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# Challenge Workshop on Advanced Manufacturing for Earth Observation Instrumentation & Space Technology

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# The Challenge (I)

- Satellite manufacture and access to space both remain costly, time consuming, and the space industry is predominantly a bespoke industry
- This remains true despite:
  - *Innovation at SSTL and elsewhere*
    - SSTL can build a spacecraft in ~2 years, but shorter times and lower costs are needed for commercial customers.
  - *Advances in manufacturability in the telecomms satellite industry*
    - Comsats are normally ready to fly in ~2 years, but customers want them on orbit as soon as possible, for the lowest price
- However scientific payloads and missions can take many years
  - *Times of 10, 15 and even 20 years from concept to flight are not uncommon*

# The Challenge (II)

- This is particularly challenging for commercial enterprises
  - *If a commercial services are to be profitable, or at least sustainable, then costs of the space segment must be brought to the absolute minimum.*
  - *In addition, the time to flight must be as short as possible in order to seize the commercial initiative.*
- Advanced manufacturing techniques can help potentially
  - *So what are we doing, and how well are we doing?*
  - *What needs to happen to add momentum to these efforts?*
  - *What are we doing in CEOI-ST?*
  - *What is ESA doing?*
  - *What can the High Value Manufacturing Catapult bring to the UK space community?*

# Additive Layer Techniques

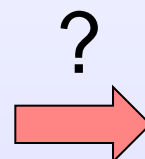
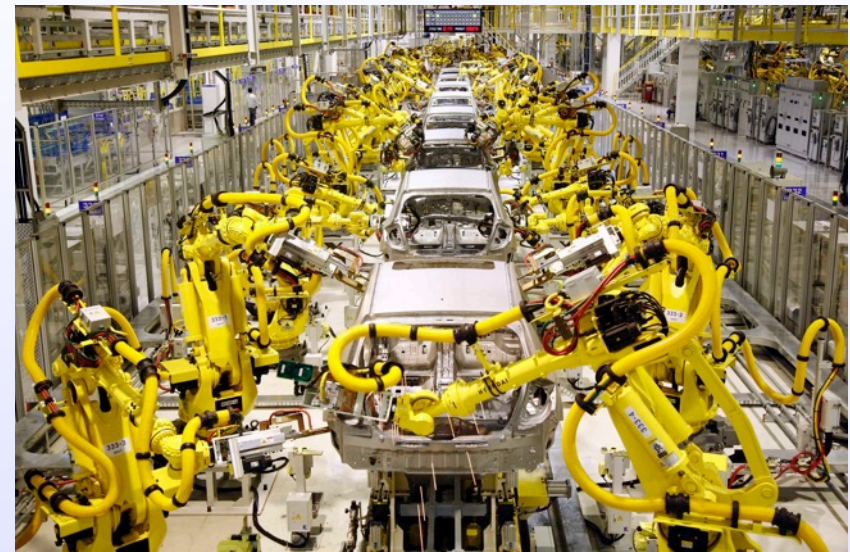
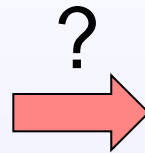


- ALM is already a massive subject & market
  - *Tends to dominate discussions of Advanced Manufacturing*
  - *Large peripheral industry growing regarding design, post-processing, materials, qualification and standardisation*
- There are other techniques however
  - *Robotic assembly*
  - *New techniques in machining and conventional engineering*
- Hence this talk will simply set the scene for the day by posing questions rather than attempting to outline answers

# Can we ever approach the methodology of the automotive industry?

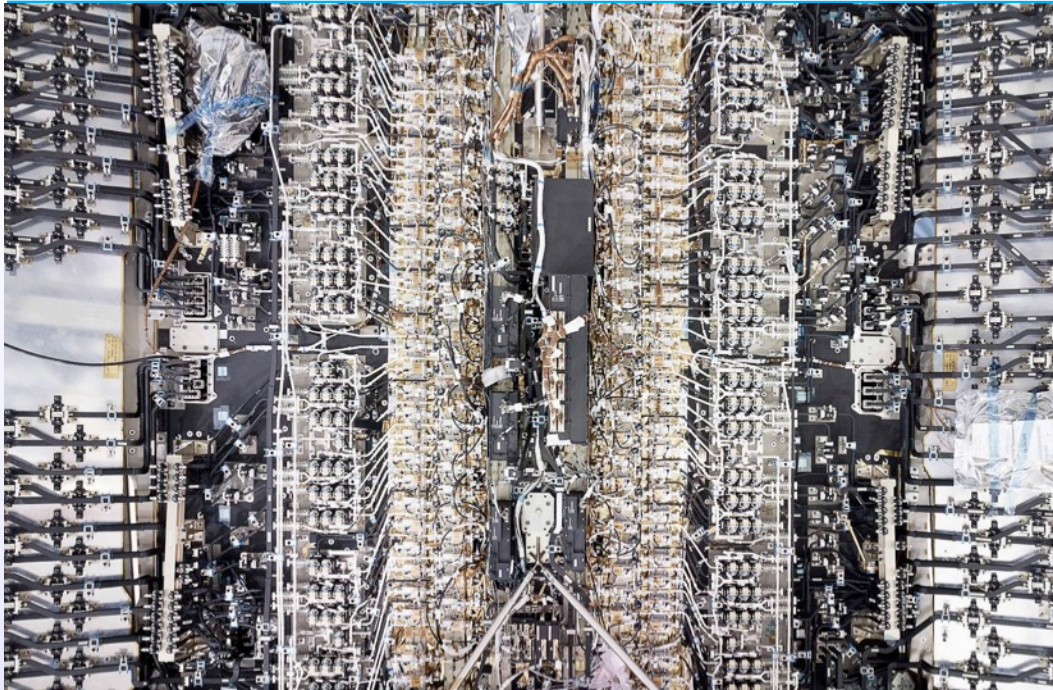


Automated assembly?

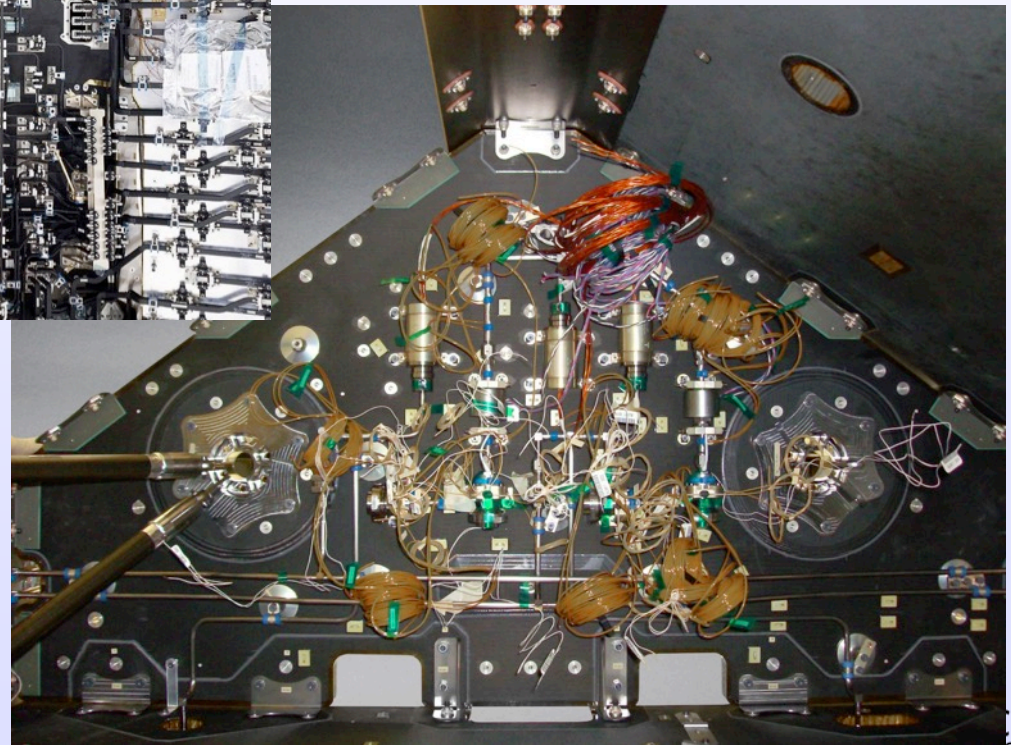


Standardised subsystems and parts?

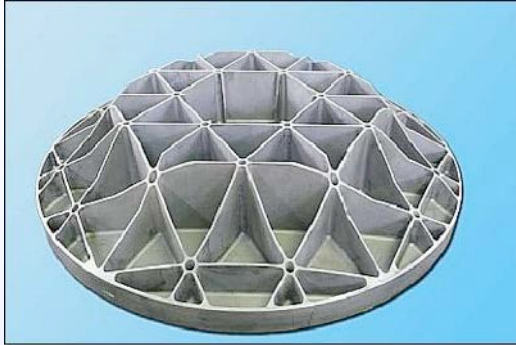
# Complexity – pipes & waveguides



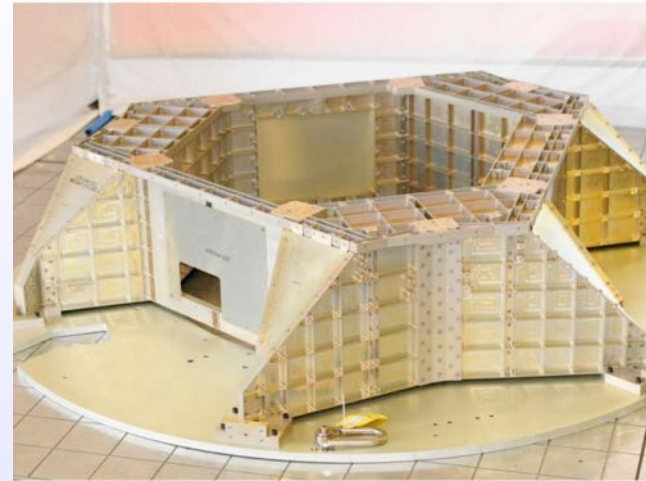
- Complex topology,
- Many joints
- Many potential failure points
- Cost, manpower



# Complexity - structures



Lightweight mirrors

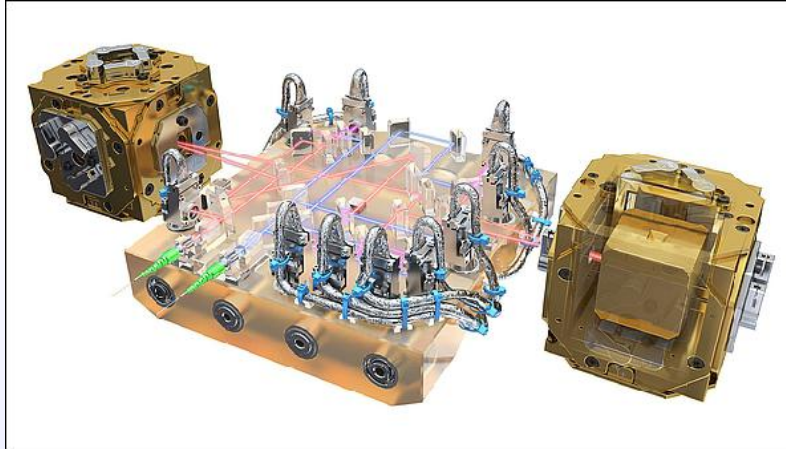


Complex structures

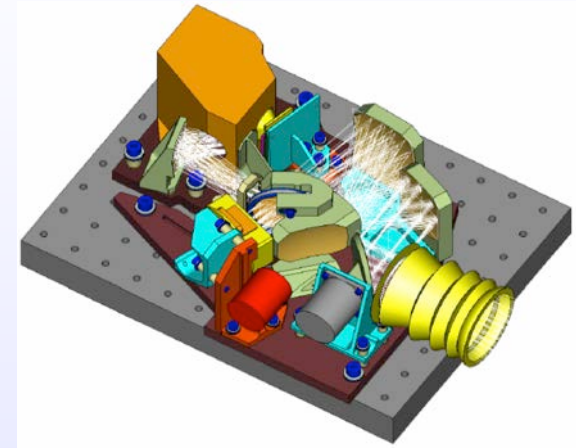
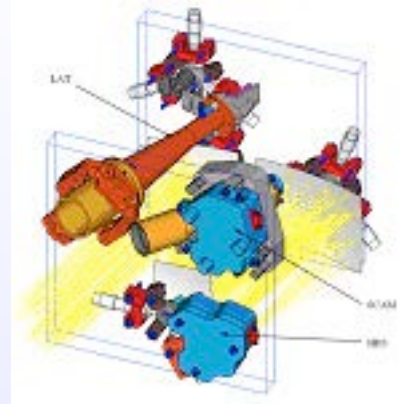


Tankage etc

# Complexity - Instrumentation



High precision optics



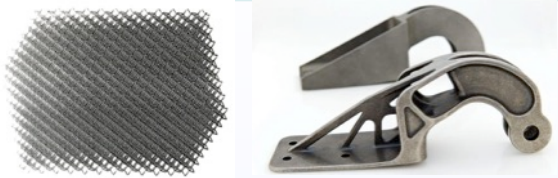

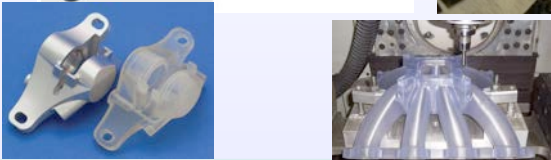


'Highly Integrated Payload Suites'



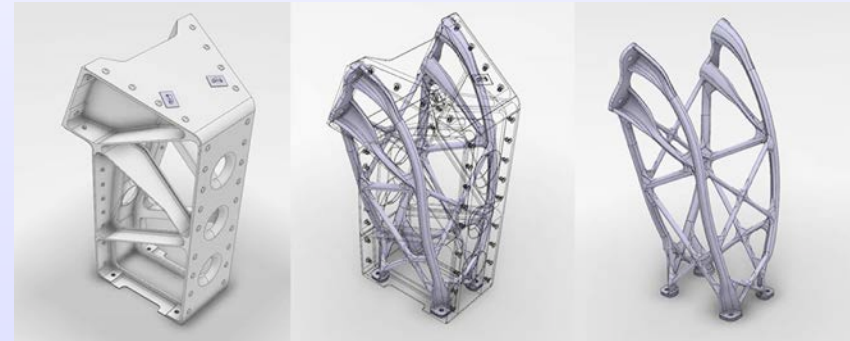
Thermal infrared payloads



# Some AM Techniques

<b>Electron Beam Melting (EBM)</b>	
<b>Selective Laser Melting (SLM)</b>	
<b>Stereo Lithography</b>	
<b>Robotic assembly</b>	
<b>Lithography-based Ceramic Manufacturing (LCM)</b>	

- CAD techniques
  - *There are some significant limitations in current generation of CAD SW for 3D printing*
- Structural optimisation with genetic algorithms etc.



- Metals
  - *Metals available are suitable for fabrication*
  - *But are these materials suitable for space applications?*
  - *What materials are in the pipeline?*
- Re-use of materials
  - *how many times can unfused powder be re-used, and how do we quantify this for process qualification?*

# Advantages

- Potential for efficiency savings in manufacturing step
  - *Elimination (or great reduction) of waste material*
  - *From CAD to fabrication via universal machines*
  - *Light-weighting – joint-free closed honeycomb structures*
  - *Repeatability – in principle*
  - *Potentially time saving*
- Fabrication of complex shapes containing voids, without the need for jointing of multiple segments.
- New configurations not possible by traditional machining
- Rapid prototyping using polymers, prior to metal printing
- **However – what is the quantitative gain of AM over traditional techniques?**
  - *What is the gain, once drawbacks are taken into account?*

# Issues

- Surface finish
  - *Metal parts often have loose particles and a finish resembling a nail file.*
  - *Need to ream pipes and ducting, and treat surfaces with abrasives, and/or heat and/or chemicals*
- Materials
  - *Voids in bulk printed material*
  - *Crystal structure – need for heat treatment*
    - Heat soak for bulk stress removal
    - Hot isostatic pressing (HIP) – crystal regrowth
  - *Material recycling*
  - *Material suitability for space – need for specific materials – e.g. noble metals*
- Practical issues and ‘black magic’
  - *Orientation during build, structural support - slumping*
  - *Community (users plus machinery vendors) still learning*
- CAD issues
  - *CAD software unable to represent complex shapes, and present coherent files to ALM machines*
  - *Need new generation of CAD which is fully aware of Additive techniques?*

- Ideally one should not be locked into a specific AM foundry
  - *Process and material qualification*
  - *Confidence needed in parts produced at different locations to same specification and CAD file*
- Some way to go for full space qualification of AM-built subsystems
  - *Some components easier to qualify than others?*
- Need for national initiative to mobilise and enable UK community?

- Frequent user requests from Additive Manufacturing
  - Increased resolution
  - Improved surface quality
  - More materials
  - Process control/repeatability
  - Design guidelines
  - Standardisation
  - Any more from UK?

# Breakout questions

- Q1: *What are the emerging manufacturing challenges for commercial and institutional space?*
- Q2: *What are the burning issues arising from the use of Advanced Manufacturing (surface finish, process repeatability, space qualification)?*
- Q3: *How can CEOI-ST/SAC/HVMC and UKSA help consortia both exploit new manufacturing techniques, whilst addressing repeatability, quality and space qualification challenges?*
- Q4: *What are the next steps for all? – (e.g. visits to advanced manufacturing centres, future workshops, themed project calls etc., - incorporation into national strategy?)*