

Newton vs. Einstein

Why not let him fly?

First jet operations from a carrier

AEROSPACE

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2020

YEAR-IN-REVIEW Researchers, industry persevere through the pandemic.



Steady progress for space in a year of uncertainty

BY BRIAN C. GUNTER

The **Astrodynamics Technical Committee** advances the science of trajectory determination, prediction and adjustment, and also spacecraft navigation and attitude determination.

Despite the challenges brought about by the covid-19 pandemic, the astrodynamics community achieved a number of milestones in 2020. This started with the first full year of the **U.S. Space Force**, which was formally established in December 2019. The first mission for the U.S. Space Force was in March and saw the **sixth Advanced Extremely High Frequency communications satellite** reach its geosynchronous orbit. The launch marked the 83rd of an Atlas V rocket, the 138th launch for United Launch Alliance. The rocket also deployed the **TDO-2** ride-share small satellite built by Georgia Tech.

Progress continued toward completing what is already the largest satellite constellation as SpaceX launched its 13th and 14th batches of **Starlink** broadband satellites, bringing the total number to 895 as of October out of a planned constellation of 12,000. The same rockets that launched the Starlink satellites in June and August also carried satellites for Planet, the San Francisco company that operates the second most satellites, now at approximately 150. Specifically, the Falcon 9s launched a total of six SkySat imaging satellites for Planet to complete the 21-satellite SkySat constellation, and those joined Planet's 130 or so Dove imagers.

▼ A view of Comet

NEOWISE when it was visible in the predawn sky in early July 2020.

NASA



The year also saw renewed attention on Mars exploration, with multiple missions launched to the red planet in a two-week time frame. The first launch came on July 20, when a Japanese H-IIA launch vehicle boosted the **Hope probe** toward Mars for the United Arab Emirates, commencing its first deep-space mission. Hope will study the Martian climate and atmosphere. Then, on July 23, a Chinese Long March 5 rocket launched an orbiter and rover to begin **Tianwen-1**, which is China's first independent Mars exploration mission. A week later, on July 30, an Atlas V lifted off to begin NASA's **Mars Perseverance** mission, which is scheduled to land the rover on the planet in February 2021.

Early 2020 was also marked by the visit of two natural, but unusual satellites. **Comet Borisov**, or 2I/Borisov, was discovered in late 2019 by amateur astronomer Gennady Borisov and traveled through the solar system much of 2020, undergoing a change in trajectory due to the sun's gravitational pull. The comet is believed to be the second confirmed interstellar object ever detected, with the first being the asteroid **Oumuamua** (1I/2017) in 2017. Meanwhile, in March, NASA's **Near Earth Object Wide-field Infrared Survey Explorer** spotted a comet that scientists named **NEOWISE** (C/2020 F3) after the comet- and asteroid-hunting mission. NEOWISE was the brightest comet visible from the Northern Hemisphere since comet Hale-Bopp in 1997. Its highly elliptical orbit put its closest approach to the sun within Mercury's orbit and its farthest distance well beyond that of Pluto and the Kuiper belt, with an estimated orbital period of 6,700 years.

NASA's **OSIRIS-REx** mission reached a milestone in October when it completed its first touch-and-go, or TAG, sample collection from the asteroid Benu. Following two approach maneuver rehearsals in April and August, the satellite came close enough to the asteroid's surface to deploy its robotic sampling arm to gather up to 2 kilograms of asteroid material and will begin the return journey to Earth in early 2021. The mission has relied on landmark-based optical navigation methods to conduct the various approach maneuvers and to maintain the frozen orbit that allows the spacecraft to stay within a kilometer of the surface between touch-down events. ★