Stratasys
FOR A 3D WORLD™

The CubeSat Challenge & Additive Engineering for Space

Scott Sevcik, 24-Jun-2015

2015 Electronics Technology Workshop

Stratasys

01 Who We Are

02 The GrabCAD CubeSat Challenge

03 Other Applications in Aerospace

04 Future Development

What is Additive Manufacturing

Creating an object through adding material rather than taking it away

Fused Deposition Modeling

Thermoplastic filament is heated to a semi-liquid state and extruded across computer-controlled tool paths to build parts layer-upon-layer.

Material Jetting

Deposits droplets of UV-cured resins in multiple colors and textures for fine detailed prototypes

Laser Sintering

Uses a laser to fuse metal or thermoplastic powders layer-by-layer to produce highly complex geometries from sliced CAD data

The Value of Additive Manufacturing

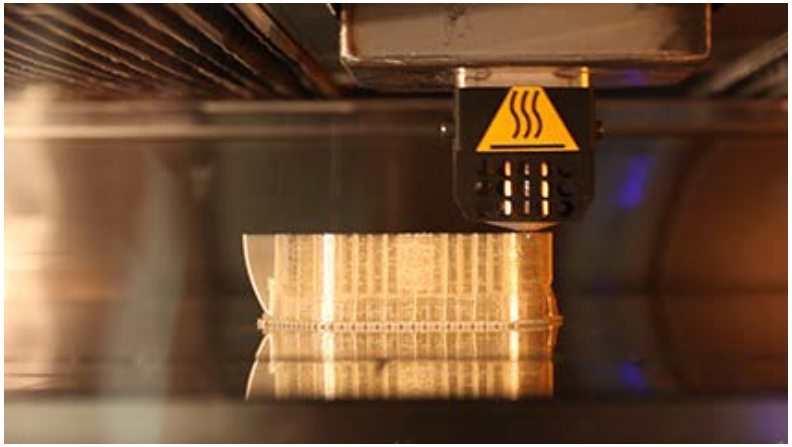
Acquisition Cost

Operational Cost **(Weight Reduction)**

Design Freedom

Speed to Capability

Supply Chain Flexibility




26
Global Offices
+600
Patents
4
AS9100C Certified
Manufacturing Locations
+300
AM Systems Producing
Deliverable Parts
+130,000
Systems Installed at
Customer Sites
System Sales & Support
Parts Services
Corporate Headquarters

Vertical Solutions

- Stratasys is accelerating its efforts into markets where disruptive solutions can unlock significant value across enterprise manufacturing processes
- New Vertical Solutions Business Unit (VBU) enables market-specific value creation with dedicated and focused resources developing unique market-specific solutions and/or go-to-market strategies
- Focused global team combines technical, commercial, and market-specific expertise to drive and support accelerated vertical penetration today while improving the vertical value proposition tomorrow
- Goal to maintain and grow market leadership in each identified strategic vertical market

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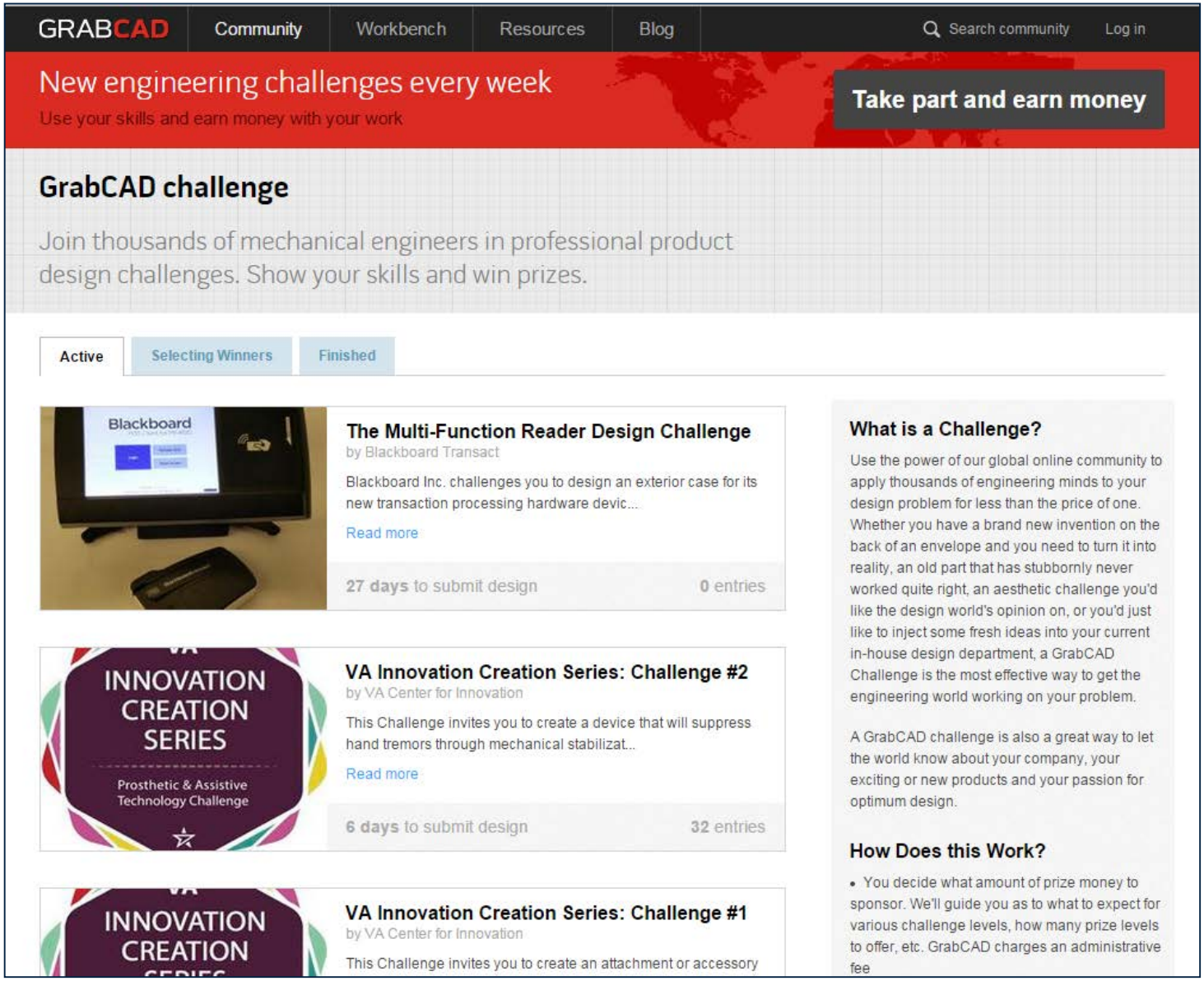
The Platform



Past Success

GRABCAD | Community | Workbench | Resources | Blog | Search community | Log in

New engineering challenges every week

Use your skills and earn money with your work

Take part and earn money

GE jet engine bracket challenge

Description | Entries 640 | Results

DEADLINE
Passed

TOTAL ENTRIES
640

All aircraft engines require the use of efficient and cost effective brackets. Additive manufacturing creates opportunities to build unique and highly efficient bracket-like structures. Here is an opportunity to show your best design.

When designing critical components for aircraft engines, today's designers are constantly challenged with the tradeoff between performance requirements for strength and stiffness on one hand and size and weight on the other. Recently, software tools have been developed to aid designers in optimizing their part designs. However, today's manufacturing methods restrict designers ability to take advantage of these optimized structures beyond a certain level of complexity. Additive manufacturing is lifting the constraints of traditional manufacturing processes, giving designers the ability to grow practically any shape, enabling the use of fully optimized lightweight designs that do not sacrifice performance.

Participants in this challenge will use additive manufacturing as the basis for optimizing an existing aircraft engine bracket.

Past Success

GRABCAD | Community | Workbench | Resources | Blog | Search community | Log in

NASA Handrail Clamp Assembly Challenge

Description | Entries 469 | Results

About this Challenge

NASA is seeking to challenge the GrabCAD Community by sponsoring an open competition where participants utilize the new additive manufacturing capability on the International Space Station (ISS). The competition will be to design a complementary Handrail Clamp Assembly (HCA) which is currently utilized by astronauts to provide rigid mounting locations required in a microgravity environment for normal daily operations. The complementary HCA design will be referred to as the CHAMP (Clamp for Handrail with Additively Manufactured Parts). The printed part will be analyzed to further our understanding of the effects of microgravity on the fused deposition method of manufacturing.

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We developed the Center of Excellence for Collaborative Innovation so we could work with groups like GrabCAD, which has almost 2 million members, and tap the creativity of the world to solve tough engineering problems. Using innovators to contribute to solutions to technical challenges is playing a crucial role for NASA in developing the technologies needed for humans to become Earth-independent and pioneer missions to Mars and other deep space destinations.

Jason Crusan, Director of NASA's Advance Exploration Systems Division

We, at NASA, were overwhelmed with both the quantity and quality of the submissions for the NASA GrabCAD Challenge! Going into this, we were confident that we would benefit greatly from the experience that this broad community of talented designers brings to the table, but we were extremely impressed with the level of interaction, creativity, and iterations that took place within the community throughout the challenge process. The capability to exchange technical ideas and gain feedback during the challenge was as impactful as the submissions themselves. NASA hopes to have the opportunity to utilize this high-value, high-impact collaboration mechanism more in the future.

Niki Werkheiser, NASA In-space Manufacturing Project Manager

DEADLINE
Passed

TOTAL ENTRIES
469

Who's in the jury?


Niki Werkheiser
NASA In-space Manufacturing Project Manager


Quincy Bean
NASA In-space Manufacturing Principal Investigator


Drew Hood
NASA Exploration EVA Tools Engineer


Jason Waggoner
NASA Marshall Space Flight Center Structural & Mechanical Design Branch Chief


Sara Sigel
Community Manager at GrabCAD

ENTRIES (469)

The CubeSat Challenge

GRABCAD | Community | Workbench | Resources | Blog | Search community | Log in

New engineering challenges every week

Use your skills and earn money with your work

Take part and earn money

The CubeSat Challenge

Description | Entries 211

This Challenge invites you to re-think the CubeSat using additive manufacturing!

DEADLINE
Passed

TOTAL ENTRIES
211

Who's in the jury?

Jordi Puig-Suari
Professor at California Polytechnic State University and co-inventor of the CubeSat Standard

Jonathan Cook
Director of Product at MakerBot

Adam Hadaller
Mission Manager at Spaceflight Industries

Patrick Price
Aerospace Additive Manufacturing Research Engineer at Stratasys

Jesse Marin
Aerospace Project Engineer at Stratasys Direct Manufacturing

About This Challenge

The goal of this challenge is to design a small satellite frame optimized for additive manufacturing. By using the benefits of design for additive manufacturing (DFAM) principles:

- Mass distributions and materials can be rethought to minimize weight
- Part count can be reduced to improve producibility

and ultimately, cost can be reduced.

The Judges

Jordi Puig-Suari
Professor at California Polytechnic State University and co-inventor of the CubeSat Standard

→ CubeSat Standard Originator

Jonathan Cook
Director of Product at MakerBot

→ AM Expert

Adam Hadaller
Mission Manager at Spaceflight Industries

→ CubeSat Launcher

Patrick Price
Aerospace Additive Manufacturing Research Engineer at Stratasys

→ AM Application Engineer

Jesse Marin
Aerospace Project Engineer at Stratasys Direct Manufacturing

→ AM Manufacturing Engineer

David Espalin
Center Manager at W.M. Keck Center for 3D Innovation, University of Texas

→ Driving AM Research for Space Applications

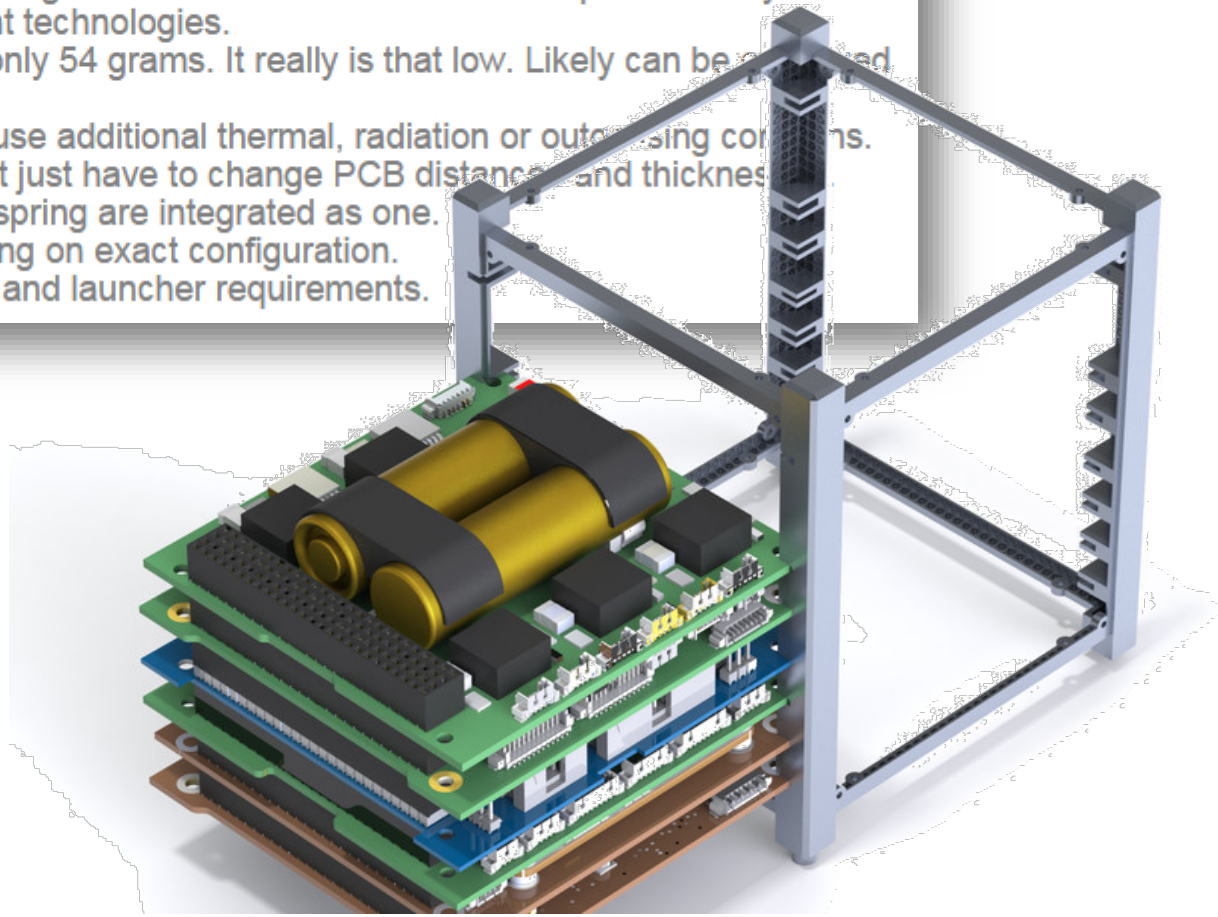
Robert Hoyt
CEO & Chief Scientist at Tethers Unlimited Inc.

→ Space Technology Practitioner

It is a simple printable part. You can apply either additive technology. Just print two same parts, turn to faces to each other and connects!

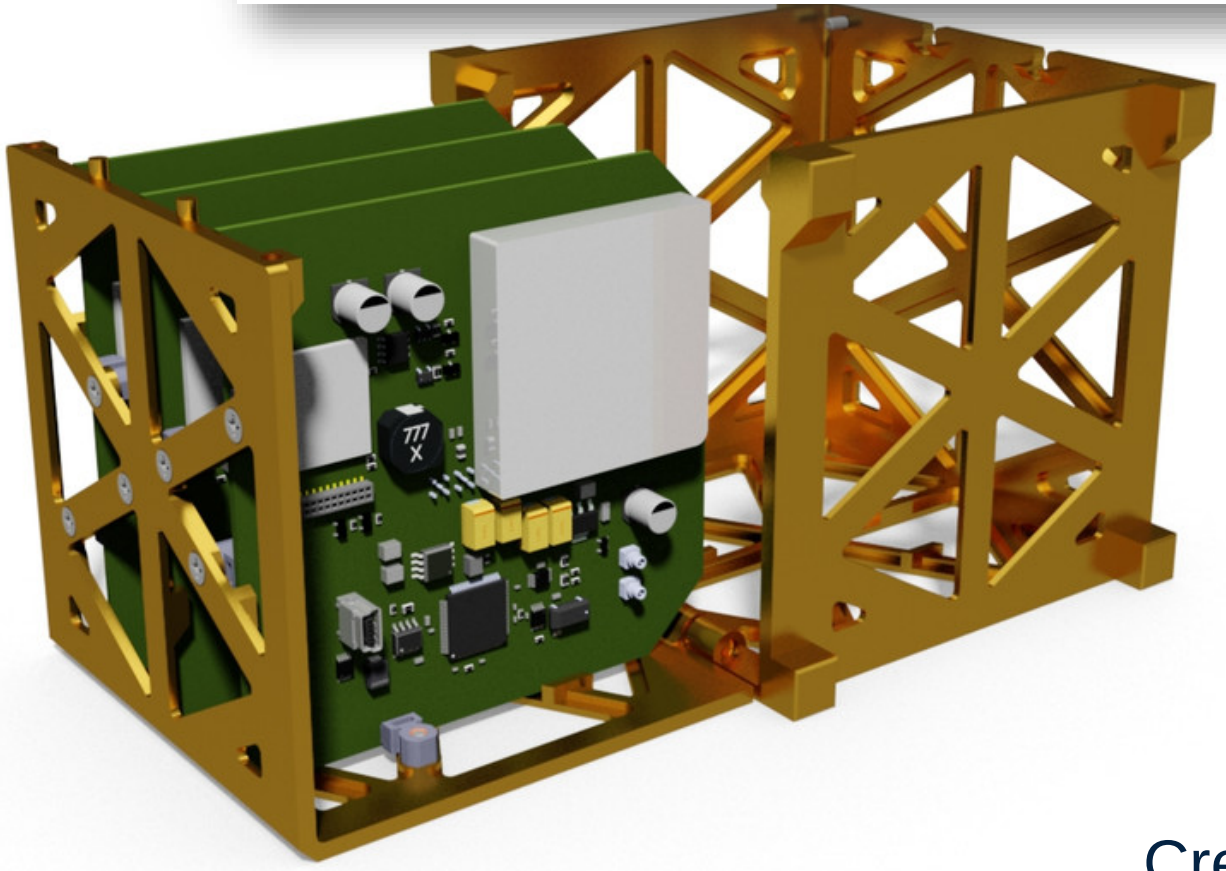
Credit: Jager Tamas

-- DESIGN AND ADVANTAGES --
Benefits of this design:
- Structure is only one single part.
- Helicoil reinforced solar panel mounting holes to attach and remove side panels many times.
- Possible to manufacture with current technologies.
- Mass of 1U aluminium structure is only 54 grams. It really is that low. Likely can be [illegible] even more.
- Made from aluminium. Does not cause additional thermal, radiation or outg[illegible]sing co[illegible]ns.
- Quick and easy modifications, might just have to change PCB distanc[illegible] and thickne[illegible]
- Deployment switch and separation spring are integrated as one.
- Scalable to 12U and more, depending on exact configuration.
- Conforms to CubeSat Specification and launcher requirements.



Credit: Paul Liias

The Wells CubeSat was specifically designed to:
1. Reduce the overall part count by designing a 1-piece unibody structure, allowing for a more simplified producibility using materials that are commercially available, reducing overall cost.
2. Reduce the weight of the structure while maintaining enough strength to survive the environmental requirements.
3. Create a structure that would reduce the CubeSat payload environment by reducing the loads generated by the vehicle and qualification random vibration environments.



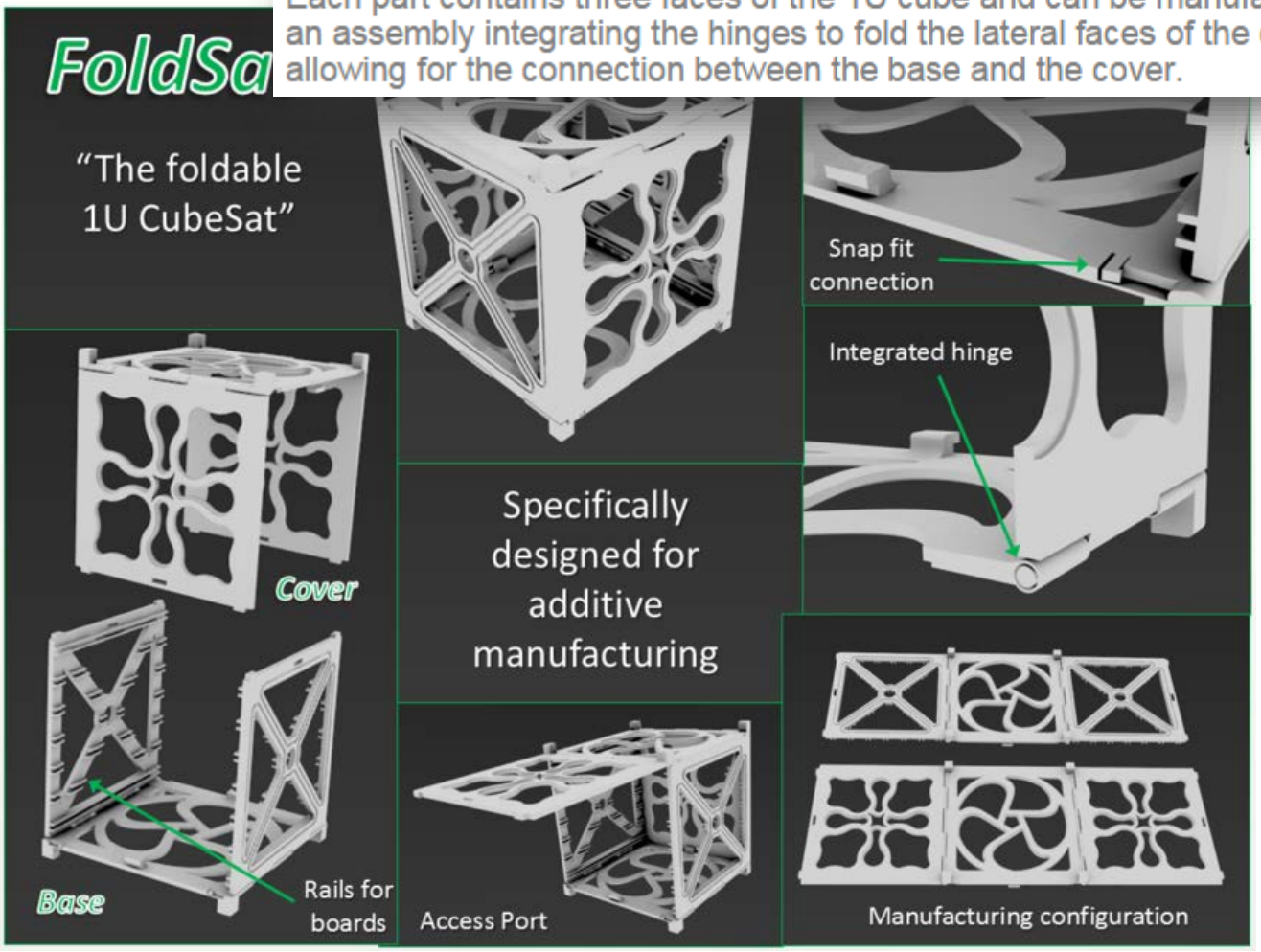
Credit: Stephen Wells

The main feature in the design is the flat print configuration. This low Z-Height is optimal for additive manufacturing, since print time is highly dependent on part height. Hinges are printed into the structure that allow it to be articulated into the standard cube shape once the print has been completed. As each panel is raised, a snap fitting will connect it to its neighboring side panel. This fitting will hold it in place during the rest of assembly. Once the frame is fully assembled, a counter-sunk screw is used in each corner to securely fasten the sides together. This will allow the CubeSat to withstand the vibrations of the launch environment.

Credit: Chris Esser

The FoldSat is a foldable version of the 1U CubeSat. The FoldSat is designed for additive manufacturing to minimize manufacturing time and support material waste. The FoldSat is composed by two parts, a base and a cover.

Each part contains three faces of the 1U cube and can be manufactured as one piece because it is an assembly integrating the hinges to fold the lateral faces of the cube together with some snap fits allowing for the connection between the base and the cover.

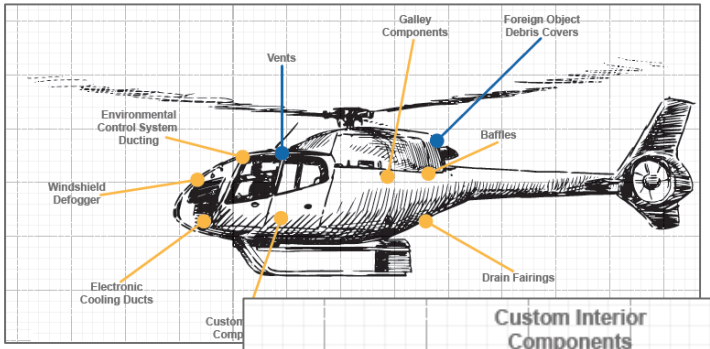


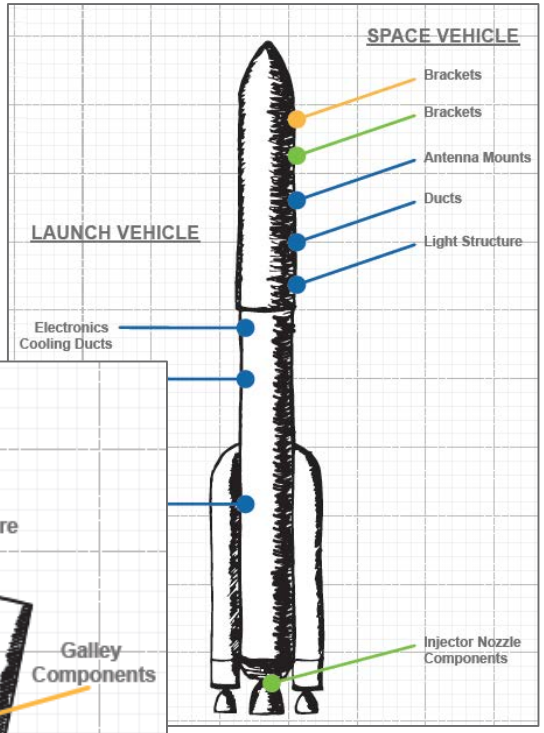
Credit:
Paolo Minetola

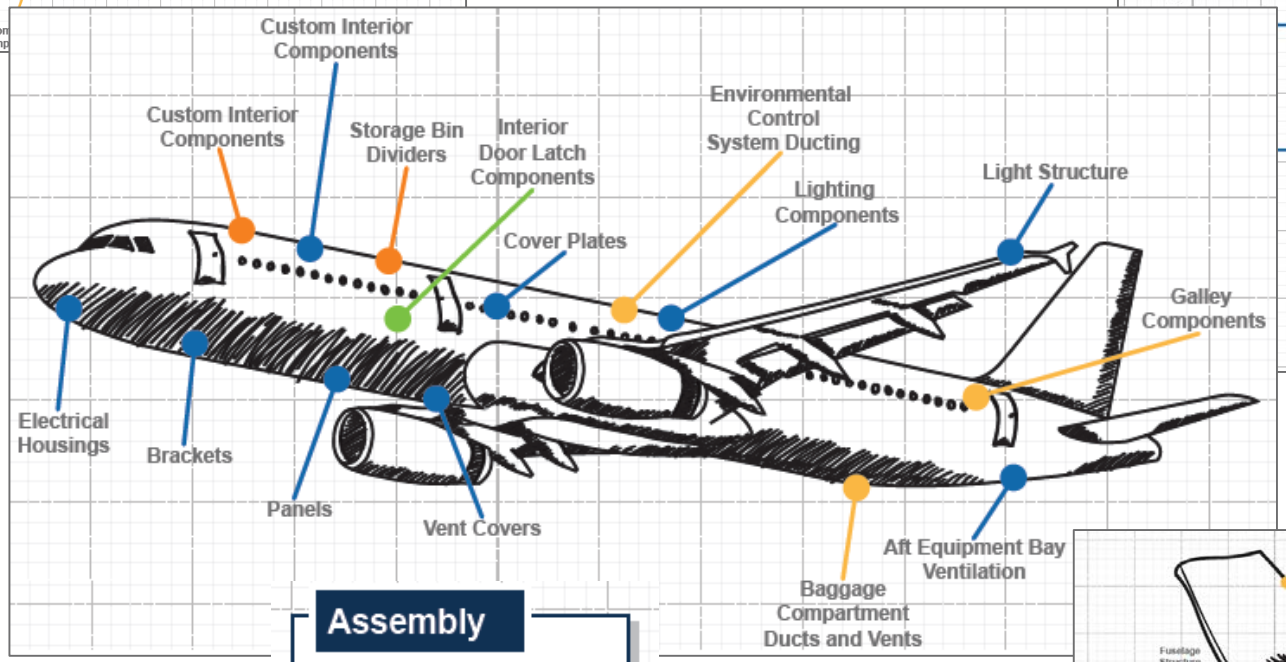
Stratasys

Where Used

Stratasys®

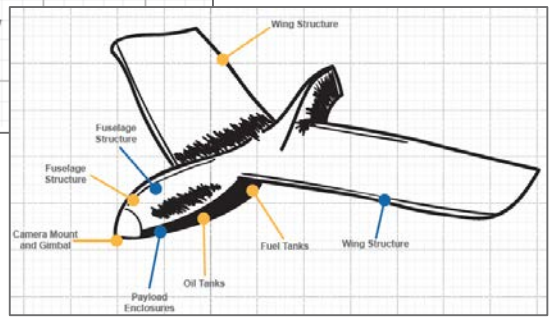






Assembly

- Assembly Fixtures
- Assembly Fixtures
- Carbon Fiber Layup Tools
- Metal Forming Tools
- Surrogate Parts

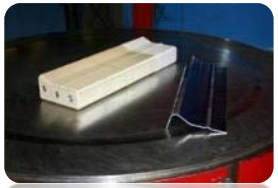


FUSED DEPOSITION MODELING
LASER SINTERING
METALS
URETHANE

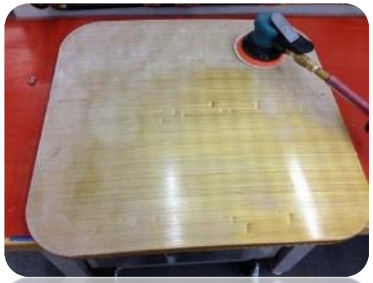
Tooling Applications

Thermoforming

Metal Forming



Composite Layup

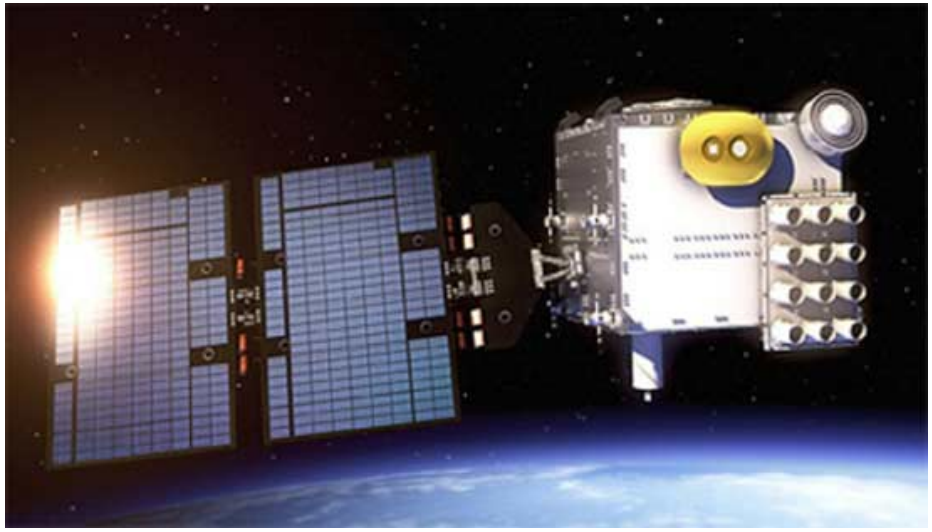


Soluble Core

Large Tooling

Boeing FDM C-channel Mandrel, SAMPE 2012

COSMIC-2 Antenna Array Mount



Critical Exterior Component

Flight Qualification

- UV
- Atomic oxygen
- Outgassing
- Vibration/Acoustic loads
- Thermal

Cost and Time Savings

United Launch Alliance

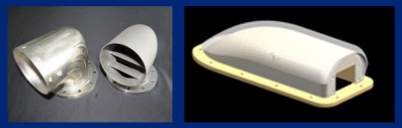
Stratasys

ULA™
America's Ride to Space

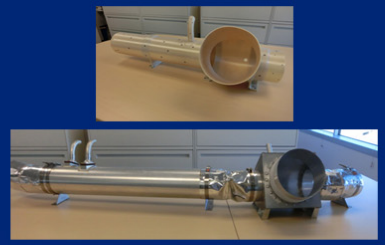
Additive Manufacturing—NGLS

Additive manufacturing on NGLS will save time and money while increasing performance capabilities.

Functional Prototypes for Launch System Rapid Development Cycle time

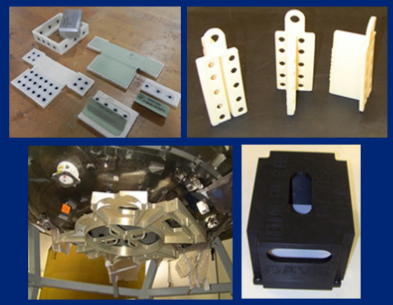


Flight Components for Launch System performance



Mechanical Ground Support Equipment for Launch Ops

Tooling, Jigs, Mockups for Production Ops



https://youtu.be/l9Z9xAvAofQ

United Launch Alliance

Stratasys

ULA™
America's Ride to Space

Additive Manufacturing—NGLS

Additive manufacturing on NGLS will save time and money while increasing performance capabilities.

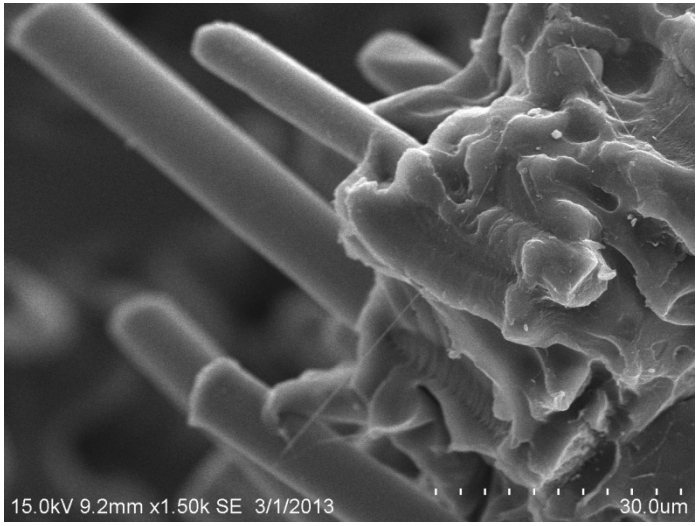
Part consolidation and material replacement

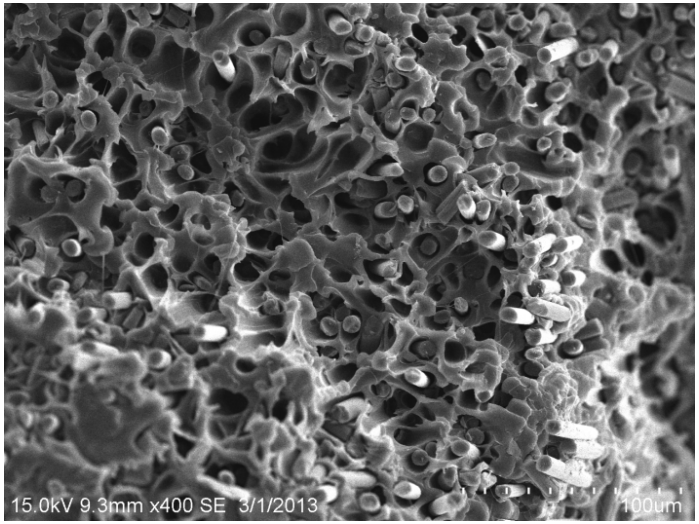
- 140 aluminum pieces reduced to 16 printed parts
- 57% reduction in direct cost

Flight Components for Launch System performance

https://youtu.be/l9Z9xAvAofQ

Material Development





High Performance Thermoplastics

PEI, PES, PPU, TPU

Semi-Crystalline Materials

PA, PEKK, PPS, PP, PE, PET, PEEK

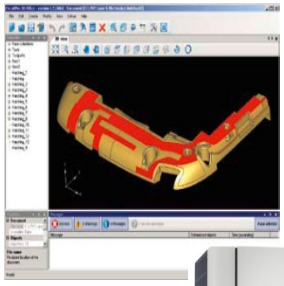
Composites

CF-PA, GF-PP, CF-PEKK, CF-PEI, CF-PET

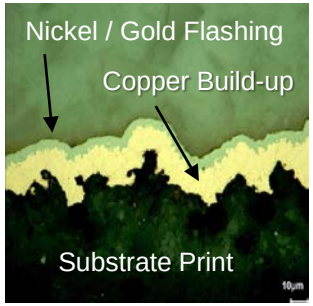
- Strength
- Tailored Thermal Properties
- Tailored Electrical Properties

Functional Materials

Laser Direct Structuring



CAD



Print

Ablate

Plate

LDS was developed by LPKF

3D Printing Multifunctionality

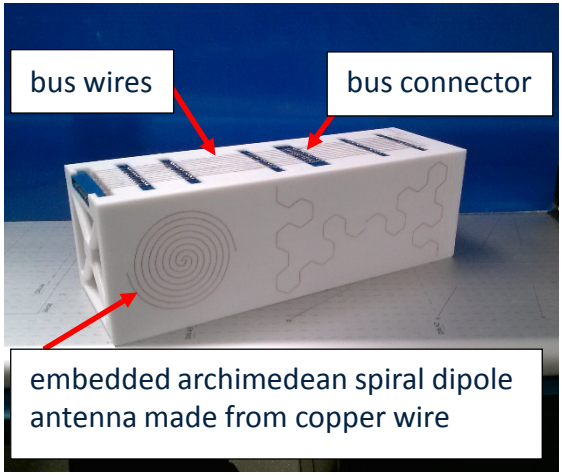
Project Title

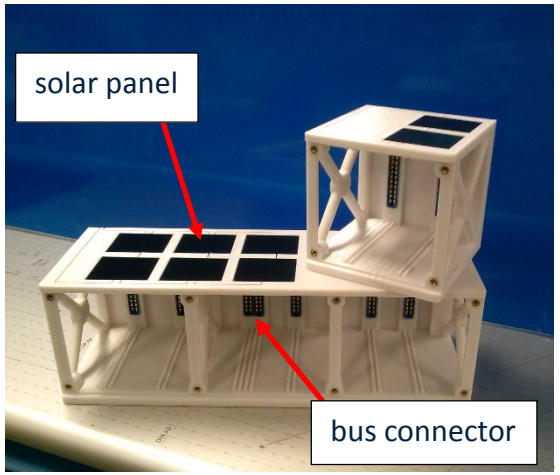
- 3D Printing Multifunctionality: Additive Manufacturing for Aerospace Applications

Goals

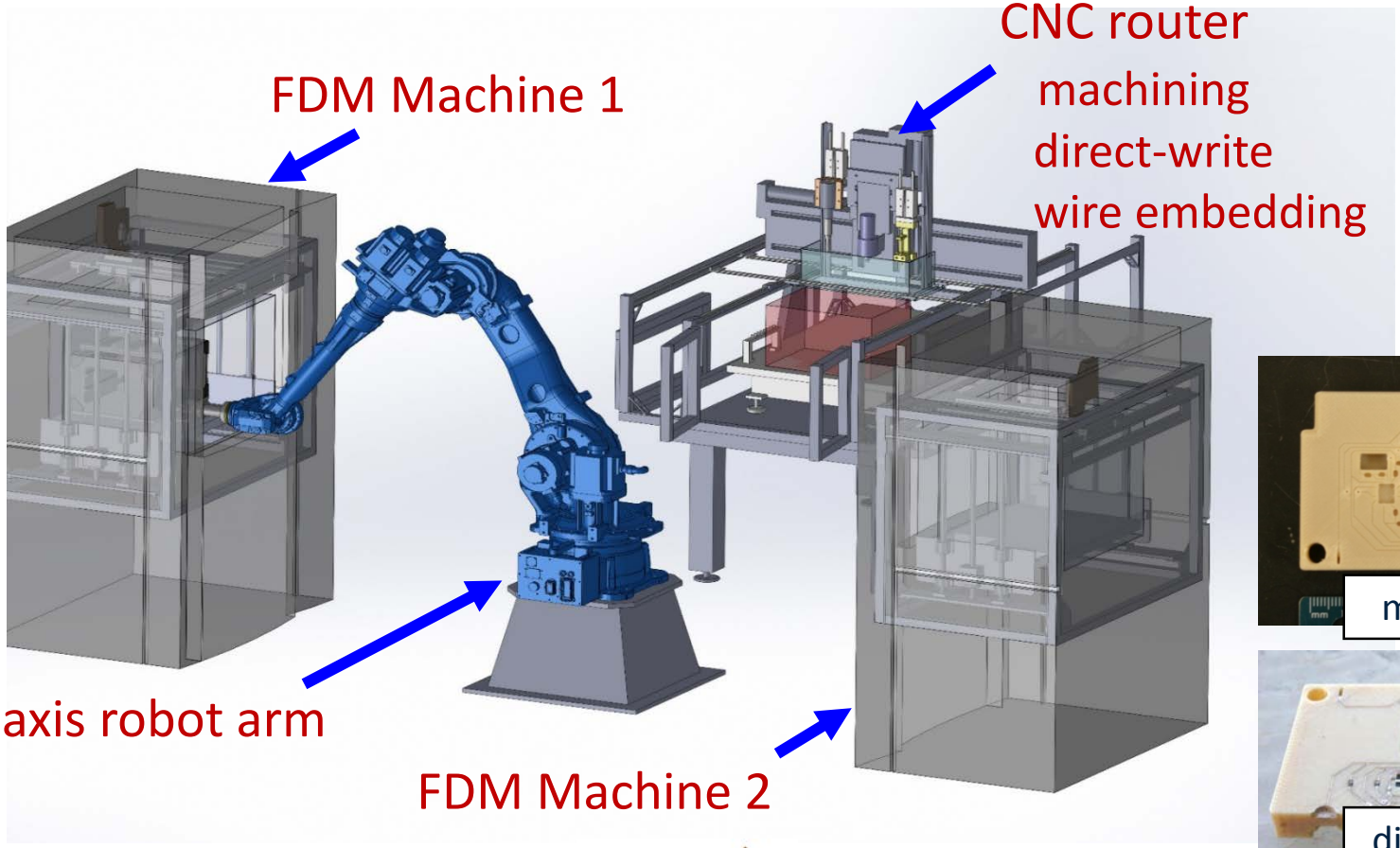
- Use multiple technologies to produce parts with multifunctionality
  - Structures with electronics
- Integrated technologies with automation to reduce touch labor and lead times.
- Increase the use of AM in the fabrication of aerospace components
  - Small satellites
  - UAVs

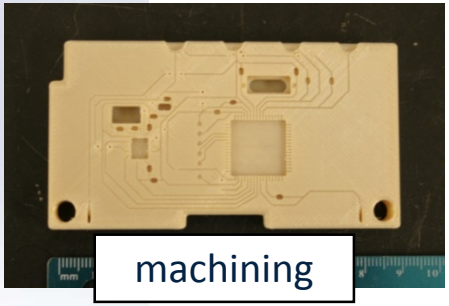
3U CubeSat

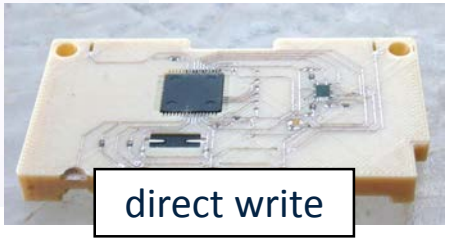




Overview of Multi3D system







Thank you

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