

ST-R3-09 Multi-resolution Scanning – ISS / Astrobee



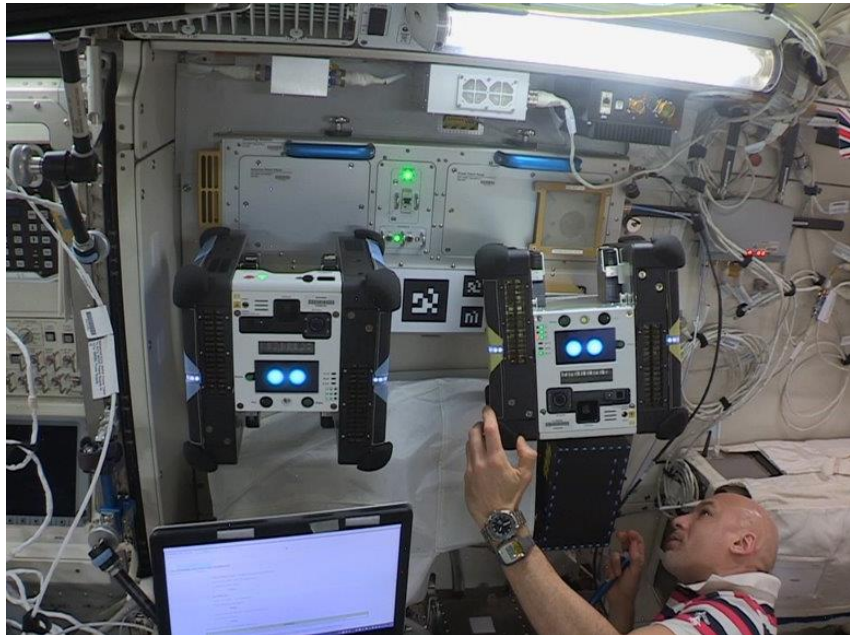
Astrobee Working Group
June 2023 Update

Summary

- This slide deck presents details on the CSIRO Space Technology Future Science Platform (FSP) Round 3/4 project : **ST-R3-09 Multi-resolution Scanning – ISS / Astrobee**
- The goal is to develop a sensor payload for the Astrobee robotic platform onboard the International Space Station (ISS) to support multi-resolution 3D scanning
- Future applications of the technology include extra-vehicular scanning and off-world scanning

Outline

- Introductions and background
- Technical progress
- Next steps



Introductions and background

Project Team

- **CSIRO:**

- Marc Elmouttie - (Project leader) stereo-depth fusion algorithm
- Ross Dungavell – lidar SLAM implementation
- Paul Flick – payload design
- Peter Dean – stereo-depth fusion implementation
- Tom Molnar – software engineer ROS integration
- Lauren Hanson – mechanical engineering payload
- David Haddon – systems integration
- Matt van de Werken – electronics engineer
- Michael Lofgren – software engineering advisor
- Rosie Attwell – flightplan scheduling



- **Boeing :**

- Connie Miller – (Payload Developer) Space & Launch Focal
- Leighton Carr – Associate Technical Fellow

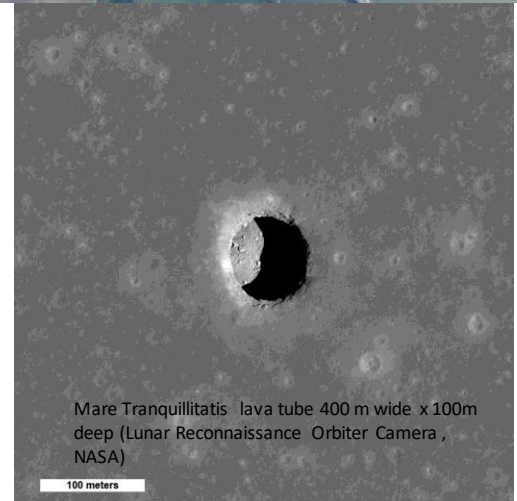


Motivation

- Collaboration with Boeing to develop a fused sensor system to support space based autonomous multi-resolution scanning from multiple platforms and payloads, including:
- Interior ISS/Gateway using autonomous scanning, supported by Astrobees & sensor payload
- External hull integrity scanning using systems such as CanadARM2 and Seeker CubeSAT
- Off-world surface scanning on lunar or mars rovers or potentially multi-legged robots

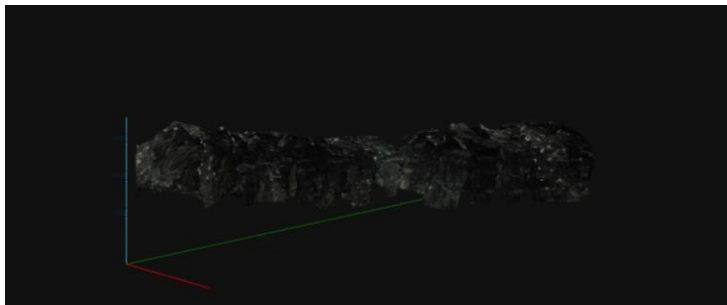


STS114 image of ISS (NASA)



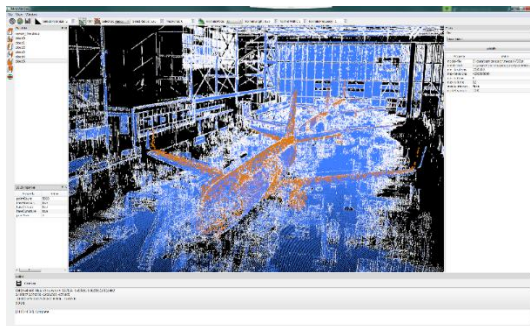
Mare Tranquillitatis lava tube 400 m wide x 100m deep (Lunar Reconnaissance Orbiter Camera, NASA)

Multi resolution scanning – key technologies



CSIRO SDF – Hi Resolution stereo-depth fusion scanning

+



CSIRO 3D SLAM – large area position and mapping

Target performance metrics – ISS internal scanning

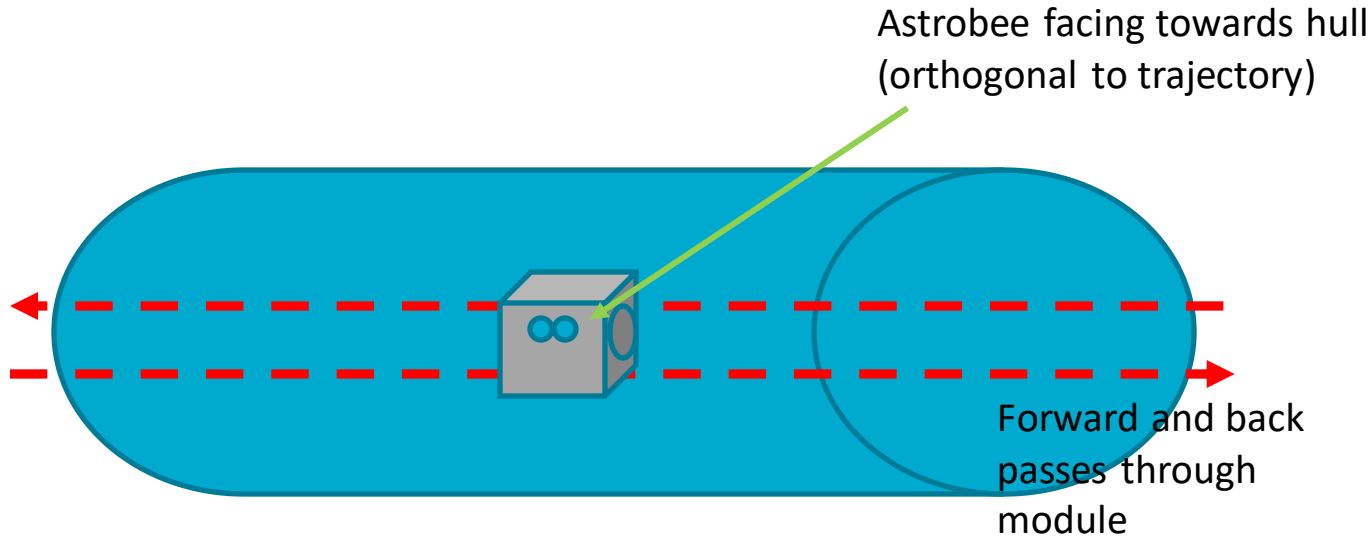
- Scan speeds up to 0.3 m/s
- Scanning range up to 2.5m
- Point cloud resolutions down to sub-millimeter to mm



ISS Japanese Experiment Module (NASA)

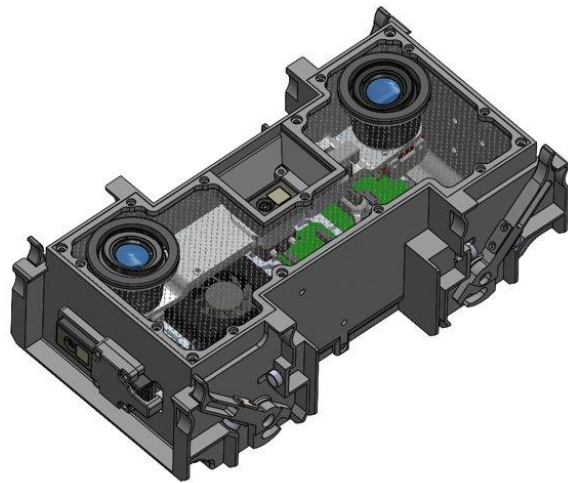
Proposed experiments on ISS

- Full internal scan, initial testing in Japanese experimental module
- Scanning of other modules to follow
- Trajectory to be finalised with NASA



Current Specifications

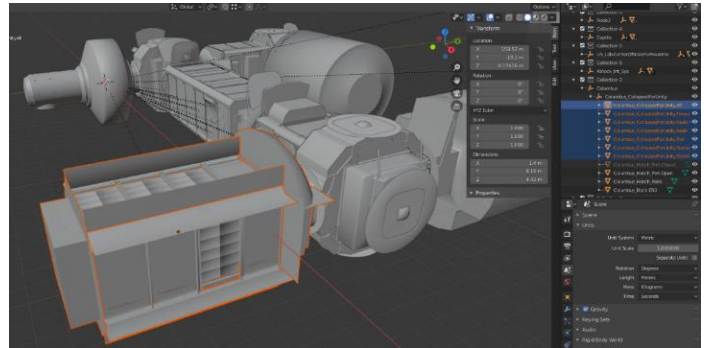
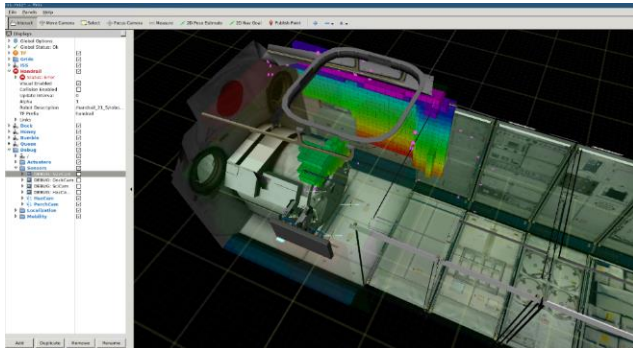
- Housing
 - ULTEM ~500g
- Compute
 - Xavier NX
 - Mass 100gms / Power 15W +
- Stereo camera
 - Machine vision or similar units
 - Mass ~400gms / Power consumption (~5W)
- Additional sensors
 - Picoflexx (x 3) & IMU
 - Mass 30 gms / Power consumption ~2W
- Total mass: ~1500gms
- Note: Astrobees payload nominals
 - power supply (14V/2A) / ~1900gms



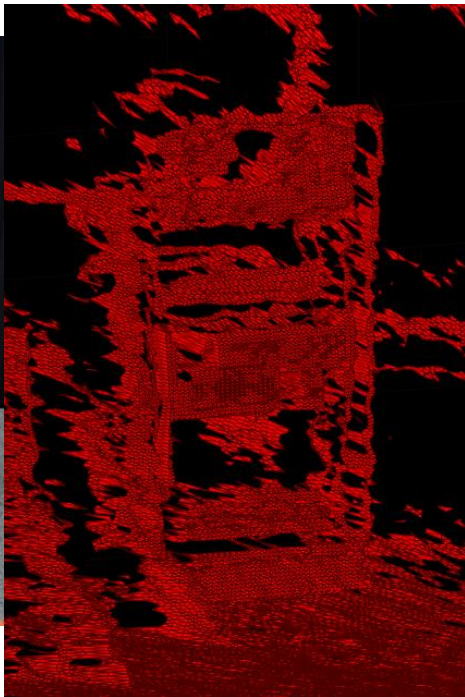
Payload testing

Simulation

- Astrobee simulator used to assess
 - Sensing performance
 - Flight trajectories

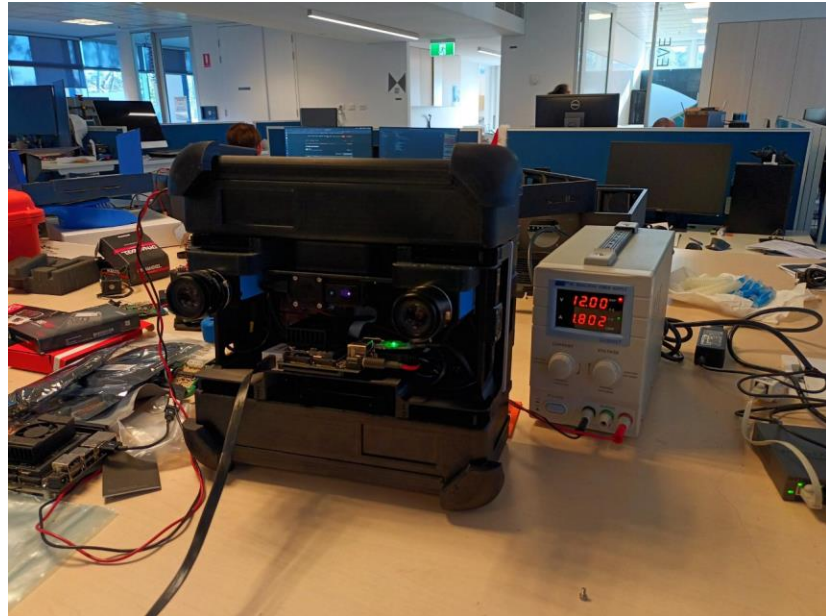
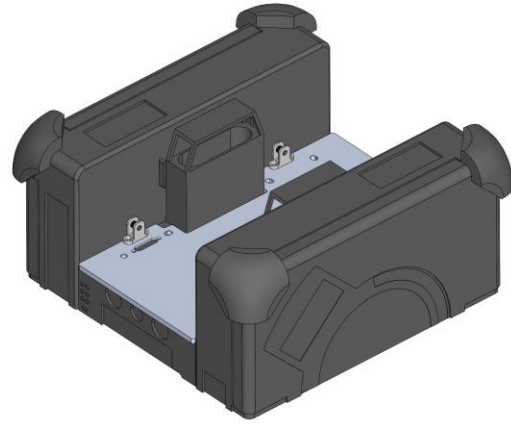


Testing & Validation



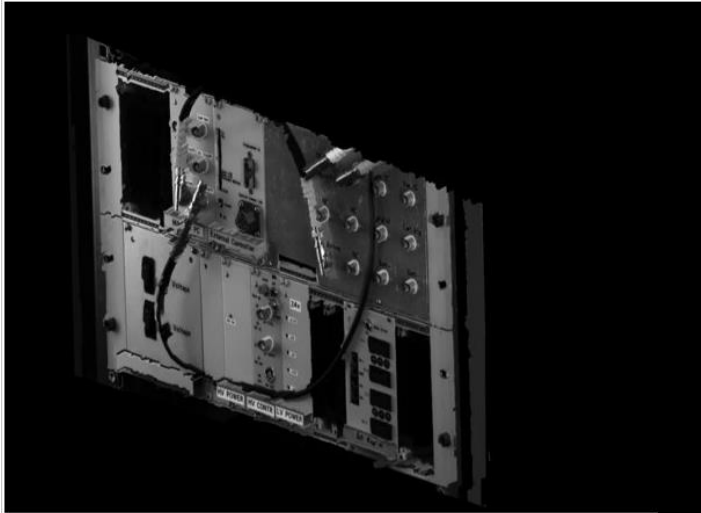
Testing framework

- Software and hardware mockups of the Astrobee to support testing in Australia
- Verification of mechanical, electrical and comms interfaces



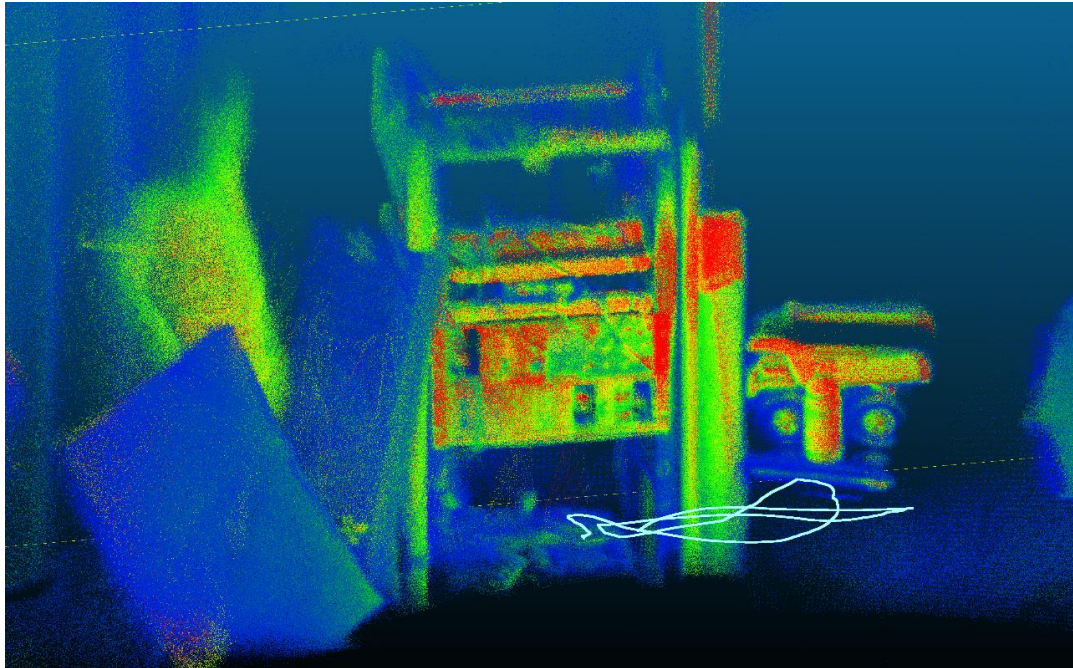
Testing & Validation

- High resolution 3D reconstructions from payload



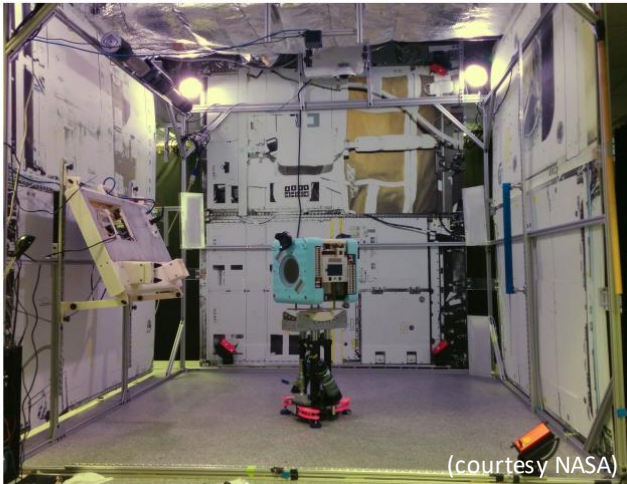
Testing & Validation

- SLAM trajectory and Point Cloud

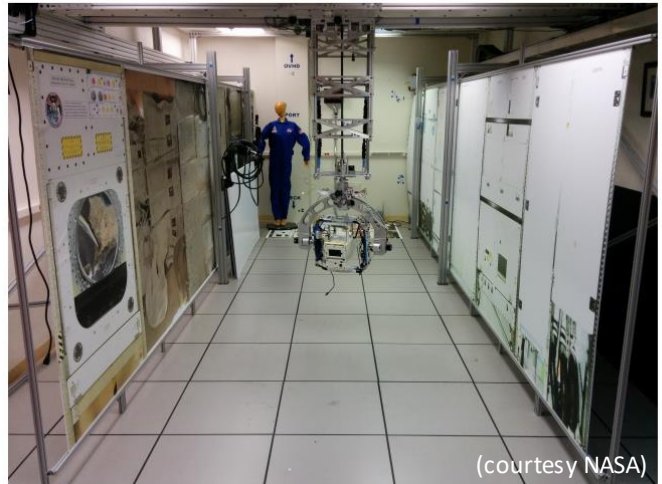


NASA AMES Astrobee Test Facilities

- Payload to undergo full suite of ground-based testing



Granite Lab.

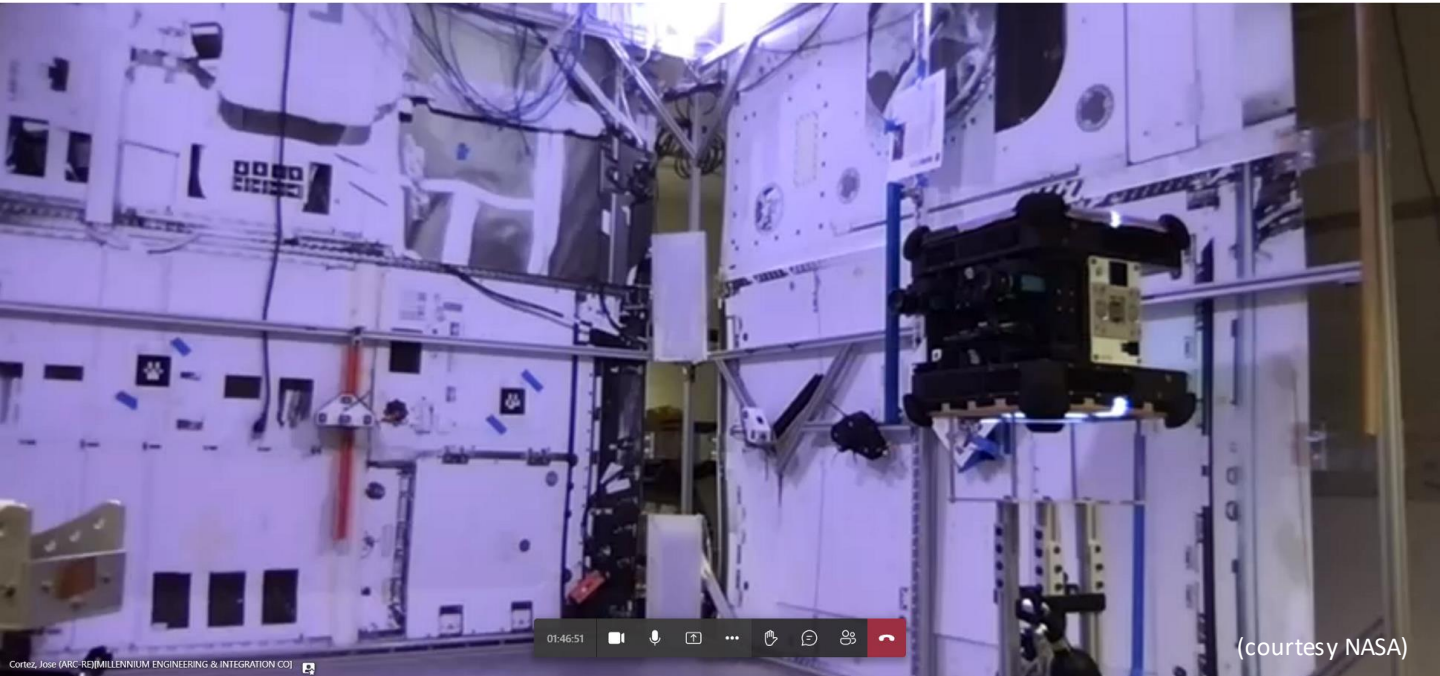


Micro-Gravity Test Facility

NASA AMES Granite Lab Testing



NASA AMES Granite Lab Testing



NASA AMES Granite Lab Testing

Activities Terminator Aug 31 08:19

Top Xavier NX (Developer Kit Version) - JC: Running - 20W 6CORE

nvtop Xavier NX (Developer Kit Version) - Jetpack 4.6.2 [L4T 32.7.2]

CPU	Schedutil	75%	1.4GHz	CPU4	Schedutil	72%	1.4GHz
CPU1							
CPU2							
CPU3							

Mem 2% BG [3.8G/8.0GB (lfb 125x4MB) 0.039GB/3.9GB (cached 0MB) 43% 1.9GHz

GPU [8% 1.1GHz 18.4GB/26.8GB

[Info]	[Sensor]	[Temp]	[Power/mW]	[Cur]	[Avr]
UpT: 0 days 0:27:3	AO	41.88C	CPU GPU CV	5576	2111
FAN [100%]	AUX	40.58C	SOC	1950	1478
Jetson Clocks: running	CPU	43.08C	ALL	11863	7210
NV Power[8]: 20W 6CORE	GPU	41.88C			
[HW engines]	thermal	41.78C			

APPE: 150MHz
NVDEC: [OFF]
NVJPG: [OFF]

1ALL 2GPU 3CPU 4MEM 5CTRL 6INFO Quit Raffaello Bonghi

mol112@yorkshire-ph:~\$ robot_master mrs-payload-1
mol112@yorkshire-ph:~\$ roslaunch rqt_image_view rqt_image_view /plco_flexx_front/image_mono8

/etc/mrs/catin_ws/src/astrobee/launch/scan.launch http://localhost:11311

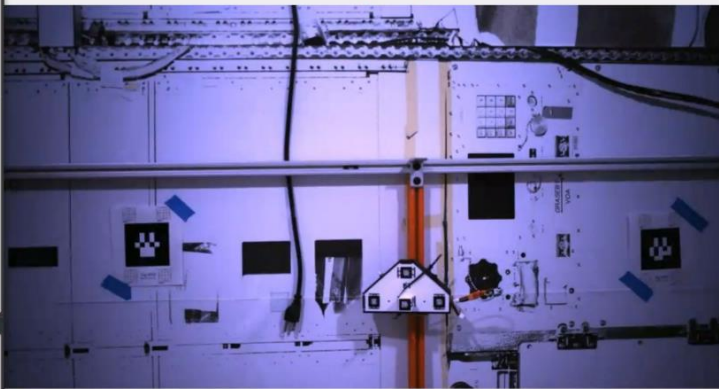
process[sdf_nodelet-1]: started with pid [25329]
process[meshbuilder_nodelet-2]: started with pid [25330]
process[ras_record_scan-3]: started with pid [25331]
[INFO] [/sdf_nodelet]: Loading nodelet /sdf_nodelet of type sdf_ros/SDFNodelet to manager sdf_manager with the following remappings:
[INFO] [/meshbuilder_nodelet]: Loading nodelet /meshbuilder_nodelet of type meshbuilder/MeshbuilderNodelet to manager sdf_manager with the following remappings:
[INFO] [/meshbuilder_nodelet]: /tick -> /camera_trigger/tick
[INFO] [/ras_record_scan]: Recording base path: /data/astrobee/bagfiles
[INFO] [/ras_record_scan]: Recording to output folder: /data/astrobee/bagfiles/2022_08_30_22_18_28Z
[INFO] [/ras_record_scan]: Launching subprocess /opt/ros/melodic/lib/rosbag/rec

teams.microsoft.com is sharing your screen. Stop sharing Hide

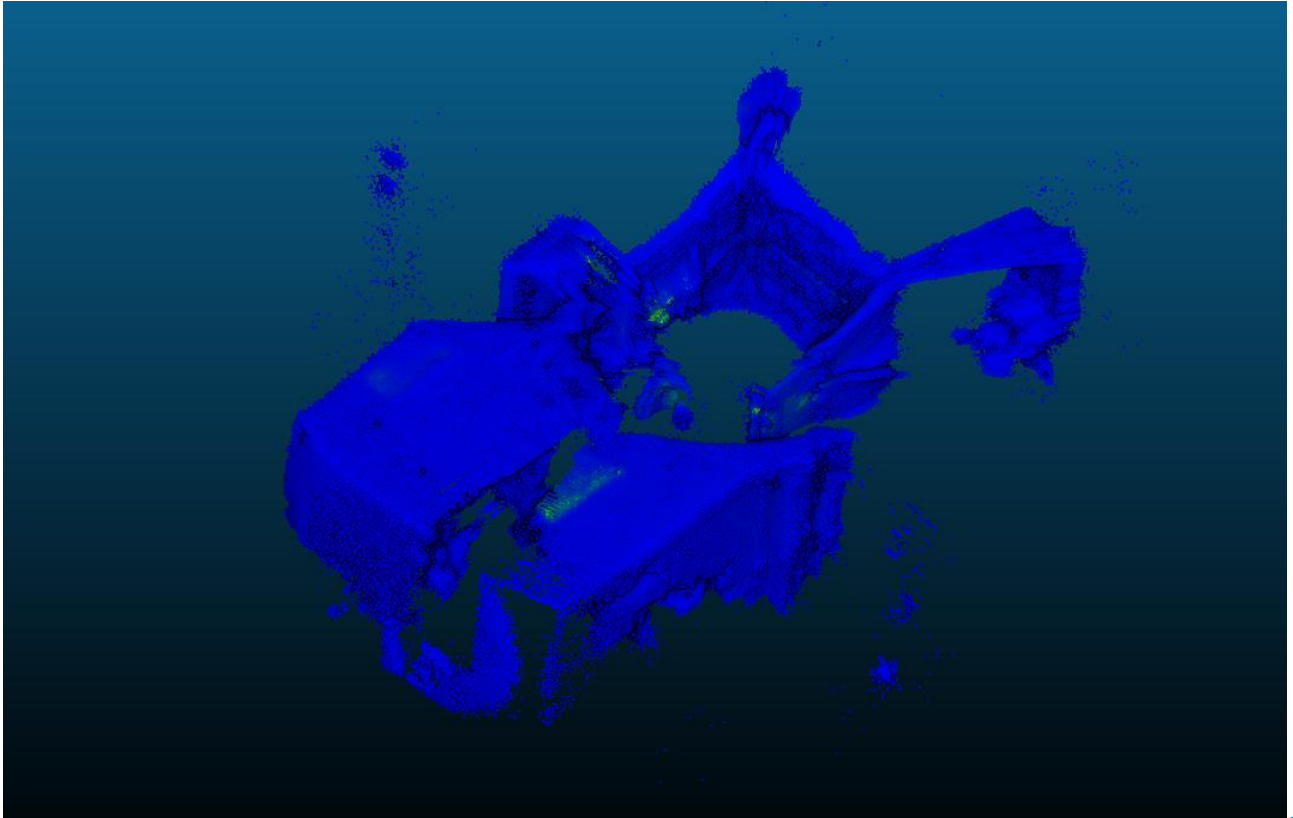
rqt_image_view - rqt

/left_image/compressed

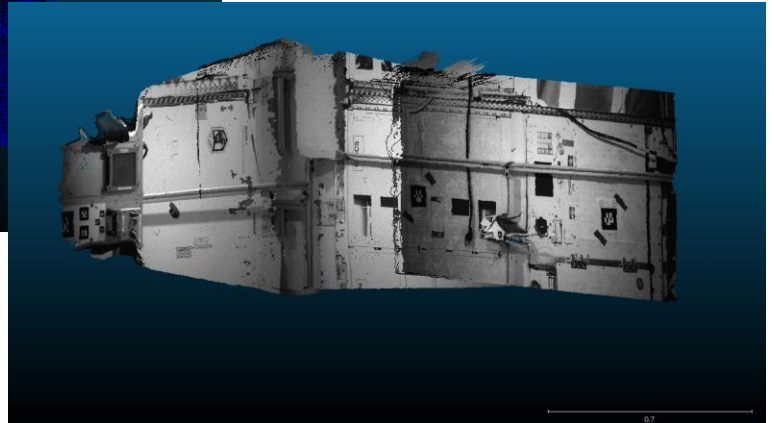
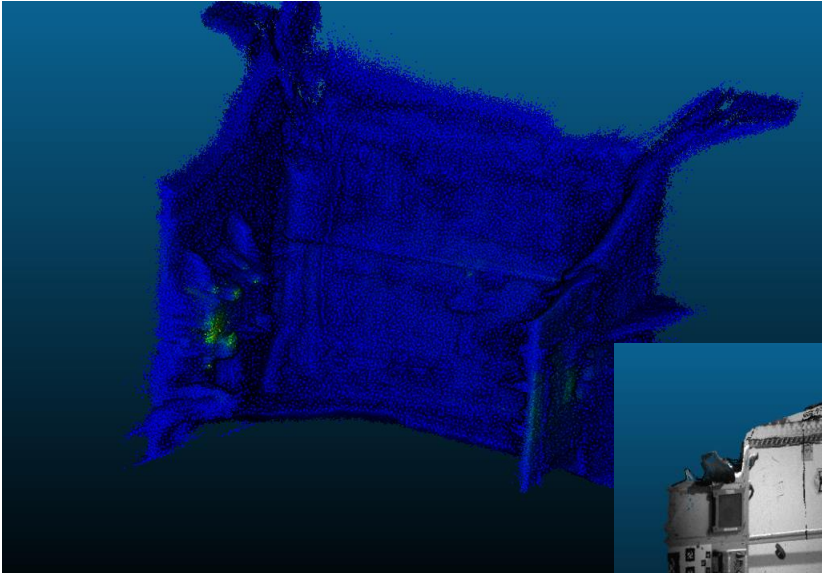
/left_image/compressed_mouse_left ✓ Smooth scaling 0° Gray



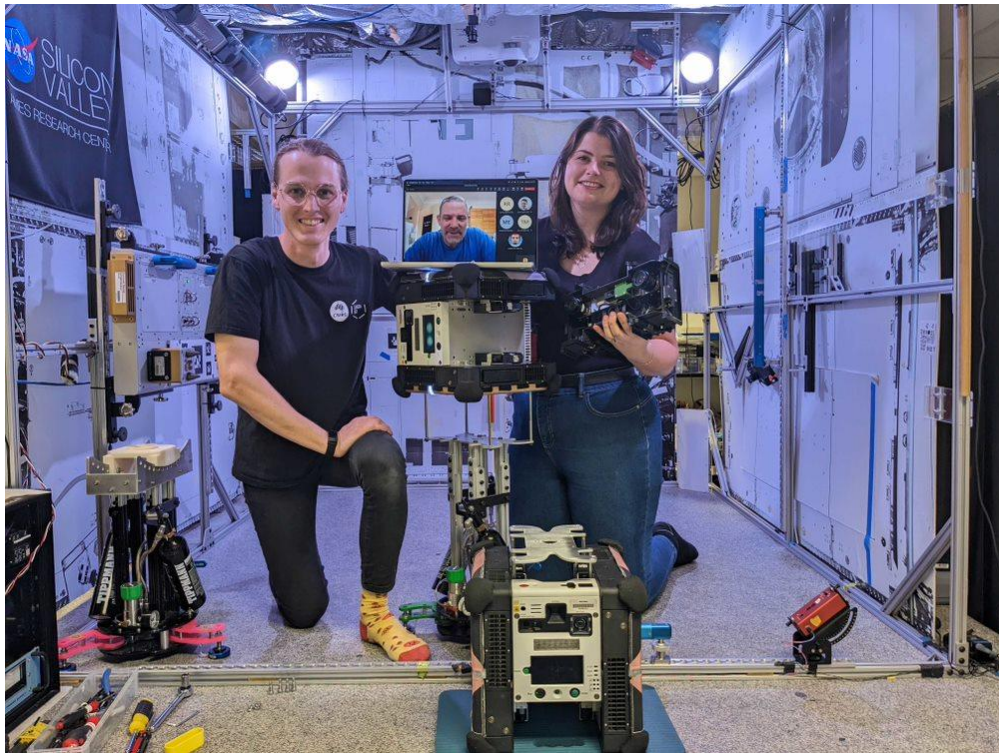
NASA AMES Granite Lab Testing



NASA AMES Granite Lab Testing



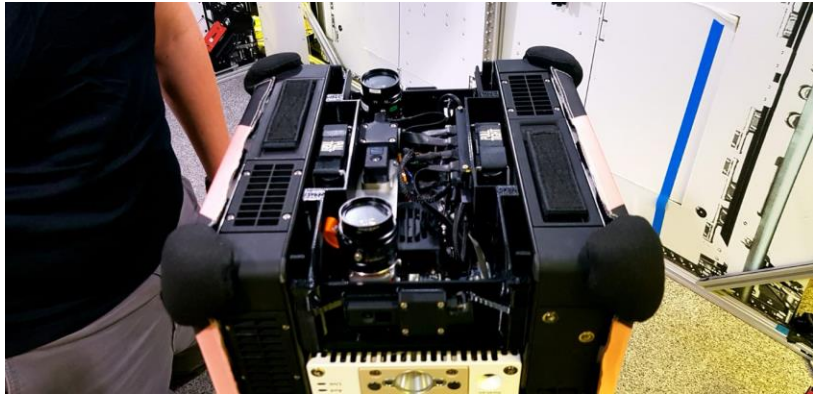
NASA AMES Granite Lab Testing



Payload integration process

Safety Assessment Process

- NASA responsible for the overall integrated safety of ISS and safety requirements of the ISS Program (ISSP)
- Compliance assured through a structured safety review process conducted by NASA ISS Safety Review Panel (ISRP)
- Hazard identification and mitigation
- Testing and certification



Safety Assessment Process

- Phase 0 – identification of applicable safety requirements, known hazards and causes
- Phase 1 – identify hazards with planned and/or implemented controls
- Phase 2 – hazard controls implemented and incorporated into design and verifications document
- Phase 3 – final safety review and acceptance

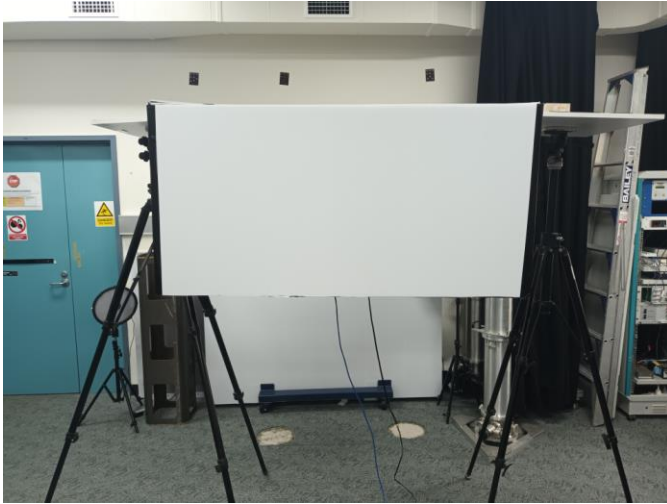


Next steps

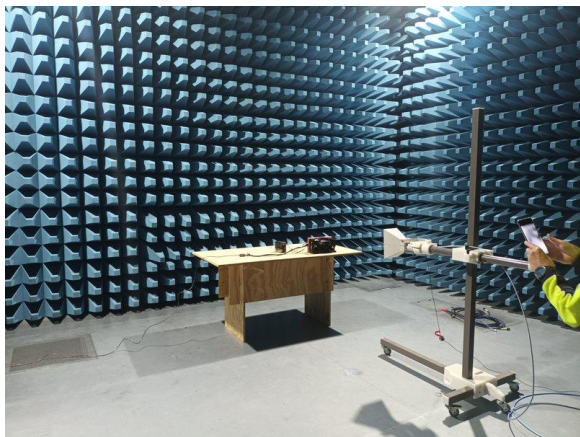
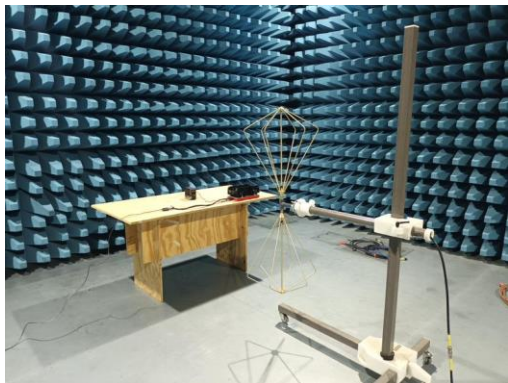
Final testing

- Thermal testing
- EMI testing
- Mechanical testing
- Software updates

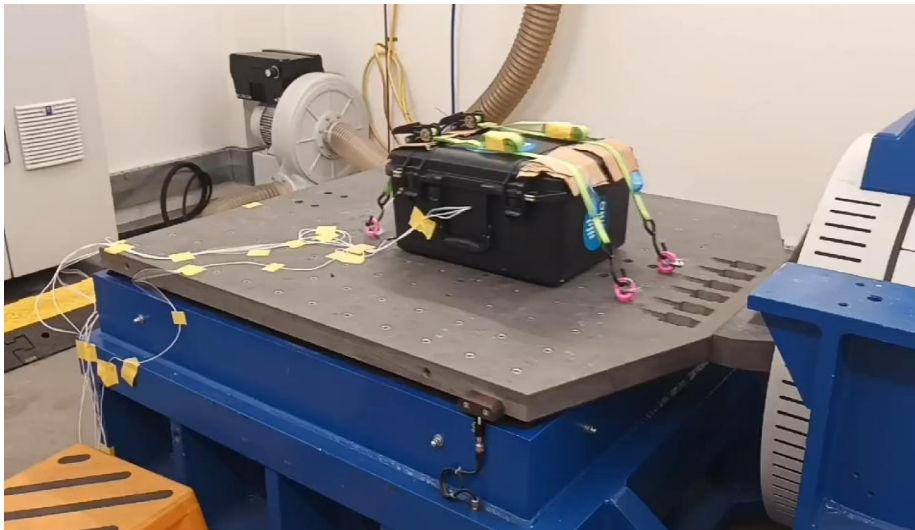
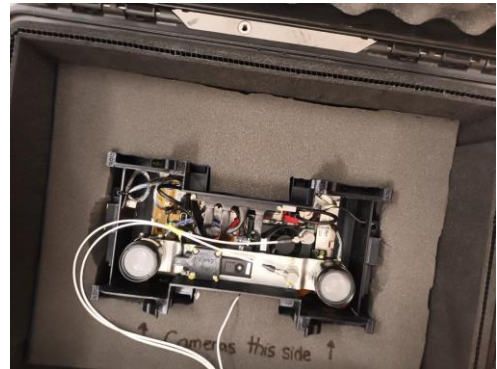
Thermal Testing Phase 1



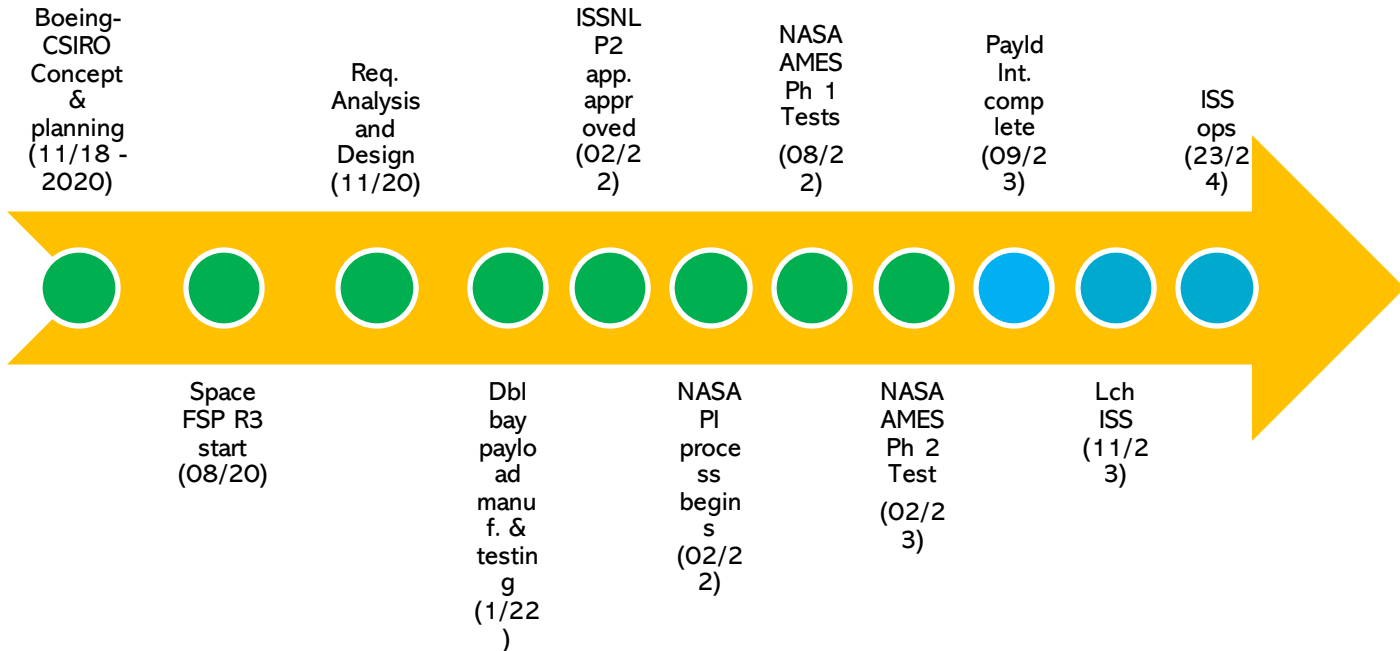
EMI Testing Phase 1



Vibration Testing Phase 1



Timeline



Acknowledgements

- Significant financial and technical support is being provided by the following organisations
- CSIRO Space Technology Future Science Platform
- CSIRO Minerals and Data61 Business Units
- Boeing
- NASA
- ISS National Lab

Thank you

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