



INTERNATIONAL ASSOCIATION
FOR THE ADVANCEMENT OF
SPACE SAFETY



INTERNATIONAL SPACE
SAFETY FOUNDATION

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Issue 8
Summer 2013



**The
Pedestrian
Cause of a
Spectacular
Crash**



**Water-filled Helmet
Ends EVA:
The Close Call of
Luca Parmitano**



**Space Walker:
The Story of
Astronaut
Jerry Ross**

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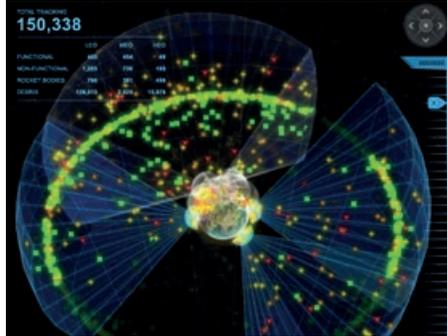


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Rising Up, Aiming Down



Assembly of a Proton rocket. – Credits: Pavel Kolotilov, Wikimedia

In the past two years, almost at regular intervals, we received recurrent news about the failure of a Russian rocket launch. A few weeks ago, on July 2, a three-stage Proton-M took off from Baikonour Cosmodrome. The rocket started veering off course right after leaving the pad, deviating from the vertical path in various directions and then plunging to the ground nose first less than 40 seconds after liftoff. The fragmenting and still thrusting vehicle crashed approximately 2.5km from the launch pad. The immediate safety concern was the 600 tons of fuel: unsymmetrical dimethylhydrazine, a toxic chemical compound that can be absorbed through the skin, and dinitrogen tetroxide, an inhalation and contact hazard causing edema and skin burns. Toxic clouds began drifting over the Kazakh plains following the crash. The Cosmodrome was evacuated and the inhabitants of Baikonour were instructed not to leave their homes, to deactivate air conditioners, and tightly close all doors and windows to avoid intake of contaminated air. In the following days a total area of 13,100m³ had to be treated with detoxifying chemical solutions.

The rocket slammed into the ground under full thrust, thus creating a catastrophic risk for launch personnel. The impact

created a 40 by 25 meter crater with a depth of up to five meters.

The broader cause of this and, indeed, all Russian rocket failures of recent years is the frequent inadequacy and disparity of the quality control system of the myriad companies involved in the manufacturing of space hardware. It is a problem that will require a vast cultural revolution to resolve.

The Russians started paying attention to quality as early as 1961 when a decree on “measures to improve military technology” laid the basis for institution of quality control by the military to improve the reliability of space systems. The core of their approach, however, was a capillary network of technical surveillance activities performed by military inspectors. This was exactly the opposite of what was being done in the same years in the US, where military inspections were basically dismantled in favor of the institution of independent quality assurance services by manufacturers, with emphasis on prevention. In 2009 the independent military oversight of Russian launcher production was disbanded and each company had to establish its own quality assurance capability.

The Proton’s failure was caused by some critical angular velocity sensors

that had been installed upside down. The paper trail led to a technician responsible for the assembly of the hardware. The improper installation apparently required some considerable physical effort in a location difficult to access. The technician’s supervisor and a quality control specialist, who were supposed to check upon completion of the installation, both signed the assembly log to indicate that they had done so. The investigation team identified deficiencies in the installation instructions and in the mechanical design of the hardware.

How is it possible that a technician fails to perform an operation that has been repeated successfully hundreds of times over several decades? Russian technicians and engineers need to abandon their traditional attitude of seeking and maintaining jealous ownership of technical knowledge, and of guarding their mastership – the “secrets of their trade” – as a safe-conduct and a personal asset.

Knowledge must be managed and transferred by means of specifications and procedures which are maintained through an effective system of non-conformances, reporting, and corrective actions. Furthermore, critical process procedures need to be revalidated by means of modern techniques like Process FMEA (Failure Mode and Effects Analysis), to ensure that effective means of human error prevention are in place. Re-establishing independent military inspection of space hardware is not the right answer to the current quality problems of the Russian space industry. Inspection is not prevention, and PREVENTION is the essence of modern QUALITY CONTROL!



Tommaso Sgobba
IAASS President

By Merrill Azriel

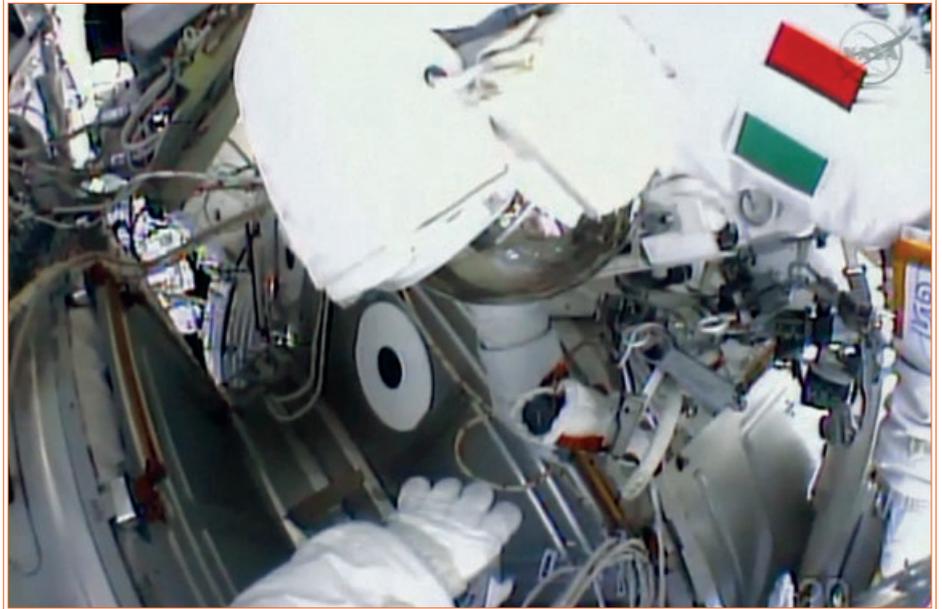
Water-filled Helmet Ends EVA: The Close Call of Luca Parmitano

Those watching the live feed of EVA-23 from outside the International Space Station (ISS) on July 16 may be forgiven for not realizing that they were watching the worst Extravehicular Activity (EVA) accident in ISS history. The calm, professional response of both those on orbit and in Mission Control belied the gravity of the situation as astronaut Luca Parmitano, on just his second spacewalk, faced mortal danger when a substantial leak filled his helmet with water. In the unforgiving vacuum of space, removal of his helmet would have meant an even quicker death than drowning or choking on the inexorably building water climbing over his face.

Progression of the Incident

EVA-23 began at 11:57 AM UTC, 13 minutes ahead of schedule, with astronauts Chris Cassidy and Luca Parmitano heading out of the Quest airlock. They split up, with each astronaut's first two tasks going well. At 12:47 PM UTC, Parmitano reported feeling wet on the back of his head. He continued his work, aware that this wasn't the first time an astronaut encountered this issue. One particular suit used on three EVAs during STS-129 and STS-130 manifested reduced audio quality when the wearer felt dampness around the ear cups; yet, post-EVA analysis in those cases found no water in the affected area and the issue was attributed to condensation. But by 12:54 PM it became clear that Parmitano's issue went well beyond condensation. After visual assessment, Cassidy reported seeing approximately 500 ml of water centered at the back of Parmitano's head, but creeping forward. Suspecting the drink bag may be to blame, Parmitano eliminated that source by the simple expedient of drinking the bag dry. He also drank water that had accumulated on the visor - it tasted a bit off, but that was to be expected due to the visor's anti-fog coating.

Alas, the water buildup continued - clearly the drink bag was not the source.



"How much can I sweat, though?" Parmitano asks when considering possible sources of the fluid in his helmet just before the EVA was terminated. - Credits: NASA

Mission Control didn't think the cooling system was likely; the astronauts considered bodily fluids. By 1:05 PM, it didn't matter what it was: Mission Control made the call to terminate the EVA. "There is some [water] in my eyes, and some in my nose," Parmitano said before losing the ability to communicate entirely. "It feels like a lot of water." With Cassidy's help, Parmitano made his way back to the airlock. At 1:17 PM Parmitano's eyes, ears, and nose were covered in water and his mouth was only free because he kept drinking. Unable to speak, Parmitano let Cassidy know he was ok by squeezing his hand - and waited as Cassidy cleaned up the equipment.

After a slightly expedited repressurization procedure, the internal hatch opened at 1:37 PM. The rest of the ISS crew waited just inside to help with Parmitano's expedited doffing procedure. At 1:38 PM astronaut Karen Nyberg got Parmitano's helmet off and cosmonauts Pavel Vinogradov

and Fyodor Yurchikhin converged on him with towels. There was water everywhere. Parmitano emerged looking very shaken, as well he might. In a press conference a few hours later, lead spacewalk officer Karina Eversley reported that if the situation had warranted they could have expedited reentry even further; but there is no question that this was a close call.

Investigation and Repercussions

After taking some deep breaths, the ISS crew got to work examining Parmitano's Extravehicular Mobility Unity (EMU), designated 3011, for the most likely culprits. They were able to quickly rule out some suspects, but the leak, probably located somewhere in the primary life support system (PLSS) backpack, proved difficult to find. Soon enough, the crew had to go back to their day jobs, the mystery still undiscovered. But they've been running a few tests in between times and NASA has two teams working on the ground: an Anomaly Resolution Team (ART) to help trace ▶▶

“It feels like a lot of water,”

L. Parmitano during EVA-23

“I don’t ever remember seeing a problem like this,”

J. Ross

the physical failure and a Mishap Investigation Board to derive lessons learned and prevent future recurrence. Neither team has announced any findings yet, although NASASpaceflight.com reported that the ART fingered the T2 port that vents into the helmet as the most likely source of the leak. The T2 is the juncture just before the water line is routed through the helmet, where it is designed to cool the air that is blown into the top rear of the helmet to keep the astronaut cool and ventilated; that incoming air vent was the entry point for the water that plagued Parmitano. When tested on orbit, the T2 line showed external accumulation of droplets, although not the high volume stream that might have been expected.

While the investigation remains underway, any routine EVA activity involving the EMUs is on hold out of concern that EMU 3011 may not be the only suit with this problem. This is considered to be unlikely given the history of the suit, and in a real emergency the astronauts would probably be permitted to don the other suits.



Chris Cassidy explains where the leak occurred in Parmitano’s helmet. – Credits: NASA

EVA-23 was intended to be the final US EVA until 2015. However, with several tasks remaining, including preparation for the new Russian module scheduled to be installed at the end of 2013, sooner or later EVA-23 tasks will have to be completed.

The Path Forward

I don’t ever remember seeing a problem like this in the past and I don’t know that anyone else will remember one either,” seven-time astronaut and EVA specialist (now retired) Jerry Ross told Space Safety Magazine. The incident resulted in the shortest EVA since astronaut

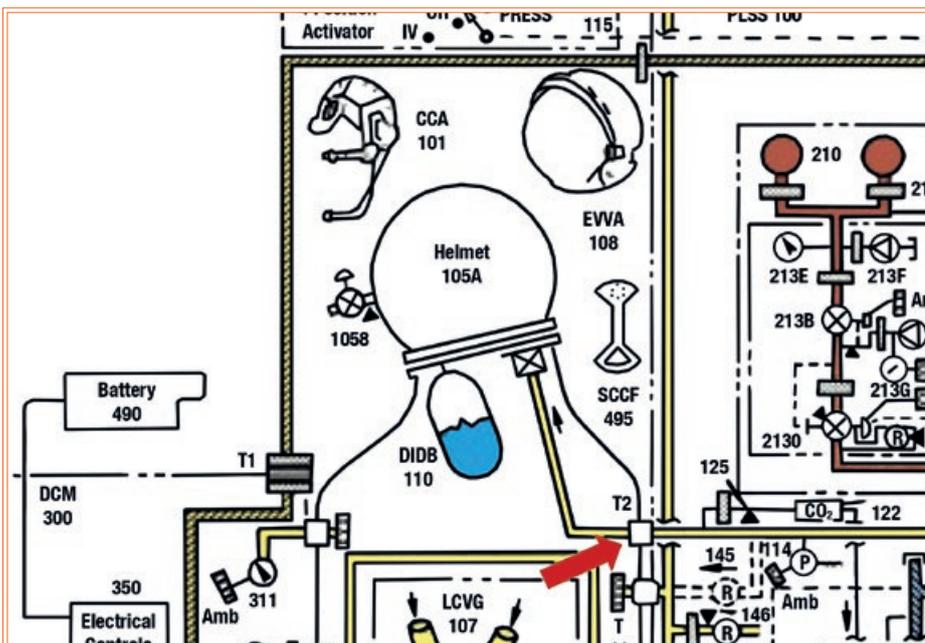
Mike Fincke’s 14 minute abort when he lost pressurization in his primary oxygen tank during ISS Expedition 9 in 2004. One must look to the earliest days of EVA to identify another incident close to the severity of Parmitano’s July 16 mishap.

Although initially reluctant to do so, NASA finally decided that EMU 3011 is going to need some specialized work and they booked its passage back to Earth on the upcoming SpaceX Dragon flight in January 2014. Dragon is the only substantive downmass capability available to ISS, so it is not possible to take measures any sooner. According to NASASpaceflight.com, a special rack is being constructed to hold the suit on its return journey.

Removal of the suit will have the unfortunate effect of leaving ISS without a medium-sized Hard Upper Torso (HUT) unit. While other elements of the suit may be adjusted to individual astronauts’ sizes, the HUT only comes in three sizes and mismatches with HUT size preclude an astronaut from qualifying to perform EVAs.

Longer term responses to this incident have yet to be defined. The Mishap Investigation Board is certain to develop a response procedure to be enacted if such an incident should occur again. They might also reexamine the shelf life of the EMU – currently set at 25 EVAs or six years – and consider training procedures for such an occurrence. It might even be prudent to make more extensive use of the PLSS in EVA testing and training on Earth. Currently, the PLSS is used only in vacuum chamber tests.

It seems unlikely that there will be any fault found to be associated with this occurrence; it is simply another reminder that however routine space activities might appear to have become, space remains an unforgiving habitat requiring preparation and constant vigilance to survive.



Pneumo-Hydraulic schematic of the PLSS. The arrow indicates the port most likely to be at fault for the EVA-23 leak. – Credits: NASA

By Merryl Azriel

The Pedestrian Cause of a Spectacular Crash

At 2:38 AM GMT on July 2nd 2013, a routine launch of three navigation satellites out of Baikonour Cosmodrome turned decidedly atypical when the rocket took a nosedive into the launch site seconds after takeoff.

The crash has been repeatedly described as “spectacular,” and it’s hard to stay away from the adjective. A television crew expecting to capture live footage of the launch instead found themselves rapidly adjusting their viewing angle as the rocket hewed left, right, and then over, shedding fairing and nose cone in its fiery, rocket-accelerated return to the ground.

The immediate aftermath entailed evacuation of the Cosmodrome, where the Proton’s 600 tons of toxic fuel was feeding orange flames at the site of the crash. Announcements went out to residents of the three nearest towns to stay inside with windows closed and air conditioners off to prevent inhalation of highly hazardous fuel vapors. By a combination of adherence to safety procedures and sheer good luck, no one was injured in the initial crash or its aftermath and a combination of rain and the fire quickly dissipated the gaseous clouds of fuel.

Looking for a Culprit

In time-honored fashion, the next stages of the incident involved rampant speculation and the formation of an investigation commission. Given the epidemic of quality-related failures coming out of Russian space in the past three years, statements from government officials were characteristically harsh, promising criminal prosecution and polygraph tests for the engineers involved in Proton’s manufacture. Initial speculation focused on the 0.4 second premature separation of the rocket from ground system cabling and an apparent 1,200°C temperature spike in one engine – indicative of a fire – at the time of liftoff. Neither of these factors have yet been accounted for and as of the time this article goes to press, the investigation commis-

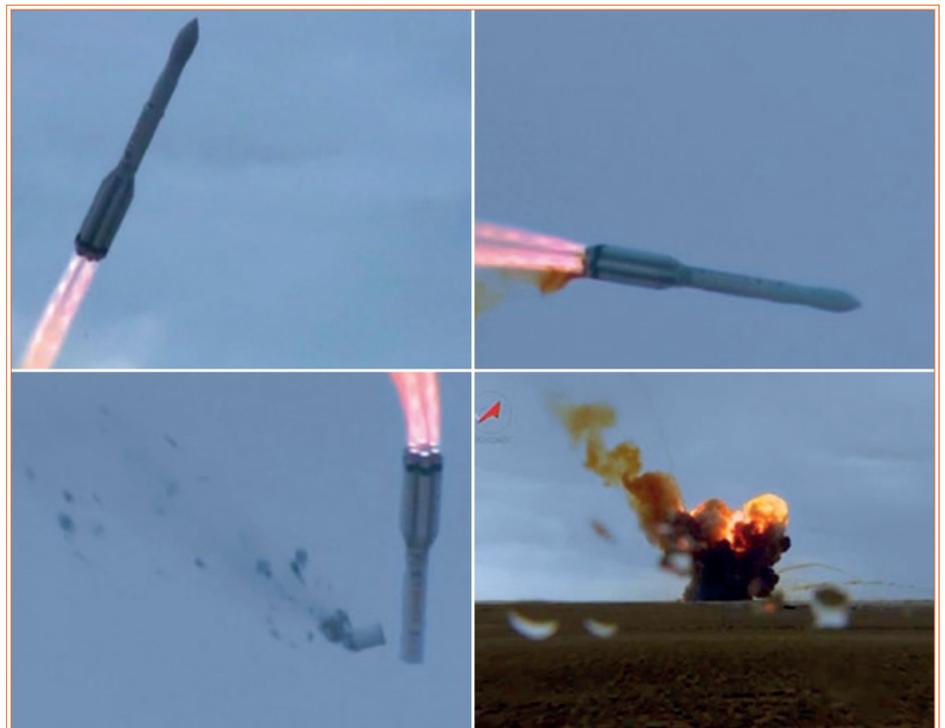
All three yaw angular velocity sensors in the rocket had been installed upside down

sion is still looking into possible causes and ramifications.

These factors were quickly overtaken as candidates for the primary cause of the failure by one finding: all three yaw angular velocity sensors in the rocket had been installed upside down. Aleksandr Lopatin, chair of the investigation committee, confirmed this root cause in a press conference on July 18. Lopatin reported that the faulty installation had taken place on November 16, 2011 before some of the most recent quality controls had been put in place. As is common throughout the Russian rocket assembly process, no photographic or video documentation was taken of the installation. Two supervisors signed off on the installation, apparently without

checking too closely, since an arrow on each sensor that was supposed to point upward, instead pointed downward in the rotated installation position. However, Lopatin noted that there was some room for interpretation in the instruction manual and there was no corresponding arrow in the mounting plate with which to match the one on the sensor. There are pins on one end of the sensor intended to ensure correct installation, but experimenting investigators found that these could be forced into the wrong position with a little effort.

The commission plans to recommend photographic documentation throughout the rocket assembly process, a step that has recently been implemented for Breeze-M manufacture in response ▶▶



Confused by upside down sensors, a Proton-M launched on July 2 was airborne for only seconds before it crashed back to the ground. – Credits: Vesti.ru, Roscosmos

to the multiple failures of that upper stage in recent years. Proton-Ms in storage have been inspected for a similar deficiency, but all appear to have their angular velocity sensors properly installed. There is currently no method other than visual check to determine whether these sensors have been correctly installed: color-coded cables work in either direction and angular velocity of a rocket at rest is zero, whether upside down or right side up.

It was initially thought that environmental cleanup of the toxic propellants would require shutting down the Cosmodrome for up to three months, but soil, water, and air sample testing seemed to allay fears of rampant contamination. Some personnel were back onsite within days, and although over 13,000m² were treated with a hydrogen peroxide and iron complexonate solution to neutralize the contaminants, officials reported that none of their samples tested above safe levels of nitrogen tetroxide or unsymmetrical dimethylhydrazine (UDMH). Within a couple weeks, all non-Proton launches were put back on schedule. The first post-crash launch took place on July 27 with the takeoff of the Progress M-20M cargo ship headed for the International Space Station. Proton is scheduled for a return to flight in September.

From Reliability to Uncertainty

The Proton rocket is one of the longest operating and most reliable heavy launch vehicles, rivalled only by the Soyuz family. The first Proton, developed from intercontinental ballistic missiles, was launched in 1965. It has seen several upgrades since that time that improved fuel consumption, reduced mass, increased payload capacity, and consolidated production under Khrunichev. The latest variant, Proton-M Enhanced, has been operational since 2007.

There have been several mission failures of Proton-lofted spacecraft in recent years, feeding into the general manufacturing quality crisis of the Russian Federation's space program. These failures, however, have generally been attributable to the booster attached to Proton-M, most commonly the Breeze-M. A September 2007 launch was an exception, when a pyrotechnic firing cable failed to disconnect the Proton's first stage before the second stage commenced firing. In that instance, the rocket crashed over 600km away from the Cosmodrome. One must

The commission plans to recommend photographic documentation throughout the assembly process

look back to the early days of Proton's development to find an analogous first stage failure of this persistent launcher.

In 1969, in the Proton's 17th flight, a missing hydraulic lock plug allowed oxidizer to leak into a pump shaft. The result was ignition of the shaft and failure of one engine that brought down the entire craft 30 seconds after launch. By 1977, however, the Proton's reliability rating was considered to be 90%. To-date 388 flights have been undertaken by this launcher, of which 23 have failed. Of those failures, five occurred within the past three years.

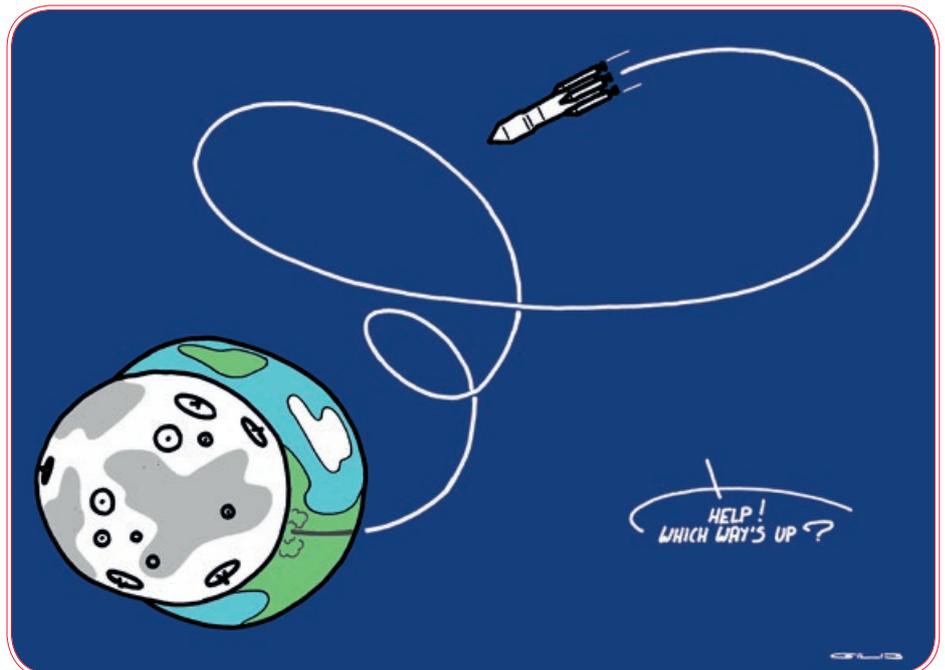
The July 2nd flight did not use the near-ubiquitous Breeze-M, but a new upgrade to the Block DM. This was the second attempt to test out the Block DM-03, the first having exploded due to over-fueling in 2010.

While commercial operators scramble

to find alternative launchers for their satellites, Russia itself may be feeling the impact of this crash for some months to come. If unable to loft their Express-AT1 and Express-AT2 satellites in the next few months, broadcasting during the Sochi-hosted winter Olympics could be compromised. Already, cable channels have gone dark throughout much of the country due to an orientation issue with the operational Express-MD1's antennae.

"This particular issue with Proton can be probably resolved quickly," RussianSpaceWeb's Anatoly Zak recently told Space Safety Magazine. "It is crazy that in the age of digital cameras and iPhones, they still do not have photographic and video documentation of all assembly procedures." Whether the lessons from this crash will be applied to the broader Russian space industry is a question only time can answer.

Gil's Corner



Navigational confusion. Credits: Gilles Labruyere

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

Space Situational Awareness Sharing for the 21st Century

By Mr. Davis Florick,
Col. Lina Cashin,
Mr. Robert A. Sims,
Mr. Jason Sturch,
and Maj. C. Patrick Dozier

As space becomes more congested, maintaining a timely and accurate picture of space activities simultaneously becomes both more important and difficult. With an ever-increasing number of space-faring entities comes the expectation of the utmost protection for their satellites. This only increases the workload for operators at satellite operation centers around the world. As a leader in space, international partners expect the US government to head the effort in protecting each and every asset. The greatest example of this is the collision between the US Iridium LLC and Russian Federation Cosmos satellites. The net result of the incident was more than 2,000 additional pieces of debris. Considering that there are roughly 100,000 objects orbiting Earth, it becomes clear that there is a cumulative effect to such collisions. It cannot be emphasized enough that as the number of assets orbiting Earth increases the danger of and effects of collisions also increases.

Addressing Global Needs

The United States has an extensive network of space surveillance sensors; however, no single nation has the resources and full accesses to the geographic locations necessary to precisely track all orbiting space objects. To meet this challenge, the US is implementing a new approach to the exchange of information regarding space objects. This approach empowers others in the space community to make more informed decisions regarding their assets, thereby reducing the dangers of miscommunication, mishaps, misperception, and mistrust. In a time when barriers to entry in the space environment are decreasing, it is beneficial to reevaluate the utility of data sharing and its effects on spaceflight safety. Such changes should occur gradually, however, to allow other governments, international organizations, and private industries to mature their space situational awareness capabilities in a deliberate fashion. As an example of international cooperation,

No single nation has the resources necessary to precisely track all orbiting space objects

USSTRATCOM has worked with multiple foreign entities, commercial and governmental, in updating the Conjunction Summary Messages (CSM) currently used for notification of a predicted on-orbit close approach. The updated format was jointly developed with these partners to ensure a universal approach to Space Situational Awareness (SSA); and such practices will be applied to formatting more data and products as we move further down the road towards greater integration.

Today, the US Department of Defense (DoD) publicly releases data on tens of thousands of objects. Of these, only about 1,100 of them are satellites performing an active mission the bulk of the orbiting population is debris, rocket bodies, and retired or inoperable payloads, many of which cannot maneuver. Additionally, there is still an indeterminate amount of small debris for which we cannot generate reliable orbital estimates. While these objects are smaller than a pebble, NASA estimates the total number of objects to

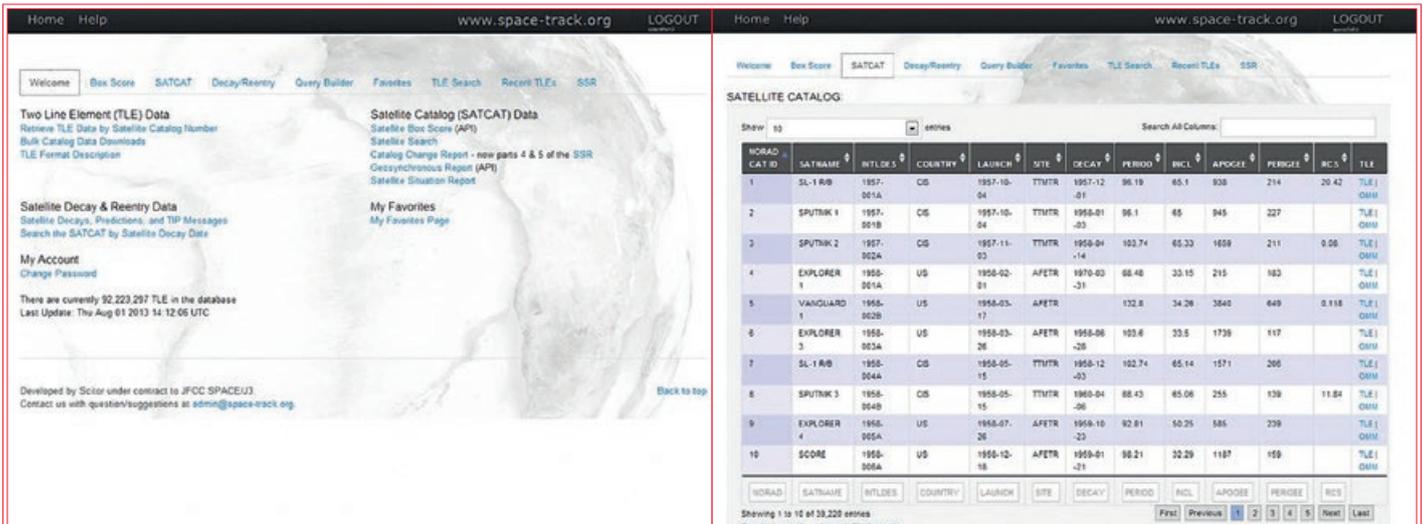
be in excess of 100,000. Despite their small size, these pieces can harm satellites and degrade operations. The long-term cumulative effect of debris in space is becoming one of the greatest hazards space faring entities must contend with. As an increasing number of objects fill the low Earth orbit (LEO) regime there is a risk that a tipping point exists where too much clustering exists, creating collisions and debris and thereby making LEO nearly unusable. It is imperative to share as much actionable information as possible with other space-faring parties, consistent with our national security interests.

To that end, SSA data sharing is intended to improve safety and transparency in space. Due to the responsible sharing of information with like-minded partners including foreign governments, private industries, and intergovernmental organizations, the space community is becoming increasingly cognizant of its environment. SSA sharing has become not only a mechanism to exchange data, but also a ▶▶



US Strategic Command Headquarters Gen. Curtis E. LeMay Building.

Credits: USSTRATCOM



On the left, the main menu of Space-Track.org. On the right, a catalog of space objects ordered by date, with Sputnik 1 and its rocket booster on top. Credits: USSTRATCOM

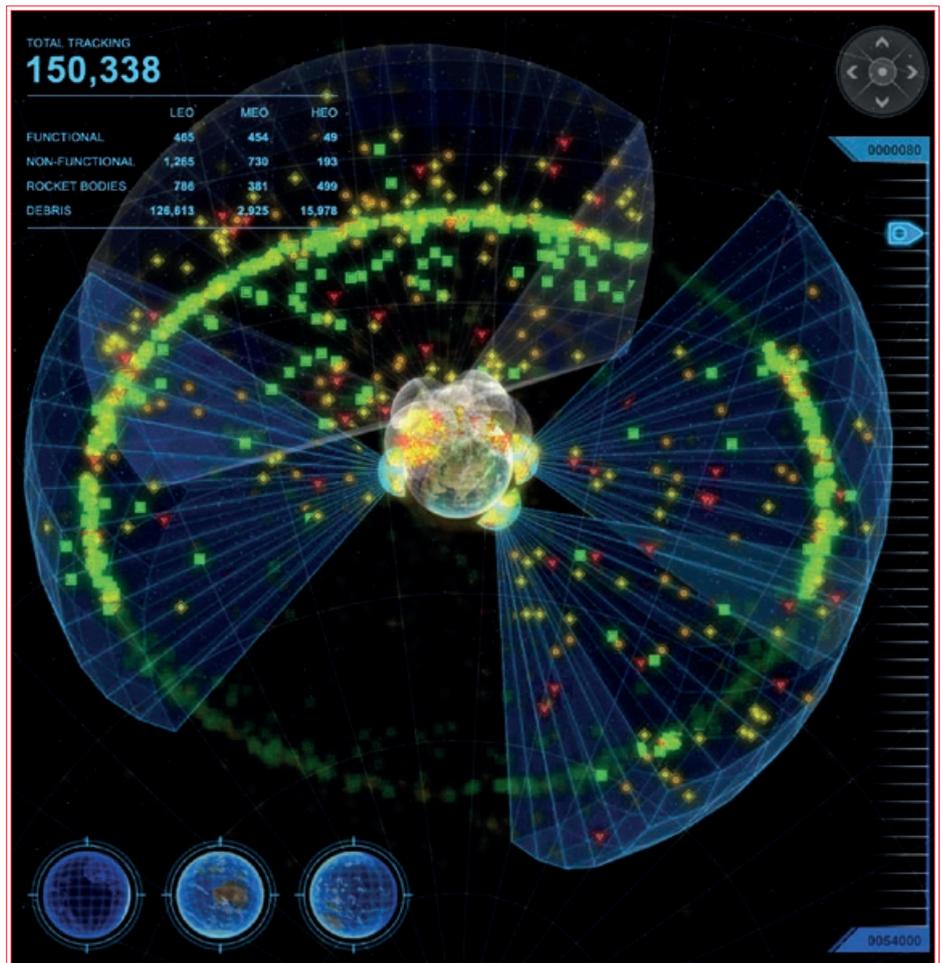
Transparency and Confidence Building Measure (TCBM) which has resulted in the creation of underlying norms of behavior for many leading space entities. In a relatively short period, great strides have been made in releasing US information. But greater potential for opportunities to share information exists. Using a dynamic approach to SSA information sharing has helped make it possible for other space-faring entities to further develop their body of knowledge for space expertise.

USSTRATCOM's SSA Sharing Program

The 2009 collision of the Iridium and Cosmos satellites generated the driving force behind many of the current US space data sharing policies. In 2009, Congress passed legislation authorizing the sharing of SSA data outside the US government. In 2010 and 2011 respectively, President Obama signed the National Space Policy and the Secretary of Defense and Director of National Intelligence jointly signed the National Security Space Strategy. These two documents further the importance of the responsible use of space, spaceflight safety, and US leadership. The SSA sharing program is one way to do that.

USSTRATCOM's SSA sharing program is designed to reduce the chances of future satellite collisions and improve the sustainability of the space environment. Prior to USSTRATCOM assuming this mission, many budget and human resource challenges needed to be met. The first step for USSTRATCOM was ▶▶

Today, the US DoD publicly releases data on tens of thousands of objects



The Space Fence program is one initiative USSTRATCOM is undertaking to improve space situational awareness. – Credits: Lockheed Martin

SSA data sharing is intended to improve safety and transparency in space

to focus on identifying information necessary for satellite and launch operators to conduct responsible space operations. Within that context, different categories of support exist, from basic support to highly tailored information for owner/operators.

There are three levels of SSA support services that comprise the program. The first is emergency notifications which alert satellite operators to potential collisions. The second level is the USSTRATCOM-sponsored website, Space-Track.org, which serves as an available repository of basic satellite catalog information. Basic satellite catalog information includes positional data and background information (country of origin, launch date, etc.). The third level includes specific advanced services supporting safe space flight operations during launch, on-orbit, and decay or reentry operations. This third level of services is available to commercial and governmental satellite and launch operators. Together, these support services increase the safety, security, and sustainability of the space domain through an enhanced understanding of satellite positional information. However, without a better understanding of the three levels of SSA support it is impossible to fully comprehend this enterprise.

First, in practice, the Joint Space Operations Center (JSpOC) seeks to identify close approaches for active payloads in Earth orbit with any known object. As the DoD conduit for SSA information the JSpOC is the operational epicenter for all bilateral and multilateral space information sharing. On average, 20-30 close approach notifications are sent per day. To the greatest extent possible, the JSpOC contacts the affected owner/operator with information regarding the predicted close approach. The information provided is in the form of a CSM. This information allows the owner(s)/operator(s) to make informed and educated operational decisions to protect their assets and the space environment. At no point does the JSpOC direct another entity to conduct a maneuver to avoid a potential conjunction. USSTRATCOM products are merely advisory. Once a CSM has been provided to an affected operator, the JSpOC offers to evaluate any potential maneuver to avoid a second potential conjunction in the process of avoiding the first conjunction. To give an idea of global reach, of the 1,100 active payloads in orbit today, the JSpOC currently has sufficient contact information to provide emergency notifications to the operators of more than 98% of those payloads.

Second, Space-Track.org is the next level of support. For any interested person or entity, USSTRATCOM offers this website as a source of basic satellite catalog products. Anyone wishing to access the site must acknowledge a user agreement and submit a web-based request for an account. To date, over 88,000 total users from 185 countries have registered for an account. Considering that there are only 195 countries in the world today, USSTRATCOM is very proud of our global outreach efforts.

Third, advanced services are designed to support safe spaceflight operations during launch, on-orbit, and decay or reentry operations. US law requires the DoD to establish written agreements with satellite owners and operators, launch providers, and country partners in order to permit advanced service data exchanges. With agreements in place, entities may request specific support for their operations, and USSTRATCOM can provide this support, within resource constraints, with the caveat that it is consistent with US national security interests. This information can be viewed in seven categories including: Conjunction Assessment, Launch Support, Deorbit and Reentry Support, Disposal/End-of-Life Support, Collision Avoidance, Anomaly Resolution, and Electromagnetic Interference Investigation. These agreements help develop relationships between the JSpOC, commercial firms' operations centers, and partner nations' space operations centers worldwide. By exercising this valuable exchange of orbital data, USSTRATCOM works to preserve the ability for all nations to use and explore space, and provide a safer and more responsible environment.

In summary, as a global leader in space, the US is creating a safer more stable space environment through the responsible exchange of actionable information via the SSA sharing program. By sharing this information, USSTRATCOM is reducing the possibility for miscommunication, mishaps, and mistrust. The Command has recognized and is addressing many of the problems that led to incidents such as the Iridium-Cosmos collision and have turned the tide with the SSA sharing program. There is now an established process to improve the safety and reliability of space today and for future generations.

Opinions expressed are those of the authors and do not necessarily reflect the views of the USSTRATCOM team.



Artist conception of the various elements, both space and ground based, of a space situational awareness system. – Credits: ESA

The Nixon Administration and Shuttle Safety

By Joseph N. Pelton

Part 1

Many people know that the initial design of the Space Shuttle was a matter of dispute between the NASA engineers and officials on one hand and the Nixon White House and the budget hawks within the Office of Management and Budget (OMB) on the other. The final design, after much negotiation, was a compromise between cost and performance. NASA was able to keep a large 4.5 by 18 meter cargo area, but was convinced to use a solid fuel booster strap-on to propel the shuttle into orbit. This combination of a solid booster with the liquid fueled Shuttle orbiter was intended to reduce cost but over time it proved to increase cost while adding major risk elements. The exploding foam insulation that separated the Shuttle orbiter from the Solid Rocket Booster was officially ruled the cause of the Columbia failure. The Columbia failure led to a nearly three year suspension of Shuttle launches and added nearly \$3 billion in costs to the Shuttle program and perhaps billions more to the International Space Station due to the years of delay while the Shuttle was grounded.

Solid boosters have been effectively used for heavy lift cargo but they are questionable launch systems when human crews are aboard. Once ignited, solid boosters cannot be shut down, a condition that precludes effective astronaut escape capability. In many ways the “flawed design” of the Shuttle can be traced back to the initial decisions with regard to Space Shuttle design in the 1969 to 1972 time period.

After Apollo: What Next?

In the United States, 1972 was a presidential election year and the big space question at the time was “What comes after Apollo?” President Nixon wanted to sustain an American lead in the space race against the Soviet Union, but did not want to spend big bucks to do so. The answer that had begun to evolve as early as 1969 was

Space safety was virtually absent from critical decision-making discussions

the Space Transportation System (STS) – now popularly known as the Space Shuttle. But there were key technical and management issues very much up in the air. What exactly would a Space Shuttle entail in terms of technical design? And how much would it cost?

A historical review of the Nixon administration’s Shuttle decision four decades ago indicates that space safety was virtually absent from the critical decision-making discussions. Efforts to cut costs dominated the discussion, ultimately adversely affecting the design integrity of the Shuttle, reducing its safety. The OMB recommended cutting NASA’s budget sharply. The cuts for fiscal year (FY) 1973 would have been \$205 million, followed by a \$400

million for FY 1974 year and a \$1.1 billion for FY 1975. Proposed options that would have achieved these cuts were the downsizing of the Shuttle, cancelling Apollo 16, 17, and 18, closing some NASA Centers, and reducing international programs with the Soviet Union.

Few people know just how bruising and difficult that decision process actually was. The White House objective was clearly to keep NASA expenditures in the post-Apollo age under control. OMB had both NASA programs and Centers in their cross hairs. Documents from the recently released private archive of Nixon White House official Clay T. (Tom) Whitehead reveal that the Space Shuttle program – like the 2006 Hollywood comedy of the same name – might have gone down in history as the “Failure to Launch” program.

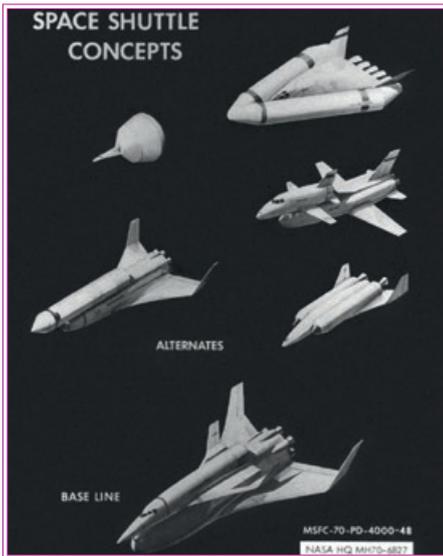
Contradictory Objectives

The Nixon White House had two contradictory objectives in 1970 and 1971. On one hand, they wanted to get what they considered to be wildly ▶▶



President Nixon speaks with the Apollo 11 crew, in quarantine after their historic mission.

Credits: NASA



The original concept was to use the shuttle as a staging ground for planetary exploration and to establish a space station. That scope was narrowed when the requested \$24 billion budget came back as \$6 billion.

Credits: NASA

expensive NASA spending on the Apollo Program – a legacy from Presidents Kennedy and Johnson – under control and to establish a “normal level” of space expenditure. On the other hand, the Nixon White House also wanted a new and exciting space initiative to replace the popular Apollo program, one that promised continued American space leadership.

This new space initiative from the Nixon Administration quickly became known as the Space Shuttle. It was conceived of as a “space truck” that would, at least in concept, offer low cost and reliable access to low Earth orbit. Advocates proceeded to promote this new initiative to provide competitive launch costs for commercial satellites and also allow projects like a space station or manned space missions in low Earth orbit to be undertaken at reasonable cost.

The papers from the Whitehead archive reveal a significant tug of war between ways to cut NASA’s “unrealistically high spending” on the Apollo program and yet still initiate an exciting new space program. It appears that there were several officials in the Nixon White House and OMB who were designated to sort out this difficult issue. Line responsibility fell to one of Nixon’s Presidential Assistants, Peter Flanigan. Flanigan turned to the President’s Special Assistant Tom Whitehead, formerly a Rand economist who had three graduate degrees from MIT and was

Safety was simply “assumed” in all the alternative designs

charged with policy authority over all science agencies.

All of the key people worked with NASA Administrator James Fletcher and NASA scientists and engineers to seek out a compromise design for a curtailed version of the STS on which both President Nixon and White House staff and NASA officials could agree. Different sized Shuttles were considered. Versions that were all liquid fueled and self-contained and other designs with a solid fuel booster were evaluated for performance and cost. Safety was simply “assumed” in all the alternative designs. Finally, different and longer development periods were considered along with options like using the Titan III or Atlas for booster lift capability. The objective became to drive the cost of developing and building the Shuttle down by \$15-\$16 billion to levels that were under \$9 billion.

The budgetary knives also targeted a shutdown of the Marshall Space Flight Center, since conventional rockets were

thought to be less important once the Shuttle was available, and the Jet Propulsion Lab, after several planetary missions were over. Ames Research Center was slated for staff reductions and Wallops and what is now known as Glenn Research Center went on the chopping block. Ultimately none of these cuts were made, but efforts to cut NASA funding in significant ways left few programs safe from budgetary scrutiny.

Top-Down Decisions

Initially NASA had considered a payload bay area for the Shuttle as long as 26 meters and its design was initially based entirely on liquid fueled propulsion. Liquid fueled engines – as opposed to solid-fueled rockets – can be instantly commanded to shut down and thus facilitate a crew escape capability. Relatively early in the tug of war with OMB, NASA management agreed to add an external solid-fuel tank to reduce the development costs. Part of the dynamic in these considerations involved the advocates from western states who promoted Utah-based Thiokol as the developer of the solid fuel booster. These states used professional lobbyists to actively intervene in the Shuttle discussions to promote the use of the solid rocket booster. ▶▶



On January 5, 1972, President Nixon announced the Shuttle Program. He is pictured here with NASA administrator James Fletcher later that day. – Credits: NASA

The decision to include the solid rocket booster was clearly taken from the top down and without consideration of the implications for crew escape capabilities or even the possible complications that might, in fact, boost rather than reduce cost.

Other budgetary cuts that were advocated by OMB in its recommendations for NASA were to undertake new space development in a modular fashion, allowing common use of these modules by NASA, the Department of Defense, and commercial entities with little or no change. This could reduce spending on manned space while allowing some increases for space applications and aeronautics.

The concern of the White House staff, specifically Flanigan, Whitehead, and Special Assistant to the President Jon Rose, was that in its eagerness to contain the NASA budget OMB was proposing economies in the design of the shuttle based upon presumed engineering expertise that it did not have.

It was Whitehead who sought to be the voice of reason and prudent compromise. "We succeeded when we first came into office in averting NASA's high flying plans for space stations and Mars trips, and in bringing the budget down to a more realistic level consistent with the President's wishes," he wrote in a memo to Flanigan. "It was, however, our intention not to continue to erode NASA's budget indefinitely, but to induce

OMB was proposing economies in design based on engineering expertise it did not have

them to come up with a sound, forward-looking evolutionary space program for the coming decade that would not lock the President into excessively large budgets now or in the future."

Whitehead's memo – dated in December 1971 just before the Shuttle was formally announced – largely argued the NASA position for a Shuttle program that seemed reasonable and achievable:

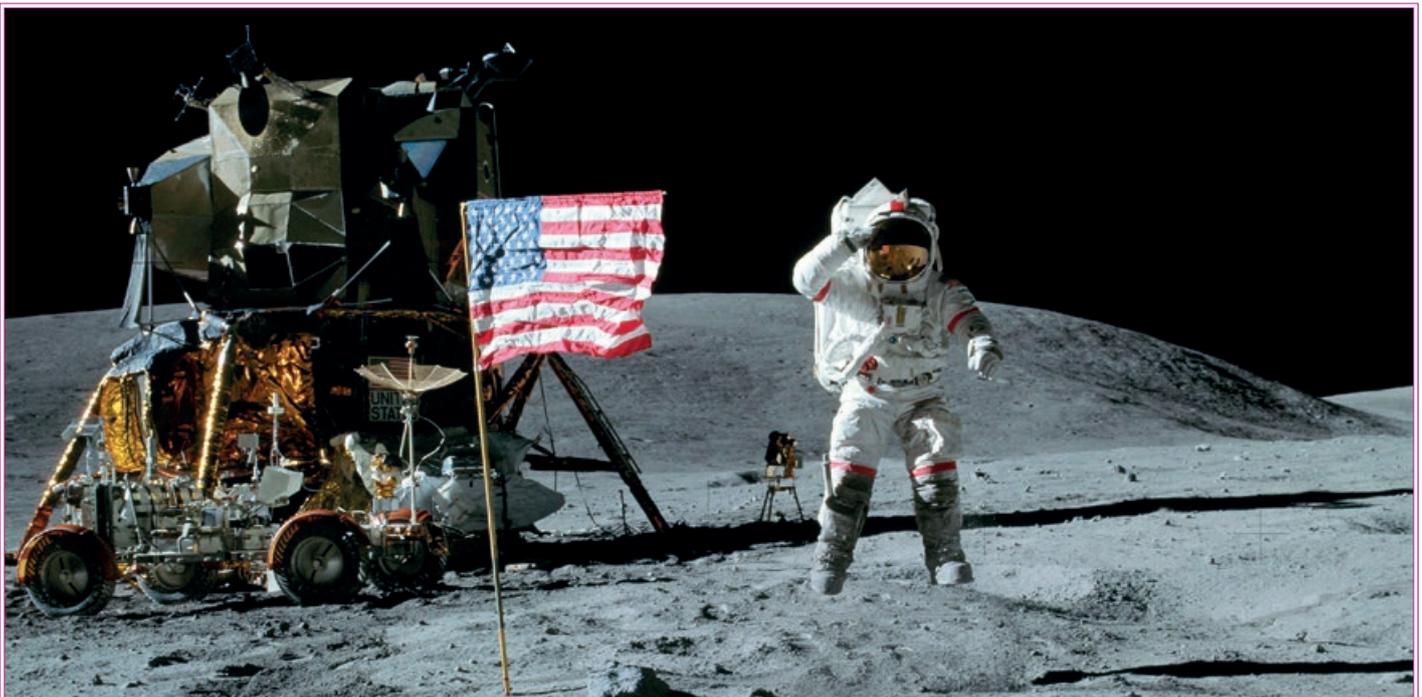
"...OMB and NASA have been bickering, principally about the space shuttle. I held a series of meetings to bring the various Executive Office groups together and met with Jim Fletcher, I hope to some constructive effect. ...Jim has done what I believe to be an outstanding job of devising a space shuttle concept that is consistent with reasonable budget lev-

els and sensible technology, and still builds for the future. Without burdening you with all the ins and outs of how we got from there to here, the debate is now focused around two shuttles... I tend to believe the larger shuttle is the more prudent course...I suspect OMB will try to push fairly hard for the smaller version. NASA might buy this as a last choice, but the impact on their morale and that of the aerospace industry would be unnecessarily negative."

It would appear that Whitehead's arguments carried the day. Just a month later, President Nixon announced the larger version of the Shuttle and two more Apollo flights. But the problem remained that instead of the Shuttle being designed from the "bottom up" based on systems and safety analysis, it was designed from the top down with unrealistic budget constraints and based on totally impossible performance expectations.

This article is largely based on documents drawn from the Whitehead archive at the Library of Congress. In next issue, we conclude with the ramifications of these early decisions on the direction of the Shuttle program.

Dr. Joseph N. Pelton is on the Executive Board of the IAASS and former dean of the International Space University.



John Young (pictured here while saluting the flag on Apollo 16's first EVA) received the news about the approval of the Shuttle program while walking on the Moon. He would later become Commander of the Space Shuttle inaugural flight. – Credits: NASA

By Hubert Foy

Moving Towards a Ghana Space Agency



Ghana Space Science and Technology Centre logo. – Credits: MESTI



Ongoing construction of the Ghana Space Science and Technology Institute on the Ghana Atomic Energy Commission's Graduate School of Nuclear and Allied Science facility in Kwabenya, Accra. – Credits: AFRICISIS

In January 2016, Ghana will become the 6th African country to have a national space agency when the Ghana Space Science and Technology Institute becomes the Ghana Space Agency (GhSA). GhSA is intended to lead the nation's civilian space exploration efforts, in accordance with the National Science, Technology and Innovation Policy and Development Plan for 2011-2015.

The Hon. Ms. Sherry Ayittey, Minister for the Ministry of Environment, Science, Technology, and Innovation (MESTI) in Ghana, first conceived the idea of a national space program in 2008 and inaugurated the Institute in May 2012. Ghana's prosperity stems in part from its nuclear industry and its future economic transformation will depend, to some extent, on an advanced space industry. The aim is to establish a center of excellence in space science and technology to enable the economic transformation of Ghana through cutting-edge research, aerospace-industry development, advanced scientific training, and satellite and application activity coordination.

"The expectation is that new jobs will be created as new materials and minerals are researched [leading to] the creation of whole new industries such as those related to the field of semiconductors and electronic engineering," said the late President John Atta

Mills in his keynote message for the program's inauguration. Mr. Mills emphasized that the bold initiative would not only take Ghana into the elite club of countries benefiting from space science and technology, but will also focus on exploiting them for the benefit of humans.

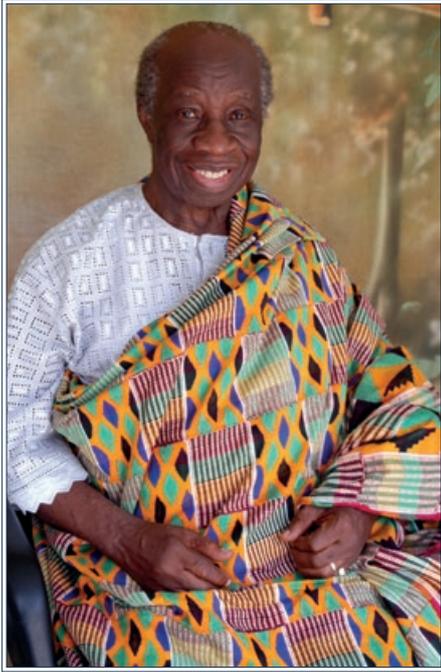
Professor Francis Allotey, the Chairman of the Interim Committee of the Ghana Space Science and Technology Institute, an internationally respected mathematical physicist credited with establishing the "Allotey Formalism" based on his soft x-ray spectroscopy research, advises the Ghanaian government by quoting the US rocket pioneer Robert H. Goddard: "Real progress is not a leap in the dark, but a succession of logical steps." He asserts that creation of the Institute's predecessor, the Ghana Space Science and Technology Center, was the foundation phase and one of several strategic steps towards a Ghana Space Agency.

"In the long term, the Agency is intended to be a generator of scientific-driven minds for Ghana, Africa, and the world," asserts Allotey. In this context, it is expected that the scientific and technological space-related facilities will increase Ghana's economic capability so that it approaches those of the most advanced countries in the world, ultimately allowing Ghana to become a spacefaring nation.

Strategic Approach

Ghana's strategy to establishing GhSA is modelled on the experience and success of regional space programs, particularly the South African National Space Agency (SANSA) and Nigeria's National Space Research and Development Agency (NARSDA), which have thrived despite regional constraints. The Ghana Space Science and Technology Center and Institute were established to advance the country's space endeavour agenda; to achieve that goal, they were placed under the Ghana Atomic Energy Commission, a center of excellence at the frontiers of nuclear science research, development, and training for more than half a century.

In addition to intellectual resource concentration, the Atomic Energy Commission offers existing infrastructure including a 30kW Miniature Neutron Source Reactor, an accelerator facility, and a Gamma irradiation facility that are important resources for training scientists and engineers for work in the aerospace industry. It also provides collocation with the Commission-sponsored Graduate School of Nuclear and Allied Sciences (SNAS), facilitating coordination of experts and relevant intellectual resource development through ►►



Professor Francis Allotey, Chairman of the Interim Committee of the Ghana Space Science and Technology Center.

Credits: MESTI

university programs in mathematics, science, and engineering

Getting Started

At the beginning of 2013, development of GhSA advanced with creation of the intermediate Space Science and Technology Institute and its funding through the national budget. The Institute will focus on training young aerospace scientists and technologists and conducting research in various aspects of space science and astrophysics. Looking forward, the Agency is seeking international technical collaboration with NASA, JAXA, SANSAs, and NARSDA to enhance effective takeoff of the Agency through technology transfer and training in core space areas.

The progress towards GhSA to-date is a modest start for a governmental national space agency. Although Ghana may not be able to afford big NASA-style or European Space Agency (ESA)-style facilities, infrastructure and capacity development are two important and costly elements to develop in the long term.

“Over the period 2013-2024, Ghana Atomic Energy Commission and the Ministry of Environment, Science, Technology and Innovation is seeking US\$5 billion financial support to model the Agency’s infrastructure and develop the nation’s space talents, from a global



Prof. B.J.B. Nyarko, Director-General, GAEC. – Credits: AFRICISIS

consortium of multinational institutions — including the World Bank Group International Finance Corporation and the British banking and financial services organization HSBC — and through bilateral and multilateral agreements,” says Allotey.

The next steps in the strategic approach of GhSA include undertaking policy reforms and accelerating development and integration of communications and Earth observation satellites and applications in the socio-economic transformation of Ghana. Satellite communications offer a viable network in areas where difficult terrain, climatic conditions, or bodies of water separate territories, rendering impossible terrestrial methods of transmissions such as fiber, coaxial cable, and microwave networks. In the short term, the Agency will develop and implement information and communication technology platforms to provide an affordable and cost effective solution that meets the telecommunications, broadcast, maritime, defense, and security needs of Ghana.

Earth observation satellites show how nations can promote economic development in an environmentally sustainable manner by putting a price on nature’s resources. The Agency’s strategy in the medium term is to develop and implement a National Space Data Infrastructure as a unique repository and source for satellite images to serve the



Hon. Ms. Sherry Ayittey, who first conceived the idea of a Ghana Space Agency.

Credits: MESTI

needs of national and private entities. In addition, the Ghana Photographic Interpretation Center will be created to analyze overhead photography and produce interpretation reports, briefing boards, and videotapes for national-level consumers, as well as to provide support for the military.

Stepping back, leaping forward

By looking back to how South African and Nigerian space agencies developed from their economic, geographical, and technological conditions, GhSA can build on their successes and better chart its path forward. In this context, the staffing plan, training programs, projects, and activities of the Institute aim to train the first generation of aerospace scientists, engineers, and technicians through regional and international exchange programs.

Allotey says that the first flagship space project, the Ghana Radio Astronomy Project, involved the conversion of an abandoned Vodafone Earth satellite station at Kuntunse, near Accra, into a radio astronomy telescope. The station was built in 1981 by the government of Ghana as the backbone of Ghana’s telecommunications at the time. The dish was abandoned in 2004 when ►►



The Ghana Radio Astronomy Project involved the conversion of an abandoned Vodafone Earth satellite station into a radio astronomy telescope. – Credits: GSSTI

satellite-dish technology evolved. The conversion process started in mid-2012 and is scheduled to last one year. Ghanaian and South African experts have replaced worn out parts and made the equipment operational after nine years of inactivity. For the Institute and its predecessor, the conversion process has been used to train newly employed staff and reorient skilled engineers and technicians into space disciplines including radio telescope engineering, configuration management, African Very Long Baseline Interferometry (VLBI) Network techniques, radio frequency engineering, software engineering, and mechanical engineering.

After the successful conversion of the dish at Kuntunse, Ghanaian scientists and engineers will use their knowledge and skills to lead the conversion of 16 other antennae in Africa. The 17 converted dishes will eventually comprise a network of radio telescopes — the African Very Long Baseline Interferometry (VLBI) Network. A VLBI facility can train many geographically distant dishes on the same astronomical object, superimposing the signals they collect to give a much higher resolution image than a solo telescope can achieve. At present, the only member of a VLBI network in Africa is a 26-meter dish at South Africa's

radio astronomy hub in Hartebeesthoek, which makes observations with partner telescopes across the world.

According to Tom Muxlow of the Jodrell Bank Centre for Astrophysics near Manchester, UK, the GhSA radio astronomy stands to benefit global VLBI science. The most powerful VLBI networks are in the United States and Europe, but equatorial skies are not as well covered; this gap reduces the quality of images available to radio astronomers, potentially missing fine details such as faint jets of plasma from the regions around black holes. "The addition of a dedicated array of African antennas observing the equatorial sky, by itself or in combination with global arrays, has the potential for a truly transformational step in imaging quality," Muxlow says.

Benefits

Ghana's space agency will promote the use of existing national laboratories like GAEC's National Nuclear Research Institute (NNRI) [and] provide for the creation of new laboratories, that should, in collaboration with universities and other research institutions, lead inquiries into the most relevant issues of science, such as the life sciences,

astronomy, macrophysics, and microphysics," says Professor B.J.B Nyarko, Director-General of the Ghana Atomic Energy Commission. "In this way, arguably, taxpayer's money is all spent here on Earth, in Ghana, and not being spent in space."

According to Nyarko, techniques developed to explore space including satellite communications, image processing, and medical technology have the potential to revolutionize standards of living. "For example, communications satellites can be employed as a strategic tool to improve delivery of equitable healthcare through Tele-Medicine services and online education through online services." In this light, the Ghanaian government can provide basic healthcare and education to all Ghanaian citizens, not as a privilege, but as a fundamental right, for the many who lack the most basic services.

Read more about the Ghana National Science, Technology and Innovation Policy and Development Plan that calls for GhSA at http://bit.ly/ssm_ghana

Hubert Foy is founder and Director of the African Centre for Science and International Security in partnership with the Ghana Atomic Energy Commission.

Under Pressure: A Brief History of Pressure Suits

Part 3

By Phillip Keane

The Future

In the last issue, we looked at high speed, high altitude aviation, the dawn of the space race, and the pressure suits that kept the pilots and astronauts alive in those extreme environments. We also noted that pressure suit design is a long process, and that the state of the art of aerospace vehicles can often overtake that of pressure suits, meaning that pressure suit design really hasn't changed in over half a century. In this chapter, we will look at the future of pressure suit design.

Spacediving

One of the better publicized developments in recent history came from the David Clarke Company that designed and manufactured the suit worn by Felix Baumgartner for the Red Bull Stratos project. On 14th October 2012, Baumgartner completed his historic jump from 38.969 km and became the first man to break the sound barrier without the aid of an engine. Baumgart-

The Z-1 is the first officially endorsed NASA suit design in 20 years

ner ascended in a pressurized gondola and utilized a custom pressure suit made by the David Clarke Company for his descent. As skydivers require visual cues from their environment, the Red Bull suit featured mirrors and a heated visor to defog the screen from breath-induced condensation. The suit was both flame retardant and offered thermal protection in the range of +37°C to -67°C. To aid stability, the suit contained a drogue parachute and sensors that would deploy the chute in the event that its wearer lost consciousness. In addition to accelerometers and gyros for measuring linear and angular acceleration, pressure sensors were routed through a controller which regulated

the pressure within the suit according to altitude. It is hoped that the information gleaned from the jump will aid development of fighter pilot suits for use in the event of high-altitude bail out.

ILC Dover: Still Going Strong

Since the design of the Space Shuttle's semi-rigid EMU (Extravehicular Mobility Unit) suit in 1980, ILC Dover has supplied an unbroken run of innovative designs. In 1988, the company unveiled the developmental ILC Dover Mk III, which featured a rear-entry system for more rapid entry than the waist-entry EMU suit. The high operating pressure (57 kPa) of the Mk III would enable astronauts to transfer from a pressurized air environment, such as a space station, into an oxygen rich suit without a pre-breathe required to avoid the bends. The combination of hard and soft materials enabled a wider range of motions, including bending fully at the knees, than early Apollo and EMU suits. Despite the success of tests, this suit was never used in space, as NASA favored an even more flexible soft suit option.

I-Suit

Design features from the Mk III carried over to the I-Suit. Development started in 1997, with the first generation waist-entry suit being delivered the following year. The second generation featured improvements and included a rear-entry system, a redesigned helmet for greater visibility, and weight reduction measures. A heads-up display was incorporated into the helmet and GPS functionality added. The I-Suit was developed for planetary excursions, using fewer heavy bearings and more soft fabrics to minimize the weight. The I-Suit featured a pure oxygen breathing system, water cooling, and was pressurized to 29.6 kPa, which also allowed for greater mobility. ►►



Felix Baumgartner stands in his pressure suit right before his 14 October jump.

Credits: Red Bull Content Pool

NASA Z-Series

The Z-Series is the culmination of the previous efforts of ILC Dover. The Z-1 was the first prototype in the Z-series, revealed in November 2012; it is the first officially endorsed NASA suit design in 20 years. Z-1 is a full-pressure design with power supply, CO₂ scrubbers and thermal control. It features a rear port intended to connect to a docking port on a Lunar or Martian ground vehicle. This will prevent astronauts from bringing contaminants such as abrasive lunar regolith or toxic Martian soil into the vehicle. The port will enable astronauts to don the suit much faster than is possible with current suit designs. With the suit at the same pressure (57.2 kPa) and gas mixture as its connected vehicle, there will be no need for the user to pre-breathe oxygen before an excursion. ILC Dover has already won the contract to design the Z-2. If all goes well, the best elements of both suits will be combined into the production level Z-3, to be tested on the International Space Station in 2017.

Constellation Suit

The Constellation Space Suit System (CSSS) concept was designed by Oceaneering, a company that previously specialized in deep-sea exploration technologies. This was the first NASA award to a company outside the “big 3” suit makers. The CSSS has two



The ILC Dover Z-1 prototype suit, which NASA plans to test on the International Space Station in 2017. – Credits: NASA



The ILC Dover Mk III is tested by Desert Research and Technology Studies (RATS) team in Arizona Desert. – Credits: NASA

configurations: an IVA soft-suit, similar in design to the ACES pressure suit, which could be worn during launch and reentry operations for protection in the case of cabin pressure loss and a hard shelled mode for EVA use, providing protection from micrometeoroids, radiation, and abrasive lunar dust. The suit was originally intended to be worn by the Orion capsule crew, but development was axed along with the majority of the Constellation Program.

Mechanical Counterpressure Suits

Earlier segments in this series explored the design flaws that have traditional space suits, largely due to pressurization needs. The gas envelope within the suit can cause a ballooning effect when worn in a vacuum environment that restricts the wearer’s movement, as well as tiring astronauts due to the extra effort required to perform each motion.

In 1959, whilst working on the Mercury project, German born engineer Hans Mauch and his team noticed that when a closed cell foam was subjected to lower than ambient pressures, the cells within the foam would expand.

When contained in a tight-fitting outer garment, this expansion would provide a force perpendicular to the body surface. This effect was similar to that utilized by the gas and fluid filled bladders in g-suits. Thus, the concept of the Mechanical Counterpressure Suit (MCP) was born. The system was developed further as part of the X-20 DynaSoar project, but was abandoned in 1962 when the suit was shown to be less mobile than predicted.

The advantages of the MCP largely stem from elimination of gas pressurization. Contrary to popular belief, exposure to hard vacuum does not cause the body to explode but tends to make the body swell and expand, and take on the appearance of a bodybuilder. The elastic fabrics of the MCP would apply pressure to the body to counteract the swelling, keeping the astronaut alive. Additionally, due to the soft materials used, if the astronaut were to get hit by a micrometeoroid then the damage would be localized to the impact area, and would not result in a rapid decompression as would be the case in a gas pressure suit.

The development of improved fabrics spurred NASA engineer Paul Webb to revisit the concept of the MCP, and in 1968 he published an article in Aerospace Medicine that attracted positive attention from the industry. Now referred to as the “Space Activity Suit,” and described as an “elastic leotard for Extravehicular activity,” contracts were awarded for the development of the new suit. The Space Activity Suit was tested in vacuum chambers, with puncture holes up to 1mm in diameter and showed no lasting harmful effects to the wearer, aside from a small blemish which faded quickly.

The concept had been validated, but due to problems with maintaining constant pressure over the joints in the body, the program was dropped, and research into MCPs all but stopped for nearly thirty years. ▶▶

The advantages of the MCP largely stem from elimination of gas pressurization

Bio-Suit

It is apparent that future visitors to Mars will be involved in strenuous physical activities that require a more agile space suit than the current state of the art allows. For this purpose, Prof. Dava J. Newman at MIT has been working on an updated version of the MCP, aka the "Bio-Suit." Like the MCP predecessors, the Bio-Suit is also a skin-tight garment, but where the previous versions were made from foam, the Bio-Suit uses a fabric woven into a 3D matrix. The lines visible on the exterior of the suit are elasticated, and follow lines of non-extension over the body. The matrix acts in compression and tension, exerting a constant mechanical pressure over the body, but unlike previous iterations, the Bio-Suit retains equal pressure over joints, even when they are bending. Professor Newman is an expert in the field of biomechanics, and in particular has extensive experience in the use of computers for monitoring body movements, a critical factor in overcoming the shortfalls of prior MCP suits. Similar to previous designs, the Bio-Suit can withstand small punctures without risk of rapid decompression, and the punctures can be healed immediately with strips of elasticated fabric, providing the wearer time to return to the safety of a pressurized environment.

Skin-tight space suits have been a staple since the early days of science fiction for various reasons, ranging from aesthetics to advanced mobility. Buck Rogers wore one in the early comic books, and a similar garment called the "walker" was used for exploration of the Martian surface in Kim Stanley Robinson's Mars Trilogy. In a lot of respects, the Bio-Suit seems to be making the transition from art into reality...or it was. Like most of the innovative designs in this chapter, development of the Bio-Suit has been put on hiatus.

The Ideal Suit

The ideal suit should be easy to don and doff and provide protection for intra- and extra-vehicular activities, both on planet and off. It should be lightweight and mobile, yet should offer protection against radiation, micrometeoroids, dust, and temperature extremes. It seems like a tall order, but the technologies to achieve all of these

objectives have been developed, prior to cancellations.

One thing is for sure: we can't rely on designs that are half a century old, à la aviation pressure suits. Perhaps the biggest challenge facing suit design is the lack of direction for crewed space programs. It is relatively easy to design for a lunar mission when you know where your destination is, but designing for all scenarios without concrete direction can be expensive and time consuming.

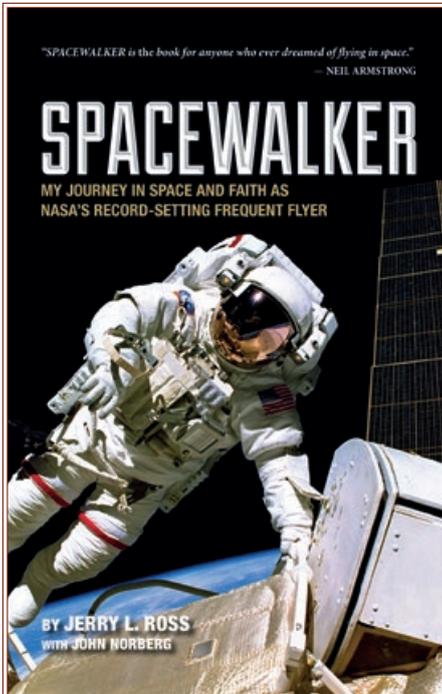
The biggest challenge facing suit design is the lack of direction for crewed space programs



The Bio-Suit was invented by MIT Professor Dava Newman (pictured here) designed by Guillermo Trotti (A.I.A., Trotti and Associates, Inc., Cambridge, MA), and fabricated by Dainese (Vicenza, Italy). – Credits: Donna Coveny

By Merrill Azriel

Space Walker: The Story of Astronaut Jerry Ross



Jerry Ross' account of his time as an astronaut. – Credits: Purdue University Press

In January 2012, Astronaut Jerry Ross retired from NASA after a 32 year career. He was there for the first Shuttle flight, and the last. He broke the record for most spaceflights – seven – and became NASA's Extravehicular Activity (EVA) expert. He was one of two members of the Silver Team, a pair of spacewalking astronauts who were also grandfathers. After a full career doing the job he'd dreamed of from age ten, his vehicle was finally retired and it was his turn too. Suddenly confronted with a wide open calendar, free of the ever-changing Shuttle schedule that for three decades could yank him away from his family at a moment's notice, Ross knew exactly what he had to do first: write it all down.

One year later, Ross' book, co-written with John Norberg, was released. "Spacewalker: My Journey in Space and Faith as NASA's Record-Setting Frequent Flyer", provides an unvarnished account of Ross' successful quest to become an astronaut and the curious, inspirational, alarming, and amusing encounters he experienced

“I stuck around for a long time,”

along the way. Space Safety Magazine sat down with Ross to discuss some of those anecdotes and their implications.

The Importance of Experience

We asked Ross what exceptional quality he possessed that allowed him to fly seven flights, the first to break John Young's record six flights. After all, at the peak of the Shuttle program there were hundreds of astronauts and astronaut candidates waiting for their turns, and Ross' EVA specialty was a popular one. He described the advantages of his athleticism and passion, saying that wearing a spacesuit felt second nature to him. But he also got in on the ground floor and, as he says, "I stuck around for a long time." Many astronauts didn't: satisfied with one or two flights or discouraged by accidents and long down times, they left for other pursuits.

One of the advantages of Ross' three decades of experience is that he can spot hardware and EVA problems be-

fore they happen. He can reach back into his personal history to say: we tried that, it didn't work. He has many examples of when that expertise prevented significant, even disastrous, mistakes from occurring on orbit. He recounts at the beginning of the International Space Station (ISS) program, managers decided not to perform thermal vacuum testing on any components. "We advocated very strongly that that was not the right thing," Ross recalls for us. The program gave him just enough money to perform three vacuum chamber tests. "One of the very first pieces of station hardware that I identified to test was the ammonia connector, the fluid QDs that we used to hook up the ammonia lines all around the exterior of the station," he says. He suited up and attempted to throw a handle to close a valve while in the vacuum chamber under conditions simulating the extreme cold of space. The handle wouldn't move. "The hardware provider engineers were sitting there in the control room outside," Ross relates. "They said 'Oh it'll move, just push the handle a little bit harder.' I said 'I'm push- ▶▶



On the left, Ross' original astronaut portrait from 1981. On the right, his final astronaut portrait from 2002, featuring his seven mission patches. – Credits: NASA

“Had we not tested that on the ground, we may have lost the station because of that,”

ing pretty hard now, you sure you want me to push harder?’ And he said ‘Yeah push harder.’ So I pushed a little harder and actually bent the handle. Had we not tested that on the ground, we would’ve got on orbit and would have had a real bad case on our hands. We would have had to completely rebuild fluid lines; we may have lost the station because of that.”

Another time, Ross learned that the ISS program was not planning to perform integrated fit checks on the ground before launching ISS segments into orbit. “All they were going to do was to validate that the Interface Configuration Documents (ICD) were compatible. And I said ‘Guys, we’ve done this before throughout the Shuttle program. We’ve done fit checks, and we found a lot of problems.’” Ross went back to the Astronaut EVA office where he served



For Ross, pictured here during STS-37, it was all about the EVA. – Credits: NASA

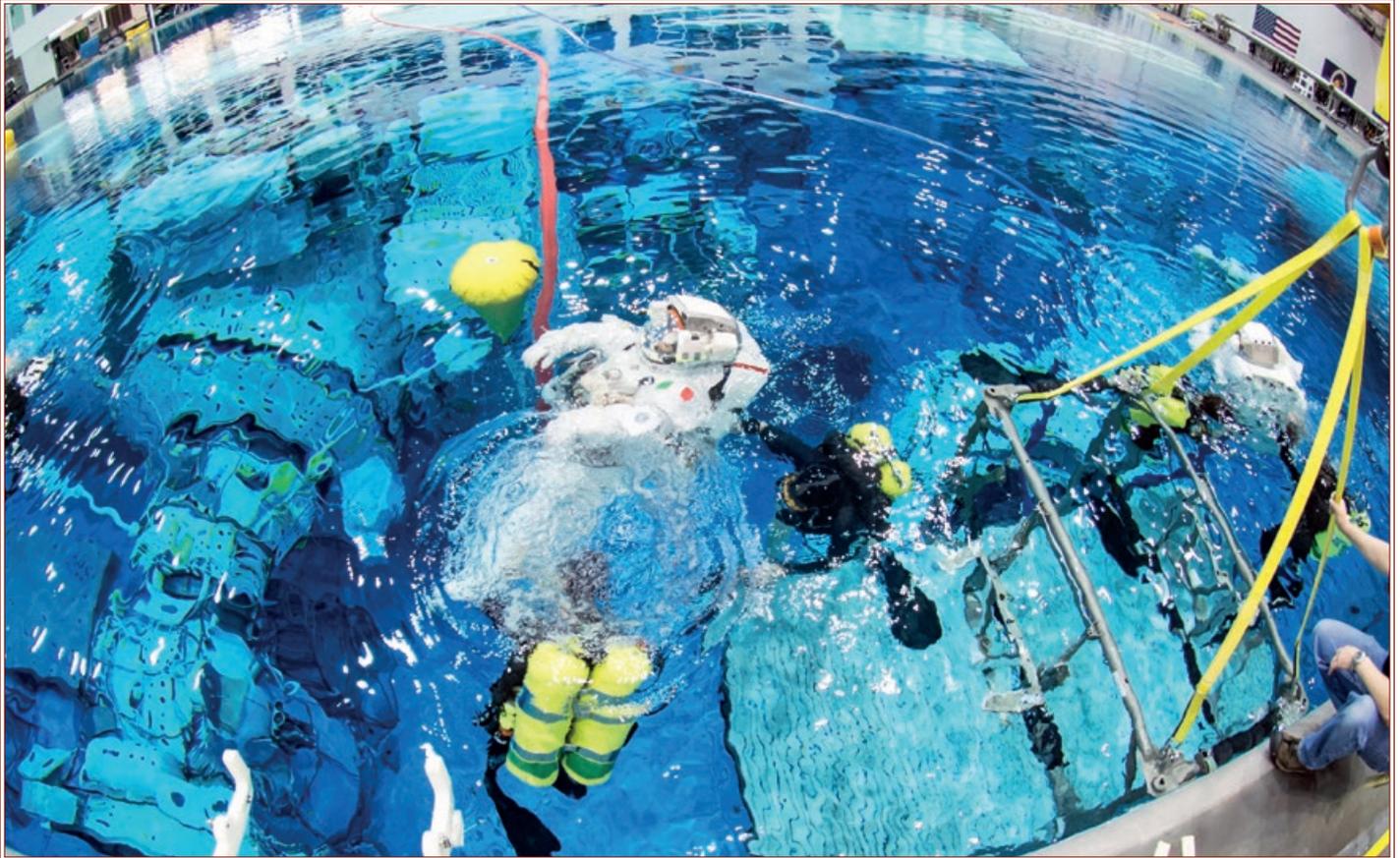
as chief and had his staff search the records. “In less than half a day they came back with three or four great examples of where the paperwork didn’t get things right.” Program managers gave in, and Ross got his ground testing, where numerous problems were identified and corrected. He’s proud that the work he did made sure ISS construction proceeded smoothly, with no major EVA hiccoughs.

The Role of Advocacy in NASA

Most of the things we had to go back to the station program and urge them to do, the managers really knew that they should be doing it; but they were being forced by schedule and especially by cost to try to do things in a streamlined fashion,” Ross explains. “We had to go back and demonstrate to them that there were reasons that we did this in the past and help kind of jog their conscience and help them to make the right decisions.” In “Spacewalker,” he writes about how his advocacy green lighted development of Simplified Aid for EVA Rescue (SAFER), an upgrade to the retired Manned Maneuvering Units (MMU). SAFER was designed to allow an adrift astronaut to propel himself back to the ship. During the Shuttle years, self-rescue was a low priority; after all, the Shuttle could always fly over and pick up a drifting astronaut. Not so with ISS. Ross’ request for SAFER development was initially turned down, until he asked what the program manager would tell an astronaut’s spouse when said astronaut was drifting off with low oxygen and failing battery. “It was the right answer and it still is the right answer,” Ross says now. ▶▶



Astronaut Jerry L. Ross, anchored to the foot restraint on the remote manipulator system, approaches the Assembly Concept for Construction of Erectable Space Structures (ACCESS) device during STS-61B. – Credits: NASA



Astronauts train in the Neutral Buoyancy Laboratory, which was built due to Ross' advocacy. – Credits: NASA

"In fact, I understand that they are in the process of building a follow up unit because the ones that are up there now are running out of their mission lifetime."

Without advocacy, many safety-related needs just never get addressed. Every NASA program must compete for the same pile of time, money, and attention. "We did that throughout the entire career of the Shuttle and station," says Ross. "That was one of my biggest roles as a crewmember, identifying the hardware that was needed and the capabilities that were needed; forming a consensus within the EVA community; and using that leverage to go advocate for and hopefully secure the capability we needed."

With the retirement of the Shuttle program and associated layoffs, and the earlier exodus upon termination of the Constellation program, expertise in some tasks is getting scarce at NASA. "We also lost a lot of early and midyear people from the agency because they have been frustrated with the lack of definition of what we're going to be doing in the future," says Ross. "That is a severe loss to the agency."

Absence of that expertise is already showing. We asked about the August

“We had to jog their conscience and help them to make the right decisions,”

30, 2012 spacewalk by astronauts Suni Williams and Aki Hoshide during which a bolt got stuck during replacement of a power unit. "I think it was an error, or a loss of knowledge that caused them to not do that task properly the first time," Ross says. They should have driven one bolt out completely before backing out the second bolt, he explains. "The first one to back out is like a locking bolt to securely hold the box in place. The other bolt is the one that is longer and actually drives the electrical connectors on the back of the box into the receptacles on the station structure. That is how the hardware was designed to be operated." (Editor's note: Space Safety Magazine asked NASA's Johnson Space Center to confirm this explanation; they did not respond.)

Routine and Risk

There are other incidents that Ross recounts in his book that ring alarm bells for the safety minded. There was the time on EVA in STS-88 when communications were interrupted by a sports broadcast using an illegal frequency, causing Ross and fellow spacewalker Jim Newman to halt work until they passed the signal's range. Or the time on STS-27 when the Shuttle launched with a small leak in one of its tires and the crew kept the bottom of the orbiter oriented towards the Sun during flight to keep the pressure up. And after STS-27 when inspection showed the spot where a lucky doubled layer of metal was all that kept the orbiter from a complete burn through: over seven hundred thermal protection tiles had been damaged and one was missing.

Ross recounts in *Spacewalker* that after the loss of the Space Shuttle Challenger on January 28, 1986, "all of us in the Astronaut Office were shocked, disappointed, and mad." Ross himself still feels that officials at NASA's ►►



Ross, building ISS on his final EVA, STS-110. – Credits: NASA

“I had no problem talking to anyone at NASA if I thought there was something wrong,”

Marshall Space Center should have been held legally accountable. “After the accident, they were still doing things to try to conceal or cover up what had happened,” Ross says. “That’s why I thought they should have been held criminally liable for what they’d done.” He was also upset that there had been people who were aware of the O-ring problem, but no one bothered to tell the astronauts. “Had we been more knowledgeable on that we would have focused a lot more attention on that and would have been much more critically involved in the review process.”

Columbia was different; when STS-107 was lost during reentry on February 1, 2003, the Astronaut Office was well aware that foam was coming off the External Tank on pretty much every flight. “I think that we were subject to the same thing many of the managers were,” Ross tells us, “that the hardware survived some dings from foam coming off, so therefore I guess we all kind of

started to feel that the thermal protection systems were a little bit more robust than what we originally thought. There was plenty of blame to be shared by almost everybody in the agency on that one.”

Post-Flight

Ross’ last flight was STS-110 in 2002. After Columbia, he knew he’d never fly again. But he stayed at NASA anyway, hoping to make it safer for his friends to fly. “I had no problem talking to anyone at NASA if I thought there was something wrong,” he wrote in “Spacewalker.” “What were they going to do if they didn’t like what I had to say? Tell me I couldn’t fly anymore?” He served in the newly formed NASA Engineering Safety Center (NESC) as Chief Astronaut during that time.

Ross recalls feeling relieved when Atlantis flew its last in July 2011. “As sad as I was to see that, it was time for

the program to end,” he wrote. In addition to the need for a vessel that could explore beyond low Earth orbit, Ross says he had a nagging feeling in the pit of his stomach every flight after Columbia, asking himself if there was some hazard they had missed. “On nearly every mission we found additional issues about which we were concerned. If the Shuttle had continued to fly, statistically it would have been just a matter of time until we lost another vehicle and another crew.”

Ross doesn’t want to see the end of human spaceflight: he just wants it to be safer, and faster. He doesn’t understand why NASA is funding four different spacecraft – three commercial vessels along with Orion – instead of focusing on just one, and getting it completed. “There’re so many unknowns at this point, it’s frustrating,” says Ross, both for the folks still at NASA and those watching – and looking for something to cheer on – from home.

By Matteo Emanuelli and Tommaso Sgobba

Assessing the Aviation Risk from Space Debris and Meteoroids

The risk that an airplane is hit by a meteoroid or space debris, although probably very remote, has never been precisely quantified. In 2007, an aircraft from Chilean LAN Airlines flying from Santiago to Auckland, NZ spotted burning objects falling from the sky in front of and behind the aircraft. The aircraft was not hit and the objects were later identified as most likely being meteors. In January 2012, uncontrolled reentry of Russia's Phobos-Grunt resulted in a request to EUROCONTROL to close the airspace above Europe for two hours. These are just two examples of the risk that space debris and meteoroids may pose to aircraft.

Despite increasing efforts to accurately predict space debris reentry, the exact time and location of reentry is still very uncertain. Partially, this is due to a skipping effect uncontrolled spacecraft experience as they enter the atmosphere at a shallow angle due to natural decay. The effect depends on atmospheric variations of density and winds, and is very difficult to predict. The trajectory and the overall location of surviving fragments can be precisely predicted only when the bouncing ends and atmospheric reentry starts, but by then the time to impact with ground or to reach airspace becomes very short. All of these factors together mean that population centers, ships, and aircraft have very limited to no time to respond to incoming space debris.

The Columbia Disaster

The disintegration of the Shuttle Columbia on February 1, 2003 was a watershed moment in the history of reentry safety. It highlighted the need to select vehicle reentry trajectories that minimize the risk to ground populations and the need to take measures to keep air traffic away from falling debris. The Columbia accident initiated a chain of events that demonstrated the need for a deliberate, integrated, and international approach to public safety

The disintegration of Columbia was a watershed moment in the history of reentry safety

during reentry operations, particularly for the management of air traffic and space operations.

Following the release of the final report of the Columbia Accident Investigation Board (CAIB), the US Federal Aviation Administration (FAA) funded a more detailed aircraft risk analysis that used records of actual aircraft activity at the time of the accident. That study found that the probability of an impact between Columbia debris and commercial aircraft in the vicinity was at least one in a thousand and the chance of an impact with a general aviation aircraft was at least one in a hundred. The analysis used the current models, which assumed that any impact anywhere on a commercial transport with debris of mass above 300 grams would produce a catastrophic accident: all people on board are killed. Those practices were captured at that time in RCC 321-07

“Common Risk Criteria for the National Ranges,” published by the Range Commanders Council (RCC), which provided a vulnerability model for the commercial transport class.

Shuttle Hazard Area to Aircraft Calculator

After FAA executives were briefed about the potential for aircraft impacts during the Columbia accident, the FAA established procedures to be used as a real-time tactical tool in the event of a Columbia-like accident to identify how to redirect aircraft around space vehicle debris. The tool developed for the purpose was called the Shuttle Hazard Area to Aircraft Calculator ▶▶



A PAM-D rocket stage module crashed in an unpopulated area in the Saudi Arabian desert. Between 10 and 40% of a spacecraft's mass is destroyed by the extreme reentry conditions; the remainder poses a threat to ground as well as air traffic. – Credits: NASA

The probability of an impact between Columbia debris and a general aviation aircraft was one in a hundred

(SHAAC). SHAAC used a simplified Shuttle debris catalog to predict the size and location of the aircraft hazard area, or debris footprint, for each Shuttle state vector. Such a hazard area depicts the extent of the airspace that could contain falling debris hazardous to aircraft if the Shuttle were to break apart at the time, position, and velocity associated with the input state vector. In addition to a Shuttle trajectory file, SHAAC imported forecasted wind data from the National Oceanic and Atmospheric Administration (NOAA), incorporating an uncertainty factor to account for forecasting uncertainty. The SHAAC output a set of four coordinate pairs for each hazard area that formed a box surrounding the airspace containing the falling fragments.

The procedures established after the Shuttle Columbia accident to clear the air space are only feasible for non-destructive controlled reentries such as those typically performed for crewed missions. But according to The Aerospace Corporation, there are about 100 large manmade space objects that reenter the Earth's atmosphere randomly each year. Current forecasts of the time

and location of uncontrolled reentries may have errors of several thousand kilometers and are available only minutes before reentry. Consequently, air traffic controllers cannot issue specific "Notice To Airmen" (NOTAMs) on impending reentries. NOTAMs are effective only when mission planners can provide a specific time and location in advance, as in the case of controlled reentries. In conclusion, air traffic is subjected to an annual total flux of reentering space debris and meteoroids whose collision risk is not generally controllable and has been never quantified.

A New Risk Assessment Tool

The International Association for the Advancement of Space Safety (IAASS), having realized that although there are a number of methodologies and tools to assess the risk for public on the ground there is none for aviation risk, has determined that the risk for aviation with its intrinsic higher potential for multiple casualties needs to be



ATV-1 Jules Verne on reentry as observed from a DC-8 aircraft over the Pacific Ocean in September 2008. – Credits: ESA

computed on an annual as well on an event basis. This risk should reflect the entire spectrum of reentering cataloged space objects, ranging from 10cm to complete spacecraft and rocket upper stages, plus meteoroids. Furthermore, the risk needs to be assessed for each high density traffic region, namely Europe, the US, Japan, and East China, and not as a worldwide average as is usually done for ground population risk.

To accomplish this goal, IAASS has gathered a pool of industry, agency, and independent experts. The aim is to develop a tool that will enable a more complete assessment of compliance with current safety requirements levied by national authorities that will support tactical decisions by crisis management units of air traffic authorities and will provide reference data for insurance companies. The tool is intended to expand the capability of existing reentry risk tools. Fragment modelling and characterization, such as ballistic coefficient and number of debris, will be considered as inputs. To ensure a certain flexibility the software will be able to import debris fragmentation data from different sources, including SCARAB (ESA) and ORSAT (US), and will support automatic air traffic data collection and processing for periodic updates of air traffic density maps.

After a preliminary phase, consisting of a comprehensive study involving everything from fragmentation and aircraft vulnerability models to collision algorithms, air traffic density maps, and analysis of space objects flux, the project will move to the development phase. The kick-off will take place at a workshop in early October 2013 where the partners will gather under IAASS leadership to discuss the principal issues that will need in-depth analysis and to prepare the document that will finalize the statement of work.



Visualization of global flight path data. The image clearly shows that Europe, the US, East China, and Japan are areas where the density of air traffic is heightened. – Credits Michaela Markieta/Arup

By Siddharth Raval

Chris Hadfield A Space Oddity

When Canadian astronaut Chris Hadfield blasted off for his third space mission on 19th December 2012, little did we know that in the next five months he would rock the planet with his outreach activities. He became the first Canadian astronaut to command the International Space Station (ISS), a major accomplishment for Hadfield, who had already visited Russian Space Station Mir in November 1995 and the ISS in April 2001. Hadfield's duties on Expedition 35 included performing "ordinary" robotic operation tasks, operating Canadarm2, and taking part in two space walks, including one unplanned spacewalk to repair a dangerous ammonium leak. But in addition to executing his challenging technical duties, Hadfield brought to the ISS something more that turned out to be just as valuable: a new way to conduct outreach activities that made use, among other things, of his talent for music.

The Space Rockstar

On Christmas Eve 2012, just a few days into his mission, Hadfield wrote and performed "Jewel in the Night." The YouTube video of the performance, later edited with time-lapse images captured from the ISS, was viewed around the world. The lyrics, describing the beauty of Earth as seen from space, introduce a message of peace directed to everyone on planet Earth. "Love for the families that gather below, Love for the stranger that you'll never know, For those who are with you, who wander above."

On February 8, 2013, Hadfield performed I.S.S. (Is Somebody Singing), an original song from aboard ISS accompanied by The Barenaked Ladies' Ed Robertson performing on Earth along with a collegiate choir. The song describes the emotions connected to spaceflight and to the vision of "that ball of shiny blue," that "houses everybody anybody ever knew." The final message is a reflection on the space program, "what once was fueled by fear, now has fifteen



Hadfield playing on the International Space Station, a regular pastime. – Credits: NASA

Nations orbiting together here." The song received huge appreciation, to Hadfield's evident satisfaction. "I want to communicate the incredible experience of being in space — what it's like to launch on a rocket and live on the International Space Station," he said.

A few months later, the song was performed across Canada in a nation-wide sing-along event. Afterwards, Hadfield spoke with curious students gathered at the Ontario Science Center in Toronto. "I think music makes me a better astronaut," commented Hadfield. "The type of skills you develop in learning to play an instrument, with the discipline, learning to play in a group, with the harmony, and then the fundamental skills that come along with handling those things together — they're applicable whether you're an astronaut or really anybody trying to do anything," he told the eager crowd.

Just before leaving ISS, Hadfield did yet another thing which had never been

done before in Space: recording a real music video for his rendition of David Bowie's Space Oddity, while orbiting 370 km above Earth. Bowie's classic takes on new life when recounted from the perspective of a space veteran that has just spent five months in space: "though I've flown one hundred thousand miles, I'm feeling very still, and before too long I know it's time to go." This music video went viral, in just one day receiving more than 1.8 million views.

The Social Media Savvy Astronaut

Hadfield was titled as "perhaps the most social media savvy astronaut ever to leave Earth," by Forbes after accumulating a massive fan-following on social media, including over 1,000,000 Twitter followers as of June 2013. ▶▶

“What once was fueled by fear,
now has fifteen Nations
orbiting together here,”

From I.S.S. (Is Somebody Singing)



Hadfield looks through a floating ball of water, demonstrating refraction on the International Space Station. – Credits: NASA

For the first six months of 2013, the ISS was the talk of the town, in every town, and the credit goes to Commander Hadfield who updated Earthlings with tweets, Google hangouts, and Facebook posts from Space. Hadfield posted more than 140 educational videos that included demonstrations on brushing teeth, cutting nails, and even crying in space, receiving millions of views on social media. Many astronauts have posted updates on social media, but what made Hadfield different was that he adapted his content to what his audience demanded. Rather than posting long lectures on life in space he made short videos. Hadfield reached out without being too serious or formal, as demonstrated by Nuts In Space, a 27 second video he posted of a can of nuts mixing it up in microgravity. He chatted with Star Trek's original Captain Kirk and a fellow Canadian, William Shatner, just before the latest film of the series was released.

In one of his best outreach efforts, Hadfield worked with Jamie Hyneman and Adam Savage of Mythbusters to perform experiments designed by the two Earthlings and document the kind of activities astronauts perform in their free time. In one episode, Hadfield demonstrated Space Darts, a game that can only be played in space, and also built and tested a game proposed by Hyneman and Savage. "Working with Adam and Jamie was fun!" wrote Hadfield in one of his tweets.

Space Education and Outreach is important to increase public awareness of

“[My mission] included millions of people around the world,”

what is going on in space and to motivate the future generation to pursue STEM careers. “The purpose is to help people to understand what is possible on the space station, and the things we are doing,” Hadfield explained.

During one Reddit Ask Me Anything (AMA) session, Hadfield was asked for advice for students and young people considering a career in space science. Hadfield's response to this question hit the heart of Australian cartoonist Gavin Aung Than, who made a cartoon depicting the astronaut's journey from child to astronaut. “I wish someone had given me that advice when I was younger,” Than told the Huffington Post Canada. “I definitely experienced a few years of drifting aimlessly through life having forgotten what my passion was.”

Return to Earth & Resignation

Commander Hadfield and his team returned to Earth on May 13th in their Soyuz spacecraft. On June 10 2013, Chris Hadfield announced his retirement after a 35 year career in aerospace. “I've

decided to retire from government service after 35 years of serving our country,” said Hadfield while announcing his retirement during a Canadian Space Agency press conference. “I didn't say I don't want to do this anymore, but every one of us is going to retire. This is just a natural part of the process.”

“[My mission] included millions of people around the world,” he added. “We, as a combined force, reached a level of public involvement and public interest which was unprecedented.”

Hadfield hasn't decided on his further plans but for the near future, he expects to make some public appearances and continue working with students. With more than 140 educational videos, 45,000 pictures, and numerous conferences, Hadfield has charmed space enthusiasts and students across the world. Since he blasted off to ISS on his third trip, Hadfield became perhaps the most celebrated astronaut, reaching a spot beside Neil Armstrong, his hero and inspiration.

For a gallery of the most significant videos of Hadfield, visit http://bit.ly/ssm_hadfield



An astronaut's advice, delivered by Hadfield and illustrated by Gavin Aung Than.

Credits: zenpencils.com

By Matteo Emanuelli

The Cosmonaut, an Intimate and Fantastical Voyage into the Soviet Space Program



“The Cosmonaut” raised €400,000 through a crowdfunding campaign and it explores new avenues of distribution.

Credits: Riot Cinema Collective

The Cosmonaut,” a crowd-funded film produced by the Riot Cinema Collective, is a fusion of science fantasy and history inspired by the legends of the lost Soviet cosmonauts. The film is set between 1967 and 1976, and follows the life of three characters, Stas, Andrei, and Yulia, in the recently built Star City. They will be witnesses and actors of the successes and failures of the Soviet space program, fueled by passion and innovative technical ideas, but frustrated by political intrigues and power struggles. We contacted director Nicolás Alcalá to know more about this fascinating production.

The Soviet Moon Race

Andrei and Stas meet with Yulia, a telecommunication engineer, while they are training to become cosmonauts at Star City. They will both establish a deep friendship with Yulia, drifting towards love but never quite getting there.

“I fell in love with the space race, especially the Soviet part,”

During their training, they are surrounded by the prominent figures of the Soviet space race, from Gagarin to Korolev, living the epic of that pioneering era, focused on reaching the Moon before the US.

Back in the 1960s “the reasons to go to the Moon were not scientific or technological, although it served those purposes too,” says Alcalá. While the US government funneled all its efforts through a single organization, the newly founded NASA, in the USSR the space program became an internal political business, divided among four competing design bureaus: Korolev’s OKB-1, Yangel’s OKB-586, Glushko’s OKB-456, and Chelomei’s OKB-52. While Korolev was the main architect of the first successes of the Soviet space program, Chelomei managed to acquire the support of Nikita Khrushchev, First Secretary of the Soviet Union’s Communist Party. Chelomei loses political support, however, after Khrushchev’s fall in 1964, and the lunar program was put in the hands of Korolev, who was developing the powerful but flawed N1 rocket. Korolev died in

1966, and his successor, Mishin, was not able to fix the rocket, which failed in four consecutive launch attempts.

After the American lunar landing of 1969, Stas joins Chelomei’s design bureau and takes active part in the Apollo-Soyuz mission of 1975, while Andrei continues his training for a mission that could never happen. Here “The Cosmonaut” diverges from history, imagining Brezhnev, the new Soviet leader, giving Chelomei the secret mandate to develop his lunar rocket. Andrei is chosen for the mission, finally accomplishing his ultimate dream.

Lost Cosmonauts

The Cosmonaut” follows the history of the Soviet space program quite accurately, giving a personal and sometimes intimate point of view of the events. “Many of the stories that cosmonauts told me are in the film,” Alcalá says. “I fell in love with the space race, especially the Soviet part, and decided to tell my story in that period, with all those ▶▶



From left to right, the director, Nicolás Alcalá, Leon Ockenden aka Stas, Katrine Lister aka Yulia, and Max Wroottesley aka Andrei. – Credits: Daniel Mayrit

incredible achievements and conspiracies and epic stories.”

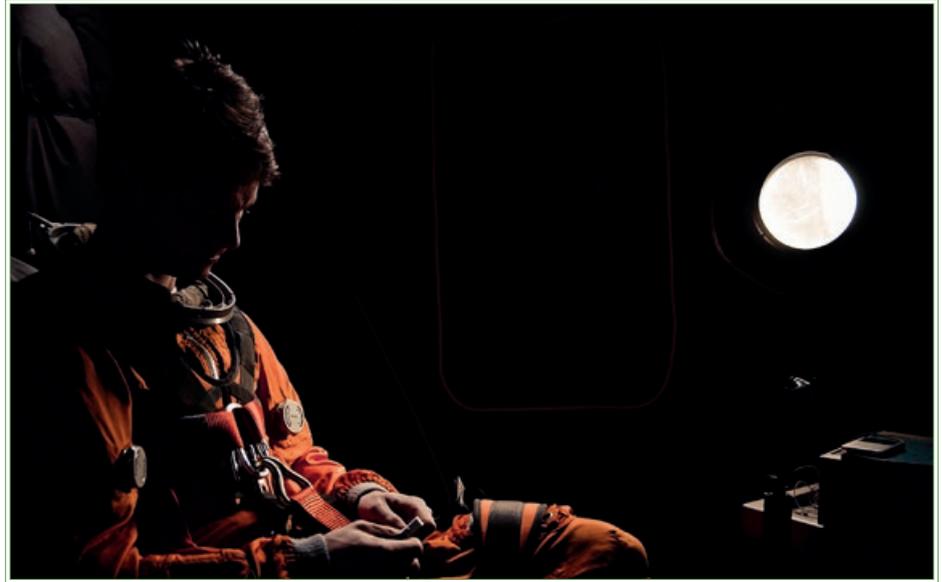
According to Alcalá, the inspiration for the movie came from stories and black legends about secret accidents and cosmonauts lost in space, never being able to return to Earth or dying during reentry. “The idea of a human being, alone, 400,000 km away from home, knowing he is going to die, just blew my mind,” says Alcalá.

The legend about lost cosmonauts in space was fueled by recordings made in the early 1960s by the Judica-Cordiglia brothers in Turin. Achille and Giovan Battista Judica-Cordiglia were two amateur radio operators who intercepted signals from various space missions, from Sputnik and the Vostok program to the Explorer-1 and Mercury, with amateur equipment. The brothers then set up their own experimental tracking station in a disused German bunker from the Second World War on a hill near Turin, where they claimed to have captured radio communications from secret Soviet space missions. Their recordings, from 1960 to 1964, include an SOS Morse code allegedly sent by a spacecraft leaving Earth orbit and an eerie recording of a female cosmonaut dying during reentry.

Although the veracity of these recordings has never been substantiated by evidence from the USSR archives, opened to the West after the collapse of the Soviet Union, the work of the Judica-Cordiglia brothers significantly contributed to the atmosphere of mystery surrounding the Soviet space program. The recent disclosure of the truth about Gagarin’s death leaves the doubt that something more may be revealed in the future.

An Era Lost Forever

Although “The Cosmonaut” is clearly a movie about space, space is not represented as it is usually done in Hollywood’s movies, full of explosions and “cowboy” dialogues. Most of the technical details of the movie come from historical reconstructions, with a notable exception: “The UR700 in the film was inspired by the original designs of Chelomei, while the Kolibri capsule was one of the few things that we have decided to not be historically accurate and it is nothing like the original LK700 module,” Alcalá explains. “We made a design that might have existed but it was inspired more in science fiction models



Stas alone in the Kolibri capsule. The model for the capsule was inspired by a science fiction model from the 1960s. – Credits: Miki Auvila

“People got bored about space. We need to turn it into a human story again,”

from the sixties than in something made by Chelomei.”

What makes the difference in “The Cosmonaut” is the representation of Space as a state of mind characterized by an overwhelming isolation, an intimate and fantastical voyage that wants to describe the condition of those men and women who dared to go beyond human limits for the sake of exploration, leaving their loved ones behind on Earth.

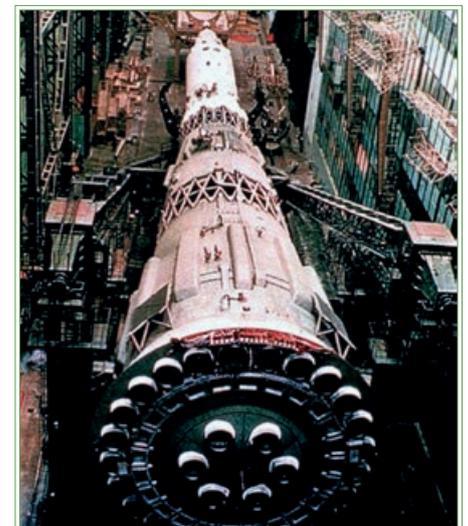
The movie tries to answer the question: is it worthwhile to explore space and go beyond our cradle, when the risk is never coming back? The answer is indeed controversial. “There is a moment at the end of the film where Andrei says he has had a dream where he asked Stas if it was worth it to have lost Yulia to walk on the Moon,” says Alcalá. “He dreams about Stas saying to him that it was not, but that, for just a fraction of a second, he felt alive.”

“The Cosmonaut” stands as a detailed canvas of the early phases of the space

age in Russia in an era, maybe lost forever, where the focus was on extending the boundaries of what was possible for humans, and not only for technology. “When that [era] ended, the next step was not Mars but just a lot of pretty intriguing scientific and technological stuff, interesting only for scientists and technological companies,” concludes Alcalá. “It was not about human beings conquering the cosmos anymore, and I think that is why people got bored about space. We need to turn it into a human story again.”

Check out “The Cosmonaut” experience for yourself at:

<http://en.cosmonautexperience.com/>



Korolev’s powerful, but flawed, N1 Rocket was meant to be the workhorse of the Soviet Moon Race. All four launch attempts ended in flames. – Credits: Russian Federation

By Tommaso Sgobba

Announcing the Journal of Space Safety Engineering



Journal of Space Safety Engineering. – Credits: Kristhian Mason

The International Association for the Advancement of Space Safety (IAASS) was established in the aftermath of the Shuttle Columbia accident at the initiative of an international group of space safety engineers and managers involved in the International Space Station (ISS) program. The original aim was to give voice to the “silent” international human spaceflight safety engineering community.

In the eight years since, IAASS has organized regular conferences and professional gatherings. While these were initially centered on Shuttle and International Space Station safety, the scope grew to include participation of specialists from disciplines as varied as launch and reentry, orbital operations, nuclear payloads, and more. Unfortunately, growing travel limitations due to US budget constraints have seriously disrupted participation of US government organizations to recent foreign conferences, including that of IAASS. It is very sad to see the human spaceflight safety community once again back in silent mode in the year of the 10th anniversary of the Columbia Shuttle accident. Concurrently, the nascent commercial hu-

man spaceflight industry is missing the opportunity to be kept widely informed on safety lessons learned from the major international human spaceflight cooperative program, and is not much encouraged to share its own safety experiences and lessons learned.

To compensate for these reduced communication pathways, the IAASS has decided to supplement safety conferences and workshops with an additional tool for scientific and technical communication: the Journal of Space Safety Engineering. A journal can be an excellent additional tool for engaging the interest of the academic community, which in the past has not been much encouraged to support space safety engineering, research, and education. In this respect, the IAASS has published two textbooks, *Safety Design for Space Systems* (2009), and *Safety Design for Space Operations* (2013) to provide a reference for university education. The Journal of Space Safety Engineering can further build on those books by reporting new developments, results of research, and operational experiences.

The Journal of Space Safety Engineering (JSSE) will be a quarterly publication

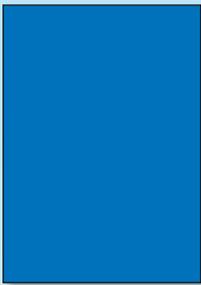
of the IAASS starting in October 2013. JSSE will be published using an open access publication model, meaning that all interested readers will be able to freely access the journal online without the need for a subscription; authors are not charged and retain the copyrights to their work. JSSE will provide an authoritative source of information in the field of space safety design, research, and development. It will serve applied scientists, engineers, policy makers, and safety advocates with a platform to develop, promote, and coordinate the science, technology, and practice of space safety. JSSE seeks to establish channels of communication among industry, academy, and government in the field of space safety.

The journal has a distinguished Editorial Board with extensive qualifications, ensuring that the journal maintains high scientific and technical standards and has broad international coverage.

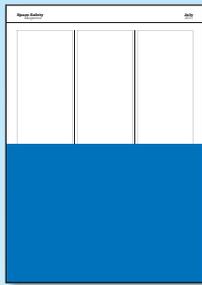
More information about submitting papers for publication in the JSSE are available at <http://iaass.space-safety.org/publications/journal/>

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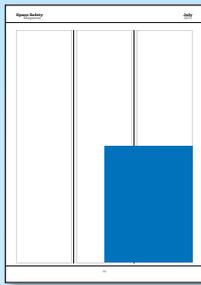
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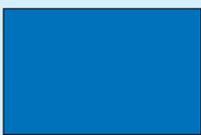
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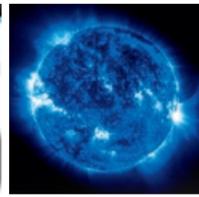
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