

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



◀ **A camera aboard the MarCO-B cubesat** snapped this image of Mars as it flew by the red planet in November 2018 after completing its telemetry relay contribution to NASA's Mars InSight mission. In February, NASA announced that both MarCO satellites had gone silent.

NASA/JPL-Caltech

Small satellites deliver science, communications, commercial missions

BY MARTIN LINDSEY

The **Small Satellite Technical Committee** works to advance the science and engineering of satellites, launch vehicles and ground systems to enable the development of small and highly capable spacecraft.

Small satellites arrived big time on the stages of global commerce and interplanetary research in 2019, and many anticipated regulatory changes promise to further hasten the revolution.

Several companies expanded their commercial offerings focused on information derived from **frequent Earth observations** in many phenomenology. Although the first synthetic aperture radar small satellite demonstration missions occurred in previous years, this year saw the first realization of their commercial potential. The 70-kilogram **ICEYE X3** launched in May, and X4 and X5 launched in July, providing 1-to-10-meter resolution X-band SAR imagery for government and commercial customers. San Francisco-based Capella Space is also poised to provide **ubiquitous SAR imagery** to the commercial market. With its first demonstration launch in December 2018 and first commercial launch scheduled before the end of 2019, Capella had raised \$50 million as of June toward realizing its mission of flying 36 satellites with a **resolution of 50 centimeters and one-hour revisit rates**. San Francisco-based companies Planet and Spire and Virginia-based companies Black Sky and Hawk-Eye360 and several other commercial ventures expanded their on-orbit constellations and firmly established the commercial market for imagery and business intelligence products.

Global broadband internet took two large steps forward in 2019. In February, OneWeb launched six

of its prototype small satellites on a Soyuz-ST-B Fregat mission. The company has a planned constellation of **648 microsats of 125 kg each**. The first six satellites were dedicated to connecting remote schools throughout the world. OneWeb also announced in September that it would be the first company to provide **300 gigabytes-per-second communications capacity to Arctic regions** above 60-degrees north latitude by late 2020. Although the communications satellites would not technically be small satellites at 227 kg each, OneWeb announced its Arctic plans after SpaceX began launching its global internet constellation, **Starlink**, in May with 60 satellites of a planned constellation in the thousands.

Small satellites continued expanding their interplanetary research contributions as well. The **Mars Cube One, or MarCO-A and -B satellites**, NASA's first interplanetary cubesats, completed their mission in January providing near real-time telemetry relay of Mars **InSight's entry, descent and landing**. MarCO-B, carrying a commercial camera with a fish-eye lens, returned a stunning "farewell" image of Mars after completing its primary mission. The first commercial lunar lander mission, **Beresheet** at 150 kg, made it to lunar orbit in April but suffered an engine failure on descent to the lunar surface and crashed upon its attempted landing in Mare Serenitatis.

This past year also saw **quicker launch cadence** and a promising increase of launch opportunities for small satellites. As of October, Rocket Lab had launched five small-satellite-dedicated missions in 2019, deploying 15 small satellites. Virgin Galactic's Launcher One was slated for its initial test flight before the end of 2019. ★

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