Space News Update

— October 13, 2017 —

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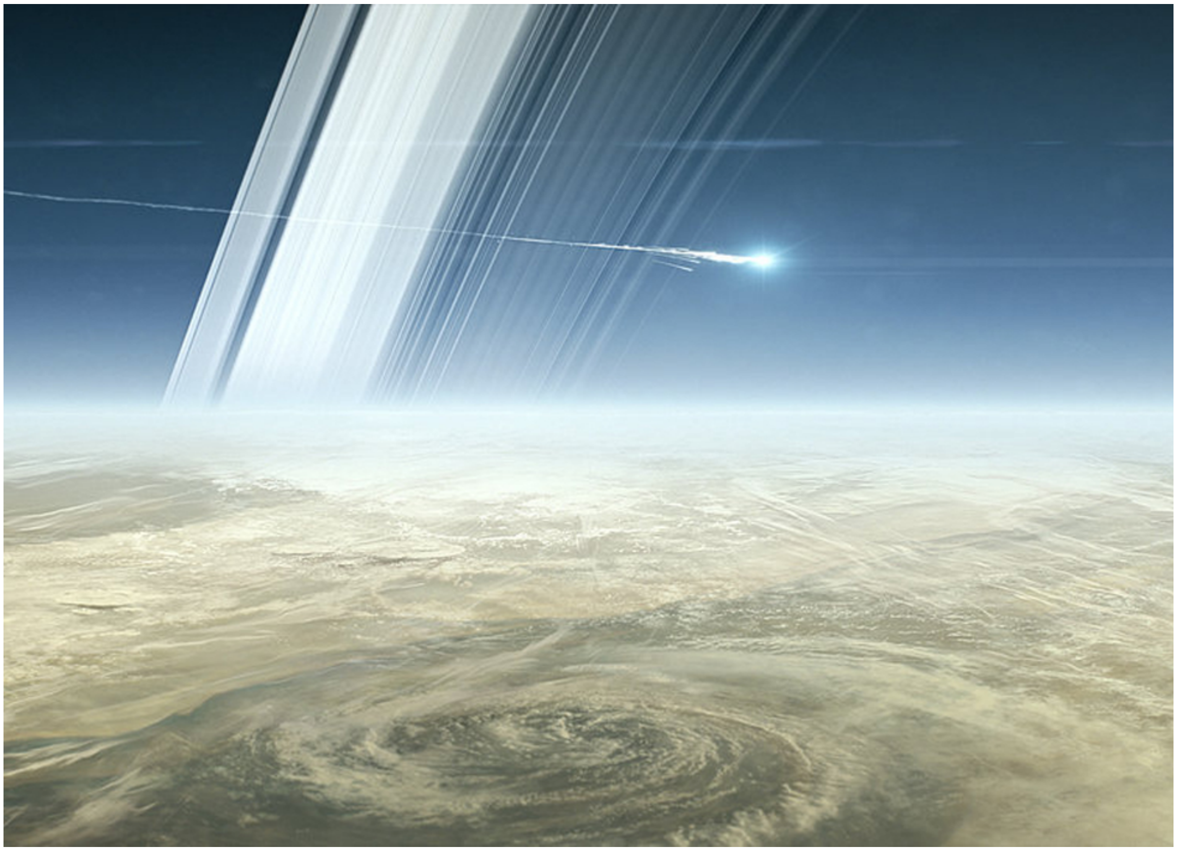
1. Reconstructing Cassini's Plunge into Saturn



As NASA's Cassini spacecraft made its fateful dive into the upper atmosphere of Saturn on Sept. 15, the spacecraft was live-streaming data from eight of its science instruments, along with readings from a variety of engineering systems.

While analysis of science data from the final plunge will take some time, Cassini engineers already have a pretty clear understanding of how the spacecraft itself behaved as it went in. The data are useful for evaluating models of Saturn's atmosphere the team used to predict the spacecraft's behavior at mission's end, and they help provide a baseline for planning future missions to Saturn.

Chief among these engineering data, or telemetry, are measurements indicating the performance of the spacecraft's small attitude-control thrusters. Each thruster was capable of producing a force of half a newton, which is roughly equivalent to the weight of a tennis ball on Earth.

During the final moments of its plunge, Cassini was traveling through Saturn's atmosphere, which was about the same density as the tenuous gas where the International Space Station orbits above Earth. In other words, there's barely any air there at all. Despite the fact that this air pressure is close to being a vacuum, Cassini was traveling about 4.5 times faster than the space station. The higher velocity greatly multiplied the force, or dynamic pressure, that the thin atmosphere exerted on Cassini. It's like the difference between holding your hand outside the window of a car moving at 15 mph versus one moving at 65 mph.

Data show that as Cassini began its final approach, in the hour before atmospheric entry it was subtly rocking back and forth by fractions of a degree, gently pulsing its thrusters every few minutes to keep its antenna pointed at Earth. The only perturbing force at that time was a slight tug from Saturn's gravity that tried to rotate the spacecraft.

"To keep the antenna pointed at Earth, we used what's called 'bang-bang control,'" said Julie Webster, Cassini's spacecraft operations chief at NASA's Jet Propulsion Laboratory, Pasadena, California. "We give the spacecraft a narrow range over which it can rotate, and when it bangs up against that limit in one direction, it fires a thruster to tip back the other way." (This range was indeed small: just two milliradians, which equals 0.1 degree. The reconstructed data show Cassini was subtly correcting its orientation in this way until about three minutes before loss of signal.)

This animation shows the last 30 seconds of Cassini's X- and S-band radio signals as they disappeared from mission control on Sept. 15, 2017. The video has been sped up by a factor of two. Credit: NASA/JPL-Caltech

At this point, about 1,200 miles (1,900 kilometers) above the cloud tops, the spacecraft began to encounter Saturn's atmosphere. Cassini approached Saturn with its 36-foot-long (11-meter) magnetometer boom pointing out from the spacecraft's side. The tenuous gas began to push against the boom like a lever, forcing it to rotate slightly toward the aft (or backward) direction. In response, the thrusters fired corrective gas jets to stop the boom from rotating any farther. Over the next couple of minutes, as engineers had predicted, the thrusters began firing longer, more frequent pulses. The battle with Saturn had begun.

With its thrusters firing almost continuously, the spacecraft held its own for 91 seconds against Saturn's atmosphere -- the thrusters reaching 100 percent of their capacity during the last 20 seconds or so before the signal was lost. The final eight seconds of data show that Cassini started to slowly tip over backward. As this happened, the antenna's narrowly focused radio signal began to point away from Earth, and 83 minutes later (the travel time for a signal from Saturn), Cassini's voice disappeared from monitors in JPL mission control. First, the actual telemetry data disappeared, leaving only a radio carrier signal. Then, 24 seconds after the loss of telemetry, silence.

These data explain why those watching the signal -- appearing as a tall green spike on a squiggly plot of Cassini's radio frequency -- in mission control and live on NASA TV -- saw what appeared to be a short reprieve, almost as though the spacecraft was making a brief comeback. The spike of the signal first began to diminish over a few seconds, but then rose briefly again before disappearing with finality.

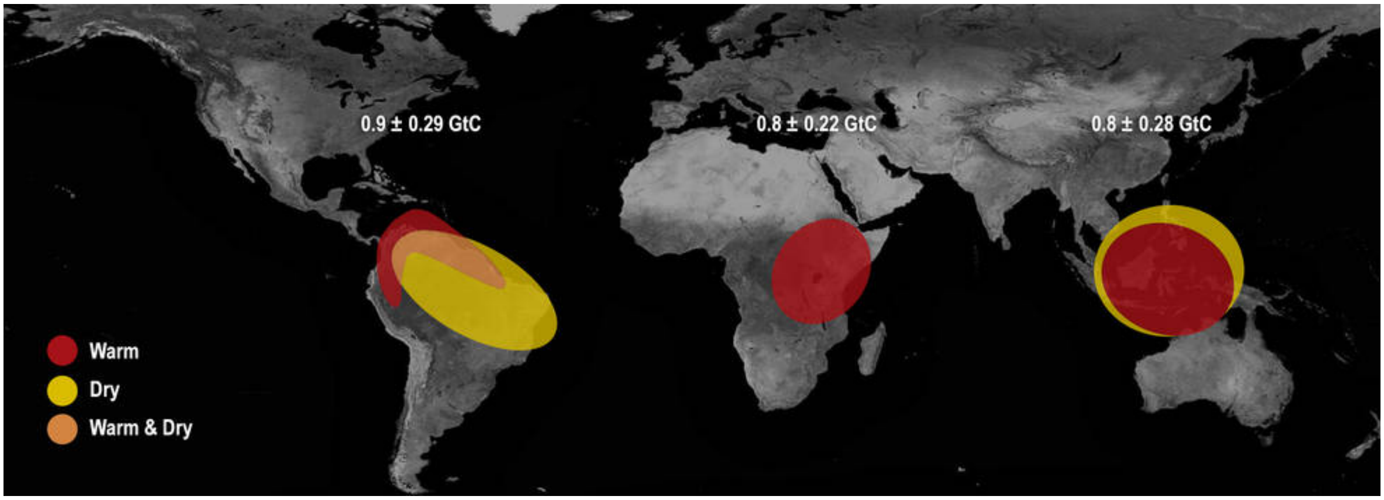
"No, it wasn't a comeback. Just a side lobe of the radio antenna beam pattern," Webster said. Essentially, the reprieve was an unfocused part of the otherwise narrow radio signal that rotated into view as the spacecraft began to slowly tip over.

"Given that Cassini wasn't designed to fly into a planetary atmosphere, it's remarkable that the spacecraft held on as long as it did, allowing its science instruments to send back data to the last second," said Earl Maize, Cassini project manager at JPL. "It was a solidly built craft, and it did everything we asked of it."

The Cassini-Huygens mission is a cooperative project of NASA, ESA (European Space Agency) and the Italian Space Agency. NASA's Jet Propulsion Laboratory, a division of Caltech in Pasadena, manages the mission for NASA's Science Mission Directorate, Washington. JPL designed, developed and assembled the Cassini orbiter.

Source: NASA Return to Contents

2. NASA Pinpoints Cause of Earth's Recent Record Carbon Dioxide Spike



A new NASA study provides space-based evidence that Earth's tropical regions were the cause of the largest annual increases in atmospheric carbon dioxide concentration seen in at least 2,000 years.

Scientists suspected the 2015-16 El Nino -- one of the largest on record -- was responsible, but exactly how has been a subject of ongoing research. Analyzing the first 28 months of data from NASA's Orbiting Carbon Observatory-2 (OCO-2) satellite, researchers conclude impacts of El Nino-related heat and drought occurring in tropical regions of South America, Africa and Indonesia were responsible for the record spike in global carbon dioxide. The findings are published in the journal Science Friday as part of a collection of five research papers based on OCO-2 data.

"These three tropical regions released 2.5 gigatons more carbon into the atmosphere than they did in 2011," said Junjie Liu of NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, who is lead author of the study. "Our analysis shows this extra carbon dioxide explains the difference in atmospheric carbon dioxide growth rates between 2011 and the peak years of 2015-16. OCO-2 data allowed us to quantify how the net exchange of carbon between land and atmosphere in individual regions is affected during El Nino years." A gigaton is a billion tons.

In 2015 and 2016, OCO-2 recorded atmospheric carbon dioxide increases that were 50 percent larger than the average increase seen in recent years preceding these observations. These measurements are consistent with those made by the National Oceanic and Atmospheric Administration (NOAA). That increase was about 3 parts per million of carbon dioxide per year -- or 6.3 gigatons of carbon. In recent years, the average annual increase has been closer to 2 parts per million of carbon dioxide per year -- or 4 gigatons of carbon. These record increases occurred even though emissions from human activities in 2015-16 are estimated to have remained roughly the same as they were prior to the El Nino, which is a cyclical warming pattern of ocean circulation in the central and eastern tropical Pacific Ocean that can affect weather worldwide.

Using OCO-2 data, Liu's team analyzed how Earth's land areas contributed to the record atmospheric carbon dioxide concentration increases. They found the total amount of carbon released to the atmosphere from all land areas increased by 3 gigatons in 2015, due to the El Nino. About 80 percent of that amount -- or 2.5 gigatons of carbon -- came from natural processes occurring in tropical forests in South America, Africa and Indonesia, with each region contributing roughly the same amount.

The team compared the 2015 findings to those from a reference year -- 2011 -- using carbon dioxide data from the Japan Aerospace Exploration Agency's Greenhouse Gases Observing Satellite (GOSAT). In 2011, weather in the three tropical regions was normal and the amount of carbon absorbed and released by them was in balance.

"Understanding how the carbon cycle in these regions responded to El Nino will enable scientists to improve carbon cycle models, which should lead to improved predictions of how our planet may respond to similar conditions in the future," said OCO-2 Deputy Project Scientist Annmarie Eldering of JPL. "The team's findings imply that if future climate brings more or longer droughts, as the last El Nino did, more carbon dioxide may remain in the atmosphere, leading to a tendency to further warm Earth."

While the three tropical regions each released roughly the same amount of carbon dioxide into the atmosphere, the team found that temperature and rainfall changes influenced by the El Nino were different in each region, and the natural carbon cycle responded differently. Liu combined OCO-2 data with other satellite data to understand details of the natural processes causing each tropical region's response.

In eastern and southeastern tropical South America, including the Amazon rainforest, severe drought spurred by El Nino made 2015 the driest year in the past 30 years. Temperatures also were higher than normal. These drier and hotter conditions stressed vegetation and reduced photosynthesis, meaning trees and plants absorbed less carbon from the atmosphere. The effect was to increase the net amount of carbon released into the atmosphere.

In contrast, rainfall in tropical Africa was at normal levels, based on precipitation analysis that combined satellite measurements and rain gauge data, but ecosystems endured hotter-than-normal temperatures. Dead trees and plants decomposed more, resulting in more carbon being released into the atmosphere. Meanwhile, tropical Asia had the second-driest year in the past 30 years. Its increased carbon release, primarily from Indonesia, was mainly due to increased peat and forest fires -- also measured by satellite instruments.

“We knew El Ninos were one factor in these variations, but until now we didn't understand, at the scale of these regions, what the most important processes were,” said Eldering. “OCO-2's geographic coverage and data density are allowing us to study each region separately.”

Scott Denning, professor of atmospheric science at Colorado State University in Fort Collins and an OCO-2 science team member who was not part of this study, noted that while scientists have known for decades that El Nino influences the productivity of tropical forests and, therefore, the forests' net contributions to atmospheric carbon dioxide, researchers have had very few direct observations of the effects.

“OCO-2 has given us two revolutionary new ways to understand the effects of drought and heat on tropical forests: directly measuring carbon dioxide over these regions thousands of times a day; and sensing the rate of photosynthesis by detecting fluorescence from chlorophyll in the trees themselves,” said Denning. “We can use these data to test our understanding of whether the response of tropical forests is likely to make climate change worse or not.”

The concentration of carbon dioxide in Earth's atmosphere is constantly changing. It changes from season to season as plants grow and die, with higher concentrations in the winter and lower amounts in the summer. Annually averaged atmospheric carbon dioxide concentrations have generally increased year over year since the early 1800s -- the start of the widespread Industrial Revolution. Before then, Earth's atmosphere naturally contained about 595 gigatons of carbon in the form of carbon dioxide. Currently, that number is 850 gigatons.

The annual increase in atmospheric carbon dioxide levels and the magnitude of the seasonal cycle are determined by a delicate balance between Earth's atmosphere, ocean and land. Each year, the ocean, plants and trees take up and release carbon dioxide. The amount of carbon released into the atmosphere as a result of human activities also changes each year. On average, Earth's land and ocean remove about half the carbon dioxide released from human emissions, with the other half leading to increasing atmospheric concentrations. While natural processes are responsible for the exchange of carbon dioxide between the atmosphere, ocean and land, each year is different. In some years, natural processes remove as little as 20 percent of human emissions, while in other years they scrub as much as 80 percent.

OCO-2, launched in 2014, gathers global measurements of atmospheric carbon dioxide with the resolution, precision and coverage needed to understand how this important greenhouse gas -- the principal human-produced driver of climate change -- moves through the Earth system at regional scales, and how it changes over time. From its vantage point in space, OCO-2 is able to make roughly 100,000 measurements of atmospheric carbon dioxide each day, around the world.

Institutions involved in the Liu study include JPL; the National Center for Atmospheric Research in Boulder, Colorado; the University of Toronto; Colorado State University; Caltech in Pasadena, California; and Arizona State University in Tempe.

For more information on NASA's Orbiting Carbon Observatory-2 mission, visit https://www.nasa.gov/oco2.

Source: NASA

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3. Giant Exoplanet Hunters: Look for Debris Disks

There's no map showing all the billions of exoplanets hiding in our galaxy -- they're so distant and faint compared to their stars, it's hard to find them. Now, astronomers hunting for new worlds have established a possible signpost for giant exoplanets.

A new study finds that giant exoplanets that orbit far from their stars are more likely to be found around young stars that have a disk of dust and debris than those without disks. The study, published in The Astronomical Journal, focused on planets more than five times the mass of Jupiter. This study is the largest to date of stars with dusty debris disks, and has found the best evidence yet that giant planets are responsible for keeping that material in check.

"Our research is important for how future missions will plan which stars to observe," said Tiffany Meshkat, lead author and assistant research scientist at IPAC/Caltech in Pasadena, California. Meshkat worked on this study as a postdoctoral researcher at NASA's Jet Propulsion Laboratory in Pasadena. "Many planets that have been found through direct imaging have been in systems that had debris disks, and now we know the dust could be indicators of undiscovered worlds."

Astronomers found the likelihood of finding long-period giant planets is nine times greater for stars with debris disks than stars without disks. Caltech graduate student Marta Bryan performed the statistical analysis that determined this result.

Researchers combined data from 130 single-star systems with debris disks detected by NASA's Spitzer Space Telescope, and compared them with 277 stars that do not appear to host disks. The two star groups were between a few million and 1 billion years old. Of the 130 stars, 100 were previously scanned for exoplanets. As part of this study, researchers followed up on the other 30 using the W. M. Keck Observatory in Hawaii and the European Southern Observatory's Very Large Telescope in Chile. They did not detect any new planets in those 30 systems, but the additional data helped characterize the abundance of planets in systems with disks.

The research does not directly resolve why the giant exoplanets would cause debris disks to form. Study authors suggest the massive gravity of giant planets causes small bodies called planetesimals to collide violently, rather than form proper planets, and remain in orbit as part of a disk.

"It's possible we don't find small planets in these systems because, early on, these massive bodies destroyed the building blocks of rocky planets, sending them smashing into each other at high speeds instead of gently combining," said co-author Dimitri Mawet, a Caltech associate professor of astronomy and a JPL senior research scientist.

On the other hand, giant exoplanets are easier to detect than rocky planets, and it is possible that there are some in these systems that have not yet been found.

Our own solar system is home to gas giants responsible for making "debris belts" -- the asteroid belt between Mars and Jupiter, shaped by Jupiter, and the Kuiper Belt, shaped by Neptune. Many of the systems Meshkat and Mawet studied also have two belts, but they are also much younger than ours -- up to 1 billion years old, compared to our system's present age of 4.5 billion years. The youth of these systems partly explains why they contain much more dust -- resulting from the collisions of small bodies -- than ours does.

One system discussed in the study is Beta Pictoris, which has been directly imaged from ground-based telescopes. This system has a debris disk, comets and one confirmed exoplanet. In fact, scientists predicted this planet's existence well before it was confirmed, based on the presence and structure of the prominent disk.

In a different scenario, the presence of two dust belts in a single debris disk suggests there are likely more planets in the system whose gravity maintains these belts, as is the case in the HR8799 system of four giant planets. The gravitational forces of giant planets nudge passing comets inward toward the star, which could mimic the period of our solar system's history about 4 billion years ago known as the Late Heavy Bombardment. Scientists think that during that period, the migration of Jupiter, Saturn, Uranus and Neptune deflected dust and small bodies into the Kuiper and asteroid belts we see today. When the Sun was young, there would have been a lot more dust in our solar system as well.

"By showing astronomers where future missions such as NASA's James Webb Space Telescope have their best chance to find giant exoplanets, this research paves the way to future discoveries," said Karl Stapelfeldt of JPL, chief scientist of NASA's Exoplanet Exploration Program Office and study co-author.

For more information about exoplanets, visit https://exoplanets.nasa.gov.

Source: NASA

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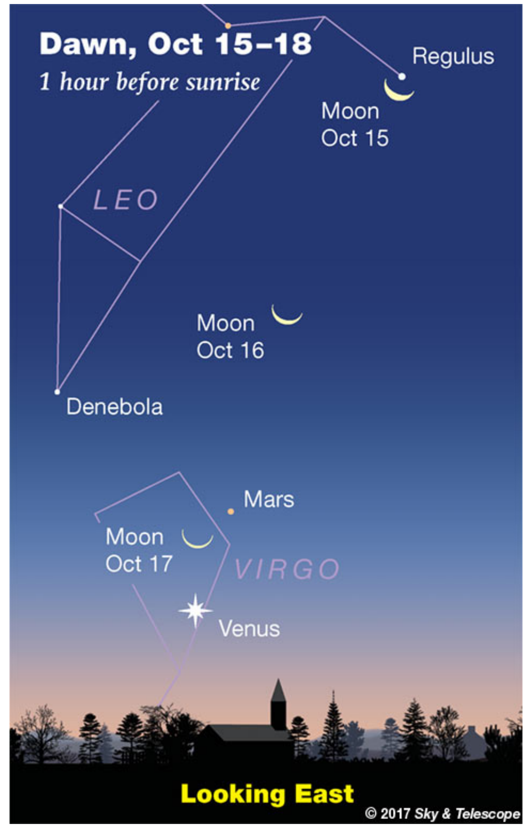
The Night Sky

Friday, October 13

• Now that we're in mid-October, Deneb has replaced Vega as the zenith star soon after nightfall (for skywatchers at mid-northern latitudes). So, accordingly, Capricornus has replaced Sagittarius low in the south.

Saturday, October 14

• Early on Sunday morning the 15th, the bright limb of the waning crescent Moon occults Regulus for telescope users in much of North America. The disappearance happens during dawn for the East and earlier in darkness farther west. The West Coast misses the disappearance; the Moon won't have risen yet.



But then, up to an hour or more later, Regulus reappears from behind the Moon's dark limb. This will be a naked-eye event for much of the USA and southeastern Canada! The reappearance will be "arguably the best lunar occultation of the year for the US, with the Moon only 20% sunlit," writes David Dunham of the International Occultation Timing Association (IOTA). "And for those with telescopes of about 10 inches or larger, it might provide a fleeting opportunity to see Regulus's elusive, 12th-magnitude white-dwarf companion, discovered in 2005, just before the blazing primary emerges. The only other time that the companion was imaged was during an occultation of Regulus by the asteroid 268 Adorea that Joan and I recorded with a 10-inch 'suitcase' telescope from Papua New Guinea on Oct. 13, 2016."

Here are a map and detailed timetables of the disappearance and reappearance for many locations, including the altitudes of the Moon and Sun at those times. (The page consists of three long tables, not very clearly divided: first the disappearance, then the reappearance, then the locations of cities.)

To record the grazing occultation along the northern limit, writes Dunham, "I believe the best place will be Bemidji, MN, but other places, such as Billings, MT, and Bismarck, ND, will be good too, as well as rural parts of Ontario and Quebec." Details of the graze.

Sunday, October 15

• Vega is the brightest star in the west these evenings. Less high in the southwest is Altair, not quite as bright. Just upper right of Altair, by a finger-width at arm's length, is little orange Tarazed (Gamma Aquilae). Straight down from Tarazed runs the stick-figure backbone of Aquila, the Eagle.

• Algol is at minimum brightness in eclipse, magnitude 3.4 instead of its usual 2.1, for about two hours tonight centered on 1:25 a.m. EDT (10:25 p.m. PDT). Algol takes several additional hours to fade and to rebrighten.

Monday, October 16

• The Great Square of Pegasus is now high in the east-southeast after dark, still, for now, balanced on one corner for the world's mid-northern latitudes.

• As dawn brightens on Tuesday morning the 17th, a super-thin waning crescent Moon hangs above Venus and left or lower left of faint Mars, as shown above. Look very low in the east. Binoculars will help.

Source: Sky & Telescope Return to Contents

ISS Sighting Opportunities

For Denver:

Date	Visible	Max Height	Appears	Disappears
Fri Oct 13, 7:53 PM	3 min	75°	19° above WNW	59° above SSE
Sat Oct 14, 7:00 PM	6 min	55°	10° above NW	12° above ESE
Sat Oct 14, 8:38 PM	1 min	14°	12° above WSW	14° above WSW
Sun Oct 15, 7:46 PM	3 min	28°	26° above WSW	15° above S
Mon Oct 16, 6:54 PM	4 min	57°	33° above WNW	10° above SE

Sighting information for other cities can be found at NASA's Satellite Sighting Information

NASA-TV Highlights

(all times Eastern Daylight Time)

Friday, October 13

6 p.m., Replay of SpaceCast Weekly (all channels)

9 p.m., Replay of SpaceCast Weekly (all channels)

Saturday, October 14

4 a.m., Coverage of the Launch of the ISS Progress 68 Cargo Ship to the ISS (Launch scheduled at 4:46 a.m. EDT) (Starts at 4:15 a.m.) (all channels)

Monday, October 16

6 a.m., Coverage of the Docking of the ISS Progress 68 Cargo Ship to the ISS (Docking scheduled at 7:09 a.m. EDT) (Starts at 6:15 a.m.) (all channels)

12 p.m., ISS Expedition 53 In-Flight Event for a JSC Facebook Live on "The Year of Education on Station" with Flight Engineers Joe Acaba of NASA and Paolo Nespoli of the European Space Agency (Starts at 12:05 p.m.) (all channels)

Watch NASA TV on the Net by going to the NASA website.

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Space Calendar

- Oct 13 - UPDATED [Oct 13] Sentinel 5P Rokot/Briz-KM Launch, Successful
- Oct 13 - Comet 73P-AE/Schwassmann-Wachmann At Opposition (1.119 AU)
- Oct 13 - Comet 355P/LINEAR-NEAT Perihelion (1.716 AU)
- Oct 13 - NEW [Oct 12] Apollo Asteroid 2017 TT1 Near-Earth Flyby (0.007 AU)
- Oct 13 - NEW [Oct 12] Aten Asteroid 2017 TU1 Near-Earth Flyby (0.013 AU)
- Oct 13 - NEW [Oct 13] Apollo Asteroid 2017 TK2 Near-Earth Flyby (0.013 AU)
- Oct 13 - Aten Asteroid 2005 TE49 Near-Earth Flyby (0.022 AU)
- Oct 13 - Apollo Asteroid 2014 UR116 Near-Earth Flyby (0.072 AU)
- Oct 13 - Asteroid 5256 Farquhar Closest Approach To Earth (1.365 AU)
- Oct 13 - Asteroid 6135 Billowen Closest Approach To Earth (1.769 AU)
- Oct 13 - Kuiper Belt Object 19308 (1996 TO66) At Opposition (46.381 AU)
- Oct 14 - HOT [Oct 07] 70th Anniversary (1947), Chuck Yeager Breaks Sound Barrier
- Oct 14 - HOT [Oct 12] Progress MS-7 Soyuz-2.1a Launch (International Space Station 68P)
- Oct 14 - UPDATED [Oct 13] NROL-52/ Quasar 21 Atlas 5 Launch
- Oct 14 - Comet P/2017 S5 (ATLAS) At Opposition (1.263 AU)
- Oct 14 - Comet C/2017 O1 (ASASSN) Perihelion (1.499 AU)
- Oct 14 - Comet 73P-AM/Schwassmann-Wachmann Closest Approach To Earth (2.025 AU)
- Oct 14 - Comet 263P/Gibbs Closest Approach To Earth (2.070 AU)
- Oct 14 - NEW [Oct 12] Aten Asteroid 2017 TV1 Near-Earth Flyby (0.014 AU)
- Oct 14 - Apollo Asteroid 2016 UO41 Near-Earth Flyby (0.055 AU)
- Oct 14 - Asteroid 14061 Nagincox Closest Approach To Earth (1.130 AU)
- Oct 14 - Asteroid 7328 Casanova Closest Approach To Earth (1.198 AU)
- Oct 14 - Asteroid 12574 LONEOS Closest Approach To Earth (1.638 AU)
- Oct 14 - Asteroid 9725 Wainscoat Closest Approach To Earth (1.670 AU)
- Oct 14 - Asteroid 1618 Dawn Closest Approach To Earth (1.883 AU)
- Oct 15 - Moon Occults Regulus
- Oct 15 - Comet 9P/Tempel At Opposition (2.591 AU)
- Oct 15 - Apollo Asteroid 2013 UM9 Near-Earth Flyby (0.044 AU)
- Oct 15 - Apollo Asteroid 2012 EN5 Near-Earth Flyby (0.091 AU)
- Oct 15 - Asteroid 136 Austria Closest Approach To Earth (1.205 AU)
- Oct 15 - Asteroid 5720 Halweaver Closest Approach To Earth (1.529 AU)
- Oct 15 - Asteroid 224 Oceana Closest Approach To Earth (1.682 AU)
- Oct 15 - 20th Anniversary (1997), Cassini Launch (Saturn Orbiter)
- Oct 15 - 45th Anniversary (1972), Valera Meteorite Fall (Hit Cow in Venezuela)
- Oct 16 - Comet 294P/LINEAR At Opposition (3.915 AU)
- Oct 16 - Comet C/2015 T2 (PANSTARRS) At Opposition (6.196 AU)
- Oct 16 - Atira Asteroid 2013 JX28 Closest Approach To Earth (0.733 AU)
- Oct 16 - Asteroid 32096 Puckett Closest Approach To Earth (1.394 AU)
- Oct 16 - Asteroid 294727 Dennisritchie Closest Approach To Earth (2.224 AU)

Chuck Yeager in front of the Bell X-1

Source: JPL Space Calendar

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Food for Thought

70 Years of Supersonic Flight: NASA Continues To Break Barriers

NASA's Quiet SuperSonic Technology Preliminary Design, or QueSST, has brought the agency ever closer to making the Low-Boom Flight Demonstration aircraft, or LBFD, a reality. Decades of NASA research in supersonics have gone into the unique design of NASA's next X-plane, including numerous efforts under the Commercial Supersonic Technology project, or CST.

These efforts, a number of which are based at NASA's Armstrong Flight Research Center, have dealt with research in several areas related to supersonic research, including the use of cutting-edge visualization technology to study shockwaves, the use of F-15s to examine methods for improved cruise efficiency, the integration of displays to help pilots monitor the audial effects of supersonic flight and the impacts of the environment on sonic booms. Each area of research goes into realizing the goal of CST and of QueSST, which includes the eventual demonstration of quiet supersonic flight over land.

In April 2016, NASA's goal of developing a quiet supersonic aircraft took another step closer following a pair of successful first flights in a series demonstrating patent-pending Background Oriented Schlieren using Celestial Objects (BOSCO) technology, effectively using the sun as a background in capturing unique, measurable images of shockwaves.

The tests flown from Armstrong built on other recent NASA tests to further the art of schlieren photography. Schlieren is a technique that can make important invisible flow features visible. Although schlieren has been in use for over a century, recent research by NASA has enabled its application in flight and greatly enhanced the detail of the images that can be obtained. In this case, NASA improved schlieren captured the visual data of shockwaves produced by a U.S. Air Force Test Pilot School's T-38 aircraft traveling at supersonic speeds.

As a result of the research, the supersonic aircraft and its shockwaves are seen with distinct clarity in front of the solar background. Observing air density changes makes the details clearer.

Visualizing these complex flow patterns of shockwaves produced by a supersonic vehicle will help NASA researchers to validate computational design tools used to develop the LBFD.

In May 2017, NASA also began a series of supersonic flights to examine efforts to improve the cruise efficiency of future supersonic aircraft.

At supersonic speeds, the force of drag that must be overcome is significant. Due to the interaction of flow with the aircraft's surface, this friction drag contributes about half of the total drag at supersonic speeds. This particular series of flights will explore ways of reducing friction drag and increasing efficiency through new and innovative methods of achieving swept wing laminar flow.

Future supersonic aircraft seeking to achieve a low-boom, such as NASA's LBFD, will rely on a swept wing design in order to fly at supersonic speeds without producing a loud sonic boom. The swept wing design generally produces crossflow, which is a name for air flow disturbances that runs along the span of the wing, resulting in turbulent flow, increased drag and ultimately higher fuel consumption.

“Swept wings do not have much laminar flow naturally at supersonic speeds, so in order to create a smoother flow over the wing, we put small Distributed Roughness Elements, or DREs, along the leading edge of the wing,” says CST Subproject Manager Brett Pauer. “These DREs can create small disturbances that lead to a greater extent of laminar flow.”

Swept wing laminar flow technology allows NASA to consider wing designs that have low boom characteristics, yet can be more efficient.

The development of advanced tools and instrumentation has also resulted from NASA’s supersonic research. In December 2016, NASA pilots flew with a display that provides guidance to the exact locations where sonic booms were hitting the ground.

This flight series, which marked the second phase of the Cockpit Interactive Sonic Boom Display Avionics project, or CISBoomDA, continued from the project’s first phase, where only a flight test engineer could see the display. With the ability to observe the location of their aircraft’s sonic booms, pilots can improve on keeping the loud percussive sounds from disturbing specific locations or communities on the ground.

“The display is there to minimize the impact of sonic booms on the ground. Sonic booms generally don’t cause damage at higher altitudes, but they can disturb people, and we want to make sure that we are good stewards to the public,” said Pauer. “The use of this software allows pilots to maximize their flight, and still not bother people on the ground, if used properly.”

The display shows the location of sonic booms based on tracking the aircraft’s trajectory and altitude, and is founded on an algorithm designed by Ken Plotkin of Wyle Laboratories, who died in 2015.

The display will ultimately be used to help NASA proceed with supersonic research in a way that minimizes disturbance on the ground and provides detailed guidance information for future of supersonic technology research.

“Flying with the CISBoomDA display was really interesting,” NASA research pilot Nils Larson stated. “It was great to have it in the cockpit, and I think it’s a valuable tool for the future. As a matter of fact, I’ve asked to be allowed to start using the display on my proficiency flights, just so I can keep practicing with it.”

Finally, NASA’s supersonic research, which already spans several NASA centers, extends to other mission directorates within the agency.

In August 2017, NASA’s Kennedy Space Center played host to the second series of Sonic Booms in Atmospheric Turbulence flights, or SonicBAT, continuing from 2016’s successful supersonic research flights flown at Edwards Air Force Base. The project’s second series of flights took place at KSC to be able to study how the region’s humid atmospheric conditions influence sonic booms.

SonicBAT helps NASA researchers better understand how low-altitude atmospheric turbulence affects sonic booms, which are produced when an aircraft flies at supersonic speeds, or faster than the speed of sound. The flight series is a key initiative in validating tools and models that will be used for the development of future quiet supersonic aircraft, which will produce a soft thump in place of the louder sonic boom.

The SonicBAT flights in Florida marked a rare opportunity for NASA’s aeronautics and space operations to comingle, and for Kennedy showcases that center’s transformation into a 21st century multiuser spaceport.

“This shows that, as NASA, we are all striving for the same thing,” said Pauer. “We’re willing to work together and help each other in any NASA mission that may be happening, whether it be space-based, which we do a lot of at our aeronautics centers, or the space centers to help us out with aeronautics. I think there’s a great amount of cooperation, even more than may be expected, between NASA centers.”

Peter Coen, CST Project Manager, added. “It seems to me that ‘one NASA’ is the best way to describe the cooperative spirit that makes it possible for teams to reach out across the agency, and receive the kind of support SonicBAT has received from Kennedy Space Center.”

NASA’s supersonic research itself is a multicenter initiative to push the boundaries of aeronautics. The Swept Wing Laminar Flow research conducted at Armstrong resulted from successful wind tunnel testing at Langley Research Center in Virginia. Subscale models of LBFD continue to undergo similar wind tunnel testing at Glenn Research Center in Ohio and Langley Research Center in Virginia. NASA Ames Research Center has been instrumental in assisting with developing advanced schlieren imaging techniques.

The next steps that result from milestones achieved at NASA’s centers throughout the country are sure to be exciting.

Source: NASA Return to Contents

Space Image of the Week

Under the Galaxy

Explanation: The Large Magellanic Cloud, a satellite galaxy of the Milky Way, stands above the southern horizon in this telephoto view from Las Campanas Observatory, planet Earth. In the dark September skies of the Chilean Atacama desert, the small galaxy has an impressive span of about 10 degrees or 20 Full Moons. The sensitive digital camera's panorama has also recorded a faint, pervasive airglow, otherwise invisible to the eye. Apparently bright terrestrial lights in the foreground are actually very dim illumination from the cluster of housing for the observatory astronomers and engineers. But the flattened mountain top along the horizon just under the galaxy is Las Campanas peak, home to the future Giant Magellan Telescope.

Image Credit & Copyright**:** Yuri Beletsky **(**Carnegie Las Campanas Observatory**,** TWAN**)**

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