

Robot maker

What does this plane need?

Goddard's moon treatise and more

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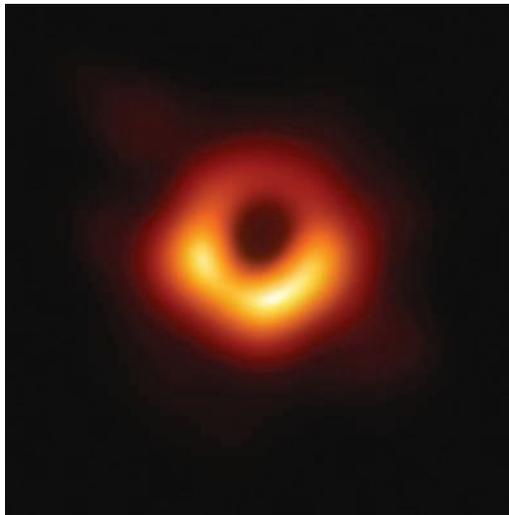
YEAR IN REVIEW

 A circular inset image shows the Artemis lunar lander on the moon surface. The lander is white with a yellow flag and a circular antenna. The background is the dark, cratered surface of the moon.

Artemis
INCLUDING PAGES
16, 42, 45,
61-64, 67, 72, 75

► Astronomers in April released the first-ever image of a black hole. This one is 6.5 billion times more massive than the sun and is located at the center of the galaxy Messier 87. The image was made by an array of eight ground-based instruments called the Event Horizon Telescope.

Event Horizon Telescope Collaboration



Space systems deliver progress toward space economy

BY JOHN CARSTEN

The **Space Systems Technical Committee** fosters the development, application and operation of space systems, and addresses emerging issues in the area.

The trend of reprogrammable communications satellites continued in 2019, with Boeing announcing in September that its “software-defined” **702X geosynchronous satellites** will dynamically allocate bandwidth.

Turning to space science, China’s **Chang’e-4 lander and Yutu-2 rover** spent the year exploring the area around their landing site on the far side of the moon. The rover and lander alternated between a dormant mode during the long lunar nights and active mode during the days. The China National Space Administration, which provided regular mission updates on its website, reported in August that Yutu-2 had driven 271 meters. The January touchdown marked the first soft landing of a spacecraft on the lunar far side. Next, China plans to launch Chang’e-5, a lunar sample return mission.

In February, NASA announced the **end of the Mars rover Opportunity** mission after receiving no response from the rover since June 2018 when a dust storm temporarily enveloped the planet. The dust probably crippled Opportunity by covering its solar cells and sensors. Opportunity traveled a total of 45.16 kilometers since its arrival in 2004, NASA said.

Researchers from the **Event Horizon Telescope project** in April released the **first image of a black hole**, specifically one located 54 million light years away in the center of the galaxy M87. The image was produced by an array of eight ground-based

telescopes. The breakthrough was announced in a series of six papers published in a special issue of the *Astrophysical Journal Letters*. “We have taken the first picture of a black hole,” said Event Horizon Telescope project director Sheperd S. Doelman of the **Center for Astrophysics Harvard & Smithsonian**. “This is an extraordinary scientific feat accomplished by a team of more than 200 researchers.”

In human spaceflight, SpaceX in March launched its **Crew Dragon** spacecraft on an uncrewed demonstration flight to prepare for its first flight with a crew. The capsule’s docking at the International Space Station and splashdown in the Atlantic Ocean brought NASA a step closer to restoring the country’s ability to launch astronauts to and from the space station. “These are all capabilities that are leading to a day when we are launching American astronauts on American rockets from American soil,” NASA Administrator Jim Bridenstine said after the mission. The mission was a milestone in NASA’s **Commercial Crew program** in which contracts were awarded for Crew Dragon and Boeing’s **CST-100 Starliner**. NASA had hoped to certify the spacecraft for crew flights in 2017.

In the budding space tourism sector, Virgin Galactic in August opened its Gateway to Space building at the **Spaceport America** site in New Mexico. Earlier in the year, the company announced that it was ready to move its Eve carrier aircraft, the **Virgin Space Ship Unity** passenger spacecraft, and supporting staff and equipment to the site in preparation for Virgin Galactic’s first launch of space tourists. Virgin expects to begin commercial operations in 2020. Also, Blue Origin in January and May launched its **New Shepard** vehicle from Texas without passengers in preparation for its first flight with people.

In June, NASA announced that “**private astronauts**” would be permitted to fly to the International Space Station twice a year for short stays starting in 2020. The change in policy is part of NASA’s strategy to “stimulate a low Earth orbit economy.” Participants in these privately funded missions would have to ride on NASA-certified spacecraft, meaning the Crew Dragon or Starliner once those are certified by NASA.

The space station is not the only potential venue for those who want to visit space. Bigelow Aerospace of Las Vegas this year continued development of its Genesis modules, inflatable space habitats to be launched aboard Vulcan rockets. The startup Orion Span of California plans to build a luxury space hotel, Aurora Station, offering guests 12 days of lodging in a pill-shaped structure. ★