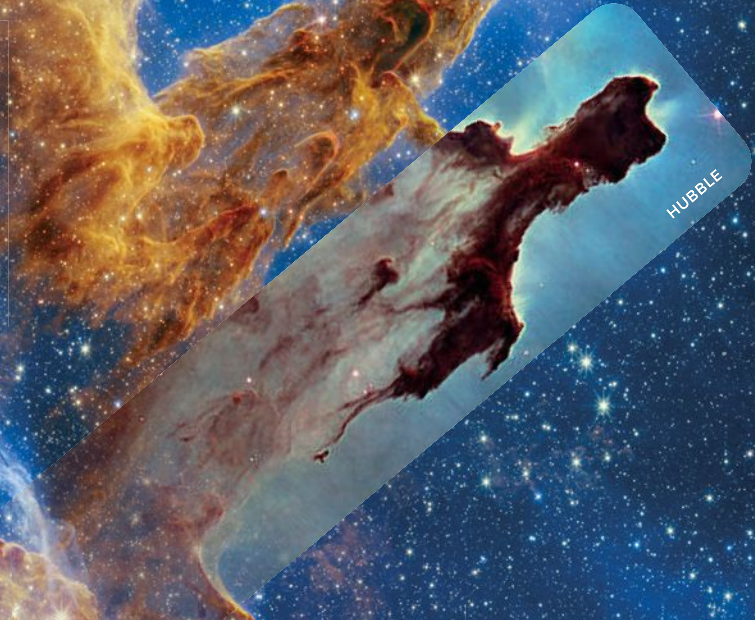
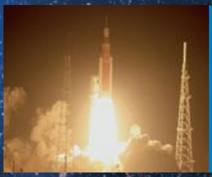
AEROSPACE AMERICA

2022 YEAR IN REVIEW

The Pillars of Creation from the Webb telescope



NASA'S DART MOVES AN ASTEROID



NASA'S SLS ROCKET NAILS ITS DEBUT

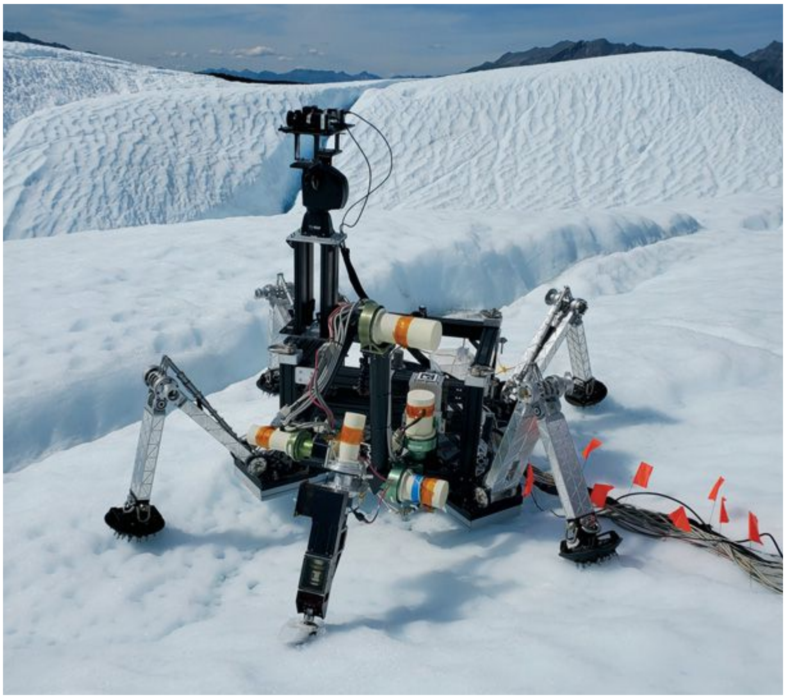
DECEMBER 2022 | A publication of the American Institute of Aeronautics and Astronautics | aerospaceamerica.aiaa.org

AIAA
SHAPING THE FUTURE OF AEROSPACE

Year of autonomy in Alaskan glaciers, flight, Earth orbit, cislunar space and Mars

BY KERIANNE HOBBS

The **Intelligent Systems Technical Committee** works to advance the application of computational problem-solving technologies and methods to aerospace systems.



▲ A Europa Lander mockup excavates ice on Matanuska Glacier in Alaska to simulate autonomous subsurface sample collection where potential biosignatures may be protected from Jupiter's radiation. Stereo cameras atop the lander allow it to perceive its environment, and cables coming out of the base provide offboard power and computation.
Jet Propulsion Laboratory

This year saw several demonstrations of air and space autonomy, including self-driving on Mars, autonomous vertical takeoff and landing vehicle flight tests, orbit determination in cislunar space, testing of autonomous robotic sampling in Alaska in preparation for Europa missions, and prognostics and health management of spacecraft main actuators for orbital missions.

In March, **NASA's Perseverance rover's autonomous self-driving system** helped secure several new planetary rover driving records during the monthlong Rapid Traverse campaign. The science team was anxious to relocate from the floor of **Jezero Crater** to the ancient delta region near the crater rim over 5 kilometers away. Having spent 13 months traversing the first 5 km of the route, the rover completed the next 5 km to the delta in just one month using 24 drives over 30 Martian days, with the autonomy system having planned more than 95% of the overall driving. Perseverance exceeded the previous longest daily distance record for a planetary rover — 220 meters, set by Opportunity in 2005 — 11 times and set a new continuous drive record of 699.9 meters by operating with no human reviewing or choosing its path over 3 sols of driving.

In June, the **U.S. Air Force Research Laboratory's Intelligent Control and Evaluation of Teams** flight test program flew an uncrewed aerial system in coordination with ground systems to provide aerial support in virtually contested environments. The flight test team was able to demonstrate this on a **vertical takeoff and landing vehicle** with both electric and conventional fuel propulsion systems onboard. The UAS was able to plan and execute these missions autonomously using onboard hardware. It was the first time the **Julia programming language** was flown on the embedded hardware — algorithms were precompiled ahead of time. The algorithms used to perform the various missions involved feedback control, mixed-integer linear programming and optimal control.

In November, NASA's **Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment** arrived at its near-rectilinear halo orbit around the moon. Mission controllers regained control of CAPSTONE in October after the spacecraft began spinning in September, likely due to a stuck thruster valve. Among the mission objectives are demonstrating autonomous orbit determination in cislunar space. Using ranging measurements from the **Lunar Reconnaissance Orbiter**, the CAPSTONE spacecraft can determine its orbital position and perform stationkeeping maneuvers without the need for Earth-based localization, paving a way for greater numbers of more independent cislunar and deep space probes.

In August, engineers at **NASA's Jet Propulsion Laboratory** completed a three-week field test of an autonomous robotic sampling system on Alaska's Matanuska Glacier for the **Europa Lander** pre-project, a proposed concept to land on the surface of Jupiter's icy moon Europa to search for biosignatures. The campaign demonstrated end-to-end sample collection in an environment that challenged the autonomy in ways difficult to recreate within a laboratory. The system surveyed the surrounding workspace, identified a suitable sampling site, excavated a trench and collected a sample without any human input.

In November, the **Department of Mechanical Engineering at Santa Clara University** and **Maxar Technologies'** California branch developed a novel model-based/data-driven hybrid framework for diagnostics, prognostics and health management of spacecraft main actuators. The proposed prognostics and health management will be used for predicting the remaining useful life of reaction wheels — the most common actuator in spacecraft attitude control systems. This predictive algorithm will help manage large multisatellite constellations by providing advanced and early warning for reaction wheel issues, thus supporting constellation replenishment planning. ★