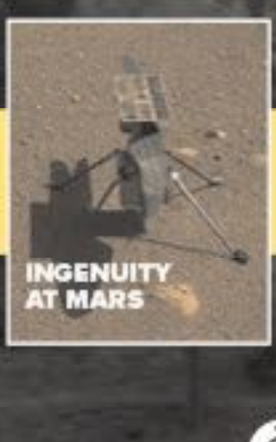
AEROSPACE
★ ★ ★ AMERICA ★ ★ ★

2021 Year in review

247 kilometers on one charge
and dozens of other breakthroughs



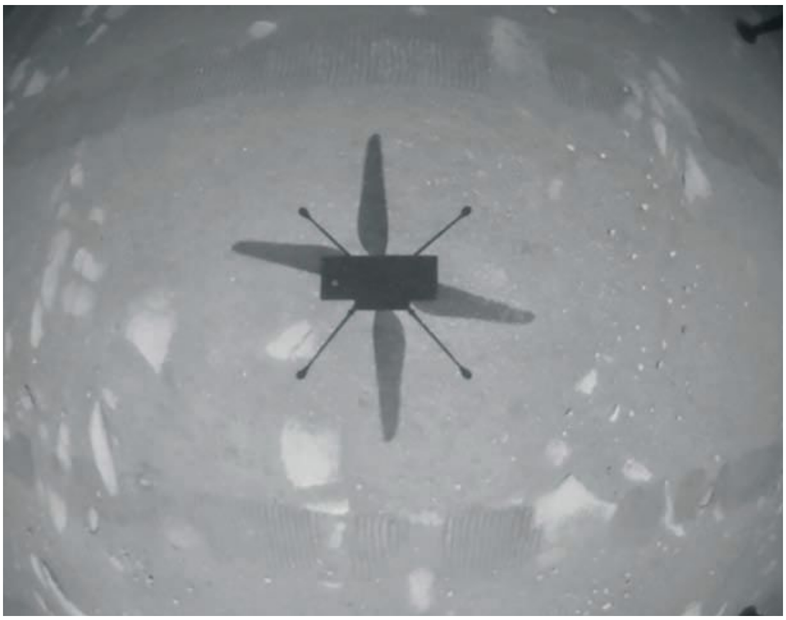
AIAA
SHAPING THE FUTURE OF AEROSPACE

DECEMBER 2021 | A publication of the American Institute of Aeronautics and Astronautics | aerospaceamerica.aiaa.org

A drone on Mars hints at space computing things to come

BY RICK KWAN

The **Computer Systems Technical Committee** works on advancing the application of computing to aerospace programs.



▲ The navigation camera on NASA's Ingenuity Mars Helicopter shot this photo of its shadow as it hovered over the Martian surface.

NASA

NASA's **Ingenuity Mars Helicopter** had made 15 flights on Mars through mid-November. Originally carried as a technology demonstrator, it produced scouting images for the Perseverance rover. Ingenuity employs a three-level avionics computing stack. A quad-core Qualcomm Snapdragon 801 running a version of Linux developed for the drone market handles the helicopter's high-level functions. A pair of TI Hercules TMS570 high-reliability processors that operate in lockstep handles real-time flight control. Sensor and actuator signals are fed through a MicroSemi ProASIC3L radiation-tolerant field-programmable gate array. Ingenuity can also power-cycle either of the Hercules processors in case of a detected fault.

NASA's High Performance Spaceflight Computing project made progress in software but suffered a setback in hardware. NASA's **Goddard Space Flight Center** in Maryland and **Jet Propulsion Laboratory** in California completed **HPSC Middleware Release 4** midyear. The middleware handles such functions as resource allocation, configuration, power and performance, and sharing hardware resources. NASA expected a prototype radiation-hard dual quad-core ARM Cortex-A53 chiplet in April. However, given the retirement of the intended 32-nanometer fabrication line, NASA is reformulating HPSC.

JPL is leading a design study that considers requirements from advanced mission concepts as well as earlier use cases. While the overall assessment continued to favor general purpose central processing units, a new direction involving artificial intelligence and machine learning emerged. JPL published a request for proposals in May asking vendors to submit detailed implementation plans but also allowing for proposals of low-risk features that show market adoption.

The primary radiation-hard processor in U.S.-based designs was the **BAE Systems RAD750**, based on the Power/PowerPC architecture. In Europe, it was the **Gaisler LEON3FT** (FT for fault tolerant), based on the SPARCv8 architecture. However, the IEEE Space Computing Conference in August showed that a lot of researchers were looking at **RISC-V, RAD5545 and LEON5**.

The fastest supercomputer in the world remained **Japan's Fugaku**, reaffirmed in June and November by Top500.org. In fact, its High Performance Linpack rating rose from 415.5 to 442 petaflops (million billion floating-point operations per second). This made it three times faster than the second-fastest machine, Oak Ridge National Laboratory's Summit in Tennessee, which was rated at 148.8 petaflops. Built by Fujitsu, Fugaku is based on the ARMv8.2-A architecture with Scalable Vector Extension. By contrast, Summit combines two architectures: IBM Power9 CPUs and Nvidia Volta graphics processing units. The largest aerospace computational fluid dynamics simulations take a few days on Summit.

A **global microchip shortage** delayed the manufacturing of a wide range of products and drove up prices. General Motors and Ford made deep cuts in manufacturing due to the shortage. Observing the impact on automotive, aerospace manufacturers began to look more closely at their supply chain vulnerabilities. Responding to the shortage, the leading chip manufacturer Taiwan Semiconductor Manufacturing Co. ramped up production by 30% between January and June over 2020 levels. It prioritized orders such as automotive. Following order cancellations in 2020 due to economic slowdown, several industries placed production orders simultaneously against limited fabrication capacity. However, chip fabrication and packaging normally take several months.

In June, **TSMC** began construction of a $12 billion fabrication facility in Arizona, but it won't start production until 2024. Intel is also building two new facilities in Arizona but will also use some TSMC facilities for CPU tiles that are later sewn together to create a chip package. AMD was expected to complete its acquisition of Xilinx, a leading manufacturer of FPGAs, before the end of the year. Intel acquired FPGA manufacturer Altera in 2015. Both Xilinx and Altera produce radiation-hard FPGAs used in aerospace. ★