Innovation Quarterly

3D printing done right

Applying additive manufacturing in integrated mechanical designs.

Satellite design is characterized by extreme mass criticality, multifunctional structures, low production volumes, low duty cycles, high reliability and speed to market. Because of that, spacecraft and satellite platforms have presented an ideal opportunity for the design and analysis of flight vehicle products using additive manufacturing.

Additive manufacturing—also known as 3D printing—enables an efficient design process that can achieve design solutions that we could not have imagined in the past.

With the 702SP satellite development program, Boeing changed the engineering model. We established an integrated design approach with all mechanical elements consolidated under a single technical lead. This lead engineer was responsible for platform mechanical architecture, load paths, subsystem integration, development of new materials, and the synergistic execution of loads development, design, stress and manufacturing. The lead engineer also held all the budgets for the various disciplines and was accountable not only for the design, but also for the manufacturability and test of the platform mechanical subsystem.

GAME CHANGER
Boeing applied additive manufacturing technology to the CST-100 program to reduce mass, cost and cycle time. The team was awarded a NASA Spaceflight Awareness Award. Some of the members of the team are pictured here with astronaut Ricky Arnold, from left, Erick Li, Nicole Hastings, Matt Herrmann, Sean Dungan, Nick Meyer, Anna Tomzynska, Andrew Scott, Emily Woods and Richard Aston.
Boeing Photo

configurations that had once been un-producible were now possible. This new capability enabled engineers to “think additively” and be creative in the development of structural solutions.

Our success was a function of several factors, including a multi-skilled team with individuals capable of design, stress, materials and manufacturing engineering, and full product ownership from concept to launch.

A systems approach to additive manufacturing

The first significant application of additive manufacturing in this area of Boeing was to the SES-15 spacecraft. The team identified several areas of opportunity, including a new design for a nadir surface mounted optical bench. This architecture required a systems approach, which not only addressed additive manufacturing but also the way that the additively manufactured components would function in an integrated assembly.

Additive manufacturing alone did not offer significant technical advantages. But additive manufacturing when applied in concert with new composite and adhesive materials yielded a lightweight, low cost and thermally stable design solution.

The SES-15 project was used to establish the acceptance test regime that is now applied to all flight hardware that is 3D printed within the Boeing Space and Missile Systems organization.

As additive production has been deployed, cost and cycle time data have been collected and reflected back into future part selection decisions. With three different material systems at TRL 9 and an expanding supply base, additive manufacturing is now being actively traded and applied to flight systems.

Going mainstream

At Boeing, we have moved beyond satellites and human-rated spacecraft and applied the technology to missiles, helicopters and airplanes. In space systems alone, a small, multi-skilled team is delivering nearly 1,000 additively manufactured parts to flight programs.

As additive manufacturing becomes a mainstream fabrication method, significant manufacturability improvement and cost reduction can be achieved by approaching design as an integrated mechanical system. Optimizing additive components will not be possible without sufficient understanding and redesign of the entire system design as a

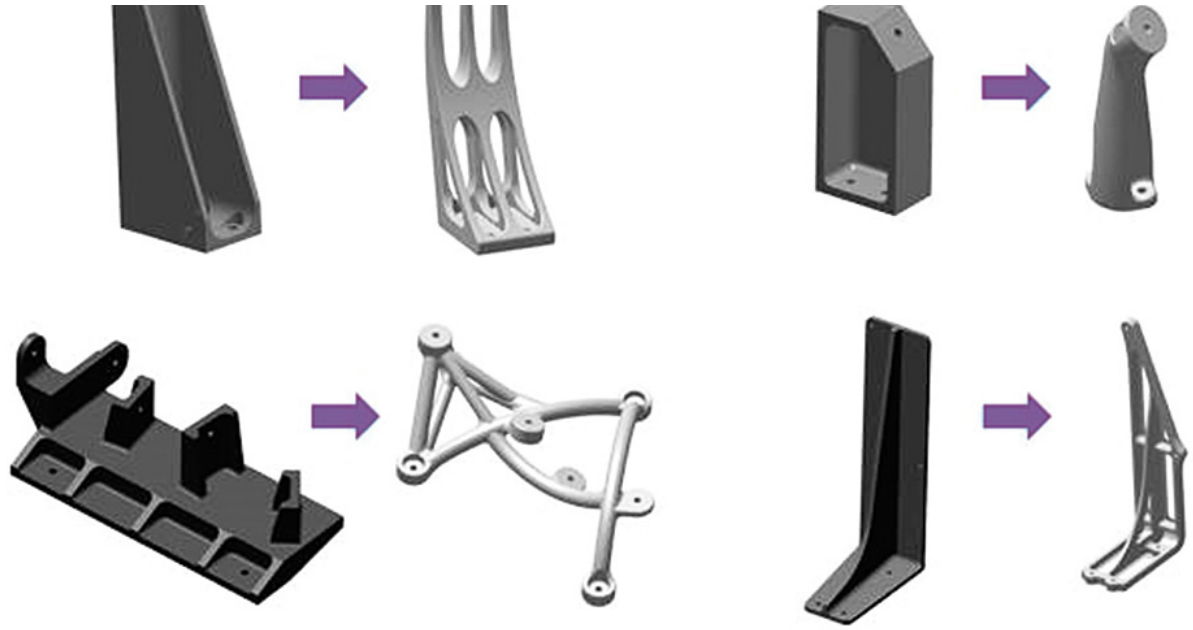
will be an additive ecosystem grounded in mechanical systems engineering and integrated design. This would be complemented by multi-skilled engineers who have depth of knowledge in design, stress analysis, materials, manufacturing and loads to develop innovative and cost-effective solutions for the life cycle of the product.

Additive manufacturing machine technology is evolving quickly. Reduction of piece parts and part weight can be achieved through appropriate implementation of additive manufacturing, while simultaneously improving system performance.

Richard Aston is a Senior Technical Fellow for satellite systems and an expert in composite technology and additive manufacturing. He has more than 30 patents and patents pending, and is the co-inventor of the Boeing 702HP and 702SP space platforms.

By Richard Aston, Senior Technical Fellow

Design Freedom



The ability to print parts opens the possibility to create more efficient mechanical designs.

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