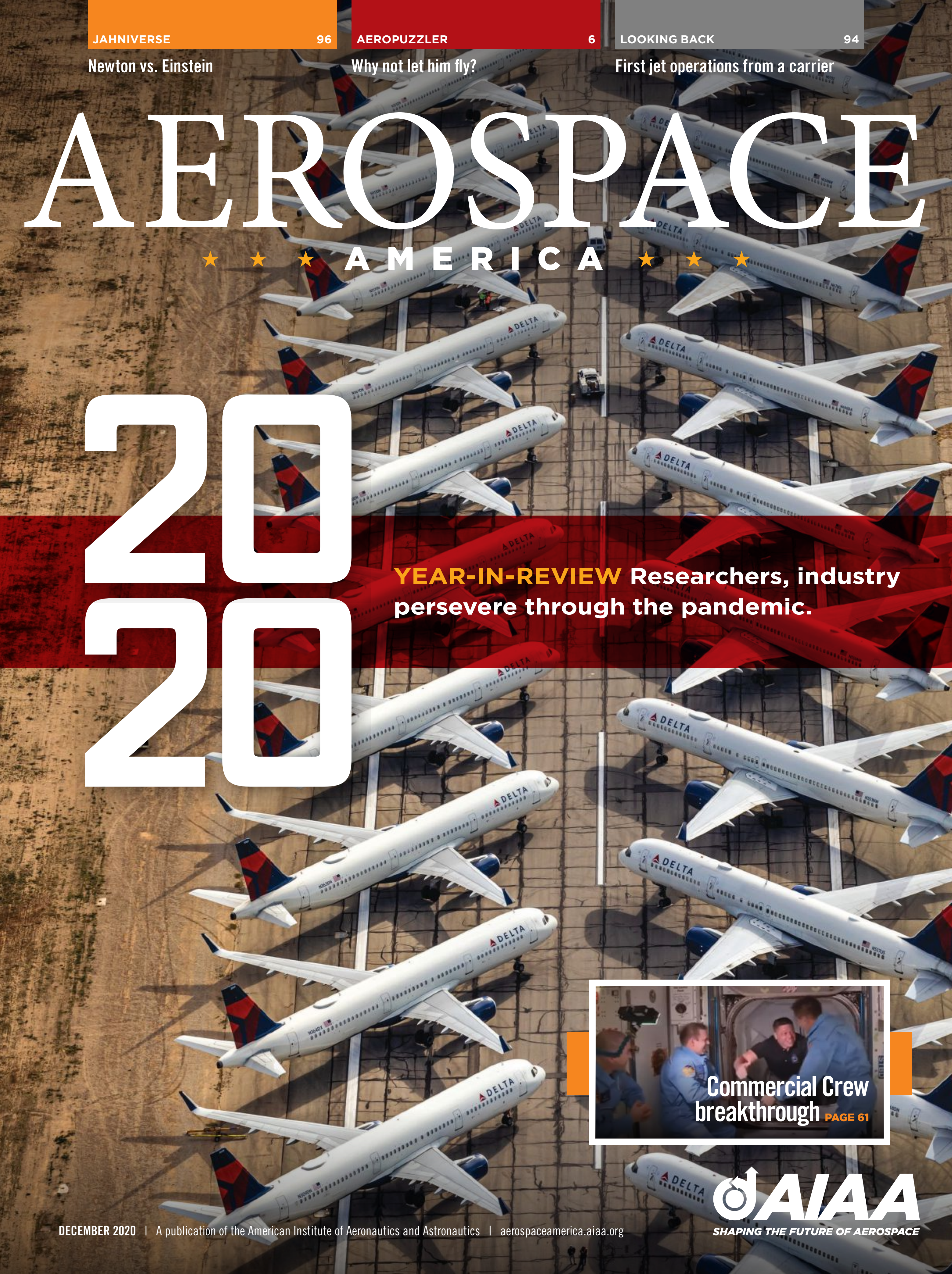
JAHNIVERSE 96
Newton vs. Einstein

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

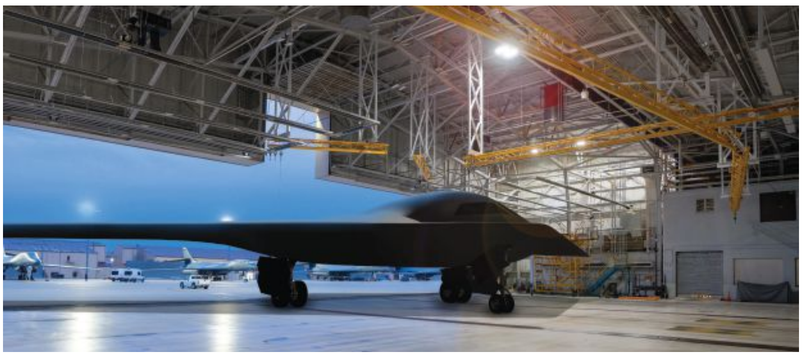
DECEMBER 2020 | A publication of the American Institute of Aeronautics and Astronautics | aerospaceamerica.aiaa.org

AIAA
SHAPING THE FUTURE OF AEROSPACE

New architectures, agile development and next-gen rad-hardening lead work in computing

BY RICK KWAN

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



▲ **Flight hardware for a** U.S. Air Force B-21 stealth bomber ran software produced by agile development practices in a Defense Department enterprisewide secure software development environment. The process allows software to be deployed in containers, in effect, apps on a smart mobile airborne platform.
Northrop Grumman

Scientific and engineering supercomputing took a giant leap in performance this year due to innovation in computing architecture. The agile software development pipeline stretched its way from enterprise computing to flight-ready hardware. Computing in the radiation environment of space is on the brink of a performance boost.

As for supercomputers, **the fastest in the world**, as measured by High Performance Linpack, is now **Fugaku**, according to Top500.org. Fugaku, named after Mount Fuji, was made by **Fujitsu** of Tokyo and is installed at Japan's **RIKEN Center for Computational Science**. The TOP500 list, released in June, placed it at 415.5 petaflops (million billion floating point operations per second), about 2.8 times faster than its closest competitor, **Summit at Oak Ridge National Laboratory** (148.6 petaflops) in Tennessee. The major difference between them is architecture. Summit epitomizes a hybrid cluster of traditional multicore central processing units and highly parallel graphics processing units. For Summit, these were nodes of IBM Power9 CPU and Nvidia Volta GPU chips connected by Nvidia NVLink within a node and Mellanox EDR InfiniBand between nodes.

By contrast, Fugaku is built with Fujitsu's 48-core A64FX CPU chips based on the ARMv8.2-A architecture, but exploiting its Scalable Vector Extension. Published in 2016, SVE adds instructions that handle 32 vector registers, which are between 128 and 2048 bits wide. In the case of A64FX, the vector registers are 512 bits. The registers can hold eight double-precision or 64 single-byte elements in parallel. In addition to pushing CPU-based parallelism, SVE is pushing the compiler technology necessary to achieve it. Begun in 2014, Fugaku is expected to start public service in 2021.

Many computers on the TOP500 list are now part of the **Covid-19 High Performance Computing Consortium**. They support 80 research projects in bioinformatics, epidemiology and molecular modeling.

Turning to agile development, software containers and aircraft, in a drive to deliver war-fighting capabilities in a timely fashion, the **U.S. Air Force** has embarked on broad adoption of agile software development practices and infrastructure. It has deployed a variety of Defense Department enterprisewide **DevSecOps** (software development, security, software operations) services. Developers utilize secure source code repositories, build digitally signed software container images, and run them on **Kubernetes**, a platform for running a cluster of containers. In May, Will Roper, the assistant secretary of the Air Force for acquisition, technology and logistics, congratulated developers for getting a Kubernetes cluster to run on "flight-ready hardware" of a **B-21 stealth bomber**. The B-21 isn't slated to fly until December 2021 at the earliest. But the Air Force ran a Kubernetes cluster on a Lockheed Martin F-16 during flight in late 2019.

In the area of **radiation-hardened computing**, **Perseverance**, the new NASA rover launched toward Mars in July, has the same chassis design as its predecessor Curiosity. That includes the **BAE Systems RAD750**, a radiation-hardened cousin of the 32-bit single-core IBM/Motorola PowerPC 750. It has been a mainstay for roughly 15 years of rovers, landers and orbiters at the moon, Mars and beyond, with clock speeds of 110 to 200 megahertz, reaching a processing rate of 266 million instructions per second. Its successor, the **RAD5545**, saw its first shipments in July to Lockheed Martin in the form of a rad-hard software-defined radio. The RAD5545 is a 64-bit quad-core design based on the PowerPC e5500. It is capable of 5.6 Dhrystone giga (billion) instructions per second, or 3.7 giga floating-point operations per second.

Boeing continued prototype development of the rad-hard **High Performance Spaceflight Computing processor** based on the ARM Cortex-A53, a quad-core 64-bit design that has been used in several smartphones and single-board computers, such as the Raspberry Pi 3. Prototypes of this processor are scheduled for delivery in 2021.

The increases in performance for spacecraft computers should translate into greater spacecraft autonomy deeper into the solar system, as well as real-time capabilities such as software defined radio. ★