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FOR THE ADVANCEMENT OF
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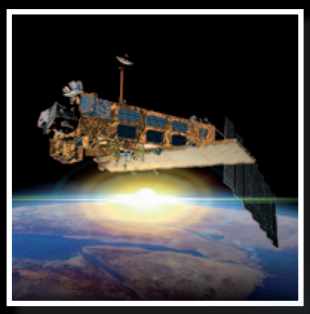
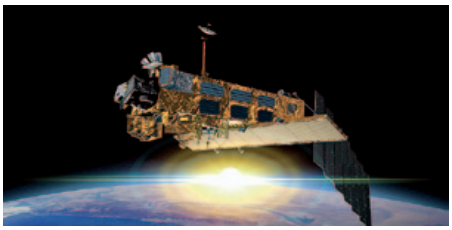
Special Report Space Traffic Management



Envisat: Science Loss And Debris Threat

Landing a Nuclear Powered Rover

Index



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info@spacesafetymagazine.com
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Cover pictures:
SpaceX Dragon is grappled by the Canadarm2 robotic arm at the ISS - Credits: NASA
Central Region of the Milky Way - Credits: NASA, ESA, SSC, CXC, and STScI

IAASS Conference 2013 "Safety is Not an Option": Call for Papers

Welcome back to Space Safety Magazine! We are glad to announce that the sixth IAASS international space safety conference "Safety is Not an Option" will be held 21-23 May, 2013, at McGill University in Montreal, Canada. The conference, organized in cooperation with the International Space Safety Foundation (ISSF), McGill University, and the Canadian Space Agency, is an invitation to reflect and exchange information on a number space safety and sustainability topics of national and international interest. The conference is also a forum to promote mutual understanding, trust, and the widest possible professional international cooperation in such matters.

The once exclusive "club" of nations with autonomous suborbital and orbital space access capabilities is becoming crowded with ambitious new entrants. Commercial spaceports are being built and are becoming operational. In the manned spaceflight arena, the historic flight to ISS of the private SpaceX Dragon spacecraft, which will soon be followed by Orbital Science's Cygnus, is inaugurating the era of commercial spaceliners providing commercial cargo and crew transportation services to orbit. International cooperation, both civil and commercial, is also gaining momentum. In the meantime, robotic space exploration will accelerate and with it the need to better internationally regulate the unavoidable usage of nuclear power sources.

Space bound systems and aviation traffic will share a more and more crowded airspace, while aviation will increasingly rely on safety-critical services based in near-space for navigation, air traffic control, and communication. Finally, most nations nowadays own important space assets, mainly satellites of various kinds and purposes, which are under the constant threat of collision with other spacecraft and with the ever increasing number of space debris. Without effective initiatives we risk negating access and use of space for future generations. Awareness is increasing internationally, (as solemnly declared decades since in space treaties), that space is an asset of all mankind and that we all have the duty to care for it.

6th IAASS Conference. - Credits: Kristhian Mason. Background image courtesy of Joe Tucciarone.

Usually about 150 papers are selected for presentation at IAASS conferences. The representations are grouped in 40 sessions, including panel discussion sessions. The conference sessions provide participants with specialized insight, innovative strategies, and open discussion on important aspects of space safety. At the sixth IAASS Conference there will be sessions on classical topics of design for safety and risk assessment/management as well as specialized sessions on three main topics which need to garner more attention from the space community: Space Debris Remediation, International Space Traffic Control, and Commercial Human Spaceflight Safety. Active removal of dead satellites and spent launcher upper stages from orbit and international coordination of space traffic are mandatory steps both for safe orbital operations as well as for the safety of the public on the ground. The safety of commercial human spaceflight is a critical element for the expansion, and perhaps even continuation, of human spaceflight. The success of commercial spaceflight requires the achievement of a substantially higher level of safety - not solely a reduction in costs.

At the occasion of the IAASS safety conference we recognize leading safety professionals and safety conscious inventors and designers with awards like the *"Jerome Lederer - Space Safety Pioneer"* award and the *"Vladimir Syromiatnikov – Safety by Design"* award. Please visit the IAASS website **www.iaass.org** for more information on how to submit nominations for these prestigious IAASS awards. We look forward to receiving your abstracts.

Best regards

Tommaso Sgobba
IAASS President

To submit abstracts on-line and register for the sixth IAASS international space safety conference "Safety is Not an Option," visit: **http://iaassconference2013.spacesafetyfoundation.org**

By Tereza Pultarova

Dragon: A Breakthrough Mission

The Dragon mission is a milestone for international spaceflight. This is the first time that a commercial spacecraft has flown to the ISS and docked with the Station," European astronaut André Kuipers wrote in his blog after the Dragon capsule departed from the International Space Station and headed for splash down into the waves of the Pacific Ocean. "You could say a new era of spaceflight have begun," the astronaut concluded, "soon private companies will take people to and from space." Kuipers, together with his American counterpart astronaut Don Pettit, was in charge of the berthing operations. On the 26th of May, the whole world was watching as these two men carefully operated the two spacecraft and the robotic arm to connect the private space capsule to the Harmony node of the space station. Especially nervous, but also incredibly relieved, was Elon Musk, the former PayPal entrepreneur and Dragon's spiritual father. Back in 2002, he founded Space Exploration Technologies (SpaceX) and invested $100 million dollars of his own money in his vision to provide cost effective space transportation. Ten years later he is celebrating a major success that some liken to the achievements of NASA in the Apollo era.

A Journey to Make History

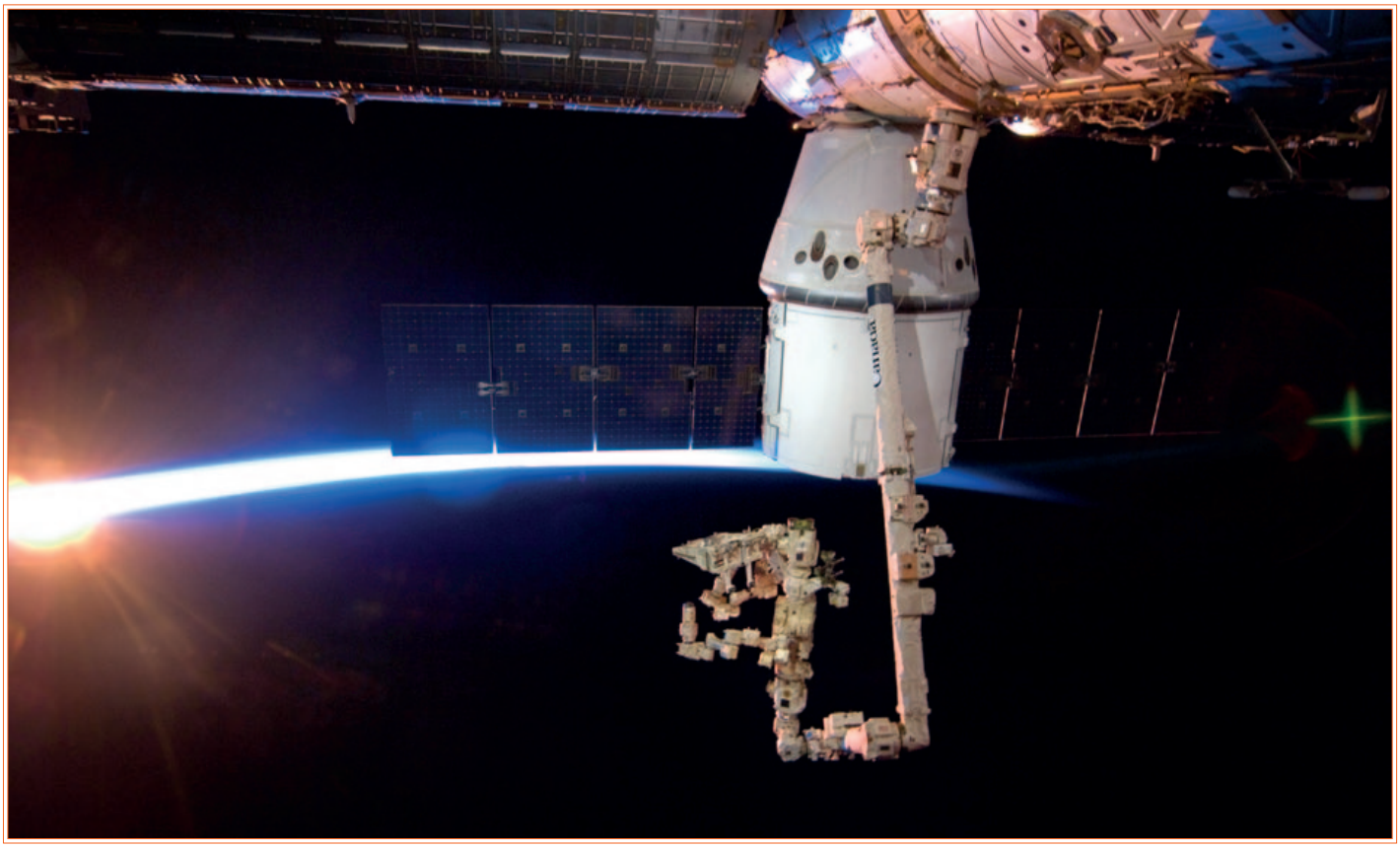
It was probably one of the biggest events in the world of spaceflight in the whole year. If 2011 was a year of nostalgia because of the Space Shuttle retirement, 2012 is a year of excitement and thrill about a new age of private spaceflight.

But the journey wasn't all that easy. In August 2006 SpaceX signed a $1.6 billion contract with NASA as a part of the space agency's Commercial Orbital Transportation Services program (COTS). It happened right after the failure during the maiden flight of Falcon 1, a small partially reusable rocket, which exploded immediately after lift off due to a fuel line rupture.

> "Kuipers: The Dragon mission is a milestone for international spaceflight"

As a part of the COTS contract, SpaceX committed to design and demonstrate a launch system that would be able to provide regular resupply missions to the ISS. The retirement of the Space Shuttle was already planned and instead of developing a new family of launchers and spacecraft for near Earth space travel, NASA wanted

The first attempt to send Dragon towards the ISS was stopped by an automated program that had identified a faulty check valve in the last second of the countdown. - Credits: NASA



The Dragon connected to the International Space Station. - Credits: NASA

to focus on deep space exploration and eventual human missions to an asteroid or Mars. SpaceX was expected to become the first regular private provider to take the burden of regular missions to ISS off NASA's shoulders.

The first demonstration flight of Dragon took place in December 2010, two years after it was initially scheduled. Still, it was enough for SpaceX to become the first private company ever to succeed in launching, orbiting, and recovering a spacecraft. Dragon was sent to space atop the medium lift Falcon 9 rocket, successfully reached orbit, and twice circled around the Earth. After a controlled reentry, it was recovered from the Pacific Ocean off the coast of Mexico.

It took another year and a half to bring Dragon to its rendezvous with the International Space Station. The historical flight was subject to extreme scrutiny: previously governmental agencies had exclusive access to space in the framework of the human space program. "The whole Gemini program had test objectives that, in essence, are all being condensed into this one mission," said Jeff Greason, founder and CEO of rival company XCOR Aerospace."If they get even halfway there, that's still one for the books."

Three, Two, One and Lift Off… Oh, Actually, Cut Off!

The test flight required to prove the ability of Dragon to berth with the ISS was initially scheduled for December 2011. It was the last milestone to be completed before the private capsule starts delivering regular supplies of food, water, scientific experiments, and propellant to the orbital outpost. Dragon would also restores the capability, lost with the Space Shuttle, to return voluminous material to Earth.

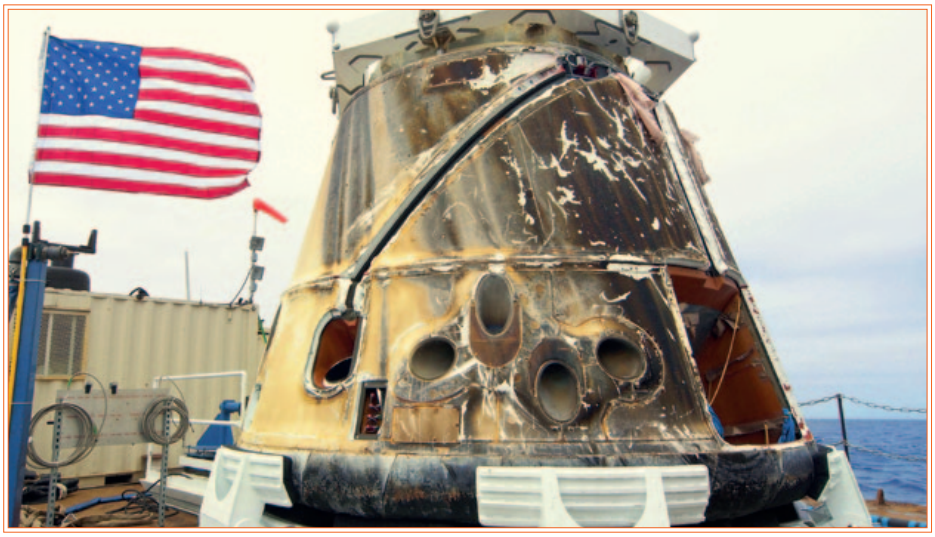
> "Dragon restores the capability to return voluminous material to Earth"

The software controlling the automated spacecraft was mainly responsible for the delay of the last test flight. After the April rescheduling, SpaceX founder Elon Musk explained to the media that the system was basically too sensitive: "the Dragon essentially gets scared and runs away when it shouldn't," he said.

After final approval by NASA, ISS managers, and SpaceX engineers, Falcon 9 with the Dragon capsule aboard was standing on the launch pad in Cape Canaveral on early morning May 19, ready to blast off. But instead of relief and celebrations came a rather heart stopping moment. Even NASA announcer George Diller was at a loss for words when, after the successful countdown and beginning of the ignition sequence, the rocket didn't go anywhere. Speaking on the live footage from the attempted launch, Diller was heard counting: "Three, two, one, zero and liftoff!" When he realized that the rocket was still on the pad, he reported: "We've had a cutoff! Liftoff did not occur." Later on, a faulty check valve was determined as the reason why the automatic computer stopped the launch in the last second.

Due to the fuel demanding orbital maneuvers ahead of Dragon, its launch

European astronaut André Kuipers unloading supplies from inside the capsule.
Credits: NASA



The spacecraft was successfully recovered after splashing down into the Pacific Ocean. Recovery will allow restoring large downmass capability which had been lost with retirement of the Space Shuttle. - Credits: SpaceX

window was extremely narrow. Once the right second was missed, SpaceX had to wait for another three days to embark on its maiden mission towards the ISS.

What's Next?

"I think it really shows that commercial spaceflight can be successful," Musk commented after Dragon concluded its mission by splashing into the waters of the Pacific Ocean on the morning of June 1. "This mission worked for the first time right out of the gate. It was done, obviously, in close partnership with NASA, but in a different way, and it shows that that different way works and we should reinforce that," he said.

But what is coming next? Aren't the expectations too high? Is the onset of private human spaceflight really going to turn the space travel into a treat available for everyone? The first regular service flight of Dragon might take place as early as September. And there are other players lining up to prove their abilities. The next commercial vessel that will attempt to rendezvous with ISS could be Orbital Science's Cygnus vehicle in December, while Boeing, Virgin Galactic, and Alliant Techsystems are working hard to reach their milestones.

It seems that just a few decades after the end of the space race between the USA and USSR, a new competitive paradigm is on the rise: the paradigm of free market competition in space. And while the legal community will probably have considerable work to do to adjust the current framework to the new circumstances, the ambitious dreams of those involved are already one step closer.

Last year, NASA awarded SpaceX additional $75 million to develop a revolutionary launch abort system that would enable Dragon to safely carry astronauts to orbit. This milestone should be achieved by 2015 and regain America the ability to send crews in space aboard a US vehicle.

Speaking with CBS earlier this year, Musk revealed that his ambitions are even more daring: "I think it's important that humanity become a multi-planet species, I think most people would agree that a future where we are a spacefaring civilization is inspiring and exciting compared with one where we are forever confined to Earth until some eventual extinction event. That's really why I started SpaceX."

> "Musk: It's important that humanity become a multi-planet species"

Working towards his goals steadily, Musk included an on-target propulsive landing system into the human rated version of the Dragon capsule. This feature could potentially enable it to land on other planetary bodies with less dense atmosphere, or no atmosphere at all.

At the same time, SpaceX is developing the Falcon Heavy, a rocket capable of lifting up to 53 metric tons to low Earth orbit. Several studies are considering the use of Falcon Heavy and modified Dragon capsules to send large scientific payloads to Mars, a scenario technically within the capability of SpaceX's hardware. Bringing these ideas to the extreme, Dutch private venture Mars One has recently unveiled its plan for human colonization of the red planet by 2023 using vehicles derived from the Dragon capsule.

Mars One proposed an ambitious plan to colonize Mars by 2023 using vehicles derived from the Dragon capsule. - Credits: Mars One

By Andrea Gini

Envisat: Looming Collision Threat

On May 9, 2012, ESA declared Envisat's mission over. "Despite continuous commands sent from a widespread network of ground stations, there has been no reaction yet from the satellite," reads the official ESA press statement. "As there were no signs of degradation before the loss of contact, the team has been collecting other information to help understand the satellite's condition."

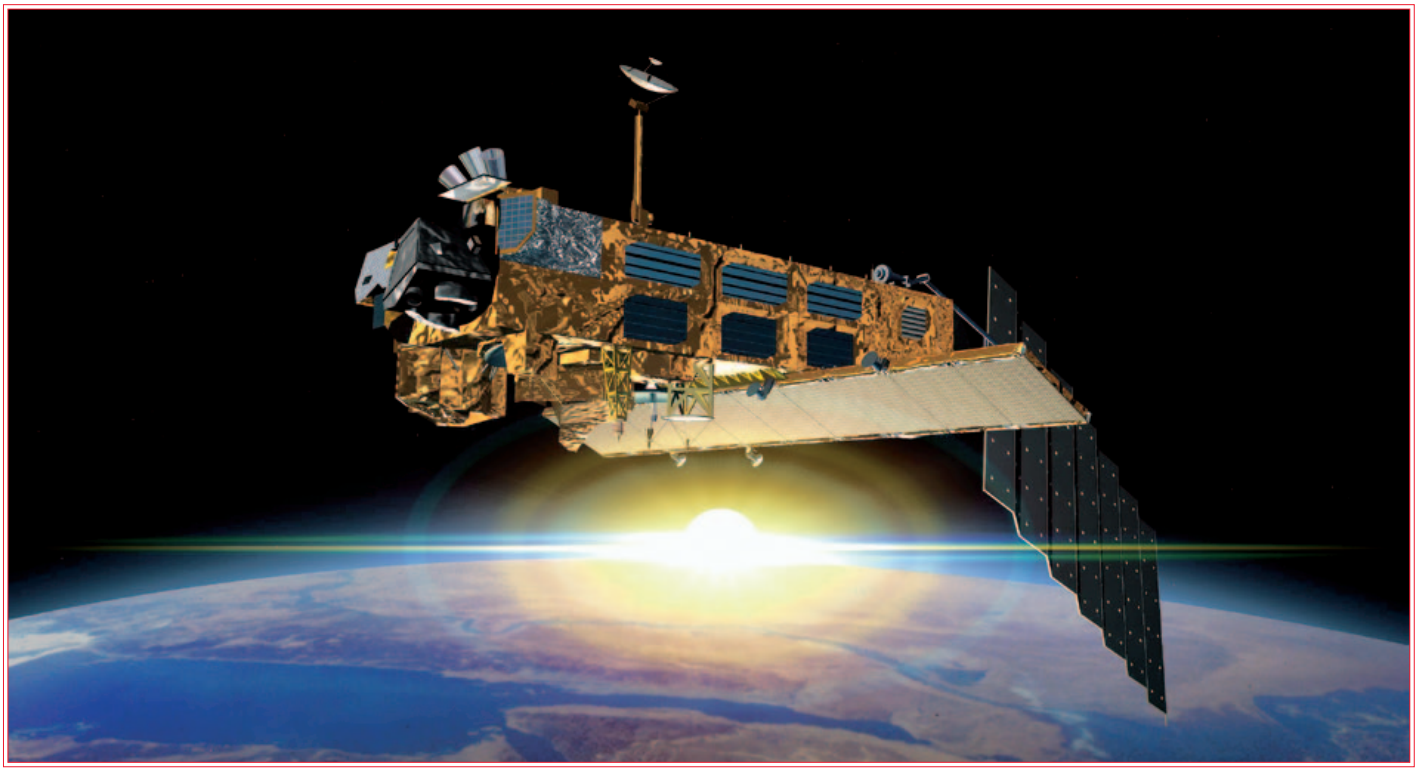
The agency lost contact with the satellite on April 8, 2012 and failed to regain communications in the weeks that followed. And while ESA kept trying to regain contact with the satellite for a few more weeks, the chances of recovery have been considered to be extremely low since then.

Engineers were unable to determine what caused the communication breakdown in a month of investigations. The investigation team analyzed the available telemetry and collected images from ground radar and the French Pleiades satellite, coming up with possible failure scenarios. A likely scenario is the loss of the power regulator, making it impossible to send telemetry and receive commands thereby leaving the satellite incapable of communication. A second scenario is the combination of a short-circuit that triggered a transition into a safe mode, followed by a second anomaly that may have occurred during such a transition, leaving the satellite in an intermediate and unknown condition.

> "Envisat is perhaps the largest civil Earth observation satellite ever built"

10 Years of Great Science

Launched in 2002, Envisat is perhaps the largest civil Earth observation satellite ever built. The main objective of the Envisat program was to enhance Europe's remote sensing capabilities, expanding those of the European Remote Sensing (ERS) missions with instruments dedicated to ocean and ice monitoring. Thanks to its 10 sensors, capable of generating a huge variety of data on environmental phenomena of land, oceans, ice, and atmosphere, Envisat made a significant contribution to studies of atmospheric chemistry, ozone depletion, biological oceanography, ocean temperature and color, wind waves, hydrology, agriculture and arboriculture, natural hazards, digital elevation modeling, monitoring of maritime traffic, atmospheric dispersion modeling (pollution), cartography, snow, and ice.



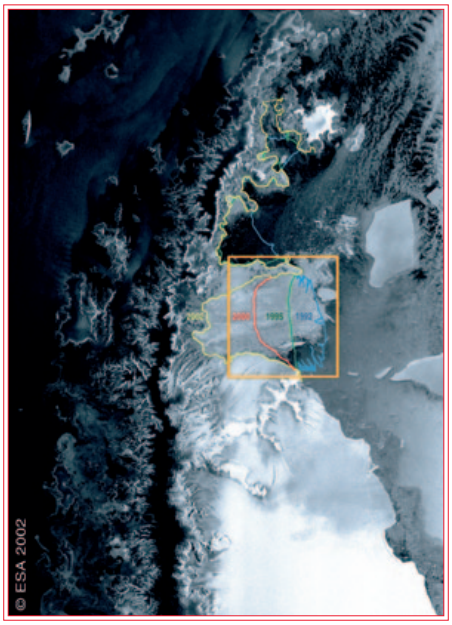
Artist's conception of ESA's Envisat satellite. - Credits: ESA

Along with ERS 1 and 2, Envisat supported more than 4000 projects in over 70 countries, providing the global community with precise measurements on phenomenon such as climate change.

Envisat was originally intended for a 5 year service life as part of the European Global Monitoring for Environment and Security (GMES) initiative. It had reached the 10 year mark in 2012 and was expected to continue operating through at least 2013, when the replacement observation satellite Sentinel is due to launch. "The outstanding performance of Envisat over the last decade led many to believe that it would be active for years to come, at least until the launch of the follow-on Sentinel missions," commented ESA in a press release. "The interruption of the Envisat service shows that the launch of the GMES Sentinel satellites, which are planned to replace Envisat, becomes urgent," added Volker Liebig, ESA's director of Earth observation.

A Debris Threat: Don Kessler on Envisat

Aside from the gap in environmental data that will result from the loss of the satellite, Envisat is expected to pose considerable risk as space debris in its current sun synchronous polar orbit at an altitude of 782 km. With a mass of about 8 metric tons, the spacecraft is 9 meters long and 5 meters wide, with a huge sail-like 5 by 14 meter solar array, Envisat has become a huge target for orbiting objects.



This photo, taken by Envisat on 18 March 2002, documents the 100 km retreat of the Larsen B ice shelf . - Credits: ESA

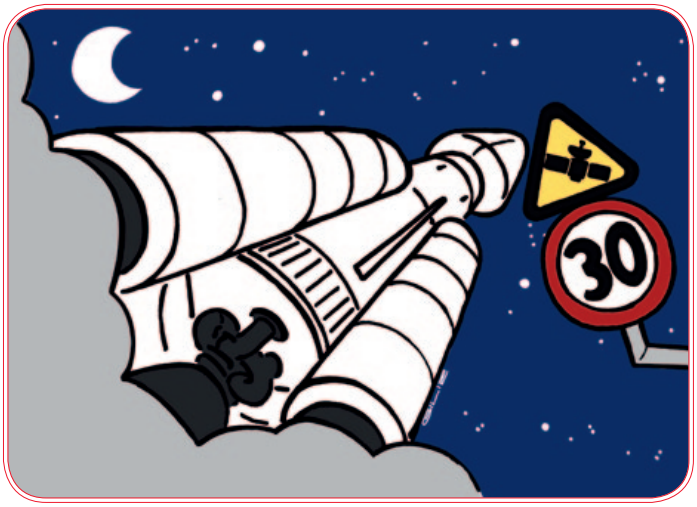
> "Envisat's natural orbital decay will take up to 150 years"

Without communication capability, it is impossible to deorbit the bus-sized spacecraft. Even if possible, it could be a hazardous endeavor, since large parts of the satellite would be likely to survive reentry. It is expected that Envisat's natural orbital decay will take up to 150 years. In its current location, Envisat poses a severe collision risk. Given its mass, volume, and shape, such a collision might generate a cloud of smaller debris large enough to populate the orbit, initiating the so called Kessler Syndrome, a self-sustaining chain-reaction of collisions and fragmentation that produces new debris. This phenomenon, named after physicist and former NASA scientist Don Kessler, could eventually make space operations difficult or even impossible, and prevent access to space for future human generations. Space Safety Magazine asked Don Kessler, Orbital Debris and Meteoroid Consultant and honorary member of IAASS, for a comment on this looming crisis.

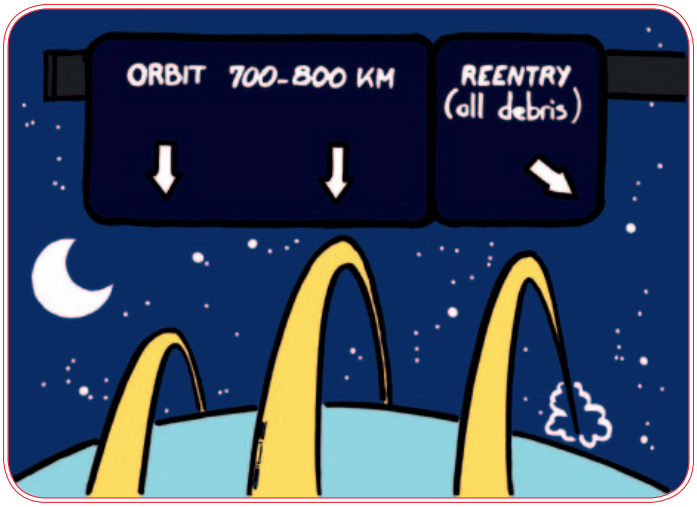
"It seems ironic that a satellite intended to monitor the Earth's environment is at risk from the space environment and is likely to become a major contributor to the debris environment," said Kessler. "Envisat is probably one of the best examples of a satellite that should have followed either NASA's 1995, or ESA's

Gil's Corner

Danger, Satellites!



Reentry Lane



Credits: Gilles Labruyere, The-Cow.over-blog.com

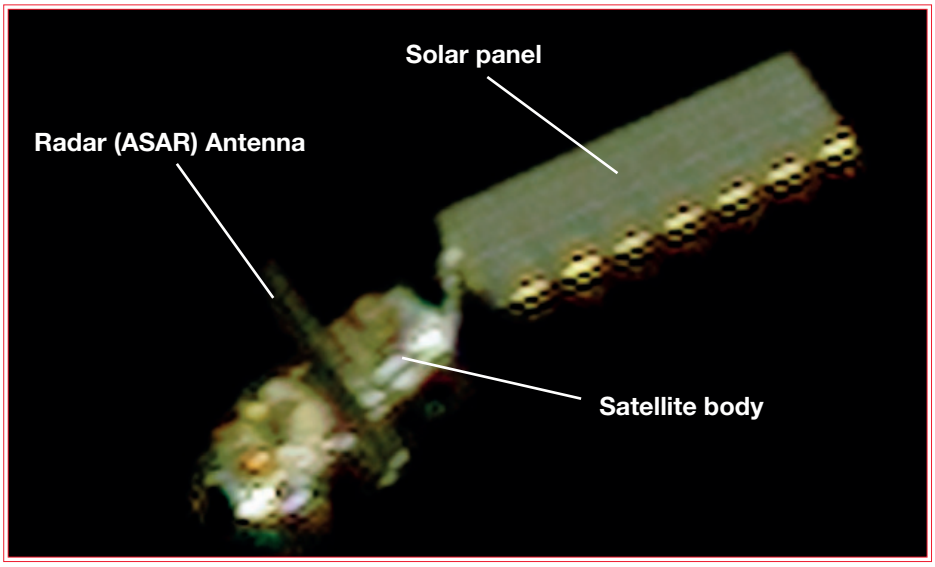
Gilles is Principal Mechanical Engineer of the Aeolus satellite at ESA, and previously of Envisat. He has been drawing space related cartoons since 1994.

> "Kessler: Envisat is near the top of a list of satellites that should be removed"

2002, debris mitigation guideline. Envisat is a very large target, operating at an altitude where the debris environment is the greatest and likely to increase. In the next 150 years that the satellite will remain in orbit, it will become a significant debris source and could easily become a major debris contributor from a collision with debris as small as 10 kg."

In 2010, the satellite narrowly avoided a collision with a spent upper stage. If the collision had occurred, it was expected to produce ten times the debris caused by the infamous 2009 Iridium-Cosmos collision. Now without active control, such a collision would no longer be preventable. "The need for a collision avoidance maneuver from the 1500 kg Chinese rocket is not a surprise," said Kessler. "Envisat is currently flying in an environment where two catalogued objects can be expected to pass within about 200 meters of Envisat every year, which would likely trigger the need for a maneuver to avoid a possible collision. I fully agree that if Envisat had collided with the Chinese rocket, 'it likely would have polluted a highly used portion of low Earth orbit with 10 times as much junk as what was caused by the 2009 collision of an operational Iridium communications satellite with a retired Russian Cosmos spacecraft', as stated in your email."

Asked about whether the event might have triggered a collisional cascade, Kessler commented: "Although I would not use that exact statement, I would not object to anyone else using the term in this case. The cascade process can be more accurately thought of as continuous and as already started, where each collision or explosion in orbit slowly results in an increase in the frequency of future collisions. But since Envisat is so massive, if the collision had occurred it would have instantly produced a debris environment that, under the most optimistic conditions, we would not expect to have for at least 100 years. That is close to what most might call a 'trigger' event."



A picture of Envisat, taken from a distance of about 100 km by the Pleiades Earth observation satellite. High resolution images of Envisat could provide important data on the small-debris population at an altitude that has not been measured before. - Credits: CNES

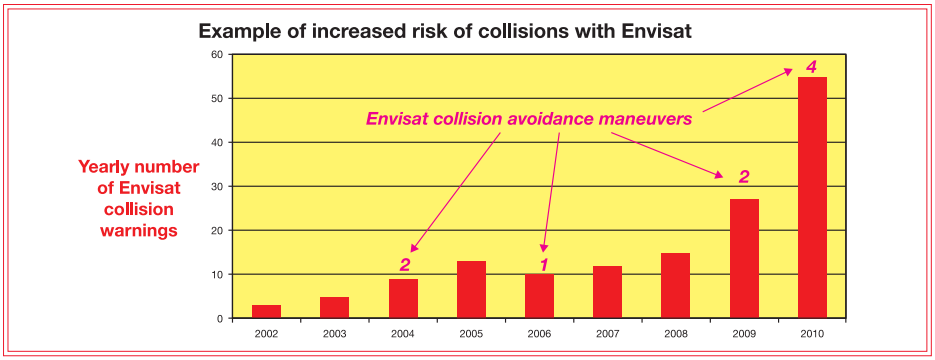
A Case Study?

While the official Envisat mission is over, there may still be a chance to make good use of the satellite. "Envisat could serve as a different type of 'Environmental Satellite' by providing information on the orbital debris environment," said Kessler. "It would be invaluable to learn the consequence of that environment by closely examining the spacecraft's surface before intentionally removing Envisat from orbit."

"Envisat is near the top of a list of satellites that should be removed from orbit, both because of its size and because of its location," added Kessler. "Those same two qualities would make it an excellent object for study, with benefits similar to what was learned from the Long Duration Exposure Facility (LDEF) satellite, recovered from orbit in 1990. Studying Envisat could be even more valuable, as it is located within the region of Earth orbit that contains the most operational satellites – and the most debris."

With the retirement of the Space Shuttle, which had a theoretical capability to fly into polar orbit from Vandenberg Air Force Base, an intact recovery of Envisat appears highly unlikely. "Recovering the intact satellite would be ideal, but expensive," commented Kessler. "If no one is willing to make that investment, obtaining high-resolution images would provide important data on the small-debris population at an altitude that has not been measured before."

"We expect that Envisat is covered with many more craters from small-debris impacts than were examined on the LDEF satellite," Kessler concluded. "It also should have more than were observed on the Hubble Telescope during repair missions and more than were observed on the Space Station during EVAs. It is likely that some of those craters will indicate surface penetration. If any such penetration of Envisat is over a critical component, it might explain any anomalies and/or failures."



Envisat yearly collision warning and corresponding avoidance maneuvers. - Credits: ESA

By Leonard David

Landing a Nuclear Powered Rover

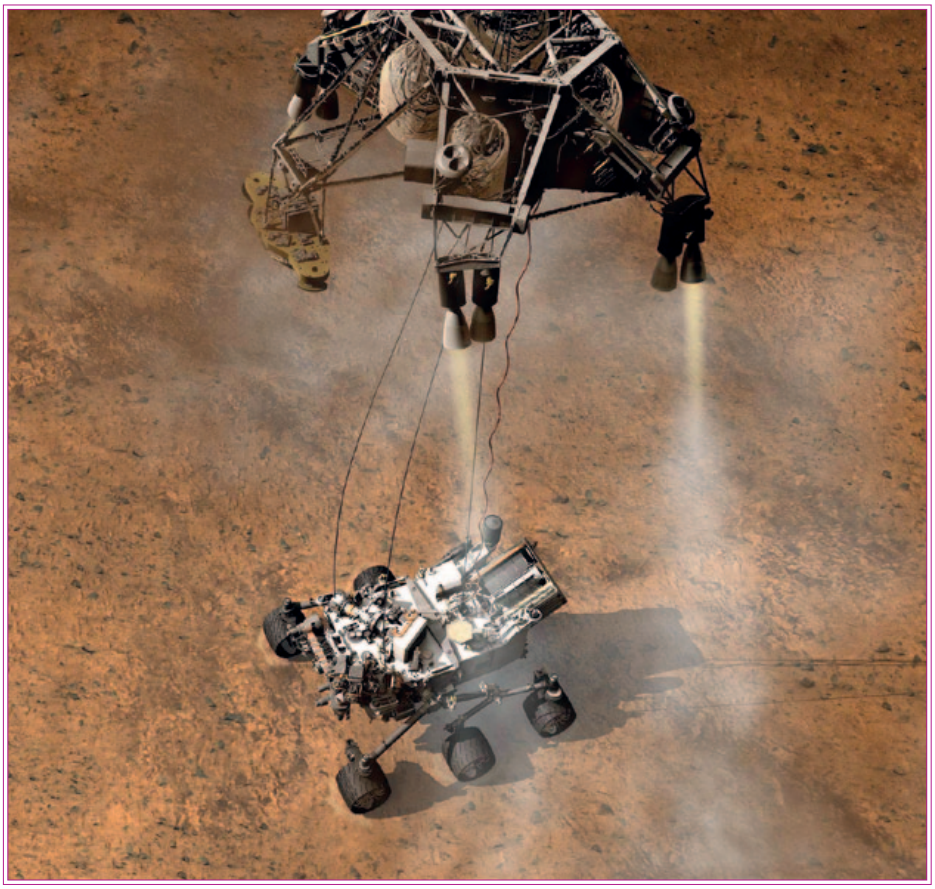
The next grand adventure in exploring Mars is set to begin in early August. NASA's now en route Mars Science Laboratory (MSL) mission is on track to dispatch onto the Martian landscape the 900 kg nuclear-powered Curiosity rover.

The MSL rover is loaded with a suite of instruments built to seek answers to questions of geochemistry and biological processes, and measure aspects of surface and sub-surface materials potentially linked with ancient life and climate. The MSL could also pave the way for a future sample return mission.

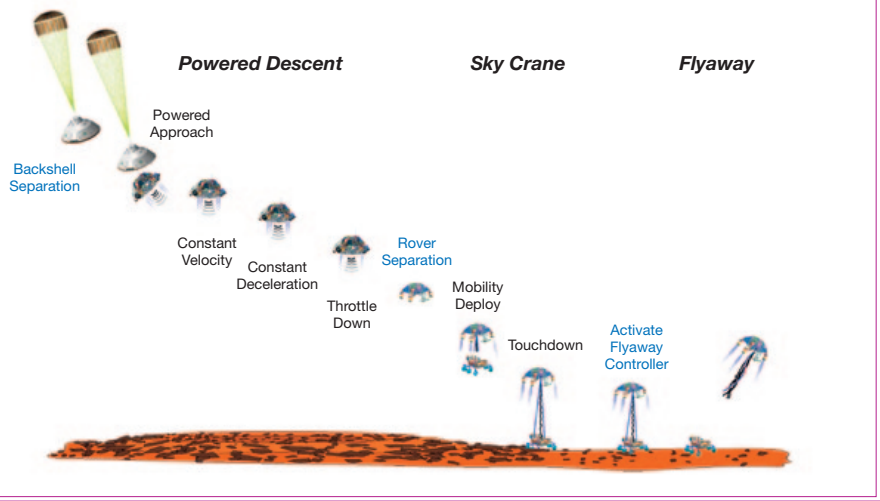
Curiosity's meeting with Mars is set for the evening of August 5, Pacific Daylight Time (Aug. 6, Universal Time and Eastern Daylight Time) to begin a two-year mission of reconnoitering the red planet. But getting MSL's Curiosity rover down safe and sound is no easy feat.

Plunging through the thin atmosphere of Mars, MSL will perform a guided entry. The spacecraft will be controlled by small rockets during descent through the atmosphere towards the surface. The craft will then be slowed by a large parachute. In powered descent mode, rockets will control the spacecraft's descent until the rover separates from its final delivery system - the novel, never flown before, Sky Crane. Like a large crane on Earth, the Sky Crane system will lower the rover via a bridle system to a "soft landing" – wheels down – on the terrain of Mars. If all goes well, Curiosity will land at about 0.75 meters per second.

Sensing touchdown, the landed craft will cut the connecting cords and the Sky Crane will fly out of the area, destined to crash-land away from the rover's position.



Pictorial description of the touchdown, after pyrotechnic cutters have severed the connections between the rover and the spacecraft's descent stage, which will fly away and crash at a safe distance. - Credits: NASA/JPL-Caltech



The MSL descent will be guided by small rockets, and then slowed by a large parachute. As the spacecraft loses speed, rockets will control the deployment of the Sky Crane, which will lower the rover to a soft landing. - Credits: NASA/JPL-Caltech

> "Getting MSL's Curiosity rover down safe and sound is no easy feat"

Rover Power

Curiosity is powered by a multi-mission radioisotope thermoelectric generator (MMRTG) supplied by the U.S. Department of Energy. The MMRTG makes use of a heat source that contains 4.8 kilograms of plutonium-238 dioxide – a non-weapons-grade form of the radioisotope – and a set of solid-state thermocouples that convert the plutonium's heat energy to electricity.

Heat emitted by the MMRTG will also be circulated throughout the rover system to keep instruments, computers, mechanical devices, and communications systems within their operating temperature ranges.

The electrical output from the multi-mission radioisotope thermoelectric generator charges two lithium ion rechargeable batteries. This enables the power subsystem to meet peak power demands of rover activities when the demand temporarily exceeds the generator's steady output level. The batteries, each with a capacity of about 42 amp-hours, are expected to go through multiple charge-discharge cycles per Martian day.

Wary of Water-Ice

The MSL mission is complying with a requirement to avoid going to any site on Mars known to have water or water-ice within a meter of the surface. This is a precaution against any landing-day accident that could introduce hardware not fully sterilized by pre-launch dry heat treatment. The concern centered on heat from the mission's radioisotope thermoelectric generator meeting a Martian water source, a situation that could provide conditions favorable for microbes from Earth to grow on Mars.

Curiosity is targeted to land within a flat section of Gale Crater – a feature that includes a 5 kilometer high mountain of layered materials in its middle.

Scientists suggest that flowing water appears to have carved channels in both the mound and the crater wall. To get to the mound, the nuclear powered rover will work its way upward, layer by layer of the huge mound. Along the way, the wheeled robot can survey how the layers formed and the environments in which they were created.

According to Catharine Conley, NASA's Planetary Protection Officer, the Gale Crater landing site was preferred by those concerned with planetary protection.

Curiosity will land near the foot of a mountain – dubbed Mount Sharp – inside the 154 kilometer wide Gale Crater. - Credits: Art Kees Veenenbos, Data Mola Science Team (NASA)

> "In early MSL planning, scientists and engineers did evaluate unfavorable landing scenarios"

"All available research suggests that ice is not present within reach of the surface," Conley told Space Safety Magazine. "Even in the unfortunate event of an off-nominal landing, the very dry conditions at Gale Crater mean that the small number of Earth microbes carried on MSL wouldn't be able to grow."

NASA Credo

Planetary protection is the term given to the practice of shielding solar system bodies – planets, moons, comets, and asteroids – from contamination by Earth life. This action is also designed to protect Earth from possible life forms that may be returned from other solar system bodies.

According to NASA: "Planetary protection is essential for several important reasons: to preserve our ability to study other worlds as they exist in their natural states; to avoid contamination that would obscure our ability to find life elsewhere — if it exists; and to ensure that we take prudent precautions to protect Earth's biosphere in case it does."

The credo adopted by NASA's Office of Planetary Protection is "all of the planets, all of the time."

Clean Machine

The assignment of categories for specific missions is made by the NASA Planetary Protection Officer based on multidisciplinary scientific advice.

Given the selected landing site and as a result of changes in hardware configuration, Conley said that MSL was re-evaluated several months before launch and the mission was given a Category IVa classification.

Why the re-evaluation and classification change? They were driven by a set of drill bits carried by the Curiosity rover. Project developers made an internal decision not to send the equipment through a final ultra-cleanliness step. That marked a deviation from the MSL planetary protection plans.

That judgment, however, didn't reach Conley until very late in the game.

Conley said that the initial plan called for placing all three of the drill bits inside a sterile box. Then, after Curiosity reached Mars, the box would be opened for access to the sterilized bits via the rover's robot arm - extracted one by one and fit onto a drill head as the mission progressed. But in readying the rover for departure to Mars, the box was opened, with one drill bit affixed to the drill head, Conley said. Also, all of the bits were

tested pre-launch to assess their level of organic contamination. While done within a very clean environment, that work strayed from earlier agreed-to protocols, she said.

Despite this procedural breakdown, Conley said the Curiosity assembly team and technicians did an excellent job of keeping Curiosity cleaner than any robot that NASA's sent to Mars since the Viking landers in the 1970s.

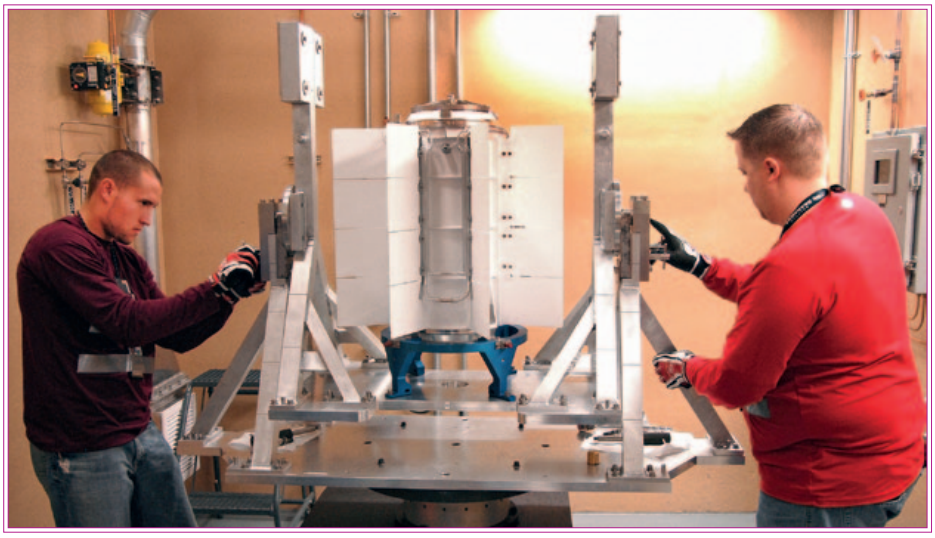
A Category IV includes certain types of missions – typically an entry probe, lander or rover – to a target body of chemical evolution or origin-of-life interest, or for which scientific opinion holds that the mission would present a significant chance of contamination which could jeopardize future biological exploration.

Requirements include rather detailed documentation, bioassays to enumerate the microbial burden, an analysis of contamination probability, an inventory of the bulk constituent organics, and an increased number of implementing procedures.

The latter may include trajectory biasing of the spacecraft, the use of clean rooms (Class 100,000 or better) during spacecraft assembly and testing, bioload reduction, possible partial sterilization of the hardware having direct contact with the target body, a bioshield for that hardware, and, in rare cases, a complete sterilization of the entire spacecraft.

Subdivisions of Category IV – designated IVa, IVb, or IVc – address lander and rover missions to Mars, with or without life detection experiments, and missions landing or accessing regions on Mars which are of particularly high biological interest.

> "COSPAR: We don't anticipate any RTG-related issues, with or without a soft landing"



The Mars Science Laboratory's radioisotope power system was fueled and tested at the U.S. Department of Energy's Idaho National Laboratory. - Credits: Idaho National Laboratory

Clean Up Our Act

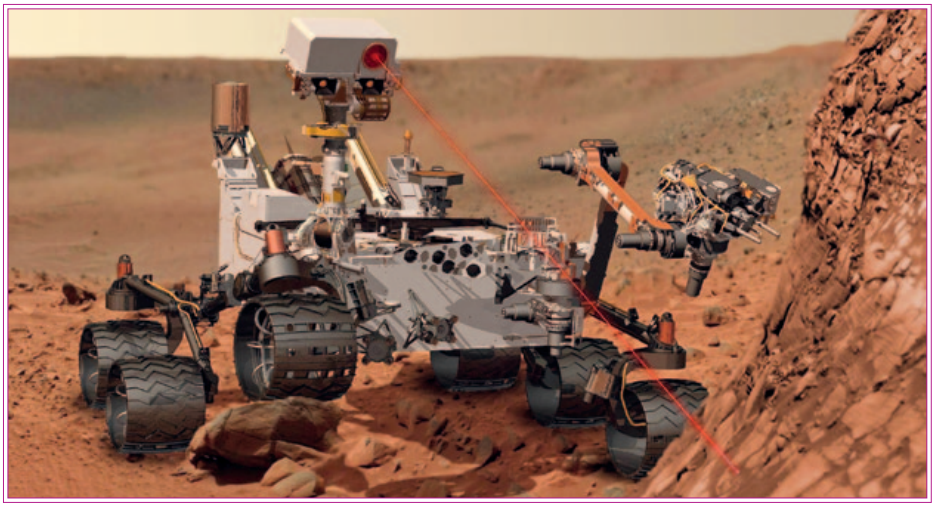
In early MSL planning, scientists and engineers did evaluate unfavorable landing scenarios, said John Rummel, a professor of biology at East Carolina University, Chair of the COSPAR Panel on Planetary Protection and former Planetary Protection Officer for NASA.

Such a situation could result from a failure of the Sky Crane, leaving the RTG and not-fully-sterile spacecraft to land together on top of ice - and under dirt within a meter or so of the surface. That scenario can yield a warm little pool where microbes can grow, Rummel said.

"So MSL was constrained not to go to a place where ice is detectable under the surface. The Gale Crater landing site met that requirement," Rummel told Space Safety Magazine, "so we don't anticipate any RTG-related issues at Gale, with or without a soft landing."

Rummel added that, for the future, if one wants to land at a place with ice, or poke into places with gullies/seeps and find out what that is all about…then the whole spacecraft will have to be sterilized.

Accordingly, it is likely that the RTG will have to be 'sterilizable' – as were the Viking RTGs sent to Mars in the 1970s – and that poses a problem for both the ASRG (mechanical systems) and the MMRTG (materials choices) currently available, Rummel added. "Late, aseptic assembly of the RTG into the sterile spacecraft should be the answer to that problem," he said, "but clearly if we want to go to the best places we know about on Mars, then we need to be able to clean up our act and get there with a usable power supply."



Artist's conception of NASA's Curiosity rover, as it uses its Chemistry and Camera (ChemCam) instrument to investigate the composition of a rock surface. - Credits: NASA/JPL-Caltech

Leonard David is an American space journalist and a senior research associate with Colorado-based Secure World Foundation. His articles can be read at SPACE.com, AIAA Aerospace America, and in the Space Safety Magazine.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The Need for Space Traffic Management

The time of space traffic management has arrived

By Michael K. Simpson

As the number of orbiting objects increases with the launching of new applications and the accumulating debris of old ones, spacefarers like seafarers before them will need to agree on the codes of behavior that will permit them to ensure compliance with one critical law: two objects cannot occupy the same space at the same time.

With the relative utility of critical arcs such as geosynchronous, sun synchronous, and low earth orbits rising in relief against less crowded ones, the need to consider the location of other objects, both active and derelict, has taken on growing importance in planning and operating space missions. Closer to Earth's surface, the need to keep aircraft away from falling space debris is also commanding attention.

Although several countries have developed the capability to track objects in orbit well enough to decrease the odds of their satellites colliding with them, much of the world has come to rely on conjunction analyses provided by the USA's Joint Space Operation Center (JSpOC) for warnings of possible collisions or dangerously close approaches in orbit. While U.S. willingness to share analysis and provide a free service has earned it considerable praise and respect, there is a growing fear that leaving such an important function to any one country is risky in an era where 41 countries or international organizations have registered objects in Earth orbit. This has led to a growing call for a more robust, more modern, more widely dispersed system of tracking and analysis.

One response to this call has been the establishment in 2009 of the Space Data Association (SDA), a private, not-for-profit organization that links 14 satellite operators in a network of data sharing and analysis. This network is designed to coordinate operator-provided data and use it to supply the best possible estimates. The theory behind this Association is that no one knows better than the operators where their satellites are at any moment in time or where planned maneuvers will cause them to be at a specific future point in time. With maximum knowledge of satellite locations, the likelihood of accurate conjunction estimates is also maximized.

With a mission of promoting the sustainable use of space through international cooperation, the Secure World Foundation has taken a substantial interest in space situational awareness and its potential to facilitate peaceful, cooperative, and widespread use of space to meet human needs.

The Secure World Foundation has sponsored studies of space traffic management and has created a database of ground-based sensors whose data might eventually feed a more robust international system of informed conjunction analysis. We have also worked hard to increase awareness of the problems presented by space debris to our planet's ability to benefit from uninterrupted access to space-based services, and we have encouraged discussion of the impact space weather can have on the functioning and even on the location of objects in orbit.

Dr. Michael K. Simpson, Executive Director of Secure World Foundation.

Linking all our efforts in this domain is our belief that cooperative sharing of data, transparency in operations, and broad involvement of countries, institutions, and launch and satellite operators are critical to managing space activity without creating a fertile ground for conflict and tension.

We accepted the kind invitation of the International Association for the Advancement of Space Safety and of the International Space Safety Foundation to cooperate in developing the special report on "Space Traffic Management," because in space more than any other domain, safety and security represent the two sides of the same coin. Preventing further degradation of the space environment and promoting cooperation in space traffic management is at the center of our common action.

Sputnik-1 was completely unencumbered by concerns of conjunction analysis or reentry planning. Those concerns and many others have imposed themselves as satellites became larger and more numerous. This is perhaps the strangest measure of our evolution as a spacefaring species – the progressive loss of spontaneity in our use of orbital assets. The time of space traffic management has arrived.

Dr. Michael K. Simpson is the Executive Director of Secure World Foundation and former President of the International Space University (ISU).

What is Space Traffic Management?

The extreme challenge of predicting and avoiding collisions in real time

By Brian Weeden

The Joint Space Operations Center provides a focal point for the operational employment of worldwide joint space forces. - Credits: US STRATCOM

Space Traffic Management (STM) is an important and challenging topic to discuss because of the many possible definitions of what STM is and all the potential misunderstandings of what is possible or even desirable given the unique aspects of orbital mechanics and the space environment. A brief overview of those unique aspects and a discussion of the major areas of focus for STM now and in the near future is necessary to really understand this topic.

It is important to clarify that it is actually impossible to actively monitor all objects in space all the time. The volume of space around the Earth between the lowest orbiting satellites and geostationary belt encompasses trillions of cubic kilometers. Current space situational awareness (SSA) techniques rely on periodic spot checks of space objects as they orbit around the Earth to build models of their motion. These models are then used to predict space objects' trajectories into the future.

Prediction is important because it is extremely challenging to determine and avoid collisions between two space objects in real time. The relative speeds of such an encounter in low Earth orbit (LEO) routinely reach upwards of 10 kilometers per second. As a direct consequence, the closer two objects are to a possible collision, the larger a maneuver is needed to avoid it, at the expense of a satellite's limited fuel supply. Short-notice avoidance maneuvers can also disrupt services provided by that satellite and result in a new orbit which could potentially have an even more serious opportunity for collision.

These challenges have led to the current system of periodic checks of the location of space objects, maintenance of a catalog of their orbits, and predictions to determine close approaches called conjunctions. Data on the most dangerous close approaches is provided to satellite operators, who determine the probability of a collision and decide upon the best course of action. A decision on whether or not to maneuver is not easy. It is virtually impossible to predict a collision with certainty, and the farther into the future a conjunction is, the more uncertain it becomes.

In addition, there are two other categories of space activities which warrant more specialized STM procedures and higher levels of awareness and control. The first one is rendezvous and proximity operations (RPO) between two or more space objects, which includes formation flying of two or more satellites in close proximity to each other as well as docking maneuvers to space objects such as the International Space Station or with an orbital debris removal spacecraft. The second category is the interface between space traffic and air traffic, which includes both space launches and atmospheric reentry of space objects. Although space objects by definition are only in air spaces for a brief amount of time, they can present a significant hazard to air traffic and people and facilities on the ground.

While the advisability of having a single international entity to oversee all space traffic management is still debatable, there are important steps that should be taken in the meantime to improve the current situation. The first step is to enhance global SSA capabilities and increase information availability to all space actors. A second step is to encourage data sharing between space actors and improve the existing systems to detect potential collisions and warn satellite operators. A third step is to develop best practices and standard operating procedures for the two high risk categories of RPO and space object launch and reentry. Taking these steps will help prevent future collisions and accidents in space and is crucial to the future of safe and sustainable space activities.

Brian Weeden (bweeden@swfound.org) is the Technical Advisor for Secure World Foundation and a former US Air Force officer with a background in space surveillance.

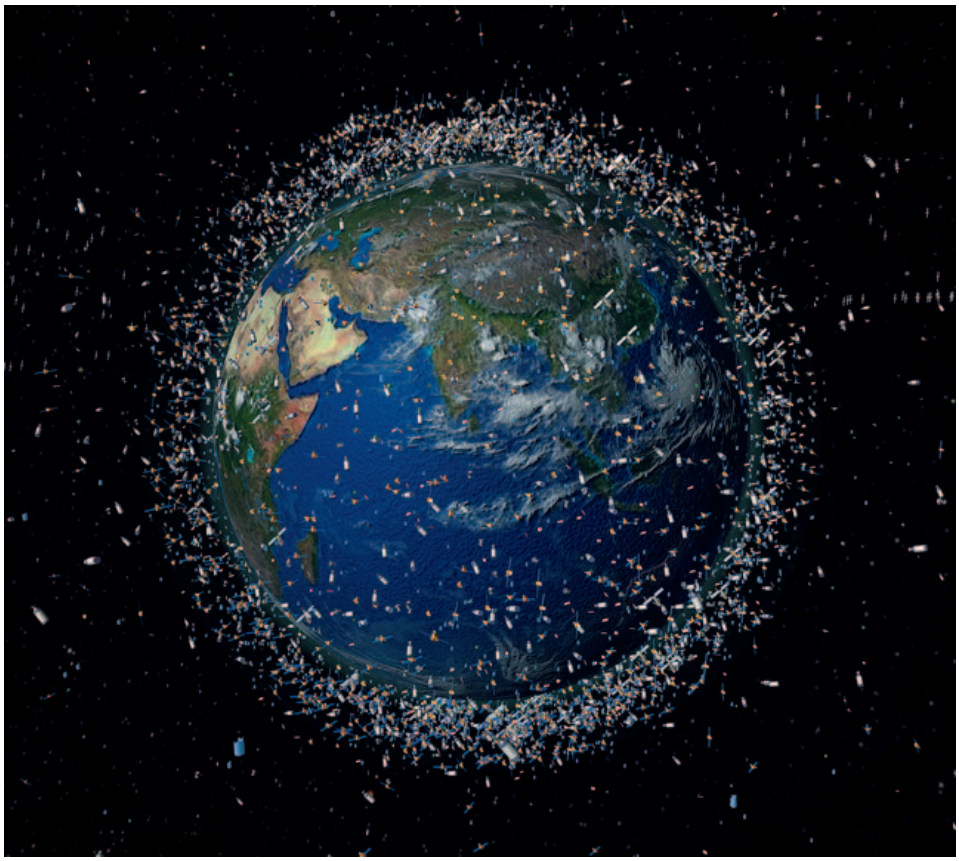
Challenges of the Code of Conduct

A code of conduct risks running contrary to domestic space policies

By Michael J. Listner

The Code of Conduct for Outer Space Activities has taken many turns since the concept was introduced in 2008 by the European Council. The EU Code of Conduct in its modified form was presented to the nations of the world at the end of 2010 to facilitate discussion about space security. From the beginning, it was intended to be a non-binding measure, addressing matters of space security including space traffic management, protection of high value space assets, and space debris mitigation. Moreover, the Code of Conduct sought transparency among the space-faring nations in regards to their space policies both internal and external.

After a year of efforts by the European Council to promote the Code of Conduct to the nations of the world, support for the measure was scarce. A further blow to the EU Code was dealt when the United States withdrew its support for the measure in January 2012. Right after the announcement of its withdrawal, the United States began to work on its own version of the Code of Conduct, based on the EU draft, which was named the International Code of Conduct.



Artist's impression of the debris population in low Earth orbit (size of debris has been exaggerated as compared to Earth). - Credits: ESA

National Security

The first and foremost challenge of a code of conduct is national security interests of the various nations participating in it. The United States cited undisclosed national security concerns as its rationale for withdrawing from the EU Code effort and pursuing one of its own. However, as the United States presses forward to encourage other nations to adopt the measure, it will likely find resistance from many who will be reluctant specifically because of national security. Besides a nation's technical and military capabilities, national security includes internal policies and procedures as well. A code of conduct would encourage transparency for both the technical and internal policy side of a nation, something that may prove to be unpalatable to many nations. Furthermore, the space traffic management system envisioned by the Code of Conduct would implicate military and other sensitive space missions. To the extent that these missions would call into question the security of a nation, compliance would be in question.

Effect on Domestic and Foreign Policies

A code of conduct also poses the risk of running contrary to domestic space policies and regulation, or even of being redundant to them. For example, space debris mitigation was a high priority with the proposed EU Code of Conduct; however, nations that have placed a low emphasis on space debris mitigation, like China, may find the requirements running contrary to their domestic policies addressing the same problem. On the other

hand, nations such as India may consider such a requirement to be redundant to their own measures.

In both instances, requirements from a non-legally binding code might be considered intrusive in domestic affairs, given that even though a code of conduct would be voluntary at the international level, the effect on domestic regulations would be mandatory. Additionally, as in the case of the United States, domestic political differences between two branches of government over a code of conduct could lead to a political stalemate whereby a code of conduct could be signed at the international level by one branch but prevented from being implemented domestically by another, nullifying the effectiveness of a code of conduct. This scenario is being played out now with the US Congress, wary of the influence a code of conduct could have on national security and interstate commerce – particularly the budding commercial space sector, already taking steps to block the implementation of any code of conduct signed by the current presidential administration.

An additional challenge is how a code of conduct would affect the foreign policy of a given nation. For instance, China and the Russian Federation have co-sponsored a treaty in the UN Conference of Disarmament dealing with the issue of space weapons. The Treaty on the Prevention of the Placement of Weapons in Outer Space (PPWT), which seeks to define and ban space-based weapons, has met considerable resistance from the United States and other nations for various reasons. Even though the PPWT will likely not become binding international law, both China and the Russian Federation have gleaned considerable soft-power benefits by continuing to promote it at the United Nations. Such a soft-power advantage translates into greater geopolitical prestige and influence for both nations. Yet, it has been suggested that if a code of conduct was adopted, the PPWT would be effectively neutralized, and with it the soft-power advantage it created.

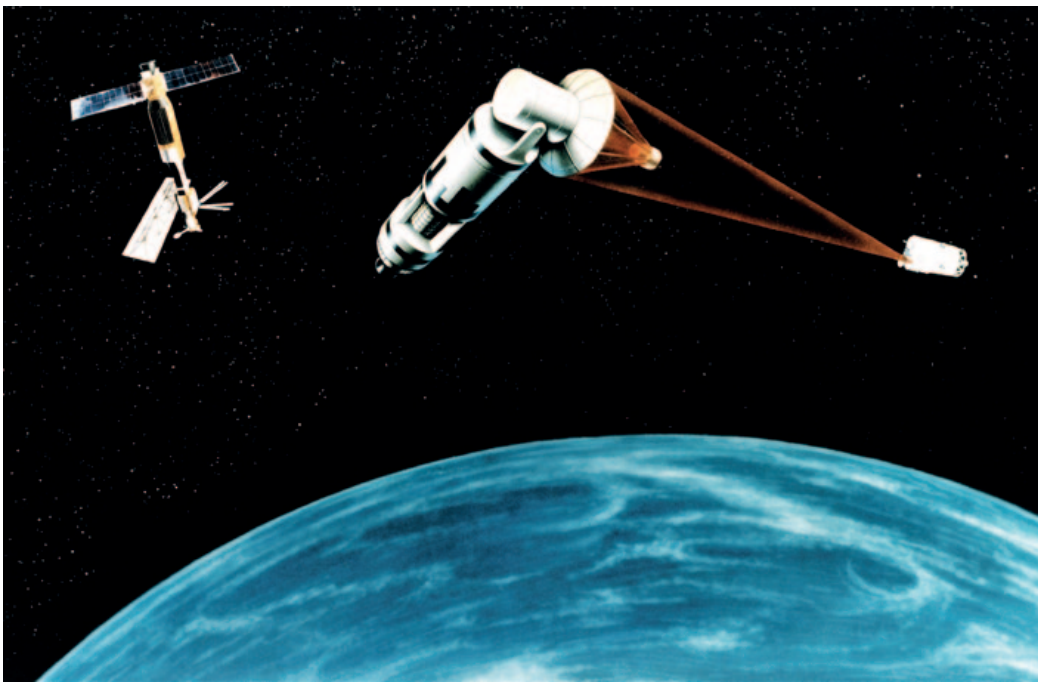
Enforceability

Yet another concern among some nations is the enforceability of a code of conduct. The proposed code of conduct is voluntary in nature, and as such it would not have the legal force of a treaty. Several nations have expressed concern about its non-legal nature and the lack of an enforcement mechanism or penalties for a nation's failure to adhere. More onerous is the specter of multiple codes of conduct being proposed. The EU has announced its support of an International Code of Conduct through Council Decision 2012/281/CFSP, signed in Brussels on May 29, 2012 thereby extinguishing any concerns of discord from the countries that comprise it. However, there is the possibility that nations within the Asia-Pacific Region could propose their own code of conduct, which coupled with the proposed International Code could either result in harmonious co-existence or in a condition of inconsistency that would cause the very disorder they sought to avoid.

A code of conduct can be a positive step towards addressing security in outer space

Conclusion

The implementation of a code of conduct can be a positive step towards addressing security in outer space, both to preserve the environment and to protect expensive national assets from harm. However, like any other facet of international relations, a code of conduct will be subject to the geopolitical interests of individual nations. While the underlying purpose of a code of conduct is to promote cooperation in outer space in order to promote general security, the fact remains that nations will first look to see how the provisions of a code of conduct will integrate with their own national interests, or whether those provisions will be incongruent to them. And because of the very nature of geopolitics, if an agreement is reached there is no guarantee that it will be applied or otherwise disregarded in the event of open conflict between nations.



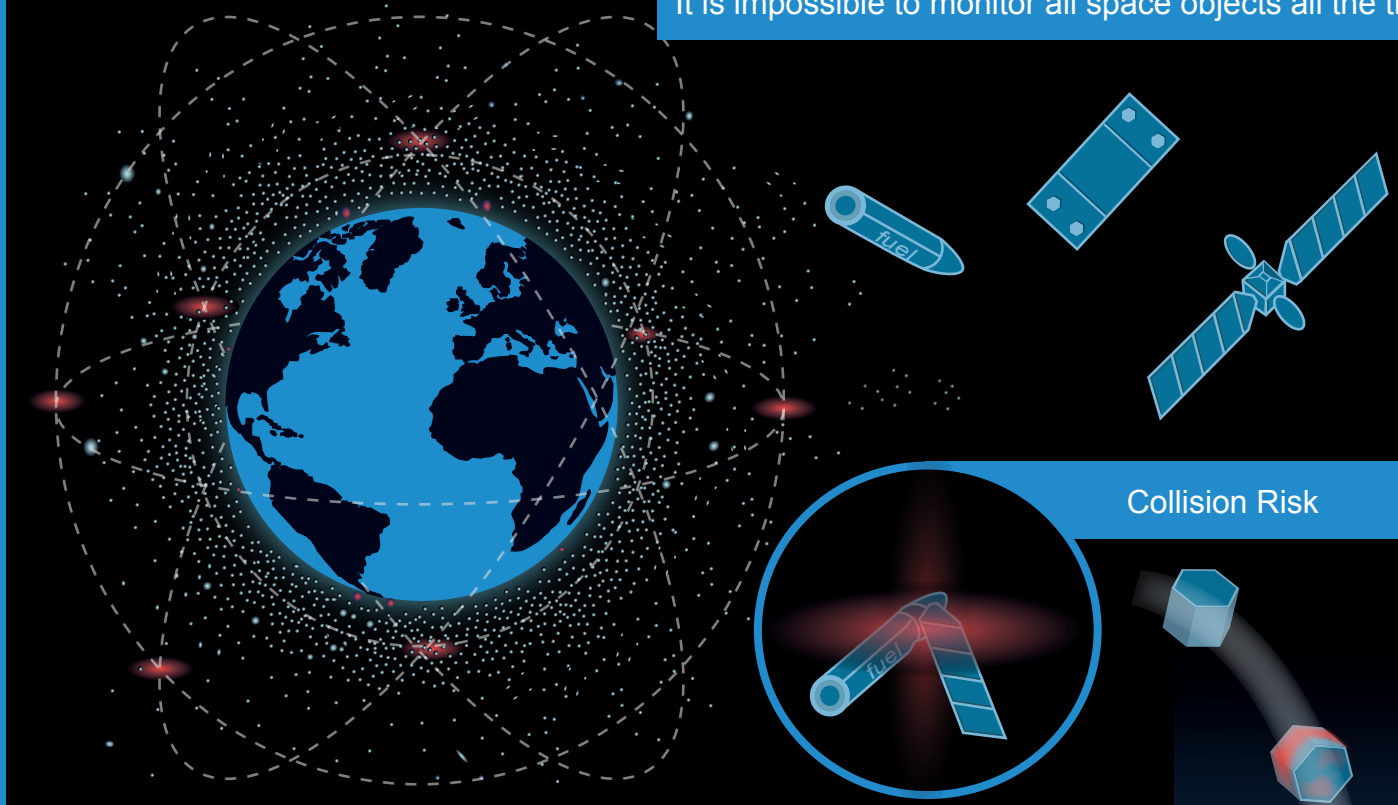
Artist's concept of a Space Laser Satellite Defense System. The space weapons policy is one of the major discussion points of the International Code of Conduct. - Credits: US Air Force

SPACE TRAFFIC MANAGEMENT

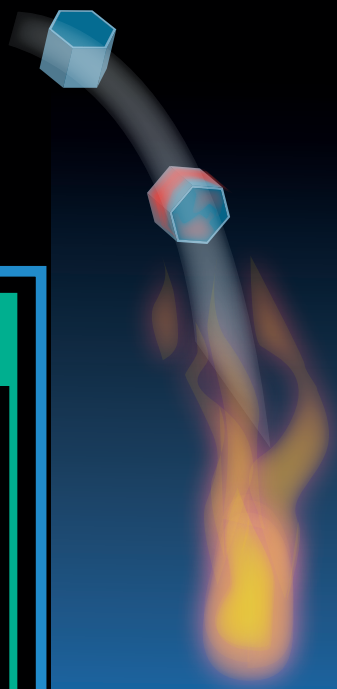
Infographic by Stanislav Lazarevic

THE PROBLEM

It is impossible to monitor all space objects all the time



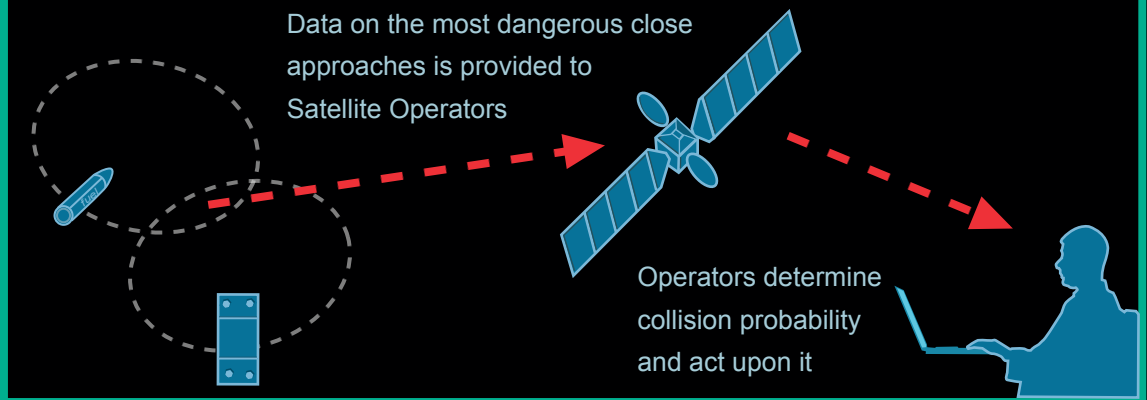
Collision Risk



Hazard to air traffic, and people and facilities on ground and at sea

STM: CURRENT APPROACH

Periodic checks of the location of space objects

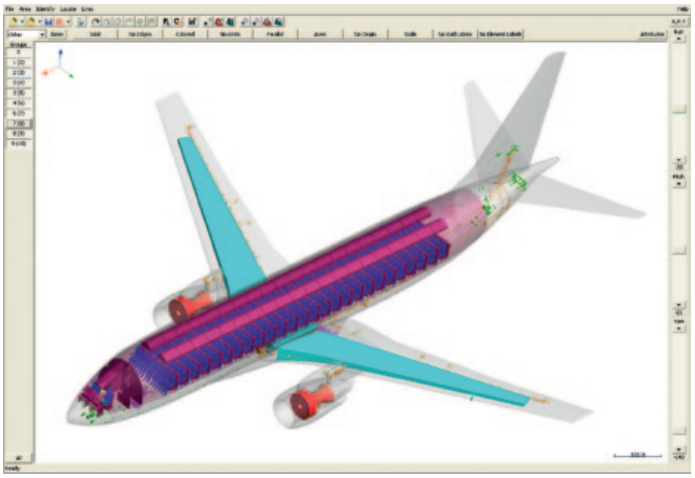


STEPS THAT SHOULD BE TAKEN

1. Enhance global SSA capabilities and increase information available to all space actors
2. Encourage data sharing among space actors and improving the existing systems to detect potential collisions and warn satellite operators
3. Develop best practices and standard operating procedures for rendezvous and proximity operations, launch, and reentry

Protecting Aircraft During Launch and Reentry

By Paul D. Wilde



Computer Model of a Commercial Transport Aircraft Used to Assess Debris Impact Vulnerability

The US Federal Aviation Administration (FAA) Office of Commercial Space Transportation (AST) was established, at least in part, to facilitate safe and efficient sharing of the National Air Space (NAS) by launch and reentry vehicles as well as aircraft. Aircraft are protected during US launch and reentry operations by implementation of temporary flight restrictions, special use airspace, altitude reservations, or notices to airmen (NOTAMs). There are four major elements of the aircraft protection approach applied in the US: safety criteria, aircraft vulnerability models, debris dispersion models, and mishap response systems.

Safety criteria allow establishing an appropriate level of protection for aircraft from launch or reentry vehicle hazards, such as collision with planned or accidental debris. The FAA requires that commercial launches and reentries operate at the same level of safety as government sponsored operations. Specific safety measures are designed to ensure that the general public is not exposed, individually or collectively, to a risk level greater than normal background risks. For example, an individual annual risk of casualty below one in a million is commonly seen as so low that it merges into the background risks of life. The aircraft protection requirements and guidelines published by the Range Commanders Council (RCC) in the consensus based 321-07 Standard and Supplement on "Common Risk Criteria Standards for National Test Ranges" describe how operators can meet those requirements. The aircraft protection measures put forward in RCC 321-07 include probability of impact limits for debris capable of causing a casualty, as well as explicit quantitative risk acceptability criteria, debris hazard thresholds, and vulnerability models for various classes of aircraft.

Aircraft Vulnerability Models (AVMs) are used to quantify the areas of aircraft susceptible to an undesirable outcome from a debris impact, such as a casualty due to a fragment that penetrates the fuselage or an uncontrolled landing following a ruptured fuel tank. The FAA-AST and US Department of Defense co-sponsored the development of AVMs for debris impacts on civilian aircraft, leveraging past work done to assess military aircraft survivability and the threat posed by potential fragments from an uncontained aircraft engine failure, such as turbine blades. These efforts produced improved AVMs for commercial transport and long range business jet aircraft adopted in RCC 321-07 after multiple independent reviews by recognized experts in various fields. The FAA continues to sponsor tests and analyses to produce more refined AVMs. Future AVMs will use more detailed information on the location and vulnerability of critical systems in commercial transport aircraft.

Debris dispersion models are sophisticated physics-based computer models that predict the probability of an impact on an aircraft by identifying four-dimensional regions (including time) where falling debris could impact an aircraft. These models account for various sources of debris dispersion, including launch or reentry vehicle trajectory deviations, break-up induced velocities applied to fragments, lift and drag uncertainties for irregular fragments, and atmospheric winds, as well as the likelihood of foreseeable debris generating events and a variety of vehicle fragmentation scenarios.

Mishap response systems are used to alert aircraft and rapidly clear potentially threatened airspace. In the event of an unplanned debris event, the FAA is immediately notified of the region potentially threatened by debris.

The FAA is currently expanding the real-time aircraft warning system based on containment for debris that exceeds aircraft hazard thresholds, a measure that was implemented in response to the Columbia accident, to more efficiently integrate launch and reentry vehicles into the NAS without compromising safety by activating aircraft hazard areas based on a probabilistic analyses.

Dr. Paul Wilde , Ph.D., P.E., is an IAASS founding fellow with over 20 years of experience in safety standards development, launch and reentry safety evaluations, explosive safety analysis, and launch operations. He is currently a technical advisor for the Chief Engineer in the FAA's Office of Commercial Space Transportation.

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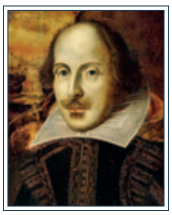
By Michael J. Listner

Let's Not Kill All the Lawyers Yet



In Shakespeare's play *Henry the 6th* an unmemorable character named Dick the Butcher utters one of the few unforgettable lines from the entire three-part production: "Let's kill all the lawyers." Dick promotes the Utopian idea supported by the promises of the treacherous Jack Cade who surreptitiously contends that all lawyers do is shuffle parchments back and forth in a systematic attempt to ruin the common people. Cade's demagoguery is simply a calculated plea to simple folks who want to be left alone. Yet, while one may recognize Cade's moral flaws, they still may sympathize with Dick's idea regarding lawyers in general.

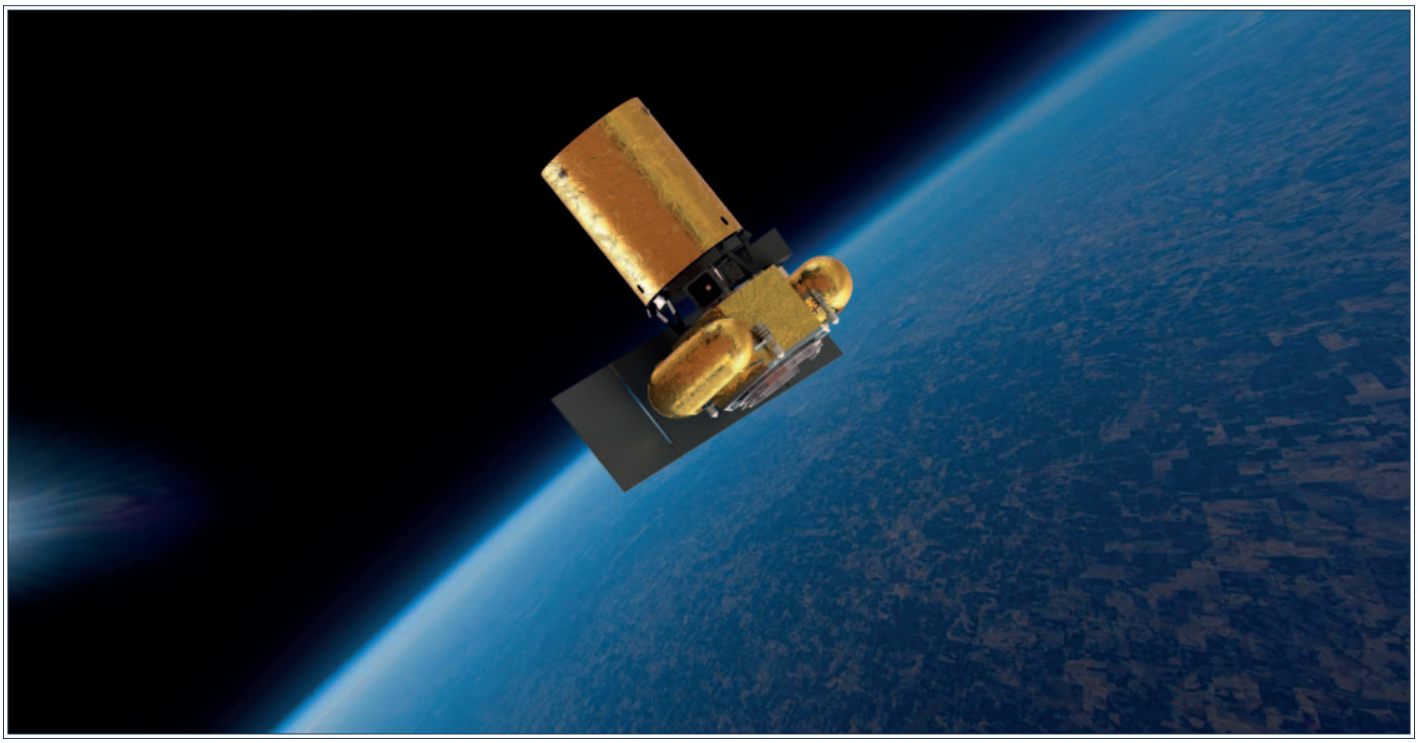
After the April 24, 2012 announcement by Planetary Resources of its goal to mine near-earth asteroids, many lawyers questioned the leglilty of such an operation under the current body of international space law

> "Extraction of extraterrestrial resources is not prohibited per se by the Outer Space Treaty"

and noted legal deficiences that would need to be addressed. These comments elicited echoes of Shakespeare when critics resounded with commentary on the applicability of the current body of international space law. Some called for a new legal regime to address such commercial activities, citing the restrictions the current regime might place on free enterprise and commercial space development. However, despite these criticisms, killing the lawyers at this juncture would not be wise, since someone must resolve questions of applicability, and if need be, write the new laws that will allow Planetary Resources to make its goals a reality.

The Outer Space Treaty

Lawyers will be required to determine how the proposed plan by Planetary Resources to harvest resources from asteroids will implicate the Outer Space Treaty. The United States, which will likely serve as the launching State for Planetary Resources' activities, will ultimately be responsible for the activities performed in outer space by the company. This means that the United States will not only be responsible for approving the proposed activities, but lawyers will be pivotal to demonstrating to the rest of the international community that Planetary Resources' activities are consistent with the principles of the Outer Space Treaty.



The Arkyd-101 space telescope developed by Planetary Resources will gather data from Near-Earth Asteroids to determine their commercial value. - Credits: Planetary Resources

Artist's conception of asteroid mining. - Credits: Phil Smith

Phil Smith is a freelance artist specializing in space subjects across a range of media. He is also a Senior Space Analyst with The Tauri Group based in the Washington, DC area.

Extraction of extraterrestrial resources is not prohibited per se by the Outer Space Treaty; however, such an activity could be prohibited if the extraction implicates a property interest, since the Outer Space Treaty prohibits the appropriation of outer space and extraterrestrial bodies such as the Moon and asteroids as sovereign territory. While there is no disagreement about sovereign nations claiming property rights in outer space, whether private individuals, including legal entities such as Planetary Resources, can make claims and appropriate these bodies and the resources within them is up for debate.

The crux of the debate is whether an exception that allows private ownership exists within the Outer Space Treaty. This question is a matter of continuing debate, with one side claiming that no such exception exists and the other claiming that it does. Until now, the debate has been abstract, and both sides have proffered arguments supporting their positions. However, with the potential of actual resource extraction occurring by the next decade, the stakes are substantially higher than winning an academic debate. Billions of dollars will be invested to perform extraction missions on near-Earth asteroids, and if the status of private property rights is not settled, the United States government may be faced with the choice of either halting Planetary Resources' extraction activities or facing the possibility that it may be sanctioning an activity that could be illegal under international law, with the resultant diplomatic and political fallout. The ultimate answer to space property rights relies in part on how lawyers will interpret and apply the provisions of the Outer Space Treaty.

> "With this magnitude of activities, what is the proper amount of insurance to post?"

The Liability Convention and Indemnity

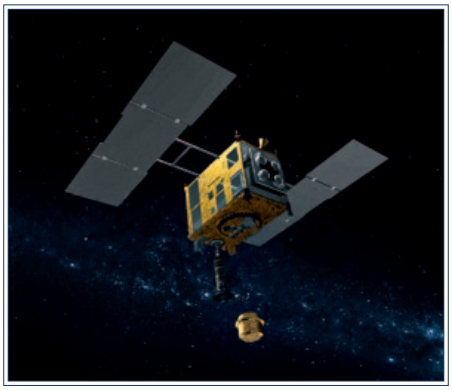
Another legal concern that will have to be addressed by the lawyers surrounds liability for any incidents arising out of Planetary Resources' activities. The Liability Convention has stood as a sentinel protecting the interests of other nations for damage caused by space activities both on the surface of the Earth and in outer space. However, the effectiveness of the Liability Convention is questionable.

The Liability Convention was first invoked during the Cosmos 954 incident of 1979, resulting in an agreement that, while based on the duties and obligations of the Soviet Union under both the Rescue Agreement and the Liability Convention, has been criticized since the Soviet Union never fully compensated the Canadian government for the amount agreed to. The concern is: if Planetary Resources' activities cause appreciable damage on the surface ▸▸

of the Earth, will the Liability Convention's precepts be sufficient to ensure fair and just compensation?

The question of effectiveness also applies to incidents that may occur in outer space as a result of Planetary Resources' activities. This second scenario, outlined in Article III of the Liability Convention, has yet to be tested. The incident between Cosmos 2251 and Iridium 33, which could have invoked this scenario of the Liability Convention, failed to trigger because there was insufficient evidence to determine which party was at fault and to what extent. With Planetary Resources' activities likely to increase the amount of traffic in both medium and low Earth orbit, the potential for accidents to occur will increase. The question is whether the Liability Convention, as it stands today is sufficient to address the potential incidents that could be caused by this activity.

Notably, the Liability Convention implicates government responsibility for the activities of those operating under its jurisdiction, and for any damages that may occur as a result. It is common practice for a launching State to require an entity performing outer space activities under its jurisdiction to provide indemnification for any damage that the government may have to pay compensation for. For example, the recent COTS mission with the SpaceX Dragon required that SpaceX procure an undisclosed amount of third-party liability insurance. However, with the magnitude and scope of activities planned by Planetary Resources, the question is: what is the proper amount of insurance to post? Moreover, given the potential wealth that these mining operations will generate, should the amount of compensation made available to an aggrieved party go beyond what a government would offer as fair compensation?



The Japanese asteroid sampling spacecraft Hayabusa, which returned samples from asteroid Itokawa on June 13, 2010.
Credits: Jaxa/ISAS

Conclusion

While the words and sentiment of Dick the Butcher and Jack Cade may ring true with many when it comes to the role lawyers play, their role in resolving the legal issues that eventually will lead to the successful exploitation of extraterritorial resources by Planetary Resources and other entities will be pivotal. Not only does the current legal regime of outer space law need to be addressed, but the creation of new legal rules will be required. And in the end, if we kill all the lawyers, not only would injustice reign, but the dreams of harvesting outer space resources would die with them.

By Merryl Azriel

Space Access: The Worst Case Scenario

Exploring worst case scenarios can be a good way to avoid the consequence of a threat. On the occasion of the 16th International Space University Annual Symposium dedicated to "Sustainability of Space Activities," Bernard Molard, Vice President of Defence & Security for Astrium and retired General of the French Air Force, highlighted a worst case scenario of what could happen in a very near future if no steps are taken to resolve some specific space problems. Over the course of his career, Molard used this strategy to find solutions in peacekeeping operations, disaster management, and improvement of international relations.

"I believe that sometimes it is useful to extrapolate a specific situation to a worst case scenario in order to shock our political decision makers out of complacency," said Molard. "It is our role to warn them about the risk of a 'No Decision and No Action' strategy."

In a dramatic presentation, Molard imagined what could happen to humanity's space access if the worst were to happen.

Lasers, such as those emanating from Starfire Optical Range pictured here, have been proposed for space debris elimination. What happens when those lasers are turned to non-peaceful uses?
Credits: U.S. Air Force

The Future of Near Earth Space

In real life, it's frequently the ridiculous, the random, and the accidental incidents that tip us over the edge into a worst case scenario. The 2001 terrorist attack on the World Trade Center saw an unanticipated use of a seemingly innocuous airliner. Likewise, a civilian rocket can be used to launch otherwise harmless cubesats and smash them into larger satellites, triggering a cascading process which could block access to an entire orbit. Civil space technology can in turn become a potentially dangerous weapon in the hands of nations or individuals willing to weaponize it.

Molard drew a comparison between the maturation of sea exploration and today's maturation of space exploration. In the age of pioneers, on the sea as in space, there is room for everyone and voyagers are celebrated heroes. Everyone knows the names of Yuri Gagarin and Neil Armstrong, but who knows the names of today's International Space Station crew? The age of space pioneers is clearly over, and after the age of pioneering usually comes the age of power and, sometimes, the age of war. Molard questioned whether it is possible to say with certainty that a space war is not coming next. What would such a war look like? And where could it lead us?

> "After the age of pioneers comes the age of war"

Molard took this moment to point out a major difference between sea battles and space battles. "When a warship is sunk, the battle continues with the remaining assets. But in space, things are more complicated," he said. In space, a "sunk" ship remains part of the battle, as space debris.

Even without a battle, space debris has increased by 50% within the last five years, primarily following the 2007 Chinese anti-satellite test that destroyed the Fengyun 1-C weather satellite and the accidental Iridium/Cosmos satellite collision in 2009. Chances are that the situation will worsen before getting better. How much worse can it get and what will it mean for life on Earth – and in space?

The Worst Case

The 2004 American science fiction film *The Day After Tomorrow* chronicles a situation of catastrophic climate change that results in a mini-ice age, ending life in North American and European latitudes. Molard sees parallels between the problem of climate change and that of space debris. Both are important questions discussed politely and at length in international circles.

To illustrate how much worse the consequences of a *Day After Tomorrow* scenario in space could be, Molard introduced four hypothetical nations whose characteristics may resemble those of real life terrestrial powers.

Darkland: After developing a ballistic missile program despite United Nations opposition in 2015, Darkland has now developed operational anti-satellite (ASAT) capability and dares to shoot at satellites in 2015 and 2017 before destroying the International Space Station in 2022.

Crazyland: Annoyed at receiving regular ultimata from old space powers, Crazyland initiated a nuclear explosion in space in 2017 as a demonstration of power.

Laserland: Laserland developed a powerful ground based laser to remove debris, but starts to use it against satellites belonging to unfriendly nations in 2020 and 2025. The turn around sets back other debris removal initiatives out of fear that they could also become hostile.

Dreamland: This newcomer is trying to build a low cost Space Station aimed at Moon exploitation for tourism, but faces huge technical difficulties and a terrible accident occurs in 2025, setting back their program and littering near-Earth space with the wreckage.

> "By 2027, all space applications would be at an end"

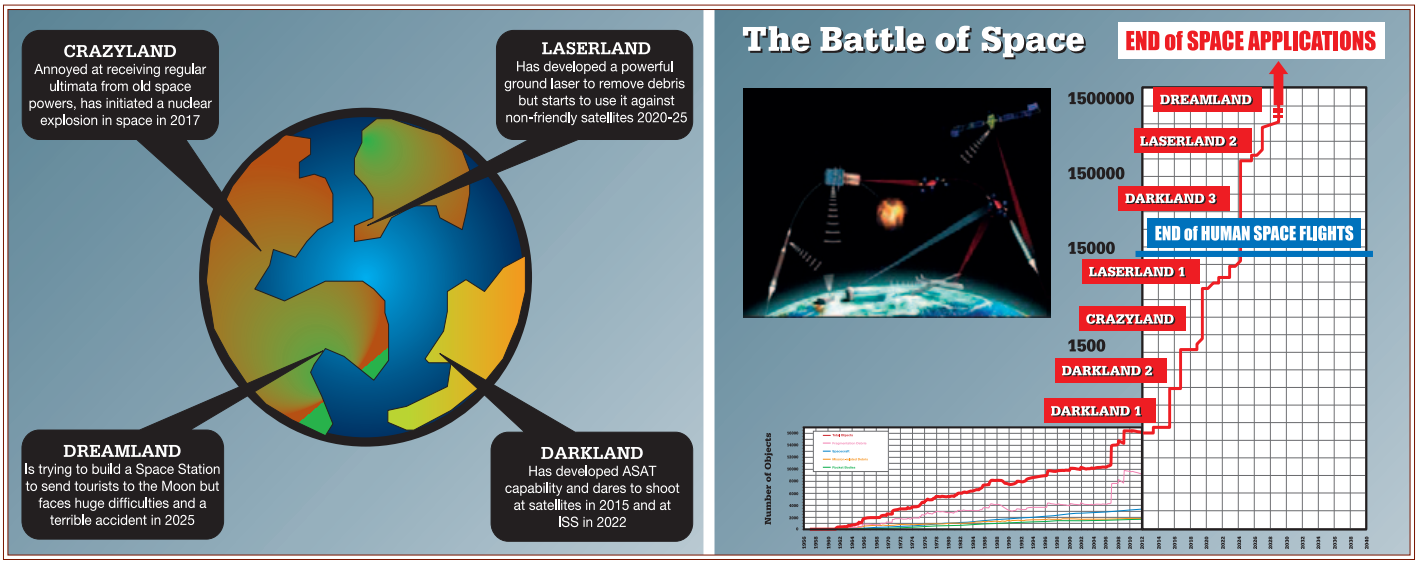
Are any of these events unimaginable in today's world? The aggressor, the isolated independent, the good intentions gone astray, and the emerging power are all familiar figures in the realm of politics. If all their activities collided in exactly the wrong ways, the combination could severely constrain global access to space, well beyond the damage that could result from any of their activities alone. The quantity of debris that could be expected to result from the four nations' incidents could rise so quickly that 2025 could see the end of human spaceflight. By 2027, all space applications would be at an end, with one trillion pieces of debris making it impossible to even launch a satellite into Earth orbit.

"Such a catastrophic situation would sign the end of the space adventure for more or less a century and humankind would be back in the 1930's," said Molard. With loss of satellite communications, environmental monitoring, disaster monitoring, internet connectivity, and navigation and network synchronization the world will become more and more unstable, creating new risks and new threats very difficult to manage at an international level. Financial institutions would crash, commercial flights be put at risk, and power systems disrupted due to lack of coordination.

The Lesson

Far from expecting such a future to become reality, Molard hopes that illustrating the possibility will galvanize world leaders to avoid it. He expressed his optimism that nations are becoming more aware of their responsibilities in space and of the need to take appropriate decisions to maintain more efficient space activity for the benefit of peace and security.

Yet Molard's message is a timely one and it is clear to space professionals around the world that the dangers to space access are real and looming. Although several initiatives are currently being envisaged at national and European levels to mitigate space debris proliferation, overall awareness of the risks associated with the reckless use of space is still severely lacking. Political leaders must understand the gravity of the situation and how quickly an advanced civilization can be made fragile by a few errant, even well-meaning, players. Such understanding is the first step to achieving more concrete measures to protect near-Earth space assets and access, and ensure the sustainability of the space domain.



Four hypothetical nations acting unilaterally could unintentionally bring an end to space applications. - Credits: Bernard Molard

By Tereza Pultarova

Soyuz TMA-11 Ballistic Reentry

When Soyuz TMA-11 undocked from the International Space Station at 5 AM (GMT) on April 19 2008, not one of the three people aboard had the slightest idea that just a few hours later their lives would be in imminent danger. Yuri Malenchenko and Peggy Whitson were members of ISS Expedition 16 and they were about to leave the station after 192 days. Together with them in the capsule was the first South Korean spaceflight participant, scientist So-Yeon Yi. She had arrived at the station 11 days before with members of Expedition 17.

When the capsule reached the upper layers of the Earth's atmosphere after a smooth departure at 7:40 AM (GMT), the braking engine started firing, but then something went wrong. The crew later reported experiencing extreme shaking and buffeting. Less than a minute later the capsule switched to ballistic reentry. "We were spinning up to 8 Gs and coming in on a steeper descent," Peggy Whitson recalled later, "I saw 8.2 Gs on the meter."

Under the normal circumstances, the flight control system takes advantage of the aerodynamic properties of the landing capsule. The spacecraft generates a small amount of lift which keeps it at a higher altitude while slowly approaching Earth. In contrast to that, ballistic reentry is uncontrollable, steeper, and much shorter.

Rescued by Kazakh Peasants

Less than an hour later the crew landed, 420 kilometers away from the nominal landing site, in the town of Arkalyk in Kazakhstan. As the communication links were cut during the reentry, the ground support crew only learned about the actual touch down site thanks to an aircraft that was assigned to cover the possibility of a ballistic reentry. However, the support crew arrived late only to see the crew climbing out of the damaged capsule still in their landing suits and the local residents gathering around.


The ritual blessing of a Soyuz (TMA-04M pictured) has been a tradition since the early '90s.
Credits: Bill Ingalls/NASA

> "The apparatus was so hot that the ground started burning"

Assisting the exhausted crew were members of the local agricultural community who were disturbed by the landing when planting seeds. Their leader, Zhalgaskan Shurenov, later gave his account of the event to a Kazakh newspaper: "On the ground there was a black apparatus, which looked like a pot. The moment we approached there was a boom. We jumped back. Immediately, a cover, which looked like a fry pan flew off and an antenna jumped out. The apparatus was so hot that the ground started burning. We were waiting what would happen next. Then a man fell out of the pot. 'We are cosmonauts,' he told us, neither his hands nor feet were moving. He was pale and sweaty. We put him on the ground, gave a pillow under his head, while he asked to get others out," Shurenov said.

Too Many Women Aboard

Soon after, experts worldwide started speculating about the causes of the incident. The Chief of the Russian Federal Space Agency at that time, Anatoly Perminov, speaking at a press conference after the landing gave a rather surprising explanation: "You know in Russia, there are certain bad omens about this sort of things. Of course in the future, we will work somehow to ensure that the number of women will not surpass the number of men. When a majority of the crew is female, sometimes certain kinds of unsanctioned behavior or something else occurs," he said.

However, this was not the first time that Soyuz suffered similar problems. Just seven months before an unmanned Soyuz landed in a comparable un-

A Russian ground crew member examines the over turned soil near the Soyuz TMA-11 spacecraft after it landed. - Credits: NASA/Reuters/Pool

controlled ballistic way. Also the return to the Earth of the Soyuz 5 with 3 male cosmonauts aboard in 1969 underwent the steep descent. Are women really to blame?

Soon, the improper separation of the propulsion and service module was identified as the most probable culprit. Yuri Malenchenko reported signs of smoke during the reentry inside the capsule, and an examination revealed more extensive heat damage. According to the investigation the service module was still loosely connected to the spacecraft during entry in the upper atmosphere. As a consequence the correct orientation of the capsule was impossible. Instead of flying with the heat shield first, the capsule with the module still attached was hurtling with the entry hatch forward exposing it to extreme heat loads.

Crew Was in Danger, Insider Said

Insiders familiar with the investigations told the Russian press agency Interfax that the heat damage could have led to the loss of pressure inside the capsule. Also damaged was an external portion of the valve which balances the pressure between interior and exterior and so was the communication antenna.

Had the front section melted just a little bit more, the nearby parachute containers could have been damaged. In that case, the crew would not have had a chance to survive.

During the investigation, the assembly of the next Soyuz vehicle was stopped. There were concerns about the safety of Soyuz TMA-12 that was docking with ISS at the time. The possibility of an unmanned landing of the capsule was seriously considered which would have left the crew waiting to be brought back to Earth on a subsequent Space Shuttle mission.

Degraded Wire in a Pyrotechnic Bolt

The most likely cause for the late separation of the service module was a failure of a special pyrotechnic device that breaks the connection between the capsule and the module before the reentry. The scientists and engineers performing the investigation concluded that the wire leading electric current to the pyrotechnical bolt may have been degraded because of the exposure to cosmic plasma around the space station.

Almost three months after the ballistic descent of Soyuz TMA-11 it was decided, for the sake of the crew's safety, to remove the critical bolt in Soyuz TMA 12. On July 10 2008 the ISS crew commander Sergei Volkov and Flight Engineer Oleg Kononenko conducted a 6 hour 18 minute spacewalk, where they inspected the Soyuz TMA-12 capsule and removed the pyro bolt by disconnecting one of the locks holding the capsule and the service module together. Three months later, on October 24 2008, Soyuz TMA-12 performed a nominal landing safely.

> "Several improvements were designed for the following Soyuz TMA-13 and 14"

Several improvements were designed for the following Soyuz TMA-13 and 14. Additional wiring for the separation system was added as well as cabling providing a backup source of electrical current for the pyrotechnic devices.

Safety of Soyuz spacecraft is of strategic importance as, with the retirement of the Space Shuttle in 2011, the Russian vehicle provides the only way to transport human crew to and from the International Space Station.

And despite the proven reliability demonstrated after long years of service, even a system so thoroughly tested as the venerable Soyuz can present a conditional probability of a failure that requires a design revision, a failure that can happen despite the number of women in the crew.

NASA astronaut Peggy Whitson, Expedition 16 commander, receives assistance at a helicopter after landing in the Soyuz TMA-11 spacecraft.
Credits: NASA/Reuters/Pool

By Carmen Victoria Felix

Pioneer One: Science and Entertainment

A mysterious space capsule has entered Earth's atmosphere. A US Department of Homeland Security investigation recovers the lone young passenger in an unstable mental condition, dressed up in a Soviet space suit. A note in Russian, found at the crash site, claims the man is the child of cosmonauts living at a base on Mars. And while the investigation unfolds, a cover up story of an old radioactive satellite fallen from the sky is spread to the media. This is the basis of the plot of Pioneer One, an American web series produced and directed by Josh Bernhard and Bracey Smith. The show, whose recently concluded first season counts six episodes, has been recognized as the Best Drama Pilot at the 2010 New York Television Festival. The first episode received over 420,000 downloads, creating a worldwide fan base. We contacted Josh Bernhard, creator of the story, to learn more about this show.

A Radioactive Debris Accident

The series got our attention because of its artful mix of science fiction and accurate technical and scientific facts, which provides a mix of science, drama, and action that is not just entertaining, but also educational. "I've always been very interested in the space program and in Cold War history," said Bernhard. "With those two topics swirling around in my head for years and years, the story for Pioneer One seems to have shaken out."

The first episode introduces the scenario of a spacecraft fallen from the sky, initially considered to be space debris potentially capable of spreading a wave of radiation. "While I was making my research for the pilot, I discovered that an incident involving a re-entering Soviet satellite spreading radioactive material over Canada had actually happened in the late 70s," Bernhard explains referring to the Cosmos 954 incident. "At the core of the show was this idea of the Cold War era re-introducing itself during the so-called War on Terror," he adds, "so the idea that a malfunctioning space capsule would re-enter the atmosphere and its damaged battery would spread radioactivity would be interpreted through that lens of terrorism." About the actual risk of radioactive contamination from falling debris, Bernhard explains "I was overstating the danger of the re-entering capsule for the sake of drama and to justify the idea that it be interpreted as an act of terrorism. I think nuclear power is a huge boon for space travel and should not be wholly written off because of terrestrial concerns."

> "I've always been very interested in the space program and in Cold War history"

Josh Bernhard, writer, and Bracey Smith, director of Pioneer One. - Credits: Josh Bernhard

The cast of Pioneer One. - Credits: Josh Bernhard

Science and Fiction

The show illustrates the effects of the space environment on the human psyche and physiology through Yuri, the young cosmonaut found inside the Russian capsule. "His DNA is human, but he's not quite one of us," says Bernhard. He suffers from osteoporosis, a decrease of bone mineral density that can be caused by long term exposure to microgravity. He also presents all the symptoms of radiation poisoning, which is considered the major risk in a deep space human mission. Finally, Yuri experiences severe psychological distress: "He's grown up in a completely alien environment, with at maximum a handful of other human beings," says Bernhard. "To him, the existence of 'People' was a story. Now he's been ripped from that environment and found himself in that world that up until now had been a fairy tale."

Over the first season, Yuri finds a way to interact while establishing a relationship with Jane, a Russian speaking nurse: "His experience with her is a tragic one, which makes him human. We'll continue to explore the consequences as the show continues."

The plot presents a somewhat plausible political scenario, with a complex and detailed interaction between US and Russian politicians to illustrate the intricacies of diplomacy, international law, policy, and regulations. "I was fascinated with the notion that a returnee from Mars would be caught up in a situation where his legal status was questioned," says Bernhard. "It's not enough to survive the trip from Mars to Earth, you need to overcome skepticism and red tape!"

The Production

The episodes are all planned in advance," says Bernhard about the production. "When we shot the pilot, I had a rough outline of the rest of the season, and then when we knew we were going to be able to do more, I sat down and started writing the full scripts. But the whole show has an arc and a shape and has been leading somewhere since day one," he adds.

The protagonist, portrayed by James Rich, studies Yuri's cosmonaut helmet in episode 6 "War of the World." - Credits: Josh Bernhard

> "One of our goals is to try to bring back public interest in space exploration"

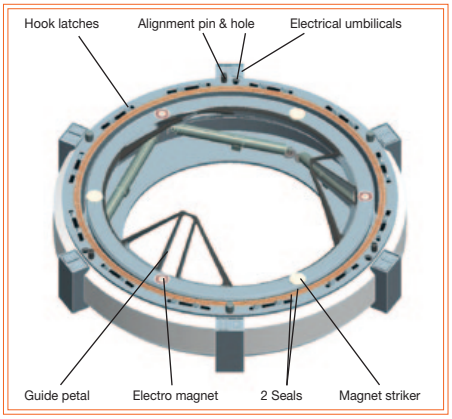
The first episode was produced through a campaign with Kickstarter. "We like to think of ourselves as one of their early success stories," Bernhard said, and added "the show was funded about 75% through fan donations, and the rest was contributed by two independent investors. But the lion's share was donations from the audience, which is quite humbling to know there was enough support out there from people we'd never met."

The fan donations worked out well for the first season, but now Bernhard and Smith are working with BitTorrent directly: "We're going to try to marry some of their sponsors to the show to provide the budget for year two. While we'd not be opposed to working with a more traditional network, we're really excited about making the show a success online, where we have an opportunity to define our own destiny as it were," said Bernhard. Four more seasons are planned at this time. Bernhard says they are open to new ideas that can improve the quality of the content along the way.

Besides winning the "Best Drama" award for the pilot at the 2010 New York Television Festival, Pioneer One was also nominated for "Best Drama" at the 2012 International Academy of Web Television awards. "One of our goals is to try to bring back public interest in space exploration as best we can," commented Bernhard. "By creating a compelling drama where our characters are sympathetic and passionate, you care about what they care about," he concludes. "The initial response to the show proved beyond a shadow of a doubt that there's a demand for this kind of content: our goal is to continue and finish the show."

Pioneer One can be downloaded for free at pioneerone.tv/watch/. The Season 1 DVD and Blue Ray can be ordered at pioneerone.tv/dvd.

Dragon Needs Docking Upgrade to Carry Crew



The International Docking Mechanism. Credits: ESA

The crewed version of the Dragon will need an entirely different docking system from its cargo counterpart to meet an important safety requirement. "In the event that the crew needs to leave for some reason, you don't want to be dependent on a system on the ISS like the arm," says Skip Hatfield, manager of the development projects office for the ISS program at Johnson Space Center (JSC). "You want to be able to jump in the thing and just depart, in case you're having a bad day, so to speak."

All of NASA's potential commercial providers will need to use the NASA Docking System (NDS), the only docking system so far that is compliant with the International Docking System Standard. Dragon will carry two International Docking Adaptors (IDA) in its cargo runs for installation on Harmony and in another as yet undetermined location. The adaptors will allow NDS spacecraft to dock with Russian ports. IDA installation will be performed by two ISS crewmembers in an EVA.

Source: Merryl Azriel

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

Micrometeoroid Hit ISS Cupola

On June 10, ISS crew spotted a micrometeoroid impact on Cupola Window 2. The window was immediately shuttered and damage appears to be minor. The Cupola is used by ISS crew to take photographs of Earth and space, provide enhanced visibility of visiting spacecraft, and maneuver the robotic arm. The Cupola has seven windows – one on top and six in a hexagon around the circumference. Each one has a shutter that is closed when the window is not in use to add an additional layer of protection from the space environment.

MMOD impacts occur all the time on ISS and other spacecraft, although most are not easily visible through a window. For now, the shutter remains protectively closed over Window 2 while ISS managers evaluate the danger. It is expected that they will soon give the ok to lift the shutter.

Source: Merryl Azriel

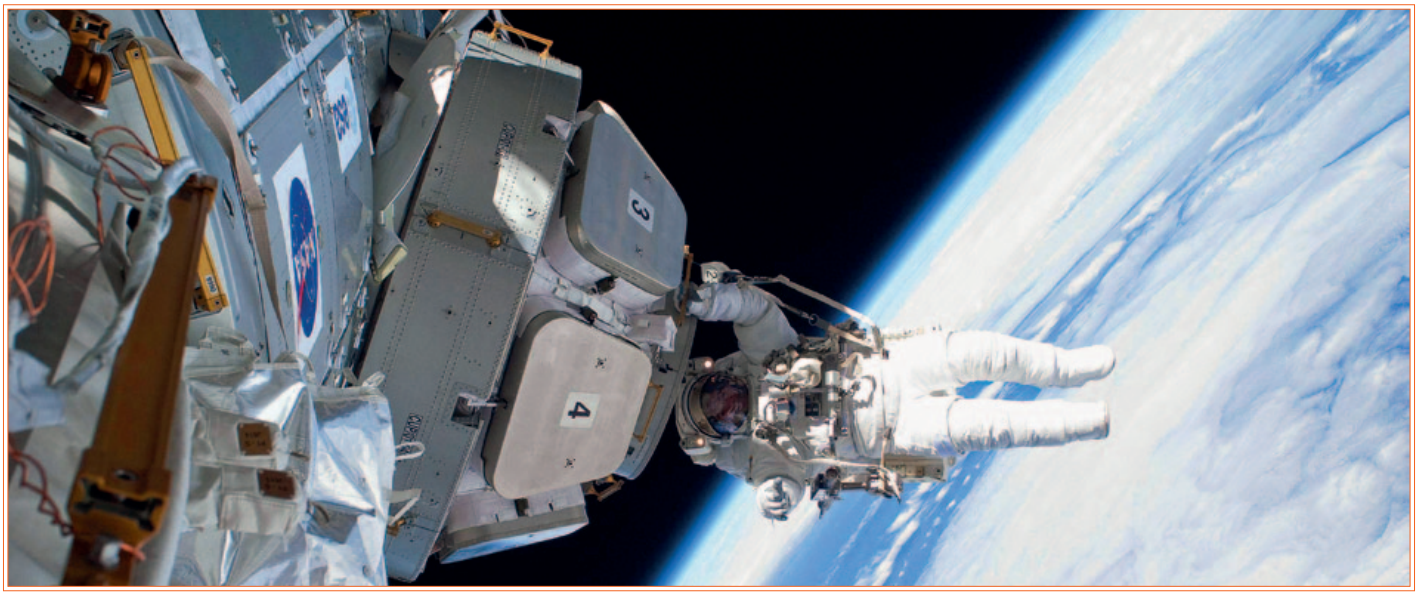
Read the full story:
http://bit.ly/mmod_hits_cupola

Liu Yang, the First Female Taikonaut

Liu Yang, the first female taikonaut. Credits: Ministry of National Defense of The People's Republic of China

On June 16, China's Shenzhou-9 spacecraft successfully launched Liu Yang, Jing Haipeng, and Liu Wang into orbit en route to dock with Tiangong-1. "We won't let you down," said Liu Yang before the launch that made her the first Chinese woman in space. The mission is fueling expectations for increased international collaboration with China. "It is impossible to get access to others' technologies currently, but with the development of China's technologies, other countries will gradually open," said Shenzhou scientist and Long March developer Lu Xinguang. "They will choose to cooperate with us when China has enough abilities."

Source: Merryl Azriel



Cupola with window shutters closed during installation. - Credits: NASA

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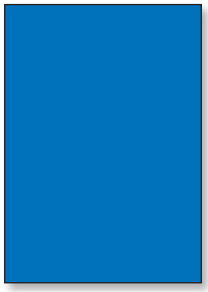

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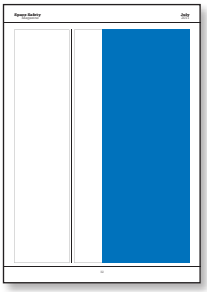

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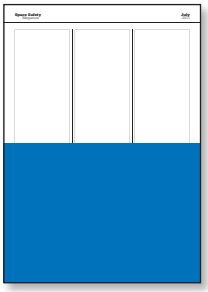

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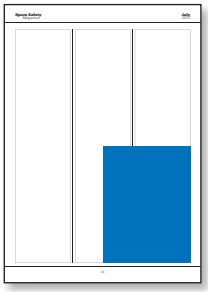

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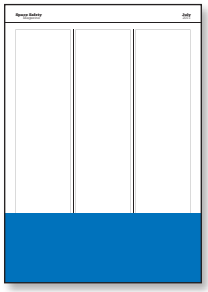

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Andrea Gini:
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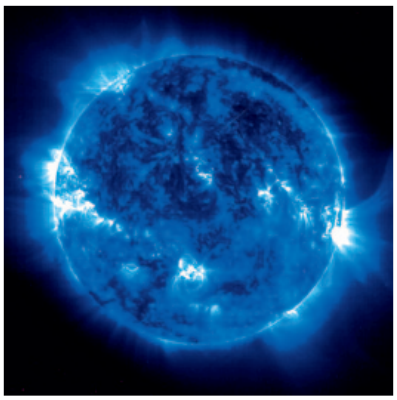

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Earl's Court Conference Centre,
London
16-17 October 2012

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63rd International Astronautical Congress Space Science and Technology for the Needs of All
Mostra d'Oltramare,
Naples, Italy
1-5 October 2012

2013 MAY 21-23
6th IAASS Conference Space Safety is Not an Option
Montreal, Canada
21-23 May 2013

2012 OCTOBER 6
ISSF Advisory Council Meeting
Capri, Italy
6 October 2012

2013 SEPTEMBER 23-27
64th International Astronautical Congress
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23-27 September 2013