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

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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, chaired by Ed Tagliaferri, 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 kilometersize 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.

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