Liftoff

New Zealand's space exploration magazine

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Discovery's final voyage

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- **MESSENGER orbits Mercury**

Liftoff

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NZSA News and Notices

Auckland meetings

The next Auckland meetings are on **2 May** and **6 June** at 7:45 pm at MOTAT, Great North Road, Western Springs (entry via Stadium Rd).

The Auckland Branch meets at MOTAT on the first Monday of each month (except January).

Committee changes

After three decades in the job, Jeff Green has stepped down as Secretary/Treasurer. Jeff has done a thoroughly professional job in this time and always kept a steady hand on the tiller.

Matthew Pavletich and Mike Ryan have been appointed Acting Secretary and Treasurer, respectively, until formal elections are held.

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Subscriptions 20010-2011 *(now reduced!)*

Subscription rates for 1 September 2010 to 31 August 2011 are as follows:

ORDINARY	$45
SENIOR CITIZEN	$40
STUDENT	$37.50

New subscriptions paid after 1 February 2011 may elect to receive *Liftoff* for only the second half year by paying half the above rates.

Note, too, that for each new member you introduce to the NZSA, providing they join for a full year and nominate you on their membership form, you will receive a credit of $5 against your next subscription. There is no limit to the number of credits you can qualify for.

Cover Photo: Space Shuttle Discovery approached the International Space Station during its 39th and final mission, STS-133. The European-built Leonardo module can be seen in in the cargo bay (NASA)

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Editor's Corner

April 12 this year marked two very significant space anniversaries: the 50th anniversary of the first human space flight by Yuri Gagarin in 1961 (see the photo feature on p. 21), and the 30th anniversary of the first Space Shuttle launch in 1981.

These anniversaries come at a time when human spaceflight, at least in the United States, is at something of a crossroads. As we all know, President Obama has cancelled the next US human spaceflight programme, Constellation, in favour of as-yet-undefined commercially-provided launch services to Earth orbit, with NASA tasked with developing a multipurpose crew-carrying vehicle for deep space missions (essentially the Orion vehicle from Constellation) and a heavy-lift rocket that Congress wants flying by 2016. The only trouble is, there's not enough money to do it in that time. And as for commercial crew-carrying craft, these only exist on paper (apart, perhaps, from SpaceX's Dragon vehicle which made a test flight last year). SpaceX say they could have a crew-carrying version of Dragon ready in three years, but that may be an ambitious goal, especially if government funding isn't forthcoming.

In short, it is unlikely that US astronauts will be flying on US-built spacecraft for at least five years. Limited seats will be available on Soyuz frights to the ISS, but (surprise, surprise) the Russians have just increased the price for these.

Meanwhile, China's Shenzhou spacecraft is being prepared for its next flight, ans the Chinese are also developing a small space station for Shenzhou to link up with. India has also expressed interest in developing a crew-carrying spacecraft, and the European Space Agency is looking at developing its ATV cargo-carrier into a human-rated vehicle. And let's not forget the suborbital space tourism market being spearheaded by Virgin Galactic. As this market develops, it is more than likely that these companies will want to offer orbital services as well.

So we are in something of a transition phase in human spaceflight at the moment. Within a few years launching people into orbit will no longer be the sole preserve of government-run programmes. So while things may seem a little quiet for the next few years, after that there will be something of a boom in crew-carrying launch services. Who will lead the way remains to be seen.

-- *David Maclennan*

Dawn gets Vesta target practice

This image shows a model of the protoplanet Vesta, using scientists' best guess to date of what the surface of the protoplanet might look like. It was created as part of an exercise for NASA's Dawn mission involving mission planners at the Jet Propulsion Laboratory and science team members at the Planetary Science Institute in Tuscon, Ariz. The images incorporate the best data on dimples and bulges of the protoplanet Vesta from ground-based telescopes and NASA's Hubble Space Telescope. The cratering and small-scale surface variations are computer-generated, based on the patterns seen on the Earth's moon, an inner solar system object with a surface appearance that may be similar to Vesta. (NASA/JPL-Caltech/UCLA/PSI)

There is an old chestnut about a pedestrian who once asked a virtuoso violinist near Carnegie Hall how to get to the famed concert venue. The virtuoso's answer: practice!

The same applies to NASA's Dawn mission to the giant asteroid Vesta. In the lead-up to orbiting the second most massive body in the asteroid belt this coming July, Dawn mission planners and scientists have been practicing mapping Vesta's surface, producing still images and a rotating animation that includes the scientists' best guess to date of what the surface might look like. The animation and images incorporate the best data on the dimples and bulges of Vesta from ground-based telescopes and NASA's Hubble Space Telescope. The The topography is color-coded by altitude. The cratering and small-scale surface variations are computer-generated, based on the patterns seen on Earth's moon, an inner solar system object with a surface appearance that may be similar to Vesta.

"We won't know what Vesta really looks like until Dawn gets there," said Carol Raymond, Dawn's deputy principal investigator, based at the Jet Propulsion Laboratory, Pasadena, Calif., who helped orchestrate the activity. "But we needed a way to make sure our imaging plans would give us the best results possible. The products have proven that Dawn's mapping techniques will reveal a detailed view of this world that we've never seen up close before."

Vesta is one of the brightest asteroids in the night sky. Under the right conditions, Vesta can be seen with binoculars. But the best images so far from ground-based telescopes and Hubble still show Vesta as a bright, mottled orb. Once in orbit around Vesta, Dawn will pass about 650 kilometres above the asteroid's surface, snapping multi-angle images that will allow scientists to produce topographic maps. Later, Dawn will orbit at a lower altitude of about 200 kilometres, getting closer shots of parts of the surface.

The Dawn mission will have the capability to map 80% of the asteroid's surface in the year the spacecraft is in orbit around Vesta. (The north pole will be dark when Dawn arrives in July 2011 and is expected to be only dimly lit when Dawn leaves in July 2012.) The mission will map Vesta at a spatial resolution on the order of the best global topography maps of Earth made by NASA's Shuttle Radar Topography mission. Vesta formed very early in the history of the solar system and has one of the oldest surfaces in the system. Scientists are eager to get their first close-up look so they can better understand this early chapter.

Starting in August 2009, Dawn's optical navigation lead, Nick Mastrodemos, based at JPL, developed a computer simulation of the orbits and images to be taken by the spacecraft. He adapted software developed by Bob Gaskell of the Planetary Science Institute, Tuscon, Ariz. Mastrodemos created a model using scientists' best knowledge of Vesta and simulated the pictures that Dawn would take from the exact distances and geometries in the Dawn science plan. He sent those images to two teams that use different techniques to derive topographical heights from imaging. One, led by Thomas Roatsch, was based at the Institute of Planetary Research of the German Aerospace Center (DLR) in Berlin. The other, led by Gaskell, was based at the Planetary Science Institute in Tuscon. (Like the Roatsch team, the Gaskell team did not have prior knowledge of the model from which the simulated data were created.) The groups sent their digital terrain models back to JPL, including the video produced by Frank Preusker from DLR that is based on his full stereo processing.

Mastrodemos compared their products to the original model he made. Both techniques reproduced the known data set well with only minor differences in spatial resolution and height accuracy. "Working through this exercise, the mission planners and the scientists learned that we could improve the overall accuracy of the topographic reconstruction, using a somewhat different observation geometry," Mastrodemos said. "Since then, Dawn science planners have worked to tweak the plans to implement the lessons of the exercise."

The exercise helped both teams get an early start on updating their software and planning the necessary computer resources. "In order to plan for proper stereo coverage of an unknown body like Vesta, practice is essential," said Roatsch, who is responsible for the framing camera team's stereo observation planning. For now, the Virtual Vesta exercise gives the Dawn science team a fleshed-out model to consider. But to see whether their educated guesses were right, the team will have to wait until Dawn arrives at its target in July.

When is an asteroid not an asteroid?

On 29 March 1807, German astronomer Heinrich Wilhelm Olbers spotted Vesta as a pinprick of light in the sky. Two hundred and four years later, as NASA's Dawn spacecraft prepares to begin orbiting this intriguing world, scientists now know how special this world is, even if there has been some debate on how to classify it.

Vesta is most commonly called an asteroid because it lies in the orbiting rubble patch known as the main asteroid belt between Mars and Jupiter. But the vast majority of objects in the main belt are lightweights, 100-kilometres-wide or smaller, compared with Vesta, which is about 530 kilometres across on average. In fact, numerous bits of Vesta ejected by collisions with other objects have been identified in the main belt.

"I don't think Vesta should be called an asteroid," said Tom McCord, a Dawn co-investigator based at the Bear Fight Institute, Winthrop, Wash. "Not only is Vesta so much larger, but it's an evolved object, unlike most things we call asteroids."

The layered structure of Vesta (core, mantle and crust) is the key trait that makes Vesta more like planets such as Earth, Venus and Mars than the other asteroids, McCord said. Like the planets, Vesta had sufficient radioactive material inside when it coalesced, releasing heat that melted rock and enabled lighter layers to float to the outside. Scientists call this process differentiation. McCord and colleagues were the first to discover that Vesta was likely differentiated when special detectors on their telescopes in 1972 picked up the signature of basalt. That meant that the body had to have melted at one time.

Officially, Vesta is a "minor planet" -- a body that orbits the sun but is not a proper planet or comet. But there are more than 540,000 minor planets in our solar system, so the label doesn't give Vesta much distinction. Dwarf planets – which include Dawn's second destination, Ceres – are another category, but Vesta doesn't qualify as one of those. For one thing, Vesta isn't quite large enough.

Dawn scientists prefer to think of Vesta as a protoplanet because it is a dense, layered body that orbits the sun and began in the same fashion as Mercury, Venus, Earth and Mars, but somehow never fully developed. In the swinging early history of the solar system, objects became planets by merging with other Vesta-sized objects. But Vesta never found a partner during the big dance, and the critical time passed. It may have had to do with the nearby presence of Jupiter, the neighborhood's gravitational superpower, disturbing the orbits of objects and hogging the dance partners.

Other space rocks have collided with Vesta and knocked off bits of it. Those became debris in the asteroid belt known as Vestoids, and even hundreds of meteorites that have ended up on Earth. But Vesta never collided with something of sufficient size to disrupt it, and it remained intact. As a result, Vesta is a time capsule from that earlier era.

"This gritty little protoplanet has survived bombardment in the asteroid belt for over 4.5 billion years, making its surface possibly the oldest planetary surface in the solar system," said Christopher Russell, Dawn's principal investigator, based at UCLA. "Studying Vesta will enable us to write a much better history of the solar system's turbulent youth."

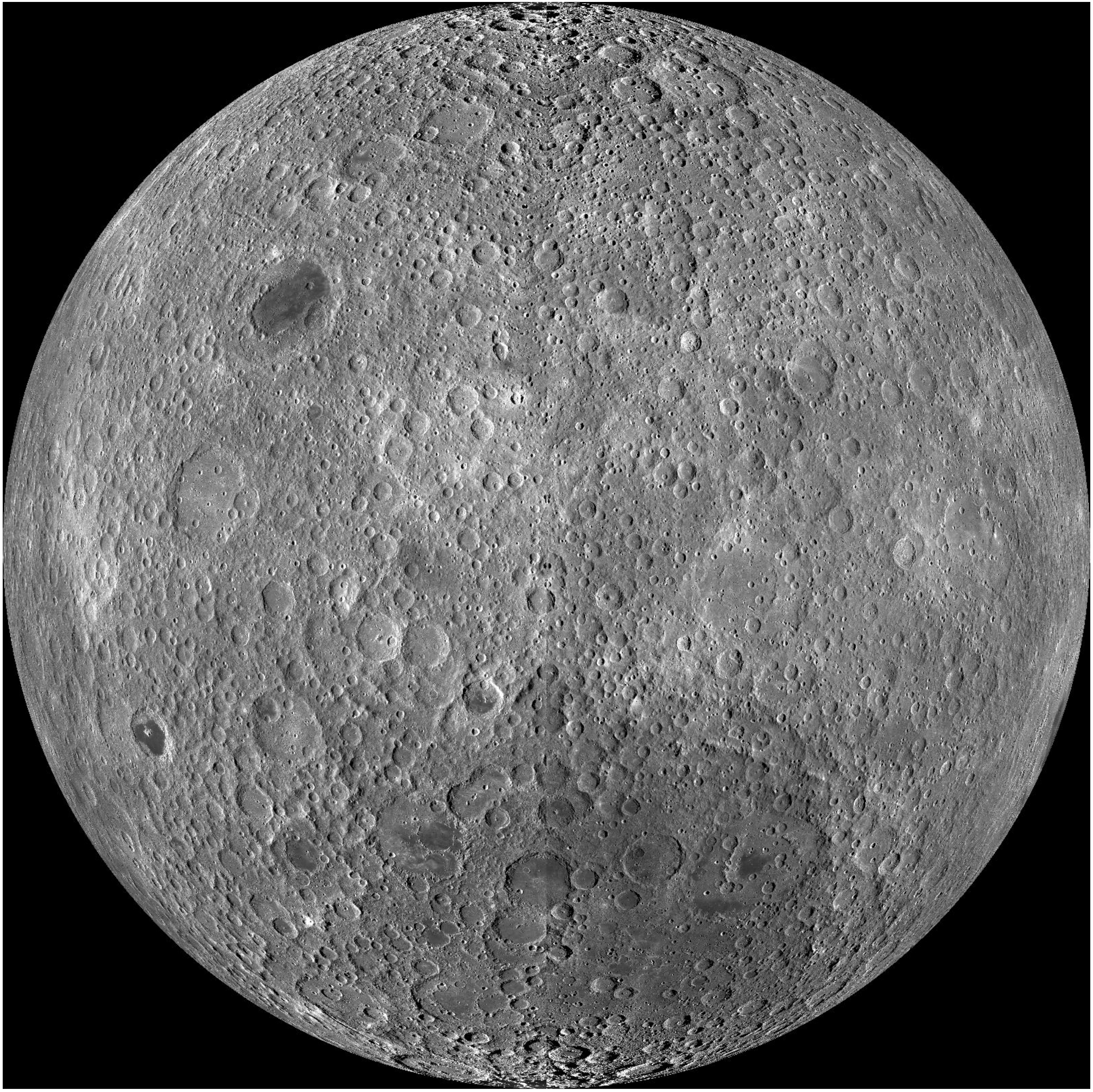
Dawn's scientists and engineers have designed a master plan to investigate these special features of Vesta. When Dawn arrives at Vesta in July, the south pole will be in full sunlight, giving scientists a clear view of a huge crater at the south pole. That crater may reveal the layer cake of materials inside Vesta that will tell us how the body evolved after formation. The orbit design allows Dawn to map new terrain as the seasons progress over its 12-month visit. The spacecraft will make many measurements, including high-resolution data on surface composition, topography and texture. The spacecraft will also measure the tug of Vesta's gravity to learn more about its internal structure.

"Dawn's ion thrusters are gently carrying us toward Vesta, and the spacecraft is getting ready for its big year of exploration," said Marc Rayman, Dawn's chief engineer at NASA's Jet Propulsion Laboratory, Pasadena, Calif. "We have designed our mission to get the most out of this opportunity to reveal the exciting secrets of this uncharted, exotic world."

LRO delivers treasure trove of data

NASA's Lunar Reconnaissance Orbiter (LRO) team has released the final set of data from the mission's exploration phase along with the first measurements from its new life as a science satellite.

With this fifth release of data, striking new images and maps have been added to the already comprehensive collection of raw lunar data and high-level products, including mosaic images, that LRO has made possible. The spacecraft's seven instruments delivered more than 192 terabytes of data with an unprecedented level of detail. It would take approximately 41,000 typical DVDs to hold the new LRO data set. "The release of such a comprehensive and rich collection of data, maps and images reinforces the tremendous success we have had with LRO in the Exploration Systems Mission Directorate and with lunar science," said Michael Wargo, chief lunar scientist of the Exploration Systems Mission Directorate at NASA Headquarters in Washington.



A global mosaic of the Moon’s far side assembled from images taken by the Lunar Reconnaissance Orbiter (NASA)

Among the latest products is a global map with a resolution of 100 metres per pixel from the Lunar Reconnaissance Orbiter Camera (LROC). To enhance the topography of the Moon, this map was made from images collected when the sun angle was low on the horizon. Armchair astronauts can zoom in to full resolution with any of the mosaics – quite a feat considering that each is 34,748 pixels by 34,748 pixels, or approximately 1.1 gigabytes.

"Because the Moon is so close and because we have a dedicated ground station, we are able to bring back as much data from LRO as from all the other planetary missions combined," said LRO Project Scientist Richard Vondrak of NASA's Goddard Space Flight Center in Greenbelt, Md.

LRO's Diviner Lunar Radiometer Experiment is providing new data relating to the Moon's surface. These include maps of visual and infrared brightness, temperature, rock abundance, nighttime soil temperature and surface mineralogy. The data are in the form of more than 1700 digital maps at a range of resolutions that can be overlaid easily on other lunar data sets.

The Lyman-Alpha Mapping Project, which collects information to help identify surface water-ice deposits, especially in permanently-shadowed regions of the Moon, also has new data. This release includes new maps of far-ultraviolet (FUV) brightness, albedo and water-ice data as well as instrument exposure, illumination and other conditions.

As a complement to the high-resolution digital elevation maps, representing 3.4 billion measurements already released by the Lunar Orbiter Laser Altimeter team, the group is delivering new maps of slope, roughness and illumination conditions. New maps from the Lunar Exploration Neutron Detector, and the latest data from the Cosmic Ray Telescope for the Effects of Radiation and the Miniature Radio Frequency instruments, also are featured.

"All these global maps and other data are available at a very high resolution -- that's what makes this release exciting," said Goddard's John Keller, the LRO deputy project scientist. "With this valuable collection, researchers worldwide are getting the best view of the Moon they have ever had."

The complete data set contains the raw information and high-level products such as mosaic images and maps. The data set also includes more than 300,000 calibrated data records released by LROC. All of the final records from the exploration phase, which lasted from 15 September 2009 through 15 September 2010, are available through several of the Planetary Data System nodes and the LROC website.

To access LRO data, visit: **http://pds.nasa.gov**

Proposed mission to Jupiter system achieves milestone

With input from scientists around the world, American and European scientists working on the potential next new mission to the Jupiter system have articulated their joint vision for the Europa Jupiter System Mission. The mission is a proposed partnership between NASA and the European Space Agency. The scientists on the joint NASA-ESA definition team agreed that the overarching science theme for the Europa Jupiter System Mission will be "the emergence of habitable worlds around gas giants."

The proposed Europa Jupiter System Mission would provide orbiters around two of Jupiter's moons: a NASA orbiter around Europa called the Jupiter Europa Orbiter, and an ESA orbiter around Ganymede called the Jupiter Ganymede Orbiter. "We've reached hands across the Atlantic to define a mission to Jupiter's water worlds," said Bob Pappalardo, the pre-project scientist for the proposed Jupiter Europa Orbiter, who is based at the Jet Propulsion Laboratory in Pasadena, Calif. "The Europa Jupiter System Mission will create a leap in scientific knowledge about the moons of Jupiter and their potential to harbor life."

The new reports integrate goals that were being separately developed by NASA and ESA working groups into one unified strategy. The ESA report was being presented to the European public and science community in February, and the NASA report was published online in December. The NASA report is available at **http://www.lpi.usra.edu/opag** .

The proposed mission singles out the icy moons Europa and Ganymede as special worlds that can lead to a broader understanding of the Jovian system and of the possibility of life in our solar system and beyond. They are natural laboratories for analyzing the nature, evolution and potential habitability of icy worlds, because they are believed to present two different kinds of sub-surface oceans.

The Jupiter Europa Orbiter would characterize the relatively thin ice shell above Europa's ocean, the extent of that ocean, the materials composing its internal layers, and the way surface features such as ridges and "freckles" formed. It will also identify candidate sites for potential future landers. Instruments that might be on board could include a laser altimeter, an ice-penetrating radar, spectrometers that can obtain data in visible, infrared and ultraviolet radiation, and cameras with narrow- and wide-angle capabilities. The actual instruments to fly would be selected through a NASA competitive call for proposals.

This artist's concept shows NASA's Jupiter Europa Orbiter which will carry a complement of 11 instruments to explore Europa and the Jupiter System. The spacecraft is part of the joint NASA-ESA Europa Jupiter System Mission. (NASA/ESA)

Ganymede is thought to have a thicker ice shell, with its interior ocean sandwiched between ice above and below. ESA's Jupiter Ganymede Orbiter would investigate this different kind of internal structure. The Jupiter Ganymede Orbiter would also study the intrinsic magnetic field that makes Ganymede unique among all the solar system's known moons. This orbiter, whose instruments would also be chosen through a competitive process, could include a laser altimeter, spectrometers and cameras, plus additional fields-and-particles instruments.

The two orbiters would also study other large Jovian moons, Io and Callisto, with an eye towards exploring the Jupiter system as an archetype for other gas giant planets.

NASA and ESA officials gave the Europa Jupiter System Mission proposal priority status for continued study in 2009, agreeing that it was the most technically feasible of the outer solar system flagship missions under consideration. Over the next few months, NASA officials will be analyzing the joint strategy and awaiting the outcome of the next Planetary Science Decadal Survey by the National Research Council of the U.S. National Academies. That survey will serve as a roadmap for new NASA planetary missions for the decade beginning 2013.

Forensic sleuthing ties ring ripples to impacts

Like forensic scientists examining fingerprints at a cosmic crime scene, scientists working with data from NASA's Cassini, Galileo and New Horizons missions have traced telltale ripples in the rings of Saturn and Jupiter back to collisions with cometary fragments dating back more than 10 years ago.

The ripple-producing culprit, in the case of Jupiter, was comet Shoemaker-Levy 9, whose debris cloud hurtled through the thin Jupiter ring system during a kamikaze course into the planet in July 1994. Scientists attribute Saturn's ripples to a similar object – likely another cloud of comet debris – plunging through the inner rings in the second half of 1983. The findings are detailed in a pair of papers published online in the journal *Science*.

"What's cool is we're finding evidence that a planet's rings can be affected by specific, traceable events that happened in the last 30 years, rather than a hundred million years ago," said Matthew Hedman, a Cassini imaging team associate, lead author of one of the papers, and a research associate at Cornell University, Ithaca, N.Y. "The solar system is a much more dynamic place than we gave it credit for."

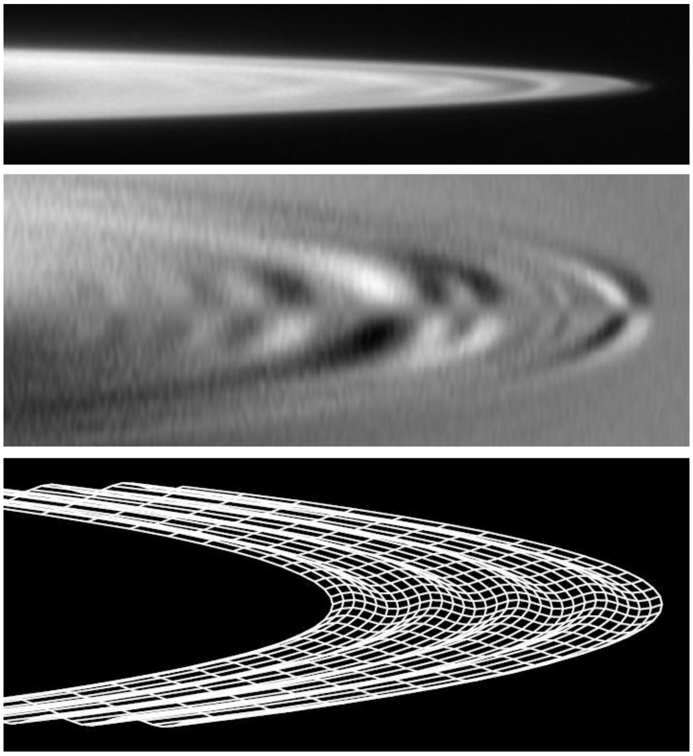
From Galileo's visit to Jupiter, scientists have known since the late 1990s about patchy patterns in the Jovian ring. But the Galileo images were a little fuzzy, and scientists didn't understand why such patterns would occur. The trail was cold until Cassini entered orbit around Saturn in 2004 and started sending back thousands of images. A 2007 paper by Hedman and colleagues first noted corrugations in Saturn's innermost ring, dubbed the D ring.

A group including Hedman and Mark Showalter, a Cassini co-investigator based at the SETI Institute in Mountain View, Calif., then realized that the grooves in the D ring appeared to wind together more tightly over time. Playing the process backward, Hedman then demonstrated the pattern originated when something tilted the D ring off its axis by about 100 metres in late 1983. The scientists found the influence of Saturn's gravity on the tilted area warped the ring into a tightening spiral.

Cassini imaging scientists got another clue when the sun shone directly along Saturn's equator and lit the rings edge-on in August 2009. The unique lighting conditions highlighted ripples not previously seen in another part of the ring system. Whatever happened in 1983 was not a small, localized event; it was big. The collision had tilted a region more than 19,000 kilometres wide, covering part of the D ring and the next outermost ring, called the C ring. Unfortunately spacecraft were not visiting Saturn at that time, and the planet was on the far side of the sun, hidden from telescopes on or orbiting Earth, so whatever happened in 1983 passed unnoticed by astronomers.

Hedman and Showalter, the lead author on the second paper, began to wonder whether the long-forgotten pattern in Jupiter's ring system might illuminate the mystery. Using Galileo images from 1996 and 2000, Showalter confirmed a similar winding spiral pattern. They applied the same math they had applied to Saturn, but now with Jupiter's gravitational influence factored in. Unwinding the spiral pinpointed the date when Jupiter's ring was tilted off its axis: between June and September 1994. Shoemaker-Levy plunged into the Jovian atmosphere during late July 1994. The estimated size of the nucleus was also consistent with the amount of material needed to disturb Jupiter's ring.

The Galileo images also revealed a second spiral, which was calculated to have originated in 1990. Images taken by New Horizons in 2007, when the spacecraft flew by Jupiter on its way to Pluto, showed two newer ripple patterns, in addition to the fading echo of the Shoemaker-Levy impact. "We now know that collisions into the rings are very common – a few times per decade for Jupiter and a few times per century for Saturn," Showalter said. "Now scientists know that the rings record these impacts like grooves in a vinyl record, and we can play back their history later."



These images, derived from data obtained by NASA's Galileo spacecraft, show the subtle ripples in the ring of Jupiter that scientists have been able to trace back to the impact of comet Shoemaker-Levy 9 in July 1994. The top image was obtained by Galileo on 9 November 1996, and shows the tip of the Jovian ring. The middle image is a version of the same image that has been computer-enhanced to show the ripples. The third image shows a computer model derived from the data. (NASA)

The ripples also give scientists clues to the size of the clouds of cometary debris that hit the rings. In each of these cases, the nuclei of the comets – before they likely broke apart – were a few kilometres wide.

"Finding these fingerprints still in the rings is amazing and helps us better understand impact processes in our solar system," said Linda Spilker, Cassini project scientist, based at the Jet Propulsion Laboratory, Pasadena, Calif. "Cassini's long sojourn around Saturn has helped us tease out subtle clues that tell us about the history of our origins."

Hubble rules out one alternative to dark energy

Astronomers using the Hubble Space Telescope have ruled out an alternate theory on the nature of dark energy after recalculating the expansion rate of the universe to unprecedented accuracy.

The universe appears to be expanding at an increasing rate. Some believe that is because the universe is filled with a dark energy that works in the opposite way of gravity. One alternative to that hypothesis is that an enormous bubble of relatively empty space eight billion light-years across surrounds our galactic neighborhood. If we lived near the center of this void, observations of galaxies being pushed away from each other at accelerating speeds would be an illusion.

This hypothesis has been invalidated because astronomers have refined their understanding of the universe's present expansion rate. Adam Riess of the Space Telescope Science Institute (STScI) and Johns Hopkins University in Baltimore, Md., led the research. The Hubble observations were conducted by the SHOES (Supernova Ho for the Equation of State) team that works to refine the accuracy of the Hubble constant to a precision that allows for a better characterization of dark energy's behavior. The observations helped determine a figure for the universe's current expansion rate to an uncertainty of just 3.3 percent. The new measurement reduces the error margin by 30 percent over Hubble's previous best measurement in 2009. Riess's results appeared in the 1 April issue of *The Astrophysical Journal*.

"We are using the new camera on Hubble like a policeman's radar gun to catch the universe speeding," Riess said. "It looks more like it's dark energy that's pressing the gas pedal."

Riess' team first had to determine accurate distances to galaxies near and far from Earth. The team compared those distances with the speed at which the galaxies are apparently receding because of the expansion of space. They used those two values to calculate the Hubble constant, the number that relates the speed at which a galaxy appears to recede to its distance from the Milky Way. Because astronomers cannot physically measure the distances to galaxies, researchers had to find stars or other objects that serve as reliable cosmic yardsticks. These are objects with an intrinsic brightness, brightness that hasn't been dimmed by distance, an atmosphere, or stellar dust, that is known. Their distances, therefore, can be inferred by comparing their true brightness with their apparent brightness as seen from Earth.

To calculate longer distances, Riess' team chose a special class of exploding stars called Type 1a supernovae. These stellar explosions all flare with similar luminosity and are brilliant enough to be seen far across the universe. By comparing the apparent brightness of Type 1a supernovae and pulsating Cepheid stars, the astronomers could measure accurately their intrinsic brightness and therefore calculate distances to Type Ia supernovae in far-flung galaxies.

Using the sharpness of the new Wide Field Camera 3 (WFC3) to study more stars in visible and near-infrared light, scientists eliminated systematic errors introduced by comparing measurements from different telescopes. "WFC3 is the best camera ever flown on Hubble for making these measurements, improving the precision of prior measurements in a small fraction of the time it previously took," said Lucas Macri, a collaborator on the SHOES Team from Texas A&M in College Station.

Knowing the precise value of the universe's expansion rate further restricts the range of dark energy's strength and helps astronomers tighten up their estimates of other cosmic properties, including the universe's shape and its roster of neutrinos, or ghostly particles, that filled the early universe.

"Thomas Edison once said 'every wrong attempt discarded is a step forward,' and this principle still governs how scientists approach the mysteries of the cosmos," said Jon Morse, astrophysics division director at NASA Headquarters in Washington. "By falsifying the bubble hypothesis of the accelerating expansion, NASA missions like Hubble bring us closer to the ultimate goal of understanding this remarkable property of our universe."

Earth’s gravity revealed in unprecedented detail

After just two years in orbit, ESA's GOCE (Gravity field and steady-state Ocean Circulation Explorer) satellite has gathered enough data to map Earth's gravity with unrivalled precision. Scientists now have access to the most accurate model of the 'geoid' ever produced to further our understanding of how Earth works. The new geoid was unveiled recently at the Fourth International GOCE User Workshop hosted at the Technische Universität München in Munich, Germany. Media representatives and scientists from around the world were treated to the best view yet of global gravity.

The geoid is the surface of an ideal global ocean in the absence of tides and currents, shaped only by gravity. It is a crucial reference for measuring ocean circulation, sea-level change and ice dynamics – all affected by climate change.

Prof. Reiner Rummel, former Head of the Institute for Astronomical and Physical Geodesy at the Technische Universität München, said, "We see a continuous stream of excellent GOCE gradiometry data coming in. With each new two-month cycle, our GOCE gravity field model is getting better and better. "Now the time has come to use GOCE data for science and applications. I am particularly excited about the first oceanographic results.

"They show that GOCE will give us dynamic topography and circulation patterns of the oceans with unprecedented quality and resolution. I am confident that these results will help improve our understanding of the dynamics of world oceans."

The two-day workshop provided the science community with the latest information on the performance of the satellite and details about data products and user services. Participants also discussed how the GOCE geoid will make advances in ocean and climate studies, and improve our understanding of Earth’s internal structure.

For example, the gravity data from GOCE are helping to develop a deeper knowledge of the processes that cause earthquakes, such as the event that recently devastated Japan. Since this earthquake was caused by tectonic plate movement under the ocean, the motion cannot be observed directly from space. However, earthquakes create signatures in gravity data, which could be used to understand the processes leading to these natural disasters and ultimately help to predict them.

The GOCE satellite was launched in March 2009 and has now collected more than 12-months of gravity data. Volker Liebig, Director of ESA's Earth Observation Programmes said, "Benefiting from a period of exceptional low solar activity, GOCE has been able to stay in low orbit and achieve coverage six weeks ahead of schedule. This also means that we still have fuel to continue measuring gravity until the end of 2012, thereby doubling the life of the mission and adding even more precision to the GOCE geoid."

GOCE has achieved many firsts in Earth observation. Its gradiometer – six highly sensitive accelerometers measuring gravity in 3D – is the first in space. It orbits at the lowest altitude of any observation satellite to gather the best data on Earth's gravity. The design of this sleek one-tonne satellite is unique. In addition, GOCE uses an innovative ion engine that generates tiny forces to compensate for any drag the satellite experiences as it orbits through the remnants of Earth's atmosphere.

STS-133 Mission Report

By Ed Case

Space shuttle Discovery's main gear touches down on Runway 15 at the Shuttle Landing Facility at NASA's Kennedy Space Center in Florida for the last time. Landing was at 11:57 a.m. (EST) on 9 March 2011, completing a more than 12-day STS-133 mission to the International Space Station. STS-133 was Discovery's 39th and final mission. This was the 133rd Space Shuttle Program mission and the 35th shuttle voyage to the space station. (NASA)

Discovery crew:

Steven W. Lindsey (Commander; 5th flight)
Eric A. Boe (Pilot; 2nd flight)
Stephen G. Bowen (Mission Specialist; 3rd flight)
Michael R. Barratt (Mission Specialist; 1st flight)
Nicole P. Stott (Mission Specialist; 2nd flight)
Alvin Drew (Mission Specialist; 2nd flight)

Notes: 133rd shuttle flight; 39th flight for Discovery and the 35th flight to the ISS. Bowen replaced Kopra because of a bicycle accident.. Discovery has spent 365 days in space and has flown 238.1 million kilometres. This is the last flight for Discovery in the shuttle program. Achievements for Discovery: first shuttle retired from NASA's fleet; first flight after Challenger accident; launched Hubble Space Telescope; first flight of a Russian cosmonaut on a shuttle; first Mir rendezvous; first female pilot; first on-orbit shift in new Mission Control Center; highest altitude known for a shuttle flight; final shuttle-Mir docking; flight to return John Glenn to orbit as oldest human to fly in space; first ISS crew rotation; first flight after Columbia accident; final use of the shuttle for full ISS crew rotation and there were other firsts. Docked once with the Mir Space Station and this will be the 13th docking with the ISS. First launched on 30 August 1984.

On Thursday, 24 February, after a momentarily delay due to an issue in the range safety command computer system, *Discovery* lifted off at 3:53 p.m. EST from Pad 39A. *Discovery,* on its last mission, was headed for the International Space Station with the Permanent Multipurpose Module prominent in its cargo bay. The PMM is on its eighth trip to the station. Seven were as the Multipurpose Logistics Module Leonardo. The reinforced and rewired Leonard will provide nearly 70 cubic metres of additional pressurized space for the station.

Since the crew was launched late afternoon, the crew had a short day on their first day in space. On Friday 25 February the crew awoke at 5:54 a.m. and spent the day performing an inspection of the orbiter's thermal protection system. They also checked out spacesuits and rendezvous tools in preparation for docking with the ISS. Lindsey, Boe and Drew used the shuttle's robot arm and its orbiter boom sensor system extension to look at the reinforced carbon-carbon on the spacecraft's nose and wing leading edges, and some of its heat-resistant tiles. The crew configured shuttle systems for orbital operations. The crew configured shuttle systems for orbital operations

On Saturday 26 February the shuttle slowly approached the station, with both spacecraft moving at 28,57 kilometres per hour, it paused about 183 metres below it to do the standard backflip. Aboard the ISS, Paolo Nespoli and Cady Coleman used cameras with 400mm and 800mm lenses for a minute-and-a-half photo session, shooting numerous pictures of the shuttle's thermal protection system. The photos were sent down for analysis by experts to check for any damage.

Discovery docked at the ISS at 1:14 p.m. CST. After a delay to let the relative motion between the two spacecraft (a combined mass of around half a million kilograms) dampen out, hatches separating crews were opened at 3:16 p.m. All seven astronauts moved into the station. Following handshakes, hugs and a welcoming ceremony by the station crew – Expedition 26 Commander Scott Kelly and flight Engineers Oleg Skripochka, Alexander Kaleri, Dmitry Kondratyev, Paolo Nespoli and Cady Coleman – *Discovery*'s astronauts received the standard station safety briefing.

The crews promptly went to work, with Barratt and Scott preparing to use the station's robotic arm to pluck Express Logistic Carrier 4 from the shuttle cargo bay and hand it off to the shuttle's arm, operated by Drew and Boe. After moving the base of Canadarm2, the shuttle arm was to hand ELC4 back for installation on the Earth-facing side of the station's starboard truss. There it will be used for stowage or spare parts, including a spare radiator launched aboard *Discovery*.

On Sunday 27 February, the crew's wakeup call to begin their fourth day in space came at 6:23 a.m., giving them 30 minutes of extra sleep to make up for a later than expected bedtime on Saturday. The astronauts kept busy by moving equipment and supplies between *Discovery* and the ISS with robotics activities and preparation for the spacewalk. About 907 kilograms of cargo had already been brought to the station and about 1,179 kilograms was ready to be returned to Earth by the shuttle.

On Earth, experts completed their analysis of 302 photos that was taken of the heat shield taken by the crew before docking. Spacewalkers Drew and Bowen also configured tools for their Monday spacewalk. Finally, the shuttle crew, with Kelly and Coleman, talked with media representatives during the afternoon.

First spacewalk

On Monday 28 February, the crew wakeup call was at 5:23 a.m. CST. The first spacewalk, lasting six hours and 34 minutes, began at 9:46 a.m. CST when spacewalkers switched their suits to battery power. The first task was to install the extension cable between the Unity and Tranquility nodes. That included work in an area that will be inaccessible after the Leonardo Permanent Multipurpose Module is in place. The crew also moved a failed 362.8-kilogram ammonia pump module.

Drew then retrieved a tool to be used on the next spacewalk to remove ammonia from the failed pump. Bowen installed a foot restraint on the station arm to get ready for the module's move from the arm's mobile base to a more permanent position on an external stowage platform near the airlock. The work was delayed slightly by a problem with the robotic arm controls in the cupola, but Barratt and Kelly moved to a duplicate control center in the Destiny laboratory to complete their work with Canadram2.

The astronauts then removed tether and cart stoppers along with railway of the mobile transporter, and lengthened the track with an extension on each rail. Then they moved a pump module vent tool, installed a camera wedge, relocated a tool stanchion and worked with a Japanese project to bring a bit of space back to Earth: the "Message in a Bottle." They opened a metal canister, autographed by astronauts, to capture a bit of the vacuum of space, and then sealed it. The canister was returned on *Discovery* for display.

Mission Specialist Nicole Stott helped coach the spacewalkers from inside the station, while Mission Specialist Michael Barratt and station Commander Scott Kelly operated the station's Canadarm2 for the spacewalk. Astronaut Tim Kopra, who had been scheduled to be one of the spacewalkers himself before being hurt in a bicycle accident weeks before launch, joined spacecraft communicator Stanley Love on console in the station flight control room.

The spacewalk was the sixth for Bowen and the first for Drew. On leaving the airlock, Drew became the 200th human to walk in space.

Next day (Tuesday 1 March) Barratt and Stott, along with Commander Steve Lindsey and station commander Scott Kelly, talked to KTRK-TV of Houston, and KING-TV, of Washington, Barrett's home state. The crew spent the day preparing for the second spacewalk, and Bowen and Drew spent the night in the Quest airlock. Meanwhile crewmembers inside the complex continued transferring more cargo from *Discovery* and loading trash into the Japanese Kounotori 2 H-II transfer vehicle for eventual disposal.

Second spacewalk

The second spacewalk, lasting six hours and 14 minutes, took place on Wednesday 2 March. The spacewalkers, Mission Specialists Steve Bowen and Alvin Drew, spent most of their time outside working separately. The start of the spacewalk, which began when the crew members switched their spacesuits to battery power at 9:42 a.m. CST, had been delayed 24 minutes to replace an O-ring on the lithium hydroxide canister of Bowen's suit to fix a minor leak.

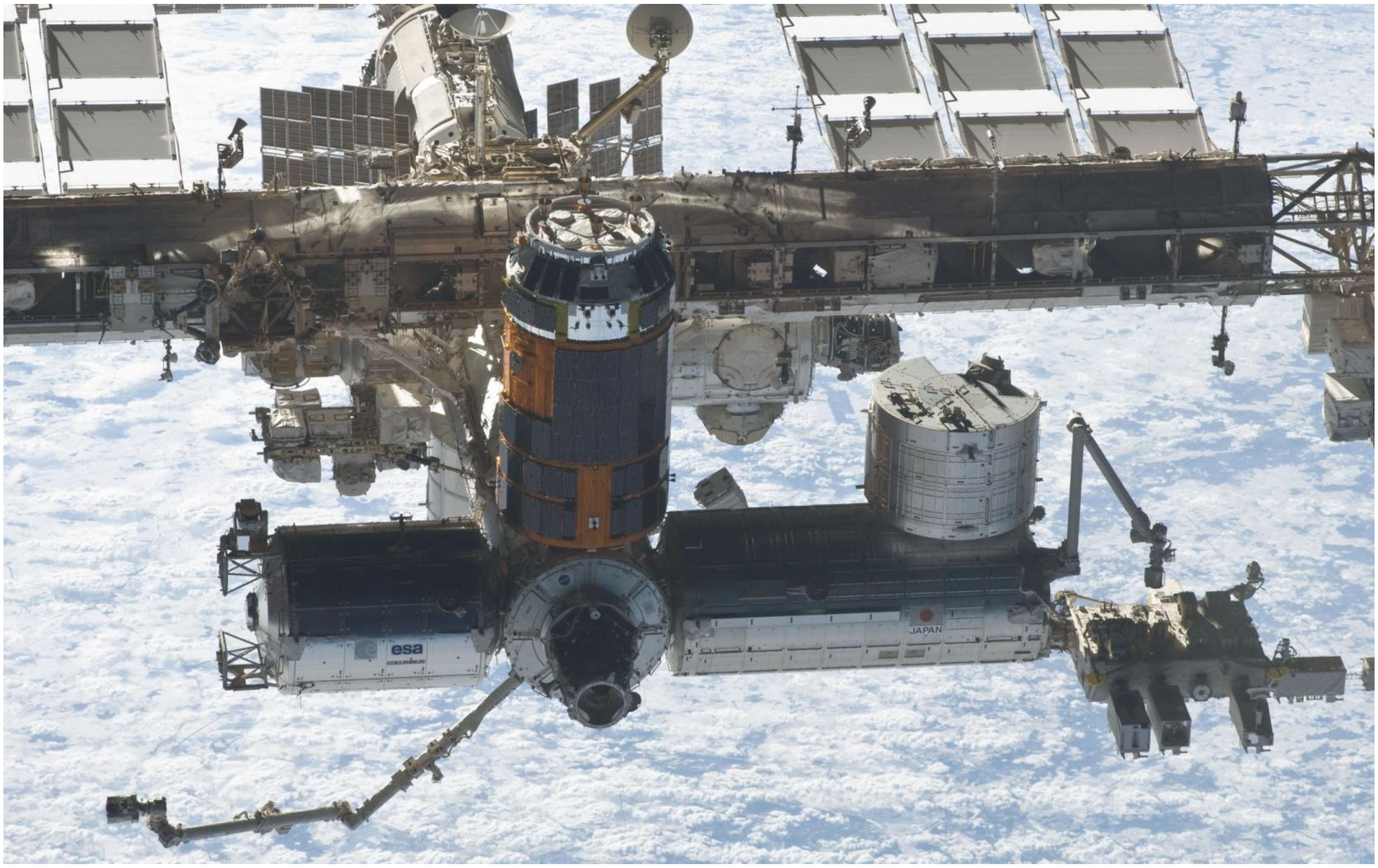
Astronaut Scott Kelly, Expedition 26 commander, is pictured in the newly-installed Permanent Multipurpose Module (PMM) of the International Space Station while space shuttle Discovery was docked with the station. (NASA)

Bowen began by setting up the station's Canadarm2, operated by Mission specialist Michael Barratt and station Commander Scott Kelly. He moved on to retrieve a lightweight adapter plate assembly, an experiment holder, from the outer end of the Columbus module and installed it in *Discovery*'s cargo bay for return to Earth.

Drew started with the relocated pump module for the station's external ammonia cooling system, using a device he had installed on Monday's spacewalk to vent the remaining coolant from the pump. He subsequently removed the device for return to the airlock. Coaching the spacewalkers was Mission Specialist Nicole Stott inside the station. Astronaut Tim Kopra also helped advise the crew from the station flight control room.

Bowen spent about an hour working on Dextre, the Special Purpose Dexterous Manipulator, installing a camera light pan and tilt assembly and removing some insulation. Meanwhile, Drew removed and Jettisoned insulation and repositioned a slipped sunshade on a nearby camera. He then installed a light on one of the small handcars, a crew and equipment translation aid. The astronauts use the carts, mounted on the station's truss rails, to move objects.

After doing some cleanup, Bowen installed a camera lens cover on the arm's elbow and relocated a foot restraint and a Russian cargo arm adapter. Drew moved on to the port truss to



(Top) A close-up view of the International Space Station is featured in this image photographed by an STS-133 crew member on space shuttle Discovery after the station and shuttle began their post-undocking relative separation. ESA's Columbus laboratory is at bottom left, and Japan's Kibo laboratory at bottom right. Atop the connecting node is the Japanese Kounotori 2 H-II Transfer Vehicle. (NASA)

(Bottom) In the grasp of the International Space Station's Canadarm2, the Italian-built Permanent Multipurpose Module (PMM) is transferred from space shuttle Discovery's payload bay to be permanently attached to the Earth-facing port of the station's Unity node. (NASA)

(Top) NASA astronauts Steve Bowen and Alvin Drew, both STS-133 mission specialists, are barely visible at the bottom of the picture as they participate in the mission's first spacewalk. (NASA)

(Bottom) The docked space shuttle Discovery and the Canadian-built Dextre, also known as the Special Purpose Dextrous Manipulator (SPDM), are featured in this image photographed by an STS-133 crew member on the International Space Station. (NASA)

repair insulation on a radiator beam valve module. He also secured a grapple fixture stowage beam. Near the end of the spacewalk, Drew's helmet light set came loose from his suit. Attempts by Bowen to reinstall it were unsuccessful so they attached a tether to take it back to the airlock.

This was the final STS-133 spacewalk, the 244th by U.S. astronauts. It was the seventh for Bowen totaling 47 hours, 18 minutes, and places him sixth on the all-time list of most time spent by U.S. spacewalking astronauts. It was the second spacewalk for Drew who now has a total of 12 hours, 48 minutes. It was the 155th spacewalk in support of the ISS assembly and maintenance, totaling 973 hours, 53 minutes, which is the equivalent of 40 full days of spacewalking. This spacewalk took six hours and 14 minutes.

Astronaut Cady Coleman, Expedition 26/27 flight engineer, poses with Robonaut 2, the dexterous humanoid astronaut helper, in the Destiny laboratory of the International Space Station. (NASA)

On Thursday 3 March, crewmembers took part in several media interviews, and President Barack Obama made a long-distance call to the dozen members of the *Discovery* and ISS crews a little after 4 p.m. CST.

"We are always inspired by the images of you guys at work as you work to put some of the final pieces in place to the ISS fully operational," Obama told the space fliers, traveling eight kilometres a second 355.5 kilometres above the Earth. "You are setting such a great example with your dedication, your courage, your commitment to exploration. Col. Lindsey, it must be a great honor to be the last commander of *Discovery*."

"On behalf of the crew, it's a real privilege for us to get to fly *Discovery* on her final mission. We think that when we land. *Discovery* will flown in space for 365 days," said Commander Steve Lindsey. The crewmembers also discussed with the president the delivery of the humanoid Robonaut 2 and international cooperation, exhibited by the presence of vehicles and components from all of the programme's partners.

Space shuttle and ISS managers decided today to extend the STS-133 mission by an additional day, providing more time for the shuttle crew to help unpack and outfit the Leonardo Permanent Multipurpose Module and fill the Japanese Kounotori 2 H-II Transfer Vehicle with trash before its planned late-March undocking.

The crews' day included continued transfer of equipment and supplies between the station and shuttle, stowage of spacewalk equipment, exercise and maintenance. Lindsey and Pilot Eric Boe were on the flight deck for a morning reboost of the docked spacecraft. The 26-minute firing of *Discovery*'s small attitude control jets raised the orbit by about a mile. The astronauts enjoyed much of their afternoon off.

On Friday 4 March, the first of two days added to the shuttle's stay at the ISS, they unloaded more from the Leonardo Permanent Multipurpose Module they brought into space. The crew began their day's activities with the NASA Educational technology services team and student interns as Marshall Space Flight Center in Huntsville, Ala. Joined by station Commander Scott Kelly and Flight Engineer Cady Coleman for the event just after 6 a.m. CST, they answered students' questions submitted through the NASA education Taking Up Space blog.

Most of the shuttle crew went right to work on Leonardo activities, moving supplies and equipment from the new module into the station and outfitting the interior of the module. Both crews joined new a news conference and took questions from reporters at Johnson Space Center, Kennedy Space Center and in Italy.

During their afternoon, Bowen and Drew stowed tools they used outside on their spacewalks, while colleagues continued with the Leonardo-related work. Kelly said the extra days with the shuttle astronauts gave the station crew an important leg up on that work. The Discovery crew's sleep period began at 6:23 p.m.

On Saturday 5 March, the crews started their day at 2:24 a.m. They continued work to unpack and reconfigure Leonardo, the Permanent Multipurpose Module, that they had brought to the station. Commander Steve Lindsey, Pilot Eric Boe, and Mission Specialists Alvin Drew, Steve Bowen and Nicole Stott and station Flight Engineer Cady Coleman spent most of their day in the module. The movement of material from Leonardo to the station was virtually complete.

In addition to unpacking and working on Leonardo's interior, they moved packing material into the Japanese H-II Transfer Vehicle for destruction on its re-entry after undocking later in the month.

Station Flight Engineer Paolo Nespoli and Mission Specialist Michael Barratt worked on the Carbon Dioxide removal Assembly in the Destiny laboratory, bypassing a failed heater circuit, and Station Commander Scott Kelly worked to install a new filter on an Oxygen Generation Assembly. "All in all, it was a great day in orbit," said Royce Renfrew, lead station flight director. The *Discovery* astronauts' sleep period began at 6:23 p.m.

Sunday 6 March, the crews' last day together, started at 2:23 a.m. "We had a great time on board with you," replied station Commander Scott Kelly. We'll miss you, but most of all we'll miss *Discovery*. We wish her fair winds and following seas," he said of the orbiter flying its 39th and final mission. Both thanked teams on the ground for their support.

"The mission is going extremely well," shuttle lead Flight Director Bryan Lunney said at an afternoon briefing. "We couldn't be more pleased. *Discovery* and her systems continue to perform flawlessly."

After an hour for a midday meal they had some free time during their afternoon. Later Bowen and Barratt checked out rendezvous tools discovery will use as it moves away from the station.

After a last-minute transfer of some medical experiments to *Discovery* for return to Earth, the farewell ceremony was held beginning a little after 2:30 p.m. In the ceremony, *Discovery* Commander Steve Lindsey talked about the mission's accomplishments and thanked the station crewmembers for their hospitality. After the crews separated and hatches were closed, Drew and Stott installed a centerline camera to help Boe as he pilots the shuttle away from the station after the scheduled undocking. The shuttle crew began their sleep period at 6:23 p.m.

On Monday 7 March, the last day at the ISS, the theme from *Star Trek*, performed by Alexander Courage, served as the wake up music for Discovery's crew at 2:23 a.m. As a bonus, Actor William Shatner recorded a special introduction to the song: "Space the final frontier. These have been the voyages of the Space Shuttle *Discovery*. Her 30 year mission: to seek out new science. To build new outposts. To bring nations together on the final frontier. To boldly go, and do, what no spacecraft has done before."

It was a fitting beginning to the day that would see *Discovery* undock from the space station for the last time. *Discovery* was the first space shuttle to dock to the ISS, during the STS-96 mission in 1999, marking just one time it did what no spacecraft had done before.

Discovery undocked from the ISS at 6:a.m. CST, ending a stay of eight days, 16 hours and 46 minutes. As the shuttle moved away, Station Commander Scott Kelly praised the cooperation among crewmembers of both spacecraft. *Discovery* Commander Steve Lindsey said the team effort had allowed them "to accomplish well over 100 percent of our objectives."

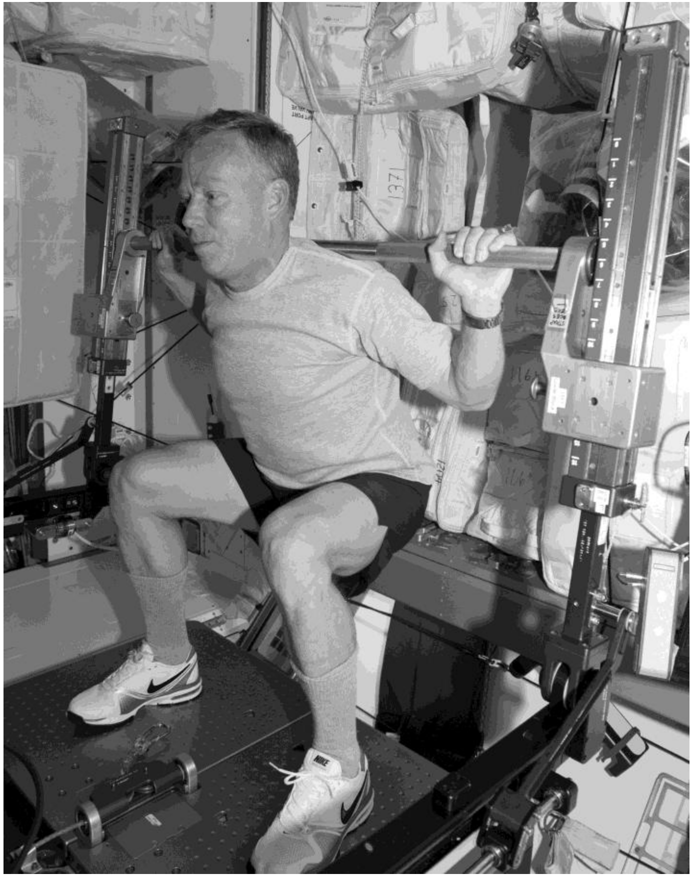
Pilot Eric Boe flew the orbiter in a vertical circle around the station while crewmembers took pictures of the station to document its condition. One big change from the previous fly-around by Atlantis during STS-132 last May was the addition of the Permanent Multipurpose Module brought up by Discovery. The circle complete, discovery did two separation burns to take it away from the station.

Lindsey later had words for Bryan Lunney, the lead STS-133 shuttle flight director working his last shift before leaving NASA. "Bryan has been a great friend, a terrific flight director and a leader. We're going to really miss him," the Discovery commander radioed down during a farewell gathering in Mission Control.

Lindsey, Boe and Mission Specialist Alvin Drew devoted much of their day to the standard late inspection of the heat resistant reinforced carbon-carbon surfaces. Using the robotic arm and its 50-foot orbiter boom sensor system extension, they began the inspection just after 10 a.m. with a look at the right wing. The subsequent nose cap inspection was followed by a look at the left wing. Images and data from the survey are sent to the ground for evaluation by experts. They will make sure no damage to the thermal protection system occurred during its stay in orbit. The crew began their sleep period at 6:23 p.m.

Tuesday 8 March was *Discovery*'s last full day in space. The wakeup call at 2:23 a.m. was "Blue Sky" by Big Head Todd and the Monsters. The song was performed live by Todd Park Mohr, vocalist and lead guitarist of the band, accompanied by fellow band mates Brian Nevin, Rob Squires and Jeremy Lawton. The song received the most votes in NASA's Top 40 song contest receiving 722,662 votes (29 percent of the 2,463,774 total). It was originally written as a tribute to the space program and workforce, and is routinely played in concert by the four-member band. This live performance was the first time a shuttle crew has been awakened "live" from Mission Control, Houston.

The crew spent much of their day getting ready to come home. Commander Steve Lindsey, Pilot Eric Boe and Mission specialist Nicole Stott powered up *Discovery*'s flight control system and tested the flaps and rudder that will control the shuttle's flight once it enters the Earth's atmosphere. They test-fired the jets that will control the shuttle before it reaches the atmosphere.



Pumpin' iron in space: Steve Lindsey, STS-133 commander, exercises using the advanced Resistive Exercise Device (aRED) in the Tranquility node of the International Space Station. (NASA)

Next, Lindsey and Boe worked with the ram Burn Observations (RAMBO) experiment. They did burns of an orbital maneuvering system engine for the experiment, aimed at bettering understanding spacecraft engine plumes.

The crew spent considerable time stowing items in *Discovery*'s cabin in preparing for re-entry and landing. All participated in a deorbit briefing before lunch. After the meal the crew took time off from packing to talk with representatives of ABC News, CBS News and the Associated Press. The crew is to begin its sleep period at 6:23 p.m.

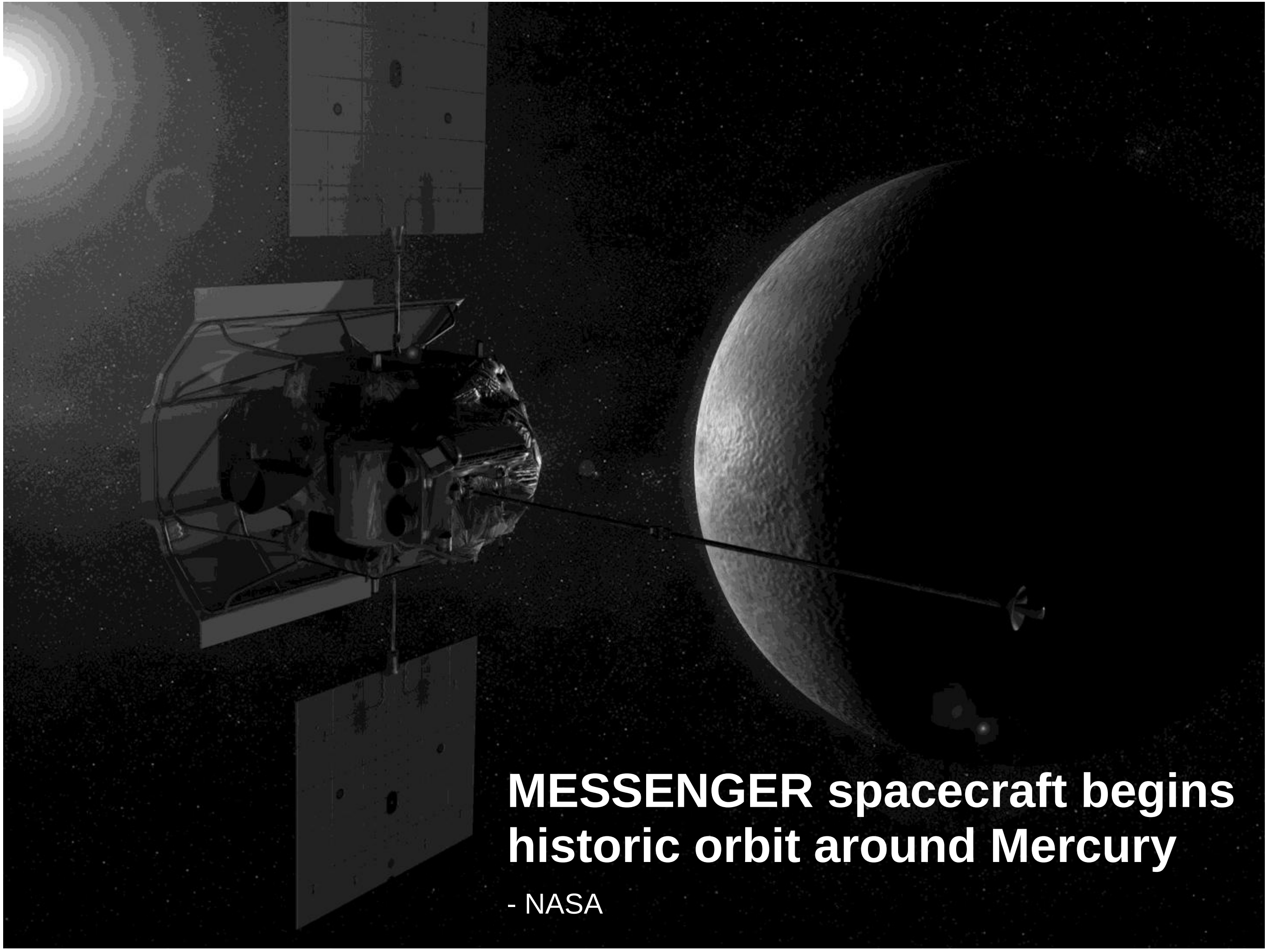
Finally, on Wednesday 9 March, *Discovery* made its last landing at KSC, wrapping up a successful flight to the ISS. "Discovery for the final time, wheels stop," said Commander Steve Lindsey.

"A great job by you and your crew," said Capcom and fellow astronaut Charlie Hobaugh. "That was an awesome docked mission you all had." Lindsey thanked flight controller teams, the station crew and the team at Kennedy for giving them "a perfect vehicle from start to finished."

The landing, like the rest of the mission, was virtually flawless. *Discovery*'s wheels touched down on the concrete runway at 10:57 a.m. CST, after a flight of 12 days, 19 hours and four minutes and 8,534,361 kilometres in 202 orbits.

The unofficial mission elapsed time was 12 days, 19 hours, four minutes and 50 seconds. The flight gave Discovery a total of 238,488,675 kilometres traveled in 5,830 orbits since 1984.

Panama-based NZSA member Ed Case is our regular correspondent on Shuttle and ISS news.



MESSENGER spacecraft begins historic orbit around Mercury

- NASA

NASA's MESSENGER spacecraft successfully achieved orbit around Mercury at approximately 9 p.m. EDT on 17 March 2011. This marks the first time a spacecraft has accomplished this engineering and scientific milestone at our solar system's innermost planet.

At 9:10 p.m. EDT, engineers Operations Center, received the anticipated radiometric signals confirming nominal burn shutdown and successful insertion of the MESSENGER probe into orbit around the planet Mercury. NASA's MErcury Surface, Space ENvironment, Geochemistry, and Ranging, or MESSENGER, rotated back to the Earth by 9:45 p.m. EDT, and started transmitting data. Upon review of the data, the engineering and operations teams confirmed the burn executed nominally with all subsystems reporting a clean burn and no logged errors. MESSENGER's main thruster fired for approximately 15 minutes at 8:45 p.m., slowing the spacecraft by 3,103 kilometres per hour and easing it into the planned orbit about Mercury. The rendezvous took place about 54 million kilometres from Earth.

"Achieving Mercury orbit was by far the biggest milestone since MESSENGER was launched more than six and a half years ago," said Peter Bedini, MESSENGER project manager of the Applied Physics Laboratory (APL). "This accomplishment is the fruit of a tremendous amount of labor on the part of the navigation, guidance-and-control, and mission operations teams, who shepherded the spacecraft through its 4.9-billion-mile [7.8 billion kilometres] journey."

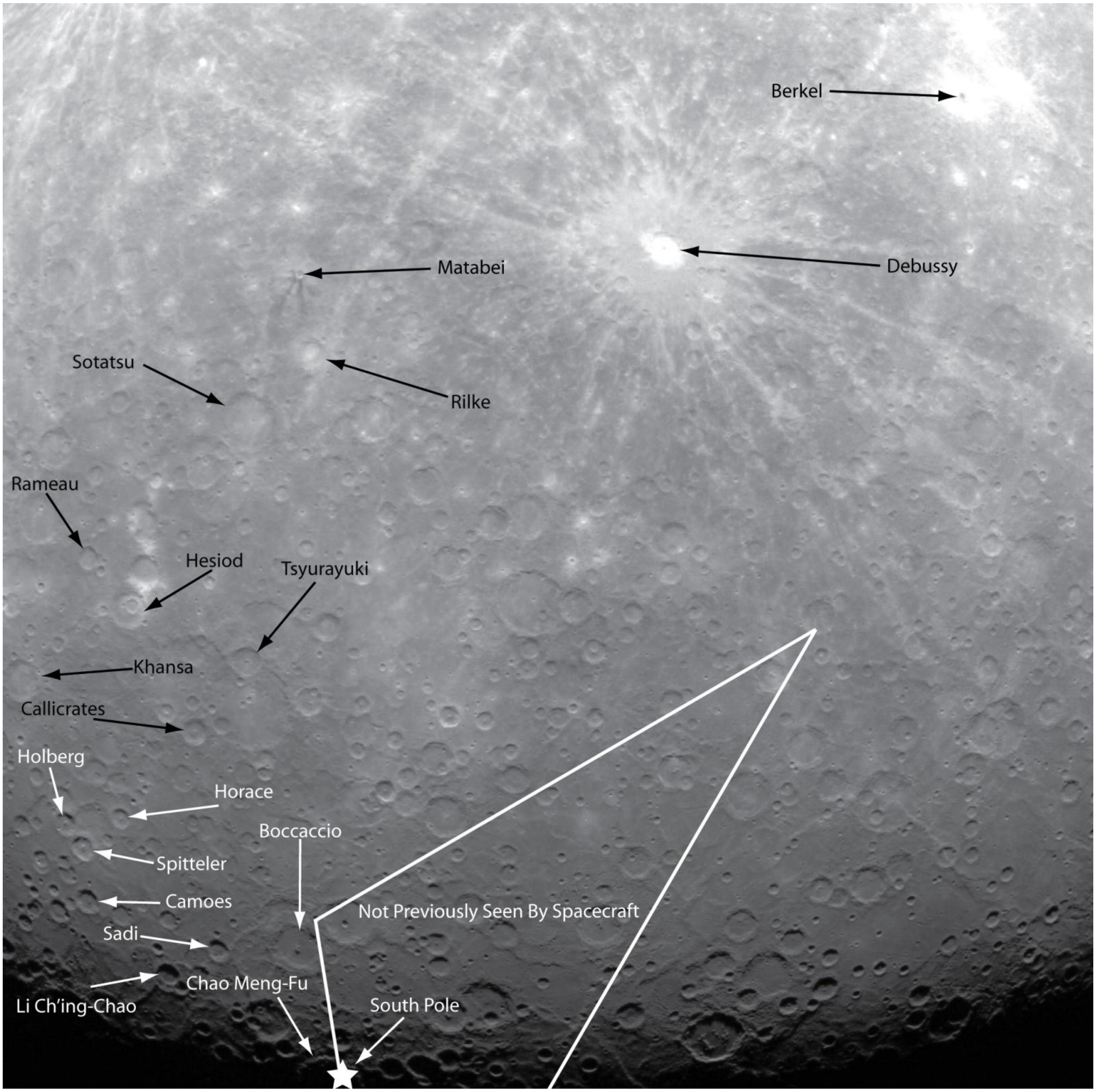
For the next several weeks, APL engineers will be focused on ensuring the spacecraft's systems are all working well in Mercury's harsh thermal environment. Starting on March 23, the instruments were turned on and checked out, and on April 4 the mission's primary science phase began.

"Despite its proximity to Earth, the planet Mercury has for decades been comparatively unexplored," said Sean Solomon, MESSENGER principal investigator of the Carnegie Institution of Washington. "For the first time in history, a scientific observatory is in orbit about our solar system's innermost planet. Mercury's secrets, and the implications they hold for the formation and evolution of Earth-like planets, are about to be revealed."

Staying there

After MESSENGER arrives in its primary science orbit, small forces, such as solar gravity — the gravitational attraction of the Sun — slowly change the spacecraft's orbit. Although these small forces have little effect on MESSENGER's 12-hour orbit period, they can increase the spacecraft's minimum altitude, orbit inclination, and latitude of the surface point below MESSENGER's minimum altitude. Left uncorrected, the increase in the spacecraft's minimum altitude would prevent satisfactory completion of several science goals.

To keep the spacecraft's minimum altitude below 500 kilometres, propulsive maneuvers must occur at least once every Mercury year — one complete revolution around the Sun, or 88 Earth days. The first, third, and fifth maneuvers after



This historic first orbital image of Mercury was acquired on 29 March 2011, 37 years to the day after Mariner 10's historic first flyby of the innermost planet. Labels have been added to indicate several craters that were named based on Mariner 10 images, as well as Debussy, Matabei, and Berkel, which were named based on MESSENGER flyby images. The surface contained in the white lines is terrain previously unseen by spacecraft, and the star indicates the location of the south pole. (NASA/JHU/APL/Carnegie Institution of Washington)

Mercury orbit insertion will occur at the farthest orbital distance from Mercury, where a minimum amount of propellant will be used to slow the spacecraft just enough to lower the minimum altitude to 200 kilometres. The act of lowering the spacecraft's altitude in this way has an unavoidable side effect of also lowering orbit period by about 15 minutes.

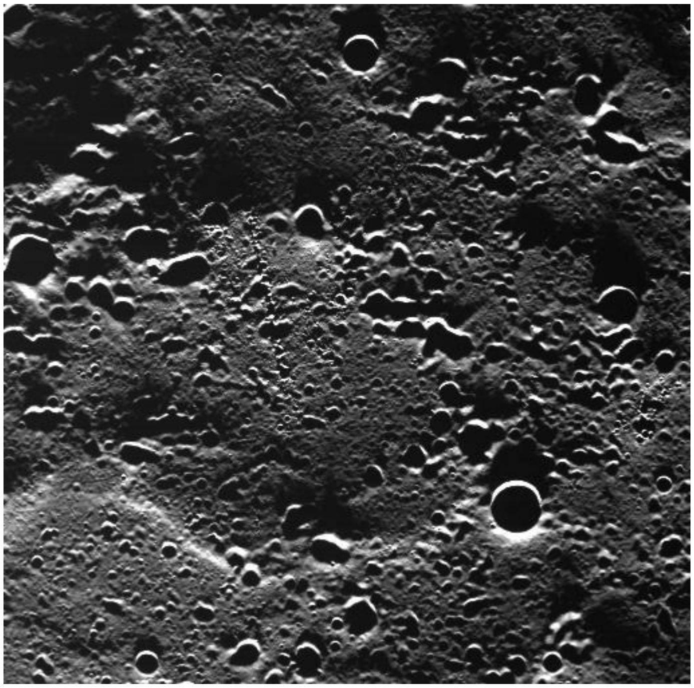
The second and fourth maneuvers after orbit insertion will increase the orbit period back to about 12 hours by speeding up the spacecraft around the time when it is closest to Mercury. Because the sunshade must protect the main part of the spacecraft from direct sunlight during propulsive maneuvers, the timing of these maneuvers is limited to a few days when Mercury is either near the same point in its orbit as it was during Mercury orbit insertion, or near the point where Mercury is on the opposite side of the Sun from that for orbit insertion.

Science orbit: working at Mercury

The MESSENGER mission has six specific science objectives.

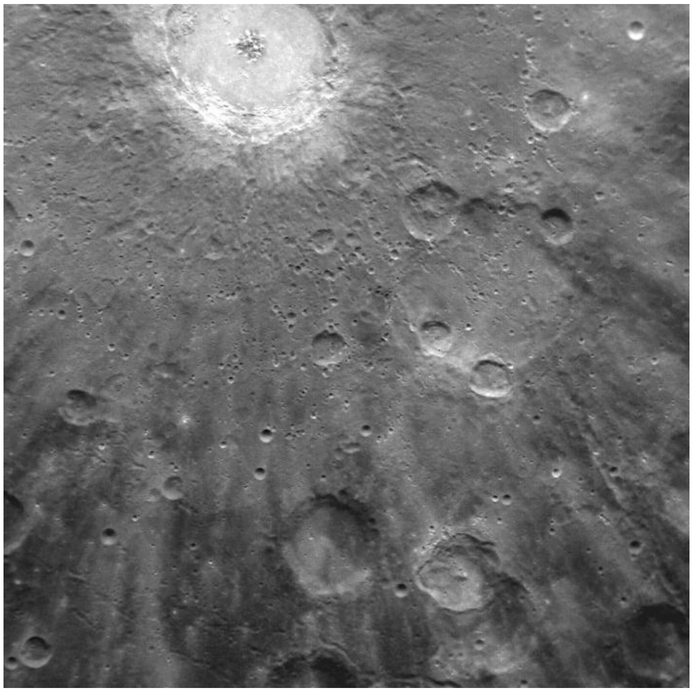
- Provide major-element maps of Mercury to 10% relative uncertainty on the 1000-kilometre scale and determine local composition and mineralogy at the ~20-km scale.

- Provide a global map with > 90% coverage (monochrome, or black and white) at 250-metre average resolution and > 80% of the planet imaged stereoscopically. Also provide a global multi-spectral (colour) map at 2 km/pixel average resolution, and sample half of the northern hemisphere for topography at 1.5-m average height resolution.
- Provide a multi-pole magnetic-field model resolved through quadrupole terms with an uncertainty of less than ~20% in the dipole magnitude and direction.
- Provide a global gravity field to degree and order 16 and determine the ratio of the solid-planet moment of inertia to the total moment of inertia to ~20% or better.
- Identify the principal component of the radar-reflective material at Mercury's north pole.
- Provide altitude profiles at 25-kilometre resolution of the major neutral exospheric species and characterize the major ion species energy distributions as functions of local time, Mercury heliocentric distance, and solar activity.



This WAC image showing a never-before-imaged area of Mercury's surface was taken from an altitude of 450 km above the planet during the spacecraft's first orbit with the camera in operation. The area is covered in secondary craters made by an impact outside of the field of view. Some of the secondary craters are oriented in chain-like formations. This image was taken during MESSENGER's closest approach to the sunlit portion of the surface during this orbit, just before crossing over the terminator. The oblique illumination by the Sun causes the long shadows and accentuates topography. (NASA/JHU/APL/ Carnegie Institution of Washington)

To accomplish these science goals, the MESSENGER spacecraft must obtain many types of observations from different portions of its orbit around Mercury. Some major constraints must be met, including completing the observations within two Mercury solar days (equivalent to one Earth year) and keeping the spacecraft sunshade facing the Sun at all times. The observation plan must also take into account MESSENGER's orbit around Mercury. The orbit is highly elliptical, with the spacecraft passing 200 kilometres above the surface at the lowest point and more than 15,193 kilometres at the highest. At the outset of the orbital phase of the mission, the plane of the spacecraft's orbit is inclined 82.5° to Mercury's equator, and the lowest point in the orbit is reached at a latitude of 60° North.



Bright rays, consisting of impact ejecta and secondary craters, spread across this NAC image and radiate from Debussy crater, located at the top. The image, acquired on 28 March 20111 during the first orbit for which MDIS was imaging, shows just a small portion of Debussy's large system of rays in greater detail than ever previously seen. Images acquired during MESSENGER's second Mercury flyby showed that Debussy's rays extend for hundreds of kilometers across Mercury's surface. (NASA/JHU/APL/Carnegie Institution of Washington)

The spacecraft's orbit is elliptical rather than circular because the planet's surface radiates back heat from the Sun. At an altitude of 200 kilometres, the re-radiated heat from the planet alone is four times the solar intensity at Earth. By spending only a short portion of each orbit flying this close to the planet, the temperature of the spacecraft can be better regulated.

Observing the surface

MESSENGER's 12-month orbital phase covers two Mercury solar days; one Mercury solar day, from sunrise to sunrise, is equal to 176 Earth days. This means that the spacecraft passes over a given spot on the surface only twice during the mission, six months apart, making the time available to observe the planet's surface a precious resource. The first solar day is focused on obtaining global map products from the different instruments, and the second focuses on specific targets of scientific interest and completion of a global stereo map.

As Mercury moves around the Sun, the spacecraft's orbit around the planet stays in a nearly fixed orientation that allows MESSENGER to keep its sunshade toward the Sun. In effect, Mercury rotates beneath the spacecraft and the surface illumination changes with respect to the spacecraft view. At some times, the spacecraft is traveling in an orbit that follows the terminator — the line that separates day from night. These are known as "dawn-dusk" orbits and are good for imaging surface features such as craters, as shadows are prominent and topography and texture can be clearly seen. At other times, the spacecraft follows a path that takes it directly over a fully lit hemisphere of Mercury, then over a completely dark hemisphere. These are called "noon-midnight" orbits and are good for taking color observations on the dayside, because there are fewer shadows to obscure surface features.

Some instruments, such as Mercury Laser Altimeter (MLA), can operate whether the surface is lit or not, but others, such as Mercury Dual Imaging System (MDIS), need sunlight in order to acquire data. The low-altitude segments of the orbit over the northern hemisphere will allow MESSENGER to conduct a detailed investigation of the geology and composition of Mercury's giant Caloris impact basin — the planet's largest known surface feature, among other goals.

Discoveries from MESSENGER's Mercury flybys

In addition to providing key gravity assists that enable orbit insertion as well as opportunities to test scientific operations and command sequences for all payload instruments, MESSENGER's three flybys of Mercury yielded a number of discoveries that have markedly changed our view of Mercury and influenced our preparations for orbital operations. These include:

Geology

- *Volcanism was widespread on Mercury and extended from before the end of heavy bombardment to the second half of solar system history.*
- *Mercury experienced explosive volcanism, indicating that interior volatile contents were at least locally much higher than thought.*
- *Contraction spanned much of Mercury's geologic history.*

Composition and surface-derived exosphere

- *Mercury's surface silicates, even in fresh crater ejecta, contain little or no ferrous oxide.*
- *Mercury's thermal neutron flux matches that of several lunar maria, indicating that iron and titanium are present in comparable collective abundances, perhaps as oxides.*
- *Magnesium and ionized calcium are present in Mercury's exosphere.*

Internal structure and dynamics

- *The equatorial topographic relief of Mercury, in agreement with earlier radar results, is at least 5.5 kilometres.*
- *The case for a liquid outer core in Mercury is greatly strengthened.*
- *Mercury's internal magnetic field is dominantly dipolar with a vector moment closely aligned with the spin axis.*

Magnetospheric dynamics

- *Mercury's magnetosphere is more responsive to interplanetary magnetic field (IMF) fluctuations than those of other planets.*
- *Under southward IMF, rates of magnetic reconnection are ~10 times that typical at Earth.*
- *Loading of magnetic flux in Mercury's magnetic tail can be so intense that much of Mercury's dayside could be exposed to the shocked solar wind of the magnetosheath during such episodes.*

Orchestrating the observations

Different instruments are given priority in determining spacecraft pointing at different portions of the spacecraft orbit and as a function of the parts of Mercury's surface that are illuminated at any given time. For example, the MLA "drives" the spacecraft pointing whenever its laser can range to the planet's surface (less than ~1500 km altitude), the Ultraviolet and Visible Spectrometer (UVVS) controls the pointing when no other instruments can "see" the planet, and the Magnetometer (MAG) and Energetic Particle and Plasma Spectrometer (EPPS) primarily ride along and collect data regardless of what else is going on, since they generally don't need to point at the planet's surface. The two MDIS imagers are mounted on a common pivot, and so they can often look at the surface or at other targets when the rest of the instruments are pointed in a different direction.

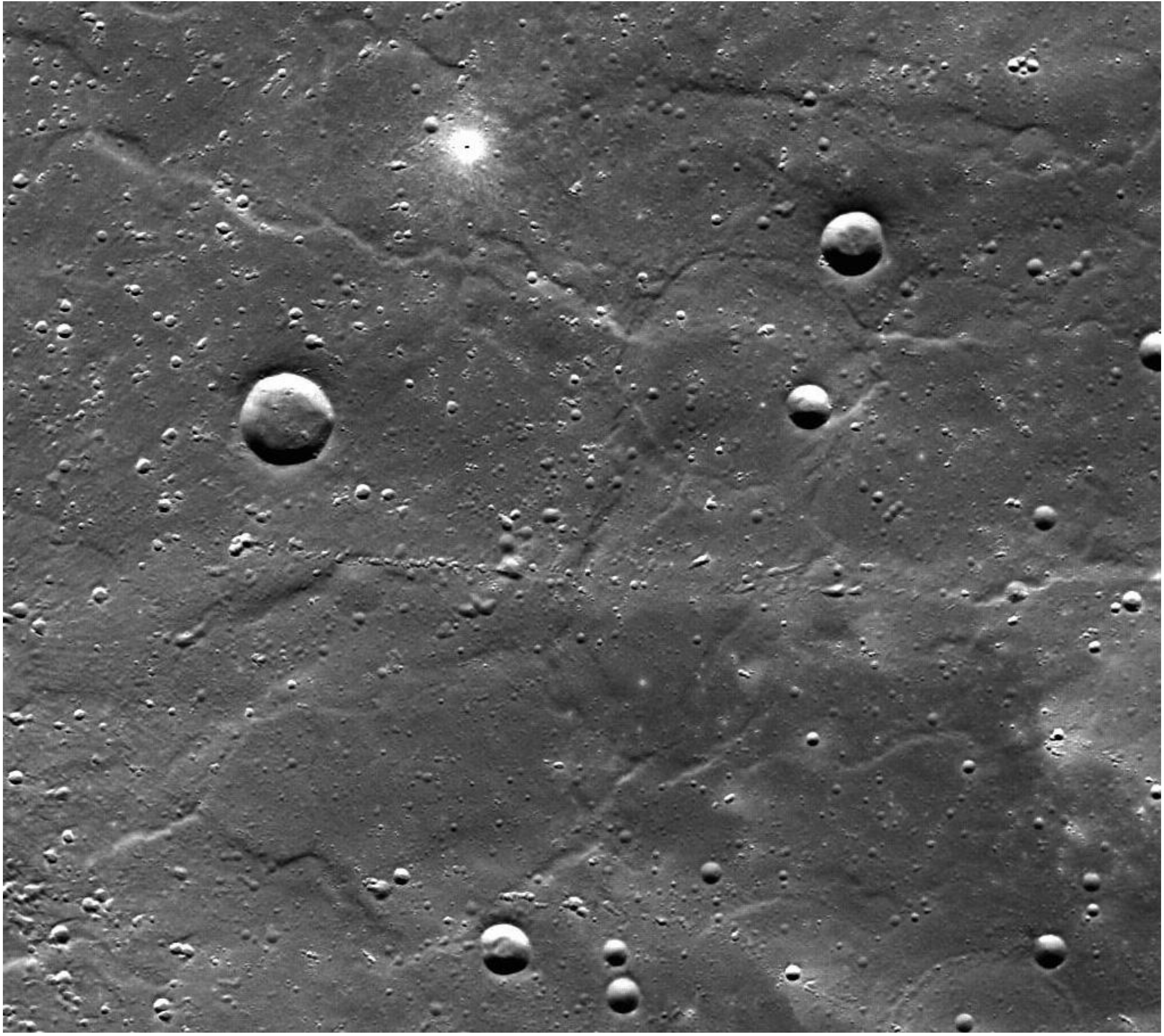
To meet the mission science objectives while taking into consideration the constraints associated with spacecraft safety and orbital geometry, the MESSENGER Project has planned the entire year of observations in advance of the orbital phase. Because of the large number of different science observations required to meet the science objectives, a special software tool has been developed to help carry out the complicated process of maximizing the scientific return from the mission and minimizing conflicts between instrument observations. This task is particularly challenging because most of the instruments are fixed on the spacecraft and are pointed in the same direction, but the different instruments may need to be pointed toward different locations at different times to meet the science goals.

Some observations also must be taken under specific observing conditions (such as taking colour images when the Sun is high overhead), and the software tool works by finding the best opportunities for each of the instruments to make their measurements and then analyzing how those measurements contribute toward the science goals of the entire mission. Many iterations are necessary before a solution is found that satisfies all the science goals while staying within the limitations associated with the spacecraft's onboard data storage and downlink capacity.

Although a baseline plan for the entire year has been formulated, commands to execute the plan will be sent up to the spacecraft on a weekly basis. Each "command load" contains all the commands that the spacecraft will need to execute during a given week. Because each command load is different and contains many tens of thousands of commands, the mission operations engineers start each load three weeks ahead of time. This schedule permits the command load to be thoroughly tested and reviewed before it is sent up to the spacecraft. Because of this process, mission operations personnel at any given time will be working on several command loads, each of which is at a different stage of development.

The Science Team has also developed the capability to regenerate the plan at short notice in order to respond to any anomalies that might occur in flight, such as an instrument problem, or on the ground, such as a missed Deep Space Network track.

Under this plan, each instrument will obtain the data needed to fulfill MESSENGER's science objectives. Once in orbit, MDIS will build on the imaging it acquired during the three Mercury flybys to create global color and monochrome image mosaics during the first six months of the orbital mission phase. Emphasis during the second six months will shift to targeted, high-resolution imaging with the Narrow-Angle Camera (NAC) and repeated mapping at a different viewing geometry to create a stereo map. MLA will measure the topography of the northern



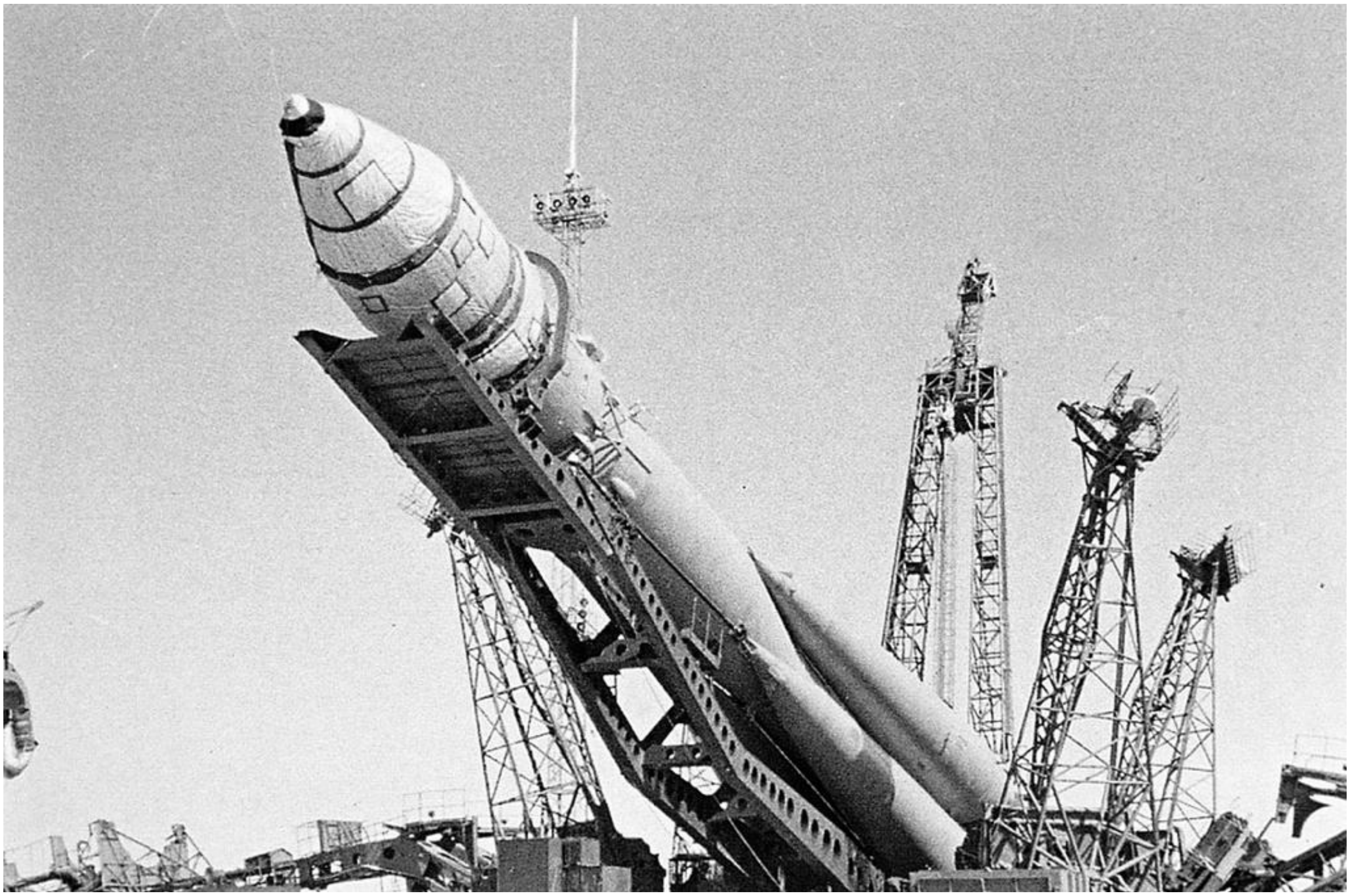
This image covers an area of ridged plains to the east of the rim of Hokusai crater on Mercury. The crater's bright rays and ejecta cross the location. Here we see chains of small secondary craters that were formed by chunks of debris thrown out of Hokusai during its formation, surrounded by more diffuse high-reflectance rays. A very small, very bright, very fresh (young) primary impact crater and its ejecta blanket light up the top-middle part of the image. North is approximately to the top in this image. (NASA/JHU/APL/Carnegie Institution of Washington)

hemisphere over four Mercury years. The Gamma-Ray and Neutron Spectrometer (GRNS) and the X-Ray Spectrometer (XRS) will build up observations that will yield global maps of elemental composition. MAG will measure the vector magnetic field under a range of solar distances and conditions. The Visible and Infra-Red Spectrograph (VIRS) will produce global maps of surface reflectance from which surface mineralogy can be inferred, and UVVS will produce global maps of exospheric species abundances versus altitude. EPPS will sample the plasma and energetic particle population in the solar wind, at major magnetospheric boundaries, and throughout the environment of Mercury at a range of solar distances and levels of solar activity. The radio science experiment will extend topographic information to the southern hemisphere by making occultation measurements of planet radius, and the planet's obliquity and the amplitude of the physical libration will be determined independently from the topography and gravity field.

Each orbit is 12 hours in duration, so MESSENGER orbits Mercury twice every Earth day. Once a day, the spacecraft stops making measurements and turns its antenna toward Earth for 8 hours, in order to send data back to the Deep Space Network, from which it will be sent on to the MESSENGER Mission Operations Center.

Yuri's flight

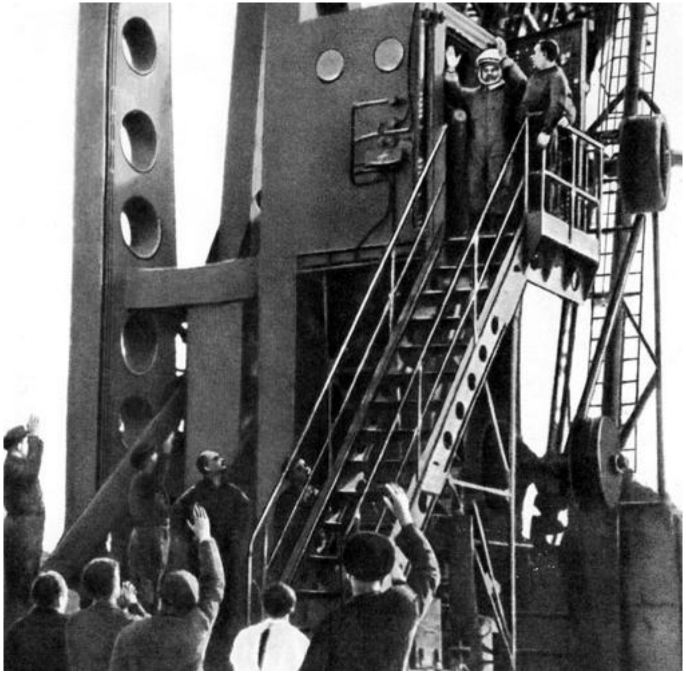
50th anniversary of the first human space flight

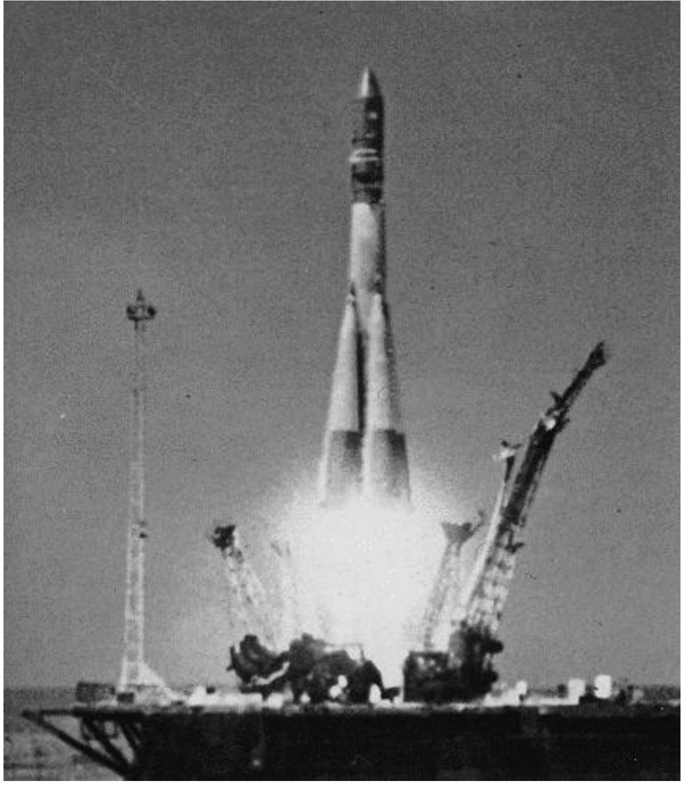


The Vostok 3KA-3 spacecraft (Vostok 1) awaits the launch of Yuri Gagarin on April 12, 1961, which would make him the first human to travel into space. (ESA)

(Left) Yuri Gagarin in his spacesuit (RSC Energia)

(Above) Gagarin, in the foreground, and backup cosmonaut Gherman Titov are seen in the transfer bus en route to the launch pad. (RSC Energia)





(Above left) Gagarin waves to the ground crew prior to boarding Vostok 1 (RSC Energia)

(Above right) Launch of Vostok 1 on 12 April 1961. (NASA)

Here the re-entry capsule of the Vostok 1 spacecraft is seen with charring and its parachute on the ground after landing south west of Engels, in the Saratov region of southern Russia, after a single 108-minute orbit of the Earth (ESA).

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28 PAGES TODAY

The Huntsville Times

Where Progress... Covers The Valley!

VOL. 51, NO. 21 · CHICAGO DAILY NEWS SERVICE · HUNTSVILLE, ALABAMA, WEDNESDAY, APR. 12, 1961 · ASSOCIATED PRESS — WIREPHOTO · 45c PER WEEK

Man Enters Space

'So Close, Yet So Far,' Sighs Cape

U.S. Had Hoped For Own Launch

CAPE CANAVERAL, Fla. (AP) — The Redstone rocket which the United States had hoped would boost the first man into space stands on a launching pad here. The Soviet Union beat its firing date by at least two weeks.

"So close, yet so far," commented a technician who is helping groom the Redstone to send one of America's astronauts on a short sub-orbital flight, hopefully late this month or early in May.

"If we hadn't had those troubles last fall and on the chimp and Little Joe shots this year, we might have made it," the technician said.

"But you have to give the Russian scientists credit. They've accomplished a remarkable breakthrough."

Dr. Hugh Dryden, deputy director of the National Aeronautics and Space Administration, told the House Space Committee in Washington Tuesday that the earliest possible date for the manned launching is about April 28.

Project Mercury officials had hoped to achieve a manned Redstone flight last December or January. A series of launch mishaps necessitated additional launchings to qualify the system.

On Nov. 8, a space capsule failed to separate from a Little Joe rocket fired from Wallops Island, Va., in a test of the escape system.

Two weeks later, a Redstone fizzled because of a faulty connection which caused the escape tower to fire, leaving the rocket and capsule on the pad. This test had to be repeated before Ham, the space chimpanzee, was sent up on a short trip Jan. 31.

An engine thrust regulator stuck on the chimp shot, creating excessive thrust which lofted the chimp, Ham, higher and farther than intended. Another Redstone was fired to prove out corrections made in the regulator, again delaying the manned trip.

Another setback occurred March 18 when a repeat of the Little Joe escape test fizzled. Another try is set for about April 20 and must succeed before the Redstone now on the pad hurls aloft an astronaut.

* * *

By ARTHUR J. SNIDER
Chicago Daily News Science Writer

The momentous Russian achievement has taken some of the zest out of the buildup for the first American astronaut's rocket hop down the Atlantic missile range.

There had been hope, swelling each day, that the United States might slip the first human being into space ahead of the Soviets.

For many months — ever since last fall — it had been expected that the Russians would cash in on their capability and launch a space man at any time.

But as the weeks went by and nothing happened, American missilemen began envisioning the [illegible]

Turn to Page 2, Column 1

Hobbs Admits 1944 Slaying

By BOB WARD
Of The Times Staff

Isham D. Hobbs confessed today to the brutal murder in 1944 of Mrs. Margaret Thornton Fleming, Circuit Solicitor Macon L. Weaver said.

Hobbs, now 43, is held by Air Force authorities at Eglin Air Force Base, Fla. He signed a statement there detailing his knife-slaying of the prominent 52-year-old widow, Weaver said he learned from Air Force officials.

* * *

The suspect, who has undergone psychiatric treatment by military authorities since Feb. 6, has recovered his memory in full, Weaver was told. Psychiatrists said Hobbs' apparent amnesia resulted from "hysteria" rather than from any medical cause.

Hobbs, who attempted suicide last November at Bartow, Fla., and was then exposed as a long-time fugitive, will be returned to MacDill Air Force Base, near Tampa, Fla., from Eglin AFB.

Weaver plans to travel to MacDill tomorrow, he said.

Hobbs, accused also of deserting from the Army Air Corps in October, 1943, reportedly will be court-martialed, and released to civil authorities here. He was wanted for desertion and was still at large when the murder charge was brought against him in May, 1944.

* * *

Hobbs told Eglin authorities he was living in a cave in the mountainous region near Mrs. Fleming's home north of Farley when the killing occurred, Weaver said.

He stated he went to the Fleming home in an effort to get a shotgun he believed to be there. Finding Mrs. Fleming's daughter, Vivian, asleep when he broke into the house before dawn, he decided to knock her unconscious and spirit her away to his cave, he stated.

The blow he struck the 21-year-old girl (now Mrs. Frederick Mar[illegible]) not only stunned her, and her screams attracted Mrs. Fleming and her cousin, Mrs. Vare Thornton, Hobbs reportedly said.

Hobbs stated he panicked, jabbed wildly with his hunting knife and left it [illegible] someone['s] body, he reportedly said.

This is Russian Maj. Yuri Gagarin, history's first man in space. The Russians today rocketed him around the earth in an orbit taking slightly less than 90 minutes and brought him back safely to a prearranged spot in the Soviet Union. (AP Wirephoto via radio from Moscow)

Praise Is Heaped On Major Gagarin

'Worker' Stands By Story

LONDON (AP) — The Daily Worker, Communist party paper in Britain, said today it is standing by its story that the Soviet Union launched a man into space last Friday.

* * *

A spokesman for the editor said: "Our story came from good sources. All we know is what we published today. Now of course there is this one."

By "this one," he referred to the Moscow announcement that Maj. Yuri A. Gagarin made an orbital flight around the earth today in a five-ton space ship and returned safely.

* * *

The Worker said in this morning's edition that the Soviet Union sent an astronaut aloft last Friday on three trips round the world, brought him back alive, and then put him under treatment for after-effects. He was identified in the story as the test pilot son of a top-ranking Soviet aircraft designer. Gagarin is the son of a farmer.

The party organ said the official announcement of the flight would be made today.

First Man To Enter Space Is 27, Married, Father Of Two

LONDON (AP)—Moscow television presented a picture of the Soviet Union's first space man today, describing him as a man with "a good honest smile."

The portrait of Maj. Yuri A. Gagarin was shown and then came this broadcast comment, repeated by Moscow radio:

"For those who did not see this picture we should like to give a description of this splendid man.

"On the screen appears the image of a man aged about 25-28 with a kind, Russian face, eyes set well apart, fine bushy brows and high forehead.

"He wears a flying helmet, a light overall suit. He smiles a good, honest smile. And is there any need to add that this man who has been the first to dare to fly to space, to reach for the stars, to look down on our earth, is a man of a very great and very real character. This is evident in his smile, in the intelligent, fine eyes."

* * *

Gagarin was 27 just a month ago.

He is married to Valentina Gagarina, 26, who also has a scientific background. She was graduated from medical school at Orenburg.

They have two daughters, Yelena, 2, and Galya, just a month old.

* * *

The cosmonaut has an ideal Soviet background: his father, a joiner, his mother a housewife.

Gagarin was born March 9, 1934, in the Gzhatsk district of

Turn to Page 2, Column 2

Reds Deny Spacemen Have Died

By THE ASSOCIATED PRESS

Have some Soviet astronauts been killed in space flight experiments before Yuri A. Gagarin's sensational trip?

No, Soviet officials insist.

But some Western sources say they believe one or a few Russians did perish in unsuccessful attempts. Brig. Gen. Don Flickinger, head of the medical section of the U.S. Air Force astronaut selection and training program, says he thinks so.

"Utter fabrication," is the Soviet reply.

Soviet Officer Orbits Globe In 5-Ton Ship

Maximum Height Reached Reported As 188 Miles

MOSCOW (AP)—A Soviet astronaut has orbited the globe for more than an hour and returned safely to receive the plaudits of scientists and political leaders alike. Soviet announcement of the feat brought praise from President Kennedy and U.S. space experts left behind in the contest to put the first man into successful space flight.

By the Soviet account, Maj. Yuri Alekseyvich Gargarin, rode a five-ton spaceship once around the earth in an orbit taking an hour and 20 minutes. He was in the air a total of an hour and 48 minutes.

The whole sequence of events and the announcements relating to it raised a number of questions. The Soviet announcement said the flight took place today between 9:07 and 10:55 a.m., but some persons in Moscow's Western colony were skeptical that the feat actually came off today.

There was a curious sequence of events leading up to the announcement.

Rumors had been circulating several days that the space coup had been pulled off. Two days ago, Soviet TV technicians moved into the Central Telegraph Office with the evident purpose of getting pictures of correspondents in action as they reported such a story. There were various reports, none verifiable from official sources, that the flight had been made.

* * *

Then Tuesday night the Daily Worker, London Communist newspaper with apparently sound connections in Moscow, reported that the flight took place last Friday. In splash headlines, the Daily Worker heralded "the first man in space," saying he had completed three orbits before returning to earth suffering from "after-effects of the flight."

* * *

That led up to today.

About 9:30 a.m., Western correspondents were tipped off to be listening to their radios at 10 a.m. The announcement came at 10 a.m., saying the astronaut still was in orbit. At two intervals the radio broadcast messages, reportedly from him over South America and Africa.

Then came the announcement that the spaceship had been called back to earth.

Some in the Western colony expressed wonderment that the Soviet Union, with its tight control over communications, would take such a chance—announcing the flight before a successful completion.

* * *

As these skeptics saw it, the event would have turned into perhaps the most publicized disaster in history if anything had gone wrong between 10 a.m. and the announced time of landing, 55 minutes later.

That led them back to speculation whether the London Daily Worker knew what it was talking about in reporting the space flight

Turn to Page 2, Column 5

VON BRAUN'S REACTION:

'To Keep Up, U.S.A. Must Run Like Hell'

Timesfoto by William McCormick

WERNHER VON BRAUN
He Praises A Russian Achievement

By BILL AUSTIN
Of The Times Staff

A disappointed Dr. Wernher von Braun, arriving in Huntsville today, called Russia's space flight a tremendous thing and labeled it the "shot heard around the world."

"I'm disappointed because here again we came in in second place," he declared.

Von Braun arrived at the Huntsville airport from Grove City, Pa., where he had addressed a college group yesterday.

He said we had hoped all along the United States would be able to place an astronaut up first, but he said Russia has an excellent space program and they demonstrated it by this flight.

"We are going to have to run like hell to catch up," he asserted.

He also said he was convinced this was Russia's first attempt to put a man in orbit, but he did not

Turn to Page 2, Column 7

No Astronaut Signal Received At Ft. Monmouth

FT. MONMOUTH, N.J. (AP)—The Astro Observation Center did not receive any radio signals from the Soviet satellite containing the first space navigator, a spokesman said today.

The center, operated by the U.S. Army Signal Engineering Laboratories, attempted to monitor radio transmissions from the space ship. Officials said the Soviet spaceman "probably would not be transmitting on this side of the hemisphere. He would be sending only when he was near Russia to conserve the vehicle's electrical energy."

Reds Win Running Lead In Race To Control Space

By [illegible] PRICE

[illegible]

cal ratio between the amount of thrust required to lift a given amount of payload into orbit.

The first real indication of the size of Soviet boosters came with Sputnik III which weighed 3,000 pounds.

The rocket needed to boost that particular satellite into orbit required a take off thrust of 440,000 pounds.

It would be no major feat to cluster these engines and put seven tons in orbit.

By and large, U.S. rocket engines produce a thrust of about 150,000 pounds.

At the moment U.S. hopes of obtaining rocket thrusts anywhere near those of the Soviets rest on successful operation of the Saturn booster.

By clustering eight of its present operational engines, the United States hopes to achieve a total thrust of 1.5 million pounds sometime late this year or in 1962.

If the Soviets cluster eight of their rocket engines in similar fashion, they will achieve a thrust of 3.5 million pounds.

* * *

While the added weight of the rockets themselves reduces the ultimate payload, the United States hopes to be able to lift 15 tons into space. With their clustered engines, the Soviets could lift [illegible]

Turn to Page 2, Column 3

Today's Chuckle

Be friendly with folks you know—if it weren't for them you would be a stranger.

Renowned space artist, the late Robert McCall, was commissioned to design the crew patch for STS-1, the first Space Shuttle mission. This is his original artwork for the patch.