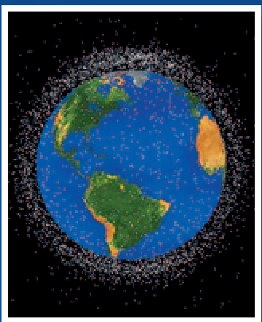
INTERNATIONAL ASSOCIATION FOR THE ADVANCEMENT OF SPACE SAFETY

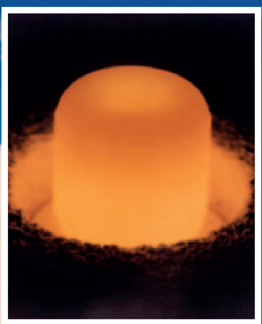
ISSF INTERNATIONAL SPACE SAFETY FOUNDATION

Space Safety Magazine

Issue 1
Fall 2011



Commercial Space Debris Removal



Safety of Nuclear Powered Missions

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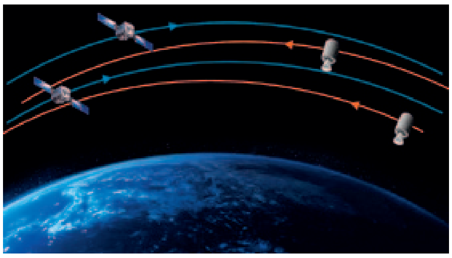

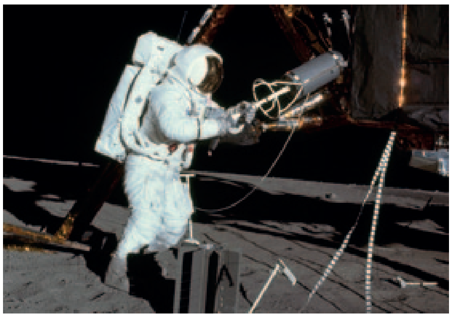

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Cover pictures:
Artist concept of SLS launching - Credits: NASA
Central Region of the Milky Way - Credit: NASA, ESA, SSC, CXC, and STScI

Welcome to the First Issue of the Space Safety Magazine

Dear Reader,

Welcome to the first issue of the Space Safety Magazine, which is the joint "voice" of the IAASS (International Association for the Advancement of Space Safety) and of the ISSF (International Space Safety Foundation). The Space Safety Magazine supersedes the IAASS Newsletter that you were familiar with and enjoyed.

There is an important change of scope and target audience for the magazine. The main objective of the IAASS Newsletter was to publish opinions, thoughts, studies, analyses and experiences of the IAASS members to maintain a continuity of information exchange between IAASS conferences. The IAASS Newsletter was written by members for members. The Space Safety Magazine is written instead by space safety specialists (members and non members of IAASS) and by professional scientific journalists for the wider audience of those that have an interest, need or simply curiosity to know the current developments in the field of space safety and sustainability. The magazine will still include information about IAASS and ISSF upcoming events and life, but the relevant websites will truly be the main source of such information.

Why then a joint "voice" for the IAASS and for the ISSF? The Association and the Foundation are two essential pillars of the same project. One brings the knowledge, independence and dedication of its professional members, the other the financial support of corporations and government organization, which recognize the added value of independent safety research and academic education to their strategic objectives.

The space industry is expanding worldwide and with it the safety risk because of poor attention, lack of technical progress in the field, cumulative effects, and weak or non-existent international rules. Eventually the prospect for industry growth will be badly hurt if the necessary course of corrective actions is delayed. Safety risk in space missions refers to the general public safety (on ground, on air and at sea), safety of launch range personnel, and safety of humans on-board. Space safety is also generally defined in a wider sense as encompassing the safeguard of valuable facilities on ground (e.g. launch pads), of strategic and costly systems on orbit (i.e. global utilities), payloads as well as the safeguard of the space and Earth environment.

The International Association for the Advancement of Space Safety (IAASS) is the premiere association of professionals working in space safety and related engineering and management fields, but because of the very specialized field of interest the IAASS is and will remain a relatively small group of professionals yet a unique think-tank with a great potential for shaping attitude and culture of the wider space programs community. Because (numerically) small, the IAASS is unable to financially support all its initiatives and needs, in particular the support of sponsors and donors for the promotion of independent space safety research and specialized academic education. Providing this financial support is the purpose of the International Space Safety Foundation.

The question is then, why should a corporation or government organization sponsor independent research and academic education? There are multiple reasons, but the top one is that safety is often a strategic business growth driver. Safety advancement remains one of the key prerequisite for the success and expansion of many businesses. Sometimes continuous safe performance is even critical for company, program or sector survival. The faulty design of a single product can ruin its manufacturer's business (as it happened several times in aviation). An unsafe design may terminate a unique design and operational concept (e.g. Shuttle, or the supersonic Concorde). A single major disaster can endanger an entire industrial sector (e.g. nuclear power generation after Fukushima). Any support to safety initiatives is therefore a positive contribution to the well being, progress and expansion of the space industry as well.

It is a symbolic although accidental circumstance that the first issue of this Space Safety Magazine coincides with the retirement from service of the Space Shuttle and the end of that program. We truly believe that this is not the end of the Space Age, as someone has written recently, but the start of a new era in which it is recognized that commercial space is the key player in "near space" while the preparation of the next government exploration missions requires the prerequisite achievement of technological advancement and breakthrough that would make them feasible, affordable, safe and finally useful because of their technological fall-out on the society. We are not at the end of an era but at the beginning of a new one. The space race ended with the Moon landing. The international cooperation in space (not just bi-lateral symbols of goodwill) truly started with the International Space Station which the Space Shuttle and the International Partners made possible. The International Space Station is the highest moment (physically, technologically and morally) of cooperation between nations to date in human history and hopefully just the beginning of larger cooperation. The race is finished, now it is the time for steady and safe progress!

Welcome Space Safety Magazine, welcome to you!

Tommaso Sgobba
IAASS President

Frederick D. Gregory
ISSF Board Chairman

The Need for an Integrated Regulatory Regime for Aviation and Space

by Andrea Gini

Springer, October 2011
Ram S. Jakhu (Editor),
Tommaso Sgobba (Editor),
Paul Stephen Dempsey.

> "The global air transport is remarkably safe, secure and sustainable due to the fact that states have consistently and systematically honoured their commitment in abiding by the Chicago Convention"

The space industry has its historical roots in the Cold War. The United States and the Soviet Union developed rocketry as a mean to deliver nuclear weapons, satellite technology to spy the enemy territory without violating airspace, Global Positioning Systems (GPS) for precision targeting and so on. The civil space program, the peaceful face of the arm race, evolved from these roots: it is not a coincidence that the first astronauts were chosen among military pilots, and that both the R7 and the Atlas, which carried respectively Yuri Gagarin and John Glenn to orbit, were originally developed as intercontinental ballistic missiles.

The new space age, born after the end of the Cold War, brought a new degree of international cooperation and a massive commercial exploitation of space in particular in the field of telecommunications. The manned space programs of US and Russia are now tightly interconnected, as they both serve the International Space Station (ISS). New commercial operators will soon join governmental agencies in transferring goods and crews to the ISS. Commercial human spaceflight, both suborbital and orbital, will open new access opportunities to space. China and India are pursuing ambitious manned and unmanned exploration programs.

The new space age urgently requires an international regulatory framework to coordinate transparently and effectively space traffic control, launch and re-entry safety, and a number of support services such as space weather forecast and orbital debris monitoring. Such organization could be a new one or an extension of the International Civil Aviation Organization (ICAO), an organization which allowed the civil aviation to become the safe and reliable enterprise it is nowadays. The case for extension of the ICAO convention is based mainly on the observation that aviation and space have important operational interfaces and share common interests, such as space-bound and returning traffic through the international airspace, and space-based safety critical services for navigation, communication, space and atmospheric weather forecasts. Furthermore some future commercial space vehicles may be required to

An historical meeting during the 1944 Chicago Conference.
From left to right: A. M. Burden. Asst. Sec. of Commerce for air, L. Welch Pogue, Civil Aeronautics Board; Alfred L. Bulwinkle; Senator Josiah W. Bailey; Adolph A. Berle. Jr., Assistant Secretary of State, Chairman; Senator Owen Brewster; Edward Warner; Rep. Charles A. Wolverton; Fiorello H. La Guardia.

Conceptual view of the Space Fence control room, a program developed by Lockheed Martin enhance U.S. Air Force identification and tracking of orbiting objects. - Credits: Lockheed Martin

be certified for both regimes, and could operate from airports.

One of the original promoters of the idea of extending the ICAO convention to space is Dr. Assad Kotaite, who served at the ICAO for 50 years , 14 of which as Representative of Lebanon on the Council of ICAO, 6 as Secretary General and 30 as President of the Council. We asked Dr. Kotaite to comment on this idea, which is also the thesis of the book "The Need for an Integrated Regulatory Regime for Aviation and Space: ICAO for Space?", published by Springer in September and sponsored by the International Association for Space Safety (IAASS).What follows is an account of his personal vision on the ICAO mission, the accomplishments of the organization and the needs for an ICAO for space.

> "Transparency and globalization contribute to maintaining the integrity of the global air transport system"

Lessons learned from aviation: The ICAO Convention

"The International Civil Aviation Organization is a Specialized Agency of the United Nations created in 1944 at a Conference convened by the United States of America in Chicago to promote the safe and orderly development of international civil aviation through the world. ICAO, as a global organization, sets the standards and regulations necessary for aviation safety, security, efficiency and regularity as well as aviation environment protection. The Organization serves as a forum for cooperation in all fields of civil aviation among its 190 contracting states. The global air transport is remarkably safe, secure and sustainable due to the fact that states have consistently and systematically honoured their commitment in abiding by the Chicago Convention and its 18 Annexes which, altogether, contain some 10,000 technical and operational standards. During my tenure as President, the Council adopted Annexes 16, 17 and 18:

- Annex 16 relates to environment and aviation protection;
- Annex 17 relates to aviation security;
- Annex 18 relates to the transport of dangerous goods.

International Conventions on Aviation Security, which are now universally accepted, as well as the 1999 Montreal Convention which revised the Warsaw System, are in force."

"I think that one of the main issues relating to the safety of civil aircraft was reflected in Article 3bis of the Chicago Convention after the shooting down in 1983 of the KAL Korean Airline by the USSR military air force. Article 3bis, which is in force, relates to the interception of civil aircraft by military aircraft. It stipulates that States should refrain from the use of weapons against civil aircraft and establishes a procedure for interception of civil aircraft without endangering the flight."

Global Governance of Space: extending ICAO to Space?

"The first time that the sub-orbital flights and outer space were mentioned at an ICAO Assembly was at the 35th Session of the September 2004 ICAO Assembly when I opened the

Dr. Assad Kotaite, ICAO Secretary General, speaking at the 3 October 1975 inauguration of the new ICAO Headquarters building in Montréal. Sitting besides are Mr. Walter Binaghi, President of the Council, The Honourable François Cloutier, Minister of Intergovernmental Affairs of Quebec, and His Worship Jean Drapeau, Mayor of Montreal.

Assembly with the following words: «100 years from now regular passenger flights in sub orbital space and even in outer space could become common place»".

"To date, we have no definition yet as to where the air space ends and where the outer space begins, and, of course, no international treaty has yet been established."

"A sub-orbital flight is a flight that goes up to a very high altitude but does not involve sending the vehicle into orbit. The broad question which we should apply to the concept of "An ICAO for Space?" would then be the following: "To which extent do sub-orbital flights performing with such vehicles constitute international civil aviation and thus fall within the scope of the Chicago Convention, which is the ICAO «Charter»? There are a number of legal issues under this broad question, such as:

- The definition of an aircraft or space object;

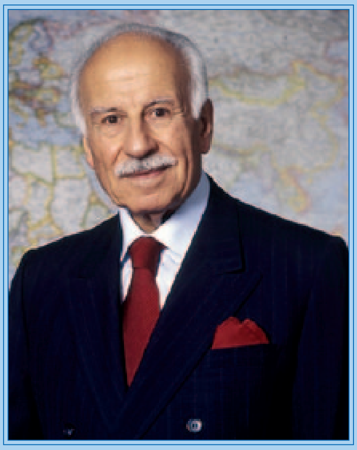
Dr. Kotaite's 50 Years in ICAO

"I have successfully negotiated various delicate and difficult issues:

- The issue between the European Union and the United States regarding the hush kits aircraft (editor's note: hush kits are noise suppressor devices for jet engines, to prevent acoustic pollution);
- The opening of the airspace of Pakistan and the airspace of India to their respective airlines, which were closed to one another following the December 1999 high jacking of the Air India flight from Kadmandu, in Nepal, to New Delhi in India;
- The over flight of the USA airspace by Cubana, the Cuban Airline, in its operations from Cuba to Montreal and Toronto;
- The South China Sea between China and Vietnam concerning the Sanya FIR (Flight Information Region) which I had been negotiating for 25 years;
- The return to Kuwait Airways of the 6 Airbus Aircraft which were seized by Iraq in 1990 and sent to Iran during the invasion of Kuwait by Iraq.
- The most politically difficult issue was my negotiations, over a period of 17 years, between the Republic of Korea and the Democratic Peoples Republic of Korea for the opening of their respective airspace to one another. This issue was successfully resolved with the signing of an Agreement on 27 October 1997 between North Korea, South Korea and myself, in New-Delhi, at the Conference of the Directors General of Civil Aviation for Asia and the Pacific."

"These are but a few examples which reflect the mission and objectives of ICAO, as well as some of my achievements which I was able to carry through mainly thanks to the cooperation of the ICAO Member States and their confidence in my negotiating capacities as a person of convictions rather than a person of conflicts."

"While some 30 million flights per year carry more that 2.6 billion passengers and more than 41 million tons of freight, there are fewer accidents and fatalities than when ICAO began keeping records in 1947. Safety remains a sine qua non condition for the growth of air transport. Transparency and globalization contribute to maintaining the integrity of the global air transport system. Air transport fundamentally remains the safest mode of transportation in the world. Without safety and security there is no growth of air transport. As civil aviation by definition is global, I believe that the key to success, past, present and future can be summarized in two words «global cooperation»".



Dr. Assad Kotaite, who served ICAO for 50 years.

"My views for the future is that by 2050 air transport may reach 6 billion passengers or more and that special attention should be given to the availability of qualified pilots and air traffic controllers as well as, in general, to an adequate infrastructure for civil aviation."

"The implementation by the Member States of the ICAO Standards is strengthening thanks to the ICAO Audit Safety Oversight and the ICAO Audit Security Programs with the objective of a safer sky, more transparency, infrastructure improvements, more economic aircraft operation and, finally, an aim to achieving zero-carbon emissions."

- The sovereignty of national air space and liability;
- The responsibility for ensuring proper air navigation services."

"From a specialist's viewpoint, there is no clear indication in international law as to the delimitation between air space and outer space which would permit to conclude on the applicability of either air law or space law to sub orbital flights. The United Nations Committee on the Peaceful Use of Outer Space, and more particularly its Legal Sub-Committee, is considering the question of possible issues with regard to aerospace objects."

"I believe that the time has come to examine how to apply to sub orbital flights and outer space the same kind of global management process that has worked so successfully for international air transport through the Chicago Convention. For that, we should find answers to a few questions such as:

- Which rules should govern litigations and compensations in cases of incidents and accidents?
- How far into space does the sovereignty of a state extend?
- How will user charges be defined and collected if, indeed, they exist at all?"

"With the Chicago Convention we have a model at our disposal. We should not ignore this precious lesson of history. By acting expeditiously we can tackle issues before we are forced to do so. My sense is that today we are in a similar situation with respect to outer space and how best to harness the extraordinary potential of this new frontier."

"The Standards and Recommended Practices of the Chicago Convention which regulate international civil aviation have proven effective in adapting to the dramatic transformation of civil aviation during the past 50 years or so. A global forum of nations is essential for achieving consensus on the management of outer space and there already exists such a structure. ICAO could do it by expanding its mandate and, if necessary, by amending the Chicago Convention."

"I believe that in this new frontier of sub orbital flights and outer space non-governmental organizations such as the IAASS can contribute to promoting the concept of an «ICAO FOR SPACE?» by their research and analysis as well as with their independent views".

> "To date, we have no definition yet as to where the air space ends and where the outer space begins"

The views expressed in this article reflects the personal and independent opinion of Dr. Assad Kotaite, and as such does not reflect the official point of view of ICAO, IAASS or other organization to which Dr. Kotaite is or has been affiliated.

by John T. James

Space Toxicology

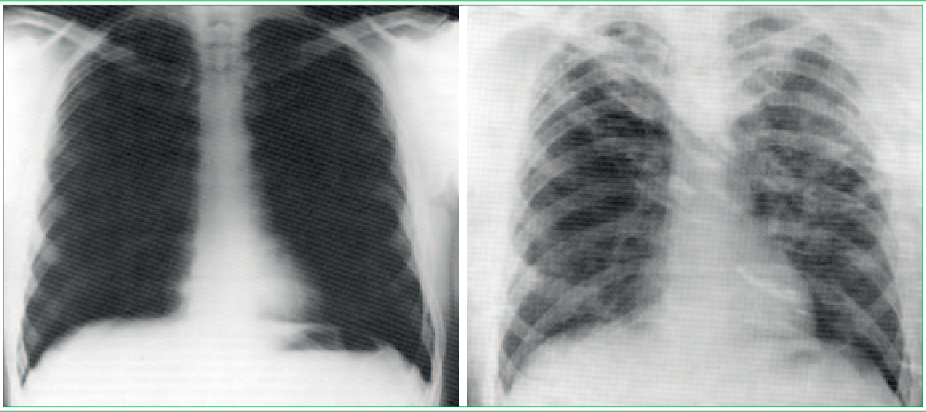
Safe breathing air for space faring crews is essential whether they are inside an Extravehicular Mobility Suit (EMU), a small capsule such as Soyuz, or the expansive International Space Station (ISS). Sources of air pollution can include entry of propellants, excess offgassing from polymeric materials, leakage of systems compounds, escape of payload compounds, overuse of utility compounds, microbial metabolism, and human metabolism. The toxicological risk posed by a compound is comprised of the probability of escaping to cause air pollution and the magnitude of adverse effects on human health if escape occurs. The risk from highly toxic compounds is controlled by requiring multiple levels of containment to greatly reduce the probability of escape; whereas compounds that are virtually non-toxic may require little or no containment. The potential for toxicity is determined by the inherent toxicity of the compound and the amount that could potentially escape into the breathing air. This reflects the fundamental premise in toxicology that "dose makes the poison."

> *"Dose makes the poison"* is the fundamental premise in toxicology

ASTP and Mir: Lessons Learned the Hard Way

During nearly a half-century of human spaceflight, space faring nations have learned to control toxicological risks well, but some of our lessons learned have been acquired the hard way – that is, through events that have placed the crew at risk of harm. We learned not to put pressure-equalization valves too close to thrusters when the Apollo capsule became highly polluted with nitrogen tetroxide at the end of the Apollo Soyuz Test Program. When the capsule was descending through the atmosphere, thrusters started to fire in an attempt to stabilize the

The ASTP Apollo Command Module awaits recovery. Astronauts Thomas P. Stafford, Vance D. Brand and Donald K. Slayton, still inside, have just been exposed to toxic fumes from attitude thrusters, fortunately with no permanent consequences. - Credits: NASA



Normal Roentgenogram (left) and one from an Apollo astronaut (right) accidentally exposed to propellants during capsule descent. The second figure suggests fluid infiltrate of the lungs. - Credits: NASA/JSC

descending capsule, while at the same time outside air was allowed in to increase the capsule pressure to sea level. The crewmembers experienced respiratory symptoms and delayed release of fluid into the lung. They were treated with oral steroids and released from the hospital 6 days after landing.

Remains of the solid fuel oxygen generator that combusted aboard Mir space station in 1997. - Credits: RSA/Energia

No lasting effects have been reported.

Fires, whether smoldering or openly burning, are frightening events during spaceflight. The toxicological threat from a fire cannot be judged from the apparent severity of the fire. For example, in 1997 aboard the Mir Station, a solid fuel oxygen generator caught fire and burned openly in the cabin for at least a minute. Samples of air revealed that dangerous combustion toxicants, such as carbon monoxide, remained at somewhat elevated but safe levels. The Mir air revitalization system restored the air to nominal conditions within two days and there were no adverse effects on the crew. In contrast, a year later the trace contaminant control system in the Mir Station produced a small amount of smoke when a heat-regenerated filter was prematurely placed into the flow stream. This caused a cellulose component to smolder. The air was quickly cleared of the smoke, but an experimental instrument suggested that levels of carbon monoxide were worrisome (these levels were confirmed later by ground-based analysis of samples acquired during the event). The crew reported no immediate symptoms and went about their duties. A few hours later the crew reported nausea and headache. These symptoms were consistent with the toxicological effects expected from the indicated levels of carbon monoxide. Carbon monoxide can require hours to enter the blood via the lungs and bind to hemoglobin where it blocks oxygen exchange. The crew recovered from their exposures by the next day as carbon monoxide levels decreased; however, it is known that exposures roughly double those experienced in this incident could have been lethal. Design and operational changes were made to reduce the risk of fire in both units.

Excess Offgassing and Microbial Hygiene

Excess offgassing from overheated polymeric materials can rapidly pose a threat to air quality. During the STS-40 Spacelab mission, an acrid odor was noted from the Orbiter Refrigerator Freezer (ORF). The odor ▸▸

> "Some of our lessons learned have been acquired the hard way"

Astronaut Jerry Linenger wears a respirator mask following the 1997 fire aboard Mir. Credits: NASA

Motor from STS-40 Orbiter Refrigerator/Freezer that produced formaldehyde because of overheating during STS-40 Spacelab mission. - Credits: NASA/JSC

was rapidly getting worse, so the unit was shut down and all openings were covered with duct tape. Inspection of the ORF on the ground revealed that a small motor with a Delrin® frame had overheated. Heated Delrin® produces formaldehyde. This irritating compound and others thought to be produced in the event had seriously polluted the atmosphere. The cause of the overheating had been a seized motor and no thermal protection to stop the current from trying to rotate the motor. Henceforth, thermal cutouts have been required on any devices that could overheat to a level capable of polluting the cabin or starting a fire. Although this event made for an unpleasant experience on orbit, the crew suffered no lasting effects.

Toxicological accidents can originate in unexpected ways and from unusual sources. During the STS-55 Space Shuttle mission the waste management system failed; therefore, waste was being stored in contingency waste bags. The crew reported that the bags were not leaking; however, a noxious odor was emanating from them. Because of the persistent odors, the crew refused to continue squeezing the bags to empty their contents into space. It was late in the mission and ground controllers concurred with the crew's decision. An air sample, analyzed later on the ground, revealed that methyl sulfide compounds were being produced inside the bags. These compounds, originating from microbial metabolism, were small enough to penetrate the walls of the bag. This incident serves as a reminder that microbial hygiene is critical to maintaining air quality and that bags designed to hold liquids may not retain gaseous compounds associated with the liquids.

Unpredictable Sources of Toxicological Risk

Toxicological risks sometimes originate from totally unpredictable sources. An example of this occurred aboard the ISS after mission 7A.1. During that mission Metox filters from the EMU suits were placed in the regeneration apparatus. Regeneration involves flowing hot air through the canisters to desorb pollutants from the filters into the ISS atmosphere. The apparatus was not performing as the crew expected, so they stopped the process and the canisters remained in the regeneration apparatus for about 6 months, during which unheated ISS air slowly passed through the canisters. When the next crew attempted to regenerate the canisters the flow from the apparatus produced noxious pollutants. The process was stopped, and the crew took refuge in the Russian segment of ISS for 30 hours while the air in the U.S. segment was scrubbed. During the 6 month period, the charcoal elements in the canisters had slowly absorbed ISS air pollutants, and the regeneration process had rapidly removed these compounds and dumped them into the ISS atmosphere. The major compounds found in an air sample were ethyl acetate and n-butanol. There was no apparent harm to the crew; however, considerable resources were expended in managing the pollutants and then understanding what happened and ensuring that there would be no repeat of this event.

> "Toxicological risks sometimes originate from totally unpredictable sources"

Space toxicologists, in cooperation with engineers, crew trainers, operations personnel, and other technical groups, focus on prevention of air pollution within habitable areas through many careful controls; however, our efforts are not always successful. In order to manage the inevitable toxicological events when they occur, we are expanding our air monitoring capabilities aboard the ISS. Our ultimate goal is for exploration crews to have all the tools they need to manage any plausible toxicological problem that could occur when they cannot rely on ground assistance.

By Joseph N. Pelton

The Vision: An International Institute for Space Safety

Ever since the founding of the IAASS six years ago and the ISSF three years ago, the creation of an International Institute for Space Safety has been a part of our vision.

As the age of commercial space travel now looms large and a new cadre of space entrepreneurs challenge us to think in new ways about space travel, we must begin to think more boldly about the future and how space safety can be much better achieved.

Within the past decade space-based communications and navigation systems have become absolutely vital to aviation safety and increasingly so for space missions. Hybrid vehicles that are part space vehicle and part aircraft will redefine what we mean by space transportation. Over time these vehicles will take us into new and exciting activities that transcend today's concepts of space tourism or "space adventures". Bristol Aircraft Ltd. has carried out design studies for a hyperspeed "spaceplane" that might fly 300 passengers from London to Sydney in a matter of about 3 hours. Aircraft and spaceplanes will routinely share airspace. Bigelow Aerospace is already leading the way forward in deploying private space stations for research and space adventures that go well beyond 4 minutes of weightlessness. In the next few years space safety concerns will broadly extend to issues such as space situational awareness, space weather, solar flares, space debris and the long-term sustainability of space. Space safety in the 2020s will be a matter of concern to much more than a few space agencies and defense ministries. This will be a concern to almost everyone. Once obscure issues such as space traffic management will be on the front burner.

> "Safety in the 2020s will be a matter of concern to much more than a few space agencies"

And how are we equipped to teach young engineers and space systems designer about the demanding science, engineering, and regulatory aspects of space safety to deal with this exciting space future? In a single word "Poorly".

Only a limited number of universities offer courses in space safety and there are no graduate degrees. The ISSF and the IAASS is seeking to fill this void in higher education. This we are doing by seeking to encourage universities to develop courses in space safety and writing key books in the field plus we are making a concerted attempt to launch the International Institute for Space Safety (IISS) either in the summer of 2012 or the summer of 2013.

We hope that there can be on-site instruction at the beginning and the end of the 1 year course of instruction that will alternate between U.S. and European locations. The key concepts for the ▶▶

The International Space University, after which the IISS is modeled. - Courtesy of ISU

Institute, as now conceived by a working group of professors, former astronauts, governmental space agencies and regulators plus industry experts, can be outlined as follows:

- To start the Institute we would offer to the equivalent of half of a Masters Program as a "Certificate in Space Safety". This course of study would be made available on a tight 12 month schedule. These courses would be delivered via a combination of e-learning and on site lectures. We could be able to accommodate students that work fulltime.
- In the first edition, the program would require the students to take 3 mandatory courses, plus 3 optional courses out of a possible five alternatives.
- The on-site part of the program will cover two mandatory courses each compressed into a 3 week period (one at the beginning of the Certificate program and one at the end); the other courses would be offered on an online basis within a 6 weeks format.
- World class instructors will teach these courses either on site or via the Internet.

Artist's conception of the Ascender space plane from Bristol Spaceplanes.
Courtesy of Bristol Space Ltd

- Tuition for the year-long program is currently estimated to be about $15K to $20K per student--assuming 24 to 30 participants and exclusive of any travel or housing costs. Top students would be recruited so as to ensure most could complete the program.

In many ways this program is designed on the model developed by the International Space University that I helped to start 25 years ago. It is hoped that the program could expand into a full Master's degree program that would still allow the certificate program option to continue in addition to the Masters. If we succeed in this effort, then one of the key original visions of the IAASS and the ISSF founders can be achieved. As we say in the field of space safety, the sky is no longer the limit.

Joseph N. Pelton, Former Dean of the International Space University and Acting President of the International Space Foundation

Introducing IAASS

INTERNATIONAL ASSOCIATION FOR THE ADVANCEMENT OF SPACE SAFETY

The International Association for the Advancement of Space Safety (IAASS, Legally established 16 April 2004 in the Netherlands, is a non-profit organisation dedicated to furthering international cooperation and scientific advancement in the field of space systems safety. In 2004 IAASS became a member of the International Astronautical Federation (IAF). In 2006 former US Senator John Glenn, first American to orbit, became Honorary Member of the IAASS. In 2010 IAASS was granted Observer status at the United Nations COPUOS (Committee on the Peaceful Uses of Space).

In accordance with the Association Charter, the IAASS membership is open to anyone having a professional interest in space safety. Members can be physical persons, corporations, agencies, universities, institutions, and other professional associations.

The Association exists to help shape and advance an international culture of space safety (technical, organizational and socio-political), which would contribute to make space missions, vehicles, stations, extraterrestrial habitats, equipment and payloads safer for the general public, ground personnel, crews and flight participants. The Association also pursues the safeguarding and sustainability of the on-orbit environment to allow unimpeded access to space by future generations.

The Association work will contribute to propagate the idea that the time is ripe for the establishment of an international civil space safety organization according to the model of ICAO (International Civil Aviation Organisation), which so effectively advanced air travel safety.

Mission

Advancing space safety forms the foundation of our endeavour. Compared with the vastness of political, financial and intellectual resources that space programs require our forces are minute, truly a drop in the ocean. Nevertheless, we want to be that drop and indeed a catalyst drop. We are committed, through the dedication and knowledge of our members, to internationally advance space safety as parents are to their children, to help finally ensure that:

- No accident shall ever happen because the risk was badly measured or willingly underestimated.
- No accident shall ever happen because the necessary knowledge was not made available to others.
- No accident shall ever happen because of lack of management commitment and attention.
- No accident shall ever happen because lack of personal accountability makes people negligent.

The IAASS with its members and sponsors aims therefore to:

- **Advance** the science and application of space safety.
- **Improve** the communication, dissemination of knowledge and cooperation between interested groups and individuals in this field and related fields.

- **Improve** understanding and awareness of the space safety discipline.
- **Promote** and improve the development of space safety professionals and standards.
- **Advocate** the establishment of safety laws, rules, and regulatory bodies atnational and international levels for the civil use of space.

IAASS Primary Services

The IAASS primary services are:

- Facilitate information exchange between members through networking, news and website
- Organisation of safety conferences and seminars
- Establishment and maintenance of a world-class searchable database of published and electronic knowledge
- Performance of independent studies on behalf of corporate and institutional members
- Offer world-class space safety educational and training program and tools
- Offer/advertise selected consultancies from (retired) members
- Establish (or participate in) working group to develop international space safety standards.

Values and beliefs

The association's fundamental values and beliefs are:

Excellence – The Association will work to maintain its position as the primary and most knowledgeable forum worldwide for discussion, study and exchange of information on space safety.

This also means that the work of the Association's Technical Committees will be further developed, and will continue to be based on robust processes for analysis, judgement and formulation of policies and recommendations, without cognitive bias. The only basis for confidence will be properly understood data and scientifically grounded assessments. Assumptions will be explicitly acknowledged and constantly challenged.

Independence – The Association will maintain an absolute independence stance by never subscribing to those policies (of sponsors and non-sponsors) contrary to the Association beliefs, while continuing to press resolutely but discretely for their modification.

Integrity – Integrity will be the primary asset of the Association, on which to build a reputation as the world leading professional association for space safety. Nothing, nor sponsor's wishes, not financial support nor opportunity for growth, will be more important than preserving the Association's integrity.

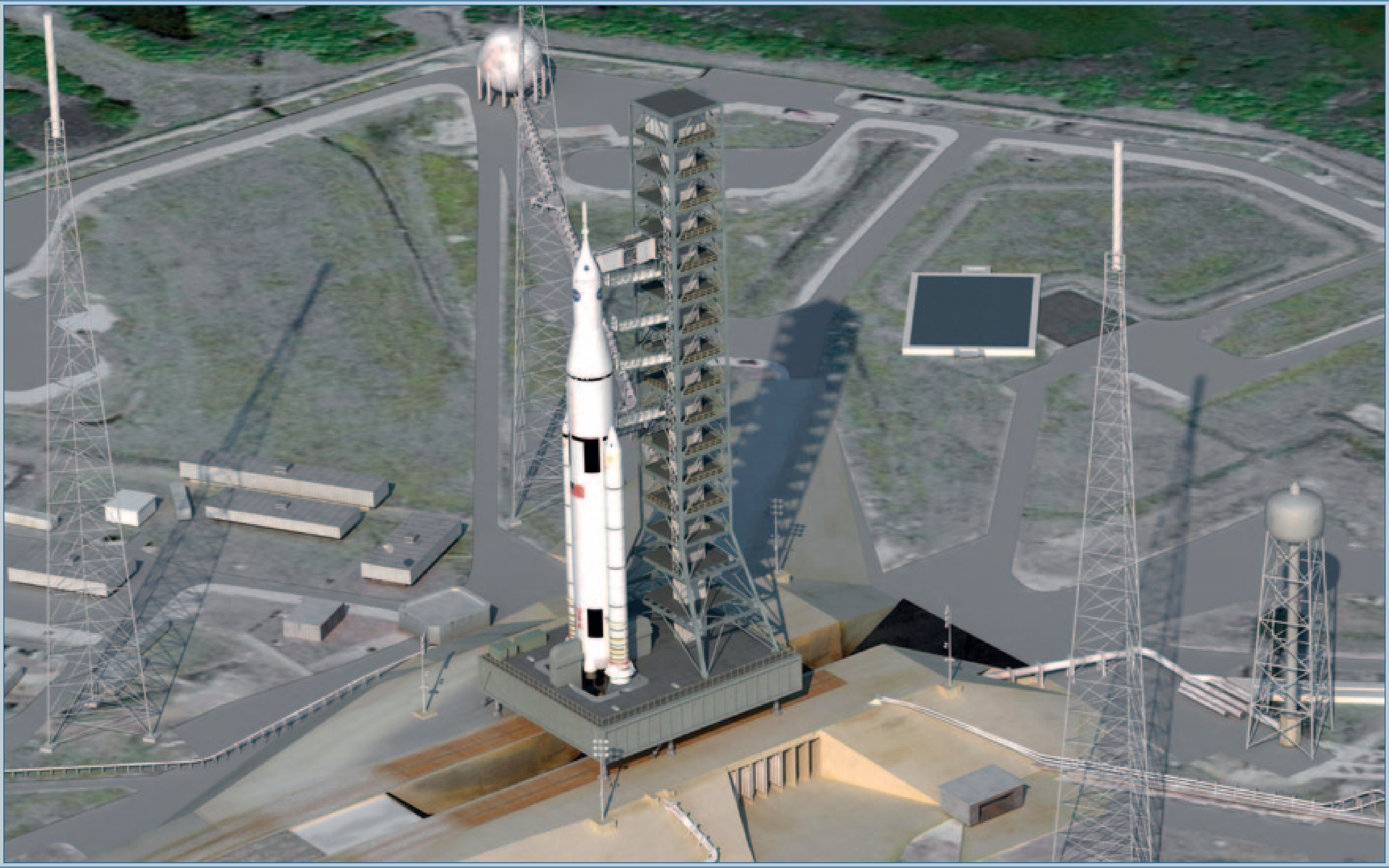
Communication – Free and unobstructed flow of information inside the Association. This means also having the courage to question current assumptions, and the willingness to ask even seemingly obvious questions, to listen actively, and be ready to teach and to learn. It also means being able to disagree vigorously and profitably and engage in productive dialogue.

Education and Training – The Association believes that space safety will be enhanced through expanded educational curricula, continuous professional development, and general professional upgrading through promotion and recognition of achievements of outstanding individuals. This also means that the Association considers safety education and training at every level of space programs and organizations a formidable tool for accident prevention.

Proactive – The Association believes that space safety is no accident. The Association will constantly seek to influence all segments of space programs management, engineering and operation, to improve space safety standards, methods, organization, and to push the use of adequate technologies and inherently safe design solutions. This also means that the Association will spare no effort to make good policies and recommendations known to decision-makers.

Accountable – The Association is fully accountable to its stakeholders, members and sponsors for accurate and appropriate use of resources to achieve the goals of the Association.

Field test of the Hamilton-Sundstrand advanced space exploration concept suit at Haughton Crater, Devon Island. - Credits: NASA



Artist's conception of the Space Launch System (SLS), NASA's next generation heavy-lift vehicle. - Credits: NASA

Organisation

The governing body of the Association is the IAASS Board, which comprises up to 30 physical persons, who select the President. The IAASS Board members are elected by the General Assembly. The Board ensures by means of criteria approved by the General Assembly, that the nationality of its members adequately reflects the nationality of the members of the Association.

The IAASS is further organized in technical and standing committees. The chairmen of such committees are also members of the IAASS Board.

Technical Committees

The Technical Committees develop the IAASS vision for space safety, and create a strong link between professionals from agencies, industry and academia. Only senior members and honorary higher-level members (associated fellow, fellow) of the Association, which satisfy specific criteria of expertise and excellence can become members of the technical committees. The chairmen may also appoint non-members of the Association responding to the same criteria above as members of the technical committees.

The following committees are established under the lead and coordination of the IAASS Technical Director:

- Space Exploration & Systems Safety
- Launch Range Safety
- Space Hazards
- Space Safety Laws & Regulations
- Human Factors & Performance for Safety
- Suborbital Space Safety

Standing Committees

Any members of the Association can volunteer to fill vacancies in the following Standing Committees:

- Conference Programme Committee
- Information and Communication Committee
- Membership Committee
- Safety Awards Committee
- Professional Training Programs Committee
- Academic Committee

Membership Policy

The Association is based on the intellectual interaction of individual members who together shape the technical vision of the association and make the Association services available to stakeholders. Individual members of the Association have voting rights.

Corporate and institutional members of the Association have a sponsor role and are the primary target of the Association services. Sponsors can participate to the general assembly but they cannot vote.

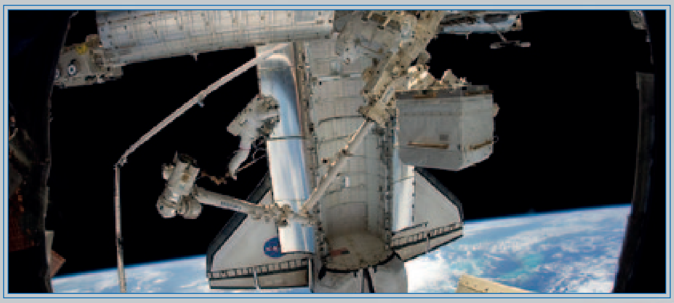
Why to become a member?

The general motivation for becoming an (individual) member of the Association is to know, to be known and share experiences with other space safety professionals. In addition a selected number of members (senior members, associated fellow and fellow members) may volunteer to take part to the work of the Technical Committees (and specialized subcommittees) that shape the IAASS vision. The Technical Committees (and subcommittees) goal is to become recognised world-class think-thanks in their field.

For the sake of establishing the excellence of the Association and to attract highly knowledgeable individuals, it is important that belonging to a higher membership level truly reflects the implied professional standing. In this respect the access to high membership levels (associated fellow, fellow) are defined in terms of objective admission criteria, and will be subjected to strict scrutiny to be adhered to with outmost zeal.

Prospective members are required to fill in a detailed questionnaire from which their professional profile will emerge as well their potential for involvement as lecturers or instructors in the educational and training programs of the Association. One of the primary cares of the Association is to facilitate effective networking of its members, or professional and social purposes. Members are encouraged to socially interact also on a local basis by forming Chapters, and by holding convivial meetings. The membership database will be accessible to all members under a code of privacy and confidentiality.

Excalibur Almaz space capsule, based on Soviet-era technology. Credits: Excalibur Almaz



Human-robotic cooperation in a complex EVA. - Credits: NASA

Why to become a sponsor?

Because of the very specialized field of interest the IAASS will remain a relatively small group of professionals yet a unique think-tank with a great potential for shaping attitude and culture of the wider space programs community. As a consequence the IAASS is unable to self-finance all its initiatives, and it needs sponsors support in particular for the space safety research and educational programs.

Why should a corporation, agency or government organization be interested to sponsor the IAASS? There are various reasons. Safety is a strategic business interest in the space industry, as in many other high-tech industries like commercial aviation, high speed trains, pharmaceuticals, etc. A faulty single product can kill people as well as the manufacturer's business. One or two accidents may cause the termination of a unique operational concept like it happened with the. Shuttle and with the supersonic Concorde. A single major disaster can even endanger an entire industrial sector like it is happening in the nuclear power generation business after the Fukushima disaster.

For the above reasons supporting space safety education and independent research can contribute to the future well being, progress and expansion of the entire space industry. Furthermore space industry, government organizations and agencies are also interested to develop and maintain a "safety culture" within their own organizations. The IAASS training activities and gatherings represent in this respect a unique opportunity. In particular they allow cultural interactions between experts from all three communities operating in space, namely civil, military and commercial community.

Which role for academia?

The Association is the ideal ground for the academic world to meet and interact with industrial and institutional organisations. By attracting academic interest and involvement in space safety research activities the Association aims to effectively advance space safety to new levels, and possibly establish space system safety as an autonomous technical discipline. University members of the Associations will commit to promote specific academic programs, such as a Master in Space Safety, undergraduate space safety courses, and PhD opportunities. The Association will also promote the establishment of scholarships for undergraduate and postgraduate students.

Artist's conception of the new Malaysian spaceport for commercial suborbital spaceflight. - Credits: Space Tourism Society

Goals

Every space accident has a tremendous synergetic impact on the overall progress of space missions due to calendar delays, draw on resources, and diminished political motivation for new endeavours. The Association estimates that the collective impact of the two Shuttle accidents may account for an effective loss of progress in the US human spaceflight program of 15-20 years.

Advancing safety is not only a moral duty but the key for expanding space programs and making them more economically viable.

The IAASS assumes in pursuing its mission and providing services that:

- The international cooperation in civil space programs is the way ahead and it will become more and more important in future. Such cooperation will require innovative organisational solutions.
- The international dimension of public safety risk related to launch/re-entry operations will become progressively more and more evident.
- Space-based safety critical services (e.g., air traffic control) and commercial human spaceflight will precipitate the establishment of international spaceflight regulations.
- No economic or political consideration justifies constraining the circulation of safety crucial and possibly life-saving information.
- Uniform safety standards are an important element to prevent unfair competition and expand commercial space activities.

General public Acceptability of Space Safety risk

The risk level currently achieved in human spaceflights much differs from what is perceived as acceptable by the general public and by political representatives. Such discrepancy is a major threat to the continuation of human space programs, including commercial human spaceflight.

General public tolerance of accidents varies from system to system (and changes with time). In the US, one million people were killed in car accidents in the period 1975-2000. On the average every year 10 millions vehicles are involved in crashes, resulting in more than 40,000 people killed and 3.0 million injured. The risk of car accident is about 1 in 5000 departures. The safety risk in civil aviation is 1 in 2-3 millions departures. Although the aviation safety record is quite impressive compared to other transportation means, the aviation regulatory bodies have launched an initiative to reduce the accident rate to 1 in 10 million or better. The reason is that the projected traffic increase in the next decades would lead to an (absolute) number of accidents per year which could negatively influence the general public perception of air safety and in turn impact further industrial growth.

The level of risk of very complex space systems is embedded in the architecture and operational concept selected, as well as driven by the available technologies. One accident in less than 100 spaceflights was somehow "built-in" in the Shuttle program and could have been improved only marginally. Would the Shuttle have flown at a rate comparable to the initial plans, the entire fleet would have been wiped-out within few years.

Pioneers of commercial human spaceflight often state that their sub-orbital craft would be "100 time safer" of government space systems. While they concede that sub-orbital flights are order of magnitude less complex of orbital flights they seem eventually to count mainly on public risk acceptance comparable to early times of aviation and on a protective legislation. Unfortunately (for them) public acceptance of safety risk is much different nowadays. There is in particular very little or no public tolerance for failures which are within the reach of current knowledge and technologies, but are caused by economic pressure or by lack of suitable management / regulatory attention. Regardless of the extent by which liability laws may try to protect the commercial human spaceflight interests, industry may not be able to survive the public's response to first few accidents.

Goal # 1

The Association will promote a program management culture that puts safety targets ahead of mission objectives since the early stages of conceptual design to achieve risk levels representing a substantial improvement on previous generation's vehicles, and continuously improve on previous achievement.

Goal # 2

The Association will advocate an international regulatory framework for commercial human spaceflight, as well as the legal definition of personal responsibility and accountability for space preventable accidents.

International Human Spaceflight Cooperation

International human spaceflight programs (in lieu of national ones) may be the norm in future. There are important cultural differences that can increase the safety risk. This applies to crew operations as well to design teams and goes beyond the language barrier.

Some differences are related to national culture in general while other are specific of the safety culture maturity The differences originate from traditions, past experiences, environment, government policies and various degrees of public "tolerance" to accidents.

An example of general cultural attitude that may increase the safety risk is the one towards procedures and standards. In some cultures, technical procedures and standards are highly respected as the expression of experts' consensus and as repositories of collective knowledge. Compliance to procedures and standards is a therefore regarded as a "natural" attitude of mature organisations. In other cultures, the "master" attitude, which is the jealous ownership of personal technical knowledge, may be common and the individual expert judgement could easily prevail over anonymous standards unless enforced by law. Of course, each cultural attitude has its pros and cons. Geniality and inventiveness are not captured and passed by means of procedures and standards. Blind adherence to standards can sometimes generate a burocratic mind detached from reality, which may generate unexpected hazards. Nevertheless standards related to safety have been in many industries the first to be generated for the obvious purpose of communicating lessons learned from accidents.

With reference to specific safety culture differences, we can mention as example the fact that in western world manufacturers have the duty and responsibility of preventing accidents due to foreseeable misuse of their products. This is not the case in certain other cultures where the manufacturer has only the responsibility to provide correct "instructions for safe use".

Bridging technical cultural differences when an international space program is already under way is quite demanding and not very efficient, due to non–technical factors such as schedule constraints, political will, organisational set-up etc. Instead carrying out technical exchange and co-ordination in advance and in a "neutral" atmosphere away from the immediate program's pressure could greatly facilitate active listening and un-bias attitudes.

Goal # 3

The Association will promote an international culture of space safety in the form of consensus standards and recommended practices. Ideas, concepts and experiences would be compared and judged uniquely on the basis of their technical value.

International Public Safety Risk

In space programs there are several public risk management issues which are at the same time national and international in scope. Launches and re-entries represent often a safety risk for both local and foreign populations due to nominal conditions and failures (high stored energy, debris trajectories, use of radioactive power generation sources etc.)

There are a number for trends to be watched in the launch industry:

a) privatisation of launch service and spaceports,
b) commercial pressure to make current (western) safety standard less stringent with reference to launchers design and frequency of use of flight corridors,
c) relocation of launchers away from their original launch sites, to more densely populated areas and on different flight paths.

d) increased automation of safety officer tasks for flight termination.

Safety of re-entry is also attracting new attention:
a) following recent uncontrolled re-entries of big decommissioned satellites,
b) increased concern for aviation safety following the Shuttle Columbia accident,
c) new entrants in the controlled re-entry arena.

Furthermore, deep space exploration missions will continue to require use of nuclear power source (NPS). This is a safety field in which international regulations are long overdue. The safety certification process varies from country to country, although the risk is absolutely global in nature.

Goal # 4

The Association will watch and evaluate space programs to see how well a positive public safety record is reached and maintained world-wide. The Association will promote international regulations to ensure uniform safety certification processes, and the use of validated risk assessment tools.

IAASS Code of Ethics and Professional Conduct

A IAASS member shall at all times order his conduct as to uphold the dignity and reputation of the Association. He will act with fairness and integrity towards all persons with whom his work is connected and towards others members.

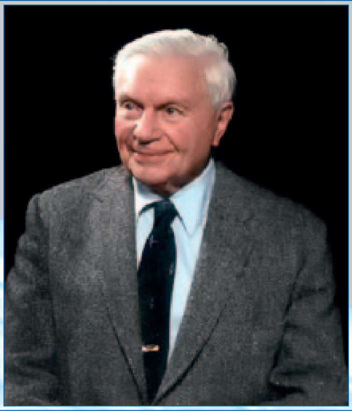
1. A member shall at all times take care to ensure that his work and the products of his work constitute no avoidable danger of death or injury.
2. A member shall take all steps to maintain and develop his professional competence by attention to new developments in space safety science and engineering. He shall also encourage persons working under his supervision to do so.
3. A member shall not undertake responsibility as a safety scientist, engineer or manager, which he does not believe himself competent to discharge.
4. A member shall accept personal responsibility for all work done by him or under his supervision or direction. He shall take all reasonable steps to ensure that persons working under his authority are competent to carry out the tasks assigned to them and that they accept personal responsibility for work done under the authority delegated to them.
5. A member whose professional advice is not accepted shall take all reasonable steps to ensure that the person overruling or neglecting his advice is aware of any danger, which the member believes may result from such over-ruling or neglect.
6. A member shall not make any public statement in his capacity as a safety scientist, engineer or manager without ensuring that his qualification to make such a statement and any association he may have with any party which may benefit from the statement are made known to the person or persons to whom it is directed.
7. A member shall not recklessly or maliciously damage or attempt to damage whether directly or indirectly the professional reputation, prospects or business of another safety professional. A member shall never publicly criticise others members (individual or corporate) or take any initiative that can somehow tarnish their public image.
8. A member shall not in self-laudatory language or in any manner derogatory to the professional dignity, advertise or write articles for publication, nor shall he authorise any such advertisement or article to be written or published by any other person.
9. A member shall not use his access to personal data of other members for purpose different from professional networking. In particular he will not use such access to recruit personnel, for direct offering of professional services, or for direct selling and advertising products of any kind.
10. Membership in IAASS may at times place individual in situations where their statements or actions could be interpreted as carrying the "weight" of the Association. An IAASS member will exercise care not to misrepresent IAASS, or positions and policies of IAASS.
11. IAASS is an international association devoted to the values of equality, tolerance and respect for others. Discriminatory attitude between members on the basis of race, sex, religion, age, disability, nationality, or other such factors is an explicit violation of IAASS policy.

By applying to become a member of the IAASS an explicit commitment is made to observe the above code of Ethic and Professional Conduct. Violation of the code is inconsistent with memberships in the IAASS.

Jerome Lederer
Space Safety Pioneer Award

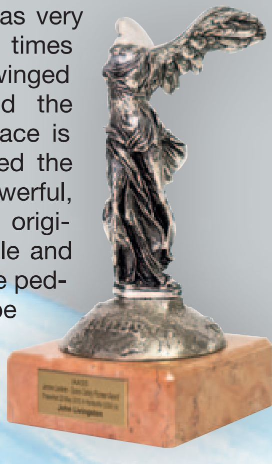
The "Jerome Lederer - Space Safety Pioneer Award" is a means for the IAASS to honour professional who made outstanding contribution or improvements to Space Safety.

The Award is named in honour of. Jerome Lederer (1902 – 2004), whom in the course of his 46 year public service career, performed groundbreaking safety studies for the Air Mail Service, the Civil Aeronautics Board's Safety Bureau and the National Advisory Committee for Aeronautics. He is credited with introducing blinking anti-collision lights and flight data recorders to aircraft. In 1967, following the tragic Apollo 1 fire, NASA Administrator James Webb asked Mr. Lederer to become director of the NASA Office of Manned Space Flight Safety. He worked to upgrade NASA-wide safety policies and to implement safety awareness programs throughout the Agency. He contributed greatly to the success of NASA's lunar landing missions. In 1969, Mr. Lederer received NASA's Exceptional Service Medal. He retired in 1972.



Jerome Lederer
Pioneer in Pursuit of Flight Safety
(1902 - 2004)

The "Jerome Lederer - Space Safety Pioneer Award" takes the form of a solid silver statuette reproducing an ancient master piece the "Winged Victory", or Nike (Greek for "victory") of Samothrace, standing on a hemisphere representing the surface of Mars. Victory was very early in ancient times depicted as a winged female figure, and the one from Samothrace is generally considered the most beautiful, powerful, and majestic; the original, made of marble and set on a large stone pedestal in the shape of a ship's prow, stood on a cliff overlooking the sea.



Vladimir Syromiatnikov
Safety-by Design Award

The "Vladimir Syromiatnikov Safety-by Design Award" is a means for the IAASS to honour individual(s) who is or has been working for a large part of its career full time in the design of space systems. He would have shown outstanding support and dedication to space safety, and achieved national and/or international recognition. The award is assigned to an individual or to a group of individuals who have been closely co-operating.

Named in honour of Vladimir Syromiatnikov (1934-2006) the Russian designer of one of the most successful piece of space hardware, the docking system APAS. The APAS was used in the Apollo-Soyuz Test Project in 1975, successful in more than 200 dockings of Soviet/Russian, spacecraft, on the Shuttle and on the International Space Station.

Vladimir Syromiatnikov
Russian designer of the docking system APAS
(1934-2006)
Credits: Nasa

The "Vladimir Syromiatnikov Safety-by Design Award" takes the form of a solid bronze statuette representing Athena wielding a silver shield. In the Greek mythology Athena is the goddess of wisdom, science, courage, inspiration, civilization, strength, strategy, justice, skills and shipbuilding. Athena was the embodiment of prudent and intelligent tactics. Athena is the goddess of heroic endeavour. The shield of Athena, called Aegis, represents in this award the safety knowledge. (The term "aegis" has entered modern English to mean protection by a powerful and knowledgeable source).

Commercial Space Debris Removal

by Jerome Pearson, Eugene Levin, Joseph Carroll

Debris Removal, Wholesale

The nearly 2,200 spent stages and dead satellites in low Earth orbit (LEO) – a mass of nearly 2,000 tons – is starting to act as a slow-release anti-satellite (ASAT) system, randomly targeting valuable space assets. The Cosmos-Iridium collision of 2009 produced an effect very similar to the Chinese ASAT test in 2007: the satellites shredded each other, producing over 2,000 tracked fragments and over 100,000 untracked fragments, a cloud of "shrapnel" potentially lethal to operational spacecraft. These debris clouds have spread out and will persist for decades. The probability of more catastrophic collisions is no longer negligible: it has now reached 8% per year, and will scale with the square of the number of large objects in congested regions of LEO. Given the current launch rates, this collision rate could double within the next 20 years.

The Cosmos-Iridium collision involved a total mass of 1.5 tons, which was substantially less than what was statistically expected to be involved in an average collision between intact objects. The next catastrophic collision is more likely to be on a larger scale, which could easily outweigh the Chinese ASAT test and the Cosmos-Iridium collision combined.

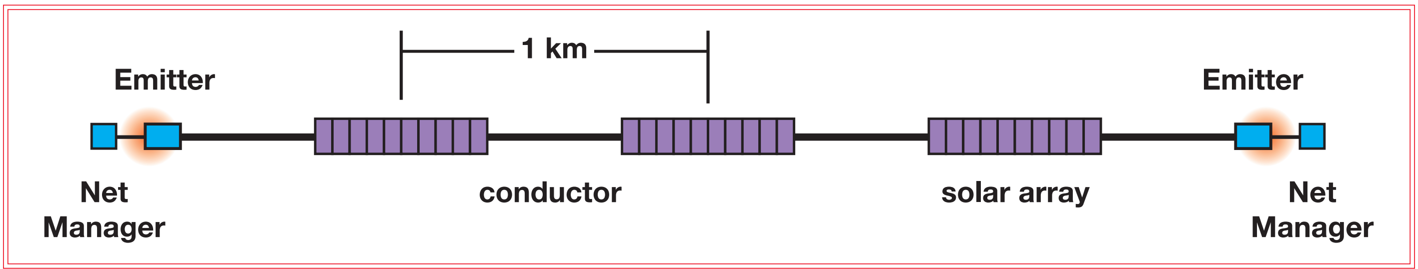
Neither better conjunction analysis nor common debris mitigation measures address the root cause of the problem, the generation of untracked "shrapnel" in collisions between large debris objects. To make a real difference, most large debris objects, the primary source of "shrapnel," must be removed from crowded low Earth orbits.

Space Shuttle window being inspected for orbital debris impacts. - Credits: NASA/JSC

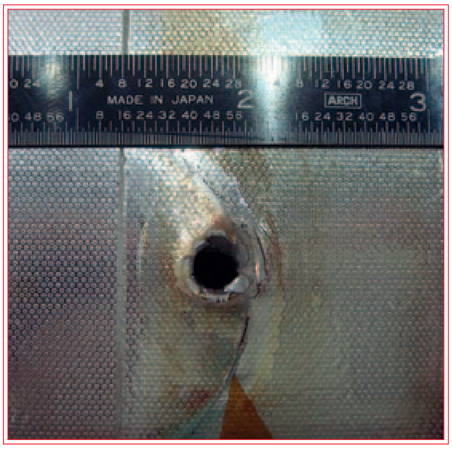
> "To make a real difference, most large debris objects must be removed from low Earth orbits"

The task of wholesale debris removal is very challenging. It would take 2,200 trips with an average payload of 900 kg to remove all spent stages and dead satellites from LEO. Even though many of them are clustered in inclination and altitude, it would require many large velocity changes (delta-Vs). Neither passive drag devices nor rockets are well suited for this task. Passive drag devices have to be delivered and attached to the objects. Slowly spiraling down in large numbers through populated regions in LEO, they would increase the collision risks to operational satellites, the ISS, and each other until they reenter. Rockets can be less risky, but the existing propulsion systems have specific impulses much lower than needed for affordable wholesale debris removal from LEO.

Debris removal has never been attempted before. There are several reasons: first of all, the ASAT nature of the LEO debris field was not experienced until recently; secondly, debris removal with rockets is too expensive; thirdly, debris ownership is international; finally, the overall task is daunting. As a result, debris removal technologies have not been developed. But now there is at least one way to affordably remove ▸▸



EDDE: an electrodynamic "garbage truck" for debris removal (not to scale).



Entry-hole damage (5.5mm diameter hole) to Endeavour's left-side aft-most radiator panel observed during post-flight inspection. - Credits: NASA/JSC

all existing large debris from LEO and start a regular service of removing newly launched upper stages and failed satellites.

One Enabling Technology

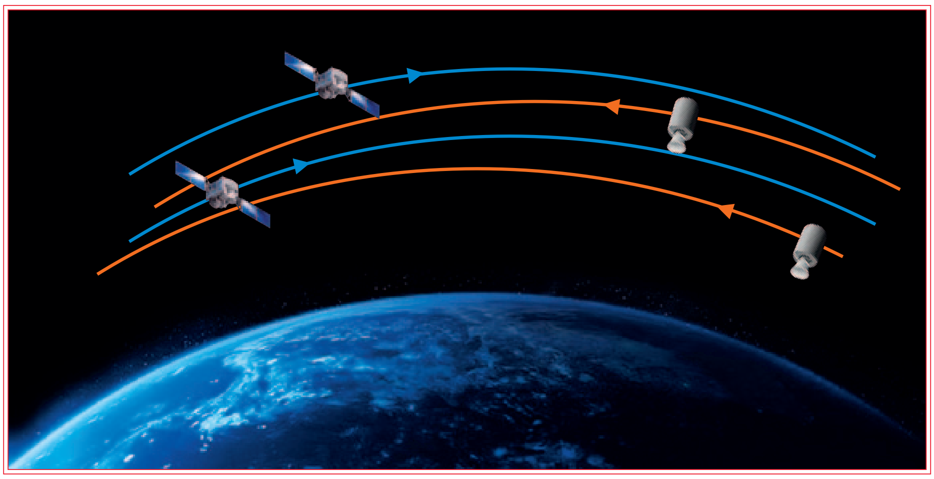
The ElectroDynamic Debris Eliminator (EDDE) is a vehicle of a new class that was unveiled at the NASA/DARPA International Conference on Debris Removal in December 2009. It is a propellantless roving space vehicle for LEO that "sails" in the magnetic field. EDDE is solar-powered. It uses electric current in a long conductor to thrust against the Earth's magnetic field. Electrons are collected from the plasma near one end by an electron collector, and are ejected at the other end by an electron emitter. The current loop is closed through the plasma. This kind of operation was demonstrated in orbit by NASA Johnson Space Center on their Plasma Motor-Generator (PMG) flight test in June 1993.

Operating without propellant, EDDE can repeatedly change its altitude by hundreds of kilometers per day and its orbital plane by several degrees per day, providing enormous delta-Vs of hundreds of km/sec over its operational lifetime. It can be described as several nanosats "taped" together with long conductor segments. EDDE weighs only about 100 kg, but it can move multi-ton payloads throughout LEO. It has a modular design and can be assembled in various configurations, depending on the mission. Recent innovations greatly improve its performance and reliability.

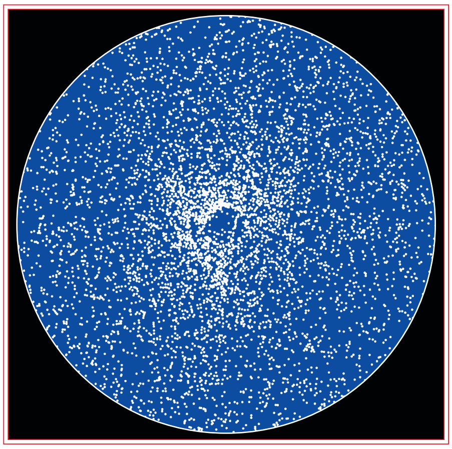
Propellantless thrust and on-board GPS allow EDDE to actively avoid all tracked objects by wide margins. The fiber-reinforced foil conductor tapes can tolerate most impacts by micrometeoroids and small debris. The probability of a tape cut by untracked debris in the centimeter range is much lower than a typical probability of failure of spacecraft avionics. And even if the conductive tape is cut, both halves of EDDE remain controllable and can deorbit themselves in days, avoiding all other objects.

For debris capture, the payload managers at each end carry about 100 house-sized, lightweight nets weighing 50 g each. Once the debris object is captured, the multi-newton tension in the net induced by the rotation of the entire vehicle quickly de-tumbles and passively stabilizes the debris object, and continues to hold it firmly in the net during deorbit. The nets can handle even the heaviest debris objects in LEO, the 8300-kg Zenit upper stages.

> "In 9 years, 97% of the debris-generation potential can be removed"



Head-on traffic at high inclinations created by large debris from the 81°- 83° cluster and satellites in sun-sync orbits.



A "snapshot" of the tracked LEO debris in the Northern sky

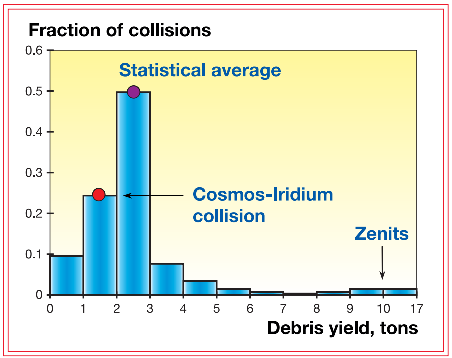
The Naval Research Laboratory plans to test key aspects of electrodynamic propulsion in orbit in 2012, with the Tether Electrodynamic Propulsion Cubesat Experiment (TEPCE). Two satellites share a 3U CubeSat slot and carry a conductive electrodynamic tether 1 km long. The next step will be to test a high-performance mini-EDDE, and then a full-scale EDDE. This development fits into the NASA Space Technology Roadmap and can be done with NASA support.

Commercial Service

When EDDE becomes operational, a commercial debris removal service can be offered to the government agencies and commercial satellite and launch operators. A dozen EDDE vehicles can remove all large debris from LEO in less than 7 years. They can all be launched on one ESPA ring, but our analysis shows that phased deployment has advantages. Two EDDE vehicles can be launched every year and retired after 5 years of service. In 9 years of operations, 2,000 tons of large debris and 97% of the debris-generation potential can be removed at an average cost under $400 per kg and an average annual cost of $84M. In this projection, we reserved substantial amounts for liability insurance, something that is ▸▸

currently not required, but that may become part of future regulations.

Being propellantless, EDDE reduces the unit cost of debris removal to a small fraction of the typical launch costs, and enables wholesale removal. In contrast, the unit cost of debris removal using rockets is comparable with the launch costs. The service must be much cheaper than launch to make economic sense to satellite operators: it would be hard in fact to justify debris removal if the cost per kg was comparable to those of a launch.



The next collision is likely to generate much more debris than the Cosmos-Iridium collision.

Since EDDE makes large-deltaV delivery affordable throughout low Earth orbit, it creates a novel opportunity to collect spent stages and selectively salvage their accessible aluminum alloys and other materials. This could generate a supply of up to 100 tons per year of metals deliverable to ISS or other orbits on demand. Such "barely extraterrestrial" materials could be the starting point for large-scale space manufacturing. They may also help pay for debris removal, if businesses can buy and recycle spent stages.

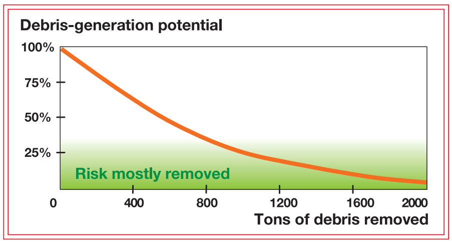
International Framework

Even though it is still in development, EDDE technology provides the first glimpse into a world where commercial debris removal services are not only technically possible, but also affordable. Better alternatives may be developed over time, but this technology is mature enough to provide an insight into how debris removal could actually work.

There are two problems: legacy debris and an absence of rules requiring prompt removal of newly launched upper stages and failed satellites. Waiting for the nations to remove their own legacy debris may take a long time. But if the 12 members of the Inter-Agency Space Debris Coordination Committee (IADC) decide to undertake the removal of legacy debris, they will be in position to set rules going forward, untying both knots at the same time.

> "EDDE provides the first glimpse into a world where commercial debris removal services are technically possible"

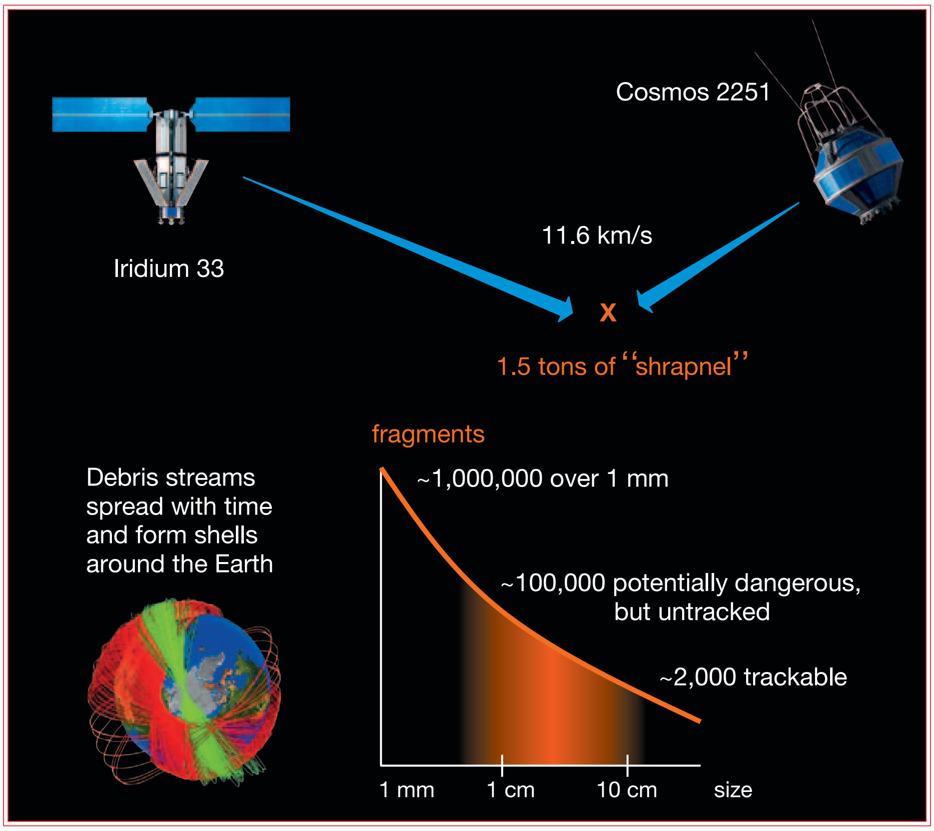
In financial terms, hiring a commercial operator to remove debris with EDDE-type vehicles may be surprisingly affordable, with a low price tag of only $6-7M per agency per year on average.



Only wholesale removal can radically improve the future debris environment in LEO.

In 10 to 12 years, all intact legacy debris could be removed, and the campaign will be over. Once removal is proven affordable, a legal framework requiring prompt removal of spent stages and failed satellites can be established. The 25-year rule is a good prototype, but a much shorter grace period is preferable, when it becomes technically possible and affordable. Once a system, process, and rules are in place, satellite and launch operators should be able to call on the service for the end-of-life removal of objects that cannot de-orbit themselves. This will make sense only if it costs a small fraction of the launch cost, as it is projected for EDDE.

As an added benefit, new norms regulating space activities and traffic will be created and tested in the process of debris removal. This may be very important for future space development.



The outcome of the Cosmos-Iridium collision.

by Andrea Gini

Safety of Nuclear Powered Missions

The use of Plutonium as a power source is still considered the best choice for certain type of deep space missions. The extraordinary scientific results of missions like Voyager, Pioneer and Apollo would have not been possible without nuclear power. Yet, the US Senate Appropriations Committee decided not to fund the administration's request for $15 million for the Department of Energy to restart production of plutonium-238 (Pu-238) in the 2012 energy and water appropriations bill. Pu-238 is an isotope used in radioisotope thermoelectric generators (RTGs) for NASA science missions. According to the scientific community, the lack of Pu-238, currently imported from Russia, will make impossible to conduct certain important types of planetary missions.

Which is the role of nuclear power in today's space missions? Which are the safety concerns related to its use in potentially hazardous operations like those involved in a rocket launch? And most important: how are those safety concern addressed in a nuclear powered mission planning? We interviewed Dr. Firooz Allahdadi and Dr. Sayavur Bakhtiyarov from the Space Safety Division, US Air Force Safety Center/SES, two leading experts in safety of nuclear power for space applications.

Space Safety Magazine: Which are the main areas of applications of nuclear power systems in planetary missions?

Dr. Firooz Allahdadi and Dr. Sayavur Bakhtiyarov: Power generation is one of the most important applications the long-term space missions. Nuclear-based power systems can supply electricity, heat, and propulsion for missions that are well beyond the capacities of solar power, fuel cells, and traditional chemical/explosives methods.

SSM: When it is recommended using nuclear instead of solar?

FA and SB: For short times and low power levels, chemical/explosive or solar energy can be used to make electricity. However, at high power levels for long periods of time nuclear energy is the only way (at the present time) to ▸▸

> "RPSs are compact, lightweight and very dependable power systems that provide enough power uninterruptedly in space environment"

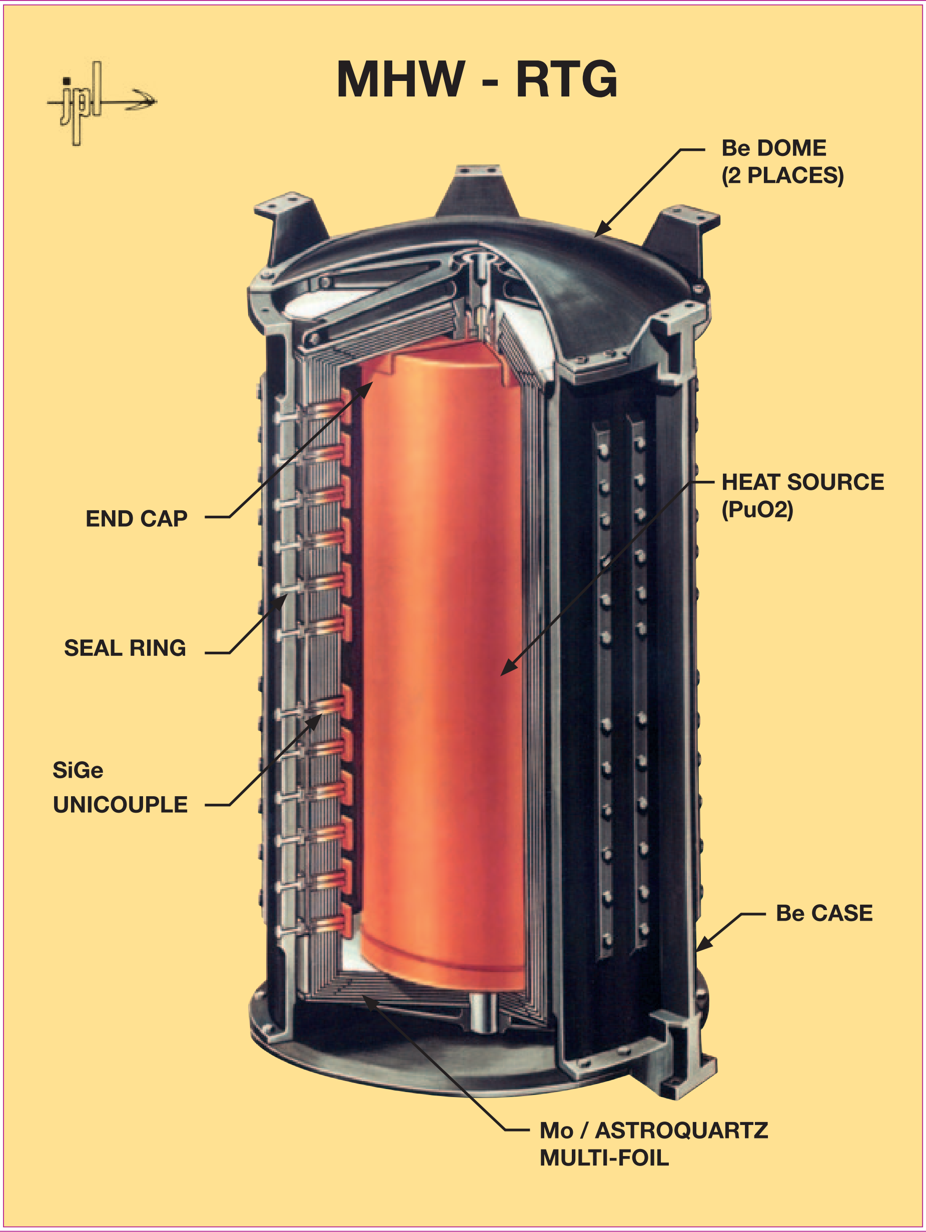
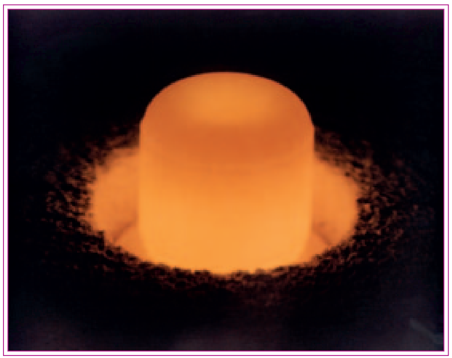


Diagram of a Radioisotope Thermal Generator. - Credits: NASA



A glowing Plutonium-238 sphere. These pellets are used for Radioisotope Thermal Generators (RTGs). - Credits: US Department of Energy

produce the necessary electrical power. Currently, Radioisotope Power Systems (RPSs) are considered the only existing reliable power source that can work in the extraterrestrial environment for long periods of time. RPSs are compact, lightweight and very dependable power systems that provide enough power uninterruptedly in space environment.

SSM: Can you describe the working principle of Radioisotope Thermal Generators (RTGs)?

FA and SB: The high decay heat rate of Plutonium dioxide enables us to generate electricity using Seebeck effect principle (electrical current is present in a series circuit of two dissimilar metals, provided the junctions of the two metals are at different temperatures) to power spacecraft, satellites, navigation beacons, etc. A very attractive and practical feature of RTG is that the alpha particle decay process does not require an extensive shielding nor it has any moving parts. The heat from the oxide fuel is converted to electricity through static thermoelectric thermocouples. The RTGs are safe, reliable and maintenance-free, and can provide heat or electricity for several decades at very harsh conditions, especially where solar power is not feasible.

SSM: Which notable space missions have been made possible by nuclear power?

FA and SB: So far 45 RTGs have powered 25 U.S. space missions (Apollo, Pioneer, Viking, Voyager, Galileo, Ulysses and New Horizons) as well as many civil and military satellites. For example, the Cassini spacecraft was equipped with three RTGs providing 870 watts of power during the exploration of Saturn. The Voyager spacecraft has been transmitting pictures of the distant planets for more than 20 years, and is expected to send signals powered by their RTGs for another 15-25 years. The Galileo spacecraft launched in 1989 was equipped with a 570 watts power RTG. The Viking and the Rover Landers were both equipped with RTG for their mission to Mars in 1975. The Mars Science Laboratory Rover "curiosity" which is scheduled to launch in November 2011 will be equipped with MMRTG (Multi-Mission RTG). Russia concentrated its efforts mainly on fission reactors for space power systems. Between 1967 and 1988 the former Soviet Union launched 31 low-powered fission reactors in Radar Ocean Reconnaissance Satellites (RORSATs) during the Cosmos missions.

SSM: Which are the risks involved in using nuclear power in a space mission?

FA and SB: Clearly, the consequences are human effects due to radiation exposures and land contamination. The following are the predominant risk contributors:

- Probability of launch vehicle failure with land impact;
- Accidents resulting in significant insult to the RTG's Fueled Clad (FC);
- Extended high temperature associated with solid propellant fires;
- Population exposure due to aerosolized particle dispersal.

Prelaunch and Early Launch are the flight phases where all these four factors may occur. Traditionally, the Early Launch accidents hold the highest risk (approximately 99% of the total risk), and the probability of release of radioactive material in this phase is around 1in 360.

SSM: How nuclear safety is handled during the launch to orbit cycle?

FA and SB: Even with the protective containment systems, the integrity of the RPS may be compromised in the case of accident causing radioactive material release into the biosphere. To evaluate this risk, the U.S., for example, has established the Interagency Nuclear Safety Review Panel (INSRP) for any RPS-powered mission. During this process the Department of Energy (DoE) prepares a detailed Safety Analysis Report (SAR) to evaluate radiological risk for each mission. The Final Safety Analysis Report (FSAR) is reviewed by the INSRP. The INSRP coordinators conduct an independent safety review and evaluation of the nuclear risk for each RPS involved mission.

Jet Propulsion Laboratory workers handle a radioisotope thermoelectric generator (RTG) for the Cassini spacecraft mission to the Saturnian system. - Credits: NASA/JPL

Saturn eclipsing the Sun, as photographed by Cassini. Missions like Cassini would have not been possible without RTGs. - Credits: NASA/JPL

The INSRP is supported by technical experts in the following working groups: Launch Abort, Reentry, Power Systems, Meteorology, Biomedical and Environmental Effects, and Risk Integration and Uncertainty. The INSRP then prepares a Safety Evaluation Report (SER) which identifies and characterizes probable accident scenarios, including the probabilities that Plutonium dioxide will be released. NASA submits both FSAR and the SER to the President Office of Science and Technology Policy (OSTP) to obtain the launch approval. The launch approval process in U.S. typically takes three years. Separate from the INSRP's independent analyses, every launch sites in U.S. develops a specific contingency plan to manage hazards associated with a post-crash event.

SSM: How a possible launch failure is handled?

FA and SB: Launch, orbital and final trajectory insertion, and space flight involve certain risks of failure. The most important mission phases are launch and ascent, when significant quantities of propellants are present. The accidents during these phases can damage an on-board nuclear power generation system due to the blast overpressure, thermo-mechanical shock, fires, and fragment impact. It is estimated that the probability of catastrophic launch accidents with nuclear release is a few percents. The space nuclear power generation systems are designed to withstand such accidents without presenting risk to the population and environment. For example, the early versions of RTGs were designed to burn upon entering the Earth atmosphere. Currently, the design requirement for RPSs and Radioisotope Heater Units (RHUs) under accidental reentry conditions has changed from complete breakup and scattering at high altitude to preservation of the fuel through the reentry.

SSM: Which are the most dangerous accidents occurred so far involving a nuclear powered mission? Which consequences they produced?

FA and SB: The first serious failure occurred in 1964 when the *TRANSIT 5BN-3* navigational satellite with 2.1 pounds of plutonium-238 failed due to the computer breakdown. The satellite and its SNAP-9A RTG power supply reentered the Earth's atmosphere and completely burned up as the system was designed. Approximately 20,000 Curies of plutonium-238 were released into the upper atmosphere spreading over the vast space. Even though this accident did not cause a health threat to the Earth population, it marked the fact that an uncontrolled release of radioactive material into the biosphere is a reality.

> "Design requirement for RPSs has changed to preservation of the fuel through the reentry"

There are many operations that may successfully prevent the release of radioactive material into the atmosphere. In 1968, approximately one minute into the launch of the nuclear (two RTGs) powered *NIMBUS B-1* meteorological satellite, the Range Safety Officer at Vandenberg Air Force Base in California (U.S.) destroyed the launch vehicle by command destruct action to avoid errant launch trajectory. The launch vehicle, upper stage, and spacecraft were completely destroyed. However, the two on-board SNAP-19B2 RTGs survived undamaged. The radioactive plutoniun-238 fuel was not released and it was used on a following space mission.

In April 1970 the *APOLLO 13* mission was terminated on the way to the Moon due to the explosion of an oxygen tank in the Service Module. A SNAP-27 RTG was on the board to power *APOLLO 13* Lunar Lander. The Lunar Lander with the SNAP-27 RTG returned to Earth with the Crew Reentry Module. The SNAP-27 RTG survived reentry undamaged, with no release of the radioactive material. The RTG plunged into the South Pacific Ocean where it remains now.

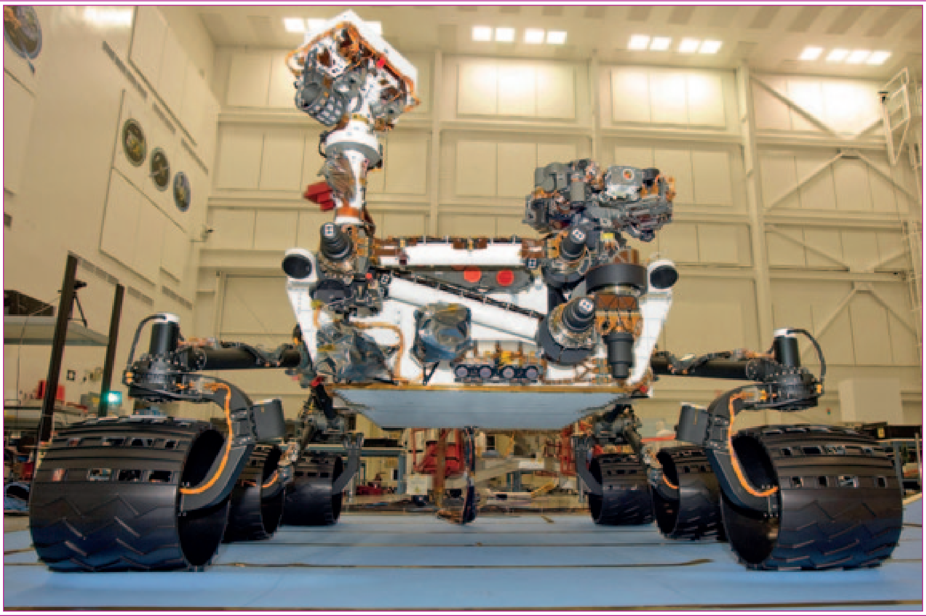
The first Soviet accident involved Cosmos-954 in 1977. The Cosmos-954 RORSAT operated in low Earth orbit for 43 days. At the end of its operational mission, the BUK reactor successfully separated from the spacecraft, but failed to boost to its intended orbit. Consequently, the reactor reentered the Earth's atmosphere and landed in the Northwestern Territories of Canada (fortunately, in an unpopulated area) in January, 1978. The BUK reactor was designed to burn-up on reentry, but ▸▸

> "Safety efforts must focus on planning rather than investigations of accidents"

reentry burn-up of the reactor was not complete. About 65 kg of radioactive debris and nuclear fuel was recovered from the crash site.

The second Soviet accident involved Cosmos-1402 on August, 1982. During this RORSAT mission, an anomaly occurred and the spacecraft automatically separated into three parts. The BUK reactor has reentered over the South Atlantic on February, 1983. No radioactivity was detected from this reentry or impact. After the Cosmos-954 accident the design of the BUK space reactor was modified to ensure its intact reentry.

The third Soviet space nuclear accident involved Cosmos-1900 launched on December, 1987. On May, 1988 the Soviet Union reported that it had lost a communication with the Cosmos-1900 RORSAT. In September, 1988 the BUK reactor automatically separated from the spacecraft and boosted to a higher orbit.

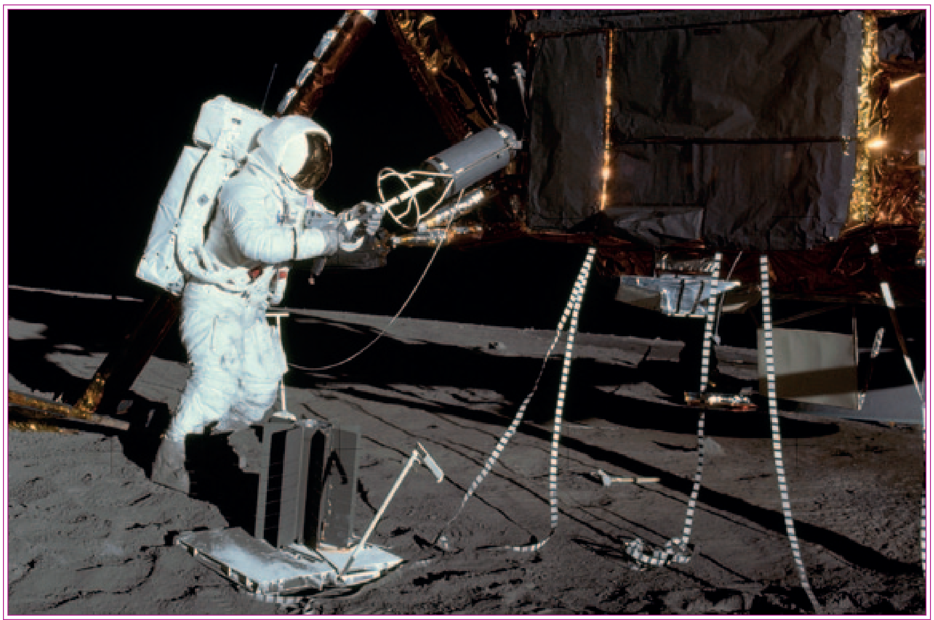


The Martian rover Curiosity, powered by RTGs. - Credits: NASA/JPL

SSM: What are the main lessons learned from past accidents?

FA and SB: Space failures/accidents have occurred over the years, and there is a possibility of occurrence in the future. However, space systems and structures have been designed to withstand extraordinarily severe/harsh conditions. They are designed to tolerate and survive elevated mechanical and thermal insults including impulsive shock loading, intense and prolonged hypergolic fuel fire engulfment/impingement, intense thermal fluxes and hypervelocity particle impacts to guarantee no releases of harmful radioactive material. The historical record, including the failures/accidents discussed above, serves as a reminder to have a confidence that the space nuclear safety program in the U.S. has been and continues to be effective as well as vital. In a more general term, the following lessons are learned from the previous space nuclear missions:

- Budget and Schedule: Budget and mission schedule must not take priority over the safety concerns.
- Technical questioning: Employees must be encouraged to report safety concerns.
- Staff qualification: Strong technical competence combined with continuing technical and management training is crucial for complex missions.
- Prevention rather than Correction: Safety efforts must focus on preventive actions rather than corrective ones.
- Planning rather than Investigation: Safety efforts must focus on planning rather than investigations of accidents.
- Critical self-assessment: A critical self-assessment must be accomplished even for the successful mission.
- Risk communication: It is important to prepare and make available the mission risk information as early as possible before any protests appear. The information must be clear, accurate and receptive. The spokesmen must effectively communicate with the concerned public. Independent outside experts must express their opinions in the media.



Astronaut Alan Bean (Apollo 12) put the Plutonium 238Pu Fuel into the SNAP 27 RTG. A similar device reentered Earth atmosphere at the end of the ill-fated Apollo 13.
Credits: NASA

by Curt Botts

What Do You Want To Be When You Grow Up?

So, here's something you're not likely to hear when asking your youngster or grandchild the age old question –

"What do *you* want to be when you grow up?"

"I wanna be a **Safety Engineer!**"

No – not a lot of aspiring youth clamoring to learn the trade that is often looked upon as "an impediment to progress." Since 1993, when I accepted a civil service position as an Air Force Safety Engineer (Occupational Series 0803), I've worked with many "803s" that had never really made it their life's ambition to become one. For the most part, we're engineers of the aerospace, mechanical, or electrical bent. But, I have known *Safety Engineers* who were learned scholars of ocean engineering or meteorology working on the hazards of rocket flight. I have heard that there actually is an elusive creature known as the "degreed Safety Engineer", who set out in their educational pursuits to knowingly become "one of us".

In all fairness, I'm somewhat blinkered in my view of the Safety Engineering career field since my exposure has been limited to "Range Safety". "Working as an Eastern Range Safety Engineer is an incredibly challenging and consequently rewarding career. It does come with the ubiquitous problem that so many in the Safety industry can attest – when you are doing your best work the result is "nothing". If I design an aircraft, I get to see it eventually fly. If I bake a cake, I get to eventually eat it. But, keeping people safe from harm tends to be a bit more invisible.

> "Working as an Eastern Range Safety Engineer comes with a problem: when you are doing your best work the result is "nothing""

When I first came to *The Range* I thought about how I arrived, and was somewhat astonished with a vague memory from my childhood education. It was standard practice in the 7th Grade that each student would take a class in Guidance Counseling, with a hope that much would be learned about the many choices ahead in life. I recall a particular lesson in which we were acquainted with a box of cards and asked to start with the first, answer questions, and follow the instructions designed to lead one in a search for the perfect employment.

"Do you like *math*?" the card would query and a "Yes" response would send you to another card asking if you enjoyed art, or *working outdoors*, or *dark enclosed spaces* (not sure what that one was about). After a considerable number of card selections, which I believe required nearly the remainder of the 50 minute class period, a final card was to reveal the optimal career, tailored to my very soul. Upon pulling that last card I was somewhat flabbergasted to view a picture of a man in a hardhat staring intently at a convolution of piping and obviously making important notations on the clipboard in hand. ▸▸

12 December 1959 - First attempted launch of a Titan 1 C-2 ICBM from Launch Complex 16.

Terry Naughton - 2nd on the left.

I read the job description somewhat haphazardly – "inspecting facilities for dangers… verifying structural integrity of this or that… maintaining compliance with regulatory requirements…".

I looked around to make sure no one else had seen me *labeled* as a Safety Engineer and, after sliding the card back in its place, quickly started looking for the Astronaut card or the Stuntman card.

To think, that I was somewhat predetermined since 7th grade to become this *Safety Engineer* was a bit odd. But, as I began learning what I was back then and what I needed to be, I came to realize that it was a noble profession – even if the recipients of the fruits of your labor may not even realize the benefits.

The latest (2008) occupational statistics show that in the U.S. there were approximately 151 million workers of which 25,700 (0.02%) were employed in the field of Health and Safety Engineering.

Interestingly, 19,700 (0.01%) were Actuaries – "business professionals who mathematically evaluate the likelihood of events and quantify the contingent outcomes in order to minimize losses". At Range Safety the contingent of engineers and mathematicians who evaluate the existing launchers and maiden voyagers must use similar techniques.

Through the use of Bayesian Statistics and failure probabilities, we are the "actuaries" for Rocket Ships. But, our bottom line is not, as in the insurance game, calculating the appropriate premium for the newborn, maturing, or aged person based on their inevitable risk of death.

Rather, our *bottom line* directly influences human safety. Our examinations of the newborn, maturing, and aged launch vehicles of the World determine how much risk is afforded to our personnel and the general public.

When the insurance company gets it wrong, the harm is theirs to bear.

When we get it wrong, we push the burden of potential harm onto others.

Of the federal employment payroll, there were 2,838,000 civilians (1.9%) in the U.S. workforce in September 2009 according to the Office of Personnel Management. The Department of Defense subgroup includes the Air Force which touts a total of 87 persons in the Safety Engineering career field (June 2011). In my particular Major Command, Air Force Space Command, 48 of us "803s" are responsible for making sure that the risks to the public are well understood and mitigated when possible or thoroughly reviewed and accepted when the task is deemed important enough. Launching rockets is dangerous work.

Learning from Our History

No doubt you've seen the films and still photographs from the early days of the Eastern Range, when rockets were experimental and explosions were common. The transition from missile to launch vehicle was wrought with early failures. While statistically it was perhaps easier to simply assume the next launch would end in a fiery collapse, it had to make it much more difficult to convey the risks. A *containment* approach was well warranted.

As rocketry matured the advent of risk analysis and modeling provided for a better view of how what could go wrong may affect public and personnel safety. Encroachment and increasing population density around the prime oceanside real estate prompted the use of sophisticated evaluation techniques in order to provide launch decision makers with the best picture of risks involved.

But, let's look back to those origins and the difficulties experienced.

While researching historical launch vehicle failures, I stumbled upon a most interesting biography. The Writings of Terry Naughton (aka Scavenger) caught my eye since I wondered why my "launch vehicle failure" query had provided a positive hit. As I began to read I was at first somewhat disinterested in Terry's "There I was…" descriptions of flying his cyber aircraft in a pre-world-wide-web game. I'd already heard plenty during my Air Force service; especially during Squadron Officer's School when several hundred Captains learning to be Majors were thrown together for two months. The pilots enjoyed telling tales.

My interest piqued however, as Terry transitioned to his account of how he ended up being a Safety Engineer. His unusual path toward this career is best described as, and many Safety Engineers would echo, "I never set out to become one, but ended up there one day".

Terry Naughton worked the early years of spaceflight in the 1960s and learned quickly how those of the Safety profession are often thought of as *necessary evils*. Through his discoveries and efforts he proved *our* worth many times, insisting on procedures and mitigations, often facing the alternative of unemployment.

To those who work in the Safety Engineering field or to those seeking to enter this often unrewarding and conversely always gratifying career I invite you to take some time to read Terry's words provided at the link below. I did some minor editing and added photographs to help illustrate his chronology: enjoy the reading.

http://bit.ly/TerryNaughton

Press Clips

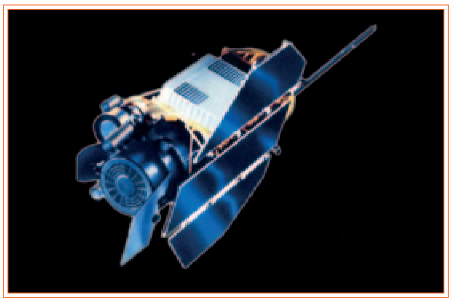
A Progress Report on Commercial Cargo and Crew

At a recent panel, company officials discussed the progress they were making with their cargo and crew vehicle efforts even while changes to the crew program cause concern among some advocates for that effort. A panel session of the AIAA Space 2011 conference in Long Beach, California, was devoted to NASA's Commercial Orbital Transportation Services (COTS) and Commercial Crew Development (CCDev) programs, and featured representatives from all the companies that have current awards under those two programs. The two-hour panel became an opportunity for the companies to provide a status report on their efforts on those programs.

Read the full story:
http://bit.ly/ccdev_report

Satellite Reentry: ROSAT is Next

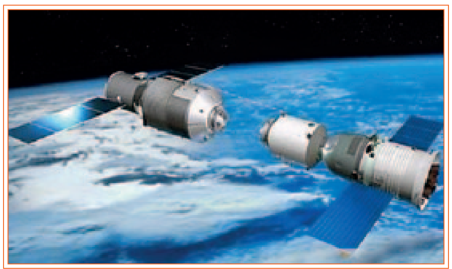
A 2.4 tonnes German X-Ray telescope is expected to plunge into Earth's atmosphere at the end of October. The massive ROSAT, short for Röntgensatellit, was built by the German aerospace agency DLR, and launched by NASA on June 1, 1990 on a Delta II rocket. Mission requirements drove the design of a large shield to protect the spacecraft's mirrors. Now, the shield is likely to increase the mass and size of the debris that will result from the impact of ROSAT with Earth's atmosphere. According to ROSAT website, DLR estimates that "up to 30 individual debris items with a total mass of up to 1.6 tonnes might reach the surface of the Earth."



The german ROSAT space telescope.
Credits: PD-USGov-NASA

Read the full story:
http://bit.ly/rosat_is_next

Chinese Chief Designer Discusses Tiangong-1 Docking



Artist's conception of docking between Tiangong-1 and a Shenzhou space capsule.

According to Xinhua, China plans to use more speed and cut costs in order to acquire the technology, a crucial element in a space station program. "We can never count on other countries to sell their mature technology to us, " said Zhou Jianping, chief designer of China's manned space program, "so we have to rely on our own." According to Zhou, the most advanced microwave radar and laser radar systems have been used to insure accurate positioning; yet, those facilities have not been tested in an environment comparable to space.

Read the full story:
http://bit.ly/china_docking

Has Anyone Been Hit by Space Debris?

US website Aerospace reports the story of Lottie Williams, the only human being who has been hit so far by an orbital debris: "Reportedly, only one individual has been struck by debris from a reentering spacecraft's. Lottie Williams of Tulsa, Oklahoma reported that she was struck on the shoulder while walking. The timing and location were consistent with debris from the Delta second stage reentry from which debris was recovered several hundred miles away in Texas." According to Space.com, "The debris was later confirmed to have been part of a fuel tank from a Delta 2 rocket, and other pieces of the booster were recovered several hundred miles away in Texas."

Read the full story:
http://bit.ly/hit_by_debris

Lottie Williams shows the piece of debris that hit her. - Credits: Aerospace

Columbia Tank Found on Lakebed

An aluminum tank from Space Shuttle Columbia has been found in Lake Nacogdoches, Texas in August 2011. The fragment emerged from the lake following an unusually severe drought. NASA has recognized the fragment as a Shuttle tank, and is now organizing its recovery. Soon the tank will be brought back to NASA Kennedy Space Center, in Florida, along with the other fragments of the spacecraft.

Read the full story:
http://bit.ly/columbia_tank

A tank from Shuttle Columbia. - Credits: NASA

Aircraft are Vulnerable to Small Space Debris

The recent uncontrolled re-entry of the UARS satellite has drawn general attention to the issue of ground safety due to falling debris, but the risk for aviation went virtually unnoticed. The disintegration during re-entry of the Shuttle Columbia on February 1, 2003 highlighted the need to keep air traffic away from falling debris if a re-entry accident occurs. The FAA funded a more detailed aircraft risk analysis that used the actual records of aircraft activity at the time of the accident. That study found that the probability of an impact between Columbia debris and commercial aircraft in the vicinity was at least one in a thousand, and the chance of an impact with a general aviation aircraft was at least one in a hundred!

Read the full story:
http://bit.ly/aircraft_debris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Boeing Studies X-37B Evolved Crew Derivative
OCTOBER 6, 2011 7:41 PM NEWS 0
According to Aviation Week, Boeing is studying scaled-up variants of the reusable X-37B orbital test vehicle (OTV) for potential delivery of cargo and crew to the International Space Station (ISS) and other low-Earth-orbit
NEWS
FOCUS
Canadian Satellite Malfunction Disrupts Air Traffic
A malfunction of the Telsat Anik F2 on October 6, 2011, left thousands of people in northern Canada without communications services, such as lond/distance calling, cell phone, internet DSL and ATM services. The disruption in communication also grounded 48 ariflights, leaving about a thousand people on the ground. According to Telsat officials, the malfunction began [...]
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Tiangong-1 Is In Ready for Docking
According to Xinhua, the first Chinese space station module Tiangong-1 has reached the desired 363 kilometers high orbit. All the systems appears to be in good condition and all tests went on fine during the first days of orbital activities. The unmanned module, Tiangong-1, or Heavenly Palace-1, was launched on Sept. 29 from Jiuquan Satellite [...]
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