RocketSTEM

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Wonder and beauty of Earth's Auroras

New spacecraft to study Moon, Mars and Earth

Spaceplanes for a new era

Abraham Benrubi geeks out on space

Behind the scenes: "Weather go for launch!"

Orbital Sciences Corporation successfully launched their Cygnus spacecraft to the International Space Station on Jan. 9th. With freezing cold and clear blue skies as a backdrop the company sent Cygnus skyward atop their Antares rocket, which thundered away from the Mid-Atlantic Regional Spaceport launch Pad-0A at NASA's Wallops Flight Facility in Virginia. The mission, Orb-1, marks the first of eight contracted resupply flights for Orbital under a $1.9 billion agreement with NASA.

Photo: AmericaSpace.com/Mike Killian

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Also Inside:

It's 2014, and along with the change of the calendar, arrives the first issue from our second year of publishing RocketSTEM. Whether it is your dream to fly into space, or just view the beauty from the ground, we've got you covered within these pages. Enjoy. We'll see you again in March.

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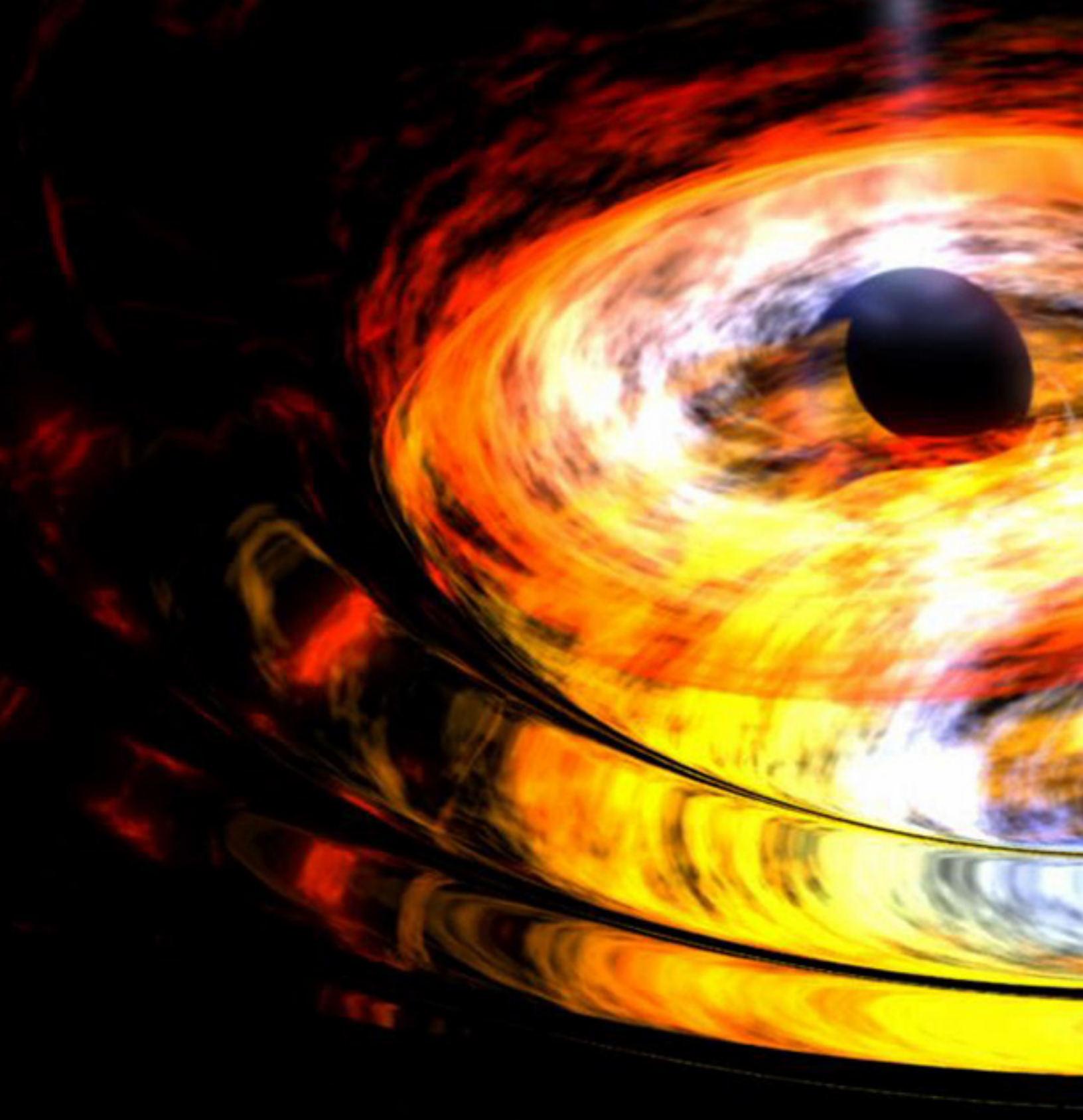
On the Cover: *The Aurora Australis as seen from aboard the International Space Station.* *Image: NASA*



WISE discovers black hole duo merging together

Two black holes are entwined in a gravitational tango in this artist's conception. Supermassive black holes at the hearts of galaxies are thought to form through the merging of smaller, yet still massive black holes, such as the ones depicted here.

NASA's Wide-field Infrared Survey Explorer, or WISE, helped lead astronomers to what appears to be a new example of a dancing black hole duo. Called WISE J233237.05-505643.5, the suspected black hole merger

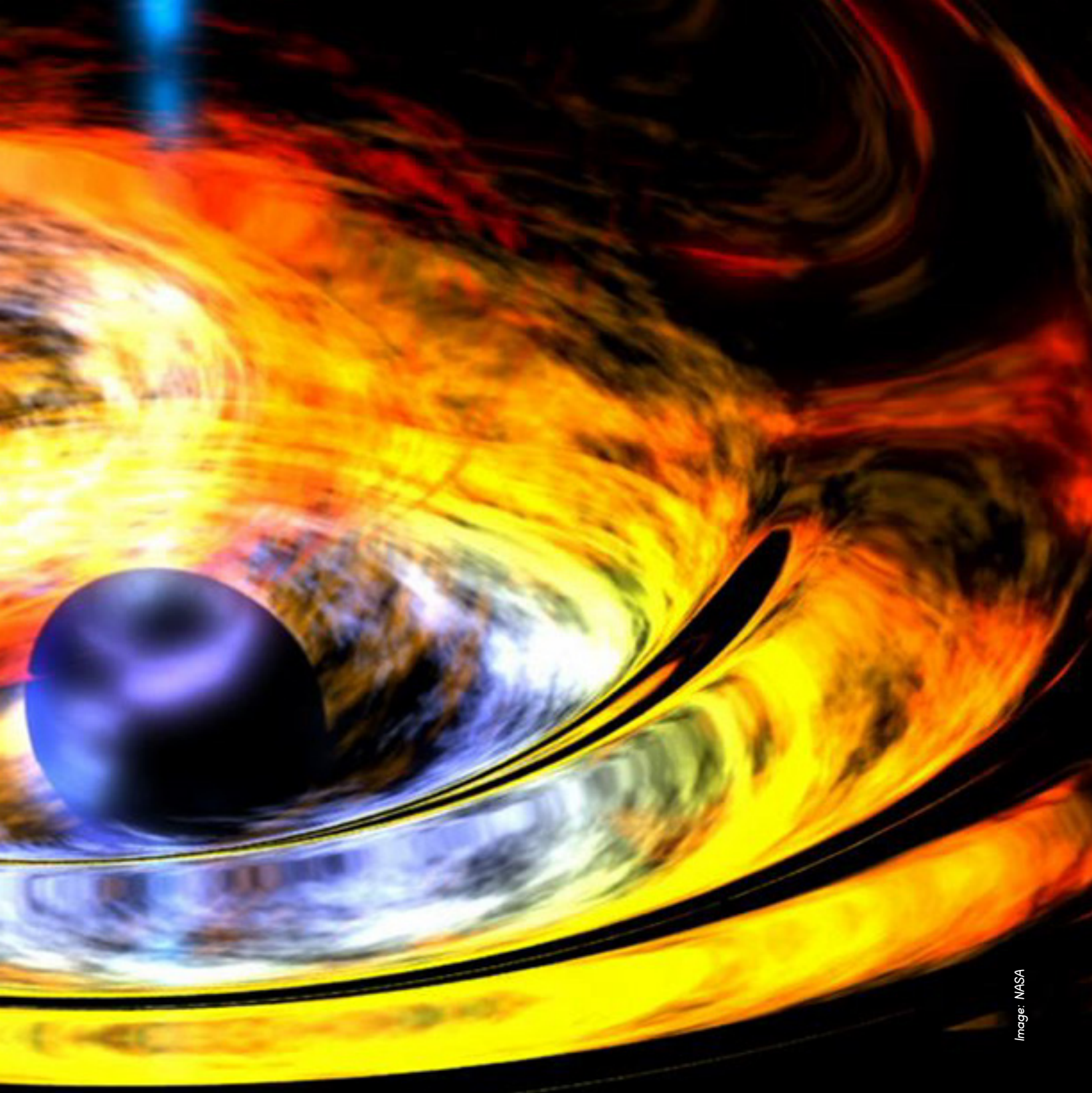


Image: NASA

is located about 3.8 billion light-years from Earth, much farther than other black hole binary candidates of a similar nature.

NASA's Jet Propulsion Laboratory, Pasadena, Calif., manages and operates the recently activated NEO-WISE mission for NASA's Science Mission Directorate. The WISE mission was selected competitively under NASA's Explorers Program managed by the agency's Goddard Space Flight Center in Greenbelt, Md. The science instrument was built by the Space Dynamics Laboratory in Logan, Utah. The spacecraft was built by Ball Aerospace & Technologies Corp. in Boulder, Colo. Science operations and data processing take place at the Infrared Processing and Analysis Center at Caltech. Caltech manages JPL for NASA.

More information is online at http://www.nasa.gov/wise and http://wise.astro.ucla.edu and http://www.jpl.nasa.gov/wise.

One of the Swarm trio orbiting over Italy.
Image: ESA/AOES Medialab

ESA's Swarm trio monitoring our planet's magnetic shield

ESA's three-satellite Swarm constellation was lofted into a near-polar orbit by a Russian Rockot launcher in late November, 2013. For four years, it will monitor Earth's magnetic field, from the depth of our planet's core to the heights of its upper atmosphere.

The Swarm satellites will give us unprecedented insights into the complex workings of the magnetic shield that protects our biosphere from charged particles and cosmic radiation. They will perform precise measurements to evaluate its current weakening and understand how it contributes to global change.

The Rockot launcher lifted off from the Plesetsk spaceport in northern Russia at 12:02 GMT (13:02 CET) on 22 November.

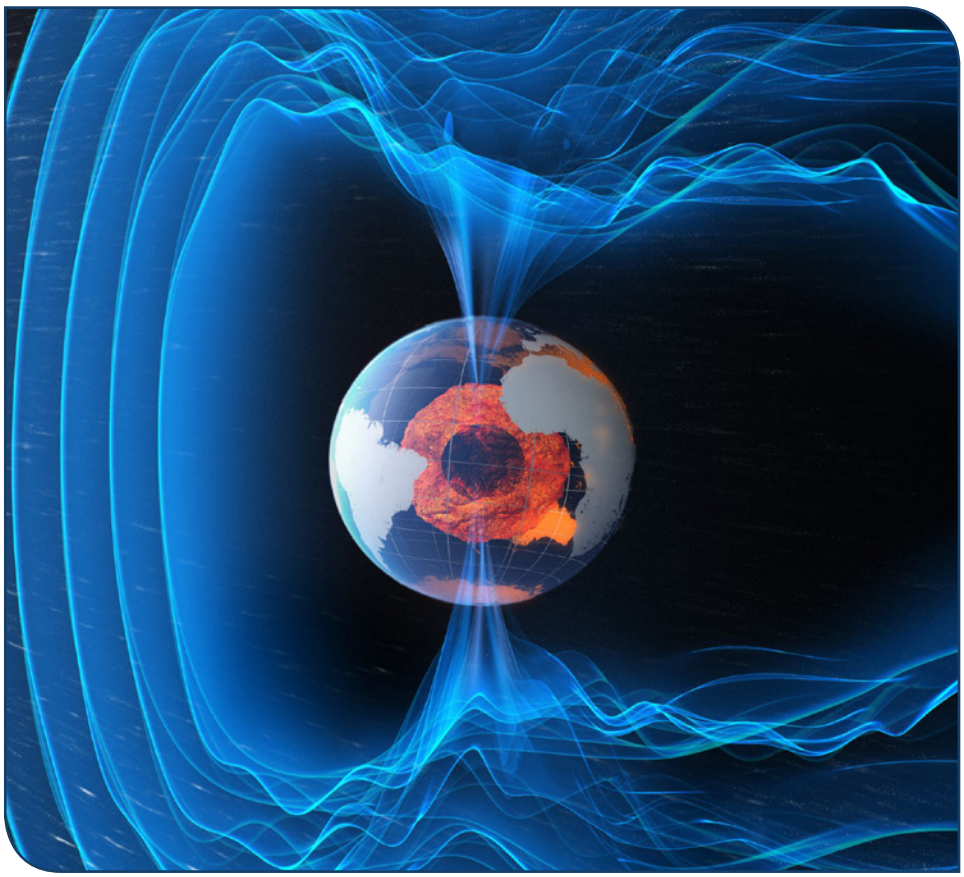
Some 91 minutes later, its Breeze-KM upper stage released the three satellites into a near-polar circular orbit at an altitude of 490 km.

Contact was established with the trio minutes later through the Kiruna station in Sweden and the Svalbard station in Norway.

All three satellites are controlled by ESA teams at the European Space Operation Centre in Darmstadt, Germany. In the next hours they will deploy their 4 m-long instrument booms. Over the next three months of commissioning, their scientific payloads will be verified and they will move to their respective operational orbits.

The lower pair will fly in formation side by side, about 150 km (10 seconds) apart at the equator and at an initial altitude of 460 km, while the upper satellite will rise to a higher orbit, at 530 km.

"Swarm is about to fill a gap in our view of the Earth system and in our monitoring of global change issues," noted Volker Liebig, ESA's director for Earth observation.



The magnetic field and electric currents near Earth generate complex forces that have immeasurable impact on our everyday lives. Although we know that the magnetic field originates from several sources, exactly how it is generated and why it changes is not yet fully understood. ESA's Swarm mission will help untangle the complexities of the field.

Image: ESA/ATG Medialab

"It will help us to better understand the field that protects us from the particles and radiation coming from the Sun."

About Swarm

Swarm is ESA's fourth Earth Explorer mission, coming after the successful CryoSat, GOCE and SMOS satellites – all missions that expand our knowledge of Earth and its environment.

The combination of data collected by Swarm will give precious information on the sources of the magnetic field inside Earth. This includes understanding how the magnetic field is related to the motion of molten iron in the outer core, how the conductivity of the mantle is related to its composition and how the crust has been magnetised over geological timescales.

They will also investigate how the magnetic field relates to Earth's environment through the radiation belts and their near-Earth effects, including the solar wind energy input into the upper atmosphere.

Swarm will also be able to distinguish between the various sources of our planet's magnetic field and ensure continuity in its monitoring from space in conjunction with measurements from ground observatories.

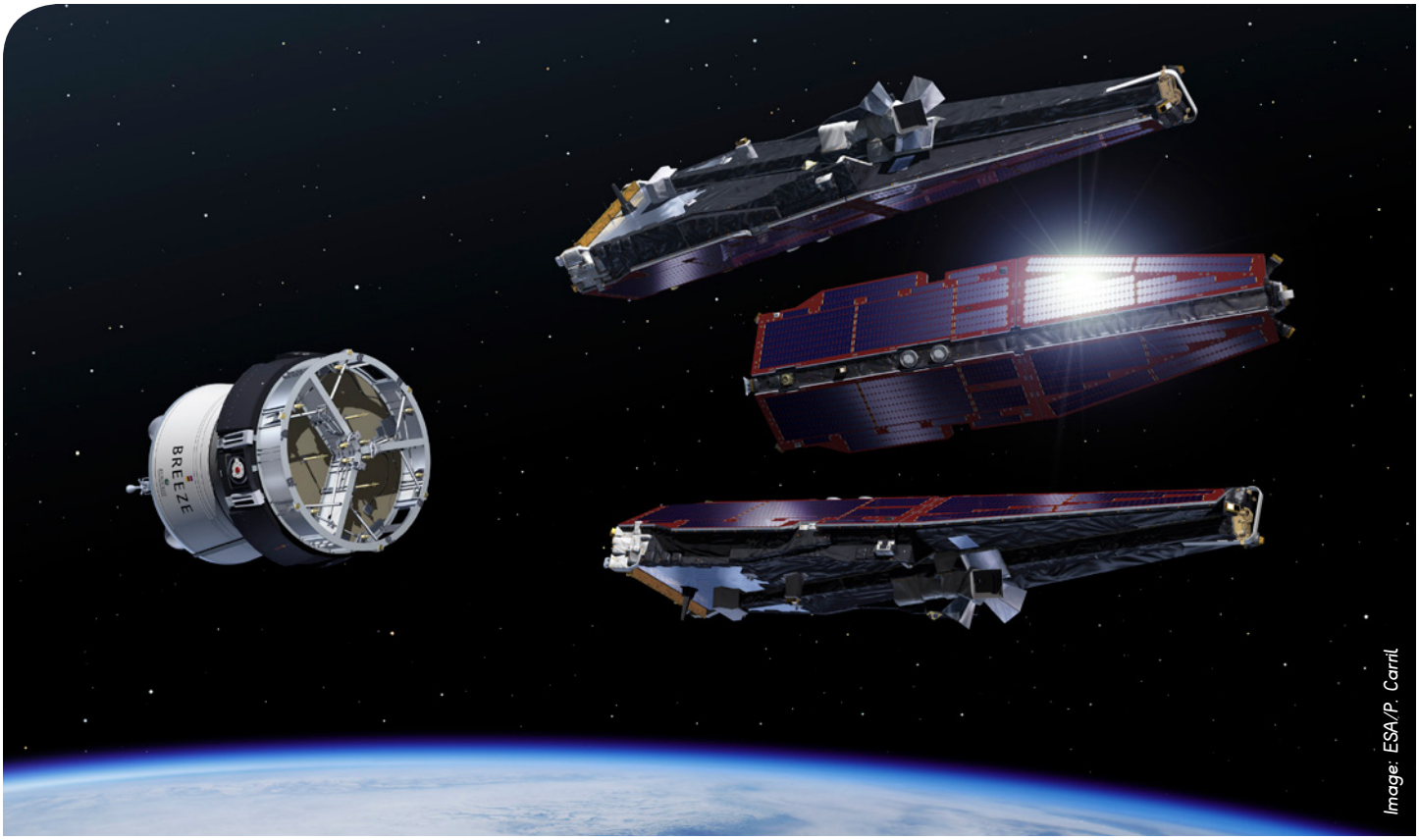


Image: ESA/P. Carril

An artist view of the separation of the Swarm trio of orbiting satellites is pictured above. The three-satellite Swarm mission aims to unravel one of the most mysterious aspects of our planet: the magnetic field. The field protects our planet from cosmic radiation and charged particles that bombard Earth in 'solar winds'. Without this protective shield, the atmosphere as we know it would not exist, rendering life on Earth virtually impossible. All three Swarm satellites are pictured below in vertical positions, ready to join the launch adapter.

Photo: ESA/M. Shafiq

Our magnetic field plays a major role in protecting the biosphere because it generates a bubble around our planet that deflects charged particles and traps them in the radiation belts. This shielding protects all life on Earth from the bombardment of heavy ions coming from the Sun and deep space.

Since the 1980s, previous missions have showed this field to be weakening, which could be a sign that the north and south magnetic poles are beginning to reverse – known to have occurred on multiple occasions during geological times.

Although such inversions usually take thousands years to complete, a further weakening of our magnetic protection could lead to an increase in events that damage our orbiting satellites or disrupt power grids and other electrical systems on the ground.

The ESA's three identical Swarm satellites were launched together. Two satellites orbit almost side-by-side at the same altitude. The third satellite is in a higher orbit and at a slightly different inclination.

Image: ESA/P. Carril

About the European Space Agency

The European Space Agency (ESA) is Europe's gateway to space. It is an intergovernmental organisation, created in 1975, with the mission to shape the development of Europe's space capability and ensure that investment in space delivers benefits to the citizens of Europe and the world.

ESA has 20 Member States: Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom, of whom 18 are Member States of the EU.

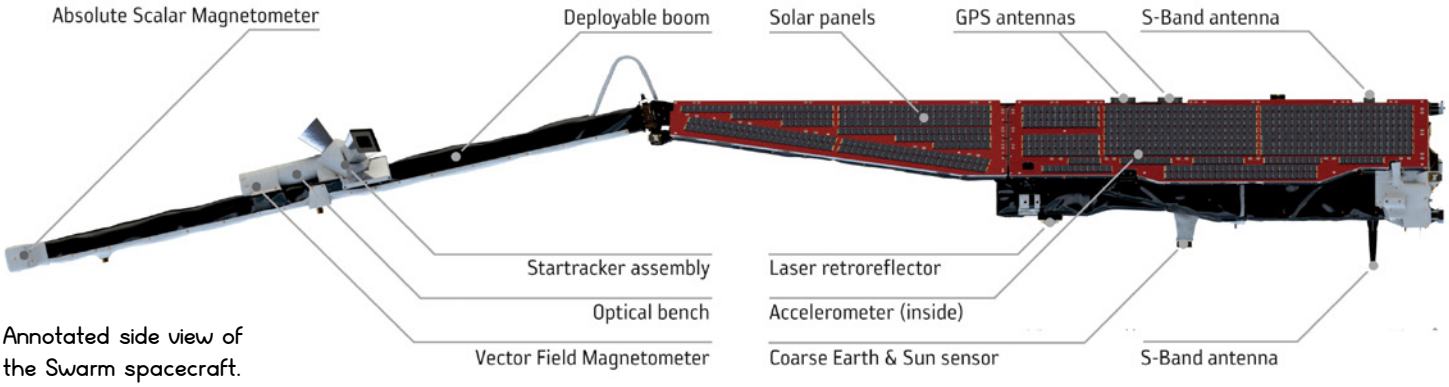
ESA has Cooperation Agreements with eight other Member States of the EU. Canada takes part in some ESA programmes under a Cooperation Agreement.

ESA is also working with the EU on implementing the Galileo and Copernicus programmes.

By coordinating the financial and intellectual resources of its members, ESA can undertake programmes and activities far beyond the scope of any single European country.

ESA develops the launchers, spacecraft and ground facilities needed to keep Europe at the forefront of global space activities.

Today, it launches satellites for Earth observation, navigation, telecommunications and astronomy, sends probes to the far reaches of the Solar System and cooperates in the human exploration of space.



Annotated side view of the Swarm spacecraft.

Image: ESA/AOES Medialab

Students ace 'Hole-In-One' contest at JPL

Students from 19 high school teams across Southern California, as well as NASA professionals, took part in a "Hole-in-One" contest in the Invention Challenge last month at NASA's Jet Propulsion Laboratory, in Pasadena, Calif.

The objective of the annual challenge was to create a device that could propel or move a golf ball into a pyramid-shaped target located about 5 feet (1.5 meters) away from the device. Only one attempt was allowed, and the team that completed the task in the fastest time was crowned the winner.

Taking the top prize was Alexander Hamilton High School, located in Los Angeles. They shot a hole-in-one in just 0.6 seconds.

Paul MacNeal of JPL created and produced the first Invention Challenge 16 years ago and has been running it ever since.

"All students should be exposed to the fun of engineering in this thought-provoking event," said MacNeal. "Students learn skills that are valuable, like brainstorming, teamwork, scheduling, fabrication, failure analysis and competitive design. When they see real engineers having fun, they can believe that engineering might make for a good career goal."

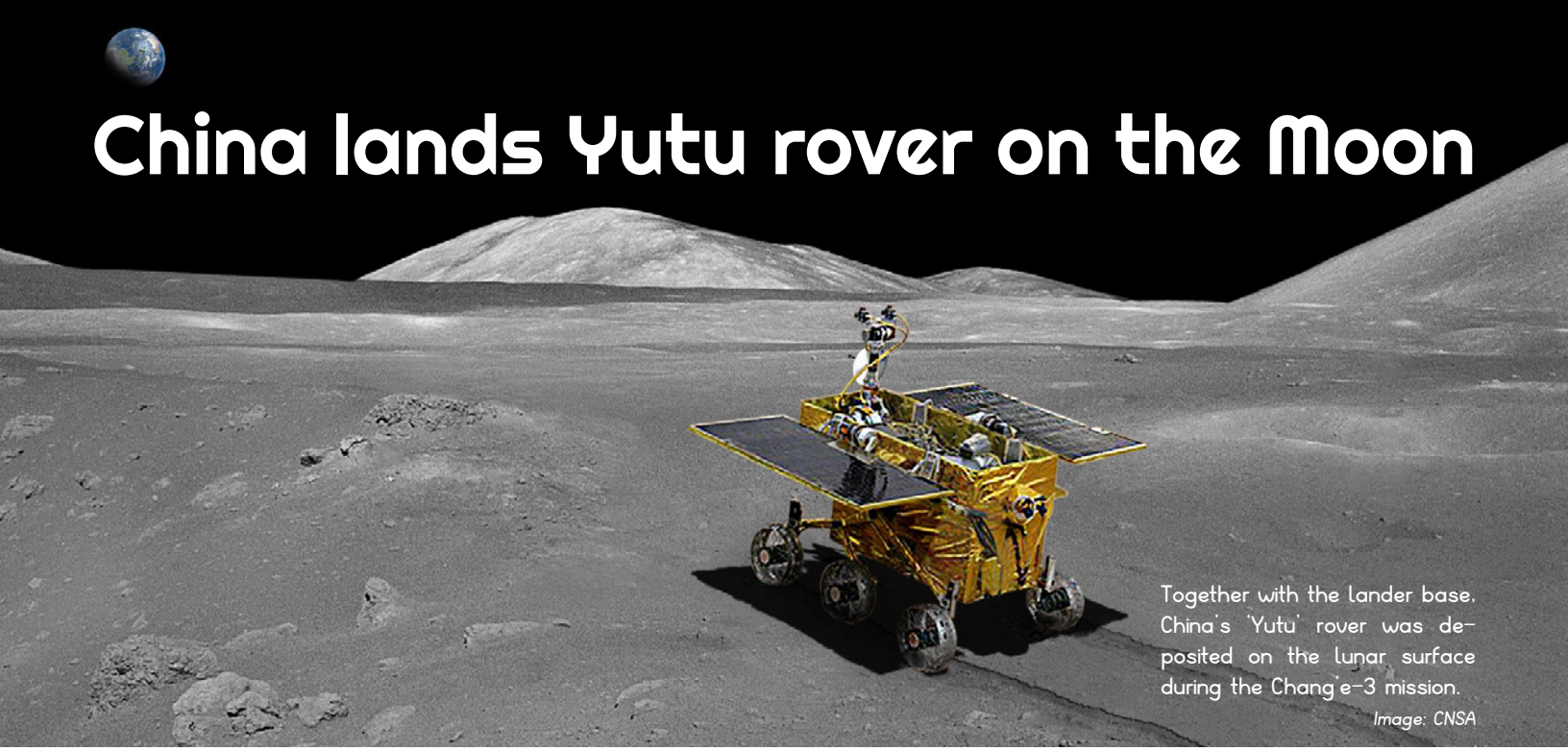
And while the Invention Challenge is really for the kids, JPL employees are always encouraged to participate. This year, 11 additional teams made up of engineers and scientists from JPL competed for pure bragging rights. The JPL winning team, consisting of Alan DeVault and Scott Nolte, earned a time of 0.62 seconds, a hair slower than the winning student team.

If you're interested in getting the specs on next year's challenge, start checking the Invention Challenge Web site in mid-August 2014 for details, at: http://www.jpl.nasa.gov/events/inventionchallenge/.

The goal of this year's Invention Challenge was to build a device that could score a "hole-in-one" by propelling or moving a golf ball into a pyramid-shaped target. Thirty student and professional teams entered the contest. *Photos: NASA/JPL*


DAWN
29
PTS ROCKET
15

China lands Yutu rover on the Moon



Together with the lander base, China's 'Yutu' rover was deposited on the lunar surface during the Chang'e-3 mission.
Image: CNSA

China scored a stunning, history making success with the successful touchdown of the ambitious Chang'e-3 probe with the 'Yutu' rover on the surface of the Moon Dec. 14, 2013, on the country's first ever attempt to conduct a landing on an extraterrestrial body.

The dramatic Chang'e-3 soft landing on the lava filled plains of the Bay of Rainbows occurred at about 8:11 am EST, 9:11 p.m. Beijing local time, 1311 GMT.

The monumental feat is the first landing on the Moon by any entity in nearly four decades. It was broadcast live on CCTV, China's state run television network. This marks a milestone achievement for China and clearly demonstrates the country's technological prowess.

A tidal wave of high fives was unleashed by the huge teams of Chinese space engineers teams controlling the flight from the Beijing Aerospace Control Center (BACC).

China now joins an elite club of three, including the United States, who have mastered the critical technology required to successfully touch down on Earth's nearest neighbor.

'Yutu' could very well serve as a forerunner for testing the key technologies required for a Chinese manned lunar landing in the next decade.

The Chang'e-3 mission is comprised of China's 'Yutu' lunar lander riding piggyback atop a much larger four legged landing vehicle.

The voyage from the Earth to the Moon began 12 days earlier with the flawless launch of Chang'e-3 atop China's Long March 3-B booster at 1:30 a.m. Beijing local time, Dec. 2, 2013 (12:30 p.m. EST, Dec. 1) from the Xichang Satellite Launch Center, in southwest China.

Chang'e-3 made a rocket powered descent to the Moon's surface by firing the landing thrusters starting at the altitude of 15 km (9 mi) for a soft landing targeted to a preselected area on the Bay of Rainbows. The powered descent was autonomous and took about 12 minutes.

The variable thrust engine enabled Chang'e-3 to reduce its deceleration as it approached the moon. The descent was preprogrammed and controlled by the probe itself, not from the ground.

The descent engine fired until the lander was about hovering 100 meters above the lunar surface.

After determining it was safe to proceed, the lander descended further to about 3 meters. The engine then cut off and the lander free fell the remaining distance. The impact was cushioned by shock absorbers.

The Bay of Rainbows, or Sinus Iridum region, is located in the upper left portion of the moon as seen from Earth. You can see the landing site with your own eyes.

It was imaged in high resolution by China's prior lunar mission – the Chang'e-2 lunar orbiter.

Yutu, which translates as Jade Rabbit, stands 150 centimeters high, or nearly 5 feet – human height. It weighs approximately 120 kilograms and sports a robotic arm equipped with advanced science instruments.

The rover and lander are equipped with multiple cameras, spectrometers, an optical telescope, ground penetrating radar and other sensors to investigate the lunar surface and composition.

The radar instrument installed at the bottom of the rover can penetrate 100 meters deep below the surface to study the Moon's structure and composition in unprecedented detail.

Authored by Ken Kremer, an expanded version of this article appeared first at www.universetoday.com.

Stephen Colbert presents honor from NASA to Voyager scientist

As if NASA's Voyager mission didn't have enough firsts in its 36-year journey, what with sending the first spacecraft to Uranus, Neptune and, most recently, interstellar space! Now, it has another first back here on Earth: on the December 3, 2013 episode of the Colbert Report, host Stephen Colbert floated across the stage in a spacesuit worthy of a1950s-era sci-fi movie and presented Voyager Project Scientist Ed Stone with a NASA Distinguished Public Service Medal. The prestigious award honors Stone for his work as project scientist of the venerable Voyager spacecraft since 1972.

"I was on the Colbert Report to talk about what I think of as humankind's greatest – and certainly most extensive – journey of exploration, and I certainly didn't expect the host to hand me an award," said Stone, a professor of physics at the California Institute of Technology and former director of NASA's Jet Propulsion Laboratory, Pasadena, Calif. "That surprise on my face was real."

The NASA Distinguished Public Service Medal is the highest honor for a non-government individual. The citation, put forth by NASA's associate administrator for the Science Mission Directorate, John Grunsfeld, commended Stone "for a lifetime of extraordinary scientific achievement and outstanding leadership of space science missions, and for his exemplary sharing of the exciting results with the public."

Galactic commander and talk show host Stephen "Tiberius" Colbert presented Ed Stone, the project scientist of NASA's Voyager mission, with a NASA Distinguished Public Service Medal. Stone was a guest on Colbert's show on Dec. 3, 2013. *Photo: K. Long*

Stone grew up in Burlington, Iowa, and attended Burlington Junior College and the University of Chicago. He was inspired to enter the fields of planetary science and space exploration by the launch of Sputnik in 1957, and his career has spanned the space age.

Stone has been a member of the Caltech faculty since 1967. In 1972, he became the Voyager project scientist, and he has the distinction of serving as Voyager's one-and-only project scientist. He has seen the two spacecraft, Voyager 1 and 2, through the planetary encounters of Jupiter, Saturn, Uranus and Neptune and is now eagerly poring through the data coming back from Voyager 1, now exploring interstellar space.

While serving as director of JPL from 1991 to 2001, Stone oversaw numerous NASA projects, such as Galileo's mission around Jupiter, the launch of the Cassini mission to Saturn, a new generation of Earth science satellites and the successful Pathfinder landing on Mars.

Stone's current projects also include serving as vice chair of the board of directors of the Thirty Meter Telescope project, which is preparing to build the most advanced and powerful optical telescope to date.

Against the backdrop of an image of Saturn's rings taken by NASA's Voyager mission, project scientist Ed Stone describes the 36-year journey of the two Voyager spacecraft. *Photo: K. Long*

Jeremy Samuel, a range weather forecaster at the 45th Weather Squadron, monitors the weather ahead of a launch. The squadron keeps their eyes on a variety of weather sensors located throughout the Space Coast area in order to safely access if it is safe to launch a rocket from either Kennedy Space Center or Cape Canaveral Air Force Station. *Photo: USAF*

Keeping an eye on launch-day weather

By Tony Rice

Before MAVEN can study the atmosphere of Mars, it had to not only overcome Earth's gravity but also make it through Earth's atmosphere. Central Florida's sometimes volatile weather can make launching rockets difficult. Weather is responsible for more than a third of launch delays and nearly half of the scrubs.

The meteorologists of the 45th Weather Squadron (45WS) at the Cape Canaveral Air Force Station (CCAFS) keep a close eye on that weather. In addition to the satellite images and radar your local weather forecasters use, 45WS scientists have one of the most unique sets of sensors in the world.

The 45WS provides weather information for launches of rockets like MAVEN's Atlas V, but also for the SpaceX Falcon, Delta rockets carrying missions like GRAIL, and the Space Shuttle launches and landings at the Kennedy Space Center. They also forecast wind and lightning threats for activities like moving sensitive spacecraft and rockets to the launch pad.

Nearly four dozen weather towers start 27 miles (43 km) west of the launch pad and are scattered throughout CCAFS, and ocean buoys extend 30 miles (48 km) to the east. Towers and buoys are topped with instruments measuring wind direction, wind speed, and temperature. Nearly three dozen field mills measure the strength of the electrical fields in the atmosphere, helping forecasters judge the potential for lightning. Weather balloons are also released about 5 hours and 2 hours before launch (and as needed) to measure upper level winds.

Readings from those instruments are fed into the rocket's computers up until the final moments of the countdown, to allow for accurate steering as it rises through layers of the atmosphere.

Weather isn't just measured remotely. Meteorologists and trained Air Force pilots watch approaching thunderstorms, and observe clouds from the ground and skies. Anvil shaped clouds are watched very carefully, as they indicate thunderstorms which may produce lightning.

Lightning is a big concern for launching rockets, and the 45WS is especially well prepared for it. Only the African country of Rwanda has more lightning strikes than central Florida.

In addition to the detection of cloud-to-ground lightning that your local meteorologist probably has access to, the 45WS can detect cloud-to-cloud lightning. This gives them a unique 3-dimensional view of a thunderstorm. All this information is put to use to keep rockets, as well as the people launching them, safe.

The next time you watch a rocket launch, listen for the launch weather officer, and hope for a "Go!"

Photo: USAF/Staff Sgt. Erin Smith

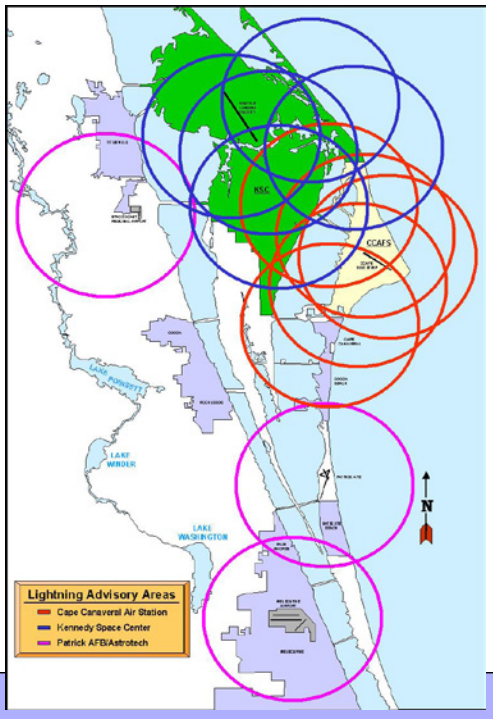


Image: NOAA/Darien Davis

The 45th Weather Squadron at the Cape Canaveral Air Force Station (above) monitors weather before rocket launches. A map of the KSC/CCAFS region (right) displays Lighting Advisory Areas, while another map (below) shows the myriad of weather sensors utilized by the squadron.

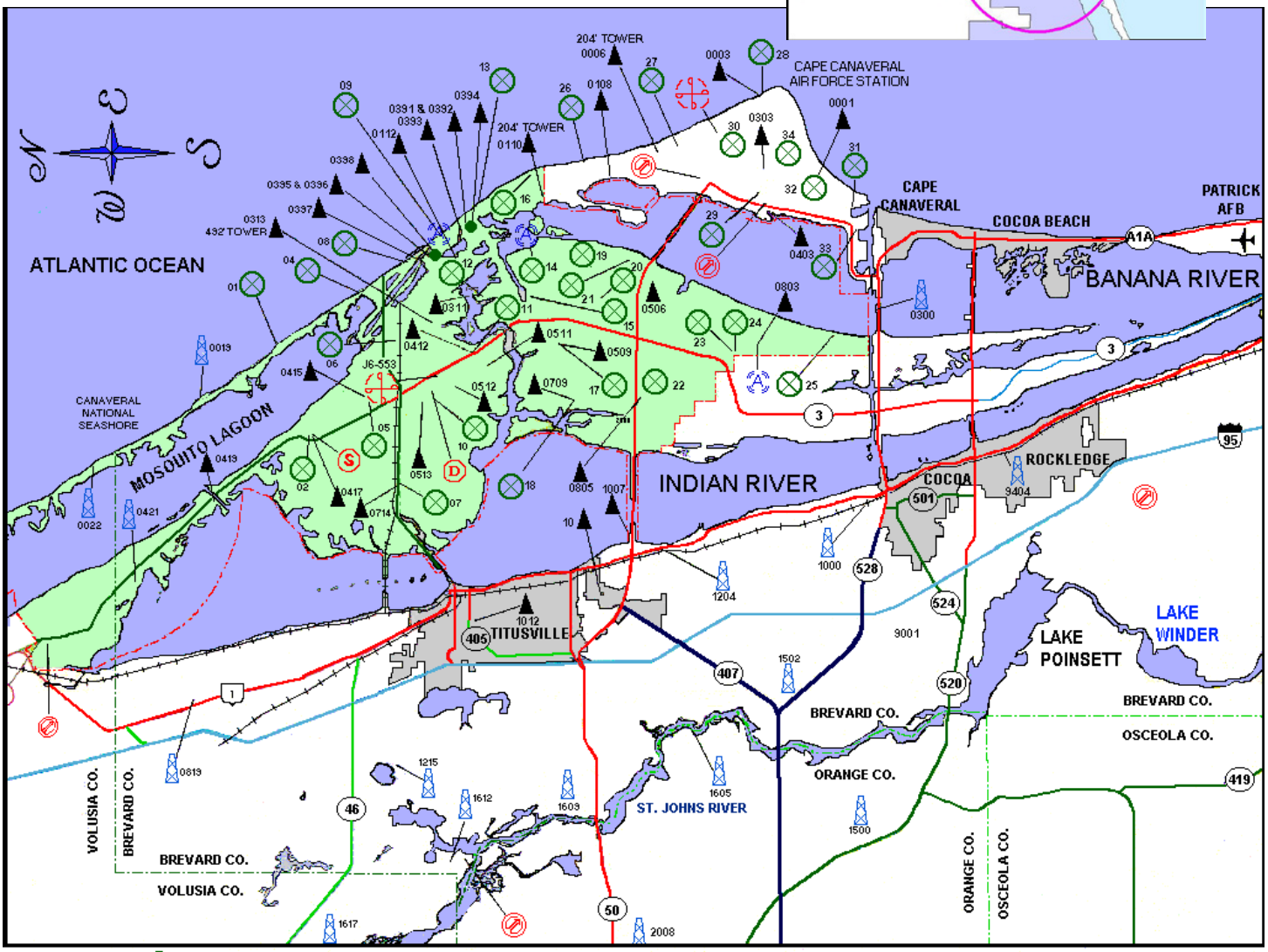


Image: NASA/USAF

NASA's MAVEN on way to Mars

By Ken Kremer

NASA's Mars Atmosphere and Volatile Evolution (MAVEN) space probe thundered to space on Nov. 18 following a flawless blastoff from Cape Canaveral Air Force Station's Space Launch Complex 41 at 1:28 p.m. EST atop a powerful Atlas V 401 rocket.

"Hey Guys we're going to Mars!" gushed Bruce Jakosky, MAVEN's Principal Investigator at a post launch briefing for reporters at the Kennedy Space Center.

"Now I am a Martian," beamed Jakosky gleefully. And so is everyone else who has worked on MAVEN since the project was conceived some ten years ago."

Technicians working on NASA's MAVEN spacecraft with solar panels unfurled inside the clean room at KSC prior to its November 2013 launch. *Photo: Ken Kremer*

The absolutely perfect countdown culminated in a spectacular on time lift off that rumbled across the Florida Space Coast to the delight of cheering crowds assembled for the historic launch aimed at discovering the history of water and habitability stretching back over billions of years on Mars.

NASA's Mars bound MAVEN spacecraft launches atop an Atlas V booster from LC-41 at CCAFS. *Photo: Ken Kremer*

"I take great pride in the entire team," said Jakosky. "Everyone was absolutely committed to making this work."

The $671 Million MAVEN spacecraft separated from the Atlas Centaur upper stage some 52 minutes after liftoff, unfurled its wing like solar panels to produce life giving power and thus began a 10 month interplanetary voyage to the Red Planet.

"We're currently about 14,000 miles away from Earth and heading out to the Red Planet right now," said MAVEN Project Manager David Mitchell of NASA's Goddard Space Flight Center at the post launch briefing, after the 5,400-pound spacecraft had been soaring through space for barely two and a half hours.

"Safe travels MAVEN!" said Mitchell. "We're with you all the way."

It will take the spacecraft 10 months to reach the Red Planet, with arrival scheduled for Sept. 22, 2014.

Jakosky noted that while the launch is a big milestone, it's just the beginning.

MAVEN's purpose is to accomplish world class science. After arriving at Mars and completing a check-out period it can finally begin collecting science data. The orbiter will answer key questions about the evolution of Mars, its geology and the potential for the evolution of life.

Mars was once wet billions of years ago, but no longer. Now it's a cold arid world, not exactly hospitable to life.

"MAVEN is an astrobiology mission," says Jakosky. "We want to determine what were the drivers of that change?" said Jakosky. "What is the history of Martian habitability, climate change and the potential for life?"

MAVEN will study Mars upper atmosphere to explore how the Red Planet may have lost its atmosphere over billions of years. It will measure current rates of atmospheric loss to

determine how and when Mars lost its atmosphere and water.

The MAVEN probe carries nine sensors in three instrument suites. The Particles and Fields Package, provided by the University of California at Berkeley with support from CU/LASP and NASA's Goddard Space Flight Center in Greenbelt, Md., contains six instruments to characterize the solar wind and the ionosphere of Mars. The Remote Sensing Package, built by CU/LASP, will determine global characteristics of the upper atmosphere and ionosphere. The Neutral Gas and Ion Mass Spectrometer, built by Goddard, will measure the composition of Mars' upper atmosphere.

"We need to know everythng we can before we send people to Mars."

- Dr. Jim Green

"We need to know everything we can before we can send people to Mars," said Dr. Jim Green, NASA's Director of Planetary Science at NASA HQ in Washington, DC.

"MAVEN is a key step along the way. And the team did it under budget!" Green elaborated. "It is so exciting!"

Over the course of its one-Earth-year primary mission, MAVEN will observe all of Mars' latitudes at altitudes ranging from 93 miles to more than 3,800 miles. Five deep dip maneuvers will be executed during the first year, descending to an altitude of 78 miles. This marks the lower boundary of the planet's upper atmosphere.

NASA's MAVEN orbiter and India's MOM (Mars Orbiter Mission) will "work together" to help solve the mysteries of Mars atmosphere, Jakosky told me.

India's first Mars probe joins MAVEN in race to Red Planet

By Ken Kremer

India's first ever Mars probe 'MOM' successfully fired its main engine on Dec. 1, blasting the craft free of the Earth's sphere of influence forever to begin her nearly yearlong momentous voyage to the Red Planet.

Indian space engineers initiated the 440 Newton liquid fueled engine firing precisely as planned during a critical nail-biting burn lasting some 22 minutes.

The Trans Mars Insertion (TMI) firing propelled India's Mars Orbiter Mission (MOM) away from Earth forever and placed the spacecraft on course for a rendezvous with the Red Planet on September 24, 2014 – where it will study the atmosphere and sniff for signals of methane.

The Mars insertion burn imparted the vehicle with an incremental velocity of 647.96 meters per second (m/sec) consuming 198 kg of fuel.

The maneuver dubbed 'The mother of all slingshots', enabled MOM to finally achieve escape velocity and catapulted the 1,350 kilogram (2,980 pound) spacecraft on an historic flight streaking towards Mars.

And in a rare but rather delightful coincidence, MOM is not alone on her remarkable Martian sojourn. Following the triumphant engine burn, she now joins NASA's MAVEN orbiter in a gallant marathon race to the Red Planet.

MOM was designed and developed by the Indian Space Research Organization's (ISRO) at a cost of $69 Million and marks India's inaugural foray into interplanetary flight. MOM is nicknamed 'Mangalyaan' – which in Hindi means 'Mars craft.'

MOM's journey began with a picture perfect Nov. 5 liftoff atop India's highly reliable four stage Polar Satellite Launch Vehicle (PSLV) C25 from ISRO's Satish Dhawan Space Centre SHAR, Sriharikota.

A picture perfect liftoff of the PSLV-C25 rocket carrying India's first interplanetary mission. *Photo: ISRO*

The MOM spacecraft is now traveling on 300 day long interplanetary voyage of more than 700 million kilometers (400 million miles) to the Red Planet.

Along the path to Mars, ISRO plans to conduct a series of Trajectory Correction Maneuvers (TCMs) using MOM's Attitude and Orbit Control System (AOCS) thrusters to precisely navigate the probe to the point required to achieve orbit around the Red Planet.

Following the ten month cruise through space the orbital insertion engine will fire for a do or die burn on September 24, 2014 placing MOM into an 377 km x 80,000 km elliptical orbit around Mars.

MOM will reach Mars vicinity just two days after MAVEN's arrival on Sept. 22, 2014.

If all continues to goes well, India will join an elite club of only four who have launched probes that successfully investigated the Red Planet from up close – following the Soviet Union, the United States and the European Space Agency.

NASA Mars spacecraft reveals a more dynamic Red Planet

NASA's Mars Reconnaissance Orbiter has revealed to scientists slender dark markings -- possibly due to salty water - that advance seasonally down slopes surprisingly close to the Martian equator.

"The equatorial surface region of Mars has been regarded as dry, free of liquid or frozen water, but we may need to rethink that," said Alfred McEwen of the University of Arizona in Tucson, principal investigator for the Mars Reconnaissance Orbiter (MRO) High Resolution Imaging Science Experiment (HiRISE) camera.

Tracking how these features recur each year is one example of how the longevity of NASA orbiters observing Mars is providing insight about changes on many time scales.

The seasonally changing surface flows were first reported two years ago on mid-latitude southern slopes. They are finger-like features typically less than 16 feet (5 meters) wide that appear and extend down steep, rocky slopes during spring through summer, then fade in winter and return the next spring. Recently observed slopes stretch as long as 4,000 feet (1,200 meters).

McEwen and co-authors reported the equatorial flows at the conference and in a paper published recently by Nature Geoscience. Five well-monitored sites with these markings are in Valles Marineris, the largest canyon system in the solar system. At each of these sites, the features appear on both north- and south-facing walls. On the north-facing slopes, they are active during the part of the year when those slopes get the most sunshine. The counterparts on south-facing slopes start flowing when the season shifts and more sunshine hits their side.

"The explanation that fits best is salty water is flowing down the slopes when the temperature rises," McEwen said. "We still don't have any definite identification of water at these sites, but there's nothing that rules it out, either."

Dissolved salts can keep water melted at temperatures when purer water freezes, and they can slow the evaporation rate so brine can flow farther. This analysis used data from the Compact Reconnaissance Imaging Spectrometer for Mars and the Context Camera on the MRO as well as the Thermal Emission Imaging System experiment on NASA's Mars Odyssey orbiter.

Water ice has been identified in another dynamic process researchers are monitoring with MRO. Impacts of small asteroids or bits of comets dig many fresh craters on Mars every year. Twenty fresh craters have exposed bright ice previously hidden beneath the surface. Five were reported in 2009. The 15 newly reported ones are distributed over a wider range of latitudes and longitudes.

"The more we find, the more we can fill in a global map of where ice is buried," said Colin Dundas of the U.S. Geological Survey in Flagstaff, Ariz. "We've now seen icy craters down to 39 degrees north, more than halfway from the pole to the equator. They tell us that either the average climate over several thousand years is wetter than present or that water vapor in the current atmosphere is concentrated near the surface. Ice could have formed under wetter conditions, with remnants from that time persisting today, but slowly disappearing."

Mars' modern climate becomes better known each year because of a growing set of data from a series of orbiters that have been studying Mars continually since 1997. That has been almost nine Martian years because a year on Mars is almost two years long on Earth. Earlier missions and surface landers have added insight about the dynamics of Mars' atmosphere and its interaction with the ground.

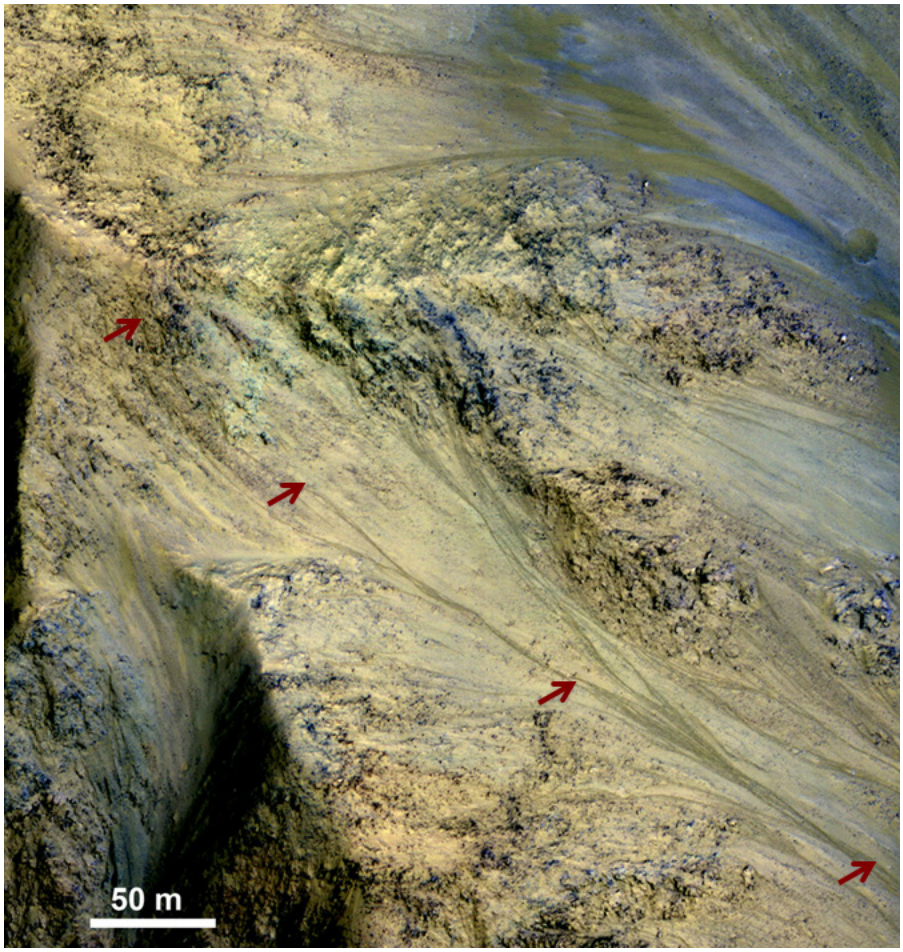
"The dust cycle is the main driver of the climate system," said Robert Haberle of NASA's Ames Research Center in Moffett Field, Calif.

One key question researchers want to answer is why dust storms encircle Mars in some years and not in others. These storms affect annual patterns of water vapor and carbon dioxide in the atmosphere, freezing into polar ice caps in winter and replenishing the atmosphere in spring. Identifying significant variations in annual patterns requires many Martian years of observations.

The data emerging from long-term studies will help future human explorers of Mars know where to find resources such as water, how to prepare for hazards such as dust storms, and where to be extra careful about contamination with Earth microbes.

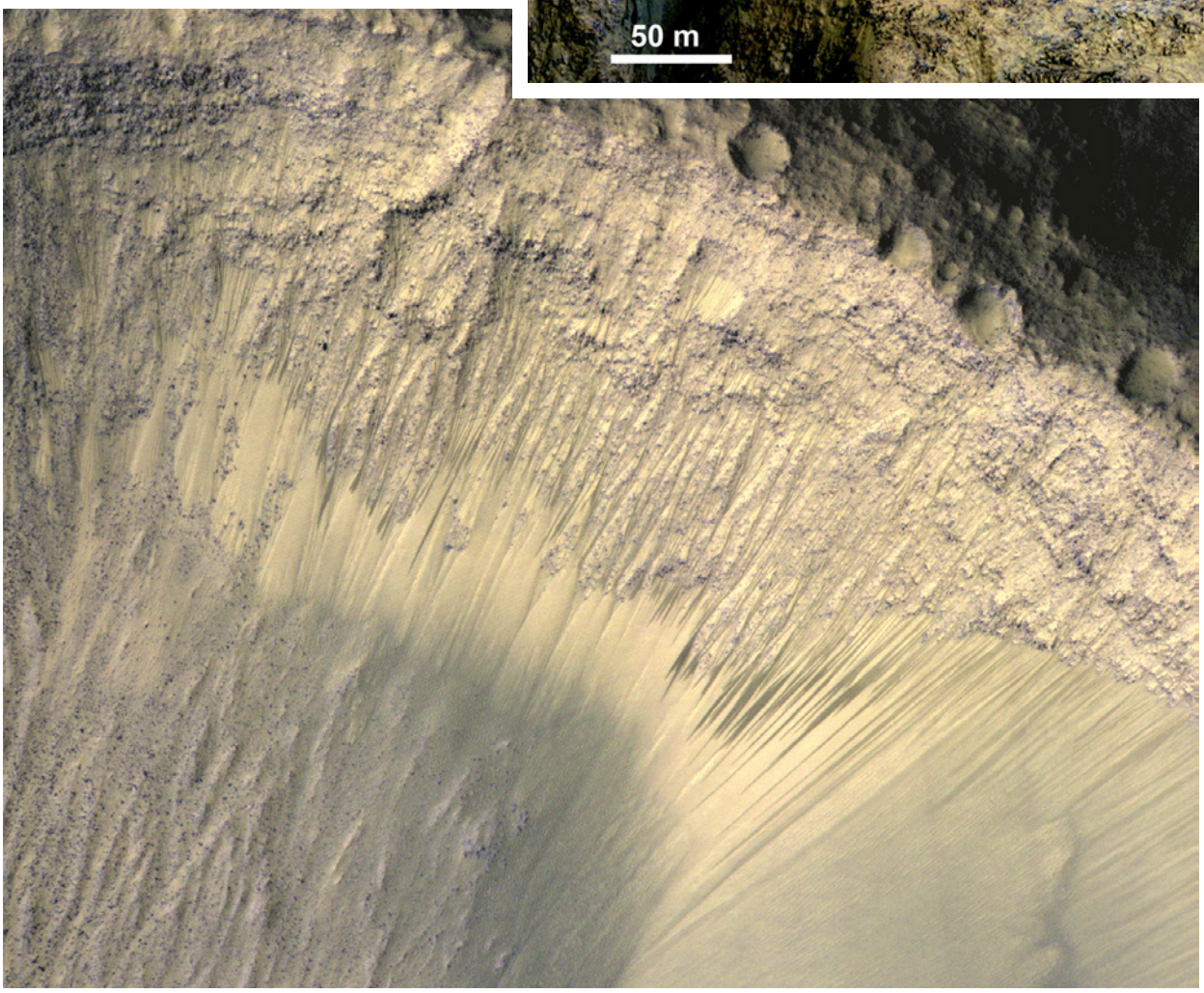
Launched in 2005, Mars Reconnaissance Orbiter and its six instruments have provided more high-resolution data about the Red Planet than all other Mars orbiters combined. Data are made available for scientists worldwide to research, analyze and report their findings.

For more information about NASA Mars exploration missions, visit: www.nasa.gov/mars. For more about HiRISE, visit: http://hirise.lpl.arizona.edu.



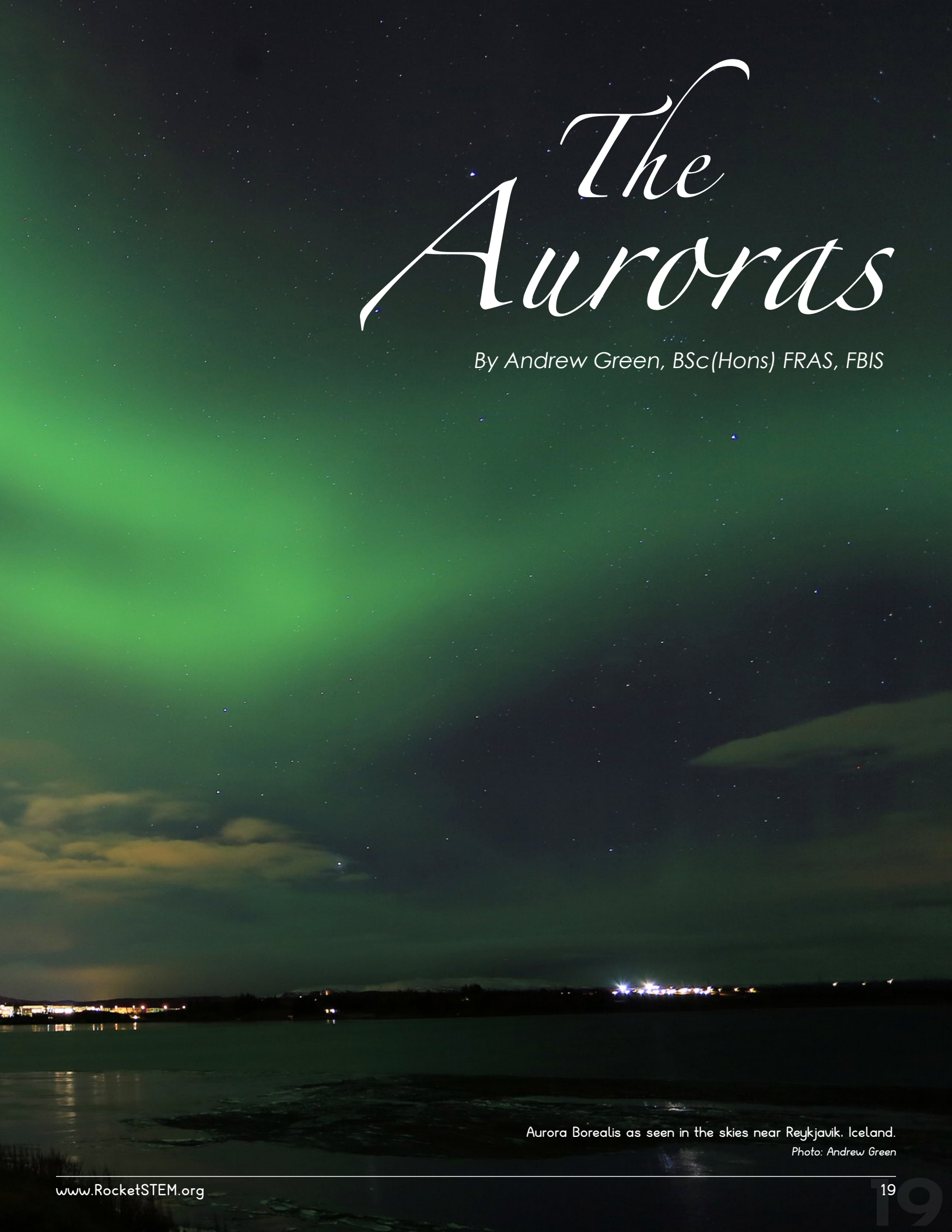
These images from the High Resolution Imaging Science Experiment (HiRISE) camera on NASA's Mars Reconnaissance Orbiter show how the appearance of dark markings on Martian slope changes with the seasons. The marks, called recurrent slope linea, extend down slopes during warmer months and fade away during cooler months.

Images: NASA/JPL-Caltech/Univ. of Arizona



The Auroras

By Andrew Green, BSc(Hons) FRAS, FBIS



Aurora Borealis as seen in the skies near Reykjavik, Iceland.
Photo: Andrew Green

Nature has an uncanny knack of producing some of the most spectacular astronomical events we can witness, the likes of Solar eclipses, meteor showers and other phenomenon that never fail to impress. There is one event however, that once you witness it, it will be burnt into your memory and will stay with you for the rest of your life, this is witnessing the Aurora.

Aurora is a Latin word for "Sunrise or Dawn" and in Roman mythology Aurora was the goddess of the dawn. "Borealis" means pertaining to the North and "Australis" to the South.

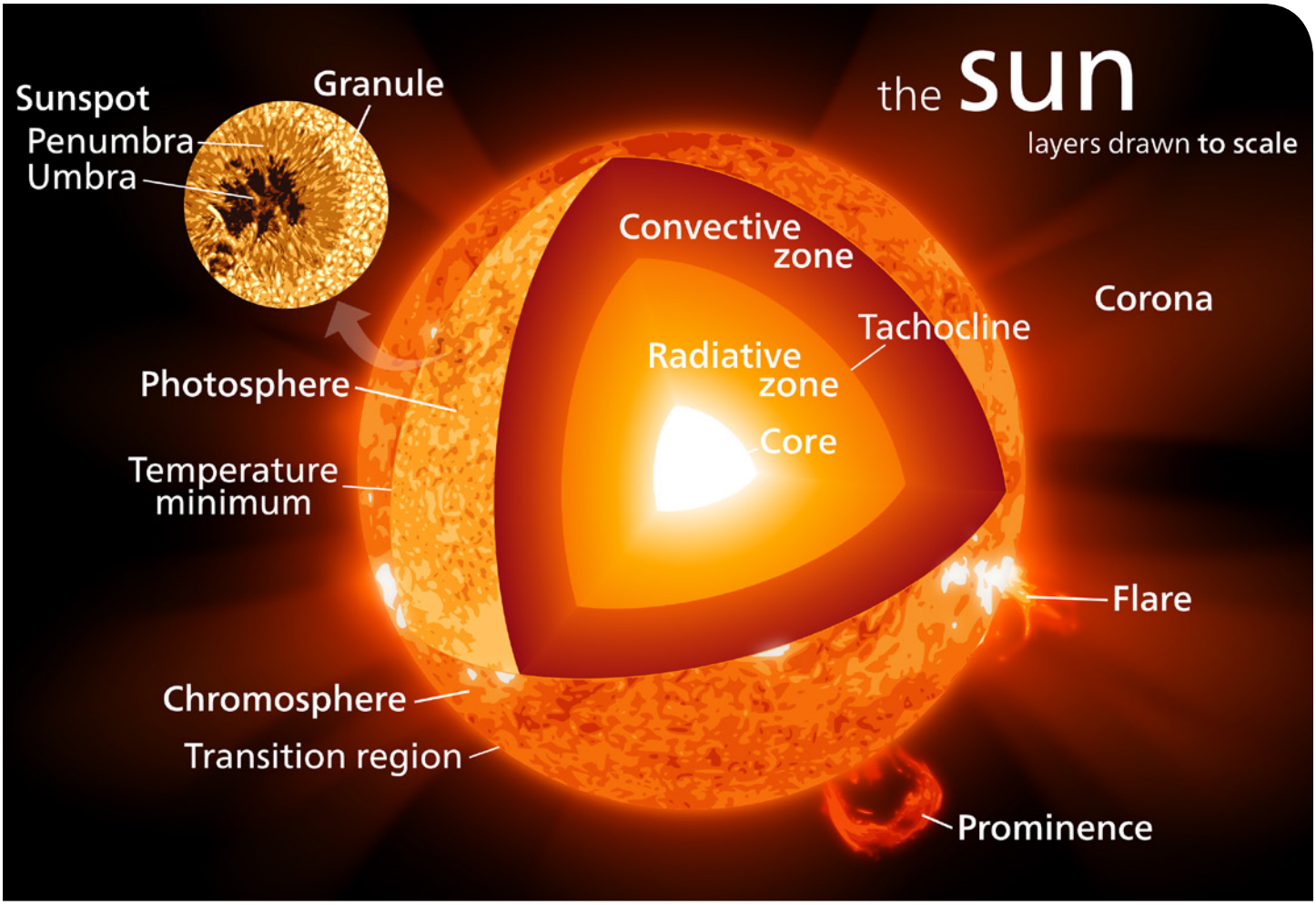
Auroral displays have been known about for 1000's of years and for those cultures in the Polar regions of the Earth they have witnessed some of the most breathtaking displays seen, but the Aurora, provided conditions are right, can be seen from many lower latitude locations around the world provided conditions are right.

To start to explain it we must first look at our own star, the Sun.

Our sun is the powerhouse at the heart of the Solar system a huge ball of gas with a nuclear furnace at its heart. Accounting for 99% of the mass of our solar system the sun is by far the largest body in our local neighbourhood. The sun itself has a diameter of about 864,938 miles and is primarily composed of Hydrogen. In the core region the Hydrogen is converted into Helium by a process called nuclear fusion the by-product of which is energy and heat. The Sun is losing approximately 4million tonnes of itself each and every second as energy and if we could turn that into power we could perhaps keep a city the size of New York or London in electricity for many 1000's of years. The Sun is very powerful!

As with the Earth and the other planets, the Sun also rotates about its axis, but in a different way to planet Earth. Here on Earth we say the earth revolves around each and every 24 hours (23h 56m4s) regardless of where you are, the sun is different! It has what we call "differential rotation". All the matter in the Sun is in the form of gas and at high temperatures, plasma. This makes it possible for the Sun to rotate faster at its equator than it does at higher latitudes and this is where the sun begins to have an effect. At the polar regions of the sun it rotates in approximately 35 days and at the solar equator in approximately 25 days and this gives rise to distortions in the sun and its magnetic field.

This rotational difference in the Sun causes its magnetic field lines to become twisted and much distorted, imagine a rubber band that has been continually spun and twisted together. Over time



An illustration of the structure of the Sun.

Graphic: Kelvinsong via Wikipedia.com

this distortion produces a magnetic field and includes loops that erupt from the Sun's surface and trigger the formation of the Sun's dramatic sunspots and solar prominences. This twisting action creates the solar dynamo and an 11-year solar cycle of magnetic activity.

When these loops and sunspot magnetism break free from the suns magnetic field they send what we term the "solar wind" out into space. From time to time it heads directly towards planet Earth. The Solar wind is a stream of charged particles released from the upper atmosphere of our star and mostly consists of electrons and protons.

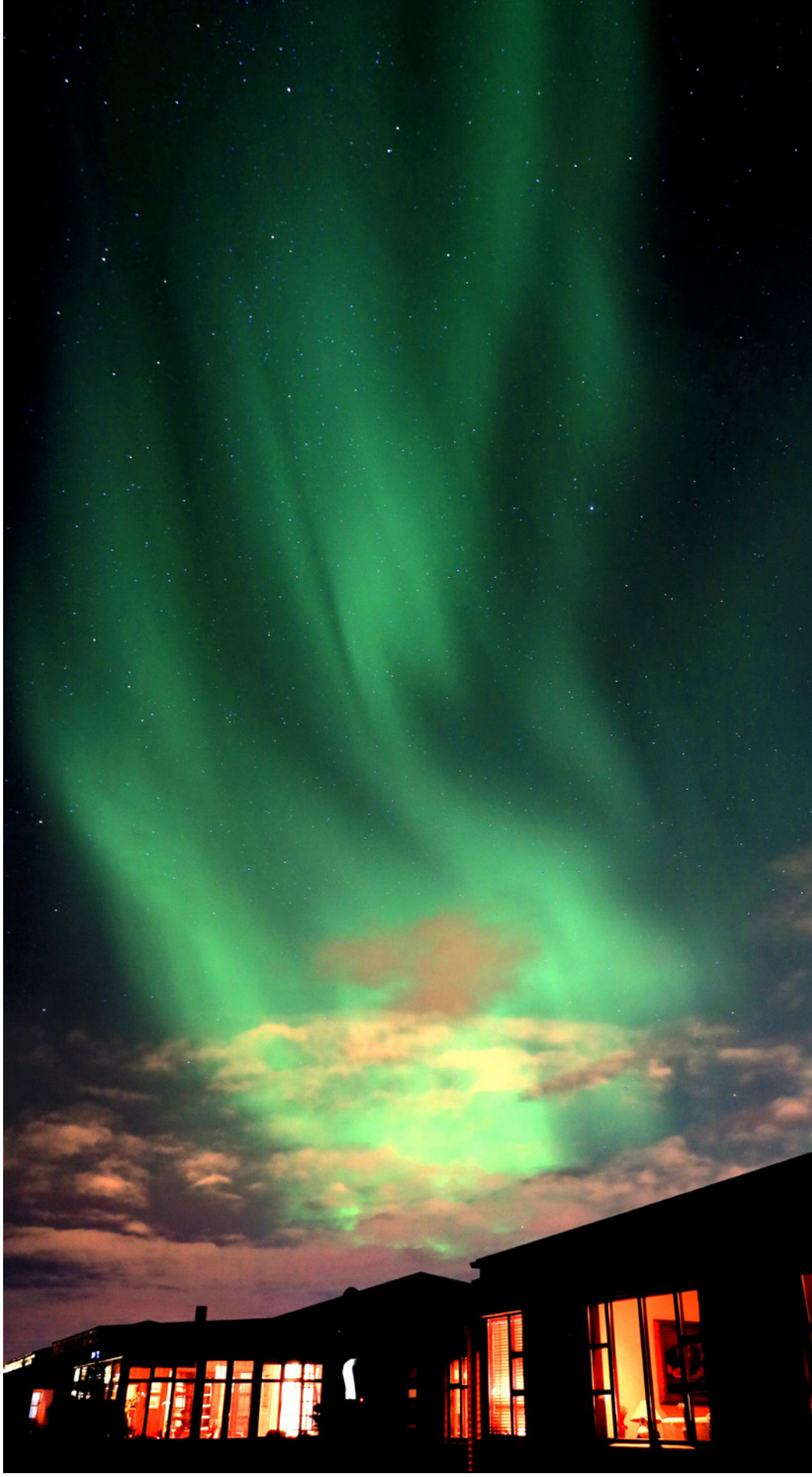
If ejected in the right direction the solar wind will race Earthward at great speed 300 – 1000kms per second and faster in some cases. Imagine a car travelling at over a million miles an hour and you begin to get the idea. Once it reaches the Earth in 2-4 days it hits our atmosphere and interacts with our own magnetic field.

Our planet is protected by what we term its magnetosphere, and this is what initially protects us from the blast of particles. As the wind is first channelled past the Earth, our magnetic field then acts as a mighty bow to deflect these particles.

Then these particles pass the Earth and re-connect, channelling back towards us and attracting them to the weakest portion of the Earth magnetic field around the poles. At the North Polar regions we see the "Aurora Borealis", and the South Polar region we see the "Aurora Australis".

Our Earth has quite a complex atmosphere but is primarily made of Nitrogen and Oxygen with smaller amounts of other gases. Critical in Aurora formation though is that Nitrogen and Oxygen.

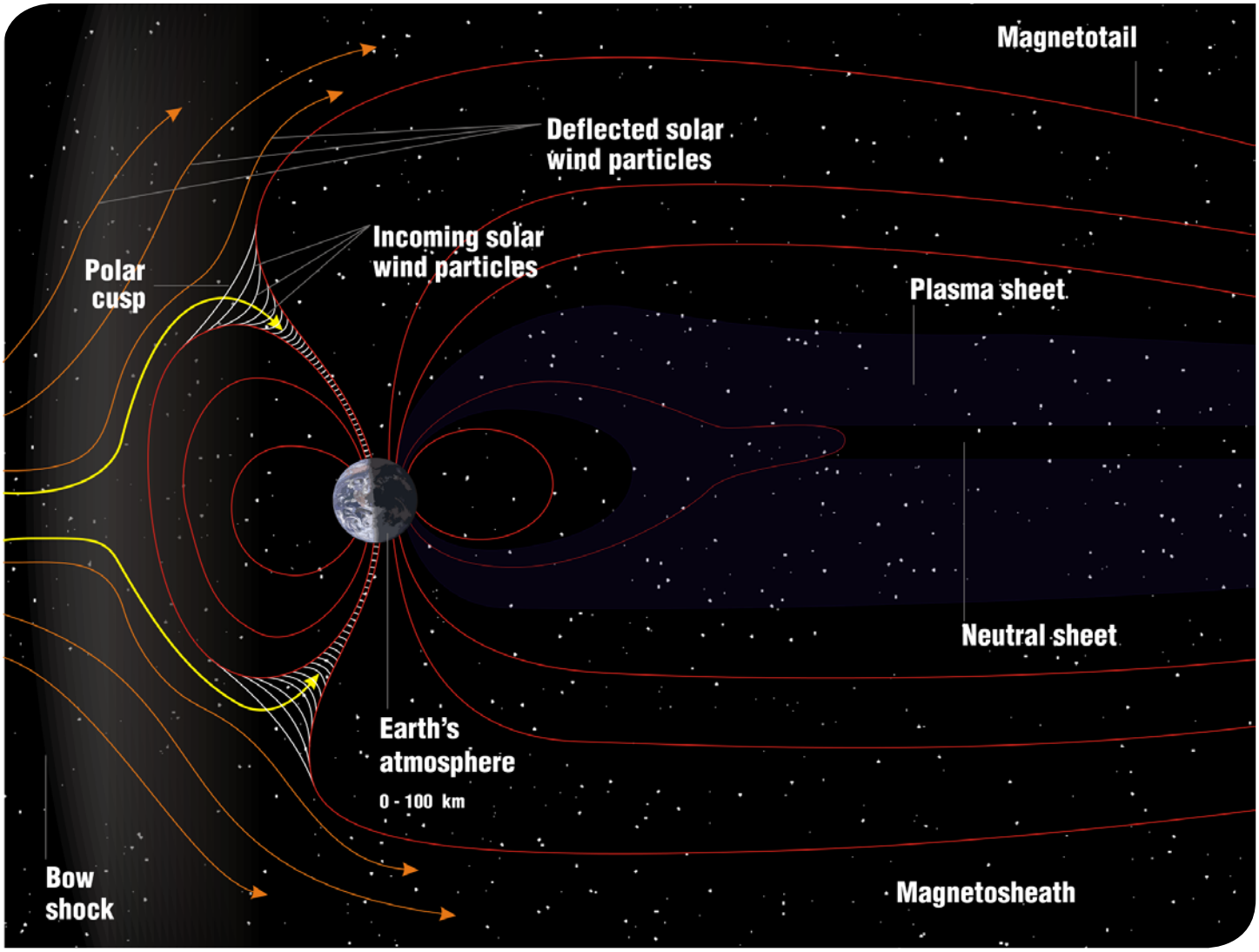
In our atmosphere we actually have 2 types of Oxygen; we have atomic Oxygen and molecular Oxygen as well as the Nitrogen. What happens to create the colours we see in the Aurora, is the interaction between these gaseous atoms and the particles from the Solar wind the electrons.



Aurora Borealis as seen in the skies above a hotel near Reykjavik. Iceland.

Photo: Andrew Green

Aurora Borealis as seen in the skies near Reykjavik, Iceland.
Photo: Andrew Green



An illustration of the structure of the magnetosphere which partially protects Earth from the Sun's radiation.

Graphic: Original image by NASA. Additional rendering by Aaron Kaase via Wikipedia.com

In essence, the electrons from the solar wind attach themselves to the orbits of the Oxygen and Nitrogen atoms in our atmosphere and excite them; this gives rise to the colours.

Aurora typically exhibit a prominent green colour, which the interaction with the molecular Oxygen. Atomic Oxygen often gives off a red glow and Nitrogen a pinky colour. The colour is actually the result of a photon of light being emitted from the exited molecule and then returning to what we call its ground state or lowest level of excitement. This takes place at higher altitudes normally way up in the Ionosphere.

To best put yourself in a god place to view the Aurora, you need to travel into the polar regions, Alaska, and Northern Canada; Northern Russia and in Europe places like Norway and Iceland are prime aurora hunting locations.

Once you find yourself in these locations in winter you then have a front row seat for natures most fantastic natural firework display.

As the Earth rotates around, your location will enter what we call the Auroral oval, this is an area of activity away from the pole of the Earth, here, when your locations moves round into this zone you should see, given good clear conditions various Aurora.

Aurora comes in many different forms, from Arcs, to Ray's, Curtains, and others. Some Aurora is quite faint, and a good dark site will be essential to see. Other bright Aurora at the time of more solar activity can easily be seen from cities.

There are of course many legends associated with the lights. In fact people left a record of aurora from around 30,000 years ago in the late Pleistocene era in France where a painting by the Cro Magnon's depicted it, and in 2500Bc the Chinese made Aurora records too.

Hesiod of Greece one of the greatest poets ever to live wrote of "Blazing Skies" and "Dragons", and Aristotle described the lights as a "Shining Cloud"

Various cultures saw the Aurora as harbingers of doom, in Northern Europe for example the lights were considered a bad omen, and warned of illness and Plague. When red aurora was seen this was said to foretell of war and the red being the "blood of battle".

Aurora Borealis as seen in the skies above a hotel near Reykjavik, Iceland. *Photo: Andrew Green*

Aurora Borealis as seen in the skies near Gullfoss, Iceland. *Photo: Andrew Green*

In some Nordic countries the lights were seen as sunlight being reflected from the shields of the Valkyries as they carried the dead to Valhalla. In another the Aurora was referred to as "Bifrost" the path between heaven and earth.

In Alaska, the Inuit feared the Aurora and carried sharp knives which they could wave at the lights dancing above them, some even believed they heard noises from the Aurora trying to communicate with them and the response of that was to whisper back.

Others saw it as a good sign too;

When good Aurora was seen many people believed it was a sign of a good harvest, in Scandinavia when the fisherman saw the Aurora the lights were seen as the reflection off shoals of herring fish and meant a bountiful catch would follow. The Copper Eskimo's of Northern Canada believed the Aurora to be spirits responsible for good weather and bountiful hunting.

One thing is for sure, any culture that has ever witnessed the Aurora will have its own tales to tell and they are many and very varied but always interesting and inspiring.

Now though, we live in the 21st century, we know more about the Aurora then we have ever done before, and with the advent of space travel, we have in orbit, a ready platform from which to observe the lights.

The International Space Station (ISS) is in prime location as it orbits the earth especially over those Polar regions we mentioned earlier. Here, in orbit, the astronauts on board the station have a perfect view of the light show. Many spectacular Aurora displays have been witnessed from this high vantage point. More recently on the ISS cameras and video cameras have all been pointed toward these displays and the resulting images from space are truly spectacular!

In summary, If you ever go to a place where you have a chance of witnessing this magical of natural phenomena, I guarantee that you will be stood in awe whist watching! Please give it a go.


СОЮЗ

The Aurora Australis – seen from a point over the southeast Tasman Sea near southern New Zealand – was photographed from the International Space Station. The station was located at 46.65 degrees south latitude and 169.10 degrees east longitude. *Photo: NASA*

Artist's rendering of NASA's ISS-RapidScat instrument (inset), which will launch to the International Space Station in 2014 to measure ocean surface wind speed and direction and help improve weather forecasts, including hurricane monitoring. It will be installed on the end of the station's Columbus laboratory.

Image: NASA/JPL-Caltech/Johnson Space Center

Watching Earth's winds, on a shoestring

Built with spare parts and without a moment to spare, the International Space Station (ISS)-RapidScat isn't your average NASA Earth science mission.

Short for Rapid Scatterometer, ISS-RapidScat will monitor ocean winds from the vantage point of the space station. It will join a handful of other satellite scatterometer missions that make essential measurements used to support weather and marine forecasting, including the tracking of storms and hurricanes. It will also help improve our understanding of how interactions between Earth's ocean and atmosphere influence our climate.

Scientists study ocean winds for a variety of reasons. Winds over the ocean are an important part of weather systems, and in severe storms such as hurricanes they can inflict major damage. Ocean storms drive coastal surges, which are a significant hazard for populations. At the same time, by driving warm surface ocean water away from the coast, ocean winds cause nutrient-rich deep water to well up, providing a major source of food for coastal fisheries. Changes in ocean wind also help us monitor large-scale changes in Earth's climate, such as El Niño.

Scatterometers work by safely bouncing low-energy microwaves - the same kind used at high energy to warm up food in your kitchen - off the surface of Earth. In this case, the surface is not land, but the ocean. By measuring the strength and direction of the microwave echo, ISS-RapidScat will be able to determine how fast, and in what direction, ocean winds are blowing.

"Microwave energy emitted by a radar instrument is reflected back to the radar more strongly when the surface it illuminates is rougher," explains Ernesto Rodríguez, principal investigator for ISS-RapidScat at NASA's Jet Propulsion Laboratory, Pasadena, Calif. "When wind blows over water, it causes waves to develop along the direction of wind. The stronger the wind, the larger the waves."

ISS-RapidScat continues a legacy of measuring ocean winds from space that began in 1978 with the launch of NASA's SeaSat satellite. Most recently, NASA's QuikScat scatterometer, which launched in 1999, gave us a dynamic picture of the world's ocean winds.

But when QuikScat lost its ability to produce ocean wind measurements in 2009, science suffered from the loss of the data. In the summer of 2012, an opportunity arose to fly a scatterometer instrument on the space station. ISS-RapidScat was the result.

Most scatterometer-carrying satellites fly in what's called a sun-synchronous orbit around Earth. In other words, they cross Earth's equator at the same local time every orbit. The space station, however, will carry the ISS-RapidScat in a non-sun-

synchronous orbit. This means the instrument will see different parts of the planet at different times of day, making measurements in the same spot within less than an hour before or after another instrument makes its own observations. These all-hour measurements will allow ISS-RapidScat to pick up the effects of the sun on ocean winds as the day progresses. In addition, the space station's coverage over the tropics means that ISS-RapidScat will offer extra tracking of storms that may develop into hurricanes or other tropical cyclones.

"We'll be able to see how wind speed changes with the time of day," said Rodríguez. "ISS-RapidScat will link together all previous and current scatterometer missions, providing us with a more complete picture of how ocean winds change. Combined with data from the European ASCAT scatterometer mission, we'll be able to observe 90 percent of Earth's surface at least once a day, and in many places, several times a day."

ISS-RapidScat's near-global coverage of Earth's ocean -- within the space station's orbit inclination of 51.6 degrees north and south of the equator -- will make it an important tool for scientists who observe and predict Earth's weather. "Frequent observations of the winds over the ocean are used by meteorologists to improve weather and hurricane forecasts and by the operational weather communities to improve numerical weather models," said Rodríguez.

Much of what makes ISS-RapidScat unusual is how it came to be. "Space Station Program Manager Michael Suffredini offered us a mounting location on the space station and a free ride on a SpaceX Dragon cargo resupply mission launching in early 2014," explained Howard Eisen, the ISS-RapidScat project manager at JPL. "We had about 18 months to put together an entire mission."

This accelerated timeline is a blink of an eye at NASA, where the typical project is years or decades in the making.

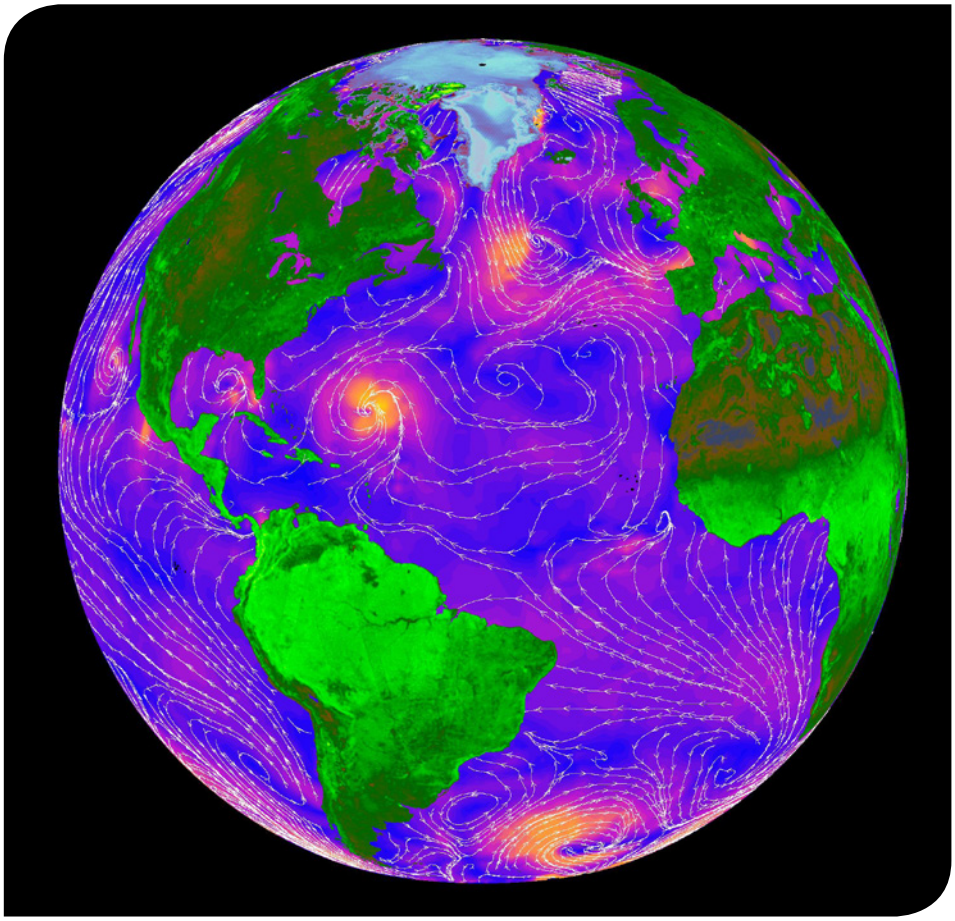
In lieu of using newly-designed instruments, which would be expensive and take too long to develop, ISS-RapidScat reuses leftover hardware originally built to test parts of the QuikScat mission. That process involved dusting off and testing pieces of equipment that hadn't seen the light of day since the 1990s. Fortunately the old hardware seems ship-shape and ready to go.

"Even though they were spares, they've done an excellent job so far," said Simon Collins, ISS-RapidScat's instrument manager at JPL.

In addition to old spare parts, some new hardware was needed to interface this instrument to the space station and the Dragon spacecraft. ISS-RapidScat will use off-the-shelf, commercially-available computer hardware instead of the expensive, hardened-against-radiation computer chips that are typically used in space missions. "If there's an error or something because of radiation, all we have to do is reset the computer. It's what we call a managed risk," said Eisen. The radiation environment on the space station is much less severe than that experienced in more traditional sun-synchronous orbits.

Cost-saving decisions like this are shaping up to make ISS-RapidScat an exceptional bargain of a space mission. Considering that the typical launch alone can cost $200 million, ISS-RapidScat's estimated $26 million price tag seems like a bargain. Previously, NASA estimated the cost of a new mission at approximately $400 million.

"Because it uses much of the same hardware QuikScat did, ISS-RapidScat will allow us to continue the observations of ocean winds already started," said Rodriguez. "Extending this data record will help us observe and understand weather patterns and improve our preparedness for tropical cyclones."



False-color image of ocean wind speeds as measured by NASA's QuikScat satellite in 1999. Orange represents the fastest wind speeds and blue the slowest. White streamlines indicate the wind direction.

Image: NASA/JPL-Caltech


Virgin
VIRGIN GALACTIC

A new era of winged spacecraft launching

The third supersonic test flight of SpaceShipTwo occurred this month as Virgin Galactic continues to progress toward being able to take paying passengers on flights to space later in 2014. *Photo: MarsScientific.com/Clay Center Observatory*

Virgin Galactic's SS2 soars during supersonic test flight

Virgin Galactic, the world's first commercial spaceline, successfully completed on January 11 the third rocket-powered supersonic flight of its passenger carrying reusable space vehicle, SpaceShipTwo (SS2). In command on the flight deck of SS2 for the first time under rocket power was Virgin Galactic's Chief Pilot Dave Mackay. Mackay, along with Scaled Composites' (Scaled) Test Pilot Mark Stucky, tested the spaceship's Reaction Control System (RCS) and the newly installed thermal protection coating on the vehicle's tail booms. All of the test objectives were successfully completed.

The flight departed Mojave Air and Space Port at 7:22 a.m. PST with the first stage consisting of the WhiteKnightTwo (WK2) carrier aircraft lifting SS2 to an altitude around 46,000 ft. At the controls of WK2 were Virgin Galactic Pilot Mike Masucci and Scaled Test Pilot Mike Alsbury. On release, SS2's rocket motor was ignited, powering the spaceship to a planned altitude of 71,000 ft. – SS2's highest altitude to date – and a maximum speed of Mach 1.4. SS2's unique feather re-entry system was also tested during the flight.

Two important SS2 systems, the RCS and thermal protection coating, were tested during the flight in preparation for upcoming full space flights. The spaceship's RCS will allow its pilots to maneuver the vehicle in space, permitting an optimal viewing experience for those on board and aiding the positioning process for spacecraft re-entry.

Editor's note: A more in-depth feature on Virgin Galactic will appear in an issue of RocketSTEM later this year.

The new reflective protection coating on SS2's inner tail boom surfaces is being evaluated to help maintain vehicle skin temperatures while the rocket motor is firing.

SS2's propulsion system has been developed by Sierra Nevada Corp and is the world's largest operational hybrid rocket motor. Although this flight saw it burn for a planned 20 seconds, the system has been successfully tested in ground firings to demonstrate performance characteristics and burn time sufficient to take the spaceship and its private astronauts to space.

Commenting on the successful test flight, Sir Richard Branson said: "I couldn't be happier to start the New Year with all the pieces visibly in place for the start of full space flights. 2014 will be the year when we will finally put our beautiful spaceship in her natural environment of space. Today, we had our own Chief Pilot flying another flawless supersonic flight and proving the various systems required to take us safely to space, as well as providing the very best experience while we're up there."

This flight was the third opportunity to see a supersonic, rocket-powered test of the Virgin Galactic system after dozens of successful subsonic test flights.

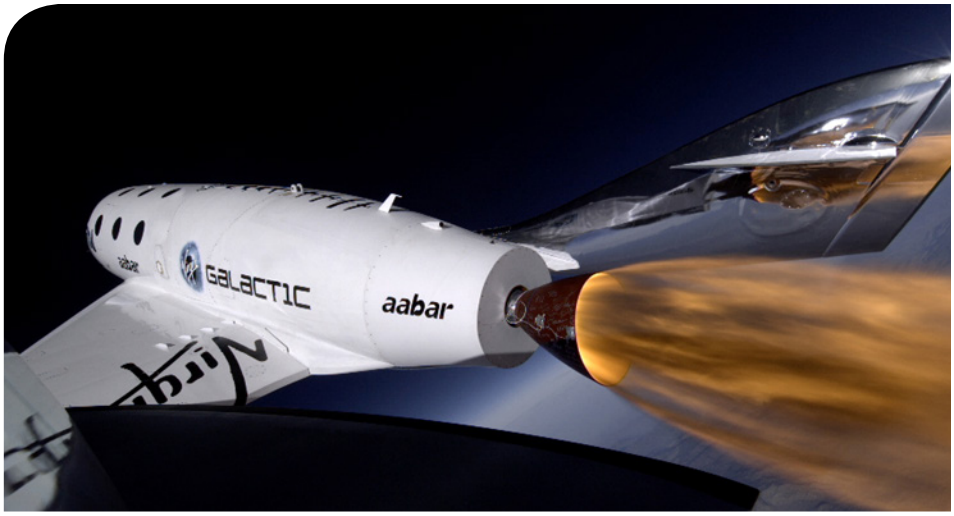
"Today's flight was another resounding success," said Virgin Galactic CEO George Whitesides. "We focused on gathering more transonic and supersonic data, and our chief pilot, Dave, handled the vehicle beautifully. With each flight test, we are progressively closer to our target of starting commercial service in 2014."

For Mackay, the flight was a "dream come true."

"I have watched SS2 evolve over the years into an incredible vehicle that is going to open up space to more people than ever before," he said. "To be behind the controls and fly it as the rocket ignited is something I will never forget. She flew brilliantly. All the tests went really well and generated vital data that will be used to further fine-tune our operations."

Virgin Galactic is on track to be the world's first commercial spaceline. To date, the company has accepted more than $80 million in deposits from approximately 680 individuals, which is 20% more than the total number of people who have ever gone to space. The new spaceship (SpaceShipTwo, VSS Enterprise) and carrier craft (WhiteKnightTwo, VMS Eve) have both been developed for Virgin Galactic's vehicle fleet by Mojave-based Scaled Composites.

The VSS Enterprise and VMS Eve test flight program is well under way, leading to Virgin Galactic commercial operations, which will be based at Spaceport America in New Mexico.



A closeup look of the rocket engine firing during the recent third supersonic test flight of SpaceShipTwo which reached a speed of Mach 1.4. *Photo: Virgin Galactic*

"2014 will be the year when we will finally put our beautiful spaceship in her natural environment of space."

- Sir Richard Branson

Tail-cam view of the hybrid engine burning during a test flight of SpaceShipTwo which saw the vehicle ascend to 71,000 feet over the Mojave Desert. *Photo: Virgin Galactic*

WhiteKnightTwo (VMS Eve) and SpaceShipTwo (VSS Enterprise) *Photo: Virgin Galactic*


TSC
THE SPACESHIP COMPANY
GALACTIC

XCOR Aerospace Lynx

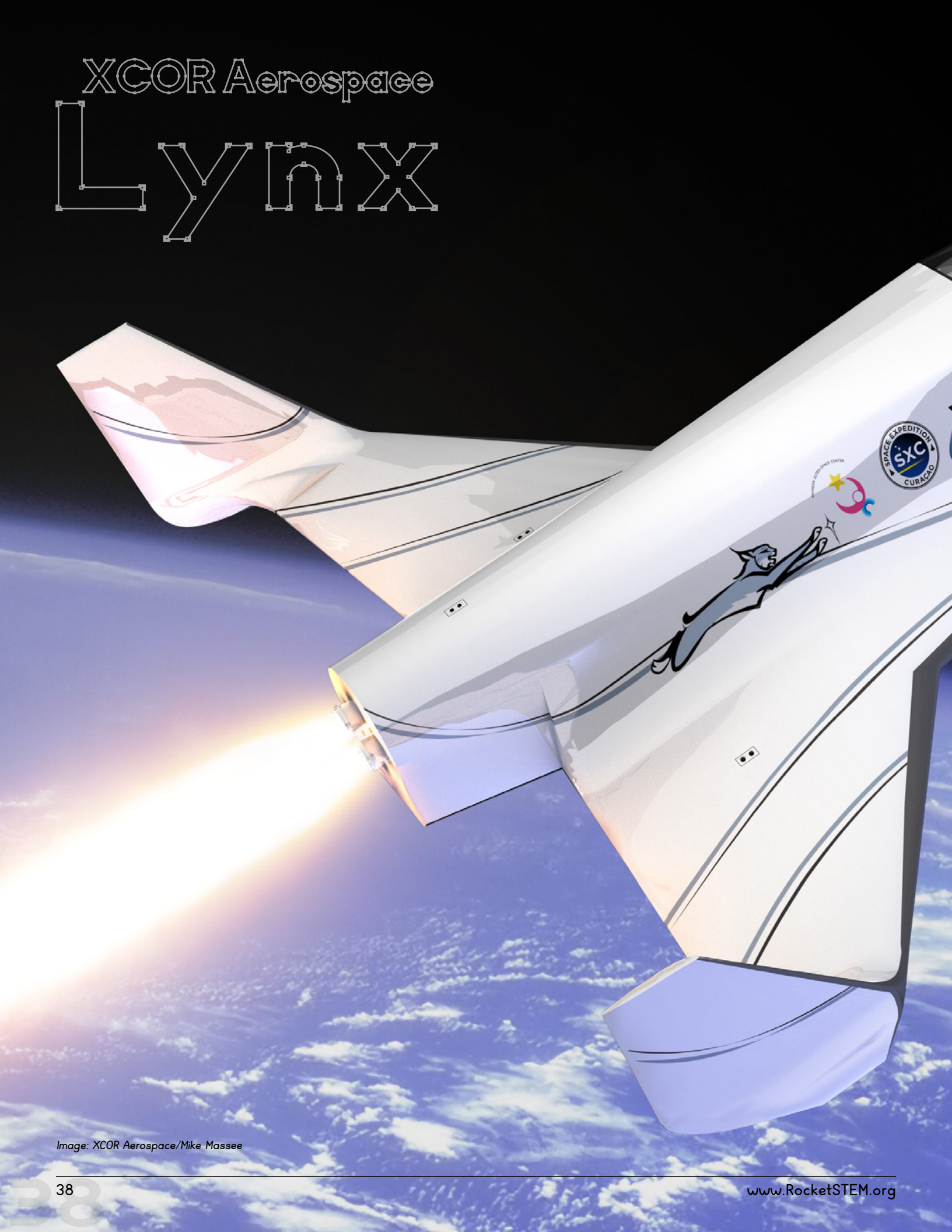


Image: XCOR Aerospace/Mike Massee

Lynx spacecraft to give big boost to space tourism

By Sherry Valare

Like a scene out of a futuristic movie, imagine an airplane that could take off from a runway, fly sub-orbital, and return to the ground with a runway landing. The concept seemed pretty far-fetched not even ten years ago. Now, a handful of commercial spaceflight companies are breathing life into what was once only sentiment. The Reuseable Launch Vehicle (RLV) industry is heating up fast. With several different companies having similar spacecraft in various stages of production or testing, the race is on, and XCOR Aerospace is close to the finish line.

XCOR has developed an RLV they call "Lynx". It is powered by a fully reusable rocket propulsion system that gives it the unique capability of taking off and landing horizontally, while most other companies are using rocket rides and air-launch methods to take to the skies. Some of the advantages the Lynx spacecraft boasts are a low operating cost and the capability of fulfilling four flights per day with two-hour turnarounds in between, without any compromise to the safety of the vehicle. Lynx will be able to operate out of any spaceport with a 7,900 foot runway, though the first flights will occur at the Mojave Air and Spaceport in California. Lynx will take paying customers for rides as tourists, and transport research payloads, as well.

A flight in the Lynx will last about thirty minutes. Fueled by a burning mix of liquid oxygen (LOX) and kerosene, 2,900 pounds of thrust will be created by each of the four XR-5K18 rocket engines residing in the back of the fuselage. This will lift the vehicle through takeoff and ascent, where it will reach a maximum airspeed of Mach 2.9 until about 3 minutes into flight. At this point, Lynx will be around 190,000 feet in the air, where it will turn off its engines and coast upwards, until it reaches apogee at 328,000 feet. It will experience weightlessness for about 4.6 minutes, followed by re-entry, with its passengers experiencing gravity four times greater than normal. The final leg of the trip is a spiral glide back to the runway where Lynx will safely touch down and roll to a stop.

Jeff Greason, President of XCOR Aerospace, explains, "It takes about a minute after engine light to go supersonic. At about 70 to 80,000 feet, the sky will start to turn dark, and by 100,000 feet, it's gone black. You will get an opportunity to maneuver, using the reaction control systems – turn it upside down, pick different attitudes, and just hold there. You're going to get a spectacular view. And then from there, it's just a long glide back home."

There are three versions of Lynx that XCOR plans to build. The Lynx Mark I, at XCOR's Mojave facilities undergoing development, is a prototype spacecraft that will serve as a test vehicle. It is due to begin its flight test program this year. Its equipment and systems will be tested until the full flight profile has demonstrated capability.

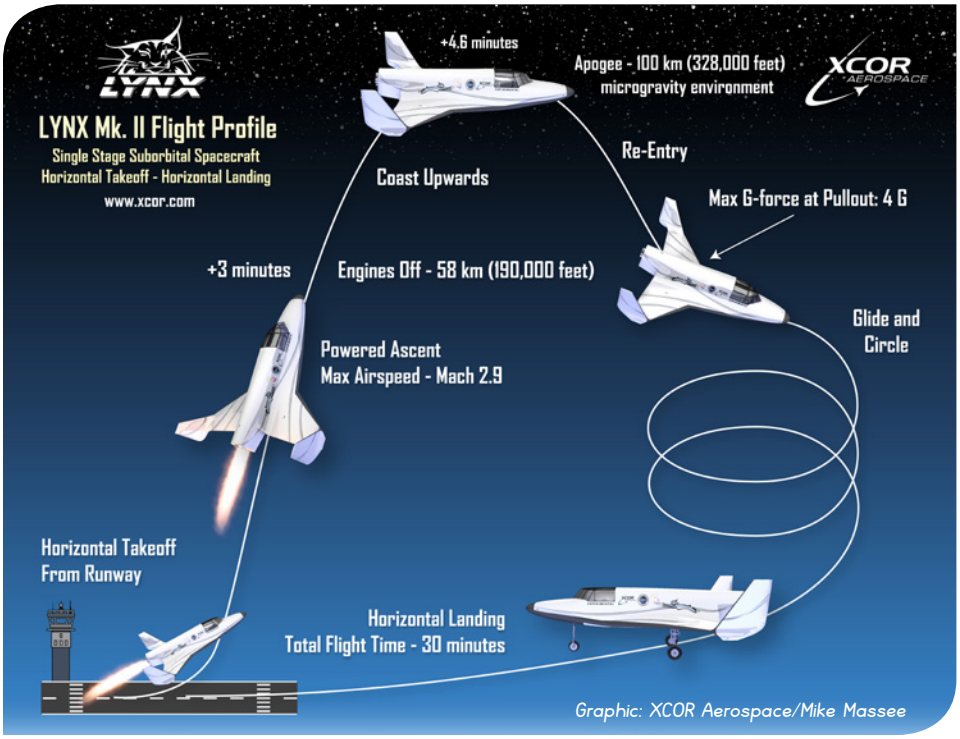
Once complete, the craft will be licensed as a launch vehicle under Federal Aviation Administration rules to provide commercial services. This version will primarily be used to train pilots and crew for the Lynx Mark II and is only made to reach an altitude of about 200,000 feet.

Lynx Mark II is the version that will take tourists and commissioned payloads into sub-orbital space. It will undergo construction and assembly as the Lynx Mark I is going through its development program. This is the craft which will carry passengers so they can get the experience of being in space, as it takes them to a weightless environment at the peak of the flight, along with a view of the curvature of the earth against an infinite backdrop.

The Lynx Mark II will also carry microgravity and biotechnological experiments to take advantage of its internal payload volume. This version of Lynx will use identical propulsion and avionics systems as its predecessor, but it will have a lower dry weight leading to a higher performance due to key innovations currently proprietary to XCOR. It is designed to reach an altitude of 328,000 feet as long as specific payload weight limits are achieved.

The third version of the spacecraft will be derived from the Mark II model, with several modifications for enhanced payload capability. This will be achieved by adding a dorsal pod to the body of the craft, allowing for up to 650 kg additional payload, which can be in the form of experiments, or even small satellites. This Lynx Mark III model will have upgrades to its core structure, landing gear, and aerodynamics. It will also receive needed improvements to the power of its propulsion system to accommodate the extra weight it will be modified to carry.

Artist rendering of the Lynx suborbital vehicle. *Image: XCOR Aerospace/Mike Massee*



Graphic: XCOR Aerospace/Mike Massee

So if you wanted to take a ride on Lynx, here is how it would work. First, you will have to purchase a ticket, which comes with a price tag of about $100,000 per flight. However, you cannot just buy a ticket and hop into the passenger seat. XCOR will thoroughly educate you and conduct a screening process prior to flight preparation. You will then need to undergo medical screening and G-force training with other space tourists before you aim for the stars. XCOR is currently offering reservations for future flights. To begin the application process, go to www.xcor.com, and click on the link for ticket purchasing.

When it is time to fly, you will be outfitted with a fully pressurized suit in case an emergency situation should arise. The cabin is pressurized,

but spaceflight is always risky business and contingency life support is a must. The Lynx can accommodate one passenger per flight. According to former NASA astronaut, Col. Richard Seafoss, who is now Chief Test Pilot for XCOR, "Flying with us aboard the Lynx is a whole set of different experiences. All of the things that I experienced flying the shuttle, all of those phases of flight, are there. The boosts, the weightlessness, the fact that you are up in the pilot's seat as opposed to being in the back of the plane like a passenger on an airliner – this is more like "The Right Stuff" kind of experience."

Though the price tag seems high, XCOR is offering flights at a much lower cost than its competition. The company that will emerge as the leader in this exciting area of commercial spaceflight is yet to be seen, but XCOR is speculated to send up its first tourist flight in 2014. If all goes as planned, it won't be long until we get to see the world from the perspective of a space tourist. Col. Seafoss has referred to the trip as the 'Greatest Ride Off Earth'. With that kind of description, it can easily be deduced that one's head will remain in the clouds long after the flight has landed.

The Lynx main engine being test fired at the XCOR test site located on the Mojave Air and Space Port in Mojave, California. *Photo: XCOR Aerospace/Mike Massee*

Lynx spacecraft making big screen debut

By Sherry Valare

There is a lot of excitement coming in the near future for the Lynx spacecraft and everyone involved in its development at XCOR Aerospace. In a partnership with Centerboro Productions, XCOR's Lynx spacecraft is going to be making its acting debut in the upcoming Science Fiction/Action/Thriller 3D movie "Newcomers", where a NASA astronaut becomes the last line of defense against a global alien invasion.

Scheduled to start production this year using regular and 3-D cameras on board the Lynx spaceship, this film will be the first to have exclusive footage shot from sub-orbital space by a privately owned commercial spaceflight company. The Lynx will be piloted by Col. Richard Seafoss. Andrew Nelson, Chief Operating Officer of XCOR said, "We are delighted to have our Lynx spacecraft showcased in the film. We think that Newcomers will be a fantastic piece of entertainment for science fiction fans."

There will be a number of promotions surrounding the release of the film. According to Patricia A. Beninati, Producer and Writer from Centerboro Productions, "XCOR has provided the company with tickets for rides aboard the Lynx into sub-orbital space. During production, there will be public announcements made and contests to win tickets for the ride of a lifetime". Additionally, they are planning the film's grand opening at NASA's Kennedy Space Center. There will also be giveaways at the end of the movie.

Though Beninati was unable to disclose the specific details at the moment, she did mention that inspiring our youth to critically think about issues related to the long-term survival of our planet will hopefully become an inherent side-effect of the movie's underlying theme. The producers are deeply involved in educational initiatives - especially when it comes to keeping children dreaming and making content that will inspire them to be the next group of astronauts and scientists.

"Newcomers" movie will present an exhilarating, action-packed adventure, following a NASA astronaut and Air Force pilot down on his luck, who gets called back to duty at the beginning of an alien invasion to save the planet.

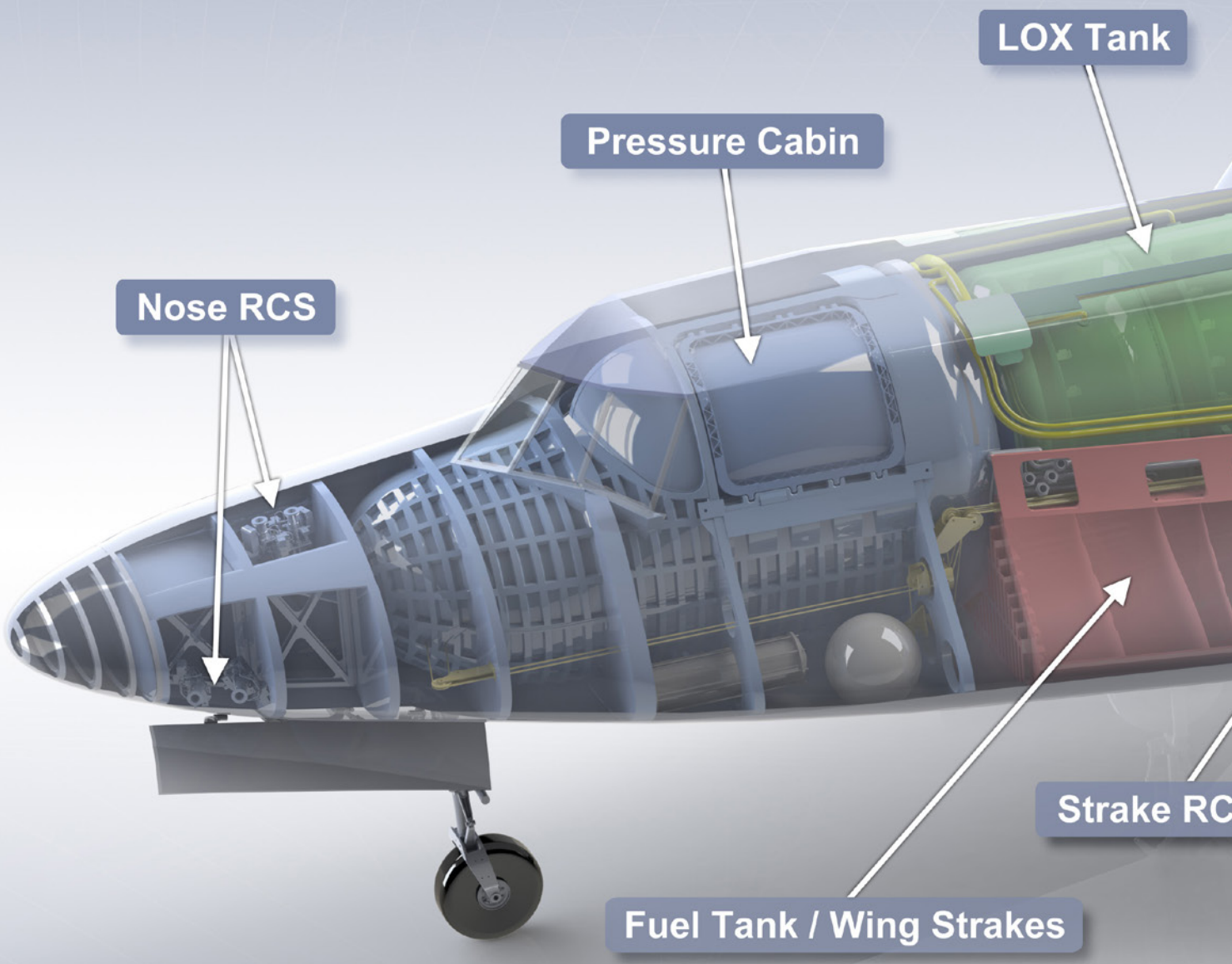
Endearing NASA astronaut Mike Massimino, whose notable space accomplishments include two shuttle missions, STS-109 and STS-125 (both of which serviced the Hubble Space Telescope), along with being the first astronaut to use Twitter from space, has a role written into the script for him to play the lead role's best friend in the movie. You may recall Massimino's previous acting experience as a guest star on several episodes of the "The Big Bang Theory".

The "Newcomers" screenplay, which will be checked for scientific accuracy by NASA scientist Lewis L. Peach, was adapted from an original story created by Beninati. Actor and crew training for the film will take place at various NASA locations and XCOR Aerospace.

Get ready for an intergalactic thrill ride that will knock you out of your seat!

LYNX®

Suborbital vehicle



Propulsion and Life Support Subsystems

Sierra Nevada Corporation

Dream Chaser

Image: Sierra Nevada Corp.

Dream Chaser nears piloted tests

By Mike Killian

On Oct. 26, 2013, Sierra Nevada Corporation put their Dream Chaser engineering test article through its first free flight Approach and Landing Test, or ALT-1, at NASA's Dryden Flight Research Center in southern California.

The important flight test, a first since the late 1970s with NASA's space shuttle test article Enterprise, performed flawlessly up until the command was given to deploy the landing gear. An anomaly was encountered, causing the left landing gear to snag, and although Dream Chaser touched down on the runway 22L centerline at Edwards Air Force Base, the vehicle did sustain some minor structural damage.

That incident, however, may actually speed up Dream Chaser's development, rather than delay it.

"We believe we had a very successful first day. The issue that we had is certainly one that I would like not to have had, but at the end of the day – on the list of things that could have gone wrong for us – it was one that is very minor in the future of the vehicle," said Mark Sirangelo, Vice President of Sierra Nevada Corporation's Space Systems at a teleconference held days after the test flight. "We don't think its actually going to set us back, in some interesting way it may actually accelerate our progress. If we got all the flight data we needed to get we may actually be able to get the vehicle back to Colorado earlier to get it ready for its next flight, which may actually accelerate the program."

The Dream Chaser was carried aloft in the skies over Edwards Air Force Base and dropped from an altitude of 12,500 feet by an Erickson Air-Crane helicopter. The release itself was accomplished perfectly, sending the vehicle into a steep 50-degree nose dive to exactly replicate the orbital re-entry flight path and prove Dream Chaser's design is truly air-worthy.

"About 10 seconds into the dive the commands were given by the vehicle, as predicted, to begin the pullout of the dive and enter into its glide into Edwards," said Sirangelo.

The Dream Chaser engineering test article (main photo) comes in for an autonomous landing at Edwards Air Force Base. Calif. The view from inside the crew compartment view is shown in the inset photo. *Photos: Sierra Nevada Corp.*

"All commands given during the flight were successful, and after a period of 30-35 seconds the vehicle began finding the runway, associating itself, getting itself ready for landing, and conducting what was almost a perfectly stable flight. In the final 20 seconds of the flight the vehicle acquired the runway and lowered its rate of descent to 1.58 feet per second, exactly as predicted, and landed at 160 knots, almost precisely on the runway where we wanted to land."

The 60-second flight itself was fairly uneventful, as the vehicle's automated flight control system did its job of steering the test article to its intended glide slope automatically based on data collected by the vehicle's sensors and flight computer. However, when the vehicle's Ground Radar Altimeter initiated the sequence to open the landing gear, an anomaly occurred—the left landing gear was snagged.

"As the vehicle began its roll down the runway the automatic software noticed that the vehicle was having some difficulty and commanded the controls to compensate for that, which was something that we had predicted but we had not known was going to happen," said Sirangelo. "Unfortunately the anomaly with the gear, which we are still investigating, caused the vehicle to eventually land down on its left side and skid off the left side of the runway. There was no damage to the runway and there were no personnel injuries of any type. The vehicle was damaged as it skidded off the runway but we believe it to be repairable and flyable again."

"The 99% of the flight that we really wanted to get - which was does this vehicle fly, is it able to be controlled, does the software work, can we autonomously fly the vehicle in to approach and land on a runway – all that was 100% successful," added Sirangelo. "In

fact, we probably performed better than the original test standards were meant to be. We deem this to be a significant success."

Although the flight did not end as everyone had hoped, the incident provided a wealth of valuable data showing how strong the vehicle is.

"The entire interior of the vehicle, the pressure vessel as we call it, or crew compartment, was completely untouched by the incident," said Sirangelo. "All systems were fully operational, there was no damage whatsoever to any of the components of the vehicle. All the flight computers continued to work, and they are still working, and there was no damage to any of the sensitive parts of the vehicle – which tells us that the composite structure and the airframe is actually quite stable and quite strong for what we needed to accomplish."

"As we stand right now we believe we have the data, we looked at all the data and its almost exactly as was predicted by our computing models," added Sirangelo. "We were so successful that we actually received all of the data we think we needed for testing."

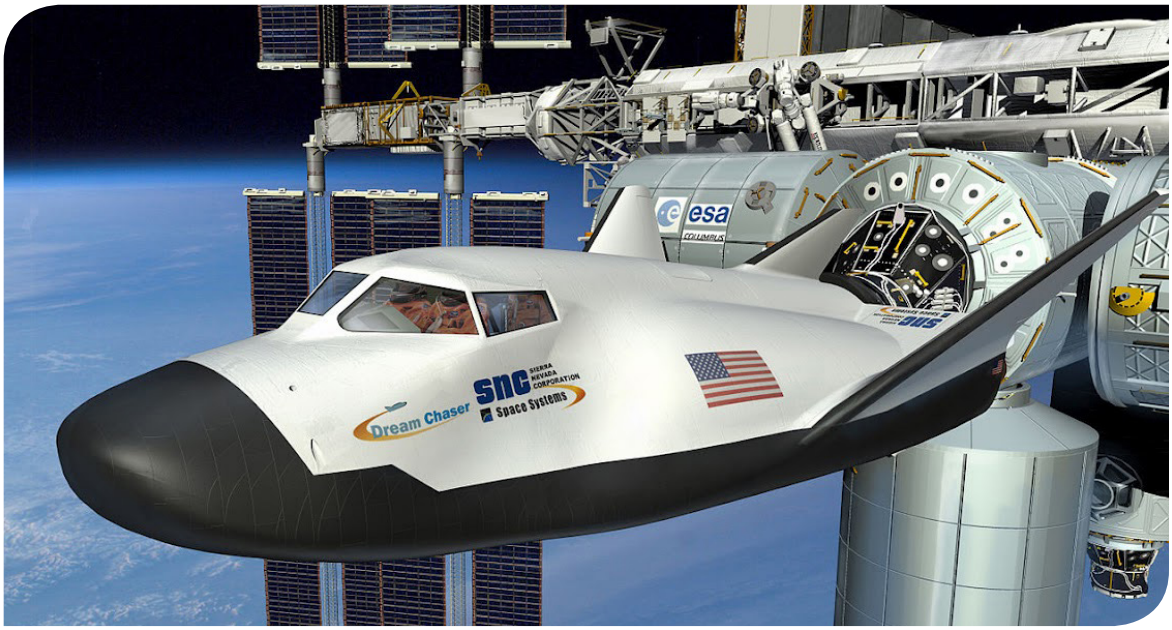
Even though the investigation of the landing gear problem is ongoing, the data points to a mechanical failure, possibly with the door or latch—as none of the primary systems that gave the commands that control the flight failed or had any problems. Both landing gear systems—main gear and nose gear—are connected; they are mirror images of each other, and the right landing gear deployed as expected and was fully functional. Had the spacecraft design or software caused the problem, it would have affected both the right and left main landing gear.

"The vehicle has all of its components, nothing was lost – the tail, the rudders, the entire structure of the vehicle is with us and sound," added Sirangelo. "The one landing gear in question is still attached to the vehicle, it did eventually deploy, obviously not properly but its still there, we didn't lose it. The vehicle is surrounded by a very strong composite structure shell, which is where all the important materials (computers, crew compartment, etc) would be, and then it is surrounded by over six inches of protective layer – which in this case was a simulated thermal protection system (TPS). That actually effectively cushioned the vehicle as it went through its flight off the runway, and while that was damaged its a fairly insignificant part of it."

"The core structure, all the flight controls, the rudders, the airlons, all those are still attached and working," added Sirangelo. "We did lose some of the protective coating and shell of the vehicle and sustained some minor damage to some of the composites and the structure underneath. The very strong front nose skid actually continued to hold the vehicle up and do exactly what it was designed to do, and it is fully functional and working right now."

The Dream Chaser, described by many simply as a "mini space shuttle," is a lifting body human spacecraft designed to carry as many as seven astronauts, and it is the only spacecraft under the Commercial Crew Development Round 2 (CCDev2) agreement with NASA's Commercial Crew Program (CCP) that is winged and designed to land on any conventional runway capable of handling commercial traffic.

"NASA Langley did a lot of research on the vehicle in the 80' and 90's, based off a Russian heritage design called the Bor 4" said former astronaut and SNC Space Exploration Systems Vice President James Voss in 2012. "They did wind tunnel analysis, a lot of



Artist renderings of the Dream Chaser docked at the ISS (right photo). and being prepared to launch atop an Atlas V rocket (following page).
Images: Sierra Nevada Corp.

computational fluid dynamics analysis, and they did simulations with it," added Voss. "They created the control laws to be able to fly it and had a lot of astronauts come in to try it and fly it, so they did thousands of hours of work on it.

"When our company (SNC) decided to pick up a vehicle to be in using we thought it was not very smart to start with a clean sheet of paper, but lets use something NASA has already put a lot of effort and research into. So we took the basic design and we changed it only slightly."

The company hopes to launch the first autonomous spaceflight in 2016 atop a United Launch Alliance Atlas-V 402 rocket, with the first crewed mission espected to launch in the third quarter of 2017.

A fleet of Dream Chasers is planned to be based out of Florida's historic launch sites at Kennedy Space Center and Cape Canaveral Air Force Station. No abort blackout zones and a 3.5-day free flight capability—with the added benefit of deorbiting at any time (since Dream Chaser can land on any conventional runway)—are a couple of the vehicle's main selling points.

The spacecraft will also be able to stay at the International Space Station for up to seven months at a time, if needed, before having to return to Earth. An expected 1.5 G nominal reentry will provide ideal conditions for returning fragile cargo and science experiments, in addition to making the return to gravity easier on the crew. SNC also anticipates there to be immediate access to crew and cargo upon landing.

A quick turnaround and an almost entirely reusable vehicle put Dream Chaser in a class all its own.

"We had over 30 conditions that we were testing for the flight, and the vehicle either met or exceeded – in a positive way – all 30 of those conditions," said Sirangelo. "The flight was extraordinary."

Sierra Nevada is one of several companies currently competing to develop commercial crew transportation capabilities in cooperation with NASA, with the goal of achieving safe, reliable, and cost-effective access to and from low-Earth orbit (LEO) and the International Space Station.


Drea
BRACKETT

SNC Dream Chaser *Photo: NASA*

While still years away from flying, the Skylon may revolutionize how humanity soars to space in the 2020s. *Image: Reaction Engines*

Bond's Skylon to achieve dream of single-stage-to-orbit vehicle

By Amjad P. Zaidi

In the UK's Oxfordshire countryside, the legacy of British invention is being passed from Sir Frank Whittle to a new group of dedicated aerospace engineers and one man in particular; Alan Bond.

The long held dream of UK spaceflight is coming closer to reality, and his dream could be a game-changer.

Despite decades of lacklustre political interest Reaction Engines Limited (REL) is working on a revolutionary engine that could herald a new era of space travel.

Historically the UK, while being rich in inventing talent, has increasingly suffered from a decline in "big growth" industries.

This was especially true due to the costly rebuilding efforts after the Second World War when successive government investment and appetite for fiscally supported industrial and sector wide initiatives has waned.

Against this stark backdrop, lifelong inventors, like Bond, have toiled away on meagre funds dedicated to their concepts, holistic thinking and often encountering obstacles along the way. However this landscape could change soon.

Alan Bond and REL are behind Skylon; the successor to Britain's aborted HOTOL space-plane concept of the late 1980s. It is an unpiloted fully reusable aircraft-like vehicle capable of transporting 15 tonnes of cargo into space and is intended as a replacement for expensive expendable launchers in the commercial market.

Skylon aims to be the first single stage to orbit (SSTO) vehicle in the world, addressing the needs of all major space launch markets (telecoms payloads, multiple small satellites, personnel, cargo, space station supplies and orbital infrastructure embedding).

The Skylon vehicle consists of a slender fuselage containing propellant tankage and a payload bay, with delta wings attached midway along the fuselage carrying the SABRE (Synergetic Air Breathing Rocket Engine) engines in axisymmetric nacelles on the wingtips.

Within these SABRE engines lies a unique technology developed by Bond and so far untapped by the wider aerospace and space industry.

Children of Apollo

Inspired by the adventures of British Astronaut pilot Dan Dare in the Eagle comics of the 1960s, Bond's inspiration for manned spaceflight began at an early age. As a teenager, Bond built rockets in his back garden shed but began to

challenge conventional thinking in launch technology.

Since Sputnik 1 in 1957, all spacecraft and satellites have been placed into orbit by expendable multi-stage rockets. Like many in the aerospace community, Bond believes that these have a fundamental design flaw. Whether a launch vehicle is powered by solid or liquid propellant, a large proportion of a vehicle's launch mass is taken up by its oxidiser that is required for combustion to take place. The irony is that for much of its launch the vehicle is passing through all the oxygen it needs in the Earth's atmosphere.

As conventional rockets have been developed with long lead times and high cost for single use, there is no learning curve or opportunity for error and cost reduction in any one vehicle. Consequently, Bond believes that there is no value for money from re-use of these vehicles. The key to reliable, responsive and cost effective access to space lies in a different aircraft / spacecraft configuration.

Alan Bond's persistent challenge to this conventional thinking is perhaps analogous to another visionary engineer, John Houboult without whom reaching the Moon during the 1960s would perhaps not have been possible.

Bond conceived a hybrid jet and rocket engine design that uses a unique air breathing rocket engine which can potentially revolutionise how future launch vehicles can reach orbit. Finessing and progressively developing this design concept over 30 years, he and his engineering team have incorporated this concept into the SABRE engine which is integral to the Skylon design.

In the 1970s during his tenure at Rolls Royce, Alan Bond began actively pursuing the holy grail of launch technology; an SSTO launch vehicle. As conventional space faring rockets have to have variations in design using three propellants (Liquid Oxygen, Liquid Hydrogen and Kerosene) and multiple largely unrecyclable stages, he believed that this design was not fit for purpose.

By 1982 he was already investigating methods for getting the oxidiser from the atmosphere, much like modern jet aircraft. By not cooling the air to liquid but cooling the gas and work needed to compress it, with a clever use of thermodynamics Bond had discovered a concept that formed the basis of the engines for HOTOL (Horizontal Take Off and Landing), Skylon's forerunner.

During the 1980's Bond teamed up with Bob Parkinson (British Aerospace) and John Scott-Scott (Rolls Royce) to lead Project HOTOL securing funding from the UK Government, British Aerospace and Rolls Royce.

Feasibly the concept was sound but the practicalities of incorporating the revolutionary engine concept into a flawed airframe design led to the project falling short of its ambitions.

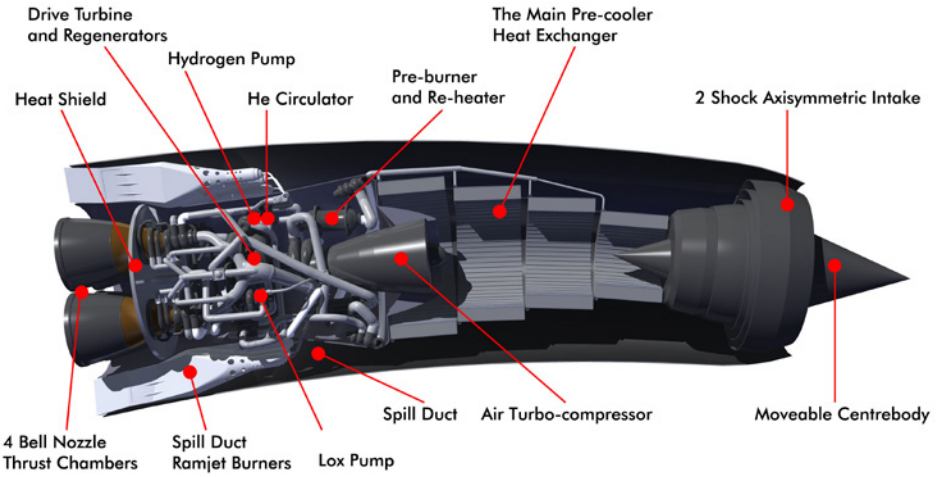
Bond's team had also discovered a method to remove super-heated air entering HOTOL's engines but were continually derailed by frosting and ice build-up as a result of their engine cooling efforts. HOTOL was seen as a failure by many within Margaret Thatcher's Conservative Government at the time; an expensively flawed and commercially non-viable space-plane compared to the US's Space Shuttle. It was also Britain's last chance to join the club of spacefaring nations. As the project came to an end, Kenneth Clarke who was then Trade and Industry Secretary in Thatcher's government pulled the plug and withdrew support.

And so began the UK's shift to being a space consumer and minor ESA partner, rather than leading the way and being a space developer of launch technologies. Any giant engineering leaps of ambition were it seemed an act of folly for the UK government and British investors, yet the dream stayed alive with true believers like Bond.

With no home government investment and sponsors Bond patented his engine designs and his team tried to approach more favourable European partners but they were quickly bound by the UK Government's Official Secrets Act.

HOTOL was off limits as proprietary UK technology could not be shared or developed with foreign firms, nations or even other UK based firms.

This was a short sighted nationalistic and militaristic manoeuvre halting development momentum and has been echoed



The Skylon will utilize the SABRE engine to accomplish single-stage-to-orbit launches as the engine is capable of pulling oxygen from the sky to use as a fuel oxider, thereby reducing the weight of the vehicle on takeoff. *Image: Reaction Engines*

years later by the ITAR issues that have stymied the US Commercial Space Sector.

Britain had closed the door on any active role in developing space vehicles and with it, independent access to space. Despite these setbacks, Bond retreated to reform his concepts with a new team.

The Three Rocketeers

Saving the best lessons learned from the HOTOL Project, in 1989 Bond formed Reaction Engines Limited with John Scott-Scott and Richard Varvill also from Rolls Royce. As a small research company on a shoestring budget, computer simulations and models were the only way they could test their theories for a very long time.

During the next twenty years the trio further refined the HOTOL concept and airframe, shifting the centre of mass to create a more stable flight design. All this was done bypassing the UK Government's Official Secrets Act and Bond's own patents with more nuanced offshoot aerospace discoveries- and also without a penny of government funding.

Bond also pioneered the new use of compact, lightweight heat exchangers within the rocket engine cycles which greatly increased their efficiency by allowing the engines to use atmospheric air to burn in the combustion chambers like conventional jet aircraft, rather than using heavy liquid oxygen stored in on-board tanks, during the portion of launch within the atmosphere.

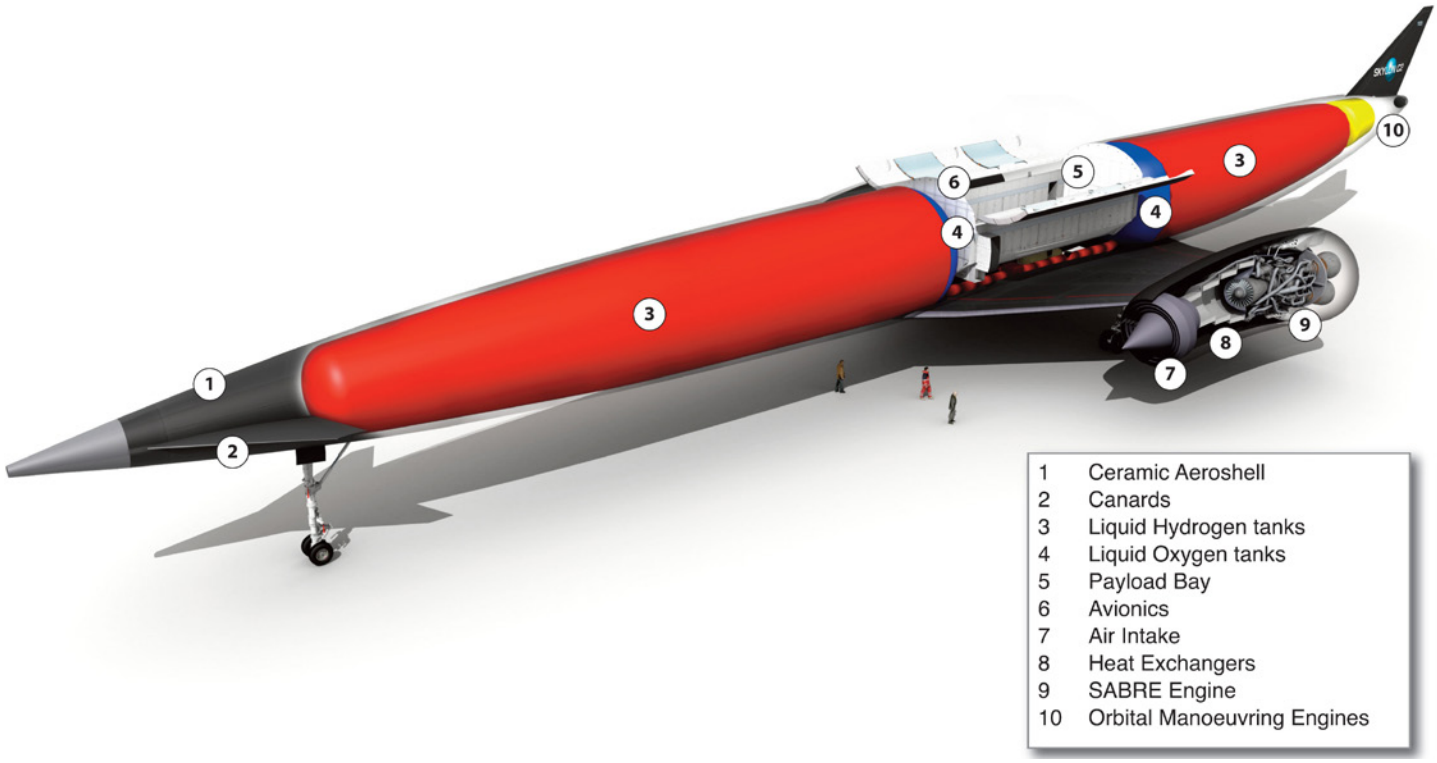
Given the high Mach speeds that the final vehicle would need to reach gravitational escape velocities, the patented heat exchanger technology enabled heat extraction from the engines at super-hot temperatures that would otherwise melt the metal alloys in the engine. This enabled the high (Mach) speed air coming into the engines to be cooled from 1000 degrees Celsius to minus 150 degrees Celsius in a microsecond. It also successfully bypassed the ice build-up problem that derailed HOTOL (via a new patented frost control system) in the process. 400 megawatts of heat could be transferred from the air before intake into the engines.

This approach also enabled SABRE-powered vehicles to save carrying over 250 tons of on-board oxidant on their way to orbit, and removed the necessity for massive throw-away first stages that are jettisoned once the oxidant they contain has been used up, allowing the development of the first fully re-usable space access vehicles, such as Skylon.

The heat exchangers are proprietary technology unique to REL and to date no other aviation or space company has anything like it in development.

Like the miniaturisation of the microchip, Bond determined that size, weight and high powered effectiveness of this key component would be the foundation of the entire project. The lightweight heat exchangers he has designed can be incorporated into REL's new SABRE engine to power modified aircraft directly to Earth orbit and propel aircraft at Mach 5 cruise speeds. The heat exchangers are reportedly 100 times lighter than any current technology and have pre-cooler tube walls only 27 microns thick but capable of withstanding pressures greater than 150 bars of atmospheric pressure at extreme temperatures.

As with all launch vehicles, weight



An annotated. cut-away view of the Skylon given a glimpse as inner workings of the spacecraft.

Graphic: Reaction Engines

As an example of the applicability of REL's SABRE engine and heat exchanger technology to Mach 5 cruise. REL and the European Union are exploring a new aircraft called LAPCAT. It would use the Scimitar pre-cooled engine – a derivative SABRE engine – which would allow for commercial flights between Brussels and Sydney – a distance of 18,700 km (11,600 miles) in less than five hours. *Image: Reaction Engines*

and material tolerances to extreme environmental variables are crucial factors and the lightweight heat exchangers appear to solve these critical problems.

During 1989-2000 work focused on the development of the SABRE engine and the final Skylon launch vehicle. Innovations in aerothermodynamics, propulsion and control technology attracted a great amount of interest, private investment and finally government support.

The innovative carbon fibre reinforced plastic fuselage for Skylon provides a strong yet lightweight airframe, surrounded by a single skin of material, a ceramic external aeroshell. This is corrugated for stiffness and thermal compliance on the substructure upon which it is mounted. A thorough research programme followed, demonstrating the techniques for full scale heat exchangers and the manufacturing techniques to build these components.

ESA independently reviewed the work performed by Bond and REL for the UK government, removing any technical concerns and largely validating Bond's approach. In 2011 ESA reported the following to the UK Space Agency:

"ESA are confident that a ground test of a sub-scale [SABRE] engine can be successfully performed to demonstrate the flight regime and cycle and will be a critical milestone in the development of this program and a major breakthrough in propulsion worldwide."

Return to flight

The UK government and the UK Space Agency had removed themselves from the launch technology game following the Thatcher government's notional withdrawal from UK space efforts in the 1980s.

However in early 2012, buoyed by ESA's recommendations, Bond and REL began testing the first full scale SABRE pre cooler with a jet engine to test heat exchanger performance in a working environment. This demonstration pre-cooler included over 50 kilometres of heat exchanger tubing weighing less than 50 kilogrammes and dropped the air temperature to minus 150 degrees Celsius in 20 milliseconds.

In November 2012 REL announced successful completion of the SABRE engine tests with its pre-cooler heat exchanger and ESA gave its official validation of the results which was backed up by the UK Minister for Universities and Science David Willetts.

Willetts has earmarked SABRE and Skylon as a "high priority" technology project and is working with the UK's Department of Transportation to allow Skylon flights within UK airspace. Bond himself has said;

"These successful tests represent a fundamental breakthrough in propulsion technology. Reaction Engines' lightweight heat exchangers are going to force a radical re-think of the design of the underlying thermodynamic cycles of aerospace engines. These new cycles will open up completely different operational characteristics such as high Mach cruise and low cost, re-usable space access, as the European Space Agency's validation of Reaction Engines' SABRE engine has confirmed.

"The REL team has been trying to solve this problem for over 30 years and we've finally done it. Innovation doesn't happen overnight. Independent experts

have confirmed that the full engine can now be demonstrated. The SABRE engine has the potential to revolutionise our lives in the 21st century in the way the jet engine did in the 20th Century. This is the proudest moment of my life."

In July 2013 the UK Coalition government announced its intention to invest £60 million ($90 million) into the full development of the SABRE engine, creating 21,000 jobs in the UK aerospace and space sectors. This will maximise the UK's access into the high growth £13.8 billion ($20.7 billion) launcher market over the next 30 years with all the associated economic benefits rippling out from this investment. The initial £60 million will prime the pump for the remainder of the investment capital needed to fully develop the SABRE engine and will be divested over 2013-16 to REL.

The SABRE development programme itself is expected to last from 3-5 years. A prototype SABRE engine is expected in 2017 with flight tests around 2020.

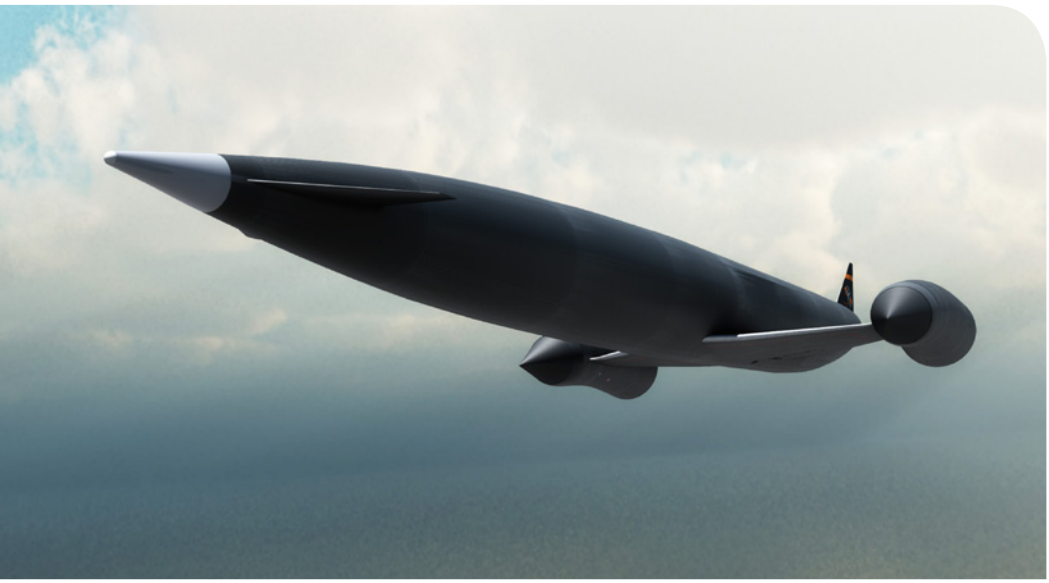
In August 2013 ESA funded a £0.9 million ($1.35 million) study, by a consortium of companies to establish a business case for Skylon's operation in the satellite launcher market from 2020 onwards. In November 2013 Bond himself announced that the upcoming development phase of Skylon will be expanded from £240 million ($360 million) to £360 million ($540 million), and will now include the construction of a full-scale working version of SABRE.

The potential game-changing characteristics of Bond's SABRE engine have finally been recognised. REL estimates it would cost around £8 billion ($12 billion) to develop Skylon itself. That is comparable to the development costs of the Airbus A380 or the Ariane 5 manufactured by Astrium.

Initial Skylon launches would cost about £23 million ($35 million) but that could fall by as much as £7 million ($10 million) as more Skylons are brought onto market.

It seems that confidence in the capacity for British engineering has grown again. Since the cancellation of HOTOL in the late 1980's, the same technology has been refined and re-accepted by the current UK government.

Simultaneously, while the demand for satellite launches has increased, the high cost and unreliability of conventional rocket launches has not improved by the same pace. The world is ready for something new and timing is everything.



An artist's rendering of the Skylon spacecraft in flight. *Image: Reaction Engines*

Inheriting the crown

As for Alan Bond, this decades long odyssey to develop an enabling technology and a viable spacecraft for economic and reliable access to space has become a very personal journey. He has spent many years working in the wilderness due to lack of governmental foresight and support but, like all great engineering visionaries has stayed dedicated to his idea and doing whatever it takes to realise that idea.

With a wider overview away from Skylon, Bond believes in a greater journey for humanity with longer strides beyond the Moon with more advanced propulsion. Skylon is a way to take those first steps.

"What is absolutely clear to me is that the human race and its petty squabbles are confined to one piece of debris near a fairly ordinary star.

"Without easy access to the abundant resources of space, the human race can never sustain Western standards of living and a growing global population. Getting into space is not just what long-haired scientists do as a bit of fun. It's something that's absolutely crucial to the continuing progress of the human race."

Bond's history with the development of SABRE and Skylon echoes that of Sir Frank Whittle, inventor of the turbojet engine. Whittle himself demonstrated an early aptitude for engineering and also without the UK Air Ministry's support in his time, formed a company with limited funds to develop the first prototype jet engine. The Jet Age began shortly after and made the world the much more interconnected place we live in today.

Considered in a BBC poll as one of the 100 Greatest Britons, Whittle's legacy remains intact today.

Bond is on the way to echoing Whittle's success and creating his own legacy with the advent of a new age in spaceflight. His is a story of overcoming adversity, skepticism, winning over governmental intransigence and defeating the Official Secrets Act, to realise his ambitions. It appears today that he is on the threshold of his personal dream, to reach Earth orbit in a single giant leap.

Image: Reaction Engines

How the Skylon fleet would operate

By Amjad P. Zaidi

A fleet of Skylon vehicles can operate from a spaceport. A Vehicle Loading Hall receives and processes payloads which are installed in the Skylon payload bay. Skylon is then towed to the spaceport's Refuelling Apron. Liquid Oxygen and Liquid Hydrogen propellants are loaded through connections in the wheel wells. Skylon is towed to the runway for pre-flight checks.

At the start of the take-off roll the vehicle weighs 275 tonnes, whilst maximum landing weight is 55 tonnes. At take-off the vehicle carries approximately 66 tonnes of liquid hydrogen and approximately 150 tonnes of liquid oxygen for the ascent.

The SABRE engines are ignited in air-breathing mode, burning hydrogen fuel with air. Air must be heavily cooled by heat exchangers before being used by the hybrid SABRE engine.

The SABRE engines have a dual mode capability using the same nozzles, pumps and hydrogen fuel in-air breathing mode as in rocket mode. In rocket mode the engine operates as a closed cycle Lox/Lh2 high specific impulse rocket engine. In air-breathing mode (from take-off to Mach 5) the liquid oxygen flow is replaced by atmospheric air, increasing the installed specific impulse 3-6 fold. The airflow is drawn into the engine via a 2 shock axisymmetric intake and is cooled to cryogenic temperatures prior to compression. The hydrogen fuel acts as a heat sink for the closed cycle helium loop before entering the combustion chamber. The intake and heat exchangers supply the engines with air until the engine switches to rocket mode.

Upon entering rocket mode the air intakes close, the heat exchangers stop and the engines transfer to the on-board liquid oxygen supply for rocket mode. This transition takes place at Mach 5.5 and 25 kilometres altitude. Skylon then pitches up and accelerates climbing rapidly towards space. Orbital manoeuvring engines in the tail give the final boost into orbit.

In orbit, the payload doors are opened. Skylon can deliver a range of payloads to low Earth orbit. The Skylon D1 configuration has a 15 ton capacity to deliver a variety of modern payloads from space science satellites, Earth observation satellites, and small satellite constellations to Low Earth Orbit.

It can also launch Upper Stages for deploying geostationary satellites even further into space. The Upper Stage propels a satellite towards the correct orbit, separates from the satellite and enables the satellite to begin operations. The Upper Stage continues on its orbit to rendezvous with Skylon and be reused on future missions.

Skylon can launch satellites and so much more. Its large payload bay makes it a flexible launch system capable of transporting people and supplies into space, enabling space station resupply missions, and transporting modules for the construction of space stations.

Even more is possible with space hotels, servicing and fuel stations, and large Orbit Transfer Vehicles, performing construction and logistics missions, using components and supplies delivered by Skylon.

This even includes components for the construction of vehicles for missions to the Moon, Mars and beyond.

On returning the Earth, the Orbital Manoeuvring Engines fire, reducing speed and allowing Skylon to re-enter the atmosphere. Skylon then glides to a runway landing, completing its mission. Skylon is then towed back to its hangar to be made ready for its next mission taking place within 48 hours.

Sources about the Skylon:

- www.reactionengines.co.uk
- Bloomberg: Skylon Spaceplane Discussion 31.07.13
- www.spacefuture.com
- www.bbc.co.uk/news/science-environment-23590080
- www.rocketeers.co.uk/taxonomy/term/42
- www.wired.co.uk/news/archive/2013-08/12/skylon-alan-bond
- BBC Documentary: The Three Rocketeers

Skylon *Image: Reaction Engines*


2

It's a bird! It's a plane! No...it's a spaceplane!

Image: Reaction Engines

Vocabulary

- *Latitude:* The number of degrees north (or south) from the equator.
- *Orbital Altitude:* The height above Mean Sea Level of an orbiting spacecraft.
- *Orbital Inclination:* The angle that an orbit makes as it crosses the equator.

Narrative

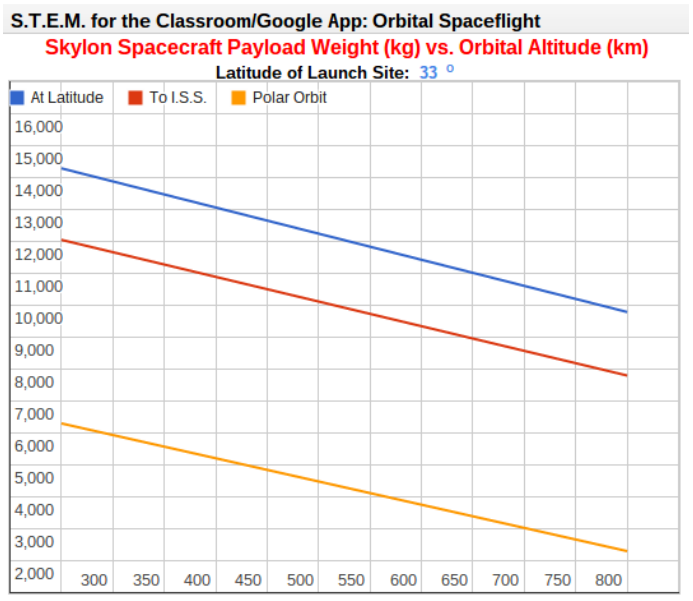
Across the pond is an innovative rocket company that toils away in relative obscurity designing a revolutionary new space launch vehicle system while being out-shined by comparable U.S. companies such as SpaceX and Virgin Galactic. This launch vehicle design is unique in that it looks and acts like an airplane from takeoff to landing; it just so happens that this particular airplane can remarkably fly all the way into Low Earth Orbit (LEO)! And the best part? It's reusable, unlike those other expendable launch vehicles. Nice!

This futuristic rocket company is called Reaction Engines, Ltd. out of the United Kingdom (www.reactionengines.co.uk), and they want to build the Skylon spaceplane that would fly from virtually any airport on the planet, and incredibly, would not require an expensive launch tower to perform a liftoff!

For a more in-depth treatment of this high school project by Joe Maness & Rich Holtzin visit www.stemfortheclassroom.com.

This spaceplane would operate just like any ordinary airliner, except if you want to operate this bird, you'd better call it a spaceliner! The REL Skylon spacepl -er-spaceliner is designed to have a payload bay just like what the US Space Shuttle had, albeit a bit smaller. Can we derive the equation of the payload capability of the REL Skylon? Sure we can! The students in the High School Algebra 2 class at The Learning Community Charter School (www.tlcnm.net) in Albuquerque, NM certainly did!

Fortunately for us, REL has made public their extensive data on the Skylon, including the lift capability. Using this information, a graph can be created:



The horizontal axis represents the orbital altitude, and the vertical axis represents the payload weight. For the purposes of this exercise, we will be launching from - err - taking off from Spaceport America near Las Cruces, New Mexico, which is located at 33 degrees N Latitude. The orbital inclination will always be the same as the latitude of the launch site (unless, of course, you expend more propellant to go into a different orbital inclination), so the orbital inclination is 33 degrees. The blue line in the graph represents such an orbit. The red line represents an orbital inclination to the International Space Station (ISS) , and the yellowish-orange (orangish-yellow?) line represents a polar orbit.

Analysis

As we can see from the graph, it not only takes more propellant to go higher but to also change the inclination. Therefore (and again for the purposes of this exercise), we will only be looking at the blue line, i.e., the "at latitude" line. For example, the graph tells us that the lift capacity of the REL Skylon at latitude to a 650 km orbital altitude is about 11,000 kg (11 mT).

The endpoints of the graph show us that the REL Skylon can lift 14,250 kg to 250 km, and 9,700 kg to 800 km. Putting this together, we get two points!

$$(250, 14290) \text{ and } (800, 9700)$$

We can now write the general linear equation in slope-intercept (y=mx+b) form for the payload launch capability, which is operating from a launch site of 33 degree Latitude going into a 33 degree inclined orbit:

$$\text{Payload}_{\text{Alt}} = m\text{Alt} + \text{Payload}_0$$

where

- $Payload_{Alt}$ = The weight of the payload going into space
- m = constant of variation
- Alt = Orbital Altitude
- $Payload_0$ = Initial payload weight

Using the techniques of finding the slope between two points and the vertical-axis intercept, we get:

- m = -8.18
- $Payload_0$ = 16,335 kg

Therefore, our REL Skylon/Spaceport America Linear Equation becomes

$$\text{Payload}_{\text{Alt}} = -8.18\text{Alt} + 16335$$

Example

What is the lift capacity of the REL Skylon operating from Spaceport America to an orbital altitude of 400 km?

The input to the REL Skylon/Spaceport America Linear Equation is the orbital altitude, which is 400. Plugging that into our equation, we get:

$$\text{Payload}_{400} = -8.18(400) + 16335 = 13{,}063 \text{ kg}$$

Conclusion

The REL Skylon spaceliner could lift around 13 mT to a 400 km, 33 degree LEO from Spaceport America, which can be verified by the graph. For comparison, the SpaceX Falcon 9 has a published lift capacity of about 13 mT to a 28.5 degree LEO. The major difference, of course, is this one would be reusable, which would help drive the operational costs down.

So, why are we still using throwaway rockets in the 21st Century again?

Reaction Engines Limited has designed the Skylon to showcase the SABRE engine which can power the craft from the ground. through the atmosphere and into space.

Image: Reaction Engines

National Aeronautics and Space Administration

Transportation

Spinoffs

Charged with carrying the human race to frontiers distant and challenging, it only makes sense that NASA has had a profound impact on transportation. Since its founding in 1958, NASA's pioneering research has advanced aeronautics and other modes of transportation as well. Through partnerships with private industry, NASA expertise and technologies developed for space travel are leading to safer, more efficient, and more environmentally friendly transportation on Earth. Whether providing for zero-emission automobiles, warning airplane passengers of turbulence, or saving millions of gallons of fuel, these spinoffs—among the over 1,600 such technologies NASA has recorded—are taking us places

Insulating Foams Save Money, Increase Safety

Polyimide foam insulation developed by NASA for cryogenic propellant tanks on the space shuttle has been improved through partnership with private industry. The flame retardant, flexible foam—a "NASA Commercial Invention of the Year"—shows promise for use in watercraft, aircraft, and automobiles.

Lithium Battery Power Delivers Electric Vehicles to Market

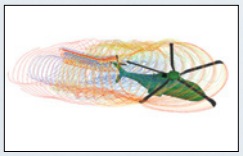
NASA contributed engineering experience to the development of an advanced battery management system for electric cars and tested a fleet of the zero-emission vehicles, leading to a series of commercially available, purpose-built, lithium electric autos aimed at the urban and commuter environments.

Fluid Prevents Ice Before It Forms

An environmentally friendly anti-icing fluid, invented by NASA, keeps hazardous ice from building up on airplane wings, improving safety while saving time and money. The fluid is also available as a spray for automobile windshields, providing protection down to 20 °F.

Guidance System Provides Pilots with Synthetic Vision

NASA and research partners created a 3-D display for pilots which provides clear vision regardless of outside conditions. The system—now flying in small aircraft all over the world—creates a computer-generated view of the surroundings, as well as flight plans and feedback about the area outside of the aircraft.



Modeling Tool Advances Rotorcraft Design

NASA-funded research developed a comprehensive tool for the three-dimensional modeling of the complete aerodynamics of rotorcraft in general flight conditions. The software performs analysis on advanced aerodynamic designs and aids research on new designs. It is currently used by major rotorcraft manufacturers and the U.S. military.

Polyimide Resins Resist Extreme Temperatures

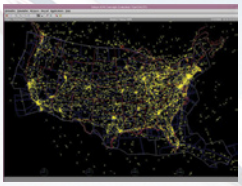
Designed as an environmentally-friendly alternative to other resins capable of combating the high temperatures of aerospace applications, RP–46 is now used for thermal skins on aircraft, aerospace engines, and exhaust duct systems. Other applications include the high-speed motor sports industry.

Aerodynamics Research Revolutionizes Truck Design

Starting in the 1970s, NASA conducted tests to refine the shape of trucks to reduce aerodynamic drag and improved efficiency. This core research led to a change in the design of the modern semi truck, a softening of the leading edge that greatly improves fuel efficiency.

Turbulence Detection Steers Aircraft Clear of Choppy Air

NASA designed software for aircraft radar that can provide flight crews advance warning of turbulence, helping keep themselves and their passengers out of harm's way, or, at a minimum, allowing the crew to prepare the aircraft for a bumpy ride.



Comprehensive Software Eases Aircraft Traffic Management

To help air traffic control centers improve the safety and the efficiency of the National Airspace System, NASA developed the Future Air Traffic Management Concepts Evaluation Tool (FACET), which alerts dispatchers to forecasted demand and capacity imbalances, helping them anticipate and act to relieve congested airspace and delays at airports

Winglets Improve Fuel Efficiency

The winglet is an upturned wingtip, a lifting surface designed to operate in the wingtip "vortex," a whirlpool of air at an airplane's wingtips. It takes advantage of the turbulent vortex flow by producing forward thrust. This reduces drag and improves fuel efficiency.

For more information about NASA spinoffs, please visit **spinoff.nasa.gov**.

Liftoff for ESA's billion-star surveyor

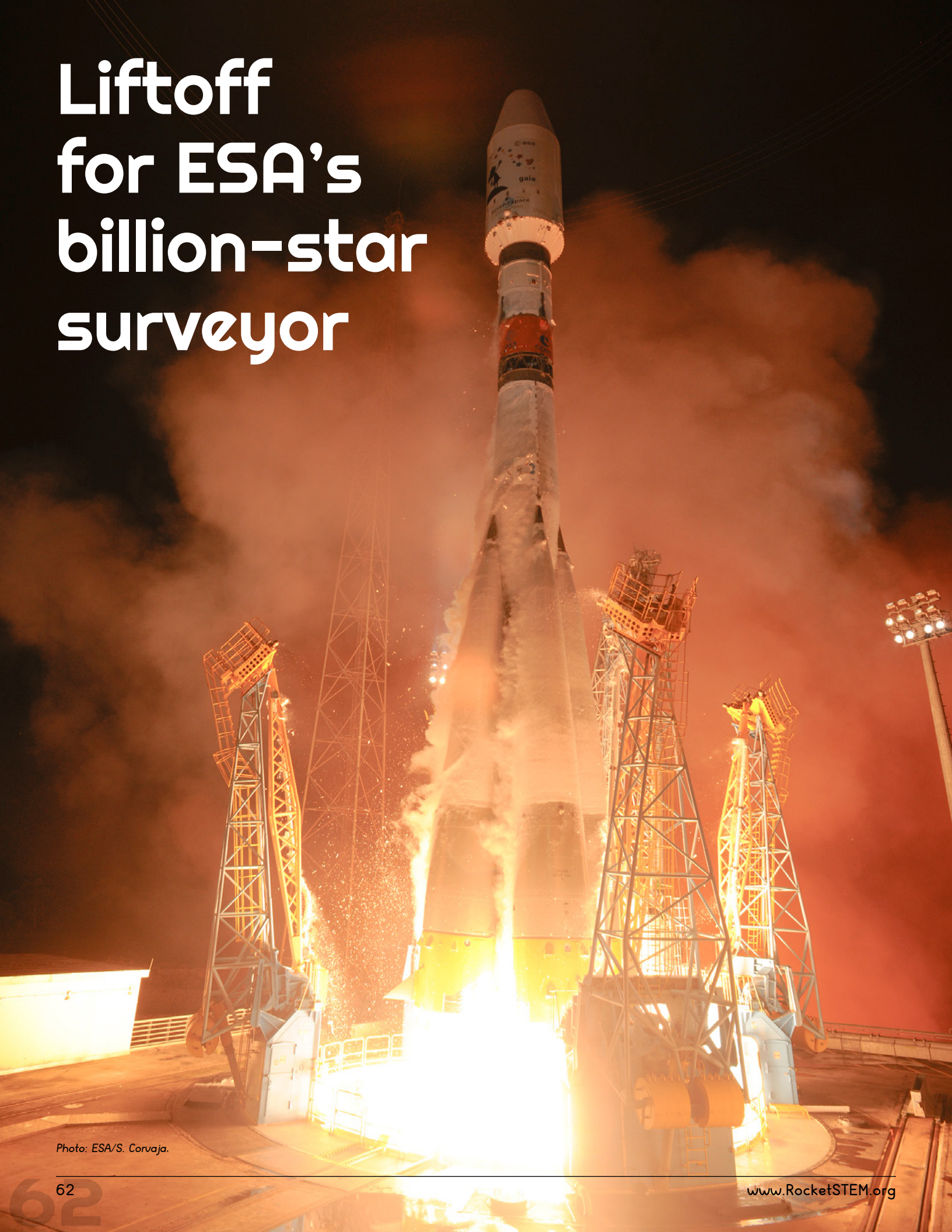


Photo: ESA/S. Corvaja.

ESA's Gaia is destined to create the most accurate map yet of the Milky Way. By making accurate measurements of the positions and motions of 1% of the total population of roughly 100 billion stars, it will answer questions about the origin and evolution of our home Galaxy.

The Gaia mission blasted off the morning of Dec. 19, 2013 on a Soyuz rocket from Europe's Spaceport in Kourou, French Guiana, on its exciting mission to study a billion suns.

Gaia will settle into orbit around a gravitationally-stable virtual point in space called L2, some 1.5 million kilometres beyond Earth as seen from the Sun.

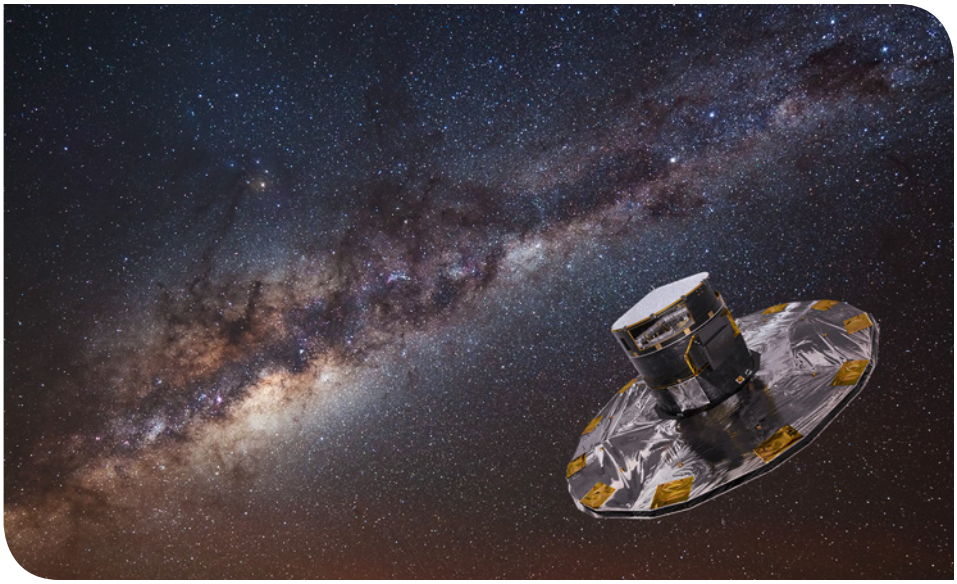
After a four-month commissioning phase – during which all of the systems and instruments will be turned on, checked and calibrated – Gaia will be ready to begin its five-year science mission.

Gaia's sunshield will block heat and light from the Sun and Earth, providing the stable environment needed by its sophisticated instruments to make an extraordinarily sensitive and precise census of the Milky Way's stars.

"Gaia promises to build on the legacy of ESA's first star-mapping mission, Hipparcos, launched in 1989, to reveal the history of the galaxy in which we live," says Jean-Jacques Dordain, ESA's Director General. "It is down to the expertise of Europe's space industry and scientific community that this next-generation mission is now well and truly on its way to making ground-breaking discoveries about our Milky Way."

Repeatedly scanning the sky, Gaia will observe each of the billion stars an average of 70 times each over the five years. It will measure the position and key physical properties of each star, including its brightness, temperature and chemical composition.

By taking advantage of the slight change in perspective that occurs as Gaia orbits the Sun during a year, it will measure the stars' distances and, by watching them patiently over the whole mission, their motions across the sky.



ESA's Gaia mission will produce an unprecedented 3D map of our galaxy by mapping the position and motion of a billion stars. *Image: ESA/ATG Medialab/ESO/S. Brunier*

The position, motion and properties of each star provide clues about its history, and Gaia's huge census will allow scientists to piece together a 'family tree' for our home Galaxy.

The motions of the stars can be put into 'rewind' to learn more about where they came from and how the Milky Way was assembled over billions of years from the merging of smaller galaxies, and into 'fast forward' to learn more about its ultimate fate.

"Gaia represents a dream of astronomers throughout history, right back to the pioneering observations of the ancient Greek astronomer Hipparchus, who catalogued the relative positions of around a thousand stars with only naked-eye observations and simple geometry," says Alvaro Giménez, ESA's Director of Science and Robotic Exploration.

"Over 2,000 years later, Gaia will not only produce an unrivalled stellar census, but along the way has the potential to uncover new asteroids, planets and dying stars."

By comparing its repeated scans of the sky, Gaia will also discover tens of thousands of supernovas, the death cries of stars as they reach the end of their lives and explode. And slight periodic wobbles in the positions of some stars should reveal the presence of planets in orbit around them, as they tug the stars from side to side.

Gaia will also uncover new asteroids in our Solar System and refine the orbits of those already known, and will make precise tests of Einstein's famous theory of General Relativity.

After five years, the data archive will exceed 1 Petabyte or 1 million Gigabytes, equivalent to about 200,000 DVD's worth of data. The task of processing and analysing this mountain of data will fall to the Gaia Data Processing and Analysis Consortium, comprising more than 400 individuals at scientific institutes across Europe.

"Where Hipparcos catalogued 120,000 stars, Gaia will survey almost 10,000 times as many and at roughly 40 times higher precision," says Timo Prusti, ESA's Gaia project scientist.

"Along with tens of thousands of other celestial and planetary objects, this vast treasure trove will give us a new view of our cosmic neighbourhood and its history, allowing us to explore the fundamental properties of our Solar System and the Milky Way, and our place in the wider Universe."

The spacecraft was designed and built by Astrium, with a core team composed out of France, Germany and the United Kingdom.

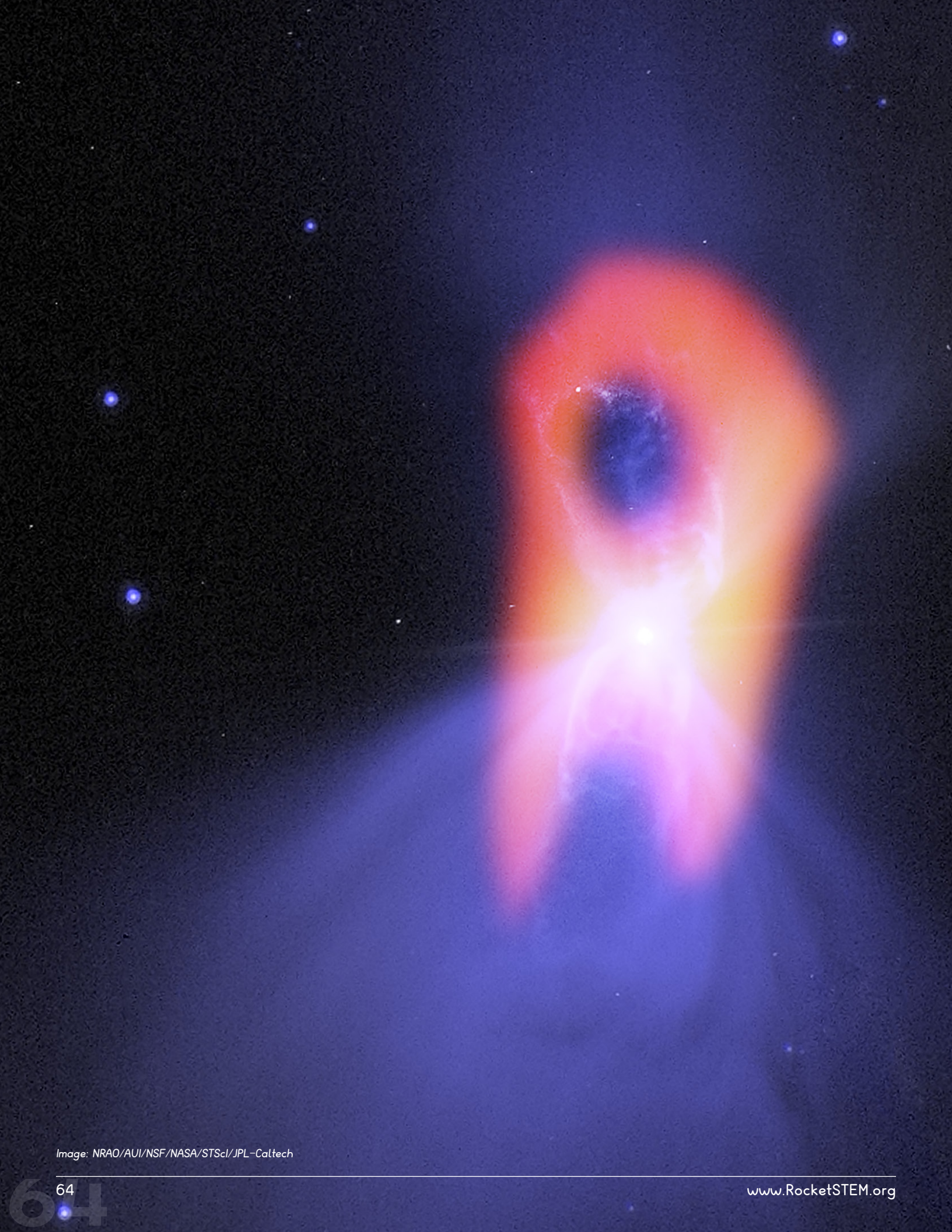


Image: NRAO/AUI/NSF/NASA/STScI/JPL-Caltech

Ghostly specter haunts 'coldest place in universe'

At a cosmologically crisp one degree Kelvin (minus 458 degrees Fahrenheit), the Boomerang nebula is the coldest known object in the universe -- colder, in fact, than the faint afterglow of the Big Bang, the explosive event that created the cosmos.

Astronomers using the Atacama Large Millimeter/submillimeter Array (ALMA) telescope in Chile have taken a new look at this object to learn more about its frigid properties and to determine its true shape, which has an eerily ghost-like appearance.

"This ultra-cold object is extremely intriguing and we're learning much more about its true nature with ALMA," said Raghvendra Sahai, a researcher and principal scientist at NASA's Jet Propulsion Laboratory in Pasadena, Calif., and lead author of a paper published in the Astrophysical Journal. "What seemed like a double lobe, or boomerang shape, from Earth-based optical telescopes, is actually a much broader structure that is expanding rapidly into space."

As originally observed with ground-based telescopes, this nebula appeared lopsided, which is how it got its name. Later observations with NASA's Hubble Space Telescope revealed a bow-tie-like structure. The new ALMA data, however, reveal that the Hubble image tells only part of the story, and the twin lobes seen in that image may actually be a trick of light as seen at visible wavelengths.

The researchers discovered a dense lane of millimeter-sized dust grains surrounding the star, which explains why its outer cloud has an hourglass shape in visible light. These minute dust grains have created a mask that shades a portion of the central star and allows its light to leak out only in narrow but opposite directions into the cloud, giving it an hourglass appearance.

"This is important for the understanding of how stars die and become planetary nebulas," said Sahai. "Using ALMA, we were quite literally, and figuratively, able to shed new light on the death throes of a sun-like star." The Boomerang nebula, located about 5,000 light-years away in the constellation Centaurus, is a relatively young example of an object known as a planetary nebula. Planetary nebulas, contrary to their name, are actually the end-of-life phases of stars like our sun that have sloughed off their outer layers. What remains at their centers are white dwarf stars, which emit intense ultraviolet radiation that causes the gas in the nebulae to glow and emit light in brilliant colors.

Read the full ALMA release at https://public.nrao.edu/news/pressreleases/alma-reveals-coldest-place-in-the-universe. Additional authors on this paper include Wouter Vlemmings, Chalmers University of Technology, Onsala, Sweden; Patrick Huggins, New York University, New York; Lars-Ake Nyman, Joint ALMA Observatory, Santiago de Chile; and Yiannis Gonidakis, CSIRO, Australia Telescope National Facility.

ALMA, an international astronomy facility, is a partnership of Europe, North America and East Asia in cooperation with the Republic of Chile. ALMA construction and operations are led on behalf of Europe by European Southern Observatory, on behalf of North America by the National Radio Astronomy Observatory (NRAO), and on behalf of East Asia by the National Astronomical Observatory of Japan (NAOJ). The Joint ALMA Observatory (JAO) provides the unified leadership and management of the construction, commissioning and operation of ALMA.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

The California Institute of Technology in Pasadena manages JPL for NASA.

Starting in astronomy

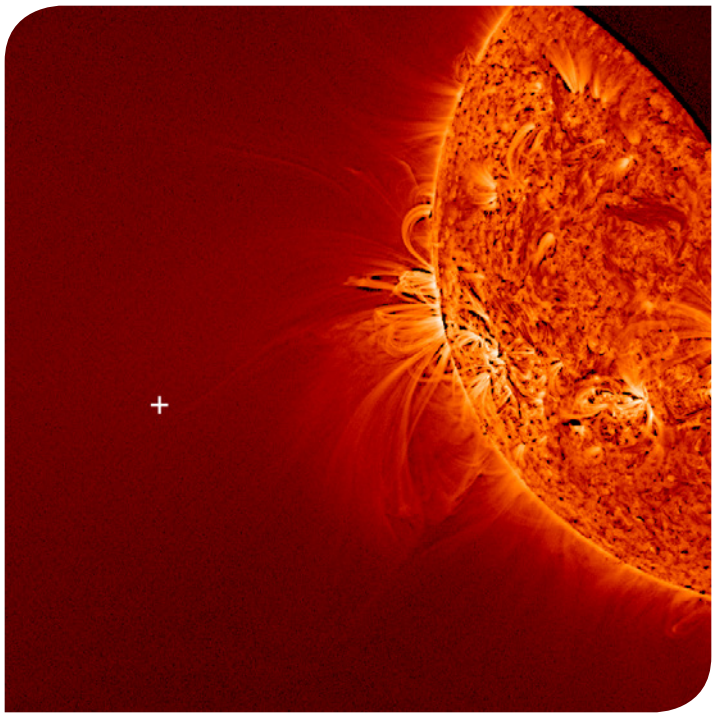
beginner's guide to stargazing

By Mike Barrett

Comets are unpredictable beasts

The media was full of talk of comets with the inaugural visit of Comet ISON C/2012 S1. It was pre-hyped as being "The Comet of the Century", being visible in daylight etc, etc. The reality of the matter is that comets are strange beasts and are rarely predictable unless they have been round a few times.

Comet ISON was spotted a long way out in the solar system and had been tracked all the time it was approaching the Sun. This meant that it was reasonably easy to predict its trajectory as it came flying in towards the Sun. The first thing that was realised was that this would be a Sun-grazing comet coming within one Sun's width of our primary star. This was special for a number of reasons, but most especially because we now have so many instruments that are able to observe the Sun and have the capability to view the interaction between the comet and the Sun.



This image from NASA's Solar Dynamics Observatory shows the Sun, but no Comet ISON was visible. A white plus sign shows where the Comet should have been had it survived. *Image: NASA/SDO*

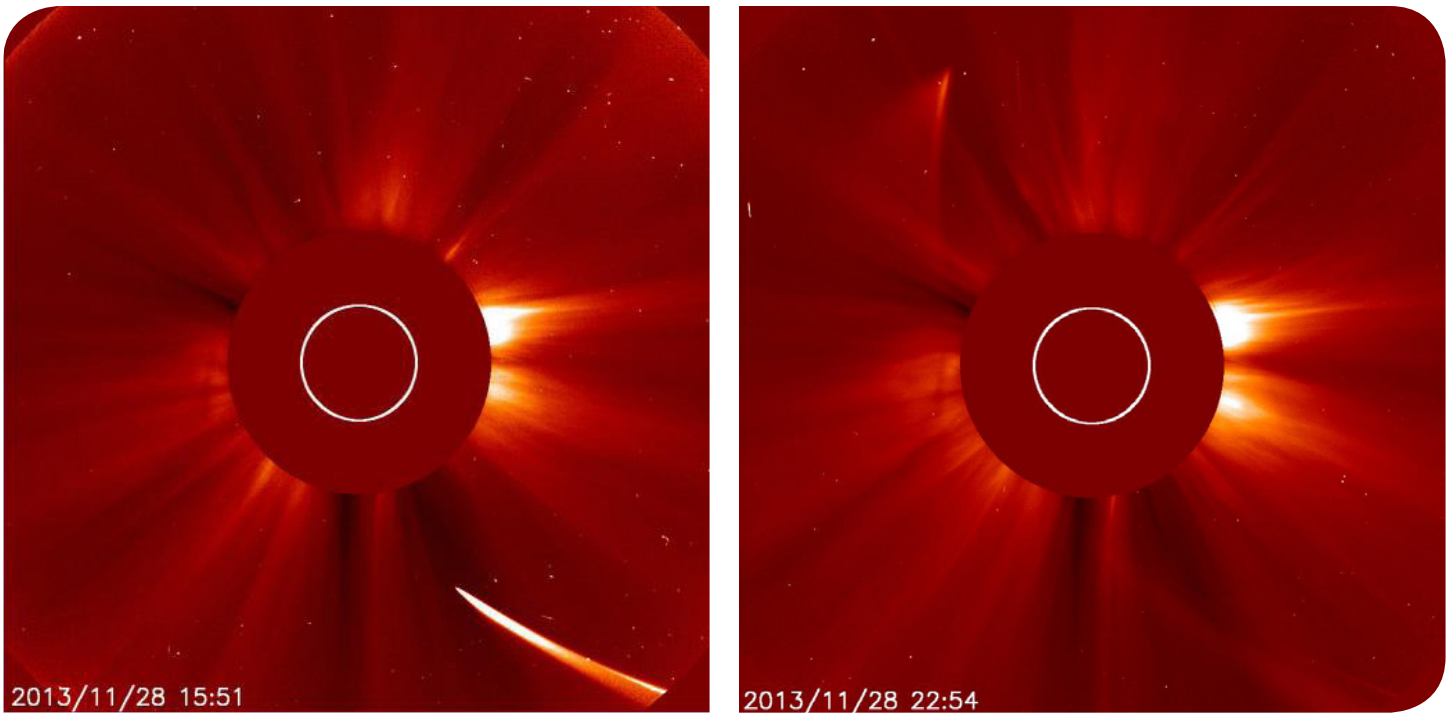
But we are getting ahead of ourselves, first we need to understand what comets are and where they came from: A comet is a small icy body composed of rock, ice, and dust. The ice is created not only from water, but also from gasses such as oxides of carbon, etc and many organic compounds. It has been proposed that some of the water on Earth and also possibly the building blocks of life were deposited by a passing comet. Generally there is more ice than solid components in a comet, though some comets can contain more solids than ice. A suitable analogy to an earthbound structure would be that of a dirty snowball and these comets are often described as such.

A comet can range in size from a few hundred feet to a tens of miles. Comet ISON is believed to be between one and two miles across, but it is very difficult to determine as the coma obscures the nucleus.

Comets are believed to originate in either the Oort Cloud or the Kuiper Belt where the residue of planetary construction materials are now found. These are dislodged from their orbits by gravitational forces or collisions with other bodies and start their journey diving towards the Sun. Some comets will only visit the sun once before being catapulted out of the solar system, others will have periodic elliptical orbits returning to pass the Sun at regular intervals.

In the outer Solar System, where the temperature is very cold, the comet will travel as a frozen ball. As the comet nears the Sun it starts to melt and consists of four distinct parts: the nucleus; a coma; an ionised gas tail and a dust tail. The nucleus is the 'dirty snowball' of rock, ice and dust. The coma is an 'atmosphere' formed from the evaporation of the ices into liquids which will contain suspended dust particles. The dust tail is a stream of dust particles that have been liberated from the coma and are left trailing behind the comet pushed away by the solar winds. The ion tail is formed from electrically charged gas molecules that are ejected from the coma. The two tails take slightly different paths as the ionised gasses are lighter and more susceptible to the solar wind than the dust tail. Thus the ion tail will be straight and narrow where the dust tail will curved and wide.

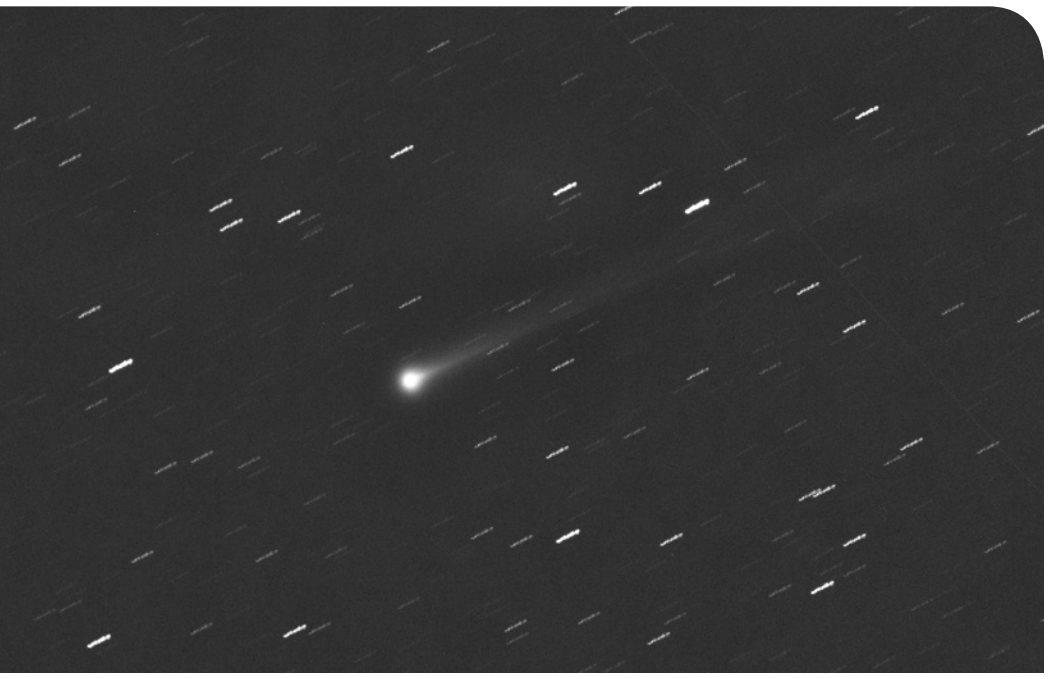
Getting back to Comet ISON. As the comet approached the inner Solar System it started to



Comet ISON passed just 1.2 million kilometres from the Sun's visible surface on Thanksgiving Day. A small chunk of ISON's nucleus, along with a lot of dust was seen after the comet's encounter with the Sun, but within days had faded completely. *Images: ESA/SOHO*

reflect sunlight making it visible in telescopes. As the comet gets closer to the Sun more of it's constituent parts heat up creating more ejaculate from the coma resulting in longer tails and also brighter surfaces. The theory was that as the comet approached the Sun it would brighten dramatically, making it so bright that it would be visible during daylight. ISON confounded the experts by remaining dimmer than anticipated and not becoming the 'Comet of the Century' as predicted. Then all of a sudden there was a dramatic brightening and it was speculated that ISON could live up to its name.

The dramatic moments came on November 28th when the comet approached perihelion. Perihelion is when the comet slingshots around the sun and starts on its way back out again. As the comet approached the Sun some of the instruments observing it saw what looked like an explosion as ISON was diving towards the closest approach. This left experts thinking that the comet had broken up and vaporised as it was affected by the extreme heat of the approach. This seemed to be confirmed when the comet did not appear on the SDO instrument and even ESO scientists were confirming that ISON had gone.



Comet ISON viewed from Earth as it streaked through space on Nov. 13, 2013.
Photo: Peter Carson http://www.astromania.co.uk

Shortly after the ESO announcement the comet remains could be seen on the LASCO C2 instrument looking comet shaped, but much fainter than expected. However at 12:30 UT on the 29th the LASCO C3 imagery is showing what looks like a comet, certainly more than debris heading on the expected trajectory of ISON. Whilst not as large or bright as originally expected it was quite faint compared to the comet pre-perihelion, but definitely there. This however faded to nothing a few days later, proving that comets are fickle, unpredictable celestial bodies.

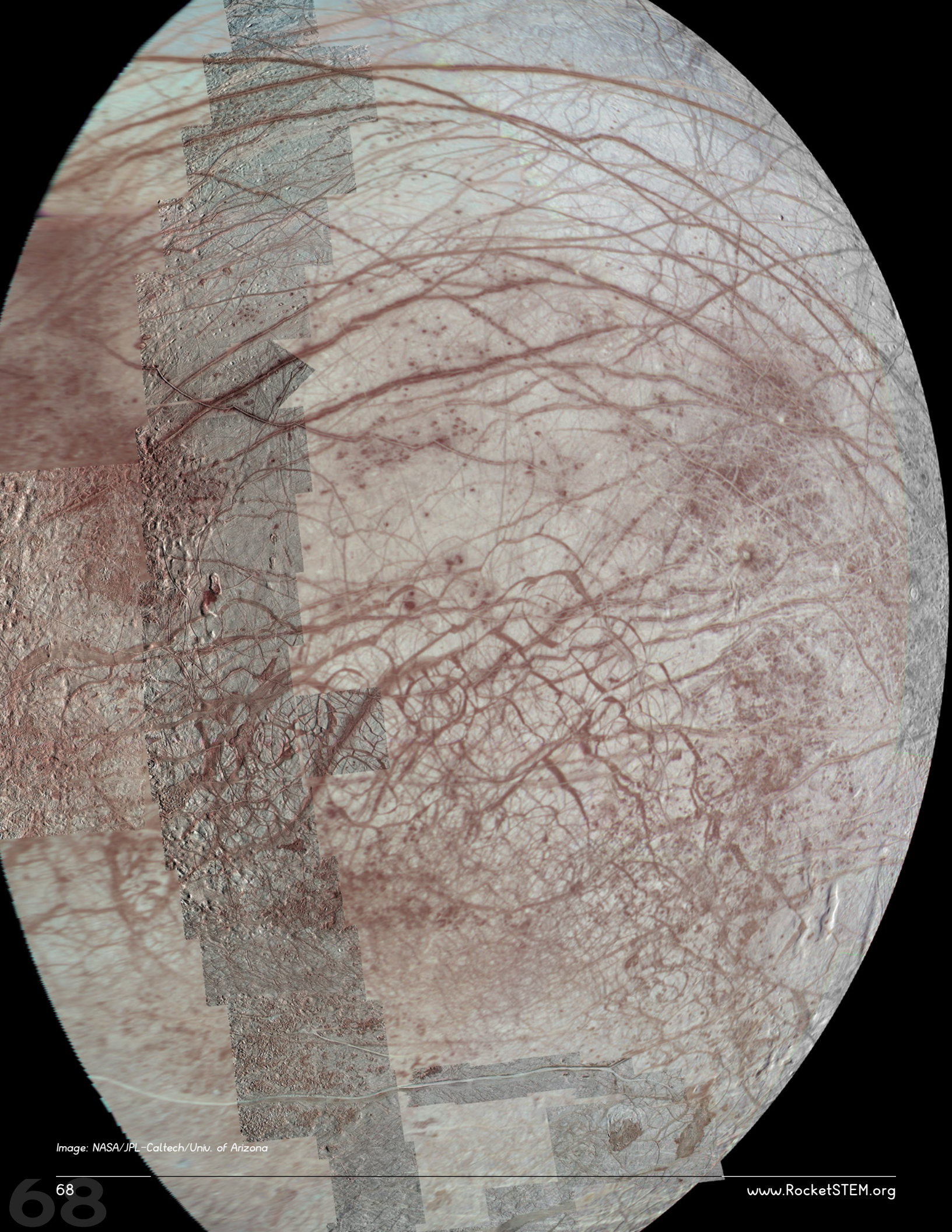


Image: NASA/JPL-Caltech/Univ. of Arizona

Europa likely off-kilter at one time

By analyzing the distinctive cracks lining the icy face of Europa, NASA scientists found evidence that this moon of Jupiter likely spun around a tilted axis at some point.

Europa's tilt could influence calculations of how much of the moon's history is recorded in its frozen shell, how much heat is generated by tides in its ocean, and even how long the ocean has been liquid.

"One of the mysteries of Europa is why the orientations of the long, straight cracks called lineaments have changed over time. It turns out that a small tilt, or obliquity, in the spin axis, sometime in the past, can explain a lot of what we see," said Alyssa Rhoden, a postdoctoral fellow with Oak Ridge Associated Universities who is working at NASA's Goddard Space Flight Center in Greenbelt, Md. She is the lead author of a paper in the September-October issue of Icarus that describes the results.

Europa's network of crisscrossing cracks serves as a record of the stresses caused by massive tides in the moon's global ocean. These tides occur because Europa travels around Jupiter in a slightly oval-shaped orbit. When Europa comes closer to the planet, the moon gets stretched like a rubber band, with the ocean height at the long ends rising nearly 100 feet (30 meters). That's roughly as high as the 2004 tsunami in the Indian Ocean, but it happens on a body that measures only about one-quarter of Earth's diameter. When Europa moves farther from Jupiter, it relaxes back into the shape of a ball.

The moon's ice layer has to stretch and flex to accommodate these changes, but when the stresses become too great, it cracks. The puzzling part is why the cracks in Europa's icy layer point in different directions over time, even though the same side of Europa always faces Jupiter.

A leading explanation has been that Europa's frozen outer shell might rotate slightly faster than the moon orbits Jupiter. If this out-of-sync rotation does occur, the same part of the ice shell would not always face Jupiter.

Rhoden and her Goddard co-author Terry Hurford put that idea to the test using images taken by NASA's Galileo spacecraft during its nearly eight-year mission, which began in 1995.

"Galileo produced many paradigm shifts in our understanding of Europa, one of which was the phenomena of out-of-sync rotation," said Claudia Alexander of NASA's Jet Propulsion Laboratory in Pasadena, Calif., who was the project manager when the Galileo mission ended.

Rhoden and Hurford compared the pattern of cracks in a key area near Europa's equator to predictions based on three different explanations.

The first set of predictions was based on the rotation of the ice shell.

The second set assumed that Europa was spinning around a tilted axis, which, in turn, made the orientation of the pole change over time. This effect, called precession, looks very much like what happens when a spinning toy top has started to slow down and wobble.

The third explanation was that the cracks were laid out in random directions.

The researchers got the best performance when they assumed that precession had occurred, caused by a tilt of about one degree, and combined this effect with some random cracks, said Rhoden. Out-of-sync rotation was surprisingly unsuccessful, in part because Rhoden found an oversight in the original calculations for this model.

The results are compelling enough to satisfy Richard Greenberg, the professor from the University of Arizona, Tucson, who had earlier proposed the idea of out-of sync rotation.

"By extracting new information from the Galileo data, this work refines and improves our understanding of the very unusual geology of Europa," said Greenberg, who was Rhoden's undergraduate advisor and Hurford's graduate advisor.

The existence of tilt would not rule out the out-of-sync rotation, according to Rhoden and Greenberg. But it does suggest that Europa's cracks may be much more recent than previously thought. That's because the spin pole direction may change by as much as a few degrees per day, completing one precession period over several months. On the other hand, with the leading explanation, one full rotation of the ice sheet would take roughly 250,000 years. In either case, several rotations would be needed to explain the crack patterns.

A tilt also could affect the estimates of the age of Europa's ocean. Tidal forces are thought to generate the heat that keeps Europa's ocean liquid, and a tilt in the spin axis might suggest that more heat is generated by tidal forces. This heat might keep the ocean liquid longer.

The analysis does not specify when the tilt would have occurred. So far, measurements have not been made of the tilt of Europa's axis, and this is one goal scientists have for any future Europa mission.

"One of the fascinating open questions is how active Europa still is. If researchers pin down Europa's current spin axis, then our findings would allow us to assess whether the clues we are finding on the moon's surface are consistent with the present-day conditions," said Rhoden.

The Galileo mission was managed by NASA's Jet Propulsion Laboratory, for the agency's Science Mission Directorate. JPL is a division of the California Institute of Technology.

Space enthralls Abraham Benrubi

By Nicole Solomon

Abraham Rubin Hercules Benrubi is a beloved character actor who has been working in film and television for more than two decades. He is known by many names: Mose from "Open Range," Jerry from "E.R.," and Larry 'The Kube' Kubiac from "Parker Lewis Can't Lose." He is also the voice of Fidel Castro, Optimus Prime, Darth Vader and a host of other characters on the Cartoon Network's irreverent "Robot Chicken." His most recent film, in which he plays Santa Claus, is "A Country Christmas." A native of Indianapolis, Benrubi is a self-defined music, comic book and Dungeons and Dragons junkie, a voracious reader and an unapologetic beach bum. He is enthralled by all things space, having attended space shuttle launches and NASA tweetups, and even was present at NASA's Jet Propulsion Laboratory for the landing of the Mars Curiosity rover. When he's not in front of the camera, he advocates for NASA every chance he gets.

Q: *Marvel or DC?*

Abe: I always preferred Marvel comics to DC. I think I identified more with the struggling heroes like Spider-Man and the X-Men, social outcasts, nerds even. The DC heroes felt more untouchable. I mean Superman has only one weakness and it's a rare (though not rare enough) stone from his birth planet. Daredevil is freakin' blind. The only DC book I ever really got into was the Marv Wolfman/George Pérez run on Teen Titans. I don't even read super-hero comics anymore. It all got pretty formulaic. I go for crime & supernatural comics like Ed Brubaker's Criminal & Fatale. Those I still buy.

Q: *Star Wars or Star Trek?*

Abe: This isn't REALLY a fair question. I grew up on Star Trek, but Star Wars changed my life. I remember standing in line to see what my father had billed as "some UFO movie." I'd never seen a line for a movie before. We got in late and wound up sitting in like the fourth row. When that Star Destroyer came rumbling across the screen, the theater shook. Star Trek always felt a little clean and cheesy after that. I watched the Next Generation but didn't really pay attention to Trek afterwards. I still watch Star Wars and Empire. Still listen to those soundtracks.

Q: *Aliens or Robots?*

Abe: I guess I prefer aliens. Robots always seem to either betray their makers or break down. Aliens are mysterious and unpredictable. Exotic. I always loved Wayne Barlowe's Guide To Extraterrestrials. Those illustrations were amazing. That's how I found out about H.P. Lovecraft, Jack Vance, Stanislaw Lem and so many authors I came to adore.

Q: *Superhero or Villain?*

Abe: The villains always look way cooler and have a better time, even when they lose. Darth Vader is one of the coolest characters ever. Doctor Doom should have handed the Fantastic Four their behinds numerous times. I remember a cover where Magneto has Wolverine almost impaling himself with his own claws. So cool. When Arcade traps the X-Men. The Joker in Frank Miller's Dark Knight Returns. Thanos. Galactus. Goldfinger. Jaws, both the shark AND the Bond villain!

Q: *Orion slave girl or the Borg's 7 of 9?*

Abe: I don't even know who 7 of 9 is, so obviously it's the Orion slave girl. Want to know something amazing? Both the Orion slave girl AND Batgirl in the 1960's Batman TV show (which I loved) are played by the same actress!! The uber-hottie Yvonne Craig! Somebody got their chocolate in my peanut butter!

Q: *Build things or destroy them?*

Abe: Sometimes you have to destroy then rebuild. I am a lifelong fan of Lego's so building is in my nature. I do like to destroy some stuff though!


Abraham Benrubi


ROVER
XING


SOCIAL

Q: *Favorite astronaut, scientist, engineer or inventor?*

Abe: That's a lot of people to choose from. I admire anyone who has the discipline to pass the rigorous physical and mental challenges required by space travel. I am grateful to most of the scientists, engineers and inventors throughout history, who's accomplishments have brought us into this marvelous modern age.

Q: *Favorite planet?*

Abe: Mars holds a lot of allure, and seems like the most likely candidate for human occupation in my lifetime. I am fascinated by Venus, rolling clouds of carbon dioxide. The most beautiful planet is Saturn. The unique rings. The many moons. But ultimately Earth has to be the favorite. It's home.

Q: *Favorite space agency?*

Abe: NASA, of course. I am particularly fond of the work being done at the Jet Propulsion Laboratory. I don't think the general public really understands just how much our space agencies do for the world.

Q: *Favorite NASA mission?*

Abe: STS-134. The second to last Space Shuttle launch. I had the privilege of attending the launch with a NASA tweetup group and even though it was scrubbed, we were graced with an extraordinary tour of the Kennedy Space Center. So much history. So many amazing artifacts from the entire history of space flight. I highly recommend taking a tour of KSC's visitor's center.

Q: *Favorite space movie?*

Abe: 2001: A Space Odyssey. This film is one of my earliest memories of space travel, and still seems the most realistic. I remember as a young man sitting on the massive grass terraces behind the Indianapolis Museum of Art and watching Kubrick's masterpiece on a massive outdoor screen. Looking up at the glittering night sky, it was easy to imagine that one day, man would travel by space ship.

Q: *If you could play any part in any sci-fi/space film or TV show, past, present, or future, what would it be?*

Abe: Darth Vader. I actually do play Darth Vader in the Robot Chicken Star Wars Specials, AND a semi-super-secret Star Wars show called Detours that may eventually see the light of day. I would also love to play Godzilla.

Q: *If you could travel to Mars, what five things would you take with you?*

Abe: Water. Sunscreen. A beach towel. Flip-flops. And a record player (with records).

Q: *If you could travel to any single place in the solar system where would you go?*

Abe: I guess the rings of Saturn, but I would take the scenic route.

Q: *If you were a spacecraft which one would you be?*

Abe: In real life? I like Cassini. In fiction? Imperial Star Destroyer!

Q: *Why are you excited about space exploration?*

Abe: It's the final frontier. Is there other life (as we know it) in the universe? Space exploration is a human endeavor that could unite all the people of the world.

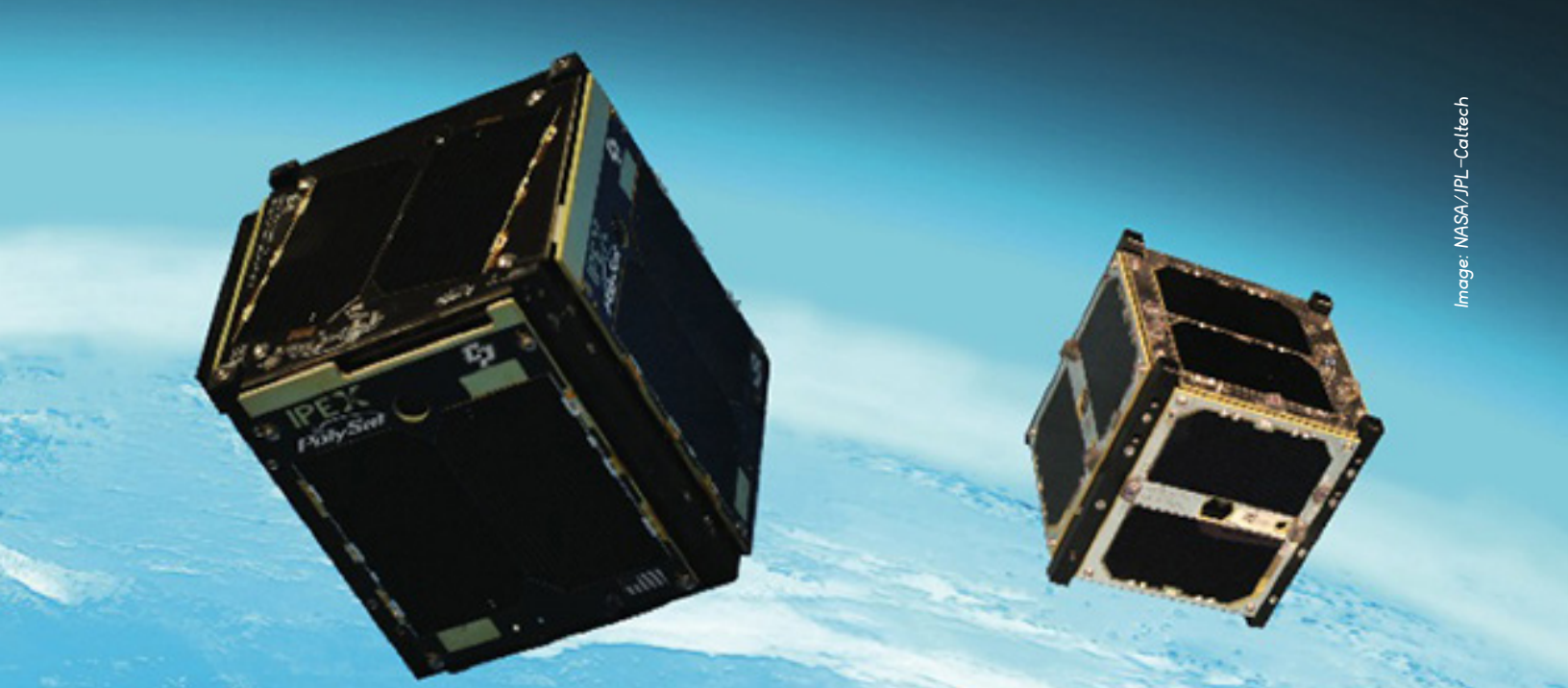


Image: NASA/JPL-Caltech

Thinking inside the box, launching into space

Two tiny, cube-shaped research satellites hitched a ride to Earth orbit to validate new hardware and software technologies for future NASA Earth-observing instruments.

The cube satellites, or "CubeSats," which typically have a volume of exactly 1 liter, were launched on a United Launch Alliance Atlas V rocket on the night of Dec. 5, 2013 from California's Vandenberg Air Force Base as part of the NROL-39 GEMSat mission. Led by NASA's Jet Propulsion Laboratory, Pasadena, Calif., and developed with university and industry partners, these two CubeSats will help enable near-real-time processing capabilities relevant to future climate science measurements.

One of the CubeSats that launched was developed in collaboration with California Polytechnic State University, San Luis Obispo, and is called the Intelligent Payload Experiment, or IPEX. It enables imagery to be transmitted more rapidly from satellite missions back to Earth. By using new software and algorithms, the spacecraft can sift through the data, looking only for the most important images that the scientists urgently need on the ground. This method is designed to speed delivery time of critical data products from days to minutes.

"IPEX will demonstrate software that will enable future NASA missions to recognize science events such as flooding, volcanism and wildfires, and respond by sending alerts and autonomously acquiring follow-up imagery," said Steve Chien of JPL, principal investigator for the IPEX mission.

The other CubeSat launched is the Michigan Multipurpose Mini-satellite/CubeSat On-board processing Validation Experiment, or M-Cubed/COVE.

M-Cubed, developed in partnership with the University of Michigan, Ann Arbor, will image Earth. The COVE payload will use these data to validate an instrument image data processing algorithm that will greatly reduce the science data transmission rate required for on-orbit operations.

"The COVE payload will advance processor and algorithm technology designed for use in a future science instrument to characterize properties of aerosols and clouds, which will help our understanding of global climate change," said Paula Pingree of JPL, principal investigator of the MCubed/COVE-2 mission.

These technology validation missions are sponsored by NASA's Earth Science Technology Office. They are designed to satisfy their science objectives within six months, but will remain in Earth orbit for many years.

For additional information on NASA's CubeSat Launch Initiative program, visit: http://go.nasa.gov/nXOuPI .

The NROL-39 GEMSat mission, carrying two cube satellites, launched from California's Vandenberg Air Force Base aboard a United Launch Alliance Atlas V rocket. *Photo: Pat Corkery/ULA*

‘Witch head’ brews baby stars

A witch appears to be screaming out into space in this image from NASA’s Wide-Field Infrared Survey Explorer, or WISE. The infrared portrait shows the Witch Head nebula, named after its resemblance to the profile of a wicked witch. Astronomers say the billowy clouds of the nebula, where baby stars are brewing, are being lit up by massive stars. Dust in the cloud is being hit with starlight, causing it to glow with infrared light, which was picked up by WISE’s detectors.

The Witch Head nebula is estimated to be hundreds of light-years away in the Orion constellation, just off the famous hunter’s knee.

WISE was recently “awakened” to hunt for asteroids in a program called NEOWISE. The reactivation came after the spacecraft was put into hibernation in 2011, when it completed two full scans of the sky, as planned.

Image: NASA/JPL-Caltech