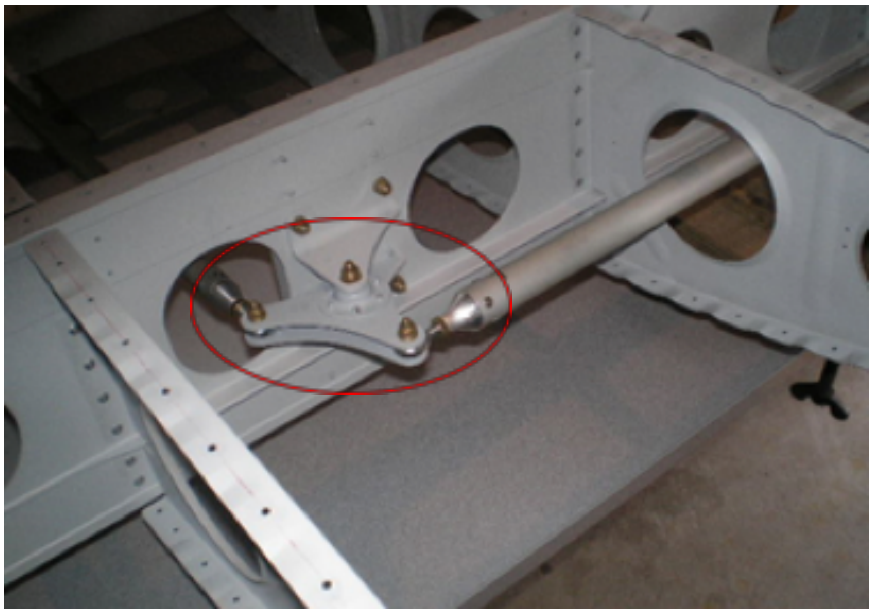
PROJECT SUMMARY 3006

# Maturation of Advanced Manufacturing for Low Cost Sustainment – Bell Crank Family of Parts



*An example of a simple bell crank that transfers force from the actuator to the arm at 90° from the actuator. More complex bell cranks have significant transitions from thick to thin sections and tight tolerance features like hole locations, concentricity, and parallelism between holes.*

## PROBLEM

The bell crank for the B-1 aircraft has been identified by the Air Force as a challenging component for metal additive manufacturing (AM) fabrication. The Air Force Sustainment Center has difficulty obtaining this part using conventional fabrication technologies such as casting or machining. The bell crank has numerous thick to thin transitions and multiple angular features which make machining from wrought plate difficult and time consuming. The original component is cast. Although specific cost and time data are not available (but are to be determined at the beginning of this project), it is assumed that casting tooling production involves a substantial lead time with high tooling costs, particularly considering the complex part geometry.

## OBJECTIVE

This project aims to improve the ability of the Air Logistics Complex (ALC) to rapidly find replacements for challenging parts required for legacy aircraft. Specifically, the effort is focused on manufacturing a flight-critical bell crank for the B-1 aircraft which includes features of varying thicknesses and complex geometries. Challenges, solutions, and opportunities identified through the AM fabrication of the bell crank have significant application to supplying legacy parts to the Department of Defense (DoD) supply chain. The project intends to provide a baseline for AM execution in a tooling-based sustainment community.

**AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP**

This project aligns to:

VALUE CHAIN

**ASTM PROCESS CATEGORY:** Powder Bed Fusion

**EQUIPMENT:** EOS M-290/M-280, 3D Systems ProX320

**MATERIAL:** Aluminum Alloy AlSi10Mg,

## TECHNICAL APPROACH

This project plans to fabricate a significant number of bell cranks and coupons on two metal laser powder bed fusion system types (EOS and 3D Systems), measuring and recording each layer of the structure during the build. Metrology is to be executed and recorded during each post processing step (e.g. stress relief, build plate removal, annealing, hot isostatic pressing, heat treatment, machining), thus populating and recording the digital thread of the component. Repeatability, process robustness, and the ability to specify requirements that are not machine-specific in a technical data package are being evaluated with multiple AM systems.

## PROJECT START / END DATE

May 2017 - May 2019

## EXPECTED DELIVERABLES

- Safety plan for aluminum powder operations
- Demonstration plan for bell crank effort to include the design-build-test matrix and the metrology plan
- Final report with datasets for part replacement demonstrations to include:
  - Hardware samples, data, and results
  - Modeling and simulation results
  - Analysis results and recommendations including comparisons to alternative approaches and viability assessments
  - Powder specification
  - A metal AM standard work procedure that ensures consistent, repeatable part production in the form of a deposition process specification (DPS)
  - List of barriers and challenges

## FUNDING

**$4.1M total project budget**
($3.5M public funding/$600K private funding)

## PROJECT PARTICIPANTS

**Project Principal:**
Youngstown State University

**Project Participants:**
Pennsylvania State University – Applied Research Lab
M-7 Technologies
Youngstown Business Incubator
Boeing Company
Oerlikon
Lockheed Martin

**Public Participant:**
U.S. Department of Defense

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