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

Astrobee Working Group
November 2023 Update

CSIRO

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

CSIRO

Introductions and background

CSIRO

Project Team

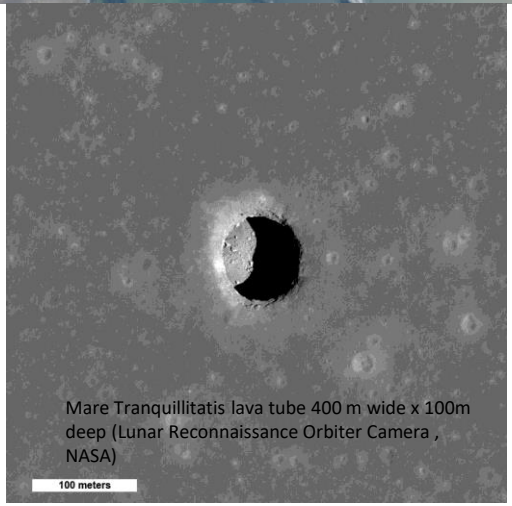
- **CSIRO**:
- Marc Elmouttie - (Project leader) stereo-depth fusion algorithm
- Ross Dungavell – lidar SLAM implementation
- Paul Flick – payload design
- Peter Dean – stereo-depth fusion implementation
- Tea Molnar – software engineer ROS integration
- Lauren Hanson – mechanical engineering payload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

- **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 Astrobee & 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

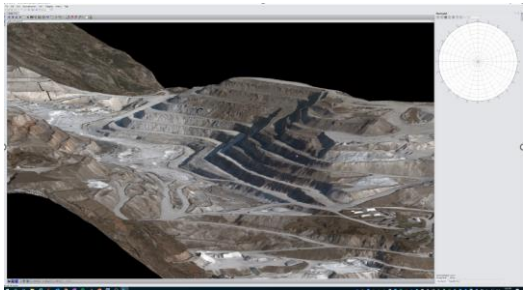
STS114 image of ISS (NASA)



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

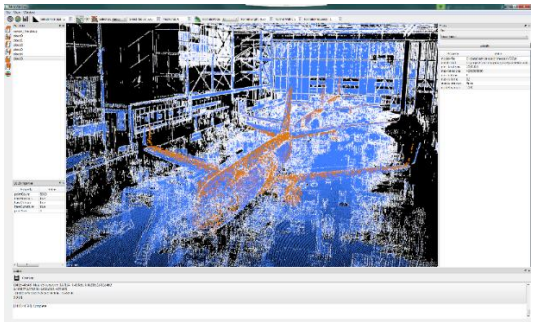
CSIRO

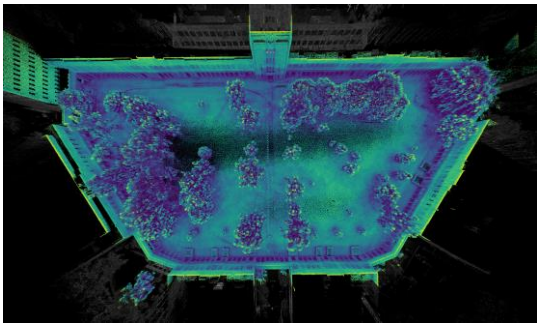
Multi resolution scanning – key technologies



CSIRO Stereo-Depth Fusion (SDF) – Hi Resolution stereo-depth fusion scanning

+



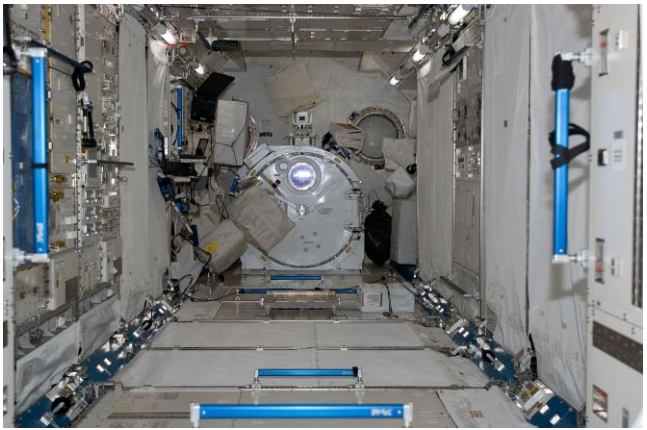


CSIRO WildCat SLAM (Simultaneous Localisation and Mapping) – large area positioning and mapping

CSIRO

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

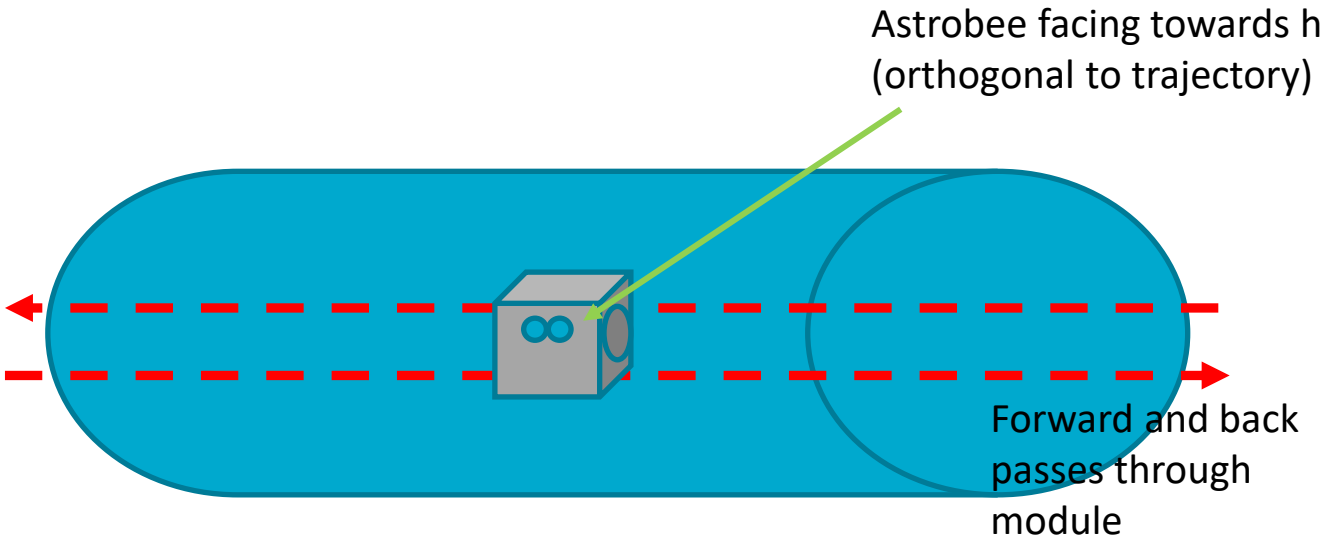


ISS Japanese Experiment Module (NASA)

CSIRO

Proposed experiments on ISS

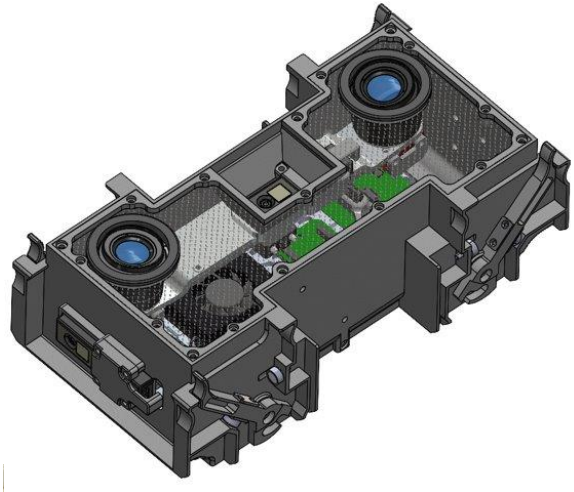
- Full internal scan, initial testing in Japanese experimental module
- Scanning of other modules to follow
- Trajectory to be finalised with NASA

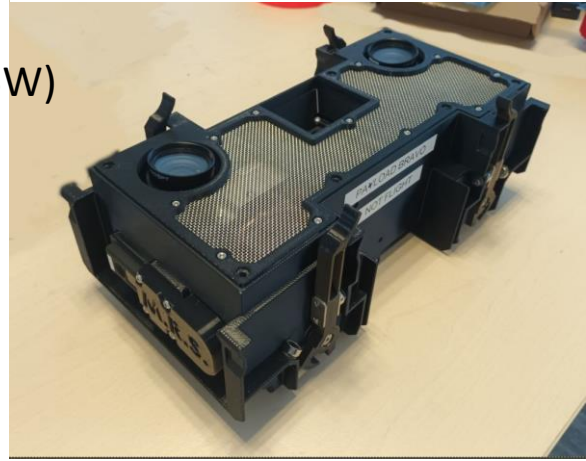


CSIRO

Specifications

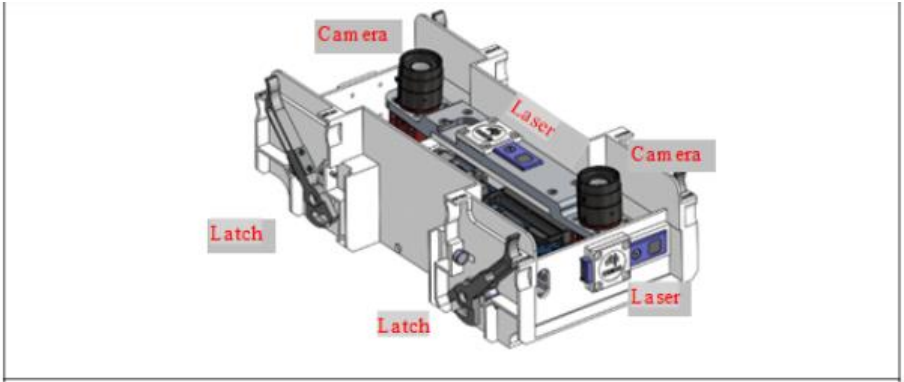
- Housing
  - ULTEM ~500g
- Compute
  - Xavier NX
  - Mass 100gms / Power 15W +
- Stereo camera
  - Machine vision or similar units
  - Mass ~400gms / Power consumption (~5W)
- Additional sensors
  - Picoflexx (x 3) & IMU
  - Mass 30 gms / Power consumption ~2W
- Total mass: ~1500gms
- Note: Astrobee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

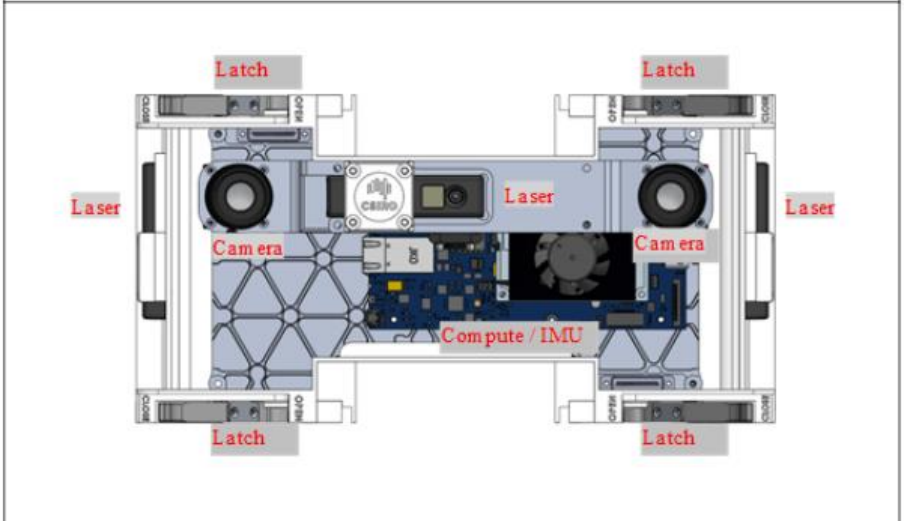




CSIRO

Sensor Layout





CSIRO

Payload testing

CSIRO

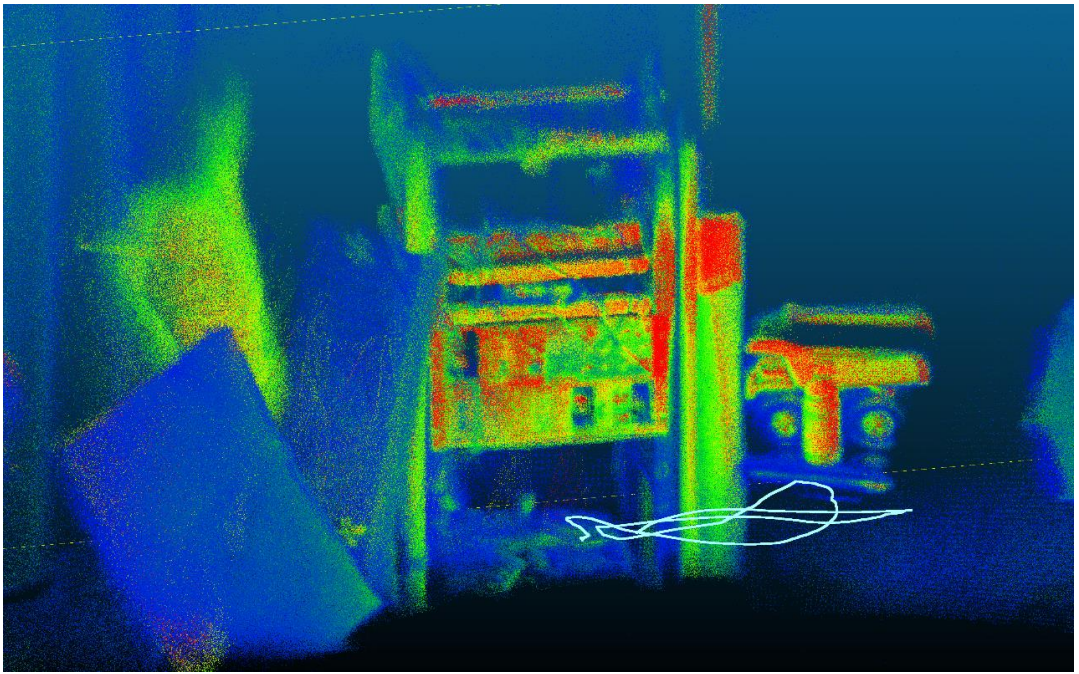
Testing & Validation

- High resolution 3D reconstructions from payload

CSIRO

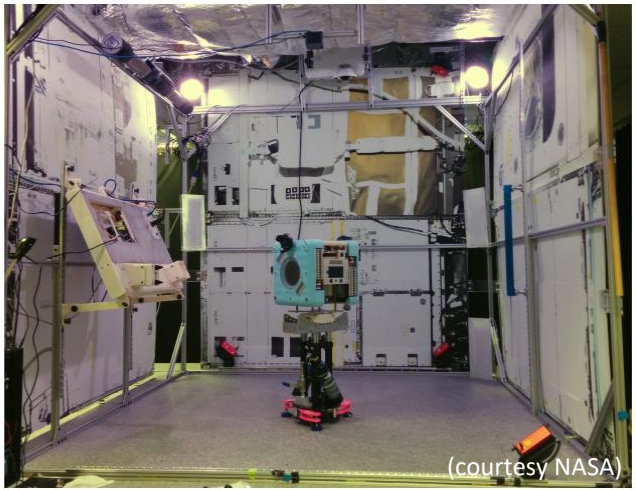
Testing & Validation

- SLAM trajectory and Point Cloud

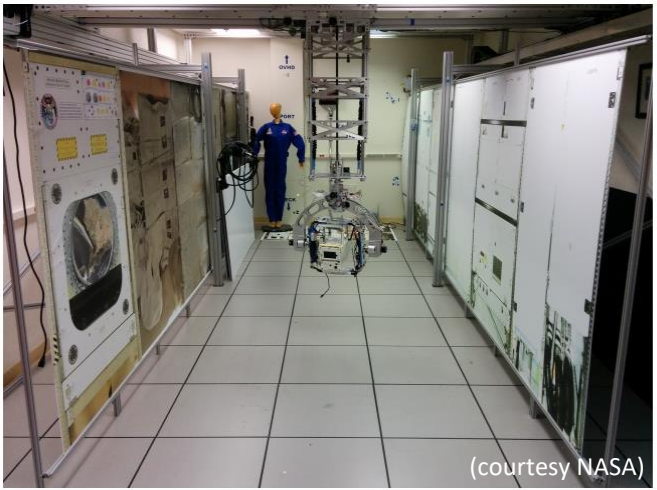


NASA AMES Astrobee Test Facilities

- Payload to undergo full suite of ground-based testing



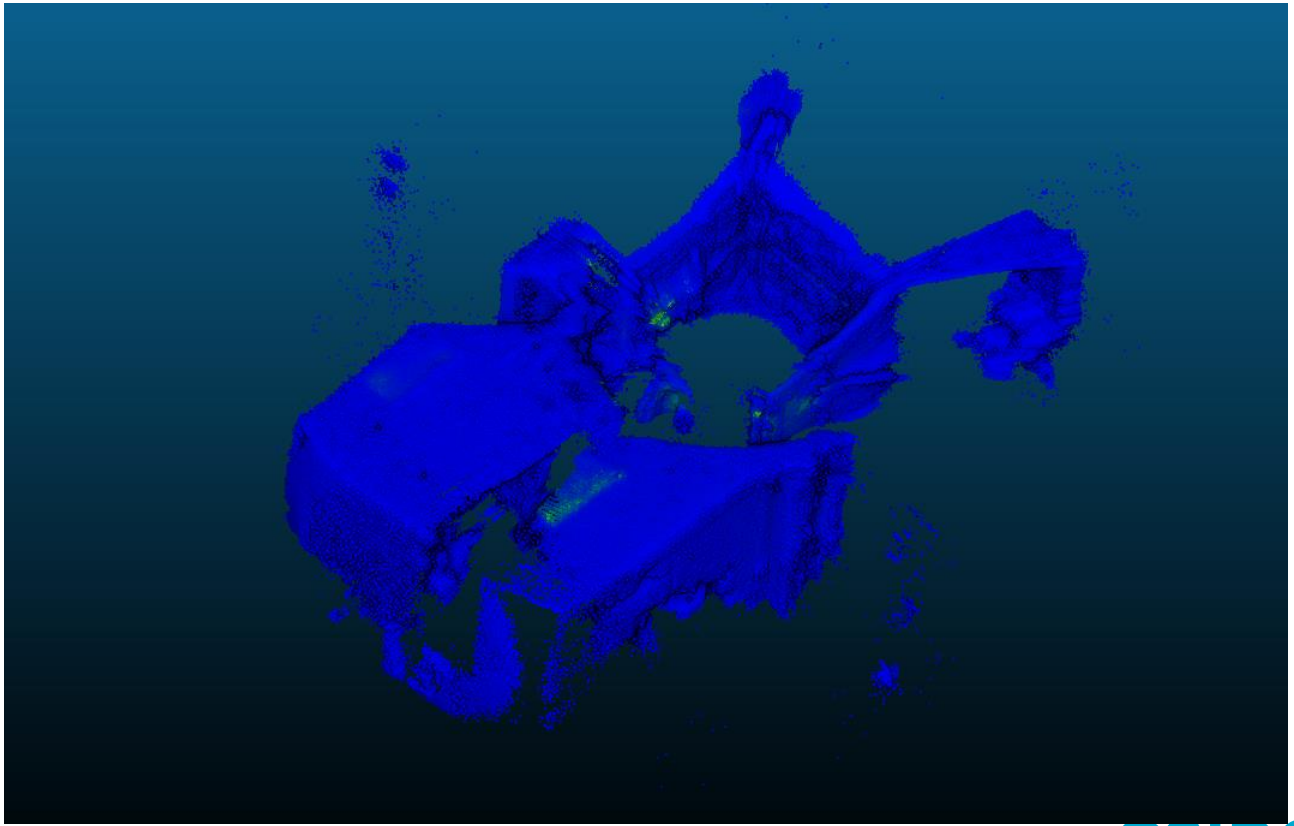
Granite Lab.



Micro-Gravity Test Facility

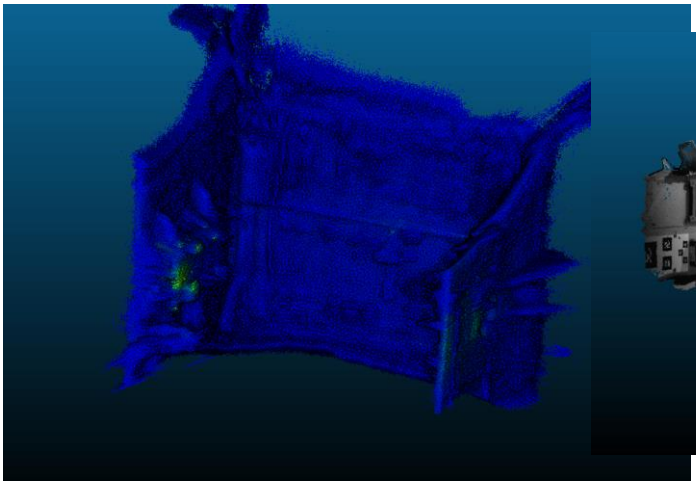
CSIRO

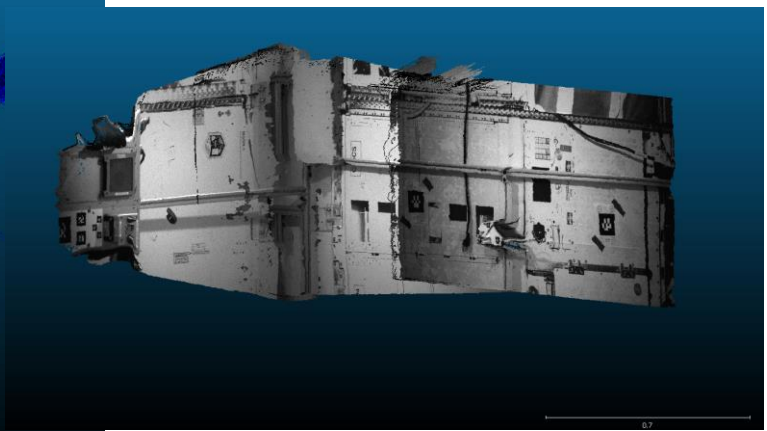
NASA AMES Granite Lab Testing AUG 2022



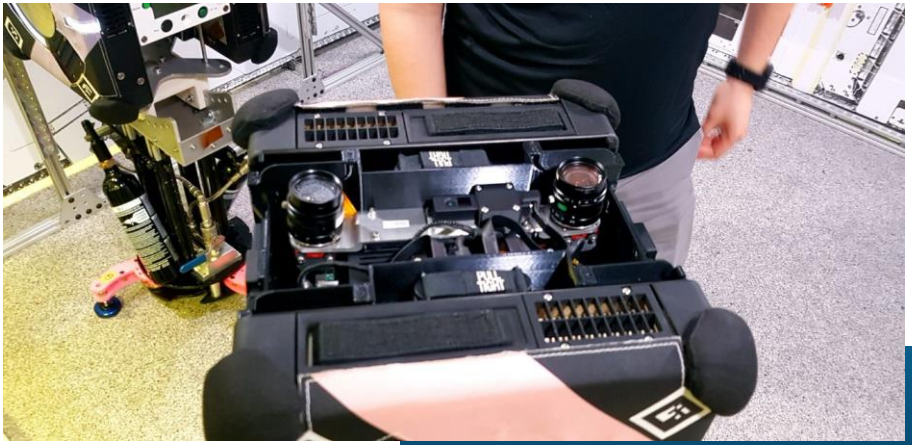
CSIRO

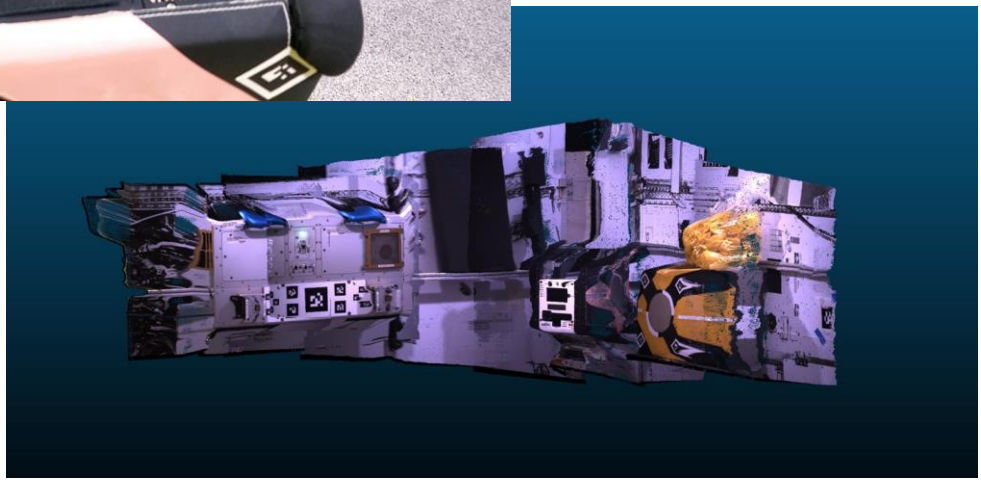
NASA AMES Granite Lab Testing AUG 2022





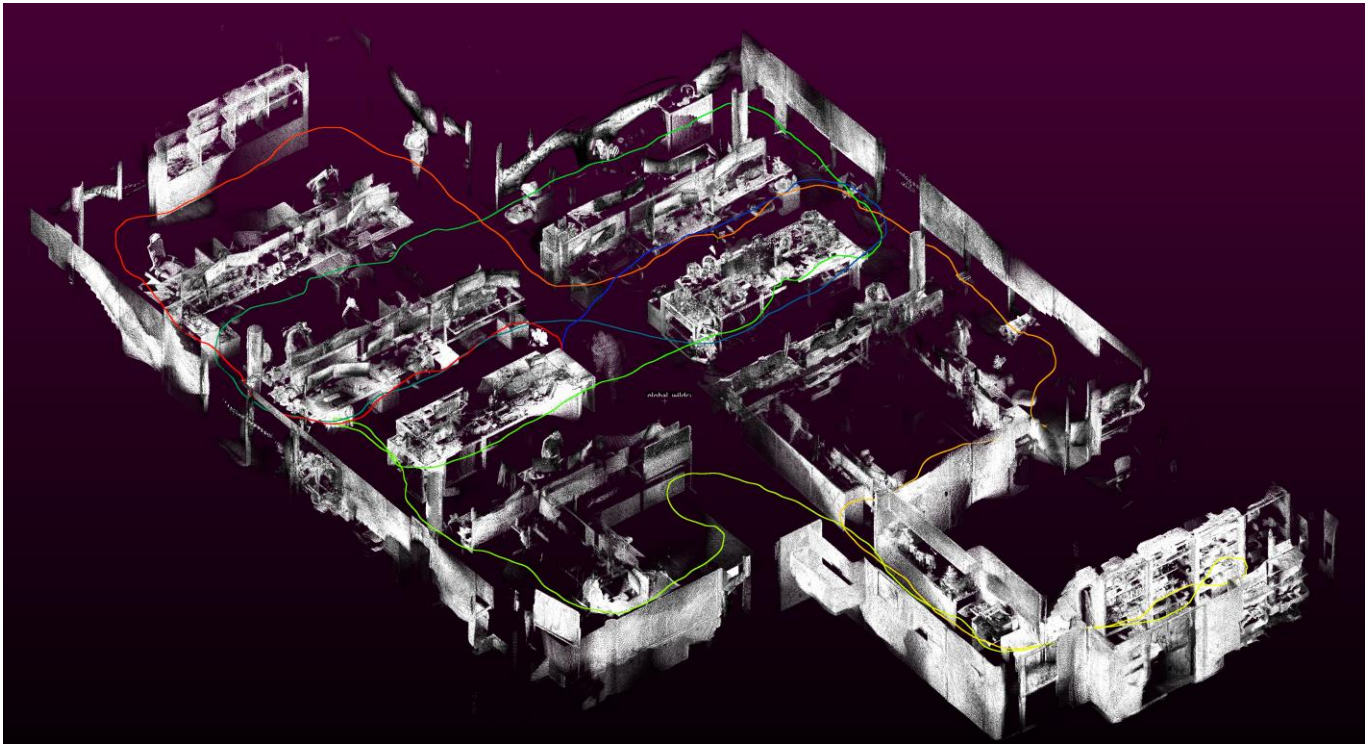
NASA AMES Granite Lab Testing MAR 2023





CSIRO

Testing & Validation



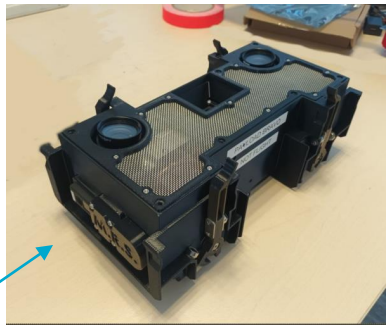
CSIRO

Payload integration process

CSIRO

Safety Assessment Process

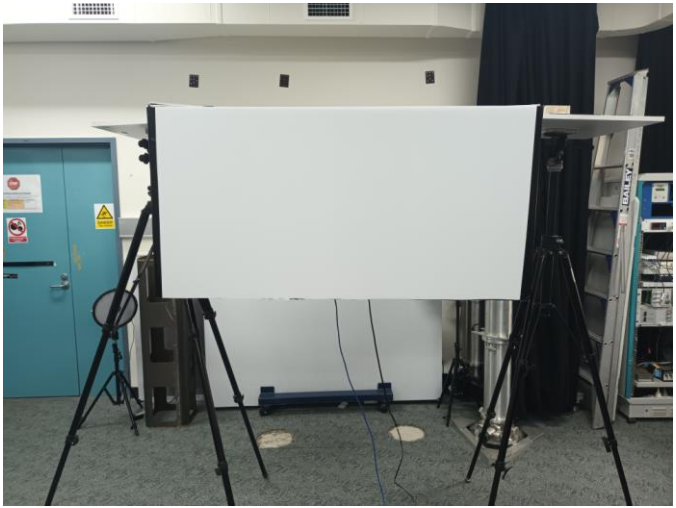
- Phase 0 – identification of applicable safety requirements, known hazards and causes
- Phase 1 – identify hazards with planned and/or implemented controls
- Phase 2 – hazard controls implemented and incorporated into design and verifications document
- Phase 3 – final safety review and acceptance



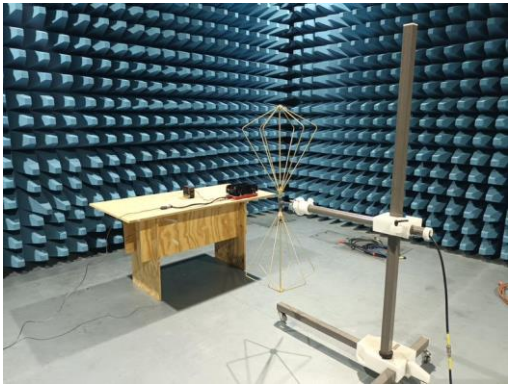
Mesh – design update

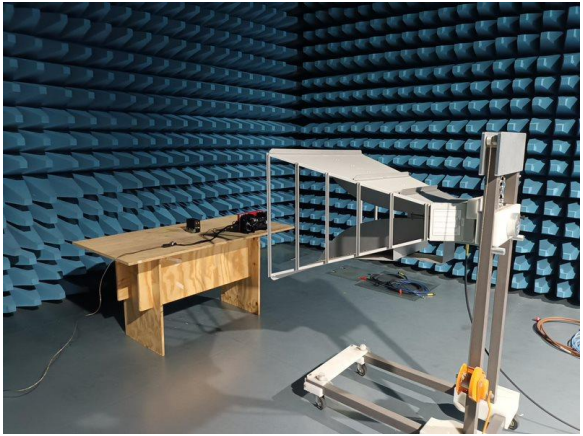
CSIRO

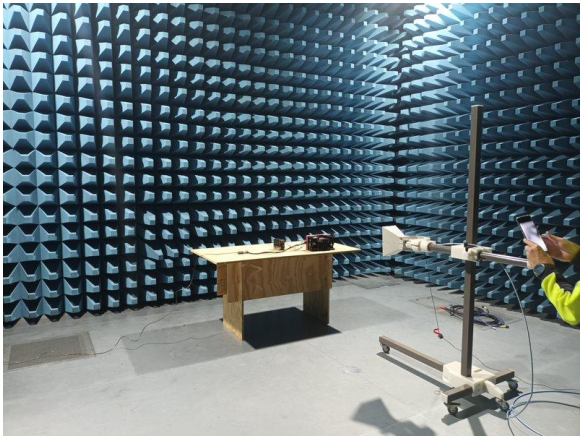
Thermal Testing Phase 2



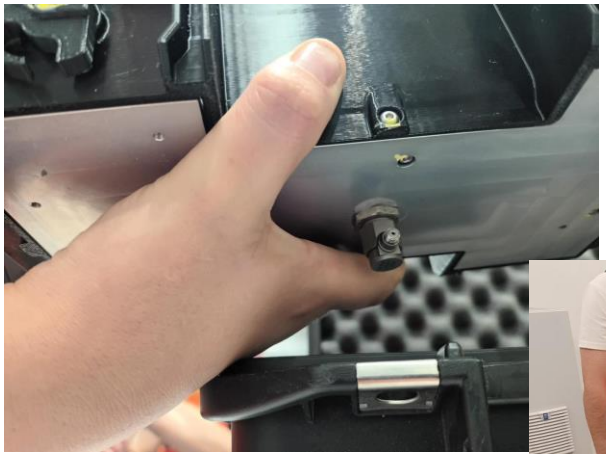
EMI Testing Phase 2

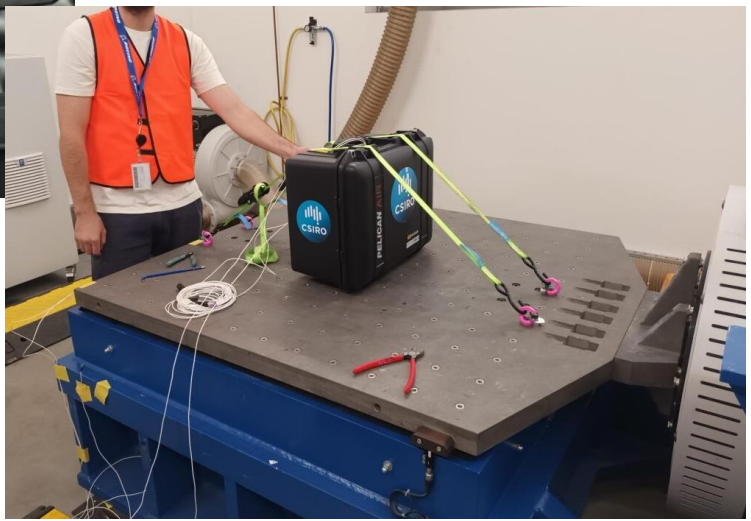






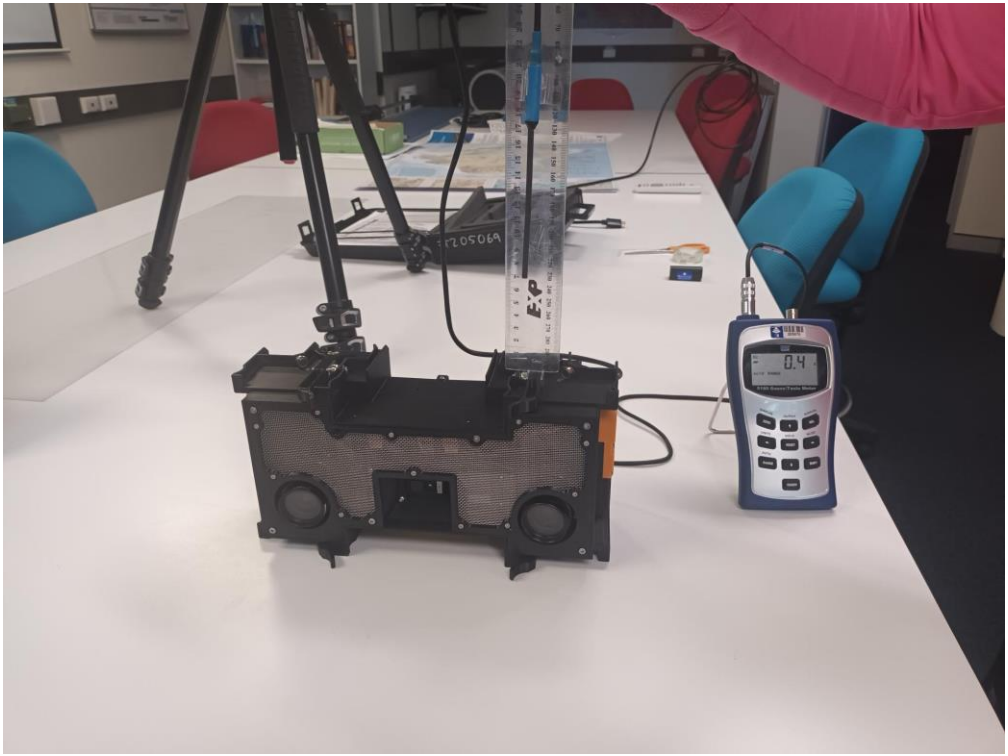
Vibration Testing Phase 2





CSIRO

Static magnetics

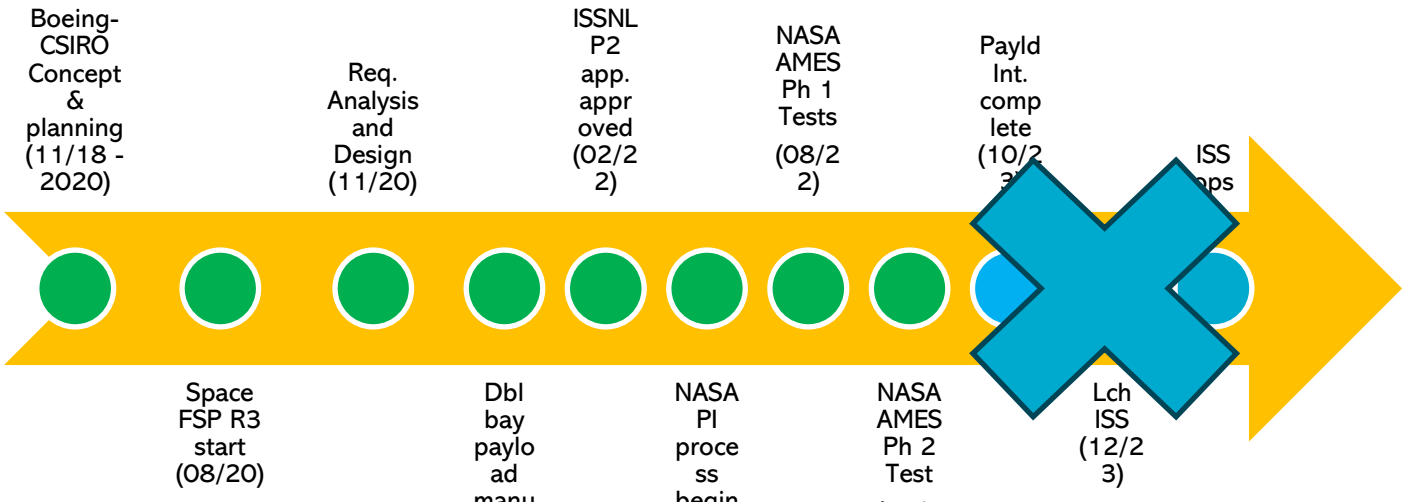


CSIRO

Challenges

CSIRO

Timeline

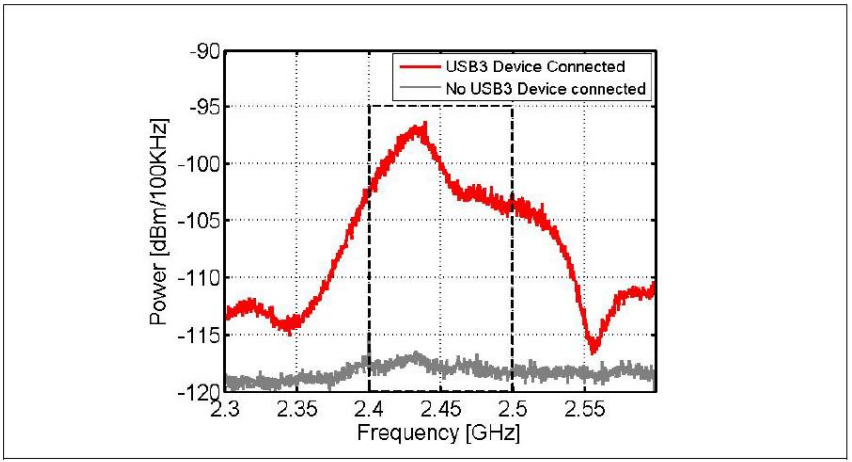


CSIRO

Challenges

- Manufacturer specs aren't always accurate! Average vs Peak power.
- USB3 is noisy!

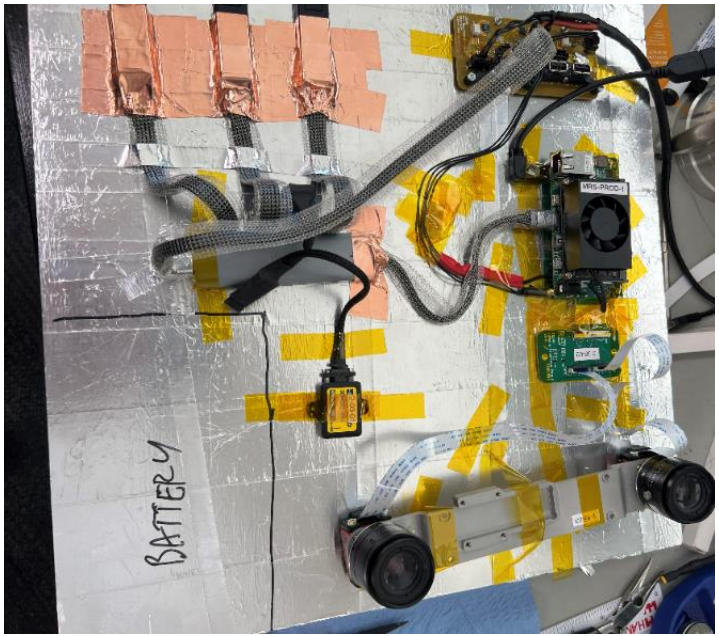
Figure 3-3. Noise from External USB 3.0* Hard Disk Drive



USB 3.0* Radio Frequency Interference Impact on 2.4 GHz Wireless Devices
Intel White Paper Document: 327216-001

CSIRO

Challenges



CSIRO

Next steps

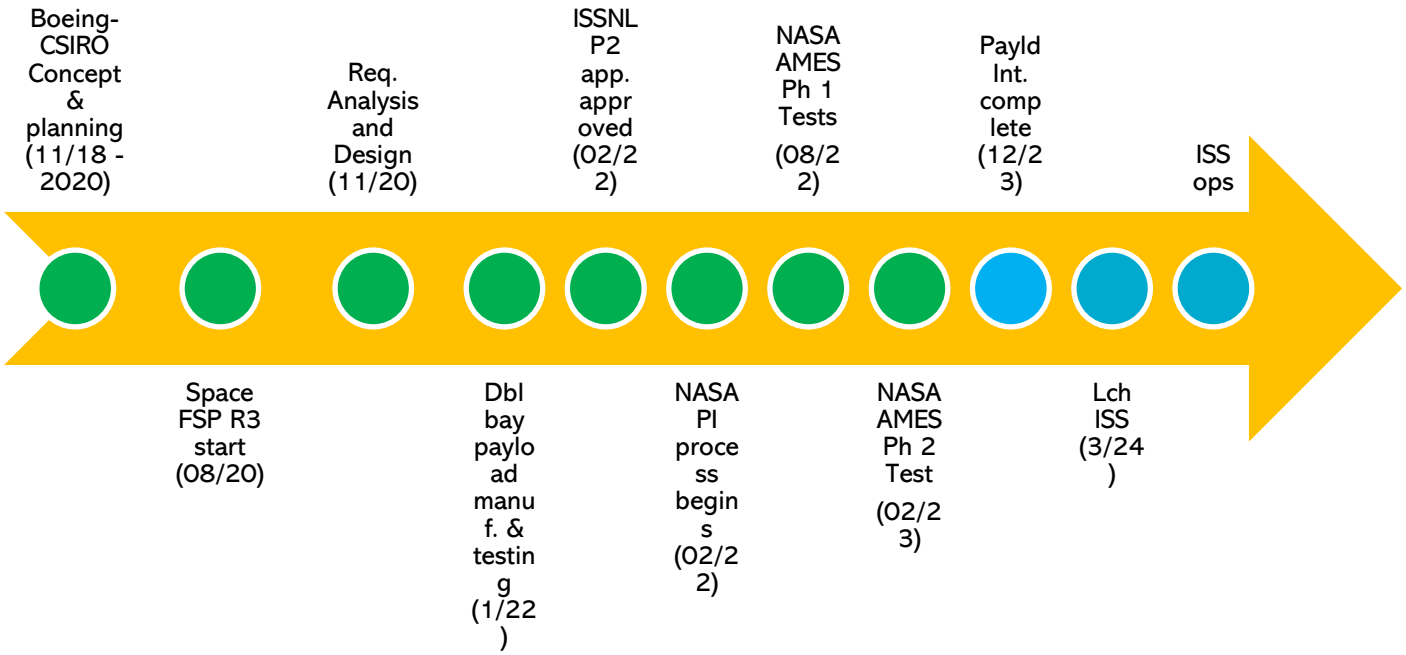
CSIRO

Next steps

- Phase 3 – final safety review and acceptance
- AMES testing & HFIT
- CONOPS finalisation

CSIRO

Timeline



CSIRO

Acknowledgements

- Special thanks to the entire NASA team including Jose Benevides, Jose Cortez, Cristian Garcia, Ruben Garcia, Jonathan Barlow, Simeon Kanis, Aric Katterhagen, Gerald Readore, Henry Orosco, Antonius Widjokongko, Tameka Stewart, Katrina Whitlock, Melissa Boyer, Larry Kim, Alla Shuhatovich

- 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

CSIRO

Thank you

Contact details:

Project Lead : Marc Elmouttie
Marc.elmouttie@csiro.au
PH: +61 7 3327 4775

Space Technology Future Science Platform Director: Kimberley Clayfield
kimberley.clayfield@csiro.au
PH: +61 7 3833 5927