Space News Update

— November 23, 2018 —

Contents

1. NASA InSight Team on Course for Mars Touchdown

NASA's Mars Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) spacecraft is on track for a soft touchdown on the surface of the Red Planet on Nov. 26, the Monday after Thanksgiving. But it's not going to be a relaxing weekend of turkey leftovers, football and shopping for the InSight mission team. Engineers will be keeping a close eye on the stream of data indicating InSight's health and trajectory, and monitoring Martian weather reports to figure out if the team needs to make any final adjustments in preparation for landing, only five days away.

"Landing on Mars is hard. It takes skill, focus and years of preparation," said Thomas Zurbuchen, associate administrator for the Science Mission Directorate at NASA Headquarters in Washington. "Keeping in mind our ambitious goal to eventually send humans to the surface of the Moon and then Mars, I know that our incredible science and engineering team — the only in the world to have successfully landed spacecraft on the Martian surface — will do everything they can to successfully land InSight on the Red Planet."

InSight, the first mission to study the deep interior of Mars, blasted off from Vandenberg Air Force Base in Central California on May 5, 2018. It has been an uneventful flight to Mars, and engineers like it that way. They will get plenty of excitement when InSight hits the top of the Martian atmosphere at 12,300 mph (19,800 kph) and slows down to 5 mph (8 kph) — about human jogging speed — before its three legs touch down on Martian soil. That extreme deceleration has to happen in just under seven minutes.

"There's a reason engineers call landing on Mars 'seven minutes of terror,'" said Rob Grover, InSight's entry, descent and landing (EDL) lead, based at NASA's Jet Propulsion Laboratory in Pasadena, California. "We can't joystick the landing, so we have to rely on the commands we pre-program into the spacecraft. We've spent years testing our plans, learning from other Mars landings and studying all the conditions Mars can throw at us. And we're going to stay vigilant till InSight settles into its home in the Elysium Planitia region."

One way engineers may be able to confirm quickly what activities InSight has completed during those seven minutes of terror is if the experimental CubeSat mission known as Mars Cube One (MarCO) relays InSight data back to Earth in near-real time during their flyby on Nov. 26. The two MarCO spacecraft (A and B) are making good progress toward their rendezvous point, and their radios have already passed their first deep-space tests.

"Just by surviving the trip so far, the two MarCO satellites have made a giant leap for CubeSats," said Anne Marinan, a MarCO systems engineer based at JPL. "And now we are gearing up for the MarCOs' next test — serving as a possible model for a new kind of interplanetary communications relay."

If all goes well, the MarCOs may take a few seconds to receive and format the data before sending it back to Earth at the speed of light. This would mean engineers at JPL and another team at Lockheed Martin Space in Denver would be able to tell what the lander did during EDL approximately eight minutes after InSight completes its activities. Without MarCO, InSight's team would need to wait several hours for engineering data to return via the primary communications pathways — relays through NASA's Mars Reconnaissance Orbiter and Mars Odyssey orbiter.

Once engineers know that the spacecraft has touched down safely in one of the several ways they have to confirm this milestone and that InSight's solar arrays have deployed properly, the team can settle into the careful, three-month-long process of deploying science instruments.

"Landing on Mars is exciting, but scientists are looking forward to the time after InSight lands," said Lori Glaze, acting director of the Planetary Science Division at NASA Headquarters. "Once InSight is settled on the Red Planet and its instruments are deployed, it will start collecting valuable information about the structure of Mars' deep interior — information that will help us understand the formation and evolution of all rocky planets, including the one we call home."

"Previous missions haven't gone more than skin-deep at Mars," added Sue Smrekar, the InSight mission's deputy principal investigator at JPL. "InSight scientists can't wait to explore the heart of Mars."

JPL manages InSight for NASA's Science Mission Directorate. InSight is part of NASA's Discovery Program, managed by the agency's Marshall Space Flight Center in Huntsville, Alabama. Lockheed Martin Space in Denver built the InSight spacecraft, including its cruise stage and lander, and supports spacecraft operations for the mission.

A number of European partners, including France's Centre National d'Études Spatiales (CNES) and the German Aerospace Center (DLR), are supporting the InSight mission. CNES and the Institut de Physique du Globe de Paris (IPGP) provided the Seismic Experiment for Interior Structure (SEIS) instrument, with significant contributions from the Max Planck Institute for Solar System Research (MPS) in Germany, the Swiss Institute of Technology (ETH) in Switzerland, Imperial College and Oxford University in the United Kingdom, and JPL. DLR provided the Heat Flow and Physical Properties Package (HP^3) instrument, with significant contributions from the Space Research Center (CBK) of the Polish Academy of Sciences and Astronika in Poland. Spain's Centro de Astrobiología (CAB) supplied the wind sensors.

For more detailed information on the InSight mission, visit https://mars.nasa.gov/insight.

For more information about MarCO, visit https://www.jpl.nasa.gov/cubesat/missions/marco.php.

Source: NASA Return to Contents

2. Big Test Coming up for Tiny Satellites Trailing Mars Lander

A pair of tiny experimental satellites trailing NASA's InSight spacecraft all the way to Mars face their biggest test yet.

Their mission: Broadcast immediate news, good or bad, of InSight's plunge through the Martian atmosphere on Monday.

Named WALL-E and EVE after the main characters in the 2008 animated movie, the twin CubeSats will pass within a few thousand miles (kilometers) of Mars as the lander attempts its dicey touchdown.

If these pipsqueaks manage to relay InSight's radio signals to ground controllers nearly 100 million miles (160 million kilometers) away, we'll know within minutes whether the spacecraft landed safely.

A look at InSight's itty-bitty sidekicks:

HITCHHIKERS

WALL-E and EVE, each the size of a briefcase, hitched a ride on the same rocket that launched InSight to Mars in May. CubeSats always share rockets; they're too small and inexpensive to warrant their own launch. This Mars Cube One project, or MarCO, built and managed by NASA's Jet Propulsion Laboratory, cost $18.5 million.

FLIGHT FORMATION

NASA kept the CubeSats about 6,000 miles (10,000 kilometers) away from InSight during the 300 million-mile (483 million-kilometer) journey to Mars to prevent any collisions or close calls. The mini satellites were just as far from each other for the same reason. The elbow room in this "very loose formation," as chief engineer

Andy Klesh describes it, has varied during the mission and is narrowing as the spacecraft draws ever closer to Mars.

BEST BEHAVIOR

For the record, EVE has behaved better than WALL-E during the 6 1/2-month voyage to Mars. Each CubeSat has the same type of cold gas propulsion that's used in fire extinguishers to spray foam. In the film, WALL-E uses a fire extinguisher to propel through space. In reality, WALL-E has been leaking fuel almost since liftoff. Flight controllers have worked around the problem. Meanwhile, "EVE seems to follow her namesake and has been flying beautifully throughout the mission," said Klesh.

DRY RUN

In June, WALL-E and EVE aced a series of radio-relay tests using signals from a big dish antenna near Palo Alto, California. Klesh said that gives engineers confidence in the CubeSats' ability to do the same with InSight's signals on landing day. Last month, the pair sent back photos of Mars from 8 million miles (13 million kilometers) out. Mars was merely a bright pinpoint, but the team said it marked a proud CubeSat first.

ALL EARS

It takes eight minutes and seven seconds for a radio signal to get from Mars to Earth, one way. It should take less than a minute on top of that to get word from InSight, if the mini satellites cooperate. That means NASA could know InSight's fate close to real time. If WALL-E and EVE are mum, confirmation would come directly from the lander or, hours later, from spacecraft circling Mars.

FUTURE GOAL

As NASA explores new worlds, it would be handy to have listening outposts to beam back descent and landing updates. Spacecraft already in orbit around Mars serve that purpose whenever NASA sends a lander. But where there are no satellites—think asteroids or dwarf planets on the fringes of our solar system—CubeSats could step in, with little overhead and low cost.

BEYOND MARS

Whether or not they provide any insight on InSight, WALL-E and EVE will zoom past Mars and remain in an elliptical orbit around the sun. Engineers expect them to keep working for a couple weeks beyond Mars depending on how long the fuel and electronics last.

Source: Phys.org Return to Contents

3. Hubble Reveals a Giant Cosmic 'Bat Shadow'

A Shadows on Earth can be mysterious and foreboding, but when they occur in space, they can convey information we otherwise could not know.

In a stellar nursery called the Serpens Nebula, nearly 1,300 light-years away, a young star's game of shadow play is revealing secrets of its unseen planet-forming disk. The near-infrared vision of NASA's Hubble Space Telescope captured the shadow cast by the fledgling star's brilliant light being blocked by this disk.

Named HBC 672, this Sun-like star is surrounded by a debris ring of dust, rock and ice -- a disk that is too small and too distant to be seen, even by Hubble. But like a little fly that wanders into the beam of a flashlight shining on a wall, its shadow is projected large upon the cloud in which it was born.

In this Hubble image, the feature -- nicknamed the "Bat Shadow" -- spans approximately 200 times the length of our solar system. It is visible in the upper right portion of the picture.

"This is an analog of what the solar system looked like when it was only 1 or 2 million years old," explained Klaus Pontoppidan, an astronomer at the Space Telescope Science Institute (STScI) in Baltimore, Maryland. "For all we know, the solar system once created a shadow like this."

The presence of a shadow means that the disk is being viewed nearly edge-on. This is something that could not otherwise be known because of the disk's great distance from us, which makes it too small to be seen by

Hubble.

The disk's shadow is similar to what is produced by a cylindrical lamp shade. Light escapes from the top and bottom of the shade, but along its circumference, dark cones of shadow form. Although the disk that gives rise to the shadow is a common object around young stars, the combination of an edge-on viewing angle and the surrounding nebula is rare.

Scientists can use the shadow to figure out the shape of the disk. For example, they now know that the disk is puffy, which implies that it is full of gas. While most of the shadow is completely opaque, scientists can look for color differences along its edges, where some light gets through. They can use the shape and color of the shadow to determine the size and composition of dust grains suspended in the disk.

"These shadows are not easily seen in visible light, but the stellar disks and the shadows they project onto the surrounding nebula can be easily detected in infrared light," said Max Mutchler, a research and instrument scientist at STScI. "This infrared Bat Shadow reveals properties of both the small, dusty disk and the much larger nebula."

The shadow is an example of what the future James Webb Space Telescope will be capable of studying in even greater depth. "Webb's power lies in its ability to see into the dust and gas of these disks to understand the material that comprises these environments that form planets," explained scientist Alexandra Lockwood of STScI.

A similar-looking shadow phenomenon emanates from another young star, at the upper left of the Hubble image. At the lower right, what appears to be a void is likely a part of a foreground cloud. Light from the red, double star inside the void is partially blocked by this cloud.

The image will be used with NASA's Universe of Learning to illustrate how shadows can convey information about phenomena invisible to us. This program creates materials and experiences to enable learners to explore the universe for themselves. NASA's Universe of Learning materials are based upon work supported by NASA under award number NNX16AC65A.

The Hubble Space Telescope is a project of international cooperation between NASA and ESA (European Space Agency). NASA's Goddard Space Flight Center in Greenbelt, Maryland, manages the telescope. The Space Telescope Science Institute (STScI) in Baltimore, Maryland, conducts Hubble science operations. STScI is operated for NASA by the Association of Universities for Research in Astronomy, in Washington, D.C.

For more information about NASA's Universe of Learning, see: www.universe-of-learning.org

Source: Spaceref.com Return to Contents

The Night Sky

Friday, November 23

• The Moon, just past, shines near Aldebaran tonight, to the star's left as shown here. Watch the Moon draw farther away from Aldebaran through the hours of the night.

Saturday, November 24

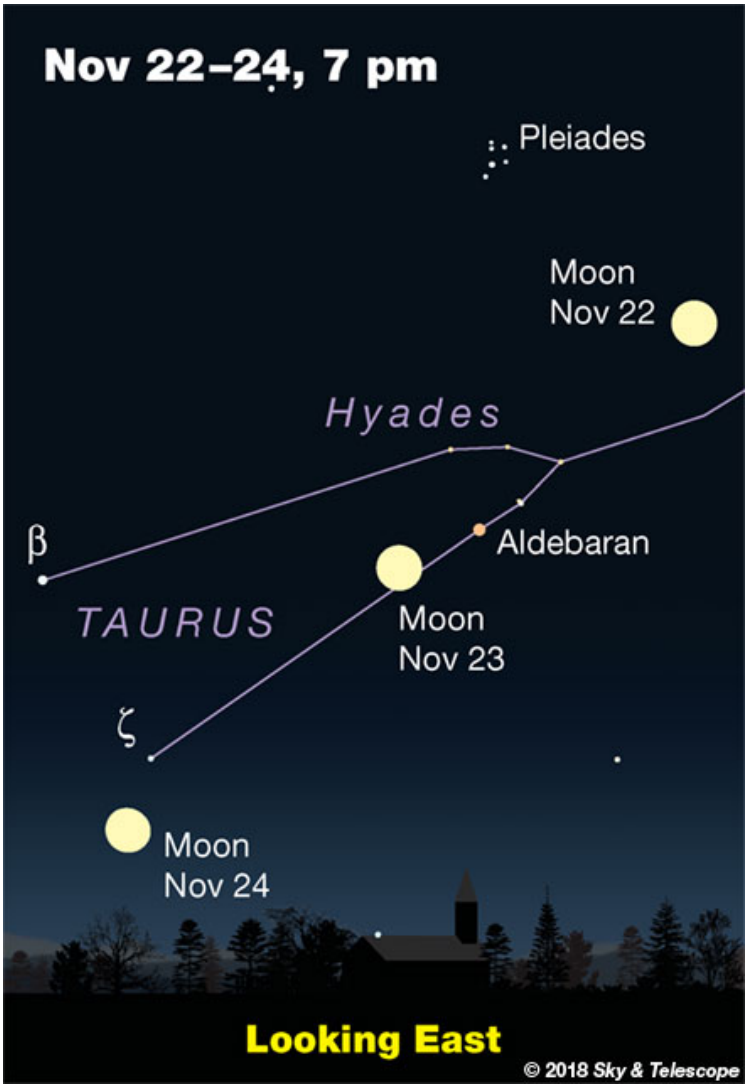
• The bright waning gibbous Moon rises around the end of twilight and climbs high through the evening. It's now below the horns of Taurus: Beta (β) and, much closer to the Moon, fainter Zeta (ζ) Tauri.

Sunday, November 25

• The bowl of the Little Dipper descends in the evening at this time of year, left or lower left of Polaris. By about 11 p.m. this week it hangs straight down from Polaris.

Monday, November 26

• The asteroid 3 Juno is just past opposition and still unusually close to Earth. It's about magnitude 7.5, visible in large binoculars but still not very bright for such a low-numbered asteroid. Juno is substantially smaller than 1 Ceres, 2 Pallas, and 4 Vesta; only by a stroke of luck was it the third asteroid discovered.



Juno is in northern Eridanus south of Taurus, in high view by late evening. See the article and finder chart in the November *Sky & Telescope,* page 49.

Source: Sky & Telescope

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ISS Sighting Opportunities

For Denver: No sighting opportunities

Date	Visible	Max Height	Appears	Disappears
Fri Nov 23, 5:30 PM	3 min	17°	10° above S	15° above ESE
Fri Nov 23, 7:07 PM	< 1 min	18°	18° above W	18° above W
Sat Nov 24, 6:15 PM	2 min	87°	19° above SW	78° above NE
Sun Nov 25, 5:22 PM	5 min	44°	13° above SSW	15° above ENE
Sun Nov 25, 6:59 PM	< 1 min	17°	15° above WNW	17° above WNW
Mon Nov 26, 6:08 PM	2 min	37°	24° above W	29° above N

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

NASA-TV Highlights

(all times Eastern Daylight Time)

Sunday, November 25

1 p.m., Mars InSight Final Pre-Landing Update News Conference (all channels)

4 p.m., Mars InSight NASA Social Speaker Program (all channels)

Monday, November 26

6 a.m., Mars InSight Live Shots (NTV-3 (Media))

1:30 p.m., Mars InSight Clean Feed of cameras inside JPL Mission Control with mission audio only (NTV-3 (Media))

2 p.m., Mars InSight Landing Live Commentary (NTV-1 (Public))

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

Space Calendar

- Nov 23 - Comet 198P/ODAS Closest Approach To Earth (1.026 AU)
- Nov 23 - Comet 25D/Neujmin Closest Approach To Earth (1.906 AU)
- Nov 23 - Comet 73P-AP/Schwassmann-Wachmann At Opposition (3.195 AU)
- Nov 23 - Comet P/2015 F1 (PANSTARRS) At Opposition (3.479 AU)
- Nov 23 - Comet 237P/LINEAR At Opposition (3.578 AU)
- Nov 23 - Apollo Asteroid 2018 VR Near-Earth Flyby (0.074 AU)
- Nov 23 - Amor Asteroid 2011 AA37 Near-Earth Flyby (0.099 AU)
- Nov 23 - Asteroid 3355 Onizuka Closest Approach To Earth (1.066 AU)
- Nov 23 - Asteroid 16740 Kipthorne Closest Approach To Earth (1.620 AU)
- Nov 23 - Centaur Object 54598 Bienor At Opposition (13.867 AU)
- Nov 23 - Antoine Darquier de Pellepoix's 300th Birthday (1718)
- Nov 24 - Comet 359P/LONEOS Closest Approach To Earth (2.976 AU)
- Nov 24 - Comet 73P-AS/Schwassmann-Wachmann At Opposition (3.235 AU)
- Nov 24 - Comet 73P-BC/Schwassmann-Wachmann At Opposition (3.274 AU)
- Nov 24 - NEW [Nov 19] Apollo Asteroid 2018 WD Near-Earth Flyby (0.012 AU)
- Nov 24 - Amor Asteroid 2018 VZ7 Near-Earth Flyby (0.073 AU)
- Nov 24 - Asteroid 5277 Brisbane Closest Approach To Earth (1.188 AU)
- Nov 24 - Asteroid 12410 Donald Duck Closest Approach To Earth (1.263 AU)
- Nov 25 - Comet 69P/Taylor Closest Approach To Earth (1.532 AU)
- Nov 25 - Comet 213P-B/Van Ness Closest Approach To Earth (2.446 AU)
- Nov 25 - Comet 213P/Van Ness Closest Approach To Earth (2.448 AU)
- Nov 25 - Comet 73P-AL/Schwassmann-Wachmann At Opposition (3.320 AU)
- Nov 25 - Aten Asteroid 2018 VT7 Near-Earth Flyby (0.021 AU)
- Nov 25 - Aten Asteroid 2009 WB105 Near-Earth Flyby (0.039 AU)
- Nov 25 - Asteroid 1094 Siberia Closest Approach To Earth (1.331 AU)
- Nov 25 - Asteroid 90125 Chrissquire Closest Approach To Earth (1.358 AU)
- Nov 25 - Asteroid 945 Barcelona Closest Approach To Earth (1.668 AU)
- Nov 25 - William Denning's 170th Birthday (1848)
- Nov 26 - HOT [Nov 19] InSight Mars Landing
- Nov 26 - HOT [Nov 19] Mars Cube One 1 & 2, Mars Flyby
- Nov 26 - NEW [Nov 19] Comet P/2018 VN2 (Leonard) At Opposition (1.541 AU)
- Nov 26 - Comet 14P/Wolf Closest Approach To Earth (2.587 AU)
- Nov 26 - Amor Asteroid 2018 VUT6 Near-Earth Flyby (0.057 AU)
- Nov 26 - Asteroid 73511 Lovas Closest Approach To Earth (2.353 AU)
- Nov 26 - 55th Anniversary (1963), Explorer 18 Launch
- Nov 26 - Ted Bowell's 75th Birthday (1943)

Source: JPL Space Calendar

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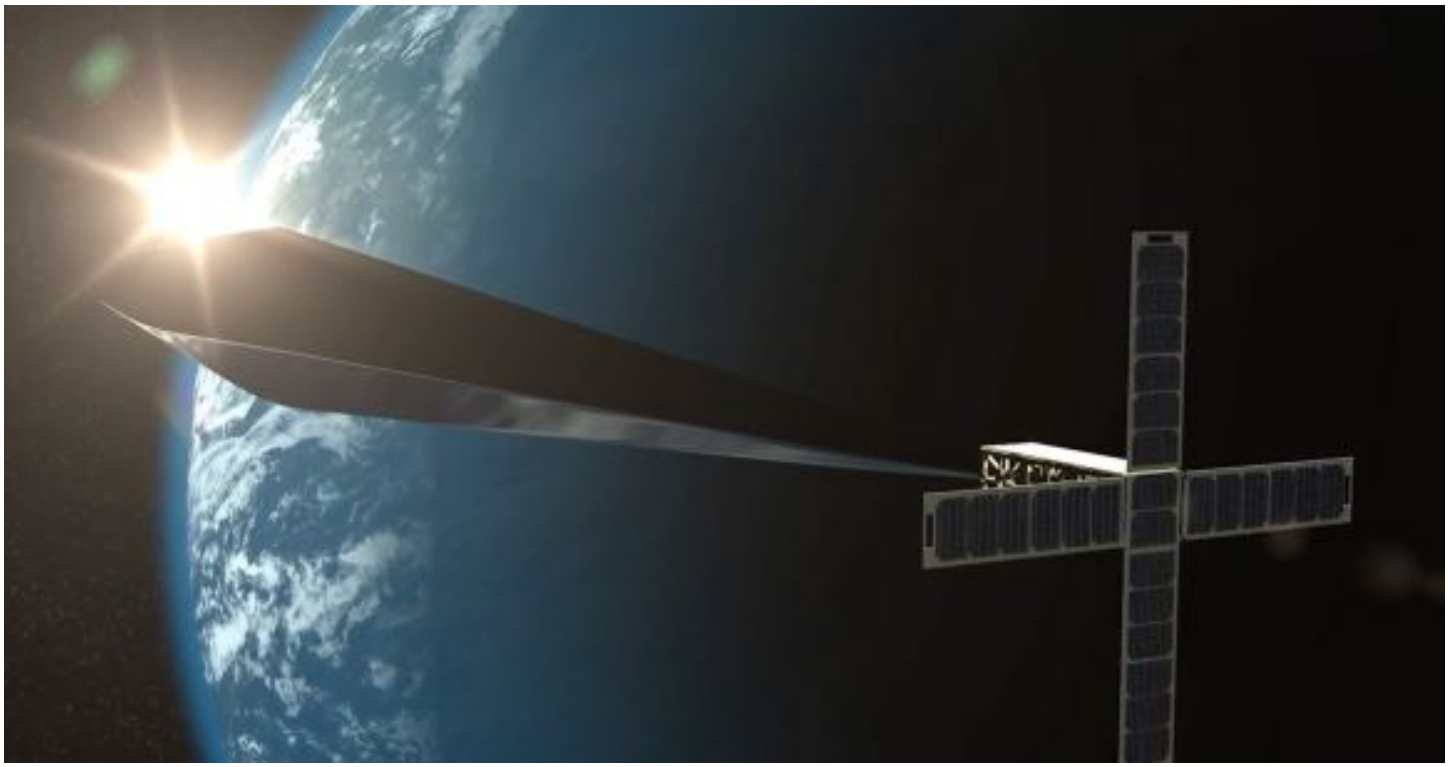
Food for Thought

SpaceX to Launch 64 Satellites, Including Orbital Reflector



A unique smallsat mission promises to be the latest satellite “brighter than a Full Moon!” in the night sky… or not.

The Mission: We’re talking about Orbital Reflector, conceived by Trevor Paglen and fielded by the Nevada Museum of Arts. Dubbed as the “first art exhibit in space,” the $1.3 million dollar project seeks to put a smallsat payload with a deployable reflector in low Earth orbit. The mission is just one of a multitude of satellites aboard the next SpaceX launch set to liftoff from Vandenberg Air Force Base in California atop a reused Falcon-9 stage 1 booster. And while the 64 small satellite payload isn’t a record—that title still goes to an Indian PSLV rocket, which launched 104 satellites in one shot last year on February 15th, 2017—this *will* mark the first time a SpaceX Falcon-9 rocket stage 1 booster has been reused, twice.

The Launch: The Spaceflight SSO-A smallsat express mission has been an on-again, off-again affair for most of 2018. The launch was set to go this past Monday on November 19th, until SpaceX pushed the date back, citing a need for further pre-flight booster inspections. A new launch date is forthcoming from SpaceX, and probably won’t occur until after U.S. Thanksgiving on November 22nd.

The SSO-A (Sun Synchronous Orbit) mission is the first fully dedicated ride-share mission, with 64 spacecraft contributed by 25 international organizations from 17 countries. For an exhaustive who’s who list of the entire manifest, click and explore the Spaceflight SSO-A press kit. Unlike most cubesats, which hitch a ride along with a primary large satellite payload, Spaceflight’s SSO-A launch is exclusively dedicated to small-sat missions.

Orbital Reflector is the mission on the roster that most backyard observers and satellite spotters will be watching for.

After it departs its satellite dispenser, Orbital Reflector will deploy an obelisk-shaped, lightweight reflective balloon 30 meters long by 1.4 meters wide.

A Brief History of Putting Shiny Things in Orbit

Ironically, one of the first reflective satellites was also the best and brightest: The U.S. put Echo-1 in low Earth Orbit on August 12th, 1960 a large 30.5 meter (interestingly, about the same length as Orbital Reflector) in diameter inflatable balloon meant to test satellite relay technology. Echo-1 was easily visible to millions as a negative magnitude 'star' and remained in orbit until June 7th, 1969.

Wackier ideas have also persisted over the years, though thankfully, they've never been implemented (yet). For example, the U.S. kicked around the idea of putting large reflectors in orbit during the Vietnam war, effectively abolishing night over southeast Asia. There have also been ideas to put advertising in space... though for now, you won't have to worry about Pepsi or McDonald's logos drifting through your astrophotos.

More recently, China has made a vague claim that it wants to put an orbital mirror "brighter than the Moon" over its cities to abolish night, but has failed to release much by way of specifics. Our own back-of-the-envelope calculations suggest you'd need place a 99% reflector about 1-2 kilometers in diameter in geostationary orbit to approach the brightness of a Full Moon. With an albedo of 10-12% (about that of worn asphalt), the Moon is actually a terrible reflector, but even though it's ten times farther away than GEO orbit, it's much much larger, at just under 3,500 kilometers across.

Semi-successful reflector satellites in recent years have been much less ambitious. Progress M-15 deployed the Znamya-2 demonstrator, though it was only briefly spied by observers watching from the high Arctic prior to reentry.

The Iridium era ushered it the age of predictable flaring satellites, a happy though unintended side benefit of the communications constellation fielded by Motorola and now run by Iridium Corporate. These satellites are now rapidly getting phased out, and de-orbited in favor of the newer (non-flaring) series of Iridium satellites.

Some satellites, such as NanoSail-D2 and InflateSail are testing solar sail and controlled reentry technologies and also tend to flare in dramatic fashion. If the Planetary Society's Lightsail-2 mission makes its way into orbit next year aboard a Falcon Heavy rocket as a secondary payload, it could shine at a brilliant magnitude -4 once unfurled.

Other attempts at making a deliberate space reflector, such as Humanity Star and Mayak have proved to be underwhelming. We caught sight of Humanity Star as a flashing +1st magnitude 'star' at best, and Mayak eluded most observers all together.

Public outreach, or menace to the night sky? Orbital Reflector bills itself simply as art, a reflection of humanity and our aspirations as we look space-ward. Trevor Paglen states that "Orbital Reflector is a work of aerospace engineering for engineering's sake," on the company's website, and goes on to state that "When we look up into the starry night sky, we tend to see reflections of ourselves." Satellite tracker Marco Langbroek also notes that "The question raised by Trevor is pertinent: Space is a public space. At the same time, it is not public at all, but strongly the domain and playground of nation states, and notably of the military of those nation states."

While many decry this as a stunt at best, or another intrusion on dark skies at worst, we feel that anything that gets folks out looking at the night sky is a good thing, and 'fizzle sats' such as Mayak and Humanity Star show us that lovers of dark skies have little to fear from these efforts just yet.

Prospects for viewing: What can we expect from Orbital Reflector? Well, it's entering a sun synchronous orbit along with the other Spaceflight SSO-A satellites, in a path inclined 97.6 degrees to the equator in a Low Earth Orbit, 575 kilometers in altitude. This means it will be in a highly inclined, retrograde orbit moving against the Earth's rotation from east-to-west, instead of the standard west-to-east. Vandenberg typically launches satellites in this direction, as they head out over the Pacific to the west of California after launch, rather than over populated areas. Sun synchronous orbits are favored by Earth-observing (and spy satellites) placed in low-Earth orbit, as they make several successive passes over target regions with the same sun-angle, handy for image interpretation.

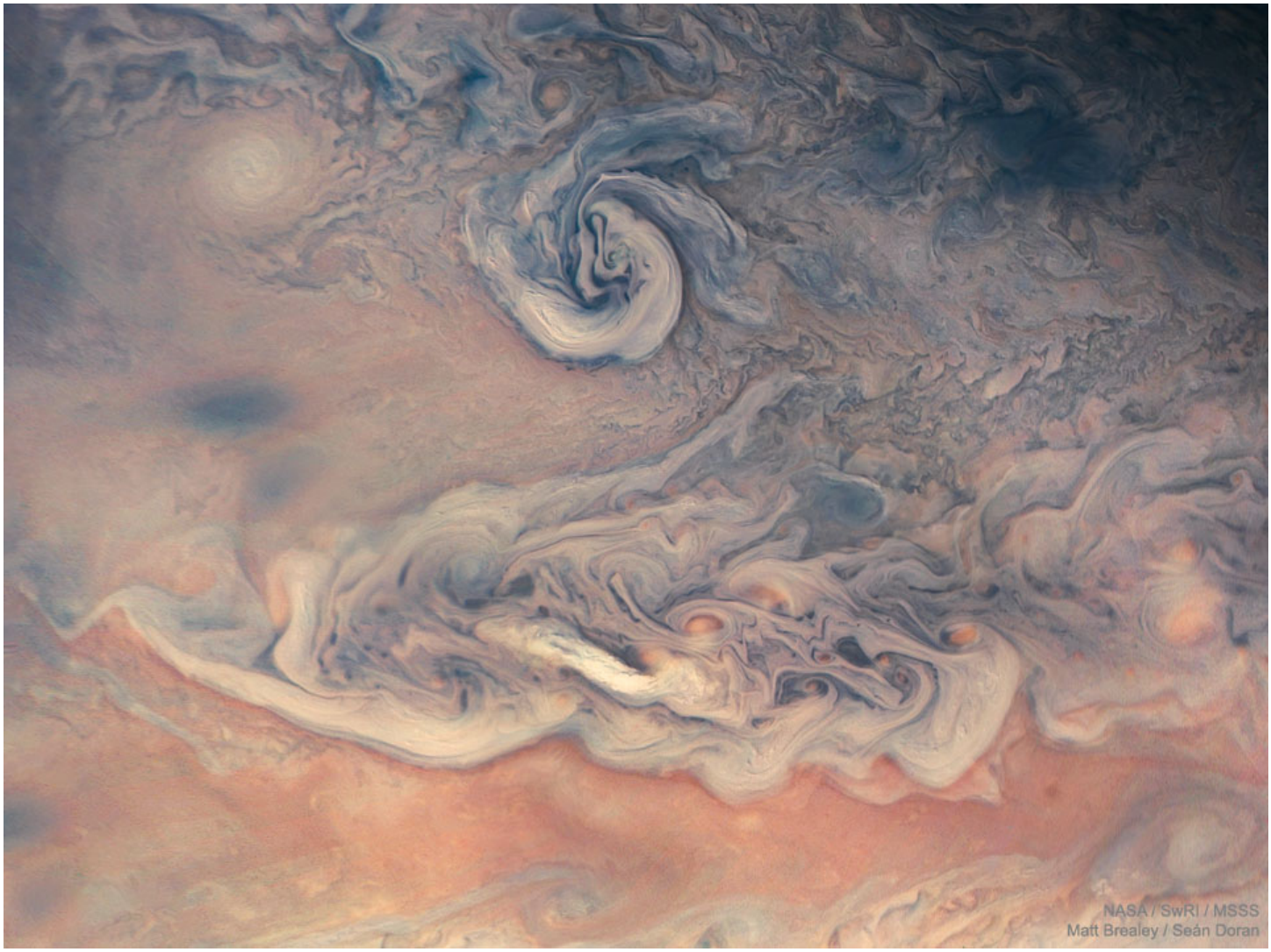
This does, however, present some difficulties with spotting Orbital Reflector shortly after launch and deployment, as it'll only be visible initially from high southern and northern latitudes. Dr. Marco Langbroek also notes that Orbital Reflector will produce specular flares like the first generation of Iridium satellites, meaning that flashes into the negative magnitudes will only briefly be visible along narrow paths across the Earth's surface at dawn or dusk. Langbroek also notes that if Orbital Reflector survives into the Spring of 2019 (it's only meant to last for three months) we could start to see it at lower latitudes.

Turns out, it's tough to deliberately make a good reflector satellite these days... I think it's interesting that the most dependable and brilliant of the flaring satellites—the first generation of Iridiums—were actually never intended to specifically do so, but in the process, became great public outreach tools for astronomy. Unfortunately, the newer generation of Iridiums do not flare in the same fashion.

We'll be using our tried and true method to stalk Orbital Reflector: first, note a good time when its passing near a bright star on Heavens-Above near dawn or dusk... then sit back, aim at the target star with binoculars at the assigned time for your location, and watch as Orbital Reflector (hopefully) drifts through the field of view.

Source: Universe Today Return to Contents

Space Image of the Week



Swirls and Colors on Jupiter from Juno

Explanation What creates the colors in Jupiter's clouds? No one is sure. The thick atmosphere of Jupiter is mostly hydrogen and helium, elements which are colorless at the low temperatures of the Jovian cloud tops. Which trace elements provide the colors remains a topic of research, although small amounts of ammonium hydrosulfide are one leading candidate. What is clear from the featured color-enhanced image -- and many similar images -- is that lighter clouds are typically higher up than darker ones. Pictured, light clouds swirl around reddish regions toward the lower right, while they appear to cover over some darker domains on the upper right. The featured image was taken by the robotic Juno spacecraft during its 14th low pass over Jupiter earlier this year. Juno continues in its looping elliptical orbit, swooping near the huge planet every 53 days and exploring a slightly different sector each time around.

Image Credit: NASA, Juno, SwRI, MSSS; ***Processing & License:*** Matt Brealey, Seán Doran

Source: APOD

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