

Astrobee System Overview

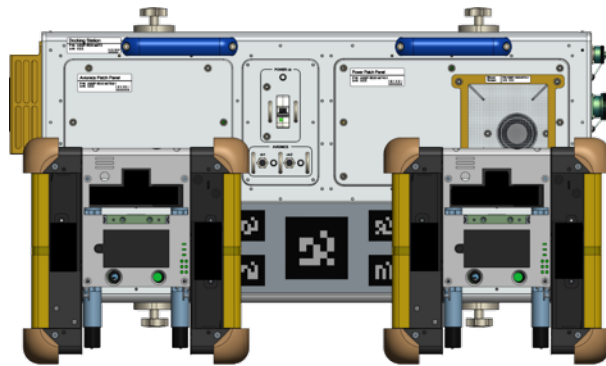
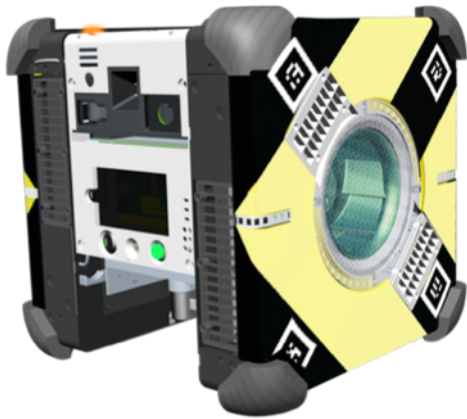
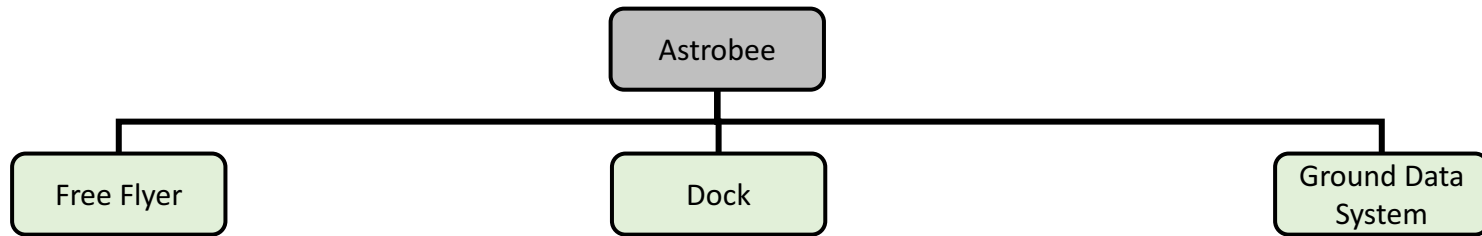


SPHERES/Astrobee Working Group

November 30, 2017

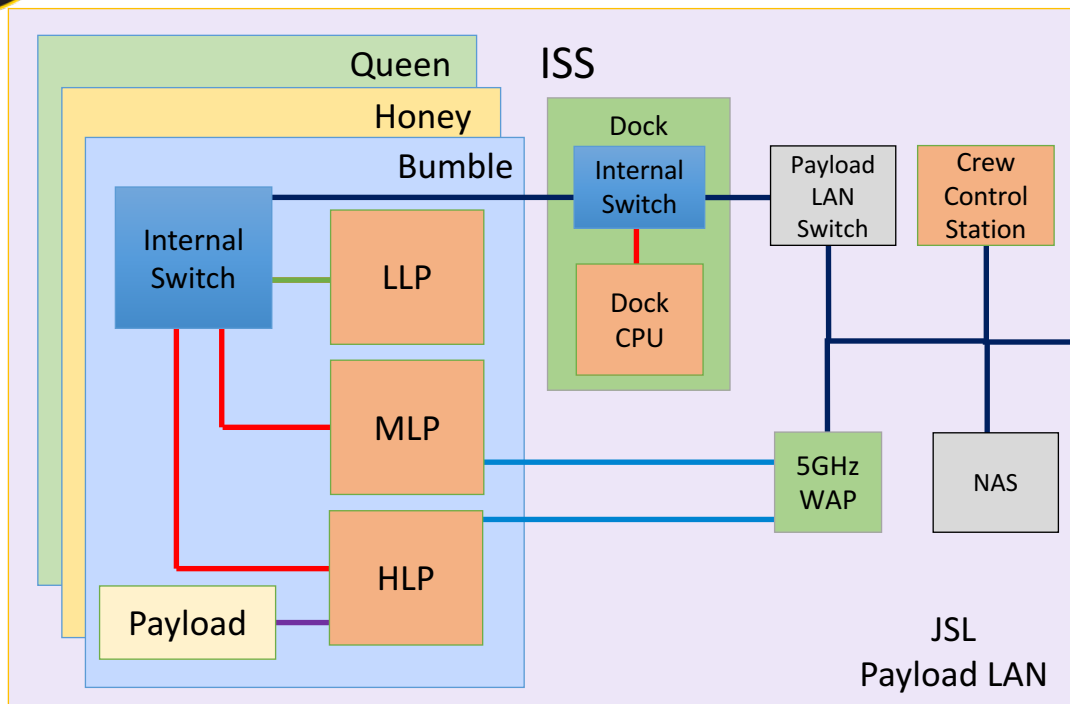


Astrobee Elements





System Data Flow Diagram



Link Legend

Ethernet/LAN

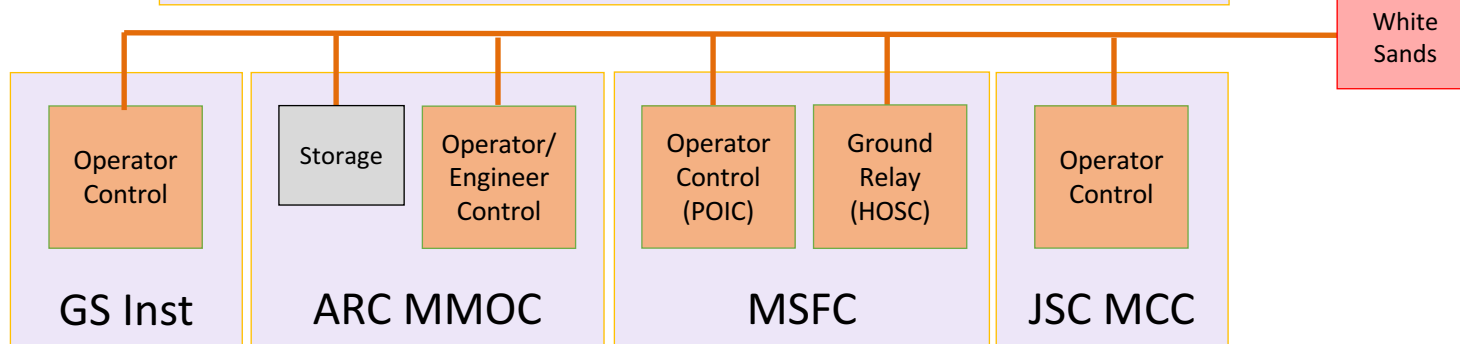
Ethernet:
Internal IP

Ethernet:
Internal and
Payload LAN

WiFi:
Payload LAN

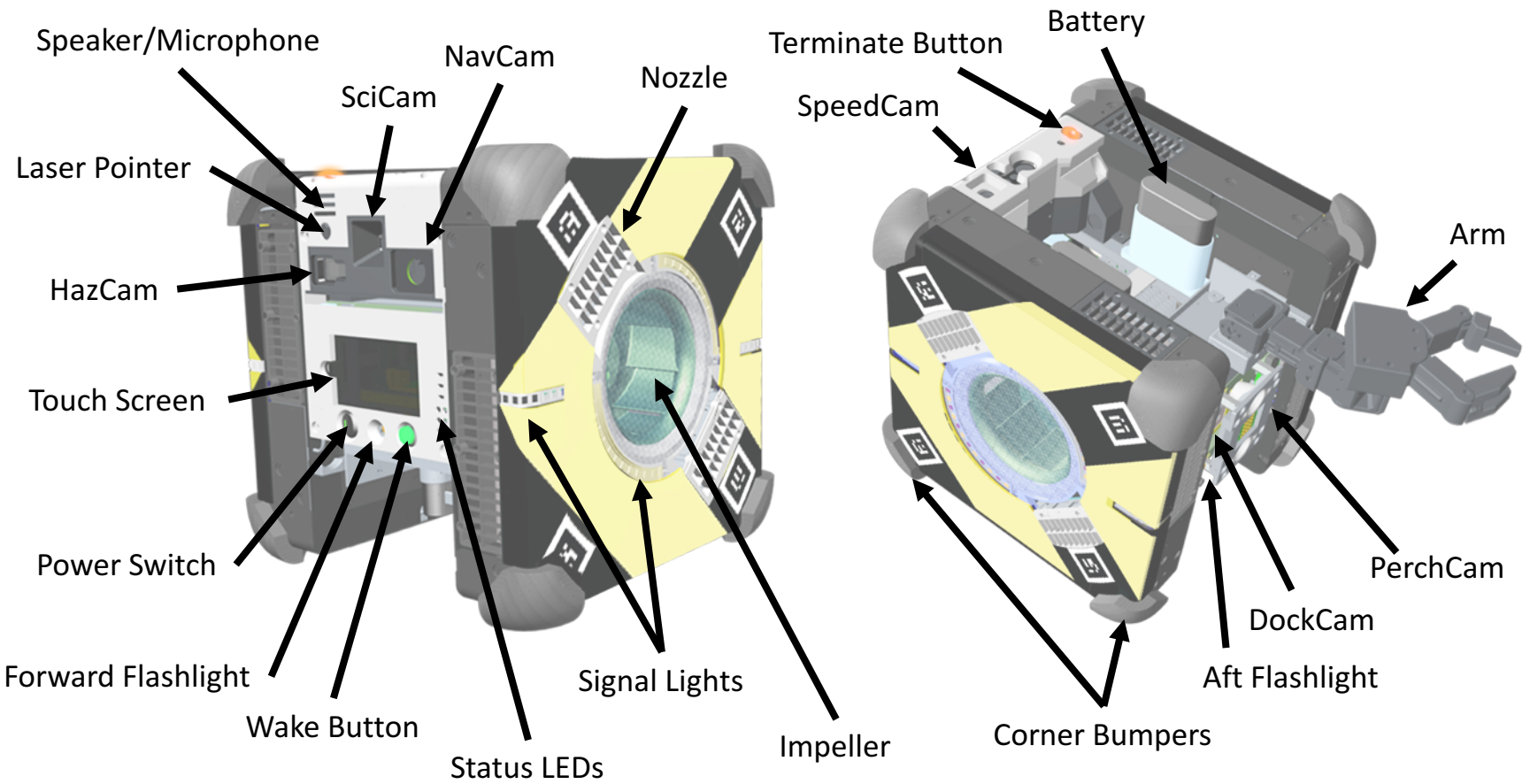
USB

Other/LAN





Astrobee

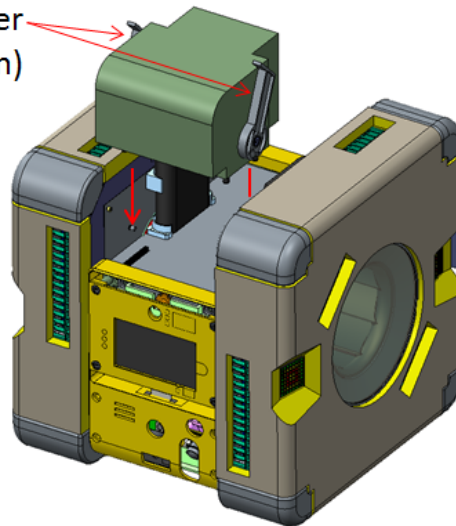




Payload Attachment Options

Quick "No Tool" Payload Attachment

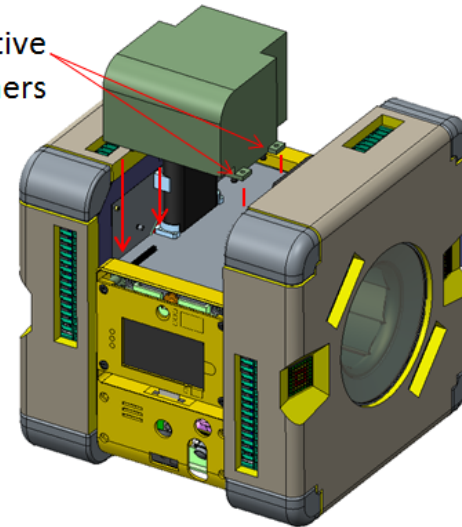
2X Lever
(open position)



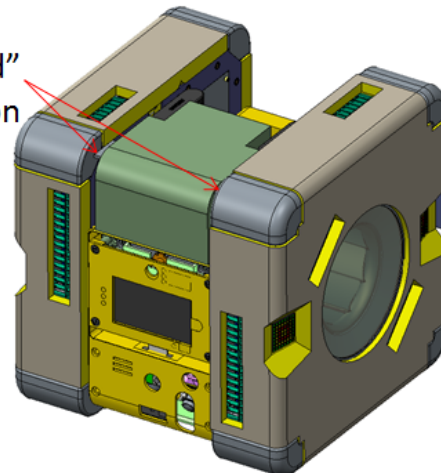
Lever engages and disengages payload connector and provides mechanical attachment

4X Fastener Payload Attachment

4X Captive Fasteners

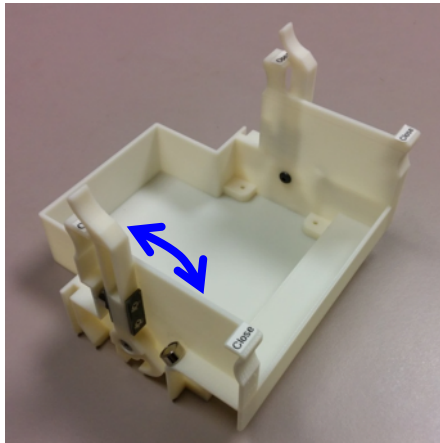


Lever in "Locked" position

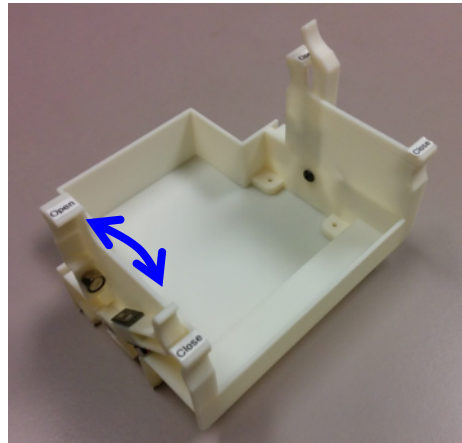




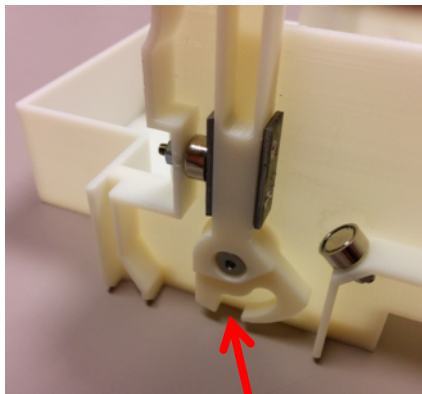
Quick-Release Mechanism Prototype



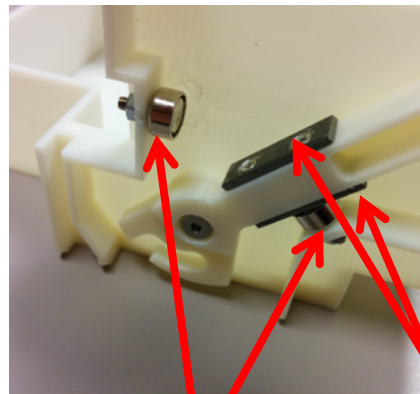
Open Position



Closed Position



Clevis Slot



Magnets

Steel Striker Plates

- Mechanism shown will be part of the payload reference design (payload developers are encouraged to use)
- This mechanism is part of Astrobee's baseline perching arm, which can be swapped with a payload
- Clevis slot engages with a simple fixed clevis in the payload bay, pulling the payload down into a tight fit
- Levers can be actuated individually with one-handed pinch motion (crew human factors)
- Lever actuation will also mate/demate avionics connector (not shown)
- To enable rapid payload development, mechanism is designed to be 3D printed in ISS-compatible Ultem material, supplemented with small COTS hardware items (magnets, plates, screws, etc.)



Dock

Air Vent Deflector

Subsystem Breakers

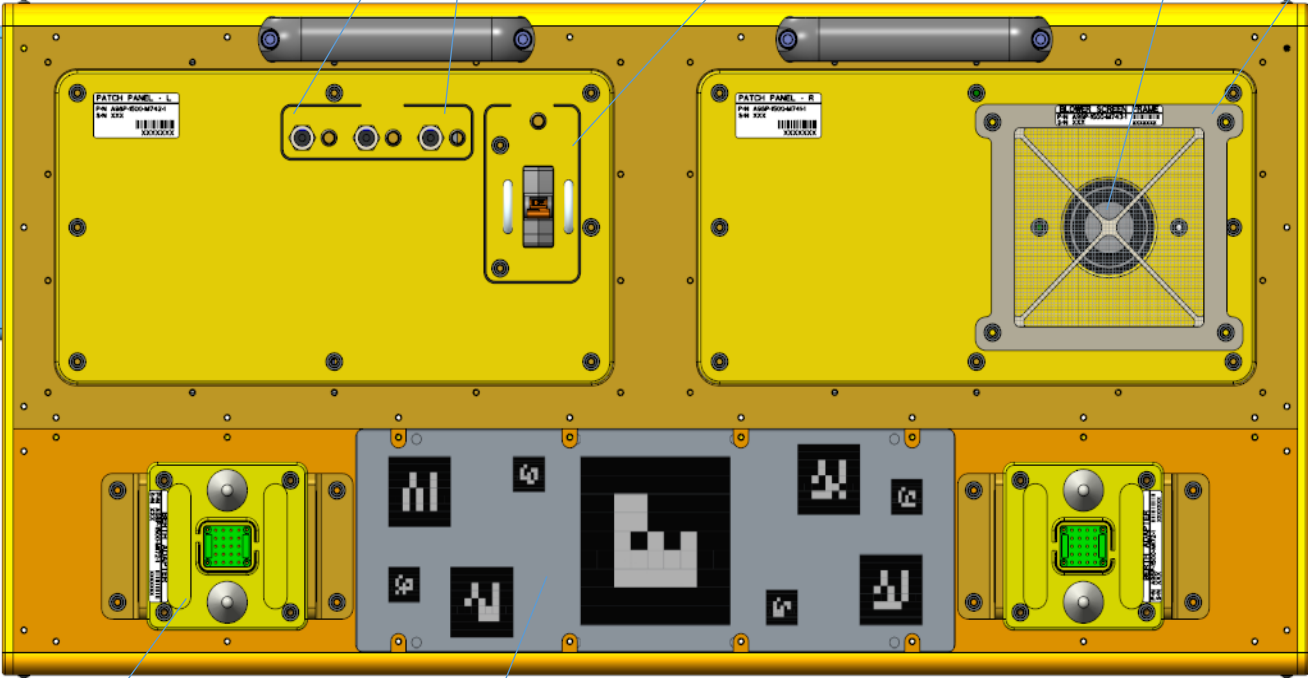
Main Power Breaker

Cooling Fan

Cooling Fan Screen

RJ-45 Connector

Power Connector



Free Flyer Berth

AR Target



Plan Editor Tab (Operator/Engineering)

File Edit View Modeling Help
Plan Editor Run Plan Teleoperation

GPS 15Jun16 20:36:18

Plan Editor

Plan Name BB
Estimated Duration 00:16:34
Validation Validated Validate

Plan Step	Duration
BB	
0 Station	
0-1 Segment	00:01:14
1 Station	
1-2 Segment	00:02:06
2 Station	
2-3 Segment	00:02:06
3 Station	
3-4 Segment	00:02:06
4 Station	
4-5 Segment	00:02:06
5 Station	
5-6 Segment	00:02:06
6 Station	
6-7 Segment	00:02:06
7 Station	
7-8 Segment	00:02:06
8 Station	
8-9 Segment	00:02:48

Add Delete Add via 3d View

2 Station

Location Based Coordinate Based Bookmarks Commands

Module Node 2
Bay 2
Offset Wall 1 Center Deck 0.2
Offset Wall 2 Center
Orientation N/A Forward

00:00:00 Message goes here

Log Help Exit

Interactive Plan Viewer Reset View

Plan info

List view of Plan

Element editor



Run Plan Tab (All)

File Edit View Help
Run Plan | Teleoperation | Guest Science

FreeFlyerA Comm ● Control DW@DW-Windows7-32 Batt 1 Docking Station ● GPS 11Jan17 18:19:32

Health and Status Details

Operating State	Ready
Mobility State	Stopped
Operating Limits	Default_Safeguard
Plan	ExamplePlan
Plan Status	Paused

Initialization

Wake

Grab Control

Robot Commanding

File ... C:\Users\DW\Desktop\FPlans\ExamplePlan.fplan

Plan Valid

Load Run Skip Step

Description
A plan that goes in a spiral.

Plan

Total Elapsed Time 00:00:00

Plan Step	Duration	Success
ExamplePlan		
0 Station		
0-1 Segment		
1 Station		
1-2 Segment		
2 Station		
2-3 Segment		
3 Station		
3-4 Segment		
4 Station		
4-5 Segment		
5 Station		

11/30/2017

Live Telemetry | Live Images | Science Camera

Reset View
Center on Bee

Select valid plan and upload to Astrobee

List view of loaded plan

Model of loaded plan



Teleoperation Tab (All)

The screenshot shows the teleoperation interface for the Astrobee robot. The interface is divided into several sections:

- Health and Status:** A table showing the robot's current state.

Operating State	Ready
Mobility State	Stopped
Operating Limits	Default_Safeguard
Plan	
Plan Status	Idle
- Manual Commanding:** A section for manual control, including:
 - Initialization:** Buttons for 'Wake' and 'Grab Control', and a dropdown for 'No Bookmark Selected'.
 - Manual Inputs:** A grid of sliders for movement parameters: Aft (0.5), Fwd, Port (-0.5), Stbd, Ovhd (0.0), Deck, Roll (-0.0), Pitch (-0.0), and Yaw (-45.0). A red box highlights this section with the annotation 'Construct movement command'.
 - Options:** Buttons for 'Allow Lateral Motion', 'Override Obstacles', and 'Override Keepouts'. A red box highlights this section with the annotation 'Adjust settings'.
 - Commands:** Buttons for 'Move' and 'Stop'. A red arrow points to the 'Move' button with the annotation 'Send movement command'.
- Configurable Teleop Commands:** A section on the left with buttons for 'Open', 'Idle', 'On', 'Set', and 'Send'. A red box highlights this section with the annotation 'Buttons here can be changed via config file'.
- Live Telemetry:** A 3D view of the robot in a simulated environment with various lab stations (LAB1S1-LAB1S5, LAB1D1-LAB1D3). A red box highlights the robot's position with the annotation 'Drag preview to adjust movement command'.

At the bottom left, the text '11/30/2017' is visible. At the bottom right, the text 'SPHERES/Astrobee Working Group' and '10' are visible.



Guest Science Tab (Crew)

Crew Control Station

File Edit View Help

Run Plan Teleoperation Guest Science

Docking Station ● GPS 17Jan17 18:44:47

Astrobee Selection and Status

Control	Batt	Summary	Plan	Plan Status	Health
<input type="checkbox"/> FreeFlyerA	nobody	85		Idle	●
<input checked="" type="checkbox"/> FreeFlyerB	DW@DW-Windows7-32	85		Idle	●
<input type="checkbox"/> FreeFlyerC					●

Checkboxes select Astrobees to command

Status summaries

Names of loaded Plans

Details

Commanding for FreeFlyerB

Wake Grab Control

Plans

Load

Run Stop

Manual Commanding

Guest Science Command

Send Command

11/30/2017

Command Astrobees

Live Telemetry Live Images Science Camera

Monitor Astrobee positions in 3D window

SPHERES/Astrobee Working Group

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Advanced Guest Science Tab

(Operator/Engineering)

Plan Editor | Run Plan | Teleoperation | Guest Science | **Advanced Guest Science** | Advanced | Advanced 2 | Modeling | Debugging

Station ● GPS 18Jan17 20:00:58

Select APK to see Status

Astrobee Selection and Status

Control	Batt	Summary	Plan	Plan Status	Plan Step	APK	APK Status	Health
<input checked="" type="checkbox"/> FreeFlyerA	DW@DW-Windows7-32	85	Starter1	Idle	2 Station	Geiger Counter	Running	●
<input checked="" type="checkbox"/> FreeFlyerB	DW@DW-Windows7-32	85	TestPlan	Idle	7 Station	Grappling Hook	Running	●
<input type="checkbox"/> FreeFlyerC	100							●

Details

Commanding for FreeFlyerA, FreeFlyerB

Plans

APKs

Manual Commanding

APK

Command

Send Command

Start and Stop APKs directly

Preview and change APK command before sending

Live Telemetry | Live Images | Science Camera | **Guest Science Telemetry**

AstrobeeA

APK	STATUS
Turbo	Idle
Grappling Hook	Idle
Geiger Counter	Running

APK	Topic	Label	Value
Geiger Counter	Astrobe...	Status	"Off"
Geiger Counter	Astrobe...	Summary	"Nominal"
Geiger Counter	Astrobe...	Data	25

AstrobeeB

APK	STATUS
Turbo	Idle
Grappling Hook	Running
Geiger Counter	Idle

APK	Topic	Label	Value
Grappling Hook	Astrobe...	Status	"Off"
Grappling Hook	Astrobe...	Summary	"Nominal"
Grappling Hook	Astrobe...	Data	25

View detailed telemetry from APKs



Advanced Tab (Engineering)

Astrobe Engineering Workbench

File Edit View Modeling Help

Plan Editor Run Plan Teleoperation Guest Science Advanced Guest Science Advanced Advanced 2 Modeling Debugging

FreeFlyerA Comm Control nobody Batt 11

Docking Station GPS 18Jan17 18:23:54

Detailed Health and Status

Disabled Subsystems	Subsystem A, Subsystem C
Control	nobody
Operating State	Ready
Raw Mobility State	Stopping
Sub Mobility State	0
Operating Limits	Default_Safeguard
Plan	
Plan Status	Idle
Temperature	-
Arm Mobility	-
Arm Gripper	-

Detailed Health and Status

FreeFlyerA Operating Limits

Select Operating Limits Configuration ...

Configure Data

Name	Value	Units
Profile Name	Default	
Flight Mode	Default	
Target Linear Velocity	1.0	m/s
Target Linear Accel	1.0	m/s/s
Target Angular Velocity	1.0	rad/s
Target Angular Accel	1.0	rad/s/s
Collision Distance	1.0	m
Check Obstacles	true	
Check Keepouts	true	

View and change Operating Limits

FreeFlyerA Data to GDS 2

Telemetry	Current Freq (Hz)	Change to (Hz)
position	5	5 Set
ekfState	7	5 Set
commStatus	8	5 Set
diskState	17	5 Set

Configure telemetry sent to Control Station

Camera	Streaming	Resolution	FPS	Bandwidth
science	No	640_480	640_480	0.0 0.0 0.0 0.0 Set
navigation				0.0 0.0 Set
hazard	No	640_480	640_480	0.0 0.0 0.0 0.0 Set

Fault ID

Fault ID	Description	Subsystem	Node
Triggered			
120	SciCam is inoperable	Subsystem A	Node 2
127	Fuse is broken	Subsystem C	Node 3
Not Triggered			
100	Processor overheated	Subsystem A	Node 1
201	Arm Overcurrent	Subsystem B	Node 3

Triggered and Not Triggered Faults

FreeFlyerA Power State

Battery Total 1

Voltage 2

Current 2

Battery	Present	Voltage	Current
Batt 1	No	-	-
Batt 2	No	-	-
Batt 3	Yes	32	16
Batt 4	No	-	-
Batt 5	Yes	91	30
Batt 6	Yes	73	10
Batt 7	No	-	-

Detailed battery status

FreeFlyerA Data to Disk

Download Data Stop Data Download Clear Data

Disk	Data Size (GB)	Disk Size (GB)
Disk A	0.000002	0.000002
Disk B	0.000003	0.000003
Disk C	0.000003	
Disk D	0.000003	
Disk E	0.000005	
Disk F	0.000006	
Disk G	0.000005	

Disk usage

FreeFlyerA Component States

Component	Present	Powered	Temp (C)	Current (A)
HLP	Yes	No	33	-1.458
MLP	Yes	Yes	112	2.107
LLP	Yes	No		
Fan1	Yes	No		
Fan2	No	No		
Cam1	No	No		
Cam2	Yes	No		
Cam3	Yes	No		

Detailed component status

Topic	Downlink	Freq (Hz)
RosTopic0	Immediate	5.0
RosTopic1	Immediate	5.0
RosTopic2	Immediate	5.0
RosTopic3	Delayed	10.0
RosTopic4	Delayed	
RosTopic5	Delayed	
RosTopic6	Delayed	

View and configure data saved to disk

Message 11/30/2017

Select a fault to view message.

00:00:00 Message goes here

SPHERES/Astrobee Working Group



Astrobee Status

- Drawings complete
- Available to Guest Scientists:
 - Beta release of Flight Software/Simulator
 - Mechanical Payload ICD drawings
 - Initial draft of the Guest Science Guide
- Finalizing procurement
- Integration begins December 19th
- On-dock (hardware delivery) date April 4, 2018