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International Association for the Advancement of Space Safety
A 3 POINT ACTION AGENDA TO ADDRESS COSMIC HAZARDS AND PLANETARY DEFENSE

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ABSTRACT
The IAASS and the JSSE gives its prime focus to astronaut safety and safe space transport, but one of its important areas of concern is that of cosmic hazards and planetary. This is a significant area because strategies for planetary defense could involve the safety of millions if not billions of people. This article addresses the latest information as to the nature of significant areas of cosmic risks, gaps in our knowledge, and an agenda for research to further planetary in future years.

U.K. Royal Astronomer, Sir Martin Rees has noted: “Throughout its history, the Earth has been impacted by asteroids and comets and buffeted by solar flares. But the consequences of these natural phenomena are more catastrophic today, because the infrastructure on which our civilization depends is more elaborate and more vulnerable. …we have instruments, both on the ground and in space, that can give us forewarning of threatening flares and impacts. We are learning how to make our systems more robust and resilient. Moreover, we will not remain helpless in the face of these threats because we are empowered by advancing technology and engineering.” (Rees)

But despite this quite hopeful statement by the U.K. Royal Astronomer, the truth is that there are many severe planetary risks ahead. Current space agency agendas, space instrumentation, changes to the earth’s magnetosphere, and research programs are, in fact, not fully responsive to the needs of a truly effective planetary defense. (Pelton and Allahdadi)

This article sets forth some of the greatest lacks in current space programs and notes new or revised efforts that could better prepare our small six sextillion metric ton planet from cosmic dangers. Currently there are several cosmic concerns. These include asteroid and comet strikes from Near Earth Objects, solar flares and coronal mass ejections, and the build-up of orbital space debris that could endanger the safe launch of critical space infrastructure over the longer term future. This article focuses on potentially hazardous comets and asteroids and severe solar storms.

1. INTRODUCTION
The urgency and importance of cosmic hazards has only recently come into clear focus with the development of historical knowledge that has come from researching the past mass extinction events that have over time eliminated over 99% of all species that have ever existed on planet Earth. The biggest single extinction event occurred some 67 million years ago. This so-called K-T extinction event eliminated over 70% of all species on the planet — both animals and vegetation — and this was caused by a 6 kilometer asteroid smashing into the coast of Mexico and the Atlantic Ocean. Imaging from the International Space Station reveals from space the remnants of the huge crater that is the aftermath of this tremendous collision that created a death cloud over the planet that screened out the life-giving light of the Sun and killed off the dinosaurs.

![Figure 1: Photo from the ISS of the crater along the coast of Mexico from the K-T Mass Extinction Event (Figure courtesy of NASA)]
IT networks and electrical grids to be disabled by solar events. Second the protective shield provided by the geomagnetosphere appears to be weakening. (Wocover) The magnetic North Pole has slipped down to Siberia and headed further South. Some computer modeling estimates developed at the Max Planck Institute suggest that the protective system provided by the Earth’s magnetic field in coming decades might end up being only 15% as effective as it was just two decades ago. Figure 2 below depicts a modeling of the protective Van Allen Belts that could occur as the magnetic South and magnetic North Poles move closer together in coming decades. The bottom line is that there are many things that can be done to initiate a planetary defense program that are currently not being done that should be undertaken sooner rather than later.

Figure 2: Modeling of Van Allen Belts During a Reversal of Earth’s Magnetic Poles (Graphic Provided Courtesy of the Max Planck Institute, Berlin, Germany)

2. ISSUES WITH DETECTING AND TRACKING NEAR EARTH OBJECTS

There have been concerted efforts to detect potentially hazardous asteroids using both ground and space based systems. The Wide-field Infrared Survey Explorer was repurposed to become the NEOWISE to search for Near Earth Objects. (WISE) This was in response to Section 321 of the NASA Authorization Act of 2005 (Public Law No. 109-155), also known as the George E. Brown, Jr. Near-Earth Object Survey Act. The specific objectives of the George E. Brown, Jr. NEO Survey Program were “to detect, track, catalogue, and characterize the physical characteristics of NEOs equal to or larger than 140 meters in diameter with a perihelion distance of less than 1.3 AU (Astronomical Units) from the Sun”. This assignment to NASA was to achieve 90 percent completion of the survey within 15 years after enactment of the NASA Authorization Act of 2005 as signed into law by President George W. Bush on December 30, 2005. Achievement of this assignment by 2020 seems unlikely to be achieved unless NASA could accelerate plans to construct and launch the NeoCAM project that has been designed by NASA as a new Infrared telescope that is designed to complete the assigned task of potentially hazardous asteroids. This project has only be picked for “technological definition” and is geared to locating asteroids that are larger than 140 meters—as directed by Congress. (NeoCAM) There are those that would suggest that both the assignment from the U.S. Congress and the NASA search capabilities are well off the mark of what is needed for an effective planetary defense effort. This guidance in the so-called George Brown Act of 2005 was not based on careful studies that demonstrate that an asteroid under 140 meters would likely cause only minimal harm. The truth is quite the opposite. Asteroids of 35 meters are “city killers”.

To get an idea of what size of asteroid represents a major threat one only has to look at the evidence from the Tunguska asteroid event of June 30, 1904. This space rock traveling at an estimated 54,000 kilometers/hour (or about 33,500 mph) exploded some 8 kilometers (or just over 5 miles) above the Siberian forest with the explosive force more than 1000 times the force the Hiroshima Atomic Bomb. This air-based asteroid explosion flattened and incinerated a forest of 2000 sq. kilometers containing 80 million trees in an almost perfect radial design. This asteroid which could have wiped out San Francisco and Silicon Valley) was not 140 meters in diameter, not 100 meters, not 75 but rather only about 40 meters in diameter. According to Dr. Donald Yeomans, head of NASA’s Near Earth Objects office this rather “insignificant” space rock was able to do an incredible amount of damage. (The Tunguska) The destructive impact of an asteroid that was indeed as large as 140 meters in diameter and traveling at perhaps 50,000 mph (or 80,000 kilometer/hour) — a more typical speed for an asteroid traveling relative to Earth orbit — would collide with a force that was some 65 times greater (or the equivalent of 65,000 Hiroshima bombs). In short, there is a really important problem here and that is that the guidance given to NASA by the U.S. Congress now over a decade ago as to what to look NASA was instructed to look for in terms of size and urgency was, quite simply, WRONG!

In fact, asteroids some 35 meters in diameters should be considered major threats. In terms of mass an object that with a 35 meter diameter is 43 times smaller than those being searched for in the NASA search protocol. And that is the least of the bad news. As one looks for smaller and smaller asteroids the numbers go up exponentially. There are likely to be many hundreds of times more potentially hazardous asteroids that are 35 meters or more in size than there are asteroids that are 140 meters in size. The B612 Foundation, that was founded by Apollo 9 Astronaut Rusty Schweickart and now headed by Astronaut Ed Lu,
has now campaigned for years for new space programs that can detect potentially harmful asteroids down to 35 meters in size. Indeed their Sentinel spacecraft positioned in a solar orbit similar to that of Venus is under contract with Ball Aerospace. Currently close to half the funds needed to finish this infrared telescope project and launch it into orbit. This program is far from a panacea and the problem of potentially harmful comets remains to be solved. (The Sentinel Mission)

Beyond the detection of potentially dangerous space rocks, there is much work still to be done. There is a need to develop: (i) better techniques to detect asteroids on a collision course with earth; (ii) improved air burst, water burst and land burst modeling; (iii) greater understanding of the impact that solar radiation and gravitational affects can on the orbits of asteroids that come in close proximity to the sun; (iv) better characterization of the size, shape and composition of asteroids that might have to be diverted; and (v) the best techniques by which asteroids can be effectively diverted in their orbits by such means as directed energy beam systems, laser bees, or possibly even nuclear propulsion. And on top of these technical capabilities, we need to improve on and strengthen the processes that now exist with regard to the Minor Planet Center in Cambridge, Massachusetts and the Space Guard Foundation in Italy and UN authorized International Asteroid Warning Network (IAWN), as well as the Space Mission Planning Advisory Group (SMPAG).

Arthur C. Clarke in his award winning novel, Rendezvous with Rama wrote of a true planetary mission to ward off asteroids from planet Earth. For once humanity could be ahead of science fiction if all of the things were to be undertaken on a truly integrated global effort to achieve an effective asteroid and comet defensive space guard effort.

(Rendezvous)

But the problem is more than just asteroid and comet defense.

3. ISSUES WITH SOLAR HAZARDS

The damage that might come with a massive asteroids strike would be terrible indeed. The probabilities of a disastrous “black swan” event carrying out enormous damage to the global economy and great loss of life are actually much higher in the case of a major solar storm. A massive solar flare of X-Rays and even more energetic radiation can elevate the risk of cancer and genetic mutation. This is particularly true where the atmosphere is weakest in the polar region and where ozone holes can exist. The higher incidence of skin cancer in locations such as New Zealand and Southern Australia. (Ozone) But the greatest danger of all comes from the ion storms that can come from the Sun in the form of coronal mass ejections. (See Fig. 3) When the Carrington Event of 1859 occur telegraph offices caught on fire and the Northern Lights were seen in Cuba and Hawaii. In the middle of the 19th century, the risks to electrical systems were small because they did not exist. The Montreal event of 1989 that took out electrical systems from Chicago to Montreal, and the Halloween event of 2003 that damaged the electrical grid in Scandinavia are indicators that we are today increasingly vulnerable to major coronal mass ejections that end up flowing out from the sun and hitting the Earth.

A massive enough coronal mass ejection hitting Earth could possibly damage and take off line critical satellite networks, cripple electrical grids and pipelines, and possibly adversely affect information and communications networks and defense systems. If the GPS system were to be disabled, would likely lose the synchronization of the Internet.

And as noted earlier, there is data from the ESA Swarm satellite probes that suggest that the Earth’s magnetic poles are shifting and with it the protective shield represented by the Van Allen Belts are weakening. (ESA’s Swarm)

There is now coming into focus a rather disturbing equation. This equation that is possibly becoming true indicates an imbalance. It shows on one hand an increasing global population, more and more electrical grids, more electrical devices and satellites, and more and more dependency on modern infrastructure. On the other hand is a global atmosphere with a weakening protective ozone layer due to pollution, a geomagnetosphere with shifting magnetic North and South poles, and a Van Allen Belt system that is less able to protect against solar storms. These concerns, if anything are of greater concern than even the threat from killer space rocks. There are other problems as well. These include increasing build-up of space debris, and climate change issues that are also
longer term problems as well and they too require global cooperation and new technological development to address as well. The bottom line is that there needs to be a global agenda for cooperation and technological development to address these very profound space safety issues. The time for action is now. Delay in addressing these issues will likely see the problem getting worse and the solutions more costly and difficult. The urgency of action is hard to convey in a short article. If one would like to hear and see more on why cosmic hazards are to be taken seriously and learn more there are three videos on You Tube that can provide a great deal more background in a very accessible way. These videos are:

1. “If there were a day without Satellite” 3:58 min. https://www.youtube.com/watch?v=5gM7YC8Zv4
2. “Cosmic Hazards”(Short Version) 5: 50 min. https://www.youtube.com/watch?v=UJDGD73aD9s3
3. “Cosmic Hazards” (Long Version) 25 min. https://www.youtube.com/watch?v=RwRdyag2dxA

4. A NEW AGENDA FOR COPING WITH COSMIC HAZARDS

What needs to be done to address these space safety issues? The following 3 point action agenda is recommended.

a. Global assessment. This assessment and inventory of cosmic risks should be started now. Individuals countries should be considering the nature of their vulnerability to cosmic risks, but in addition, organizations such as the IAASS should cooperate to develop a global assessment of risks and possible strategies to mitigate those risks — possibly in cooperation with the UN Committee on the Peaceful Uses of Outer Space. Units or organizations such as the UN Office of Outer Space Affairs, IAASS, the McGill Air and Space Law Institute, the International Space University, the International Academy of Astronautics and other organizations with a global reach and focus could assist with such a global assessment of cosmic risk levels and possible planetary defense systems.

b. Space Agencies Raise the Priority of Planetary Defense. All of the space agencies of space-faring nations should formally adopt Cosmic Risk Assessment and Planetary Defense as a Top Priority. This should be more than a token gesture. ESA, JAXA, Roscosmos, CNSA, ISRO, and NASA should create posts just to address cosmic hazards and planetary defense. NASA, for instance, should create an Associate Administrator for Cosmic Risk Assessment and Planetary Defense. This office would oversee research on the sun, solar flares, coronal mass ejections, cosmic radiation, the Earth’s magnetosphere, ozone holes, the Van Allen Belts, climate change, NEO tracking and asteroid and comet diversion techniques, orbital debris remediation, and participation on all international forums related to these topics. Until such actions are taken within space agencies, cosmic hazards and planetary defense will continue to be treated as a low priority and non-essential function by space agencies around the world. The level of funding for such activities need to be raised from less than 1% of space agency funding to at least 5%. If this could be added a new funding to space agency budgets it would greatly facilitate the ready acceptance of this new priority mission.

c. New Priority Research related to Cosmic Hazards. After national and global assessments are made of both major cosmic hazards and potential planetary defense strategies, there should be a global space agency conference to establish a priority space research agenda. This would include such items as: (i) New ways to cope with the reduced protective capabilities of the geomagnetosphere; (ii) Possible dual-purpose deployable protective shielding and solar power generation capabilities at L-1; (iii) Other innovative strategies to address the problem of powerful solar storms during a time of reduced protective strength of the Van Allen Belts; (iv) Acceptable strategies for diversion of potentially hazardous asteroids or comets from Earth impact; etc.

5. REFERENCES

1. ESA’s Magnetic Field Mission http://www.esa.int/Our_Activities/Observing_the_Earth/The_Living_Planet_Programme/Earth_Explorers/Swarm/ESA_s_magnetic_field_mission_Swarm, last accessed on Dec. 30, 2015

2. NeoCam “Neo Cam: Finding Asteroids before they Find Us” neocam.ipac.caltech.edu, last accessed on Dec. 30, 2015


International Association for the Advancement of Space Safety


The 8th IAASS International Space Safety Conference “Safety First, Safety for All”, will be held in Melbourne - Florida (USA) in the period 18-20 May 2016. The IAASS conference is the premiere international forum dedicated to the discussion of a wide variety of space safety topics.

The conference offers a unique opportunity to meet top U.S. and international experts in space safety and related engineering fields, from industry, academia and agencies. An occasion for exchanging views and establishing new professional bonds, towards the common goal of forging a global space safety culture.

The online registration is open. You can access the online registration form at http://iaassconference2016.space-safety.org/registration/ or directly by clicking the red tab at the bottom of this page. Early Birds registration ends 14 March 2016.

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At the occasion of the Conference Gala Dinner on May 19, 2016 the IAASS will assign three awards:

- Jerome Lederer Space Safety Pioneer Award
- Vladimir Syromyatnikov Safety-by-Design Award
- Joseph Loftus Space Sustainability Award

These prestigious awards are a means to honor and recognize safety professionals and systems designers and engineers who have made outstanding contributions towards space safety.
Progress in space safety lies in the acceptance of safety design and engineering as an integral part of the design and implementation process for new space systems. Safety must be seen as the principle design driver of utmost importance from the outset of the design process, which is only achieved through a culture change that moves all stakeholders toward front-end loaded safety concepts. Superb quality information for engineers, programme managers, suppliers and aerospace technologists.

Safety Design for Space Systems, Chinese Edition
Elsevier 2011

Progress in space safety lies in the acceptance of safety design and engineering as an integral part of the design and implementation process for new space systems. Safety must be seen as the principle design driver of utmost importance from the outset of the design process, which is only achieved through a culture change that moves all stakeholders toward front-end loaded safety concepts. Superb quality information for engineers, programme managers, suppliers and aerospace technologists.

Space Safety Regulations and Standards
Elsevier 2011

Space Safety Regulations and Standards is the definitive book on regulatory initiatives involving space safety, new space safety standards, and safety related to new space technologies under development. More than 30 world experts come together in this book to share their detailed knowledge of regulatory and standard making processes in the area, combining otherwise disparate information into one essential reference and providing case studies to illustrate applications throughout space programs internationally.

Safety Design for Space Operations
Elsevier 2013

Safety Design for Space Operations provides the practical how-to guidance and knowledge base needed to facilitate safe and effective operations safety in line with current regulations. With information on space operations safety design currently disparate and difficult to find in one place, this unique reference brings together essential material on: safety design practices, advanced analysis methods, and implementation procedures.