



Australian Government

Department of Defence  
Science and Technology

# Additive Manufacturing for Defence Applications

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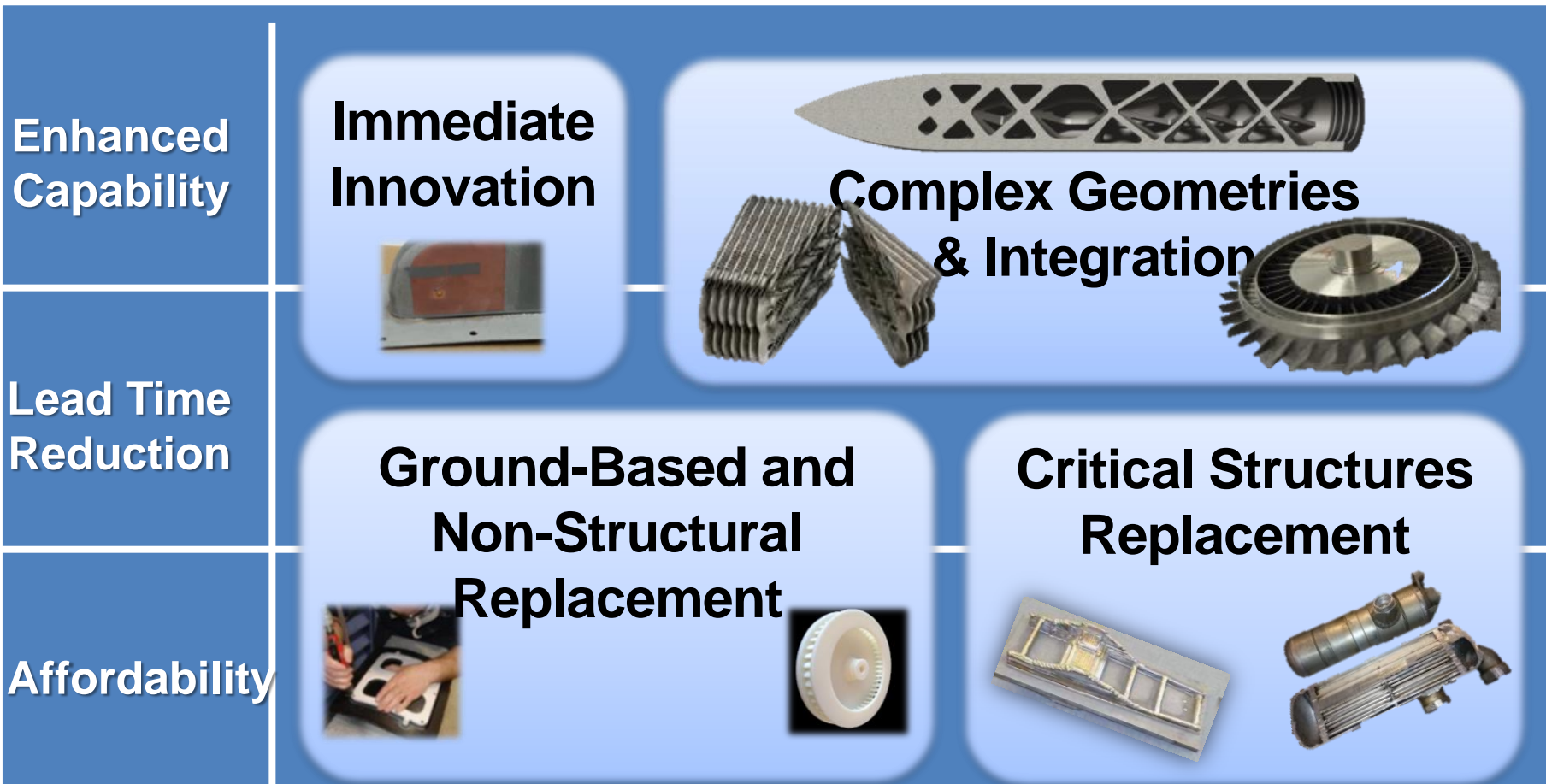
ICAS Emerging Technology Forum 2019

# Defence Opportunities for AM



**Maintenance & Sustainment + Deployed & Expeditionary + New Capability= Opportunities for AM**

# Potential for AM implementation timeframe



Near

Far

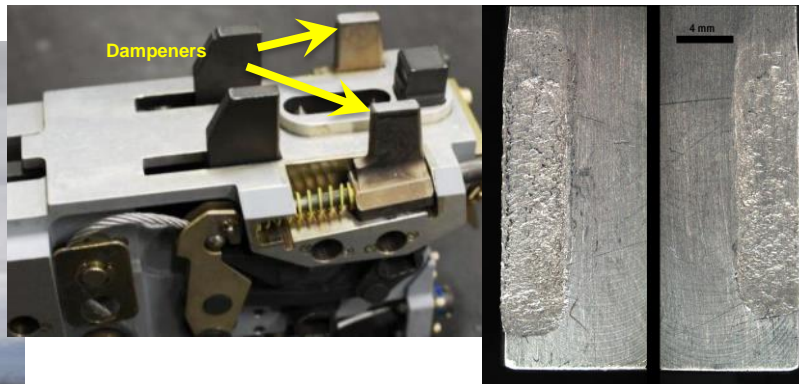
## Implementation Timeframe

# Current, Near-Term and Future States of AM “Certification”

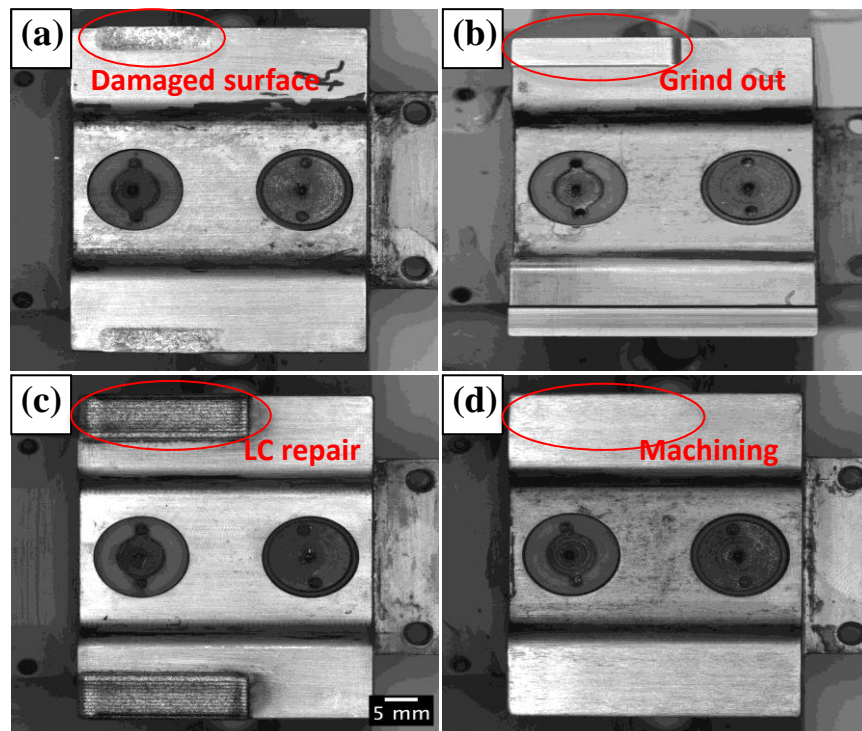
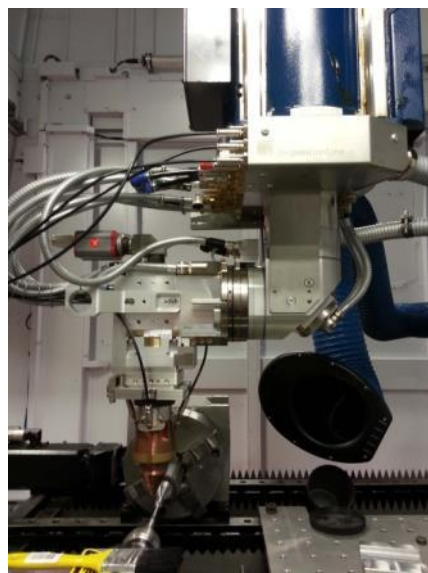
## Process Qualification of AM for Aerospace Structural Components

Future	<p>\$</p> <p>In-Process QA &amp; Process Models</p>	<p>\$</p> <p>Validated Models &amp; Selective QC Testing</p>	<p>\$</p> <p>In-situ NDE-based DADT w/ Models</p>	<p>Including Fracture Critical</p>	
	<p>\$</p> <p>AM PQR w/ In-Process QA</p>	<p>\$\$</p> <p>Fit for Purpose Tests Per M&amp;P pair</p>	<p>\$\$\$</p> <p>Post-build NDE-based DADT w/ Data</p>		<p>Non-Fracture Critical (lacking experience)</p>
	<p>Current</p> <p>\$\$</p> <p>PQR</p>	<p>\$\$\$\$</p> <p>1000s of Tests Per Part</p>	<p>\$</p> <p>None</p>		<p>Non-Critical Regions Only</p>
	<p>Conventional</p> <p>\$</p> <p>Decades of Specs w/ Established Suppliers</p>	<p>\$\$</p> <p>MMPDS &amp; Design Allowables</p>	<p>\$\$\$</p> <p>NDE-based DADT w/ Data &amp; Experience</p>		<p>Including Fracture Critical</p>
	<p>Repeatability &amp; Producibility: Demonstrated Process Control</p>	<p>Characterized Physical &amp; Mechanical Properties</p>	<p>Durability &amp; Damage Tolerance Approach</p>	<p>Application</p>	

# Example 1:



Problem:  
Faster than  
expected wear  
damage to  
hanger.



Solution: Remove  
damage, optimise  
blend and restore  
material

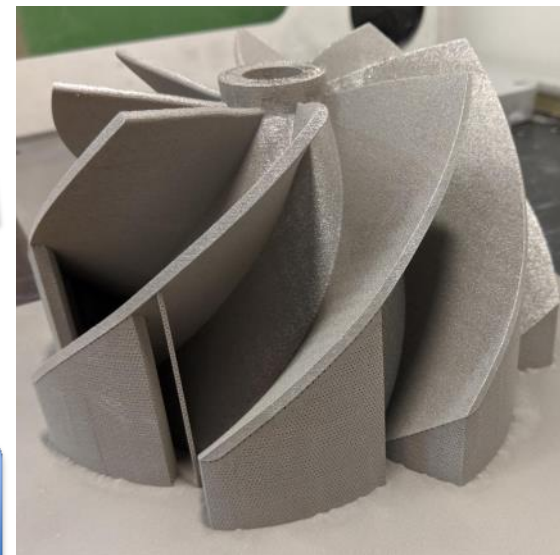
## Example 2:



Problem: Erosion of impellor leading edges.

We can make it better-with a harder leading edge

Solution: Build a replacement with SLM.



# DST Additive Manufacturing R&D Challenges

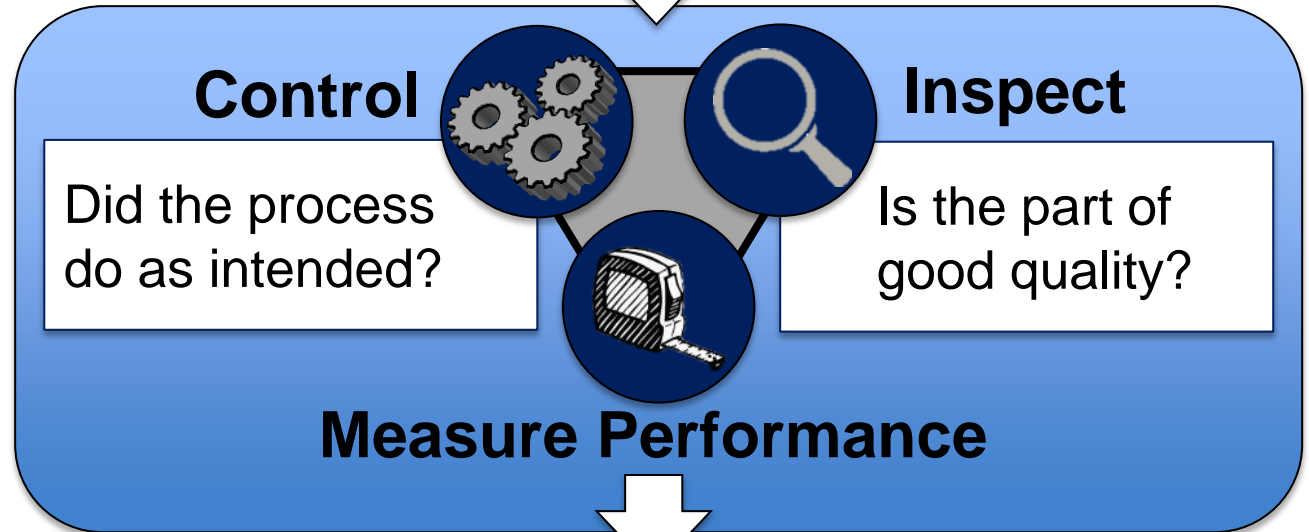
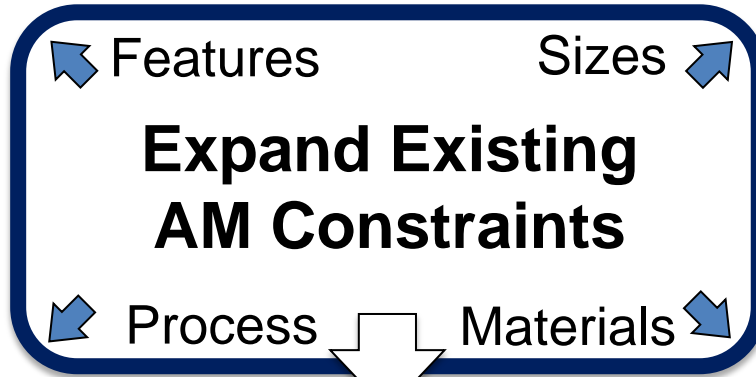
Expand AM Capability:  
**LEVERAGE**



Validate Existing AM Capability:  
**LEAD**



Implement:  
**SUPPORT**



**Demonstrated, Reliable Capability:  
Transition to Formal Defence Processes**

# Major Activities to Solve the Challenges

Real-Time Fully Automated, Repeatable, Reliable  
Detection System and On-the-Spot Rectification of  
Manufacturing Defects

In-situ monitoring of the manufacturing  
process via sensors

Modelling the outputs via the closed-  
loop control

Develop adaptive qualification  
approach

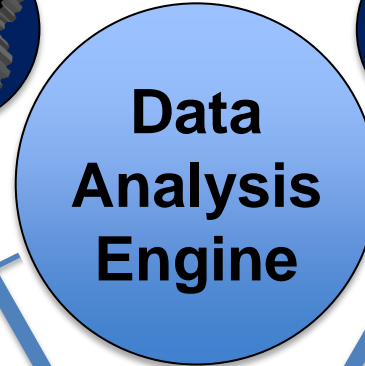
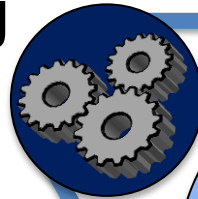


# DST Research: Integrated Data Analytics

**In-Process Monitoring**

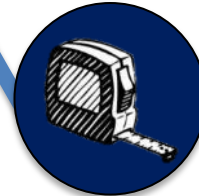
Validate Detectability

**Computed Tomography**

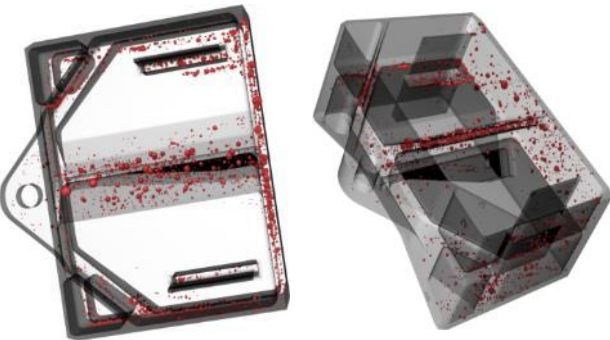


Correlate Capability

Identify Critical Flaws



**Properties & Performance**

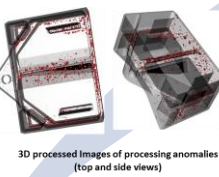
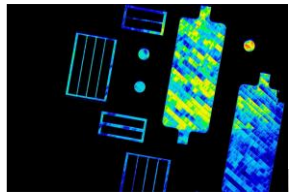


3D processed Images of processing anomalies (top and side views)

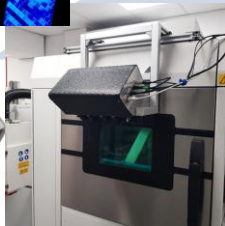
**Learn from Correlated Spatial Data**

# Timeline

Exercise the quality control of the process

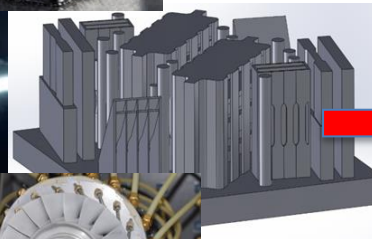
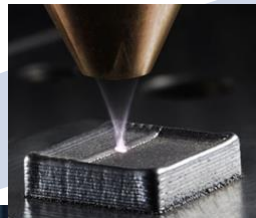


3D processed images of processing anomalies (top and side views)



**Apply and Learn-ML**

Expand to include increased component criticality, materials and processes



**Tailor and Automate**

Distributed manufacturing network for sustainment



**Broaden and distribute**

2025

2030



# Deployed & Expeditionary

Make real-time adjustments to process instructions, based of feedback from sensor data.



## Feedstock

Material heat capacity, latent heat, absorptance  
Powder Size & distribution



ML vision based control

Part Performance  
Part quality metrics

Standards

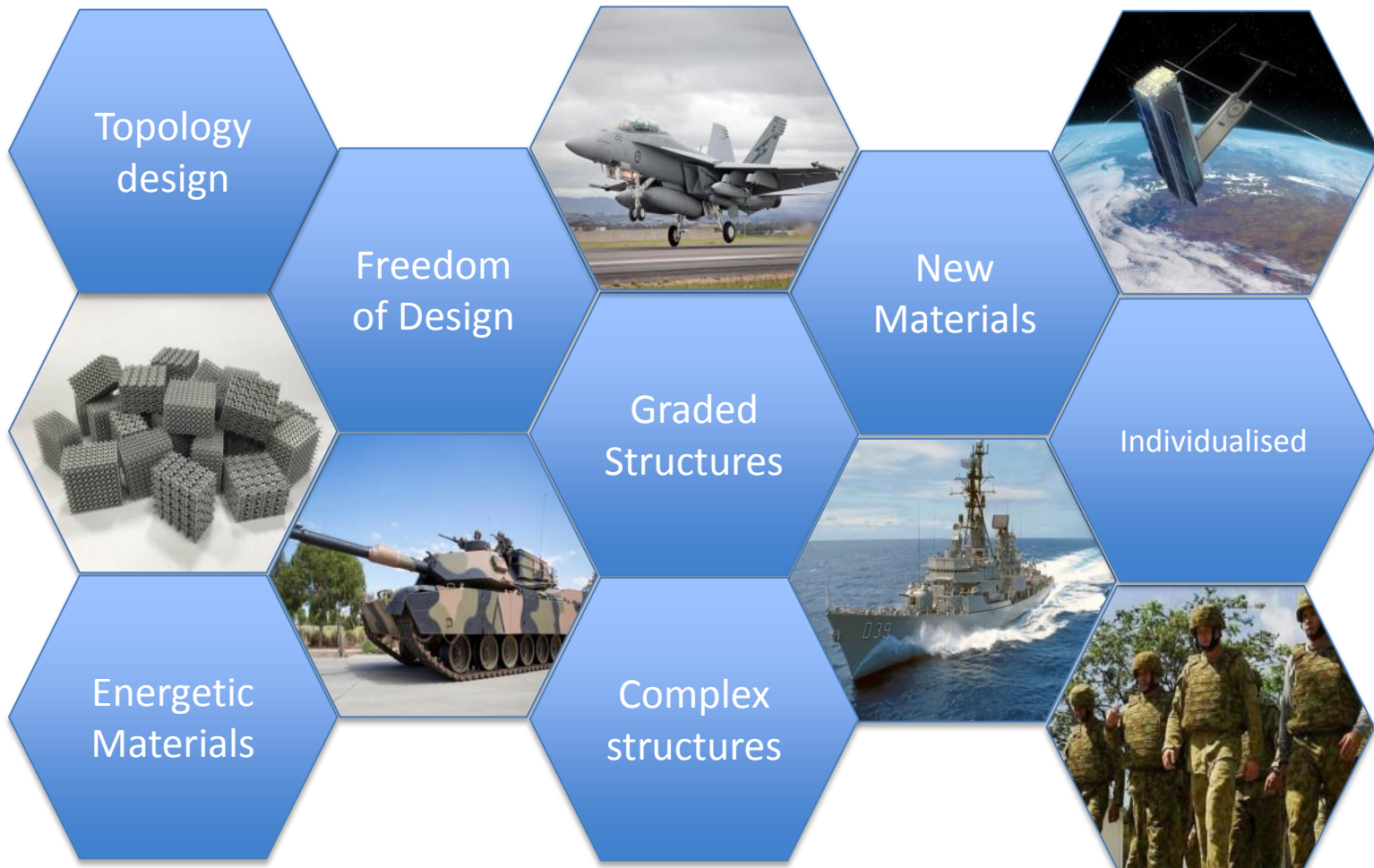
Design

V&V  
CT Scan  
Synclartron  
Sectioning



V&V  
Strength  
Ductility  
Fatigue

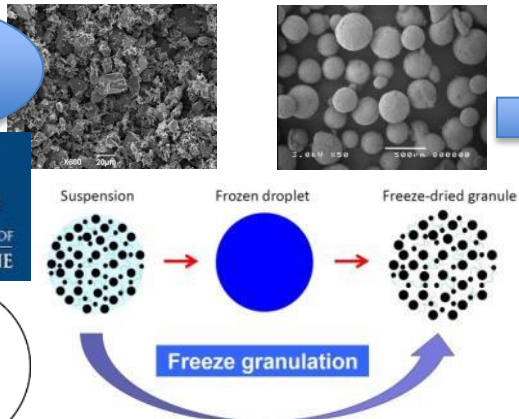
# Customised Solutions



**Opportunities: New materials & new structures, that cannot be made by conventional methods.**

# Enhanced capability – snap shot

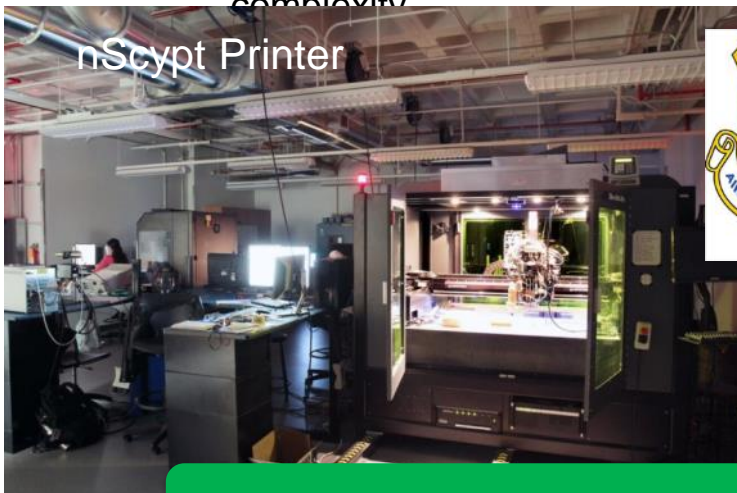
## POWDER REFINEMENT & PRODUCTION



## BUILDING PARTS



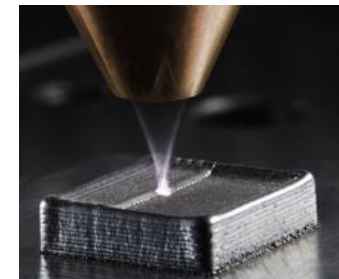
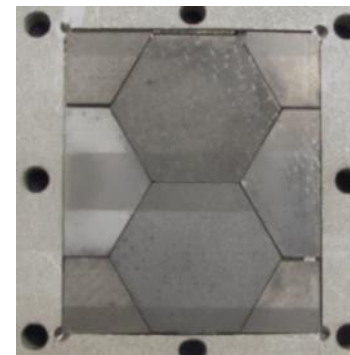
Max Phase/high entropy materials; low density. retain strength at temp >2000C,.  
 Can we move from isostatic pressing to 3D printing in increase geometric complexity



nScript Printer



Flexible electronics  
 Multi-material  
 Novel inks



(Ti alloy-SiC)

Single step production of "Dual" hard and graded materials: Hard -tough combinations

Provide Capability Enhancements

# Topological Optimisation

Thermal Stress  
Analysis

Standard  
Part or  
Component

In-Situ  
Visualisation

Microstructural  
Modelling

CT

Validation and  
Verification

# Summary

In-house parts storage



In the field parts storage

Point of location, timely manufacture & repair of components.



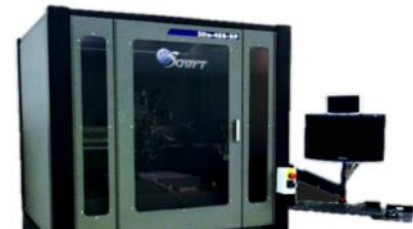
New capability

Maintenance & Sustainment + Deployed & Expeditionary + New Capability = Opportunities for AM

# DST Additive Manufacturing Capability



SLM printers



Multi-material/flexible electronics printer



Polyjet 3D printers



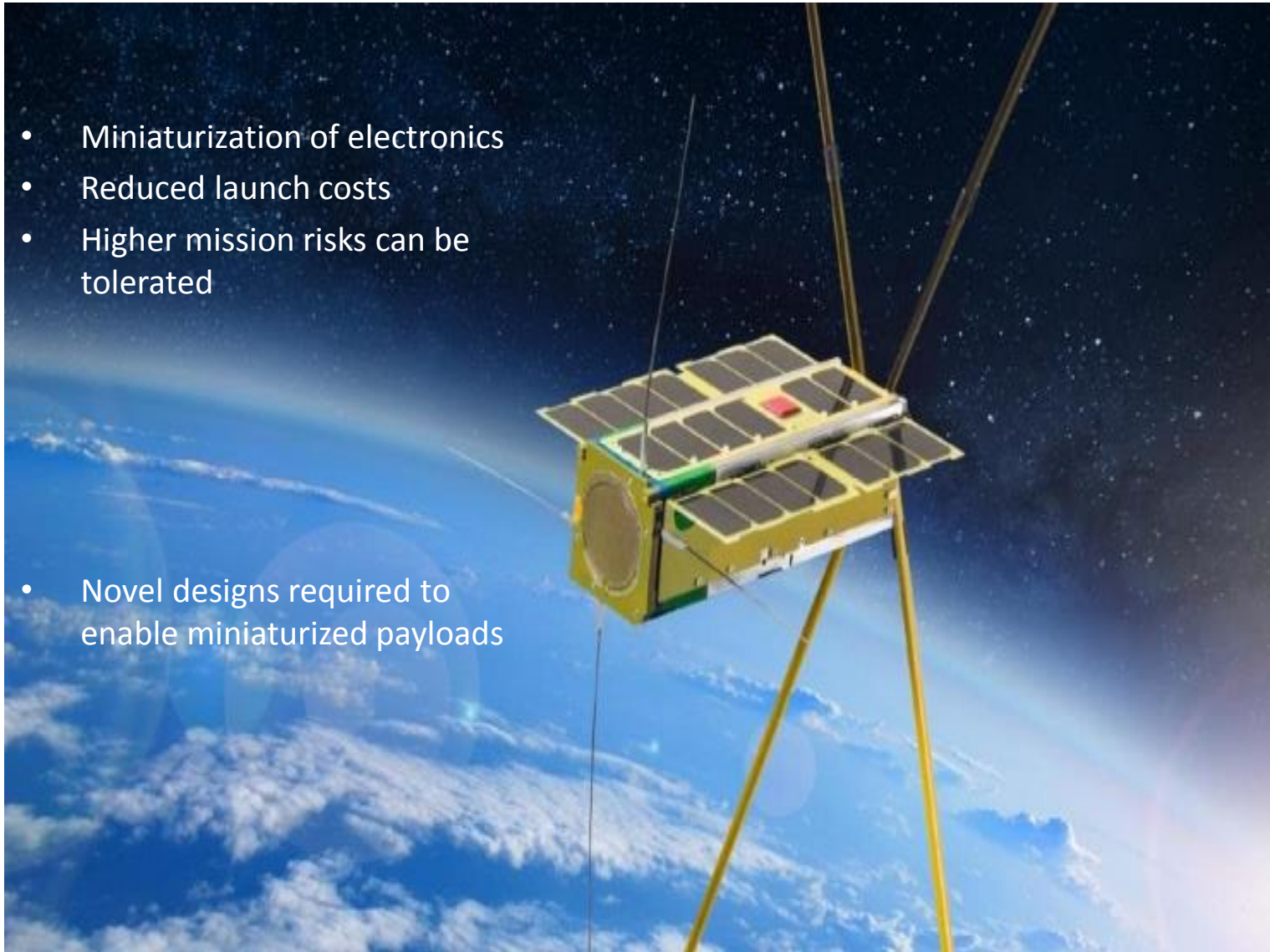
FDM printer

**Focus = prototyping and additive manufacturing research**

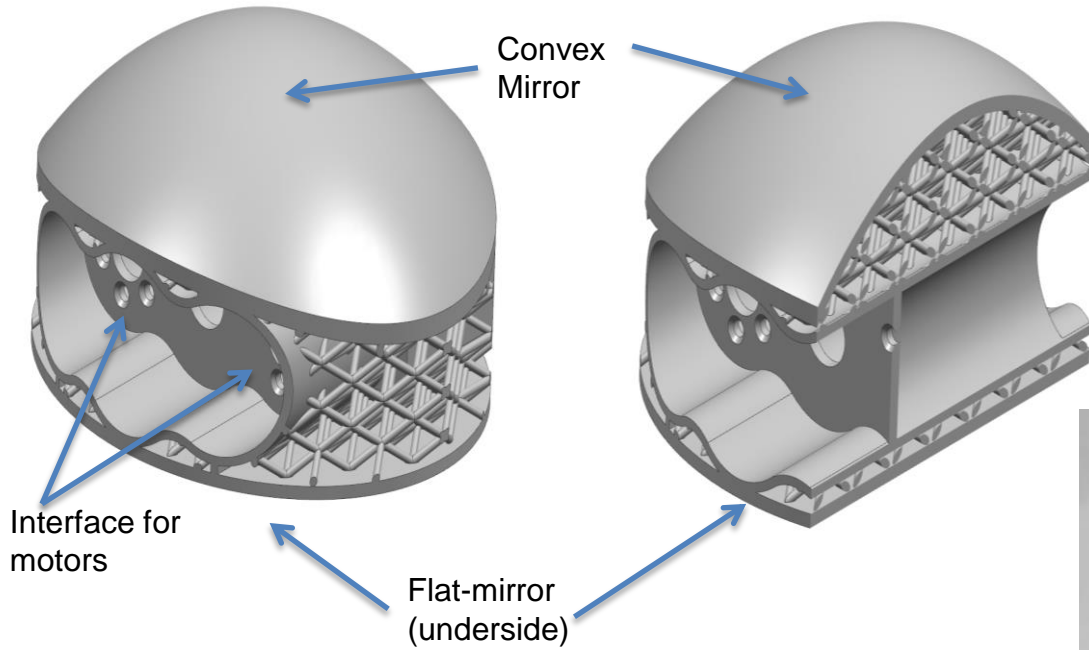


# Nanosatellites

- Miniaturization of electronics
  - Reduced launch costs
  - Higher mission risks can be tolerated
- 
- Novel designs required to enable miniaturized payloads



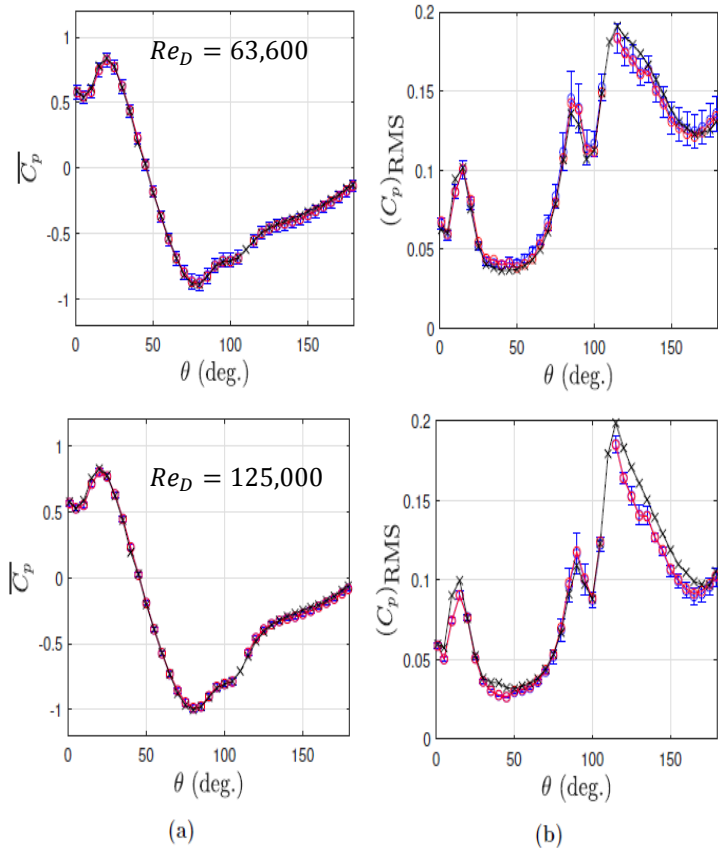
# Nanosatellites – Deployable Optics



# Wind Tunnel Models

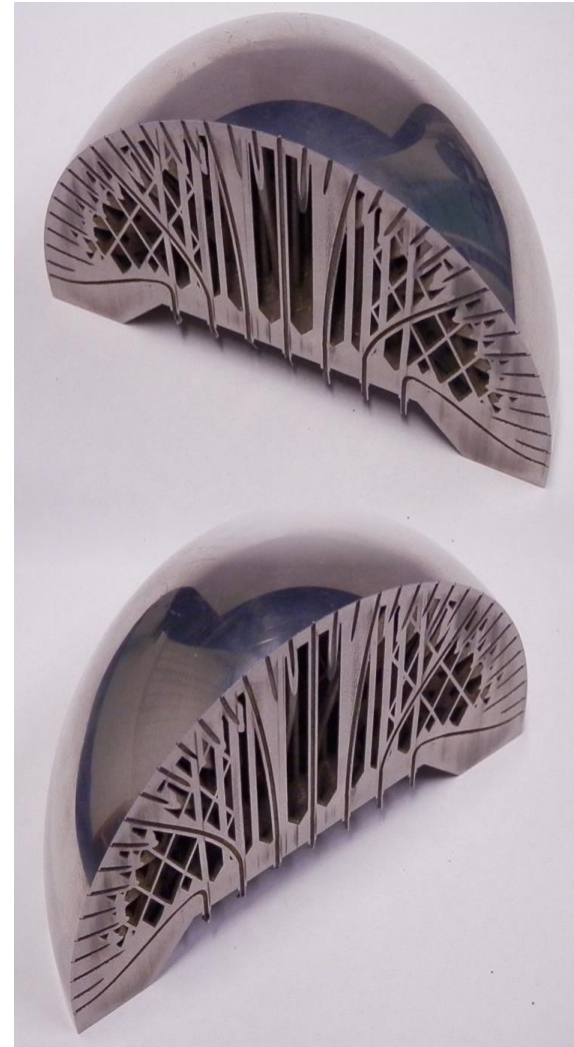


# Wind Tunnel Models



(a)  $\overline{C_p}$  and (b)  $(C_p)_{RMS}$  for flow in streamwise direction over pressure ports in AM hemisphere

J. M. McCarthy, T. Teske, S. Lam and M. Jones (2019), 'Additive Manufacturing Pressure-Tapped Metallic Models for Wind Tunnel Testing', Journal of Wind Engineering and Industrial Aerodynamics, submitted for review.



# QUESTIONS

