AEROSPACE

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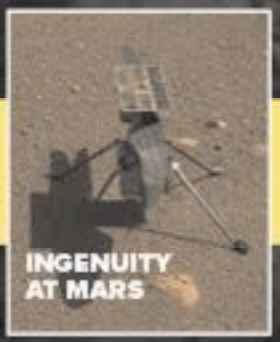
2021 Year in review

247 kilometers on one charge

and dozens of other breakthroughs



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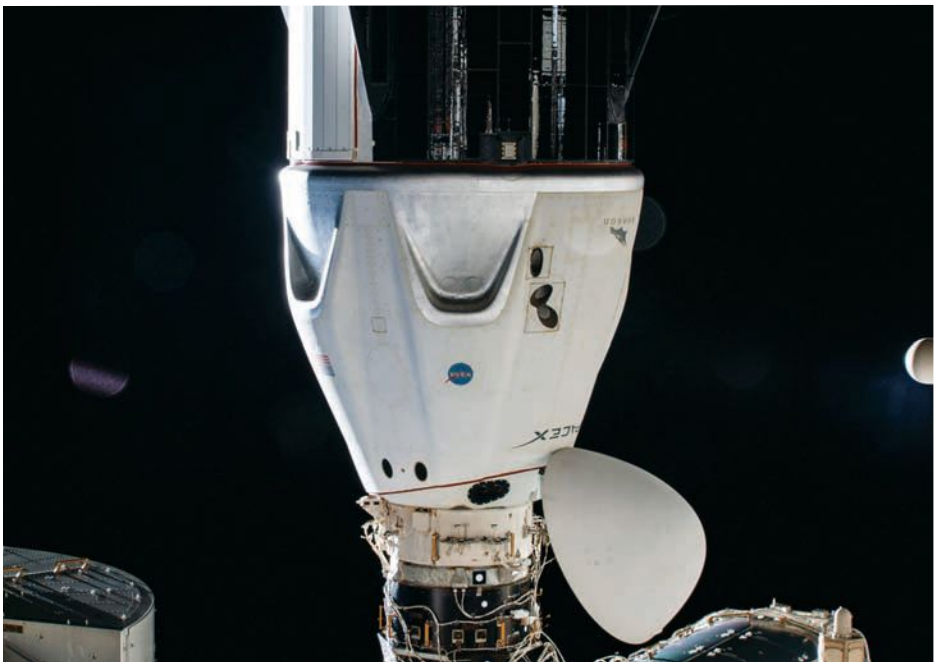
DECEMBER 2021 | A publication of the American Institute of Aeronautics and Astronautics | aerospaceamerica.aiaa.org



▲ This SpaceX Crew Dragon autonomously moved to a different docking port on the Harmony module in April.

NASA

Working on future missions with systems built over decades

BY JOHN GEBHARD AND PAUL C. LAMBERTSON

The **Systems Engineering Technical Committee** supports efforts to define, develop and disseminate modern systems engineering practices.

The year was marked by milestones and achievements in the commercialization of space, fueled by state-of-the-art systems engineering and detailed interface management.

On April 5, the Crew-1 astronauts aboard the International Space Station entered their **Crew Dragon Resilience** spacecraft and rode in the spacecraft as it **autonomously undocked and re-docked** to a different port, marking the first time a commercial spacecraft has performed such a maneuver. As of September, **11 commercial dockings, relocations and captures** were logged at ISS over the year.

Disciplined systems engineering applied since 2000 yielded benefit to the space exploration ecosystem. Boeing engineers designed and built standard interfaces into the ISS some 25 years ago, and Space X, Axiom and Blue Origin are now using those interfaces to commercialize spaceflight. This year's events demonstrate that those interfaces, designed and built leveraging legacy requirements from systems engineering work completed decades prior, not only accommodated past needs but also enabled future unknown needs.

Matt Duggan, Boeing's ISS mission operations manager, recounted some of this history to our committee: The **Common Berthing Mechanism** was designed to connect the original ISS modules together and found continued use with current ISS cargo vehicles. Duggan said that engineers designed the **International Standard Payload Rack** and its interfaces to allow large payload systems to be quickly installed in all the research modules on the ISS.

The **Expedite the Processing of Experiments to the Space Station, or ExPRESS, rack** accomplished the same purpose by hosting multiple smaller payloads within a single rack, enabling a new generation of commercial research. **Boeing** engineers designed the **NASA Docking System and the accompanying International Docking System Standard** for NASA. Docking systems built to this standard are used today by commercial spacecraft visiting the ISS.

In July, **Virgin Galactic** conducted its first suborbital flight with passengers when **VSS Unity** and two pilots carried founder Richard Branson and three other spaceflight participants to the edge of space.

Two weeks later, a **Blue Origin New Shepard** rocket boosted founder Jeff Bezos and three other passengers to the edge of space, marking another milestone in the commercialization of space. The New Shepard program "encourages system-level thinking across the entire organization and utilizes systems engineering processes for risk reduction during all life cycle phases of the program," Blue Origin said in a statement, referring to the company's vertical integration across the product development and operations processes. "This organizational structure yields systems engineering influence in all aspects of the project," the company said. "Leading up to the first human flight, the systems engineering team, tools, and processes were essential in evaluating the system design and compliance to the requirements by organizing and performing a series of System Verification Reviews," the company added.

Looking back on the year's milestones, these elegantly designed interfaces demonstrate the enduring value of thoughtful systems engineering. The space community greatly benefited from the ISS and the new commercial entrants enabled by those interfaces. Beyond this year, the challenges that remain for each of the new commercial entrants to scale up their ventures are influenced by systems engineers within each organization. Balancing the complex requirements of functionality, ease of use, product certification and operational cost may remain the significant factors as new space technologies move forward in 2022. ★