

National Aeronautics and
Space Administration



Design and Application of Tethered Spacecraft Simulators

Emma Jaynes, John Inness,
Kanak Garg, Jason Lee, Alex
Putman

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EXPLORE
MARSHALL

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graph TD; A[Introduction] --> B[Methodology]; B --> C["Structure<br/>Avionics<br/>Software<br/>Hardware"]; C --> D[Future Testing]; D --> E[Applications];
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Introduction

Methodology

Structure
Avionics
Software
Hardware

Future Testing

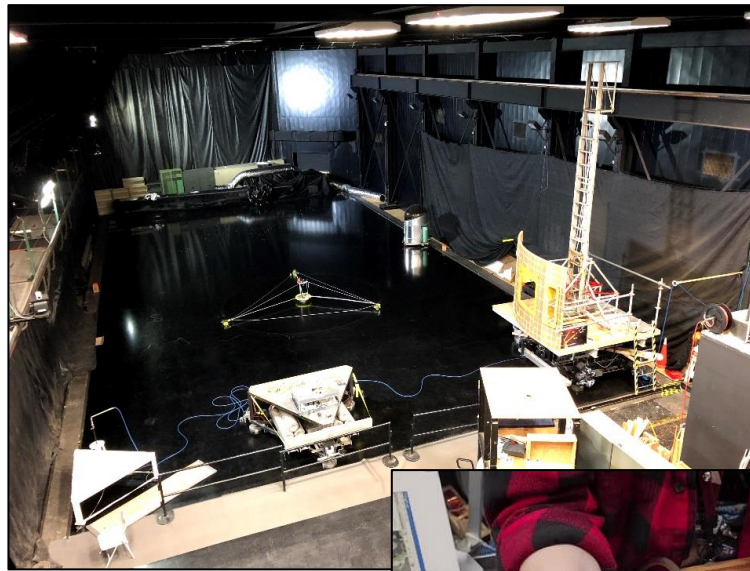
Applications

Overview

- NASA history of tethered spacecraft development going back to 1966
- Small tethered spacecraft have several key applications for space operations
 - Small vehicles that can be deployed from larger spacecraft, and reeled back in on a mechanical tether after performing required tasks



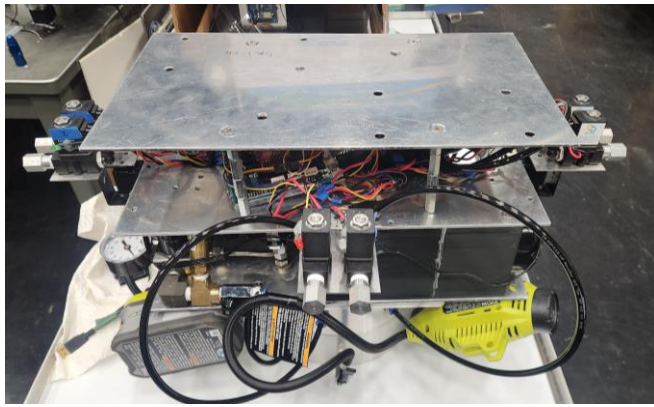
- 44 x 86-foot air bearing epoxy floor
- Bearings float on the floor with minimal friction
- Air bearing platforms and spacecraft simulators of varying size



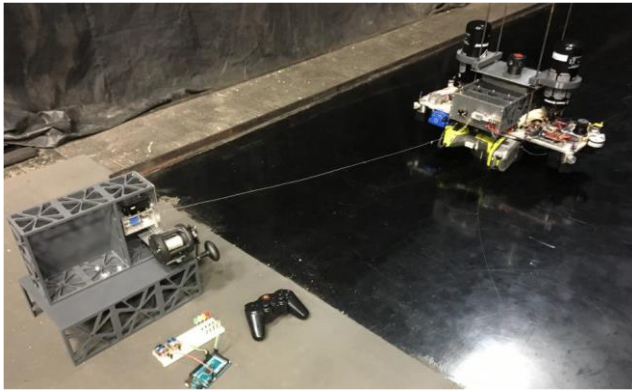
Spherical air bearings
allow up to 5 degrees of
freedom

Introduction – Flat Floor Robotics Laboratory (FFRL)





- Small spacecraft simulators ('microbases') needed to match shrinking size of spacecraft/CubeSats



- **Maneuverable Autonomous Tethered Spacecraft (MATS)** – next generation of small simulators in the FFRL

Introduction – Small Spacecraft Simulators



Electronics Deck

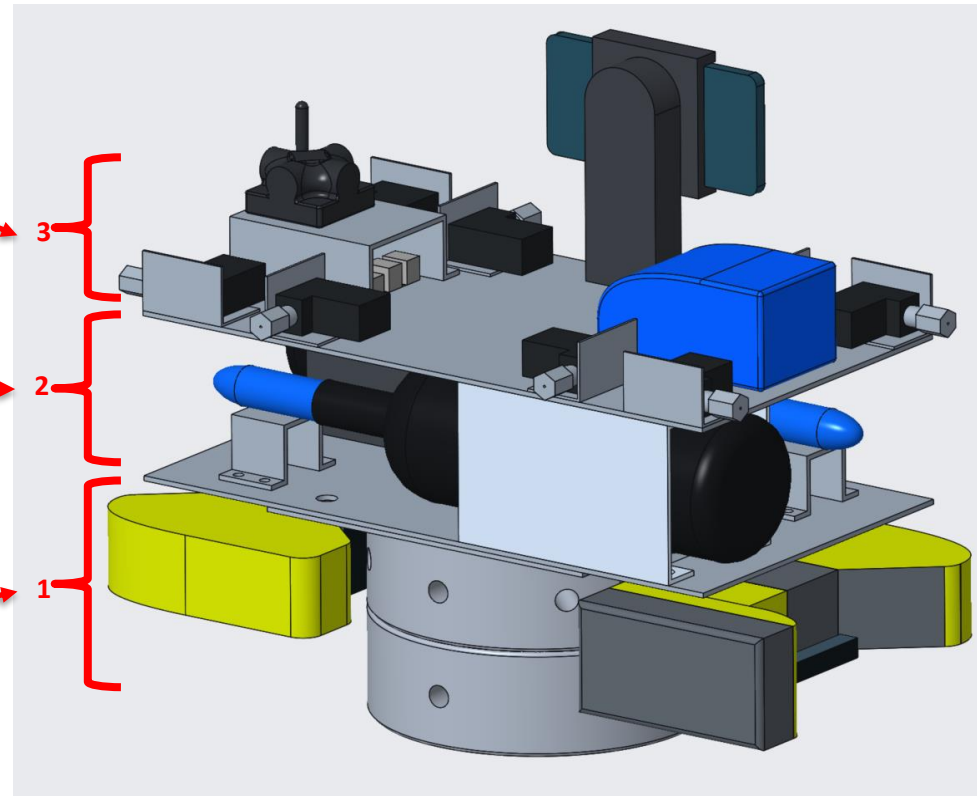
Houses thrusters, battery, avionics

Pneumatic Deck

High Purity Air (HPA) system for thrusters

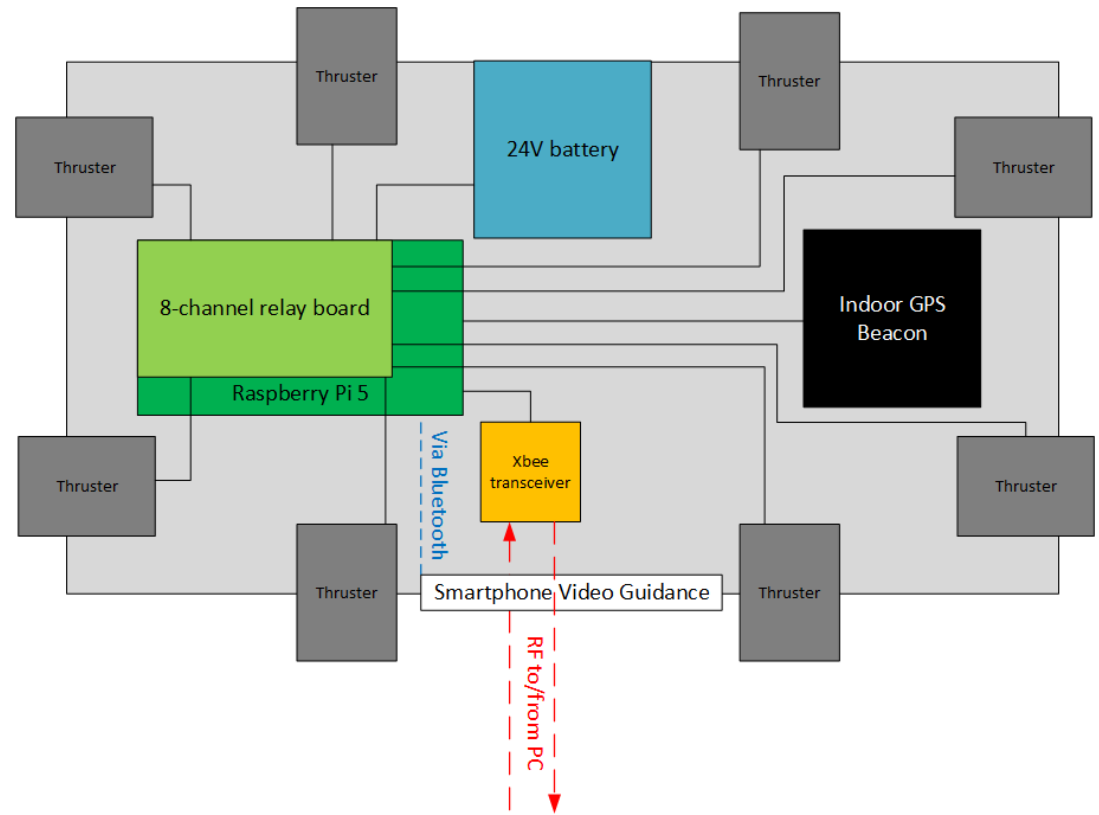
Air Bearing Deck

Air bearing/plenum platform, battery powered pumps to float bearing



MATS Methodology – Structure

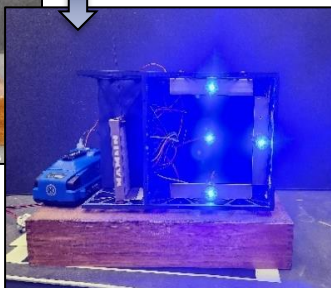
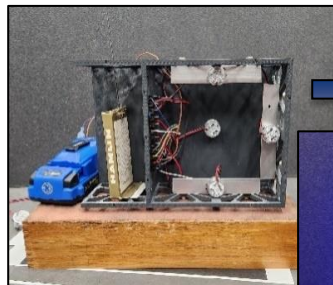
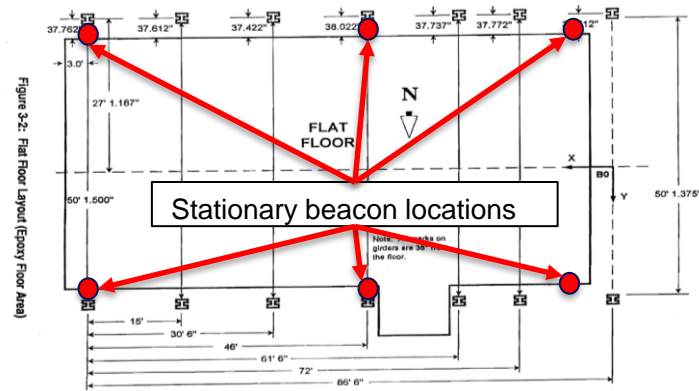
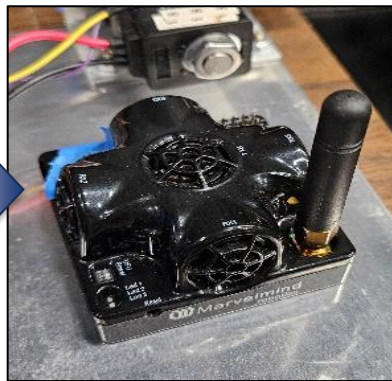
- [Raspberry Pi 5](#)
- [24V battery with 5V USB](#) powers Raspberry Pi 5 and 8x thrusters
- [Digi XBee Zigbee 3.0](#) module communicates with ground station PC



MATS Methodology – Avionics

Indoor GPS

- Marvelmind Robotics
- Ultrasonic beacons used to build submap that can locate mobile beacons within +/- 2cm



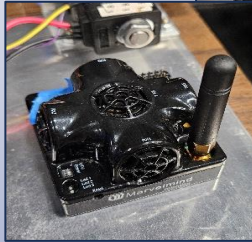
Smart Video Guidance Sensor (SVGS)

- Smartphone camera captures blue LED target
- NASA-developed Android app uses collinearity equations to determine relative position and attitude

MATS Methodology – Avionics

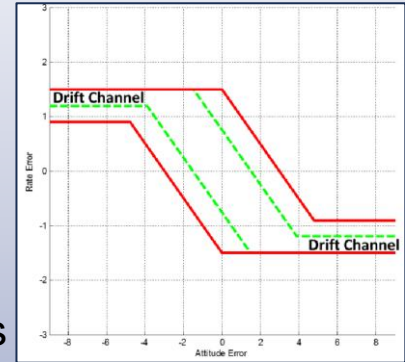
Navigation

- Indoor GPS
- SVGS



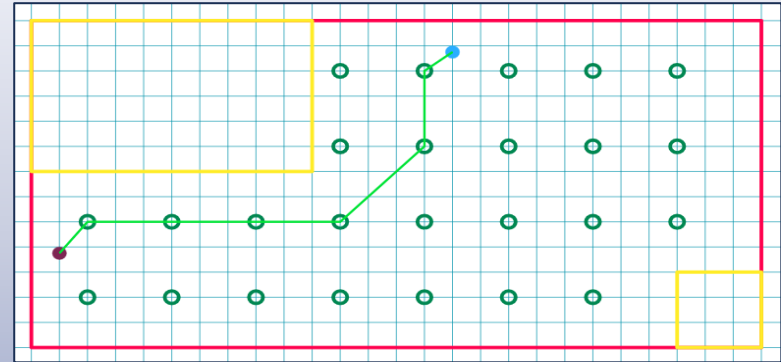
Control

- Phase plane controller
- Tuned to account for speed limitations

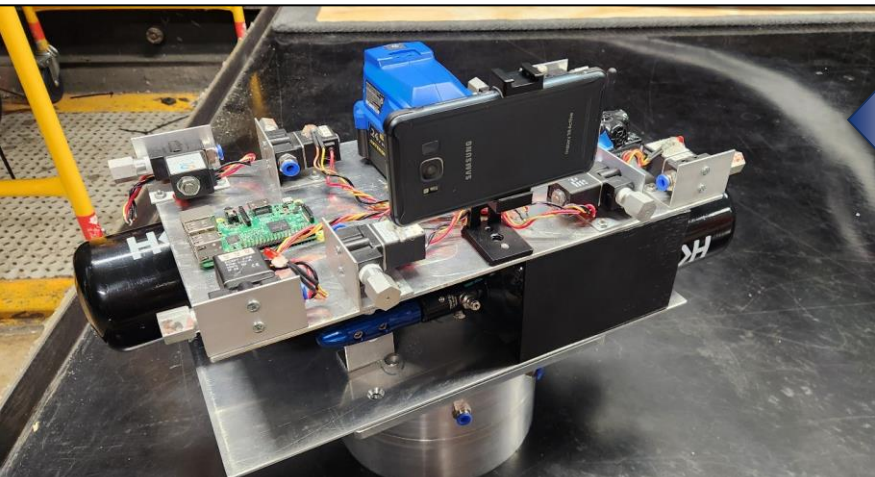


Guidance

- Path creation & path following
- A* and Nearest Node algorithm




MATS Methodology – Software



Constructed MATS
simulator hardware

A close-up photograph of the MATS simulator hardware. It features a blue motor, a black Samsung smartphone mounted vertically, a green printed circuit board (PCB) with various electronic components, and a black cylindrical component. The hardware is mounted on a silver metal plate which is attached to a larger silver cylindrical base. The entire assembly is positioned on a dark, reflective surface.

Tether mechanism
with flexible boom



A photograph showing the tether mechanism with a flexible boom. A long, thin, orange-colored boom extends from the simulator hardware on the left to a second, more complex metal frame structure on the right. The boom is supported by a thin, white, flexible tether. The setup is on a dark, reflective surface.



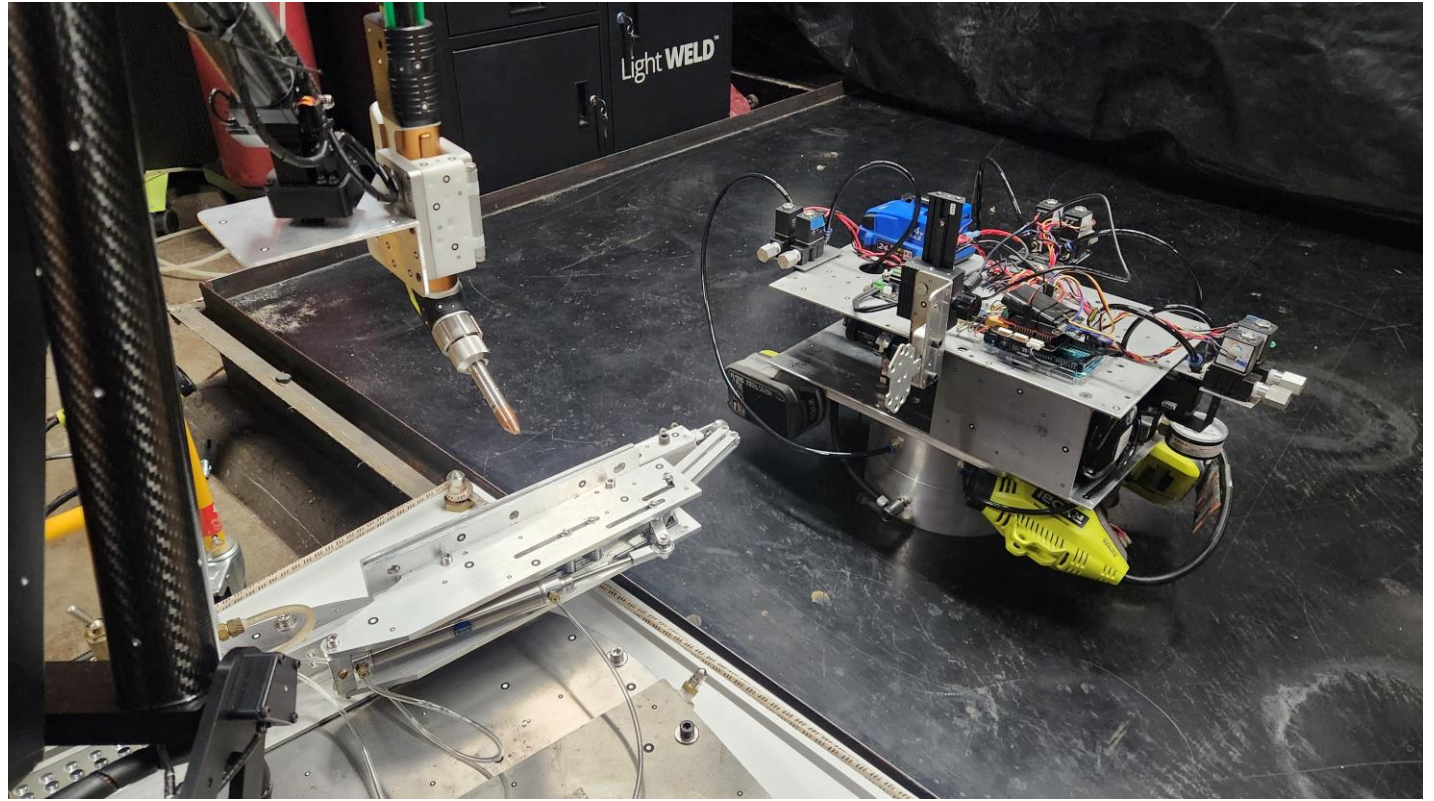
MATS Hardware

A decorative graphic in the bottom-left corner of the slide, featuring a stylized globe with a grid pattern and a blue arc above it.

- Simulink model adapted to Python
- Avionics integration
- GNC algorithm refinement
- Performance testing
- Documentation, iteration

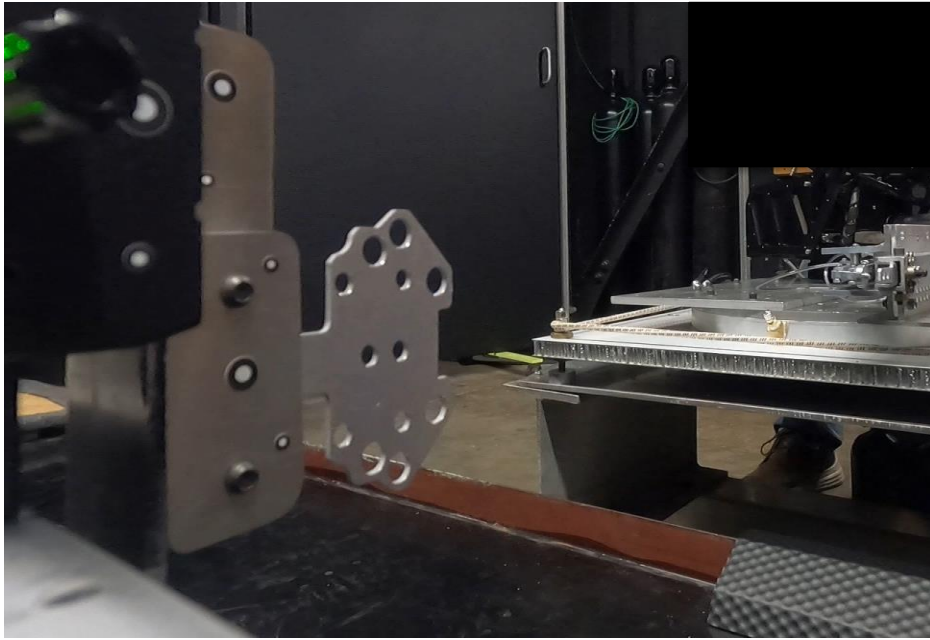


MATS Next Steps/Testing

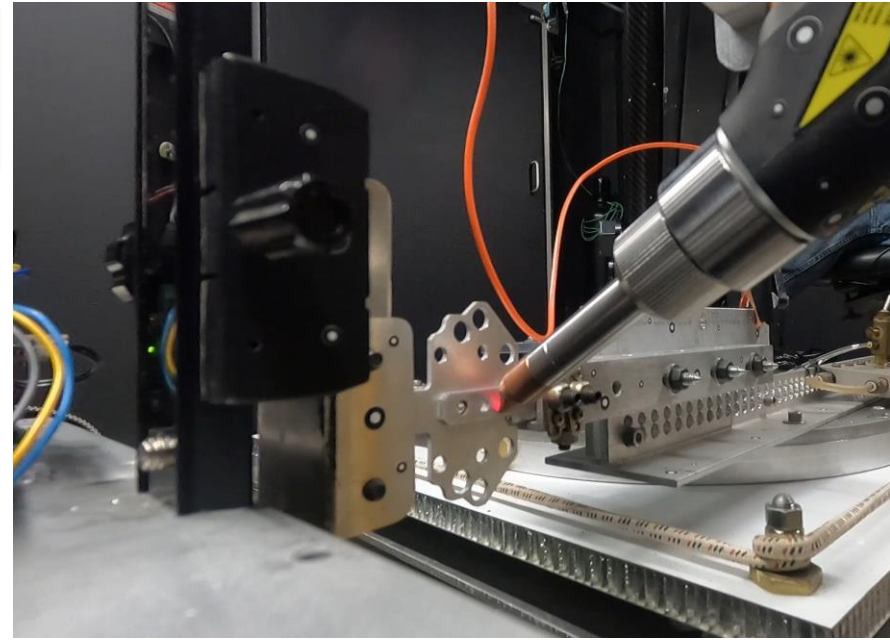


Applications – In-Space Servicing/Assembly/Manufacturing





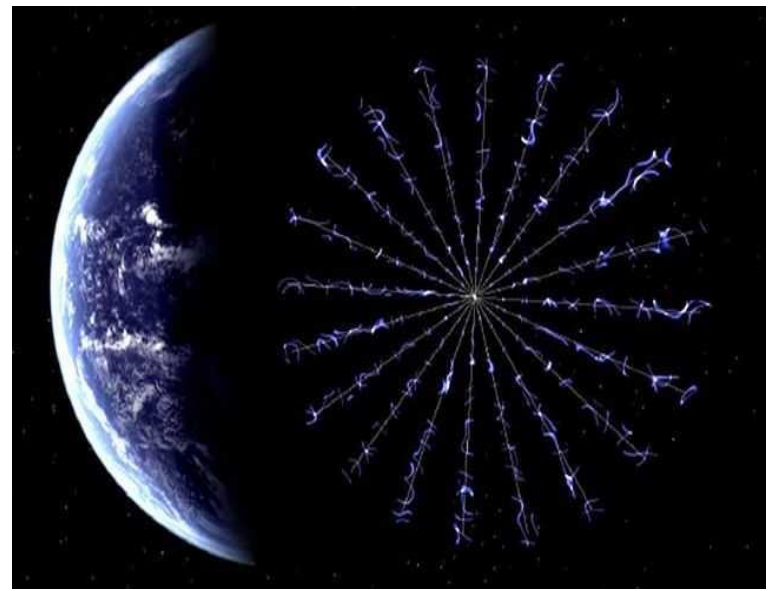
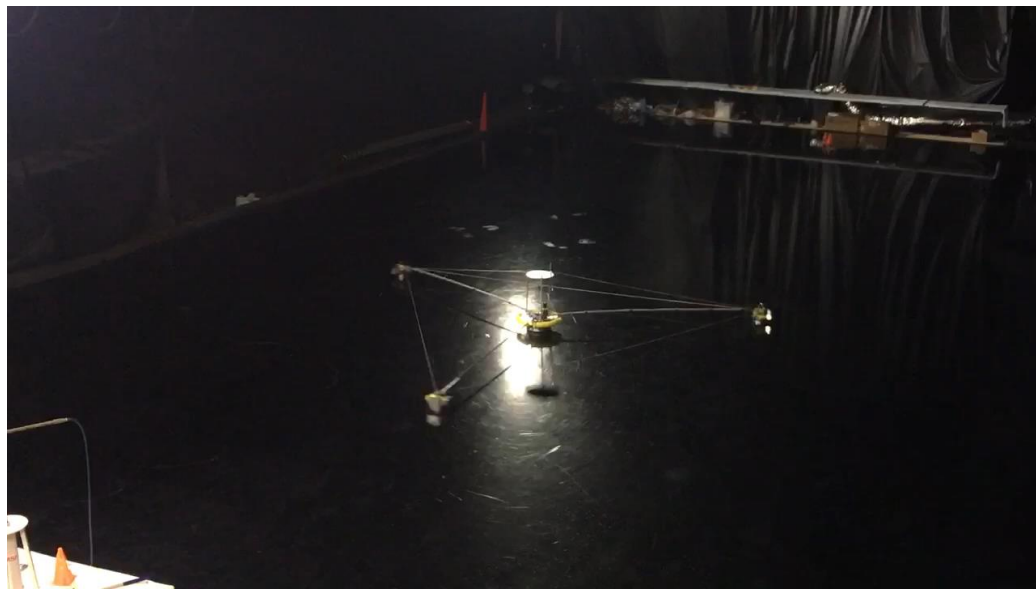
Approach/position



Weld

Applications – In-Space Servicing/Assembly/Manufacturing





- Electric Sail (E-Sail) concept requires deployment and positioning of km-long, conductive tethers
- Tethered spacecraft simulators on flat floor enables testbed for controls development

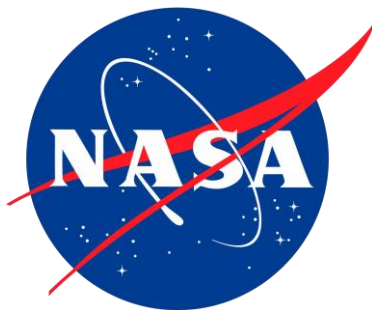
Applications – Electric Sail Deployment



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Thank you!

Emma K. Jaynes

emma.k.jaynes@nasa.gov

