AEROSPACE

★ ★ ★ AMERICA ★ ★ ★

2023

YEAR-IN-REVIEW

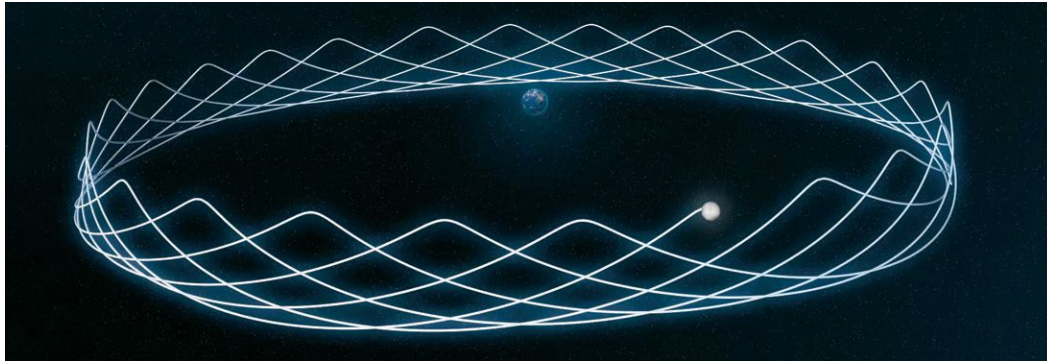**AIAA**
SHAPING THE FUTURE OF AEROSPACE

Autonomous systems adapting to uncertain and contested operating conditions

BY JULIE J. PARISH

The **Guidance, Navigation and Control Technical Committee** advances techniques, devices and systems for guiding and commanding flight vehicles.

◀ The zigzag lines in this illustration represent the trajectory of the CAPSTONE satellite in its near-rectilinear halo orbit around the moon. From this orbit, the NASA-funded satellite in May began an enhanced mission to demonstrate a technique for deducing position and velocity with the aid of the Lunar Reconnaissance Orbiter, instead of antennas on Earth.

Advanced Space

Across the guidance, navigation and control community, **autonomous and cooperative systems** for complex missions and environments have continued to improve in robustness and resilience.

In January, **NASA** updated post-flight analysis from the **Artemis I** mission, in which a **Space Launch System** rocket launched an unoccupied **Orion** capsule toward lunar orbit in November 2022. Analysis reports indicate that SLS performed nominally, including the new adaptive augmenting control technology.

In November, **SpaceX** launched its second fully stacked **Starship-Super Heavy**. The stages separated as planned over the Gulf of Mexico, but Super Heavy exploded shortly after and Starship was lost, prompting FAA to announce that SpaceX would conduct a "mishap" investigation. The November flight demonstrated the new **electronic thrust control vector system** developed after the truncated first attempt in April, in which communications were lost.

NASA has also made contributions in navigation. In May, the **Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment, or CAPSTONE**, satellite demonstrated cooperative navigation with the **Lunar Reconnaissance Orbiter**. CAPSTONE also flew a **near-rectilinear halo orbit** for over six months, allowing for further study of dynamics and control of nontraditional, fuel-efficient orbits.

In July, NASA announced its **Tipping Point** selections, which included **Psionic** of Virginia. Psionic received the license for **NASA's Navigation Doppler Lidar** The lidar will be integrated in lunar landers under development. In May, Psionic received additional **Phase-3 Small Business Innovation Research funding** from **NASA** and the **U.S. Defense Department** to develop a **high-powered photonic integrated circuit** to shrink the government lidar from 12 kilograms to under 3 kg for a commercial version.

The **European Commission's Directorate-General for Defense Industry and Space's Joint Research Center** released a report in March on its assessment of alternative position, navigation and timing solutions. Per the report, **Locata** of Australia demonstrated the highest positioning accuracy with its network of **LocataLites** ground states. Also exceeding industry benchmarks were Virginia-based **Satelles**, which operates its **Satellite Time and Location service** on low-Earth orbit satellites including the Iridium constellation, and Virginia-based **NextNav's TerraPoiNT**, which uses several sources including TerraPoiNT transmitters. In July, **NextNav** demonstrated its alternative navigation capability on TerraPoiNT using existing **LTE** and **5G** cellular signals in San Jose, California. In May, **Spirent Communications** of the U.K. announced certification of its **SimXona** satellite constellation simulator by California-based **Xona Space Systems**, which is developing the **Pulsar** small-satellite PNT service also envisioned for LEO operation.

There was also a lot of movement in the **artificial intelligence** and **machine learning** community. **DARPA** announced in February that its **Air Combat Evolution program** executed the first live-flight demonstration of the **X-62A Variable In-flight Simulation Test Aircraft** in December 2022. The **U.S. Air Force Research Laboratory** leveraged lessons learned from the X-62A flights and in July demonstrated the first flight of its machine learning-trained algorithms on an unoccupied **XQ-58A Valkyrie**. In April, an AI technology jointly developed by Australia, the United Kingdom and the United States was demonstrated in a live trial on unoccupied intelligence, surveillance and reconnaissance systems. In September, the **U.K. Royal Navy** landed a **W Autonomous Systems autonomous transport drone**, named HCMC, onto the deck of the aircraft carrier **HMS Prince of Wales**. ★

Contributor: *Shawn Stephens*