AMEBoP: Additive Manufacturing Enabled Biofilm Prevention

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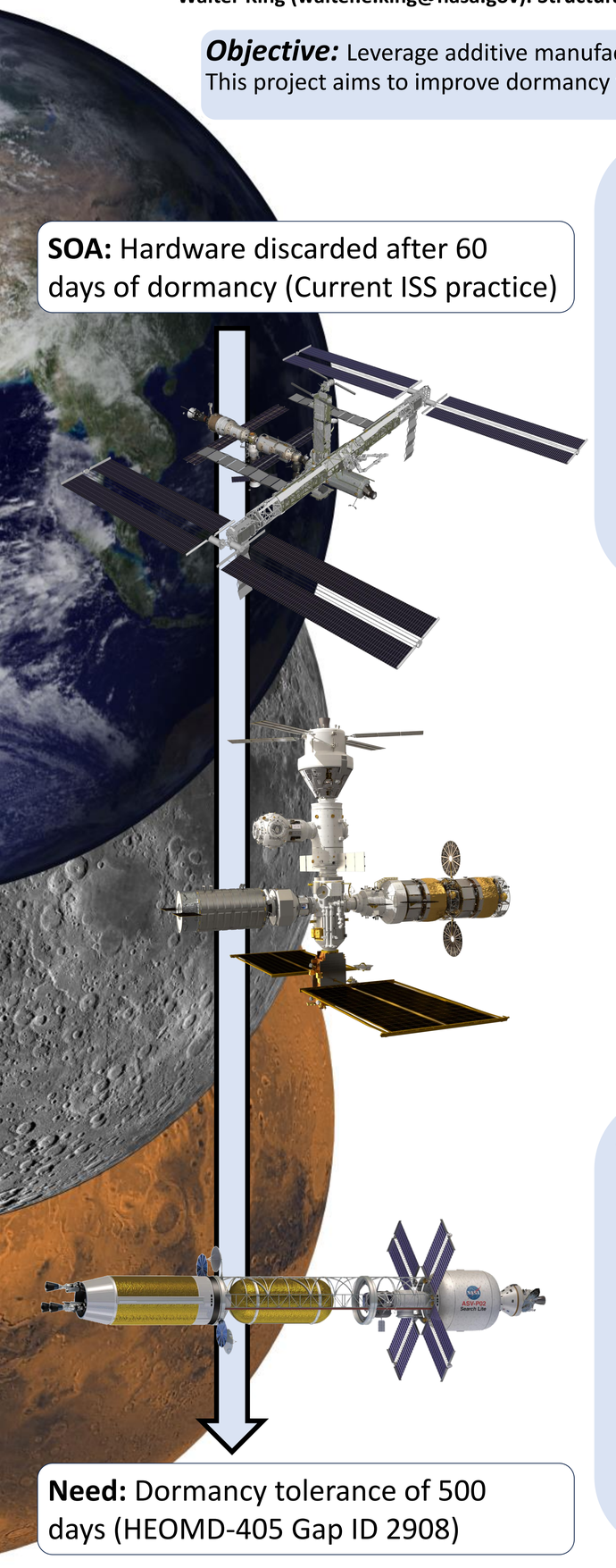
Objective: Leverage additive manufacturing to fortify ECLSS (Environmental Control and Life Support Systems) manifolds and other vulnerable components against biofilm growth during dormancy. This project aims to improve dormancy tolerance by eliminating dead legs to reduce stagnate fluid volume and to limit available nutrients, and by printing from inherently biocidal materials.

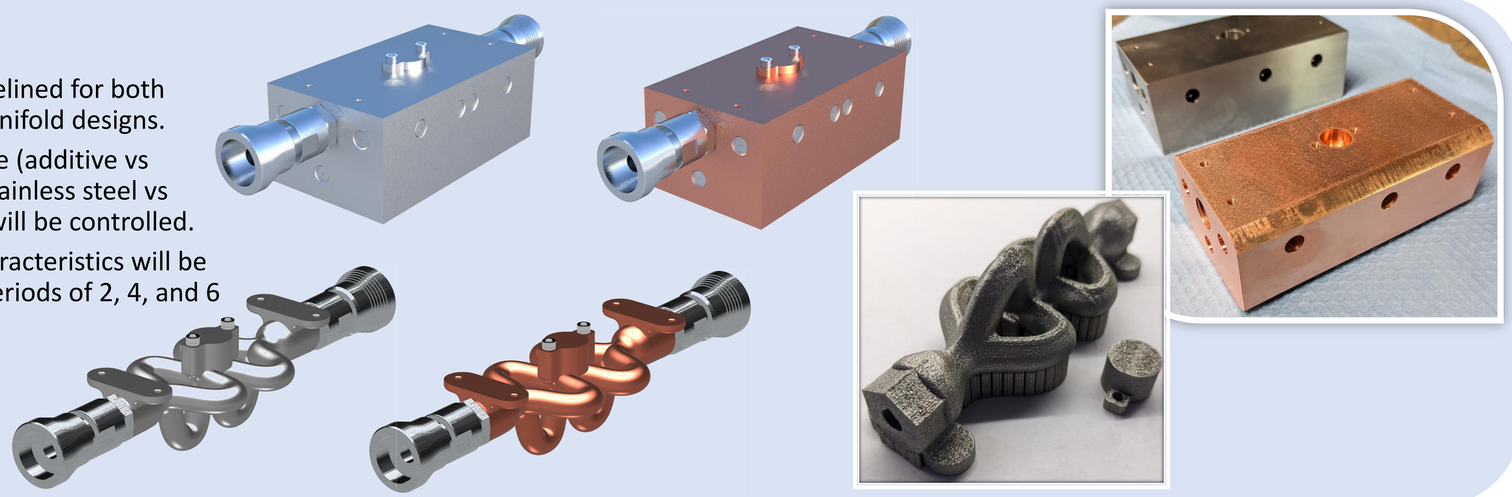
SOA: Hardware discarded after 60 days of dormancy (Current ISS practice)



Need: Dormancy tolerance of 500 days (HEOMD-405 Gap ID 2908)

Test Articles:

- Performance will be baselined for both traditional and novel manifold designs.
- Manufacturing technique (additive vs subtractive), material (stainless steel vs copper), and geometry will be controlled.
- Each combination of characteristics will be tested over dormancy periods of 2, 4, and 6 months.
- 12 test articles in total.



Metrics:

Inoculated ersatz (10^6 cells/mL) will be flowed through each test article before being allowed to stagnate within for varying periods of dormancy.

- Differential pressure from inlet to outlet for each test article will be measured before and after each dormancy period.
- Colony Forming Units (CFU) in the discharged fluid will be measured at the beginning and end of each dormancy period.
- Each test article will be sectioned, and the flow path will be inspected to assess biofilm formation. Biofilms will be imaged using a scanning electron microscopy (SEM) through a partnership with ESSCA team members in EM31.

Parameter	Unit	Measurement Method	Target
Flow characteristics	PSI	Pressure transducers	10% or less increase in differential pressure following dormancy
Fluid quality and surface growth	CFU count	Microscopy, visual inspection	< 50 CFU/mL
Dormancy tolerance	Days	Duration between replacement	Demonstration of 120-day dormancy-tolerant manifold design

Impact and Infusion:

Project Outcomes

- Characterize the dormancy tolerance of a traditional ECLSS manifold.
- Assess the merit of 3D printable biocidal materials for improving dormancy tolerance in life support systems.
- Identify promising materials and geometries for biofilm reduction in manifolds.
- Enhance biofilm management for long-duration missions beyond LEO.

MSFC Alignment, Growth, and Infusion

- Development of reduced volume and antimicrobial ECLSS components aligns with MSFC efforts to develop novel approaches to biofilm mitigation for long-duration missions beyond LEO.
- This component level dormancy testing will complement system level testing and coupon testing also occurring at MSFC.
- Lessons learned from this test campaign will provide a development baseline that can be utilized by NASA ECLSS design groups, industry partners, and academia partners.

Collaborators

- ES62, EM31, EM41, EM42, ES33

Agency Alignment

TX06.1.2 Water Recovery and Management
TX06.1.3 Waste Management
TX06.6.6 Maintainability and Supportability
TX12.1.7 Special Materials
HEOMD-405 Gap IDs 2960, 2933, 2918, 2925, 2908, 3612, 2967