RocketSTEM

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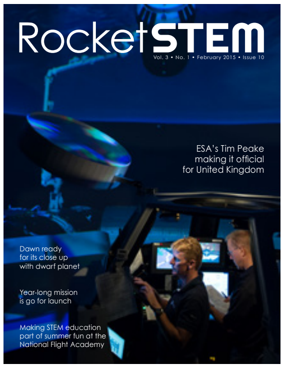
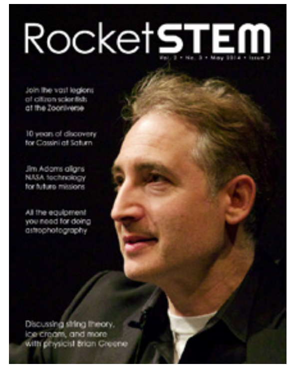
ESA's Tim Peake making it official for United Kingdom

Dawn ready for its close up with dwarf planet

Year-long mission is go for launch

Making STEM education part of summer fun at the National Flight Academy





Pledge your support to RocketSTEM

This issue marks the beginning of our third year of publishing RocketSTEM, and our continuing mission to inspire the next generation of explorers – from scientists to engineers and, yes, even astronauts. We've featured missions launched from spaceports across the globe to explore the Moon, Mars, and our own planet Earth. We've interviewed astronauts who have walked on the Moon. We've spoken with those designing, building and operating today's unmanned spacecraft exploring Mars and beyond. We given you an insight into the universe through our interviews with leading scientists such as Neil deGrasse Tyson, Brian Greene and Jay Lockman.

Since founding RocketSTEM three years ago, we've declared that each issue of the magazine will be FREE to read online. As a non-profit organization that is a mission we intend to never stray from, but we need your support in helping us keep that promise.

We've established a page at Patreon (www.patreon.com/rocketstem) where you can support our endeavours. By making a pledge via Patreon, you will be making a donation automatically after each new issue of the magazine is published. On the months where we do not publish a new issue, you'll owe nothing.

If you wish to make a one-time donation, you may do that through PayPal on our website. Our donation page's web address is: www.rocketstem.org/donate/.

We've set up several donor rewards levels, and will be adding more in the future. We're working on designs for decals, patches, hats and shirts. All that will be made available to donors in the coming months.

We hope you enjoy this magazine, and will continue to be inquisitive about the universe we all inhabit.

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On the Cover: *Expedition 47 (Soyuz 45) crew members Tim Kopra and Timothy Peake during training in the SES Alpha Cupola. Credit: NASA/Lauren Harnett*

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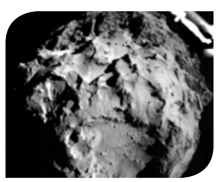

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We'll celebrate the 25th anniversary of the Hubble Space Telescope.

National Flight Academy

MAKE LEARNING *an* ADVENTURE

Who says learning can't be fun? Certainly not the leadership team at Ambition who delivers "inspired play" in six-day immersive programs at the National Flight Academy located in Pensacola, Florida. It all starts with the story – a heart-pumping, adrenaline-filled mission with squadrons competing to successfully finish a task. Whether it is a race or rescue, science, technology, engineering, and math (STEM) skills are used in tandem with the equally important 21st century learning skills including critical thinking, problem-solving, teamwork and communication to advance the team.

Since opening in 2012, more than 2,600 students from 44 U.S. states and seven countries have come aboard Ambition to participate in its next-generation innovative play. From the theme park-like sight and sound to premier technology available for students – the experience is meant to make it feel like they are actually serving aboard a real U.S. Navy aircraft carrier.

Ambition Experimental Pilots (AXPs), as the students are called, become fundamentally aware of the integration of mathematics and science into their daily lives by measuring, collecting, analyzing and interpreting data. Critical thinking, communication, collaboration, creativity and other learning skills are valuable assets the students gain from the experience.

The NFA was kind enough to allow RocketSTEM to have one of our staff members (shown on the left side of the above photo) go through the six-day deployment last summer. He was an incoming high-school freshman at the time, and the experience was the highlight of his summer.

All photos courtesy of the National Flight Academy

By Kaelan Jungmeyer

I had an amazing and unique experience at the National Flight Academy. It looked like a real aircraft carrier inside. There were sounds of planes taking off. I felt immediately welcomed. The camp had a very inviting feel.

We were separated into "CAGs" which is like the big overall groups. There were three CAGs, a CAG with the older kids, a CAG with the freshmen in high school, and a CAG with anyone younger than them. Within these CAGs there were three different squads.

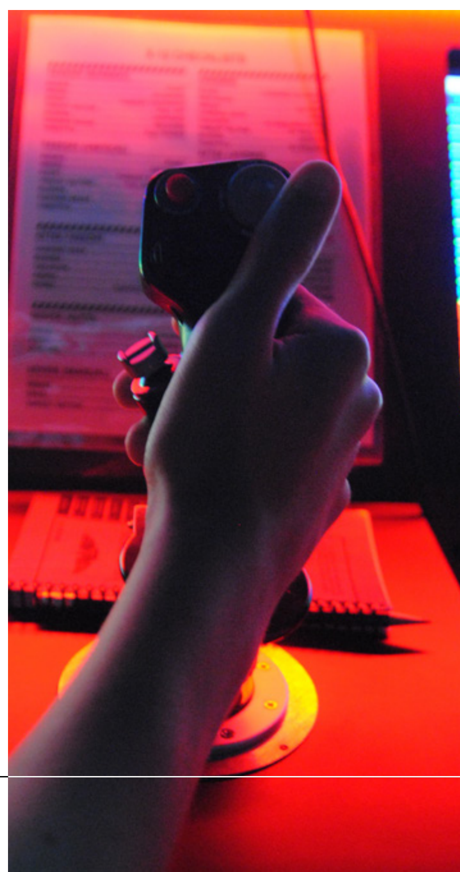
I was a part of the "Rough Raiders", and in my CAG there were also the "Yellow Jackets" and the "Scorpions". When I showed up they put me at a table that had my squad all sitting at it. They had us remotely take a test over naval terms and flight basics, then the camp started immediately.

The first thing that you noticed was the look. From the outside it looks like a big gray box with the occasional fake porthole on the sides. When you walk through the hallways, there are things like AFFF, or fire fighting material, hoses, and different items along the walls.

We went and did our first rounds. We flew, ran comms, and planned missions. We flew experimental triad jet simulators, with hover capabilities which are capable of mach 3 and reaching 90,000 ft. in altitude. We ran comms in the JOK. Running comms meant giving the planes headings, clearing them to take off and land, and helping them when needed. Planning missions happened in the JIK. We would find the speed that we needed to go, the fuel required, the true course on how to get there.

We did those three just in the first day. While one squad was running comms, one would be flying and the other would be planning the missions. We flew in the simulators the first day through a obstacle course. We got a late start, so we were working until around ten o'clock.

The flight simulators were amazing. There were three screens across the front like a cockpit window. There was a joystick in the center and throttle, rudder control and flaps on the left. On the right there was the co-pilots seat with a mouse that you could turn on comms to talk to the tower. In the center there two touch screens that would show your horizon, speed, altitude, bearing, heading, would allow you to control the burner, which is like turbo, and the fuel indication. We then had thirty minutes of "hygiene time". After that we settled into our rooms that had three bunks. Most of my squad members were in my



room. Lights out were at ten thirty, and that was just the first day.

The second day we woke up to yelling RA's at 06:30. We met in the lounge until 07:30 when we headed down to breakfast. The food was amazing. Between burgers, tacos and pasta, we rarely left food untouched. We would do our rounds of the JIK, JOK and flying usually twice a day. The second day we only did it once because we were still having things explained to us. That day we planned missions, ran comms and flew in a hover obstacle course. This was the first day that we met our morning Squad Chief. She looked somewhat like Emma Stone and was awesome.

Our Night Chief was equally, if not more, awesome. We did evening games with him that included ninja, invisible ball and face off. Face off was fun because you asked the person that you were facing off against random questions and it made you think on your feet. In categories, one member of a squad would often go against another member of another squad. The ref would call out a category, like a fruit, and the first one to say something in this category would win and face the next challenger. Before we flew or ran comms, we would meet in a briefing room with one other squad. That night we played games and had "hygiene time".

The third day we woke up bright and early to one of the most intense days. We ran one of our first true missions. We searched for illegal planes. There was a 180 degree field that was 120 nautical miles across. Each group within a squad (a pilot and a co-pilot) would cover a sixth of the semi-circle.

It was difficult because you had to fly low to the water in a zig-zag

Explore Ambition

Located adjacent to the National Naval Aviation Museum, the National Flight Academy is a 102,000 sq. ft. four-story structure designed to be fully and intensively immersive. The NFA's adventure begins with our landlocked, virtual aircraft carrier, Ambition (CVT-11). Each deck of Ambition is designed scenically and theatrically to simulate a modern aircraft carrier. The first deck houses the galley, mess deck, administrative spaces and the aircraft hangar bays. The second deck is dedicated to academic spaces including the operations and intelligence centers. The third and fourth decks house berthing (crew quarters), lounges and activity rooms. The facility is designed in compliance with the Americans with Disabilities Act.

Virtual tour of Ambition

Take a "behind-the-scenes" tour of the NFA's virtual aircraft carrier, Ambition: www.nationalflightacademy.com/virtualtour/

A day in the life of an AXP

Everyday the schedule begins at 0630 with reveille. Ambition Experimental Pilots (AXPs) are given time for a shower and personal care, nutritious breakfast, and called to their assigned stations by 0800. AXPs will be briefed on the days' action-packed mission and will work together to create a master plan, flight map, and debrief following the completion of every mission. Each mission will test AXPs' mental agility, preparedness, and communication skills, while demonstrating the importance of teamwork and goal completion. Through consistent simulator experience and immersive role-play, AXPs will have ample opportunity to see firsthand how those in Naval Aviation respond to and avert emergencies in real life. Later on, AXPs will also have a once-in-a-lifetime opportunity to watch the famous Blue Angels (when available) practice barrel rolls and aerobatic formations with an unobstructed, front-row view of the fun!

Following an action-packed week, the Ambition Experimental Pilots' squadron Commanders and the Captain will host a graduation ceremony to celebrate the AXPs' major accomplishments. The ceremony will include awards, personal recognition, and inspiring activities surrounding this exciting accomplishment. Family and friends are invited to attend graduation ceremonies.

pattern to look for ships. Once you found one you would hover over it and send pictures to whoever was running comms for my airplane.

Then not only did we do that, but we also practiced the following day's mission, which was formation flying. We elected one flight group, which was Chi-Chi and Olga to lead the flight formation. I was more or less second in command and helped keep everyone in line. We did awful. Our original formation was the leader in front with two people to the left and right, two people directly behind them, and one person in the back middle. Our squad didn't communicate well.

That day was awesome mainly because that was the day that we got our call signs. A call sign is like a nickname in the military. Mine was Gizmo, but there were others like Ohioooo, Olga, Chi-chi, Raven, and Tina. That day we had a surprising amount of free time and I had an intense multi-puck air hockey match with a kid from another CAG.

The next day was one of my favorites. This was day that we did the air rally and more formation flying. This time when we flew in formation everything went perfect. Everyone was in their spots and flew perfectly. Our new formation that I came up with was the leader in the front, I was directly behind him, one group to my right and left, and two people behind them.

After this we were briefed on the air rally. An air rally is basically an air race and obstacle course. We had to hover and take pictures, pick up cargo, do a touch-and-go, and do a hover obstacle course through pillars. It was intense because you could see the other planes and how well they were doing if they were in front or behind you.

This is also the day that we got our "motto". There was a member of our squad whose call sign was Ohio. We would call out his name but emphasize the O. It would go something like Ohioooooooo. The air rally was very intense. I had one of the best times but they never announced who officially won.

The air rally was probably my

favorite of all the activities. That night we planned the next day's mission. We planned a cross-country mission that would take almost two hours.

We woke up to the Navy's anthem over the intercom. We met in the lounge and went to breakfast. Then there was a blaring horn over the intercom. There was an emergency briefing at the breakfast tables for an emergency mission that canceled our cross-country plans.

We had to run cargo to the Ambition from an oil drill and then fly to a sinking cruise ship. We then had to save the people that fled the sinking ship. Once they were flown to the nearest airport, we had to dissipate the gas that was released from the tankard that the cruise ship collided with. In the end there were no casualties.

Being the final night at camp we should have been allowed to stay up until 11:00, but someone set off an Axe deodorant bomb and we had to go to bed at 10:30. You could smell it all down the hallway.

The final night we had to go to bed early, but the girls could stay up until 11:00. We planned on meeting in the commons area but that idea was no longer applicable. I had the idea to Facetime the girls across the hall, which ended with us having our door propped open. I think that we were up until 1:30 that night.

The final day crept up on us and before we knew it, it was graduation. We were allowed to sleep until 07:30, ate breakfast, and had free flying time. We were then told about how graduation would work and we made our way to the Blue Angel Auditorium in the neighboring National Museum of Naval Aviation. Each person was called up to the stage and given a patch and aviation wings. When Ohio graduated we all called out his name.

The fun didn't stop at graduation. Afterward we could take our parents around and show them what we had been doing for the past week. And after that, the museum was open to campers and their parents.

This camp was amazing and I will always look back on it fondly.

2015 Ambition deployment schedule

These are the spring/summer session dates for the six-day deployment programs for children in grades 7-12.

March 22-27 (Sold Out)	*June 7-12 (Sold Out)*	July 12-17
March 29-April 3	*June 14-19 (Sold Out)*	July 19-24
April 5-10	June 21-26	July 26-31
May 24-29	*June 28-July 3 (Sold Out)*	August 2-7
May 31-June 5	July 5-10	August 9-14

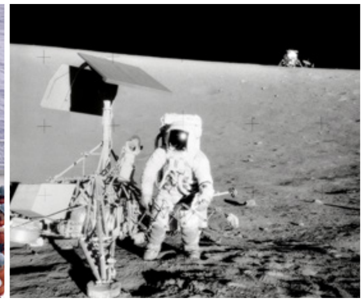
Other programs

Adventure Saturday: Introductory program for grades K-12.
Cruises: Three-day programs for grades 5-12.
Adventures: One-day youth program for groups. A great for option for scout troops.

Scholarships

The National Flight Academy accepts scholarship applications for deserving students to attend the six-day program. A limited number of $500 scholarships are available for the 2015 program. If you would like to learn more about the National Flight Academy scholarship program, please email boost@nationalflightacademy.com.

Land ... sea ... space



NAVAL AVIATORS

have led the way

The United States Navy and NASA have had a working relationship for over 55 years now and they continue to complement each other in many different aspects of space exploration. This relation was forged way back in the late 1950s when NASA first began to look for pilots to become Astronauts that would eventually fly aboard their new Mercury spacecraft. In fact three of the original seven Mercury astronauts came from the ranks of the Navy. Wally M. Schirra, Scott Carpenter, and the first American to go into outer space, Alan B. Shepard, were all Navy pilots. The Air Force added three of their own to the program, Gordon Cooper, Gus Grissom, and Deke Sleyton. Then toss in one famous Marine named John Glenn, and you've rounded out the original seven.

To date, there have been 330 NASA Astronauts, 201 of them have come from the military, and of that 201, 83 of them were from the Navy. That puts them in the number 1 spot, for now at least, beating out the Air Force by just two astronauts.

And it's not just astronauts that the Navy provides to NASA, they provide other services as well, but we'll get to that a little later. First some pioneering astronauts from the Navy that you may have heard of.

Story by Lloyd Campbell

One must be first: alan shepard


Alan Shepard in his space suit seated inside the Mercury capsule. Credit: NASA/Bill Taub

Astronaut Alan B. Shepard Jr. was born in East Derry, New Hampshire on November 18, 1923. After graduating from the U.S. Naval Academy in 1944, he served in World War II aboard the destroyer Cogswell. After the war he attended flight training school and earned his wings in 1947 and went on to be a test pilot on many different aircraft. He logged more than 8,000 hours of flying time, 3,700 hours in jet aircraft, over his career.

He went on to become one of the original Mercury astronauts and became the first American to go into space on May 5, 1961. Inside of the Freedom 7 spacecraft, he was launched into space by a Redstone rocket on a ballistic trajectory suborbital flight. The first American in space enjoyed just a 15 minute flight that carried him to an altitude of 116 statute miles and to a landing point 302 statute miles down the Atlantic Missile Range. With astronauts today staying six months aboard the International Space Station, that hardly seems impressive, but in 1961 it was a tremendous accomplishment. An inner ear problem discovered later in his career grounded him from flying again, but he remained at NASA as Chief of the Astronauts Office with responsibility for monitoring the coordination, scheduling, and control of all activities involving NASA astronauts. Following an operation on his ear, he was restored to flight status in May of 1969 where he began to train on the Apollo program. He went on to become the fifth American to walk on the Moon as Commander of Apollo 14. He spent a total of 9 hours and 17 minutes exploring the surface of the Moon. Much to the surprise of just about everyone, at NASA and elsewhere, he even hit a couple of golf balls up there.

One small step: neil armstrong

Neil Armstrong was born on August 5, 1930, in Wapakoneta, Ohio. He grew up with a fascination with airplanes and flight at an early age, having learned to fly at the age of 15, before he could drive a car. He went to Purdue University where he obtained a Bachelor of Science in Aeronautical Engineering. He later earned his Master of Science in Aerospace Engineering from the University of Southern California.

His studies were interrupted in 1949 when he was called to serve in the Korean conflict, where he flew 78 combat missions as a Navy Pilot. After the war, Neil left the Navy and returned to his studies. So unlike many of his fellow Navy Astronauts, he was not still in the Navy when NASA selected him to become an Astronaut, but he's included here since he made a few important contributions during his career at NASA.

In 1955 he joined the National Advisory Committee for Aeronautics (NACA), which later became the National Aeronautics and Space Administration (NASA). As a test pilot and engineer, he flew many high-speed aircraft, including the X-15, which could reach a top speed of 4,000 miles per hour. Over the course of his career Neil flew over 200 different aircraft including helicopters, jets, and of course rockets.


Neil Armstrong stands next to the X-15 ship after a research flight.

Selected to the second group of Astronauts in 1962, Neil went on to command the Gemini VIII mission in 1966. This would be the 6th manned Gemini flight and the first to perform a docking with the unmanned Gemini Agena Target Vehicle (GATV). The primary mission objectives were to perform rendezvous and four docking tests with the Agena target vehicle and to execute an Extra Vehicular Activity (EVA) experiment. Other objectives included parking the Agena in a 410 km circular orbit, performing a re-rendezvous with the Agena, and some other tests and experiments as well. Armstrong and his co-pilot Astronaut Dave Scott launched on March 16, 1966 and spent the next six hours catching up with the GATV which had launched an hour and forty-one minutes earlier. They docked their spacecraft with the GATV at 5:14 PM. Approximately 27 minutes later the docked spacecraft began to roll, after attempts to stop the docked spacecraft's roll, Armstrong undocked from the GATV. This however sped up their rotation; the crew then managed to shut down the Orbit Attitude and Maneuvering System (OAMS) that is used to control their spacecraft and brought up the reentry control system (RCS), which is normally only used when it's time to reenter the Earth's atmosphere, in a final attempt to stabilize their tumbling spacecraft. Their efforts were successful, and after 25 minutes of tumbling they were now stable in orbit. However due to them bringing up the RCS, they were now going to have to end their mission early per mission rules so the remaining maneuvers, EVA, and experiments would not be performed. However due to their quick thinking, extensive training, and skills as pilots, they saved what could have been a disaster.

Armstrong flew one more mission for NASA which you may remember him for, that being Apollo 11, mankind's first landing on the Moon. Armstrong will always be remembered as the first man to walk on the surface of the Moon. That however, would have not been possible had he not been the first man to land a spacecraft on the surface of the Moon.

The landing turned out to be more of a challenge than anyone had anticipated. Neil and his Lunar Module Pilot, Buzz Aldrin, encountered problems with the computer during the powered descent, Program Alarms kept displaying that they were working through with Mission Control in Houston. The computer controlled the Lunar Module (LM) through much of the descent phase, so any abnormal alarms were disheartening to say the least. While all these alarms were popping up, Mission Control was trying to determine what they were, the crew was making sure their machine was still flying correctly, and the landing spot was getting closer and closer.

On a lunar landing, the Astronauts can't even see the surface until the LM pitches over. Since Neil and Buzz were still dealing with some program alarms when the vehicle pitched over, Neil didn't get a good look at where the computer was targeting them to land until they were only about 2,000 ft. above the surface. That's where they saw a very rocky area and Neil quickly decided to retarget the landing site, further down the flight path, or land long as it is known. Manually flying the LM, he pushed the vehicle as quickly across the surface as it would allow, slowing their descent and moving some 1,100 feet to the west before finally finding a suitable landing spot. There Neil dropped the LM down and set the vehicle down for the very first manned landing on the Moon.

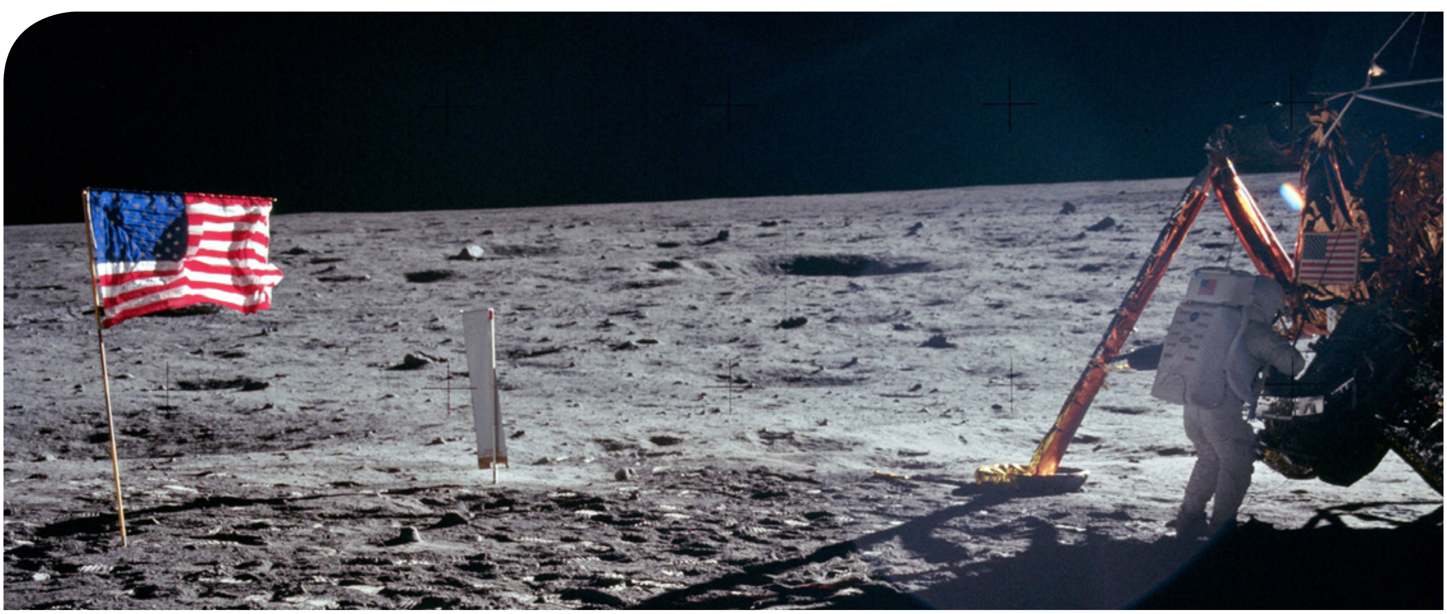
Their estimated burn time for the descent was 11 minutes and 58 seconds but they actually took 12 minutes and 34 seconds. They were definitely low on fuel, estimates indicate they had about 45 seconds of fuel left, which in reality would mean about 25 seconds as they needed 20 seconds of fuel to steady the spacecraft and abort the landing. Of course Neil would probably never have aborted; he'd have landed it anyway.

Later that day, we all know that he and Buzz Aldrin spent about two and a half hours walking on the surface, collecting samples, setting up experiments, and cementing their place in history.

After leaving NASA in 1971 Armstrong went on to teach Aerospace Engineering at University of Cincinnati for 8 years and then served as the chairman of Computing Technologies for Aviation, Inc., from 1982 to 1992.

Neil passed away on August 25, 2012. His crewmate and fellow moonwalker Buzz Aldrin summed it up best, "Whenever I look at the Moon I am reminded of that precious moment, over four decades ago, when Neil and I stood on the desolate, barren, yet beautiful, Sea of Tranquility, looking back at our brilliant blue planet Earth suspended in the darkness of space, I realized that even though we were farther away from earth than two humans had ever been, we were not alone.

"Virtually the entire world took that memorable journey with us. I know I am joined by many millions of others from around the world in mourning the passing of a true American hero and the best pilot I ever knew. My friend Neil took the small step but giant leap that changed the world and will forever be remembered as a historic moment in human history."



Neil Armstrong works at the Lunar Module on Tranquility Base during the Apollo 11 Mission. Credit: NASA

Expedition One commander William (Bill) Shepherd poses for a photo in the Zvezda Service module of the International Space Station Alpha. Credit: NASA

Did someone call for a contractor? william shepherd

Another Navy Astronaut, William Shepherd, was born July 26, 1948 in Oak Ridge, Tennessee. However if you ask him, he calls Babylon, New York his hometown. He too attended the U.S. Naval Academy where he earned a Bachelor of Science degree in aerospace engineering. However, unlike many of his fellow Navy astronauts, he did not go down the path of a pilot, instead he served with the Navy's Underwater Demolition Team Eleven, SEAL Teams One and Two, and Special Boat Unit Twenty. This was a much different path to becoming an astronaut then most other Navy astronauts before him.

Captain Shepherd was selected as an astronaut in 1984 and went on to fly three Space Shuttle missions. STS-27, his first mission was a mission for the Department of Defense. Space Shuttle Atlantis launched on December 2nd, 1988 on a 4 day mission. In its payload bay was a satellite named ONYX, the mission was to simply release it into orbit, however upon release, one of the antenna dishes failed to deploy. The crew retrieved and repaired the satellite before releasing it once again. Repairing the satellite would have required an unscheduled spacewalk which Shepherd and fellow crew member Jerry Ross would have had to perform. But that's all just speculation, in truth, only the Astronauts and some people at NASA and the DoD really know what happened since the mission, was, and still is, classified.

His next mission would be STS-41, while not a classified mission, it was never the less, very important. On board was the European Space Agency's Ulysses spacecraft which they were to send on a mission to the sun to explore its polar regions. The mission was a success, Ulysses made it to the Sun and spent 18 years orbiting our star carrying out its studies.

His last Space Shuttle mission would be on STS-52 which launched on October 22nd, 1992. The primary mission was the deployment of the Laser Geodynamic Satellite also known as LAGEOS-II. Other mission experiments were also performed and Columbia returned to a landing at the Kennedy Space Center on November 1st, 1992 after a highly successful mission.

That, however, was not the end of Captain Shepherd's career as an Astronaut. He did fly one more time aboard a Russian Soyuz spacecraft, blasting off on October 31st, 2000, and docking to the newly born International Space Station two days later. He and his crew of two Russian Cosmonauts spent almost 6 months as the very 1st crew to man the orbiting outpost. They were responsible for getting everything working inside and preparing the station for future crews and future expansion of the outpost. This was quite the daunting task to say the least, which could be why NASA put an Ex-Navy SEAL in command. Captain Shepherd returned to Earth aboard the Space Shuttle Discovery on March 21st, 2001. That would be his last time flying in a spacecraft, as he retired from NASA in 2002, but you can go outside and see his work flying overhead still today.

Columbia's gutsy twosome on the maiden voyage of a shuttle orbiter: Commander John Young (left) and Pilot Robert Crippen. Credit: NASA

There's a first time for everything: john young & bob crippen

In 1981, NASA was preparing to launch its next generation spacecraft, the Space Shuttle, for first time ever. All previous manned spacecraft were tested unmanned before allowing a crew on board. But NASA was putting a crew on the maiden flight of Columbia and that crew would be another all Navy crew. The primary mission objectives for STS-1 were to accomplish a safe ascent into orbit, check out all the systems on the orbiter and to return to Earth for a safe landing. This would also be the first time a manned spacecraft launched with Solid Rocket Boosters.

The commander of STS-1, John Young, was again from the Navy, and another pilot. John attended the Georgia Institute of Technology where he earned a bachelor of science degree in aeronautical engineering before entering the Navy. He was a veteran of four spaceflights prior to STS-1, including the first manned Gemini mission, Gemini 3, where he operated the first computer ever used on a manned spacecraft. He took the Commander's seat on Gemini 10 where he and Pilot Mike Collins completed multiple rendezvous with two different Agena target vehicles. Later as Command Module Pilot of Apollo 10, John flew to the Moon for the first time where he, Commander Tom Stafford, and Lunar Module Pilot Gene Cernan would test the entire Apollo landing process. Back in the Commander's seat for Apollo 16, Young along with Lunar Module Pilot Charlie Duke, and Command Module Pilot Ken Mattingly went to the Moon on the fifth mission to successfully land on the surface. Young and Duke would spend almost three full days on the surface. Using the Lunar Rover they were able to cover over 16 miles of surface during their three moonwalks which lasted a total of just over 20 hours.

The pilot of STS-1 would be Bob Crippen, this would be his first spaceflight after 12 years with NASA. Crippen, also a Navy pilot, attended the University of Texas prior to enlisting where he earned his Bachelor of Science degree in Aerospace Engineering.

John Young would go on to command STS-9, his sixth and final spaceflight, while Crippen would fly as Commander for STS-7, which carried the first American woman astronaut, Sally Ride, into space, and again as Commander of STS-41C and STS-41G.

While the STS-1 mission was a success, things were learned such as upon landing it was discovered that the orbiter had lost 16 Thermal Protection tiles and had damage to 148 others. An overpressure wave occurred when the Solid Rocket Boosters ignited and that caused the damage to the Thermal Protection system. Further modifications to the Sound Suppression System were made that helped minimize any damage to the TPS in later flights.

If not first, second will do: pete conrad, alan bean & dick gordon

Over the last 53 years of manned spaceflight there has even been the opportunity to have a number of all Navy crews fly a mission together.

Apollo 12, the second manned landing on the surface of the Moon, was commanded by Charles "Pete" Conrad Jr. who was also a Navy pilot before entering NASA. His fellow moonwalker, Alan Bean, also known as the Lunar Module Pilot, was a Navy pilot also. Rounding out the crew was Command Module Pilot Richard Gordon, and yes, yet another Navy pilot. They were a very close crew and were friends before and after their mission.

Crew of the Apollo 12 mission (from left): Charles "Pete" Conrad Jr., Richard Gordon Jr., and Alan Bean. Credit: NASA

Apollo 12 launched on November 14, 1969 from Kennedy Space Center Pad 39-A. One of the more memorable events occurred 52 seconds after launch when the rocket was it by lightning, not once, but twice. This caused all three fuel cells, which provide power to the Command Module, to go offline. Flying on just their batteries in the Command Module, they were able to regain power and continue on with their mission. Unlike the first landing on Apollo 11, which touched down over four miles from where the intended landing site was, Apollo 12 intended to make a precise landing in the Ocean of Storms on the Lunar Surface. One of their tasks was to retrieve a piece of an unmanned lander, Surveyor III, which had been there for over two and a half years. Conrad piloted the Lunar Module, named Intrepid, to a landing just over 500 feet from Surveyor III. Conrad and Bean made two EVAs, spending over seven hours on the lunar surface. They deployed numerous experiments and sensors on the surface and returned about 75 pounds of lunar rocks and soil to the earth for study.

Conrad and Bean went on to command different missions aboard Skylab, America's first orbiting space station while Gordon retired from NASA in 1972.

Once around the block: scott kelly

In order to better understand the side effects of a long duration spaceflight where the crew could be in microgravity for a year or more, NASA is currently preparing for a year-long mission aboard the International Space Station. Data from the mission should help NASA develop and/or validate countermeasures designed to reduce the effects of long exposures in space. This will help them with their goals of long duration Lunar missions and ultimately missions to Mars.

STS-118 Commander CDR Scott Kelly posing for a photo near a window on the Space Shuttle Endeavour. The International Space Station ISS is visible behind him. Credit: NASA

Scott Kelly and Russian cosmonaut Mikhail "Misha" Kornienko currently are scheduled to launch aboard a Soyuz rocket to the International Space Station in March of 2015 and they will stay aboard the outpost for nearly a full year.

For Scott Kelly, a former Navy aviator, this will be his 4th spaceflight. On STS-103 in 1999 he was the Pilot on Discovery on what was the 3rd Hubble Space Telescope servicing mission. On STS-118 he served as Commander of Space Shuttle Endeavour on a ISS servicing flight which delivered a third starboard truss segment to the outpost. He launched to the space station again in 2010 and served as the Flight Engineer for Expedition 25 before assuming the role of Commander on Expedition 26 after the departure of the Expedition 25 Commander.

Sailors from the amphibious transport dock, USS Anchorage, and Navy Divers attach a line to the Orion Crew Module. Credit: U.S. Navy/Corey Green

Looking for a lift? spaceship recovery

While the Navy's role in providing astronauts is one to be proud of. They offer many other services that NASA requires. Up until the Space Shuttle, all returning U.S. spacecraft landed in the ocean. From the first Mercury capsule carrying Alan Shepard, through the last Apollo flight, Apollo 17, with Navy pilot Eugene Cernan in command, and through the four Skylab flights, the Navy provided the ships, planes, helicopters, and personnel to retrieve the returning astronauts and their spacecraft from the ocean.

One of the more recognizable recovery ships, the U.S.S. Hornet is now a museum in Alameda, California, that anyone can visit. The Prime Recovery Ship (PRS) for both Apollo 11, and Apollo 12, you can see where the first men to walk on the Moon were welcomed back to Earth.

In all the Navy recovered 5 Mercury Capsules (Liberty Bell 7 was lost, but has since been recovered) and their Astronauts, 10 Gemini spacecraft and their crews, and 11 Apollo spacecraft and their crews from the ocean. They also retrieved Ham the monkey and his capsule and numerous unmanned test capsules.

Most of the times, numerous ships were dispatched to the splashdown area since a precise landing did not always occur. One ship would be the Prime Recovery Ship (PRS), with the rest being Secondary Recovery Ship(s). According to NASA's history site, on 3 occasions a SRS actually performed the recovery in the Mercury & Gemini programs.

These retrievals are not an easy task, with the capsule bobbing around in the ocean, sometimes in rough seas, divers and other Navy personnel put themselves at considerable risk accomplishing these retrievals but are always up to the job at hand.

The Navy once again took up this role with the new Orion capsule; which made its first unmanned test flight on December 5th, 2014. Exploration Flight Test-1 was designed to test the spacecraft's heat shield and other systems during a high speed re-entry at over 20,000 MPH. The heat shield will reach temperatures above 4,000 degrees Fahrenheit during re-entry.

Once again the Navy worked with NASA on procedures and equipment to safely return the vehicle to the ship. This time however instead of helicoptering the capsule back to the ship, the Navy towed it inside a ship's flooded Well Deck. Orion was secured against the bumpers in the well deck as line tenders on platforms inside the well deck help secure the capsule. Water was then drained from the well deck allowing Orion to be berthed onto its recovery cradle.

In later missions, the crew will then be extracted. The Navy hopes to accomplish the entire process from splashdown to extraction in 2 hours or less.

This is due to the spacecraft running on batteries to provide cooling and fresh air to the crew, and those batteries will only last about 2 hours. Not to mention the crew bobbing around in what is essentially a small boat, in rough waters, will not be a pleasant experience for them, particularly after being in a weightless environment for an extended period of time on a long duration flight such as those Orion will be used for.

Looks like a nice place: astronaut training

In the early days of manned spaceflight, NASA recruited pilots to become astronauts. They were already trained to fly and survive in a harsh environment if they needed to after a failure of their aircraft for any reason. With the advent of the Space Shuttle and afterwards, the International Space Station, more specialized Astronauts, known as Mission Specialists on Shuttle flights, are now required. Mission Specialists perform tasks such as servicing satellite, servicing the ISS, performing experiments, and other tasks that a military pilot might not have the advanced education and training to perform. So NASA turned to civilians and non-pilot military personnel to fill these new astronauts positions on the shuttle and ISS crews.

One part of the astronaut candidates training is known as wilderness survival training. Whether launching on a rocket, or flying in an aircraft, a mechanical failure could land them in a very remote part of the world, so survival training is a must. Much of this initial training occurs at the Navy's 12,500-acre Rangeley mountain wilderness training facility at Brunswick Naval Air Station. Here they will learn land survival, navigation, and field medicine.

Since some of these new astronauts did not come from a pilot background, they will require similar flight and survival training as their pilot counterparts had. The Naval Air Station (NAS) at Pensacola, Florida has been providing training for Astronaut Candidates (often referred to as ASCANS) for many years now. The candidates receive water survival training, aviation physiology and flight training, including flight training in simulators, familiarization flights and instrument training flights. Once selected, the astronauts will travel a lot in NASA's T-38 aircraft with an experienced pilot, so therefore flight training is essential to them.

NASA astronaut candidate Christina Hammock starts a fire successfully during wilderness survival training near Rangeley, Maine. Credit: NASA/Lauren Harnett

Group 15, 1995 Astronaut Class Candidates (ASCANs) participate in training and survival activities at Naval Air Station in Pensacola, Florida.. Credit: NASA

Ringing the bell: international space station

What a better way to end this article then with one more Navy tradition that has made its way into our human spaceflight program. Bells have been used in the Navy for a long time now. Among other things, they are used to signal the arrival or departure of important personnel, such as a Captain, Flag Officer, or other high ranking personnel. They are also used to signal a change in command. Today onboard the International Space Station, such a bell resides and is rung whenever a spaceship arrives or departs. So now we ring the bell and depart this story.

Astronauts Brent W. Jett, Jr. (left) and William M. Shepherd participate in an old Navy tradition of ringing a bell to announce the arrival or departure of someone to a ship. The bell is mounted on the wall in the Unity node of the International Space Station (ISS). Credit: NASA

THE ONE-YEAR MISSION

Astronaut Scott Kelly

Cosmonaut
Mikhail Kornienko

Credit: NASA/Bill Stafford

By Lloyd Campbell

If all goes as planned, on March 27th, a Soyuz rocket carrying the expedition 42 crew consisting of Russian cosmonaut Gennady Padalka, NASA astronaut Scott Kelly, and Russian cosmonaut Mikhail Kornienko will launch on a six-hour flight to dock with the International Space Station. The launch will begin a one-year mission for Kelly and Kornienko aboard the station, the first time anyone has stayed in space for a year or more, since the last cosmonaut flew that long ending in 1999.

Kelly and Kornienko will become only the fifth and sixth human being to spend that long in microgravity, and Kelly will be the first NASA astronaut to stay in space continuously for longer than six months.

For Kornienko, this will be his second spaceflight. He resided on the station once before from April 2, 2010 to September 25, 2010 as an ISS-23 flight engineer with cosmonaut A. Skvortsov and astronaut Tracy Caldwell-Dyson (NASA). He also performed a spacewalk that lasted for 6 hours and 43 minutes.

Kelly will be making his fourth spaceflight having flown his first mission in December of 1999 as pilot of Space Shuttle Discovery on the STS-103 mission. The mission was the third Hubble Space telescope servicing mission and restored the telescope to full working order once again. He flew again in August of 2007 on the STS-118 mission to continue the assembly of the International space Station. He served as Commander of the mission and it successfully delivered the third starboard Truss segment. His third spaceflight was a six month stay aboard the International Space Station where he assumed command of the station on Expedition 26.

Scott Kelly also comes with an additional benefit, a twin brother, former Astronaut Mark Kelly, will be back on Earth and any changes that happen to Scott can be checked against Mark. This means that Mark will not be a typical research control subject, since his environment and living habits will not mimic those of Scott's on the space station. So the research is considered observational in nature. There are no defined outcomes for the investigations; instead, this is a chance to compare data collected from genetically similar astronauts to observe the human effects of spaceflight.

In a news conference on Dec 18, 2014 you could tell Scott was excited about his upcoming mission, "What makes this exciting for me, this one-year flight is about the science and everything we're going to learn from expanding the envelope on the space station greater than what we've currently done. If we're ever going to go to Mars someday, the International Space Station is really a great platform to learn much more about having people live and work in space for longer durations."

NASA astronaut Scott Kelly, wearing an Extravehicular Mobility Unit (EMU) spacesuit. Credit: NASA/Robert Markowitz

The main purpose of the one year mission is to help us better understand the medical, psychological and biomedical challenges explorers may face on an extended stay mission. As previously mentioned, they will not be the first humans to stay in space for this long of duration, however medical and technological advances will allow better understanding of the changes Kelly and Kornienko experience over the longer duration mission.

With six month missions aboard the ISS being almost routine since 1998, scientists have acquired enough data to begin to characterize the effects of six-month sojourns in weightlessness on astronauts' bodies. Hopefully the one-year mission will show if the trends continue at the previous rates or if they decrease or increase, requiring new or modified ways to counteract them. This will help NASA prepare the spacecraft, equipment, and the explorers themselves as they venture to an asteroid, Mars and beyond.

Some of the things the researchers will be looking at are :

• Known changes that have yet to be resolved, such as changes in the eye during spaceflight. Over 30% of NASA astronauts have experienced this change. It is now known that there are structural changes to the eyes of some long-duration astronauts (those in space for six consecutive months or longer). It is suspected this could be due to an increase in intracranial pressure, or increased fluid pressure in the head and spine, which may be due to changes in body fluid volume and distribution.

• Investigation of the physiological cost of spaceflight adaptation, what changes occur in the crew member's body chemistry and metabolism, their immune function, cardiovascular capacity, and bone architecture. It's already known that long-term exposure to weightlessness causes a physiological, multi-system adaptation in crew members. These changes affect the ability of crew members to move and function upon immediate return to a gravitational environment. Scientists would like to assess functional abilities, physical performance and the state of the physiological systems in crew members shortly after their return to Earth. The intent is to develop methods for rapid evaluation of these

Follow the latest happenings on the ISS at:
http://www.nasa.gov/mission_pages/station/main/#.VLkZOyvF_uQ

NASA astronaut Scott Kelly (foreground) and Russian cosmonaut Mikhail Kornienko participate in an emergency scenario training session in an International Space Station mock-up/trainer at NASA's Johnson Space Center in Houston, Texas. Credit: NASA/James Blair

functions, create a time course for recovery, and develop field technologies that allow crew members to assess their own physiological changes. Autonomous medical testing is crucial for crew members in successfully carrying out tasks upon terrestrial landings, as well as recovering and adapting to their environment.

• Evaluate the current methods being used to counteract the physiological changes we already know occur, such as improved exercise protocols to maximize the benefit (reducing the negative physiological effects of spaceflight, such as bone loss and muscle atrophy) while minimizing the crew members' time required.

• Behavior and performance, especially sleep and wake cycles, cognitive performance, and team efficiency, including brain imaging pre-and post-flight. This research also looks at behavioral issues associated with isolation and confinement. Assessing how confinement affects individual and group performance will be crucial for long duration missions and lunar and planetary expeditions.

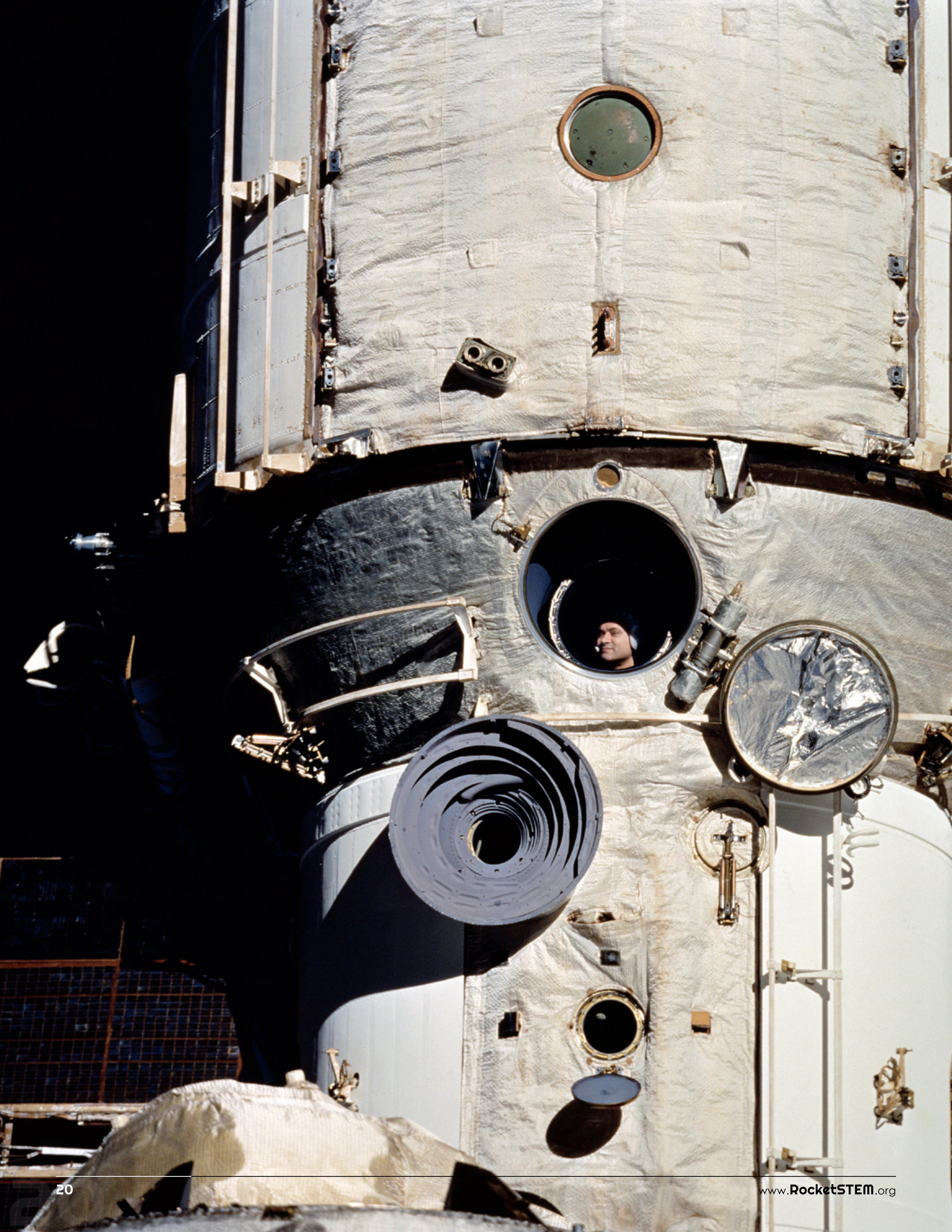
As always, there are other things to be done on the station during their mission other than biomedical research. But they'll be there in a very exciting time for the station. Two new docking adapters will be installed on two U.S. ports to accommodate the upcoming commercial crew spacecraft currently being designed and built by Boeing and SpaceX to bring astronauts to the ISS using American launch vehicles. This includes moving one of the ISS storage modules using the stations robotic arm to a new location. Currently there are at least six U.S. spacewalks planned including at least three by Kelly to support all the changes.

"I'll be doing some of the spacewalks, some of the robotics and a lot of the internal reconfiguration," Kelly said. "Actually, we're starting to refer to it as the 'reassembly of the space station' because it does involve a lot of EVAs (spacewalks) and internal work on (the) wiring of the space station and moving (components) around. It's a lot of work, and I'll be involved in all of it. I really look forward to that, too."

With their third crew member, cosmonaut Gennady Padalka, only staying for six months, and the fact that the Soyuz spacecraft are only allowed to stay in orbit for six months, some creativity was required to make sure Padalka returned home before the other two, and that there was a "fresh" spacecraft for the Year Long duo to return to mother Earth in.

In steps singer Sarah Brightman, the first "space tourist" paying for a ticket to visit the station since 2009. She will launch on September 1st along with ESA astronaut Andreas Mogensen and spacecraft commander Sergei Volkov aboard the Soyus TMA-18M spacecraft. Upon docking the trio will boost the stations occupant count to nine. This will last for just 10 days however as Brightman and Mogensen will return to Earth with Padalka in the TMA-16M spacecraft that he launched in with Kelly and Kornienko six months earlier. This will leave the TMA-18M spacecraft in place and Volkov will be the spacecraft commander when he returns to earth with Kelly and Kornienko on March 3, 2016. The mission will have lasted 341 days if the launch and landing dates do not change.

Learn more about the one-year mission at:
http://www.nasa.gov/content/one-year-crew/



Setting the record:

Fourteen months aboard Mir was dream mission for Polyakov

By Loretta Hall

"We can fly to Mars."

That was the first thing Valeri Polyakov said on March 22, 1995, after returning from a 437-day 18-hour stay aboard the Russian space station Mir. During those fourteen and a half months, he orbited the Earth 7,075 times and traveled nearly 187 million miles. After twenty years, it remains the longest continuous spaceflight of any individual. The idea behind that long mission was to simulate a trip to Mars.

It was a trip he had waited thirty years for. Polyakov finished medical school in Moscow in 1965, just four years after his countryman Yuri Gagarin completed the first manned spaceflight. That flight and other Soviet and American orbital flights that followed inspired Polyakov to specialize in space medicine. In 1972, he began training to monitor other cosmonauts during their flights and to prepare for eventual spaceflights of his own.

His first chance to live in space came in August 1988, when he flew to the Mir space station, which had been orbiting the Earth for over two years. He studied the effects of microgravity on himself and fellow cosmonauts during a 240-day mission.

"I felt very good during the whole flight – on the [launch], during the time on the orbit, and during the landing," Polyakov told an oral history interviewer in 1996. "It can be explained because I am a specialist in space medicine. I know how to use the methods of control, all of the things that protect you, how to use countermeasures the best."

In January 1994, Polyakov got his second chance to live in space aboard Mir. Originally planned for up to eighteen months, the mission length was shortened somewhat because of budget cuts and launch postponements due to rocket engine delivery delays. Until that time, the longest single mission had been 366 days 23 hours, accomplished by Vladimir Titov and Musa Manarov in 1987-88.

"My goal was to demonstrate the ability to work on Mars and come back in good health," Polyakov said in a January 2001 *National Geographic*

Valeri Polyakov watches from Mir as Space Shuttle Discovery practices an approach maneuver in February 1995. The photo was taken by Vladimir Titov aboard the Space Shuttle. Credit: NASA article. His compulsion to demonstrate that capability helped him convince his government to finance the project during the dissolution of the Soviet Union and the resulting economic chaos in Russia.

Polyakov told Robert Zimmerman, author of *Leaving Earth: Space Stations, Rival Superpowers, and the Quest for Interplanetary Travel*, that he felt very different during the launch of his second mission. "Moments before launch, Polyakov's thoughts were far different than those on his first flight," Zimmerman wrote. "Then he had felt eager, excited, and joyous about finally getting into space. Now he felt only fear. He wasn't afraid of dying. Far from it. What he feared now more than anything was failure. 'What if something goes wrong?' he asked himself.... 'I had sacrificed so much time,' he thought. 'The government has spent so much, more than they can afford.'"

But nothing went wrong. Liftoff was smooth, docking was successful, and Polyakov got to work. He and a succession of crew mates performed twenty-five ongoing experiments, mostly in life sciences. The topics included microgravity's effects on blood chemistry and volume, the circulatory system, the central nervous system, and bone density.

Polyakov, himself, was the subject of a variety of evaluations. "Mental Performance in Extreme Environments: Results from a Performance Monitoring Study During a 438-Day Spaceflight," a 1998 paper he co-authored, detailed the extensive examinations he underwent before, during, and after the mission. They measured emotional moods, cognitive performance, the ability to manually track the path of moving images, and his perceptions of workload intensity.

The results were based on only one person's responses, but they offer a glimpse of what other astronauts might experience on a long spaceflight. During the last three days before launch, Polyakov's performance declined in cognitive tasks and tracking response rates. During the first three weeks in space and following his return to Earth – periods when he had to adapt to new environments – he experienced "considerable [reductions] of tracking performance, as well as elevated [perceived] workload ratings and clear drops in subjective mood." However, during the second to fourteenth months in orbit, he showed "an impressive stability of mood and performance." After the mission, there were no long-term reductions in performance.

"My goal was to demonstrate the ability to work on Mars and come back in good health."

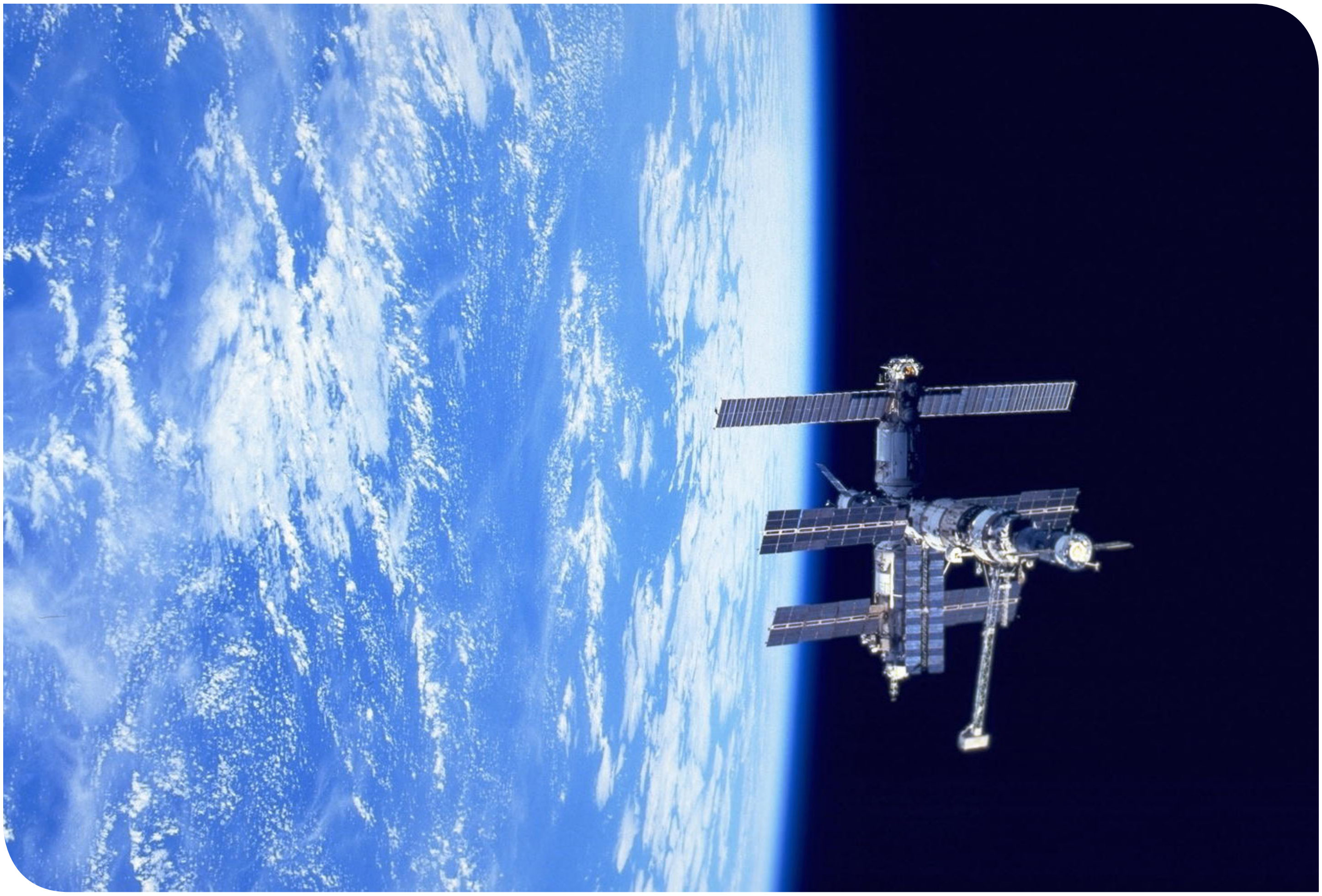
Valeri Polyakov was a cosmonaut from March 1972 until June 1995. He has remained active in space medicine. Credit: New Mexico Museum of Space History

Those carefully structured tests yielded useful results, and so did informal observations. For example, in his 1996 interview, Polyakov talked about experiencing cosmic radiation. "When you sleep at night, if the particle hits your eye, you can see the flash," he said, "like sparks in the eye when somebody hits you in the head."

He also experienced a common effect of long-duration microgravity. On Earth, a person's spine is curved. Without the normal force of gravity, the spine straightens, and the distance between the discs increases. After fourteen months in orbit, Polyakov's height increased from six feet two and a half inches to six feet five inches. That presented a problem for the trip back to Earth. "When you come back, you have to fit yourself in the chair that was made for your size as you were coming up," he said. "If you wear a special suit, it is called 'penguin,' it kind of presses you down. In that case you will have less of a problem."

Yet another informal observation came from American astronaut Norman Thagard, who arrived aboard Mir six days before Polyakov returned to Earth. "[Polyakov's] legs were just as big as tree trunks," Thagard told Zimmerman. "If he did that well after fourteen and a half months, I probably don't have much to worry about for just [a few] months."

Thagard and Polyakov were reunited in October 1996, when they were both inducted into the International Space Hall of Fame. In an oral history interview at that time, Thagard said, "Doctor Polyakov



The Russian space station Mir orbited the Earth from 1986 until 2001. This photo was taken from Space Shuttle Discovery in February 1995. Credit: NASA

told me this morning that he only lost 12 percent of bone mineral from one of the bones that we use for study, which is exactly the same I lost from that same bone in four months [aboard Mir]. He thinks that the countermeasures he did may help limit that."

Polyakov's physical condition was impressive because he exercised strenuously for two hours every day during his entire mission. He knew this was important for several reasons. It helped prevent motion sickness while in orbit as well as during the reentry flight and landing. Also, he wanted to demonstrate that after a long trip to Mars, an astronaut would be in good enough shape to work on that planet.

Polyakov proved his point when he landed in Kazakhstan. As he exited the spacecraft, he insisted on walking, with some assistance, the short distance to the chairs that awaited him and his two companions. He took a drag from a friend's cigarette and a sip of brandy offered by another. Then, after the cosmonauts were carried in their chairs into a medical tent, Polyakov stood up again and took a step or two without help. During the flight to Star City, he walked back and forth inside the helicopter, and at the end of that flight, he stepped off the aircraft and walked almost normally.

In his 1996 oral history interview, he summarized the importance of that: "I was able to come out of the capsule by myself, to walk around, to undress, to dress, to do pretty much everything. And be conscious of everything. That was pretty much the goal of the flight. I had to show that it is possible to preserve your ability to function after being in space for such a long time. But the gravity on Mars is .37. And since I was able to stand up and walk on the Earth wearing a space suit, it shows that [a] human is able, will be able to stand up and walk on Mars."

"In this century if there would be an opportunity to go to Mars, not to stay in orbit as I did, I would get permission from my wife."

Polyakov attained his goal of proving humans could maintain good physical condition after a spaceflight longer than would be needed to reach Mars. His oral history interviewer asked, if he had it to do over again, would he go into space for such a long mission. The cosmonaut replied, "In this century if there would be an opportunity to go to Mars, not to stay in orbit as I did, I would get permission from my wife."

To that, his wife responded, "He just says that. He is not even going to ask."

Exploring the **Dawn**

of the solar system

Credit: NASA/JPL-Caltech

By Chris Starr FRAS FBIS

As we celebrate the tenth anniversary of Huygens' descent to the surface of Saturn's giant satellite Titan, humanity's first landing on an outer solar system moon, and the continuing success of its parent craft Cassini, we look forward to an extraordinary year of robotic solar system exploration in 2015, and one which should bring new insights into the origins of the Earth and of our Solar System.

This is a thrilling period of discovery in which we are pushing back the frontiers of planetary science. Having visited the major planets and their systems of satellites and rings, we are now delving more deeply back through time than ever before, to the earliest days of the Sun's rich and diverse family of worlds, big and small, and even to the period shortly after the condensation of the Solar Nebula when they were still assembling.

The European Space Agency's (ESA's) Rosetta spacecraft, having entered into orbit around Comet 67P/Churyumov-Gerasimenko in September last year, and having successfully put down the Philae lander on its surface, will accompany this former Kuiper Belt world to its perihelion on 13th August 2015 and beyond. (And all of this after encounters with two main-belt asteroids too!) As well as studying changes in the comet as it approaches the Sun, then during its departure, it is hoped that the Rosetta mission may provide more information about the birth of the solar system and even, perhaps, the origins of life on Earth.

Another highlight of the coming summer will be the first ever fly-by of dwarf planet Pluto and its system of moons by the New Horizons spacecraft (NASA/Johns Hopkins University APL/South-West Research Institute) on July 14th, which should shed more light on the evolution of the frigid, outer regions of the solar system, just beyond the realm of the major planets. The revelation of Triton's active surface during the Voyager 2 fly-by of the Neptune system in 1989 and recent Earth-based and HST observations of Pluto lead us to expect an exciting encounter.

Before that, however, on 6th March, the Dawn spacecraft will enter the final phase of its incredible odyssey through the main-asteroid belt when it enters orbit around dwarf planet Ceres, 'easing into (its) gravitational embrace', as Dr. Marc Rayman, the project's Chief Engineer and Mission Director at JPL, poetically says in his engaging and regularly updated 'Dawn Journal' at http://dawn.jpl.nasa.gov/mission/journal.asp . The probe will become a permanent satellite of the dwarf planet, having already spent 14 months orbiting and studying asteroid 4 Vesta, which makes Dawn unique so far in orbiting two separate bodies beyond the Earth-Moon system. Its primary mission of observing Ceres in detail is planned to last until summer 2016.

Mission origins and development

Dawn is targeted specifically at investigating the main asteroid belt between Mars and Jupiter. It is one of NASA's Discovery Program missions, initiated in the 1990s to complement NASA's bigger "flagship" planetary explorations with more frequent, smaller missions at lower cost and with shorter development times. All completed Discovery missions – from NEAR-Shoemaker to MESSENGER, Pathfinder to GRAIL, Kepler and others - have enjoyed great success. The Program has also aimed to develop and use new technologies, as well as broadening collaboration between NASA and university and industry partners, both in the USA and abroad.

The partnership for Dawn has brought together:

• Jet Propulsion Laboratory (JPL), who are responsible for overall mission planning and management, development of the science payload, flight systems, and also for the spacecraft's ion propulsion system;

• Orbital Sciences Corporation, the spacecraft's manufacturers;

• The science team, led by Principal Investigator Professor Christopher Russell of the University of California, Los Angeles (UCLA), who initially proposed the mission to NASA, and his colleagues at the Institute of Geophysics and Planetary Physics, together with scientists from other universities and institutions across the USA and in Europe.

Then there are also the many groups which have supplied Dawn's science payload which consists of three main instruments:

• The Framing Cameras for use in imaging Vesta and Ceres, and also for optical navigation, developed and built by The Max Planck Institute for Solar System Research in Germany, together with the Institute for Planetary Research of the German Aerospace Center and the Institute for Computer and Communication Network Engineering of the Technical University of Braunschweig.

•Visible and Infrared (VIR) Mapping Spectrometer, used to determine the surface mineralogy of both Vesta and Ceres, provided by the Italian Space Agency, designed and built at Galileo Avionica, in partnership with Italy's National Institute for Astrophysics.

• A Gamma Ray and Neutron Detector for detecting the elemental composition of both Vesta and Ceres, developed by Los Alamos National Laboratory, Los Alamos, New Mexico.

The spacecraft's radio transmitter will also be used in conjunction with sensitive antennas on Earth to study the gravity fields of the two bodies and to provide clues as to their internal structure.

'A fantastic return!'

At a time when spending on planetary exploration is being squeezed, and we often hear questions about 'why money should be spent on space', Dawn (like Rosetta at 20 centimes per European citizen per year!) is a great advertisement for the cost-effectiveness and enormous returns of such scientific projects. The total cost of Dawn at launch on September 2007 came in at US$ 446 million. Marc Rayman says,'at about $US 1.50 per inhabitant of the USA – just 75¢ per world, the price of a can of coke – that's a pretty good deal. I think the return truly

Just after sunrise on Sept. 27, 2007, the Delta II rocket carrying NASA's Dawn spacecraft rose from its launch pad to begin its 1.7-billion-mile journey through the inner solar system. Credit: NASA/Tony Gray & Robert Murray

Dr. Marc Rayman, Chief Engineer and Mission Director at JPL, with Dawn during assembly. Credit: NASA

is fantastic!' This can only help to dispel the habitual myths which surround the funding of space exploration in the public imagination. And of course there are far greater benefits, as Dr. Rayman explains: 'We are lucky to live in a culture in which we have the resources to invest in such projects, just as we do in art. These enrich all of us, help us discover our place in the Universe and open our eyes to new worlds, both literally and figuratively.'

Ion propulsion

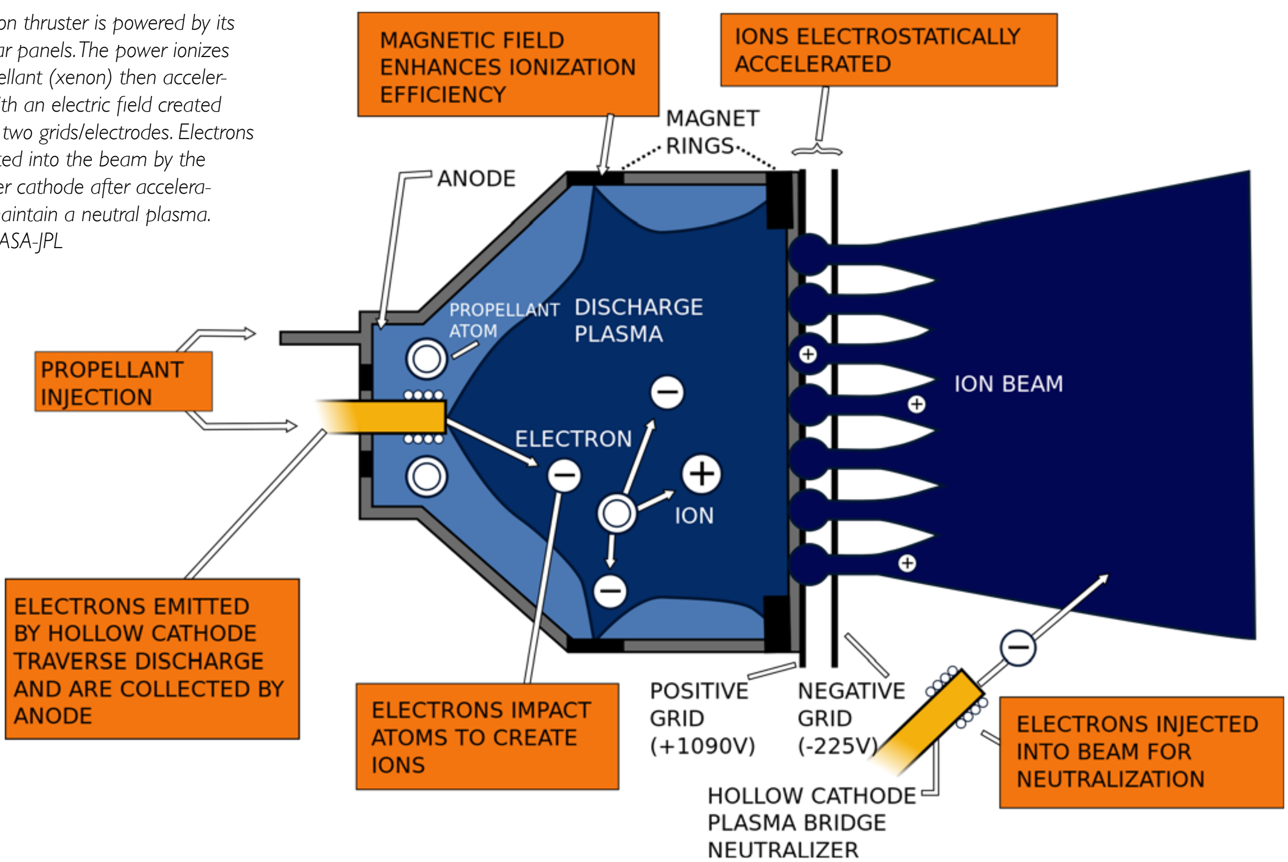
An important part of the return from the mission is the proving of alternative technologies. The radical choice of propulsion system has been of particular importance in enabling Dawn to achieve its ambitious goals. Visiting and orbiting two different bodies has been made possible thanks to an advanced ion thrust propulsion system, developed by NASA. Dawn's engines are based on the system used successfully on the Deep Space 1 trial mission for new technologies between October 1998 and December 2001. A simplified view of how the system works is shown in the graphic below. For a detailed description of the ion propulsion technology used for the mission, visit http://www.nasa.gov/centers/glenn/about/fs21grc.html

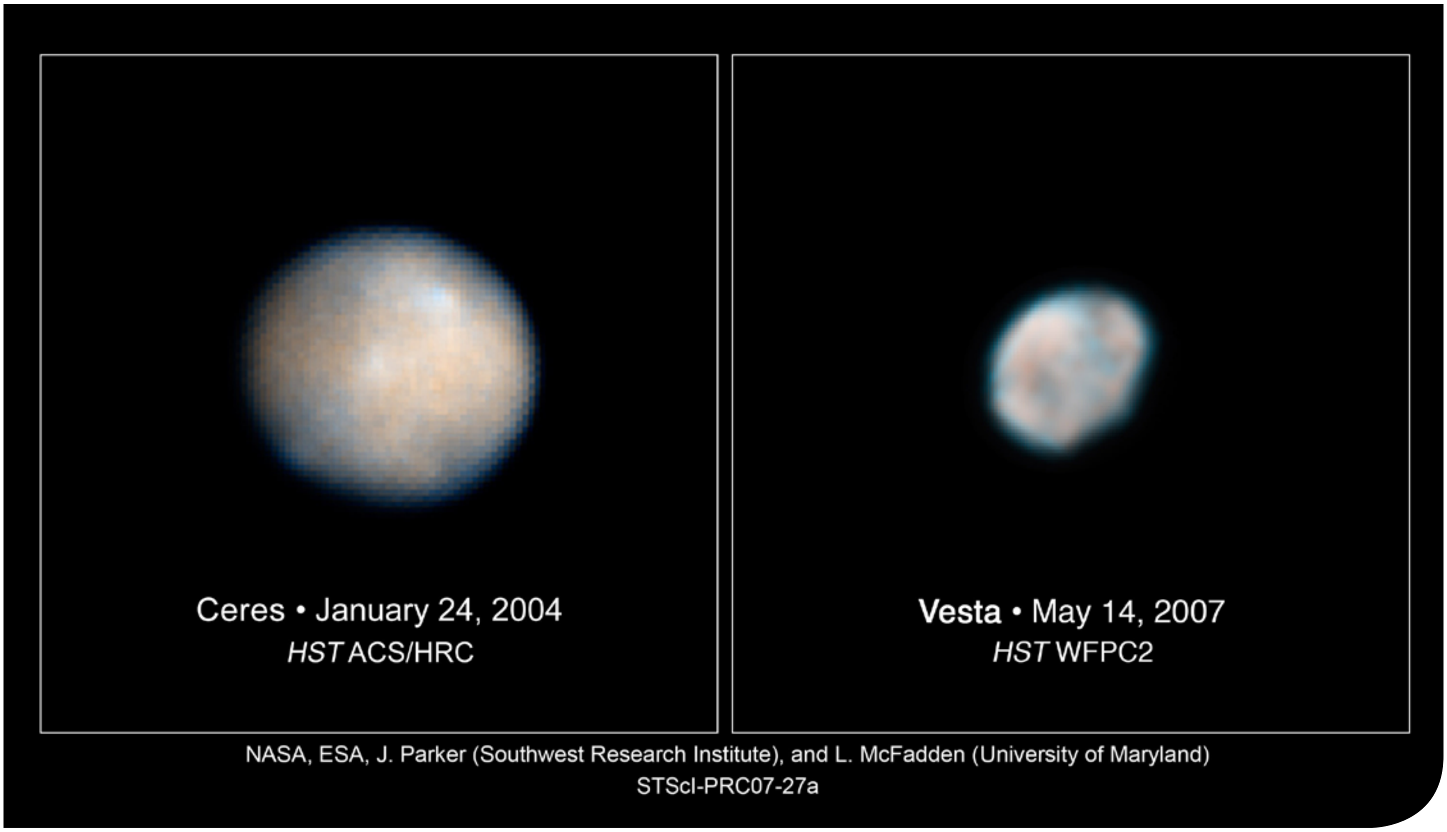
Following its launch on a Delta II from Cape Canaveral on 27 September 2007, Dawn has used three xenon ion thrusters (firing only one at a time) to take it in a long outward spiral from Earth into the main asteroid belt, via a gravity assist from Mars. The spacecraft's trajectory and timeline are shown on page 30. The engines have a specific impulse of 3100s and a thrust of 90 millinewtons (mN), and are capable of acceleration from 0 to 60 mph (97 km/h) in four days, firing continuously. While a chemical rocket on a spacecraft might have a thrust of up to 500 newtons (N = kg m s-2), Dawn's much smaller engine can achieve the same change in trajectory by firing over a much longer period of time, and, above all, using far less fuel.

This is particularly significant when planning rendezvous and orbital insertion manoeuvres, which is why Dawn is able to catch up with and orbit two separate bodies.

By October of 2014, as Marc Rayman explains in his online journal, the spacecraft had thrusted for 1,737 days (68% of its journey), using only 366kg (808 pounds) of xenon propellant out of its total reserve of 425 kg (937 pounds). 'By the end of its mission, having operated from its maximum throttle level down to lower levels when Dawn was much farther from the Sun, the spacecraft will have accumulated over five

Dawn's ion thruster is powered by its large solar panels. The power ionizes the propellant (xenon) then accelerates it with an electric field created between two grids/electrodes. Electrons are injected into the beam by the neutraliser cathode after acceleration to maintain a neutral plasma. Credit: NASA-JPL





These Hubble Space Telescope images of Vesta and Ceres show two of the most massive asteroids in the asteroid belt, a region between Mars and Jupiter. The images were used to help astronomers plan for the Dawn spacecraft's tour of these hefty asteroids before it even launched.

years of total thrust time, giving it an effective change in speed of 11 kilometers/second, or well over 24,000 miles/hour. That is about the same as the entire Delta rocket with its 9 solid motor strap-ons, first stage, second stage, and third stage, and it is far in excess of what any single-stage craft has accomplished.'

The target worlds: Why Ceres and Vesta?

Launched by NASA on September 27, 2007, Dawn's targets for study are two of the most massive objects of the asteroid belt. While small compared to Earth, dwarf planet Ceres (formerly asteroid 1 Ceres) contains roughly 30% of the total mass in that region of space and protoplanet Vesta (fromerly asteroid 4 Vesta) 8%, so Dawn is exploring almost 40% of the asteroid belt's mass. For other statistics on these worlds, see Table 1 below.

Both bodies are regarded as protoplanets, representative of the final, bigger planetary embryos, which came together to form the planets almost 4.6 billion years ago. Only a few of these now remain in the inner solar system. Dawn is revealing the conditions under which these objects formed and the different ways in which they have evolved in this key region close to where the so-called 'frost-line' may have existed. This is the limit beyond which water was able to condense into ice, due to lower temperatures in the solar nebula, whereas in the hotter environments closer to the early Sun water would have combined with other substances to form hydrated minerals.

Ceres and Vesta have been altered much less than other bodies. The Earth is very active and constantly evolving, but Ceres and Vesta are ancient and have preserved a record of the early solar system. Dawn's mission's goals include determining their composition and internal structure. By examining their surfaces and how they have been modified by impactors over time, we can get an idea of what the early conditions of Ceres and Vesta were like and how they have evolved since

Table 1: Ceres and Vesta at a glance, compared to Earth and our Moon

	Mean diameter (km)	Mean distance from Sun (AU)	Mean distance from Sun (million km)	Orbital period (years)	Mass (kg)	Mean density (g/cm3)
Vesta	525	2.36	353	3.63	2.59×10^{20}	3.456
Ceres	952	2.77	414	4.60	9.43×10^{20}	2.077
Earth	12742	1	150	1	5.97×10^{24}	5.51
Moon	3474	-	-	-	7.35×10^{22}	3.346

These are key in providing power for its ion propulsion system and for its instruments and on-board systems at a distance of almost 3 AU from the Sun. With its solar arrays fully extended, the spacecraft is 19.7 meters (65 ft) long. The solar arrays have a total area of 36.4 square metres (392 sq ft). Credit: NASA/George Shelton

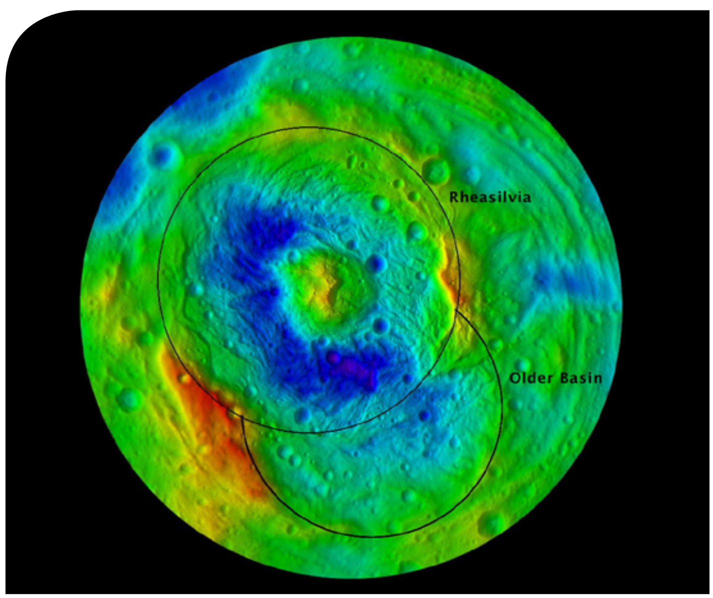
then. Vesta appears to have been hot and dry, like the terrestrial planets, and experienced at least partial melting, whereas water seems to have played a role in keeping Ceres much cooler, so that it may be less evolved.

A battered world: Vesta revealed

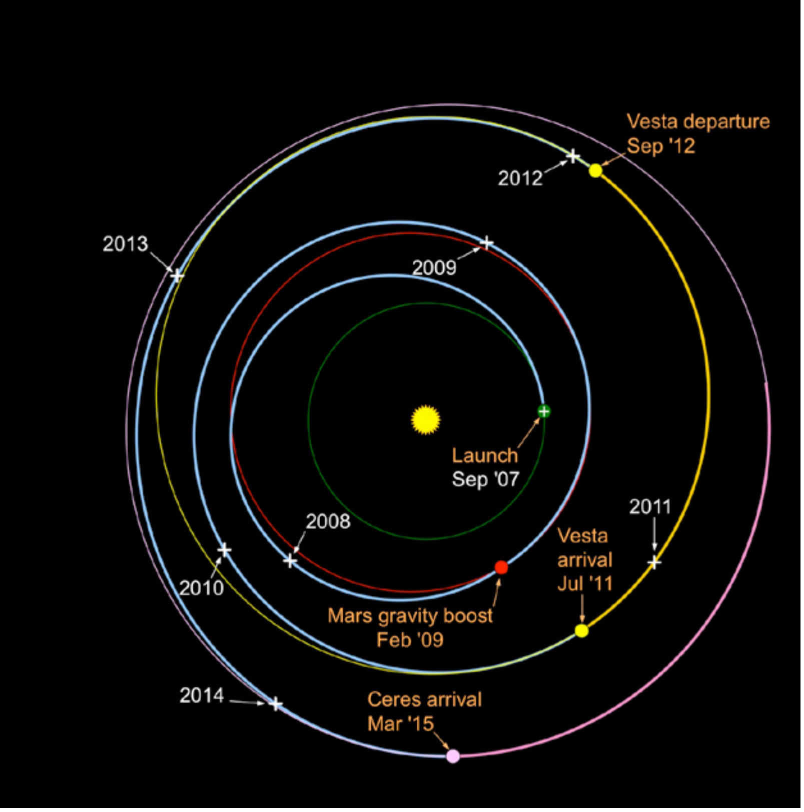
Vesta, discovered by Heinrich Wilhelm Olbers on 29 March 1807, is named after the virgin goddess of home and hearth in Roman mythology. Dawn was the first spacecraft to visit Vesta, entering orbit on July 16, 2011, and successfully completing its fourteen month survey mission of this fascinating body in late 2012.

Dawn's instruments have revealed a rocky, battered world which reflects the violent early history of the solar system. It accreted from the planetesimals in the region and would perhaps have joined with similar large planetary embryos to form a planet-sized body, were it not for the gravitational influence of massive Jupiter, which disrupted and prevented planet formation in the main asteroid belt, an explanation for the plethora of bodies in this region today.

Representative of the type of bodies which eventually collided to form the Earth and other inner planets, it is probably the last of its kind. Dawn has shown us good evidence for the internal differentiation of Vesta, with a thin crust and rocky (silicate) mantle overlying a metal-rich (iron-nickel) core, estimated to be about 220km (136 miles) across. This layering, which is uncommon among asteroids, is borne out by its mean density which is similar to that of our Moon, and not much less than that of Mars (3.93 g/cm^3). Differentiation would have occurred as heating from radioactive decay, large impacts, and gravitational pressure melted parts of the protoplanet as it grew. In melted zones heavier elements sank to the center, while lighter materials rose to the surface. The core is now solid, unlike that of the larger Earth which remains hot, thanks largely to radiogenic heating, the heat released by the radioactive decay of certain elements.



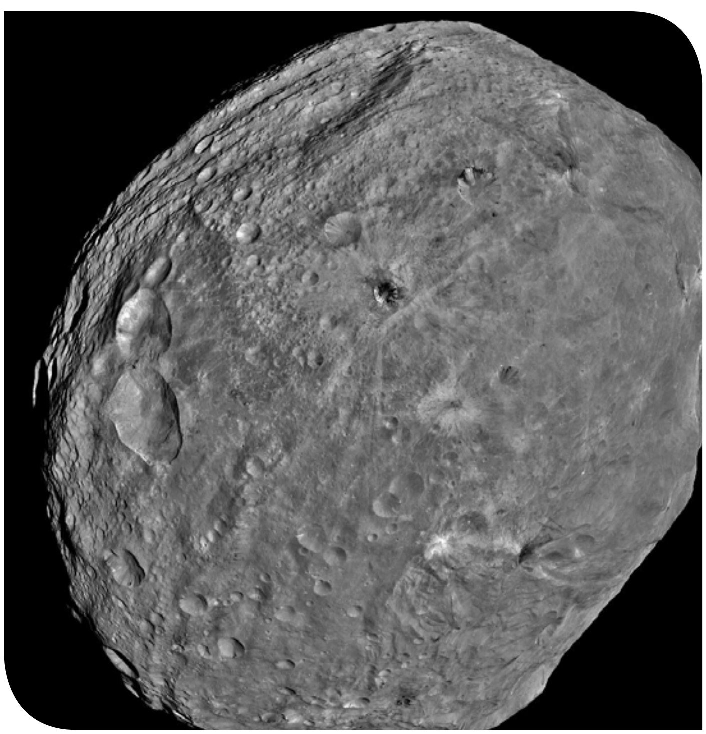
False colour image showing the relief of Vesta's south polar region and the giant Rheasilvia impact basin with its central peak. Blue areas represent lower elevation, while yellow and red areas show the highest elevations. Credit: NASA/JPL-Caltech/ UCLA/MPS/DLR/IDA



The Dawn Mission Trajectory. Credit: NASA-JPL

A major source of heating at Vesta will have been impacts, much more frequent during the accretion process when there was a lot more material to be swept up in the inner solar system. There is much evidence of these impacts, both on its heavily cratered and fractured surface, and also in fragments originating from them, many of which end up falling to Earth and other terrestrial bodies as meteorites. An estimated 6% of all meteorites observed on our own planet come from Vesta. Analysis of materials found in them provides supporting evidence for differentiation in the growing protoplanet.

On Vesta itself the scale and violence of impacts early in its history is borne out by at least seven craters of over 150km in diameter. Most impressive is the scar of an impact which may have come close to smashing Vesta apart, the giant crater named Rheasilvia. The impactor was probably as much as 50km (30 miles) across, and the resulting basin in Vesta's south polar region is 500km (300 miles) across, 12km (7.5 miles) deep and is distinguished by a central peak which rises to almost 25km (15 miles) above the basin floor. The image on the preceeding page gives an idea of the scale of this feature. The event sent monumental seismic shock waves through Vesta which caused many faults and troughs around its equatorial regions, as well as blanketing the southern half of the protoplanet with a thick layer of debris. This explains the less cratered nature of the south in contrast to the northern regions.



Vesta's battered surface as imaged by Dawn's framing cameras (full mosaic). Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA

Beyond the rim of Rheasilvia, the rest of Vesta's tormented surface is no less spectacular, and the stories it tells of the distant past will gradually be deciphered by Dawn's science team. The spacecraft broke free from Vesta's sphere of influence in September 2012 to head out towards its next destination, but its mission there is far from over. Its sensors have returned sufficient data on this unique world to keep mission scientists busy for decades, together with the continuing study of meteorites here on Earth.

Onward to Ceres

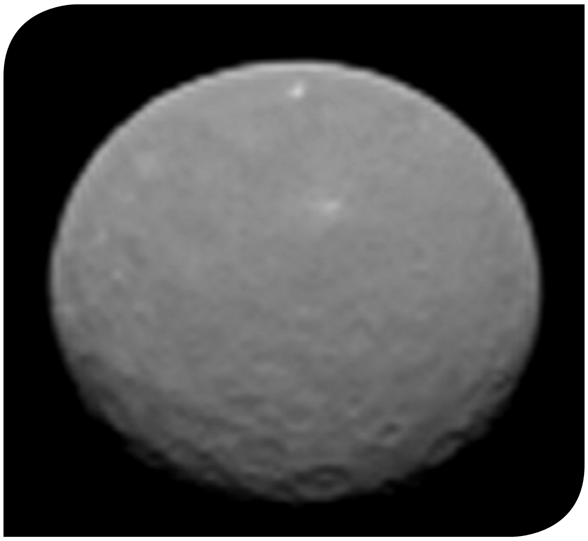
Having begun to unlock the secrets of one new world, we look forward to discovering another unique member of our Sun's family of worlds. Ceres, named for the Roman goddess of corn and harvests, grows ever more clear in Dawn's cameras, becoming a whole new world for us. This will be, to quote Dr. Rayman, 'an ambitious and exciting exploration of the alien world ahead… an intriguing and mysterious orb that has beckoned for more than two centuries….. Our goal is to develop that faint smudge of light amidst the stars into a richly detailed portrait.'

Since its discovery on 1st January 1801 by Giuseppe Piazzi, Ceres has been considered firstly as a planet, then an asteroid (or minor planet) and, since 2006, as a dwarf planet. However we classify it today, with a mean diameter of 952km (591 miles) it is the largest body between the Sun and Pluto yet to be visited by a space probe, and appears to be very different from Vesta and most other bodies in the main asteroid belt. It has a density closer to that of the big icy moons of the giant planets, like Ganymede (1.93 g/cm^3) or Titan (1.88 g/cm^3). Ceres is expected to present, beneath a thin dusty crust, a differentiated structure, but one with a water ice mantle some 100km (60 miles) thick surrounding a rocky, silicate core. The presence of ice is expected to have created differences in the dwarf planet's surface features, when compared to those of Vesta, due to the more flexible nature of ice than

Artist's concept of building planets through collisions – planetary accretion in the Solar Nebula 4.56 billion years ago. Credit: NASA

that of the latter's rocky surface, even at the relatively low temperatures (130K-200K or -73°C to -143°C) found at Ceres.

Given the surprising evidence of activity in some of the outer icy moons of the solar system, there is even speculation that liquid water could exist in pockets deep beneath Ceres' surface, although much of the necessary radiogenic heat in its core has probably long since been lost to space, and there is no large body nearby to produce tidal heating. There has recently been evidence, however, from the Herschel Space Observatory of very small amounts of water vapour emanating



NASA's Dawn spacecraft took this image on approach to Ceres on Feb. 4, 2015 at a distance of about 90,000 miles (145,000 km). Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA

from the surface of Ceres, so cryovolcanism is not ruled out, even if the water vapour may be the result of sublimation of ice caused by solar radiation.

Whatever surprises lie in store at Ceres, the Dawn team will be ready. Marc Rayman says "We are expecting changes when we get to Ceres and, fortunately, we built a very capable spacecraft and developed flexible plans to accommodate the unknowns. There's great excitement in the unexpected—that's part of the thrill of exploration."

We look forward to reporting on the first results of Dawn's primary mission at Ceres later in the year.

Additional references:

- **For mission overview and news:** http://dawn.jpl.nasa.gov/
- **'UCLA Professor Leads NASA Dawn Mission':** http://www.bit.ly/dawnprof
- **On ion propulsion:** http://www.grc.nasa.gov/www/ion/
- **On the early Solar System:** 'An Introduction to the Solar System' – Ed. David A. Rothery, Neil McBride & Iain Gilmour (Cambridge University Press, 2011)

Tim Peake

Ready to become United Kingdom's official ISS resident

By Sam Mundell

On 20th November this year, a Union Jack Flag will be safely stored on board a Soyuz rocket, and, along with its owner, will launch from the Baikonur Cosmodrome in Kazakhstan and make its way to the International Space Station.

This is not the first time that a British born citizen has flown in space, but it will be the first time a Briton will launch without the need for private funding of any sort, or having to take American citizenship. The mission will also be the first time a UK astronaut has flown and worked on the ISS as a member of the European Space Agency Astronaut Corps, and the first time a Briton has flown in space for over 20 years.

Early life

Timothy Peake was born 7 April 1972 in Chichester, England. He was educated at Chichester High School for Boys, and on leaving school a career in the British Army beckoned. Having graduated from Sandhurst Military Academy in 1992, a successful career in the Army Air Corps followed.

A qualified helicopter pilot and test pilot, Peake is well equipped for the rigorous training all astronauts must undertake before they are allocated a mission in space. His military background and ability to work under pressure will stand him in good stead for the training he has to complete, and the six-month-long mission he will undertake later in the year.

Despite having a thriving space industry, the UK has never invested in its own manned spaceflight programme. Unmanned space research has been the priority of the

Credit: NASA/Lauren Harnett

The United Kingdom's Timothy Peake is currently training for his long-duration mission to the International Space Station, to be launched in November. He will be the first British ESA astronaut to visit the Space Station. Credit: UK Department for Business, Innovation and Skills

UK's space industry along with various commercial initiatives. Opportunities for aspiring UK astronauts to launch and work in space alongside the astronauts from other countries and agencies were few and far between.

European Space Agency

However, thanks to the European Space Agency announcement that a new class of astronauts was to be selected, and UK citizens could apply, Tim Peake applied to ESA in 2008. Along with many other potential astronaut candidates, he went on to partake in a long and often gruelling selection process that would culminate in a phone call coming through on May 18 2009. On a balmy spring evening, the news he had hoped for was relayed to him – Tim had been successful in his tests and interviews and he was therefore being invited to join the European Space Agency Astronaut Corps, making him the first Briton in the history of ESA to do so.

On 20th May 2013, four years after Tim began his astronaut training, David Willetts (UK Minister for Universities and Science) announced at an eagerly anticipated press conference that Tim had been assigned a 6 month mission to the ISS, joining crew members on Expedition 46/47 with an expected launch date of Nov 2015.

"This is a landmark moment for Britain and our reputation as a leading science nation," said Willets. "Not only will we have the first UK astronaut for over two decades, but Tim Peake will be the first ever Briton to carry out ground-breaking research on the space station."

"I'm absolutely delighted by the decision,"exclaimed Peake. "It really is a tremendous privilege to be assigned to a long duration mission to the ISS."

Training underground...

As part of his extensive astronaut training programme, Tim joined a team who would, for five days, test human endurance and capabilities. In 2011, he and five other astronauts joined an international mission, living in and exploring cave systems in Sardinia.

Tim Peake spent five days exploring caves in Sardinia as part of his training. Credit: ESA

This mission enabled them to study how humans react to living in extreme conditions with very little privacy and in complete isolation from the outside world. This expedition which simulated space exploration, gave the team an idea of what they could expect and how they would cope in the confined space of the ISS.

...and below the ocean waves

NASA's NEEMO (Extreme Environment Mission Operations) gives space agencies from around the world the unique opportunity to study and test various technologies that are used, or could be used in space whilst gaining valuable information on the behaviour of crews on long missions. Similar to Tim's cave training in Sardinia, it also simulates the often harsh conditions found in space giving astronauts the chance to discover their strengths and weaknesses whilst living in difficult conditions.

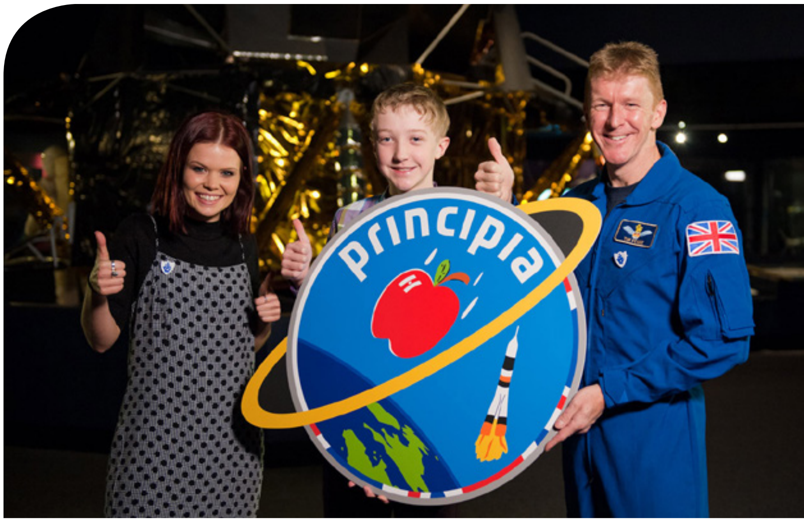
Following on from his visit to the caves of Sardinia, Peake ventured further afield to Florida, where he became the first ESA astronaut to experience the NEEMO Mission. Based off the Florida coast in the Key Largo National Marine Sanctuary, the underwater habitat of the Aquarius laboratory became Tim's home for two weeks. With the rest of his crew, he helped develop tools and technologies that may be used on a future crewed mission to an asteroid, planet or moon.

Tim Peake conducts a live video link from the Aquarius underwater habitat with the UK Space Environment Conference, in Aberdeen, Scotland. Credit: ESA/Hervé Stevenin

STEM and engaging young minds

Tim has always been a supporter and advocate of STEM subjects, and STEM Outreach, and his keen and vocal support for these was rewarded in 2009 as he was appointed an ambassador for UK Science and space-based careers. It is through this position that he is able to actively promote the STEM subjects to youngsters throughout the UK and further afield.

Due to his passion for STEM Outreach, and his enthusiasm to get children and older students involved in his mission, Tim has been able to launch a number of competitions here in the UK.



BBC presenter Lindsay Russel, logo designer Troy and Tim Peake with the Principia mission logo. The BBC's Blue Peter programme asked schoolchildren to design a mission patch for Tim and received more than 3000 entries. Credit: ESA

The 'Great British Space Dinner' competition, which ran last year, gave children the opportunity to come up with a well-balanced meal that Tim could enjoy on the ISS. It also gave young people the chance to think about nutrition, and how important food is to astronauts whilst they are in space.

Along with popular children's programme 'Blue Peter', the ESA and UKSA called upon schoolchildren of the UK to design the mission patch for Tim's Principia Mission. Both of these competitions were met with a huge deal of excitement and flair, proving that Tim's mission is gathering plenty of support and interest not only from adults but young people.

More recently, Tim, along with UK Space organisations and Raspberry Pi have offered students of all ages the unique opportunity to devise an app or experiment to run in space.

It is because of ventures such as these, that young people can hopefully see how stimulating and rewarding a career in STEM subjects can be, with Tim doing everything he can to engage and inspire school children and students in all corners of the UK, Europe and beyond.

Tim visited London in November 2014, and I had the opportunity to interview him about his upcoming mission and STEM outreach.

RocketSTEM: You have engaged with children and captivated their imaginations by involving them in your missions, with a number of competitions such as 'design a mission patch' and design a meal for the ISS'. How important is it to you that children (especially those in the UK who may not be aware of your mission or the UK Space Agency) are involved in what you do, and what impact do you hope your mission will have on them?

Tim PEAKE: "I can hope to have an inspirational impact on young people. I remember being really enthused by space and space travel, and also aviation. I hope that by having the same effect on young people we can encourage them to look at science and also look at engineering and exploration, to see it as an exciting career path, and study the relative subjects you need to have."

RS: STEM subjects and careers are obviously very important and, and getting children interested in these subjects at an early age is extremely crucial. Will children be able to participate in any of the experiments you are doing on the ISS, or even recreate them in the classroom so they can see if the results vary on Earth and in space?

PEAKE: "We are working very closely together (that's ESA and UK Space Agency) and looking at designing as many competitions as we can and having educational outreach activities whilst making them as interactive as possible. That includes using my time at weekends to do some fun voluntary science, making videos and experiments I can do on the ISS that classrooms can do back on Earth and compare results. So yes, we will be trying to make the most of this mission. It's a wonderful opportunity and I really hope we can maximise the potential for this mission. The more interactive it can be for students, the better."

Future space explorers? Kids enjoy some face time with Tim Peake. Credit: ESA

RS: You will be flying the flag for the UK and UK Space Industry whilst you are on the ISS. How do you think your mission will change the way the UK Space Industry is seen by the outside world?

PEAKE: "Obviously this is the first time a UK Astronaut has flown on board the ISS as part of the European Space Agency, so that's the big thing here. From a government perspective the UK is becoming involved in human space flight and it is something very important. I hope we go on to continue this involvement. So yes, it is very important the UK is part of this as there is so much benefit to be had from ISS research in terms of what we are doing on the ISS for people back on Earth. And also on the ISS for future exploration - looking ahead to those lunar and Mars missions, and deeper into the solar system as we go on.

"I don't want the UK to miss out on that. ESA has been doing a fantastic job, and will continue to do a fantastic job in Human Spaceflight. I think it is definitely time for the UK to be part of that, and continue to be part of it. It's only going to get bigger and better."

Before I travelled to interview Peake, and knowing how important STEM Outreach is to him, I thought some questions from the young people he is inspiring would be a good idea. Therefore I got in touch with a local junior school to see if they would like some students to think of questions for me to ask him on their behalf. The following questions are from Class 5L, Brockhurst Junior School, Gosport.

RS: Are you under pressure to complete a certain amount of research whilst on the ISS?

PEAKE: "Yes, because crew time is the most valuable resource and there is never enough of it. For every expedition that launches there is always too much to be done and not enough time. So yes, there is pressure to get things done and clearly scientific research is top priority – that is what we have built the ISS for. It is managed in such a way that the crew don't feel that pressure. The ground teams do a brilliant job of trying to offload that pressure for the crew. Clearly the crew work long days, they are working 7 days a week. They do have some free time on Saturdays and Sundays, but even in free time they are chipping away at jobs. There is a task list and this is the 'jobs the astronauts could do if you please have the time' list! So astronauts pretty much work all of the time and because crew time is so valuable you just accept it's six months where you just work very hard."

RS: Are you excited or nervous about what you might find from your research?

PEAKE: "Very excited! Not really nervous, although having said that, some of the life science experiments I'm lined up for where they offer to share results could have an impact. For example, I could be told at the end of the mission just how much radiation I have absorbed, and how much my eyesight has changed. There are things that happen to astronauts on the ISS and we are learning all the time about how our bodies adapt to microgravity. I'm not really nervous about that, I'm more interested to see what happens to a human body in space and how we can develop countermeasures for it."

RS: Will you take any samples from space, and if so, how will you do this?

PEAKE: "I'm not aware of any scientific experiments I'm doing that will involve me taking samples from space. Having said that,there are external experiments on board the ISS right now that remain outside for sometimes months or even years. So the ISS is constantly taking

Follow Peake's journey online: https://www.facebook.com/ESATimPeake

Tim Peake coordinates an EVA training session from inside the Aquarius underwater habitat. Credit: NASA

external samples if you like. For example, on the Columbus Module we have the SOLAR experiments, which are taking samples from the Sun so that we can study the Sun cycles. That experiment stays outside for a long time so we can gather data permanently about that."

RS: What have you done whilst training?

PEAKE: "Training has been going on for a number of years now. It started with basic training when I was first selected in 2009 and that was for 14 months. It really gets everyone up to speed in the core sciences, introduces you to microgravity - the vomit comet! You start Russian and that continues all the way up to launch."

RS: How have you found the Russian? Could you speak any before you became an astronaut?

PEAKE: "I've found the Russian very challenging as I'm not a natural linguist. But I've enjoyed it and I'm at the stage where I can relax and be more conversant."

RS: What advice do you have for any children who want to become astronauts?

PEAKE: "My advice is to try and find out what it is that you like, and what you enjoy doing as that tends to be what you are good at, and really pursue those activities. Try to do as well as you can at those. If you are keen on becoming an astronaut then you will have an interest in space anyway and it helps to keep up to date with space news, what is going on, what missions are being launched and what the focus of the Space Agency is. Try to get exposure if at all possible to many international environments; working with different cultures and learning languages are a good thing to do. This kind of thing will put you in the best place when there is an astronaut selection."

Tim Peake has many more months before his launch date, and the training will continue to be intensive, not only at the ESA Headquarters, but in the USA and Russia. The eyes of the world, especially the UK, will be watching as he leaves the Earth on board Soyuz TMA-19M, him and a red, white and blue flag.

I will leave the last word to astronaut Tim Peake…..

"Seeing the Earth from space will undoubtedly be one of the most beautiful and awe-inspiring sights I will ever witness, and will provide a unique perspective from which to reflect on the wonders of our universe and our place in it."

https://twitter.com/astro_timpeake

https://www.flickr.com/photos/timpeake

Tim Peake

Training for space

ESA astronaut Timothy Peake, Expedition 46/47 flight engineer, prepares for a spacewalk training session in the waters of the Neutral Buoyancy Laboratory (NBL) at NASA's Johnson Space Center. Credit: NASA/Robert Markowitz

Tim Peake (middle) endures winter survival training with Soyuz crewmates Tim Kopra and commander Sergei Zalyotin. Temperatures fell to -24C at night. Credit: GCTC

Astronauts Tim Peake and Samantha Cristoforetti build a shelter during their survival training. Credits: ESA/V. Crobu

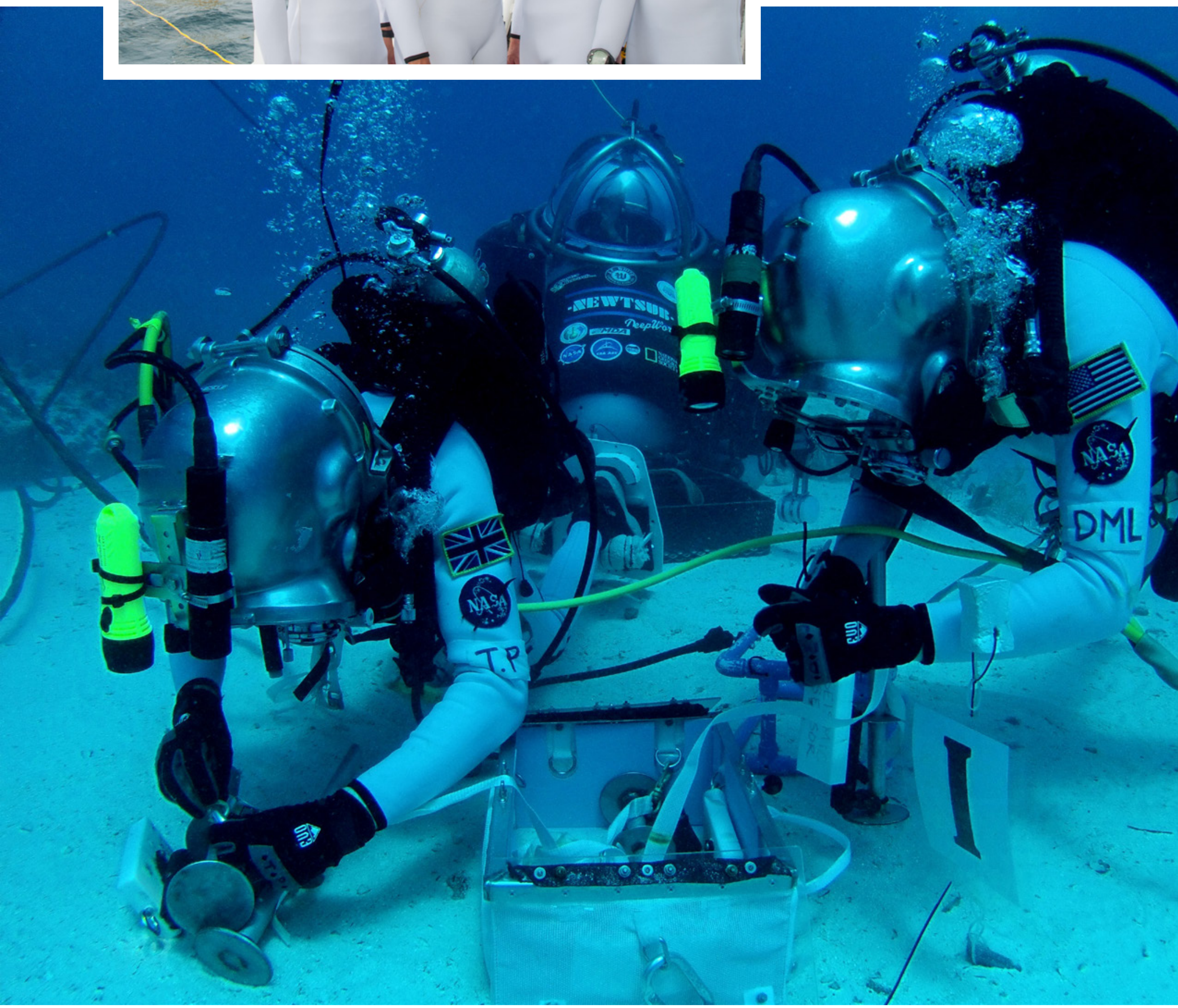
Survival training is an important part of all Soyuz mission training. When a Soyuz spacecraft returns to Earth there is always the possibility that it could land in water. Credit: GCTC

Linking up as a crew in the water, waiting for rescue. Credit: GCTC

Tim Peake during training inside the full-scale mockup of the Soyuz capsule, at the Gagarin Cosmonaut Training Centre, in Russia. Credits: ESA/S. Corvaja

Members of the NEEMO 16 Crew are, from left to right: Kimiya Yui (JAXA), Dottie Metcalf-Lindenburger (NASA), Tim Peake (ESA), Steve Squyres (Cornell, NASA Advisory Council).

Tim Peake and NASA astronaut Dorothy Lindenburger test the installation of a Geophysicial Array on an 'asteroid' during underwater training. Peake is secured by the feet to a Portable Foot Restraint carried by a mini-sub simulating a Space Exploration Vehicle, while Dottie is wearing a Jetpack. Credit: ESA/Hervé Stevenin



Expedition 46 crew members Tim Kopra of NASA, left, and Tim Peake, engage in emergency scenario training in the Space Vehicle Mockup Facility at NASA's Johnson Space Center. Credit: NASA/Bill Stafford

Tim Kopra (left) and Tim Peake, participate in a food tasting session in the Habitability and Environmental Factors Office. Credit: NASA

Tim Kopra (foreground), and Tim Peake participate in a routine operations training session in an ISS mock-up/trainer. Credit: NASA/James Blair

Tim Peake strikes a X-pose with an enthusiastic crowd at the Farnborough Air Show. Credit: UKSA

Tim Peake appears on BBC One's The One Show. Credit: UKSA

Credit: NASA/ESA/JAXA

Crews named for future ISS missions

NASA and its International Space Station partners have announced the crew members for three up-coming missions to the space station during 2016 and 2017.

Expedition 48:

Jeff Williams, NASA
Alexey Ovchinin, Roscosmos
Oleg Skripochka, Roscosmos
Kate Rubins, NASA
Anatoly Ivanishin, Roscosmos
Takuya Onishi, JAXA

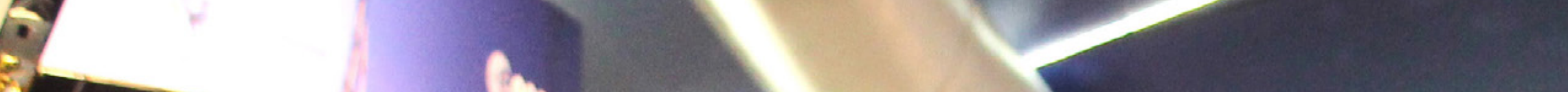
Expedition 49:

Anatoly Ivanishin, Roscosmos
Kate Rubins, NASA
Takuya Onishi, JAXA
Shane Kimbrough, NASA
Andrey Borisenko, Roscosmos
Sergey Ryzhikov, Roscosmos

Expedition 50:

Shane Kimbrough, NASA
Andrey Borisenko, Roscosmos
Sergey Ryzhikov, Roscosmos
Peggy Whitson, NASA
Oleg Novitskiy, Roscosmos
Thomas Pesquet, ESA

For more information about the International Space Station, visit: http://www.nasa.gov/station



ESA astronaut Tim Peake meets students at Farnborough. Credit: ESA

Tim Peake at a Mission X event in United Kingdom. Credit: ESA

Tim Peake with Mission-X participants on the ESA stand. Credit: ESA

By Mike Barrett

Photographing the planets *(part 2)*

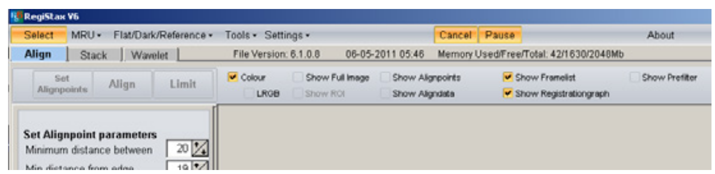
Following on from last issue where we looked at the equipment and capture of video to produce a photograph of the planets this issue looks at the processing of the video into an image. This article really only scratches the surface of image processing as there are so many variables and methodologies that can be used. Having mastered the basics will allow you to experiment and discover the best processing workflow for your requirements.

Assuming that you have captured some video. When you look at it you will find that although it looks reasonable it will be quite wobbly and the focus will fade in and out. What is required is to examine the video and remove all the bad frames, grade the remaining frames, then process the good frames. This may sound complex, and indeed it is, but there are software packages available to handle this processing.

If you think about what a video is you will discover that it is just a series of static images that are played together to form a smooth moving film. Just like the old cartoon flip books you flick through the pages and the image appears to move. We want to do the same, but in our case the image does not move very much.

There are a number of different ways to create video files, and a number of different formats. For the purposes of Planetary Imaging we need to use the AVI format. This creates a large file of individual frames. Other formats such as MP4 have reference frames followed by information on what has changed since the reference frame, this saves a lot of space but is not useful for our purposes we need a format that saves entire individual frames.

The processing software that will be used is Registax, though other applications are available Registax is the most popular. Registax is FREE and if it was not provided with your planetary camera it can be downloaded from the Internet at http://www.astronomie.be/registax/. At the time of writing the latest version available is Registax 6.1.0.8 which is the version used in this article.



The Registrax version 6.1.0.8 interface screen. Credit: Mike Barrett (All images)

When you start Registax you will see a blank canvas with some menus, tabs, and configuration controls as shown in image 1. The three tabs control the workflow of the application in the three main areas of selection of alignment parameters, aligning, and limiting and stacking the image.

First you need to load in a file. Press select and navigate to your captured files. Selecting one and loading it fills the canvas with the first frame of the file. Using the bottom control you can navigate through the video until you find a good frame to select the alignment points

More astronomy lessons

Bringing the world of astronomy to the average person has been something we've set our sights on every since the first issue of the magazine, released in January 2013.

For those who haven't been reading the magazine since Day One, we'd like to invite you to peruse the back issues. Our series of astronomy lessons to date have covered topics such as identifying the constellations, buying your first telescope, the beauty of the Earth's auroras, a must-see list of celestial objects, unpredictable nature of comets, a guide to getting started in astrophotography, and much more.

Catch up today online, download the issue as a PDF, or purchase a printed copy from Blurb.com.

January 2013 (Issue #1)

Astronomy: Guide to stargazing for students
http://wp.me/p2Wsra-4g

April 2013 (Issue #2)

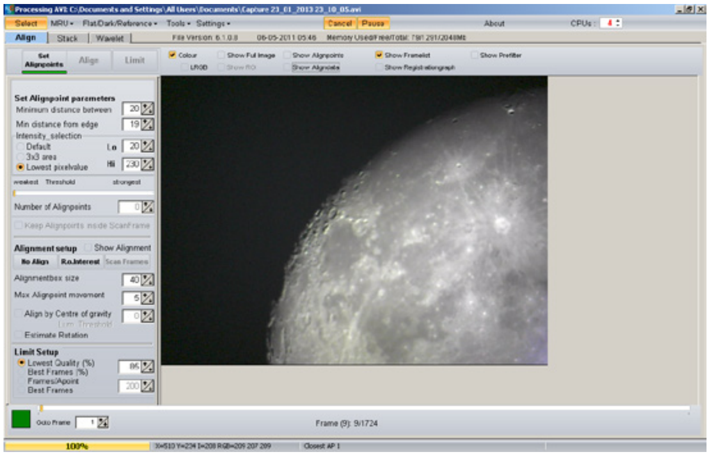
Buying your first telescope
http://wp.me/p2Wsra-cC

Orion the hunter
http://wp.me/p2Wsra-cy

October 2013 (Issue #3)

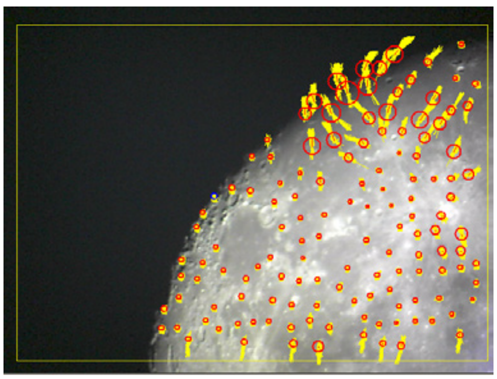
Recognising the night sky
http://wp.me/p2Wsra-iI

Cygnus the swan
http://wp.me/p2Wsra-iG



Registrax interface screen with loaded video.

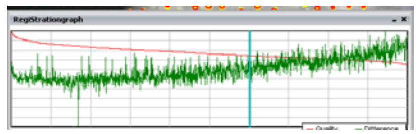
on. With an image like the Moon it is safe to let Registax decide what the align point should be. This is done by pressing the "Set Alignpoints" button. If align points are selected in the dark area of the sky then just adjust the "Lo" intensity value and hit "Set Alignpoints" again. Align points can also be set manually, which is best if you are processing a video of a planet.

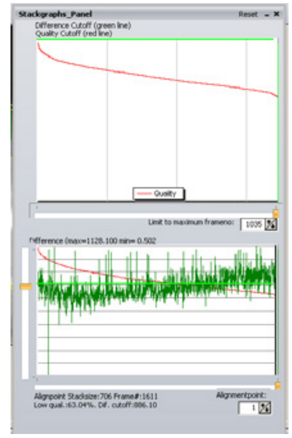


Alignment details during processing.

Once you are happy with the alignment points hit the align button. This now examines every frame of the video and attempts to determine where each of the align points appear on each frame and then register the offsets for later processing. At this point you can switch on the "Show Aligndata" option to provide a graphical overlay of the movement of each point in the video. You can also turn on the "Registrationgraph" which provides a two dimensional analysis of the frames. This is now used to set up the limits of the video for processing. I try to find a point on the Registration Graph where all parts of the green line are below the red quality line. This is done by selecting "Best Frames %" and then adjusting the values until the cyan marker is in the correct place.

Hitting the "Limit" button now removes the lowest quality frames leaving the ones ready for stacking. If you now select to show the Stackgraph you can move the sliders around to select the number and quality of the frames to be stacked. Once you have made your selections the "Stack" button is selected. This now processes all the registered frames and produces an image similar to the one below:

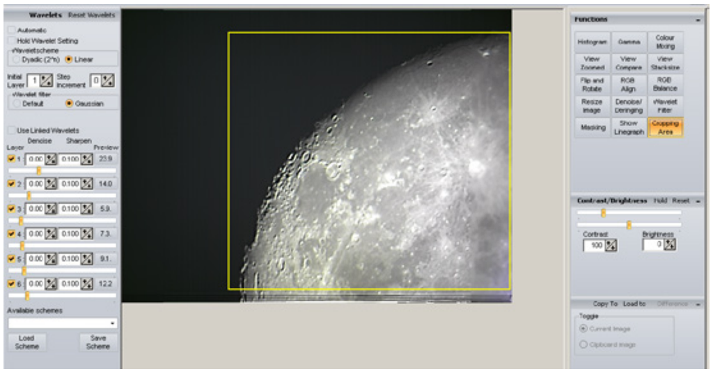




The Registrax Registration Graph and Stackgraph panel.

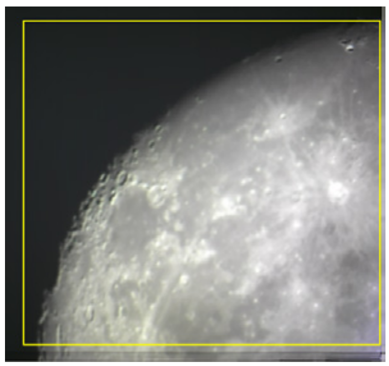
As you can see this has taken the alignment information into account leaving a stepped overlay effect at the bottom of the image. Now we move on to the "Wavelet" tab. This is where all the magic happens. There are six different layer sliders in the left hand panel, these apply different amounts of sharpening to the image at various levels.

The stacked image with align detail.



Screen image during wavelet processing.

Layer 6 provides the roughest sharpening down to layer 1 giving the finest control over the image. Even after stacking and consolidating all of the good data there is still a seemingly unfocused poor image. Applying the wavelet filters really pulls out the detail of the image and creates a stunning image from what at first sight looks like a poor image.



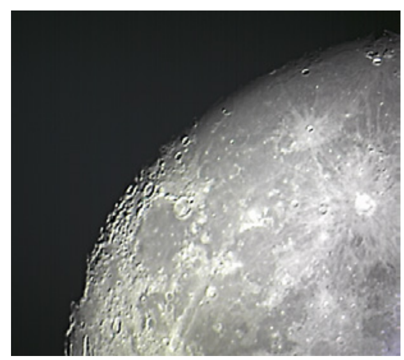
The stacked image.

When you have the wavelets adjusted to your liking you can then start using the various functions in the panel to the left to make some further adjustments. I will often save the image at this point and then edit it in PhotoShop, a professional image processing package. I normally apply a high pass filter to it, followed by an unsharp mask.

I have used a partial image of the Moon here as it is large and easy to see the effects go the process. The same steps apply to processing planets, but they can be a little trickier due to the much smaller size of the object. My setup does not allow a full image of the Moon. To get a full image I would need to create about six images and then merge them all together. To do this I would have to take all the source videos at the same time. This is because the Moon does actually move slightly and the illumination of the surface changes from day to day, and even hour to hour.

The stacked image with wavelets.

You can now see how technology can transform the wobbly object on the video into a brilliantly sharp clear final image. Compare the before and after images to see difference stacking and application of wavelets makes to bring out detail in the otherwise fuzzy shot.



The final processed Moon image.

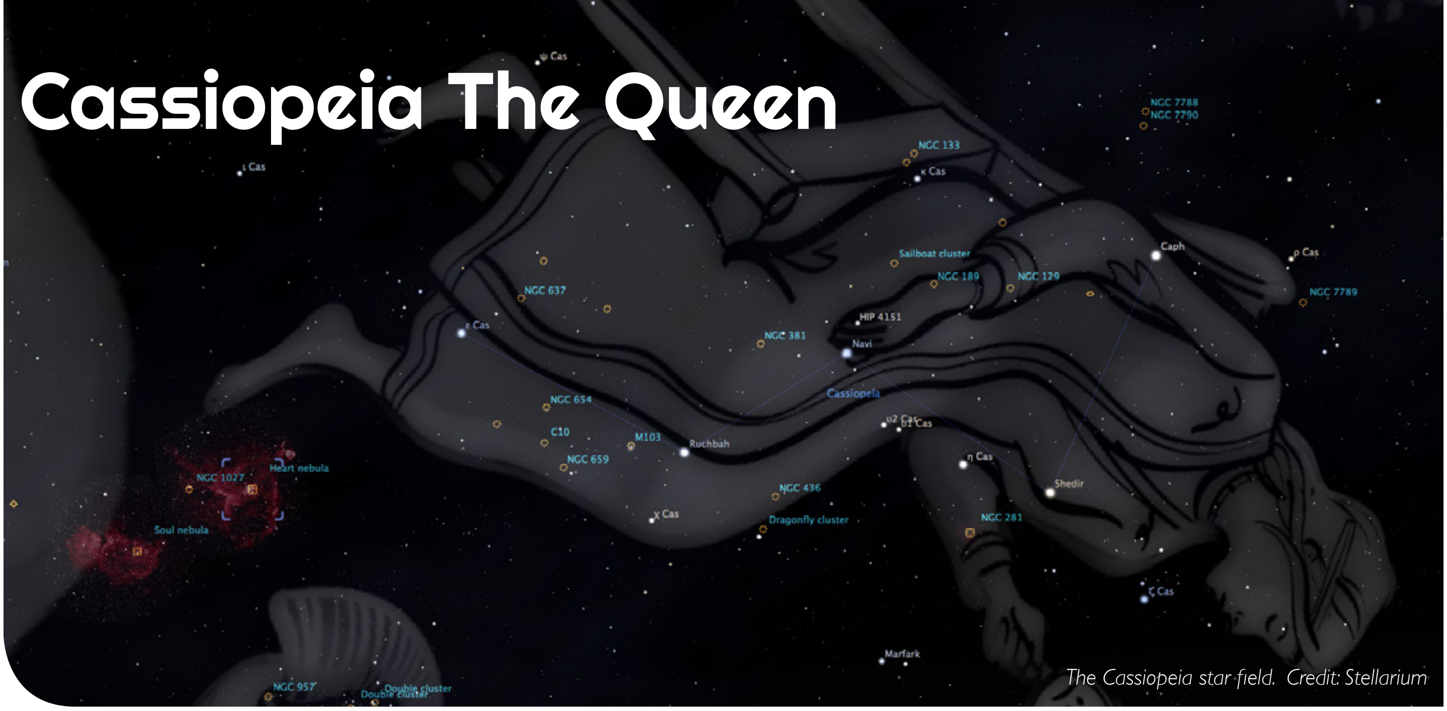
Image stacking

Stacking images is the term for the combination of multiple images into a single image. This effectively stacks the aligned images on top of each other then using an algorithm combines the images.

Image alignment

The images are aligned by selecting a number of reference points then rotating the image so that these points are in the image in the same position in each of the images.

Cassiopeia The Queen



The Cassiopeia star field. Credit: Stellarium

By Mike Barrett

Cassiopeia is a prominent constellation in the northern hemisphere which is very easily recognised as a W or M in the night skies. In most of Continental America and all of Europe it is visible year round but becomes most spectacular in the winter months, when it is elevated to a much higher altitude.

Along with The Plough (Ursa Major) The Queen (Cassiopeia) is one of the first constellations that is learnt in the heavens above. The five main stars of the constellation are quite similarly matched varying from magnitude 2.15 to 3.35 making it very easy to pick out, especially from a light-polluted site or when the moon is shining brightly.

M52 and the Bubble Nebula. Credit: Mike Barrett

Cassiopeia lies within the main band of the Milky Way. From a very dark viewing site, when there is no Moon the millions of stars forming the star field of our galaxy can be seen as a wispy cloud. Using binoculars pulls a lot of the faint stars into detail, and you will suddenly see a mass of stars popping out of the background stellar clouds. Moving up to a telescope will reveal many more stars and the beauty of the region. In fact, with binoculars and telescopes so many stars can be seen that it is difficult to navigate around the constellation.

As you would expect with an area in the Milky Way there are lots of deep sky objects to be seen and imaged. Most of these are quite dim and will require binoculars or a telescope to see. Some, though spectacular, are not visible to the eye but reveal themselves with deep sky photographic techniques.

The open star clusters of M103, NGC 7789, and M52 are easy to find and delightful to view. There are also: NGC 457, the Dragonfly Cluster; NGC 225, the Sailboat Cluster; NGC 663 or Caldwell 10; and many other smaller and fainter star clusters

M52 is the easiest to locate as you just follow a line up from the two rightmost stars of the ‘W’ and continue on about the same distance. With a modest 3-4” telescope you will be able to see a lot of hot, blue stars and a few older, cooler yellow stars.

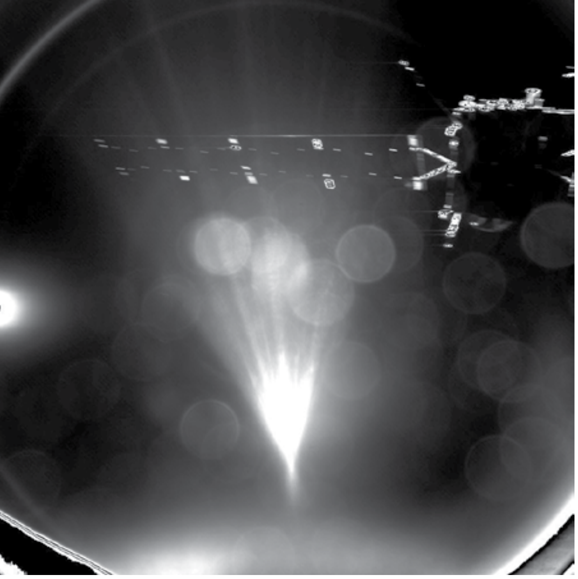
Switching from an eyepiece to an image sensor you can start to explore the deep sky objects of the constellation. Just below M52, and in the same field of view in a 3” telescope, is NGC 7635, The Bubble Nebula. The Bubble Nebula is a hydrogen emission nebula that has a cloud of hydrogen gas, with the bubble forming a shell in the centre of the gas cloud.

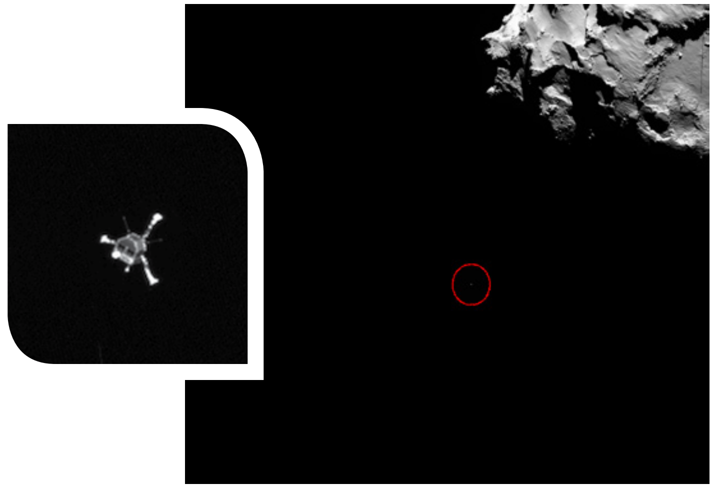
Moving to the opposite end of the constellation are two very large hydrogen emission nebula named the Heart and Soul Nebula. These are supposedly visible through a telescope, but I have never seen them. They are also huge, spanning an area 10 times wider than the Moon and eight times as high.

The best way to see this pair is by using a camera. The problem with that is that the light they emit is in the far red area which traditional cameras cut off, along with Infrared light. So the ideal way to photograph them is using a modified camera with a normal lens. I have found that a 200mm lens just about fits them in frame, but you have to be very careful with the framing.

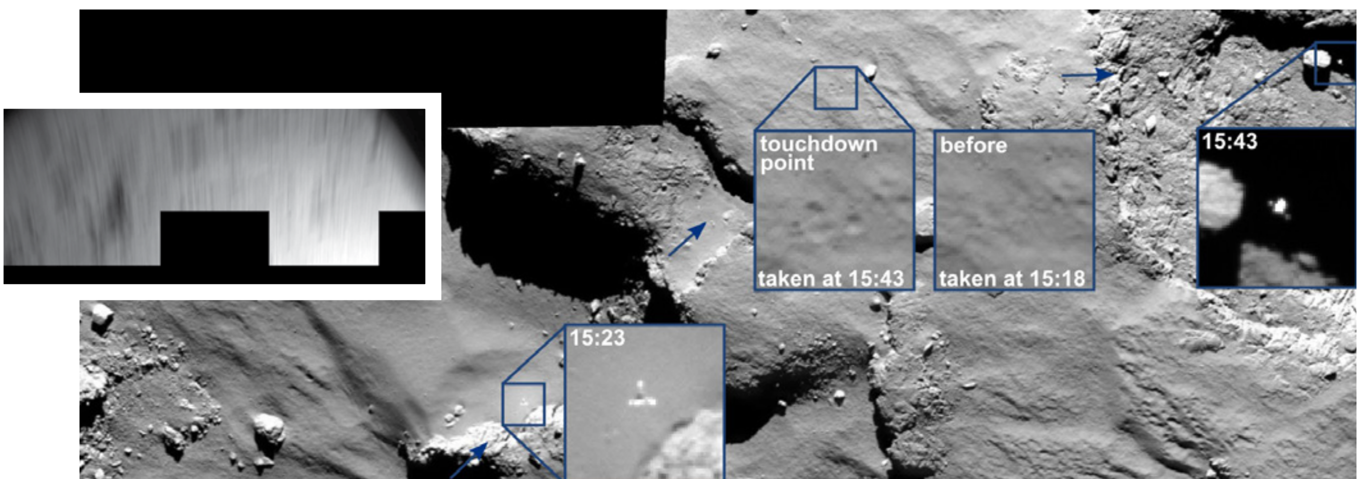
NASA has an Infra Red telescope in orbit called WISE. This camera created a false colour image by sampling light using a number of narrow band filters and assigning colours to them. As you can see on the next page, this creates an image vastly different to the normal red nebula or Hubble palette images.

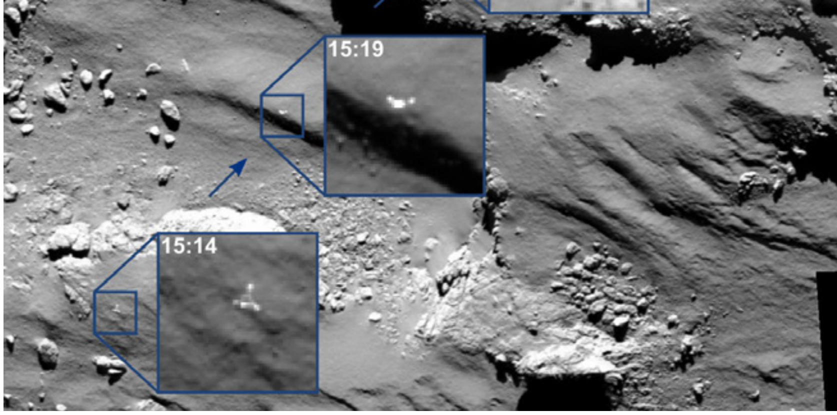
The Heart and Soul Nebulae in false colour. Credit: NASA Wise

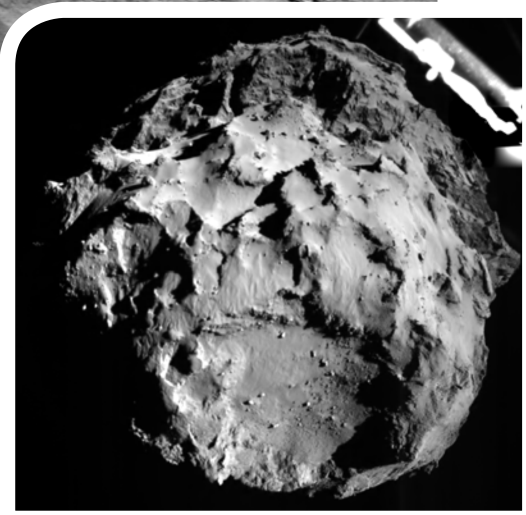




Philae bounces into history books







The Rosetta spacecraft recorded the farewell of the Philae lander as it descended to Comet 67P/Churyumov-Gerasimenko and bounced across its surface before coming to a final stop. Credits: ESA/Rosetta/Philae/CIVA; ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA,;and ESA/Rosetta/Philae/ROLIS/DLR

The Rosetta mission crew celebrate Philae successfully landing on comet 67P, at the European Operations Space Centre in Darmstadt, Germany on 12 November 2014. Credit: ESA/J.Mai

By Amy Thompson

The European Space Agency (ESA) led Rosetta mission, made history this past year, and, captured the attention of people around the world as it became the first to orbit and land on a comet. The spacecraft achieved its goal after deploying a washing machine-sized lander onto the surface of Comet 67P/Churyumov-Gerasimenko on Nov. 12. The plucky little lander defied odds and survived several bounces across the comet's surface to deliver its science data before ultimately entering into an indeterminate hibernation period.

Rosetta embarked on a ten-year journey across the solar system to rendezvous with Comet 67P/Churyumov-Gerasimenko, in hopes of unlocking the secrets of the early solar system. After launching from French Guiana's Kourou spaceport atop an Ariane 5 rocket on March 2, 2004, Rosetta reached its first major milestone a decade later, by being the first spacecraft to rendezvous with a comet.

The spacecraft is composed of an orbiter –Rosetta—and a lander, Philae. The pair was named for the famed Rosetta stone and obelisk that ultimately enabled us to decipher ancient Egyptian hieroglyphs. Comets are essentially cosmic time capsules, carrying with them primordial components from the beginning of the solar system. Just as the Rosetta stone and Philae obelisk helped unlock the secrets of an ancient language, the Rosetta spacecraft and Philae lander aim to help us understand how our planet and solar system formed.

Rosetta's journey to the comet was not easy; in fact comet 67P was not the original target. The mission was originally set to launch in Jan. 2003 with an intended target of comet 46P/Wirtanen in 2011. This plan had to be revised following a failure in the Ariane 5 rocket during a mission in 2002. After the issue with the rocket had been resolved, a new target, comet 67P/Churyumov-Gerasimenko, was selected. A new launch date of Feb. 26 was selected with a comet rendezvous to occur in 2014. Finally, after two launch scrubs, Rosetta blasted off into space on March 2, 2004.

To achieve the velocity required to rendezvous with 67P, Rosetta would require more than just the boost an Ariane 5 could provide. In order to give her the boost she needed, Rosetta would complete three flybys of Earth and one of Mars. In between planetary flybys, Rosetta also took advantage of the opportunity to flyby and photograph two different asteroids -- 2867 Šteins and 21 Lutetia. Following the final flyby or gravity assist from Earth, Rosetta now had the momentum needed to propel itself out to meet comet 67P.

In order to save precious systems on board, the Rosetta spacecraft was placed in a 31-month hibernation period. On Jan. 20, 2014, following a very successful social media campaign, people around the world waited on the edge of their seats to "wake-up Rosetta". At this point in its journey, the craft was far enough from Earth that it took almost 30 minutes for the signal to travel each way. Scientists had a window of time where they hoped to see a spike on their computer monitors; this would signal that Rosetta had successfully come out of hibernation. After an agonizing wait, scientists in the operations center at ESA jumped for joy when they saw it. Like a spike on a heart monitor, the on-screen blip announced Rosetta had awoken and was ready to begin her work.

Over the next eight months, as Rosetta closed the gap between herself and the comet, scientists began to see the first images of the comet. As the images and data came in, we learned more and more about this enigmatic body.

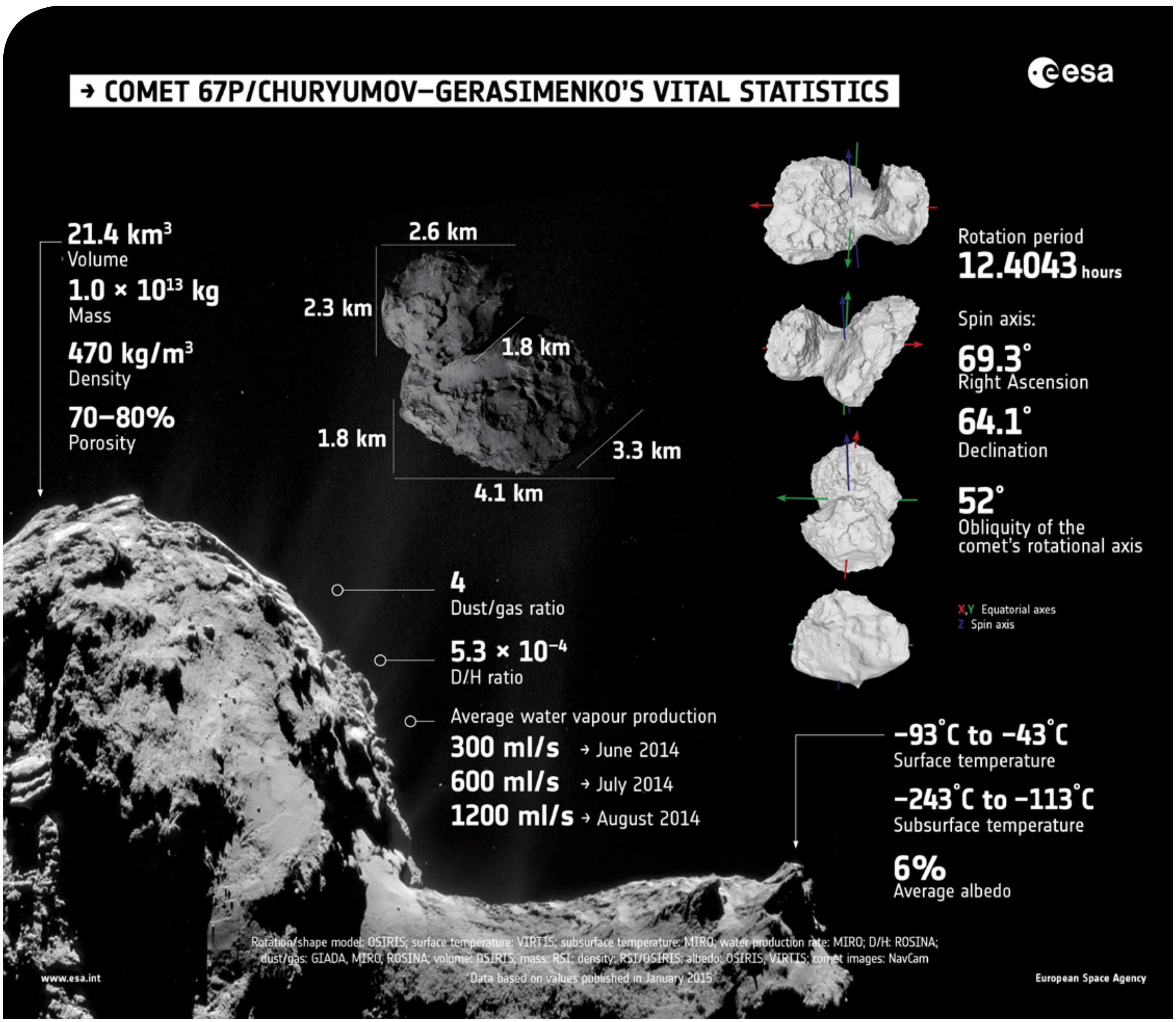
At first, the images we saw were fuzzy, but over time they showed more detail. From the beginning of the mission, based on all the data available, scientists thought comet 67P would be a spherical world; however, in July we found out this was not the case. Images coming in from Rosetta showed the comet looked more like a rubber ducky, with two distinct lobes. Scientists began to wonder if this comet was really a contact binary, meaning two separate comets conjoined following a collision. More observations and analysis is needed to completely understand why 67P has this unusual shape.

Approximately a month later, Rosetta officially "arrived" at comet 67P and inserted itself into orbit around the comet. Over the coming weeks Rosetta would be busy observing, mapping, and analyzing the comet's surface to determine a suitable landing zone. Most missions, like the rover missions to Mars, select the landing zone ahead of time. Since there was not enough information available about this icy body, the landing team had to wait until Rosetta arrived to select the perfect spot for Philae to touchdown.

In order to select the best possible site, NASA and ESA scientists had to ask themselves: Will the lander be able to maintain regular communications with Rosetta? How common are surface hazards such as large boulders, deep crevasses or steep slopes? Is there sufficient illumination for scientific operations and enough sunlight to recharge the lander's batteries beyond its initial 64-hour lifetime without causing overheating?

The sites were assigned a letter during an initial pre-selection process, which resulted in 10 potential sites. Further analysis narrowed the field down to five sites.

"The process of selecting a landing site is extremely complex and dynamic; as we get closer to the comet, we will see more and more



Summary of properties of Comet 67P/Churyumov–Gerasimenko, as determined by Rosetta's instruments during the first few months of its comet encounter. Credit: ESA details, which will influence the final decision on where and when we can land," said Fred Jansen, Rosetta's mission manager from the European Space Agency's Science and Technology Centre in Noordwijk, The Netherlands. "We had to complete our preliminary analysis on candidate sites very quickly after arriving at the comet, and now we have just a few more weeks to determine the primary site. The clock is ticking and we now have to meet the challenge to pick the best possible landing site."

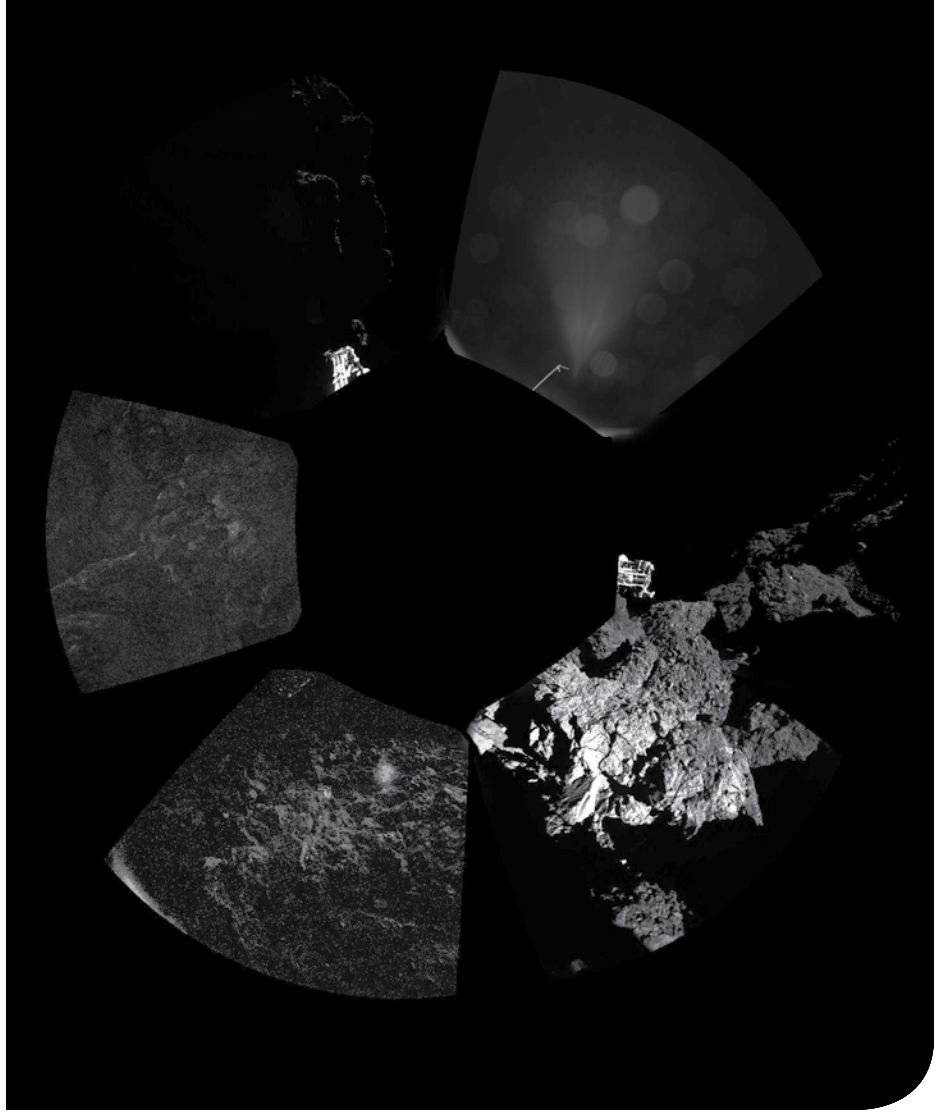
During Rosetta's approach, it was revealed that comet 67P has two distinct lobes, a smaller (head) one and a larger (body) lobe. Sites B, I, and J are located on the smaller lobe and sites A, and C are located on the larger lobe.

"Based on the particular shape and the global topography of Comet 67P/Churyumov-Gerasimenko, it is probably no surprise that many locations had to be ruled out. The candidate sites that we want to follow up for further analysis are thought to be technically feasible on the basis of a preliminary analysis of flight dynamics and other key issues – for example they all provide at least six hours of daylight per comet rotation and offer some flat terrain. Of course, every site has the potential for unique scientific discoveries," stated Jean-Pierre Bibring, a lead lander scientist and principal investigator of the CIVA instrument.

Bibring went on to say, "The comet is very different to anything we've seen before, and exhibits spectacular features still to be understood. The five chosen sites offer us the best chance to land and study the composition, internal structure and activity of the comet with the ten lander experiments."

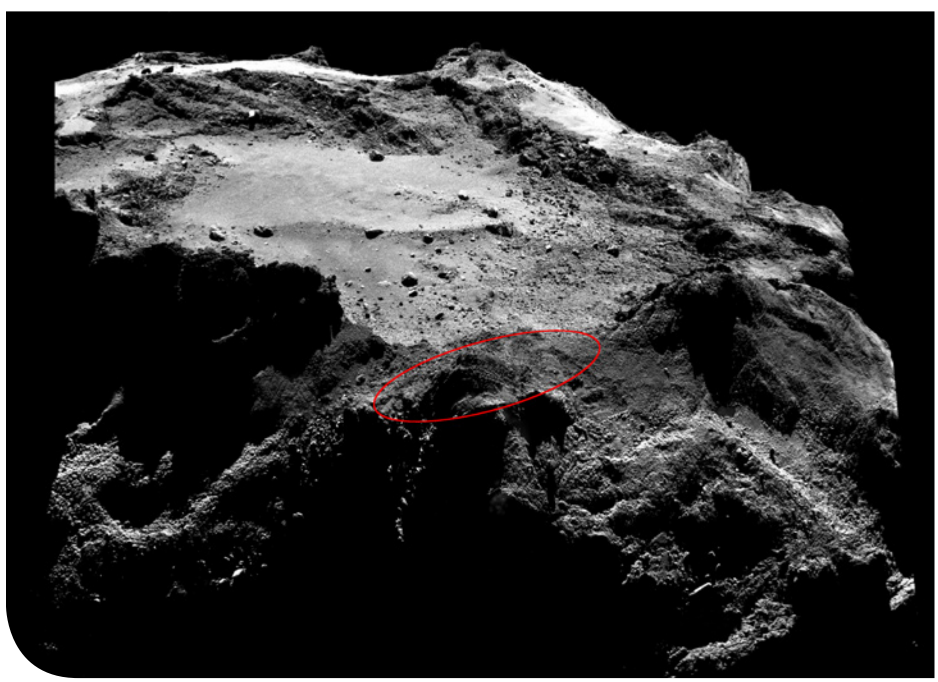
After arriving at the comet, the ALICE instrument began scanning comet 67P/Churyumov-Gerasimenko's surface in an effort to determine the origin, composition, and internal processes to gather data that cannot be collected via ground-based or even Earth-orbiting instruments. This new data helped scientists map the surface in great detail and narrow down a landing zone.

Scientists were a bit shocked to



Rosetta's lander Philae has returned the first panoramic image (above) from the surface of a comet. The unprocessed view shows a 360º view around the point of final touchdown. The three feet of Philae's landing gear can be seen in some of the frames. Credit: ESA/Rosetta/Philae/CIVA

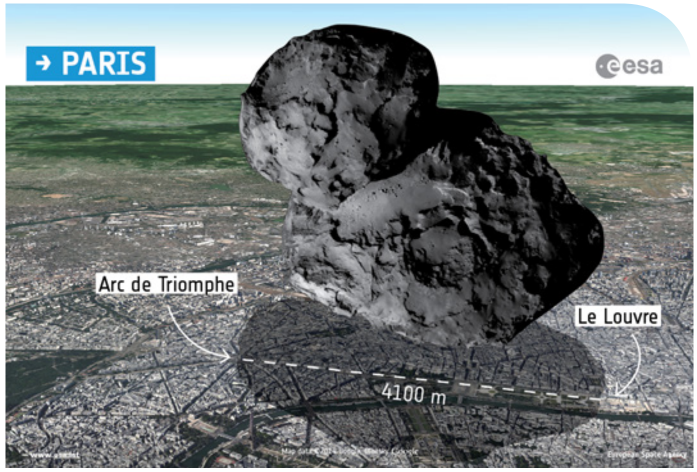
An example of the OSIRIS narrow-angle camera mosaics (below) used to search for Philae. The lander would measure only about three pixels across in these images.
Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA



discover the comet's surface was not as expected. When viewed in the ultraviolet portion of the spectrum, they observed the surface to be darker than charcoal and void of any large, icy patches. Due to its location and distance from the Sun, any exposed water-ice would not be vaporized by the Sun and would be present on the surface.

Alan Stern, ALICE principal investigator at the Southwest Institute in Boulder, Colorado stated: "We're a bit surprised at just how unreflective the comet's surface is and how little evidence of exposed water-ice it shows."

ALICE also detected the presence of both hydrogen and oxygen in the comet's coma (atmosphere). The ALICE instrument is packed with over 1,000 times the data-gathering capabilities of the previous generation's instruments, while weighing under nine pounds (4 kilograms) and drawing only 4 watts of power. ALICE is part of a group of 11 different science instruments aboard Rosetta, all designed to help unlock the secrets of comet 67P. NASA is also contributing to the Microwave Instrument for Rosetta Orbiter (MIRO), the Ion and Electron Sensor (IES), a portion of the Rosetta Plasma Consortium Suite, and the Double Focusing Mass Spectrometer (DFMS) electronics package for the Rosetta Orbiter Spectrometer for Ion Neutral Analysis (ROSINA).



Comparing Comet 67P/Churyumov–Gerasimenko with the city of Paris. Credit: ESA/Rosetta/Navcam/Google/Bluesky

On Oct. 18, 2004, ESA gave the green light for Philae to attempt the first-ever soft landing on the surface of a comet. After weeks of scrutinizing images and date from Rosetta, the team selected site J, located on the head of the comet, as the primary landing site. Following a public contest, the site was dubbed Agilkia, in honor of an island located on the Nile river. Agilkia is located close to the site where the Philae obelisk was discovered.

At 3:35 a.m. EST (0835 GMT) on Nov. 12, Rosetta released Philae, to start its seven-hour free-fall to the comet's surface. The landing process is a fully autonomous process, with ESA supplying instructions to the spacecraft and the lander prior to release. It takes 28-minutes for the signal from Rosetta to reach us here on Earth, so ESA expected to receive landing confirmation at 11:00 a.m. EST (1600 GMT).

Forty-five years ago, the world waited, glued to their television sets

Astronomical serendipity

Since 1594, when Johannes Kepler predicted that there should be a planet between Mars and Jupiter, astronomers had been searching for that "missing planet." When Giuseppe Piazzi discovered Ceres in 1801, the scientific world thought that he had ended the search. Then Ceres disappeared from sight, only to be recovered one year later. Astronomers breathed a sigh of relief and celebrated! The "missing planet" was back!

And then there were two

Wilhelm Olbers, an amateur German astronomer who was a doctor by profession, was again looking for Ceres about three months after it had been rediscovered. That was when he saw another moving object nearby! This "object,", which was later named Pallas, caused quite a stir in the astronomical community. Only one planet had been expected in the space between Mars and Jupiter.

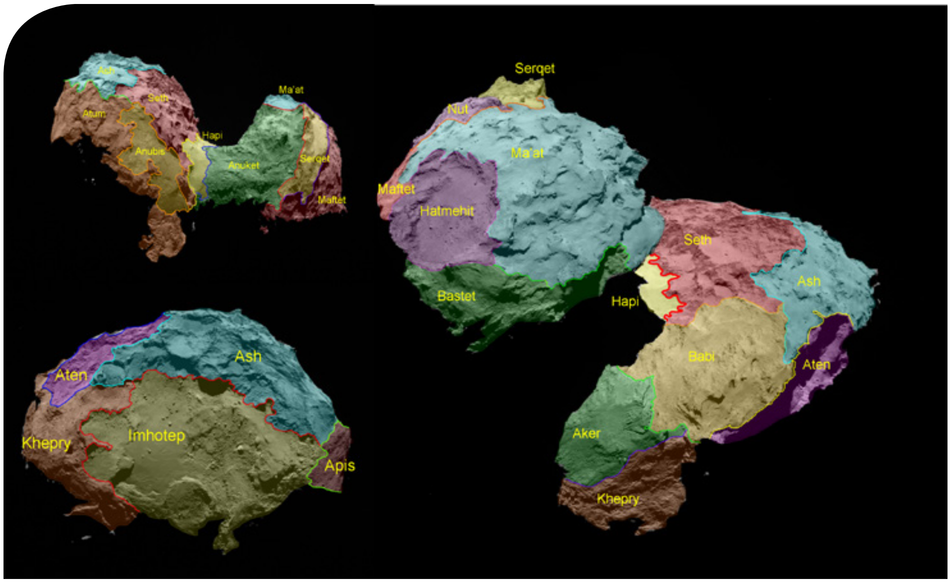
When Gauss calculated this new object's orbit, he found that both Ceres and Pallas took 4.6 years to revolve around the sun. He also found that Pallas could be seen from the Earth for only a small portion of that time. It was incredible luck and timing or, maybe astronomical serendipity that Olbers was looking for Ceres during the short period of time that Pallas happened to be passing near Ceres. Otherwise, Pallas might not have been observed for many years.

In 1802, William Herschel tried to measure the sizes of both Ceres and Pallas. He did this by looking at each "planet" through a telescope while comparing it to a disk of a known size at a given distance. He was very surprised that these "planets" were so much smaller than the other known planets. Herschel was the first to call Ceres and Pallas asteroids because of their small but "starlike" appearance.

How many more fragments are out there?

As often happens, the results of this scientific discovery led to further questions. Could there be more than two asteroids? Where did these asteroids come from?

In 1804, Olbers formulated the first and oldest theory about the origin of asteroids in a letter to Herschel. He wrote, "Could it be that Ceres and Pallas are just a pair of fragments…of a once great planet which at one time



The 19 regions identified on Comet 67P/Churyumov–Gerasimenko are separated by distinct geomorphological boundaries. Following the ancient Egyptian theme of the Rosetta mission, they are named for Egyptian deities. Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

to see a pair of NASA astronauts land on the Moon. Just a month ago, the world waited, this time glued to their computer screens, for the signal telling us the little lander was safe on the surface. Once that signal came in, the team in ESOC knew something was not quite right. Further analysis showed the lander touched down initially, and with none of the three grappling systems working, Rosetta bounced three times across the comet's surface, finally landing in the shadows. The science team was able to download data from all of Philae's instruments, and rotate the lander 35 degrees ensuring the largest solar panel would be exposed to sunlight -- ultimately giving Philae a chance to collect enough solar energy to power back up in the future. Philae is now in hibernation mode, and the team remains hopeful it will be able to power back up once the comet gets closer to the Sun.

The first images from Philae after touchdown were of the landing site, including panoramic shots of the surrounding area. Philae is equipped with sensors and will measure the density and thermal properties of the surface; use its gas analyzers to detect and identify any complex organic chemicals that might be present; as well as measure the magnetic field and interaction between the comet and solar wind. Philae is also equipped with a drill, able to dig up to 8 inches (20 cm) below the comet's surface, collecting samples for testing.

ESA project scientist, Matt Taylor, said this about the mission: "Rosetta is a big deal. The orbiter has rendezvoused, orbited and deployed a lander to the comet surface. If that isn't enough firsts, the orbiter will remain alongside the comet for over a year, watching it grow in activity

occupied its proper place between Mars and Jupiter?" If this were the case, Olbers believed that many more asteroids would be discovered. Other astronomers thought that asteroids were pieces of a planet that never formed. They estimated that there were ten more asteroids.

Olbers' belief that there were a great many asteroids to be discovered reactivated the Celestial Police. They again made careful observations of promising regions of the sky at Johann Schröter's private observatory at Lilienthal. This was one of the largest observatories in the world at that time and was very close to Bremen where Olbers lived and worked. Karl Harding discovered a third asteroid, named Juno, on September 1, 1804. However, it was much smaller than either Ceres or Pallas.

Not only did Olbers predict there were many more asteroids, he proposed a theory about where these undiscovered asteroids could be found. Olbers thought that the asteroid fragments of an exploded planet were now in different orbits around the sun. Furthermore, he even predicted a point at which these various orbits would intersect.. When he searched close to this point, he discovered Vesta on March 29, 1807. Olbers became the first person to find two asteroids.

So, by 1807, the two asteroids to be closely observed by the Dawn spacecraft had been discovered. As it turned out, the discovery of Vesta brought the first era of asteroid discovery to a close. Since the four largest and brightest asteroids had been found, additional asteroid discoveries would depend on more advanced telescope technology.

In 1813, the French army burned the city of Lilienthal as they retreated from Russia. All of Schröter's books and observation records were destroyed and his observatory was looted. The Celestial Police disbanded and Olbers continued his lonely search of the heavens until 1816, when Schröter died. No more asteroids were found during the period between 1807 and 1845.

Additional resources

- The William Herschel Museum: http://www.bath-preservation-trust.org.uk/museums/herschel/

- NASA's "Asteroids and Comets" home page: http://nssdc.gsfc.nasa.gov/planetary/planets/asteroidpage.html as it approaches the Sun, getting to within 112 million miles (180 million kilometers) in summer next year, when the comet will be expelling hundreds of pounds of material every second."

This mission has been one of ambition, science, and firsts. Rosetta is the first spacecraft to rendezvous with a comet, the first to orbit a comet, and now the first to land on a comet. So far we have seen unprecedented views of a comet's surface, discovered what a comet smells like, and even heard it "sing."

Rosetta's instruments have been busy studying the comet from different angles, and taking images at different wavelengths. Using the VIRTIS instrument, scientists were able to take the comet's temperature, determining it is warmer than expected and revealing the surface is actually dark, dusty and porous instead of icy.

ESA Director General, Jean-Jacques Dordain had this to say about the historic landing: "This is a big step for human civilization. We are the first to have landed on a comet and that will stay forever. This mission is a success, and the biggest problem with success is that it looks easy. This was not easy. It took a lot of hard work and cooperation."

Throughout history, comets have fascinated us with their unpredictability. Even though we have a better understanding of comets behave, there is still much to discover. Earlier this year, researchers observed a dramatic increase in the comet's activity, and at that time Rosetta was too far from the comet to determine the cause. In June, Rosetta's MIRO instrument started detecting water outgassing from the comet. At the time, Rosetta was located at approximately the same distance as the Earth is from the Moon, from the comet, and MIRO observed 67P 'sweat' about 1 cup (300 mL) of water per second – the equivalent of two glasses. Ever since, the activity has rapidly increased, with peaks of 1.3 gallons (5 liters) of water per second seen by MIRO.

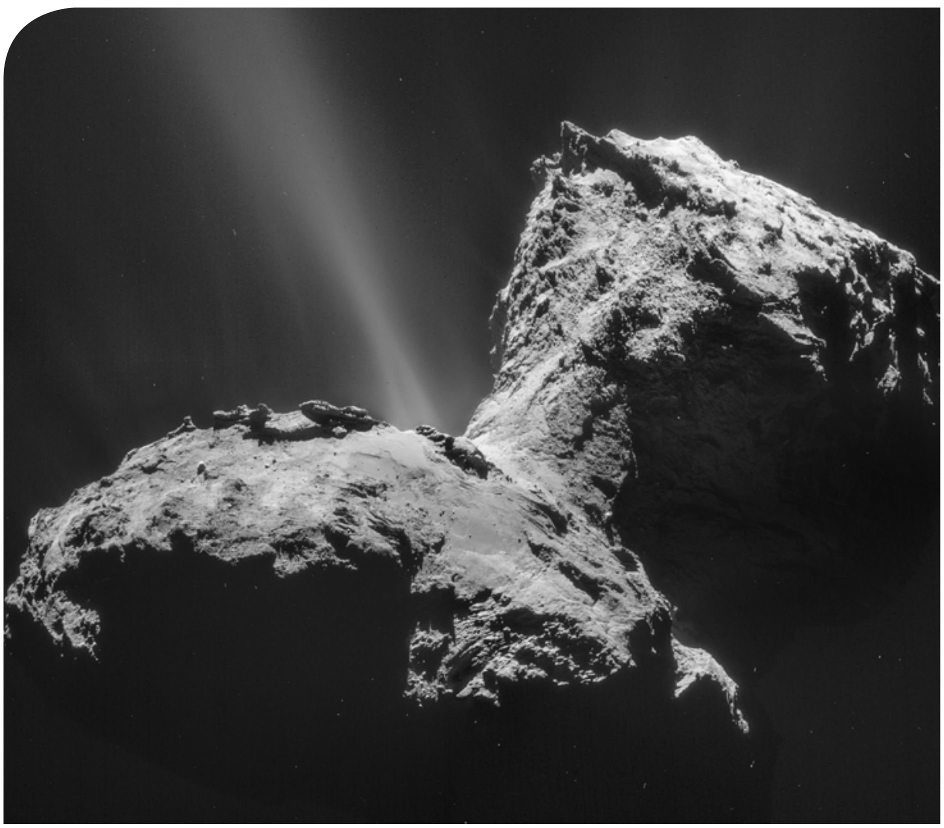
Rosetta's ROSINA instrument, also known as the 'comet sniffer' detected a variety of molecules in the coma of 67P, including water, carbon monoxide, carbon dioxide, methane, and even a few nitrogen and sulfur varieties. Translation: comet 67P smells like a combination of ammonia, urine, and rotten eggs. VITRIS also detected both water and carbon dioxide in the comet's coma, backing up ROSINA's findings.

The GIADA instrument, teaming up with COSINA, has been busy collecting dust particles, and measuring their velocities. After careful analysis, COSINA determined that at least one dust grain contains sodium and magnesium. This dust grain sparked the researchers' curiosity so much, they named it Boris. Now, both sodium and magnesium have been detected in comets before. However, in this case, the minerals were detected in the comet's inner coma and not the tail region.

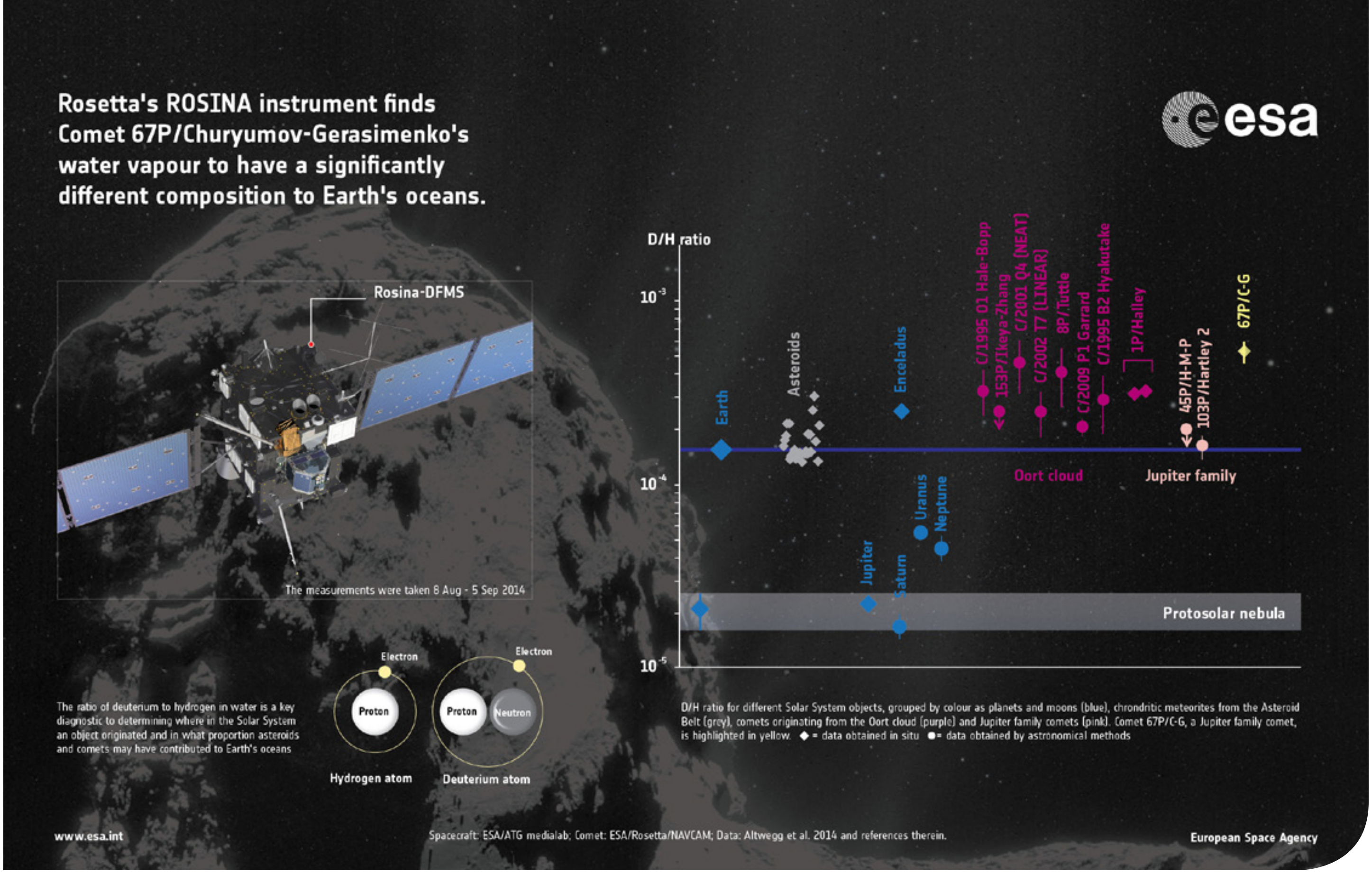
Another question the Rosetta mission hopes to answer is "Where did Earth's water come from?" Scientists have long hypothesized that comets were responsible for supplying the infant Earth with water, and ultimately life. Recently, ESA announced that water vapor collected from the comet varies significantly from the water we find on Earth, thus reigniting the debate on where Earth's water came from.

The Earth formed over 4.6 billion years ago, and in its infancy was a much hotter world than we know today. As such, any surface water present would have boiled off by the searing heat of an early Earth. Today, our home planet is very different, with two-thirds of its surface covered by water. So how did that water get here?

One hypothesis is that the water was delivered to Earth after the planet significantly cooled, further on in its development. The delivery method was most likely via comet or asteroid collision; however, this hypothesis is strongly debated. How can we tell where water came from? By analyzing the water and determining its "flavor" or composition, researchers can tell the proportion and variety of hydrogen isotope present, thus determining its origin. In the case of comet 67P's water, Rosetta's analysis discovered the water contained a ratio of hydrogen to deuterium — a



This four-image mosaic comprises images taken from a distance of 28.0 km from the centre of Comet 67P/Churyumov-Gerasimenko on 31 January 2015. The image resolution is 2.4 m/pixel and the individual 1024 x 1024 frames measure 2.4 km across. The mosaic measures 4.6 x 4.3 km. Credit: ESA/Rosetta/NAVCAM



Rosetta's measurement of the deuterium-to-hydrogen ratio (D/H) measured in the water vapour around Comet 67P/Churyumov–Gerasimenko. Deuterium is an isotope of hydrogen with an added neutron. The ratio of deuterium to hydrogen in water is a key diagnostic to determining where in the Solar System an object originated and in what proportion asteroids and/or comets contributed to Earth's oceans. The graph displays the different values of D/H in water observed in various bodies in the Solar System. The data points are grouped by colour as planets and moons (blue), chondritic meteorites from the Asteroid Belt (grey), comets originating from the Oort cloud (purple) and Jupiter family comets (pink). Rosetta's Jupiter-family comet is highlighted in yellow. The ratio for Earth's oceans is 1.56 × 10–4 (shown as the blue horizontal line in the upper part of the graph). Credit: ESA/ATG medialab/Rosetta/NavCam/Altwegg

form of hydrogen with an additional neutron – that was three times greater than the water here one Earth.

"We knew that Rosetta's in situ analysis of this comet was always going to throw up surprises for the bigger picture of Solar System science, and this outstanding observation certainly adds fuel to the debate about the origin of Earth's water," says Matt Taylor, ESA's Rosetta project scientist.

Comets are cosmic time capsules, harboring protoplanetary material left over from the early days of planet formation. These icy bodies form in various regions of the solar system and contain traces of material from where they were forged. However, solar system dynamics does not make comet origins easy to discern.

Long-period comets can originate out in far reaches of the solar system in a region known as the Oort Cloud, and typically form in the region around Uranus and Neptune. This area is far enough away from the Sun that water ice would be present. So how do they get to the Oort Cloud? As the outer planets settled into their orbits, gravitational interactions between the planets scattered the comets to the outer solar system.

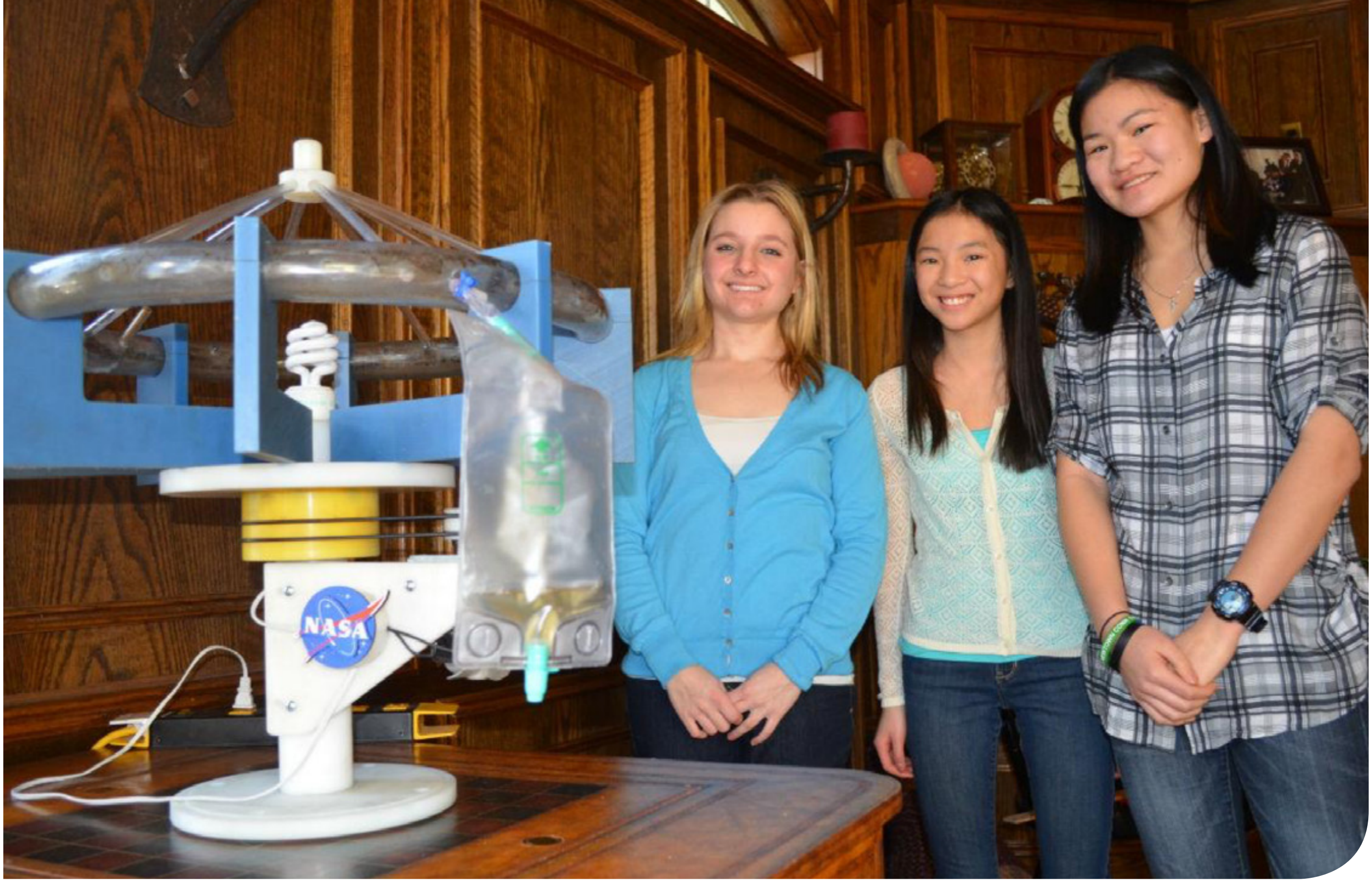
On the other hand, Rosetta's comet, belonging to the Jupiter-family of comets, is thought to have formed way out, beyond Neptune, in a region known as the Kuiper Belt. From time to time, the orbits of these comets are disturbed and as they travel through the solar system, they are captured by Jupiter's massive gravitational pull.

Scientists have measured the ratio of deuterium to hydrogen (D/H) in 11 different comets, thought to originate in different regions of the solar system, only the Jupiter-family of comets, like Comet 103P/Hartley 2, was observed to contain the same D/H ratio as the Earth's oceans. Meteorites within the main asteroid belt between Mars and Jupiter were also studied and determined to be a match to Earth's oceans. Asteroids and meteorites tend to have significantly lower water content than comets, but could still contribute to the presence of water on Earth.

Rosetta's instrument Rosetta Orbiter Spectrometer for Ion and Neutral Analysis, or ROSINA, determined the D/H ratio of comet 67P is three times higher than that of Earth's oceans, higher than the Jupiter-family comets, and higher than any Oort cloud comet.

"Our finding also rules out the idea that Jupiter-family comets contain solely Earth ocean-like water, and adds weight to models that place more emphasis on asteroids as the main delivery mechanism for Earth's oceans," Atlwegg said.

Over the coming months, Rosetta will continue to follow along with comet 67P, taking measurements and beaming data back to us on Earth. The operations team will continue to monitor how the comet evolves and behaves as it approaches the Sun.



Sisters MaryAnn Bulawa, Adia Bulawa and Lillith Bulawa have developed a hydroponic garden designed to work in the microgravity of low Earth orbit. They are presently running a crowdfunding campaign to pay for the costs of sending the experiment to the International Space Station.

Sisters sending a garden to ISS

We are Chicks in Space, a team of three sisters – MaryAnn Bulawa, Adia Bulawa and Lillith Bulawa – who are on a mission to help make future long term space missions possible. We have grown up working on NASA projects and challenges and in 2012 we participated in the Conrad Spirit of Innovation Challenge. This challenge encourages high school students to develop unique products that will benefit society.

Our project, a hydroponic garden, was specifically designed to work under conditions of microgravity. A renewable food source is essential for any long term space mission to become a reality. We called this the Garden of ETON - or Extra Terrestrial Organic Nutrition. Our garden uses centripetal force to circulate water because traditional hydroponic gardens are gravity driven and would not function in conditions of microgravity.

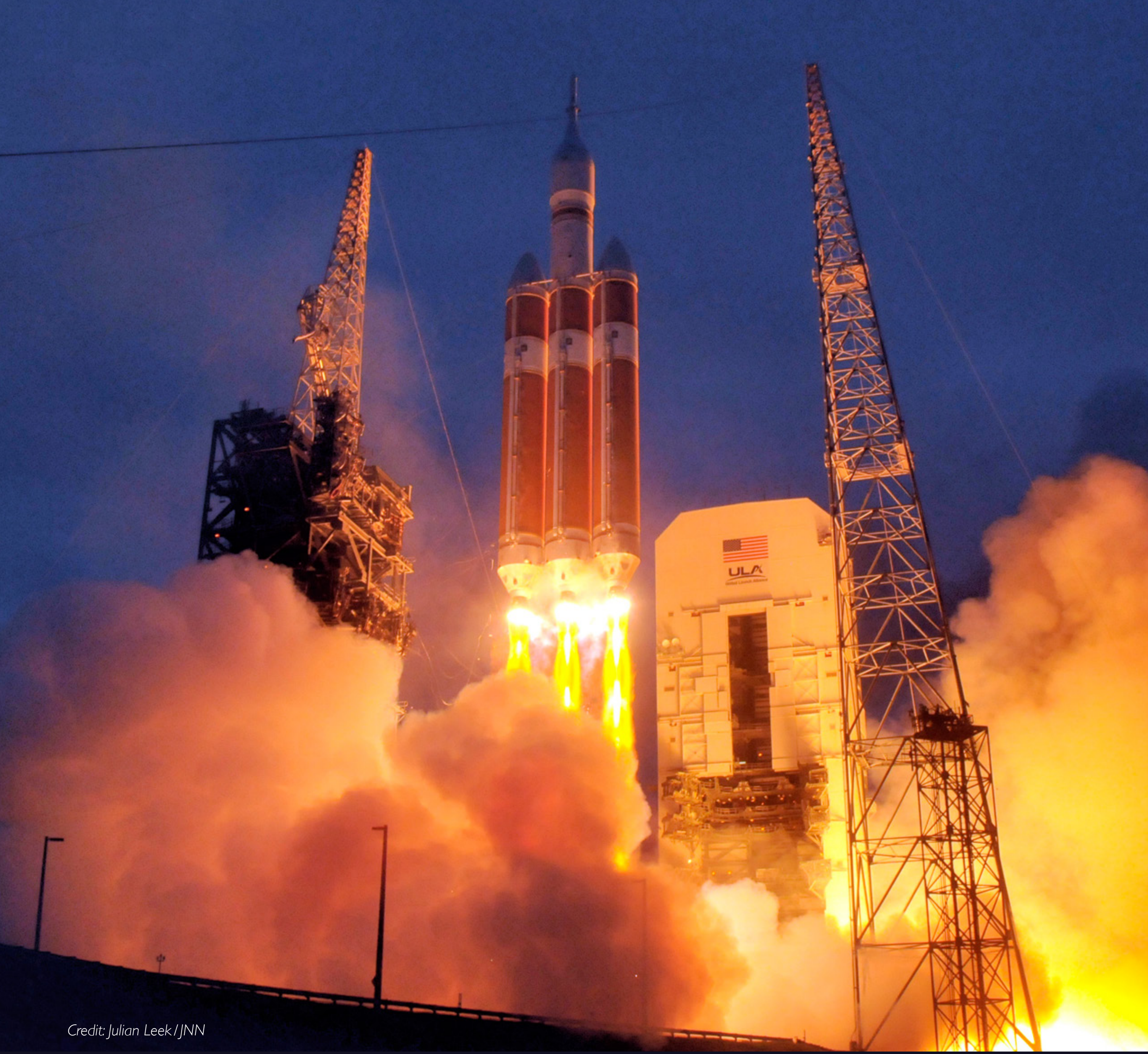
While at the Conrad Spirit of Innovation summit we were introduced to NanoRacks' Dream Up program. This program is designed

to help experiments like ours get the approval of NASA for transport to the International Space Station. We were offered the opportunity to launch a prototype of ETON on the International Space Station to test under actual conditions of microgravity. There were multiple constraints, however, the most challenging for us to overcome was that the prototype would have to be contained in a 4 x 4 x 4 inch cube.

We are now proud to present NanoETON, and we're using www.experiment.com to raise the $15,000 necessary to send NanoETON to the International Space Station.

This experience has been amazing for us. We have learned so much, not only about microgravity and plant growth, but about launching a project and the paper work involved in having it approved and cleared by NASA. We have been able to host an AMA on reddit.com with Dr. Jeffery Manber the CEO of NanoRacks, LLC (bit.ly/ETONgarden). We are so grateful that 58 people from around the world have already donated $5000 in an effort to fund our project.

You can help the Bulawa sisters send their experiment to the space station by donating at https://experiment.com/projects/sending-the-garden-of-eton-to-space



Credit: Julian Leek / JNN

Orion spacecraft performs nearly flawlessly on first test flight

NASA marked a major milestone on its journey to Mars as the Orion spacecraft completed its first voyage to space on Dec. 5, 2014, traveling farther than any spacecraft designed for astronauts has been in more than 40 years.

Orion blazed into the morning sky at 7:05 a.m. EST, lifting off from Space Launch Complex 37 at Cape Canaveral Air Force Station in Florida on a United Launch Alliance Delta IV Heavy rocket. The Orion crew module splashed down approximately 4.5 hours later in the Pacific Ocean, 600 miles southwest of San Diego. The only reported kink during the mission was the failure of all five airbags to fully inflate during splashdown, however, Orion remained afloat.

During the uncrewed test, Orion traveled twice through the Van Allen belt, experiencing high periods of radiation, and reached an altitude of 3,600 miles above Earth. Orion also hit speeds of 20,000 mph and weathered temperatures approaching 4,000 degrees Fahrenheit as it entered Earth's atmosphere.

The spacecraft was tested in space to allow engineers to collect critical data from 12,000 onboard sensors to evaluate its performance and improve its design.

The next spaceflight test of Orion will have the Space Launch System (SLS) rocket send Orion to a distant retrograde orbit around the Moon on Exploration Mission-1.

Vega VV04 IXV liftoff.
Credit: ESA–S. Corvaja

IXV prototype hoisted onto ship. Credit: Neri - Livorno (I)

Artist's view of parachute deployment.
Credit: ESA–J. Huart

ESA experimental IXV spaceplane completes research flight

An experimental vehicle to develop an autonomous European reentry capability has completed its mission. ESA's Intermediate eXperimental Vehicle flew a flawless reentry and splashed down in the Pacific Ocean just west of the Galapagos islands.

The IXV spaceplane lifted off at 13:40 GMT (10:40 local time) on 11 February from Europe's Spaceport in Kourou, French Guiana atop a Vega rocket. It separated from Vega at an altitude of 348 km and continued up to 413 km. Reentering from this suborbital path, it recorded data from more than 300 advanced and conventional sensors.

As it descended, the five-metre-long, two-tonne craft manoeuvred to decelerate from hypersonic to supersonic speed. The entry speed of 7.5 km/s at an altitude of 120 km created the same conditions as those for a vehicle returning from low Earth orbit.

IXV glided through the atmosphere before parachutes deployed to slow the descent further for a safe splashdown in the Pacific Ocean. Balloons kept IXV afloat while the recovery vessel hurried to pick it up.