



ISS Astrobees Facility

Sponsoring Org/Office Code: ISS Program, OZ3
Name of Forum: Astrobees Working Group June 2023
Date: June 1st, 2023



Jose V. Benavides
NASA Ames Research Center
Intelligent Systems Division (Code TI)
Henry Orosco
ISS Research Portfolio Manager



Purpose



- **Purpose:** Provide Astrobeer Facility overview, status and near-term plan
- **Select the appropriate box below:**
 - ☐ Request for Technical Concurrence
 - ☒ Information Only
 - ☐ Management Direction
 - ☐ Response to an Action Item
- **Agenda:**
 - Overview
 - Facility Status
 - Engineering
 - Operations



Agenda



Astrobee Working Group		Join by Teams Link:		https://teams.microsoft.com/l/meet	
Draft, Subject to change		Location: Phone, MS Teams, and NASA Johnson Space Center - ICF in-person			
Date:	Thursday, June 1st, 2023, 9am CT				
Agenda	Group	Sponsor	Project	Name	Time duration (min)
0	Badging		get badged at ICF *or* JSC Building 110	n/a	8:30 AM 0:30
0	NASA ISS		Introductions/Welcome	Henry Orosco	9:00 AM 0:05
1	NASA Astrobee	NASA TDO	NASA ISS Program TDO overview	Henry Orosco	9:05 AM 0:10
2	NASA ISS		Astrobee Facility Status	Jose Benavides	9:15 AM 0:20
3	NASA ISS TDO		Astrobee PIM Status	Cristian Garcia	9:35 AM 0:10
4	National Lab	Nat Lab	National Lab overview	Robbie Hampton/Hana	9:45 AM 0:05
5	NASA Ames	NASA STMD	ISAAC	Trey Smith	9:50 AM 0:10
6	NASA JSC	NASA AES	RFID-Recon	Andrew Chu	10:00 AM 0:05
7	Break		Break		10:05 AM 0:15
8	Astrobotic/Bosch	Nat Lab	Sound See	Sam/Charles	10:20 AM 0:15
9	JPL/USC	Nat Lab	Clingers	Dave Barnhart	10:35 AM 0:15
10	Zero G Horizons	Nat Lab	SOARS	Deepak	10:50 AM 0:15
11	Kall Morris Inc. (KMI)	Nat Lab	REACCH	Austin Morris	11:05 AM 0:10
12	ILC Inc./STEMX365/MIT	Nat Lab	Zero Robotics	Kathleen Magrane/Danielle Wood	11:15 AM 0:15
13	Stanford	NASA STMD	Gecko	Somrita Banerjee	11:30 AM 0:05
14	TBD				11:35 AM 0:15
15	Break/Lunch		Lunch *or* Limited Building-9 tour	Ernie Smith	11:50 AM 1:55
16	FIT	NASA STMD	SVGS	Hector Gutierrez	1:45 PM 0:15
17	NPS	DOD	Astrobatics	Jennifer/Marcello	2:00 PM 0:15
18	Metis	NASA SBIR	CoSLAM	Tom Zuales	2:15 PM 0:15
19	Picknik	NASA SBIR	Perception Framework	Sean	2:30 PM 0:15
20	Makel Engineering	NASA SBIR	EMMA	Darby Makel	2:45 PM 0:15
21	TRAC Labs, Inc.	NASA SBIR	PLUMMRS: A collection of Plan Ledgers and Unified Maps for Multi-Robot	Ana Quispe	3:00 PM 0:15
22	Orbit Fab	N/A	Docking-Refueling	Connor Geiman	3:15 PM 0:15
23	JAXA	JAXA	The 4th Kibo Robot Programming Challenge	Nakata Yui	3:30 PM 0:15
24	CSIRO/Boeing	Nat Lab	Multi-resolution Scanning	Marc Elmoultie	3:45 PM 0:15
25	Travel				4:00 PM 0:15
26	Group Visit to Space Center		Group Visit to Space Center	Cristian Garcia	4:15 PM 0:45
27	Travel				5:00 PM 1:00
28	Group Dinner		Group Dinner	Ernie Smith	6:00 PM



Overview



Project Description



Based at Nasa Ames Research Center, the ISS Astrobee Facility provides a free-flying robotic system for ISS research and ISS STEM outreach. The Astrobee free-flying robotic system consists of three cubed-shaped robots, software, and a docking station used for recharging. The project provides sustaining engineering tasks for ensuring the facility operational readiness on ISS. The project provides payload support to users from academia, private industry, NASA, and other government agencies in the execution of ISS approved research and STEM objectives.



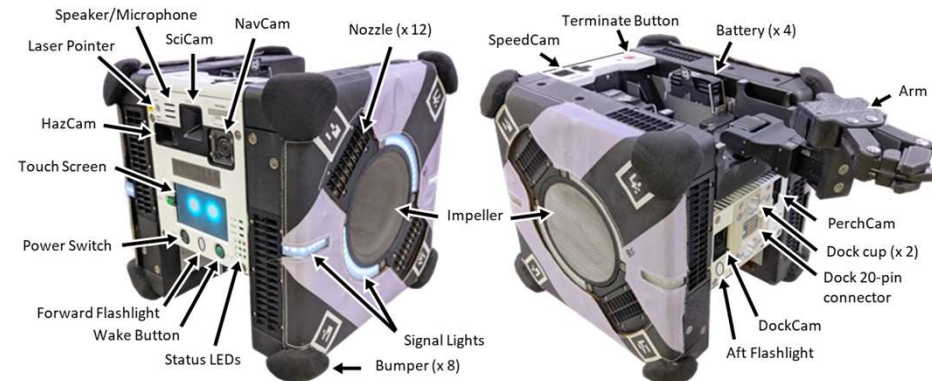
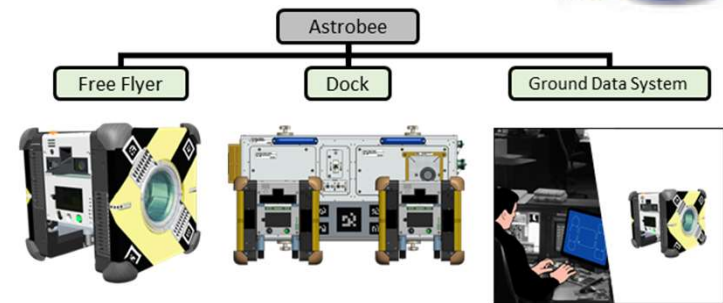
Chris Cassidy, GMT 248 2020



Astrobee Facility Overview



- Astrobee research platform ecosystem
 - Astrobee hardware: Ground and flight units
 - Ames Research Center Experimental Facilities
 - Astrobee Robot Software
 - Access to the International Space Station
- Support different research: Artificial Intelligence, manipulation, computer vision, Human Robotic Interactions, many, many other fields!





Astrobee Working Group Community



- Astrobee Working Group (AWG) meeting
 - Meet twice a year (ideally in-person)
 - Timed similarly to the POIWG conference
 - Next: Fall 2023
- Purpose:
 - Information sharing across the Astrobee community
 - Astrobee Facility shares status, updates, overall calendar
 - Discuss proposed changes/updates



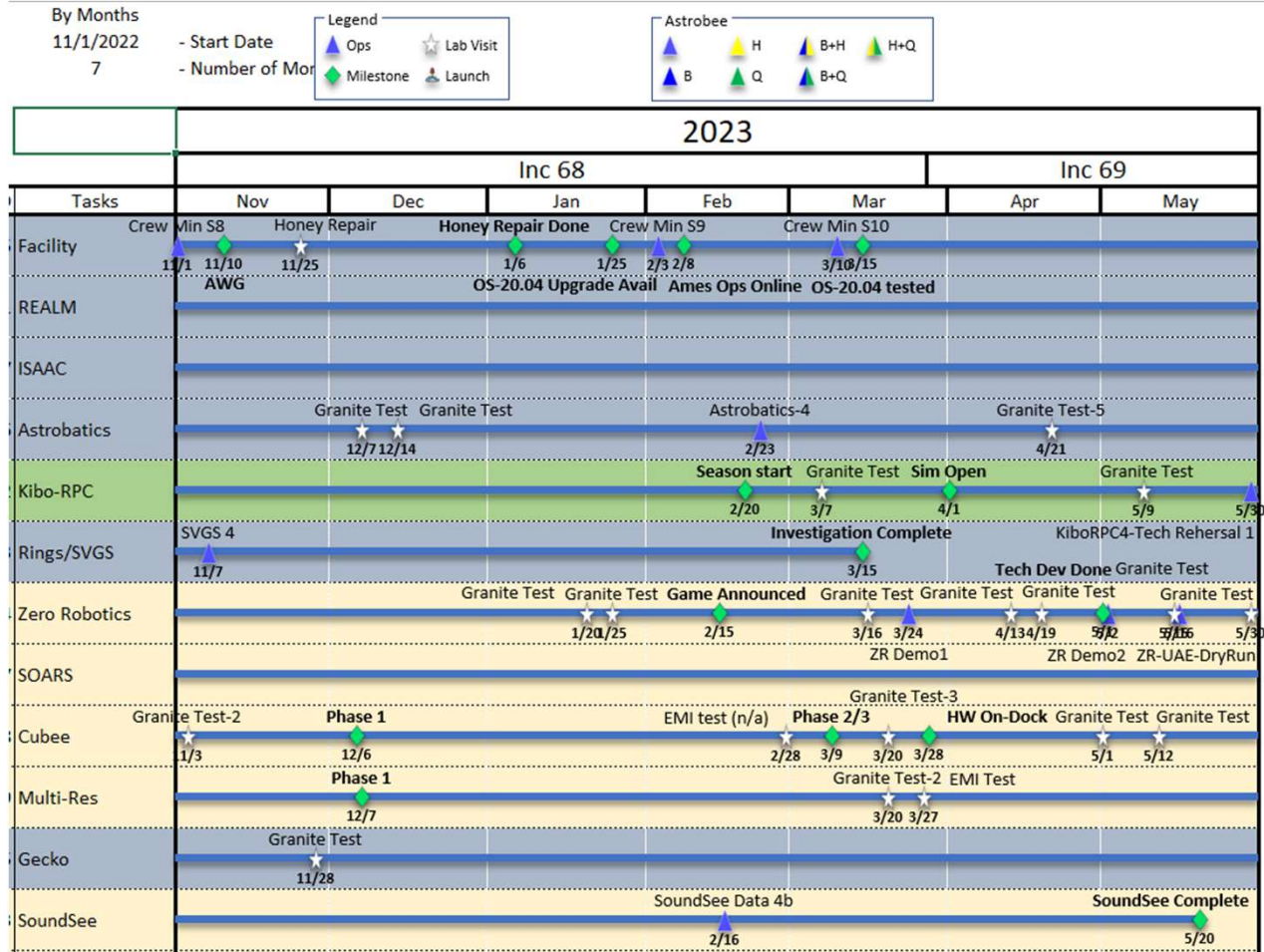
Pictures from last AWG



November 11th, 2022, Astrobee Working Group



Astrobee Summary since last AWG





By Months

4/1/2023

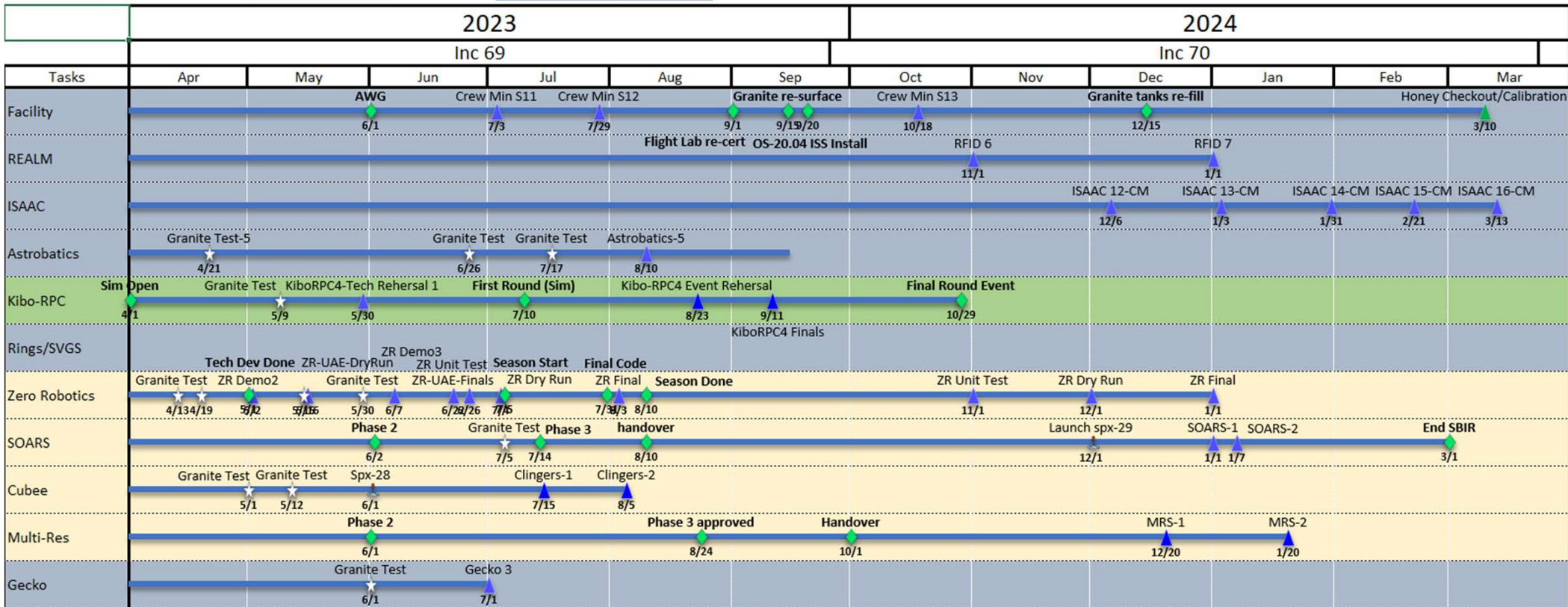
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- Start Date

- Number of Months



Astrobee 12-month forward plan





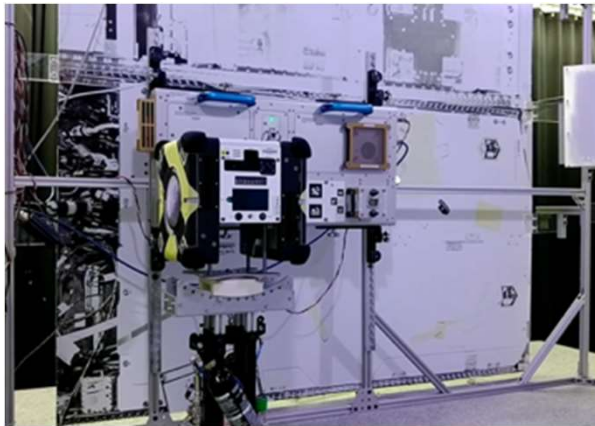
Facility Status



Hardware and Lab Status



- Granite Lab: Online



- Flight Lab: Online



- Engineering Evaluation Lab (EEL): Available upon request

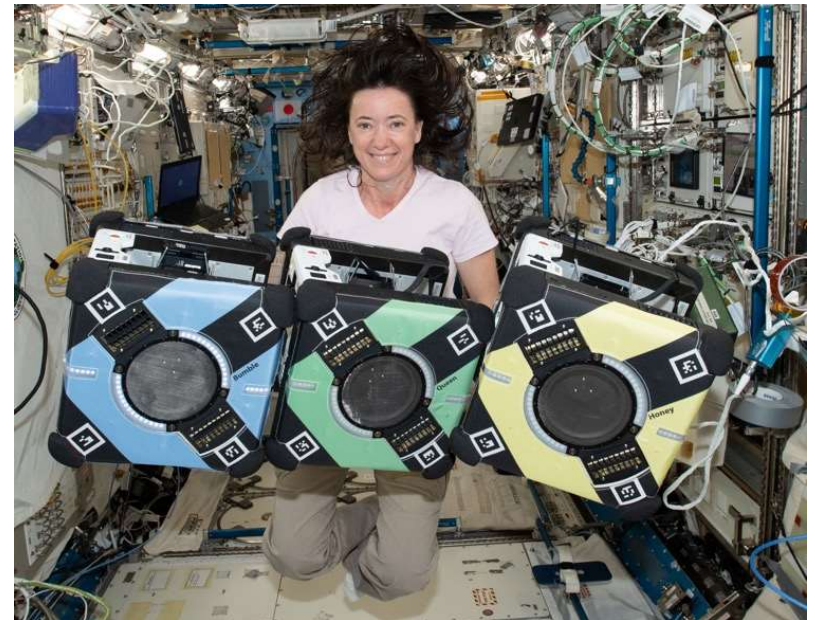
Name	Status
Flat Sat A	Operational
Flight 1 (Bumble), Flight 3 (Queen)	In Space, Operational
Flight 2 (Honey)	On Ground, Ready
Flight Spare	Operational
Cert (B#)	Operational
Ground (Wannabee)	Operational



Honey Repair



- SD card was configured
- New SD card replaced LLP, MLP, and HLP SD cards
 - Successful replacement of SD cards
- Performed (ground) Honey Checkout
 - Successful checkout complete
- Next Steps:
 - Ready to ship if needed anytime in the near future





Astrobee Ops Room



- Converted MGTF to Astrobee Ops room/ support ISS activities
- Replicate previous ops room(MMOC)
- Current status:
 - Computers are up and running
 - Running operations software
 - IVODs, VLC, Putty, HOSC VPN Client, etc.
 - Future work
 - Installing astrobee GDS, git repository
 - End to end testing

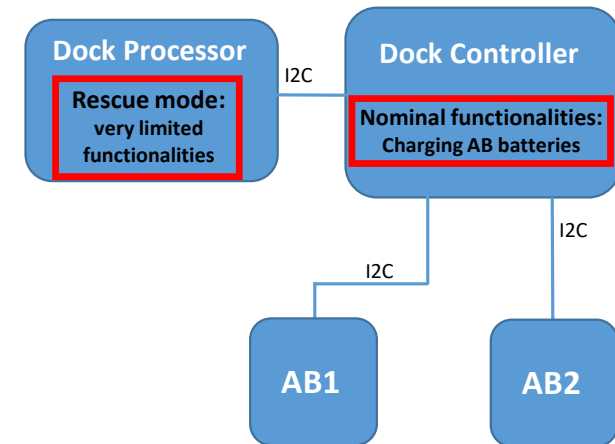




ISS Dock Station: Status



- On 10-11-22, during the prep activity for the Kibo RPC Finals 3, the dock processor presented multiple read-only errors.
- After crew performed a power cycle, the Dock Processor restarted into rescue mode.
- The Dock controller is unaffected – still able to charge Astrobee's batteries.
- Attempt to recover the Dock Processor remotely was unsuccessful.
- New, more robust SD cards are being setup and prepared for launch to replace the corrupted one on the Dock





Ubuntu 20.04 Transition



- Current status
 - All Ubuntu 20 images operational (root, rescue, custom)
 - All FSW products (Astrobee debians) ready for Ubuntu 20 armhf
 - First official FSW release supporting Ubuntu 20 armhf available (0.17.0)
 - FSW 0.17.0 installed to ground unit (wannabee) and tested since February 17th
- Next Steps
 - Continue image and FSW testing.
 - Documentation
 - Prepare deployment to ISS (procedures, testing, approvals)

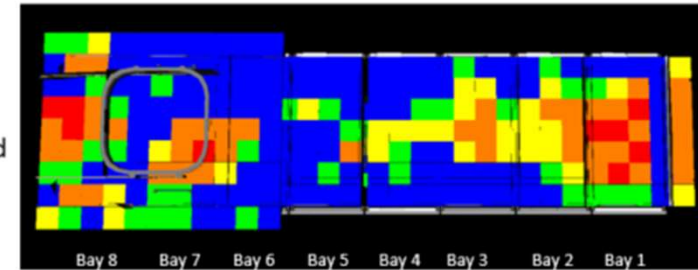


Coverage Analysis

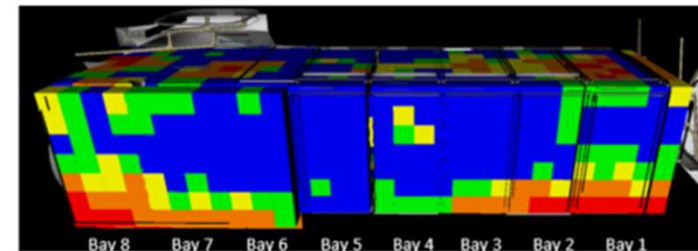
- Software tool helps visualize the coverage of a given map or Astrobees trajectory
- Coverage of a map: the number of ML features in a volume of 30cm^3 along an imaginary grid on the overhead, aft, forward, deck walls and the front of the airlock throughout the JEM
- Coverage of an Astrobees trajectory: the number of ML features the robot registered at a given pose of the trajectory.
- The more ML features, the more stable Astrobees localization will be.
- Three possible outputs:
 - 3D JEM heat map
 - 3D Astrobees trajectory heat map
 - PDF report

Color	ML features
Red	0
Orange	1-10
Yellow	11-20
Green	21-40
Blue	40+

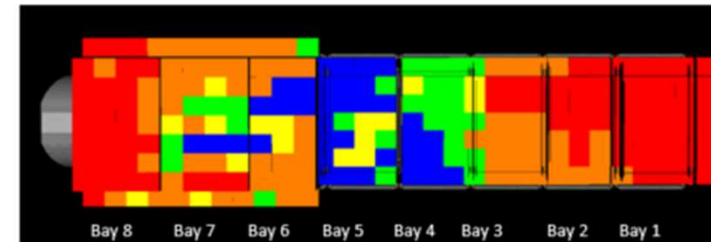
Overhead



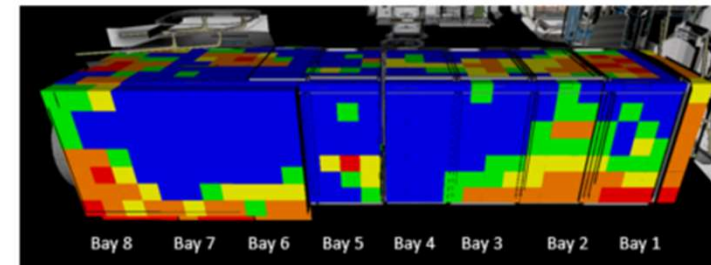
Aft



Deck



Forward

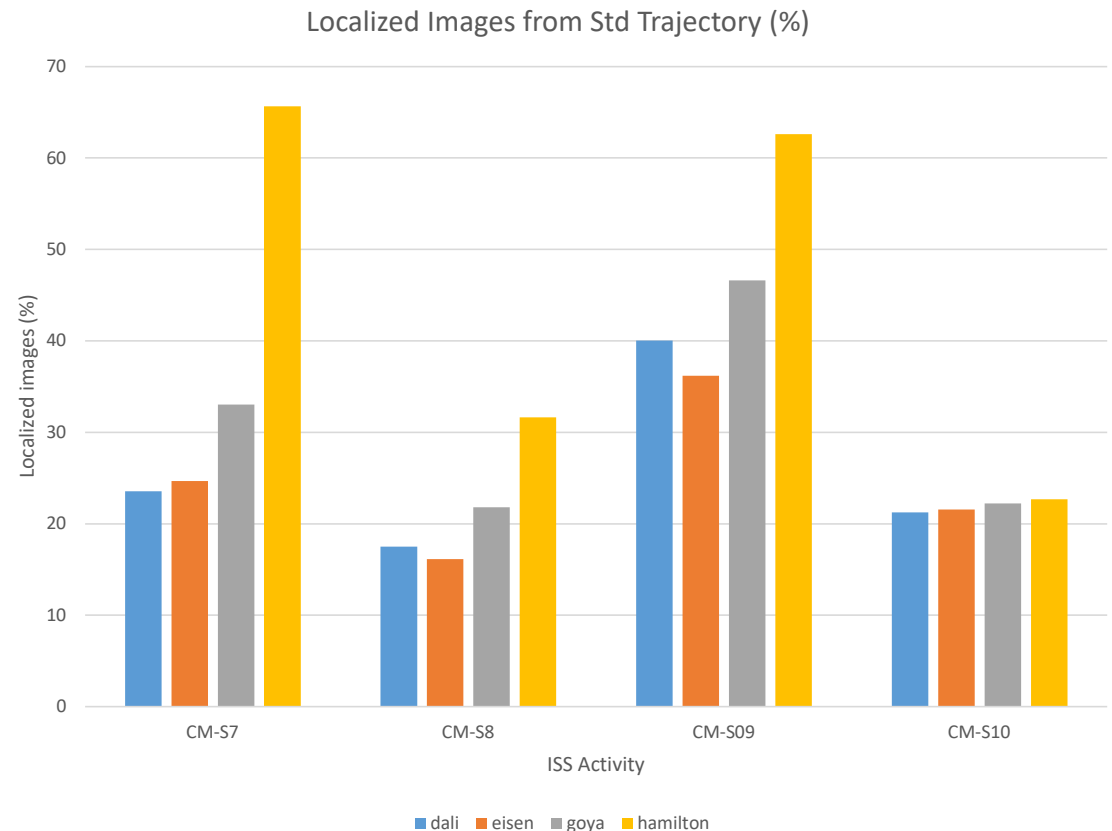




Map Update Decision Tool



- Astrobee Facility requires a method to determine when a new map or update should be done
- Standard Trajectory: Large image collection trajectory performed at every Crew Minimal activity.
- Only portion from dock to face airlock to move backwards to Bay 1.
- Historical data is compared across multiple maps
- When current map has $<10\%$ localized images than previous one, update/new map required





File Checksum



- Background:
 - On 05/02, an Astrobeer Facility error resulted in the installation of an outdated version of the APK.
 - The updated file had fixes implemented during granite lab testing of the previous APK.
 - About 15 minutes of testing time were used to diagnose and correct the issue.
- Process Change:
 - Previously checksums of files were requested from Guest Scientists as good practice
 - Checksums will now be required for all software deliveries
 - Checksums will be added as an item to review during the TRR



Operations: Functions

- Ensure Facility Readiness for ISS Test Sessions
 - All crew training is handled via Onboard Training (OBT).
 - Manage crew procedure and all planning products updates via OCR/ECR system
 - Coordinate crew time with ISS Lead Increment Scientist and POIC Cadre
 - Assist Astrobeer team & PDs in acquiring proper access to ops systems as required for real-time ops support
 - Coordinate with investigators for product development and delivery
 - Help investigators set up remote communication capabilities as needed
- Real-Time ISS Test Session support
 - Coordinate with MSFC and POIS (POIC Specialist) all deltas to real-time ops and products
 - Support crew & POIC cadre with real-time ops – plan and conduct crew conferences as needed
 - Coordinate commanding and data download window requirements and planning
 - Test session data and video management
 - Real-time commanding support
- Public Relations
 - Maintain website, work with ARC PAO office to publish material on site



Operations: Functions



- Increment Planning
 - 2-pager development and submittal, updates as needed throughout increment
 - Assist PIM (Payload Integration Manager) with CEF inputs as needed
 - Regular timeline planning with Lead PPM (Payload Planning Manager), PPM planning team and MSFC POIS/PARC team
- Safety and Verification Assessments
 - Integrated Safety & Verification Assessments as needed for Astrobee Facility and Guest Science Payload Developers (PDs)
 - Continued SPHERES Safety & Verification focuses on return of hardware.
 - Complete CoFR (Certification of Flight Readiness) for ground systems and on-orbit hardware and operations products
- Astrobee Ground Ops Development
 - Coordinate ground Engineering and Operations Readiness Tests (ERTs/ORTs) in preparation for real-time ops
 - Work with Astrobee team and PDs to develop flight procedures, coordinate reviews with MSFC for final delivery and formal ECR review



Ops Stats



- **From the last AWG (11.10.22) to date**
 - 8 Test Sessions over 33 weeks (1+ Test Session/month)
 - 3 unique crew (~9 crew hours total)
 - ~70 real-time console ops hours (not including data downloading etc.)
- **Fiscal year (Oct 2022 through May 2023) to date**
 - 12 Test Sessions (1.5 Test Sessions/month)
 - 5 unique crew (~20 crew hours total)
 - ~90 real-time console ops hours (not including data downloading etc.)
- **From 4/30/20 (our first remote ops Test Session) to date**
 - 97 (of 139 total – 70%) remote Test Sessions (2.6 remote Test Sessions/month)
 - 23 unique crew (~200 crew hours total)
 - ~800 real-time console ops hours (not including data downloading etc.)
- **From Dock Install and Checkout (February 11, 2019) to date**
 - 139 Test Sessions (2.7 Test Sessions/month)
 - 29 unique crew (~230 crew hours total)
 - ~1000 real-time console ops hours (not including data downloading etc.)



On-Orbit Activities (since 11.10.22)



AB132: Crew Minimal S9	February 3, 2023
AB133: SoundSee Science 4 Repeat	February 16
AB134: Astrobatics Science 4	February 23
AB135: Crew Minimal S10	March 10
AB136: Zero Robotics Tech Demo 1	March 24
AB137: Zero Robotics Tech Demo 2	May 2
AB138: UAE Zero Robotics Dry Run	May 16
AB139: Kibo RPC4 Technical Rehearsal 1	May 30



Ops Deliverables/Planning – MSFC



Milestone	Deadline
PD inputs (procedures, planning products, Flight Rules, PL Regs)	L-12 weeks Launch Date/Vehicle (T)
Pre-ECR Submit	Count back from ECR submittal, depending on 1 or 2 week ECR review
ECR Submit	L-6 weeks (for 2-week Impact review) L-5 weeks (for 1-week review)
Team ECR Review	L-4 weeks (week prior to IMEP with at least 2 days for comment verification)
Board at IMEP (Mondays)	L-3 weeks (or Ops-3 weeks)
PL Reg/Flight Rule/OBT/Phase III Self Study Baseline	Ops-1 week Note: more commonly, Self Study is baselined same time as crew procedures



Ops Deliverables/Planning – Astrobees Internal



Milestone	Nominal
ISS OPS (ERD+>1week)	ERD = MSFC Baseline of Ops/Flight Products
Estimated Readiness Date (ERD)	Launch Date/Vehicle (T)
Paper SIM (pre-ECR)	ERD - 7 weeks
Paper SIM if needed (pre-OCR)	ISS OPS - 3 week
PD connectivity test complete	ISS OPS - 2 weeks
PD software delivery (APK, Debian(s), etc.)	ISS OPS - 2 weeks
Ground procedure complete	ISS OPS - 2 weeks
Rehearsal ORT (Operations Readiness Test)	ISS OPS - 1 week
TRR (Test Readiness Review)	ISS OPS - 1-4 days
ARC completes working draft of Ops Products	ERD - 6 weeks
PD submission of planning inputs	ERD - 10 weeks
OPS Products Updates	ISS OPS - 2 weeks
Software (list needed for OCR)	ISS OPS - 2 weeks



Crew Procedures & Safety Status



SAFETY

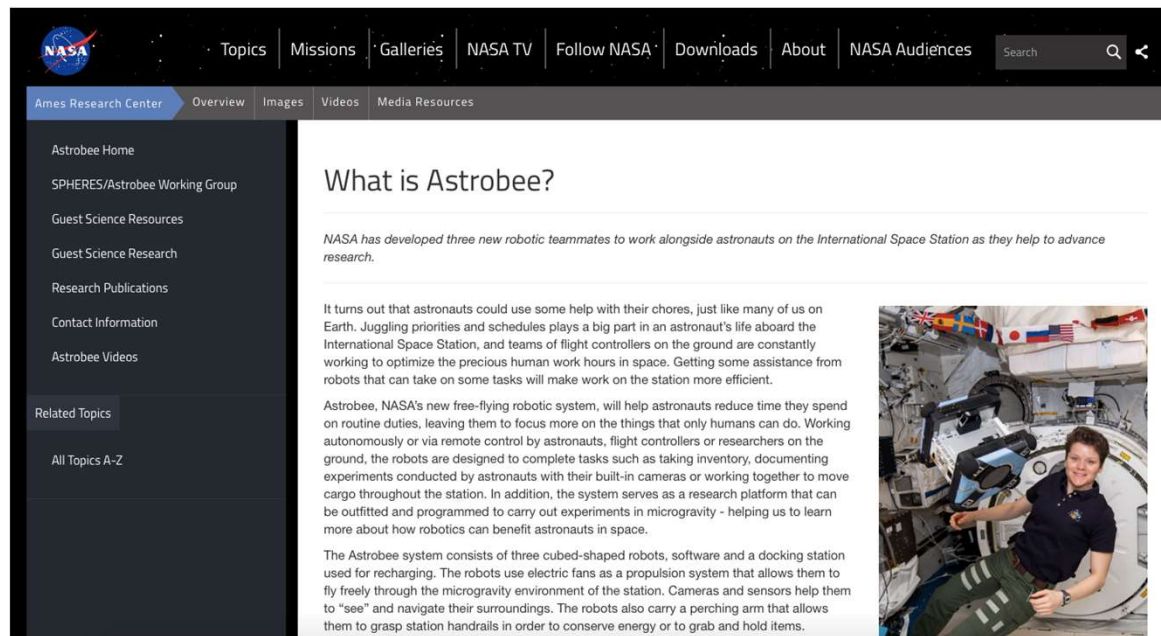
- Integrated Safety Data Package for Astrobee-Clingers – Submitted 2023-02-08

CREW PROCEDURES

- **Baselined**
 - Astrobatix - Science 4
 - SoundSee - Data Collection 4 [Repeat]
 - Zero Robotics - Tech Demo 1 and Tech Demo 2
 - JAXAs Kibo RPC-4 Tech Rehearsal 1
 - Review of crew procedure developed by JAXA
- **Ready for ECR process for baseline**
 - Clingers (crew procedures for main activity and software upload)
- **Updated**
 - Astrobee Perching Arm Installation
 - Astrobee Perching Arm REMOVAL
 - Astrobee Free Flyer Power On
 - Astrobee Free Flyer Power On with No Dock Power Cycle
 - Astrobee JEM Prep
- **Upcoming**
 - Astrobatix Science 5



Astrobee on Social Media



We are in the process of transitioning to a new Content Management System which will result to new Astrobee webpage layouts by the end of July 2023.

Website

<http://www.nasa.gov/astrobee>



QUESTIONS?



On Break, back at 01:05pm PST