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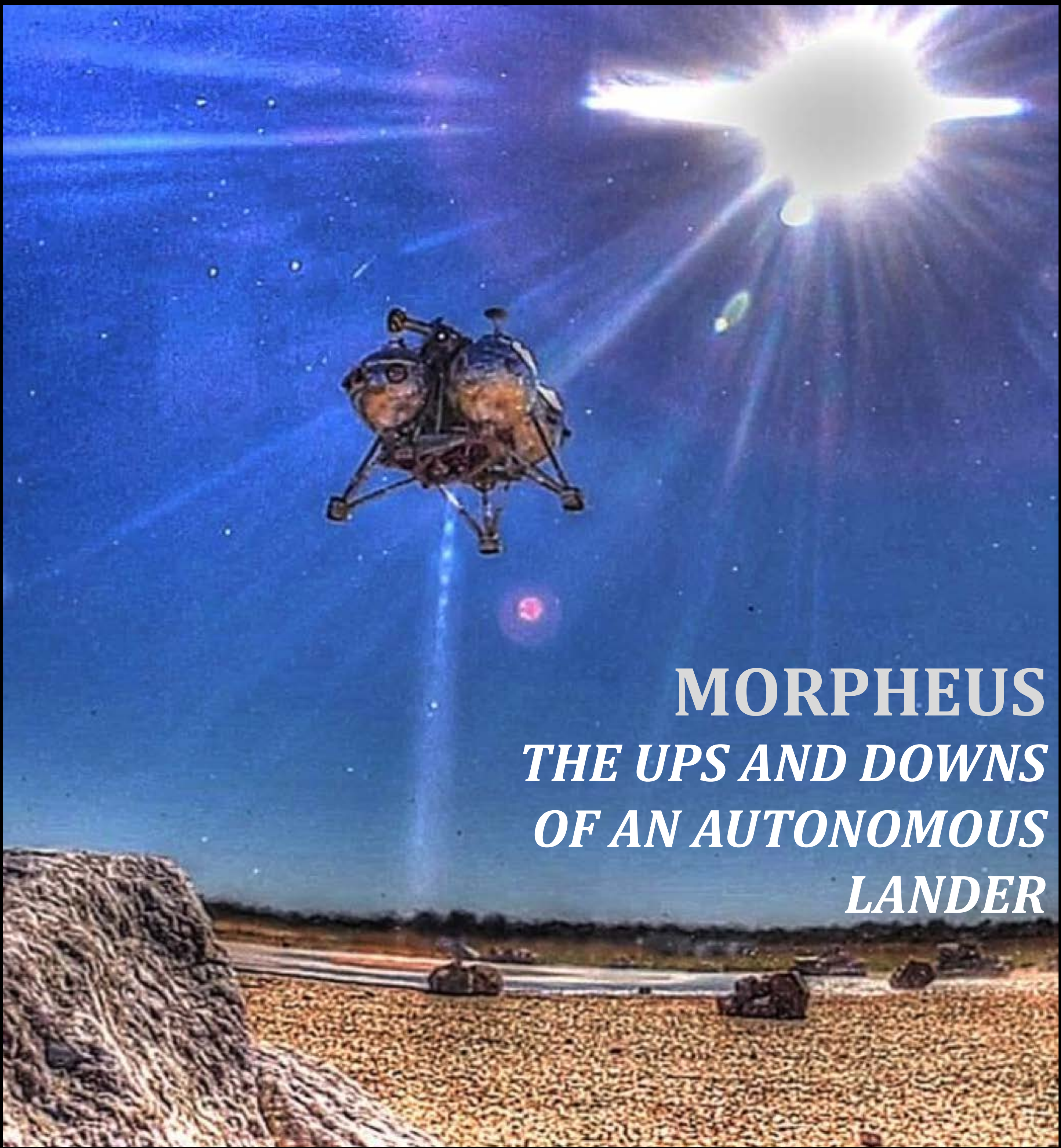

MORPHEUS
THE UPS AND DOWNS OF AN AUTONOMOUS LANDER

Horizons is a bimonthly publication of the Houston Section of the American Institute of Aeronautics and Astronautics.

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May / June 2014
Horizons, Newsletter of AIAA Houston Section

T A B L E   O F   C O N T E N T S

Congratulations!
Horizons and AIAA Houston Section Website
Section Chair Daniel Nobles
AIAA 2013 National Communications Third Place Award Winner

Front cover image: Morpheus. Image credit: NASA.
This page: The 1889 van Gogh painting, The Starry Night.
This page: Skyline of downtown Houston, Texas USA, from Sabine Park. Author: Jujutacular. Source: the Wikipedia Houston article.

Community

Michael Frostad, Chair

It has been a solid year for the AIAA Houston Section and the aerospace community we support. In the community, we have seen multiple successful Morpheus Flights which are now testing out the ALHAT system, steady progress towards Orion Exploration Flight Test 1 (EFT-1), successful Cygnus and Dragon supply runs to the International Space Station (ISS), progress towards commercial crew vehicles in the form of the CST-100, Dragon and Dream Chaser spacecraft, and initial agreements in support of a Houston Spaceport at Ellington field. In addition, the International Space Station celebrated 15 years in orbit! As I mentioned at the time, for any child born after November 2000, they have never known a time in which there have been no Humans in space! And while there are obvious challenges, it has truly been another incredible year for the aerospace field.

In the midst of these technical feats, here at the Section level, we hosted great technical lunch and learns, professional development meetings, and amazing dinner meetings with multiple astronauts. We participated in various STEM events, raised a significant donation for the Challenger Learning Center for Space Science Education, hosted another successful Annual Technical Symposium (ATS 2014), and awarded the Spirit of Apollo Scholarship. These events sought to provide professional forums to discuss our community's trade outside of our normal cubicles and offices. They provided opportunities for us to grow as professionals, to help and inspire the next generation, and to provide forums to share and collaborate on technical ideas.

This year we had quite a few new comers to the AIAA Houston Section executive council (EC) - all of different minds, all with a passion for aerospace, and all with a desire to build a stronger aerospace community. As the year progressed and the EC coalesced our momentum picked up, our communication improved and our events increased in frequency and quality. While there were some mistakes, some unforeseen circumstances, some things that could be improved – these challenges helped us grow and taught us just what it takes to pull off a successful event. With many of the EC committing to return next year (starting July 1, 2014), these lessons will not go to waste. From freshly written dinner meeting and lunch and learn step by step instructions, to expanded use of the www.aiaahouston.org website calendar function, and increased contact with AIAA Regional and National levels, AIAA Houston Section is poised to have an even better year in 2014-2015.

With the lessons learned this year I encourage those interested to come and learn from all of our leaders next year. Come participate, learn, and practice leadership - there will be ample opportunity as our next Chair, Michael Martin (PhD almost completed) is eager to see the Houston Section grow and flourish. He has ambitious plans for AIAA Houston Section with a special emphasis on energizing our local College Chapters and we would both appreciate your assistance in this.

On a more personal note, I hope to have served the 2013-2014 AIAA Houston Section Executive Committee and you, the Community at large, well this year. I will work to make sure the lessons we have learned this year are passed on to the next EC so we can continue to serve you better and I look forward to continuing to serve in the Past Chair position. This was a great opportunity to learn and practice actual leadership and I thank the community for it. It has been my honor to be the Chair of the American Institute of Aeronautics and Astronautics Houston Section for the 2013-2014 year and to work with all those on the Executive Council in providing the events above for the community at large. I hope to see you at an AIAA event soon and I will leave you with this thought: *Freedom. Life. Discovery. These are basic values of space exploration.*

As always, you can stay up to date with the AIAA Houston Section via our Section's website: www.aiaahouston.org.

In addition you can make sure your membership is up to date and that you are tied in to the National level here: www.aiaa.org. ■

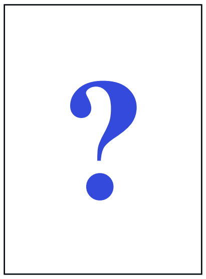
Michael Frostad
AIAA Houston Section
Chair, 2013-2014
HX5/JSC Engineering, Technology, and Science (JETS) Contract
M.S.A.A., University of Washington

Above: SpaceX Dragon 2 crew vehicle at a May 2014 announcement ceremony. Image credit: SpaceX.

Above: Orion Comes Together. The Orion crew module for EFT-1 is shown in the Final Assembly and System Testing (FAST) Cell, positioned over the service module just prior to mating the two sections together. The FAST cell is where the integrated crew and service modules are put through their final system tests prior to rolling out of the Operations and Checkout Building at NASA's Kennedy Space Center in Florida. Technicians are in position to assist with the final alignment steps once the crew module is nearly in contact with the service module. In December, Orion will launch 3,600 miles into space in a four-hour flight to test the systems that will be critical for survival in future human missions to deep space. Image credit: NASA/Rad Sinyak.

Editor's Corner Morpheus, LPSC, & the end of our AIAA Year

Douglas Yazell, Horizons Editor



Above: Our next Editor? Starting July 1, 2014, we hope to have our new Editor volunteering in that role, one year at a time. With about 800 professional members in AIAA Houston Section (mostly in the NASA/JSC community, with about 10% of membership in the Texas A&M University community), our new Editor will have a built-in audience.

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The current issue of Horizons and an extensive Horizons archive are available on this website.

An archive for Horizons on a national AIAA website is here.

[June 22, 2014]

Morpheus

Special thanks go to Jon Olansen of NASA/JSC for our outstanding cover story, *Morpheus, the Ups and Downs of an Autonomous Lander*. The article and the photographs are excellent, and the Morpheus team is doing inspiring work. The Morpheus *website* will be of interest to our readers, too:

http://morpheuslander.jsc.nasa.gov

LPSC

Dr. Larry Jay Friesen was kind enough to report to Horizons again this year from the 45th Lunar and Planetary Science Conference (LPSC). The Marriot hotel in the Woodlands was the site for this year's event, and the invited speaker for the Mazursky lecture was Apollo 15 Commander David Scott, the seventh person to walk on the Moon.

JSCAS

Our Horizons newsletter and AIAA Houston Section partnership with the Johnson Space Center (JSC) Astronomical Society (JSCAS) continues in this issue, as we present the last installment of Jim Wessel's article, *Building an Astronomer's Chair, Complete with Chair and Red Lighting*. Jim submitted two book reviews for upcoming issues of Horizons, too. These are reprints of book reviews he contributed to another publication recently.

In this issue, I also summarize an invited presentation from the monthly JSCAS meeting. Astronaut Dr. Stanley G. Love summarizes some of the challenges of traveling to Mars.

James C. McLane, Jr.

We end our Horizons tribute to the late James C. McLane, Jr. in this issue. His son James C. McLane III made a dinner meeting presentation to our Section last year about his late father, including tales of his father's NASA/JSC career. For each bimonthly issue of Horizons since then, we have been including the transcript of that speech and presenting McLane family photographs. James C. McLane III has been a frequent contributor to Horizons. With luck, that will continue.

Horizons Editor Search

AIAA Houston Section is seeking a new Editor for Horizons. I started in this role on April 11, 2011. I now need that time for other things, so I am stepping down. This role in our Section is appointed, not elected, and the volunteer service is typically done one year at a time, from July 1 to June 30. Of course, July and August are very slow months for our Section in most years.

This newsletter is bimonthly now, but it was often quarterly or monthly. As always, the Editor will have options for modernizing Horizons. We have been using the same PDF format since about 2005, so we cannot be using the best technology.

I started volunteering in various roles in our Section's council in about 1999, when Merri Sanchez was starting her year as our Chair. John Keener is one longtime Horizons Editor who served at that time. Later Jon Berndt started his service as Horizons Editor. As I recall, he started with the last issue of 2004, and his last issue was the last issue of 2007. Jon used Microsoft Publisher for Horizons formatting, an application from the Office Pro suite. Publisher works only with Windows.

I served as Acting Editor for three issues of Horizons in 2008, then Dr. Steven E. Everett served as our Horizons Editor for two years. Late in my 2011-2014 service as Horizons Editor, we used the industry standard application, Adobe InDesign, in place of Publisher. This May / June 2014 issue of Horizons is formatted using InDesign and the Mac OS X (Mavericks).

Thanks to all who made Horizons possible these last three years! AIAA Houston Section was given a legacy by our founders in 1962 and those early years. Our later generations have done and are still doing great things with that legacy. Ellen Gillespie and Steve Everett stayed with me all three years (2011-2014), and later Philippe Mairet from our Section's French sister section accepted our invitation to join our Horizons team. Shen Ge joined us, too, a recent graduate from Georgia Tech University and Texas A&M University. We recently added Wes Kelly and Ryan Miller to our Horizons team. Inactive Horizons team members Alan Simon and Don Kulba still keep in touch with us.

Book Reviews

I am in the middle of reading volume 2 (the last volume) in the authorized biography of science fiction author Robert Anson Heinlein, by the late William H. Patterson, Jr. I chose to buy it from the Apple iBooks store, but that will not include some photographs available in the printed-on-paper version.

For new or experienced writers who can write a good book review, I suggest that occasional writers can obtain their own copy of recent books by writing a book review for Horizons. ■

Morpheus

The Ups and Downs of an Autonomous Lander

Jon Olansen, NASA/JSC

All image credits: NASA.

"Ignition in 5, 4, 3, 2, 1…" announces the Test Conductor as the anticipation of flight grows in the control room.

"Ignition, throttle up, main stage," declares the Propulsion Officer, followed quickly by the GNC Officer's proclamation of "ascent, good control."

The next 98 seconds pass as steely-eyed console operators are consumed by their

Above: Morpheus Control at KSC during FF4.

scanning of telemetry data, announcing nominal performance or identifying anomalies in flight. Other than those utterances, you can hear a pin drop in the control center. The well-trained team is focused – system operators watching their systems perform, the range safety officer ensuring the test vehicle stays within pre-determined bounds, the test conductor on high alert for any indication that intervention is required.

The test ends with the calls of "at ground target," "engine shutdown," and finally "test complete...," followed by a collective exhalation.

Such is the nature of a Morpheus free flight test at the Shuttle Landing Facility (SLF) at the Kennedy Space Center (KSC).

During the final planned test campaign with the Autonomous Landing and Hazard Avoidance Technology (ALHAT) instruments integrated on board, the Morpheus Project endeavored to complete its primary tasks of advancing LOX/Methane propulsion, autonomous, precision landing, and hazard avoidance technologies to a Technology Readiness Level (TRL) of 6 – which means they've been integrated and demonstrated in a relevant flight environment. While data analysis from those flights continues at this writing, the entirety of the test campaigns at KSC has been an unmitigated success.

Background

Born out of a technology demonstration mission concept called Project M, the Morpheus Project began in earnest in June of 2010. Its primary intent has been as a lander technology development activity that could eventually support human and robotic missions to any surface.

The most visible aspect of the Morpheus Project is the autonomous, reusable, rocket-powered, terrestrial vertical test bed (VTB), which provides a platform to mature, refine, and demonstrate advanced technologies in a relevant flight environment.

The Morpheus Project was challenged to provide this vehicle, the necessary ground support infrastructure, and operations capability to conduct flight tests using a lean development approach of a small team,

Above: View from the KSC Shuttle Landing Facility at sunrise.

rapid testing and turnaround, innovative partnerships and minimal resources.

One of the primary technology components of the Morpheus Project is liquid oxygen (LOX) / liquid methane (LCH4) propulsion. A LOX/methane propulsion system is clean-burning, non-toxic, cryogenic, and space-storable. For future space missions, oxygen and/or methane potentially could be produced in situ, depending on the planetary surface. Oxygen is compatible with on-board life support systems, and oxygen / methane systems are being studied for power generation as well. These attributes make LOX/methane propulsion an attractive technology when the entire spacecraft system is considered. LOX and methane are also readily available on earth and relatively safe and easy to handle (being cryogenic but not toxic), allowing for frequent, low-cost ground testing. It is notable that Morpheus has demonstrated not just LOX/methane propulsion for the main engine, but simultaneously with a set of four integrated LOX/methane roll control engines, and is the first flight vehicle to do so.

When landing autonomously on any planetary or other surface, the vehicle must be able to identify a safe landing site that is free of large boulders, rocks, craters, or highly sloping surfaces. The second primary technology objective of the Morpheus project is to demonstrate and advance the TRL of precision landing and hazard avoidance capabilities developed by the ALHAT system. The ALHAT project has been developing an integrated Autonomous Guidance, Navigation, and Control (AGNC) hardware and software system capable of detecting and avoiding

Above: ALHAT Hazard Detection System mounted on the Morpheus "Bravo" vehicle.

surface hazards and autonomously guiding a manned or unmanned space vehicle to a safe touchdown within 90 meters of a pre-designated planetary or asteroid site.

Morpheus navigation makes use of a Global Positioning System (GPS) receiver, a high precision Inertial Measurement Unit (IMU), and a relatively inexpensive laser altimeter. The ALHAT suite of sensors, software and components are designed for use without terrestrial assets such as GPS, and include four major capabilities: (1) a Hazard Detection System (HDS) that provides identification of a safe landing site using a digital elevation map generated by a gimbaled flash lidar during a 60 m x 60 m scan of the landing area; (2) hazard relative navigation (HRN) that uses the same flash lidar but provides navigation relative to an identified surface feature near the landing site; (3) surface relative velocity using a three-beam Doppler lidar (DL); and (4) precision altitude from a laser altimeter (LAlt). The measurements from these systems feed into the onboard ALHAT navigation software, along with the onboard IMU that is used by the Morpheus navigation. With these capabilities, ALHAT provides the safe landing site selection and navigation to precisely land at the designated site.

Failing Forward

The achievements of the project are a testament not only to the dedication and perseverance of the personnel that have made up the Morpheus team for four years, but also the progressive attitude of NASA management to allow appropriate risk-taking and the use of test failures to ultimately succeed. This was best exemplified by the response to the loss of the first Morpheus vehicle.

On August 9, 2012, during the 27th integrated test and 2nd free flight attempt at Kennedy Space Center, the Morpheus 1.5 "Alpha" vehicle crashed shortly after takeoff. The entire vehicle was lost, with the exception of a handful of parts that were recovered for reuse. (Most notably, the HD4 engine injector was recovered and incorporated into the rebuilt engine currently powering the Bravo vehicle, which recently reached 3000 seconds of cumulative engine firing time.)

The cause of the crash was isolated to the loss of navigation data shortly after liftoff. Without that data—required by the vehicle to maintain its navigation state and attitude knowledge—the vehicle was flying blind and responding only to its last known state and attitude, causing it to tip over and crash a short distance from the launch pad. An excessive vibroacoustic environment was identified as a primary contributor to the hardware failure that stopped the flow of navigation data.

Above: Morpheus Alpha vehicle Free Flight 1 at ignition; and Free Flight 2 after it crash landed.

Prior to beginning Morpheus flight tests, damage or loss of test hardware was pre-declared as a potential test outcome, not a more formal "mishap," and this risk had been well communicated up through the NASA management chain. As a result, Agency leadership immediately recognized the test nature of the failure and reiterated their endorsement of the project. NASA Administrator Bolden discussed the "fail forward" nature of Morpheus and its benefits in an open letter to Agency personnel on April 19, 2013. "No one likes to lose equipment, but we recognized that failure is part of the price of learning and acted accordingly. As long as we ensure that our people are protected we can manage and tolerate failures as part of the price of progress."

With leadership support, the team gathered at the crash site the next day and began to forge their forward path. Within two months, 70 design upgrades were developed, reviewed and approved for implementation in the buildup of the Bravo vehicle, associated ground support equipment, operations and test facilities. Some critical hardware and instrumentation would get redundancy, more advanced fault detection and response algorithms would be incorporated, a flame trench was designed and deemed mandatory, and numerous other ground systems and operations procedures would be modified.

Rebuilding efforts began in earnest in October 2012, with the first integrated hot fire test completed six months later. The knowledge gained in testing the Alpha vehicle significantly improved the performance of the Bravo vehicle once its testing began.

Above: Morpheus 1.5 Bravo executing a translational Tether Test in August 2013. Mars soil simulant was deployed on the launch pad to study plume impingement for the Mars 2020 program.

Improvements for Bravo vehicle operations also included significantly enhanced flight simulation capabilities. Reliable simulation tools afforded the project the opportunity to predict vehicle performance under more risky tethered flight profiles. Planned testing progressed from simple vertical hovers (all that was accomplished with 1.5A in 2012) to multi-level vertical motion with lateral translations of up to 3 meters (m). This expanded capability enabled the testing of all different versions of gain scheduling through all phases of flight, which allowed the project to “test like you fly” in preparation for future free flights at KSC.

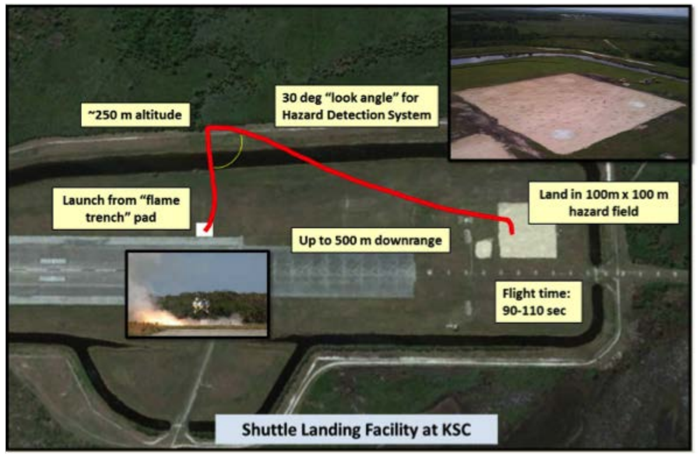
Integration with the ALHAT instruments was repeated with the Bravo vehicle during tether testing. Integrated performance was significantly improved from 2012, with nearly all discrepancies resolved and HDS pointing accuracy demonstrated within 0.15 degree. Additionally, the project collaborated with the Mars 2020 Program from the Jet Propulsion Laboratory by incorporating a plume impingement study using Mars soil simulant during a tethered test. (See photo taken shortly after ignition.)

The final test conducted at the Johnson Space Center (JSC) before the team transitioned to KSC to begin free flight campaigns was a Ground Takeoff and Landing (GTAL) test. While still constrained via tether for range safety, this test reduced free flight risk by demonstrating nominal liftoff over a flame trench to an altitude of 7 m, followed by a nominal translation of 3 m, descent and landing back on the ground. This test was successfully completed in November 2013.

KSC Test Campaigns

Designed to simulate the terminal phase of a lunar approach trajectory, the Hazard Detection Phase (HDP) was the ultimate flight profile for Morpheus free flight testing with ALHAT. Given the capabilities of the Morpheus vehicle, the approach begins from a slant range of approximately 500 m and continues until landing in the specially designed hazard field off the north end of the SLF runway. Of course, to get to the proper test conditions, Morpheus must launch from the ground and ascend 245 m before beginning the approach.

Moving from the very low altitude GTAL test at JSC to the full HDP profile required some very deliberate steps to characterize vehicle performance and identify flight constraints. A methodical series of tests was planned to expand the flight envelope of the vehicle (“envelope expansion”) and buy down flight risk before demonstrating the HDP capability. This meant incrementally increasing altitudes, distances traveled, and velocities, performing expected maneuvers, and handling environmental conditions.



Above: Morpheus/ALHAT HDP Profile at the KSC Shuttle Landing Facility.

The role of vibroacoustics in the loss of the Alpha vehicle led to a requirement to launch over a custom-designed flame trench, increasing the complexity of the envelope expansion test operations. Flying various distances to landing pads in the hazard field required various launch points. KSC team members creatively designed a portable concrete launch pad with a removable flame trench that could be relocated between test campaigns at minimal cost; one example of how the project used innovative solutions to extend limited resources.

Initially, a series of four test campaigns were planned for KSC, each including four flights over two weeks, and two weeks off between campaigns:

- Campaign 0: vehicle and equipment shipping and unpacking followed by a tether test (to test post-shipping capability) and initial free flights to demonstrate control without the tether.
- Campaign 1: envelope expansion with increasingly longer, farther and faster flights: the goal was to gain confidence flying the full HDP trajectory before integrating ALHAT onboard.
- Campaign 2: HDP trajectories with ALHAT flying open-loop (collecting data but not being used for vehicle navigation/control).
- Campaign 3: HDP trajectories with ALHAT flying closed-loop (ALHAT navigating the vehicle from launch through landing).

Although the team typically worked 10-12 hour days and took very little time off on weekends, we quickly discovered that the pace of four flights per two-week campaign was not feasible. After Campaign 0, the flight rate was cut in half and more campaigns were added to the test schedule. The team took one to two weeks between campaigns to review data before returning to KSC for more testing.

The first flight test of Campaign 0 at KSC, TT33, was completed successfully on December 6th, 2013, repeating the flight profile flown in Tether Tests 28 and 29 at JSC. TT33 confirmed

Above: Morpheus liftoff over a flame trench at the KSC SLF.

that the vehicle, ground support equipment, and team were ready to proceed with free flight testing at KSC.

Free Flight 3 (FF3) was the first attempted untethered flight of the Morpheus 1.5 Bravo and was accompanied by much angst among team members. After all, the last free flight had resulted in the loss of Alpha. Fortunately, that anxiety did not paralyze the team; rather it fostered the focus and attention to detail necessary to complete FF3 successfully on December 10th, 2013. The vehicle flew a 54-second flight profile similar to the JSC GTAL test, with an increased ascent distance (15 m) and downrange distance (7 m). Despite losing GPS data approximately 20 seconds before landing, the vehicle continued flying its pre-programmed trajectory with IMU and altimeter data and safely landed within 0.15 m of the target.

Following FF3, the team isolated the cause of the GPS data loss to a degraded part in the vehicle Command and Telemetry (C&T) radio that caused interference with the GPS frequencies. This C&T hardware was removed, replaced, and tested on the vehicle with additional vibration protection.

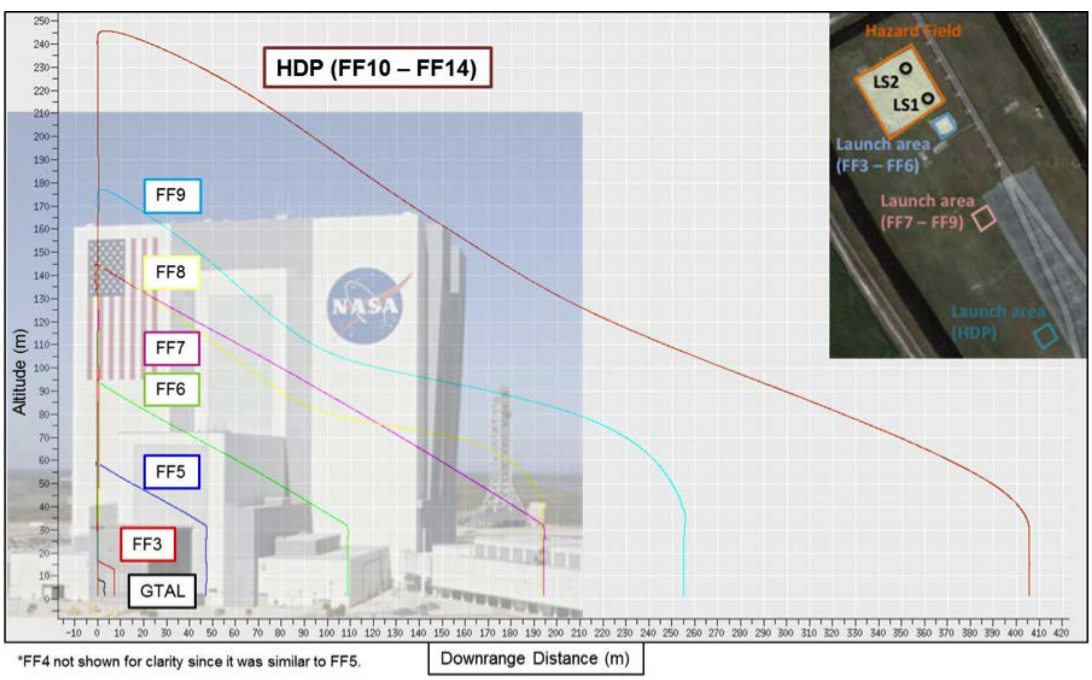
One week later, Free Flight 4 (FF4) represented a significant expansion of the flight envelope. This flight had a similar profile to GTAL and FF3, but with increased altitude (50 m) and downrange (47 m) distances. The vehicle flew its pre-programmed trajectory flawlessly and landed within 0.1 m of the target, in the hazard field (at LS1) for the first time. FF4 brought Campaign 0 and 2013 to a very successful close for the Morpheus team.

After Campaign 0, the team did some re-planning, splitting the future campaigns into more manageable pieces and providing adequate time between flight tests for vehicle maintenance and thorough data review. Campaign 1 was split into three separate campaigns (A, B and C), still designed to demonstrate readiness for ALHAT integration and the full HDP trajectory. Campaign 1A included Free Flight 5, similar to FF4 in altitude and downrange distance, but with faster vertical and horizontal velocities. The team was under time pressure during the FF5 test day due to rain expected in the afternoon. The flight test was successful, but the vehicle had to roll back to the hangar in a major downpour. Critical avionics were protected, and the vehicle was dried out in the hangar. Just five days later, Morpheus nearly doubled the trajectory size in FF6 with a flight up to 93 m altitude and 109 m downrange. This was the first flight in which the landing pad was covered with crawlerway fines (material repurposed to create the hazard field), and the vehicle was obscured by a huge dust cloud during landing. The JSC team returned to Houston after FF6, and the KSC team moved the portable launch pad farther away from the hazard field.

Campaign 1B kicked off with FF7, which took three separate attempts to complete. The first attempt was scrubbed due to a Launch Commit Criteria (LCC) violation for a fully operational Thrust Termination System (TTS) required for range safety. In that case, low radio link margin led to a temporary inability to communicate with half of the TTS which was not fixed before boil-off reduced propellant margin to unacceptable levels. The second attempt was halted by a misty rain that seemed to condense out of the air rather than fall from the sky. Finally on February 10, FF7 reached an altitude of 142 m and traversed 194 m for a 74 second flight with very little deviation from the intended landing target. However, the combination of wind direction and speed with higher vehicle velocity yielded the first saturation of roll control jet capability, leading to a single jet failing off due to high temperature late in the flight.

The propulsion and GN&C teams brainstormed and identified modifications that would enable the roll jets to operate at cooler temperatures and provide the necessary roll control torque. Before proceeding to another free flight, the vehicle was rolled out for a static hot fire test of the roll control jets to evaluate performance. After another week of data review in Houston, Campaign 1C kicked off with a successful static hot fire test of the modified roll jets before resumption of free flights

FF8 was the sixth free flight of the Bravo vehicle, ascending to 142 m, traversing 194 m, and including a pre-planned divert maneuver from the original target landing point to a designated point on the landing pad. The divert maneuver demonstrated vehicle performance that would be needed for a surface landing in which a safe site is determined mid-flight and the vehicle



Above: Morpheus free flight trajectories depicting the nature of envelope expansion at KSC.

must adjust the flight trajectory for the new location. FF8 landed within approximately 0.25 m of the target.

FF9 was the final flight before ALHAT integration, and flew up to 177 m (higher than the Washington Monument) as fast as 13.4 meters per second (mps), and downrange 255 m before landing at Landing Site 2 (LS2) in the far (north) corner of the ALHAT Hazard Field just 0.3 m off target about 83 seconds after launch. This flight was originally scheduled for the following day, but incoming weather looked threatening, so the team worked harder and longer hours to complete all vehicle maintenance, inspections, functional checks, and delta test readiness review (TRR) discussions and subsystem polls in one day rather than the usual two days prior to flight…quite a feat!

After a successful Campaign 1C, it was time to integrate the ALHAT instruments back onto the vehicle. Team members from Jet Propulsion Laboratory (JPL) and Langley Research Center (LaRC) joined JSC and KSC teams for mechanical and electrical integration of four hundred pounds of sensors, wiring harnesses, power and computer elements. The team performed a wide range of integrated tests, including rolling the vehicle outside for powered-on (but non-propulsive) navigation testing underneath a crane.

Campaign 2A kicked off with Tether Test 34, critical for confirming that integrated vehicle performance would be unaffected by electromagnetic interference and mechanical changes, and that the ALHAT components would function as required in the presence of vehicle dynamics and thermal effects under tether. TT34 was followed by Free Flight 10, the first integrated free flight with ALHAT, on a trajectory that would be used for all remaining free flights: 245 m in altitude and 406 m downrange in approximately 97 seconds and to within two meters of the intended target. For FF10, the ALHAT sensors were flying as "passengers" for data collection and characterization. The team took two weeks off to analyze data, consider modifications to sensor operational parameters, and evaluate how best to tune the ALHAT navigation filter.


Above: Morpheus rises above the KSC SLF during FF13.

Campaign 2B had two more open-loop ALHAT flights: FF11 and FF12. The vehicle performed well in both flights, matching the planned trajectories very closely while providing additional data on ALHAT sensor performance. FF12 was the first flight during which the Hazard Detection System (HDS) selected the designated landing site instead of the pre-loaded landing site. It is important to note that, for vehicle safety, the onboard Morpheus software only would have allowed an HDS-selected site that was within an allowable distance (2 m) from the known center of the landing pad.

The final test campaign, Campaign 3, started with FF13, the first closed-loop flight with ALHAT. During FF13, the ALHAT HDS scanned the Hazard Field and correctly identified a primary safe landing target within 0.5 m of the LS1 pad center, the best HDS safe site selection to date. As ALHAT navigated Bravo toward the selected landing target, the vehicle position calculated by ALHAT diverged from the "true" position calculated by Morpheus GNC until the error reached a pre-defined trajectory corridor limit, at which point Bravo automatically reverted to Morpheus navigation for the remainder of the descent to the ALHAT landing target. Thus, FF13 successfully demonstrated ALHAT HDS performance and landing site selection (as in FF12), as well as the first in-flight down-mode from ALHAT to Morpheus navigation, but not yet complete ALHAT navigation to the landing site. The ALHAT team used this flight data to diagnose the position error growth and better tune ALHAT navigation filters and sensors for FF14.

As pilots say, any landing you walk away from is a good one. Likewise, any Morpheus/ALHAT test that lands the vehicle safely for the next test is a good one. Bravo demonstrated robustness to navigation errors, lending even greater confidence to FF14 with improved ALHAT navigation performance.

On May 28, the multi-center, integrated Morpheus/ALHAT team successfully completed FF14: Bravo's twelfth flight, ALHAT's fifth free flight, and the first ever *night flight*. The purpose of flying at night was to demonstrate ALHAT's objective to


Above: Morpheus descending to Landing Site 1 in the SLF hazard field during the FF14 night flight.

perform under any lighting conditions. Data review indicated nominal performance of all Bravo vehicle systems. The ALHAT HDS performed well, but identified a safe site just 0.5 m outside the conservatively established limit (2 m) around the center of the landing pad. ALHAT then navigated the vehicle in closed-loop mode through the entire approach, with the vehicle taking over navigation from ALHAT during the descent phase of the trajectory just 25 m over the pad, 1 second before dead-reckoning, landing 0.3 m from pad center. Had less conservative position error limits allowed ALHAT to continue navigating all the way to the ground, the vehicle still would have landed safely on the pad.

The team did overcome a few preflight issues, including an automatic engine shutdown ("pad abort") immediately after ignition due to a non-critical temperature limit exceedance, which was corrected for the successful second attempt. Analysis of FF14 flight data will enable the ALHAT team to continue tuning and improving their navigation filter and sensor performance, and to determine if ALHAT system performance was sufficient to satisfy the TRL 6 objective of the flight test campaign, or if any additional flights will be required.

Project Paradigms

For Morpheus, lean development is a rapid prototype development and test philosophy that emphasizes learning through frequent test activities. Off-nominal performance in a test would yield design improvements to hardware, software or operations that were quickly implemented and tested to see if they indeed improved performance. As a result, since April 2011 the project has executed sixty propulsive flight tests with two vehicles, yielding advancements in design, integration and operations, while generating copious amounts of data for continued analysis.

The real trick to sustainable lean development is finding the right levels of rigor, discipline and risk acceptance appropriate for a particular project. One can build upon lessons from existing large NASA programs like ISS that have been operational for years, learn from more recent NASA development activities like Orion or SLS, and work with some of the aerospace startups such as Space X in order to see their different perspectives, all of which can inform choices for level of rigor for a development or prototype system. Ultimately, however, there is no formula for determining the "right" level of any of these attributes; it must be agreed upon by project leadership and compatible with team skills and experience. *It is not about having process or not having process, it is about the right level of process at the right time.*

The project's governance model was also instrumental in executing the lean development approach. Managing the rapid pace at which the Morpheus Project operated was enabled by efficient decision-making processes and a flat organizational structure. Subsystem leads were not only given authority and responsibility for their subsystems, but also had primary roles in vehicle integration. The small project management and systems engineering teams were fully engaged in all technical and operational aspects of the project on a daily basis.

Another key to lean development is accepting appropriate risk. The project must be very clear about what risk is acceptable. For early development and testing of engineering prototypes, accepting the complete loss of the prototype or engineering unit may be appropriate. This doesn't mean the project behaves irresponsibly or unprofessionally. Rather, it is simply a realization that you build prototypes because you don't have all the answers, and testing and trying different designs leads to answers. Sometimes those tests will fail, sometimes spectacularly. The project must manage appropriate and acceptable risk, acceptance of "failure," and expectations of "success" in technology development.

Above: Images of Morpheus Free Flight 11 with ALHAT on board.

Heading into free flights at KSC, it was important for the project to maintain a consistent risk posture. From the very beginning, Morpheus vehicles were built as single-string, vertical take-off and landing prototypes. That approach enabled the project to pursue lean development and make advances in design, testing and operations in a more rapid fashion than many traditional projects. However, there are inherent risks to the vehicle using this approach. The project put forth significant effort in identifying and mitigating single-point failures that could cause loss of vehicle prior to heading to KSC. That included substantial subsystem-level testing, the entire tether testing previously described, and system-level protoqual testing.

To be clear, this risk acceptance applies only to technical performance of the vehicle system. Hazards to personnel safety or infrastructure are managed at a much higher level of rigor, commensurate with all other activities done within the Agency. The primary exception to the single-string philosophy included safety measures in subsystems such as pressure systems and range safety. Pressure systems have redundant pressure relief components built in. The dual-redundant thrust termination system (TTS) on board the vehicle includes two independent valves in the propulsion system, either of which could cut engine thrust, each commanded by an independent range safety radio link. This exemplifies the project emphasis on safety, even while accepting additional risk to the test vehicle itself.

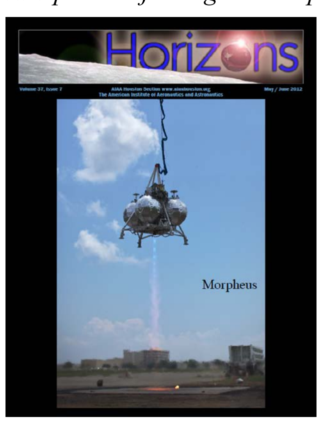
In addition to the actual testing accomplished, it was important to ensure all stakeholders were fully aware of the risk posture for free flights. The loss of the Morpheus 1.5A vehicle was pre-declared a test failure and not a mishap and, in this light, the loss of vehicle was considered an acceptable risk. Outside the Agency, however, it was equally important to explain our purpose and describe our methods to the public and allow them to follow along and understand the complexities of engineering advancement, with the additional benefit of engaging students in the process.

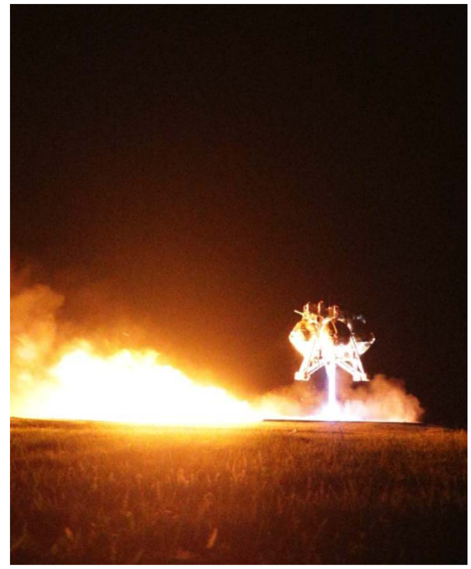
Social media today plays a very important role in public education and interest in cutting edge NASA projects, and Morpheus and ALHAT embraced that medium enthusiastically. All Morpheus flight tests were broadcast live on the Project web site, complemented by posts on Twitter, Facebook, YouTube and Flickr. As a car crash attracts rubberneckers on the road, videos of the crash and explosion of the Alpha vehicle piqued online public interest in 2012. More important and encouraging, however, was the public response to the successful rebuilding and flight-testing of the Bravo vehicle. Morpheus produced a slogan "Increase the Awesome" that began showing up in artists' renderings and multiple online outlets. Teachers posted lessons based upon Morpheus trajectories; students and NASA enthusiasts posted their art and models of Morpheus vehicles; a woman sent a letter describing how the loss of Alpha coincided with her personal health crisis, and the triumphant return of Bravo inspired her during her own physical comeback. Through social media, people worldwide watched, supported, learned about and drew inspiration from Morpheus.

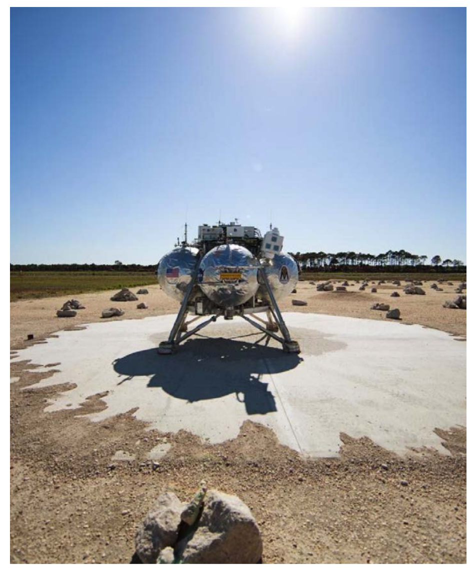
Engineers learn best by doing, by working hands-on with hardware and software, by designing, building and testing systems on an integrated flight vehicle. In just a few years, Morpheus and ALHAT have provided a prolific training ground for engineers and technical and project leaders. Lean development, rapid prototyping, emphasizing testing over analysis, allowing engineers to fail-forward to success—these tenets can enable not only lower costs and faster schedules, but, most importantly, more capable employees.

As Administrator Bolden said in his open letter, "…when you do stuff that nobody else has ever done, you have to be willing to accept risk. We have to be willing to do daring things. Put another way, **risk intolerance is a guarantee of failure to accomplish anything of significance**." With Morpheus, we have sought to balance risk with the opportunity for rapid advancement of technologies that will benefit the future of human space exploration. The spectacle of the free flights at KSC is evidence of the benefits of such an approach! ■

Dr. Jon B. Olansen serves as the Project Manager for the Morpheus Project. Jon earned his B.S. in Aerospace Engineering and M.S. in Mechanical Engineering from the University of Notre Dame. He obtained his Ph.D. in Bio-Mechanical Engineering as a National Instruments Fellow at Rice University, where he specialized in biomedical experimentation in electrophysiology and cardiopulmonary hemodynamics. He has published several journal articles related to his research and authored a reference book on biomedical instrumentation. Jon began his career at JSC as a Space Shuttle flight controller (MMACS), supporting 32 missions and logging more than 4,200 hours in Mission Control. Dr. Olansen has since held a number of positions of increasing responsibility including tours in Flight Crew Operations, Safety & Mission Assurance, the Shuttle Program Office and the Exploration Systems Mission Directorate at NASA Headquarters. Jon was Manager of the Engineering Directorate Planning & Control Office at JSC prior to joining the Morpheus Project.







Right: candidate cover images not used.
Above: Morpheus was also the cover story for the May / June 2012 issue of Horizons.

Odds & Ends

L'Oiseau Canari (the Canary Bird of 1929)

The First Crossing of the Atlantic by a French Aviation Team. An Extra 80 kg of Trouble: an American Stowaway!

[June 9, 2014. *Wikipedia*]

L'Oiseau Canari (the Canary Bird) is the second copy of the Bernard-Hubert-191GR Version "Grand Raid" of the Bernard-Hubert 190T-2 prototype airplane designed in 1927 by Jean Hubert, Technical Director of the Society of the Bernard Aircraft, and built in 1928. This high-wing monoplane was scheduled for commercial flights over long distances and large raids [military attack missions]. The Bernard 190 were classified into several derivatives of their engines, and those equipped with V12 Hispano-Suiza 500 horsepower (hp) are called 191 GR. Only three of these 191 GR prototype airplanes were produced.

The second copy, yellow, and baptized Canary Bird, was purchased by Armand Lotti, then deputy director of the Hotel Lotti, rue de Castiglione in Paris, and was prepared and developed by mechanical engineer Raoul Leroy, of the Hispano Suiza Society, who was to accompany the aircraft until its flight from the United States of America.

Attempts to cross the Atlantic, already difficult in the West-East direction, were tragic in the opposite direction. Many lives were lost in 1928. Also, the French government decided to suspend its funding and prohibit such attempts. It was therefore illegally, undocumented, and without authorization, under the guise of a radio repair, that the Canary Bird departed Paris for England, where it could legally depart to travel to the United States of America.

On Thursday, June 13, 1929 at 10:18 AM (local time), the aircraft, loaded with a mixture of 3,900 liters of gasoline and 600 liters of benzene, very laboriously took off from the long beach of Old Orchard Beach (Maine) north of Boston.

Shortly after takeoff, a stowaway appeared by inspection hatch from the bottom of the cabin, saying "Here I am!" It was Arthur Schreiber, a young American who relied on his adventure to write an article or book.

The crew, due to weather conditions, was not able to follow the optimal route, and was forced to shift its course south, increasing the distance. Further south than estimated, the empty fuel tank caused the aircraft to land on the beach prematurely on the beach at Oyambre near Comillas in the province of Cantabria in northern Spain, June 14 at 8:40 PM, after 29 hours and 22 minutes of flight, and the longest path ever traveled over the sea (5,900 miles). A navigation error due to weather conditions encountered saved their lives, since the fault would have otherwise occurred in the Bay of Biscay before reaching France. On June 16, the crew took off for Cazaux. Upon their triumphant arrival in France, running out of fuel again forced them to land the plane on a beach in Mimizan in the Landes. The airmen were energetically welcomed as heroes. While waiting for fuel to be delivered to them by road from Cazaux, the adventurers went to the Hotel of France nearby in order to recuperate. They took off the same day for le Bourget, near Paris.

The crew was received in triumph, and left with the Canary Bird for a tour in Europe. In 1932, the aircraft was purchased by the government to be displayed and preserved in the Musée du Bourget.

Above: A sketch of the airplane signed by the three airmen in 1929. Image credit: Guy villeminot.

Commemorative Monument on la Plage des Ailes (the Beach of the Wings)

On the proposal of the President of the Aero Club of the Landes, a monument was erected and inaugurated on August 21, 1931, on Mimizan Beach. The beach came to be known as la plage des Ailes (the Beach of the Wings). The street coming down from the monument bears the names of three airmen. Honoring this first crossing, Mimizan is officially twinned with Old Orchard Beach (Maine) since June 16, 1989. ■

Above: French airplane (Bernard 191 GR "Oiseau Canari," ["Canary Bird"]). Location: Bourget Museum in France. Image credit: Deep silence (Mikaël Restoux).

[June 16, 2014]

Our Horizons team sends thanks to the following website owner for the use of the images of the two postcards below:

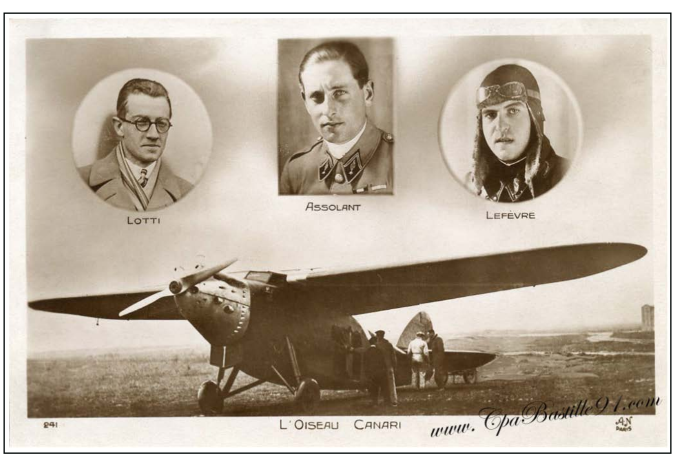
www.cpa-bastille91.com

This website page also includes a video of Mr. Lotti describing this adventure.

Another website presents images of the American stowaway, Arthur Schreiber.

Cartes Postales Anciennes
Cartes Postales Anciennes de Bastille91

www.cpa-bastille91.com



AIAA Houston Section Annual Technical Symposium (ATS 2014)

Douglas Yazell, Horizons Editor

[June 16, 2014]

Our Section's Annual Technical Symposium (ATS 2014) was a great success on Friday, May 9 2014, at NASA/JSC Gilruth Center. General Chair Clay Stangle did an outstanding job. This event already has its own *page* on our Section's website, featuring event documents and charts from some of the presenters.

The members of the organizing committee were Ellen Gillespie, Michael Frostad, Michael Martin, BeBe Kelly-Serrato, Irene Chan, Laura Sarmiento, Douglas Yazell, Ben Edwards, and our Section's 14 technical committee Chairs shown on our organization chart on our Section's *website*. Our program document shows that our corporate sponsors were AIAA Houston Section, NASA, and Jacobs.

Our morning keynote speaker was Pete Hasbrook: *the State of the International Space Station (ISS)*. Our luncheon keynote panel members were two former NASA astronauts, Chris Ferguson and Lee "Bru" Archambault, and Arturo Machuca from the Houston Airport Director's Office. The panel moderator was BeBe Kelly-Serrato.

From 9:00 AM to 11:45 AM we enjoyed two consecutive technical sessions in 75-minute segments using four rooms concurrently. We scheduled only one afternoon session, from 1:45 to 3:00 PM, again using four rooms. The International Council on Systems Engineering (INCOSE) organized all three of the sessions in the Lone Star room, with scheduled speakers Courtney Wright, Tony Williams, Ken Robinson, and Wayne McCandless.

Rice Professor Daniel Cohan and Adrian Shelley, Executive Director of Air Alliance Houston made presentations in the two climate change sessions organized by Douglas Yazell. Roger Kleinhammer, our Section's Safety & Mission Assurance (S&MA) technical committee Chair, organized two S&MA sessions with six presentations planned. Dr. Steven Everett, our Section's Guidance, Navigation & Control technical committee chair, was the session chair for two sessions including Alex Monchak and Dr. Kumar Krishen.

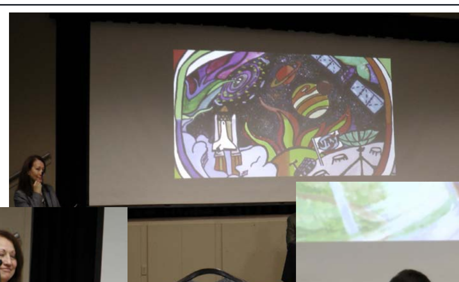
Dr. Zafar Taqvi was the session chair for speakers Dr. Paul Frenger, MD, Fatih Karabacak, and Ted Kenny. Mr. Kenny is our Section's History technical committee Chair. He spoke about his audiobook project, Suddenly Tomorrow Came, being created from the NASA book written by Henry C. Dethloff.

Dr. Albert A. Jackson IV, our Section's astrodynamics technical committee Chair, was the session chair for presentations by Wes Kelly, Triton Systems LLC, John DiIorio, and Dr. Gary Turner. Dr. Turner, our Section's College and Co-op Chair, spoke about Stability of Lunar Distant Retrograde Orbits.

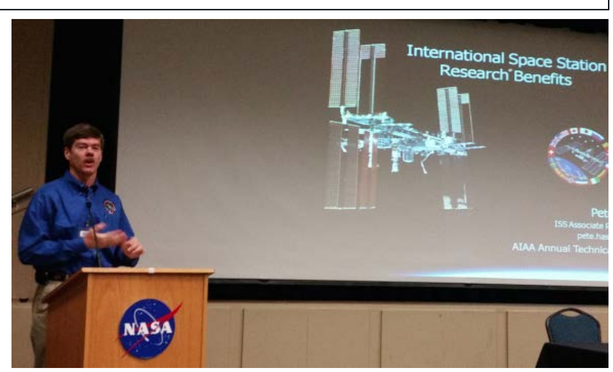
Dr. Larry Friesen was the session chair for presenters Dr. Patrick Rodi (an occasional Horizons contributor), Terry Hill (NASA/JSC, one of our INCOSE speakers), and Dr. Michele Carpenter.

Thanks to the many people and organizations that made this event possible. We look forward to ATS 2015. ■

Top to bottom: Dr. Kumar Krishen, Clay Stangle, and Wes Kelly. Image credits: Douglas Yazell.



Left to right: BeBe Kelly-Serrato, Lee Archambault, Arturo Machuca, and Chris Ferguson. Image credits: Ellen Gillespie.



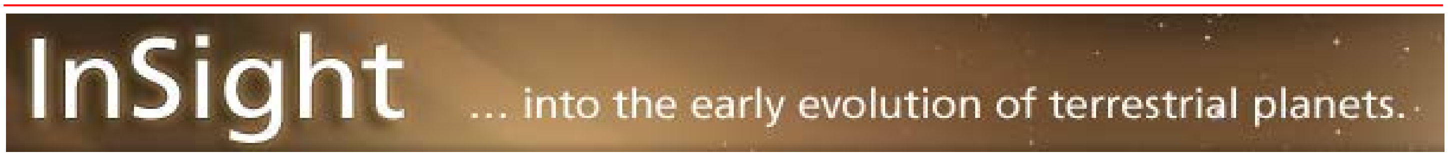
Right: Morning keynote speaker Pete Hasbrook. Image credit: Dr. Steven Everett.

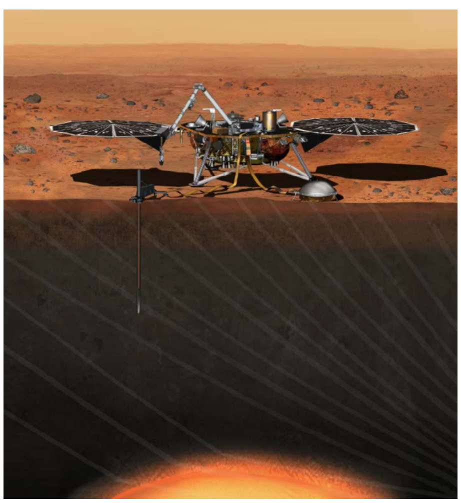
Staying Informed

[Horizons, June 5, 2014]

The NASA *press release* for SWOT is dated May 2, 2014, including the above photograph of the signing ceremony with Mr. Bolden and Mr. Le Gall. That headline refers to this Global Water and Ocean Surface Mission. Initial studies in France and the USA started in 2009. Launch is planned for 2020. Part of the science mission for this satellites relates to climate change.

Above: NASA Administrator Charles Bolden, left, and Centre National d'Études Spatiales (CNES) President Jean-Yves Le Gall sign an agreement to move from feasibility studies to implementation of the Surface Water and Ocean Topography (SWOT) mission, Friday, May 2, 2014 at NASA Headquarters in Washington. Image credit: NASA/Bill Ingalls.





Above: Artist's Concept of InSight Lander on Mars

This artist's concept depicts the stationary NASA Mars lander known by the acronym InSight at work studying the interior of Mars. The InSight mission (for Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) is scheduled to launch in March 2016 and land on Mars six months later. It will investigate processes that formed and shaped Mars and will help scientists better understand the evolution of our inner solar system's rocky planets, including Earth.

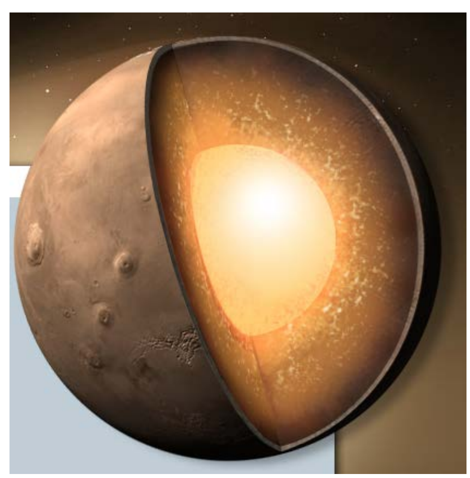
InSight will deploy two instruments to the ground using a robotic arm: a seismometer (contributed by the French space agency Centre National d'Etudes Spatiales, or CNES) to measure the microscopic ground motions from distant marsquakes, providing detailed information about the interior structure of Mars; and a heat-flow probe (contributed by the German Aerospace Center, or DLR) designed to hammer itself 3 to 5 meters (about 16 feet) deep and monitor heat coming from the planet's interior. The mission will also track the lander's radio to measure wobbles in the planet's rotation that relate to the size of its core and will include a camera and a suite of environmental sensors to monitor the weather and variations in the magnetic field. Lockheed Martin Space Systems, Denver, is building the spacecraft.

InSight is part of NASA's Discovery Program of competitively selected solar system exploration missions with highly focused scientific goals. NASA's Marshall Space Flight Center in Huntsville, Ala., manages the Discovery Program for the agency's Science Mission Directorate in Washington. NASA's Jet Propulsion Laboratory, a division of the California Institute of Technology, Pasadena, manages InSight for the NASA Science Mission Directorate. For more information about InSight, visit: http://insight.jpl.nasa.gov. Additional information on the Discovery Program is available at: http://discovery.nasa.gov.

Release Date: March 26, 2014. Credit: NASA/JPL-Caltech.

News for May 19, 2014: Construction to Begin on 2016 NASA Mars Lander.

CNES press release link of May 22, 2014.



The Experimental Aircraft Association (EAA) Chapter 12 (Houston)

Mission

The EAA's Chapter 12, located at Ellington Field in Houston, Texas, is an organization that promotes all forms of recreational aviation. The organization includes interest in homebuilt, experimental, antique and classic, warbirds, aerobatic aircraft, ultra lights, helicopters and commercially manufactured aircraft and the associated technologies.

This organization brings people together with an interest in recreational aviation, facilitating social interaction and information sharing between aviation enthusiasts. Many of the services that EAA offers provide valuable support resources for those that wish to develop and improve various skills related to aircraft construction and restoration, piloting, aviation safety and aviation education.

Every individual and organization with an interest in aviation and aviation technology is encouraged to participate. (EAA membership is not required, but encouraged.) Meetings are generally from 6:30 PM to 9:00 PM at Ellington Field in Houston Texas. We welcome everyone. Come as you are and bring a guest; we are an all-aviation friendly organization!

Profiles in General and Experimental Aviation

(1) Lance Borden (Horizons *May 2011 issue*)
(2) Paul F. Dye (Horizons *July/August 2011 issue*)
More profiles will appear as soon as possible. Thanks to Richard Sessions (EAA Chapter 12) for suggesting this series.

Ideas for a meeting? Contact Richard at *rtsessions[at]earthlink.net.*
Another email contact: *eaachapt12[at]gmail.com.*
Experimental Aircraft Association (EAA) web site: *www.eaa.org*.
Chapter 12 web site: *www.eaa12.org*. Meeting dates are noted on their calendar.

Scheduled/Preliminary Chapter 12 Event/Meeting Ideas and Recurring Events

1st Saturday of each month – La Grange TX BBQ Fly-In, Fayette Regional (3T5)

1st Saturday:	Waco/Macgregor TX (KPWG), far east side of field, Chapter 59, pancake breakfast with all the goodies 8-10 AM, Dale Breedlove, jdbvmt[at]netscape.com
2nd Saturday:	Conroe TX Ch. 302 10 AM Lone Star Builder's Ctr Lone Star Exec.
2nd Saturday:	Lufkin TX, Fajita Fly-In (LFK)
2nd Saturday:	New Braunfels TX, pancake Fly-In
3rd Saturday:	Wings & Wheels, 1940 Air Terminal Museum, Hobby Airport, Houston TX, *www.1940airterminal.org*
3rd Saturday:	Jasper TX BBQ lunch, Fly-In (JAS)
3rd Saturday:	Tyler TX, breakfast fly-in, 8-11 AM, Pounds Field (TYR)
4th Saturday:	Denton TX, Tex-Mex Fly-In
4th Saturday:	Leesville LA, Lunch Fly-In (L39)
4th Saturday:	Shreveport LA, Lunch Fly-In (DTN)
Last Saturday:	Denton TX, Fly-In, 11AM-2 PM (KDTO)

Way to go Dennis!

This is one of the best examples I have ever seen of a Cozy III. He even did it the hard way by re-engineering the entire aircraft to increase its size by 10% to get a little more room. Aircraft Spruce did a great article and you can get all the details.

Way to go Richard!

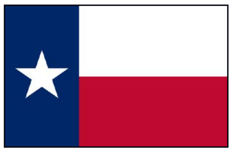
I have always struggled with which plane to build and now perhaps I am wishing that it had been this one. His attention to the little details is just insane. Our hats are off to you. Plus it has an a/c!

[May 26, 2014]

The two images above are taken from the EAA12 members' *page*. We would like Dennis Butler to be the next person in our series of profiles in Horizons, and the Aircraft Spruce *article* above already started that process! Home base for EAA12 is Ellington Field near NASA/JSC. The *source* for the image about Ellington Field (right) is: *www.waymarking.com*. ■

The 1940 Air Terminal Museum at Hobby Airport An AIAA Historic Aerospace Site

Douglas Yazell, Editor

Above: [Colorado](#) and [Texas](#) flag images from Wikipedia copyright-free images.

A bimonthly column about the 1940 Air Terminal Museum, a 2008 addition to the list of AIAA Historic Aerospace Sites. The museum is restored and operated by the non-profit Houston Aeronautical Heritage Society.

1940 Air Terminal Museum
8325 Travelair Street
Houston, Texas 77061
(713) 454-1940
www.1940airterminal.org

[May 22, 2014]

Specialty planes from Southwest Airlines make enthusiastic planespotters of everyone. Colorado One and Texas One recently passed through Hobby Airport.

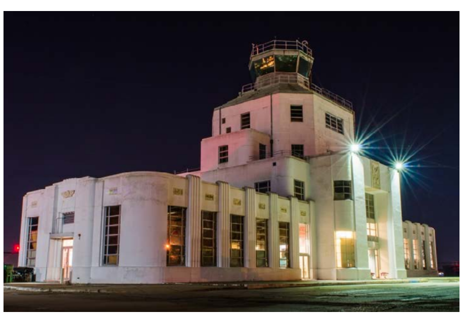
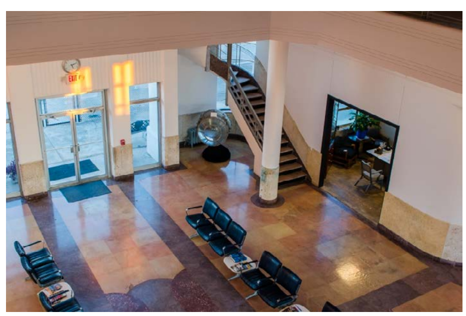
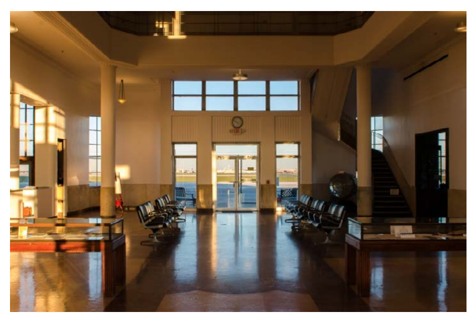
AIAA Houston Section will occasionally use the 1940 Air Terminal Museum for Section events. The atrium is the huge room on the ground floor. Using the museum as the venue for Section events will be a nice change of pace now and then for Section members and other attendees at our events.

Meanwhile, be sure to visit the 1940 Air Terminal Museum at Hobby Airport often. The museum is closed Mondays. Hours of operation are 10:00 AM to 5:00 PM Tuesday through Saturday, and 1:00 to 5:00 PM Sundays. Admission is $5 for adults and $2 for children. For those who choose to go the extra mile by becoming members of this museum, the annual membership rates are $25 for Student Members, $50 for Observation Deck Members, and $80 per family for Family Members.

Wings & Wheels events usually take place on the third Saturday of the month, scheduled from 11:00 AM to 3:00 PM. Admission is $7 for adults and $3 for children aged 12 or less. Lunch meals are usually available for purchase from a gourmet food truck such as Flaming Patties.

September 28, 1940, was the date of the dedication of the new 1940 Air Terminal and the date of a public ceremony. The Terminal was a project of the WPA, the largest and most ambitious New Deal Agency. Let us celebrate that heritage often! ■

Above: Southwest's Colorado One from a Southwest blog entry. Below: Images from the 1940 Air Terminal Museum's website.

Climate Change and Local Respones

Douglas Yazell, Article #9 in this Bimonthly Series

[June 16, 2014]

Gavin Schmidt TED Talk

An excellent new climate change TED (www.ted.com) presentation (Technology, Education & Design) appeared in March of 2014. The author is Gavin Schmidt, and the title is *The Emergent Patterns of Climate Change*. The length is less than 13 minutes. The ending focuses on three very different results we might obtain by the year 2099 with climate change. Those results depend on which of three choices we make, *Business-As-Usual, Some Mitigation, or Aggressive Mitigation.*

Moyers & Company

The website for this excellent PBS television program is *www.billmoyers.com*. A new article on the website is *Six Things Michael Mann Wants You to Know about the Science of Global Warming*. Each of these six points is essential for everyone to know, and #4 is *If Anything, Global Warming is Probably Worse than Scientists Say*.

Another new website article is *Five Things You Need to Know about the Obama Administration's Carbon Caps*, by John Light. Item #4: *This Could Help the US Become a Global Leader on Climate Change*.

Morning Reads of June 6, 2014, contains this item: *Catastrophic ideology*: The Texas GOP's new platform urges "government at all levels to ignore" global warming, according to Ari Phillips at ThinkProgress.

Cosmos: A Spacetime Odyssey

Climate change is mentioned in a few of the 13 episodes of this excellent new weekly television *series* seen on Fox TV and National Geographic television channel. Episode 12 (June 1, 2014), *The World Set Free*, is devoted to climate change. Host Neil deGrasse Tyson and the writers (Ann Druyan and Steven Soter) use strong language to communicate the challenge of climate change.

Author Naomi Oreskes

Merchants of Doubt is the 2010 book from *Naomi Oreskes* and *Eric M. Conway*.(Those two links are for Wikipedia articles about those two people, including the fact that Conway is the historian at NASA Jet Propulsion Laboratory.) The introduction for *Merchants of Doubt* describes attacks on climate scientist Ben Santer led by two retired physicists, Frederick Seitz and S. (Siegfried) Fred Singer. The introduction explains that Santer was the author of Chapter 8 of *Climate Change 1995: The Science of Climate Change*, the Second Assessment Report issued by the Intergovernmental Panel on Climate Change (IPCC) of the United Nations. The title for Chapter 8 is *Detection of Climate Change and Attribution of Causes*. It "summarized the evidence that global warming really was caused by greenhouse gases." The introduction to *Merchants of Doubt* explains that Seitz and Singer also participated in a program to discredit scientific evidence linking tobacco to cancer.

I recently enjoyed two YouTube videos featuring author Naomi Oreskes. One video (about 3 minutes long) features Oreskes confronting Nick Minchin about climate change, and the other video, more than an hour long, features Oreskes discussing Merchants of Doubt at the University of Rhode Island on March 3, 2010.

C40 Cities Climate Leadership Group

[June 5, 2014] *C40 Blog*

Houston to Convert All Streetlights to LED -- a "Big Win" for City's Greenhouse Gas (GHG) Emissions Reduction Goals

Houston Mayor Annise Parker announced last week that the city of Houston will convert 165,000 streetlights to low emissions LED lights – making it the largest project of its kind in the US. Replacing the lights will reduce the city's streetlight energy usage by 50 percent, cut municipal greenhouse gas emissions by five percent and save the city an impressive $28 million.

Cohan and Shelley at ATS 2014

I send my sincere thanks once more to the two speakers for the two climate change sessions (75 minutes each) I organized for our AIAA Houston Section Annual Technical Symposium (ATS 2014) of May 9, 2014, at NASA/JSC Gilruth Center. Professor Daniel Cohan teaches climate science, among many other tasks, at Rice University in Houston. Adrian Shelley is Executive Director of Air Alliance Houston. Their charts are available via the ATS 2014 *page* on our Section's website. My guest for a climate change session for ATS 2013 was Texas A&M University Professor Nielsen-Gammon.

Let's continue the tradition of organizing climate change sessions at our Section's Annual Technical Symposium. Urgent action is required (keeping in mind the AGU *position statement*), and climate change is central to NASA and its Earth observation satellites. AIAA formed in 1963 by merging two existing groups (one focused on rockets, and one focused on aeronautical sciences). NASA, created in 1958, is also focused on those subjects (aeronautics and astronautics). Climate change fits well with both NASA and AIAA.

In fact, just as NASA demonstrates courage, leadership, and excellence with its *http://climate.nasa.gov* website, AIAA (at all levels, Section, Region, national and international) is well-positioned to do more in response to the challenge of climate change. With 35,000 members and 100 corporate members, AIAA can publish climate change position statements and organize climate change events. With our AIAA public policy work, AIAA can demonstrate climate change leadership in ways that NASA cannot.

The United Nations IPCC

From the Wikipedia *article*:

The United Nations Climate Change Conference, COP21 or CMP11 will be held in Paris, France in 2015. This will be the 21st yearly session of the Conference of the Parties (COP 21) to the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the 11th session of the Meeting of the Parties (CMP 11) to the 1997 Kyoto Protocol. The conference objective is to achieve a legally binding and universal agreement on climate, from all the nations of the world. Leadership of the negotiations is yet to be determined. ■

James C. McLane, Jr. 1923-2012

Address to AIAA Houston Section about the late James C. McLane, Jr., Part 6 of 6

James C. McLane III, from the Presentation of June 13, 2013

The Chamber A Door Disaster

The first time the air was pumped out of Chamber A, its huge 40-foot diameter door bent and buckled off its mountings. The structure had failed due to bad design. Fortunately, the damage was minimized by halting the test before there was a more dramatic collapse of the entire facility. Chamber A was unique and it was needed for testing of the Apollo Command and Service Module. The door was hurriedly repaired and beefed up with extra braces. Finally, the facility was ready for manned tests. By this time my dad was the Chief in charge of the Space Simulation Division, one of the largest parts of the Manned Spacecraft Center.

The repairs to the chamber had cost a lot of money and the failure resulted in lawsuits. The chamber had been built by Chicago Bridge and Iron Company (CB&I) and the design engineering firm was Bechtel. CB&I had just begun to market those now-familiar water tanks shaped like giant golf balls on tees. Bechtel engineers had used a CB&I computer program to analyze stresses on the giant dish door and its frame, and it was those parts that had failed. NASA had overseen all the engineering and approved of the design approach. So exactly who was responsible?

Finally a visiting federal judge came out to my dad's office in Building 32 and convened a sort of portable court. Representatives and lawyers from all parties were present. Evidence and arguments were presented, the portable court rendered a judgment, and the government recovered some of the cost of repairs.

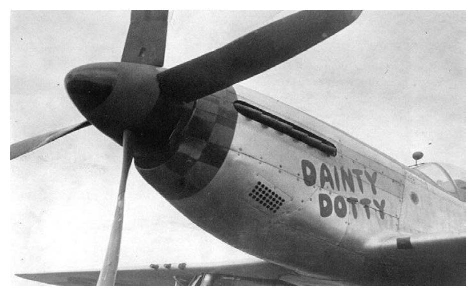
Secret Stuff

One day my dad was called to the Center Director's office for a special meeting. Somebody (I assume it was a government agency, but I never learned.) wanted to test something secret in JSC's giant space simulation Chamber A. Back then, a fair number of NASA employees had security clearances because military rockets had been used for Mercury and Gemini, and the upcoming Space Shuttle was being designed to carry military payloads.

However, no one at NASA Johnson Space Center (JSC), up to and including the Center Director, had a high enough security clearance to even talk to these folks about what they wanted to test in daddy's chamber.

The first order of the day was for my father to have a background check so he could get the required special security clearance to talk to these people. I know this involved interviewing our neighbors since they mentioned it to us.

My father never discussed this project with me except to mention some of the peculiar aspects of the test setup. The chamber was scheduled to be used for a week. While it took dozens of people to



operate the chamber, most of these folks did not need to have security clearances. The chamber windows were blanked shut and the operators of the valves and controls could not see inside.

One day the world's largest airplane, a Lockheed C5A Galaxy flew into Ellington Field. The heavily draped test object was carried by flatbed truck up Highway 3 (Old Galveston Road) and into the back gate at JSC. My dad said that security guards forced the car of one frustrated commuter into the ditch on Highway 3 when the commuter attempted to pass the convoy. After a week of tests, the object was returned to Ellington Field, loaded back on the C5A, and flown away. The top secret exercise was soon forgotten.

Years later my father became interested in the Chinese space program. He communicated with and was close to many Chinese engineers and he visited China five times. Occasionally, a lady would park her car a block away from our house and walk down the street to visit my father. I met her once. Apparently she was from a national agency that accumulated intelligence, and she came to ask my father questions about China. He was always happy to oblige his "secret sister," as he called her. But, he could only provide information on what he saw as a space program tourist, and he had absolutely no inclination to be involved in geopolitics.

In the late 1970's, when I worked for Brown and Root, my group was building an oil tanker dock in Basra Iraq. Every person who returned from Iraq would have to report downtown to a room in the Rice Hotel, where they would be interviewed about what they saw in that rather mysterious country. I guess my dad's visit by his "secret sister" was that sort of thing.

Experts say that the United States of America beat the Soviets to the Moon because we spent five times what they spent on ground testing. There is no doubt that problems discovered during space chamber testing at JSC would have been catastrophic if they had happened during an actual mission.

The importance of such testing has not

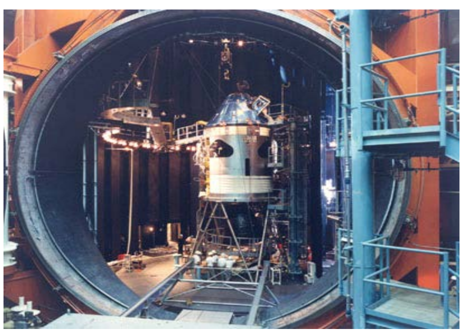
James C. McLane, Jr.
1923-2012

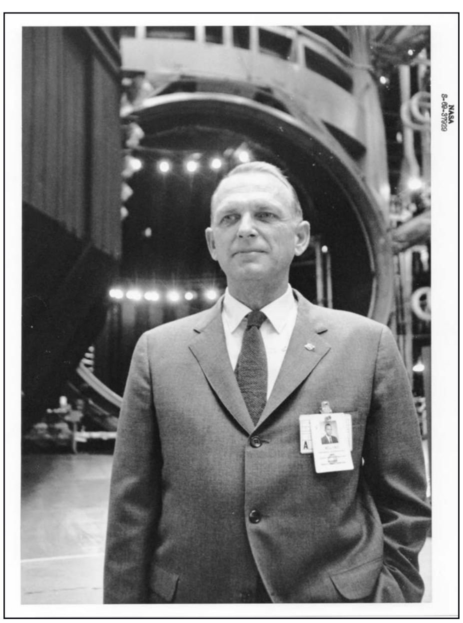
been lost on current engineers who plan to use Chamber A to test the new James Webb Space Telescope.

I was studying aerospace engineering at college during the 1960's, but I was often home on weekends and in the summer. My father took me to see a lot of the work that went on at JSC. It was a special time and there was tremendous enthusiasm in the air. The Manned Spacecraft Center was at the core of a great human endeavor that everyone understood would be historic. I am very proud that my father played a part in that effort. My dad kept excellent files on his work that I may eventually use as a basis for stories and articles. There are literally a thousand and one stories I could tell about his experiences. I appreciate this group giving me the time to recite a few.

Thank you,

Jim McLane ■





The JSC Astronomical Society

Building an Astronomer's Chair Complete with Sketch Desk and Red Lighting (Part 7 of 7)

Jim Wessel, JSCAS Educational Outreach Chairman

The JSC Astronomical Society (JSCAS)
www.jscas.net

This article first appeared in the March 2011 issue of Starscan, the JSCAS newsletter.

This Issue: A Final Conclusion.

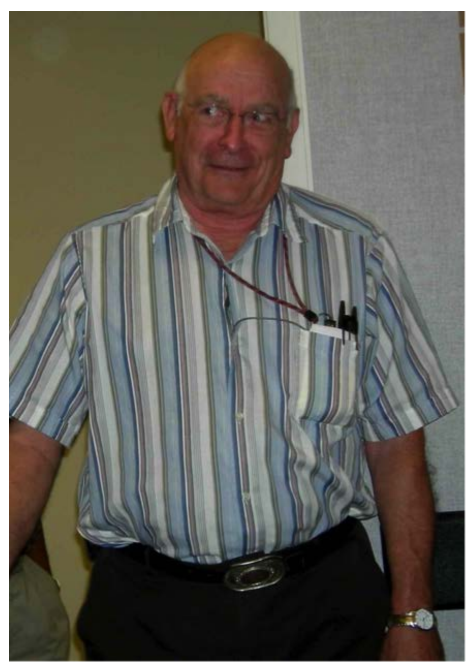
Hindsight is 20/20 vision

1. I should have made the attachment site under the seat larger to nearly the same size as the plastic seat bottom. This would have increased the strength of the armrests (the fulcrum point between the lever of the armrest would have been further out towards the bend). The pound or so of weight increase would have been worth the increased rigidity and stability of the armrests. If, for whatever reason my manufactured boat seat is compromised, I will likely bite the bullet financially and completely design my second generation seat from scratch and in doing so increase the bottom attachment site as a result.
2. I could have saved myself about $15.00 had I of bought the final thicker metal armrest supports first, rather than finding out after the first attempt that the initial thinner set wasn't up to the job. If you are going to build armrests for your chair, do yourself a favor and get the thickest metal supports that you can actually bend right from the start.
3. I wish I would have painted the seat attachment wood, armrest supports, and armrests proper as individual components BEFORE assembling them. Disassembling the parts of the attachment site on the underside of the seat might cause stripping inside the four screw housings inside the plastic base of the boat seat, so it was not done. Likewise, painting the footrest first before attaching the rope would have been a bit neater too. This is purely a cosmetic issue and doesn't detract from the final construction.
4. Ideally, I would have designed the finalized red LED light system before completing the stool. John and I had the stool completely built before we thought idea #1 about incorporating some sort of protective lighting system to prevent tripping in the dark from the spread out "feet" of the stool. This meant disassembling a few parts of the pedestal and it also meant touching up paint afterwards. Both were relatively cosmetic, but they both required some effort, all the same.

Render unto Caesar the things which are Caesar's…

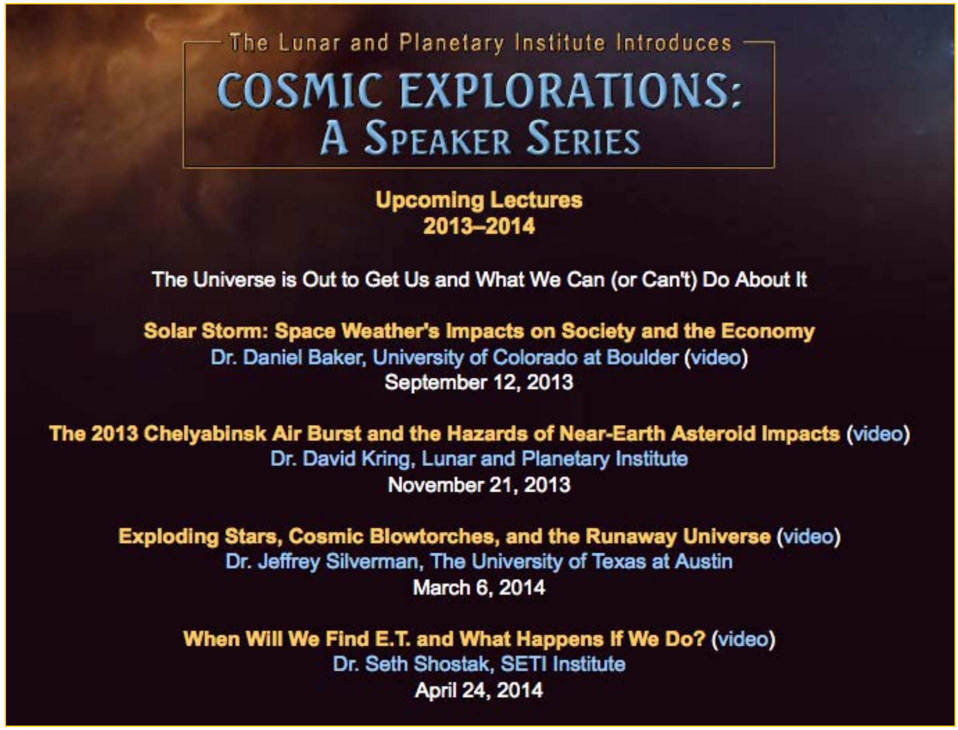
To say that I owe John Boyd a debt is an understatement. A few years ago, he allowed me to use his Celestron 8" CPC SCT and all the accessories. With it, I rekindled my enthusiasm for viewing the nighttime sky, and successfully completed my Double Star observing certification through the Astronomy League. Even now that I have my own telescope, John continues to allow me the use of some of his eyepieces so that I have a more diverse set for use. To this day we exchange magazines which allow me to keep up to date in astronomy without having to pay for my pursuit of my passion out of pocket. And now he gives me this latest gift, his unwavering attention to detail and woodworking craftsmanship that resulted in an outstandingly functional astronomy stool that will likely be passed from me to my daughters as they develop their own interests in stargazing. For this, and your continuing friendship John, I say "THANK YOU." This wonderful tool would not have had its polish or precision without your input and effort.

Here's a candid picture of the master craftsman himself, John Boyd:



The Finale

Here is the total assembled stool, foot rest, desk, red LED lighting system, and desk lighting system. It was a lot of fun to build and I look forward to many years of its use. ■



Above: [June 16, 2014] Upcoming presentations for 2014-2015 in this lecture series in the Houston Clear Lake area will be announced as soon as possible. Details will be available using the link below. (Archived video recordings are also available there.)

www.lpi.usra.edu/education/lectures/

JSC Astronomical Society (JSCAS) Calendar
Upcoming Events from the JSCAS Calendar (Updated June 4, 2014)

The JSCAS calendar: use the calendar link at www.jscas.net.

JSCAS meetings are held on the second Friday of every month at 7:30 PM in the auditorium of the USRA building (almost always at this location): 3600 Bay Area Blvd, at the SW corner of the intersection with Middlebrook Drive.

2014

This issue of Horizons will be online by June 30, 2014.

July 11 (Friday): Dr. Dan McDonald. Gravity Waves and the Big Bang
August 8 (Friday): Speaker and presentation subject to be announced (TBA)
September 6 (Sat.): LPI SkyFest (International Observe the Moon Night), 8-10 PM
September 12 (Friday): Speaker and presentation subject to be announced (TBA)
September 27 (Saturday): Haak Winery Star Party
October 10 (Friday): Speaker and presentation subject to be announced (TBA)
October 18 (Saturday): Families and Flashlights at Pearland Independence Park
October 18 (Saturday): LPI SkyFest (Sunset 6:48 PM)
October 23-26 (Thursday - Sunday): JSCAS trip to Fort McKavett
November 7 (Saturday): All Clubs Meeting, 7:00 PM, at the HMNS
November 8 (Sunday): Astronomy Day at the George Observatory (tentative)
November 14 (Friday): Speaker and presentation subject to be announced (TBA)
December 12 (Friday): Speaker and presentation subject to be announced (TBA)

Universities Space Research Association
USRA

Lunar and Planetary Institute

Challenges of Traveling to Mars

Dr. Stanley G. Love, NASA/JSC, Edited by Douglas Yazell, Horizons Editor

[June 2, 2014, from the audio recorded on May 9, 2014]

[Horizons Editor: The transcript from my smartphone audio recording is edited to less than one tenth of its length in order to create this article. Images used in this article are images I selected from NASA websites after the presentation.]

My name is Stan Love. My background: I have a degree in physics from Harvey Mudd College and a masters and PhD in astronomy from the University of Washington. I worked a couple of post-docs doing meteorites and impact physics before I got hired here as an astronaut. I have been here working since 1998. I flew on space shuttle mission STS-122.

My purpose tonight is to explain why we are not here [on Mars] yet! There are a bunch of reasons, primarily that it is really expensive because it is really hard. It's not just that flying to Mars is hard. Understanding why flying to Mars is hard, is hard! It really does take a rocket scientist. [I am happy to see some children in the audience.] ... we need to turn you all into rocket scientists.

We're going to do this in three steps. First we will talk about Low Earth Orbit (LEO), fairly close to home and fairy easy to understand. Then we will talk about flying to the Moon, and finally, Mars.

Traveling to Low Earth Orbit (LEO)

Some people would guess, if asked, that the International Space Station (ISS) is halfway to Mars! No! Earth is a ball about 8,000 miles in diameter. The ISS is 250 miles up, barely above the cloud tops!

Getting up into space is not that hard. The Germans were doing it in the 1940s, launching V-2 rockets to London and Antwerp. Those went up into space. They were the first man-made objects in space. The hard part is staying there.

Going forward that fast, so fast that by the time you would hit the ground you would be over the horizon, requires a good head of speed. When you work out all of those algorithms, you get about 20,000 miles per hour (mph). That's how fast you must be going. There is some fine print. If you listen to NASA Public Affairs Office, they always use the figure 17,500 mph. That is the speed using a stopwatch for the ISS to go between two points in its orbit.

Traveling to the Moon

It's 1,000 times further, but it is not 1,000 times harder, because the problem of going to the Moon is not the distance, it is the *speed*. You need an awful lot of speed to get into LEO, even more to get to the Moon and back. So let's total it up and see what we get.

To launch from the Earth, you need 20,000 mph to get into LEO. That is sort of the first step in our ladder to get to the Moon. Once in LEO, you burn another rocket engine to give you about 8,200 mph, to send you off on your trajectory to the Moon. Once you are on your way to the Moon, once you get close, if you don't do something to slow down, since there is no friction in space, you will fly right by the Moon and go out the other side [and perish], or you will hit the Moon, and neither one of those things is good: 2,000 mph to slow down. Once you are in orbit around the Moon, you now have to kill off your forward speed around the Moon, so that you can land. That takes about 3,900 mph. You begin the burn to slow down. That will send you down toward the surface.

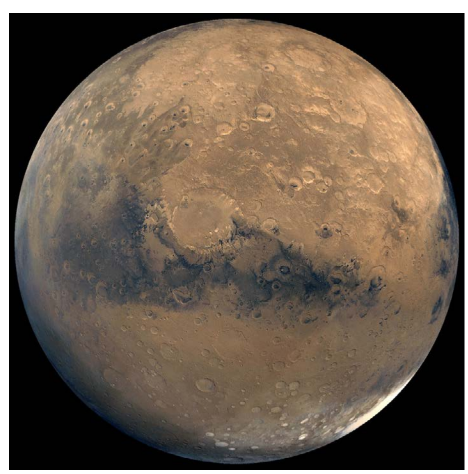
That is good to land on the Moon, except that now we would like to come back.

The first step in coming home is you have to launch off of the lunar surface and support the weight of your spacecraft while you regain orbital speed around the Moon. That takes 700 mph. If you fail, you don't get off the surface, or you go up part of the way, and crash on the surface and perish.

Once safely away from the surface, you have to re-achieve orbital velocity around the Moon, 3,900 mph. If you fail in this, you crash on the surface and perish! Once in low lunar orbit (LLO), you have break away from LLO and send yourself back towards the Earth, 2,400 mph. If you fail in this, you don't get away from the Moon, you remain in orbit around the Moon, and you perish! Are you noticing a *theme* here?! [Laughter] This is not a risk-free endeavor!

Once away from the Moon, you fall back toward the Earth. You fall from the distance of the Moon, so when you hit the top of the atmosphere you are going at a really good clip, but here, finally, Mother Nature gave us a break. You don't have to burn propellant to slow down to get back to the Earth because we can use the Earth's atmosphere to slow down. That does not cost us any propellant, but we do have to carry a big heat shield, because the temperature of the compressed air, when you come into the atmosphere at Mach 35, is 18,000 degrees Fahrenheit.

For a soft landing on the Earth, you also get a break from the atmosphere. You can put out a parachute. You don't have to burn any propellant to support the weight of your ship. The parachutes will do that for you. You land in the water. It does not cost any propellant, but let's add it all up: 42,000 mph! Wow! Remember, just getting to orbit was 20,000 mph, and that took 95% of



Above: Mars. Image credit: NASA.

our weight in propellant to get that to happen. That is why, using this 3,000-ton, 300-foot-tall rocket, we got back *that* [the crew capsule]. That little tiny thing! Everything else was either burned up and thrown out the back or was empty propellant tanks, dead weight, and you cannot afford to carry those.

The inside of that little cone, which weighed about 6 tons, contains our 3 brave explorers. They were gone for about a week, during which time they breathed up about 33 scuba cylinders worth of oxygen.

Traveling to Mars

On to Mars! Let's total up the velocities the way we did for the Moon. 20,000 mph to get us into LEO. This is with our brand new SLS rocket that they are busy working on at Marshall Spaceflight Center. Once in LEO, you burn your engines for 9,000 mph to send yourself away from LEO on the way to Mars. Remember what it was for the Moon? 8,200 mph. 10% more speed takes you to Mars!

Once again, you are able to use the Earth's atmosphere to slow you down, you have a big heat shield, and speeds coming back from Mars are maybe 10% higher than coming back from the Moon. It is not too bad. We can certainly make a heat shield that will handle that. And then once again we have enough atmosphere that you can slow down and use parachutes, it does not cost any propellant. This is an actual drop test of the Orion capsule. Hopefully it will be able to take us to and from the Moon and Mars someday. It is not flying yet. We expect our first test flight coming up this winter.

Add up all of these velocities and you get 48,000 mph. The Moon and back was 42,000 mph. 15% difference! 15%! It's been 45 years since we went to the Moon. We have waited 45 years and have not been able to get 15% more oomph out of our rockets. What's up? The answer is, "It ain't the speed, it's the *distance*." So let's talk about that for a minute.

You add those up and you get about 250 million miles, 1,000 times further out than the Moon, which is 1,000 times further out than the ISS. So the distance we are talking about are a factor of a million greater than our little jaunts to LEO.

Our only option is to wait until the planets line up again so that we can come home.

If you must wait in space, the best place to wait is on a planet.

We are going to re-enter the [Earth] atmosphere and land, and look how long that took! 3 years! You might be able to cut that down to 2 years, but you take more propellant to do it, which means fewer people, less stuff, more risk. We have done the study until we are blue in the face, and it is not really much better to do it that way. When you balance everything out, the longer trip, the slow approach, is not really any worse that doing it the fast way.

32 months in a space capsule! Let's think about that for a minute. The shrinks [psychiatrists] tell us that if we send 2 people to Mars and we lock them up in a little tiny spacecraft for 2 years together, they will kill each other! If we sent 3 people cooped up in a little tiny room for 3 years, 2 of them will gang up on 1 and will kill that one. If we send 4 people, they will gang up 2 on 2 and kill each other. Nobody knows what happens if we send 5 people. 6, we think, is good. That is enough to have a big enough social circle that avoids tensions building up. When the Russians did their Mars 500 experiment…

6 people for 32 months are going to breathe up about 9,000 scuba cylinders worth of air, about 1,200 bottles of water, and 280 grocery carts of food, and for 3 years, I don't recommend bringing the bananas. They are not going to last. What kind of ship do you need to fit all of that?

You don't have to bring fresh water to drink every day if you can recycle your water. That is what they do on ISS. My buddy … calls it turning yesterday's coffee into tomorrow's coffee!

Another thing we can do is try to design stuff that does not break.

We think we can get that ship down to about 100 tons.

Let's remember this picture. A 6-ton capsule going to the Moon. A 3,350-ton rocket to get it there and back. A velocity change of 42,000 mph. Mars and back is 48,000 mph, a little bit more than 42,000 mph. If we want to get 100 tons back from Mars, our launch vehicle, doing the math, is going to weigh about 85,000 tons. That is a lot, but it turns out we have ships that big. [The Avengers, a recent movie, an aircraft carrier…] Notwithstanding what you see on the Avengers, they [aircraft carriers] do not fly!

There are things that we can do to try to make that problem a little easier. First and foremost: heavy lift rocket. I have been working closely with the SLS guys for years now. I am sort of their crew office advocate. I go around telling everybody, heavy lift! We won't leave home without it! … Heavy lift is crucial.

Next, 2001: A Space Odyssey. The ship they sent to Jupiter in the film was nuclear powered. … Nuclear power makes everything easy in the propulsion department. … Sadly, people don't like nuclear power. … Of course, it also means that if something breaks in the back of your ship, you can't go back there to fix it.

We can also be smart about where we stage things. Not all of that mass has to go down to the surface of Mars. You can do stuff in orbit. You can have your habitat. When you get to Mars, you jump in a little capsule and you go land, and

Above: The Jan. 06, 2012, Orion test article water landing drop test. Image credit: NASA.

you habitat does not even stop. It does a flyby on Mars, inserts itself into an inclined orbit around the Sun, it takes half a Mars year to climb up above the orbit of Mars, and then come back down half a Mars year later, and you want to have the surface meet it, and then it does a flyby on Mars and gets sent back to Earth. There are some Mars launch opportunities where you can do that. It is the coolest thing in the world! You can save a ton or propellant by not having to slow that habitat down and then speed it back up again.

Finally, [we have something] … called RESOLVE. It is a little payload that we took to Hawaii about 2 years ago. It is a prototype for a machine that will actually dig up dirt and bake out oxygen that we can use for rocket propellant. If you can make some stuff that you need on Mars, you don't have to bring it there. You don't have to drag it home. It saves a ton of mass.

Life Sciences

That is a lot of rocket science. I like to say, the thing that makes human spaceflight interesting is that it has humans in it. There are some human considerations for flying to Mars and back that go beyond just crew size.

First of all, if you do not use your muscles, they will leave you. … I think we have this problem pretty well licked.

Another thing that happens to you in space… Inside your middle ear, you have all of this balance-sensing machinery, … that tells your nervous system which way down is. When down stops happening, you don't feel so good. … I think we have this problem licked.

Next, as I mentioned before, space has dangerous radiation, which is things like solar storms, and things like supernovas, cosmic rays, … We dislike radiation. … Under normal conditions, you can fly to Mars and back on a normal trajectory, and you can have an elevated risk of cancer when you got older, but you would not die on the way there! Currently, our radiation exposure limits that we have a NASA would not allow that trip. When we do get ready to send people, we will probably have to change the rules …

Just as your muscles will leave you if you don't use them, also your bones, especially your hips, lower back, and legs. … This problem is not yet fully nailed, but we are close.

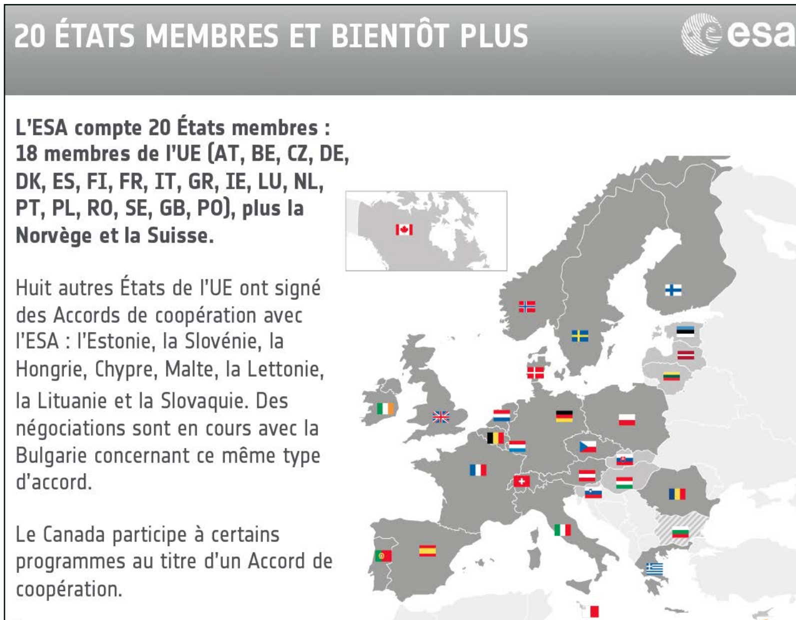
It is fairly common knowledge that when you take a small group of people and isolate them together in a confined environment under a lot of stress, things don't always go well. We are not quite sure what to do about that. … There is hope that we can keep people psychologically supported and happy on a trip like that, despite isolation and the danger.

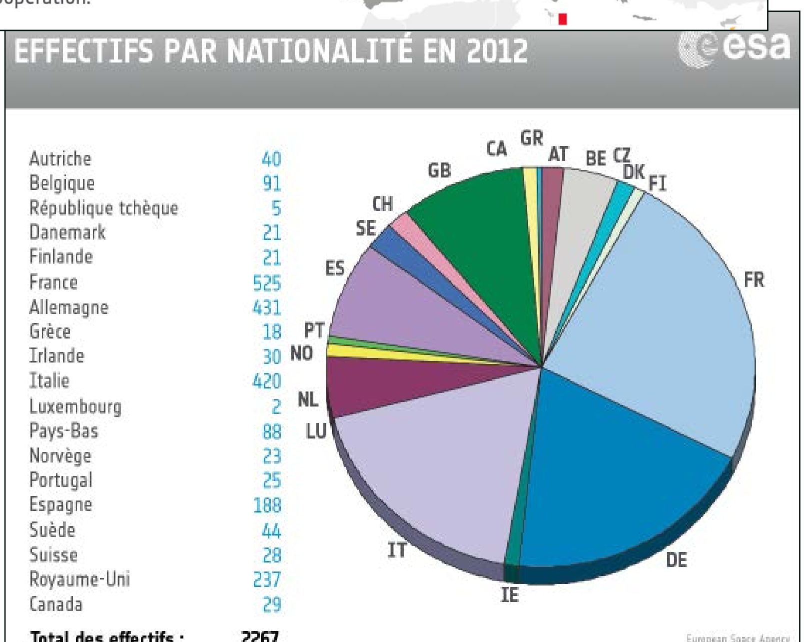
Finally, we just found this out. When you send people up into microgravity for months at a time, they will often come back with permanent bad vision. For a while, we did not realize this because we kept sending people my age up to ISS. I just recently went out and bought my first pair of reading glasses. When you send 40-something guys to the ISS, and they come back, and their vision is not so hot, well, 40-something guys start losing some visual acuity. Then we figured out that, in fact, when you get up into space, the pressure on the fluid that bathes your brain and spinal cord goes way up into unhealthy territory, and that is reflected in the inter-ocular pressure, the pressure in the fluid inside your eyeball. It actually is damaging the back of some people's eyes. That is a permanent change. It is not coming back. We said, "Oh, my God!" Then we went to the Russians and said, "Hey, our guys are coming back with these vision problems. Did any of your guys…?" They replied, "Oh, yes! We knew all about that!" They could have told us! Anyway, they did not tell us! [It is not good] … to fly to Mars, land, and then not be able to read your checklist! We have no idea what to do about this right now. That is why we have the ISS. Crews up there right now are getting ultrasound on their eyeballs. We have the smartest doctors in the world right now working on this problem, trying to figure out how to keep it from happening, or at least mitigate it as much as possible. We still have some time before we are ready to go to Mars, so hopefully they will find a solution.

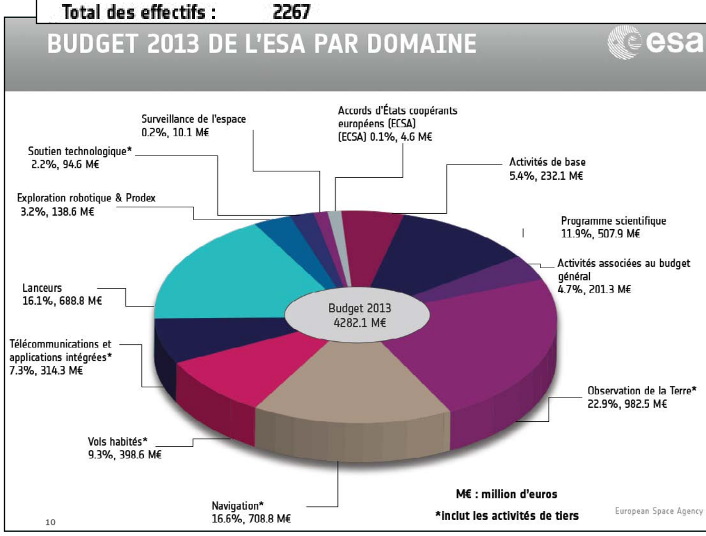
My time is up. You are now all rocket scientists! Let's go to Mars! ■

Above: Scarab is a prototype rover that carries the RESOLVE system, Regolith and Environment Science and Oxygen and Lunar Volatile Extraction. It includes a drill to penetrate soil and can demonstrate small-scale oxygen production from regolith. Technicians are shown changing tires to a prototype lunar wheel developed by Michelin. Credit: NASA.

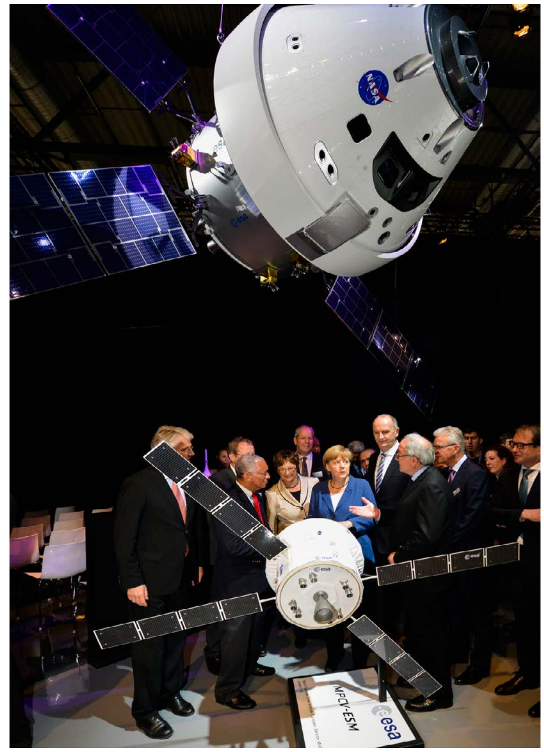
Above: Scarab is shown here on a slope of Hawaii's Mauna Kea. The prototype rover carries a small scale soil to oxygen extraction system. Credit: NASA.



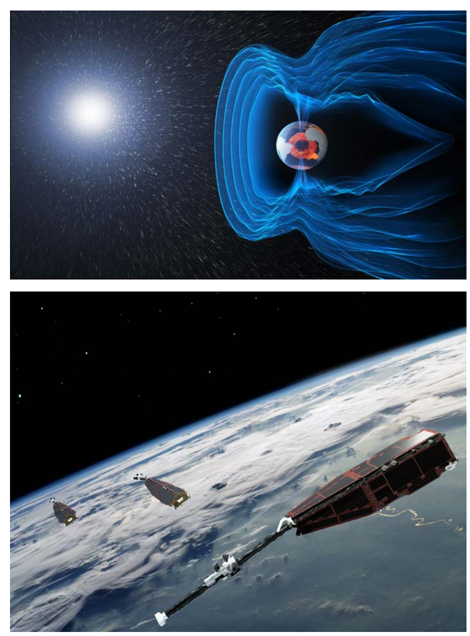




Above: Three charts from the European Space Agency (ESA) presentation available via the link at the top left of this ESA SWARM website page. Image credits: ESA.



Above: Photo highlights from the "Space for Earth'"space pavilion at ILA, the Berlin Air and Space Show, on 20 May 2014. German Chancellor Angela Merkel and the Orion European Service Module are shown. Image credit: ESA.



Above: June 19, 2014. The European Space Agency (ESA) SWARM satellites reveal new data about Earth's magnetic field, which affects everyone in everyday life. Image credits: ESA.

LPSC
March 17-21, 2014

Highlights of the 45th Lunar and Planetary Science Conference

Larry Jay Friesen

[June 22, 2014]

Here are a few notes about things I learned at the 45th Lunar and Planetary Science Conference (LPSC). The conference took place March 17 through 21, 2014, in the Marriott Hotel and Conference Center at the Woodlands. This is the fifth or sixth year the LPSC has taken place at that location. The conference is organized by the Lunar and Planetary Institute (LPI).

This report will be partial and anecdotal; things I individually learned about the Moon, the solar system, and related topics. As usual, the conference had multiple simultaneous parallel tracks of papers going on most of the time, so no one person could hear all the papers. Fortunately, as part of the registration package, each person attending received a flash memory containing the abstracts of every conference paper.

I will present an overview of the conference, then highlight papers. presentations, and discoveries that seemed significant or of special interest.

Overview

The conference really began Sunday evening, March 16. As is typical for LPSC's, as people arrived and got registered, they gathered around and socialized. Drinks and hors d'oeuvres were available. Scientists renewed previous acquaintances, made new ones, networked with each other, and discussed topics of all sorts, some scientific, some not.

Paper sessions, Monday through Friday morning and afternoon, were organized by topic. Topics included various solar system objects, solar system origin, early solar system history, processes, and extrasolar planetary systems. Poster papers, Tuesday and Thursday evening, were organized along similar lines.

Above: Welcome to the 45th Lunar and Planetary Science Conference (LPSC). Image credit: LPSC.

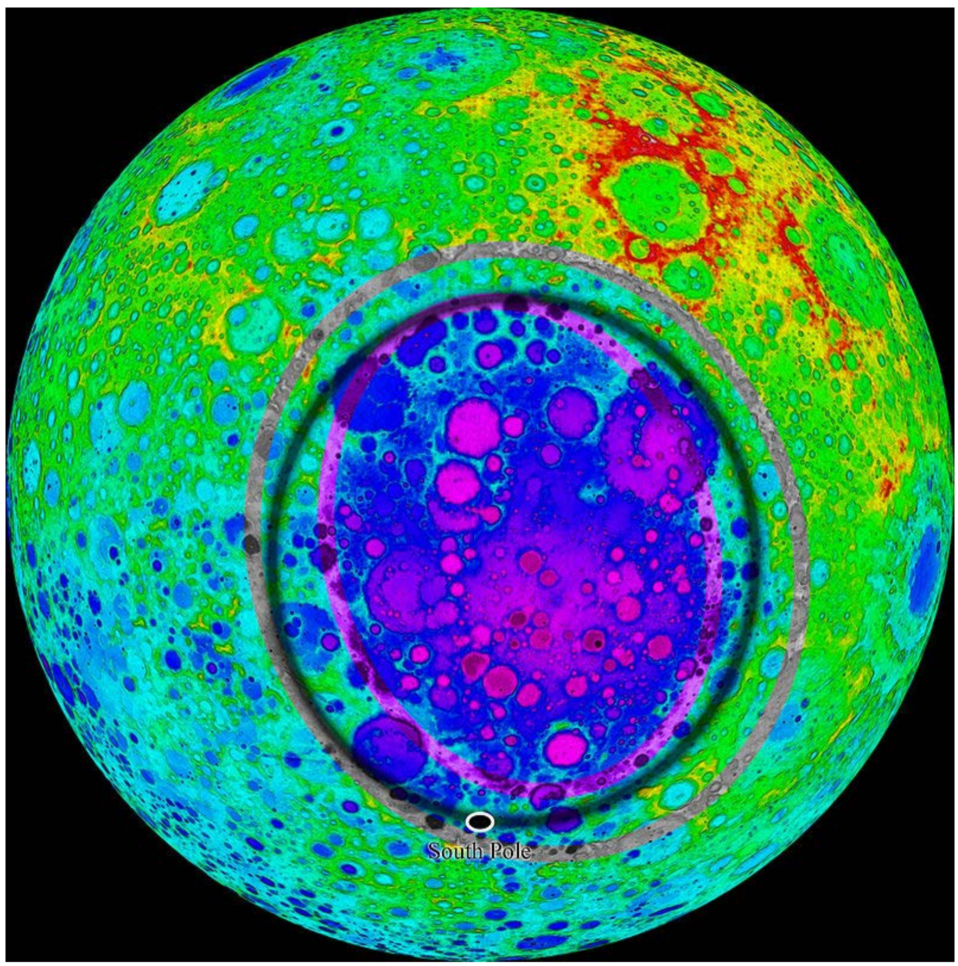
Selected Highlights

I spent most of my time Monday morning at a special session titled: New Perspectives of the Moon: Enabling future missions.

Maria Zuber presented the first paper that morning, with several co-authors. They tried to go to as low as possible with the twin Gravity Recovery and Interior Laboratory (GRAIL) satellites to get a high resolution map Mare Orientale's substructure. They conclude that whatever is going on in the lunar crust in Orientale extends at least as far down as the Moho (that's the boundary region between the crust and the mantle).

Warren and Dauphas infer from GRAIL and seismic studies that the Moon is enriched in FeO, compared to MgO, when compared with Earth's composition. They would like to give priority to heat flow studies. They think this could help resolve the Moon's magnesium composition.

Joliffe *et al.* report that there appears to be an impact melt sea in the interior of the South Pole-Aitken basin (SPA).



Above: Topographical map of the South Pole-Aitken basin based on Kaguya data. Red represents high elevation, purple low elevation. The purple and red elliptical rings trace the inner and outer walls of the basin. (The black ring is an old artifact of the image.) Image credit: Wikipedia (Ittiz).

Iron content is relatively high in the SPA interior, but Clementine and Lunar Prospector data sets don't quite agree. SPA also has a few thorium hot spots, a near lack of anorthosite, and a tremendous magnetic anomaly. The SPA chronology may cover the time interval between 4.3 and 3.9 billion years ago. Some lunar meteorites may come from SPA. Sample returns from this area are needed to resolve some issues.

Hurwitz and Kring reported that the age of SPA is not well constrained. To pin it down, we need samples of material formed *during* the impact event that formed the basin. Models imply that the impact excavated to a depth of up to 100 km. Hurwitz and Kring are convinced that noritic materials observed in the region from orbit are not excavated mantle. Whether they could have formed during the impact depends on when during the Moon's history the impact took place. We need to go *outside* the basin to get quenched impact melt sheet (which would have splashed beyond the basin during the impact process): that would be material formed at the time required to date the event. Hurwitz and Kring propose Schroedinger basin as a place where such impact melt might be found; they especially like the southern wall of Schroedinger.

Mahatni *et al.* looked at the question: How deep and how steep are small lunar craters? They made use of Lunar Reconnaissance Orbiter (LRO) data. The size range they were looking at were craters less than 200 meters in diameter. The depth to diameter ratio was smaller than they were expecting, based on comparisons with larger craters. Highland craters did not have the same range of depth to diameter as mare craters. The craters were shallower and steeper than expected from Apollo results. This transition of depth/diameter appears to come for depths in the range of 10 to 20 meters. Mahatni *et al.* also observed an increase in complexity for small craters compared with larger ones. They were not able to pin down the reasons for these findings conclusively.

Robinson *et al.* reported from LRO observations a new 18 meter crater on the Moon whose location corresponds to a flash observed from Earth on March 17, 2013. They also reported on its field of secondary impacts. They have located splotches of excavated material as far out as 30 km from the crater. There is both high and low reflectance excavated material. Such impact splashes may pose a greater hazard for long lived surface assets than previously anticipated.

Lucey *et al.* report that the Lunar Orbiting Laser Altimeter (LOLA) on board LRO permits measurements of reflectivity as well as altitude. They further report significantly higher reflectivity in permanently shadowed areas near the Moon's poles than in other areas at 1040 nanometers (nm), LOLA's operating wavelength. They discussed three hypotheses as to what caused the difference: differences in porosity of the surface layers, reduced space weathering in the shadowed areas, and ice or frost in the shadowed reasons. From infrared spectra, they infer that both the presence of frost and reduction in space weathering may be involved.

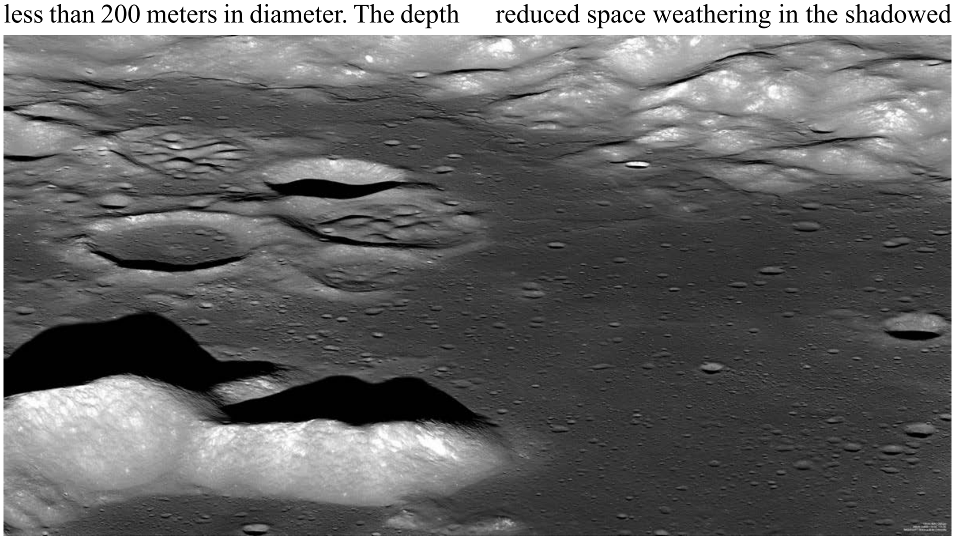
Hayne *et al.* found temperatures on the Moon to be extremely heterogeneous. They were comparing temperature data with UV reflectance near the lunar poles.

Garry sees many more flow fronts and margins at Mare Imbrium than on other lunar maria.

In a session on Titan's lakes, Luspay-Kuti *et al.* estimate from lab experiments that Titan's Ontario Lacus is 70-90% ethane, and that this composition is not in equilibrium. They wonder if there has been extensive methane evaporation. They find that nitrogen dissolves well in liquids having greater than 70% methane. [Author's note: recall that nitrogen is the primary gas in Titan's atmosphere.]

The first event Monday afternoon was, as usual, a plenary session where the Dwornik awards for student presentations at the previous year's LPSC were presented, and at which the Mazursky Lecture was presented. The Mazursky Lecture has become a tradition each year at the LPSC, to honor the late Hal Mazursky, one of the leading lunar and planetary scientists of the Apollo era.

This year's Mazursky Lecture was delivered by David Scott, who flew on the Apollo 15 mission. [Author's note: While the Apollo program was ongoing, it was usual practice for the crew of each Apollo mission to make a presentation to the LPSC, a sort of debriefing, at which they would relate their observations and impressions, describe where they had obtained certain samples, etc. I had the good fortune of listening to David Scott during the Apollo



Above: LROC NAC oblique view of Aitken crater, including the central peak, northern walls, and the Constellation Region of Interest. Scene is about 30 km wide. Image credit: NASA/GSFC/Arizona State University.

Above: David Scott delivering the 2014 LPSC Mazursky Lecture. Image credit: LPSC.

15 crew's presentation at the LPSC that followed the Apollo 15 mission.]

In the lecture, Scott emphasized than an important part of what led to the engineering success and scientific productivity of Apollo were the close, synergistic interactions among the engineers, the scientists, and the managers. He discussed examples of how that worked on Apollo. One noteworthy case was when the astronauts got managers to come out to the field to observe their training for lunar surface operations. It was very difficult to persuade the managers to come, but once they came, the managers finally understood the importance of the field training, and they finally grasped the reasons why the astronauts trained the way they did.

Following the Mazursky lecture Monday afternoon, Arvidson *et al.* reported that a black boulder encountered by the Opportunity rover at Endeavor crater on Mars turned out to be a coarse grained sandstone. Opportunity also made observations at certain spots consistent with gypsum.

While simulating planetary buildup involving large impacts in the forming solar system, Kendall and Melosh find it is hard to get chemical equilibrium if metal is added mostly via large, differentiated planetesimals. The impact process tends to spread the impactor core out into a relatively large volume of target material.

Edgar *et al.* reported on an area on Mars where sediment appears to be transported by migrating dunes. These dunes may be migrating across a river bed. Fluvial deposition in this bed appears to be common, but not continuous.

On Tuesday morning, Elphic *et al.* pointed out that the Lunar Atmosphere and Dust Environment Explorer (LADEE) spacecraft arrived a the Moon with a large load of propellant. LADEE's neutron mass spectrometer (NMS) confirms that argon in the lunar exosphere is cold trapped on the Moon's night side, then released on the day side. Exospheric nitrogen is minimum a local lunar noon, maximum at local midnight. Argon-40, neon-20, and helium-4 have all been mapped. 11,000 dust impacts had been recorded as of the time of their report.

Horanyi *et al.* reported on two types of LADEE measurements: (1) individual dust particles, and (2) integrated measurements of many particles too small to be detected individually. They have seen meteor showers in the LADEE data. They have also noticed a monthly modulation in the dust impact rate. When LADEE is in an orbit at 100 km altitude, there is a burst in the data roughly every ten days. A 10 to 100 gram impact on the Moon might generate this. A satellite at this altitude might be able to use this as a small meteoroid hazard detection technique for equipment or people on the lunar surface.

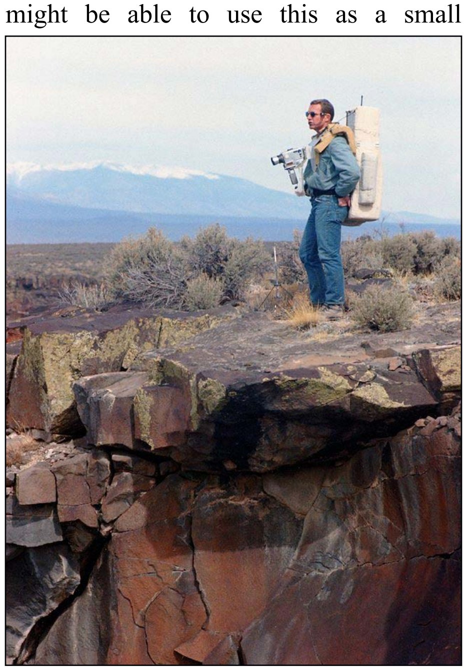
Elbeshausen *et al.* discussed a topic that is still not fully understood, even though a number of models have been put forward: How do multi-ring impact basins form? They had performed a simulation of the formation of the Orientale impact. Their simulated impact excavates quite deeply into the lunar mantle. It produces a pronounced central uplift. This falls, generates interactions with different layers of different strengths, and creates fault scarps. They get a good match for the positions of most rings, but miss the location of the Cordillera ring. They are presently trying another simulation with mantle viscosity included, to see if they get a better match that way, but that simulation was not complete by the time of the LPSC.

Stubbs *et al.* discussed the potential detection of meteor streams that were expected during LADEE's time in orbit. LADEE's LDEX instrument seems to have detected the Geminid meteoroids, but apparently not the Quadrantids. The Quadrantid radiant is further north than the one for the Geminids, so the Quadrantids may not be putting much material into the LADEE orbit.

Siegler and Smrekar discussed lunar crustal parameters that might affect heat flow: thickness, density, radiogenic element abundances. Thickness differences between nearby areas may add geometrical forcing to whatever else is going on, especially near mare edges. Mare edge effects might account for the heat flow differences observed between the Apollo 15 and 17 landing sites.

Schmerr *et al.* reported on seismic and gravity modeling of the Moon's megaregolith. Many of you may know that the regolith is the term for the Moon's top layer of finely divided material, mostly dust sized, with some rocks and even a few boulders included. In most places it is several meters deep; the depth varies from place to place. The megaregolith is the crustal layer immediately below the regolith. It has much less dust sized material, and many more rocks and large boulders; it is still quite broken up by impacts, and is not a fully consolidated solid. It may be up to kilometers thick. Schmerr *et al.* report that gravity results

Above: David Scott, Apollo 15 Commander and the seventh person to walk on the Moon. Image credit: Wikipedia.



Above: Apollo 15 Commander David Scott during geology training in New Mexico on March 19, 1971. Image credit: Wikipedia.

from GRAIL show that the megaregolith has relatively low density and high porosity. GRAIL measurements show crustal density varies from one lunar region to another.

Citron *et al.* investigated a model for lunar formation by way of several large impacts, each of which produced its own debris disk, followed by subsequent mergers, rather than a single giant impact. They think multiple impacts may place more terrestrial material into orbit than current off-axis giant impact models manage to do. [Author's note: getting the right proportions of Earth mantle material and impactor material to fit lunar sample isotope data is an ongoing problem for giant impact models for the origin of the Moon.]

Benna *et al.* discussed the ability of LADEE to map helium. Helium peaks at night, is minimum at noon, as expected from previous modeling. As they interpret the data, most lunar helium is of solar wind origin. Argon did not follow a simple model picture. For instance, argon's sunrise scale height differs between maria and highlands. Neon is well accommodated to the lunar surface throughout the night. In one mode of LADEE's operation, they were able to pick up evidence of sodium and potassium.

Jögi and Paige think they've identified a melt deposit emplaced ballistically at the antipode of the Tycho crater. They think the kinetic energy of impact remelted the material.

Hermalyn *et al.* think they may be seeing some meteor shower events with LADEE's Ultraviolet Visible Spectrometer (UVS), just as with the LDEX instrument.

Wooden *et al.* observe during occultations extinction with decreasing graze altitude (toward the lunar horizon). They derive a dust concentration above the lunar surface consistent with a previous model. They see reddening during Leonid meteor showers. They also sometimes see

Above: David Scott, the 2014 LPSC Mazursky Lecture invited speaker, with LPSC attendees. Image credit: LPSC.

blueing. They can't account for the color changes by scattering from the surface; these observations remain a mystery.

On Tuesday afternoon, Elkins-Tanton and Bercovici discussed models that show that either expansion or contraction could have occurred during the freezing of an early lunar magma ocean. Expansion would be consistent with GRAIL's findings. If any contraction did occur, the resulting scarps would have relaxed away (the Moon was then quite hot), and would not be preserved to today.

Garrick-Bethell *et al.* ask whether we can find out whether a frozen tidal bulge *and* crustal thickness changes due to tidal heating are *both* present on the Moon. After making corrections for major basins, the solution their model finds, that fits the observed data is: The Moon experienced significant tidal heating until it had tidally receded to about 25 Earth radii. The tidal bulge froze out at about 32 Earth radii. (The Moon is at present roughly 60 Earth radii away from Earth.)

Ormö *et al.* report that about 16% of near Earth asteroids are binary.

Hood *et al.* think that magnetic anomalies in old impact basins are due to metallic iron in the impact melt, formed by the reduction of iron silicates. 8 of 11 Nectarian age basins have central magnetic anomalies. 6 of 8 pre-Nectarian basins looked at do *not* have magnetic anomalies. Hood *et al.* put forward two possible explanations for the differences: 1. The Moon probably had an internal dynamo whose strength may have been weaker during the pre-Nectarian period than during the Nectarian period. 2. Anomalies that did form in earlier times may have been weakened by subsequent impacts.

Laneuville *et al.* show that the pressure and thermal conditions in the early Moon will cause the small lunar iron core to freeze from the bottom up. This will cause the core to convect, driving a long lived dynamo, hence generating a lunar magnetic field.

Andrews-Hanna *et al.* report from GRAIL data that Oceanus Procellarum is bordered by lava-flooded rift valleys and buried dikes (vertical slabs of intruded lava). The dikes outline a *rectangular*, angular pattern. [Author's note: Some researchers had proposed that Oceanus Procellarum was the location of a very large impact basin, obscured by later impacts. Others doubt such a giant impact connection. An impact basin would be expected to have a *round* outline. The angular pattern is not consistent with this.] If heat producing elements are concentrated in this region, as observations show, it will become warmer than surrounding areas early in lunar history. Because the Procellarum area is warmer, it will cool *faster*, and contract, relative to its surroundings, so we should get contraction crack polygons. The sheer size of the area brings the curvature of the lunar globe into play, so that the corners of this rectangular dike pattern meet at 120 angles...as expected for contraction crack polygons.

Kieffer *et al.* showed that impact melt sheets in lunar basins make a moderate positive contribution to the free-air gravity.

Byrne *et al.* showed some ghost (lava flooded) lunar craters. Some were detected only from topographic data; they have no optically visible rim left. All circumferential faults surrounding Mare Crisium penetrate 18-20 km down. They start at surprisingly shallow dip angles of 15-25 . The dip is outward. The angle matches the shoulder of the Crisium mascon in the mantle. The mascon is sinking, which drags the crust down. There is a compressive regime at the surface, which results in about 2 km of shortening along the basin diameter.

Besserer *et al.* stated that globally the lunar density increases with depth. There are lateral variations in this. These researchers want to map some of this variation. In mare areas, density *decreases* with depth, for shallow depths, because dense basalt lavas filling the maria overly less dense rock.

Huang *et al.* show that gravity data for the Moon's Aristarchus Plateau is consistent with the bulk highland crust density. So are the data for Kepler, Hortensius, and Cauchy craters. Gardner and the Marius Hills have large anomaly areas; high density blocks may have intruded beneath these.

On Wednesday morning, Melosh *et al.* reported that we don't see much olivine signature in material excavated from craters and basins that should have penetrated the mantle. They wonder if orthopyroxene, rather than olivine, dominates the Moon's upper mantle (not necessarily the whole mantle).

Frey and McBride are trying to find absolute ages of lunar impact basins. Results depend strongly on the age of the Nectaris basin. For a "young" Nectaris (I'm not sure how young), ages show a two-peaked structure. One peak occurs 4.1 billion years ago; the other 3.9 billion years ago. An "old" Nectaris removes much of the signal of a "late heavy bombardment" of the Moon.

Singer *et al.* showed that secondary impacts from a given cratering event on the Moon show a size falloff with distance from the primary crater. From this, they estimate the size of the largest fragment, from a given impact, that would have achieved lunar escape velocity. Secondary craters show a typical depth to diameter ration around 0.125.

Whitten *et al.* observe two groups of plains on Mercury: high albedo and low albedo. The low albedo plains are mostly impact melt.

Byrne *et al.* observe that different ideas have been advanced for the amount of Mercury's contraction. Now we have much more detailed planetary topography. For the analysis presented here, they are omitting Mercury's two largest basins. Shortening structures include lobate scarps and wrinkle ridges. Byrne *et al.* estimate about 5.7 km of radius change.

On Wednesday afternoon, Bennett and Bell discussed central mounds in large Martian craters. The central mounds they were discussing *are not* impact-produced central peaks. Their presentation focused on lacustrine sedimentary processes. One problem with this proposal is that in earlier work, some mounds appeared taller than the surrounding crater rims. On closer inspection, they find that no actual *mound* rises higher than the *entire* crater rim. (Lower parts of the rim could have been worn down by erosion and/or later impacts.)

Robinson *et al.* contend that there are multiple volatile reservoirs on the Moon with different proportions deuterium (D) to normal hydrogen (H). Tartese *et al.*, on the other hand, think D/H ratios represent a degassing trend.

Kite *et al.* discuss drying trends on ancient Mars, in river channels in the Aeolis Dorsa region. They observe the drying not to be monotonic. They see in that area an episode of substantial discharge much later than the earlier flows.

Hauber *et al.* think they see some flow features in Mars' early Amazonian period that are glaciofluvial in nature, rather than purely fluvial.

Li and Milliken contend there is a correlation between the areas of pyroclastic deposits on the Moon and hydration level. They can see hydrated areas as dark regions on Earth based radar images.

Thomas-Keprta *et al.* studied gasses associated with vesicles within lunar glass beads. They found no evidence for water, nor for carbonaceous material. However, those vesicles were near the glass surface, easy to access. They were planning to continue, looking at deeper vesicles.

Wetzel *et al.* proposed that the main driving gas for lunar fire fountains may be carbon monoxide (CO).

On Thursday morning, Burhkardt and Dauphas reported that from an isotope perspective, it looks like the Moon is made mostly of proto-Earth material. Another possible way to get their isotopes so much alike is if the Earth and the impactor that collided with Earth to form the Moon formed at similar distances from the sun.

Wilson *et al.'s* group has been studying the relation of pyroclastic deposits to lunar rilles. They offer a new mechanism for producing pyroclastics.

Pahlevan and Morbidelli show that giant impacts should produce low inclination disks. Tidal interactions should further damp inclination. Third body and solar radiation interactions can excite inclination. They propose from these effects that the Moon-forming impact was probably Earth's last major impact during its formation.

McGovern *et al.* illustrated how a combination of flexural and membrane stresses can aid magma ascent near margins of mascon maria.

Pasckeri *et al.* note that there was a long duration of volcanic activity on the Moon, with perhaps a few peaks. Within the SPA, they think they see a narrower range of ages. Two possible reasons: Perhaps magma sources beneath SPA cooled faster. Or because SPA had less insulating crust.

Petaev *et al.* proposed that condensation of a Moon from a vapor disk requires fractionation. Major elements will condense at much higher temperatures than volatiles.

Huang *et al.* reported that the Moon and Earth have the same isotopic composition for potassium, but not for zinc. One argues against, the other for, evaporative loss of volatiles during condensation.

Kleine *et al.* argue that a small excess of tungsten-182 (^{182}W) requires a late formation of the Moon, primarily from terrestrial mantle material.

Schultz *et al.* studied impact melt material from the Argentine pampas. Some pieces enclosed trapped leaves, in some cases, even preserving individual cells. High carbon abundance was observed in the plant matter. In some cases, some organic compounds seem to have been preserved. Extremely high temperature seems to be the key. Above 1800 C, macro and micro leaf morphology is preserved. They experimented with a light gas gun to see if they could replicate the conditions. They found it requires a soft sediment target for this to work.

Gaffney and Borg were trying to get some age constraints on the early lunar magma ocean. They used two Sm/Nd isotope systems. They came up with a "model age" for the source material for mare basalts of 4.34 billion years. Other labs, using other techniques, get similar results. They arrive at 4.36 billion years ago as the time of magma ocean crystallization, or a subsequent widespread magma event.

At noon on Thursday, a meeting of the Lunar Exploration Analysis Group, or LEAG, took place. LEAG is a group of scientists who offer NASA advice on the scientific aspects of lunar and planetary missions and programs. Any seriously interested scientist or engineer who wishes to can become involved with LEAG. I have.

On Thursday afternoon, Boss and Keiser reported evidence of supernova shock fronts creating compressed clumps of gas and dust. According to one school of thought, a process like this may have initiated the collapse of the pocket of gas and dust that eventually formed into our solar system.

Young reported that aluminum-26 (^{26}Al) is produced primarily in star forming regions (such as where the sun once formed!). That means the amount of this very short-lived isotope was not excessive. [Author's note: we have evidence there was a lot of ^{26}Al around in the early days of the solar system.] Much of it is produced in Wolf-Rayet (W-R) stars and their winds, rather than in supernovae. [W-R stars are very massive, very short-lived stars.] Young reported similar results for other short-lived isotopes known to have been present in the early solar system.

Stopar *et al.* reported that cones have greater summit crater to base diameter ratios than other volcanic forms seen on the Moon.

Simon *et al.* raised the question: Do lunar materials have any trivalent titanium? They reported none has yet been found.

Daubar *et al.* reported that blast zones from new Mars impacts (new meaning the craters were observed by orbiting spacecraft to form *after* the spacecraft arrived at Mars) change with time. They fade, some rapidly.

Clark *et al.* raise the question of whether lobate scarps say anything about the initial thermal state of the Moon. We need absolute ages to answer this. We would need to compare crater counts on the hanging wall vs. the foot wall. These researchers showed examples of scarps they claimed were only 7 to 40 million years old - extremely young for features on the Moon! Their observations are so far more consistent with a totally molten Moon than a shallow magma ocean. However, the value of the crushing stress needed to produce the scarps may change this. It may also turn out to be more appropriate to use cohesion strength, rather than crushing strength, in making the calculations.

Chojnacki *et al.* reported that aeolian activity has been ongoing at the Martian crater Endeavor for the last 10 Mars years. Both barcan shaped and dome shaped dunes are migrating. Turnover times range from 10 to 180 years. Turnover time refers to the time it takes a dune to travel its own along-wind length. This means the current dune arrangements are contemporary.

Debaille *et al.* propose that it took 1.8 billion years to mix back the early Earth mantle. They put forward a model in which Earth had a stagnant lid during the Archean period, and plate tectonics did not start until 2.7 billion years ago, or there were only scarce or short-lived subduction episodes. They think the Martian mantle is now convecting, but slowly, because Mars has no plate tectonics.

I looked at poster papers during both the Tuesday evening and Thursday evening poster sessions. However, I did not see anything that seemed to me to be sufficiently novel or sufficiently ground breaking to take notes on.

On Friday morning, Lisse and the CIOC team reported an overview of the Comet ISON Observing Campaign (CIOC). ISON wasn't big, yet it was observed as far out as 9.3 AU, so it had to be very active.

Wadhwa *et al.* reported data on a very ancient calcium-aluminum inclusion (CAI), a type of material from the very early solar system. It seemed less altered than other ancient samples. It may have been remelted 70,000 years after the solar system started to form. Her team has an updated "time zero" for the solar system of 4.5678 billion years. [Author's note: I have heard Wadhwa speak on the age of the solar system before. It almost seems as if every time I hear her, she adds another decimal point to the precision.]

Hemmingway and Garrick-Bethel spoke on space weathering at lunar swirls and at high lunar latitudes. They observe a color change pattern specific to swirls, which is *different* from color changes due to lunar craters. Going to higher latitudes, they observe color change patterns mimicking walking into swirls. Both changes may be due to reductions in solar wind flux. They wonder if the latitude effect could be used to calibrate swirl magnetic field strength.

Steckloff *et al.* reported that comet ISON broke up before it was within two solar radii of the sun, so tidal forces could not have been responsible for the breakup. Gas can pile up on a comet's leading edge, increasing pressure at the surface. Another possible breakup mechanism is internal sublimation, but this group thinks that would only work with a smaller comet. Sublimation pressure on the sunward side of a comet can act as a rocket. Differential sublimation pressure can exceed the crushing strength, leading to a breakup. They infer a strength comparable to Jupiter family comets, although ISON was a new comet.

Koeber *et al.* showed images from permanently shadowed high latitude regions on the Moon. So...how did they get images from places that are always in shadow? Their light source was reflection from crater rims. They can actually see albedo contrasts within permanently shadowed regions (PSR). So far, these researchers have not identified water frost within any PSR's. That being the case, what is causing anomalous radar circular polarization ratio (CPR)? Those PSR's have lots and lots of boulders in fresh craters (surface roughness is another way of getting anomalous CPR). However... the anomalous craters are neither fresh nor degraded, but of intermediate age. During Q&A, Spudis commented that we can't simply extrapolate large boulder sizes down to radar wavelengths.

Patterson *et al.* reported that the mini-RF on the Lunar Reconnaissance Orbiter (LRO) is no longer operating as a mono-static radar, but it is operating as a bistatic radar, with Arecibo as the transmitter. The floor of Cabaeus Crater shows CPR dependent on phase angle. They are observing an opposition effect. This can occur for surface roughness or for a surface composed of water ice. After comparing with other craters, they suggest near-surface, buried water ice as the cause, which could be in the form of a thin layer.

Eke *et al.* raised the question: Can radar distinguish between ice, roughness, and slope effects at high lunar latitudes?

Lu *et al.* reported that the Chinese Chang'e-3 spacecraft landed near the rim of a 450 meter crater roughly 100 million years old. They see probable downslope movement of boulders in the vicinity. Obstacle-avoidance maneuvers kept the spacecraft away from boulders during the landing. Their first analysis showed basaltic material. They expect the local surface to be immature.

I left the Conference early on Friday, and have no notes from any of the Friday afternoon papers. ■

Book Review

The Martian, by Andy Weir

REVIEWED BY BILL WEST

[June 23, 2014]

In recent years, hard science fiction, long a strong genre in the literary field of science fiction, seems to have fallen by the wayside, replaced by fantasy adventure, dystopian futures or simply horror stories dressed up as science fiction. From Arthur C. Clarke to Michael Crichton, hard science fiction authors create stories using plausible technologies based on the laws of science. The enjoyment that I always derive from these stories is that they give a glimpse of a tomorrow just over the horizon, of a possible future yet to be.

Andy Weir's recent book *The Martian* is probably the best hard science fiction story that I have read in a long time. But more than science fiction, it is a riveting tale of survival, of one lone astronaut accidentally marooned on the planet Mars.

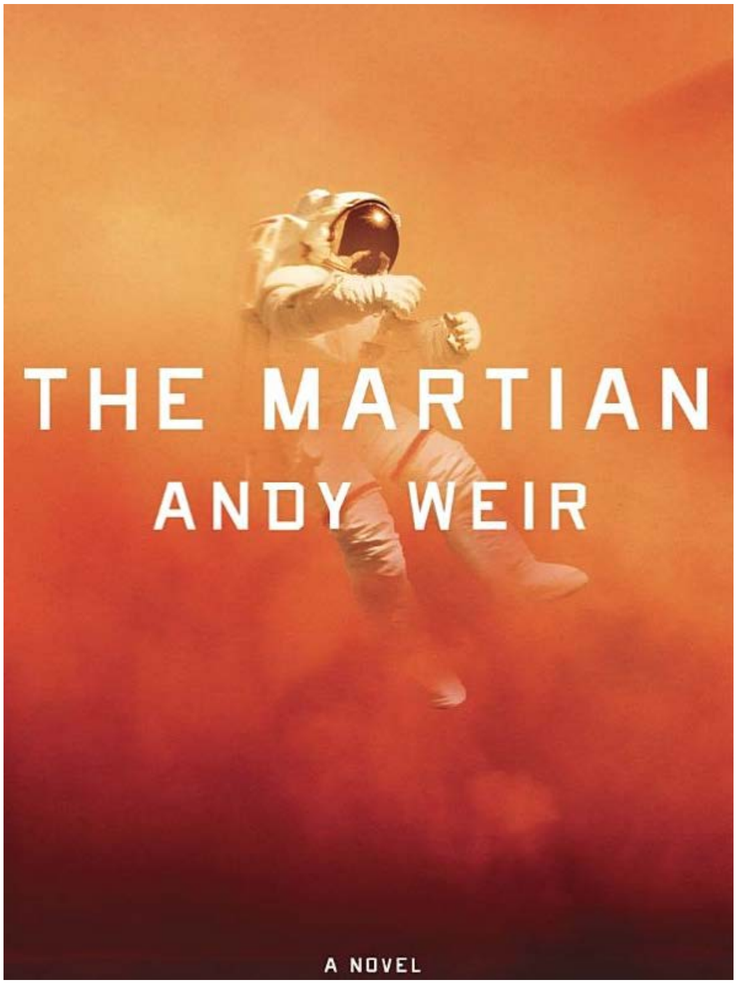
The Martian takes place in the not-to-distant future, when humans have finally set foot on the planet Mars. The story is set during the third expedition when "something" unexpected happens and astronaut Mark Watney is accidentally left behind as the rest of the crew departs in haste, aborting the mission. What follows is a classic story of survival as Watney uses all of his resources to stay alive. Of course, communication is lost, and Watney must somehow re-establish it, if only to let Earth know that he's still alive.

Much of the story is written in the first person, as Watney records his daily efforts to stay alive in a diary. Watney is alone on Mars, the only human being on an entire world, completely cut off from any possible rescue. Yet he methodically works through each of his problems, from conserving oxygen to increasing his food supply in order to maintain his daily caloric intake. (I found myself with new respect for the potato after reading this book.) Much like the fictional Robinson Crusoe, or the real life Earnest Shackleton, Watney must utilize every single resource available to maintain his life support as well as his sanity.

The Mars mission architecture selected by the author is a familiar one to those that have been involved in working on sending humans to Mars. Before the crew is sent to Mars, supplies and equipment are pre-positioned on Mars, along with a habitat and a return vehicle. The author uses this mission model to the maximum extent in the story. There are even some lessons learned in the later chapters on the importance of making hardware compatible between habitats and rovers.

What makes this book so enjoyable is that the author did not introduce any antagonist to the main character, as one was simply not needed. Mars itself, with its hostile environment, is all that is required. There are other characters later in the story, but it is Mars and Watney that take center stage for much of the story. As days grow to months, and months to years, you come to find yourself sitting with Watney, alone and completely isolated on a barren and dead world.

This is Andy Weir's first novel and it moves at a fast pace. The writer's prose and style of writing make it a fun summer read. The author had a hard time finding a publisher, so he ended up self-publishing on Amazon as an e-book. Subsequently, the book took off, and it is now published in hardback by Crown Publishers. Hopefully it marks the return of well-written hard science fiction to the publishing world. ■



Above: The Martian, by Andy Weir. Image obtained from Amazon. Visit the author's website: www.andyweirauthor.com.

Major Section Events of the Past 12 Months

Laura Sarmiento, AIAA Houston Section Programs Chair

[June 23, 2014]

AIAA Houston Section featured four major events with notable speakers this year. (Our AIAA year started on July 1, 2013.)

The first event was in late February. The Section held a dinner meeting featuring NASA Johnson Space Center (JSC) Deputy Director Kirk Shireman. Mr. Shireman presented an enlightening presentation on the State of the Center of JSC. He highlighted the many fantastic endeavors going on at JSC as well as an outlook for the future of JSC.

The second event was a luncheon featuring Dr. Sandy Magnus, AIAA Executive Director. Dr. Magnus delivered an address to discuss her visit to the House of Representatives Committee on Science, Space, and Technology in Washington, DC. She also talked with us about the future of aerospace and the future of AIAA. Her excitement for the future was contagious.

The third event was the kickoff for AIAA Houston Section's Annual Technical Symposium (ATS 2014). [An earlier page in this issue contains our report of ATS 2014.] This kickoff was a dinner event featuring NASA astronaut Chris Cassidy. Commander Cassidy presented, "Go for EVA – Words that All Astronauts Want to Hear!" He led us through a timeline of his Extra-Vehicular Activity (EVA) with European Space Agency (ESA) astronaut Luca Parmitano. A fluid leak in Parmitano's helmet was not just a bad surprise, it was a big emergency. The firsthand account of this EVA was thrilling and enlightening! The risk in an EVA was made real with Cassidy's presentation.

The final major event of the year will be the June 26, 2014, AIAA Houston Section Honors and Awards banquet featuring NASA astronaut Clay Anderson and singer-songwriter Dwayne O'Brien from the multi-platinum selling group Little Texas. [Two later pages in this issue report on this event.]

This event will also highlight the following AIAA awards: our Section's Spirit of Apollo Scholarship winner [announced on a later page in this issue], Section council members of exemplary service, people celebrating 25, 40, and 60-year AIAA anniversaries, and those who have been upgraded in membership to Senior Member, Associate Fellow, and Fellow. ■

Above and left: NASA astronaut Chris Cassidy addressing AIAA Houston Section.

Right: AIAA Executive Director Dr. Sandra Magnus addressing AIAA Houston Section.

Above: Left to right, Jennifer Wells, Treasurer, and Laura Sarmiento, Programs Chair, in the NASA/JSC Gilruth Center Alamo ballroom.

Above: NASA/JSC Deputy Center Director Kirk Shireman delivering the State of the Center address at our AIAA Houston Section dinner meeting.

Dinner Meeting
June 26, 2014

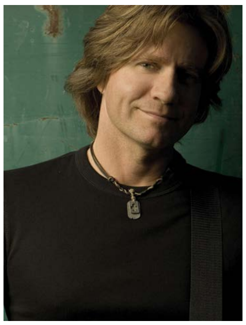
Honors & Awards Dinner

Ellen Gillespie, Councilor (Photos: Ellen Gillespie and Zach Tejral except as noted)

[June 29, 2014]

This AIAA Houston Section dinner meeting took place in the NASA/JSC Gilruth Center Alamo ballroom on Thursday, June 26, 2014, celebrating our Section's year of volunteer work ending June 30, 2014. Our two guests of honor were NASA astronaut Clay Anderson and singer-songwriter Dwayne O'Brien whose career includes his solo career and the multi-platinum selling group Little Texas. Anderson retired from NASA in January of this year, and he is working on his autobiography with the University of Nebraska Press, *Taking Up Space* [articles in collectSPACE]. More information about astronaut Clay Anderson is available via his Facebook page: www.facebook.com/astroclay and the website www.astroclay.com. O'Brien performed *Crystal Ocean* from his solo CD Song Pilot.

Honors and Award Chair Angela Beck joined Chair Michael Frostad to celebrate



Above: Dwayne O'Brien. Image credit: Jeremy Cowart. Image source: Little Texas website.

Left: NASA astronaut Clay Anderson, whose experience includes NEEMO 5, STS-117, ISS Expeditions 15 & 16, STS-120, & STS-131. Image source: Wikipedia. Image credit: NASA.

Above: Anderson in the Destiny module of the International Space Station. Image source: Wikipedia. Image credit: NASA.

Above: Angela Beck with guest of honor singer-songwriter Dwayne O'Brien, solo recording artist and member of the multi-platinum selling group Little Texas.

Above: Guest of honor Clay Anderson introduced by Evelyn Miralles, our Section's Extra-Vehicular Activity (EVA) technical committee Chair.

Section awards, service awards, and membership upgrades.

Section awards were presented to Operations Chair of the Year Laura Sarmiento (Programs Chair), Technical Chair of the Year BeBe Kelly-Serrato (Space Operations technical committee Chair), and Executive Council Member of the Year Douglas Yazell (Editor). Our Section's $1,000 check was presented to our Section's Spirit of Apollo Scholarship winner Haripriya Sundararaju (featured on a later page in this issue), thanks in part to the work our Section's Scholarship Chair Rafael Munoz. Our Section's $6,635.23 check was presented to James Talmage of the Houston Museum of Natural Science (HMNS) BP Expedition Center, formerly

Above: AIAA Houston Section Chair Michael Frostad and guest of honor NASA astronaut Clay Anderson. (AIAA Houston Section started in 1962.)

Above: AIAA Houston Section Chair Michael Frostad reviews our AIAA year from July 1, 2013 to June 30, 2014.

Above: As the evening event ended, flowers were offered to Honors and Awards Chair Angela Beck. Left to right, Angela Beck, Michael Martin, and BeBe Kelly-Serrato.

Above: Yuri's Night Houston 5k Fun Run Race Director Mana Vautier presents our check to James Talmage for the Houston Museum of Natural Science BP Expedition Center, formerly the Challenger Learning Center.

the Challenger Learning Center. These funds were raised by the 5 km Fun Run of Yuri's Night Houston. Our notes (an Excel document) remind us to thank John Lee, Aaron Greer, Michelle Gonzalez, and Landon Blair at the museum.

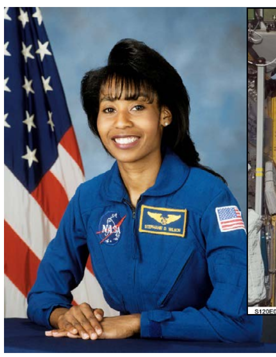
The 25-year service award list is:

- Dr. John Bain
- Michael Boczon
- David Crook
- Dr. Steven E. Everett, Chair, our Section's Guidance, Navigation & Control technical committee
- David Fleeger
- Joseph Frisbee
- Professor Andrew Meade, faculty adviser for the Rice University AIAA Student Chapter
- Wayne Rast
- Larry Roberts
- Joel Sills
- Douglas Zimpfer

Our two 40-year service awardees are Dallas Ives and Dan Yee. Our 60-year










Above: NASA astronaut Stephanie Wilson in NASA photographs from the 2007 space shuttle mission STS-120 to the International Space Station (ISS). Some of these photographs include NASA astronaut Clay Anderson, tonight's guest of honor our AIAA Houston Section Honors and Awards dinner meeting. Image credits: NASA (http://spaceflight.nasa.gov).

Right: AIAA Houston Section Chair congratulates new Associate Fellows Kauser S. Imtiaz and NASA astronaut Stephanie Wilson.


service awardee is AIAA Fellow Joseph Guy Thibodaux, Jr.

Dr. Steven E. Everett, the Honorable Wayne Rast, and Joseph Guy Thibodaux, Jr. were in the audience this night to join in our celebration of their service anniversaries.

Finally, we celebrated two upgrades to Associate Fellow (Kauser Imtiaz NASA astronaut Stephanie Wilson) and the following list of members upgraded to Senior Member:

- George W. Abbey, Jr.
- Colonel Kenneth D. Cameron
- Chase Caruth
- Dr. Sujatha Sugavanam
- William Forrester
- David B. Kanipe
- Matt Kennedy
- Joel Mozer
- Dustin Otten
- Samuel Schauer
- Clay Stangle
- Irene Chan

Left and right: Michael Frostad and Haripriya Sundararaju, winner of the AIAA Houston Section Spirit of Apollo scholarship. She is featured on a later page in this issue. Our Section Scholarship Chair is Rafael Munoz. Credit for the image at right: Haripriya Sundararaju.

Above: Top left: Vice President of Operations Eryn Beisner and Operations Chair of the Year Laura Sarmiento, Programs Chair. Top center: Michael Frostad and Angela Beck with Technical Chair of the Year BeBe Kelly-Serrato, Space Operations technical committee. Top right: Michael Frostad and Angela Beck with an award for Douglas Yazell, Executive Council Member of the Year.

- Jennifer Wells
- Michael Frostad
- Ryan Miller

Thanks again to all of our volunteers, event attendees and invited speakers for the past twelve months! These and many other people made our volunteer work possible. Some of our volunteers are listed on our 45-person organization chart on a later *page* in this issue. Please note that we seek a new Horizons newsletter Editor starting July 1, 2014.

Now our Section takes a short break as our year ends on June 30, 2014. Our tradition will probably lead to a late

Above: The 25th service anniversary for Dr. Steven E. Everett, Chair of the AIAA Houston Section Guidance, Navigation and Control technical committee.

Above: The 25th service anniversary for the Honorable Wayne Rast.

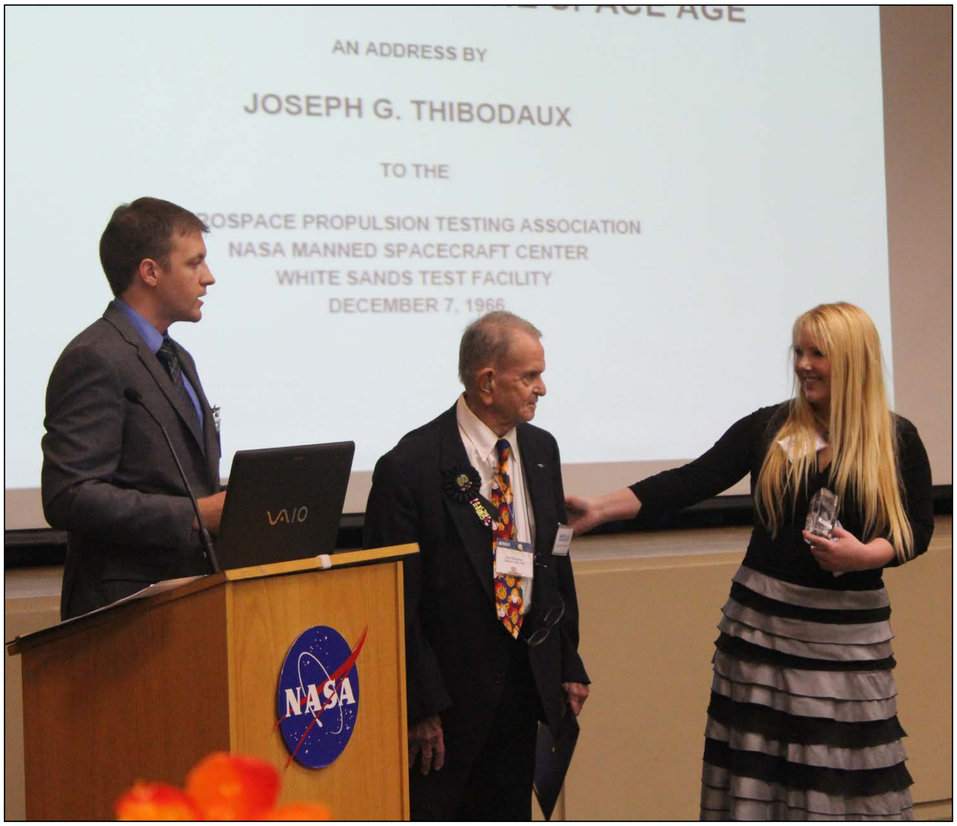
Above: Laura Sarmiento presents a gavel souvenir to outgoing AIAA Houston Section Chair Michael Frostad.

Left (two photographs): The gavel is passed from AIAA Houston Section Chair Michael Frostad to Chair-Elect Michael Martin, whose one-year term starts July 1, 2014.

Above: With guest of honor NASA astronaut Clay Anderson in the foreground, from left to right, AIAA Houston Section Executive Council members Michael Frostad, Eryn Beisner, Jennifer Wells, Svetlana Hanson, Kathleen Coderre, Irene Chan, Evelyn Miralles, Dr. Steven E. Everett, BeBe Kelly-Serrato, Ellen Gillespie, Alan Sisson, Christopher Davila, Dr. Larry Jay Friesen, & Michael Martin.

August 2014 leadership retreat as our next event. Locations used have included local restaurants, local offices of NASA/JSC contractors such as ARES corporation, and the NASA/JSC Gilruth Center.

We will return soon with more Houston Clear Lake area events, keeping in mind that our AIAA Houston Section territory extends from College Station to Houston, Texas USA. ■



Above and left: AIAA Fellow Guy Thibodaux celebrates his 60th service anniversary. His NASA career years were 1958-1980. His 1969 address to test engineers is featured on pages 44-48 of the March / April 2013 issue of Horizons. His picture is featured in the July 2010 issue of Horizons as he makes comments to our guest speaker Bohdan (Bo) Bejmuk, a member of the Augustine Committee, in a presentation titled, The Augustine Committee and Beyond.

Above: The AIAA Houston Section Executive Council, from left to right, Angela Beck, Eryn Beisner, Ellen Gillespie, Jennifer Wells, Laura Sarmiento, Svetlana Hanson, Michael Frostad, Kathleen Coderre, Michael Martin, Irene Chan, Evelyn Miralles, BeBe Kelly-Serrato, Alan Sisson, Dr. Steven E. Everett, Christopher Davila, and Dr. Larry Jay Friesen.

Above: Chair-Elect Michael W. Martin accepts the gavel as he prepares for the new AIAA year and his one-year term as Chair starting July 1, 2014.

Calendar

All calendar items are subject to change without notice.

Section council meetings (email secretary2013[at]aiaahouston.org)

Time: 5:30 - 6:30 PM usually

Day: First Tuesday of most months except for holidays.

Location: NASA/JSC Gilruth Center is often used. The room varies.

Recent Section Events

May 9, 2014: Our Section's Annual Technical Symposium at NASA/JSC Gilruth Center

June 26, 2014: Annual honors & awards dinner meeting with guest speaker NASA astronaut Clay Anderson, featuring a performance by recording artist Dwayne O'Brien

Upcoming Section events

Audiobook in work by Ted Kenny, NASA/JSC, Chair, AIAA Houston Section *History technical committee*, Suddenly Tomorrow Came, A History of JSC. The author of this 1993 book is Henry C. Dethloff. See that web page for author information and a short bio.

2014 AIAA Conferences: *www.aiaa.org* (Click on the events link.)

16 - 20 June 2014: Atlanta, Georgia, AIAA Aviation & Aeronautics Forum and Exposition (AVIATION 2014)
11th AIAA/ASME Joint Thermophysics and Heat Transfer Conference
14th AIAA Aviation Technology, Integration, and Operations Conference
15th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference
20th AIAA International Space Planes and Hypersonic Systems and Technologies Conference,
20th AIAA/CEAS Aeroacoustics Conference
21st AIAA Lighter-Than-Air Systems Technology Conference
30th AIAA Aerodynamic Measurement Technology and Ground Testing Conference
32nd AIAA Applied Aerodynamics Conference
44th AIAA Fluid Dynamics Conference
45th AIAA Plasmadynamics and Lasers Conference
6th AIAA Atmospheric and Space Environments Conference
7th AIAA Flow Control Conference
7th AIAA Theoretical Fluid Mechanics Conference
AIAA Atmospheric Flight Mechanics Conference
AIAA Balloon Systems Conference
AIAA Flight Testing Conference
AIAA Modeling and Simulation Technologies Conference
AIAA/3AF Aircraft Noise and Emissions Reduction Symposium

22 - 27 June 2014: Honolulu, Hawaii, 12th International Probabilistic Safety Assessment and Management Conference

28 - 30 Jul 2014: AIAA Propulsion and Energy Forum and Exposition (Propulsion and Energy 2014), Cleveland, Ohio

4 - 7 Aug 2014: AIAA Space and Astronautics Forum and Exposition (SPACE 2014), San Diego, California

7 - 8 Aug 2014: 2014 Regional Leadership Conference (RLC), San Diego, California

Below are upcoming local non-AIAA events of interest to our members. Click images for more information.

Cranium Cruncher: the Riemann Hypothesis

Section News

Douglas Yazell, Horizons Editor

[June 17, 2014]

We mentioned the Riemann Hypothesis in last issue's Cranium Cruncher. We came across this subject when Dr. Albert A. Jackson IV called our attention to a Numberphile internet video from the Mathematical Sciences Research Institute (MSRI), featuring mathematicians Tony Padilla and Ed Copeland. The video attracted an immense number of viewers on the internet as they explained some of the history of 1 + 2 + 3 + ... = -1/12.

In fact, this result of -1/12 is the rigorous mathematical result when the Riemann zeta function:

$$\sum_{n=1}^{\infty} \frac{1}{n^s},$$

a simple infinite series, is evaluated at -1. The Riemann zeta function is defined for a complex input number s whose real part is greater than 1, but analytic continuation extends that domain.

That result (-1/12) is so counterintuitive that when the video presenters mentioned that this result is used in many areas of physics, I started looking into that claim about "many areas of physics."

The Riemann hypothesis (published in 1859) states that the non-trivial zeroes of the Riemann zeta function have real part 1/2. The trivial zeroes occur for real inputs -2, -4, -6 ...

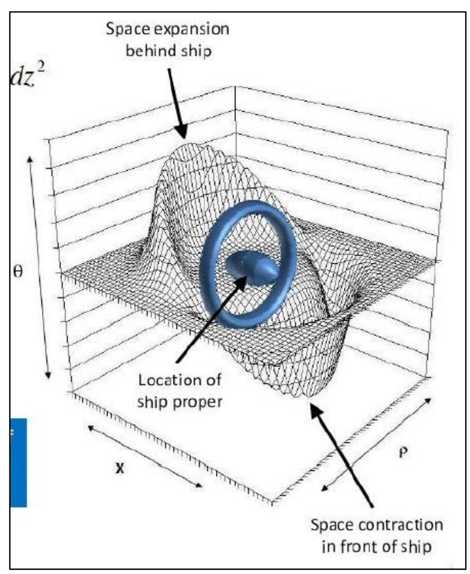
Horizons team member Philippe Mairet sent us a link for a warp drive article on a French website francetvinfo. The article featured Dr. Harold (Sonny) White of NASA/JSC. Al Jackson introduced our Section to Dr. White after the first 100 Year Starship (100YSS) public symposium (Orlando 2011). The article contains a link to Dr. White's entire warp drive presentation (a video recording) at the November 2013 SpaceX event, SpaceVision2013. In that video, Dr. White mentions some extra inspiration for this work thanks to a 100YSS public symposium. Dr. White also mentions his use (in his warp drive equations, if not a wider use) of the Casimir effect. The Wikipedia article on the Casimir effect mentions that its derivation uses the Riemann zeta function evaluated at -3, and this result is 1/120, which means that 1 + 8 + 27 + ... = 1/120, another counterintuitive result. Dr. White mentions that the Casimir effect has been measured. The Casimir effect appears to be one of those real-world (measured in a laboratory) applications of these counterintuitive mathematical results.

In the Numberphile video, Padilla and Copeland mention the use of that counterintuitive result in string theory, and they point to a recent string theory textbook. The Wikipedia Riemann zeta function article mentions that same counterintuitive result, " ... which can be useful in certain contexts such as string theory." That shows that the Wikipedia article author is also aware of real-world applications of that result, but those applications are not specified.

From the introduction to the Wikipedia Riemann hypothesis article, "There are several nontechnical books on the Riemann hypothesis, such as Derbyshire (2003), Rockmore (2005), Sabbagh (2003), du Sautoy (2003). The books Edwards (1974), Patterson (1988), Borwein et al. (2008) and Mazur & Stein (2014) give mathematical introductions, while Titchmarsh (1986), Ivić (1985) and Karatsuba & Voronin (1992) are advanced monographs." Each of those books are linked in the Wikipedia article. We link to Mazur and Stein here since that website page allows a free PDF download of that entire book!

From a Wikipedia article, "The Millennium Prize Problems are seven problems in mathematics that were stated by the Clay Mathematics Institute in 2000. As of June 2014, six of the problems remain unsolved. A correct solution to any of the problems results in a US $1,000,000 prize (sometimes called a Millennium Prize) being awarded by the institute. The Poincaré conjecture was solved by Grigori Perelman, but he declined the award in 2010." The Riemann hypothesis is fourth on a list of seven problems in that article. From that same article, "The Riemann hypothesis is that all nontrivial zeros of the analytical continuation of the Riemann zeta function have a real part of 1/2. A proof or disproof of this would have far-reaching implications in number theory, especially for the distribution of prime numbers. This was Hilbert's eighth problem, and is still considered an important open problem a century later."

[Sources: Wikipedia articles on the Riemann Hypothesis, the Riemann zeta function, the Casimir effect, and the Millenium Prize Problems.]



Above: Part of a warp drive illustration from Dr. Harold "Sonny" White, from page 27 of the January / February 2012 issue of Horizons.

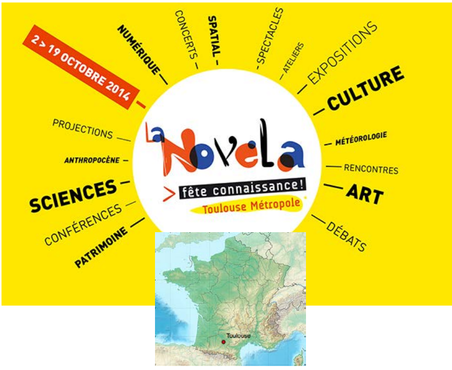
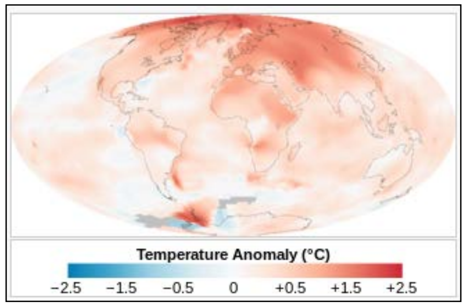


Image credits: Images are linked.

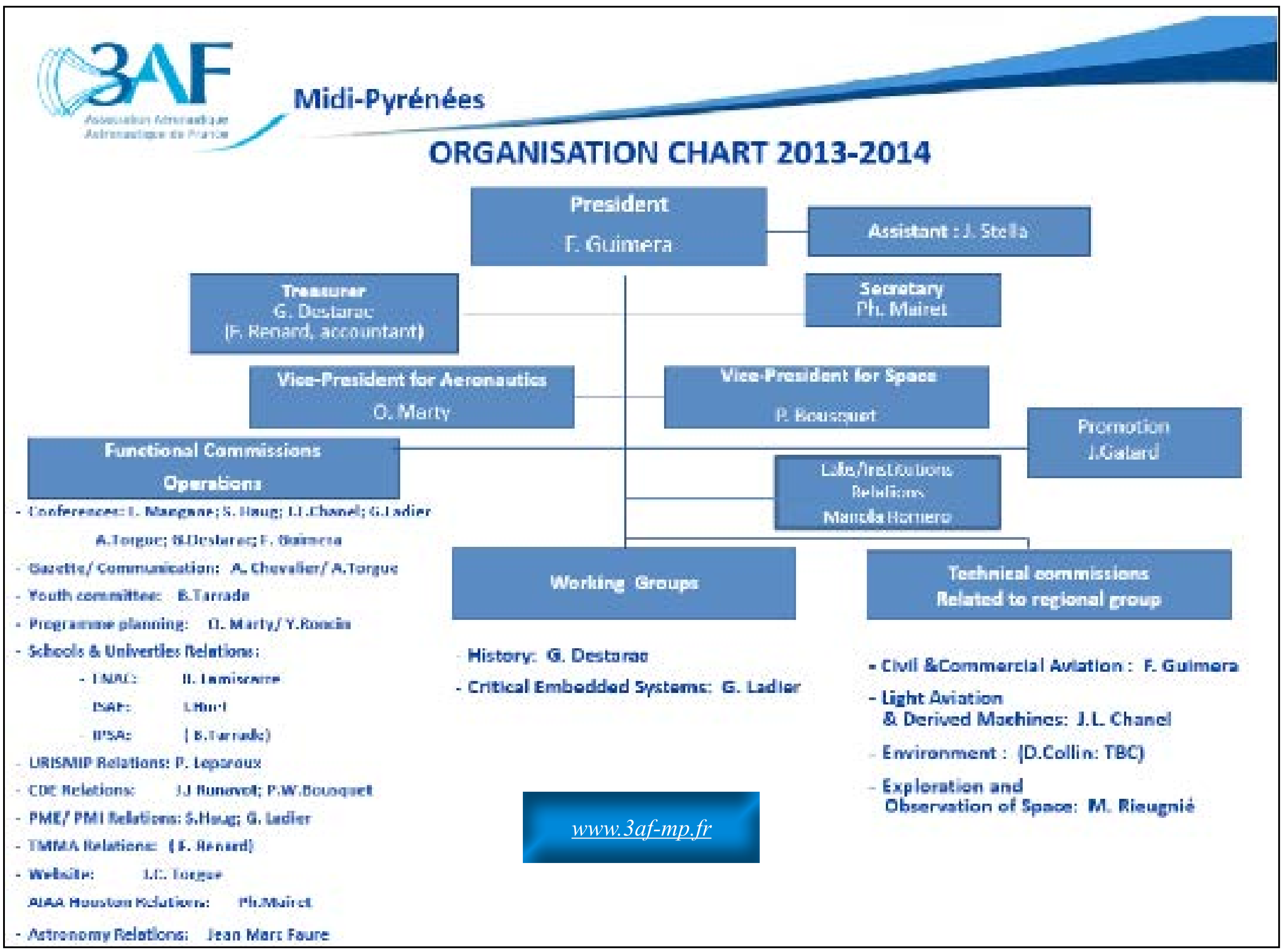


Above: Global warming (Wikipedia). The map shows the 10-year average (2000–2009) global mean temperature anomaly relative to the 1951–1980 mean. The largest temperature increases are in the Arctic and the Antarctic Peninsula. Source: NASA Earth Observatory.

In anticipation of La Novela Festival, organized by Toulouse Métropole (Metropolitan Toulouse, France), in Toulouse from **3 to 19 October, 2014**, with the theme of meteorology, the City of Space (La Cité de l'espace in Toulouse), in partnership with Météo-France, offers a distinguished and convivial evening, with surprises, **Thursday, June 19, 2014**, starting at 6:30 PM, in the Astralia at la Cité de l'espace. This event, *From a Frog to Satellites, All Kinds of Weather Forecasting!*, asks the question, "What will the weather be tomorrow, in five days, in fifty years?"

Association Aéronautique et Astronautique de France (3AF)

Sister Section of AIAA Houston Section since 2007
Jumelée avec AIAA Houston Section depuis 2007



Spirit of Apollo Scholarship Winner

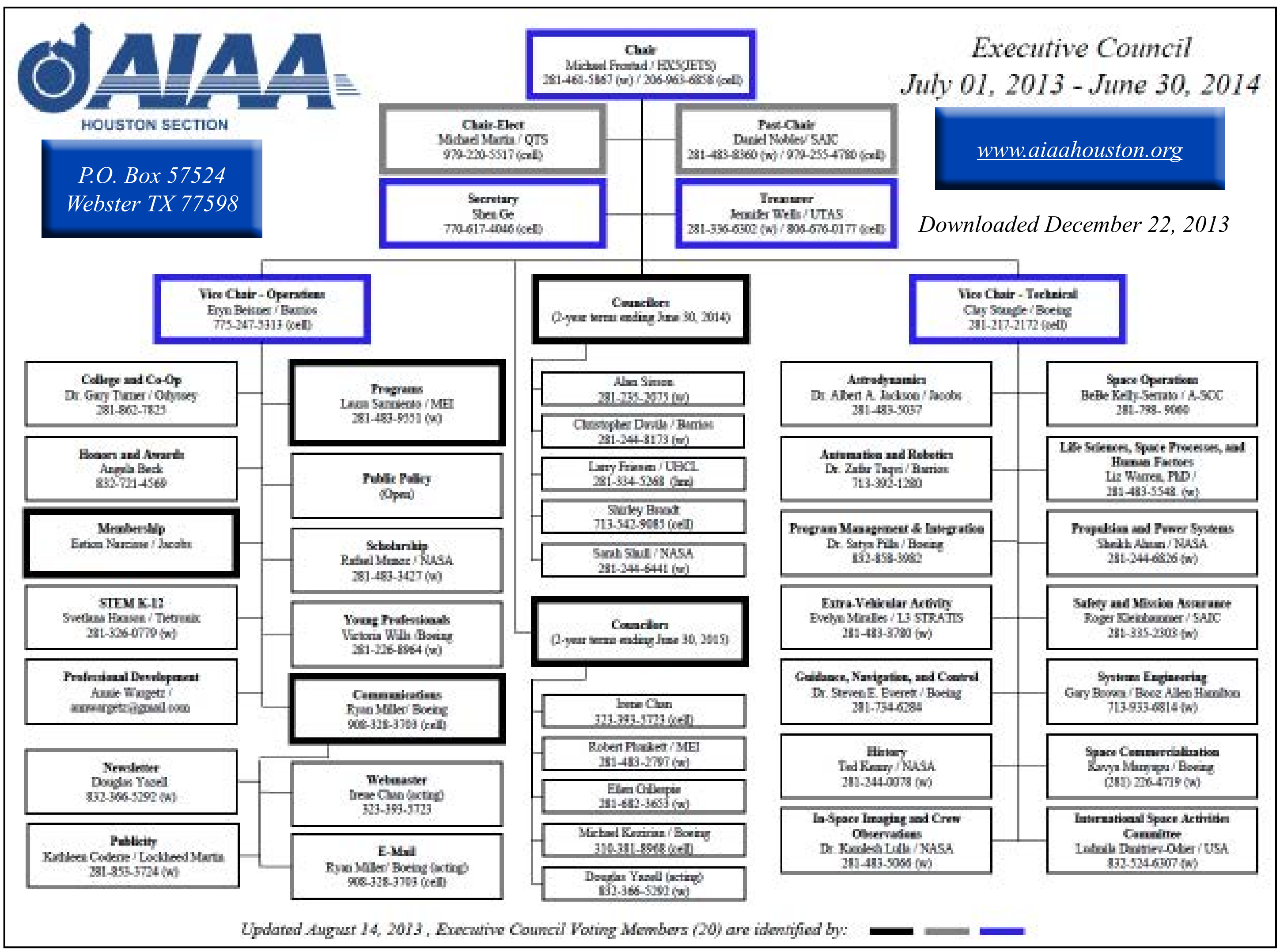
Rafael Munoz, AIAA Houston Section Scholarship Chair

[May 23, 2014]

AIAA Houston Section and our executive council congratulate Ms. Haripriya Sundararaju, the winner of our Section's 2013-2014 Spirit of Apollo scholarship. AIAA Houston Section membership includes about 800 professional members and about 1,000 members in all, mostly located in the NASA/JSC community in the Houston Clear Lake area, with a substantial number of members in the College Station area in the Texas A&M University community. AIAA has 35,000 members and 100 corporate members.

Haripriya Sundararaju is a PhD candidate at the University of Houston, majoring in mechanical engineering. She is currently researching at the National Wind Energy Center (NWEC) on the aerodynamic performance of large-scale offshore wind turbines. Her study focuses on obtaining theoretical limits of a dual-rotor wind turbine system and understanding the complex flow behavior between the rotors through computational fluid dynamics (CFD) simulations. She also takes part in the University of Houston Mechanical Engineering Graduate Association, where she coordinates events to showcase the research conducted by graduate students. Upon graduation she hopes to pursue a career in wind energy industry and improve technologies to integrate renewable resources into our society. ■

The American Institute of Aeronautics and Astronautics (AIAA)



Student Section News

Rice University AIAA Student Section Advisor:
Professor Andrew Meade, *meade[at]rice.edu*
713-348-5880, www.ruf.rice.edu/~meade/

[June 18, 2014]

The Rice Space Institute (*RSI*) is not associated with AIAA, but our members are interested in RSI activities, so we often include RSI notes here.

Houston Matters (KUHF) discusses Houston Spaceport. You can check out the broadcast *here*. Spaceport discussion starts around 19m 30s into show. [Posted April 24, 2014, on the RSI *blog*.]

Mike Massimino's Spaceport Lecture now available. A video of NASA astronaut Mike Massimino's recent lecture at Rice University on March 13 can now be viewed *here*. PLEASE NOTE THAT THE SOUND QUALITY IS NOT VERY GOOD. [Posted April 20, 2014, on the RSI *blog*.]

[June 19, 2014]

Rice University
Climate Change Research

Our AIAA Student Chapter at Rice University is not working with climate change, but this is a subject of great interest for NASA thanks to their Earth observation satellites, as shown on the NASA climate website, and all NASA studies are of great interest to AIAA.

A glance at faculty list on the website for the Rice University Department of Earth Science first led me to Dr. Carrie A. Masiello, since her page there contains this list near the top, "carbon cycling, carbon sequestration, climate change, black carbon, terrestrial-river-ocean biosphere interactions." A similar list for Dr. Gerald R. Dickens is, "paleoceanography, marine geology and low-temperature geochemistry." That same list for Dr. John B. Anderson is, "stratigraphy/sedimentology and Antarctic marine geology." Dr. Brandon Dugan lists, "hydrogeology and fluid flow; marine geology; and sediment mechanics." In the Decadal Survey of Ocean Sciences 2015: A Study by the Ocean Studies Board of the National Research Council, the blog entry of March 19, 2014 presents an interview with Dr. Dugan. One question is, "Across all ocean science disciplines, please list 3 important scientific questions that you believe will drive ocean research over the decade." The third part of Dr. Dugan's answer is, "What will be the overall oceanic (water column and seafloor) response to rapid and extreme climate change?."

Image credits: Rice University.

In the Department of Civil and Environmental Engineering, Dr. Daniel Cohan lists research interests, "photochemical modeling; atmospheric sensitivity analysis; environmental policy and management; uncertainty analysis; energy and the environment; inverse modeling; satellite data." Dr. Cohan was an invited speaker in a climate change session at the AIAA Houston Section Annual Technical Symposium (ATS 2014) of May 9, 2014, at NASA/JSC Gilruth Center. His charts from that event are available on that event's *website*. Dr. Robert (Rob) Griffin mentions, in a Rice University Griffin Lab website page, "The research interests of our group lie broadly in understanding the chemical behavior of trace gases and aerosol particles in the troposphere. Only if such behavior is understood can the magnitude of the effects of these species on human health, climate, visibility, etc. be understood."

Dr. Kyriacos Zygourakis is a faculty member of the Department of Chemical and Biomolecular Engineering.

The Rice University James A. Baker III Institute for Public Policy's Climate Change Initiative (CCI) *website* is excellent, but its most recent entry might be from 2009. The website contains links to video recordings and charts from CCI events, none of which use misleading titles such as, "Climate Change, Is the Challenge Real?" Four key CCI people are listed on that website, Neal F. Lane, Kirstin R.W. Matthews, Amy Myers Jaffe, and Kenneth B. Medlock III. A report by Neal F. Lane is dated July 13, 2007, ***Hot Topic: Navigating the Fact and Fiction of Climate Change.*** A few quotes are presented here.

"Could the climate models all be wrong? Have there not been times in history when the "best" scientific thinking was overturned by a new discovery? Yes, quantum mechanics is a good example of scientific thinking being changed. But this is unlikely to happen with climate science. Unlike quantum mechanics, climate science is not based on a single scientific theory, but rather on mountains of historical data and well-established basic laws of physics, chemistry and biology.

"Might scientists be overextending their research to gain better funding? That's not likely, either. Falsifying data or overselling research would constitute fraud; and fraud in science is very rare, not because scientists are different from other people but because scientists are unforgiving of fraud."

"But don't take my word for all this. If you want to know more about climate change science and the policy and politics involved, read a few articles and books written by reputable scientists and science journalists. Encourage them to speak at your clubs, churches or schools."

Professor Lane mentions Chris Mooney's 2007 book, *Storm World*.

The Rice University *Shell Center for Sustainability* enjoyed its tenth anniversary recently (2002-2012). ■

Student Section News
Please send inputs to Dr. Gary Turner, our College and Co-Op Chair: collegecoop2013[at]aiaahouston.org.

Student Section News

Faculty advisor: Professor John E. Hurtado
jehurtado[at]tamu.edu, 979-845-1659.
http://stuorg-sites.tamu.edu/~aiaa/

TEXAS A&M UNIVERSITY

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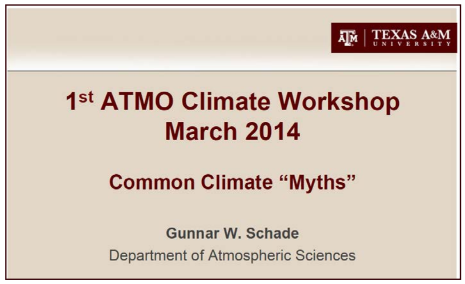
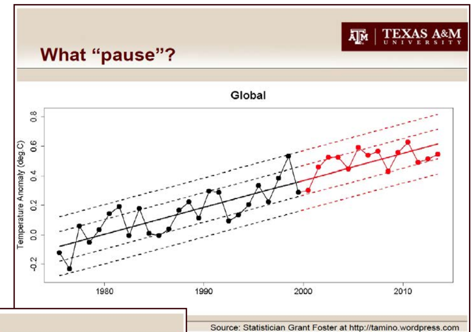
Position	Name
Chair	Rahul Venkatraman
Vice Chair	Alejandro Azocar
Treasurer	Steve Anderson
Secretary	Sam Hansen
Speaker Chair	Jacob Shaw
Activity Chair	Kristin Ehrhardt
Publicity Chair	Nick Page
SEC Representative	Nhan Phan
Webmaster	Nick Page
Gratudate Class Rep.	Chris Greer
Senior Class Rep.	Nicholas Ortiz
Junior Class Rep.	TBA
Sophomore Class Rep.	TBA
Freshamn Class Rep.	Farid Saemi

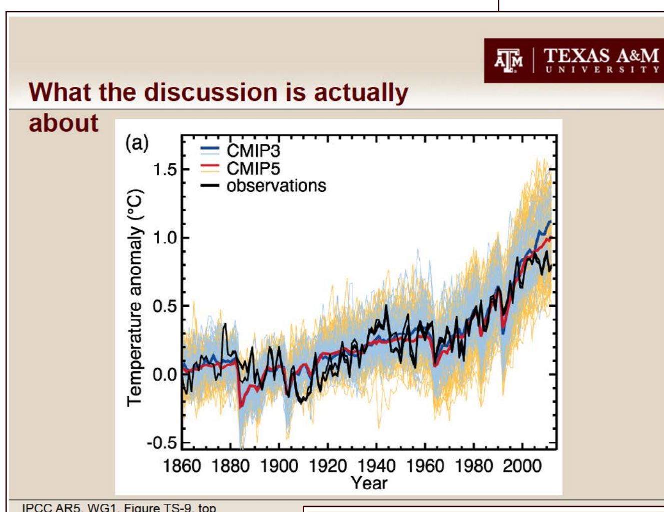
[June 23, 2014]

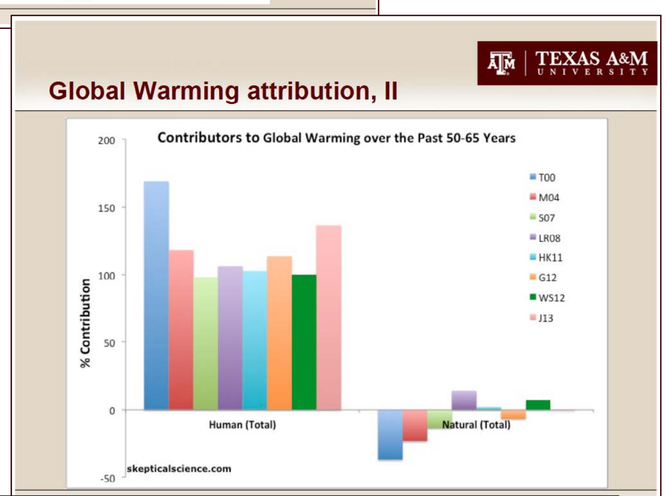
The Texas A&M University (TAMU) AIAA Student Chapter is not working with climate change, but climate change is of great interest to NASA. All NASA subjects are of great interest to AIAA. A typical example of climate change science and public policy is the American Geophysical Union's 2013 position *statement* (revised and reaffirmed since 2003), "*Human-induced Climate Change Requires Urgent Action*."

TAMU is very active in climate change research. A few charts are presented here from a recent climate change *event*.









Texas Center for Climate Studies

GEOSCIENCES TEXAS A&M UNIVERSITY

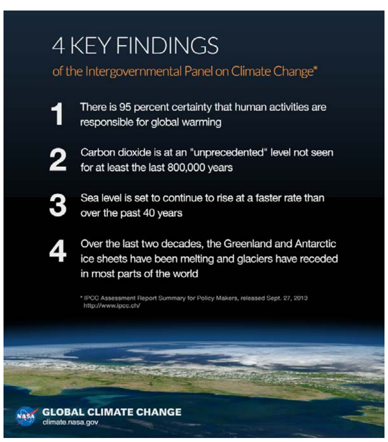
Student Section News
Please send inputs to Dr. Gary Turner, our College and Co-Op Chair: collegecoop2013[at]aiaahouston.org.

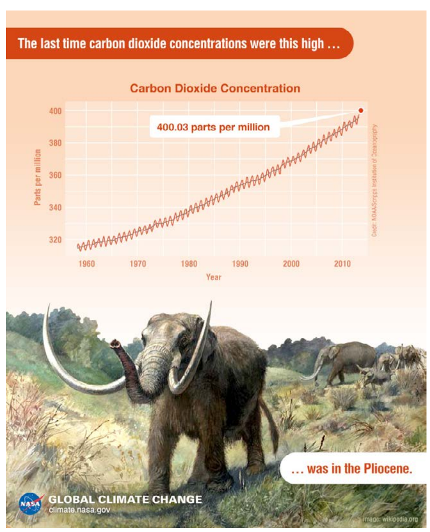
AIAA Houston Section
P.O. Box 57524
Webster, Texas USA 77598

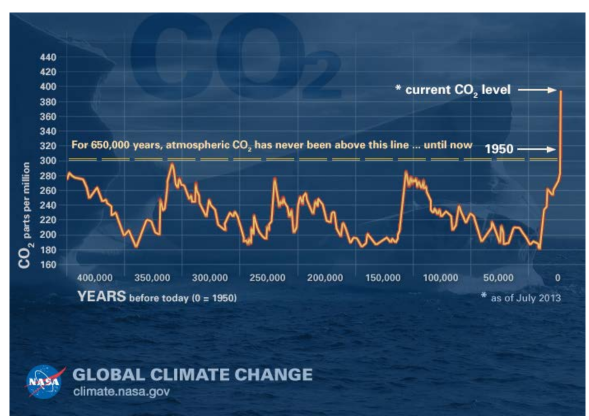
The American Institute of Aeronautics and Astronautics

In the News

The NASA Climate Change Website







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