



Additive Manufacturing at RAL

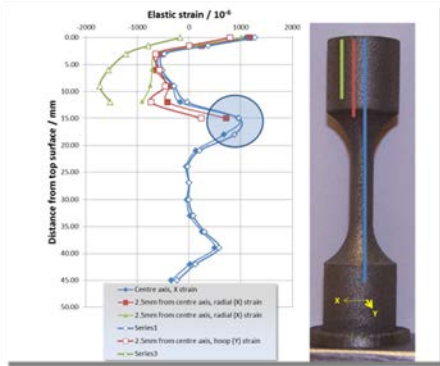
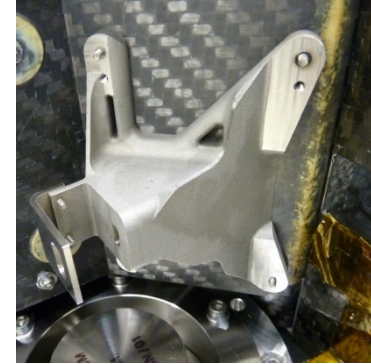
Mike Curtis-Rouse, STFC AM & Autonomy Lead

11 February 2016



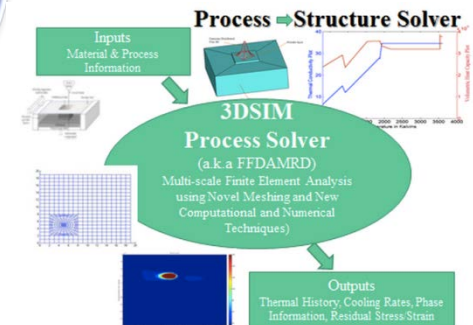
Focus

Experimental
manufacturing



NDT testing
for
components

Simulation
&
modelling



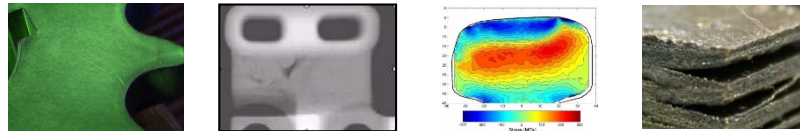
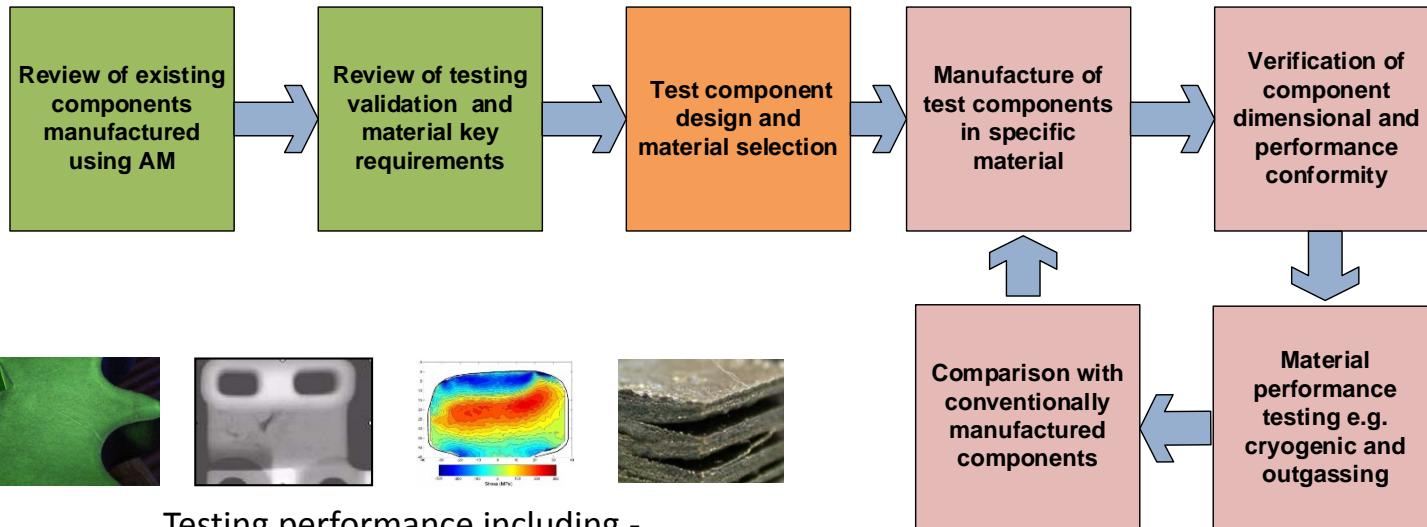
Advanced and Additive Manufacturing Facility

- Co-located with Metrology facility
 - EOS M280 FDR – upgrade to M290 in Q1 2016
 - Concept Laser MLab R
 - Stratasys Objet 30 Pro
 - Fortis 450 – Ultem 9085 etc
 - Full characterisation
 - Simulation and modelling development
 - 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.





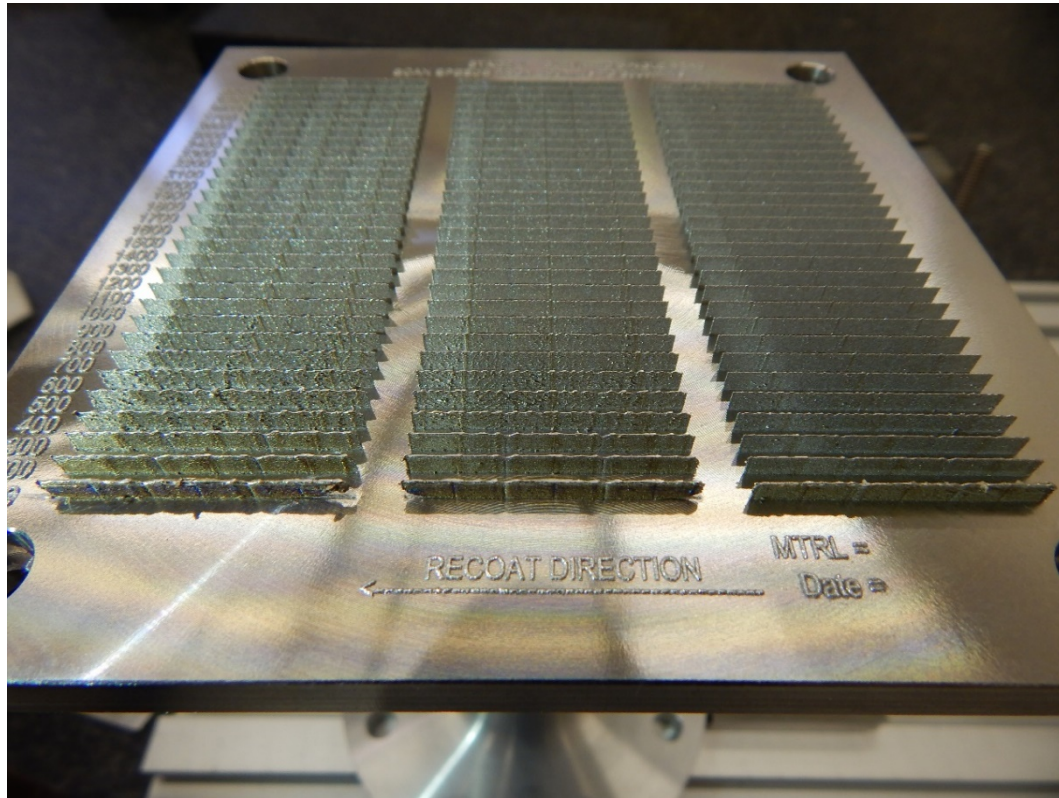
Experimental Manufacture



Testing performance including -
cracking, fractures, stress, lack of fusion

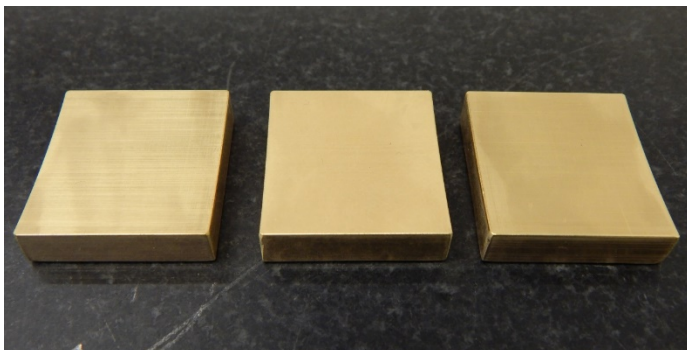
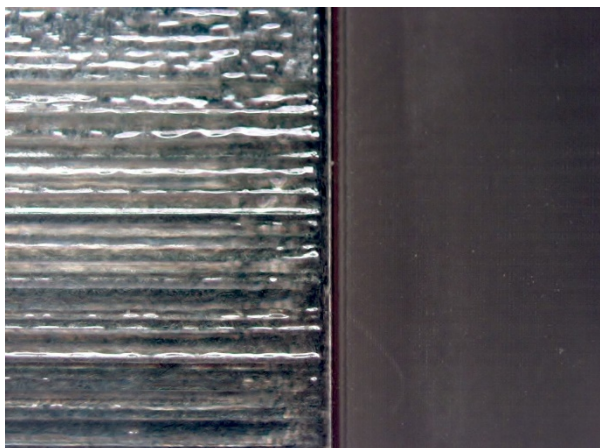
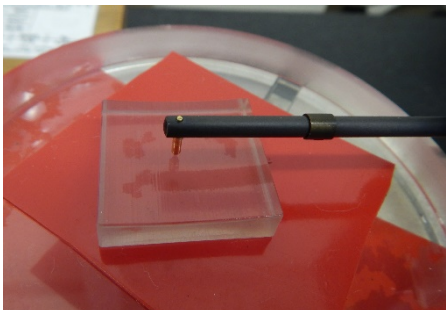


Parameter development

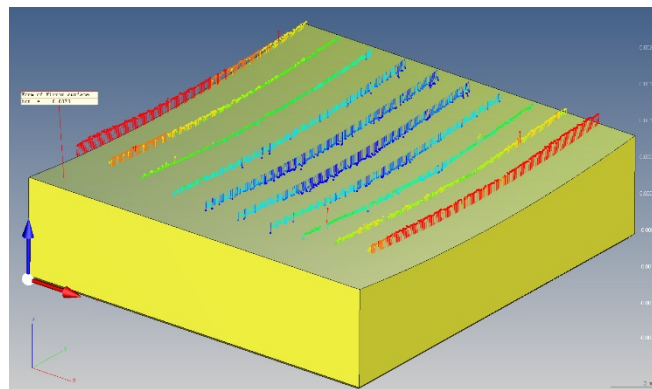


- SS316 process development
- Focus on material properties
- Refractory metal development

Freeform Mirror design



- Manufactured in plastic
- Desired surface finish of $<100\text{nm}$
- Complex surfaces achievable with associate benefits from equal thermal expansion, shorter integration...
- Plated with $100\mu\text{m Au}$
- Surface roughness $<5\mu\text{m}$





Residual Stress

Residual Stress affects:

- Thermal contraction after solidification
- Phase change during cooling e.g. ferritic steels, titanium
- Leads to distortion of component geometry
- Fatigue performance in service

Neutron NDT offers:

- Mapping of residual stresses in metallic AM
- Suitable for aerospace alloys e.g. Ti6Al4V
- Good penetration of dense alloys
- Desirable for repeatability and validation testing.
- Very high fidelity data sets

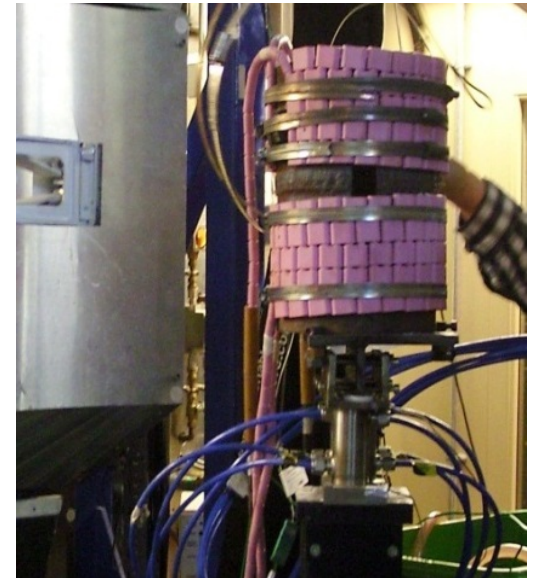
ISIS Neutron Spallation Source



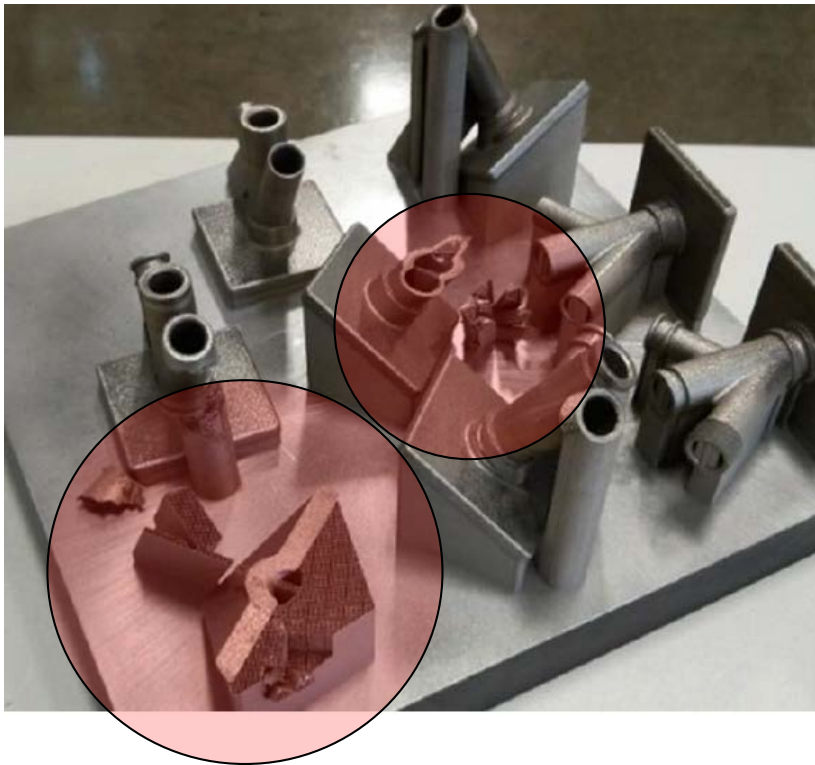


In situ SLM Build

- In situ measurement of build process
- Realizer SLM 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

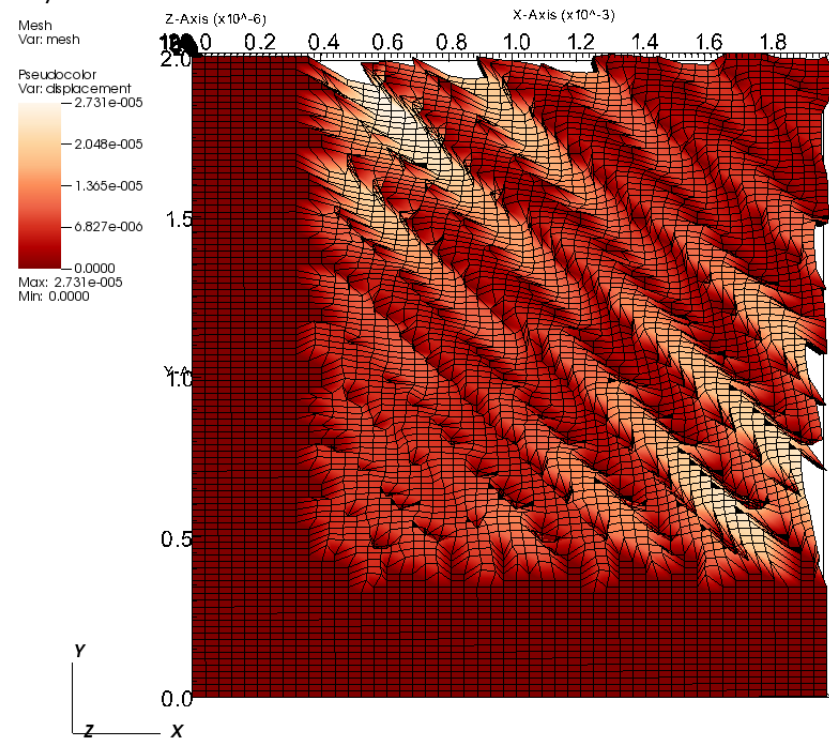


Simulation of Residual Stress



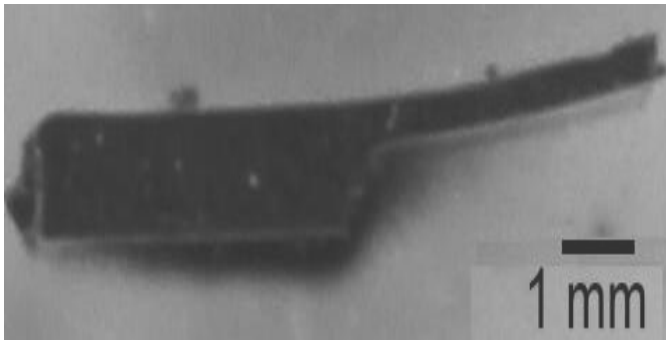
Avoiding this by...

...modelling this

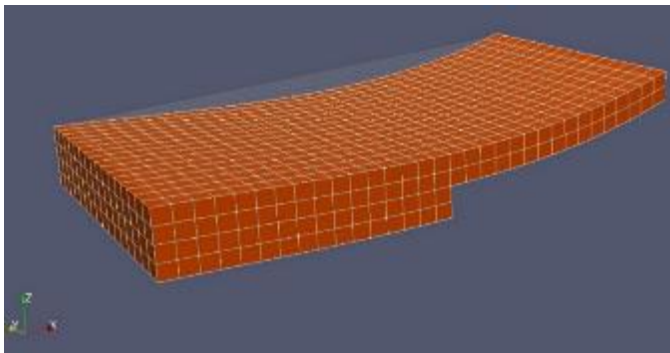


Simulation of Residual Stress

Experiment Sample

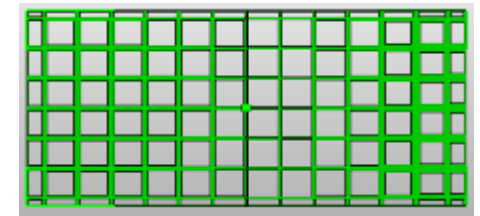
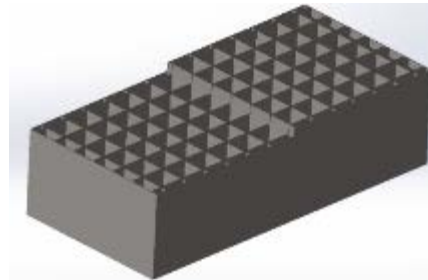


FEM Stress calculation

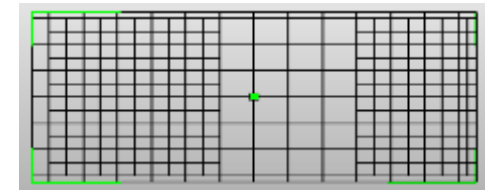
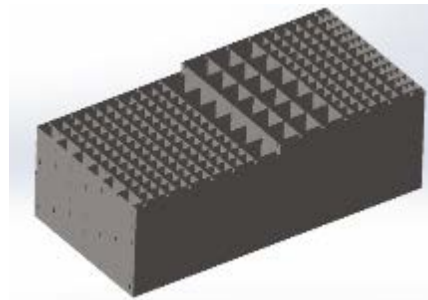


Stress based optimized support structure

Support structure with non-uniform thickness

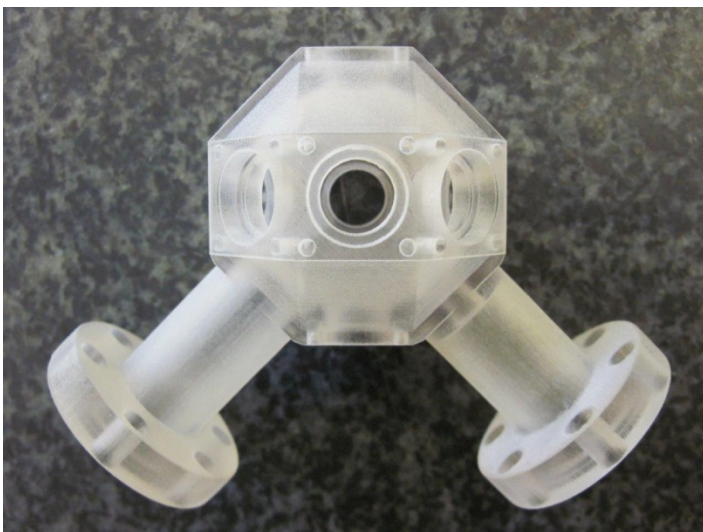
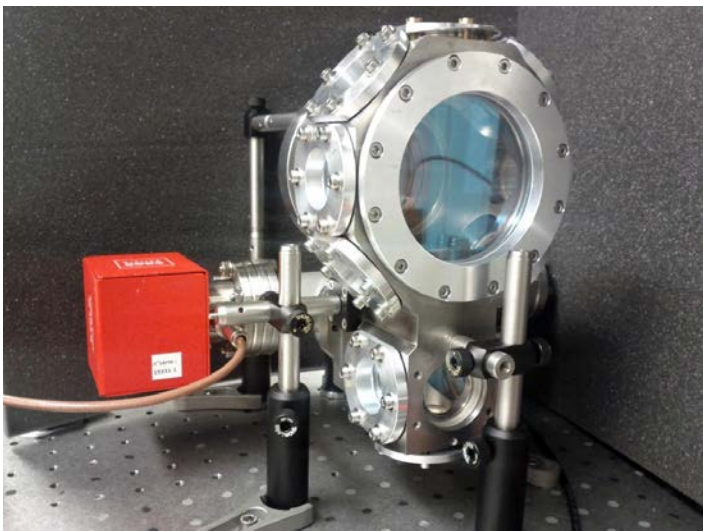


Support structure with non-uniform spacing





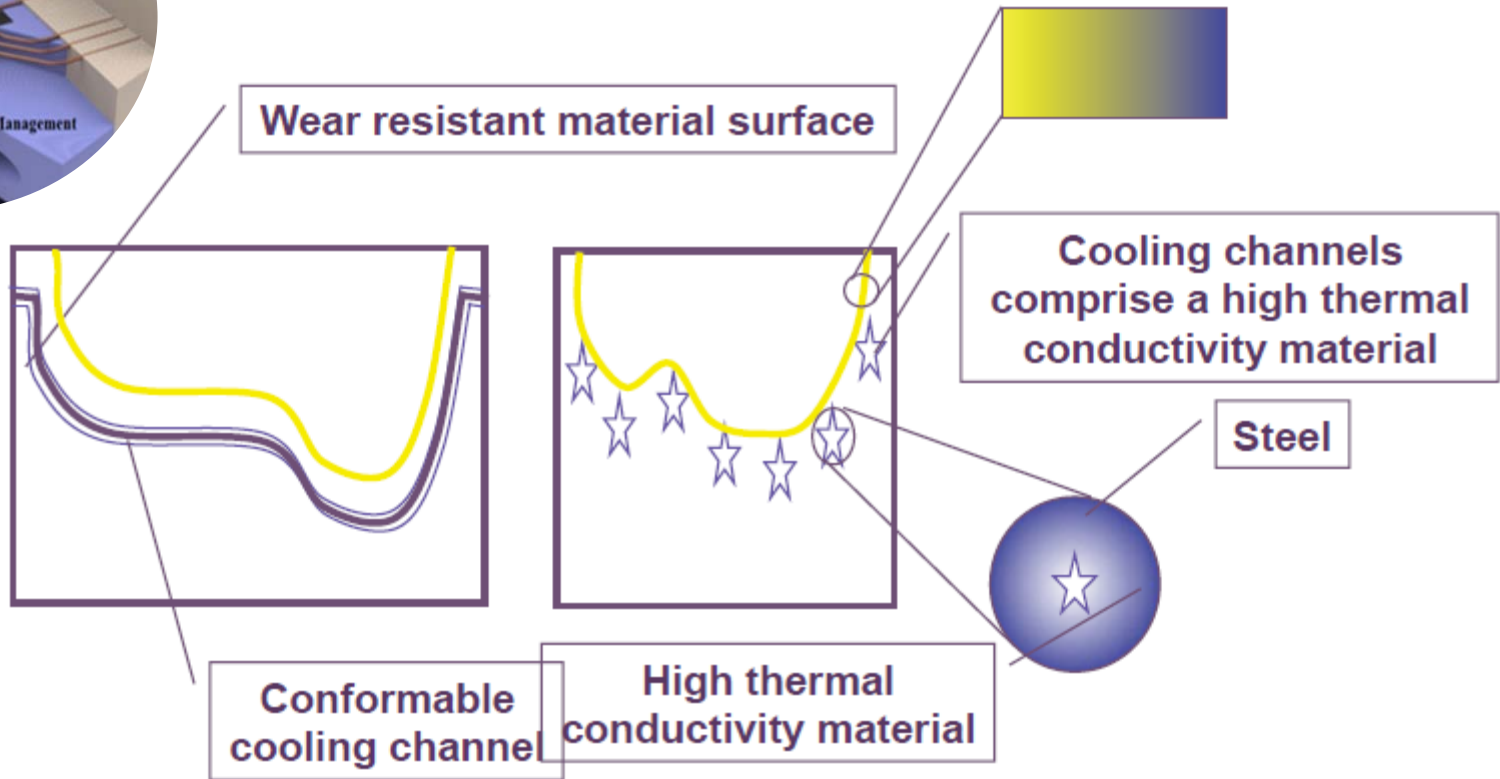
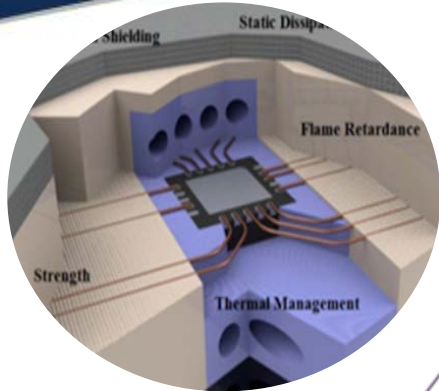
Full integration



- Mass spectrometer vacuum chamber
- Integration of eight components into one assembly
- Reduction in joints, seams, mass and volume
- Inclusion of vacuum and optical windows.
- Manufactured in plastic with view to using Ceramic binding as final process



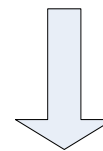
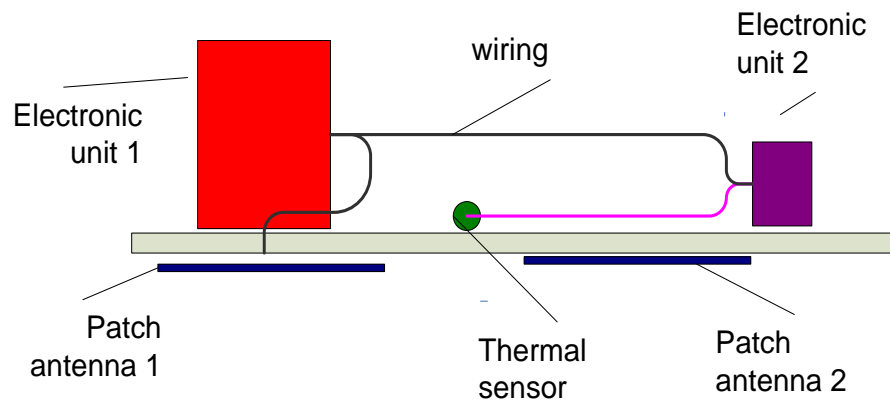
Functionally Graded Materials



Embedded functionality

Embedded functionality:

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



Encapsulated components via RP technology





Future direction

- 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

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