INTERNATIONAL ASSOCIATION
FOR THE ADVANCEMENT OF
SPACE SAFETY

ISSF
INTERNATIONAL SPACE
SAFETY FOUNDATION

# Space Safety Magazine

Number 0
July 2011

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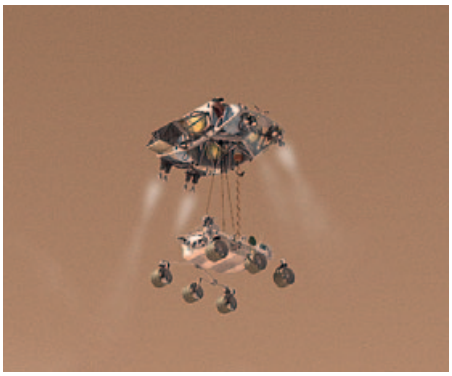





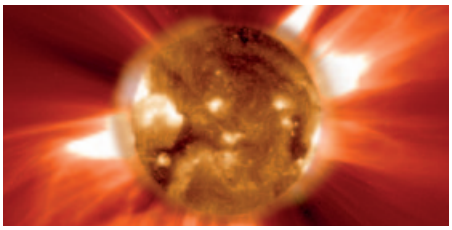



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**Cover pictures:**
**An amazing picture of the ISS-Shuttle complex.** - Credits: Paolo Nespoli, NASA/ESA
**Central Region of the Milky Way** - Credit: NASA, ESA, SSC, CXC, and STScI

# Welcome to the First Issue of the Space Safety Magazine

Dear Reader,

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

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

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

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

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

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

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

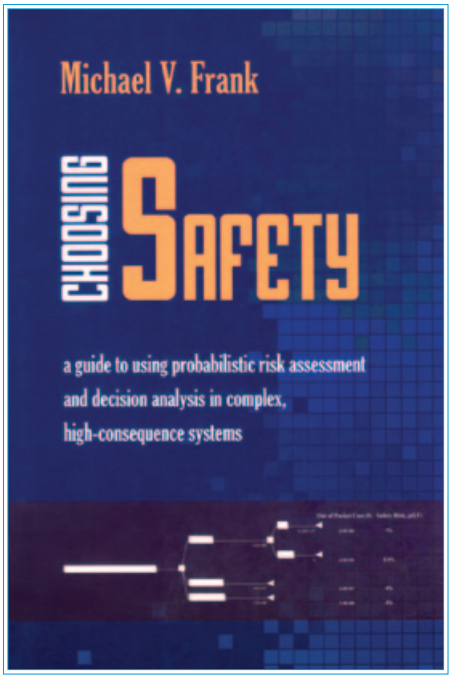
Welcome Space Safety Magazine, welcome to you!

**Tommaso Sgobba**
IAASS President

**Frederick D. Gregory**
ISSF Board Chairman

# Choosing Safety

## A Guide to Using Probabilistic Risk Assessment and Decision Analysis in Complex, High-Consequence Systems




**Michael V. Frank - RFF Press – 2008**

## From the Back Cover

The technological age has seen catastrophic and preventable failures from buildings and bridges to space and launch vehicles, from chemical factories to nuclear power plants, from ships to airplanes, and from trains to automobiles. Often the root cause can be traced to decisions that did not appropriately consider safety as a factor in design and engineering. The ideas, methods, and case studies of this book are at the nexus of probabilistic risk assessment and decision analysis. This book melds these two technologies into a method of building safety into a system or product from the very beginning of its development.

Choosing Safety is the first book to bring together probabilistic risk assessment and decision analysis using real case studies. Through more than a dozen practical examples from the author's experience in nuclear power, aerospace, and other potentially hazardous facilities, the book focuses on methods for making logical decisions about complex engineered systems and products in which safety is a key factor in design—and where failure can cause great harm, injury, or death. In a nutshell, it shows when, where, and how probabilistic risk assessment fits into decision analysis. This book provides the needed guidance and formal procedures to include safety in project decisions.

> "Risk is a representation of uncertainty associated with the probability and consequences of events or collections of events"

Choosing Safety is for managers, project leaders, engineers, and scientists who create, design, develop, operate or maintain high consequence, complex systems and products. The book is also for students and anyone else interested in a broad perspective about the union of decision analysis and probabilistic risk assessment.

## Interview with The Author

**Space Safety Magazine: Which is the primary thesis of your book?**

**Michael V. Frank:** Probabilistic risk assessment (PRA) is used to help make decisions involving safety of engineered systems and systems designed to safeguard against natural phenomena. Long before PRA was invented (early 1970's), the field of decision theory/decision analysis had been assisting corporations and government in cogent ways to think through complicated situations to arrive at a decision. If you look at the graphical constructs of decision analysis and PRA, you notice that they are quite similar. In fact, both revolve around how to identify and quantify uncertainties and they use similar mathematical methods. Therefore I wrote the book around how to merge these two fields to demonstrate how one may use PRA to make decisions that involve safety.

**SSM: Can you give a brief definition of probabilistic risk assessment and decision analysis?**

**MF:** Both PRA and decision analysis treat risk: I don't think there is a universal definition. One I find useful is: risk is a representation of uncertainty associated with the probability and consequences of events or collections of events. Both PRA and decision analysis allow a decision maker to understand how uncertainties influence the collection of factors that are important to the probability and consequences associated with an outcome. In PRA, one constructs a model to obtain the probability (or frequency) of event sequences (sometimes called scenarios) that lead to an undesired outcome (such as mission failure, launch vehicle explosion, release radionuclides in a nuclear reactor), and also the probability distribution over the severity of the undesired outcome, such as a cumulative distribution function over the number of injuries. In decision analysis, one constructs a model in order to choose among alternative courses of action. The book shows how one uses PRA within a decision model that includes safety as a decision attribute, in order to choose among alternative courses of action. This thinking was the genesis of the book's title Choosing Safety.

**SSM: How do you merge them into decision making tools?**

**MF:** In brief, one starts with setting up a decision model. A decision model involves defining alternatives, attributes, and outcomes/consequences. Attributes are those factors that the decision-maker wants to consider when trying to develop the out-

comes and then choosing among the alternatives. Probabilistic risk assessment is used to quantify with uncertainties the attribute safety for use in the decision model. The book guides the reader through the details and also provides several examples.

**SSM: How did you develop your approach?**

**MF:** I introduced modern PRA to NASA starting with the Space Shuttle PRA Proof of Concept Study (1987). After the studies completion, NASA managers begin asking what appeared to be a simple question: now that you've done this study, how do we use it? During the next decade of my work with NASA engineers, scientists and managers, that question percolated within me resulting in the book.

**SSM: You talk about "catastrophic and preventable failures": can you make an example in aerospace?**

**MF:** Often catastrophic accidents are preceded by smaller incidents, sometimes occurring multiple times, that we call accident precursors. An example that I believe fits this category is the Space Shuttle Challenger accident in 1986. That accident's proximal cause was blow-by of hot gas past two O-rings in the solid rocket booster. On previous missions, however, evidence of blow-by of at least one O-ring had been detected. In other words, our knowledge of the risk associated with O-ring blow-by increased with each accident precursor in which a blow by occurred. The proper way to interpret such failures is as evidence that a larger failure could occur. If these failures had been taken with that interpretation, then perhaps the risk mitigation strategies that occurred after the accident might have been implemented before the accident.

> "Often catastrophic accidents are preceded by smaller incidents, sometimes occurring multiple times, that we call accident precursors"

**SSM: How do you think your thesis applies in the recent nuclear power plant disaster which followed the earthquake in Japan?**

**MF:** The nuclear power industry in the United States and Europe has made extensive use of probabilistic risk assessment to make decisions about safety improvement over the last 20 years. The U.S. NRC and the industry have been working through a Severe Accident Management Program that added significant capability for emergency responses for accidents beyond the design bases. I do not know if the same processes of continuous safety improvement had been applied to the Fukushima units. If not, they should start now to develop detailed and accurate risk and decision models for severe accident management.

However, let's consider this perspective. The plant was hit with a scenario of earthquake and tsunami that has been the subject of science fiction movies. The entire area was utterly demolished. The nuclear plant, however, while damaged was still standing

**Satellite picture of the Fukushima nuclear power plant in Japan after the earthquakes and tsunami of March 11** - Credit: DigitalGlobe

**Fragments of the Columbia, stored in the RLV Hangar at Kennedy Space Center. The Columbia disaster was preceeded by similar events, without fatal consequences. These events, called accident precursors, shall be interpreted as a signal that a larger accident may occur.**
Credits: NASA - Kennedy Space Center

and the units that had been shut down remained shut down and safe. The radiation release, while significant, was not the horror depicted by the science fiction movies. As far as we can tell today, there have been no deaths and no deaths are anticipated from radiation release. This is compared to the enormous toll of injury, death and damage caused by the earthquake and tsunami itself in the surroundings.

**SSM: What do you recommend to the new generations of space engineers?**

**MF:** The current and next generations of engineers are continuously being asked to be more productive and more creative, with fewer people and resources. The management of risk and the ability to make the right decision, accounting for risk, becomes more important in an environment of constrained resources. The engineers who master dealing with risk in the identification, quantification, and mitigation, will be more successful.

**Dr. Michael V. Frank**

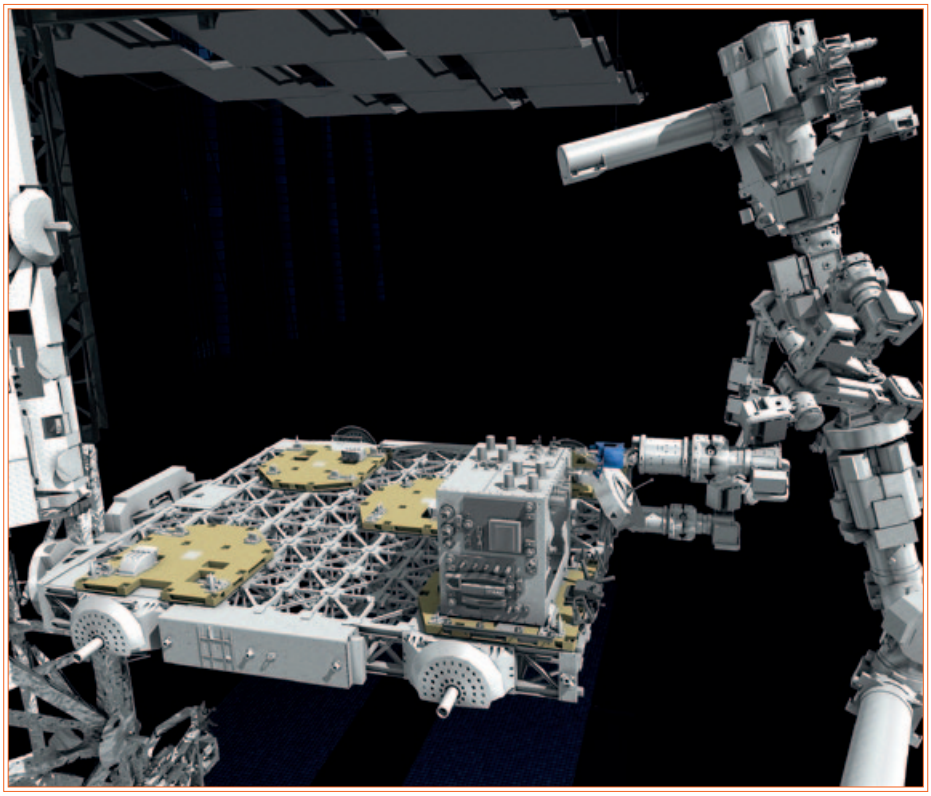
## About the Author

Dr. Michael V. Frank is the author of more than 90 technical publications in the areas of risk analysis, decision analysis and reliability engineering with respect to terrestrial nuclear power, space-nuclear missions, aerospace systems, nuclear waste repositories, and other ground facilities. He has performed more than 100 risk assessments, and has made hundreds of presentations in national and international forums. His particular expertise is the assessment and management of all risks associated with the design and operation of engineered systems and the decision-making that accompanies risk management. Among his career accomplishments are probabilistic risk assessments of the Space Shuttle, International Space Station, and the Cassini mission. A recent significant accomplishment was the risk management of the design for the Geologic Nuclear Waste Repository of the Yucca Mountain Project. Dr. Frank has an educational background in mechanical engineering, nuclear engineering, and material science as well as reliability and risk analysis from UCLA and Carnegie-Mellon University.

# NASA Launches Satellite Servicing Experiment

The Robotic Refueling Mission (RRM) experiment, a satellite servicing test platform developed by NASA's Goddard Space Flight Center in Greenbelt, Maryland, will be launched on STS-135, the last ever mission of the Space Shuttle. The Robotic Refueling Mission is a risk reduction mission to test tools, technologies and techniques to repair and refuel satellites in space, whether or not they have been specifically designed to be serviced.

When a satellite is launched into orbit, it carries onboard the fuel necessary to run the entire mission. A satellite mission ends when the fuel is over, even if the remaining hardware is operational and capable to work further. Satellite servicing has the potential to extend a satellite's operational life, bringing more value to the initial investment. It can also allow recovering a satellite launched in the wrong orbit or provide the fuel needed to dispose an obsolete one, helping reducing the problem of space debris. According to NASA, robotic refueling combined with a fuel depot would also allow expanding the extent of space exploration. Orbital refueling would in fact allow launching a spacecraft dry, thus allowing packing a larger amount of mission related hardware, equipment and capabilities at launch.

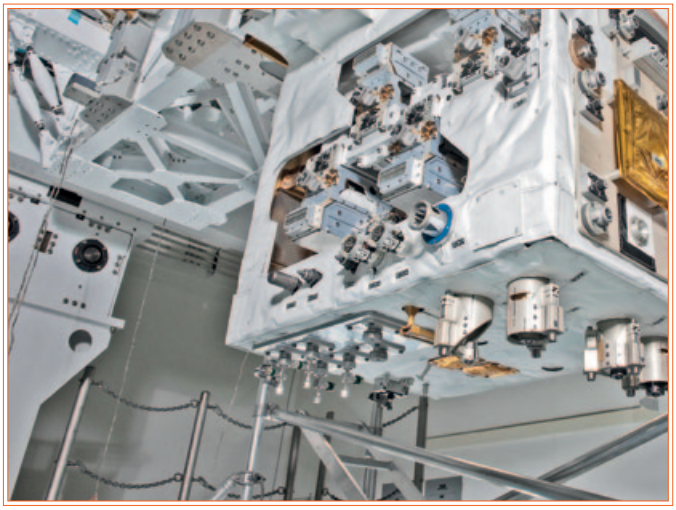


**Artist conception of Dextre performing a robotic refueling task on RRM.** - Credits: NASA

The RRM experiment will be performed outside of the International Space Station, making use of the Special Purpose Dexterous Manipulator (Dextre) – a two-armed robot developed by the CSA – complemented by a set of interfaces called "representative satellite fueling interfaces", a fluid transfer system and four robotic tools: the Wire Cutter and Blanket Manipulation Tool, the Safety Cap Removal Tool, the Multifunction Tool, and the Nozzle Tool.

A satellite fuel tank is filled through a valve that is then triple-sealed and covered with a protective blanket. The goal of the RRM is to demonstrate that a remote-controlled robot can remove the seal and refuel a satellite in space, a task that so far has been performed only in labs on Earth. Dextre will use the robotic tools to manipulate Multi-Layer Insulation (MLI), remove caps, cut wires, hook up and seal to the fuel valve, and transfer fuel from one tank to another. The valve will be modified in order to allow subsequent accesses. Additional task boards will allow Dextre to perform other servicing tasks and to evaluate machine vision algorithms.

RRM operations will be entirely remote controlled from Earth by flight controllers at the various flight centers involved in the experiment. The validation of a complete end-to-end refueling demonstration will paw the way to a comprehensive satellite servicing spacecraft design. According to NASA, the first actual satellite servicing mission could be performed by May 2013 on a weather satellite slated to be decommissioned.



**The RRM module provides the components, activity boards, and tools to practice refueling in space. The tools are retrieved and utilized byt the Dextre robot.** - Credits: NASA

# NASA Announces New Plans for the Orion Capsule

NASA Administrator Charles Bolden revealed the next-generation manned vehicle for deep space exploration during a press conference on May 24. The new vehicle – the Multi-Purpose Crew Vehicle (MPCV) – will be based on the Orion capsule, originally developed for the Constellation Program. With a pressurized volume of 20 cubic meters, the 21 tons spacecraft, composed by a partially reusable command module and a disposable service module, will be able to transport up to four astronauts into a variety of missions beyond low Earth orbit. According to Bolden, NASA is ready to resume deep space exploration, as requested by the NASA Authorization Act of 2010: "The NASA Authorization Act lays out a clear path forward for us by handing off transportation to the International Space Station to our private sector partners," he said, "so we can focus on deep space exploration."

The Orion capsule development began in 2005 as part of Project Constellation, a plan envisioned to bring the US back to the Moon by 2020. Following the Columbia disaster, Orion was conceived as an Apollo-like capsule, to be launched on a shuttle derived rocked called Ares I and to splash down in the ocean.

President Obama's 2011 United States federal budget called for a complete cancellation of the Constellation Program, following the conclusion of the Augustine Commission, which considered the program behind schedule, underfunded and over budget. The document recommended leaving transportation to LEO to the private sector to save costs, an initiative that left the Orion capsule without an immediate destination. Tension with the Congress – which opposed letting go of the Space Shuttle technology and the related industrial complex – drove the development of the new US Space Policy, which demands NASA to design a new Shuttle derived heavy-lift launch vehicle similar to the Ares V and to repurpose the Orion capsule as an escape pod for the International Space Station, to be launched unmanned, docked to the ISS and used for reentry only in case of emergency. "This Orion effort will be part of the technological foundation for advanced spacecraft to be used in future deep space missions," said President Obama when he presented the new Space Policy at KSC.

> "Charles Bolden, NASA Administrator: The NASA Authorization Act lays out a clear path forward for us by handing off transportation to the International Space Station to our private sector partners, so we can focus on deep space exploration"

The May 24 announcement reinstates Orion as a deep space crew vehicle, one of its original goals. The carrier rocket may be the heavy-lift Space Launch System (SLS), a Shuttle derived rocket whose design should be announced soon. The system will be able to perform a number of missions beyond LEO, including missions to the Moon orbit, to Lagrange point or to asteroids; yet, it remains unclear which will be the actual destination of the spacecraft.

The Orion capsule has been developed under a $7.5 billion contract awarded to Lockheed Martin in 2006. NASA is currently defining how to update the existing contracts to implement the MPCV requirements into the Orion development plan. To date, the spacecraft had a cost of nearly $5 billion, and the Congress just approved $1.2 billion to complete the development. First unmanned test may be scheduled for 2013, followed by a manned flight in 2016. According to NASA spokesman Michael Braukus, the 2013 flight test is still under review to determine fund availability. Details about the launch configuration are yet to be defined.

**The Multi Purpose Crew Vehicle ground test article in preparation for environmental testing at the Lockheed Martin Vertical Test Facility in Colorado.** - Credits: Lockheed Martin

# Human Rating the Delta IV Heavy

According to NASA, the Multi Purpose Crew Vehicle will eventually be launched on top of the next generation heavy-lift launcher SLS. While the development of the SLS will be in progress, Lockheed Martin will resort to existing expendable launch vehicles to test the spacecraft. According to Space News, Lockheed Martin contacted United Launch Alliance In November 2010 to negotiate the purchase of a Delta IV Heavy vehicle for an unmanned test in 2013. Use of a human rated version of the Delta IV to carry the Orion has been the subject of several studies, such as Aerospace's "Human-Rated Delta IV Heavy Study" of 2009 and Federal Aviation Administration's "2011 U.S. Commercial Space Transportation Developments and Concepts" of 2010. The idea of human rating the Delta IV is often discussed in Internet forums and newsgroup. But how likely is such a choice?

> "The Delta IV Heavy is the only rocket that sets itself on fire during its ignition by design"

Human rating a commercial payload launcher, which may sound like a straightforward process, presents in fact more challenges than one would think of. A launch of the Delta IV Heavy provide a graphic representation of the kind of issues that has to be taken into account during the human rating process of a rocket originally designed to carry unmanned payload. As soon as the engines ignite, the Delta IV Heavy is engulfed in a tremendous firestorm, which often chars the three boosters. Despite what appears to be a catastrophic failure on the pad, the giant rocket, still smoking and flaming, lifts off and proceed to a nominal ascent as nothing happened.

The spectacular sequence is not a surprise, even though the extent may vary between the various launches: the Delta IV Heavy is in fact the only rocket that set itself on fire during its ignition sequence by design. Five seconds before oxygen valves are opened for ignition, a mass of hydrogen is dumped though the three RS-68 engines to condition their internal temperature. The hydrogen, which wraps the vehicle creating a cloud, is then burned off by spark generators built into the pad to prevent an explosion.

We asked Professor Joseph Fragola, Vice President of Valador Inc, core member of the NASA Exploration Architecture Study (ESAS) Team and IAASS Fellow, to comment this feature, in the light of a possible use of the Delta IV Heavy as a human rated launcher:

*«The set of pictures visually indicates why a commercial payload launcher, even a reliable one, cannot be considered, without modification (that is a so-called "white tailed" version), as a crew launcher because of the conditional probability of losing the crew given an incident. In the case of the Delta IV Heavy the unmodified version, "sets itself on fire during its ignition sequence". While this may not be of concern to a conventional payload, the ignition source, which is there BY DESIGN on every launch, presents a unity conditional probability of ignition given an engine or system rupture. This is of no concern to the payload launcher, because the payload would be lost in any case, but it is of critical importance to a crewed launcher, because it may well impact dramatically the effectiveness of an abort from an initiated failure.*

*Other problems with payload launchers as crew launchers are neither so visual nor so dramatic, but they are just as real in their impact on abort effectiveness if the vehicles are used in unmodified "white tail" versions.»*

As suggested by Professor Fragola, human rating an existing commercial vehicle can be as expensive as developing a new one. The cost has in fact to take into account human rating not just the single components, but the entire stack, including the launch pad, ground facilities and all the operations from launch to orbit. The process could cost hundreds of millions of dollars, and take up to 5-7 years. For these reasons, until a final decision will be taken, a human rated version of the Delta IV will remain a speculation.

**The spectacular ignition sequence of a Delta IV Heavy.**
Credits: Vandenberg Air Force Base

by Andrea Gini

# Safety of Lithium Battery

On 3 September 2010, a UPS Boeing 747-400 crashed close to Dubai airport, killing Doug Lampe and Matthew Bell, captain and first officer on board of the plane. Right after the departure from the Dubai International airport, the crew reported smoke in the cockpit and declared an emergency. The pilots returned to Dubai, where they attempted a landing, which failed because the airplane was too high on the approach. Shortly after, radar contact was lost. The airplane crashed in an unpopulated area between the Emirates Road and Al Ain Highway.

On April 3 by the Dubai government's Civil Aviation Authority released a report, which revealed that the cargo plane was transporting lithium batteries. The batteries have not been declared as hazardous cargo, as they would have been, given their flammability. According to the report, the crew ran out of emergency oxygen, and the cockpit became so full of smoke that the crew was unable to see the flight instruments or change radio frequency. It is currently unclear if the batteries were the cause of the accident.

We asked Dr. Judith Jeevarajan, Battery Group Lead for Safety and Advanced Technology at NASA-JSC and IAASS fellow, to comment the safety of lithium battery, given their widespread use in space technology.

**Space Safety Magazine: Which are the advantages of lithium batteries?**

**Judith Jeevarajan:** The advantages of lithium based batteries are the very high energy density. Lithium-based rechargeable batteries, typically referred to as lithium-ion batteries, are the state-of-the-art battery chemistry that has the highest energy density of rechargeable batteries, has no memory effect, has good rate capability and has the highest performance efficiency. High energy density leads to lighter batteries and longer performance times. The lithium-ion battery chemistry has been used in the past decade for long term satellite applications of the LEO and GEO types also and has just been initiated into the electric and hybrid electric vehicles.

**SSM: Which are the safety concerns?**

**JJ:** The high energy density also indicates that there is much higher energy inside a small volume. The other factor is the use of a flammable electrolyte in the lithium-ion batteries. The com-


**A UPS Boeing 747-45EM(BCF) Cargo Plane** - Credits: Kevin Murphy, plane-mad.com

bination of high energy and a flammable electrolyte causes the cells to burn until all the electrolyte is used up. The lithium-ion batteries can experience fires and thermal runaway under off-nominal unsafe conditions. Lithium-ion batteries should always be used within the manufacturer's specification. Overcharge is a major hazard with the lithium-ion battery chemistry. Another hazard associated with these is external and internal shorts. The former should be protected with external safety controls and the safety for the latter hazard comes from extremely high quality manufacturing processes. The last most catastrophic hazard is extreme temperatures. The high temperature environment is more hazardous since it causes breakdown of the electrodes as well as decomposition of electrolyte leading to a thermal runaway and fire. At very low temperatures (below manufacturer's specification), the internal resistance of the cells could be so high that lithium deposition could occur easily leading to an internal short during the charging process resulting in a fire and/or thermal runaway. Lithium-ion batteries have an electrolyte that is only corrosive and does not pose any health hazards such as high toxicity. The salt used in the electrolyte is an irritant and hence they are categorized as an irritant and of a corrosive nature.

**SSM: Which precautions should be taken in handling?**

**JJ:** Lithium-ion batteries should always be used within the manufacturer's specification. Dedicated chargers or charging protocols should be used as overcharge is one of the major hazards associated with lithium-ion batteries. Cell manufacturing processes should have very high quality control and have stringent screening processes in place. NASA-Johnson Space Center has developed methods to screen for internal shorts on all flight batteries. The batteries should be used in the appropriate thermal environment.

**Site of th UPS plane crash, happened in Dubai on September 3, 2010.** Credits: Associated Press

**SSM: How their presence in 747 UPS flight may have affected the accident?**

**JJ:** The presence of a battery that has a flammable electrolyte that can burn at high temperatures will cause a battery fire until all the electrolyte in the batteries has been burnt up.

**SSM: How their use in space vehicles affect launch safety?**

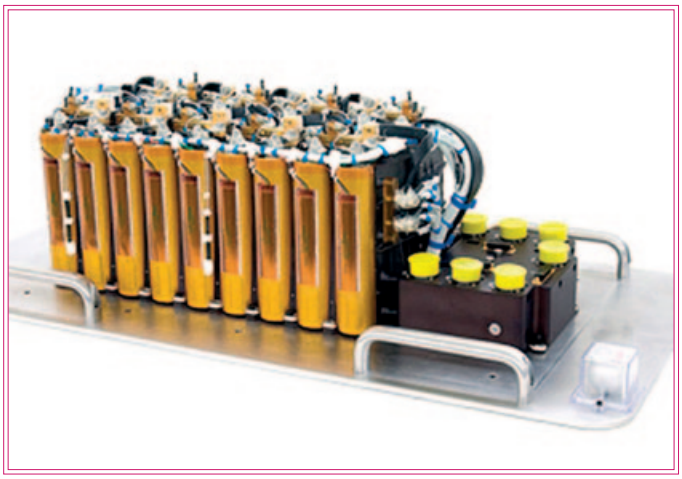
**JJ:** If the batteries are to operate in a launch environment, then the batteries should be tested to the appropriate environment and launch loads with a margin to qualify the battery design to that environment. It is not only the vibration loads but also the operational loads that must be used to test the batteries to confirm their safe operation in the relevant environment.

**SSM: Is there any concern in reentry?**

**JJ:** Yes. The batteries should be shielded to protect them from an extremely high reentry temperature by designing them with the right thermal protection. The reentry vibration loads should also be verified to not affect the integrity of the battery in any way.

**SSM: which lessons can be learned from this event?**

**JJ:** It is not clear if the batteries are a cause for the event. They probably only contributed to a bigger fire. Lithium-ion batteries do not go into flames when they are being transported in a benign condition. Other factors always contribute to their thermal runaway. One of the things that can happen is that the batteries were either not screened properly or were subjected to an off-nominal condition before their transportation which was not recognized by the personnel testing or handling the batteries. If that occurs, then the batteries could be self-heating and undergo internal changes that could then result in a catastrophic event at a later stage when they get to a point where the hazard cannot be controlled any more. The batteries should also be packaged in the right manner with protection of the cell terminals and adequate physical separation between cells and batteries to prevent inadvertent shorting of the cells and batteries. Most incidents occur due to careless processes. Hence every caution and precaution should be used to confirm that the batteries are transported in the right packaging configuration.



**An example of batteries used in aerospace** - Credits: EaglePicher

# Going to Space on an Homemade Rocket

by Andrea Gini

> "We do not hold any secrets or any patents and we want all our ideas – sketches, photos and video – to be free for everyone to distribute in order to inspire people and to spread the story, or even copy"

**Kristian von Bengtson (left) and Peter Madsen, founders of the Copenhagen Suborbitals, during the launch.**
Credits: Bo Tornvig, Copenhagen Suborbitals

On June 3, 2011, Copenhagen Suborbitals, a two people enterprise located in Copenhagen, Denmark, successfully launched a homemade rocket over the Baltic Sea. The 9 meter rocket, launched unmanned, was equipped with a capsule which has the capability to host a man in a semi-standing position. This undertaking represents an important milestone for the Danish company, whose goal is to discover "the secrets about getting into space if you are broke."

We contacted Kristian Bengtson to talk about the initiative. Copenhagen Suborbitals is non profit and open source space project founded in May 2008 by Kristian von Bengtson and Peter Madsen, two alumni of the International Space University whose dream is to launch themselves into space on top of a homemade space rocket. The initiative, headquartered in Copenhagen, Denmark, is financed with private donations and companies: "We spend about 100.000 dollars a year," they explain, "but get perhaps twice the amount in donated hardware."

According to Kristian, the flight was "Short and exciting. We only reached a 2 km of height and 8 km downrange. The trajectory was bad, but we managed to get something into the air, and that was a special corner for us to turn." The flight achieved the objectives: "We had a launch, where able to up and downlink all data and commands to the rocket and spacecraft. We separated the spacecraft, deployed the parachutes and recovered the spacecraft and all data." Equally important for them was the work atmosphere: "We had a perfect and calm operation when doing all this. We are still learning. There are so much data, still being analyzed."

**Peter Madsen checks main oxidizer valve operation through direct observation in a final dry-run test of the HEAT1X booster system.**
Credits: Sonny Windstrup, Copenhagen Suborbitals

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Copenhagen Suborbitals is definitely an unusual space company. The footer of the website reads: "Copehagen Suborbitals 2011 – Absolutely No Rights Reserved", a sort of mission statement: "I'm glad you found it," says Kristian, "It's the essence of the project. We do not hold any secrets or any patents and we want all our ideas – sketches, photos and video – to be free for everyone to distribute in order to inspire people and to spread the story, or even copy."

According to Kristian, the activity of Copenhagen Suborbitals revolves around a key principle: "Less talk and more production". The development process is geared toward finding the quickest and cheapest solution to all problems: "We basically have a ▸▸

structure where Peter and I lay the plans and ideas, and then we just build it together with our part time specialists," says Kristian, "Instead of talking too much about it, performing simulations, we build and test our ideas all the time. If they seem like a good idea and did well during the tests, we implement them in the rocket. The final launch then becomes an all up test of all these systems and ideas combined."

We asked how safety can be insured while keeping the cost down: "Low cost creates low tech solutions," replied Kristian, "Low tech solution creates high safety." He then quotes the Apollo command module as an example: "The module had about 2 million components and even with a 99.99% safety margin, NASA knew that at least 2000 components would fail during the flight to and from the moon." Simplicity turns out to be the key design factor for Copenhagen Suborbitals: "Instead of having a processing unit showing a particular pressure in a tank, on to a digital display, we will use an old fashion manometer instead. We trust solutions like this, and it is actually much cheaper," he says, "We do not believe that [relying on new technologies] is the only way. It is only a matter of "lower yourself" to a more primitive level and accepting this."

An example of this approach is the cork heat shield: "Cork is a cheap, lightweight material which can resist a lot of heat. Even more heat than the spacecraft will be exposed to. When you reach apogee you start from V=0 and fall at a relatively slow speed compared to orbit-spaceflight. Also, we have drag inducing devices that will control the fall."

This unorthodox approach poses both technical and non technical challenges, like in the case of parachutes: "No one would sell us parachutes, because this expertise is a matter of safety and reliance, "says Kristian. "I could not guarantee any manufacturer that their products would not be seen failing or even on fire. It forced us to create our own parachutes, which we did. Now we have this development in house and I trust the path we are on very much." The parachute failed during the first launch: "They are not rated for deployment just below mach 1. So the deployment failure was expected under those circumstances."

> "The activity of Copenhagen Suborbitals revolves around a key principle: "Less talk and more production""

## Safety on the Ground

The rocket is launched from the Sputnik platform, a 13.7x12 meters steel catamaran equipped with two Kubota D722 diesel engines. The platform is designed to be simple, cheap and stabile: "We like the idea of launching and landing on water," explains Kristian, "If we are able to control this environment we are basically able to launch our rockets from anywhere in the world to any height." The launch area is in the Baltic Sea, east of Bornholm, Denmark: "We have been given the military launch area for a specific date, through the Danish Admiral Fleet, and work with the Navy National Guard in Denmark, who are taking care or ▸▸

**The HEAT1X-Thyco rocket liftoff from the Sputnik launch platform.** - Credits: Thomas Pedersen, Copenhagen Suborbitals

**Ignition sequence.** - Credits: Bo Tornvig, Copenhagen Suborbitals

range safety regarding ships and closes the air space over the Baltic Sea. All these aspects are a big part of the operation and have been planned months ahead with everyone involved," he says.

The rocket uses a hybrid rocket engine, fuelled by solid polyurethane and liquid oxygen. "The components are not toxic - the polyurethane is during production. However, we recover all parts, both engine and spacecraft, after a launch if possible." About safety of operations, Kristian explains: "We always work with safety first. Human life before the operation. The mission operation was planned for many months in details and rehearsed several times. We have specific tasks for specific people, a strict command structure and mission rules taking all possible foreseeable contingencies into account."

> "It's my belief that technical progress involving inspiration to mankind will only create a better tomorrow for everyone"

## Safety of the astronaut

The Tycho Brahe spacecraft uses an unusual configuration, where the astronaut is standing along the vertical axis of the rocket, looking outside from a glass nose cone. Kristian jokes: "It's a discount space program. So you have to stand." Then explains: "it's vital for us to make the space ride a great experience where the passenger has a great panorama view. We came across the acrylic top dome, which became a design driver. The dome also fitted nicely with the chosen 64 cm diameter for the entire rocket, resulting from bending a 2 meter cheap steel plate. We knew that if the astronaut was to be lying on his/her back as usual, the rocket would be so big and heavy that it would be difficult for us to handle the size and weight."

The human body has a tolerance limit of 5g along the vertical axis, a possible source of problems: "We do not come close to that kind of acceleration," he says in that regards: "It is not a problem to half sit /half stand when being launched with only 3.5 g. When we have active guidance next year, the launch acceleration will be even less."

The Tycho Brahe capsule does not provide a Launch Escape System (LES): "We discussed the implementation of a LES, but decided that you either trust the system or not, after testing it thoroughly."

About redundancy, Kristian explains: "All systems are life critical sys- ▸▸

**The HEAT1X-Tycho rocket in flight.**
Credits: Bo Tornvig, Copenhagen Suborbitals

> "It is interesting if we are able to change the way we look at human space flight. Right now, it's a "holy grail" and can only be done by great nations will billion of dollars. If we can show that it can be done otherwise I think we can shake up the space arena a bit"

tems. Some system like parachutes systems have a redundant system and so do all communication and electronics that will deploy parachutes."

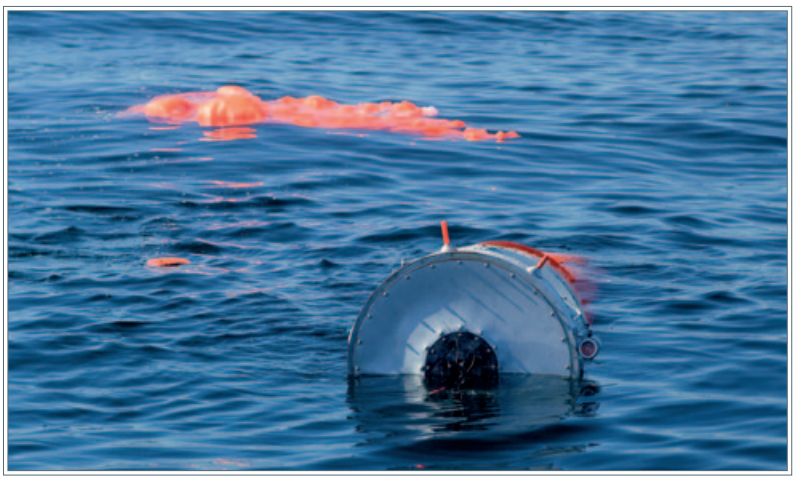
## For a Cheaper Spaceflight

To conclude our discussion, we asked to Kristian about the possible impact of their work: "it's my belief that technical progress involving inspiration to mankind will only create a better tomorrow for everyone, he says. "Besides inspiring people to go ahead and make your dream a reality – no matter the topic – I think it is interesting if we are able to change the way we look at human space flight. Right now, it's a "holy grail" and can only be done by great nations will billion of dollars. If we can show that it can be done otherwise I think we can shake up the space arena a bit.

Virgin Galactic is working to offer a suborbital ride comparable to airplane flight, in terms of perceived safety and comfort. In comparison, Copenhagen Suborbital mission profile looks more like a bungee jumping ride, a sort of extreme sport: "There are no rules for making home-made space rockets. The weight of the paper-work, for making air planes, is greater than the final product. We are not doing this as a business. We just want to go into space, in a rocket we build ourselves."

About the first manned flight, Kristian reveals: "When our test dummy Randy is done flying and we believe it is safe to replace him with a person, my partner Peter Madsen will take the first ride."

The next milestone? "We need to have a new rocket, with a new spacecraft ready for a summer 2012 launch. Next time the rocket will have active guidance."



**The Spacecraft Tycho Brahe after water splashdown. Note the homemade parachute.**
Credits: Bo Tornvig, Copenhagen Suborbitals


**The the spacecraft Tycho Brahe is recovered after the launch** - Credits: Bo Tornvig, Copenhagen Suborbitals

By Wayne Hale

# Double Indemnity

Commercial human space flight is in its infancy. It has been suggested that NASA could do much to encourage or enable the fledgling industry. Supporters cite the historical analogy of US government contracts for air mail delivery in the 1920s as a model for how to kick start the industry. A rosy hued and much abbreviated history of that era suggests that once the government started contract airmail service, modern aviation as we know it inevitably and quickly followed. It may be worthwhile to remind ourselves of a slightly more detailed version of history.

> "WWI aviation hero Eddie Rickenbacker called the Army Air Service program "legalized murder."

The US Post Office Department started scheduled airmail service while the Great War was still raging in May 1918. Government aircraft and government pilots delivered air mail in aircraft that were built to detailed government specifications for the next eight years. Twelve government pilots were killed in the first two years of this service. The US Post Office added regularly scheduled transcontinental airmail service in 1920, again with government owned aircraft and government pilots. Following the Kelly Air Mail Act of 1925, the first commercial contract air mail operations started. These were mostly flown by small start-up airlines which were frequently under-capitalized using old government surplus aircraft. By late 1926 all air mail delivery was turned over to these contracts and the government service was discontinued. Fatal accidents were still common among air mail pilots. To an even greater extent than today, the government to industry "revolving door" phenomenon was present in those days. In 1934 the great air mail scandal erupted. There were charges that government officials had colluded with industry officials (some of whom were former government officials) to fraudulently award air mail contracts to favored companies. FDR cancelled all commercial air mail contracts and called on the US Army Air Service to deliver the mail. Inexperienced military pilots and bad weather resulted in twelve pilot deaths in less than a month. WWI aviation hero Eddie Rickenbacker called the Army Air Service program "legalized murder." Within a few months, Congress passed new air mail legislation and a more

William C. "Will Bill" Hopson, an early government airmail pilot who helped pioneer the transcontinental route in 1920 flying the Omaha to Chicago leg in an open cockpit De Haviland DH-4 modified WWI bomber.

**First international airmail flight, 1919.**

closely regulated commercial air mail service was restarted. Among the features of the legislation was the provision that banned all former airline executives from further contracts. All the old air line companies were reorganized. Air mail contracts were much less lucrative and the nascent airline companies had to rely increasingly on passenger fares rather than air mail revenues to make their operations profitable. Air craft accidents continued to be frequent and in 1938 the Civil Aviation Administration was formed. The CAA started an era of tight regulations reigned over the air line industry which continued for nearly forty years.

Is this the model that people have in mind for commercial space transportation?

Of course, a paragraph or two doesn't do justice to the rich and complex history of aviation in the 1920s and 1930s. Go read the biography of Dutch Kindelberger, for example. Some airlines, like Pan Am, became profitable carrying passengers without the subsidy of air mail. The transportation of equipment and goods for purely commercial reasons apart from government contracts was a significant business. Air races stimulated technical advances. And what happened in the USA was only part of the story as airlines sprang up crossing the globe from Europe to Africa or Australia or South America. It wasn't just the air mail contracts that spurred aviation in its "golden years".

Changing focus slightly, it is often noted that the Air Force does not build its own airplane; the Army does not build its own tanks, why should NASA build its own spacecraft?

NASA, of course, does not build human spacecraft. Never has. Commercial companies have built all human spacecraft and their launch vehicles. McDonnell built Mercury and Gemini, North American Aviation and Grumman built the Apollo CSM and LM respectively. Chrysler built the Redstone rocket and the first stage of the Saturn 1B launch vehicle, and so forth. The renamed North American Rockwell built the Space Shuttle orbiter. When I became NASA's Shuttle Program Manager, I was surprised to find that the detailed design and production drawings for the Space Shuttle orbiter were the intellectual property of Rockwell International Space Division which has since become part of Boeing. The government, while definitely involved with the design, did not do the detailed part of the design and does not own the "intellectual property" for the shuttle.

> "The Air Force does not build its own airplane, why should NASA build its own spacecraft?"

**Loading airmail, late 1930s, in Detroit.** – Credits: Bill Whittaker

**Eddie Rickenbacker, World War I ace pilot and Medal of Honor recipient, called the Army Air Service program "legalized murder."** - Credits: National Aviation Hall of Fame

Many boxes and piece parts remain "proprietary" and not under the detailed purview of the government. That seems commercial at some level, doesn't it?

Thinking more about the military services, a recent speaker at NASA was from the Navy ship bureau in charge of building aircraft carriers. The Navy doesn't build aircraft carriers, a commercial company does that; but the Navy is intimately involved in the detailed design of every part of a new aircraft carrier. And the Air Force is intimately involved in the design of new jet fighters like the F-22 and the F-35. Sometimes this backfires on a company; ask about the presidential helicopter program. There is a real lesson there.

So what is being proposed for commercial human spacecraft for government use? A contract that merely asks a "provider" to transport our 4-ish person ISS crew from some place on the earth's surface to the ISS for a fee? No other questions asked? Somehow I think that is not really what is going to happen. Even the airlines and aircraft builders have to pass FAA certification for flight worthiness. So if the government contracts for transportation service there is going to be some government involvement. Oh, and don't even ask about federal procurement regulations. Remember the 1934 air mail scandal? There are a slew of laws and regulations intended to prevent something like that from happening again.

So the real question is how much or how little the government will be involved in the design/certification/operation of commercially contracted human space vehicles. Neither the current model of intimate and controlling design authority nor a totally hands off approach is realistic.

Like almost all of life, there is going to be a compromise. The devil is in the details. It seems to me that we need to spend a serious amount of thought and discussion on how best to do this. Far more than a couple of paragraphs in an essay or a report.

Indemnification. I have heard a lot about that word lately. Had to look it up. Currently the US government indemnifies the companies that build and operate our current space vehicles. If they crash, the government, not the companies, is held liable. That is not the way the airlines work; if an airliner crashes, the airline company or sometimes the aircraft manufacturer are held responsibility and are subject to civil legal action. Some of the putative commercial human space flight providers want the government to indemnify them, take the responsibility if they crash. The original airmail contracts didn't do that in 1925.

> "Neither the current model of intimate and controlling design authority nor a totally hands off approach is realistic"

Seems like we have a lot to think about as we move commercial human space flight.

We might even learn from history.

*Originally published in September 22, 2009, on the Wayne Hale Blog; reproduction authorized by the author.*

**James H. "Dutch" Kindelberger, American pioneer of aviation and leader of North American Aviation for a number of years.**

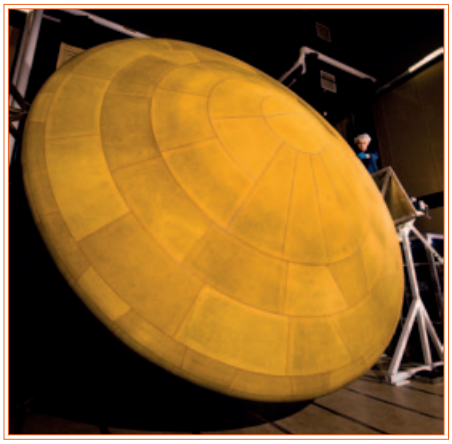
# Landing Curiosity

Landing a massive rover on Mars has always been a challenging undertaking. The atmosphere density limits effectiveness of rockets, parachutes and aero-braking systems. Previous rovers, such as Spirit and Opportunity, employed a landing gear based on airbags. But this time, the Mars Science Laboratory, nicknamed Curiosity, is too large and massive for this option. For this reason, Curiosity will be deployed on the Martian surface using an innovative four step process, which will utilize a "Sky Crane" never used on space missions.

At first, the rover will travel through space folded within a protective aero-shell. Atmospheric entry will be accomplished using a 4.5m Phenolic Impregnated Carbon Ablator (PICA) heat shield, the largest heat shield ever used in space. The Martian atmosphere will slow down the aero-shell from 6 km/sec down to Mach-2, a speed that is compatible with parachute deployment. The spacecraft will feature an onboard computer and other precision landing technologies, which will provide the ability to steer the descent module toward pre-determined landing site.

At about 7 km of altitude, the second phase will begin. The capsule will jettison the heat shield and deploy a supersonic parachute of 16 meters in diameter and 50 meters long. The parachute, significantly bigger than those used on previous missions, will set a new standard for future Mars exploration missions. All along entry, descent and landing, the rover will be capturing images to help the mission team to make early determinations of the landing site.

**Artist's conception of the Curiosity rover being lowered through a "Sky Crane" from the rocket-powered descent stage.** Credits: Jet Propulsion Lab



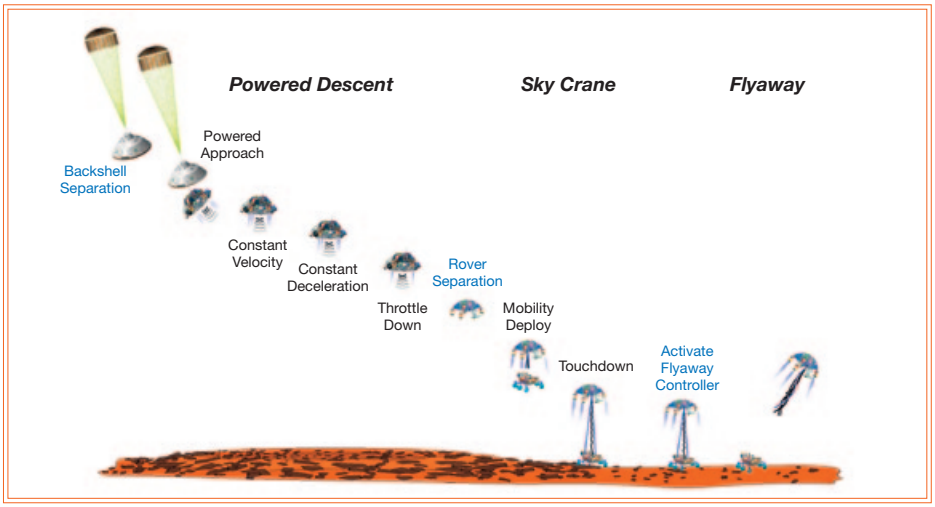
**MSL will use the largest heat-shield ever used in space.** - Credits: Lockheed Martin Corp

In the third phase, at about 1.8 km of altitude, the rover and descent stage will be dropped out the aero-shell and will proceed to a powered descent using hydrazine rocket thrusters. Power descent has been employed before to land on Mars: the eight rockets used in MSL are in fact derived from the Viking Lander engine used in the two missions of 1976. In the third phase, the rover will change to a landing configuration, deploying the various instruments previously stowed.

During deploy, phase four will begin: the descent stage will lower the rover using a "Sky Crane", a system which uses three bridles to lower the rover and an umbilical cable to carry electrical signals between the descent stage and rover. While the vehicle has been slowed down to nearly zero velocity, the rover will be lowered until it touches the ground. Right after touchdown, the bridle will be cut, and the descent stage will move away to a crash-landing site. During the lowering phase, the rover mobility and suspension systems will be deployed, making the rover ready to work upon landing.

This landing technique, which has never been employed before, will open up the deployment of even larger equipment in the future, up to a manned mission. Mars Science Laboratory will also be the first planetary mission to use precision landing techniques, improving the landing accuracy up to a range of only 20 kilometers. The launch is tentatively scheduled in November 25, 2011, in which case the landing would occur on August 6, 2012.

A video of the landing procedure can be found at http://www.jpl.nasa.gov/video/index.cfm?id=823




**The landing profile for the Mars Science Laboratory.** - Credits: Jet Propulsion Lab

# Nespoli Captures Historic ISS Photographs

By Pete Harding

The Russian Soyuz TMA-20 spacecraft, also known by its US designation of 25S, departed from the International Space Station (ISS) on Monday after five months on-orbit. Prior to a successful landing, Soyuz TMA-20 participated in a unique and historical event to photograph the ISS while the Space Shuttle Endeavour is docked to the complex, providing some amazing views.

## Soyuz Flyabout Background

Originally known as a Soyuz flyabout, the proposal to use a Soyuz spacecraft to obtain historic imagery of a Space Shuttle docked to the ISS was first revealed by NASA Spaceflight.com prior to the STS-133 mission in February this year.

The last and only time a Space Shuttle was photographed docked to a space station was during STS-71 in June 1995, when a Soyuz spacecraft undocked from the Mir space station in order to photograph the undocking of Space Shuttle Atlantis.

Today, with the Space Shuttles flying their final missions and with the US segment of the ISS now fully complete, NASA's desire to obtain visual imagery of the apex of human spaceflight was strong.

Prior to the STS-133 mission, the proposal was to undock the Soyuz TMA-01M spacecraft from the MRM-2 "Poisk" Zenith port during the STS-133 mission and back away to a safe distance, whereupon the ISS would move to an attitude which would best show off Shuttle Discovery.

The Soyuz TMA-01M crew was then to take photos of the Shuttle/Station stack, and then re-dock to the complex. However, ultimately, the fact that Soyuz TMA-01M was the first of the new 700-series "digital" Soyuzes made the operation too risky for the Russians' liking.

Following its cancellation from ▸▸

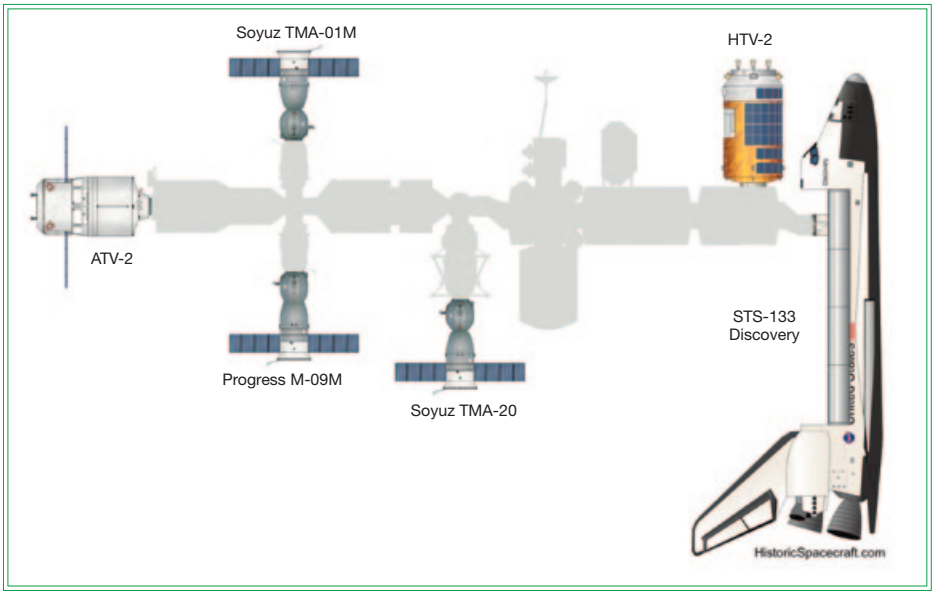
> "NASA's desire to obtain visual imagery of the apex of human spaceflight was strong"

**A side view of the ISS with the Space Shuttle Endeavour and the ATV Johannes Kepler docked at its extremities. Note the configuration of the Shuttle Remote Manipulator System, hidden behind the heat shield.** - Credits: Paolo Nespoli, NASA/ESA

the STS-133 mission, the Soyuz flyabout then moved to STS-134, with the same proposal as before except that the older 200-series "analogue" Soyuz TMA-21 would be present at MRM-2 Zenith. However, concerns relating to a potential ISS de-crew situation should Soyuz TMA-21 fail to re-dock with the station caused planning efforts to switch focus to Soyuz TMA-20 at MRM-1 "Rassvet" Nadir.

Under STS-134's original launch date of April 29th, the Soyuz TMA-20 undocking would have needed to be brought forward in order for Soyuz TMA-20 to undock during Space Shuttle Endeavour's stay at the station. Due to the launch slip of Soyuz TMA-02M,

> "Endeavour's docked mission aligned perfectly with the delayed Soyuz TMA-20 undocking"




**A Schematics representation of the docking configuration of the ISS on February 26, 2011. Note the relative position of the Shuttle and the Soyuz TMA-20.**
Richard Kruse, historicspacecraft.com

bringing the TMA-20 undocking forward was deemed unacceptable due to crew time impacts on the station and the STS-134 mission, and ultimately NASA and Russia decided to delay the Soyuz TMA-20 undocking in order to minimize crew time impacts of the Soyuz TMA-02M launch slip.

Soyuz flyabout planning then moved to STS-135 using Soyuz TMA-21 at MRM-2 Zenith; however the packed nature of the STS-135 mission timeline made finding room for the flyabout very tricky. Following STS-134's launch slip to May 16th, Endeavour's docked mission aligned perfectly with the delayed Soyuz TMA-20 undocking, and due to recent positive analysis into Dual Docked Operations (DDO), a rare and unique opportunity presented itself to flyabout planners. The opportunity was presented due to the fact that Soyuz TMA-20 would be undocking from the ISS during Endeavour's stay for a return to Earth, and so if a photography task were added to the undocking procedure, there would be no need for a re-docking with the station. This eliminated the need for a flyabout maneuver altogether, since there would be no need to re-align with the docking port, and eliminated the risks associated with a failed re-docking and subsequent loss of ISS crewmembers.

Following detailed analysis into MMOD, thermal conditions and thruster plume impingement of the station, NASA announced during last Friday's STS-134 Mission Status Briefing that a Soyuz documentary imagery task (no longer referred to as a flyabout) was being added to the Soyuz TMA-20 undocking procedure.

## Photographic Imagery Procedure

A few hours prior to the Soyuz TMA-20 undocking, the Shuttle Remote Manipulator System (SRMS) was maneuvered the Orbiter Boom Sensor System (OBSS) to a safe position behind Endeavour's heat shield, in order to protect the boom's sensors from Soyuz thruster pluming. Endeavour's Payload Bay cameras were also pointed away from the Soyuz for protection, and her star tracker doors were closed.

The Soyuz TMA-20 crew – comprised of Soyuz commander Dimitri Kondratyev of Russia, and flight engineers Cady Coleman of the US and Paolo Nespoli of Italy – suited up, conducted leak checks, and entered their Soyuz capsule per nominal procedures. Hatch closure between Soyuz TMA-20 and the ISS was on schedule, at around 2:30 PM EDT / 6:30 PM GMT.

About 40 minutes prior to the Soyuz undocking, the ISS performed a 90 degree pitch-up maneuver from its standard Shuttle docked attitude, -XVV (negative X axis in Velocity Vector), to the Soyuz undocking attitude, -ZVV (negative Z axis in Velocity Vector) under the control of Russian Segment (RS) thrusters.

Once the undocking attitude was achieved, the ISS entered a period of free drift and Soyuz TMA-20 undocked from the ISS at 5:32 PM EDT / 9:32 PM GMT. The undocking occurred one orbit earlier than normal, due to the need to spend additional time on the photographic procedures. Commander Kondratyev then began to manually fly the Soyuz away from the ISS, and the Russian thrusters resumed attitude control of the station.

The STS-134 crew was scheduled to be asleep during the undocking, but due to the light workdays surrounding the undocking, it is believed some managed to be awake for the event, and may have even attempt to photograph Soyuz TMA-20 from the port-side windows of Endeavour.

Once the Soyuz reached 200 meters away from the station, which occurred around 10 minutes after undocking, Kondratyev held position and Paolo Nespoli opened the hatch between the Soyuz Descent Module, where the crew were seated for the undocking, and ▸▸

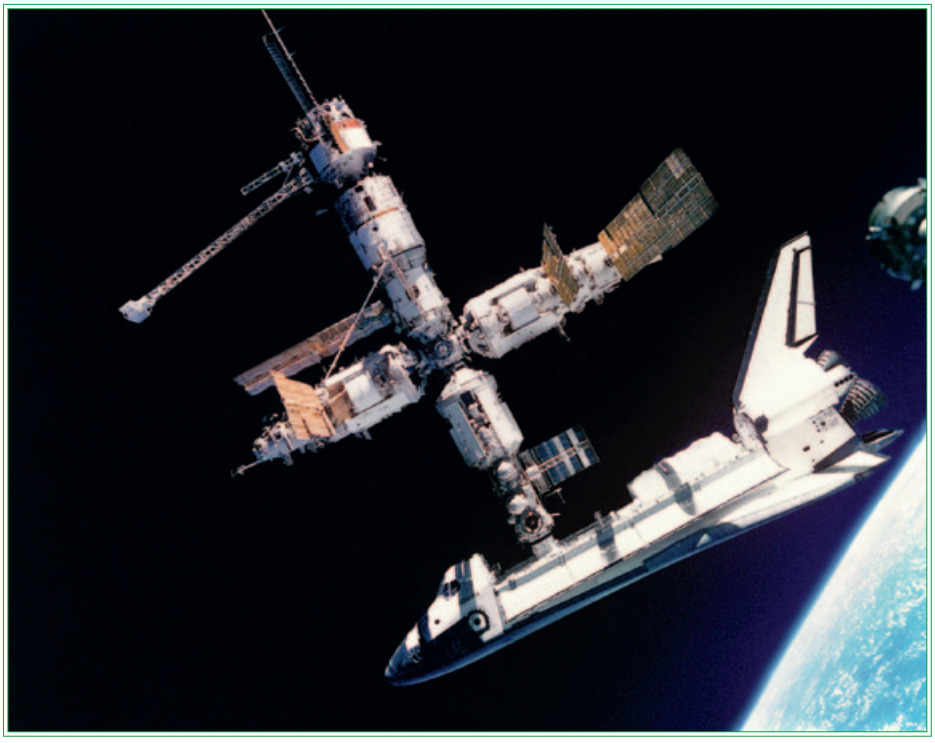
the Orbital Module. After about eight minutes of set-up, Nespoli began the imagery of the Shuttle/ISS stack using a High Definition video camcorder and a High Resolution digital camera. The Italian astronaut was heard taking the historic photos over the communication loops, as he "click, click, clicked" away at the amazing view.

Five minutes later, and with the Soyuz positioned slightly above the ISS due to the need to keep the Sun out of Kondratyev's eyes, the ISS began a 15 minute, 129 degree maneuver (at 0.2 degrees per second) which placed the ISS in the +VVV (plus V axis in Velocity Vector) attitude, at a 90 degree side-on angle to the Soyuz. Nespoli was filming and photographing the maneuver all throughout this period, and also occasionally used a handheld laser rangefinder to assist Kondratyev with his manual station keeping. This was the first time that a Soyuz has station kept with the ISS at 200m, and the first time that a Soyuz has station kept while the ISS has changed attitude.

Nespoli continued to image the station for about 10 minutes after the maneuver was complete, whereupon Kondratyev conducted a final separation burn to take the Soyuz away from the station. In total, Nespoli was expected to acquire roughly 30 minutes of stunning images and video of the Shuttle/Station complex – all in orbital daylight and with the Earth's horizon as a backdrop.

**Italian astronaut Paolo Nespoli with a camera on board the ISS.** - Credits: ESA

> "This was the first time that a Soyuz has station kept with the ISS at 200m"



**The Space Shuttle Atlantis docked to the MIR space station in June 1996.**
Credits: NASA/GRIN

Following the Soyuz separation burn, the ISS returned to its nominal -XVV Shuttle docked attitude under Russian thruster control, and Nespoli removed the memory cards from the video and still cameras. The Russian video and still cameras remained in the Orbital Module to burn up in Earth's atmosphere upon re-entry.

At that time, roughly 48 minutes after the undocking, Nespoli returned to the Descent Module, along with the memory cards, and closed the hatch between the Orbital Module and the Descent Module. The Decent Module was then leak checked for a second time, and once Nespoli donned his gloves, his Sokol suit was also leak checked. Soyuz TMA-20 then began preparations to return to Earth per nominal procedures.

## Return to Earth

Approximately 4 hours and 4 minutes after the undocking, the Soyuz conducted its de-orbit burn at 9:36 PM EDT / 1:36 AM GMT, and re-entered Earth's atmosphere roughly 23 minutes later. After eight minutes of re-entry, the parachutes deployed, and the crew hit the deck in Kazakhstan 15 minutes later, at 10:26 PM EDT / 2:26 AM GMT.

The images will have engineering value as well as historical value, since they will reveal parts of the sta-

> "NASA managers hope to see the iconic images appear in textbooks for decades to come"

tion that are normally never seen, but their true value will be their tribute to the thousands of men and women who have worked on the Shuttle and ISS programs.

For them, as well as spaceflight fans the world over, the unique chance to see the magnificent and majestic Space Shuttle flying together with its greatest legacy will be something to be remembered long after "wheels stop" is called on the final Shuttle mission in July.

NASA managers hope to see the iconic images appear in textbooks for decades to come, as a historical record of the Space Shuttle at its height of achievement, and as an example of what human beings can achieve in space.

At this time, it is not yet known whether obtaining the images on STS-134 will remove the Soyuz flyabout proposal from the STS-135 mission. NASA managers will evaluate the STS-135 Soyuz flyabout proposal following the conclusion of the STS-134 mission.

*Originally published on May 23, 2011, on http://www.nasaspaceflight.com/ as "Soyuz TMA-20 captures historic photography prior to perfect landing" – Reproduced with permission of the author and the publisher.*

**An amazing picture of the ISS-Shuttle complex.** - Credits: Paolo Nespoli, NASA/ESA

# In This Issue of the Space Safety Magazine

## Dr. Judith A. Jeevarajan

Dr. Judith Jeevarajan is a Senior Scientist at Energy Systems Division NASA-Johnson Space Center. She has worked on several battery projects using various battery chemistries and also represents the battery group at all the NASA safety panels, providing technical design and safety guidance for various projects including those with the International Partners. Batteries are designed and safety certified under her guidance and she was the first to certify and fly a lithium-ion commercial battery in a manned space environment. She is a member of the IEC/ANSI and UL Standards and Test Procedures Technical Working Groups and a member of the Electrochemical Society and International Association for the Advancement of Space Safety (IAASS).

Dr. Jeevarajan has a M.S. from the University of Notre Dame, Indiana and a Ph.D. from the University of Alabama, Tuscaloosa, Alabama. Her graduate school work was focused on electrochemistry and her post graduate work focused on battery technology, both of which serves her well in strengthening her current job skills. She has made more than 70 presentations at conferences, has given invited lectures for several organizations, has served as session chair at prestigious conferences and has won many NASA awards including the prestigious Space Flight Awareness award.

## Wayne Hale

Wayne Hale is a consultant for Special Aerospace Services of Boulder, Colorado. He served as Space Shuttle Program Manager and Shuttle Launch Integration Manager, has been a Space Shuttle Flight Director for 40 Space Shuttle flights, and prior to that a Propulsion Officer for 10 early Space Shuttle flights. He retired from NASA on July 31, 2010 as the Deputy Associate Administrator of Strategic Partnerships, Space Operations Mission Directorate.

Wayne has received special honors and awards such as: NASA Outstanding Leadership Medals in 1999, 2005, and 2007; NASA Space Flight Awareness Leadership Award 2002; NASA Exceptional Service Medal 1992; National Space Club Goddard Memorial Astronautics Engineer of the Year 2007; and National Air and Space Smithsonian Achievement Award of the Year 2007.

Wayne Hale's Blog: http://waynehale.wordpress.com/

## Joseph Fragola

Joseph Fragola is vice president of Valador Inc. with over 35 years of experience working in reliability and risk technology in both the aerospace and nuclear industries. In the past he has worked for Grumman Aerospace Corporation, and IEEE at their Headquarters in New York. He has participated in several dozen risk assessments, and was the Principal Investigator of the landmark, NASA sponsored, 1995 launch to landing risk assessment of the space shuttle, which still remains the only published work on the subject of integrated shuttle risk. Mr. Fragola recently served, by selection of the NASA Administrator, as one of the 15 core members of the NASA Exploration Architecture Study (ESAS) Team and received NASA's Exceptional Public Service Medal for his work. He was recently a Principal Scientist at SAIC and continues to be a visiting professor at the University of Strathclyde in Glasgow, Scotland. He has published almost 50 papers and two books. He received his B.S. and M.S. degrees in Physics from the Polytechnic Institute of New York.

## Pete Harding

Pete Harding is an electronic engineering student living in the United Kingdom. He started writing articles for NASASpaceflight.com in October 2010, and specialises in in-depth International Space Station reporting. He aims to eventually work in the human spaceflight industry.and continues to be a visiting professor at the University of Strathclyde in Glasgow, Scotland. He has published almost 50 papers and two books. He received his B.S. and M.S. degrees in Physics from the Polytechnic Institute of New York.

# Give Your Contribution to the Space Safety Magazine

The Space Safety Magazine is distributed to more than a thousand professionals in the aerospace industry. We are committed to the quality of this publication, which we want to establish as dependable source of information regarding safety in manned and unmanned spaceflight.

Every issue features contributions with scientists, engineers, writers, journalists and professionals in the space industry. Each one of them contributes with his knowledge, his field experience and his opinions both on recent and historical events.

If there is something you feel should be covered, whether news or an historical event, a running project or a breakthrough proposal, a scoop or an anniversary, send us a notification, because this is your Magazine, and your opinion matters.

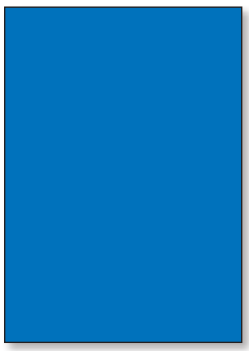
We welcome contributions in form of article proposals, insight on space projects you are currently involved, requests for interviews and comments of any kind.

You can send your proposal to Andrea Gini, the Magazine Editor-in-Chief, and to Tommaso Sgobba, IAASS President.

Andrea Gini:
ginian@gmail.com

Tommaso Sgobba:
iaass.president@gmail.com

# Advertising Placement



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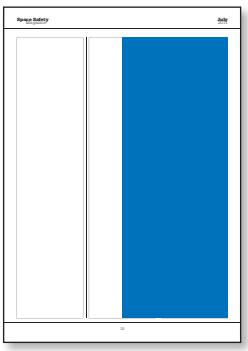

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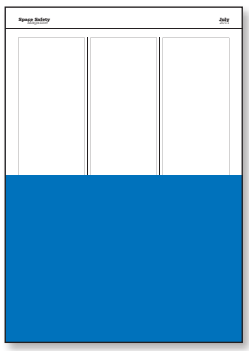

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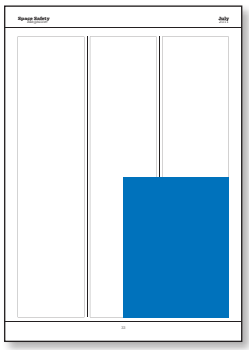

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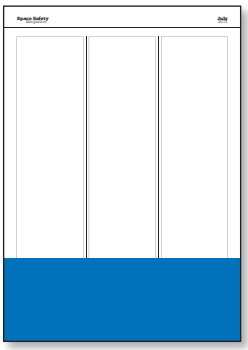

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- **PDF** (Adobe Acrobat all versions up to Acrobat 9)
- **TIF / JPG**
- **AI / EPS** (Adobe Illustrator all versions up to CS5)
- **INDD** (Adobe InDesign all versions up to CS5)

All files must be 300 dpi.
CMYK files must embed the FOGRA39 Color Profile.
Please embed all fonts or convert to outline to avoid font mismatches.
For Full page, Half horizontal page and Quarter horizontal page please add 3mm bleed (0.1") on each side.

**We don't accept:**

- **Quark XPress**
- **Word, Excel, Power Point**
- **MS Publisher**
- **Corel Draw**

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1/4 of a page $1,500 (for five numbers),
1/2 page $3,000 (for five numbers);
Back cover, full page $5,000 (for five numbers)

- **Events announcements:**
1/4 of page $450
1/2 page $900
Full page $1,800

# Press Clips

## ISS Passes Close to Space Junk

An unidentified piece of orbiting space junk came close to the ISS on June 28, 2011, missing the station by 340 meters. The debris was detected just 14 hours before the close approach, a time window that left little time to move the space station away: the amount of time needed to move the space station is in fact about two days.

Astronauts were ordered by Mission Control to take shelter into the two Russian Soyuz capsules on Tuesday morning, around 7:30 a.m. EDT. The approach happened right after 8 a.m. A few minutes later, Mission Control authorized the astronauts and cosmonauts to reenter on board the ISS.

According to NASA, this was the closest approach by space debris in the history of the ISS.

Source: NASA

## First Cygnus PCM Delivered to Orbital Sciences

The first Pressurized Cargo Module (PCM), a spacecraft developed to transport cargo to the ISS, has been delivered to Orbital Sciences Corp. The news has been announced by Thales Alenia Space, the European satellite manufacturer. The spacecraft, been developed under NASA's Commercial Orbital Transportation Services (COTS) research and development initiative, has been assembled in Thales Alenia Space plant in Turin, Italy. The first PCM will be integrated with the Cygnus service module and Orbital Taurus II rocket for the Cygnus TM demonstration mission, scheduled for December 2011.

**Artist's conception of the Cygnus spacecraft approaching the ISS.** - Credits: Orbital Sciences Corp

The PCM initial capacity is up to 2,000kg of cargo; an enhanced configuration will soon extend payload capacity to 2,700kg. After the demonstration, Thales Alenia Space will provide eight more PCM units, three in standard configuration and five in extended.

## U.S. Warned China of Debris Threats 147 Times Last Year

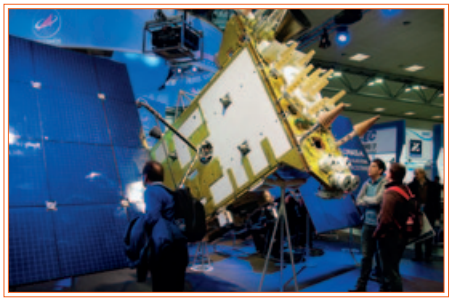
According to Frank A. Rose, U.S. State Department's deputy assistant secretary in the bureau of arms control, verification and compliance, the U.S. Government warned the Chinese government of debris threats to Chinese spacecrafts on 147 occasions in the past year. These warnings were issued as part of the policy of building trust among spacefaring nations and promoting the safe use of space.

Source: Space News

## Spacewalk Interrupted for Spacesuit Glitch

The May 20 spacewalk, whose objective was to upgrade the ISS, has been interrupted because of the failure of a spacesuit sensor that detects carbon dioxide. Astronauts Andrew Feustel and Greg Chamitoff of the Shuttle Endeavour worked for more than five hours outside the space station to replace science experiments, install new equipment and perform maintenance on the orbiting laboratory. The original plan called for an additional hour and a half of EVA operations, but the astronauts have been ordered to get back to the ISS by NASA because of the failure of the sensor on Chamitoff's spacesuit.

## Russia Opens Negligence Case Over Loss of Glonass satellites



**Glonass-K satellite prototype at CeBIT 2011.** - Credits: Jürgen Treutler

According to the agency RIA Novosti, Russian prosecutors have opened a criminal case on charges of negligence that led to the loss of three Glonass satellites in December last year. The satellites, which were meant to complete the Glonass navigation system, were lost during launch because the Proton-M carrier rocket veered off course and crashed in the Pacific Ocean. The criminal proceedings have been issued against space officials considered responsible for the loss. The failure cost 4.3 billion rubles, approximately $152.2 million. According to spokesman Vladimir Markin, the calculation error which caused the loss remained undetected due to organizational flaws and insufficient controls on the part the personnel responsible for the launch.

Source: RIA Novosti

**Artist's rendition of the Ares 1 rocket, canceled along with the Constellation program.** Credits: NASA

# Memo Marks Formal End of Constellation Program

Douglas Cooke, associate administrator for NASA's Exploration Systems Mission Directorate, signed a letter that formally closed the Constellation deep space exploration program. The Constellation project office, whose size has been significantly reduced, will transition to the new Space Launch System (SLS) and Multi-Purpose Crew Vehicle programs. NASA has not yet decided whether to use existing Constellation contract to build the SLS heavy-lift rocket, which Congress ordered to construct in the NASA Authorization Act of 2010.

Source: Space News

# SpaceShipTwo Testing Proceeds

Virgin Galactic SpaceShipTwo keeps collecting flight time, test after test. The 14th glide test has been performed successfully on June 23, 2011. On June 14 and 15, two successful glide flights have been performed within 24 hours. On May 4, 2011, the spacecraft performed its first feathered flight, a configuration that allows the vehicle to re-enter the atmosphere without the need of a heat shield. All the objectives of the tests have been accomplished so far. The testing program will continue through the year. It has not been revealed yet when commercial operations will start.

# Sbirs Satellite Reaches GEO

According to Lockheed Martin officials, the first Space-Based Infrared System (Sbirs) GEO-1, launched on May 7 from Cape Canaveral, has reached its orbital destination. The satellite reached its orbit by gradually increasing is perigee through a series of burns of its apogee engine. On May 18, the satellite deploy began, and the spacecraft began its operations. The Sbir series of satellites has been designed to replace the Defense Support System to provide missile warning, along with infrared scanning.

# Boeing CST-100 Space Capsule Review SDR Completed

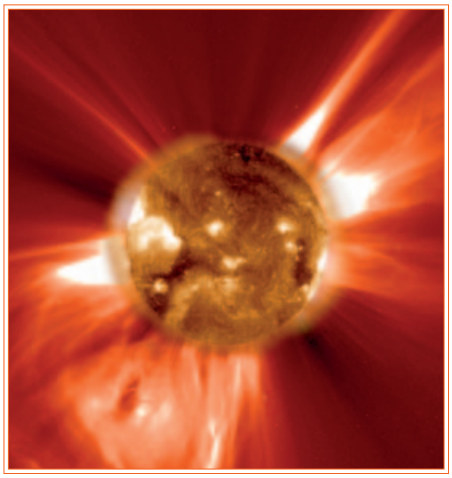
According to Boeing, the Delta System Definition (SDR) review of its Crew Space Trasport (CTS)-100 spacecraft has been completed. The review involved representatives from NASA, the Federal Aviation Administration (FAA) and independent consultants. The previous review was performed in October 2010. All the major subsystem has been reviewed, and the design has been consolidated.

**CST-100 capsule mockup.** – Credits: Boeing

Boeing expects to conduct a system-level Preliminary Design Review (PDR) under the Commercial Crew Development (CCDev)-2 agreement, to perfect the design by spring 2012. During the press release, Boeing disclosed its plans to perform the first test flight in 2014, and to begin operations in 2015.

The CST-100 Space capsule is designed to transport up to seven people to LEO, or a combination of people and cargo.

# Solar Storm Recorded on June 21



**A spectacular mass coronal ejection recorded on January 8, 2002.** Credits: SOHO/ESA/NASA

According to Spaceweather.com, a website which monitors space weather events, a powerful solar flare and eruption has been recorded on June 21 by the space-based Solar and Heliospheric Observatory (SOHO) operated by NASA and the European Space Agency. The solar storm produced a C7-class solar flare which triggered a coronal mass ejection. Coronal mass ejections are massive eruptions of charged particles and solar material from the sun's surface. Charged particles that reach Earth can interact with the magnetic field, causing auroras in Polar Regions. Powerful solar storms can affect satellites, communications and power systems on Earth.

# Upcoming Events

2011 SEPTEMBER 19-23

### IAASS Space Safety Academy, ISS Payloads Design and Operations Safety

19-23 September 2011
Turin (Italy)

2011 OCTOBER 13-14

### 3rd IAASS Workshop on Public Safety of Space Missions

13-14 October 2011
Paris (France)

2011 OCTOBER 11-14

### IAASS Space Safety Academy, Launch Flight Safety Analysis Course

11-14 October 2011
Evry-Paris (France)

2011 OCTOBER 17-19

### 5th IAASS International Space Safety Conference "A Safer Space for a Safer World"

17-19 October 2011
Versailles-Paris (France)

2011 OCTOBER 12-14

### IAASS Space Safety Academy, Workshop on Composite Overwrapped Pressure Vessels - Best US Practices

12-14 October 2011
ESA/ESTEC - Noordwijk
(The Netherlands)