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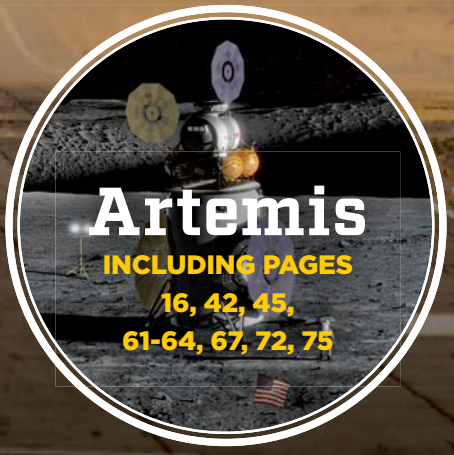
2019

YEAR IN REVIEW



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AIAA
SHAPING THE FUTURE OF AEROSPACE

Commercial Crew, engine tests mark an active year

BY DAVID J. COOTE AND VINEET AHUJA

The **Liquid Propulsion Technical Committee** works to advance reaction propulsion engines employing liquid or gaseous propellants.

▲ **The Space Launch** System's core stage pathfinder is positioned in the B-2 Test Stand at NASA's Stennis Space Center in Mississippi. Crews practice handling skills with a pathfinder before working with the real core stage.
NASA

Significant progress was made this year in NASA's **Commercial Crew program**. In March, SpaceX launched to the International Space Station an uncrewed Dragon capsule on a Falcon 9 rocket and then recovered the rocket. The Falcon 9 first stage that will launch the first crewed mission completed static hot-fire acceptance testing in April. In other Commercial Crew activities, **Boeing's CST-100 Starliner** completed key propulsion system mission static testing in May, simulating on-orbit maneuvering and high-and-low altitude abort. Blue Origin flew the New Shepard suborbital vehicle in May in preparation for its first human flight. In May, Blue Origin unveiled its BE-7, a highly efficient, deep-throttling engine with restart capability that can power in-space systems.

In other commercial activities, United Launch Alliance's next-generation launcher, **Vulcan Centaur**, powered by BE-4 engines in the first stage and RL-10 engines in the upper stage, completed its final design review in May. In January, Blue Origin initiated the process to build the **BE-4 engines** that will also be used to power its New Glenn rocket. In August, Sierra Nevada Corp. announced it would use the Vulcan for its **Dream Chaser** spacecraft, which completed its final design review in December 2018.

In August, NASA's **Space Launch System core stage pathfinder** was fit-checked in the B2 test stand at NASA's Stennis Space Center in Mississippi in preparation for installation and hot-fire testing of the SLS Exploration Mission-1 core stage in May 2020. In February, NASA and Aerojet Rocketdyne resumed hot-fire testing of the **RS-25 engines** at Stennis. Aerojet Rocketdyne also delivered eight 490 newtons (110 pounds) of thrust **R-4D** auxiliary engines to be used on the **European Service Module** supporting the Orion spacecraft for the **Artemis-2** mission.

In Europe, Ariane Group qualified its **cryogenic propulsion systems** for the Ariane 6; the upper stage Vinci engine passed its final qualification review in June, and the lower stage Vulcain 2.1 engine completed qualification testing in July, accumulating a total operation burn time of 13,800 seconds. **Prometheus**, a European Space Agency future launcher preparatory development effort to create a reusable LOX/methane engine, completed its subsystem's manufacturing readiness reviews in 2019, and two demonstrator engines are planned for hot-fire testing in 2020. JAXA, the Japan Aerospace Exploration Agency, continued the development of the first-stage **LE-9** engine and the second-stage **LE-5B3** engine for its first H3 flight in 2020. The LE-9 engine completed engineering model hot-fire testing in October and was to start qualification testing in December at Tanegashima Space Center. Testing of the Battleship H3 first stage (two LE-9s), initiated in December 2018, was to finish in December at the Tashiro Test Complex. The LE-5B3 finished qualification testing in February at the Kakuda Space Center and Tashiro.

In small thruster news, in January, Aerojet Rocketdyne's **monopropellant hydrazine propulsion system** powered the **New Horizons** spacecraft on the most distant solar system flyby as it passed within 3,500 kilometers of Kuiper Belt object **Ultima Thule**, 3½ years after its Pluto flyby. In June, as part of a joint effort among Aerojet Rocketdyne, Ball Aerospace, NASA and the U.S. Air Force Research Laboratory, the **Green Propellant Infusion Mission** was launched. It's a 13-month demonstration of the AFRL's revolutionary "green" propellant, AF-M315E.

In additive manufacturing activities, a full-scale, **3D-printed high-pressure liquid oxygen/kerosene rocket engine combustion chamber** incorporating additive copper alloy GRCop-84 completed testing in February at NASA's Marshall Space Flight Center in Alabama for Virgin Orbit, delivering 8,900 newtons (2,000 pounds) of thrust in 24 60-second test firings. In April, Aerojet Rocketdyne also completed initial testing of its next-generation **RL10C-X** engine that uses a 3D-printed injector and thrust chamber.

In April, the University of Southern California's Rocket Propulsion Laboratory designed, built and launched a rocket that passed the Karman line, believed to be a first for a student team. ★

Contributors: *Colin Cowles, Steven Baggette, Christoph Kirchberger, Scott Miller, Koichi Okita, Timothee Pourpoint, Dieter Preclik and Chandrashekhar Sonwane*