Multi: Source/Feedstock/Meter-Scale Metal AM Machine

PROBLEM
There is no commercially available multi-planar CAD to path software tool to enable the manufacturing of Medium Area AM (MAAM) and Big Area AM (BAAM) parts through a single robot, cluster, or system of coordinated multi-axis robots using directed energy deposition (DED) methods with multi-meter, multi-process, multi-material capabilities.

Printing large complex parts with multi-meter build areas typically requires large, inflexible, expensive 3-axis gantry based systems. These systems usually incorporate only one deposition modality through a single deposition head resulting in increased processing time as the part size increases. The high costs associated with such large, single head AM equipment drastically shrink the applicability of this technology on a wide array of industry applications.

OBJECTIVE
The objective of this project is to develop technology (hardware and software) enabling the commercialization of a next generation DED metal AM machine. This technology promises to position the AM industrial user base to take advantage of the lower cost and increased flexibility associated with scalable multi-axis (9 and above) robot systems. The project seeks to build on existing alpha generation CAD to path AM robotic software tools by testing and refining the CAD to path tool for a commercial first release. Basic process testing is planned to develop a multi-process, multi-meter, multi-material production ready robot-based 3DP system.

This project aligns to:

- Process
- ASTM PROCESS CATEGORY: Directed Energy Deposition
- EQUIPMENT: Custom Built Multi-Axis Equipment
- MATERIAL: Titanium, Steel, AL-Bronze
**TECHNICAL APPROACH**

The team plans to construct a demonstration system to test and refine robotic 3DP hardware and software through the printing of team member challenge parts. This effort will leverage existing Wolf Robotics proprietary CAD to Part printing tools to enable multi-axis (9 and above), multi process (laser hot wire and blown powder) printing. Software features developed allow a CAD model to be broken into sections that can be assigned to different processes, materials, and or robots within a robot cluster as part of a “build strategy” defined for a specific part by the software user. One robot is being used for printing on this project; however, the project team will investigate multi-robot coordination strategies to serve as a foundation for potential future projects related to multi-robot printing that addresses robot reach and collision avoidance.

**PROJECT START/END DATE**

January 2017 - October 2018

**EXPECTED DELIVERABLES**

- Multi-metal machine specification document
- Process monitoring methodology and tools report
- Demonstrator CAD model component design
- Print demonstrations
- Multi-robot coordinated printing literature review and assessment report
- Methodology to achieve tunable build resolution
- Process procedures and parameter sets
- Materials and part test results
- Robot CAD to path tools for AM training module
- Metal MAAM/BAAM robotic DED 3D printing short course
- Fundamentals of welding metallurgy relevant to AM course

**FUNDING**

$2.1M total project budget
($1.1M public funding/$1M private funding)

**PROJECT PARTICIPANTS**

Project Principal:
Wolf Robotics - A Lincoln Electric Company

Other Project Participants:
EWI
Oak Ridge National Laboratory
Lincoln Electric
University of Tennessee, Knoxville
IPG Photonics
Caterpillar
Case Western Reserve University
ITAMCO
GKN Aerospace
United Technologies Research Center
Youngstown Business Incubator

Public Participants:
U.S. Department of Defense
National Science Foundation
U.S. Department of Energy