Ames Research Center

Eclipse of the Floating Orbs

Controlling Robots on the International Space Station

DW Wheeler

Intelligent Robotics Group

Converge – March 20, 2017

irg.arc.nasa.gov

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- Astrobee
- The Astrobee Control Station
  - Plan Editor
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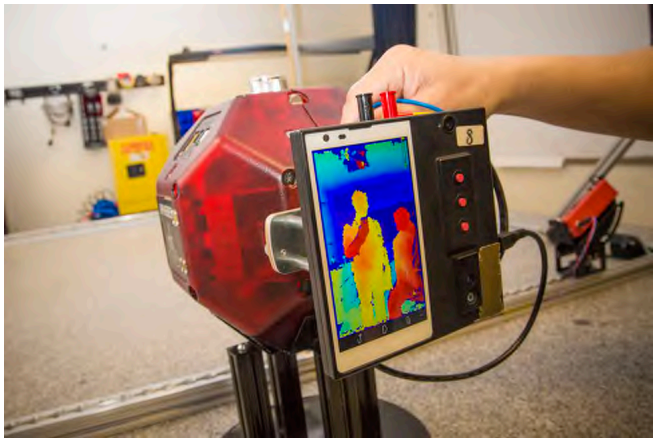
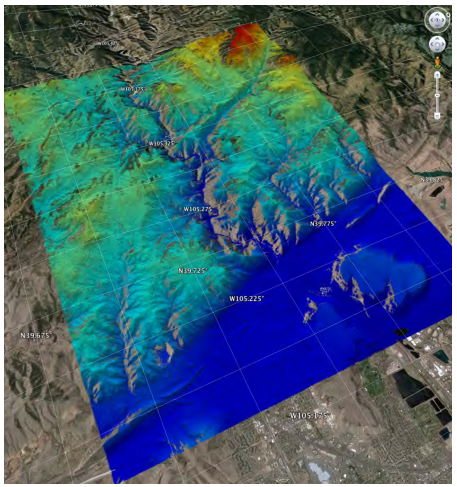
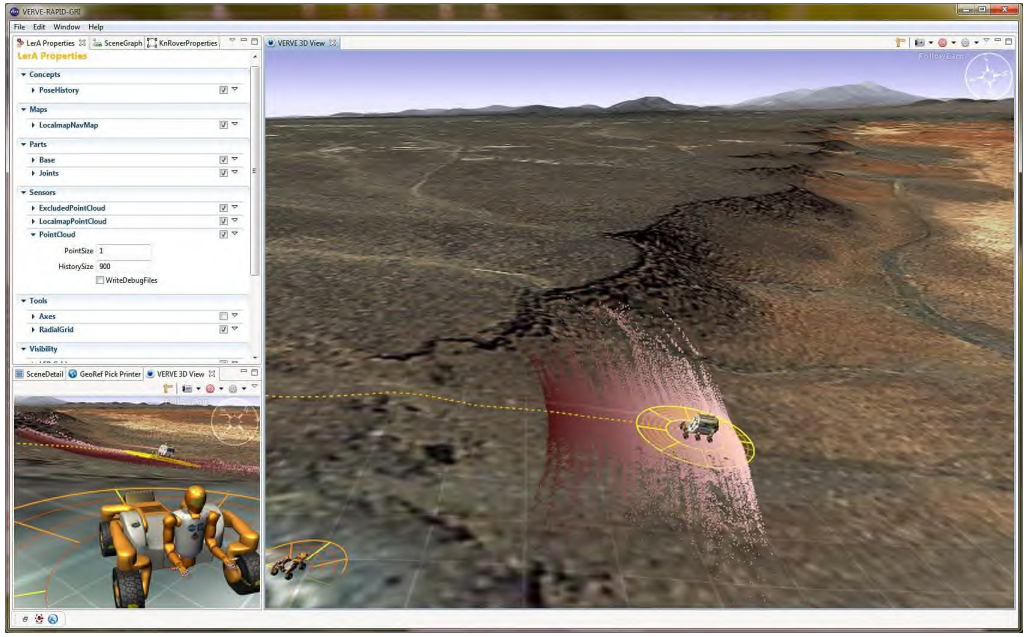
Intelligent Robotics Group



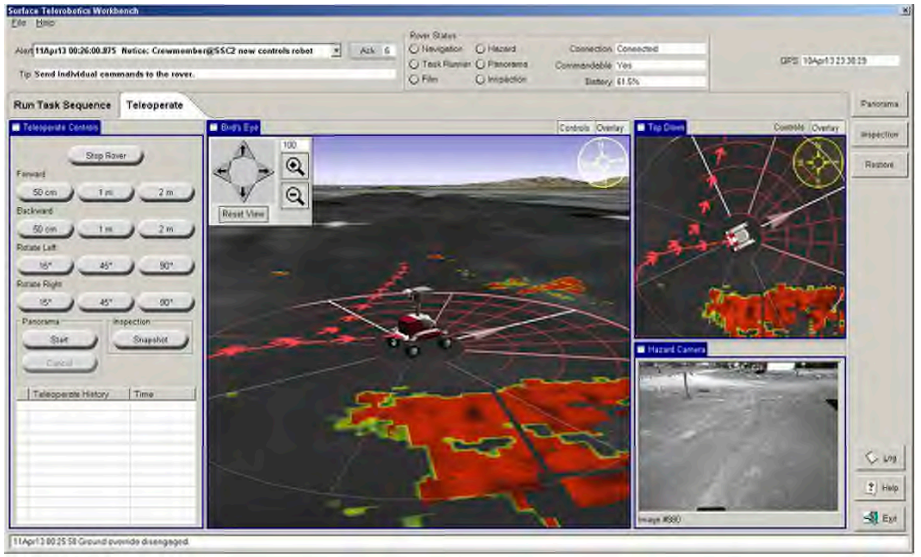


Visual Environment for Remote Virtual Exploration



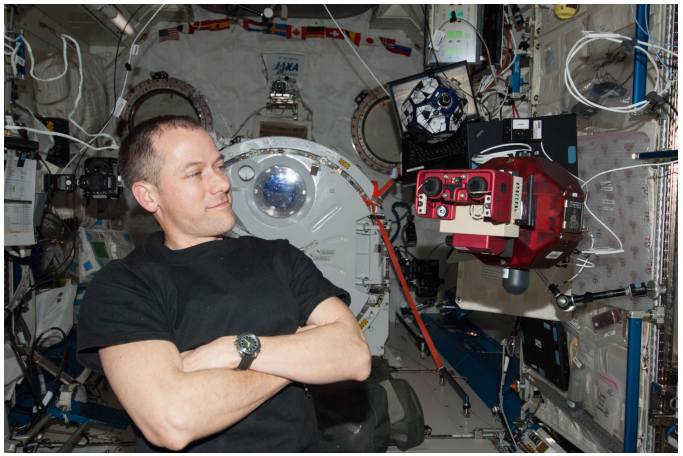
VERVE on ISS

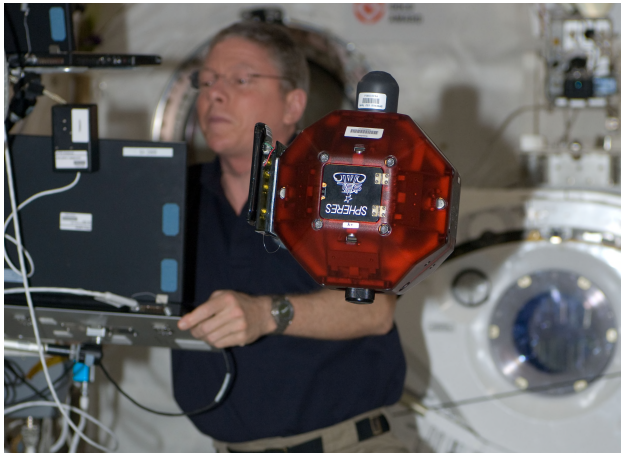

esa


Surface Telerobotics Workbench
Run Task Sequence
Teleoperate
Stop Rover
Reset View

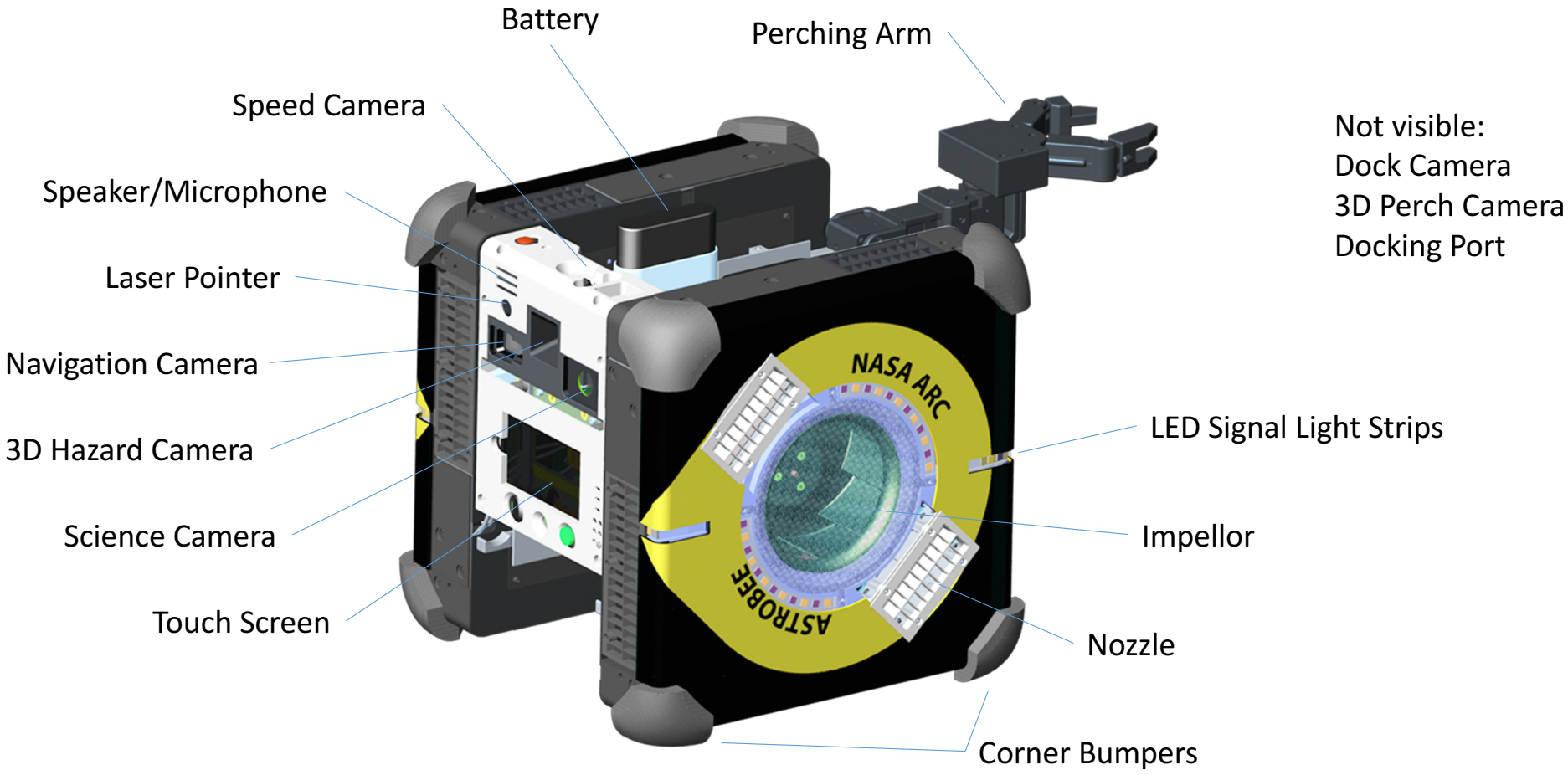
SPHERES

SPHERES Payloads





Astrobee

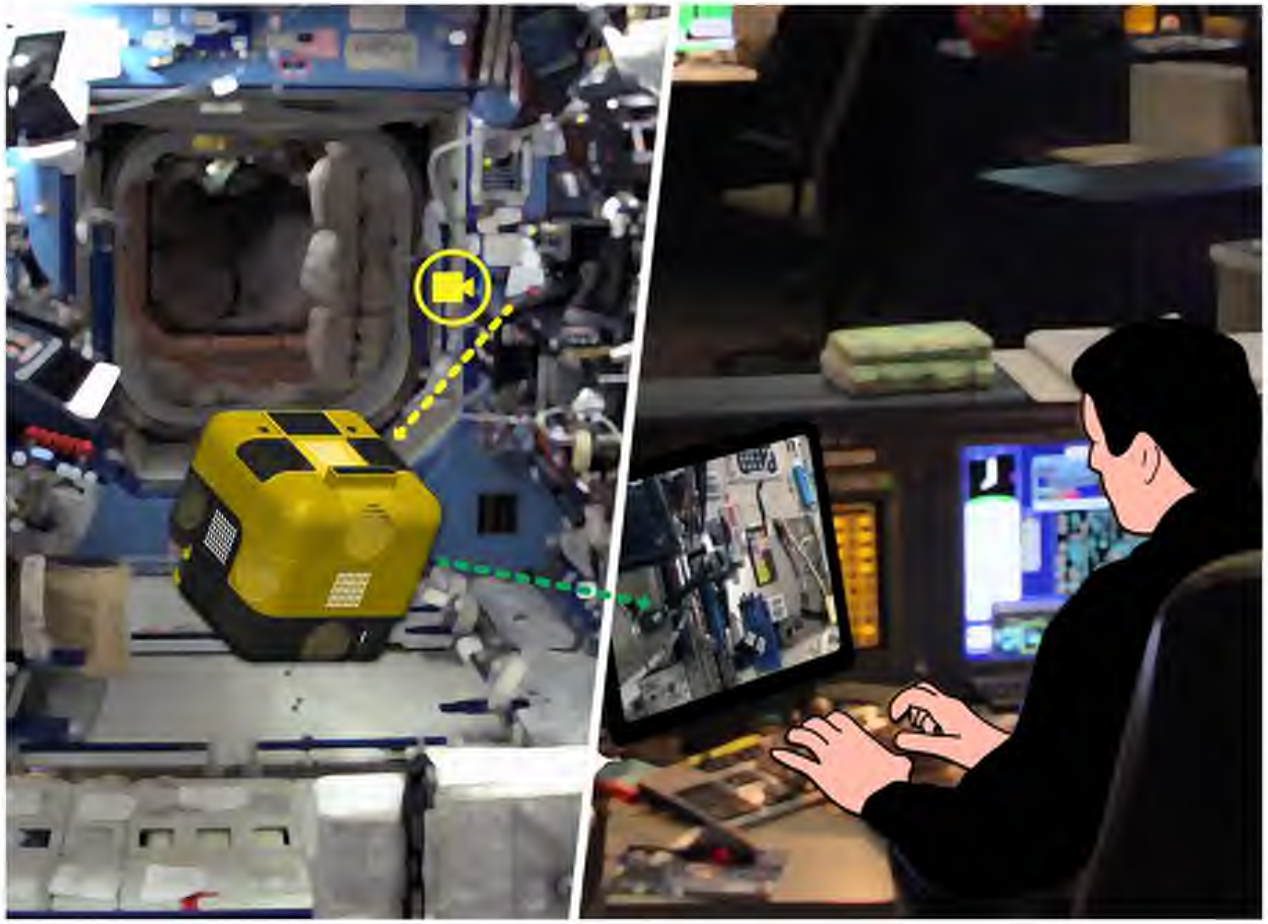


Not visible:
Dock Camera
3D Perch Camera
Docking Port

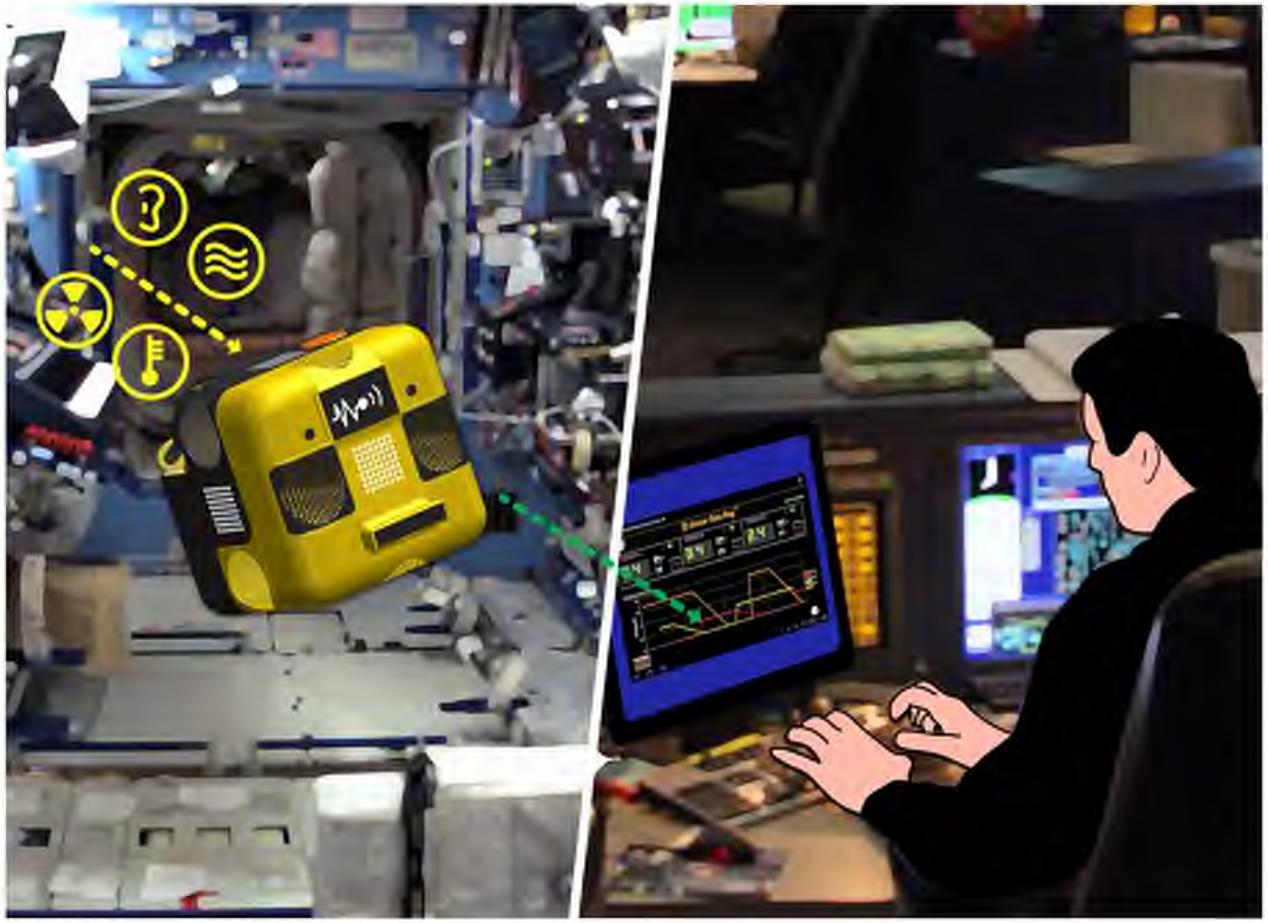
Dock and Resupply

Zero Gravity Research Facility

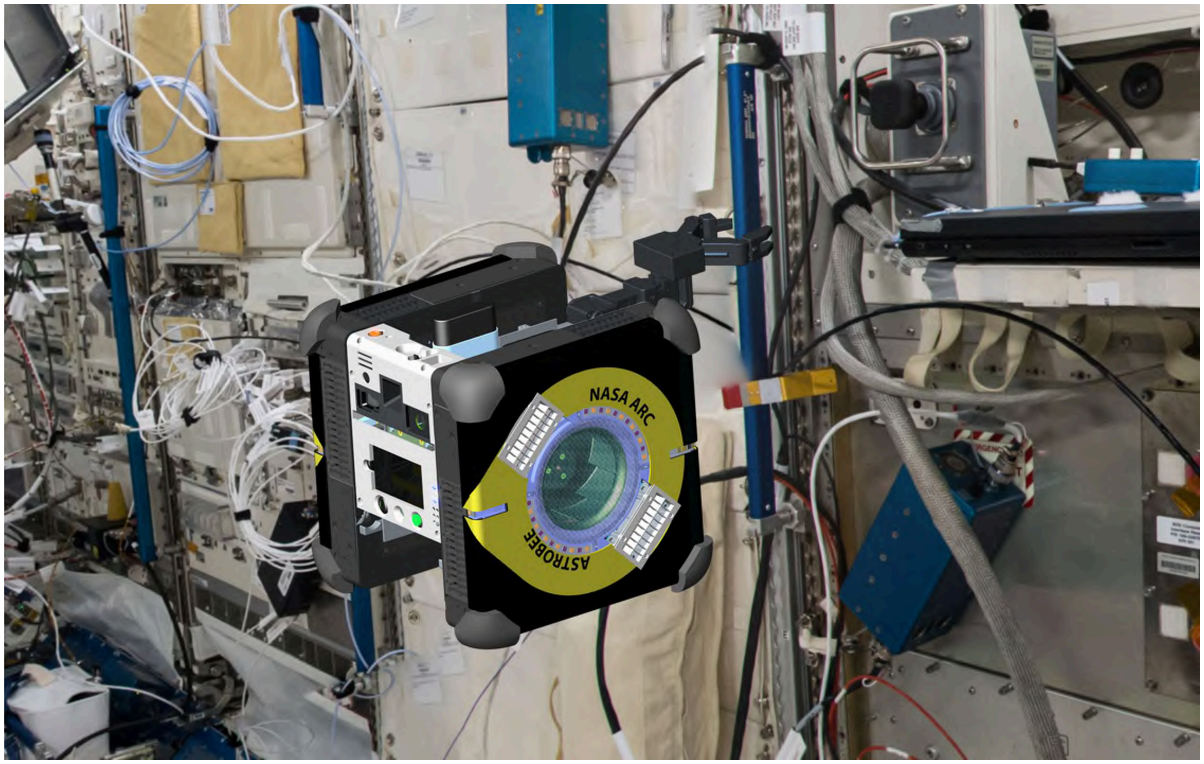
Mobile Camera



Mobile Sensor



How to Control Astrobee?



Astrobee Control Station(s)

Function	Astronauts	Flight Controllers	Astrobee Engineering and Guest Researchers
Create Plans		X	X
Run Plans	X	X	X
Teleoperate	X	X	X
Run Guest Research	X		X
Engineering Tools			X

Astronauts

ISS

Flight Controllers

Mission Control

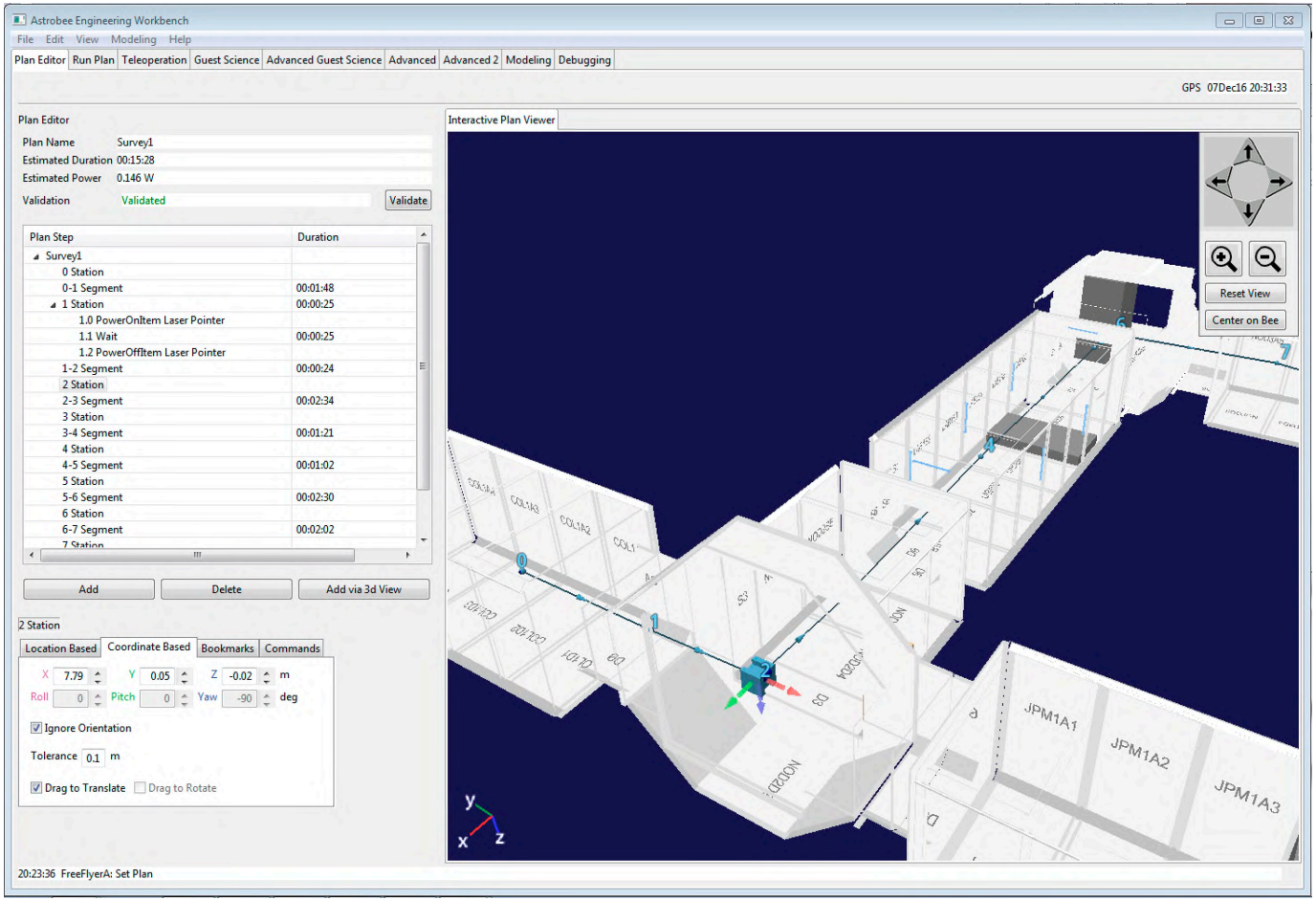
Astrobee Engineering

ARC

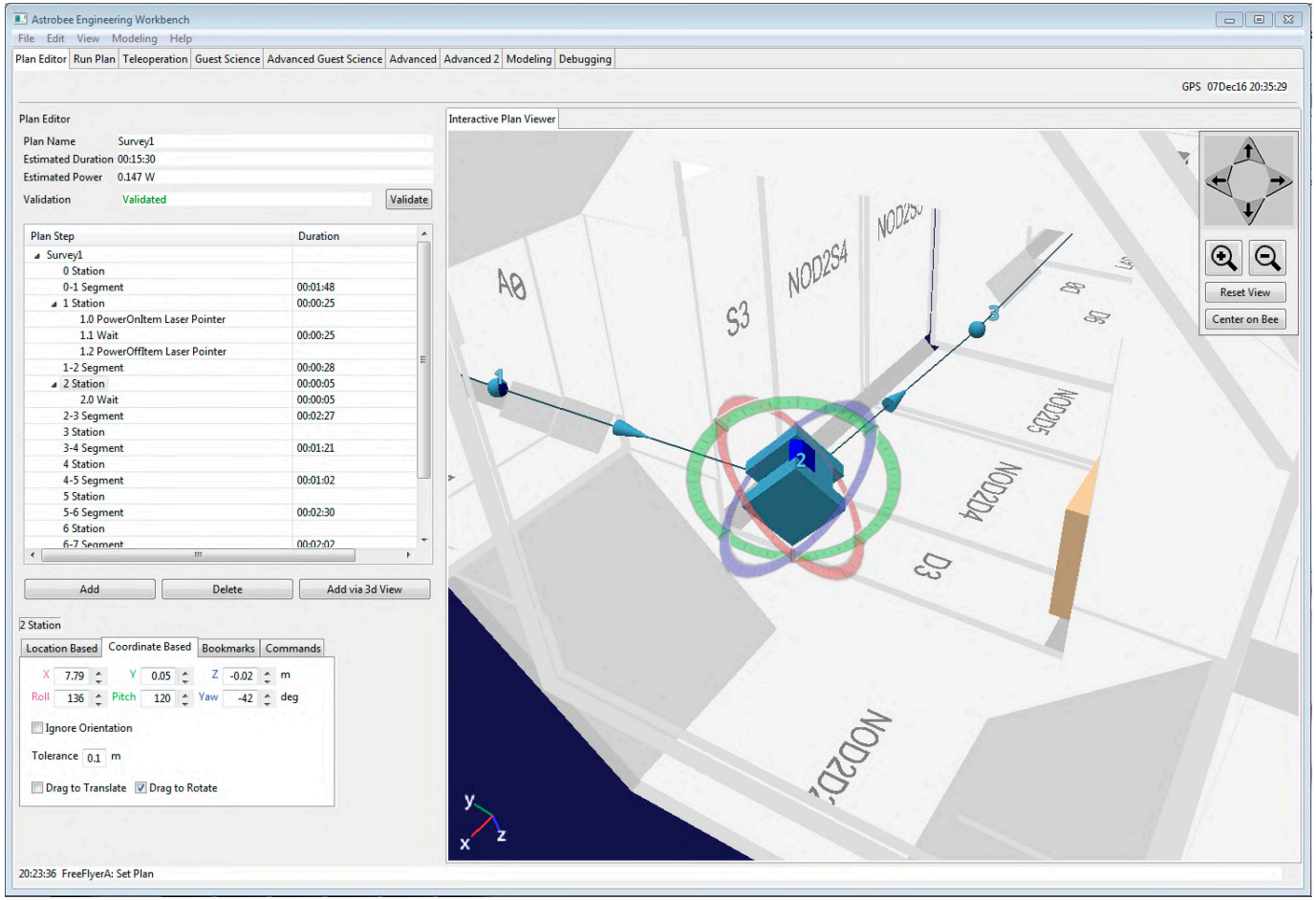
Guest Researchers

Universities

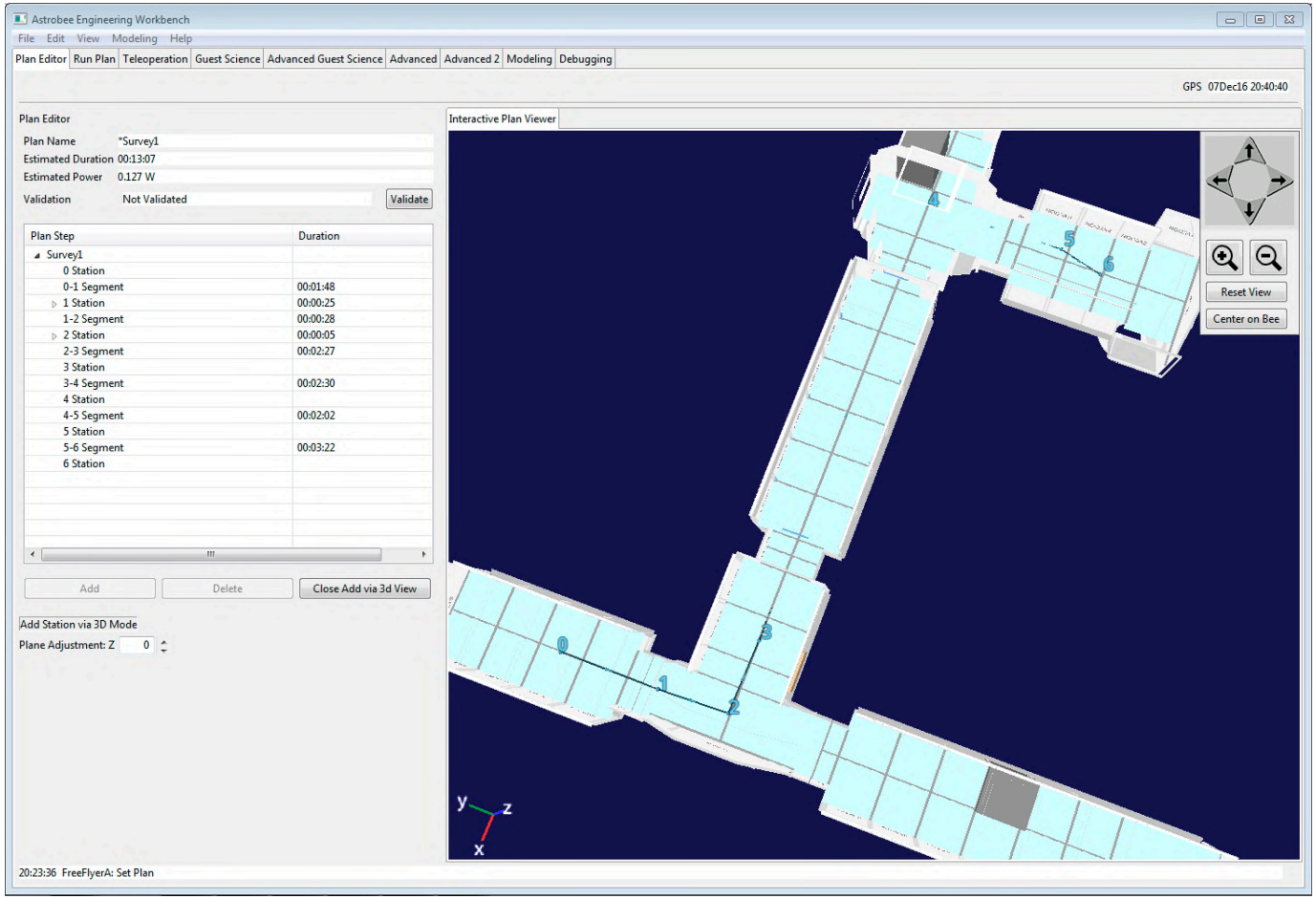
Plan Editor


Astrobee Engineering Workbench
File Edit View Modeling Help
Plan Editor Run Plan Teleoperation Guest Science Advanced Guest Science Advanced Advanced 2 Modeling Debugging
GPS 07Dec16 20:31:33
Plan Editor
Plan Name Survey1
Estimated Duration 00:15:28
Estimated Power 0.146 W
Validation Validated
Validate
Plan Step
Duration
Survey1
0 Station
0-1 Segment 00:01:48
1 Station 00:00:25
1.0 PowerOnItem Laser Pointer
1.1 Wait 00:00:25
1.2 PowerOffItem Laser Pointer
1-2 Segment 00:00:24
2 Station
2-3 Segment 00:02:34
3 Station
3-4 Segment 00:01:21
4 Station
4-5 Segment 00:01:02
5 Station
5-6 Segment 00:02:30
6 Station
6-7 Segment 00:02:02
7 Station
Add
Delete
Add via 3d View
2 Station
Location Based
Coordinate Based
Bookmarks
Commands
X 7.79
Y 0.05
Z -0.02
m
Roll 0
Pitch 0
Yaw -90
deg
Ignore Orientation
Tolerance 0.1 m
Drag to Translate
Drag to Rotate
Interactive Plan Viewer
Reset View
Center on Bee
JPM1A1
JPM1A2
JPM1A3
y
x
z
20:23:36 FreeFlyerA: Set Plan

Plan Editor


Astrobee Engineering Workbench
File Edit View Modeling Help
Plan Editor Run Plan Teleoperation Guest Science Advanced Guest Science Advanced Advanced 2 Modeling Debugging
GPS 07Dec16 20:35:29
Plan Editor
Plan Name Survey1
Estimated Duration 00:15:30
Estimated Power 0.147 W
Validation Validated
Validate
Plan Step Duration
Survey1
0 Station
0-1 Segment 00:01:48
1 Station 00:00:25
1.0 PowerOnItem Laser Pointer
1.1 Wait 00:00:25
1.2 PowerOffItem Laser Pointer
1-2 Segment 00:00:28
2 Station 00:00:05
2.0 Wait 00:00:05
2-3 Segment 00:02:27
3 Station
3-4 Segment 00:01:21
4 Station
4-5 Segment 00:01:02
5 Station
5-6 Segment 00:02:30
6 Station
Add
Delete
Add via 3d View
2 Station
Location Based
Coordinate Based
Bookmarks
Commands
X 7.79 Y 0.05 Z -0.02 m
Roll 136 Pitch 120 Yaw -42 deg
Ignore Orientation
Tolerance 0.1 m
Drag to Translate
Drag to Rotate
Interactive Plan Viewer
Reset View
Center on Bee
20:23:36 FreeFlyerA: Set Plan

Plan Editor


Astrobee Engineering Workbench
File Edit View Modeling Help
Plan Editor
Run Plan
Teleoperation
Guest Science
Advanced Guest Science
Advanced
Advanced 2
Modeling
Debugging
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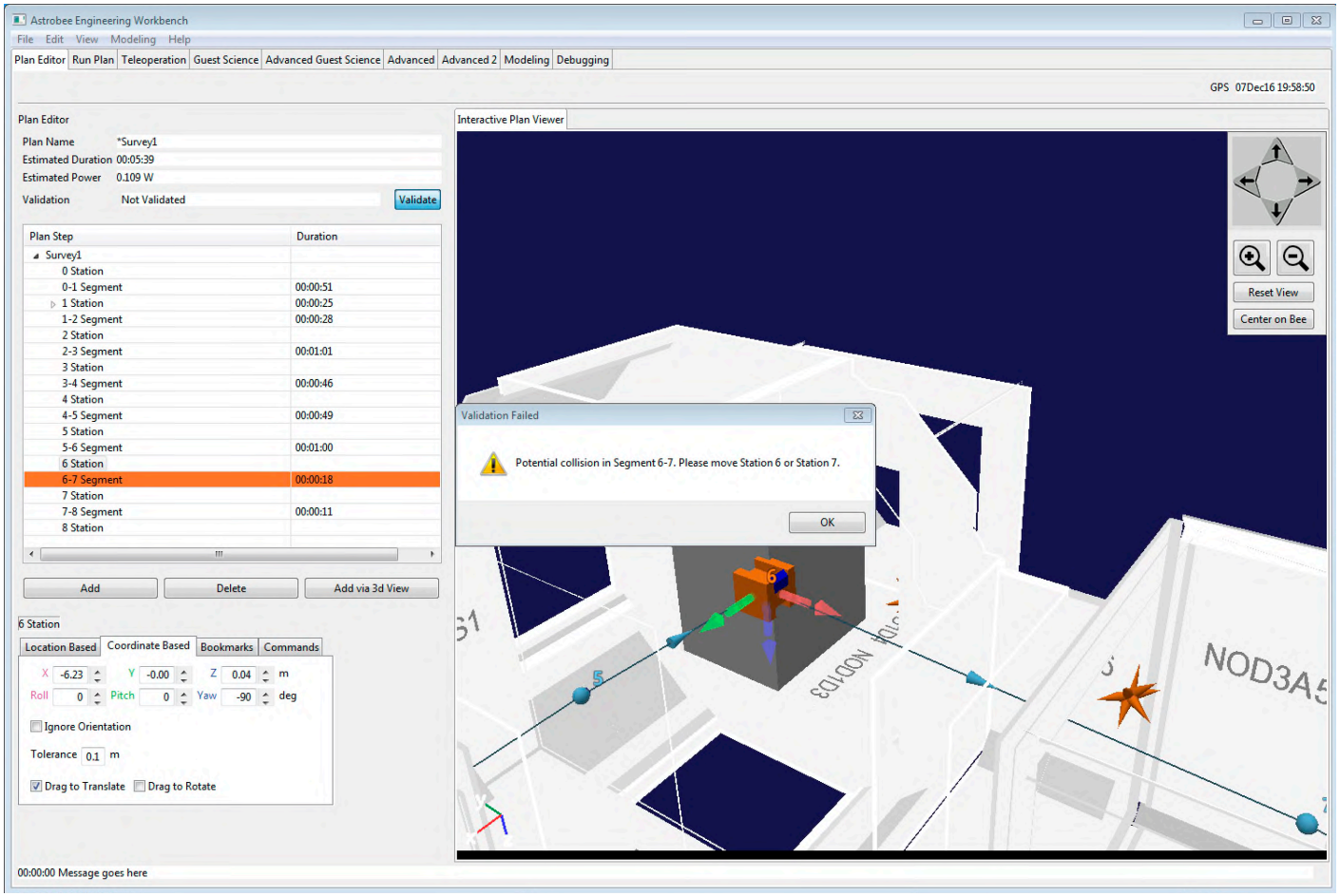
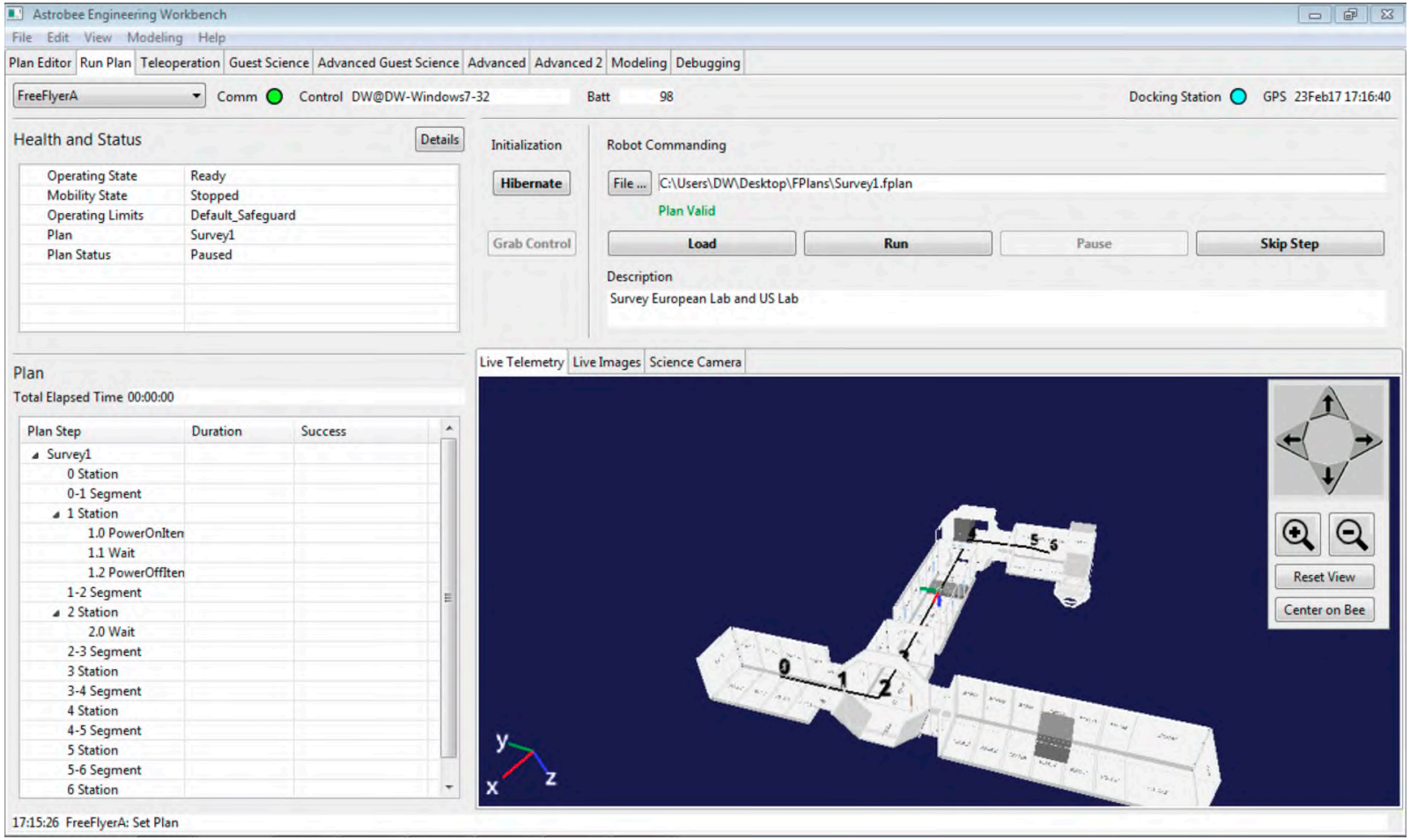
Plan Editor
Plan Name *Survey1
Estimated Duration 00:13:07
Estimated Power 0.127 W
Validation Not Validated
Validate
Plan Step
Duration
Survey1
0 Station
0-1 Segment 00:01:48
1 Station 00:00:25
1-2 Segment 00:00:28
2 Station 00:00:05
2-3 Segment 00:02:27
3 Station
3-4 Segment 00:02:30
4 Station
4-5 Segment 00:02:02
5 Station
5-6 Segment 00:03:22
6 Station
Add
Delete
Close Add via 3d View
Add Station via 3D Mode
Plane Adjustment: Z 0
Interactive Plan Viewer
Reset View
Center on Bee
0
1
2
3
4
5
6
y
z
x
20:23:36 FreeFlyerA: Set Plan

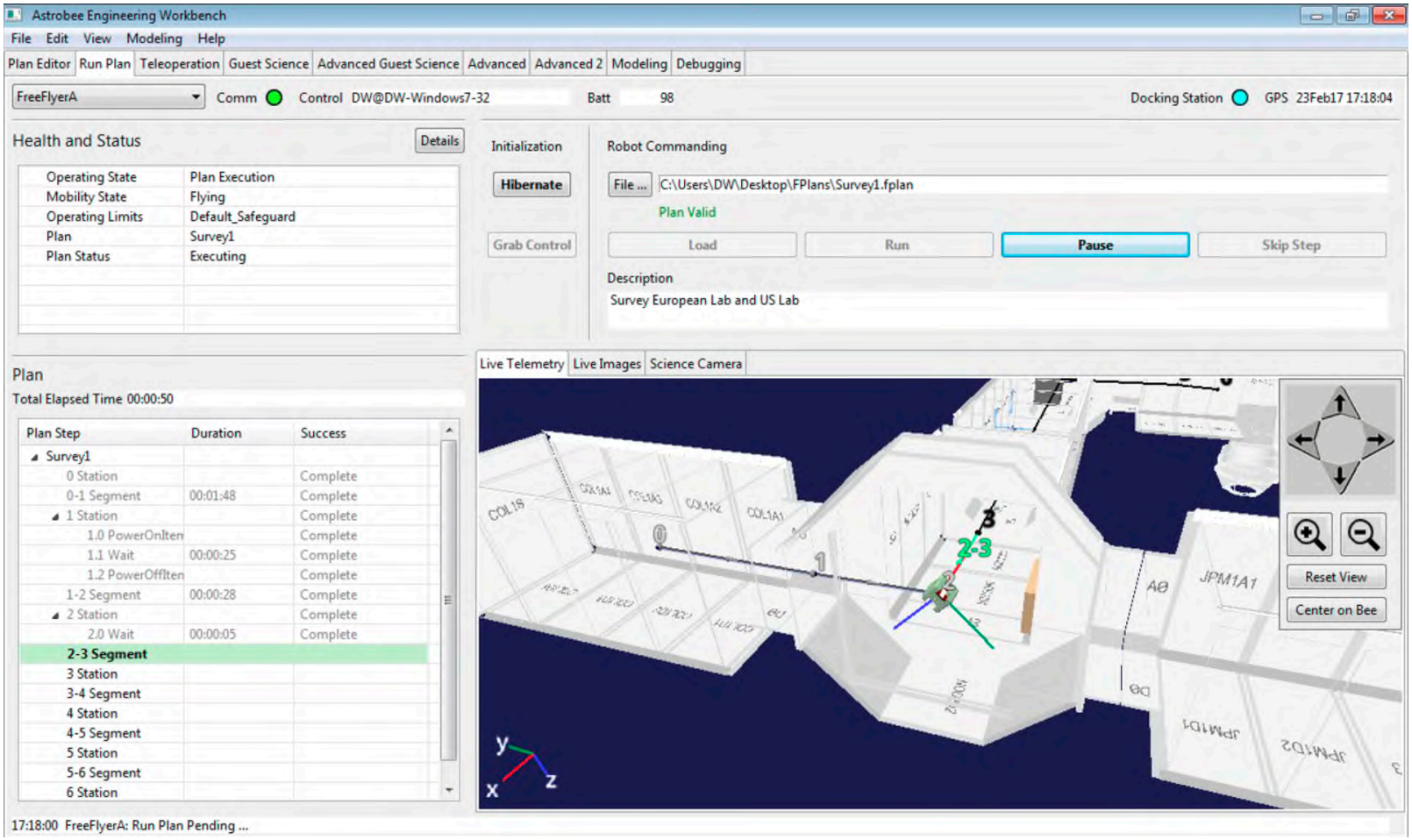
Plan Validation



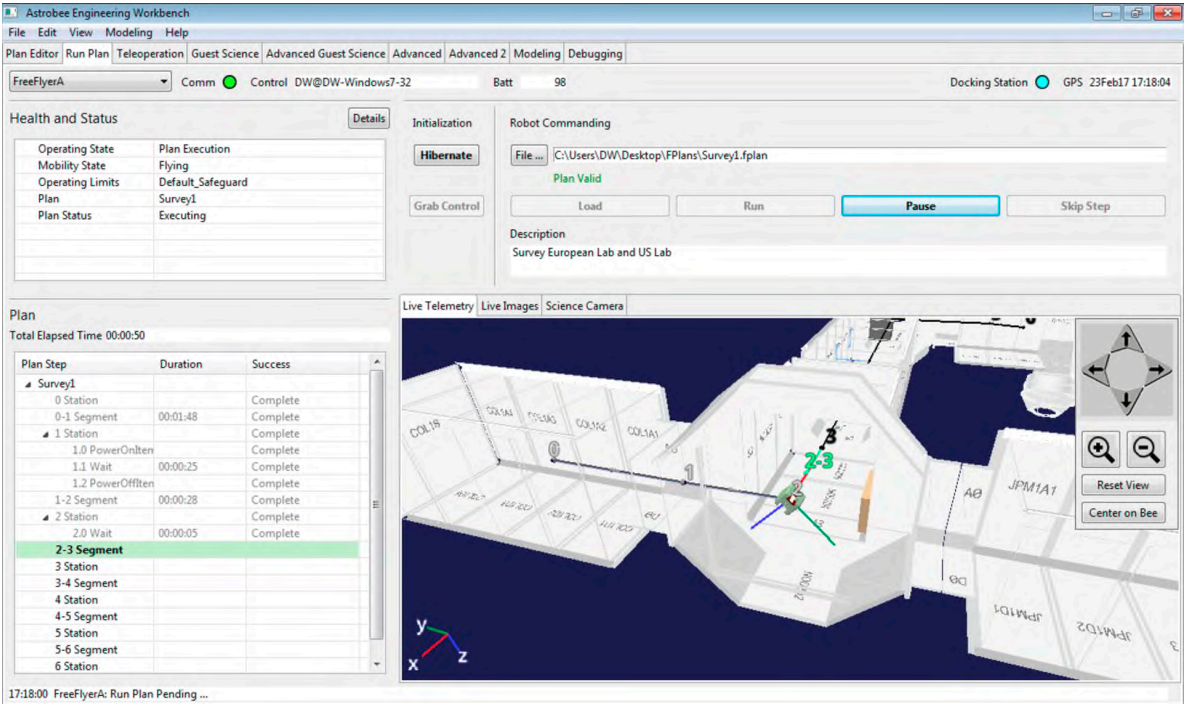
Running Plans

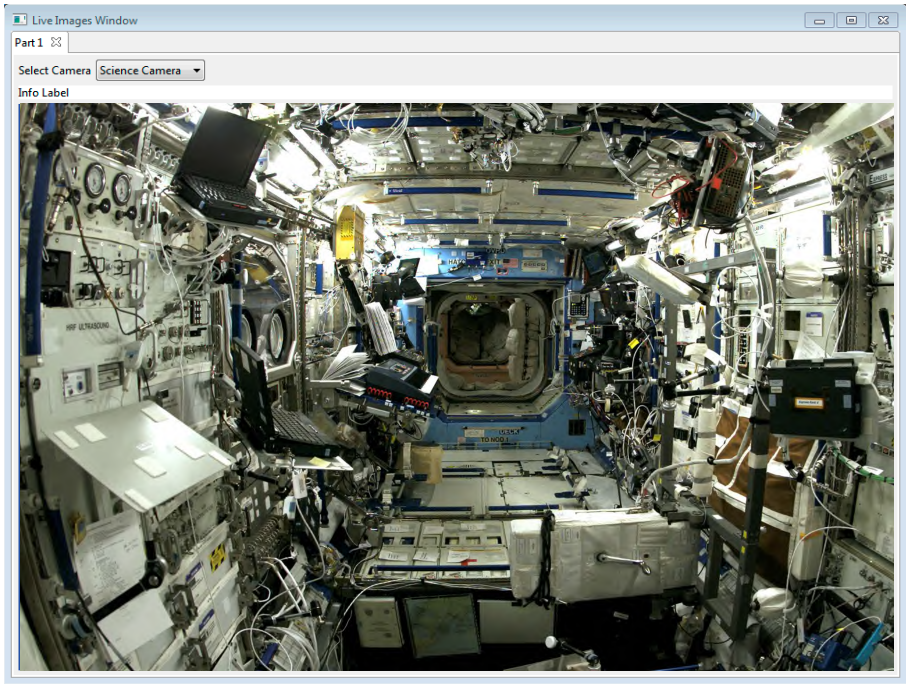


Running Plans

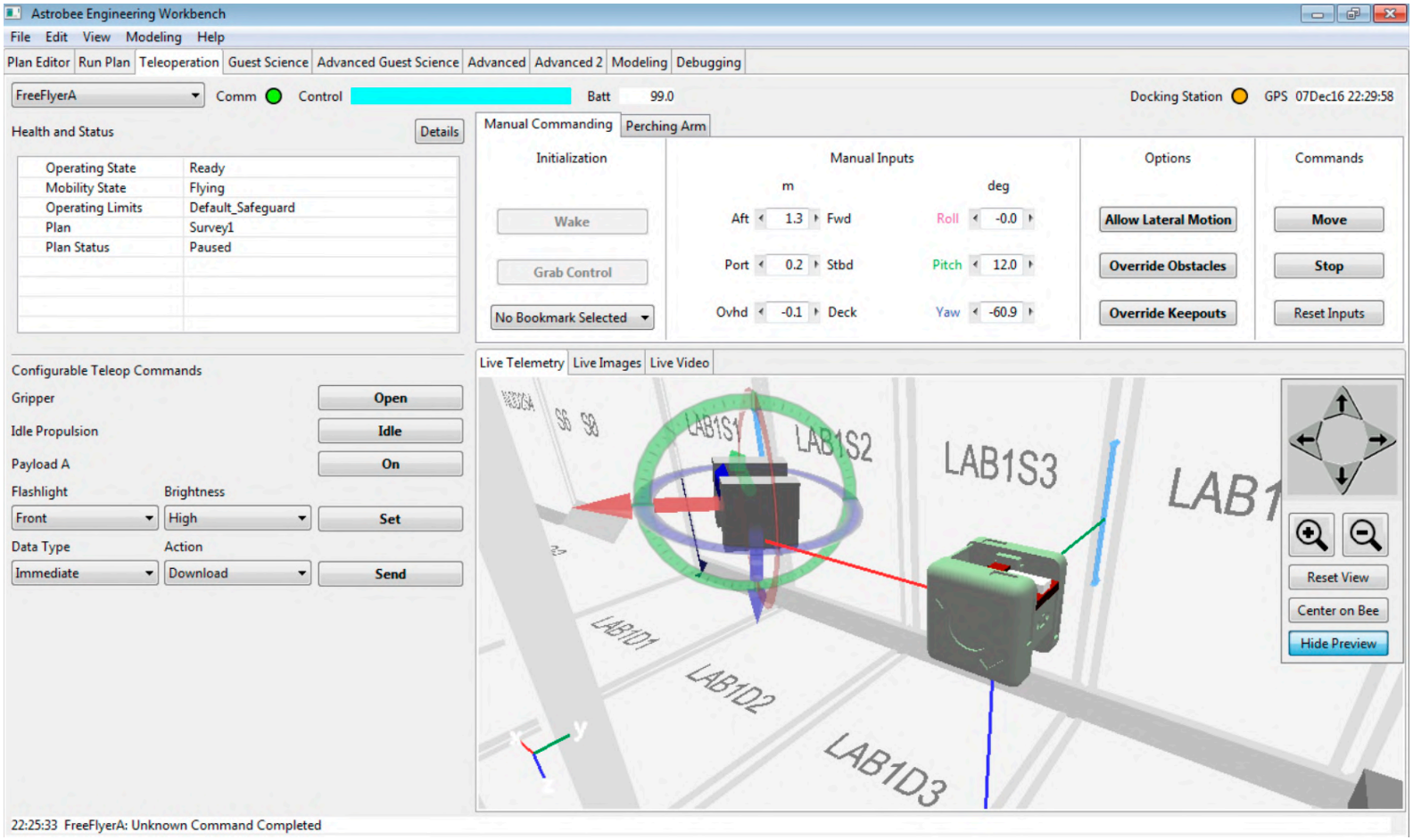


Running Plans





Teleoperation



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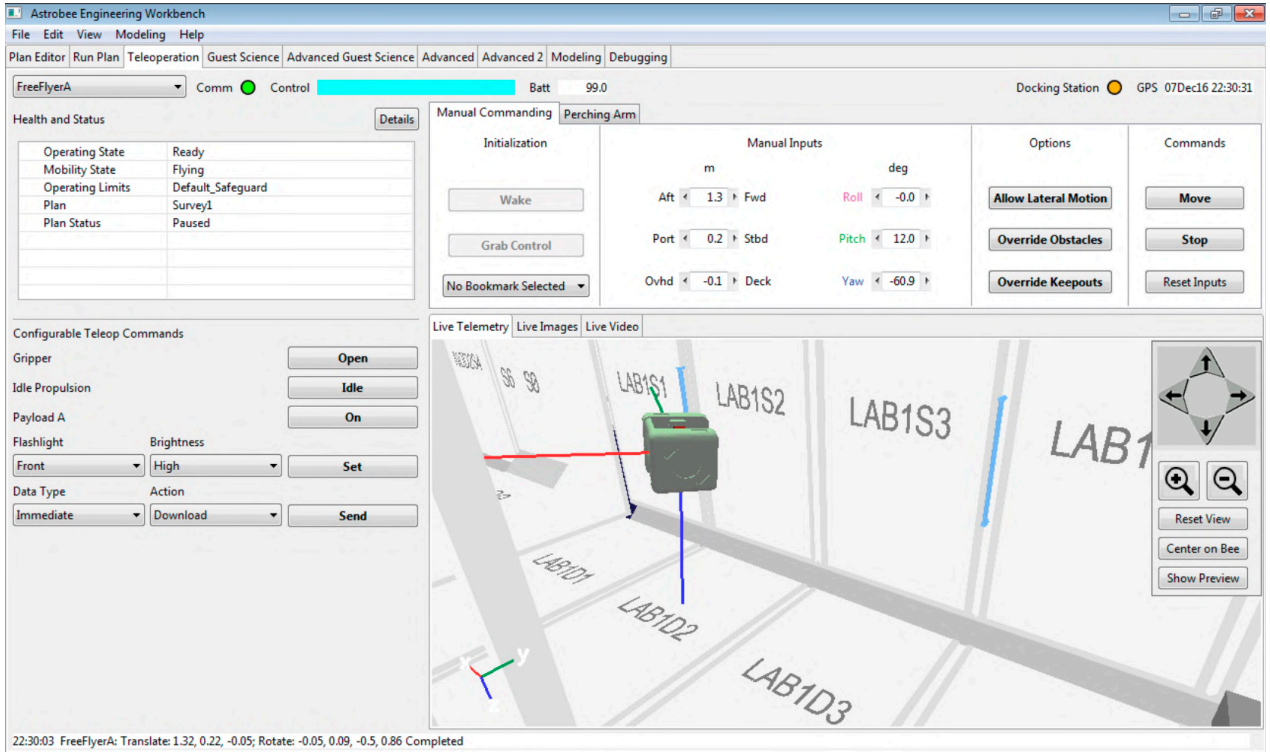
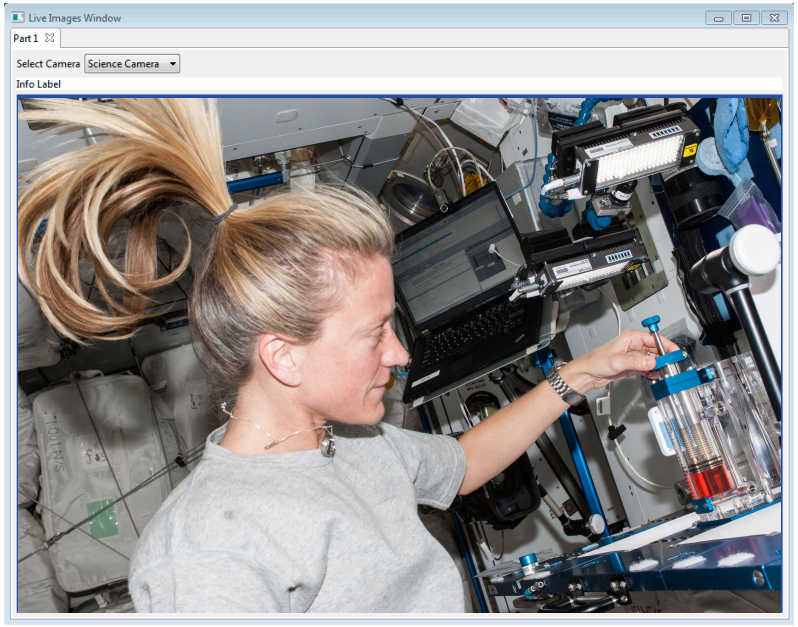
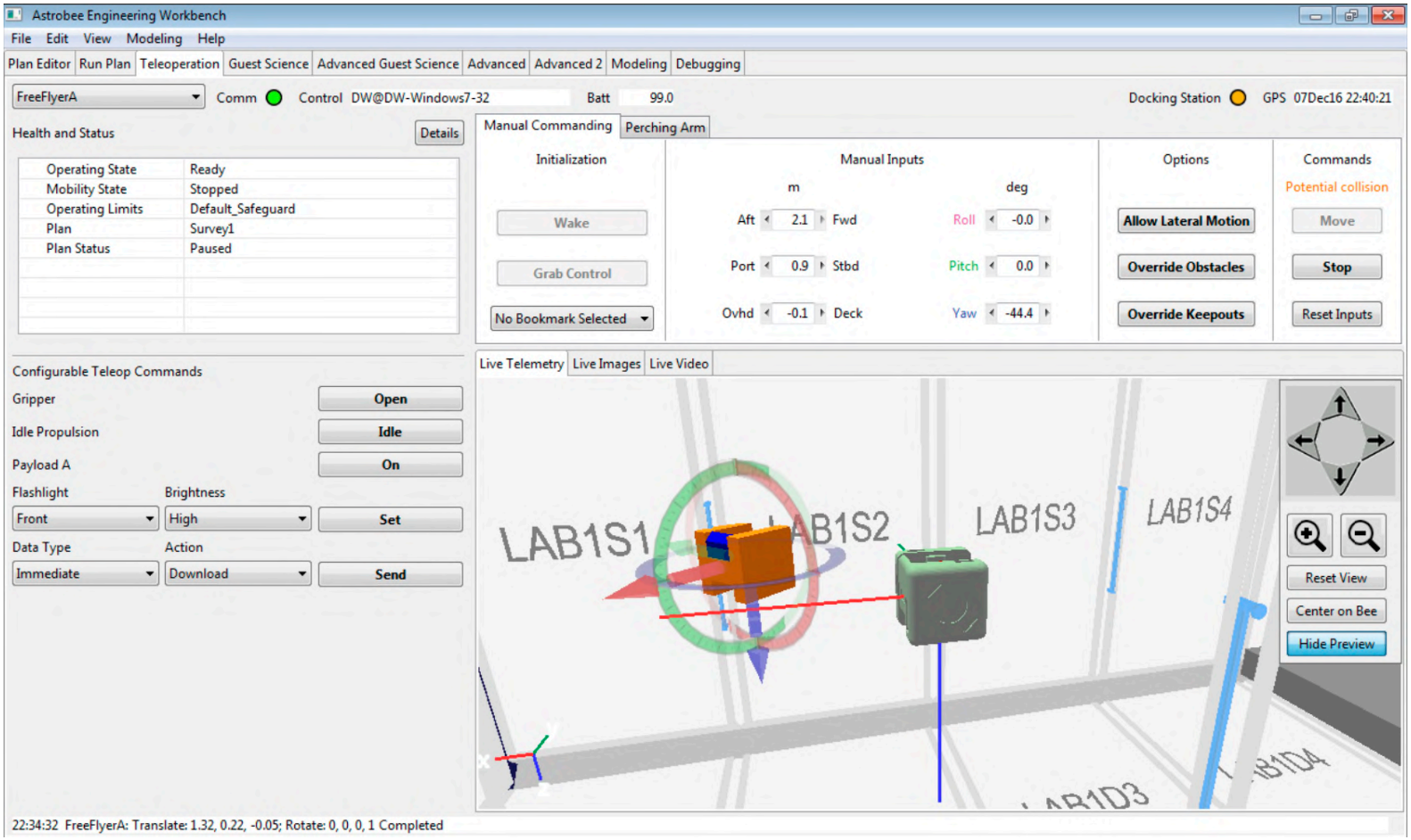
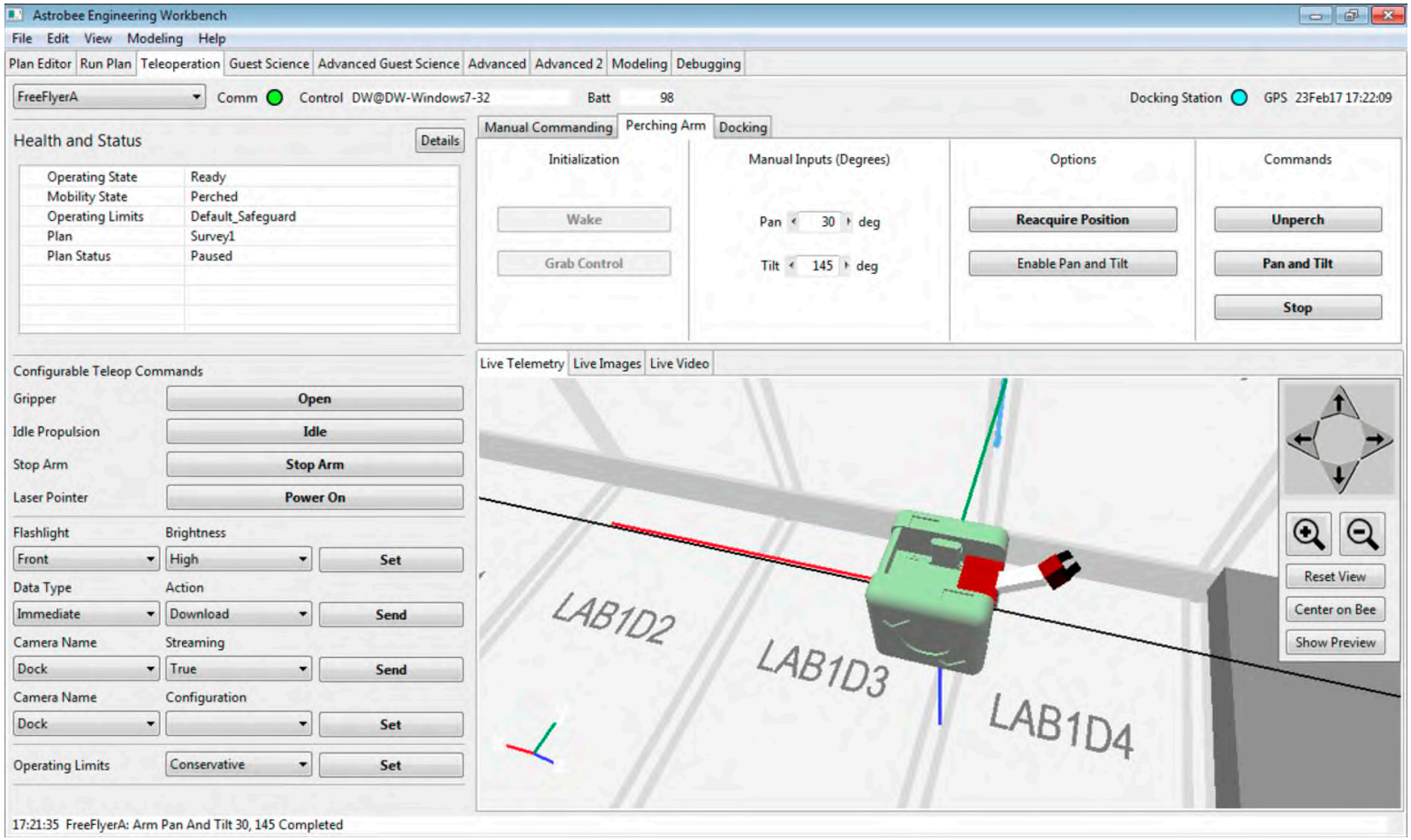




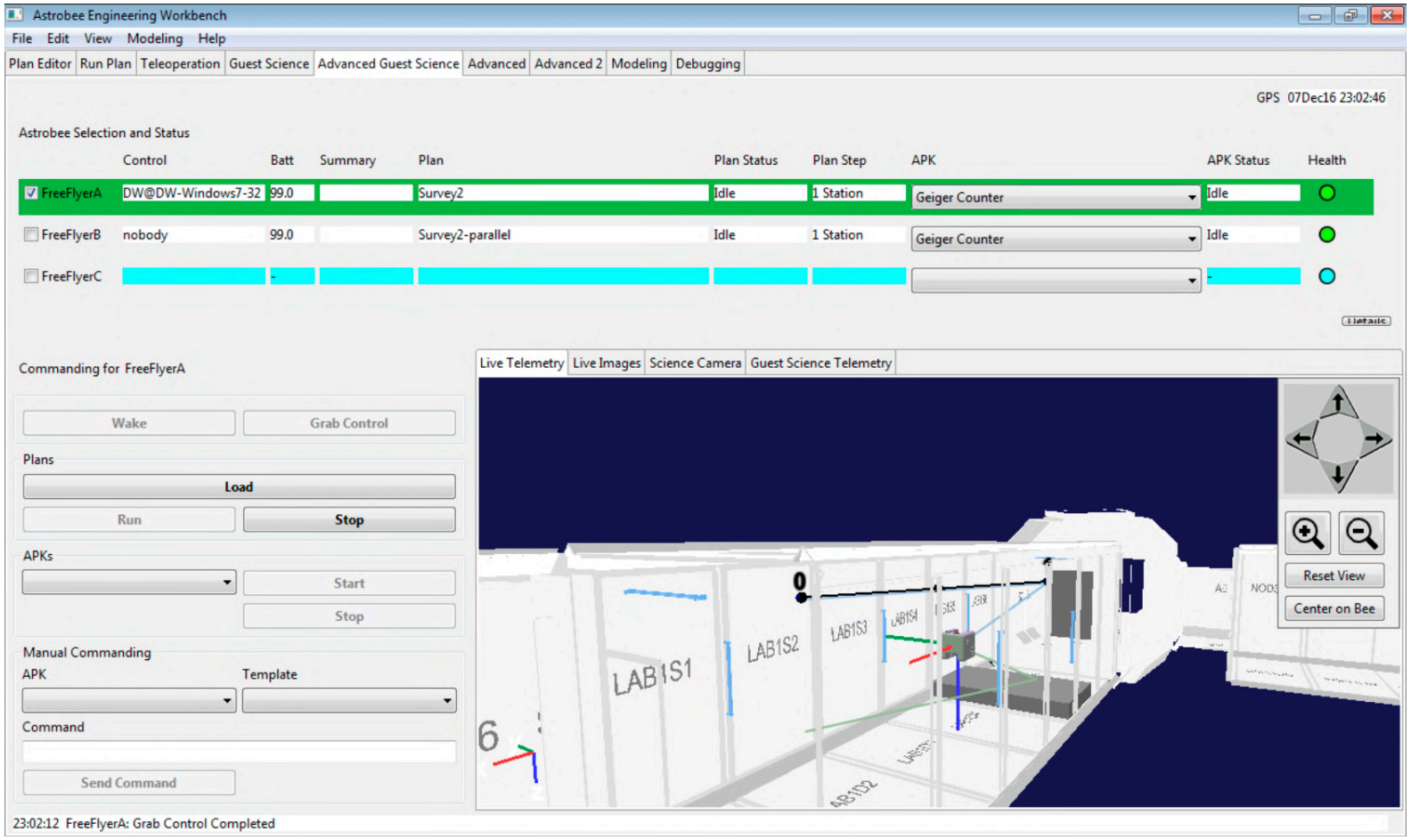
Teleoperation



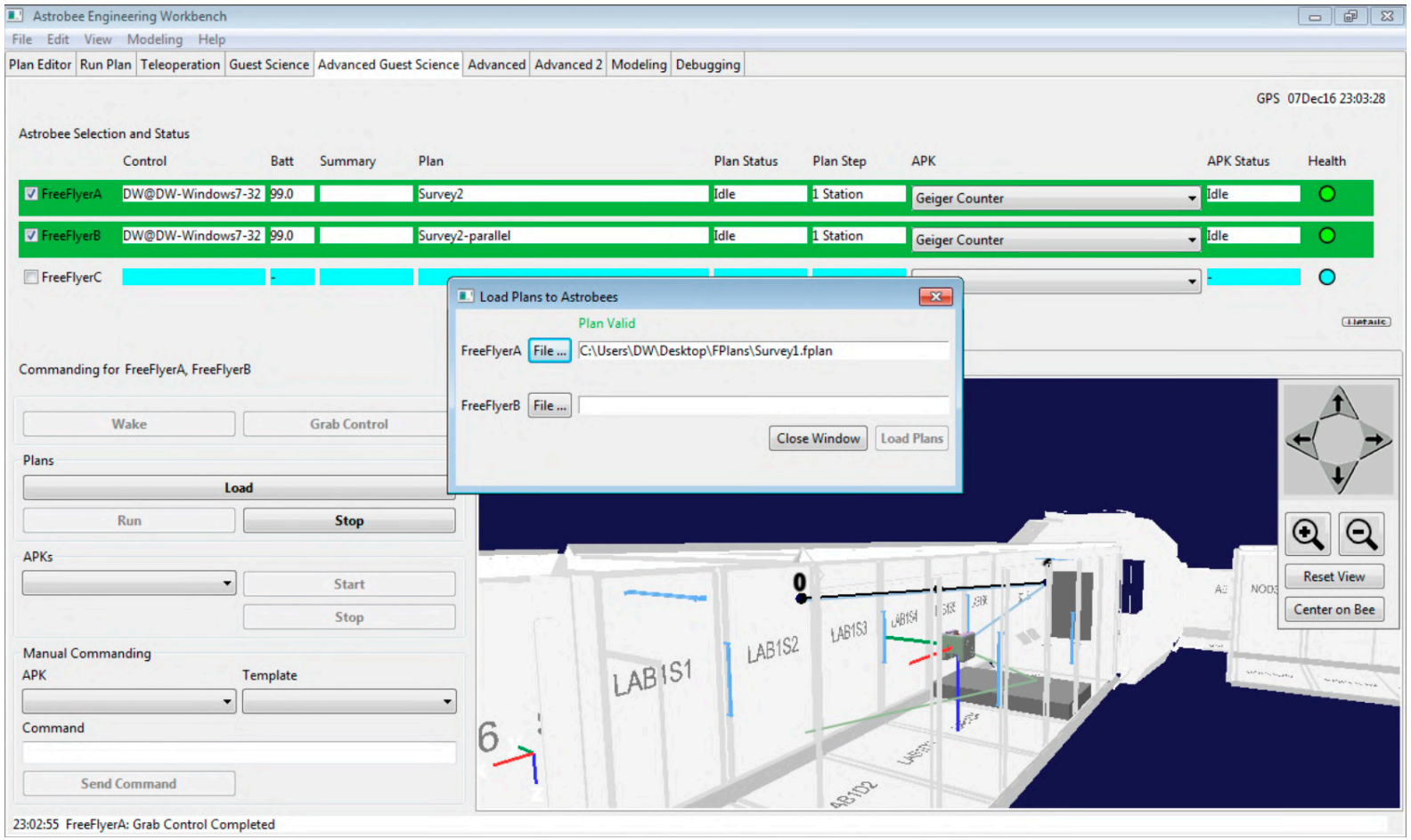
Teleoperation



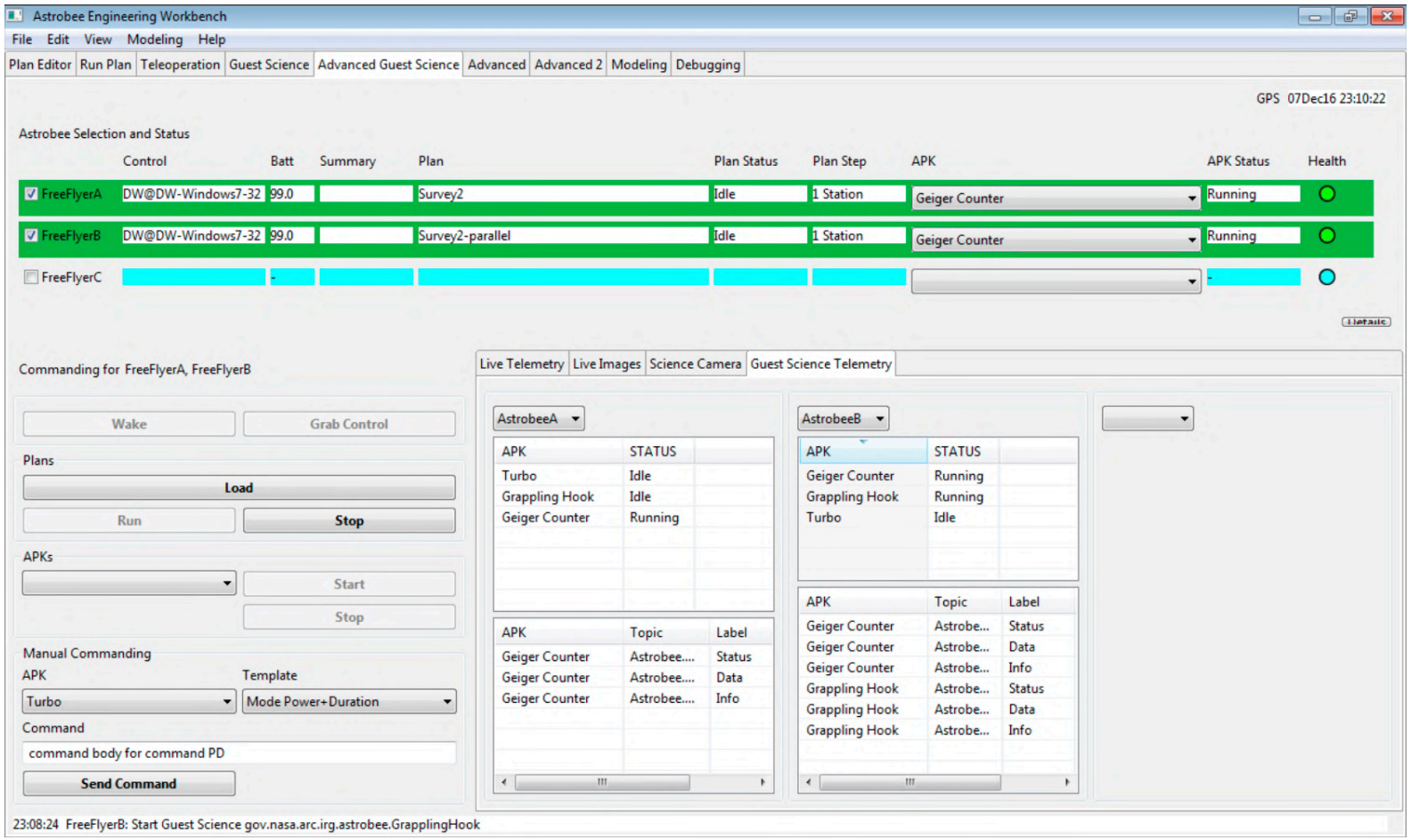
Multiple Astrobee Control



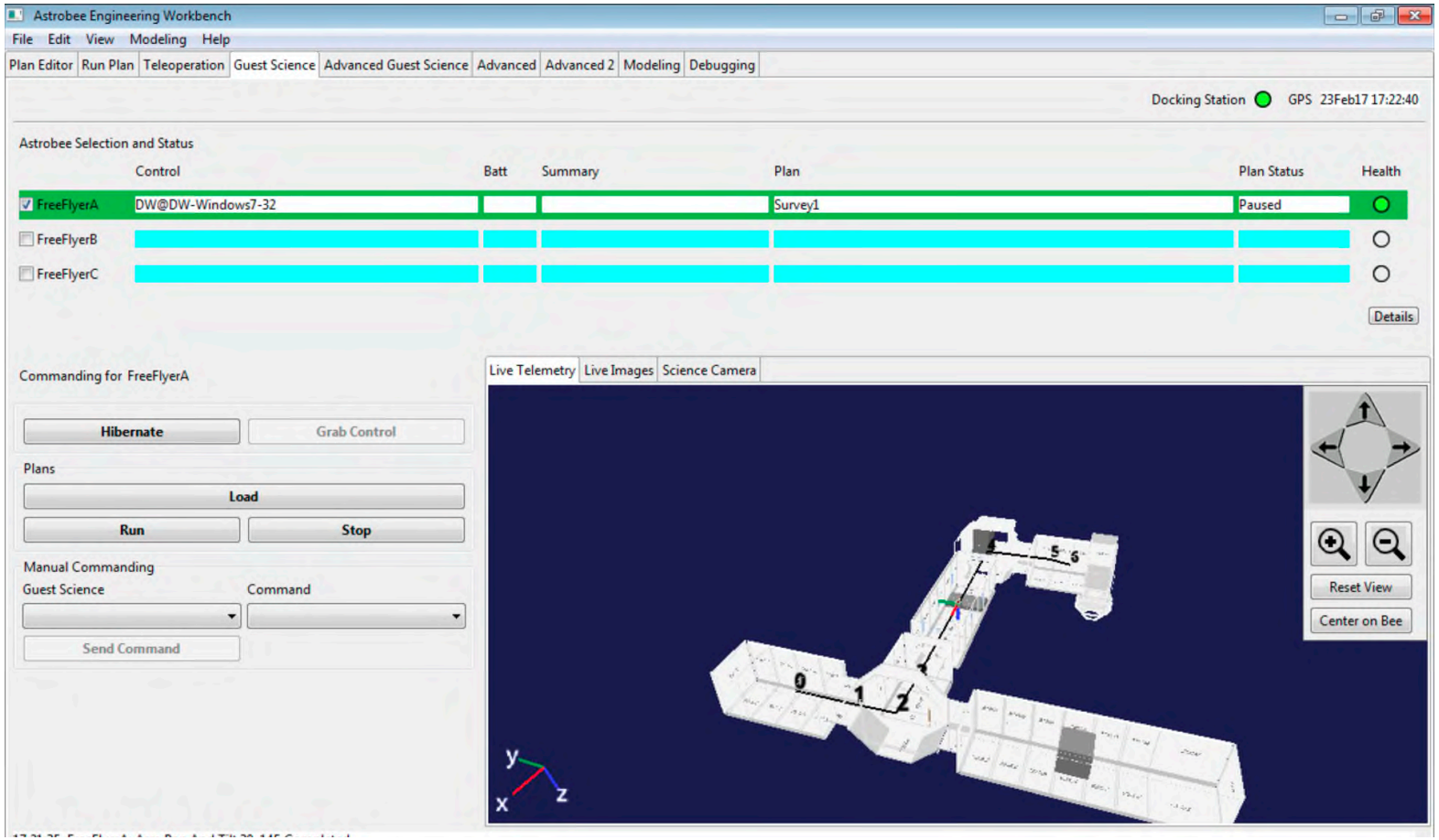
Multiple Astrobee Control



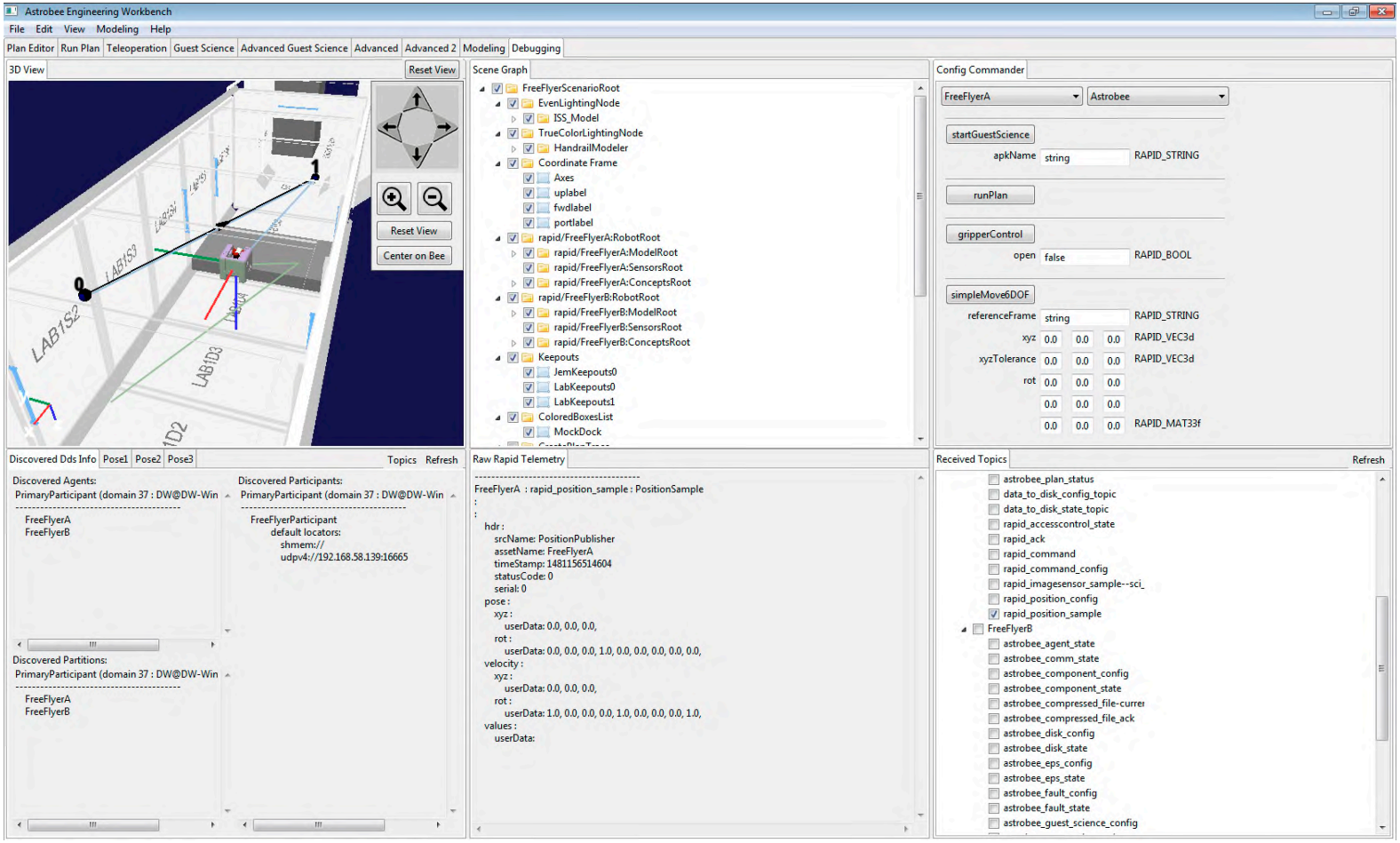
Multiple Astrobee Control



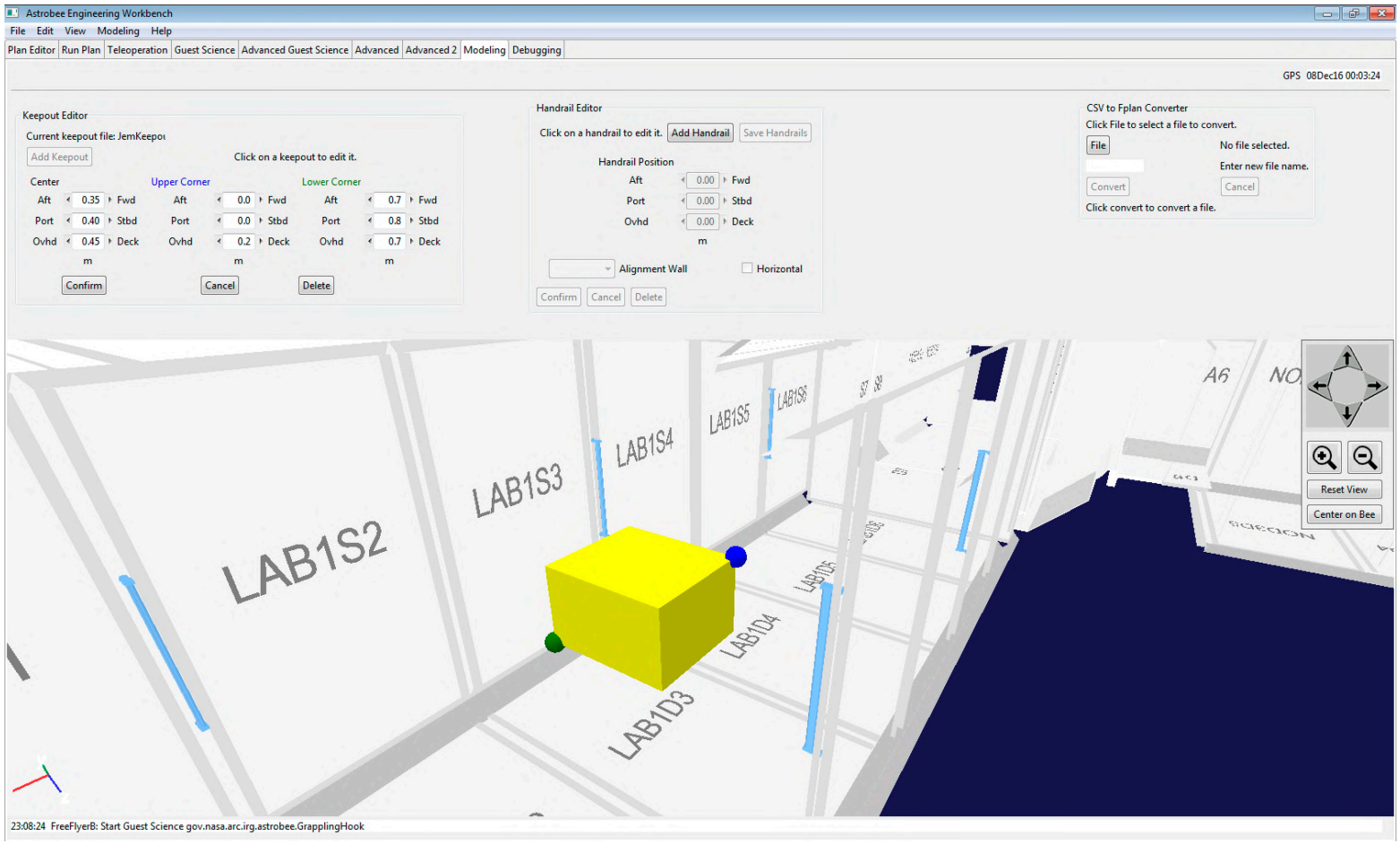
Multiple Astrobee Control - Crew



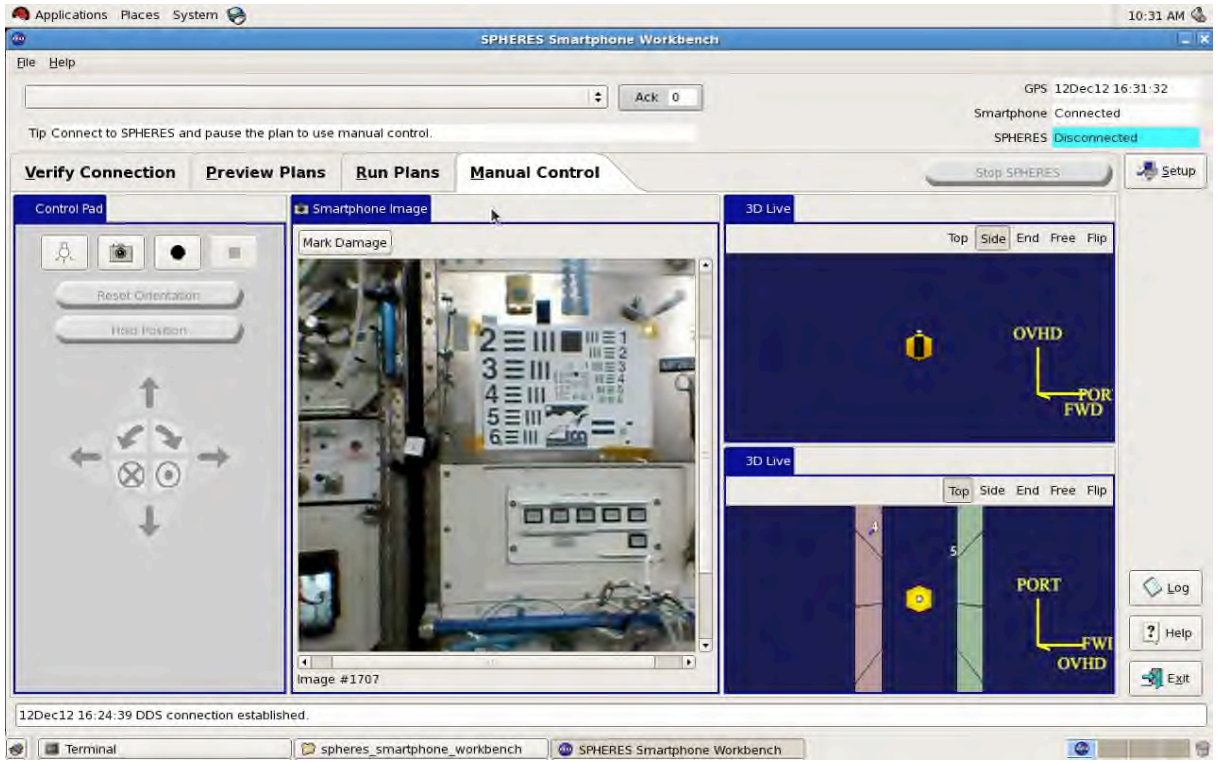
Engineering Tools - Debugging Panel



Engineering Tools - Modelling Panel

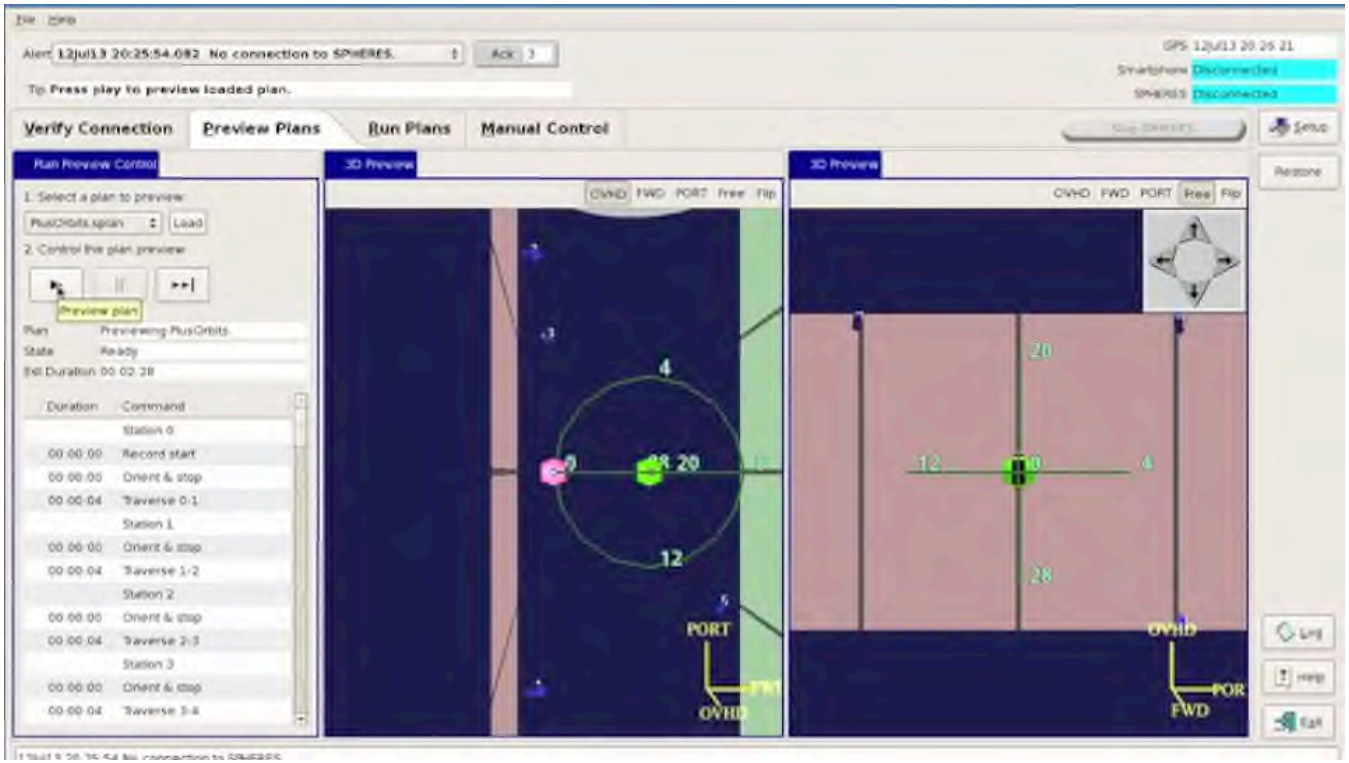


Video: SPHERES Controlled from Ground



Video: SPHERES in Space

Video: SPHERES Controlled from Space



Video: Astrobee Prototype Demo

Acknowledgements

- Astrobee Ground Data Systems Team
  - Ryan Goetz (JPL)
  - Past members: Connor Hitt, Jay Torres (JPL), Andy Martinez, Maria Bualat
  - Advisors: Jessica Martinez, Justin Cartledge (MSFC), Joe Fittipaldi (MSFC)
- VERVE Team
  - Mark Allan, Tamar Cohen, Eric Schafer
- Entire Astrobee Team
  - Terry Fong, Chris Provencher, Trey Smith, Lorenzo Fluckiger, Ted Morse, InWon Park, Jesse Fusco, Jonathan Barlow, Mike Mcintyre, Hugo Sanchez, Earl Daley, Omar Talvera, Ernie Smith, and more

Questions?

Thank you!