JAHNIVERSE 96
Newton vs. Einstein

AEROPUZZLER 6
Why not let him fly?

LOOKING BACK 94
First jet operations from a carrier

AEROSPACE AMERICA

2020

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

Commercial Crew breakthrough PAGE 61

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AIAA
SHAPING THE FUTURE OF AEROSPACE

Progress in autonomy: space robotics, satellite systems, air traffic control

BY NATASHA A. NEOGI

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

Several advances in intelligent aerospace systems were made this year.

The **Integrated System for Adaptive Autonomous Caretaking** teams at **NASA's Ames Research Center** in California and **Johnson Space Center** in Texas collaborated in June to demonstrate an integrated data approach for anomaly detection and isolation. Using a simulation of **Astrobee** in the **International Space Station**, this work combines vehicle system telemetry, static spatial information and functional relationships for vehicle hardware, and robot data, obtained by Astrobee's mapping and inspection software, to detect and isolate the root causes of anomalous data. This technology is funded by the Space Technology Mission Directorate's **Game Changing Development** Program and will inform the Vehicle Systems Manager software design, which will autonomously manage NASA's planned lunar Gateway outpost.

Also this year, the NASA-funded **Jet Propulsion Laboratory** in California conducted autonomy experiments in orbit with the **ASTERIA cubesat**, short for Arcsecond Space Telescope Enabling Research in Astrophysics. While contact was lost with ASTERIA in December 2019 after several in-flight autonomy experiments, JPL used a flat-sat ground-based replica of the ASTERIA spacecraft to continue testing and demonstrating autonomy capabilities throughout the year. The work culminated in an integration of three autonomy capabilities: 1) The Multi-mission Executive, or MEXEC, which demonstrated the use of tasknets for commanding and onboard execution that allows specification at a "task" level instead of using time-based sequences. MEXEC executed nominal science observations onboard, and is demonstrating replanning around anomalies on a ground testbed. 2) Optical navigation algorithms performed onboard orbit determination in low-Earth orbit without GPS, demonstrating an independent means of spacecraft orbit determination using only passive imaging of other bodies. 3) MONSID, a model-based approach to detect and identify hardware malfunctions, is being tested on the testbed to demonstrate in-situ hardware health assessment needed for advancing autonomy beyond monitor-response mechanisms.

Drones were flown in Reno, Nevada, as part of NASA's **Unmanned Aircraft System Traffic Management** project. Researchers shared data this year that was collected during hundreds of flights.
NASA

In the field of air traffic control, NASA's **Unmanned Aircraft System Traffic Management** project completed its last and most complex flight demonstration and in June reported the results to the aviation community. Nearly 400 flights of small uncrewed air systems were conducted in the downtown areas of Reno, Nevada, and Corpus Christi, Texas, in 2019 with the UTM system managing scenarios of high-density drone traffic. The testing involved 35 industry partners that provided the drones, ground test equipment and service supplier systems for traffic management. Data on the performance of the UTM system and the effects of flying in the urban canyons with communication and GPS navigation challenges were reported in several publications at AIAA's virtual Aviation Forum.

The **Vehicle Systems and Control Laboratory** at Texas A&M University flight tested a vision-based system for detection and tracking of small uncrewed air systems. The technology could prove useful for the counter-UAS missions. The system combines the advantages of the long-wave infrared and visible spectrum sensors using machine-learning for vision-based detection through previously difficult environments such as when the vehicles are flying above and below a treeline, in the presence of birds and sun glare. The main algorithm is built upon the **YOLOv3 object detector retrained to detect small aircraft** on synchronized and blended Red-Green-Blue and long wave infrared video frames.

Eight competitors raced to develop artificial intelligence algorithms for **DARPA's Alpha Dogfight Trials**. These algorithms, which are capable of performing **simulated within-visual-range air combat**, were tested at the Alpha Dogfight Trials Virtual Final Event in August. These eight teams competed against various AI algorithms developed by **Johns Hopkins Applied Physics Laboratory** and then against every other competitor in a round-robin tournament. Of the eight competitors, Heron Systems, Lockheed Martin, Boeing's Aurora Flight Sciences and Physics AI were finalists in a heated competition. Winner Heron Systems went on to beat an experienced human fighter pilot in the final matchup. ★

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