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Applied Astrosociology:

The New Imperative to Protect Earth and Human Societies

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[Abstract] Most of us are well acquainted with the notion of the asteroid impact on Earth that occurred approximately 65 billion years ago, killing off the dinosaurs. The space sciences have found an increasing number of objects in space capable of destroying life on our planet. The more space scientists study our galactic neighborhood, the more dangers from space phenomena they seemingly discover. This article seeks to demonstrate the value of applied (or practical) astrosociology based on its focus on the relationship between space and society. A killer asteroid or comet may be lurking. Applied astrosociologists must take part in studying these threats, making them understood as potential human tragedies, and challenging the proper social groups within their societies to construct defenses against them. We must emphasize their social consequences as well as their physical ones. Yet, just as we begin to take these risks more seriously, the greatest reaction comes from space scientists. What remains missing, therefore, is the complementary involvement of social scientists. We must not leave the connection between space and society to chance, as history has clearly demonstrated that we will eventually run out of luck. While the risk of the destruction of Earth itself is much more remote, the risk to human societies, civilizations, and the human species itself exist as much more menacing possibilities. The new field of astrosociology, though new to science, can serve to study all of the disparate social and cultural implications associated with the newly recognized imperative to protect the Earth and human societies around the world. Applied astrosociology will contribute to finding solutions.

I. Introduction: Assessing the Threats

THIS article takes the relatively rare position that the success of planetary defense efforts depends on the contribution of the social sciences to those of the space science and engineering disciplines. Indeed, many of the important concepts requiring understanding are social-scientific in nature. The concept of *planetary defense* may be "defined as activities concerned with protecting the Earth from destruction due to impact by a large piece of space debris, (an asteroid or comet), that enters the atmosphere."[1] This definition implies the destruction of parts of the Earth, or a change in the Earth, as we currently know it (such as atmospheric disruptions and threats to life). Furthermore, an important contribution of this article involves restructuring this common definition to include the protection of human cultures and societies from destruction as a primary focus. Thus, the primary contribution of this article involves the concentration on social and cultural elements sometimes acknowledged though rarely focused upon. Even so, these elements are indispensable to human life as we currently experience it.

Historically, a *great divide* existed between the social sciences and aerospace in which the social sciences were rarely involved in the space community and those in the natural sciences saw no reason to change this social pattern.[2] As will become clear, however, the need for planetary defense surpasses the usual ideas of simply avoiding a collision with the Earth. Instead, it involves saving the diversity and achievements of societies, and human civilization itself. Such a goal must involve the social sciences, behavioral sciences, and the humanities (hereafter referred to as the *social sciences* for brevity) due to their focus on issues related to society and human behavior.

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Although its subject matter was largely absent in the past,[3] astrosociology in particular now exists in order to bring in social scientists to work with space scientists and engineers. First, let us assess the cosmic threats to the existence of our social systems as well as to our lives as individuals.

Most members of the public failed to recognize any threats to our existence coming from space until quite recently.[4] Many knew about the mass extinction of the dinosaurs that was most likely due to an asteroid impact, yet they tended to dismiss it as an improbable event that killed off a bunch of dumb animals. Surely, it was commonly believed, humans would be able to counter such a threat should the unlikely possibility prove itself a real hazard once again. Therefore, until recently, even experts dismissed the threat as an improbable event and thus not worth pursuing, including many space scientists specializing in the field. As a result, the nations around the world possess nearly no capacity to protect themselves at the current time, with very little coordination among them for this purpose. If we detected a large space object on a collision course with the Earth, only a disorganized response could result as various societies attempt to coordinate some type of hasty defense.

The actual seriousness of the threat received little notice, and remained underestimated for decades despite the fact that history has shown the Earth is far from immune from cosmic impacts. For one thing, small meteorites bombard the Earth every day. One of the more famous examples is the Tunguska incident in 1908, which probably involved a meteor that exploded in the Earth's atmosphere over central Siberia sending a shockwave that flattened trees over a vast area. The tremendous devastation resulted in very little effect on the policies of societies around the world. The object hit a desolate area, so it had no great impact upon any population. Had it struck a populated area, the reaction would have brought attention to the true nature of the threat.[5] Even so, humanity lacked the capability to mitigate the threat at the beginning of the twentieth century. In part, the remoteness of past episodes in terms of both distance and time relegated the subjective threat to a gamble worth taking.

Traditionally, most scientists took a similar attitude. That is, until recently. Over the last ten years or so, scientists have become increasingly certain that a huge catastrophe is inevitable from a space-born source at some point in the future, even if they disagree about the probability of such an event.[6] Identification of a true threat to our planet could occur in a century, a decade, or tomorrow. The watershed event that put this reality into the forefront of scientists' minds, and ultimately the minds of publics around the world, occurred after Jupiter's gravitational field ripped apart Comet Shoemaker-Levy 9 after it passed too closely. Between July 16 and July 22, 1994, 21 distinct fragments of this comet struck Jupiter. It represents the only time in human history that a space object or fragments of it collided with a planet in our solar system under the scrutiny of human observers. The resulting impacts from pieces as large as approximately two kilometers traveling at sixty kilometers per second left visible scars in Jupiter's atmosphere that lasted for several weeks. Just one of the larger pieces could have ended human civilization had it struck the Earth.

The impacts of these cometary fragments served to drive home the fact that while the Earth was not targeted by this particular comet, humanity may not be so fortunate the next time around. Assessment of the threat changed overnight into a realization that our solar system is still inherently chaotic and dangerous.[7] Assessment changed from very little concern to a "new" reality in which the Earth suddenly seemed vulnerable *and* unprotected. Protection from comet nucleus and asteroid impacts suddenly became mainstream science rather than a "backwater" concern of sorts.

Near Earth Objects (NEOs) and specifically Near Earth Asteroids (NEAs) probably pose the most immediate threats. Most of these objects circle the Sun between Mars and Jupiter. If left alone, the vast majority of these objects would pose little or no threat to the Earth. Others may have already the Earth in their sights. Additionally, objects can interact with one another gravitationally and thereby change their orbital trajectories as with Comet Shoemaker-Levy 9.

While scientists can track asteroids for at least a short time, comets and asteroids from the Kuiper belt beyond Pluto and the Oort cloud even farther away from the orbit of the Earth can arrive seemingly from nowhere due to their large orbits around the Sun. If on a collision course with our planet, they would present Earthlings little or no time to react. Comets can also originate in other solar systems and later captured by our Sun. We can devise protection strategies against NEAs though other types of space objects present different problems altogether. For example, the inclusion of comet protection requires a defensive system with elements capable of reacting immediately to a newly discovered threat from near Earth observation. Elements stationed far from our planet could provide us with a greater warning period. We need to determine whether to first construct a system capable of only a considerable reaction time or strive for comet protection from the beginning. The latter would necessitate components of the system in space as well as a much more thorough survey of our solar system.

Most of us know that an impact of a cosmic object resulted in the extinction of nearly all life on the Earth approximately sixty-five million years ago. The impact resulted in a global rather than local catastrophe that

changed the course of life's evolutionary path subsequent to its occurrence in the distant past. We can trace our emergence as the dominant species to this monumental event.

> How could the impact of a 10-km asteroid or comet kill such a large fraction of the Earth's creature, including the dinosaurs? No one is sure about the details, but a number of suggestions have been put forth. To start with, there is the global cloud of impact-generated dust, sufficient to produce a layer an inch or more think over the whole planet when it settled back to the ground. Calculations show that such a quantity of dust, when suspended in the atmosphere, could block all sunlight from reaching the surface. Temperatures would have dropped, photosynthesis ceased, and perhaps 99% of the individual organisms on our planet perished within a few weeks.[8]

While not all life became extinct, the dominant species of the time certainly did. The lesson from this event informs us that we are at risk and should take some concerted actions to increase the probability of our survival. No one can predict the time of impact or degree of devastation of the next big event, but we can take rational steps in the attempt to increase the odds of our survival. Yet small objects that disintegrate in our atmosphere constantly bombard the Earth, and witnesses have documented their sightings of larger objects throughout recorded history.[9, 10] Most surviving witnesses failed to record their observations for sociological reasons. "…[O]ne need not subscribe to conspiracy theories to see that various forms of censorship and discrimination must have profoundly deterred the publication and preservation of these reports" by peasants and lower-class witnesses.[11] In contrast to the past, the events that occur today are subject to immediate dissemination to the public by the electronic and printed media.

Agreement about the size of an object capable of ending human civilization, and those of other categories of threats, has slowly increased over time.

> The threshold for global killers is usually taken to be 1 to 2 km in diameter. The definition is a bit arbitrary, because the lethality of the impact depends on where and when it lands, and to a smaller degree on its composition (density). There are conceivable circumstances in which a slightly smaller body might be equally damaging.[12]

Others such as Morrison et al. (2004)[13] estimate the size of the *civilization destroyer* at 2-3 kilometers. In contrast, space bodies of about 100 meters represent regional hazards and those of 10 meters represent local threats.[14] Each of these categories requires a different response.

> What is the likelihood of an impact?
>
> Objective estimates of the potential damage due to asteroid impacts (consequences multiplied by risk) are within the range of other risks that governments often take very seriously...Moreover, public interest is high, fueled by increasing discovery rates and the continuing interests of the international news media.[15]

The likelihood of dying by an asteroid impact is approximately one in 20,000, a probability comparable to dying in a plane crash and more likely than dying in a tornado, bite, or sting (though less likely than a car crash or electrocution).[16]

> A large impact is *not* something we expect to happen in our lifetime, in our children's lifetime, or even our grandchildren's lifetime. It would be very bad luck if it did happen. But it could happen at any time (David Morrison as quoted by Britt 2002).[17]

Further technical details about the characteristics of the strikes of these objects fall outside the scope of the present discussion. Suffice it to state that the likelihood of an impact of a large object (greater than one kilometer) is well above zero, inevitable over large time scales, so the threat demands measured attention. Smaller impacts by smaller objects are even more likely and can cause widespread devastation depending on their size. The planetary defense system discussed later does not represent something we necessarily have to construct immediately but rather a model that demands consideration and debate; one that adds new astrosociological issues to the current discussion currently dominated by space scientists, science and technology authors, and engineers. The contributions of social scientists should join the dialogue.

A cultural/social threat that often goes unconsidered involves the unwillingness to do anything about the threat, a possibility that some within the space community have considered.

> I think that what matters is how we react to this knowledge. That, in the long run, is what will make a difference to our planet and its inhabitants. It is not the impact itself that may be immediately relevant; it is how we react to the *idea* of an impact that may change the course of human history. I am afraid that we will deal with this potentially mind-expanding discovery in the way we deal with most issues that relate to matters of great consequence: we will ignore it until the crisis is upon us.[18]

Despite the widely accepted assessment of cosmic objects as real and potentially devastating threats to humankind and human societies (chiefly among space scientists and engineers), politicians and publics of various societies may indeed downplay the likelihood of being struck by a comet or asteroid. Assessment of the threat by nonscientists within societies falls under the purview of the social sciences, and the final decision concerning financing and implementation ultimately becomes the responsibility of politicians rather than scientists. The importance of bringing in social scientists should be clear as their training focuses on these exact types of issues; issues beyond the scope of the natural sciences.

II. Astrosociology as the Missing Perspective

Astrosociology is defined as the scientific study of *astrosocial phenomena* (i.e., the social and cultural phenomena that connect space and society).[19, 20] Each of the components of any planetary defense project represents astrosocial phenomena because they involve space phenomena, and even more saliently human beings and their societies. The social and cultural implications associated with the implementation and operation of proactive defensive measures against cosmic objects involves social organization that establishes patterns of social interaction that deal with the threat before, during, and following a real life-threatening incident. Astrosocial phenomena related to planetary defense represent serious issues that threaten the very existence of human beings and the societies to which they belong. In many ways, if our current assessment of the threat represents even a close approximation of its objective nature, then these types of astrosocial phenomena mandate a significant elevation of significance as threats to the future of humankind and thus the involvement of astrosociologists.

Astrosociology exists to (1) organize the social sciences among scientists and scholars interested in outer space and (2) provide a recognizable entity with which the space community can collaborate over matters that relate to both space and society. The work on space issues within the social sciences generally lags far behind the significance of the subject matter. Those who work on such issues generally do so in isolation. A single literature spanning across the social sciences and humanities does not exist. One reason I founded astrosociology relates to meeting the need to create this new body of knowledge and related literature. Another most important reason involves attracting the brightest students and professional social scientists to embrace study of astrosocial phenomena on a large scale. This may time as a greater number of social scientists become more likely to embrace astrosociology as it gains greater levels of legitimacy. The historical absence of the social sciences requires remedy due to the incalculable contributions social scientists will make in the future.

Reaching the second goal of astrosociology represents another vital accomplishment. Protection of the Earth and societies scattered upon its surface obviously require both the natural sciences and the social sciences to work together. Successful cooperation will depend upon formalization of the process through well-respected organizations such as NASA and the AIAA along with the American Sociological Association and other social science associations. This general goal currently receives partial fulfillment as this paper attests. It was not long ago that a paper about the astrosociological implications of planetary defense would never reach the level of acceptance represented by an AIAA conference such as Space 2006. This introduction of astrosociology as the missing perspective within the space community represents an important milestone to be sure.

This newly developing field emerged just three years ago to fill a missing void in both the social sciences and the natural sciences. Within the social sciences, those who focus on space do so without the benefit of an organized, common field. Within the natural sciences, the social-science perspective may result in limited recognition though formal collaboration with social scientists rarely occurs. The development of astrosociology should serve to put an end to both of these common realities within each of the major branches of science.

Astrosociology is the missing perspective in the sense that it:

> …represents a new multidisciplinary field that adds a missing perspective to the existing scientific approach to understanding space issues by adding the social/cultural dimension. It formally adds a focus on astrosocial phenomena to complement the existing focus on space phenomena.[21]

Regarding planetary defense, it expands the focus to include societies, including their cultures and various social structures. Astrosociology emphasizes the need to protect social life as well as human life; that is, existing cultural and social patterns. It points out the need to protect the current standard of living at a level no worse than before any threat is identified. Adding societal considerations to those emphasized by space scientists and engineers increases our ability to derive a more comprehensive understanding of the pertinent issues.

The value of astrosociology will prove itself as important in helping to understand many of the elements of the planetary defense planning and implementation that currently receive little or no attention at the current time. Several questions point to some of the issues relevant to astrosociology. What factors determine whether a particular society takes part in construction of a global planetary defense project? What social and cultural phenomena factor into decisions about participating in lower level of the project compared to a greater level of participation? What will occur if our defensive efforts fail in the future? What should a society's government and scientific community do then? While not all aspects of the answers to these types of questions can be determined at this early stage, some initial ideas would easily demonstrate the importance of bringing in the social sciences to the planetary defense discourse. Astrosociology must become a mainstream field within the social sciences and a new field with which the space community can collaborate in order to ensure that progress continues. By largely ignoring the contributions of social scientists, the social and cultural dimensions receive very little attention despite the fact that, in a field such as this, the social scientific considerations abound.

A. Applied Astrosociology as a "Hands-On" Approach

While most astrosociologists will probably remain "hands off" scientists in the sense that they focus on theoretical matters, a smaller though vital contingent will choose a more practical orientation. *Applied astrosociology* is defined as the application of astrosociological (or astrosocial) knowledge to address practical problems or concerns related to astrosocial phenomena.[22] In addition to solving space-related problems, then, applied astrosociologists employ the same knowledge gained for space research toward solving real issues related to astrosocial phenomena that exist in space or on the Earth. Is the threat of a cosmic impact a space problem or a social problem? Actually, it is a bit of both. With this realization in mind, it seems logical to bring in the social sciences to assist with this type of theoretical and research exercise.

The contribution of social scientists lies in the analysis of how social systems and individuals operate/act during three phases of the cosmic threat: (1) before an object is known to be heading for a collision with the Earth; (2) following confirmation that an object will impact the Earth; and (3) following the aftermath of the successful defense or actual impact (partial or unsuccessful defense). Never before has a species on the Earth possessed enough intelligence to understand the ramifications of a cosmic impact. The dinosaurs certainly did not, yet the next great impact could be just as devastating or even more intense. The behaviors of human beings and societies enter into the equation in a very real and significant way. Now that we realize that the threat is both real and serious, we must do something about it. Doing so will prove to be difficult in a multitude of different areas including the scientific and technological aspects of making the system work on a technical level, but also including areas related to cultural and social/societal considerations. The latter two related areas will exist in all phases of the construction and operation of the planetary defense system. We should appreciate this fact from the very beginning.

A continuation with the status quo in which the space community works to solve the issues related to the cosmic threat without the input of social scientists will leave us all more vulnerable. Planners of any large-scale system must take into account the various cultures to be involved which will affect each of their subjective assessments of the threat and thus the level of willingness of various governments to participate at all and, if so, how extensively. Each society will chose to protect different elements of their social and cultural systems, so planners must be sensitive to these differences even if they fail to correspond to expectations. The need to negotiate with governments who possess different sets of priorities will exist, so planners must be prepared to interact with them in ways that maintain a healthy respect for the differences.

III. Assessing the New Imperative

The new imperative exists based on the accumulating evidence that the Earth, and thus humanity, cannot avoid the cosmic catastrophe awaiting them in the future, whether later today or thereafter. The new imperative calls for immediate action, not just from space scientists, but also from all occupations including social scientists, politicians, and those within the publics of the world's societies. We know that the threat is real, now we must do something about in it a serious manner. Protection of our planet is necessary for our physical survival, but protection of our societies is necessary for ensuring our future development as a human civilization. The cultures and social structures of societies must survive. *Material culture*, or the physical manifestations of culture that characterize a society such as libraries and infrastructure (e.g., sewers and transportation routes) include important elements of society that require protection. If we survive as individuals but lose our social organization and knowledge base, then we will have to attempt to reacquire what was lost. Space travel, for example, may be lost along with astronomical knowledge. Even the more basic capabilities that were taken for granted in the past may become difficult to recover

For the most part, this article focuses on the social and cultural ramifications of planetary defense rather than the technical aspects of doing so. The literature dominated by natural scientists and engineers addresses the latter types of problems quite well. Social and cultural issues tend to receive less scrutiny because they seem like secondary considerations at best within the space community. Contrary to this popular stance, the position taken here turns the conventional wisdom on its head by arguing that societies and their cultures require protection in addition to human lives. Thus, this position assumes the importance of the protection of human lives but also increases the threshold of protection to a higher level.

Positive benefits may result from potential disaster. Much like the *overview effect* defined by Frank White, [23] the realization that humanity's future may come to abrupt end can potentially serve to bind societies together. We are all in the same "boat," so to speak. All of us live on a single planet, and we now know that our planet is under serious threat. The politically strong-minded governments, along with the assistance of the United Nations and other international bodies, should take advantage of our new perspective in a way that leads to the construction of both a planetary defense strategy and the infrastructure to carry it out. With the threat of cosmic disaster now strongly creeping into the cultures of societies around the world, the new imperative to protect Earth and human societies will

likely receive the greatest degree of support it has ever enjoyed at all levels of societal and international organization. Still, its justification will be subject to debate and controversy. The most advantageous approach is to consider the worst-case scenario and construct a system that can counter it to the best of our ability, to build the most capable system that we believe we can afford. In the end, we will have to live with our choices should a killer asteroid or comet head our way.

A. The Imperative to Protect Societies

Protection of social institutions ensures avoidance of major disruptions. The economy receives attention in the next subsection while the other institutions receive coverage here. Politics represents a most important institutional sector because space policy decisions inevitably come from governmental leaders in various national and international political positions. In the end, politicians will decide how a society will respond to recommendations from the scientific community. They will determine which areas of the planetary defense strategy merits construction and how much money goes to the various areas selected as important.

Preservation of cultural and historical knowledge must receive serious attention in order for the continuity of any particular society to occur. Preservation of ideas, including the typical lifestyle of a particular society, must receive attention as a vital goal. A large object can create extreme havoc and may result in a dystopia uncharacteristic of the original society. The ideas, norms, and material culture associated with unique cultures around the world demand attention so they can carry on with social life characteristic of pre-impact era. Historical data require saving as well so that we may continue (or begin?) to learn from our past mistakes. Even the arts require protection. A series of important questions arise from this line of reasoning. How do we protect culture, history, and the arts and literature? In addition, how much of it do we take out of mainstream access in order to protect individual items? Finally, what criteria do we employ to make such decisions? These types of considerations are long overdue.

One institution likely to receive scarce attention is the criminal justice system. It includes law enforcement, the courts, and prisons/jails. Disruption of the economy and social life in general often results in riots and other forms of chaos and disorder. We have seen this during blackouts in major cities. Great uncertainty among a population causes the norms (i.e., rules of behavior) to become less important than during the normal course of history. In their place, individual priorities including survival become paramount. During a crisis caused by an asteroid or comet, the level of panic can potentially rise to uncontrollable levels. We should plan for how to cope with this possible scenario following an impact.

All institutions require protection just as the entire structure of the social system requires protection. At some point, we may need to reconstruct our societies. Thus, institutions such as marriage and the family, religion, and the military (as well as those already discussed) may require duplication in the aftermath of a large disruption to social life. We need to preserve elements of material culture such as books and other forms of media, the existing body of knowledge in the wide range of subject areas including science, and the various technologies we have created. Physical survival of human beings remains a necessary condition although it is not sufficient to avoid a dystopia or, perhaps more importantly, the ability to reproduce the disrupted social system. The social science literature regarding disaster rescue can serve to assist planning for this particular rebuilding scenario.[24]

One way to ensure humanity's survival, and the survival of social institutions and cultures, involves sending part of the population off planet. This reality will exist, but not for a considerable period. The problem with this solution relates to the fact that the bulk of our species will remain firmly planted on the Earth. One plan may involve establishing one of the first lunar settlements populated by individuals who construct and operate components of the planetary defense system there. Realistically, we must prepare ourselves by constructing the alternatives and the necessary infrastructure to protect our planet and beyond that, our societies. Other partial solutions could involve sending partial populations, presumably volunteers, to live in underground communities and others to communities under the surface of the oceans on Earth. We cannot begin early enough for an unknown cosmic body may already have us targeted.

A benefit that may develop from the planning and implementation of a planetary defense social involves the stronger cooperation among nations exemplified by the International Space Station program. Even nations with hostile religious and political ideologies may see a larger threat that involves cooperation despite serious intrinsic differences. It boils down to a cost/benefit analysis in which the threat to one's social group or nation is contrasted against the cost of participation. In other words, which is more costly in the long term, spending capital of various sorts to protect your planet or take the risk of no doing anything. The strength of the cultural imperative to protect human societies will likely increase as our increased surveillance of NEOs uncovers a greater number of threats, both potential and someday direct.

This may be wishful thinking, however, as the more pressing terrestrial conflicts will probably occupy the minds of these group members. They will likely favor concentration on their everyday problems over difficult to imagine

threats from space. The most powerful and influential societies will need to lead by example and ultimately provide the greatest number of resources. The need for cooperation among nations will receive additional attention at a later point in this overall discussion.

B. Economic Security

Planetary defense initiatives contribute to economic security due to the extensive problems that would occur if a massive object struck the Earth. A well-functioning economic system in fact serves as a major component of overall security for a particular society. The overall attempt to ensure economic survival in all of its manifestations serves as an insurance policy for societal survival. The aftermath of an unsuccessful defense against a massive space object could easily result in dystopias around the world. Disruptions to social life including a well-functioning economic system would hinder the ability of victimized societies to recover and rebuild. Economic security partly involves our ability to protect this vital institution. We must begin to discuss our options for doing so.

By diverting funds from a variety of different budgetary categories into planetary defense, including from the military, the economies of the world could avoid the upheaval that would occur due to inaction. In fact, it is arguable that spending to build the infrastructure needed to deploy the various system components would actually pay for itself when the threat of impact becomes real at some point in the future. Disruption of economic activity represents a real potential problem, but so does reconstruction of various societal and physical components. Who will pay for the reconstruction necessary in poor developing societies should they face such circumstances? It will probably come from international sources such relief agency of the United Nations and aid from developed nations.

The availability of a planetary system can even bolster the economic systems if handled correctly. Companies that build the components of the system will profit, as will shareholders. An entire industry will probably develop not only to build the planetary protection system, but also to operate it and service it over the course of time. If we determine that we need such a system, then we should make it benefit society as best we can.

IV. Three Components of a Comprehensive Strategy

The proposal offered here will change societies around the world in ways unseen in the past. This new strategy represents an *ideal type* (i.e., the extreme form of implementation). The ideal type represents the best system humanity can produce to detect, defend, and survive any threat by any object regardless of reaction time or cost to implement. Meeting the requirements of ideal type would be impossibly expensive and require an outrageously large infrastructure, so we must decide as individual societies and as a species how close we wish to approximate this model of the "perfect" planetary defense system.

It is best to think of this type of policy decision as falling along a continuum. At one end, there is no implementation of any part of the system at all. At the other extreme, there is the full implementation of all parts of the system that perfectly matches the ideal type. In practice, humanity will select an approach the falls between the two extremes. The assumption, then, involves the great likelihood that societies will implement at least some aspects of the various components of the strategy. Two dimensions are important: (1) which features actually result in implementation and (2) the extent to which these features match those of the ideal type. Such decision-making involves a cost/benefit analysis that weighs considerations related to technical capabilities, costs, the willingness of publics around the world to participate, subjective assessments of the threat, and the potential reactions of populations to various scenarios associated with planetary defense. Thus, decisions involve technical, economic, political, social, and cultural considerations. Astrosociologists can assist in the study of the latter four categories.

The ideal type involves a three-prong strategy that is required in order to cope with the inevitability of a large space-born object on a collision course with the Earth. This proposed strategy involves many of the issues raised in the literature with an added emphasis rarely brought into the discussion. The new approach consists of three major, though interrelated, components. Emphasis on the protection of societies and their cultures shifts the common treatment of asteroid and comet defense to a higher level of protection. While protection of the Earth's biosphere remains vital to ensure human survival, the survival of social systems at their current level of development should become the new standard.

Any strategy to defend the Earth, the human species, and human societies and their cultures at this current stage of scientific and technological development cannot logically rely on a successful outcome. Other aspects of our societies and cultures such as the arts, literature, religious sites, and government buildings face potential destruction at some point in the future. Humanity must work on all three components of the strategy simultaneously in order to protect the all of these entities over the long term. Perhaps the most important thing we need to protect, in a general sense, is the characteristic details that define social life in various societies. Many elements of culture such as values, customs, and subcultural idiosyncrasies could easily disappear following an impact; yet they demand protection.

Table 1 -- Summaries of the Three Components of the Planetary Defense Strategy

(1) *Detection*	Serious efforts to detect potential Earthbound objects should continue and intensify on an ongoing basis. This component of the strategy currently characterizes the most common efforts taken by astronomers and other space scientists in the form of surveys.
(2) *Defense*	Ideally, identification and readiness of all potential means of avoiding a potential collision should occur before detection, so that this component involves only the implementation of the correct defensive method. Space scientists and engineers have already begun to consider various alternatives though this component remains in the theoretical stage for the most part.
(3) *Survival*	Steps taken to protect individual societies and the entire human civilization should the second component fail on a partial or complete basis. Ideally, this third component should be in place so that the only steps necessary would involve moving populations and objects not already in place to safe areas. This component rarely receives mention in the literature in large measure because it involves social-scientific issues.

These components exist roughly in sequential order as to their application. Practically speaking, detection of a possible threat should set into motion a logical determination of the best defensive countermeasure to implement. If components one and two occur successfully, then the third one becomes unnecessary. As a practical matter, however, we should move forward with component three as an insurance policy in the event that failures in the first two steps catch us by surprise and we have no time to implement step three from scratch. In fact, societal survival may well depend upon infrastructures currently undreamed about by space scientists and engineers, or anyone else for that matter.

The construction of infrastructure to achieve these components involves the creation of material culture. In this case, the construction of such infrastructure would demonstrate a particular society's prioritization of protecting itself from asteroids and comets. Moreover, the stylistic elements and emphasized functional elements of facilities would inevitably reflect the society's cultural ideas and beliefs in a number of different ways. These types of considerations are important if we intend to construct a global system because it will become important to put the individual pieces together to create the whole. A particular society's government could refuse to participate or favor one type of facility (e.g., detection) or another (e.g., survival). It may be possible to make up for the missing pieces in one society by building those pieces in another that may accept them, although accomplishing this will require an understanding of the cultural priorities of various societies around the world.

The detection component of the strategy currently receives the most funding followed by the defense component (especially in the form of surveys). Very little serious discussion in the literature currently emphasizes the third component of survival. This is where astrosociology and the social sciences in general can add insights normally outside the interests and expertise of those within the space community. Through collaboration, however, we can easily add this new element to the traditional list of priorities favored by space scientists and engineers. The study of the various social ramifications of all components and their outcomes, as well as political and economic phenomena that relates to the level of willingness to implement this new strategy, also fall under the purview of astrosociology.

A. Detection

A vital component of the strategy involves the search for space objects that possesses orbits that intersect near the orbit of the Earth. Obviously, the threat first requires detection before any measures can attempt to mitigate it. Detection can set into motion the other two components. This component already exists in limited form as the *Spaceguard* program, NEAT, the *Spacewatch* program, and other initiatives.[‡] For example, the *Spaceguard*

[‡] For more details about the British Spaceguard program and related materials, go to the Spaceguard UK Portal at URL: http://www.spaceguarduk.com. For additional information and links, go to the ESA site at URL: http://spaceguard.esa.int/. The Near Earth Asteroid Program (NEAT) website is at URL: http://neat.jpl.nasa.gov/. The website for the Spacewatch program is at address: http://spacewatch.lpl.arizona.edu/index.html.

program began in the United States in the early 1990s.[25] There is no question about the fact that humanity must build an effective detection system. The efforts undertaken thus far are not close to adequate. However, what is "adequate"? The answer to this question will require discussion and debate on the societal and international levels.

Eventually, the detection element alone will likely involve satellites, facilities on the Earth and the Moon, and the dedication of a many governments, organizations, and individuals. There exists the possibility that the interest of politicians and even some space scientists may wane over time without the confirmation of a threatening object. This type of social effect is best studied by astrosociologists rather than space scientists; or even more productively, with the assistance of space scientists.

An important aspect of the astrosociological component to detection comes into play when detecting an object and indisputably calculating it to be on an impact course with the Earth. How will the scientific community react? How will governments react? Will they favor secrecy or openness to their publics? If openness prevails, how will publics and the subcultures within them (e.g., religious groups and political entities) react to such dire news?

Detection of a massive object heading for the Earth will equate to a death threat unless the other two parts exist. At minimum, a successful defensive reaction would be required. In the best of circumstances, of course, we would not require the survival component due to a fully successful implementation of a defense tactic. However, even a partial success, or mitigation of the original risk, may indeed require the implementation of survival tactics. Thus, while the detection element is vital and much of our effort and resource allocation should go to its ongoing operation, the second and third components are crucial as well. We should not wait until it is too late to realize that we need a defense against a confirmed threat or, even worse, the survival tactics to protect our societies, standards of living, and characteristic ways of life.

While we should not panic, we should take reasoned steps to survey the space within our solar system and perhaps beyond it to a certain extent. The detection component is arguably the most important part of the planetary defense strategy. Unless we confirm that an object is on a collision course with the Earth, we cannot know that the other two components may become necessary. We should undertake surveys first, and we are doing so, because we can accomplish them during the downtimes of telescopes normally used for astronomical research. In time, we should dedicate instruments full time to the detection task.

B. Defense

Tactics to divert or destroy an object heading for the Earth regularly fill the pages of the writings devoted to the threat of asteroids and comets.[§] The technical details concerning this subject matter fall outside of the scope of this discussion. Suffice it to state that we need gain the capability to defend ourselves whether we do so by deflection, destruction, or some other approach. This particular topic will receive attention here from an astrosociological perspective. That is, the emphasis relates to the social and cultural implications of the defense of societies, particularly their social structures, ideas (including values and knowledge), and their material culture. The discussion in this area ties defense issues with astrosociological concerns.

One thing seems clear from the literature in this area. The potential impacting objects are so diverse in size, density, and composition that one type of defensive system cannot possibly defend the Earth or human societies. Moreover, the lead times will vary. The defense component requires an approach characterized by multiplicity rather than uniformity. The technical complexities these considerations add to the overall system in turn complicate the process of gaining approval for such a system. If viewed as too overwhelming and/or too expensive, governments may find it easier to do nothing.

A realistic approach would involve testing and implementing parts of the overall system that can defend against the smallest objects deemed potentially harmful and moving up in scale as technology and budgets allow. Simultaneously, however, systems capable of defending against larger objects should be tested and implemented if breakthroughs and political will dictate. Contingency plans could devise ways to utilize existing technologies until we build a dedicated system for a particular category of threat.

Defense, like each of the three components, requires political commitment as well as support from the population of any nation considering such a system. The financial cost will be high, so participating governments and international bodies will require adequate proof of the risks involved. Already, however, the impacts on Jupiter and a few recent near-Earth misses have already provided a clear objective picture of the risk on a global basis. The real question regarding implementation and operation of defensive systems rests on how close to the ideal type various governments and international bodies decide to go. The overall defense component will ultimately depend

[§] For examples in the literature, see the references at the end of this article (notably Lewis (2000); Lewis (1996); Morrison et al. (2004); Steel (1995), and Verschuur (1996)).

on a coordination of elements that complement one another in terms of the type of defense provided, warning time, and coverage of the planet.

C. Survival

This third component receives very little attention in the literature primarily because social scientists do not typically engage in the discourse regarding this subject matter. To be fair, the space community does not completely ignore this area of research and policymaking. For example, the AIAA[26] included this consideration in a position paper on planetary defense strategy as follows:

> **6. Sponsor research to assess the political, social, legal and disaster relief consequences of a serious NEO threat, mitigation effort, or possible impact.** The response of the public, elected and government officials, the media and disaster relief agencies to a NEO impact or to a serious threat and mitigation effort should be investigated. Such information may be critical to minimizing the effects of an actual impact or maximizing the likelihood that a deflection mission would be successful [emphasis retained from the original].

The statement above notes that essentially astrosociological research can even impact favorably upon the success of a mitigation effort. Another example comes from the Spaceguard UK website's list of recommendations. The relevant recommendation appears below.

> **Recommendation 8 - Studies of impacts and environmental and social effects.** We recommend that the Government should help promote multi-disciplinary studies of the consequences of impacts from Near Earth Objects on the Earth in British and European institutions concerned, including Research Councils, universities and the European Science Foundation [emphasis retained from the original].[**]

Even though the study of *social effects* receives only passing mention, it does nevertheless create an opening for social scientists to work on the types of issues emphasized in this discussion. Here, it receives the greatest attention of the three parts of the planetary defense strategy.

Burrows[27] argues that protection of the Earth and our collective civilization represents a vital goal, and it is best accomplished in a variety of ways including moving a sizable number of humans off planet as well as greatly improving the other two elements of this overall strategy. Much of the money needed to accomplish this, he argues, is derivable through the elimination of waste and reallocation of funds at NASA as well as other institutions and agencies that comprise the social structures of societies.

The expansion of an astrosociological approach would emphasize the protection of the human species; and more precisely, it would attempt to ensure the survivability of human societies in order to carry on from the point of impact should the defensive measures fail. Essentially, survival entails resisting the effects of a direct impact upon the Earth or any other effects that occur from a cosmic object such as the creation of tsunamis or even the equivalent of a nuclear winter. This phase of the strategy is no less challenging or less financially burdensome than the other two phases.

Social scientist Albert Harrison[28] emphasizes the need to ensure the viability of "survival communities" by determining which criteria will ensure maximum protection. The need to take other measures also exists. Another set of considerations involve:

> …finding secure locations, constructing and stocking shelters, ensuring that the people who are entitled to be at the shelter are present and accounted for, ejecting stowaways, and maintaining law, order and morale during the period of confinement.[29]

In addition, as Harrison also observes, social scientists have conducted extensive research on life in isolated circumstances that can assist us in preparing for the survival phase should it become necessary. The best approach is to protect as many people as possible in shelters scattered all around the world. Selection criteria should include the power elite while also including a proportional number of citizens that reflects the most important characteristics of the population distribution as a whole. For example, the surviving population would benefit the most from a great diversity of occupational statuses within its ranks because it could take advantage of the great variety of skills available to them. This would greatly assist the population to survive, especially in the calamitous of circumstances.

Thus, survival partly involves a similar approach to the utilization of bomb shelters against nuclear attack commonplace during the Cold War. It would require the building of infrastructure on a much larger scale, however. Another difference, obviously, involves the inability to threaten a cosmic object heading for a collision course with the Earth through the use of policies such as Mutually Assured Destruction (MAD). An asteroid, for example, is not subject to negotiation like another government. This fact requires that governments around the world commit to the construction of underground and otherwise hardened facilities that can allow for the carrying on of social life in a more or less usual manner. As with the other components, the question arises: who will pay for such facilities in developing nations or those who refuse to devote any resources to the overall project? Unlike the other two

[**] Quote taken from Spaceguard UK website at URL: http://www.spaceguarduk.com.

components of the strategy, this component involves *extensive* construction of material culture within the borders of individual nations.

Peter et al.[30] suggest the need for at least two types of shelters. *Short-term shelters* would exist for impacts of small asteroids (less than one kilometer in size) since the devastation would not occur on a global scale. Different segments of a population could access both public and private shelters meaning that different sets of decision makers would decide how to populate them. In contrast, *long-term shelters* would serve a different purpose.

> Long-term shelters should be designed to host people for 5 to 10 years. They would have the two main goals – to maintain a colony of humans to preserve humanity until they can repopulate the Earth and to preserve the key technologies, global knowledge, and culture until the Earth ecosystem returns to habitable conditions for humankind. These shelters will be underground colonies with all facilities mandatory to preserve life.[31]

This passage demonstrates again that the survival component advocated here is not a new idea. However, the intensity of research by social scientists needs to increase so that we may become better informed about the social and cultural complications that may arise. We must also become much more attentive to the needs of the populations and governments in different societies (which will differ from one another on a multitude of diverse measures).

Survival exists on three distinctive yet interrelated dimensions, all of which must occur simultaneously and successfully. The three dimensions include (1) *the cultural dimension* (i.e., ideas including values, norms, and material culture); (2) *the social dimension* (i.e., social structures such as groups, organizations, and institutions); and (3) *the personal dimension* (i.e., the individuals in the population). The most common focus involving survival in the literature falls upon saving people without enough regard to cultural or social protection. This new focus comes from a social science perspective that fall beyond the scope of research normally carried out by most members of the space community.

Do we have the willingness to build infrastructure that can ensure the survivability of societies in all three dimensions? This component of the strategy will likely receive the greatest amount of complacency and opposition due to a number of reasons including: (1) its cost; (2) our potentially unrealistic faith that we can defend ourselves from an object heading in our direction; and, perhaps most dangerous, (3) the mistaken assumption that the risk is too small to warrant a sizable or serious course of action. The most recent "scares" from asteroid Apophis and others only resulted in timid responses focusing on detection and defense improvement. The survival element of the proposed strategy received no or extremely little consideration.

In the end, each society will need to make decisions about the whether or not to put this component into practice, and beyond that, how many resources to allocate to it as well as which tactical areas would receive funding. The nature of survival component implementation would also constitute important data valuable to other nations as guidelines for their decisions. It may be that particular nations will decide to take the ultimate risk of ignoring this survival element altogether. Given the current status of our technological capability to defend against NEOs, or probably worse long-duration comets unknown to us, their recovery if struck by a cosmic object would be difficult at best.

Finally, each nation will need to decide how to implement this component of the strategy in a way that would allow them to protect their citizens, their material culture, and the body of knowledge characteristic of their culture and sciences. Options include construction of shelters for average citizens, underground libraries and art galleries, and shelters for societal elites such as government leaders and scientists. Escape plans for moving coastal residents to higher ground in the circumstance that an object strikes an ocean represents another survival tactic due to the potential of the impact creating a tsunami. Would some citizens adopt an underground lifestyle in order to operate and protect underground shelters, libraries, and art galleries? Given the fact that a large object can potentially destroy the human civilization, such considerations should receive serious consideration. The decision to implement a survival plan for developing nations will require assistance from developed nations, possibly through a program operated by the United Nations or new international body dedicated specifically to the task. We must approach this challenge on a large scale. We must take rational steps as societies to protect ourselves on all three dimensions rather than allowing nature to make such decisions for us.

D. Societal Protection on Two (or More) Fronts

Efforts to protect the Earth from impact must intensify and become coordinated on a global scale, to be sure. However, we must also simultaneously move societal assets (including, of course, populations) off the Earth. This dual strategy will increase the likelihood of the survival of human beings *and* their societal assets (i.e., cultures and social structures). It will become vital to transfer societal assets, cultural elements including material culture and social structures off the Earth along with the population. Settlements in space will need to recreate institutions such as politics, family structures, a functioning economic system, religious groups, a criminal justice system, perhaps even a military, and recreation.[32] A wide variety of statuses will help ensure the survival of the population as well.[33]

Survival tactics discussed in the previous section should involve measures taken on the Earth *and* those taken off the Earth. We can couple our return to the Moon with the construction of a lunar component of the planetary protection system. The individuals in the lunar settlement could include the families of those operating and repairing the system. If an object did evade defensive actions, this small part of humanity would survive the impact on the Earth. A shelter of sorts on the Moon may someday exist to receive selected members of the Earth's population as technology allows for this possibility. A problem, of course, will involve the selection of the privileged few, perhaps based on a lottery system (or the old standard of saving the power elite).

As already mentioned, another survival tactic could involve underwater communities in our oceans. Much thought would need to go into this but it represents another way to protect our species from possible extinction. One item to consider involves the permanency of the community. One scenario could have populations living under the sea for a specific period and then replacing by another population. Another option would involve the establishment of a permanent "oceanic society" model. Of course, both models may exist together as different social groups develop their own implementation of this basic idea. One benefit that may arise from this is that it could serve as a good analog for *space societies* (i.e., space colonies and settlements).[34] The presence of astrosociologists to study the functioning of these societies and advise alterations to avoid major social problems represents a good example of applied astrosociology.

The more diverse our survival tactics, the greater would be our chances for saving humanity and its societies to a significant extent. Societal protection beyond just the construction of shelters upon the Earth's surface would greatly improve the odds of our survival but also those of continuing our social lives the way we did before any incident occurred. We can combine space research and oceanic research with an increased capability to protect the Earth and its societies in a significant manner.

V. The Need for, and Difficulties Associated with, Global Cooperation

Construction of a planetary defense infrastructure (i.e., material culture) involves a global effort, a level of cooperation now possible due to cooperation in other areas. However, some governments may still view planetary defense as a low priority due to more urgent social problems. Developing nations in particular may hold such a view, or they may simply find themselves in a situation in which they are unable to afford a costly contribution to the overall project. Developed nations may need to finance some aspects of the project for these poorer nations. Developing nations may need to find other ways to contribute, such as the provision of land for facilities and personnel to operate them. The obvious fact is that the entire cost to construct a planetary defense system and the outlay of additional funds to operate it on an ongoing basis will escalate to the point of unaffordability for one or even a few nations.

Negotiations would become necessary, as all parts of the globe require protection. If viewed as a single project, this effort would include all societies because all represent potential targets. For late detections, a regional response may be necessary in order to execute a drastic response. The best last-minute trajectory for a missile, for example, may require a launch from a developing nation. This capability involves military considerations due to the possible need of placing space weapons in the territories (even if not under the control) of nations with lower levels of military technology and/or potential enemies of democratic nations. Many of the sociopolitical issues unrelated to planetary defense may prove just as difficult to overcome as monetary and technical issues. Many governments will initially evaluate planetary defense as a low priority, especially those developing countries that face practical social problems such as overpopulation, disease, and violence. Still, they require saving as well whether or not they agree to cooperate.

Space exploration can lead to planetary unity partly due to the economic incentives associated with doing so, but can also produce other positive effects.

> Other aspects of space exploration reinforce these trends toward unity and cooperation as well. For example, the cost of large-scale space projects encourages cooperative efforts and a natural movement toward what I have called the human space program. Because such projects are very expensive, running into the billions of dollars, joint efforts make good economic sense.[35]

However, as White also points out, large-scale projects such as the construction of a planetary defense system can result in negative outcomes such as a totalitarian world government. As we build this new system, we must also keep in mind the values and other societal assets we attempt to save in the first place. Otherwise, the unity gained harms individuals whether we are struck by an asteroid or not.

The United Nations or new dedicated international body must become involved in a coordinating effort involving the determination of which nations can afford to assist (and in what ways) along with construction efforts to implement the three components of the strategy introduced here. As we build the new system, the values, norms,

and priorities of the member nation-states should receive due consideration in order to achieve a positive outcome for humanity as a whole.

Problems may also ensue based on national security issues.[36] The impact of a comet or asteroid may harm some nations more than others. Some government leaders of the less affected nations may see this situation as an opportunity to take advantage of their historical nemeses in some way, including the introduction of warfare. Treaties at the international level can help to minimize the risk of such social problems by requiring cooperation and prohibiting conflict under these circumstances. If the impacting object is large enough to threaten humanity on a global scale, then this type of requirement should prove enforceable. However, for a localized effect, enforcement may prove more difficult. Astrosociologists and independent social scientists can provide insights before this situation arises and advice following its aftermath. Political scientists and international relations scholars could prove invaluable.

VI. Conclusion: Responding to the Threats

The objective threat of an impact according to the experts is very real. The only questions that remain unknown at this time involving an impact relate to the time, location, composition of the object, and the size of the object. With a limited detection component and virtually no defense or survival component, the threat looms much larger than it would be with these assets in place. As of today, a two-kilometer object that struck the Earth could literally result in the extinction of our species. Assessment of the threat no longer serves as the main consideration. Clearly, the important question to answer now relates to this: what is humanity willing to do about this threat as a whole and as individual societal entities?

In a sense, the main purpose of this essay boils down to a single position that favors a change in which traditional participants within the space community bring the social sciences into this area of research in a way that allows astrosociologists to receive collaborative status. Achievement of this goal will undoubtedly prove difficult based on past practices, though the future demands the change for the many reasons already discussed. There is great hope, however, as a slow though steady pace best characterizes the development of astrosociology.

The need to include social scientists who participate on a practical basis includes such a variety of applications. Policymakers of different cultures will require assistance in all the difficult decisions were will need to make. Applied astrosociologists can also provide space scientists and engineers an ongoing awareness of the social and cultural implications while participating in the planning of the overall system, individual components, and the various tactics under consideration. Research in the various social settings that will arise through the construction of the planetary defense system, including those on the Moon and on the ocean floor, requires social scientists due to the nature of these concepts and operational variables involved (leaving space scientists and engineers to pursue their own areas of expertise). The need for astrosociologists and members of the traditional space community to work together will become more apparent as plans and construction get underway, so an early start to establishing a collaborative relationship can greatly assist in the planning, construction, and operation of the overall system.

The sky is not falling. On the other hand, the threat of a serious impact is real and therefore deserves attention. The imperative to protect the Earth and human societies exists because we now know of the threat. Without panicking, we must thoughtfully develop a reasonable set of strategies to protect life, as we know it. Even the survival component requires consideration and debate before its implementation. The shelters discussed earlier may seem like going too far by many. However, we should look at the problem on a more general basis. Steps taken to protect us from asteroids and comets can also prove useful against other calamities such as terrorism, global warming, nuclear fallout, and other atmospheric calamities.

Saving the human species in the form of scattered groups of individuals, while perhaps sufficient to carry out its existence, would be inadequate to save human cultures and social structures that comprise our societies. The best defense rests in solutions that totally avoid or greatly minimize the effects of a cosmic impact. We must be vigilant in identifying cosmic threats and prepared so that we can adapt a viable solution to the problem quickly. This strategy requires development of material culture, an asteroid protection infrastructure of sorts on a global scale. This necessitates its integration into relevant institutions such as politics and the economy. Dedicated social groups must provide vigilance against cosmic threats. The several nation-states with the capacity to assist significantly in the effort in order to make this approach feasible should pay costs and take the ultimate responsibility for saving all human societies although the political challenges will prove difficult to overcome.

Individual projects led by astronomers or other space scientists represent a helpful approach as they may be fortunate enough to detect the next doomsday object. Realistically, small projects can only survey a very small portion of the space environment that surrounds our planet. National and ultimately international formalized efforts must come online to make the effort a serious one. Huge levels of political will and resources to build the necessary

physical and social infrastructures would need to develop in order to implement a serious detection component, not to mention the defense component of the overall system required to destroy or deflect the object harmlessly away from a collision course with the Earth. Do the members of human societies have the will to commit the necessary resources to build such a defense system? It appears that the overall sentiment is moving in that general direction as evidenced by the newly emerging small projects in various societies. Astrosocial knowledge that points to threats capable of destroying human societies and perhaps even humanity itself tends to evoke greater interest as the evidence accumulates.

In order to implement anything close to the ideal type of the planetary defense strategy, space scientists and engineers will need to collaborate with astrosociologists. The ideal type represents the most capable system allowable by technology and implies full support by all governments and the publics of societies around the world. However, the ideal type can never exist due to compromises resulting from less than full support by various circles within societies. Other priorities and conflicting assessments of future risk will undoubtedly complicate planning and implementation of the strategy. The space community does not exist in isolation. Space scientists and engineers will have to work within the context of the societies they attempt to protect. They will need to convince others to agree with their ideas related to the implementation (and even to pay for the planning) of a system as close to the ideal type as they deem appropriate. Even the decision about how much of a threat asteroids and comets pose involves debate within the scientific community as well as outside of it.[37] There is likely a correlation between the perceived threat assessment and how closely the planetary defense system ultimately mimics the ideal type. Additionally, other issues will undoubtedly complicate this relationship.

Moreover, politicians will make the final decisions about how much and where money is spent on the planetary defense system. While it already goes toward the detection component, the defense component and especially the survival component will prove a harder sell to a great many politicians. It is easier (and cheaper) to be a skeptic, or Pollyanna, rather than a doomsayer. Recent history seems to favor the former position. Although no one can be certain, the odds are that we have considerable time to understand the threat a bit more and implement elements of the planetary defense system proposed here in a staged manner over time, always adjusting our plans as we acquire new knowledge. Because this would represent a more affordable approach, politicians will more likely approve this piecemeal implementation. Belton[38] argues that we should approach this using a three-phase process consisting of (1) the *strategic* phase intended to clarify the overall goal of the program, set up its scope, identify its funding, and then assign responsibilities; (2) the *preparatory* phase that "includes all that needs to be done to achieve the scientific and engineering requirements on which the design of a reliable and effective mitigation system will depend;" and (3) the *implementation* phase that "can only be pursued efficiently after the preparatory phase is completed and a hazardous target has been identified." This approach, or something similar, represents a methodical response to the known threat as long as we add the survival component.

Over time, the system will become more capable and inch toward approximating the ideal type as closely as we wish to make it over a long period. At the same time, we should think about implementing at least rudimentary capabilities for all three components just in case an object comes at us without warning. Politicians in consultation with scientists and others will need to decide the extent of such an immediate capability. We have already begun detection operations on a very limited scale and discussion about (and I suspect some experimentation of) defense tactics.

Social scientists can add missing insights that fall outside the bounds of the space community based on its current membership. They can conduct research to determine how willing publics will be to support each of the components of the strategy and their reactions to detection, defense, and survival tactics should scientists detect a comet or asteroid on a trajectory intersecting the Earth. Peoples of different cultures will react differently as will subcultures within each of them. Social scientists can help to minimize the level of panic and thus help to maximize the level of cooperation. These areas of study represent new data points pertinent to a planetary defense strategy though beyond the expertise of space scientists and engineers.

Advocates of the strategy may aid their cause by linking the survival component to protection from other threats such as terrorism and even hurricanes and tornadoes. Saving money is possible if we involve the space programs and oceanographic social structures of various societies in a way that takes advantage of survival communities by conducting research of these isolated social groups for applications pertinent to their goals. Again, these types of cooperative strategies can lower the costs of the planetary defense system.

While the sky is not falling, at some point, going the way of the dinosaurs is probably inevitable without the creation of a set of social institutions located worldwide that would dedicate themselves to our protection from cosmic goliaths. While the probability of an impact at any given time is statistically low, the consequences to people living at the impact site are serious. If large enough, the consequences can threaten all of humanity and its societies. The construction and operation of a global planetary defense system with all three components puts into place the

possible salvation of humanity that may require activation of defensive and survival tactics at any time. We should look at it as an insurance policy for humankind precisely because it could pay off at any time; worthwhile whether pays off in one or more decades, or one or centuries. No one can seriously argue that we will not recoup our investment if the system saves humanity from dystopias or extinction sometime in the future.

The question boils down to the following: are we willing to protect all or part of our human civilization against an unseen enemy that may strike in 500 years, or tomorrow? No doubt exists that our predictive ability lacks precision due to the incalculable number of constantly changing variables involved. On the other hand, the next object that will someday target the Earth is out there somewhere. Ultimately, individual societies must decide for themselves the extent and character of their participation. On a general level, can we afford to continue to ignore it for the most part? If we do, just how much more intelligent are we than those clueless and long-extinct dinosaurs?

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