approach, far from being “robust” as described in the NRC report, is in fact a *Goldilocks* approach, reliant principally *not* upon the engineering of technology and method but rather upon compounded vagaries of Random-Chance and very, very Good Luck to make many things happen *Just Right*.

The Kinetic Impactor is a Hope based Tactic for a Hope based Planetary Defense. No strategic thinker worth his salt, and with the responsibility of defending the planet from this threat, would need to get past point A) to dismiss it... Even if all the stars above align and afford the KI approach model its optimum potential both in its Alpha and Beta effects it would still be 200 times more massive and therefore 200 times less effective than the nuclear ablation model.

Just to put a fine point on this, when NEOPucker Time comes, and whether it is your children and grandchildren at Ground Zero, or the survival of the species in the balance, would you want the powers-that-be using the 2,000 times Second Best Alternative? Or second best by 200 times? Or even second best by only a factor of 2?

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*To preclude such a future keyhole passage and subsequent Earth collision, each deflected NEO will need periodic monitoring to determine if some orbital fine-tuning is required.*

GS: Not if we have already blown them up...

*As extreme examples of events, NEO impact threats are especially susceptible to misperception.*

GS: Particularly those misperceptions fabricated and promoted by the NEO 'expert' astronomers, assorted scientists and academics and risk management naifs who believe that 'low-probability, high-consequence', and/or 'the probability of large asteroid impact in the next century is low', and/or by reducing the statistical probability of asteroid impact somehow reduces the Risk of asteroid impact, and/or since there are more small asteroids than there are large asteroids that the next asteroid impact will likely be small... is somehow rational and/or strategically relevant information suitable for sound Decision Making.

Random-Chance/Statistical probabilities and its constructive average relative frequency elements are completely non analogous mathematical abstractions and are a product of intentionally corrupted empirical information. As information, this makes them not only non rational and strategically irrelevant but anathema to Scientific Method.

The problem here may be that few understand that there are two kinds of probability. Despite the unfortunate inconvenience of having a common semantics and nomenclature, these two probabilistic perspectives are unique and discrete from each other and incomputable with and non constructive to each other. More importantly, one is rational and one is not.

Conditional-Empiric/Stochastic/Bayesian Probabilities are the core of rational Decision Making. They are what Politicians use to orchestrate their campaigns, what CEOs use to implement their businesses, what Stock Brokers use to select their investments, what Generals use to prosecute their wars and what aerospace engineers have used to estimate the future position and potential for impact of the asteroid Apophis with Earth. What we use to Manage Risk and manipulate things in the Real World... What we use to drive to work in the morning. This is what we use to make predictions for the future based on the laws of physics in a deterministic universe. The basis for foresight. The ability to make Conditional-Empiric/Stochastic/Bayesian Probabilistic assessments has enhanced our evolution far more even than the opposable thumb.

Random-Chance/Statistical/Frequentist Probabilities are what the boys in Vegas use to determine the payout on games of chance... and what the astronomers et al have used to obfuscate and misconstrue the existential nature of the threat of asteroid impact and our Extinction by NEO. And from time to time what we rely upon as comfort-food-for-thought when we are faced with a threat we can do nothing about. Is it any wonder then, that Academics embrace them so easily?

*NASA should lead U.S. government efforts, in public and international forums, to educate, coordinate and act in reducing the threat of a NEO impact.*

GS: Only once NASA has a clear and honest and rational understanding of this threat (no statistical sophistry or academic-slight-of-mind allowed) at both the tactical and *strategic* level.

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*Coordinated table-top exercises will be an essential training and evaluation tool in inter-agency impact threat preparations.*

GS: Just don't forget to bring the dice. Most of the principal deterministic elements of this threat are a matter of Random-Chance. If these NEO war games are going to be true Red Flag exercises we have to give the asteroid its fair chance to win... No matter how large the dice say it is.

*NASA should utilize national and international expertise to develop the legal basis for potential actions related to Planetary Defense.*

GS: The First Law here, based on the Precautionary Principal: “Governments should take action to prevent harm even when it is uncertain if, when or where the harm will occur”, would necessarily be a codified National and ultimately Global Policy... “We The People/Species shall endeavor to deflect these objects as they present themselves to be imminent impact threats. At any cost and by any means necessary.”

Governments do not/can not act without the force of Law behind them. Without a codified Policy Determination, no effective Agency or coherent Strategy or reliable Tactic will ever be funded or developed. We can not afford to wait until *after* we see the next one coming before we make a Law to deal with this and still consider ourselves to be wise. And *before* begins... Now!

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*Public education would go far in countering accidental misunderstandings, accidental or purposeful spread of misinformation, and the susceptibility of some to alarmist or catastrophist interpretations. Without such an education initiative, the loss of public confidence will likely prove very costly.*

GS: Without a manifest Fear of Death by Rock from Sky in both government and the general public there will be no Political Will to actually ever do this. Only Fear Defines Necessity. Fear tells us that there are dire consequences should we fail.

The problem here is not the alarmist and catastrophist but rather the Irrational Absence of Fear. The problem here is that the academic 'experts' driving this issue are far more afraid of being considered alarmist by their peers than of The Next Large Asteroid on its way to strike Earth. The problem here is that the academics believe in their own probabilistic abstract artifacts as if they were somehow rational deterministic information.

The problem here is not the alarmist or the catastrophist but rather the Pollyannic...

The question here would be, will NASA hold the rigorously rational and by extension the fearful high ground or will it take the politically correct path and settle for appeasing the Pollyannic academics? Will NASA settle for less than half measures? We can trust that DoD would not.

*Society now possesses sufficiently mature space technology to provide two of the three elements necessary to prevent future damaging asteroid impacts. NASA currently searches for the largest objects of concern and issues warning information for any asteroid discovered to approach Earth. New ground- and space-based search systems can increase our capability to provide impact warning for the smaller, more numerous asteroids.*

GS: What we have now and what has been proposed is only in support of a Survey effort: counting rocks in Space. It is far, far removed from any effective Early Warning Surveillance effort. In those terms, at any given time, what we have now is only observing 1 part in 4 million of the entire 100 trillion, trillion cubic mile Area of Interest that The Next Large Asteroid on its way to strike Earth is in. That would be like turning on NORAD's DEW Line 6 seconds a year...

*Although NASA has not demonstrated a specific asteroid deflection capability, the agency's current spaceflight technology shows that impact prevention is possible. Actual NEO deflection demonstrations are being studied and are excellent candidates to be part of future NEO science and technology missions.*

GS: In their 2007 NEO Workshop report NASA's PA&E concluded that at best NASA has the capability to get to only 60% of the NEO population (which should not be taken as expressing any capability for deflecting them). Given that NASA is fundamentally a launch facility, and the larger the asteroid the more launch capability required, this should be interpreted to expressing the limit NASA's capability to those objects of only 200 to 300 meters or less.



*The missing third element for NEO impact prevention is the international community's readiness and determination to respond to a predicted future asteroid collision with Earth.*

GS: The only tool here is Fear. If you want the World to get geared up for this, if you expect We The Species to survive the next asteroid impact, or if you just want more money from Congress... scare them better. Probabilistic obfuscations and trying to sweep this under a rug of Science and more research is nothing more than a formula for Suicide by NEO... BlahBlahBlah...BANG!

A Million Miles A Day  
R. Dale Brownfield  
Gaiashield Group

Gaiashield Group <<http://Gaiashield.Com>> <[HeadsUp@Gaiashield.Com](mailto:HeadsUp@Gaiashield.Com)> (810) 742-8830

### **Gaiashield Recommendations:**

1. Most people simply can not look into the abyss of this issue and not blink. Or turn away. Or worse, see what they want to see. Unfortunately, this absence of courage includes the current community of 'experts'. Therefore, the most urgent task of the proposed PDCO should be to get this business into the more capable hands and braver minds of DoD at the level of Strategic responsibility. Leave NASA with a subordinate and Tactical facilitating role (where most of the money goes in such things). Here, we can not afford the dire consequences of any Strategic miscalculations. There will be enough of those to deal with at the Tactical end of this spear.

If NASA ends up with the Strategic role here, given the true scope and scale of this threat and a commensurate response, it would take less than a decade before the responsibility of being a Strategic Agency inculcated itself into the very culture and mind-set of NASA. And the NASA we have known and loved for 60 years would be gone. No more Discovery or Exploration or Man in Space. Just The Sky is Falling, The Sky is Falling, The Sky is Falling...

2. Abandon for all time any reference to or inference or conclusion drawn from any kind of statistical probability or those elements constructive to such perspectives. To be 'rational', base your reasoning instead only on the laws of physics in a deterministic universe. 'We don't know' will always be strategically relevant. Some academic's non analogous mathematical abstract artifact only makes him look good and serves as nothing more than comfort-food-for-thought. 'We don't know' at least tells you what you need to do: where to put your intelligence resources.

3. This report is clearly leaning in the direction of the Best Case Scenario. You need to start leaning in the direction of the Worst Case Scenario. We can only ever afford to Hope for the best after we have prepared for the worst. In the face of Random-Chance, Hope should be left to only when there is nothing more we can do... Until then we stack the deck, fix the race, load the dice... game the system. Cheat. Leave Nothing to Chance! It's what we do.

4. Press/advocate/lobby the Executive Office for a clear and codified National Policy to endeavor to deflect these objects as they present themselves to be imminent Earth impact threats. Until then, do not wait for Congressional or Executive authority and funding to create a PDCO. You should have the discretionary resources to do so even if it is an office of only one man. Start this.

5. Learn to love Nukes. Sooner-or-later they will saves us all from Extinction by NEO.