



CubeSat-scale Robotic Arms in Space

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Agenda



- Quick introduction of the Naval Academy Small Satellite Program
- Robotic arm satellite motivation
- Arm functionality description
- Satellite description
- Launch and operation (Conclusion)



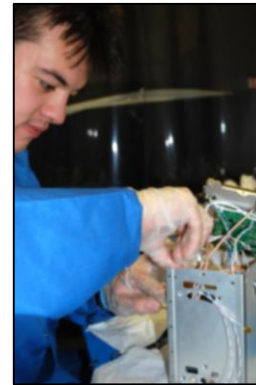


Naval Academy Small Satellite Program (NASSP)



The foundation of our space systems curriculum for the Astro Track students

- Provides midshipmen full-range of hands-on space system experiences
- Guides students through regulatory and validation procedures
- Educates future naval officers
- Research for future space technologies



Shaker



Thermal and Thermal Vacuum Chambers



Solar Simulator





Motivation

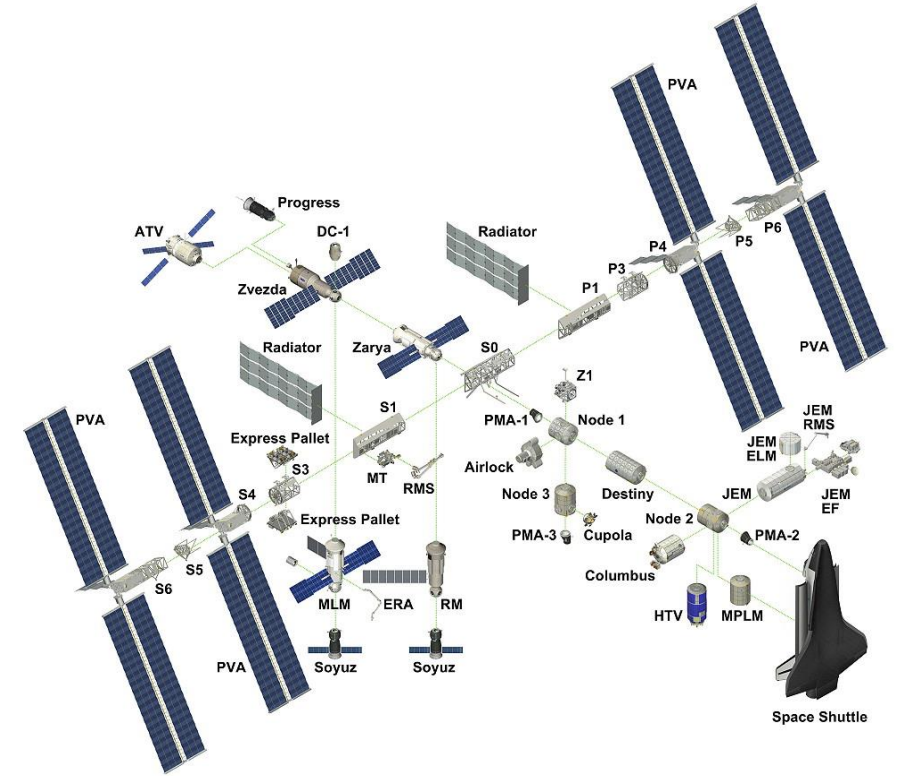


Project Motivation



1. Spacecraft require complicated assembly systems

1. Current methods aren't sufficient



To enable safe and time efficient robotic assembly, a hybrid robotic controller is needed.



Existing Solutions

- Very large
 - ISS CANADARM
- Expensive
 - Requires dedicated launch for on orbit assembly
- Limited capabilities
 - Tailored for individual missions with very low adaptability and response time



Orbital Express
[<https://spaceflightnow.com/news/n0704/03orbitalexpress/>]



CANARM
[<https://medium.com/>]



Assembly (Terrestrial vs Space)



Terrestrial Assembly



In-Space Assembly



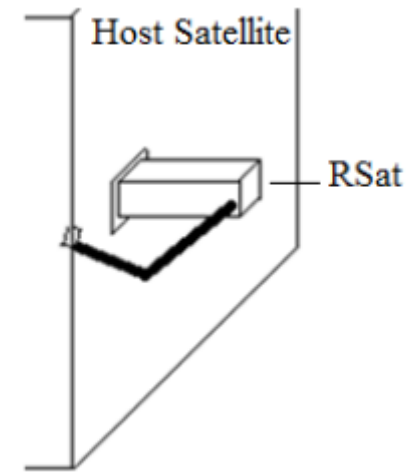
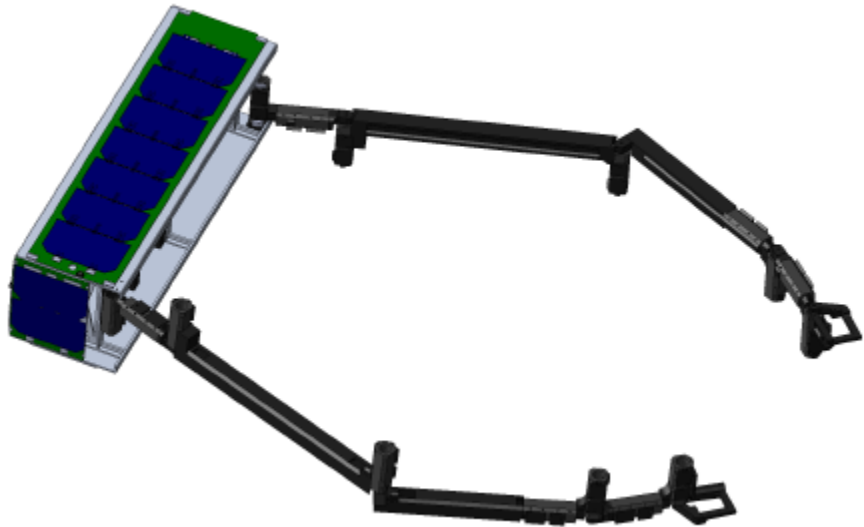
Example of On-orbit Servicing: OSAM-1



Credit: ESA



Slightly Different Approach – Miniature Robots



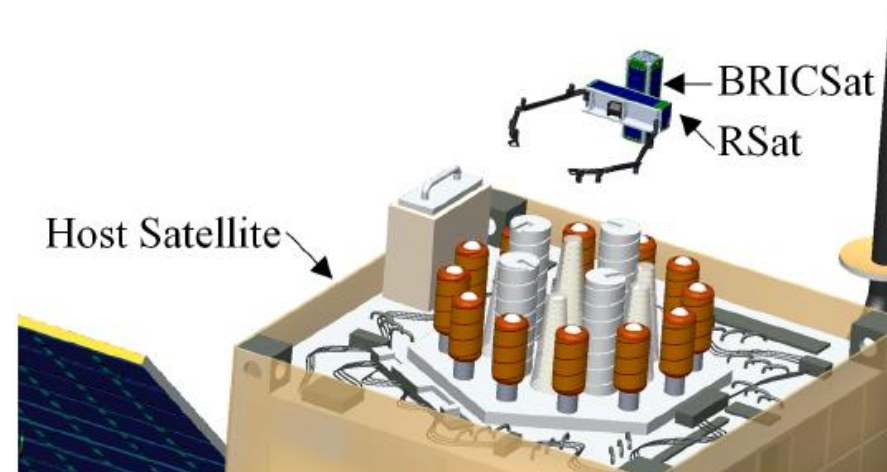
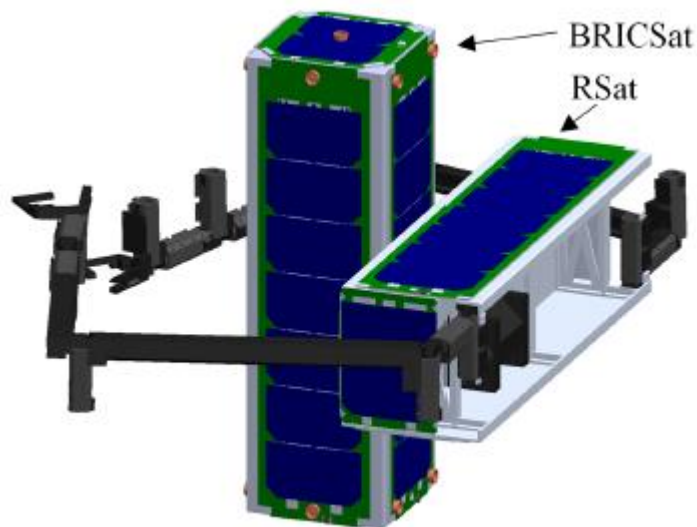
Launch together with the host, or “mothership” and used for on-orbit servicing later in mission



For Hosts Not Equipped with RSat

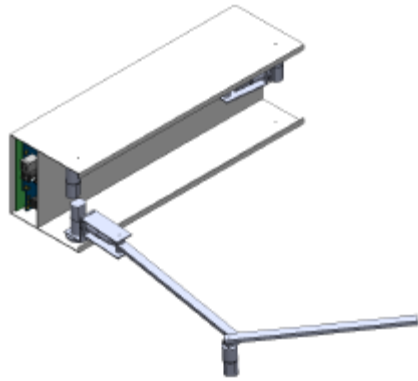
Use of propulsion unit to deliver RSat to destination

- RSat: robotic/repair satellite
- BRICSat: tug-satellite equipped with propulsion

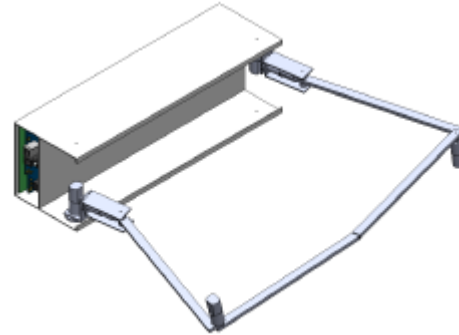




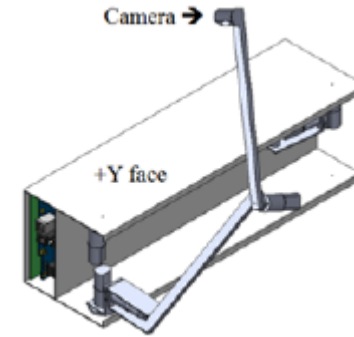
Capabilities – Start Simple



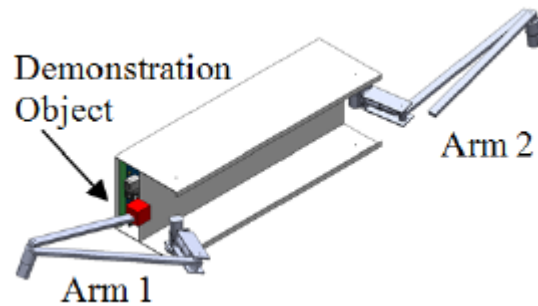
Move to point



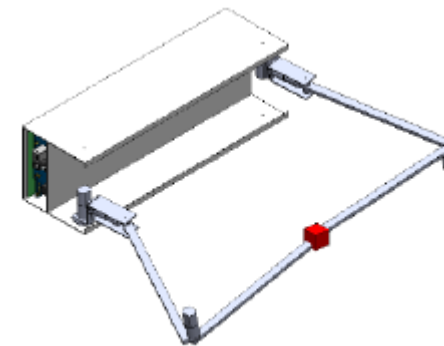
Hand shake



Camera operation



Grab object



Object hand-off



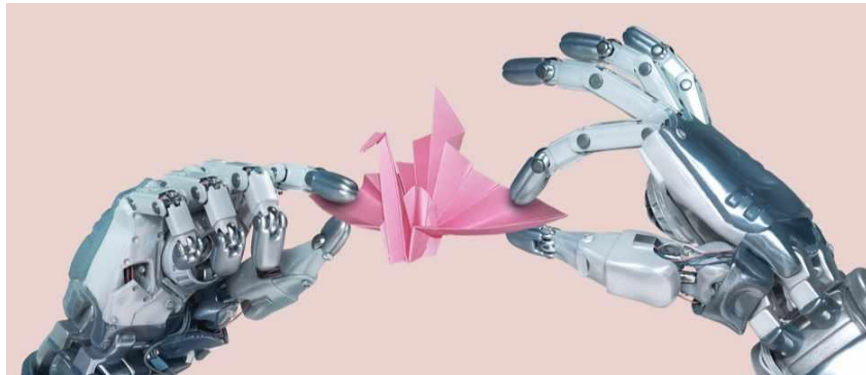
The ISS Mission



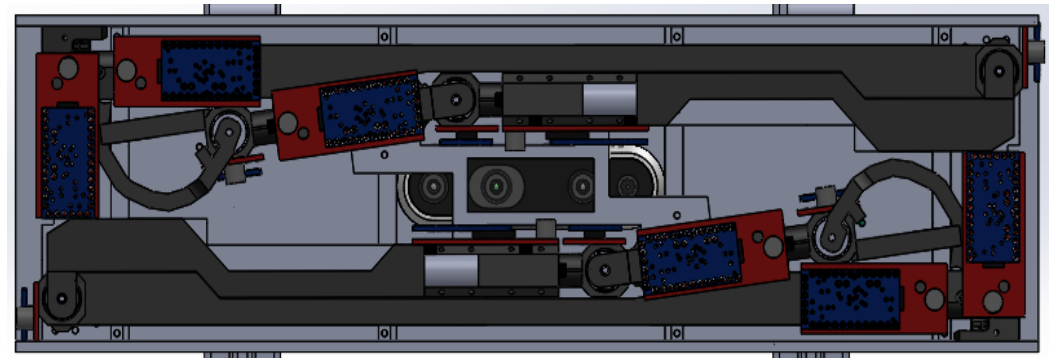
Scope



- Three primary mission objectives
 - System shall be able to “hand off” an object from one arm to the other
 - RECS shall accurately hit a designated target
 - RECS shall inspect an object from all angles in space and perform diagnostics
- ISS Hardware
 - More room to place things
 - No need for power system or communications hardware

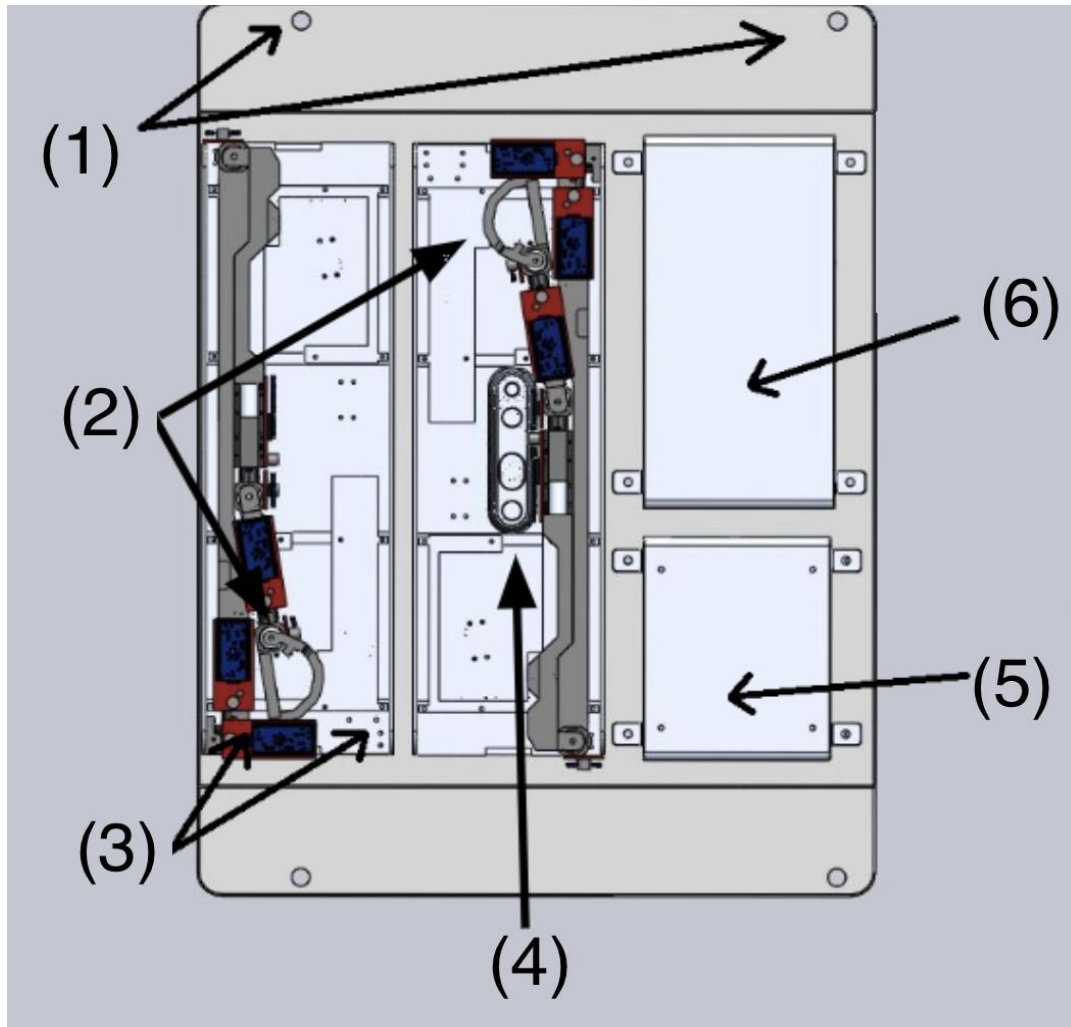


[<https://www.sciencefocus.com/future-technology/>]





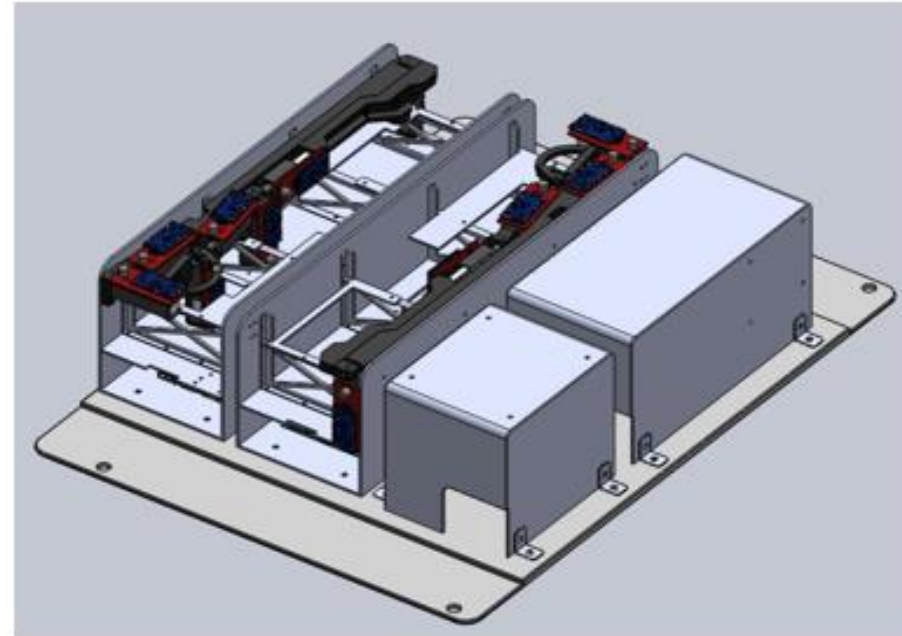
RSat – ISS Version Layout



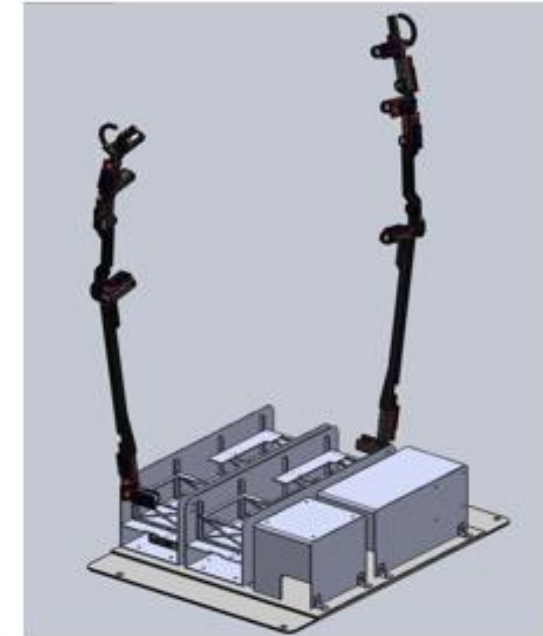
1. Microgravity Science Glovebox (MSG) mounting points
2. Arm end effectors and fiducial recognition cameras
3. Robotic Experimental CubeSat (RECS) unit mounting points
4. Intel RealSense 3D Depth Camera
5. Power control housing
6. 'Master' Raspberry Pi and Network box



Stowed and Deployed Positions



RSat - Stowed Position



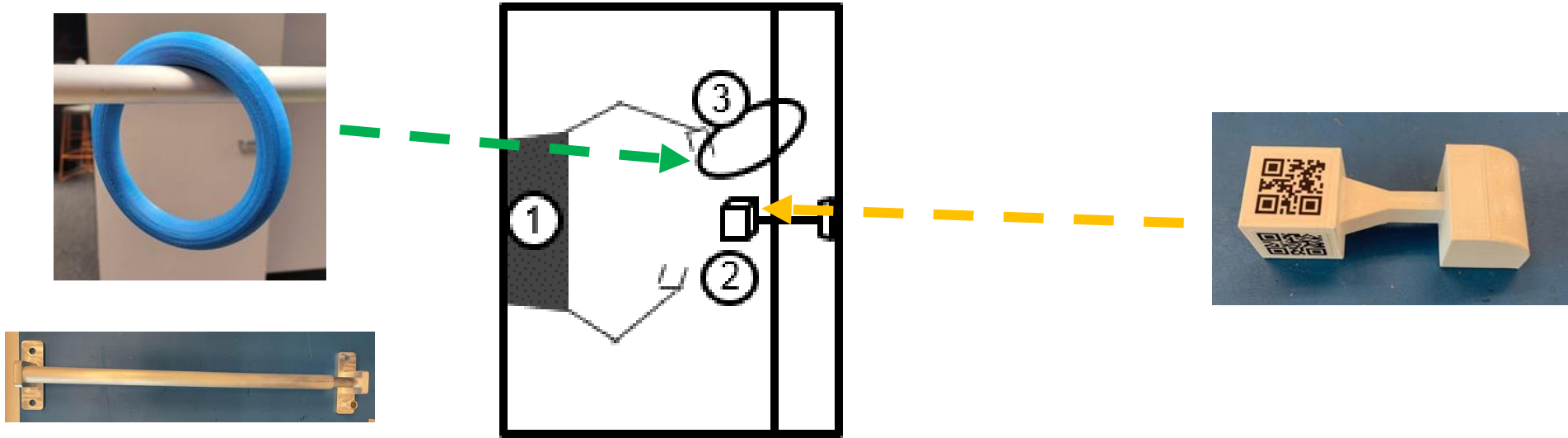
RSat - Deployed Position



Manipulation Targets



- “Floating” ring
- Mounted Cube Target with fiducials





Mounted Inside Material Science Glovebox





Launch and Operation



Launch!



- Launched to the ISS on 6 NOV 2023 on NG-18 mission



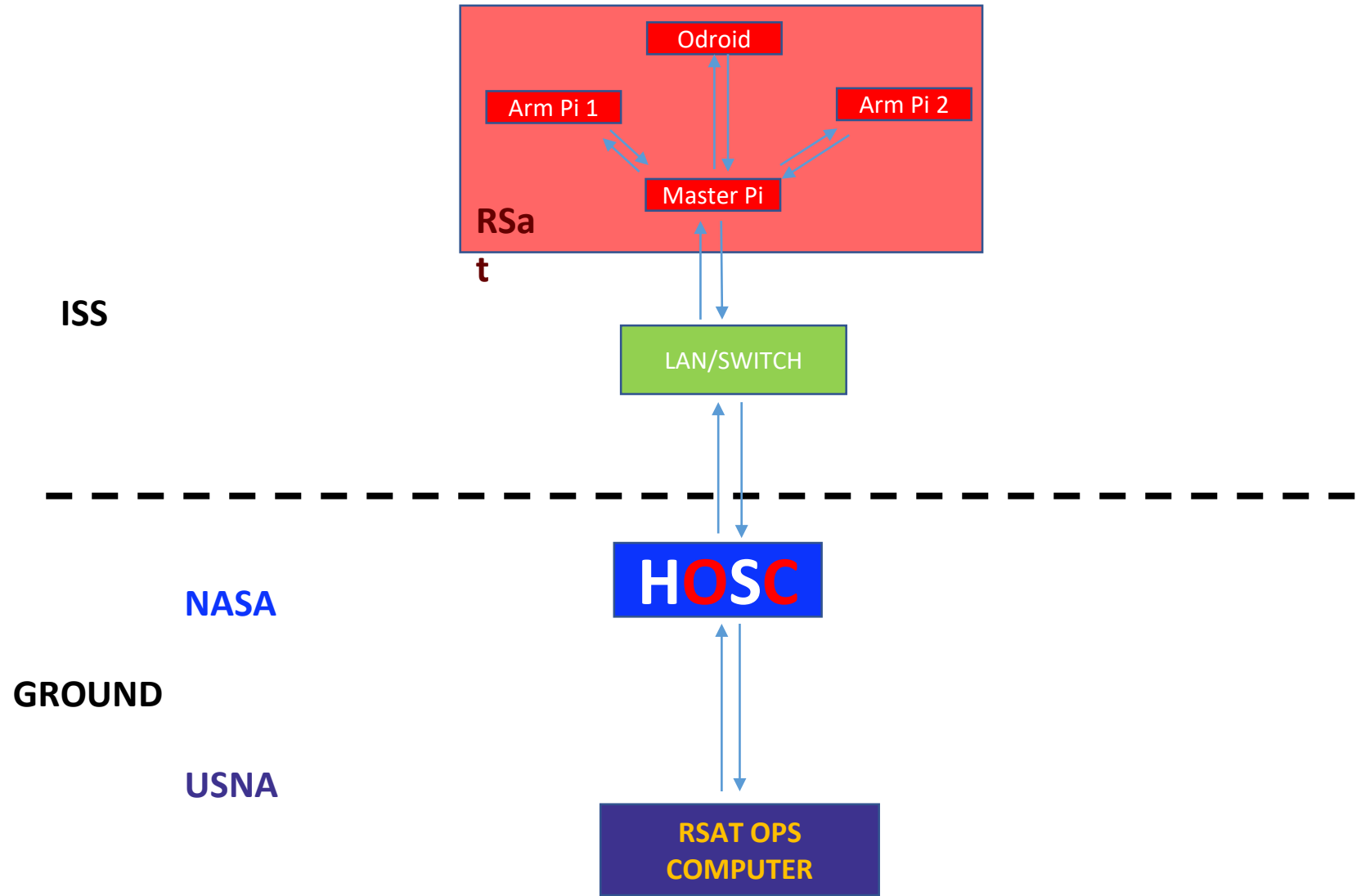


Entire Mission in One Picture





Operation Layout





Operation (Conclusion)



- ... and we wait
- Projected operation, OCT 2023
- Student teams training on operation
 - Dry runs with the ISS operation training crew
 - More time is good for proper training of students
 - Certification system
 - More underclassmen involvement

Hope to come back to you with exciting Space Operations information next time!





Thank you.
Questions?

