



**National Science Foundation's  
Hybrid Autonomous Manufacturing – Moving from Evolution to Revolution  
Engineering Research Center**

**WAAM-BAM: Improving Process Physics of WAAM by A HAMMER**

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# WAAM-BAM: Improving Process Physics of WAAM by A HAMMER

## Proposed Solution: Improve Process Physics by A HAMMER

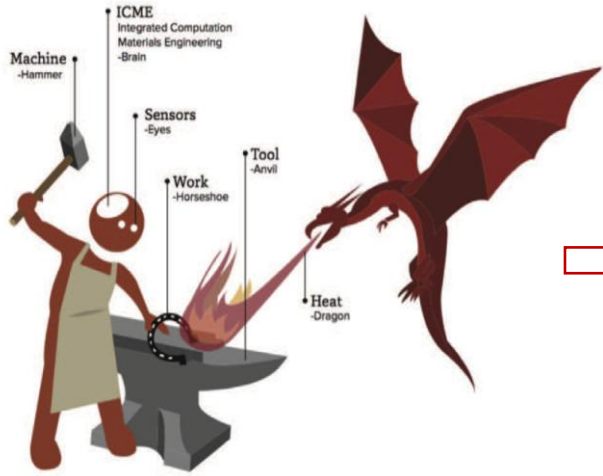
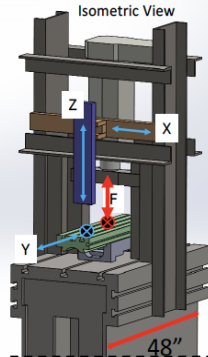


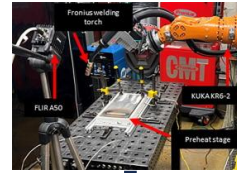
Image from Daehn and Taub, 2018.

Blacksmith → Heat + Force

### Hardware Development



WAAM-BAM (CWRU) Machine Tool deployment



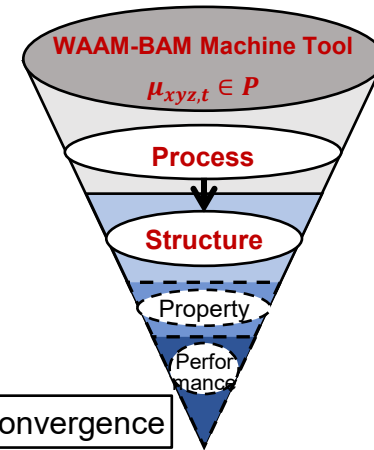
WAAM-BAM (UTK) Robotic deployment



### Software Development (Model-based CAM/CAE)

Process Parameters + Tool Path

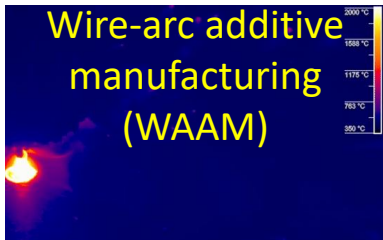
Causality



- Simulate and generate the best process parameters and path planning in G-code
- Part production with assured structures and properties

WAAM-BAM: Process and System Development

## Problem Statement



Wire-arc additive manufacturing (WAAM)

Single WAAM process (ONLY HEAT) has almost reached its physical limits

**Quality Issues:** Large grain size, columnar grains, large residual stress, distortion

## Broader Impact

- WAAM-BAM: A new hybrid manufacturing technology as HAMMER ERC's flagship engineering system
- Advance U.S. manufacturing capabilities and leadership
- Address supply chain challenges of casting and forging parts