Problem Title: Development of New Part Design Methodologies for In-Space Manufacturing

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Indicate which discipline/s is/are most appropriate to work on this problem, e.g., aerospace, mechanical, electrical, chemical, industrial, civil, computer, physics, materials, test, nuclear, earth science, other): Mechanical engineering

Marshall Problem Statement

Background: The big picture with references to previous work (Why would a student design student be excited about this work?)

NASA's In-Space Manufacturing (ISM) project seeks to develop the materials, processes, and manufacturing technologies needed to provide an on-demand manufacturing capability for deep space exploration missions. The ability to manufacture and recycle some parts on demand rather than launch them from earth has the potential to reduce logistics requirements on long duration missions and enhance crew safety. The ISM project has previously worked with commercial companies to develop polymer 3D printing capabilities, which were successfully demonstrated on the International Space Station (ISS). One current focus of ISM is adapting metal printing capabilities for a similar on-orbit demonstration by 2024. In a related and parallel activity, ISM has developed a database of candidate parts, from heritage ISS systems and future exploration systems, which represent candidates for on-demand additive manufacturing during space missions.

In a typical process flow, an additively manufactured (AM) part starts as computer-aided design (CAD) file. For heritage parts, this CAD file was likely generated with the expectation of using traditional manufacturing approaches such as milling, forging, casting, or injection molding to create the part. The CAD rendering is "sliced" into layers. The AM system deposits the material, layer by layer, in a prescribed manner driven by GCode. In this project, ISM seeks to explore redesign of heritage parts for additive manufacturing systems in use or currently in development for demonstration on ISS. Parts identified as being representative of high value applications for ISM on space missions will be redesigned to take advantage of AM capabilities. While functional and interface requirements for the parts will be preserved, the student design team will have the flexibility to change the material of the parts, infill percentage, topology, or features to best leverage AM capabilities. Prototype parts can be manufactured using desktop printing systems. At least two parts will also be printed with metal processes which are similar to those being developed for ISS. This can be done by the university where in-house metal printing capabilities exist, but funding for this project can also be used to print parts at "job shops" or vendors for AM. When possible, parts will undergo tests that replicate their intended use scenario. Results of testing will be compared with historical data from heritage, conventionally manufactured parts of the same geometry.

Recent/on-going research on the problem (What resources, if any, are available to the student design team, such as equipment, software, facility utilization)

Design teams will have access to NASA subject matter experts, who will consult on the project throughout its lifecycle. Some in-house NASA resources may be available for testing or inspection of parts (but this is not guaranteed, particularly given the covid-19 situation).

Details of the problem; design constraints, requirements (if any), outcome expected (one semester Student Design course lasts 15 weeks; two semester course lasts 30 weeks.) (What do you expect the student design team to accomplish?)

This project is intended for a 2 semester design course. The goals of this design project are to:

a) inform the overall design methodology for ISM of heritage parts on space missions

b) perform end to end case studies of design and testing for at least five parts which represent high value applications of ISM (data from testing will be compared with that of conventionally manufactured parts in the same use scenario)

c) potentially improve heritage designs by leveraging AM and rapidly iterating the design/build/test loop.

To complete the project, student teams will be expected to have access to desktop 3D printing systems (project funding can be used to procure a system if needed), CAD and finite element analysis (FEA) software. Access to a university mechanical test lab is preferred. Should access to the university or laboratories be restricted during the course of the project due to covid-19, design and analysis tasks are sufficient to complete the activity.

Student Design Project Rules:

1. Weekly telecons will be scheduled to maintain proper progress and prevent dead-end ventures.

2. Deliverables required (e.g. one semester course - a written final report; two semester course - written final report and a prototype/model (if practical)