

# NUCLEAR AMRC

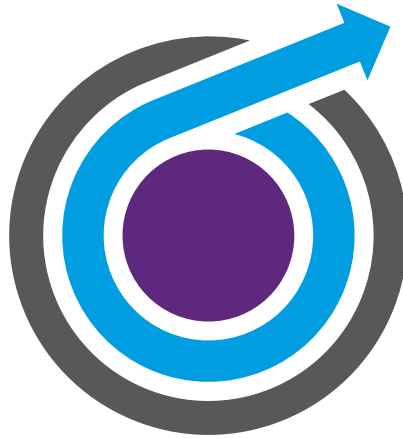
ADVANCED MANUFACTURING RESEARCH CENTRE

Advancing UK manufacturing



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Regional Growth Fund





# NUCLEAR **AMRC**

EASA Additive Manufacturing Workshop

Bulk Additive Manufacturing  
*System & Applications*

Udi Woy

Cologne, 28-29.09.16

An industrial robotic arm, primarily orange with black and white joints, is positioned above a large, empty, cylindrical metal container. The arm is suspended by a complex system of black and pink cables. The background shows a factory setting with metal beams and overhead lighting. A semi-transparent blue banner is overlaid at the bottom of the image.

# Bulk Additive Manufacturing

# System I: Technology Overview

Bulk AM is a Nuclear AMRC concept and approach to additive manufacturing of large scale components (>1m).

Defining characteristics :

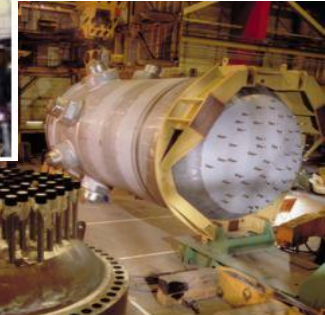
- High deposition rates
- Large volume builds
- Bigger surface area
- Large simple features

Basic principles:

- Low risk approaches
- Adapt enabling technologies
- Address current issues
- New manufacturing route



Pressure vessels



Source: [http://www.world-nuclear-news.org/C\\_Reactor\\_parts\\_deal\\_for\\_Areva\\_0511081](http://www.world-nuclear-news.org/C_Reactor_parts_deal_for_Areva_0511081).



Valve

Source: [http://targetrock.cwfc.com/products/spokes/01c\\_pilotOpSafetyValves.htm](http://targetrock.cwfc.com/products/spokes/01c_pilotOpSafetyValves.htm)



Pump

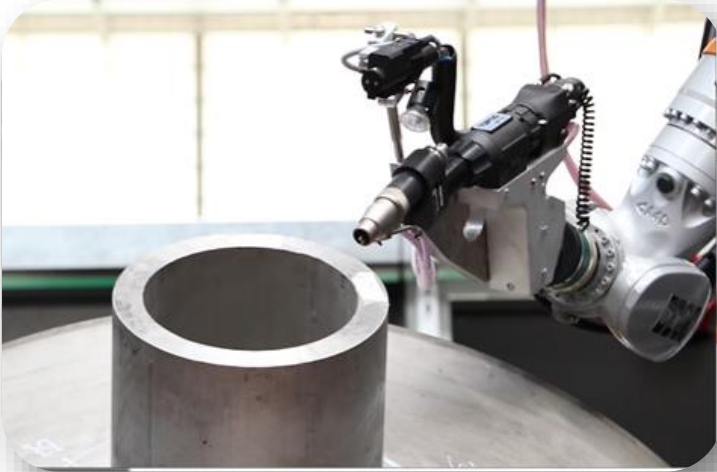
Source: <http://www.sigmagroup.cz/en/about-us/news/mochovce-nuclear-power-plant-condensate-pumps>



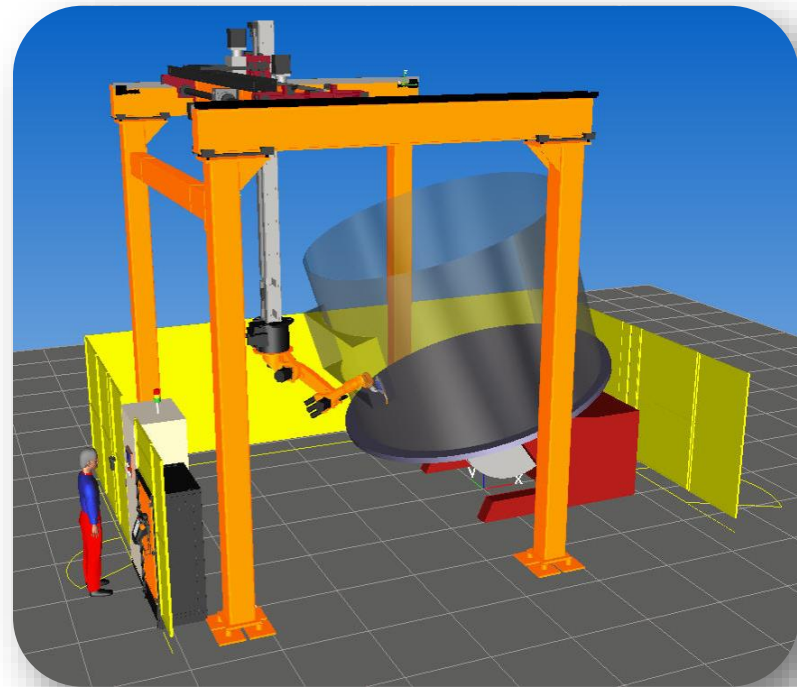
## System II: Conceptualisation Framework

Focus on exploiting robotic autonomy and modular tools

Common enabling technologies



Sizable flexibility





## System III: Capability

### Reconfigurable manufacturing cell

The system is being developed for the sustainable and efficient fabrication of high-value, quality-critical, large-scale metal (>1m) components.

#### Key Features:

- Fully integrated multi-axis robotic cell in a protective enclosure
- Virtual environment for process simulation & offline programming
- Integrated equipment and process monitoring for quality control
- Inspection capability for calibration and surface analysis

#### Challenges:

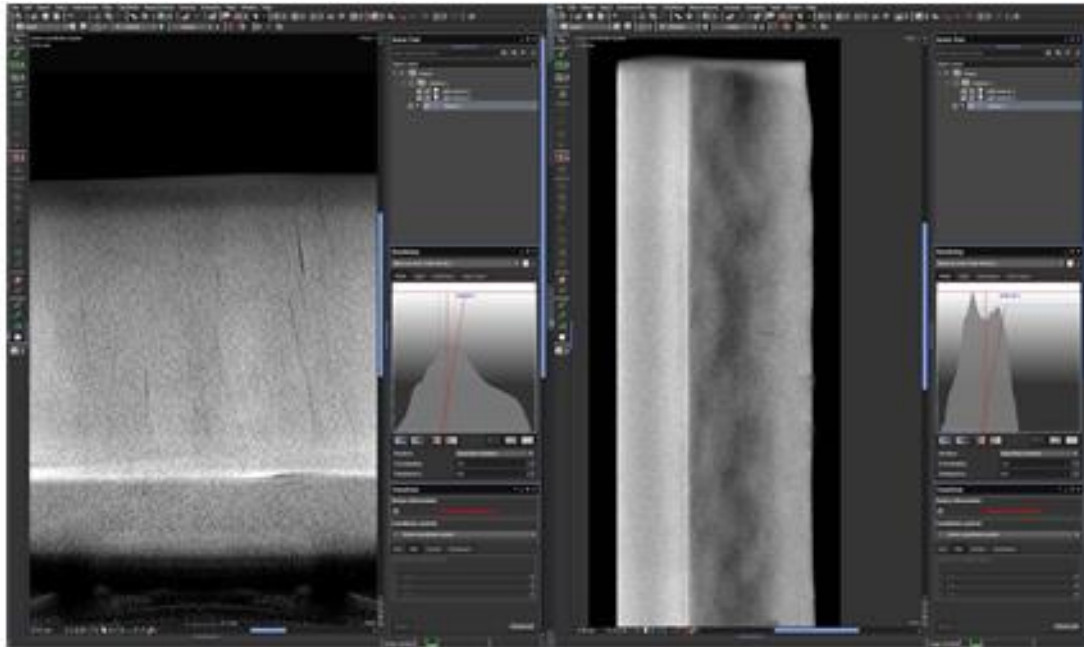
- System Integration - Complexity, Performance
- Process Control - Adaptive precision, Self awareness



# Applications I: Core R&D

## Processing effects on materials:

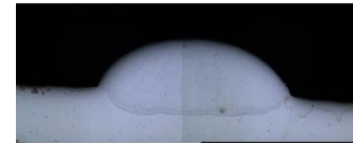
One type of energy source  
(electric arc) + powder and wire  
feedstock materials.



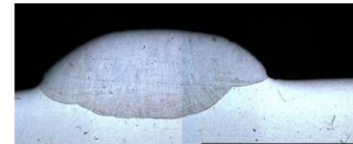
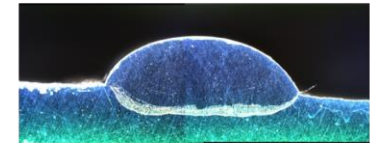
**316L powder**



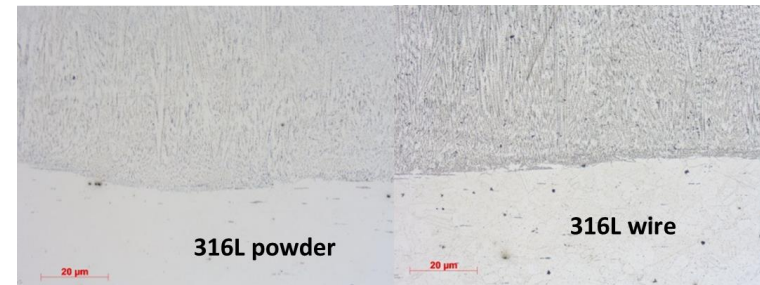
**316L wire**



**316L powder**



**316L wire**



**316L powder**

**316L wire**



## Application II: AMOS - Aerospace Repairs








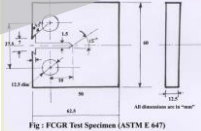
**What:** H2020 EU-Canadian project focusing on several DED AM processes.

**Why:** The reliability metal AM parts significantly contributes to barriers that influence its wide adoption in the aerospace and other high-end industries.

**Who:** University of Sheffield, GKN Aerospace, Ecole Centrale De Nantes, Digital Product Simulation; McGill University, Pratt & Whitney, Héroux-Devtek Inc., Liburdi, University of Ottawa.



# AMOS Approach

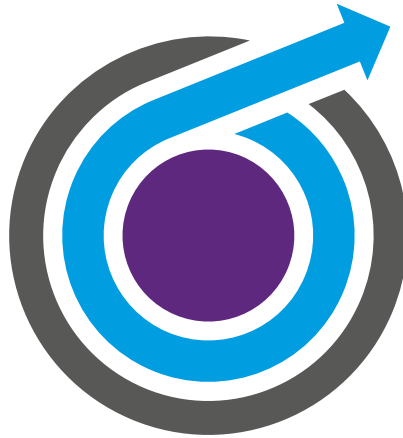
Sampling Requirements											
Evaluation Method/ Pre-test requirement	Specification	Build/ Rolling Direction	Reference material			As-built material			Interface material		
											
NDT			x			✓			✓		
Heat treatment			x			✓			✓		
Tensile (ASTM E8/E8M)	Spec 3 	Specimen Orientation	Longitudinal	45	Traverse	Longitudinal	45	Traverse	Longitudinal	45	Traverse
		Qty (built/rolled)	3	3	3	4	4	4	4	4	4
LCF (ASTM E1820)		Specimen Orientation	Longitudinal	45	Traverse	Longitudinal	45	Traverse	Longitudinal	45	Traverse
		Qty @ 1% (built/rolled)	3	3	3	6	6	6	6	6	6
		Qty @ 30% (built/rolled)	3	3	3	6	6	6	6	6	6
		Qty @ 50% (built/rolled)	3	3	3	6	6	6	6	6	6
		Qty @ 70% (built/rolled)	3	3	3	6	6	6	6	6	6
Crack Propagation (ASTM E647)	 Fig. 1: FCGR Test Specimen (ASTM E 647)	Specimen Orientation	Longitudinal	45	Traverse	Longitudinal	Traverse/ Longitudinal	Traverse	Longitudinal	Traverse/ Longitudinal	Traverse
		Qty (built/rolled direction)	3	3	3	4	4	4	4	4	4

Level	Objective	Description
1	Basic characterisation	To understand DED process capabilities.
2	Compliance assessment	To demonstrate DED process consistency by periodic sampling and testing, and also to check understanding of process variability using basic characterisation test results as a baseline.
3	Verification in repair scenario	To assess the reliability of DED processes and key test characteristics, including compliance with results from previous levels and end-user requirements.



*When AM is a complete solution, it will address a number of industrial challenges.*





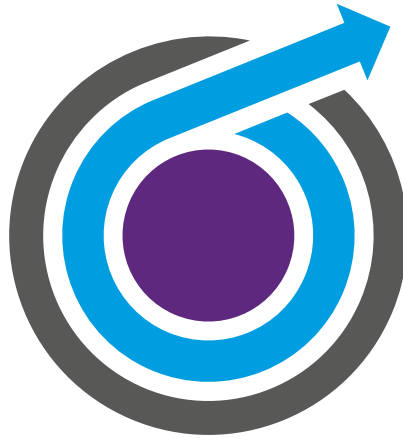
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Thank you





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