STFC Additive Manufacturing

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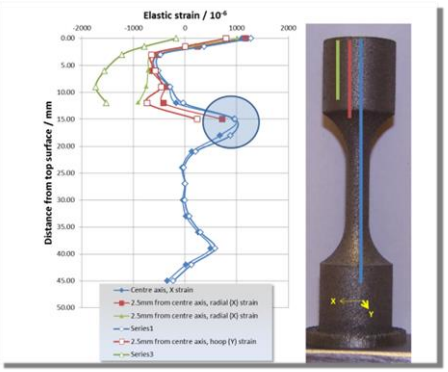
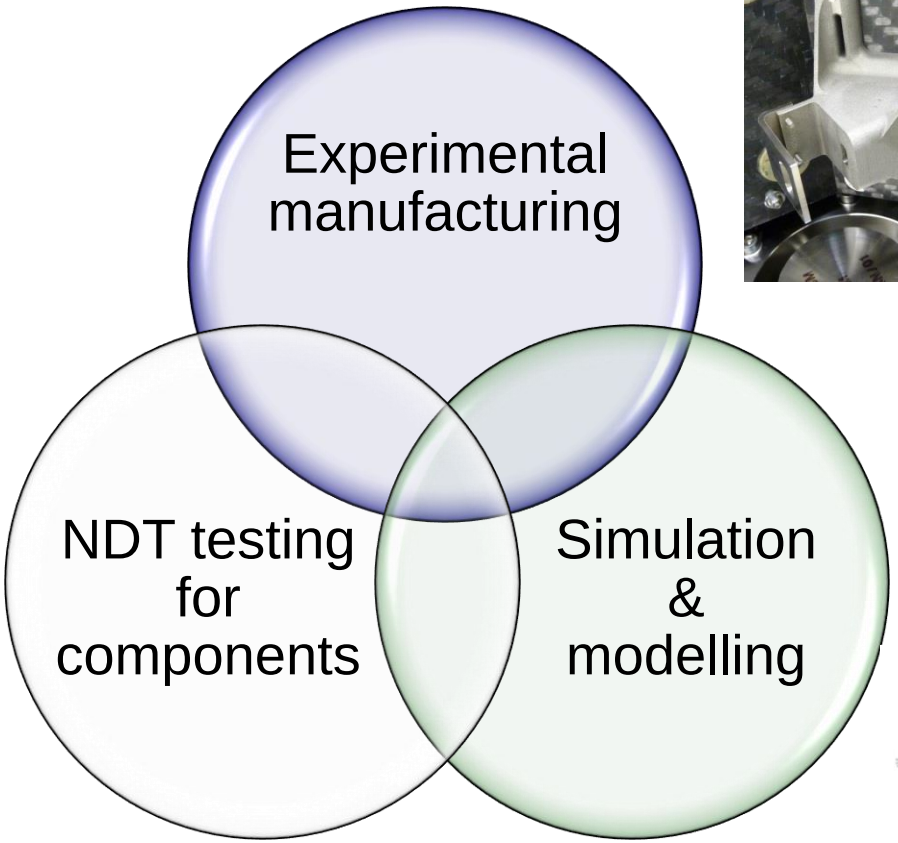
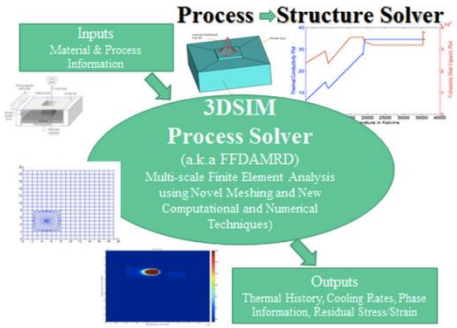
21 January 2016

Areas of interest







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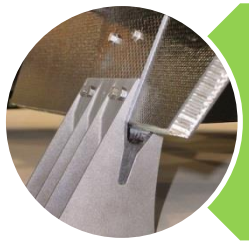
AAMF at Harwell

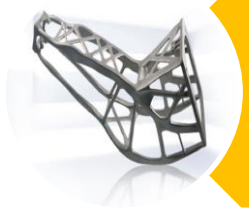
- Co-located with Metrology facility
- EOS M280 FDR – due to switch to M290
- Concept Laser MLab R
- Stratasys Objet 30 Pro
- Fortis 450 – Ultem 9085 etc
- Full characterisation
- Simulation and modelling options
- Joint development with ISIS Neutron Source

- AAMF focuses on the development of predominantly laser powder bed processes to support a variety of programmes with an emphasis on spacecraft, cryogenics and embedded systems.

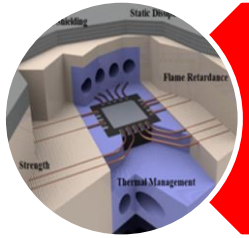
AM Design Approaches



Conventional replacement / like for like



Conventional replacement / like for unlike

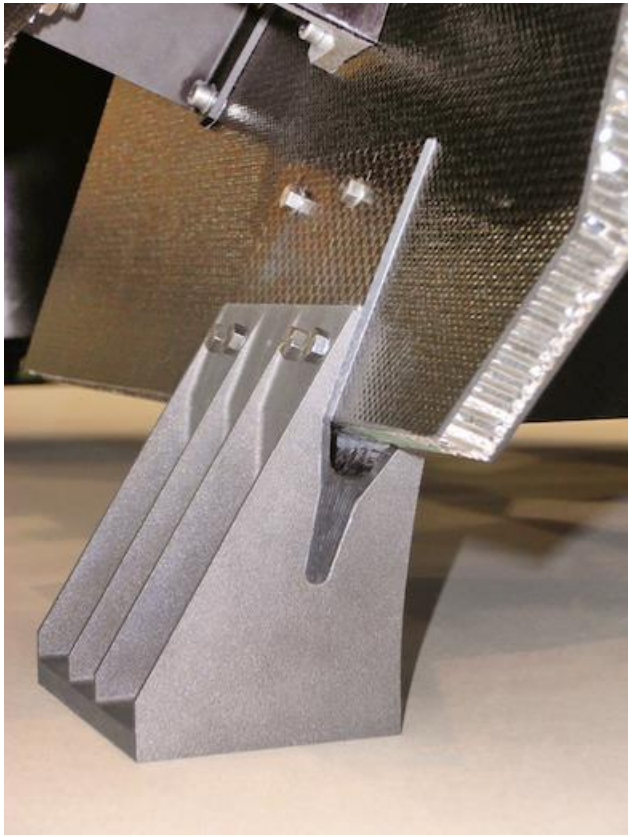


Integration of two or more conventional components into one

Increased end user benefit from integration

Complexity

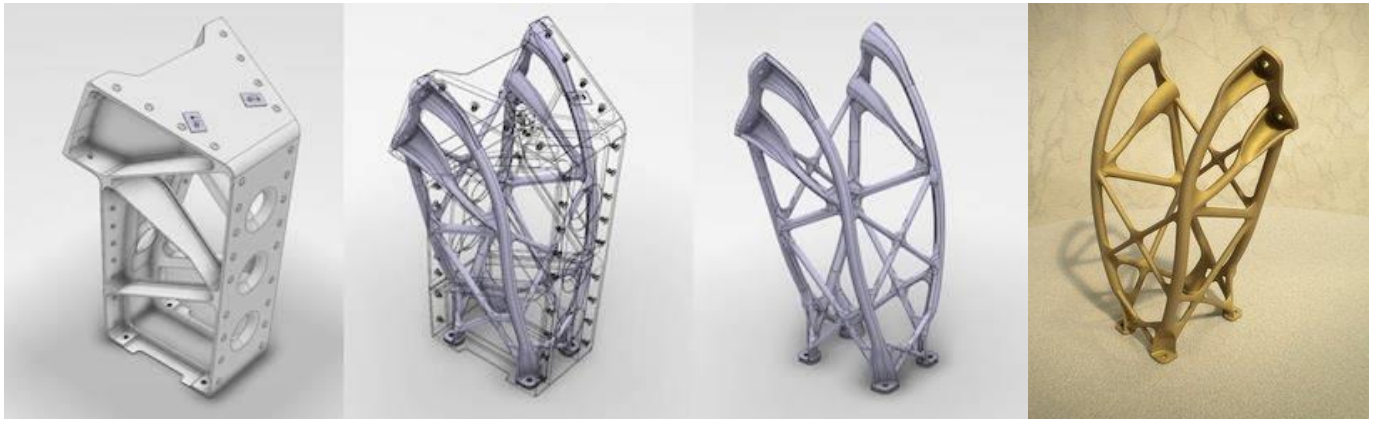
Conventional Replacement – Like for Like



Courtesy of Airbus Defence and Space & EOS GmbH

- Airbus Telecommunications satellite mounts to secure feeder horns to satellite body
- Manufactured by an EOS M280 SLM system in Titanium
- Withstands thermal variation – 180 to +150 °C
- Reduced production time
- Mass reduction of 300g per bracket

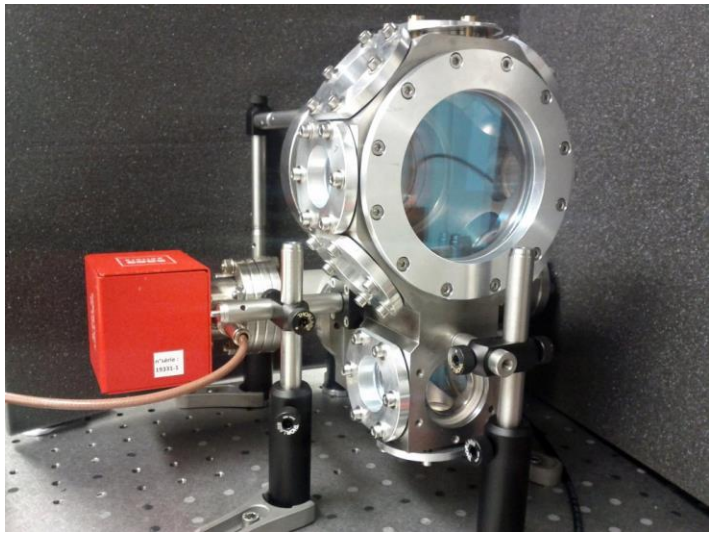
Conventional Replacement – Like for Unlike

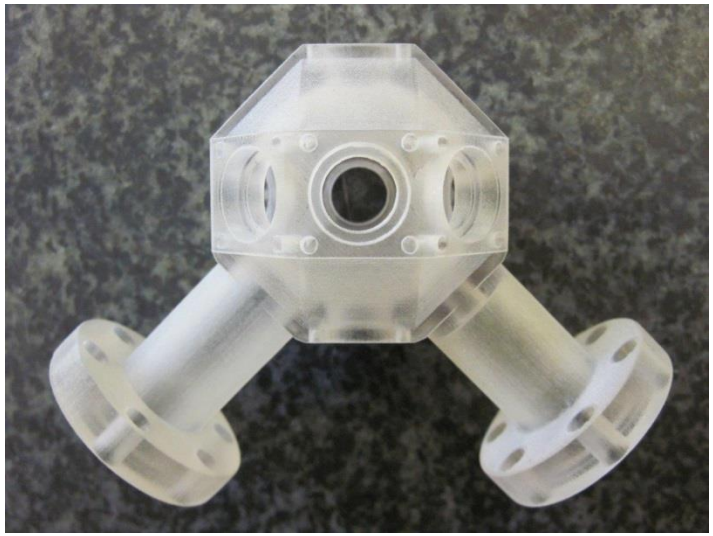


Courtesy of UK Space Agency & 3T RPD Ltd

- Telemetry and telecommands antenna standoffs for UK Space Agency satellite programme
- Manufactured in Aluminium by SLM
- Four parts reduced into one, through optimisation
- Reduction in 35% from original mass
- 40% stiffer than original components
- Due to fly in Q3 2015

Integration of two or more components





- Mass spectrometer vacuum chamber for future ESA Solar Orbiter
- Integration of eight components into one assembly
- Reduction in joints, seams, mass and volume
- Inclusion of vacuum and optical windows.
- Manufactured through Polyjet and SLM - potential for ceramic binding.

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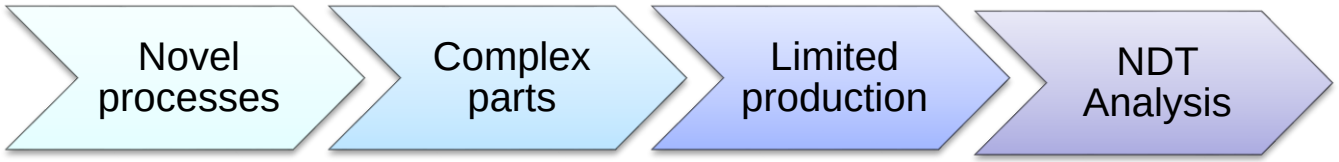
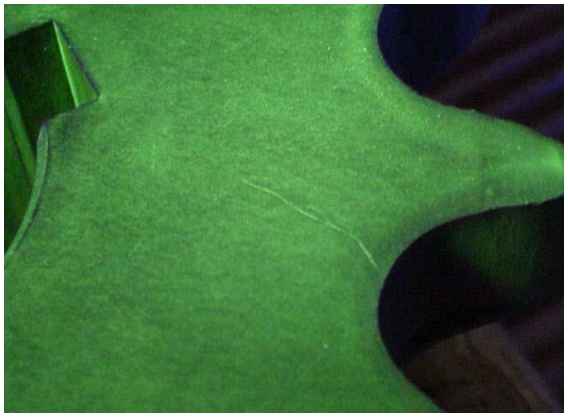
Non Destructive Testing

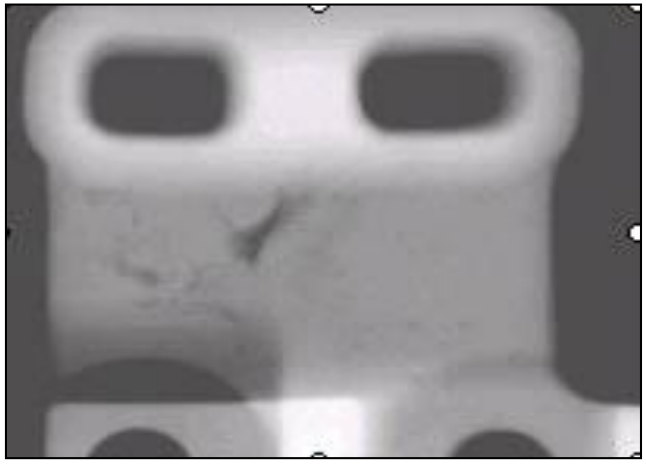
NDT for AM

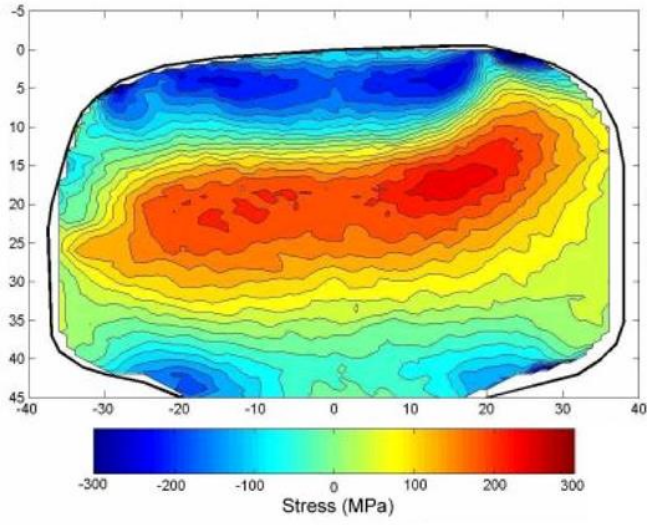
- Quantification – Measure knowns and unknowns
- Qualification – Ensure part/s are to specification
- Verification – Establish that processes are correct
- Lifetime / legacy – Repeat measurements



Conditions of interest







Insitu SLM Build

- Insitu measurement of build process
- Realizer 100 in neutron diffraction instrument
- Measurement of component build during sintering
- Match temporal duration – build vs. acquisition
- Improvement understanding of process
- Optimisation of build parameters
- Aligned to ASTM F42 work package / definition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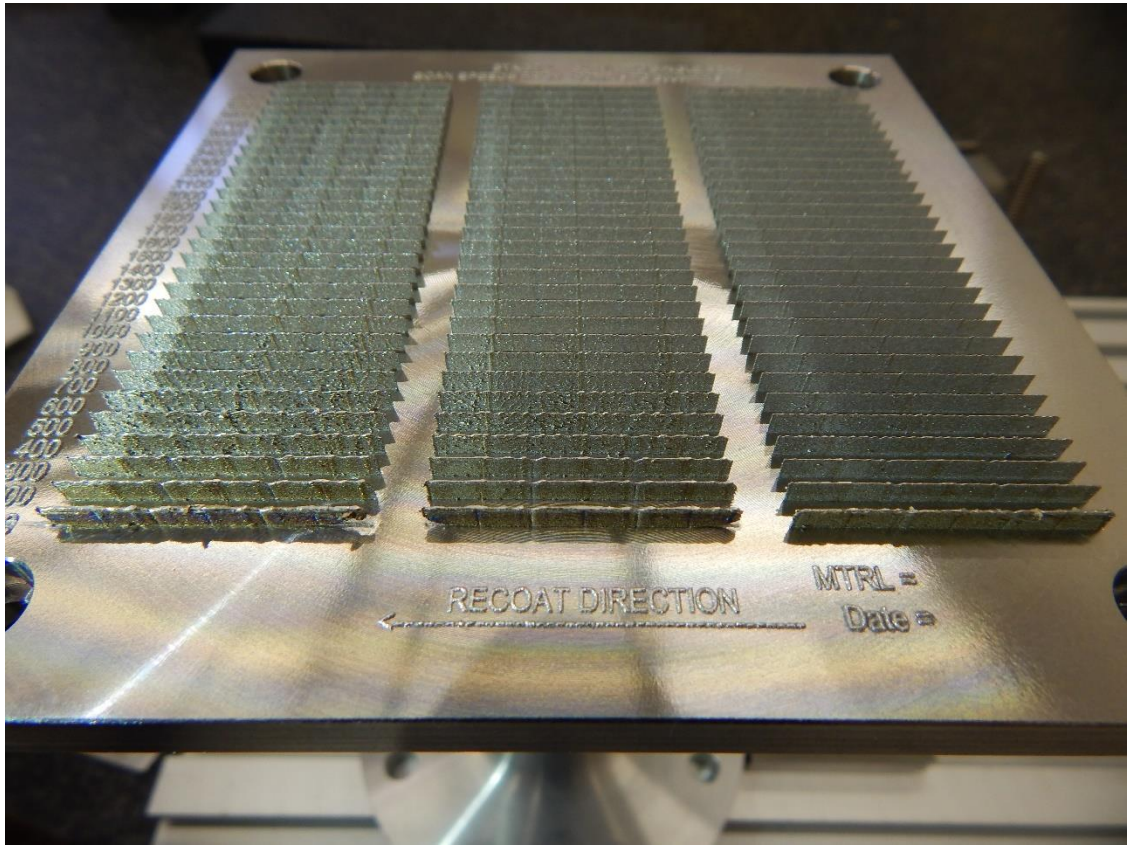
Parameter development



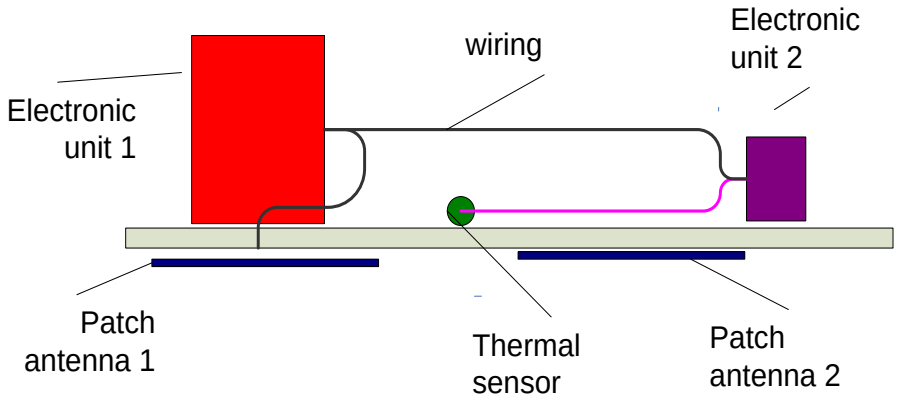
- SS316 process development
- Focus on material properties
- M280 FDR – abilities for high aspect ratio structures
- Transition to RFMs

Embedded functionality

Embedded functionality:

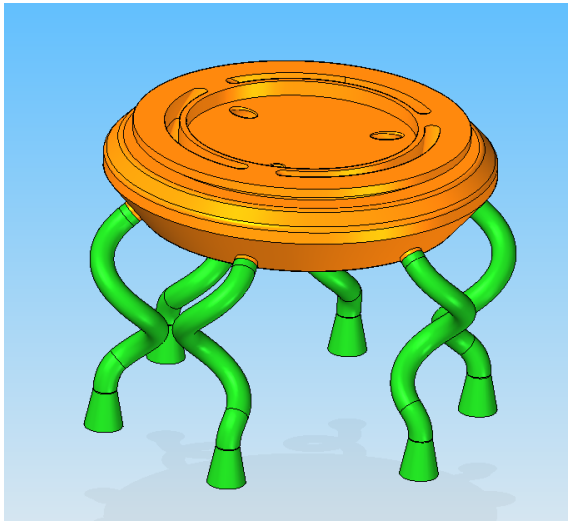
- Heat pipes
- Antennas / RF circuits
- Ablation protection
- Wiring harnesses
- Sensors

Conventional satellite component assembly



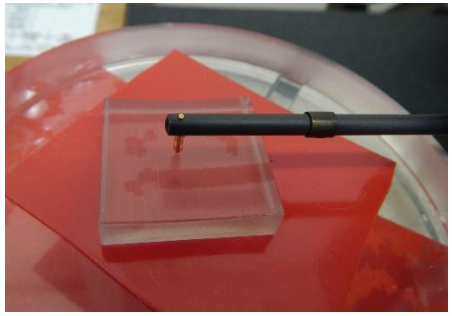
Encapsulated components via RP technology

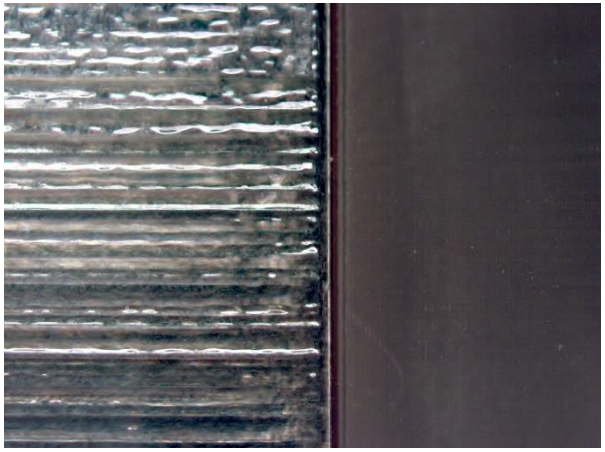
Heat exchanger / Stirling heat engine

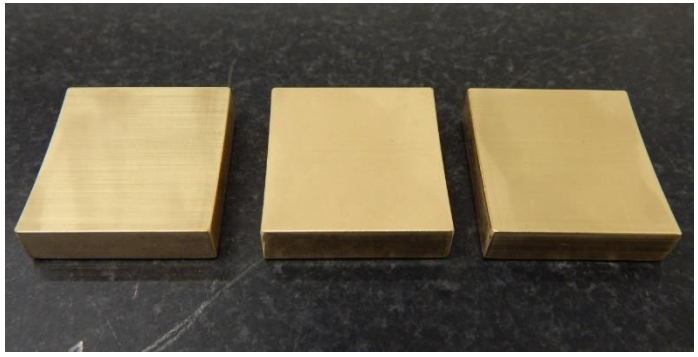


- Conceptual heat exchange
- Full component integration
- Built in SS316 – intent to move to Inc 718
- Pressure tested with He to 50Bar, Feb 2016

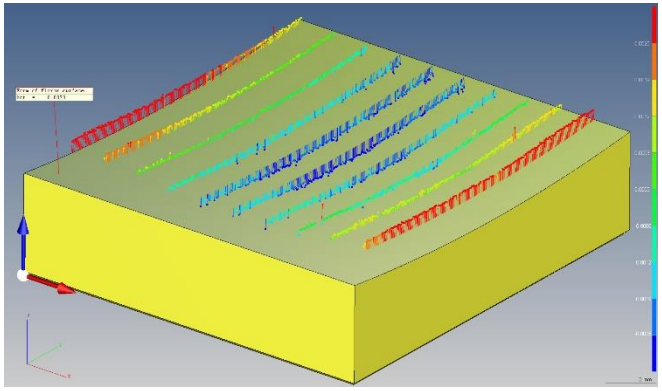
Freeform Mirror design







- Manufactured in plastic
- Desired surface finish of <100nm
- Complex surfaces achievable with associate benefits from equal thermal expansion, shorter integration etc
- Plated with 100µm Au
- Surface roughness <5µm



3d Concept CubeSat

- Rapid, inexpensive design & manufacture of highly integrated CubeSat structure:
  - Snap-fit components
  - Slot-in main electronics stack
  - Possibility for integrated propulsion system
  - Potential to build everything encapsulated e.g. incorporated harnesses, sensors
  - Partnership with Aerospace Corp for launch opportunities – proxy mission / inspector

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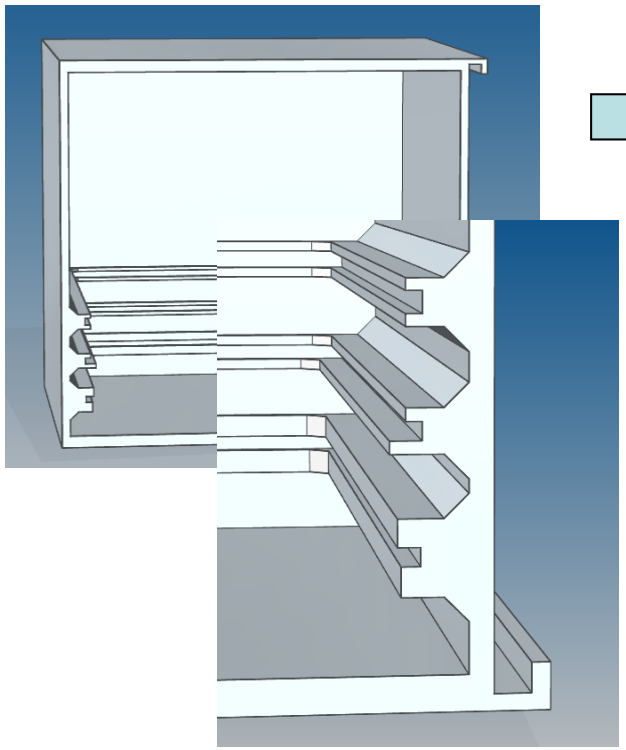
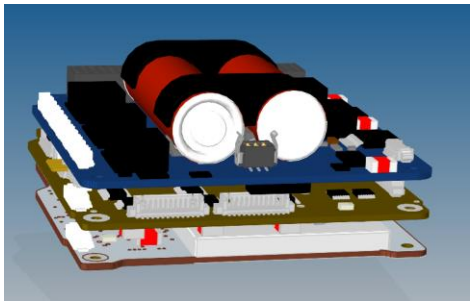
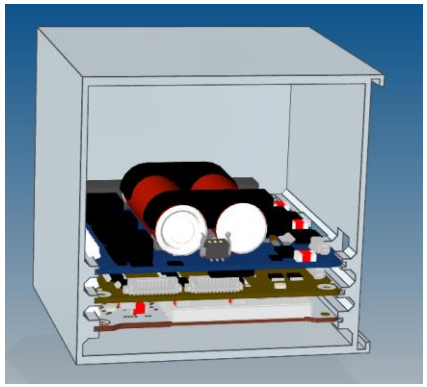
3d Concept CubeSat

Start with a ‘qualified’ structure/mounting system (includes board and PV rails)

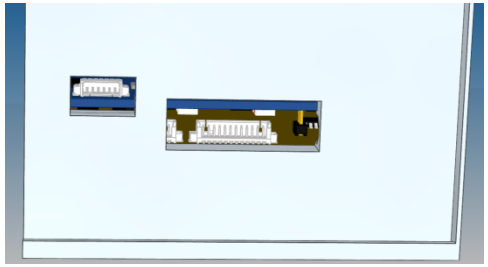




A CubeSat ‘stack’ is designed/assembled



Stack is integrated (in CAD) to determine any holes that need to be made for access



Geometry (of structure) is tweaked to match the actual structure, and re-simulated.

Assuming the right FOS, the structure can be ‘printed’ and flown

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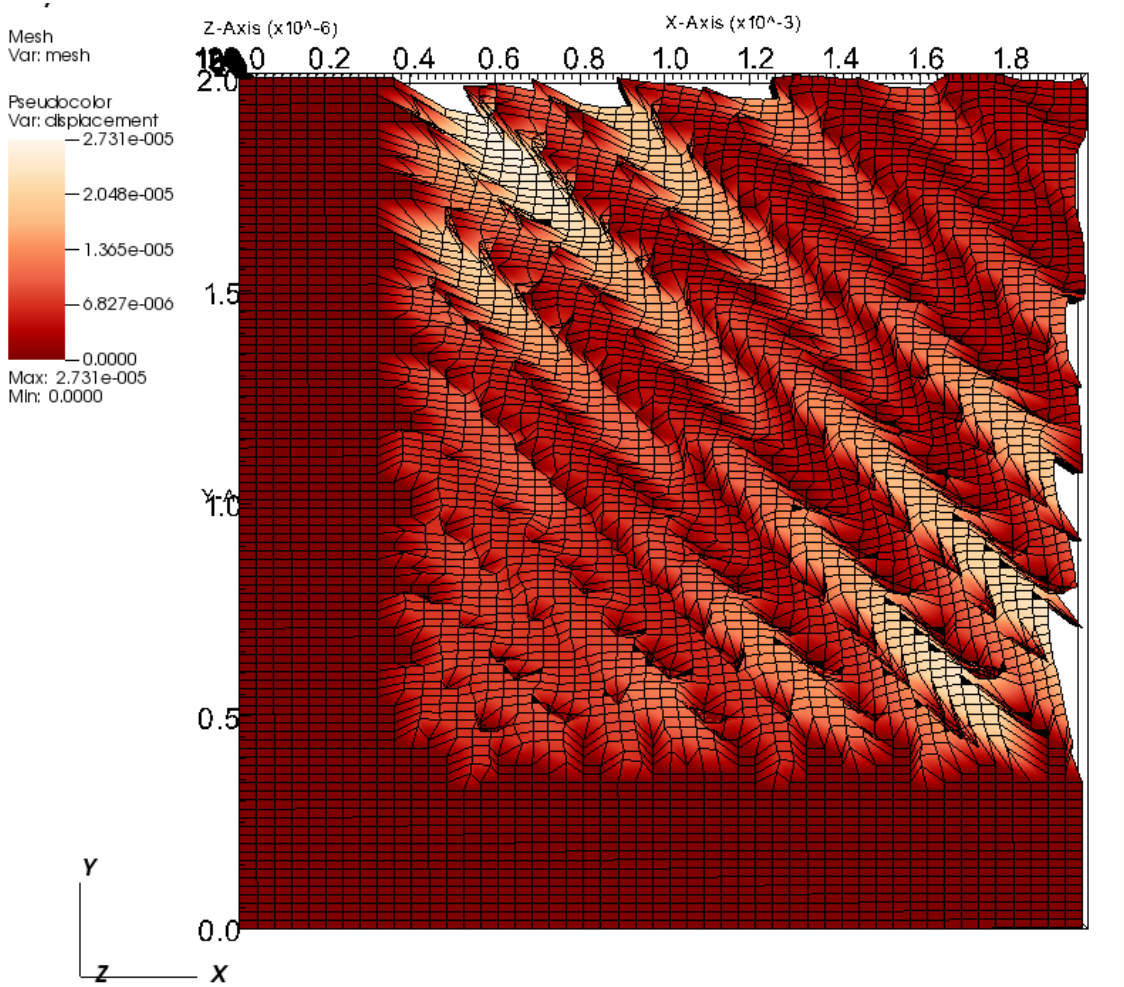
Simulation and Modelling

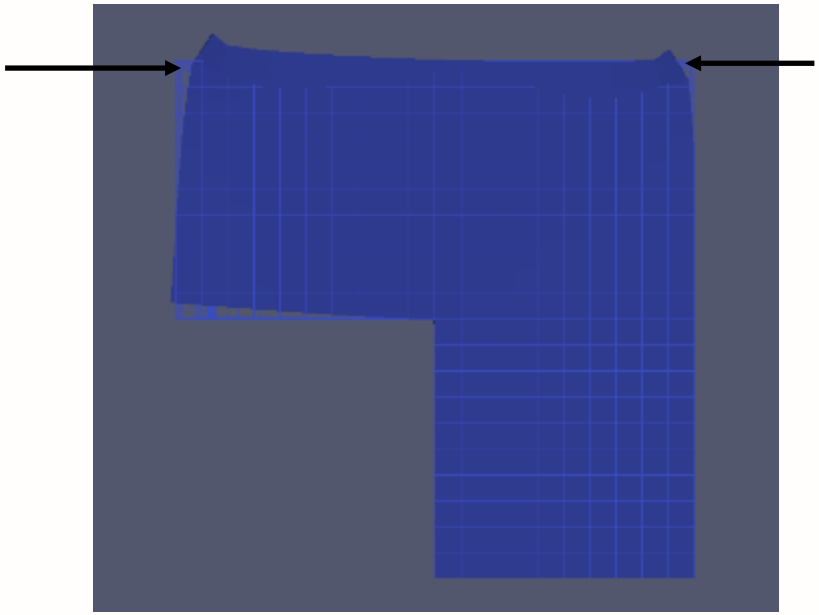
Cumulative Shrinkage Results

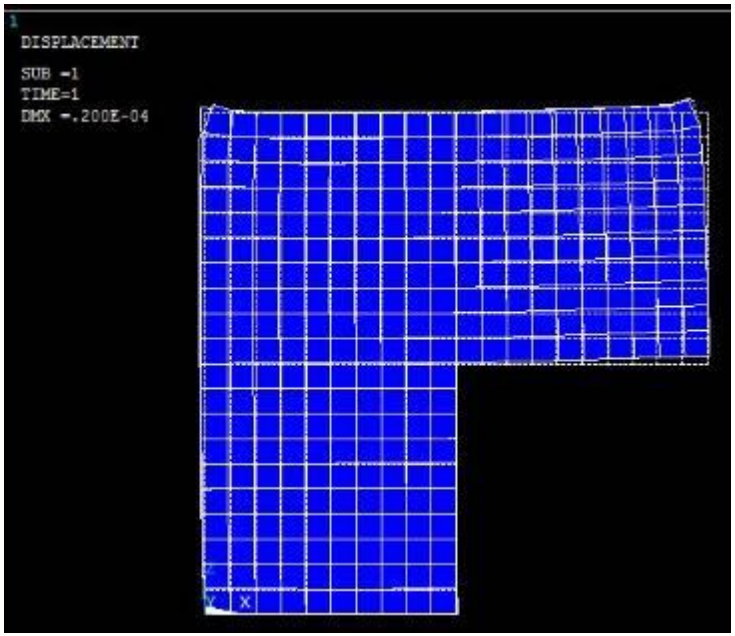


Observations:

- Greatest displacement at start of long scan lines
- Cancelling effect near end of scan line

Accuracy with simple shapes



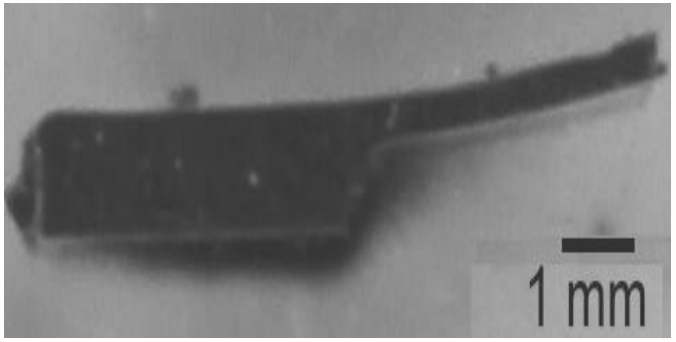


Stress at top in the model: 14k
Applied stress: 24k
Resultant tension= 24-14=10k

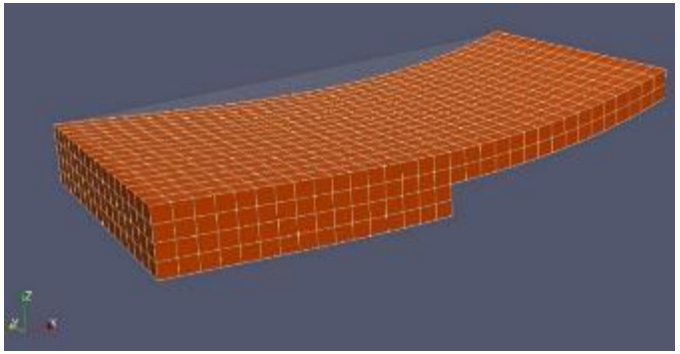
Example

Support structure Example: Standard

Experiment Sample

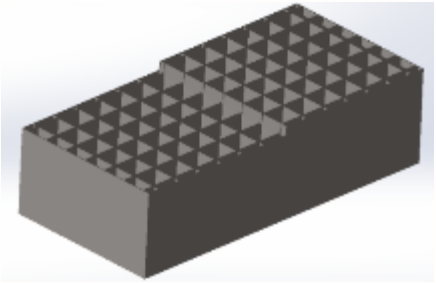


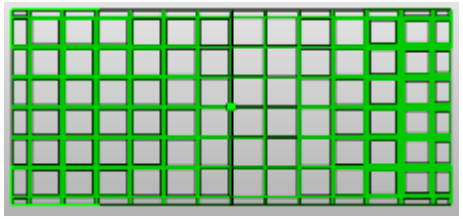
FEM Stress calculation



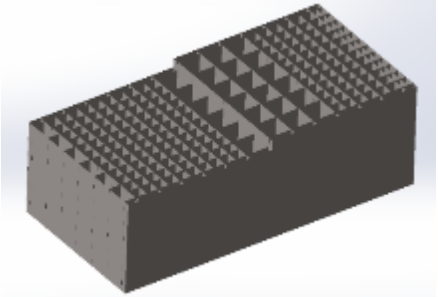
Stress based optimized support structure(Showing in 3D and 2D)

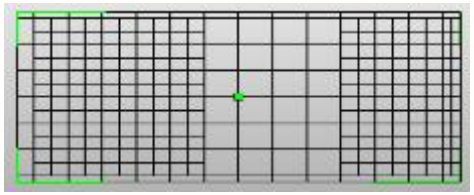
Supports structure with non-uniform thickness





Supports structure with non-uniform spacing (single bead wall)





Future interests

- Vary machine parameters during build to optimise final stress state
- Predict and include distortion effect in build geometry
- Exploit beneficial residual stress and texture, rather than minimising
- Alloys designed for additive manufacturing
- In orbit construction spacecraft and structures
- Machine design and manufacturer – small systems / WAAM
- Propulsion systems – printed solid rocket boosters

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