# AIAA Position Paper
# Responding to the Potential Threat of a Near-Earth-Object Impact

**George Friedman**
**Space Studies Institute**
**Princeton, New Jersey**

*In 1990, the AIAA published a position paper on the hazards due to asteroids which stimulated substantial recognition within Congress and helped cause the establishment of the Detection and Intercept Workshops. The 1995 position paper is an update of the previous paper and has four recommendations: a) accelerate the detection of near-earth-objects, b) establish a systems engineering and analysis program to plan followon activity, c) perform experiments in accordance with the results of b, and d) establish a management focal point to coordinate the domestic and international activity. In addition to the AIAA, this new position paper was endorsed by the Institute of Electrical and Electronic Engineer's Aerospace and Electronics Society, the National Council on Systems Engineering, and the Space Studies Institute. The planetary defense domain has received the benefit of the world's finest scientists over the past several years and it now judged timely to introduce more formal systems engineering discipline as the foundation for more progress and acceptance. Key systems issues include the deeper integration of detection and intercept parameters, the smoother flow of accuracy requirements from initial acquisition to final tactics and the choice of systems level performance criteria. Although recent progress has been good, as evidenced by the publication of the T. Gehrels edited, "Hazards due to Comets and Asteroids," and the integrated Planetary Defense Workshop which recognized the importance of systems issues, much remains to be accomplished.*

## Introduction

The near miss of Asteroid 1989FC encouraged the Space Systems Technical Committee (SSTC) of the American Institute of Aeronautics and Astronautics (AIAA) to publish a position paper, *Dealing with the Threat of an Asteroid Striking the Earth* in April, 1990. This paper, written by E. Tagliaferri, the chair of the SSTC, was submitted to Congress as part of AIAA's annual testimony. According to T. Dawson, then on the Congressional Staff, this position paper had a "seminal effect" on the Committee on Science, Space and Technology of the U.S. House of Representatives. The credibility of the threat of an impact from space to humanity was immediately elevated from its previous science fiction fringe status to a serious, scientifically and technologically sound issue facing all the nations on earth. This committee stated, in the NASA Multiyear Authorization Act of 1990,

*"The Committee believes that it is imperative that the detection rate of Earth-orbit-crossing asteroids must be increased substantially, and that the means to destroy or alter the orbits of asteroids when they do threaten collisions should be defined and agreed upon internationally.*

*The chances of the earth being struck by a large asteroid are extremely small, but because the consequences of such a collision are extremely large, the Committee believes it is only prudent to assess the nature of the threat and prepare to deal with it."*

NASA was directed to conduct two workshops as recommended by the AIAA position paper: one on the detection and another on the interception of large space objects. Over the next two years, the Detection Workshop, chaired by D. Morrison, and the Intercept Workshop, chaired by J. Rather, completed their work, wrote their reports and presented their findings to the Committee on March 24, 1993. The report on *The Threat of Large Earth-Orbit Crossing Asteroids; Hearing before the Subcommittee on Space of the Committee on Science, Space, and Technology, U.S. House of Representatives,* not only contains the full detection and interception workshop reports and the AIAA position paper, but very illuminating dialogue between the presenting scientists and the Congressional Committee members. In particular, George E. Brown, Jr., the committee chair stated,

*"If some day in the future we discover well in advance that an asteroid that is big enough to cause a mass extinction is going to hit the Earth, and then we alter the course of that asteroid so that it does not hit us, it will be one of the most important accomplishments in all of human history."*

Those concerned with the threat of Near-Earth-Objects, (NEOs) could hardly have asked for a more supportive statement made by the chair of this powerful committee. The presentations were received with great interest and spirited discussion. The workshop chairs were warmly thanked and praised for their efforts. However no significant new funding resulted. The 1989FC "wake-up call" and the first AIAA position paper were insufficient to effect a change in the face of tight budgets and existing priorities.

Within a day of this Congressional hearing, we were provided with another wake up call: Comet Shoemaker-Levy 9 was discovered at Palomar.

**The Role of Engineering Professional Societies**

As AIAA's SSTC was observing these events with great interest, they were joined by other professional societies. Since we are dealing with issues of constituency and advocacy, it would be useful to outline the diverse motivations of these organizations who wish to further the greater understanding of and appropriate response to the NEO threat:

At the most general level, these are engineering, not scientific societies. There may be astronomers, paleontologists, or nuclear physicists among their members, but these societies strive to serve the professional engineering goals of their membership, industry and society at large rather than the advancement of scientific research. Specifically, regarding the NEO threat, all the endorsing societies share the common belief that, although the likelihood of an impact is extremely low its devastating power is unprecedented and that, furthermore, humanity has the technology and the means to respond effectively and economically. Beyond these common beliefs, the endorsing organizations have different shades of emphasis:

*The AIAA* is interested in the general health and advancement of the aerospace industry, as well as the effective development of applied technology. It has proven to be a leader in the recognition and support of key technologies as well as the development of key systems concepts which optimally merge new technologies with new missions. The SSTC is specifically interested in space systems. AIAA's Systems Engineering Technical Committee (SETC), which did not exist in 1990, concentrates on the application of modern systems engineering processes and principles to the management of complexity.

*The National Council on Systems Engineering (NCOSE)*, has similar goals to the SETC, but it draws from a larger applications and personnel base. For example, it has a set of working groups, each dedicated to a specific subdiscipline such as risk management and requirements management. Also, one of NCOSE's highest priorities is to broaden the applications to include domains other than military systems, where most of its members gained their experience.

*The Institute of Electrical and Electronic Engineers' (IEEE) Aerospace and Electronic Systems Society (AESS)* is interested in the development of its members, professional standards, and the advancement of key electronic technologies such as digital electronics, communication, navigation, guidance, control and radar which it feels will be relevant to the NEO problem.

*The Space Studies Institute (SSI)* has the long-term goal of the exploitation and colonization of space, and recognizes in the anticipated populations of NEOs vast opportunities to fulfill Gerard O'Neill's vision of the "High Frontier."

**The 1995 Update of the NEO Position Paper**

The AIAA and its supporting organizations felt that it was timely to issue an update of the 1990 position paper for several reasons: Most significantly, although the NEO threat is far better known by scientists and far better recognized by government than just five years ago, it has not yet achieved the crucial breakthrough as a high priority program with appropriate funding. All the endorsing organizations want to help support this breakthrough in these times of high budgetary pressure and reorganizations. Additionally, the organizations had many concerns of a systems engineering nature on the progress of NEO systems concepts and wish to add their constructive advice. More detail on some of these concerns is provided below.

The AIAA position paper, *Responding to the Potential Threat of a Near-Earth-Object Impact* is appended to these preliminary remarks. Briefly, it recommends four interrelated actions: 1) Approve an accelerated detection program, 2) Initiate total systems studies *now,* 3) Perform key tests paced by the results of these studies, and 4) Establish a focal point to manage domestic and international NEO activity.

**Systems Aspects of the Planetary Defense Problem**

The enormous progress achieved during the first quarter of this decade continued into the second quarter as evidenced by the publication of *Hazards due to Comets and Asteroids, Tom Gehrels, Editor,* the far greater participation of the US Air Force Space Command, the accelerating international participation, and perhaps most importantly, the holding of a single integrated Planetary Defense Workshop rather than continue with separate Detection and Interception Workshops. However, there are aspects of planetary defense associated with extrapolated policies, subsystem optimizations, accuracy balance and system level criteria, which the endorsing organizations believe will impede further progress and acceptance.

These issues will be discussed briefly in the following sections. It must be emphasized that no criticism of the extremely dedicated, intelligent and idealistic group of people working the planetary defense problem is intended. We merely wish to point out that as the problem is more deeply analyzed, it is becoming more interdisciplinary, more complex and more dangerous as a potential threat to humanity. It is timely to add another, relatively young discipline to our array of problem solving and management tools: systems engineering.

**The Heritage of Extrapolated Policies**

A half century after the end of World War II, we are again at a crucial juncture in human affairs. Most of the military and space strategies of both the United States and the Soviet Union were directly responsive to the perceived demands of the cold war. With the termination of the cold war and the dissolution of the Soviet Union, the former superpowers and their allies are struggling with a multitude of new priorities which for decades have been considered subordinate to military preparation and space.

Yet, the heritage of extrapolated policies which dominated the cold war years remains as a very influential background to today's decision making and resource allocation. The very substantial allocation of resources to national defense the past several decades was resented by those involved in other worthy activities and there is a vigorous movement to cut the military back substantially. Within the department of defense, one of the highest level allocation issues was the proper balance between strategic/nuclear and tactical/conventional warfare, and there is a vigorous movement to cut back the nuclear and to view new applications of nuclear technology with great suspicion. Within NASA, high level allocations involved manned versus unmanned missions and today's struggle is how to convert from competition with the Soviets to Cooperation with the Russians and other developed nations. Within astronomy, with its centuries-old tradition of terrestrial optical observations, new options of space platforms and long range radars present a rich selection of technological alternatives.

Compared to priorities associated with education, health, crime, drugs and the environment -- which have been identified for decades and which have developed advocacies since at least as far back as the fifties -- the planetary defense problem has literally burst upon the scene only recently. It is further tainted with the impression that its only precursor in our consciousness comes from science fiction and the fact that the probabilities of global devastation due to an NEO impact are so low that they are without precedent.

The turmoil in today's decision making can be viewed as an opportunity. We need more advocacy -- which can only come from an intensified educational program and the most responsible reporting of the nature of the threat, its probability and the alternatives for mitigation. Extrapolations of old policies and strategies should not impede our selection of the best technologies, people and organizations to respond to the NEO threat.

**Subsystem Optimization**

As originally defined, the Spaceguard program appears to be an enormous bargain. Its claim that it will provide ample warning for global devastating impacts due to earth-orbit-crossing asteroids and short period comets -- representing an estimated 75% of the threat -- for about $50M in capital investment and $10/yr labor indicates an extremely attractive cost/benefit ratio.

One of the most fundamental tenets of risk management is to invest in early testing and experiments to characterize the nature of the risk. The AIAA position paper recommends immediate approval of such a program to accelerate the detection of NEOs.

However, many observers are concerned about the tendency to postpone the search for the remaining 25% of the threat and to postpone the development of mitigation systems until after a threatening NEO has actually been identified. First of all, the "detection community" appears to be giving the "interception community" excessive respect in assuming that the tremendous challenge of intercepting a 1km (or larger) object can be met from a "standing start," without the normal phases of conceptual formulation, development, testing and prototyping. Without the benefit of these phases, the inevitable response to a large, threatening NEO would involve existing nuclear warheads, with uncertain interception effectiveness and the possibility of actually aggravating the threat.

On the other hand, the "interception community" appears to be giving the "detection community" excessive respect by assuming that the warning will be given with at least a year to go until impact and with such a high confidence of hit probability that the energy required for interception will be only that required to move the NEO an earth's radius. (This assumption is discussed more in the next section.)

From the standpoint of a citizen of the world who only recently emerged from the risk of dying from a massive thermonuclear exchange and is now grappling with new risks such as global warming and ozone layer depletion, there is much confusion about the NEO risk. Only a decade ago he was completely unaware of such a risk. Then very suddenly, he was told that the estimated population of NEOs exploded by about a factor of a thousand, but with an uncertainty of about a factor of two in quantity, of about a factor of ten in effect, and at least another factor of several thousand in when the next big one is coming! In the face of all these new and gigantic uncertainties, he can perhaps be forgiven for not being very impressed that the risk is being reduced by a factor of only four -- especially when he is told that most of earth's large craters are due to comets, which are *not* the primary objects for the initial search. He could correctly classify a program like Spaceguard which makes excellent progress at very low cost as "gathering the low hanging fruit" -- or as a systems engineer would put it: optimizing a subsystem with insufficient regard to the broader context of the whole system.

In response to these concerns, the AIAA position paper also recommends that a broad systems approach be taken to the planetary defense problem and that studies and analyses be undertaken immediately to examine the systems engineering, risk management and programmatic aspects of planetary defense. The accelerated detection program should look past its most efficient task of searching for asteroids and short period comets to the more difficult (and unfortunately more expensive) task of searching for *all* threatening NEOs. Because of the recently improved understanding of the tsunami effects, the search must also include objects below 1km in size. Passive, terrestrial sensors should probably be augmented by space-based and/or active, long range radars. These extensions are far more expensive than the first phase detection system but they are necessary for the complete solution and they therefore should be designed with a total systems viewpoint. Then, beyond the augmented detection system, preliminary designs and risk reducing tests associated with potential mitigation systems should be undertaken.

**Spectrum of Accuracy**

As was indicated above, the previously disparate activities of the various contributing communities addressing planetary defense should be more tightly integrated. One important parameter of such integration is the accuracy and speed of convergence of the NEO's orbit determination. Although accuracy should be properly considered as smoothly transitioning along a continuous spectrum, the following very simplified five stages are worthy of comment:

The first stage involves the initial observation that a given NEO is indeed *new* and not a previously acquired and catalogued object. As the NEO catalogue grows over the next several decades this becomes increasingly important and a significant data management task.

The second stage is to develop sufficient accuracy that the object is not lost -- especially as it enters the sun's glare. In the early days of planetesimal discovery, most of the initial acquisitions were lost.

The third stage is to develop sufficient accuracy to predict probability of hit on earth, or more likely, predict an insignificant likelihood of hit on earth within x centuries.

Another stage is to predict probability of hit on earth for an object which is on its terminal trajectory toward earth and which was not previously measured.

A final stage is to predict hit probability with sufficient accuracy and time-to-go that interception resources can be deployed effectively. Most interception system analyses assume that the orbital error projected to the vicinity of the earth will be very small compared to the radius of the earth. In this case, the "Planetary Defense Commander" will be able to effect a successful NEO defense by deflecting the object transversely one earth's radius, at the most. If, however, the orbital error is on the order of an earth's radius, the commander's decision becomes far more complex: the probability of hit if he does nothing becomes 0.68; if he deflects the NEO by one earth radius, the probability of hit becomes 0.48; and if he deflects the NEO by two earth radii, the probability of hit becomes 0.16. With the future of humanity at stake, this is hardly reassuring. Worse yet, for deflections of one and two earth radii, the probability of converting what would have been a miss into an inadvertent hit would be 0.14 and 0.16 respectively. This would clearly be unacceptable no matter how the probability of hit were diminished: to go to all the effort of an interception only to cause the (perceived unnecessary after the fact) deaths of billions of humans! (The probabilities were based on a *very* simple normal error model.)

Yet there may be circumstances where the first acquisition of a high velocity comet which hasn't ever visited the inner solar system before is made with less than a year to go and the error projected to the vicinity of the earth would be greater than an earth's radius. The terminal kinematics of such an object would present a small angular rate and an enormous range rate to an earth based sensor. In this scenario, the value of a "several AU" range radar would be worth a billion souls. Yet, long range radars seem to have "fallen between the cracks" of analyses whose perspective was limited to detection only or intercept only. When suggested as a robust method to converge orbital accuracy rapidly, replies such as: "they're not good for search," or "they're very expensive; r-fourth law, you know" are forthcoming.

It is suggested that the long range radar is but one example of an issue involving time, energy and accuracy which can only be properly examined from the total systems view since it contributes so intimately to both the detection and intercept phases. Another was mentioned by Dr. Teller at the Planetary Defense Workshop, "Achieving greater accuracy is probably a far more intelligent strategy than deploying great amounts of energy." The context of his remark

was his realization that about a million NEOs could be employed in the "brilliant mountains" concept only if we knew their orbits with great precision. *All* forms of astrometry would be required to realize this concept. A systems analysis regarding the kinetic energy available in nonthreatening NEO to deflect threatening ones could cast a different light on the real cost and value of "several AU" long range radars and other terrestrial and space borne sensors.

**System Level Criteria**

The establishment of meaningful criteria to guide the design of complex systems and to assure that the stakeholders are truly satisfied is one the most important and difficult tasks in all of systems engineering. This is especially true for the planetary defense problem due to its newness, its multidimensionality and its unprecedentedly low probability coupled with its dreadful severity.

The work published by Morrison and Canavan in the "Hazards" book and elsewhere appears correct, thoughtful and consistent with risk analyses performed on other risks to humanity. They claim accurately that the NEO threat is really in a class by itself -- nothing else comes close regarding such a low probability of occurrence and such devastating consequences. In the final analysis we will probably have to rely on a combination of several criteria.

The most rigorous mathematical analysis can be performed employing the techniques of decision theory and using the criterion of "expected monetary value" (EMV) of the loss, given that risk mitigation is not employed. Although this criterion is respected in making business decisions and is preferred for many applications of risk management within systems engineering and program management, where the loss of human life is concerned there is usually a resistance to placing a monetary value on a casualty. An important exception is the FAA's policy of evaluating safety and maintenance alternatives on the basis that the expected value of a human casualty from a commercial aircraft accident is $2.6Million. This is relevant because as the NEO threat is listed within the context of other risks, it comes quite close to the risk of traveling on commercial aircraft. Moreover, the threat from space and the threat of air travel are broadly related as being involved with high technology regarding both their generation and their solution.

Other criteria have employed the "one in a million" threshold used by the EPA as well as the "cost to rebuild civilization" standard, which lies in the neighborhood of one $Quadrillion. However, the highest level allocations seem to be made on a qualitative, not quantitative basis.

Morrison, in his papers and speeches commented that these criteria many be useful in other, more traditional domains, but they fail to capture the incomparable, unthinkable, and incredible *dreadfullness* of the extinction of humanity. In addition to the above "cost to replace" paradigm, perhaps we should give more emphasis to the "insurance" paradigm. For example an international budget of $3B/yr would substantially mitigate the NEO threat, as well as advance science and open up vast resources of material and energy in near earth space. This will cost each human being one cent per week. Is this worth it? What percentage of world-wide traffic in drugs, alcohol and tobacco would we have to give up to fund this planetary defense program?

In the introduction, George Brown was quoted to say that a successful planetary defense would be one of the most important accomplishments in human history. Perhaps the dual of his statement drives the point home more dramatically:

*"If some day an object does strike the Earth, killing not only the human race but millions of other species as well, and we could have prevented it but did not because of indecision, unbalanced priorities, imprecise risk definition and incomplete planning, then it will be the greatest abdication in all of human history not to use our gifts of rational intellect and conscience to shepherd our survival, and that of all life on Earth."*

**Conclusions**

The threat is real and deserves a response. Clearly, the first step is to learn more about the threat with an accelerated detection program. More thorough detection programs are far more costly than Spaceguard but any rational criterion can show that they are worth it. Long range studies and plans on the total planetary defense system should be instituted immediately and key tests should be implemented to mitigate technological risk. Compared to other risks to humanity, the technologies to mitigate the NEO threat are near at hand and ample human and physical resources are available and waiting the decision to act. The total cost of a working planetary defense system will be an enormous bargain in terms of the mitigated risk as well as the advance of science and the exploitation of space resources. What is now required is to gain a broad acceptance and program initiation. This can be accomplished by education, accurate and clear communication of the true risks and effective application of a rational, balanced program and systems design. *We can do it.*

# RESPONDING TO THE POTENTIAL THREAT OF A NEAR-EARTH-OBJECT IMPACT

## An AIAA Position Paper

**Prepared by the**
**Space Systems Technical Committee**
**and the**
**Systems Engineering Technical Committee**

**Approved by the**
**AIAA Board of Directors**

**September 1995**

American Institute of Aeronautics and Astronautics
370 L'Enfant Promenade, SW
Washington, DC 20024-2518
202/646-7400

## SUMMARY

Evidence that the Earth may be impacted by an asteroid or comet large enough to cause global devastation is increasing rapidly. Recent fundamental research indicates such impacts have been primary causes of past dramatic changes in the Earth and its environment. As recommended by AIAA's 1990 position paper, congressionally-directed workshops on Near-Earth-Object (NEO) detection and intercept were conducted and interagency and international collaborations began. This position paper recommends continuing the NEO activities by: a) accelerating the search for asteroids and short period comets, and b) developing concepts and plans for follow on detection, identification and mitigation systems. Should the activities in a) and b) begin to point the way to a more substantial program in the future, the government should consider establishing an office to provide a focal point to coordinate efforts to improve detection and risk alleviation.

## BACKGROUND

In April 1990, AIAA's Space Systems Technical Committee published the position paper, *Dealing With the Threat of an Asteroid Striking the Earth*. This paper, precipitated by the close passage of asteroid 1989FC — with zero warning time — helped stimulate broad interest and concern in this potential threat to civilization and even to the survival of humanity. Soon afterwards, the U.S. House of Representatives Committee on Science, Space and Technology directed NASA to conduct two workshops related to the asteroid threat as recommended in the position paper; one for the detection and characterization of the threat, including determining the orbits with a precision which would allow the accurate prediction of an impact, and another which dealt with issues related to mitigating the threat. On March 24, 1993, the results of these workshops were summarized and discussed in a formal hearing before this same congressional committee. The class of potentially threatening objects was enlarged to include long period comets as well as earth-orbit crossing asteroids; together they were defined as near earth objects.

World-wide attention to this issue has increased enormously over the past decade, based on the knowledge and understanding acquired in recent years by sophisticated research and increasing recognition of the reality of the NEO threat. Scientific consensus that a NEO impact was the primary cause of the Cretaceous/Tertiary boundary and the sharp end of the age of the dinosaurs was further consolidated with the identification of the probable impact crater on the Yucatan Peninsula. As requested by Congress, the participation by the U.S. Department of Defense and the developed nations worldwide has begun. Public attention has been captured by the prediction of an impact on Earth by comet Swift-Tuttle (later retracted) and then by the actual impact on Jupiter by comet Shoemaker-Levy 9. This not only proved to be the most violent event in the solar system during recorded history, but was also an excellent example of rapid and accurate orbit determination.

The American Institute of Aeronautics and Astronautics (AIAA), the National Council on Systems Engineering (NCOSE), the Aerospace and Electronic Systems Society (AESS) of the Institute of Electrical and Electronic Engineers (IEEE), and the Space Studies Institute (SSI) agree that our nation has a responsibility to continue focusing national and international attention on the issues raised by the NASA workshops. By providing a forum open to a diversity of views and specialties, we can perhaps help illuminate and resolve issues with broad system and technical implications.

## CONSENSUS AND RECOMMENDATIONS

It is the consensus of these organizations that, although the likelihood of an NEO impact is extremely low, the consequence can be catastrophic, ranging from the devastation typical of a nuclear warhead for small objects to billions of fatalities, the end of civilization and even the extinction of mankind for large objects. Such consequences are significant enough that the scientific community and worldwide governments should investigate whether detection and even mitigation capabilities are within reasonable grasp.

In recognition of this, these organizations recommend:

1) Immediate approval of a program to accelerate the discovery, identification and characterization of NEOs. Extrapolating the present rate of discovery of kilometer-size NEOs by a small and dedicated team of astronomers, it would take hundreds of years to discover the 2000 objects of this size that are currently estimated by astronomers to be in earth-crossing orbits. The investment in a system to accelerate the discovery schedule to about 10 years seems to have an extremely attractive cost benefit ratio. This first phase postpones the investment of a detailed identification and mitigation system since it is estimated that 75% of the objects discovered will be asteroids or short period comets where the impending impacts will have ample warning times for the development and deployment of mitigation systems.

2) Begin immediately, and at a modest level, to study various concepts for responding to a risk, should one materialize. These studies would be devoted to a broad perspective examination of the systems engineering, risk management and cost effectiveness in such areas as:

   Improving the accuracy and speed of orbit determination,

   Improving the detection capability and warning time against large, long-period comets,

   Improving the capability against smaller NEOs capable of major mortality and destruction,

Determining the feasibility of NEO rendezvous for characterization regarding potential intercept concepts as well as scientific and potential exploitation purposes.

Developing mitigation system concepts,

Establishing a plan to reduce technical uncertainties.

Examining potential architectural issues in command, control and communications, and

Analyzing alternative plans for detection and mitigation that weigh cost, implementation time, and risk.

3) Begin planning, pending the results of actions 1) and 2), for efforts to explore capabilities to deal with collision threats in the next century. The modest investment over the next decade to accelerate detection, and the results of studies identified in 2) above, will begin clarifying for the U.S. and other nations the nature of the risk of collsions and the potential for alleviating them in the future.

In the future, the U.S. should consider establishing an office for coordinating the U.S. response to this risk and should invite other nations to participate. The objective of this office is to provide the focal point for overall program management, planning and systems engineering, as well as coordinate delegated responsibilities regarding NEO detection, intercept, rendezvous, command and control systems and activities with our international partners.

## EPILOGUE

In his opening statement to the congressional hearings on the NEO threat on March 24, 1993, George E. Brown, Jr., Chairman of the Committee on Science, Space and Technology stated:

> "If some day in the future we discover well in advance that an asteroid that is big enough to cause a mass extinction is going to hit the Earth, and then we alter the course of that asteroid so that it does not hit us, it will be one of the most important accomplishments in all of human history."

AIAA and its cooperating organizations strongly believe Congressman Brown's statement is true, as well as its converse:

> If some day an asteroid does strike the Earth, killing not only the human race but millions of other species as well, and we could have prevented it but did not because of indecision, unbalanced priorities, imprecise risk definition and incomplete planning, then it will be the greatest abdication in all of human history not to use our gift of rational intellect and conscience to shepherd our own survival, and that of all life on Earth.

## PRIMARY CONTRIBUTORS FROM ENDORSING ORGANIZATIONS:

George Friedman, Chairman, NEO Subcommittee, Space Systems Technical Committee, AIAA
Ed Tagliaferri, Special Advisor to the NEO Subcommittee, AIAA
Robert Jones, Secretary, Space Systems Technical Committee, AIAA
Rosario Nici, Space Systems Technical Committee, AIAA
Mike Simon, Space Systems Technical Committee, AIAA
Clarence Wingate, Space Systems Technical Committee, AIAA
Bruce Pittman, Chairman, Systems Engineering Technical Committee, AIAA
Al Myer, Systems Engineering Technical Committee, AIAA
Myron Kayton, President, Aerospace and Electronics Systems Society (AESS), IEEE
John Morris, Chairman, Space and Environmental Systems Panel, AESS, IEEE
Eric Honour, Chairman, Technical Board, National Council on Systems Engineering (NCOSE)
Roger O'Neill, Chairman, Space Studies Institute (SSI)

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