Meeting Kick off

Meeting Logistics

- Topic: SPHERES/Astrobee Working Group (SWG) Quarterly Meeting
- Purpose: Information sharing across the SPHERES & Astrobee community - not intended to be project reviews!
- Date: Thr, Nov. 10th, 2016
- Location: NASA ARC Building N269 Room 179
- Time: 9:00 am, PST

- JOIN WEBEX MEETING
- https://nasa.webex.com/nasa/j.php?MTID=md3f65bbe407938cbf92d49319a00cf37
- Meeting number: 992 958 795
- Meeting password: Astrobee!8

- Join by phone: 1.844.467.6272
- pass code: 445068

Agenda

9:00am SPHERES Facility 101 (10min) Jose B.
9:10am SPHERES Ops (15 min) Aric
9:25am SPHERES Engineering (20 min) Jonathan
9:45am SPHERES PIM update (10 min) Melissa

SPHERES Users
- 10:00am - Inpire II (20 min) Alvar
- 10:20am - ZeroRobotics (20 min) Alvar
- 10:40am - SLOSH (20 min) Brandon
- 11:00am - Tether (20 min) Hans

11:20am - Special Topics
- Vaios Lappas, Cranfield University (5 min)
- Quincy Bean, NASA Additive Manifacturing Facility (5 min)
- Ou Ma, New Mexico State (5 min)
- Leah Strichartz, NASA Education (5 min)
- Blaine Levedahl, Tethers Unlimited Inc. (5 min)
- Discussion (15 min)

12:00am Lab Tours & Astrobee Demo (30 min)
12:30pm Lunch (1hr)

01:30pm Astrobee overview and status (30 min)
Astrobee payload presentations
02:00pm - REALM (20 min)
02:20pm - ESI presentation (20 min)
02:40pm - ESI presentation (20 min)
03:00pm - ESI presentation (20 min)
03:20pm - Discussion
04:00pm Done

Synchronized Position Hold Engage Reorient Experimental Satellites - SPHERES

- A Facility of the ISS National Laboratory with three IVA nano-satellites designed and delivered by MIT to research estimation, control, and autonomy algorithms
- Installed on ISS in 2006
- Managed by ARC since Fall 2010
- By working aboard ISS under crew supervision, it provides a risk tolerant Testbed Environment for Distributed Satellite & Free-flying Control Algorithms
  - ✓ Formation flight, Docking, Proximity Operations
- If anything goes wrong, reset and try again!
- The satellites can be reused
  - ✓ Replenishable consumables
  - ✓ Multiple test sessions assigned per year

Scott Kelly working with SPHERES in the Kibo lab

If you can't bring the space environment to the laboratory, take the laboratory to space!

Over 119 Test Sessions (600+ hrs. of Facility Console activities involving crew)

One of the most used and popular ISS National Lab Facilities

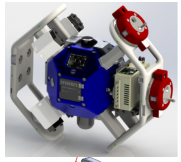
Microgravity Free-Flyer Technologies past, present, & future

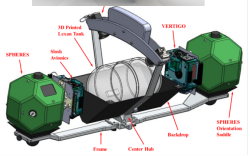
RINGS

SLOSH

Tether

Vertigo





UDP/HALO

SmartSPHERES

Interact

Zero Robotics

AERCam

PSA

SPHERES

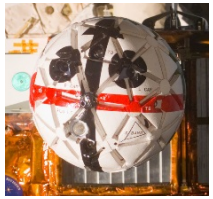
Astrobee

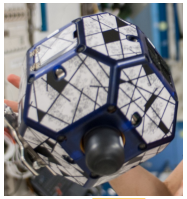
1996 - 2002

2000 - 2008

2006 - 2017

2018





TA02 In-Space Propulsion

TA05 Communication & Navigation

STEM Education

TA04 Robotics, Tele-Robotics & Autonomous

Avionics & Software Risk mitigation

SPHERES Community

❑SPHERES Working Group (SWG) Quarterly meeting

- Membership includes MIT, FIT, AFS, DARPA, CASIS, SJSU, and NASA (HQ, KSC, JSC, MSFC, and ARC)
- Face-to-Face, twice a year
- Next Face-to-Face will be scheduled in Feb. 2017 at NASA Ames

❑ Purpose:

- Information sharing across the SPHERES community
- Program office shares
  - ✓ National Lab Facility availability
  - ✓ Status of resources (batteries, CO2 tanks, etc.),
  - ✓ Overall Calendar (scheduled Test Sessions, upmass/return), and
  - ✓ Updates on “new” PD, Investigations, and ISS infrastructure.
- Provide the SPHERES community (PD, investigators, etc.) with up-to-date information to determine opportunities to use the NL Facility
- Discuss proposed changes/updates to SPHERES Nat Lab which may be required to support a specific activity or research.
- Discuss specific support requests made to the ISS Office

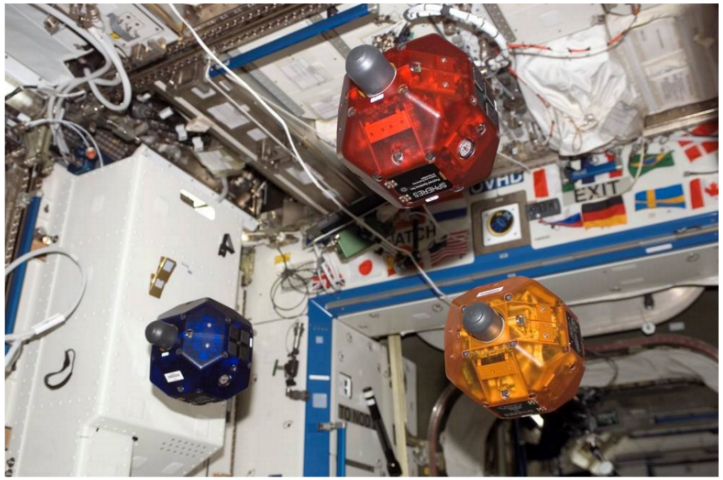
SPHERES Facility Team

- **Team**
  - Jose Benavides, Jose.V.Benavides@nasa.gov, PM
  - Aric Katterhagen, aric.j.katterhagen@nasa.gov, Ops Lead
  - Jonathan Barlow, jonathan.s.barlow@nasa.gov, Eng Lead
  - Darryl Levasseur, darryl.w.levasseur@nasa.gov
  - Jose Cortez, jose.cortez@nasa.gov
  - Robert Hanson, robert.s.hanson@nasa.gov
  - Simeon Kanis, simeon.i.kanis@nasa.gov
  - Don Soloway, Donald.i.soloway@nasa.gov

Accomplishments

- **FY16 Accomplishments**
  - **Number of Test Sessions: 12**
  - **Number of active investigations: 6**
  - **Console time: 71 hours**
  - **Crew members: 8**
  - **Quarterly Working Groups**
  - **10 Year anniversary of ISS operations**
  - **ISS GUI Software updates**
  - **Resupplied Consumables**
    - New Generation 2.5 of CO2 tanks
    - Fourth Generation of Battery Packs Qty 110
  - **SPHERES Blue Repair**
  - **Astrobee Transition Planning**
  - **Astrobee Integration & Test**

SPHERES: How a Class Project Turned into an Experiment Facility in Space



The three on-orbit SPHERES satellites fly in formation through the International Space Station, appearing like a squadron star fighters from the Star Wars universe.

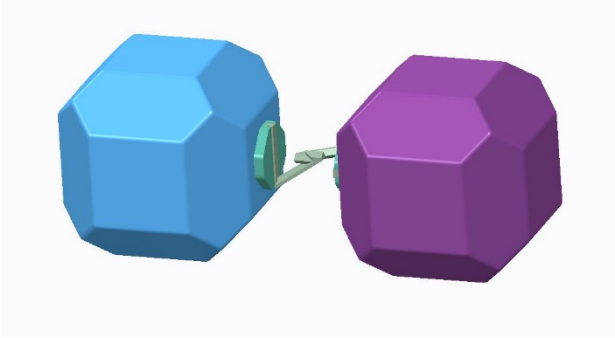
Education & Public Outreach Activities

- **Internships and mentoring**
  - Two full-time Aerospace Engineering students San Jose State University supported Operations
- **Tours and general outreach**
  - Three student tours – November 2015
  - Lab tours to visiting CA Zero Robotics students – August 2016
  - Two High School student tours – July 2016
  - Tour for Samuel Black at the OMB 8/24/2016
- **Conferences**
  - ISS R&D Conference in San Diego – June 2016 - Two Posters, One presentation
- **Media events**
  - SmallSat media event at Ames – March 2016
  - California Aerospace Day, Sacramento, CA – March 2016
  - Reaching for the Stars Foundation Science Blast – Sept 2015
  - Second Annual NASA Day in Downtown Huntsville, AL with demo hardware – June 18th
  - NASA Ames BBQ event with ISS payloads booths – August 11th
  - Supported NASA Ames ISS Destination Station event – June 2016
  - NASA Technology Day on the Hill in DC – April 2016

Universal Free Flyer AMF connector

Description and Objectives

- Develop and demonstrate a universal free flyer connector that can be utilized as the basis for all future 3D printed objects connected to SPHERES or Astrobee from the Additive Manufacturing Facility (AMF)



Technical Approach

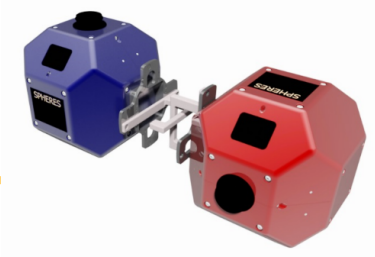
- Design a two-surface connector that can be attached to both SPHERES and Astrobee expansion ports
- An interlocking hook part can be designed to prove out the process and investigate usage performance of this new connector
- This hook part can be utilized for both research and STEM Outreach activities (Zero Robotics)

Potential Applications

- Zero Robotics game pieces, STEM Education
- Crew tool holders
- Sensor mounts
- Research non-rigid connection maneuver dynamics in microgravity
- Research SLOSH tank dynamics with Astrobee
- Research in-space collaborative assembly tasks with multiple robotic free flyers

Unique Capabilities

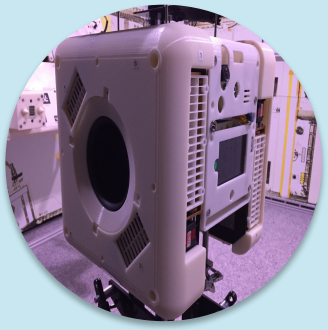
- Parts don't have to be designed to survive a rocket launch
- This opens the possibilities to rapid iteration of space optimized components. Parts can be re-designed and re-printed based on -n-situ information and lessons learned
- Leverage faster, safer, and more affordable ways to integrate and manifest a part for ISS



Program News

- **News:**
  - New pink CO2 tanks done right, target Fall 2016
  - Big lab upgrades
  - Halo & Tether on ISS
  - Successful year 2016
  - Blue Repair
  - Slosh complete
- **So what's next…**
  - InSPIRE 2: complete Halo deliverables and test sessions
  - Next ZR competition is under way
  - Tether Demo
  - New Vertigo research
- **Continue work transitioning to Astrobee**
  - **Goal: Fully operational in 2018**

Facility Transition



SPHERES Operations

Astrobee Development & Build

Astrobee Commissionin

Astrobee Operations

12 Years (Est. 2006 -)

Major Tasks
- ISS Operations
- Consumables
- Maintenance
- Payload Support

2 Years (CY 16 - 17)
- Infrastructure & Lab Upgrades
- Integration & Test Support
- Flight Build Support
- Guest Science SW & Processes
- Simulator Dev

1 year (CY 18)
- Operations Planning Products
- On Orbit Install Checkout & Demo

6 Years (- 2024)
- ISS Operations
- Maintenance
- Payload Support

SPHERES Support

Astrobee Support

Guest Scientist Program (GSP)

Overview

The GSP provides access to the source code, with examples, a SPHERES software simulator, and Operations support.

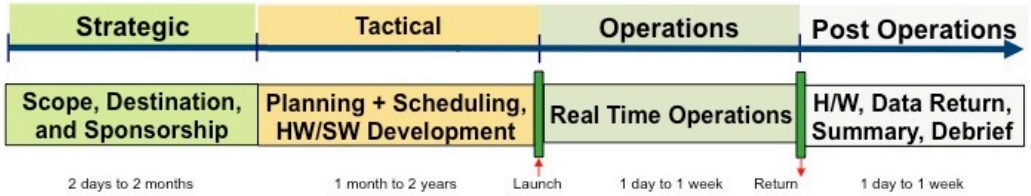
Technical Aspects

1. Download GSP from Sourceforge, including simulator
2. Dev and Test your software on the simulator
3. Test in Ames SPHERES Lab
4. Deliver Software and planning products to SPHERES Operations
5. Conduct test session aboard ISS

Operational Planning Aspects

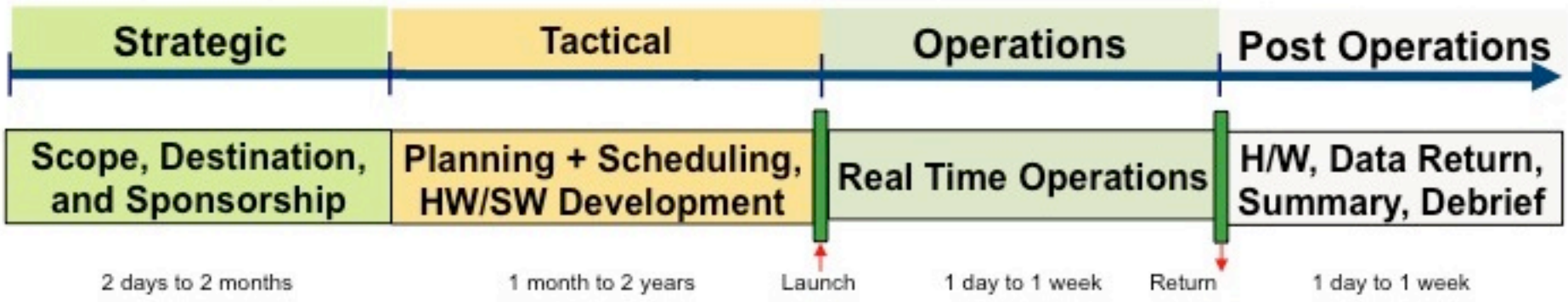
1. Deliver proposed investigation – one pager
2. SPHERES initiates request to schedule ISS Test Session
3. Generate all planning items required by ISS (e.g. Test Plan,)

www.nasa.gov/spheres/gsp

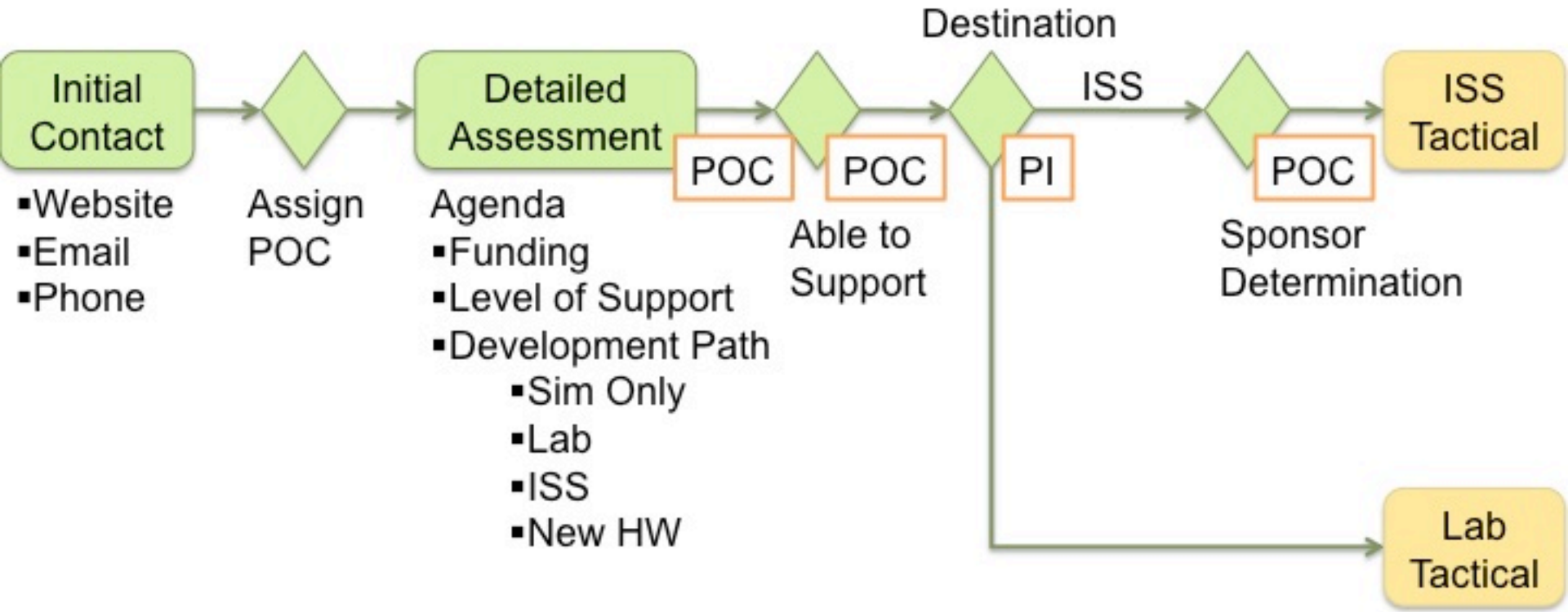


GSP Process

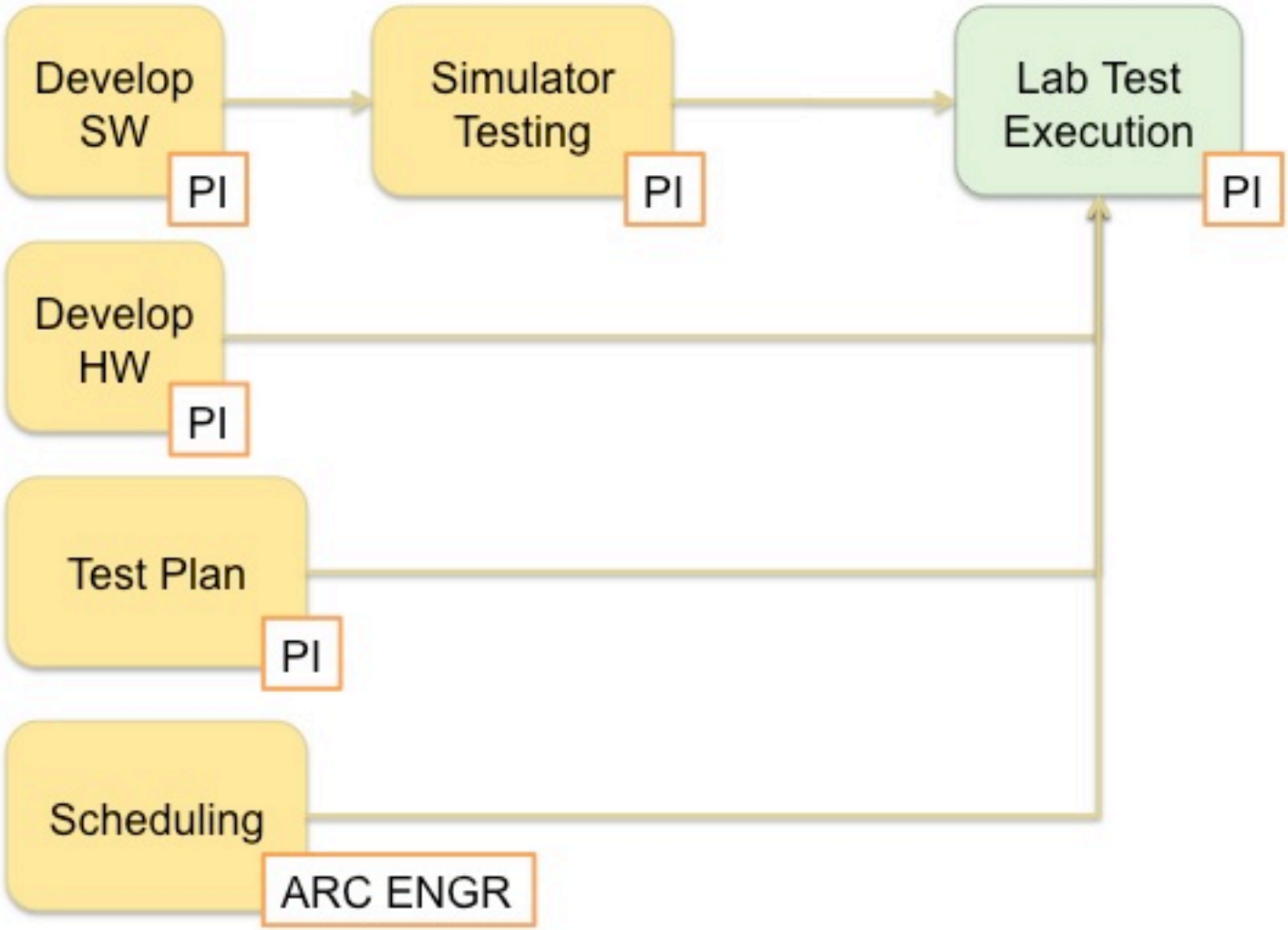
Overview



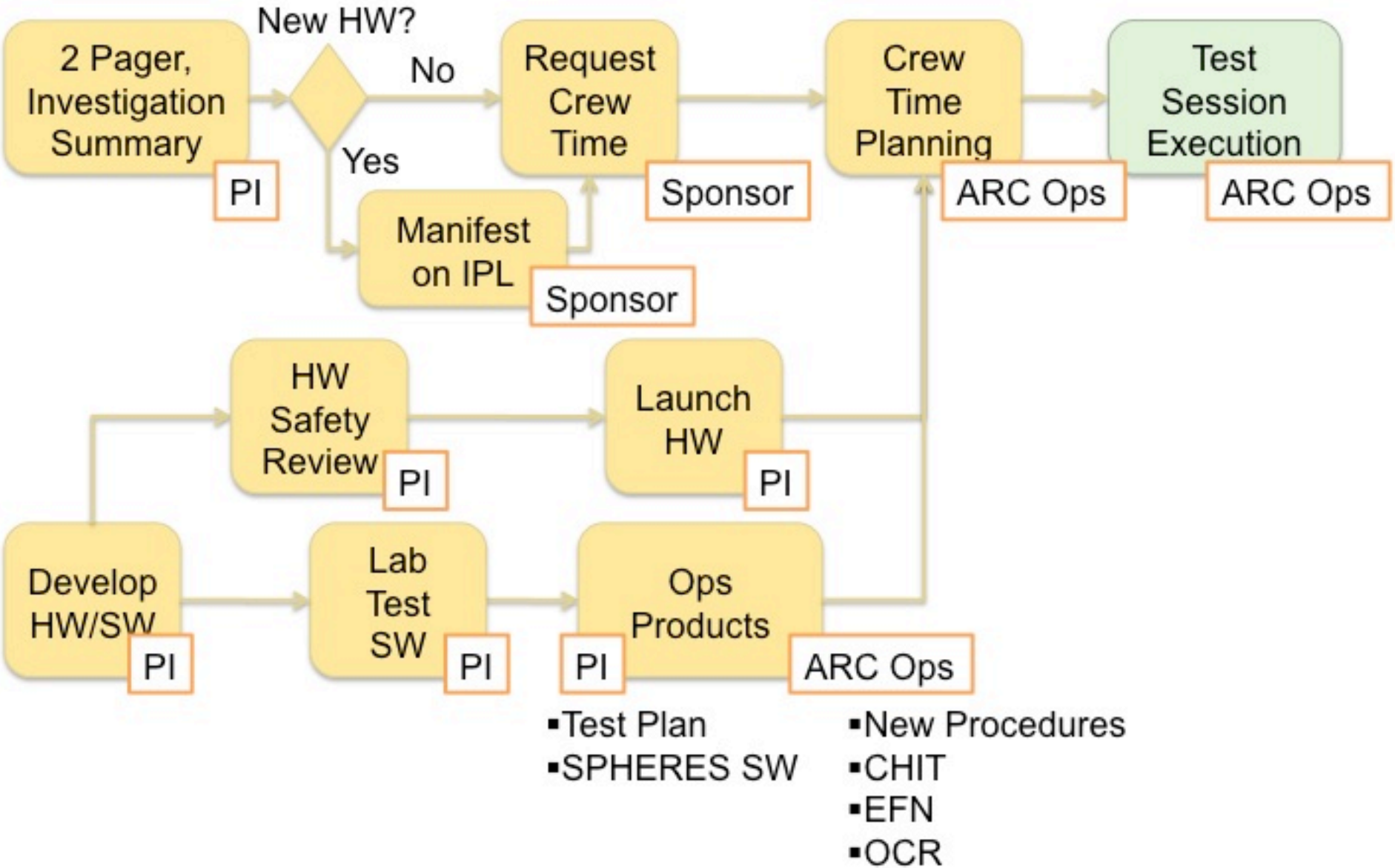
Strategic Phase



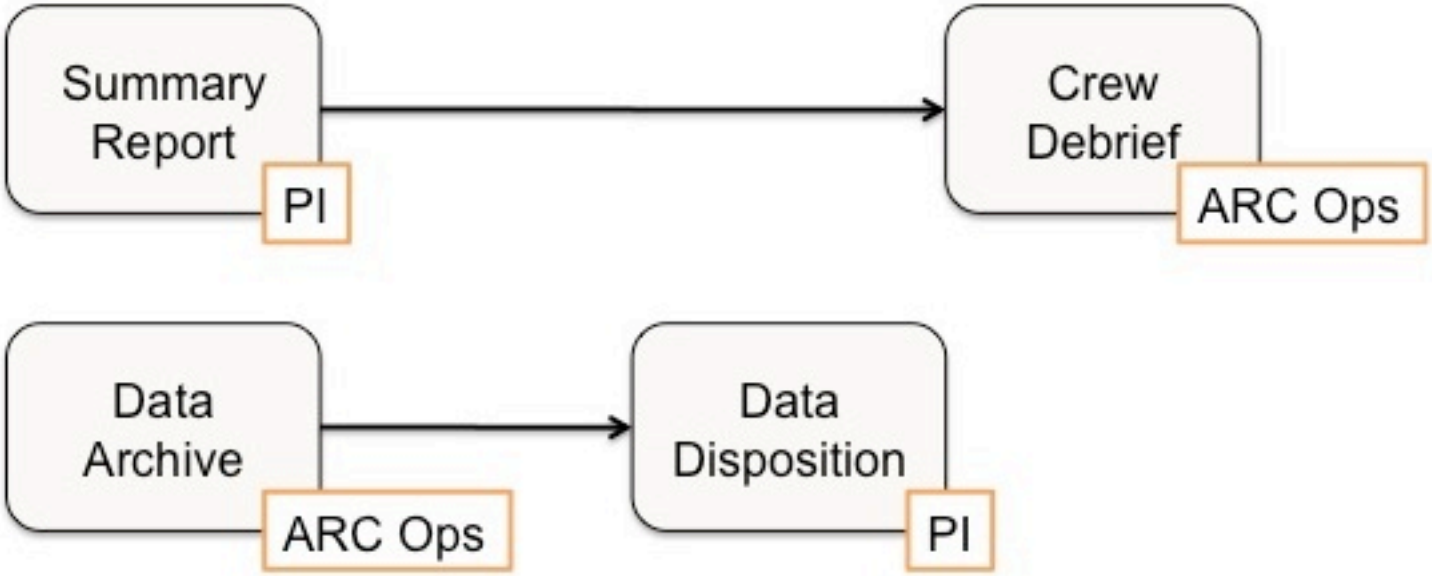
Lab Tactical and Operations



ISS Tactical and Operations

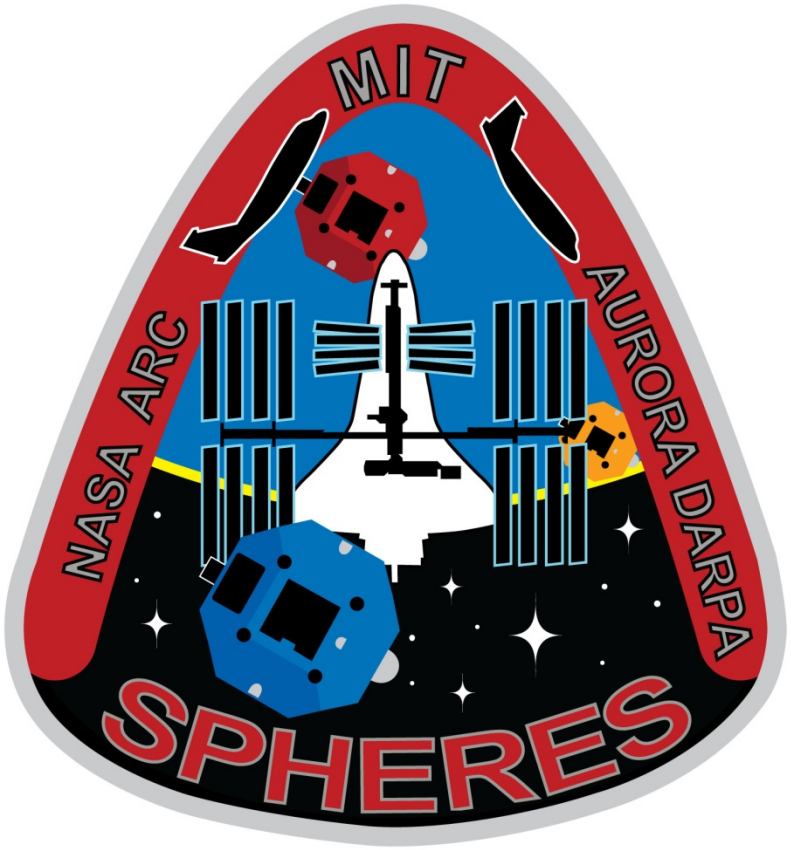


ISS Post Operations



Funding & Internship Opportunities

- **SBIR/STTR 2017 (sbir.nasa.gov)**
- **DARPA BAA's**
- **Grad student fellowships: NASA Space Technology Research Fellowship (NSTRF) - Fall 2017**
  - This is posted on NASA's NSPIRES website (Due November 3rd).
- **Grad student fellowship: NASA Education Aeronautics Scholarship and Advanced STEM Training and Research (AS&ASTAR) Fellowship**
  - This is posted every year on NSPIRES. I've submitted a research opportunity to this that should get posted to NSPIRES in about week, titled: "NASA Ames SPHERES/Astrobee Facility". It will be open for 90 days.
- **Student internships**
  - Summer Opportunity titled: "NASA Ames SPHERES/Astrobee Facility", posted to NASA's OSSI website here: (https://intern.nasa.gov/ossi/web/public/main/)
  - Due March 2017



SPHERES Operations

Operations: Functions

Ensure Facility Readiness for ISS Test Sessions

- All crew training now via Onboard Training (OBT) both English & Russian
- Crew procedure updates
- Coordinate with ISS Lead Increment Scientist and POIC Cadre
- Flight products on orbit (test plan, .spf, on-board training and review, etc.)
- Consumable (CO_2 Tanks and Batteries) refurbishment and resupply
- Support SPHERES directory/file maintenance

Real-Time ISS Test Session support

- Coordinate w/SPHERES investigators product development and delivery
- Support crew and POIC cadre real-time
- Conduct/coordinate crew conferences as needed
- Test session data and video management

Operations: Functions

Increment Planning

- PTP and 2-pager development, review, and update
- CEF support and submittal
- Timeline planning model review and update

Safety and Verification Assessments

- Conduct Integrated Safety Assessments for all SPHERES payloads
- Conduct Integrated Verification for all SPHERES payloads
- Safety & Verification assessments for Battery/Tank launches/returns
- Complete Certification of Flight Readiness for ground systems and on-orbit hardware and operations products
- Conduct ISS Requirements Change Assessments to SPHERES Facility

Public Relations

- Maintain website, work with ARC PAO office to publish material on site

Ops: Increments 47/48 & 49/50 Review

Increments 47/48 (March 2016 – Sept. 2016) & 49/50 (Sept. 2016 to March 2017)

- Increment planning on going for 49/50 (Sept 2016 – March 2017), and 50/51 (March 2017 – Sept 2017)
- Debrief questions for crewmember Jeff Williams submitted; debrief session supported 10.20.16. Jeff was the first crew member to operate SPHERES, 10 years later he performed the maintenance session helping us assess satellite health.
- Planning for Tether, Halo, ZR, Docking Port, and Slosh Coating ongoing
- The following Test Session Completed
  - Zero Robotics – Three Sessions (Unit Test, Dry Run, and Finals) Aug 1, 5, & 12 – all Russian Supported
  - Slosh Science 7 (Oct 7)
- At the request of crewmember Kate Rubins, designed a voluntary science session
- Starting to support Astrobee Con Ops development and other early planning
- Consumables and hardware manifest for HTV-6, SpX-9, SpX-10, OA-7; safety and verification support for these flights – summarized on later Ops slide and in PIM presentation

Ops: Increments 49/50 & 51/52

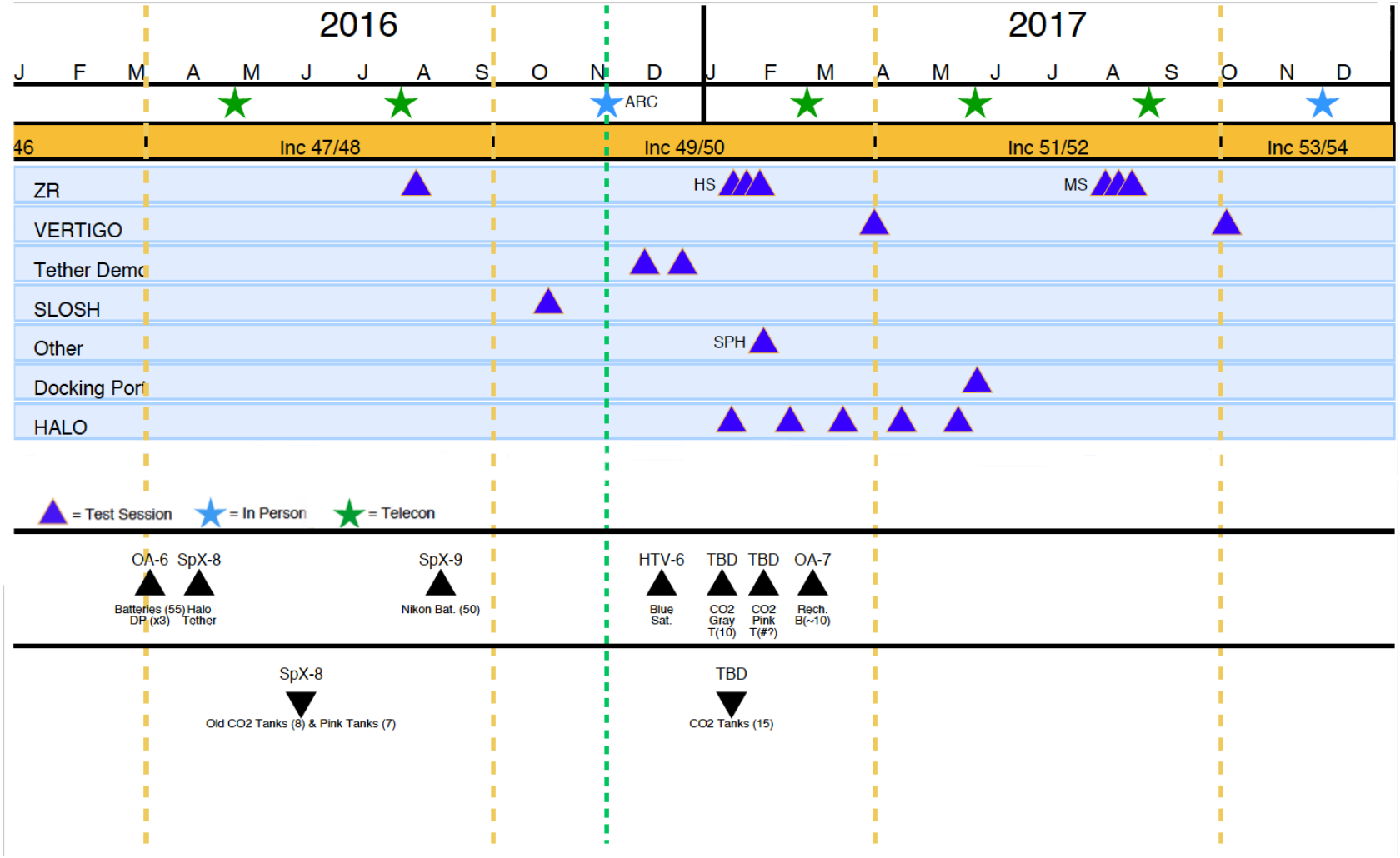
49/50 (Sept 2016 – Mar 2017) 51/52 (Mar 2017 – Sept 2017)

- Tether Checkout — November-December 2016
- Tether Science 1 — Jan 2017
- Zero Robotics High School
  - Unit Test — Dec/Jan 2016-17
  - Dry Run — Jan 2017
  - Finals — Jan 2017
- Halo Checkout — Dec 2016 – Feb 2017
- Halo Science 1 (Day 1 & Day 2) — Jan-Feb 2017
- Halo Science 2 — Feb-Mar 2017

==========[Increments 51/52]==========

- Halo Science 3 — Mar+ 2017
- Halo Science 4 — Apr+ 2017
- Docking Port Science 2 — Apr-May 2017
- Zero Robotics Middle School (3x sessions) — Aug 2017

SPHERES Calendar



Safety and Verification

Safety

Completed and submitted:

- SPHERES Blue Satellite Reflight SDP (HTV-6) 10.14.16 – Approved 10.28.16
- SPHERES RINGS batteries recertification (ISS) 9.21.16 – Approved 10.3.16
- Nikon batteries series SDP (OA-5) 5.5.16 - delivered by CMC for SpX-9 flight.

Verification

Completed and submitted:

- SPHERES Blue Satellite "Common Transport" (HTV-6) 11.4.16 – Approved 11.4.16

Upcoming or in work

- SPHERES Blue Satellite "On-orbit" Verification (HTV-6)
- SPHERES CO2 gray tanks, first generation tanks (SpX-10)
- Upgraded pink SPHERES CO2 tanks (generation '2.5') Safety and Verification
- SPHERES-Rechargeable Battery Integrated Safety & Verification (for OA-7)

Consumables Status

CO2 Tank Inventory

- **38 Tanks on orbit now – should support approximately 7 test sessions**
- Planning to up mass gray tanks - flight TBD (Dec/Jan 2017)
- Followed by pink tanks up mass soon thereafter – flight TDB

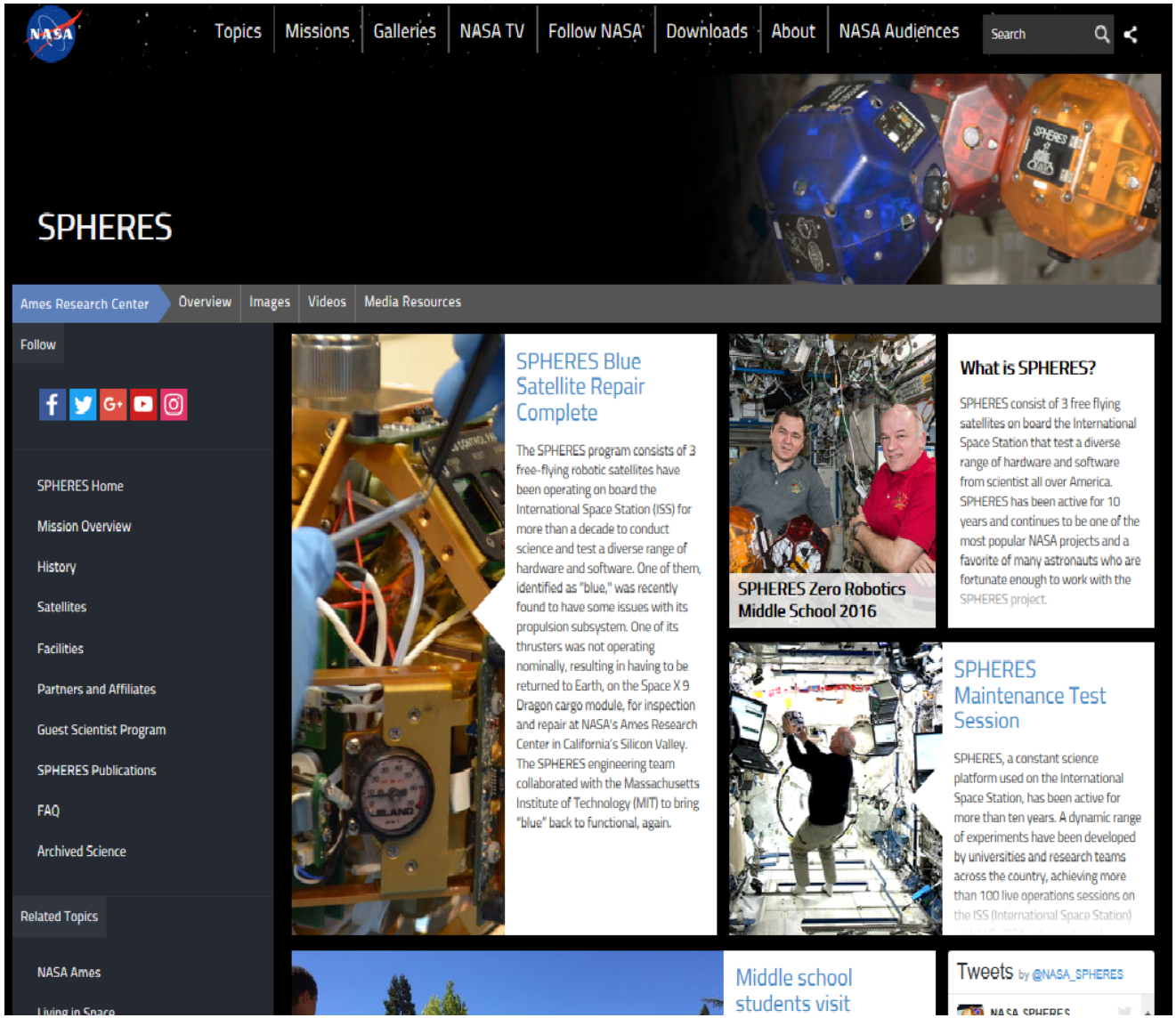
Battery Pack Inventory

- **148 Batteries on orbit now - should support approximately 24 test sessions**
- 50 Nikon Rechargeable Batteries are on station for the VERTIGO Avionics boxes. SPHERES is currently the only users of these batteries.

Consumables downmass

- Return at least 1 empty gray and the remaining empty pink tanks (12) – flights TDB

SPHERES on Social Media



Twitter

https://twitter.com/NASA_SPHERES

Website

http://www.nasa.gov/spheres

Software: GUI Update

PISVF Testing: Version 6.3.0 – Complete

PSCP Pre-Approval – Complete

First Use Onboard

- GUI ready to be installed
- First use delayed while dealing with Blue SPHERES debug

GUI Open Source

- NASA open source Approved
- Planned release: 11/08/16

Vertigo GUI interface

- Communication bug discovered
- When bug fixed, will use Pre-approval for update

Software: Gantry Control

6dof Control:

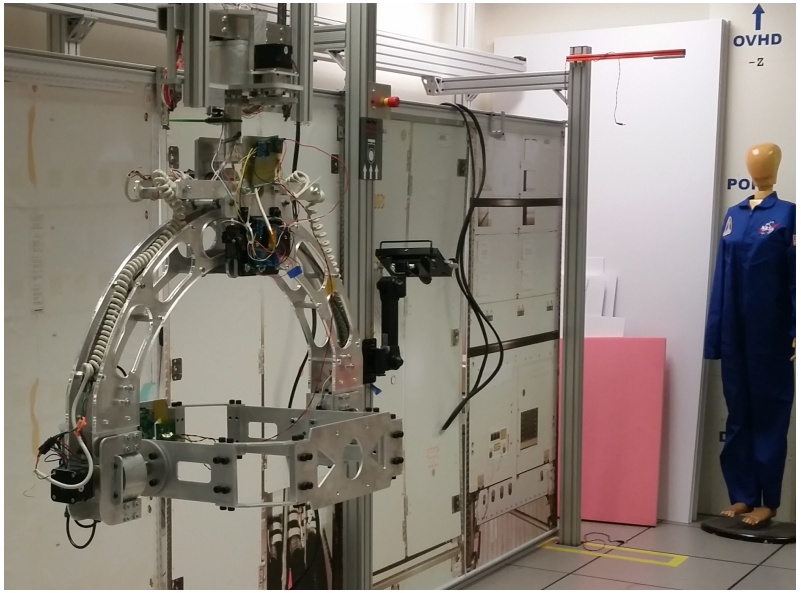
- Matlab based control software
- Position, Velocity, or Acceleration commanding
- Able to simulate trajectories or receive real time commands from the payload over XBee.

Completed Tests:

- Calibration of speed camera.

Current/Purposed Tests

- Speed camera verifications.
- Astrobee vision algorithm validation.

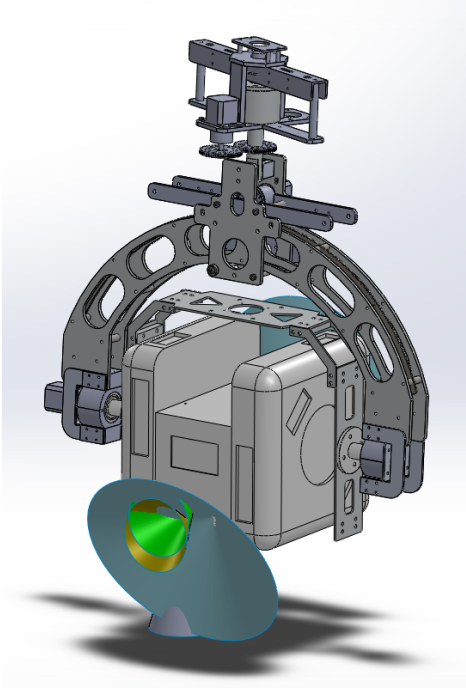


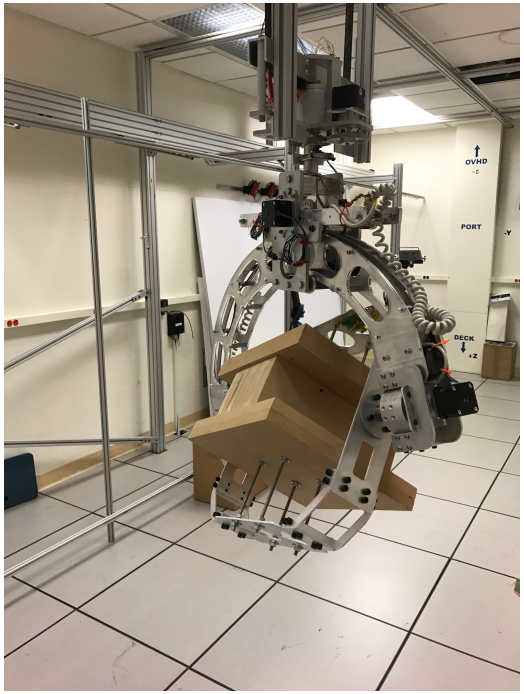
Lab Upgrades: MGTF

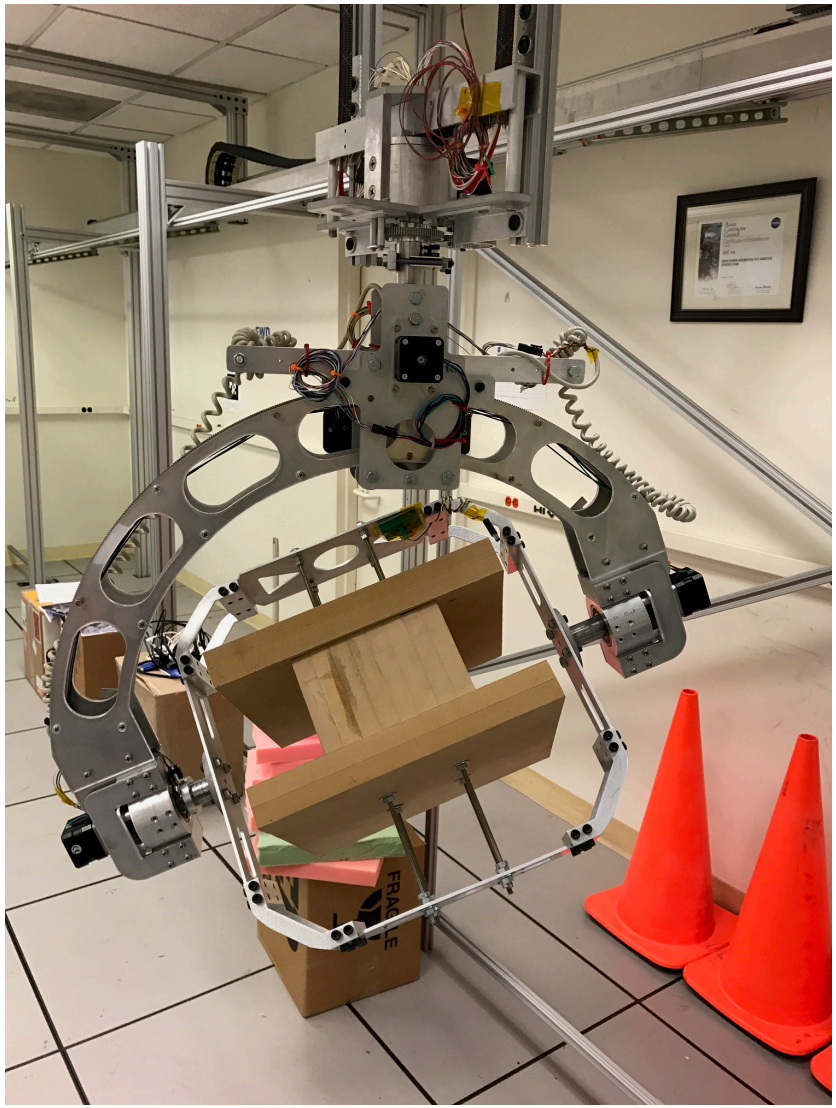
- **Environmental effects**
  - Background
  - Mock ISS Panels
  - LED Lighting
  - Active Gimbal

MGTF Gimbal

- **Gimbal Specs**
  - Active Gimbal
  - Yaw 360°Roll 126°Pitch 180°
  - Weight ~ 16lbs (without satellite)

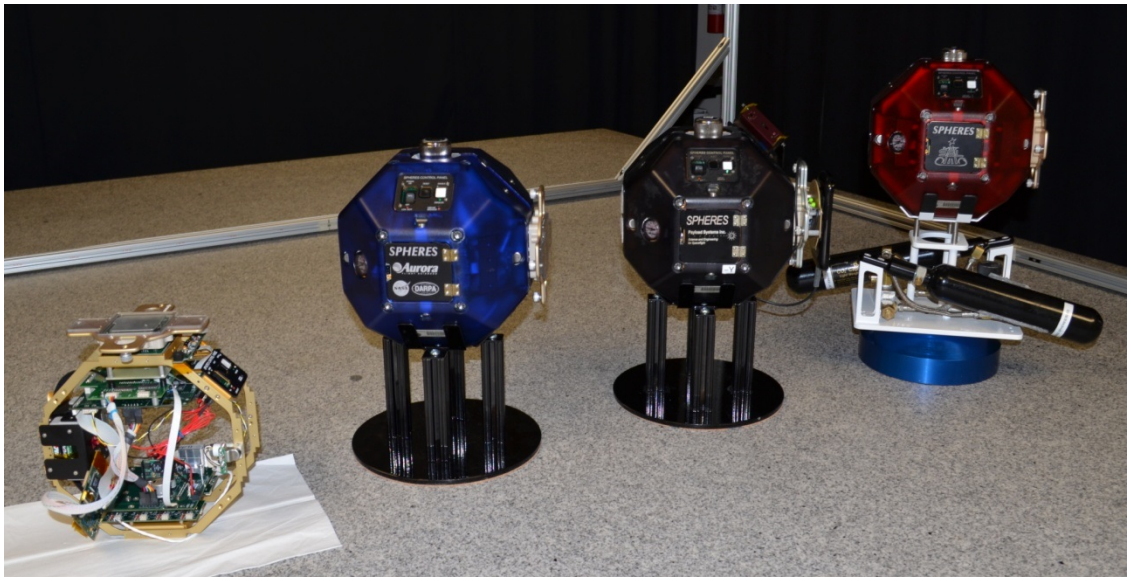


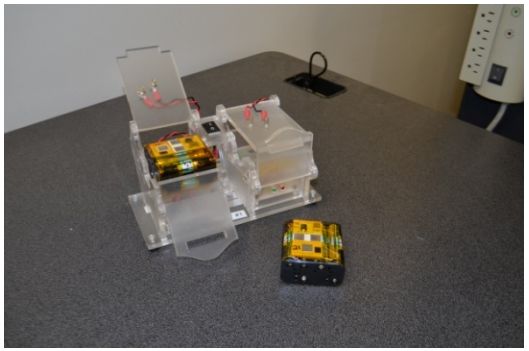


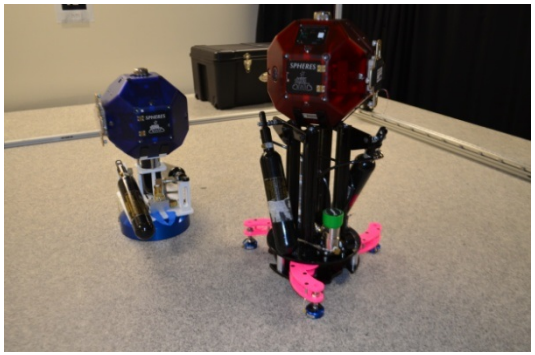


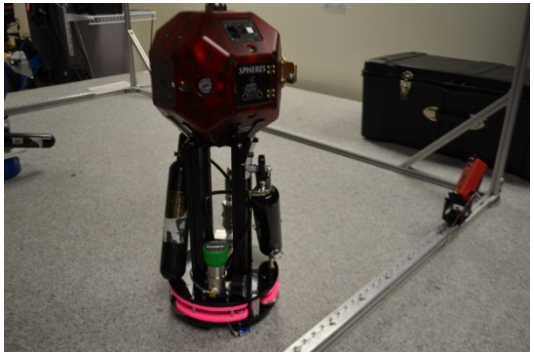
Hardware Status

- **Hardware status**
  - Red: 100%
  - Blue: 100%
  - Black: 30%
  - Orange: @ MIT
  - Stack: 100%
  - Battery recharger: 4 of 4
  - New air carriage: 3 of 4
    - ✓ Tall 3-puck: 2 of 3
    - ✓ Single puck: 1 of 1
    - ✓ More in work









Gen 2.5 CO2 Tank Status

Inventory

- Qty-136 Tanks Arrived (PSI-Plus delivered extra)
- 5 Gal F694 Black Plasti-Dip
- 1 Gal F938 Primer
- 2/3 Decals (IMS In order process)
- Qty-125 Pinvalves (In shipping process)

Schedule:

Tank Dipping: End of November

Decal Placement: Early December

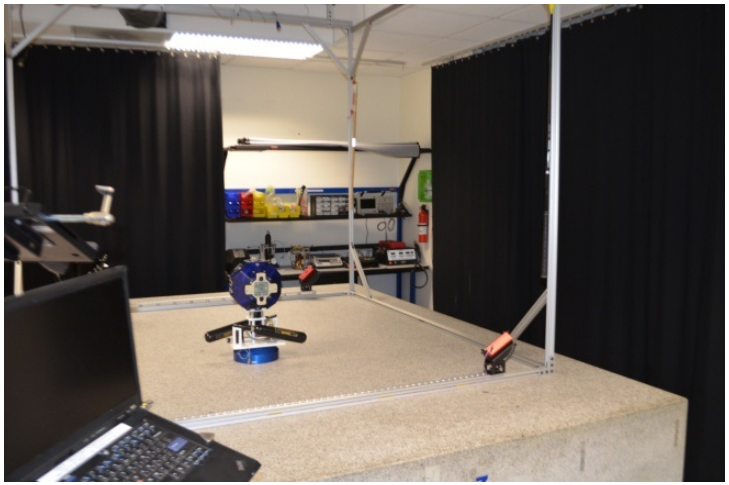
Pinvalve Torquing: Early December

Filling: December

1 Month rest time for leak check: December to January

Lab Status

- Granite Lab: Online

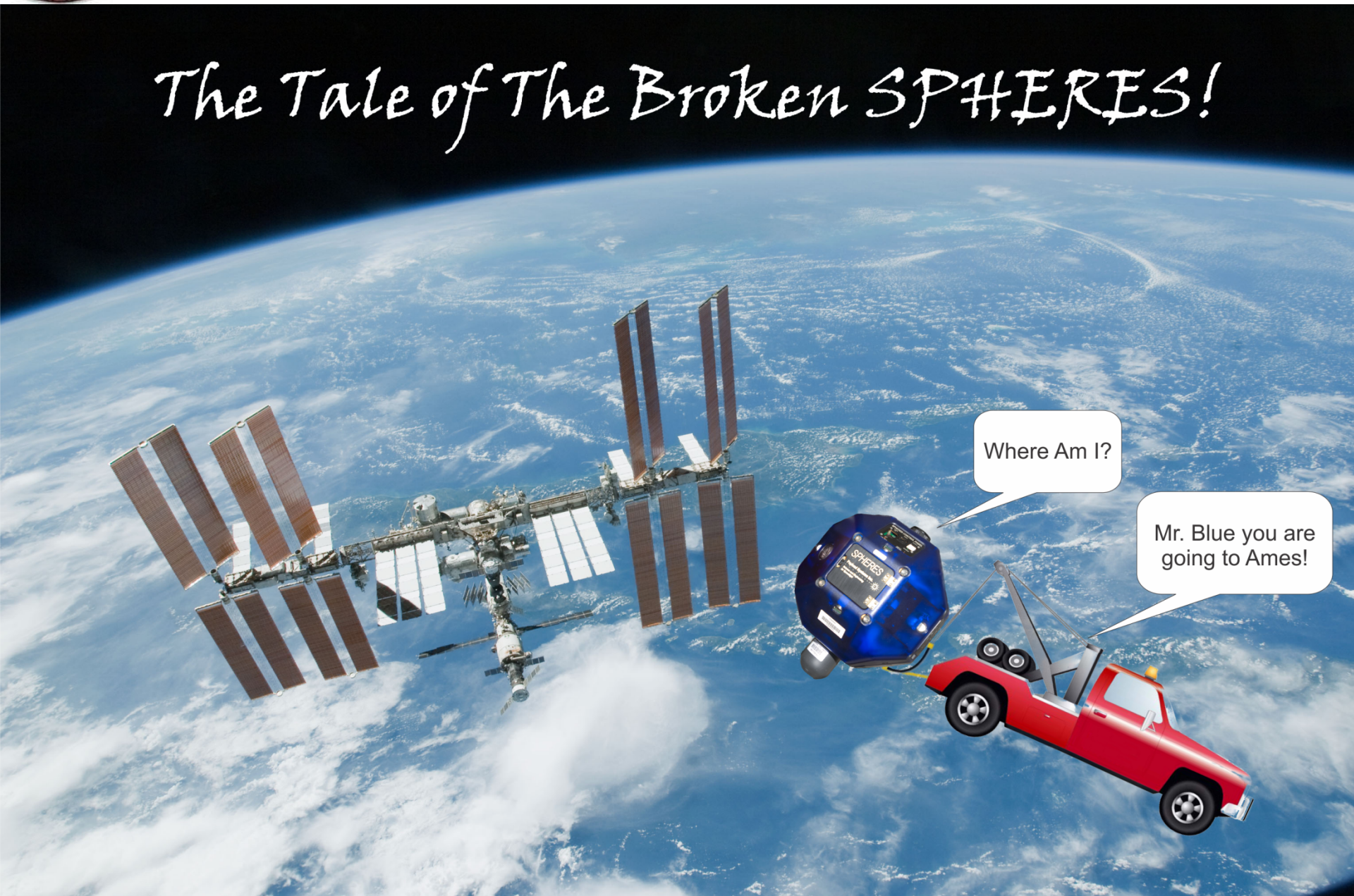


- Flight Lab: Online

- Micro Gravity Test Facility (MGTF) Lab

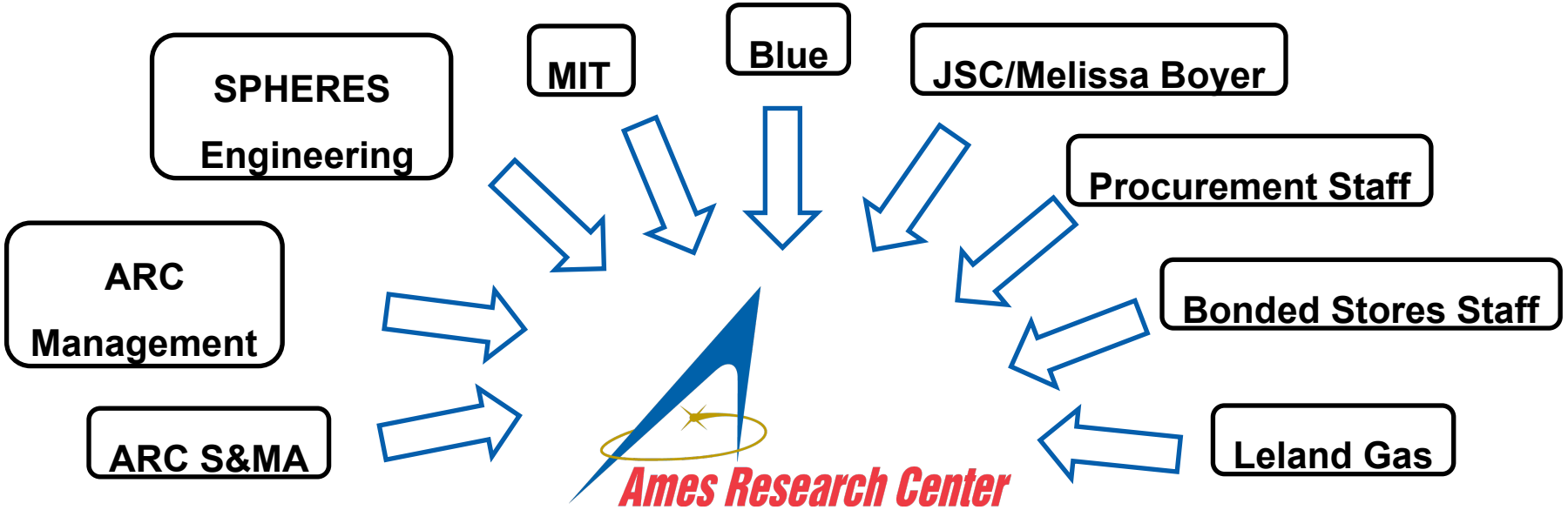
- Engineering Evaluation Lab (EEL): Available upon request

Blue Flight Repair



So What Started This?

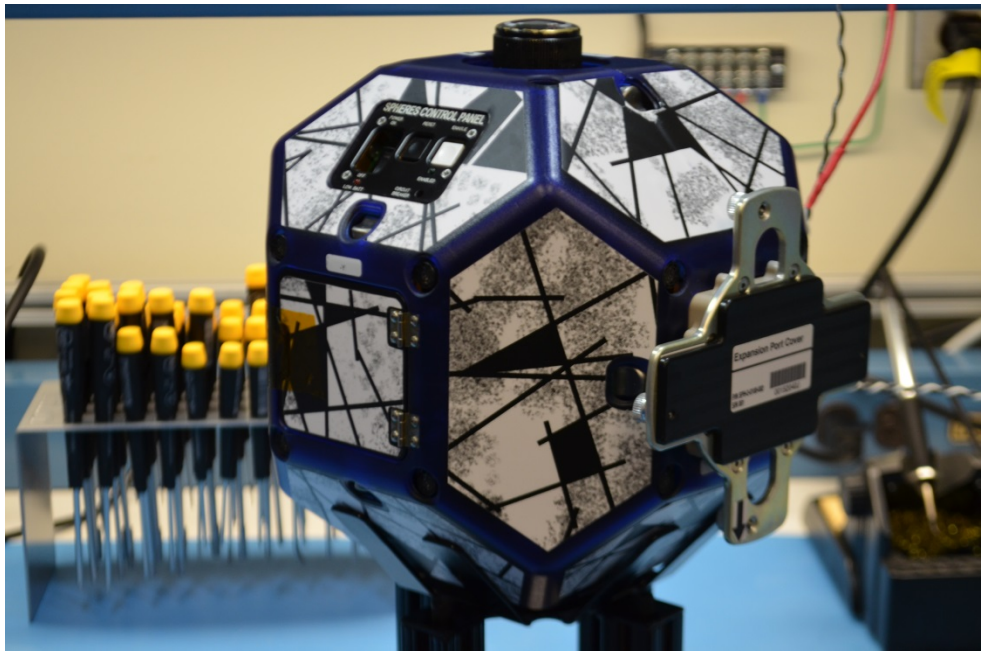
- During recent test sessions Blue was behaving off nominal with localization issues.
- Early Theories suggested avionics issues
- Down mass and quick turn around opportunity arose.
- 4 week window of diagnosis and repair (extremely unconventional task, and opportunity, with only 4 weeks of notice for preparation)

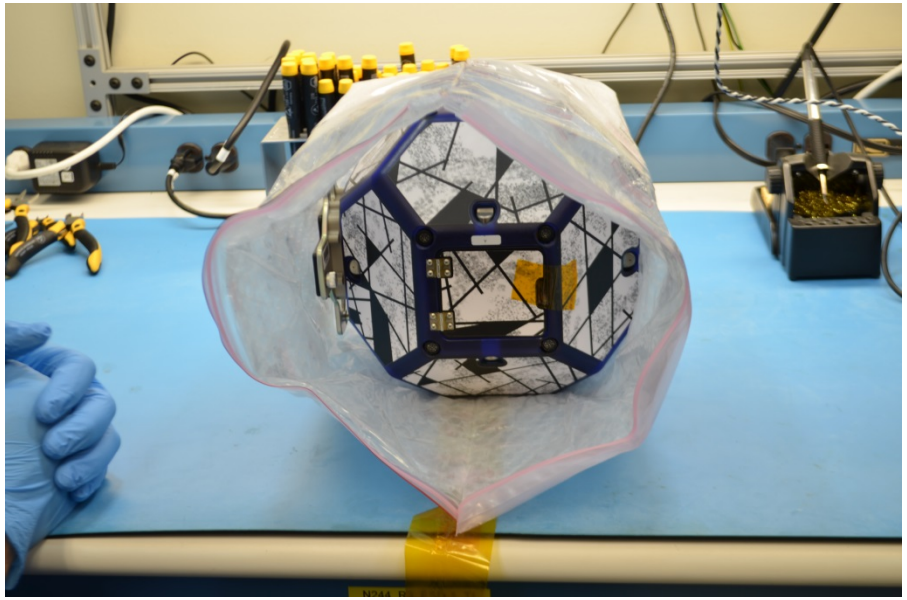


Docking Port Science 1 (TS81)

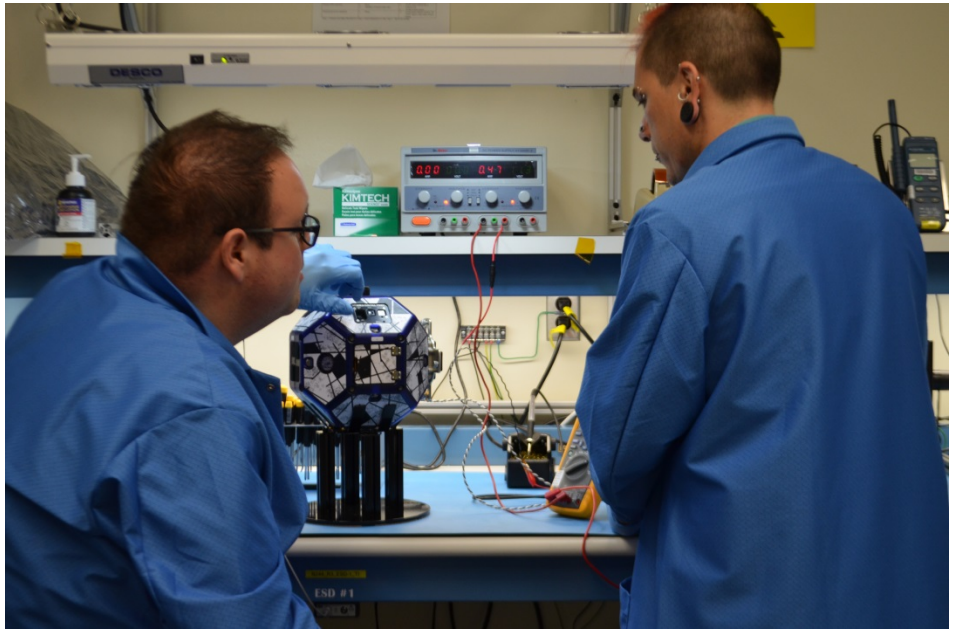
Fresh From The ISS

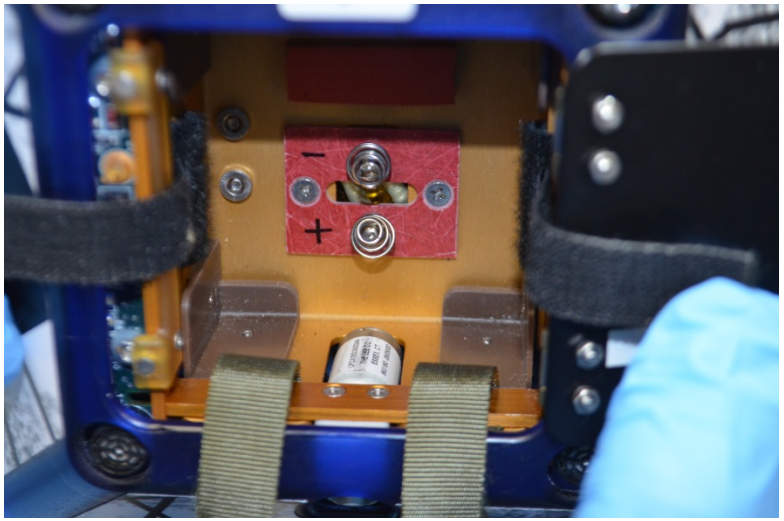
- Unpacking and overall visual inspection
- Remarkably good condition

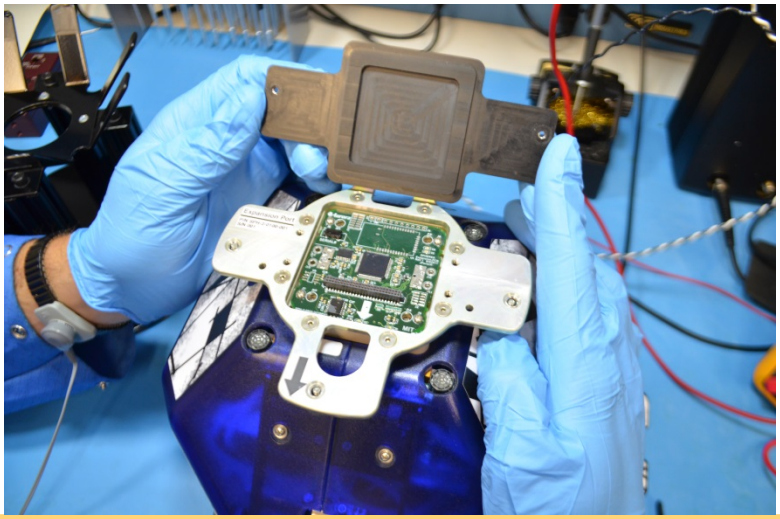


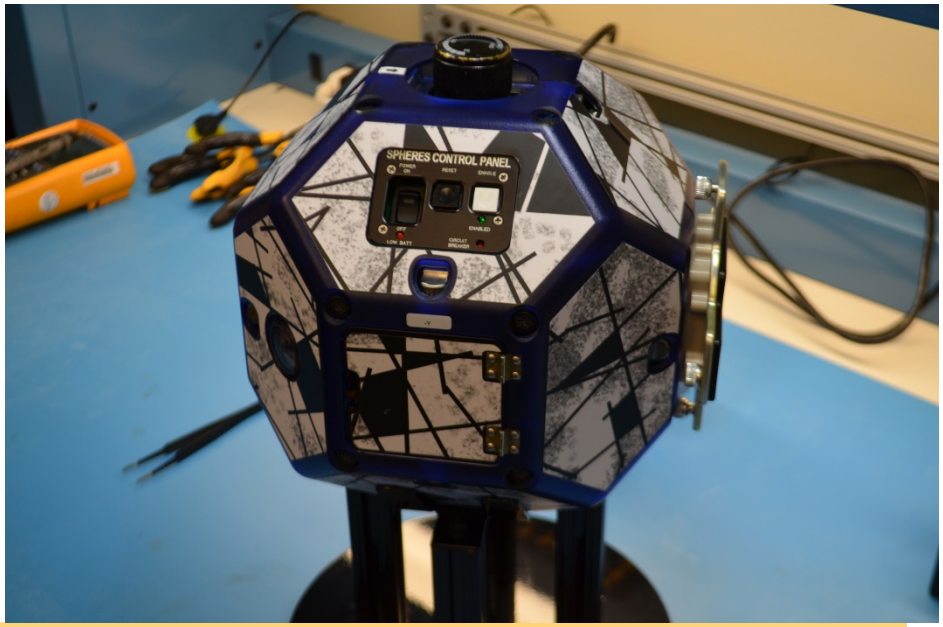


Health Check





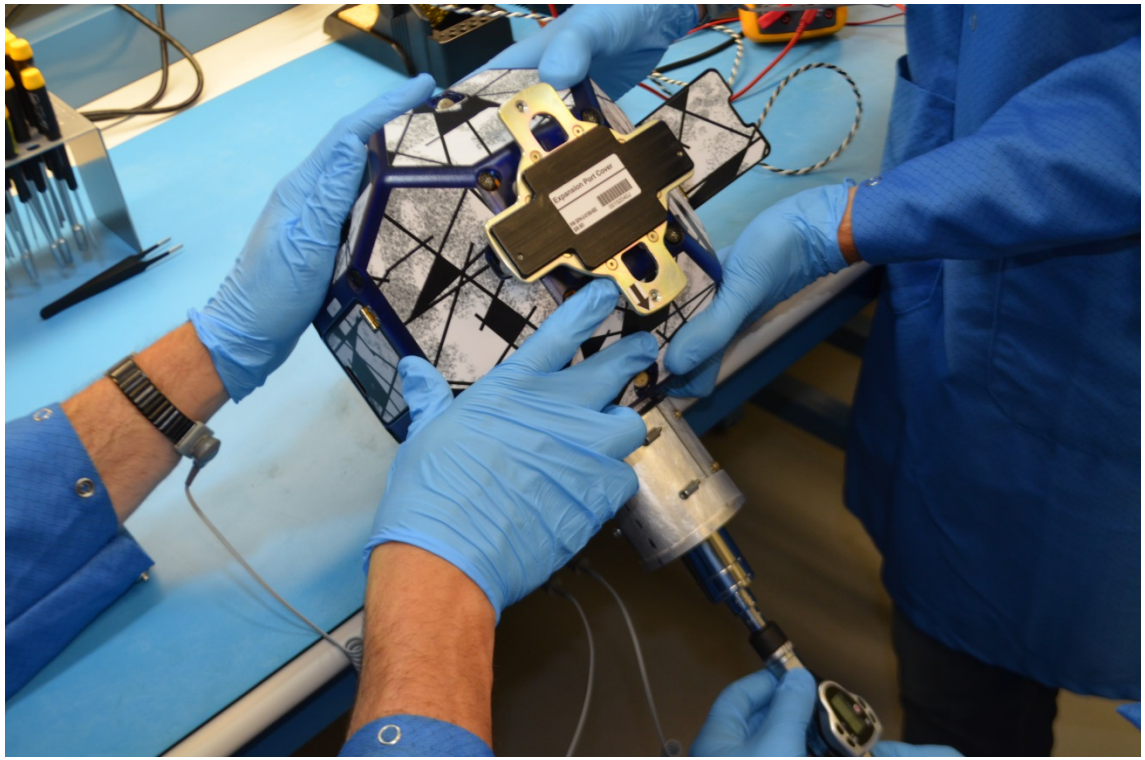


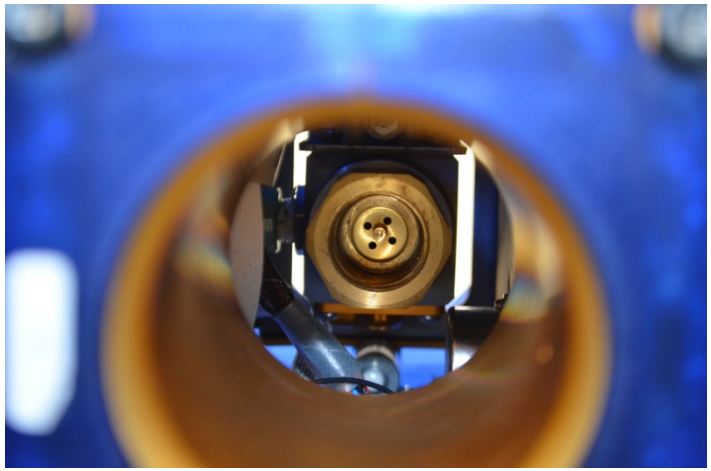


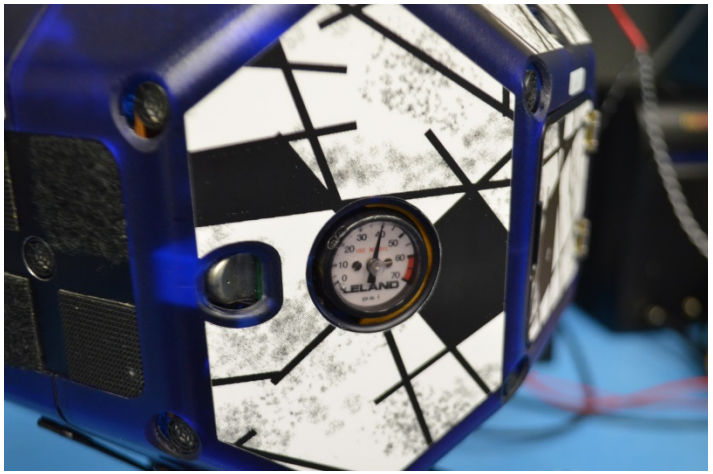
What Is That I See?

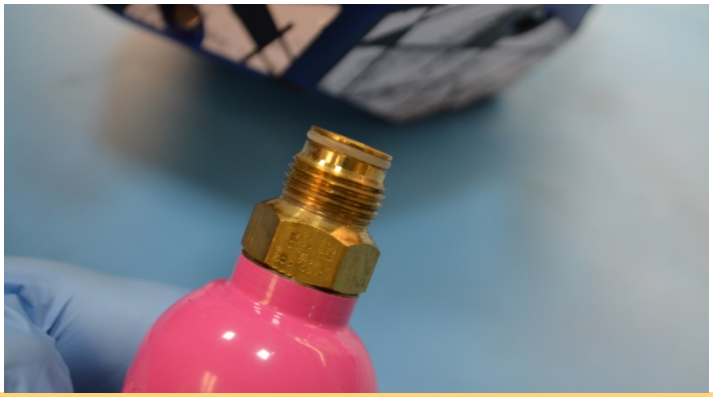
- Internal Borescope visual inspection

You Wont Vent? Smoking Bullet!

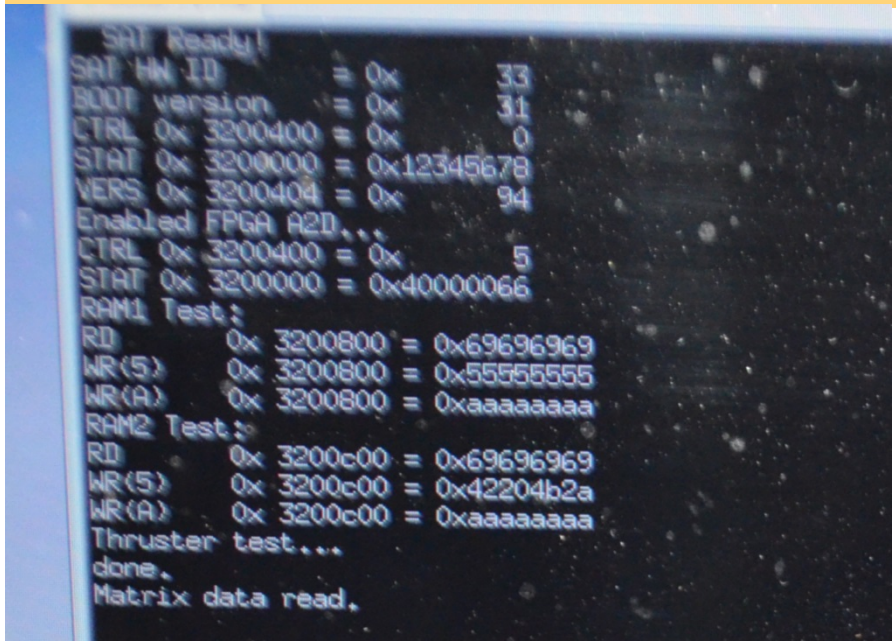


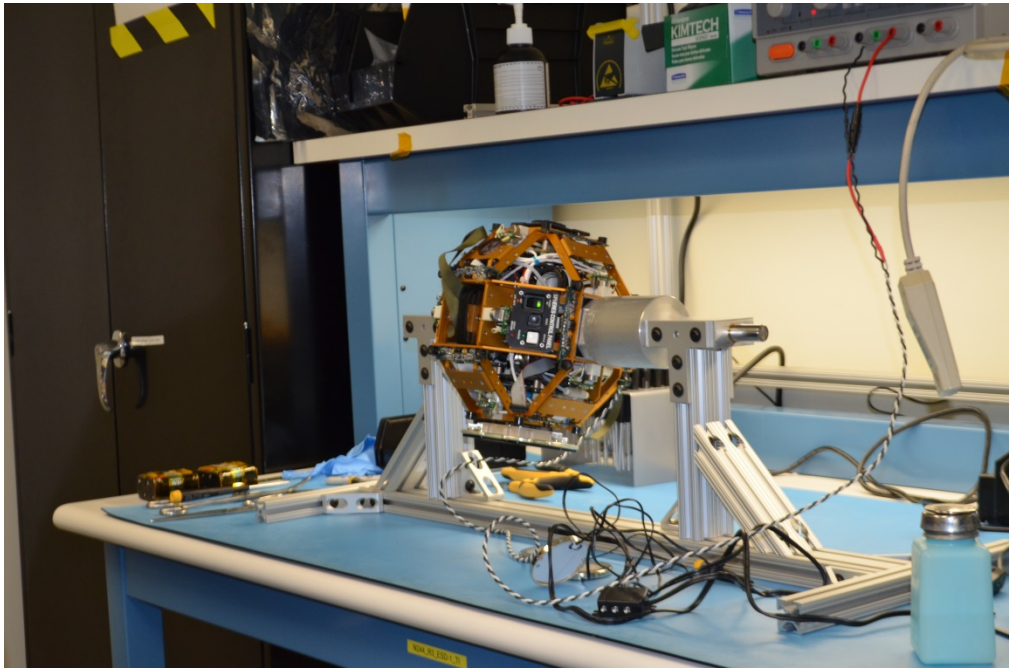






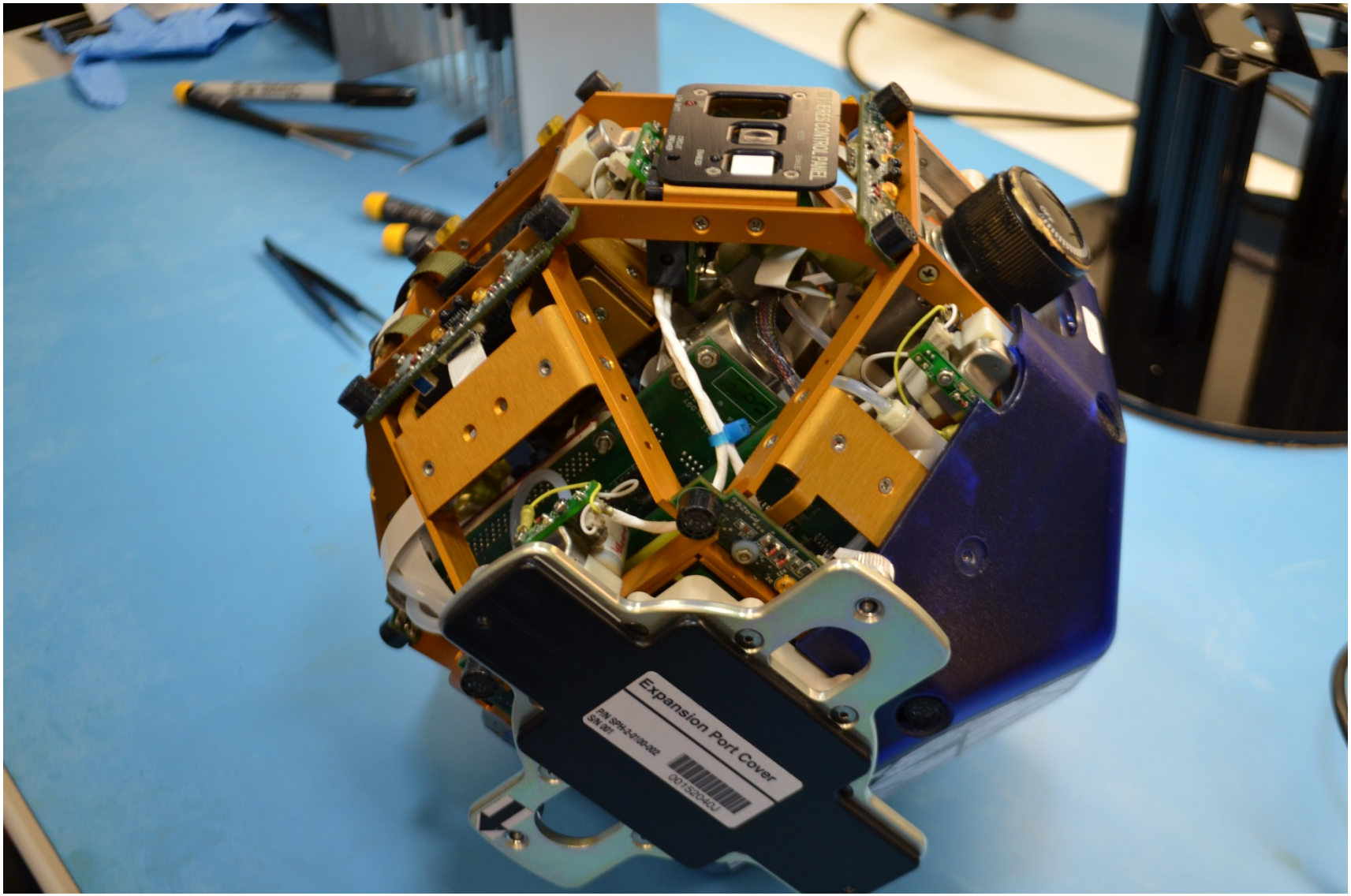
Smoking Gun! Update Please!



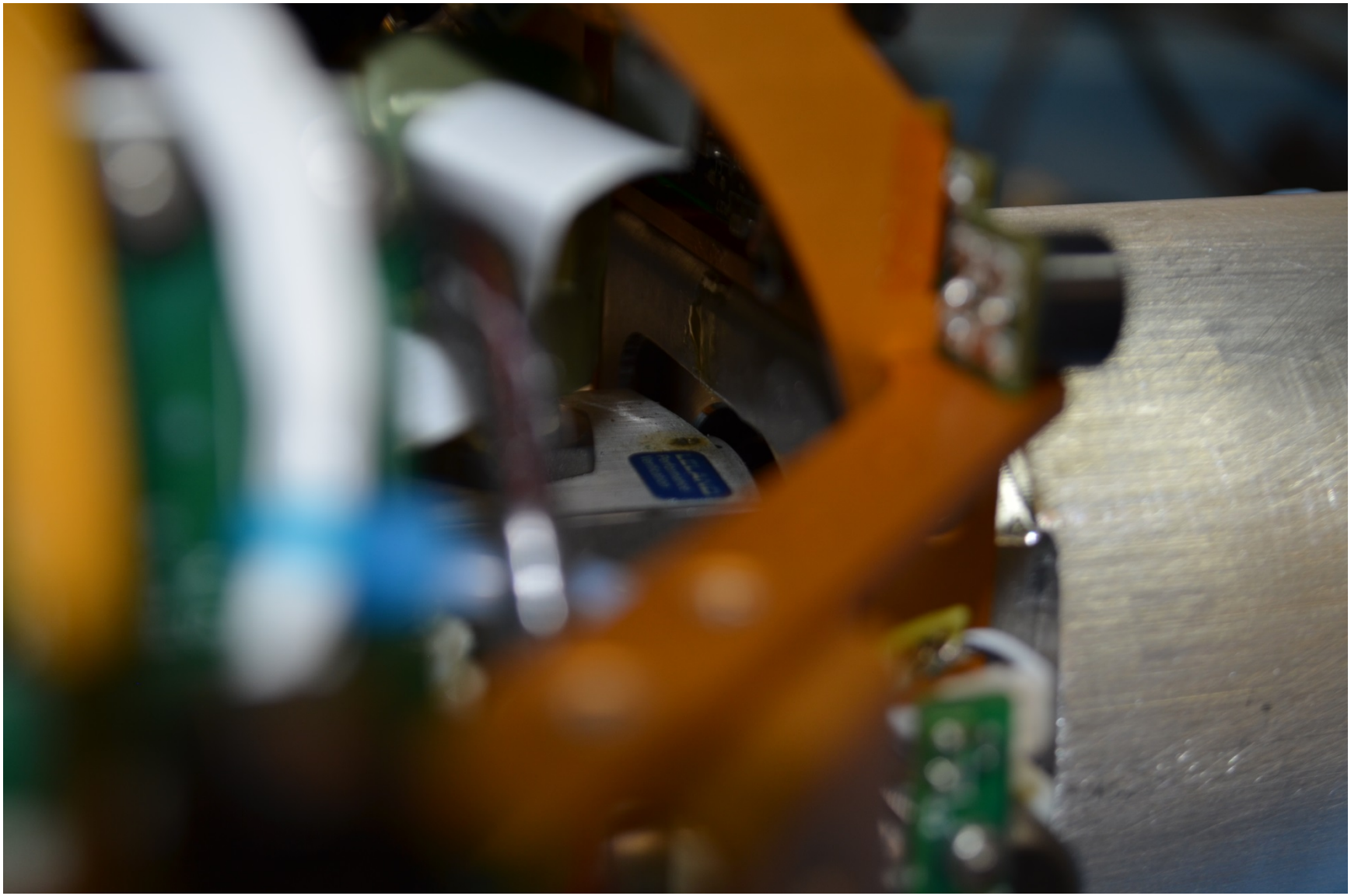


Color	Serial #	Firmware Version	Checkout Date	Wait Time	Shipped Out
Orange	3	0x94	2/23/2005	10 days	3/5/2005
Red	2	0x101	2/1/2006	0 days	2/1/2006
Blue	1	0x102	3/31/2006	120 days	7/31/2006

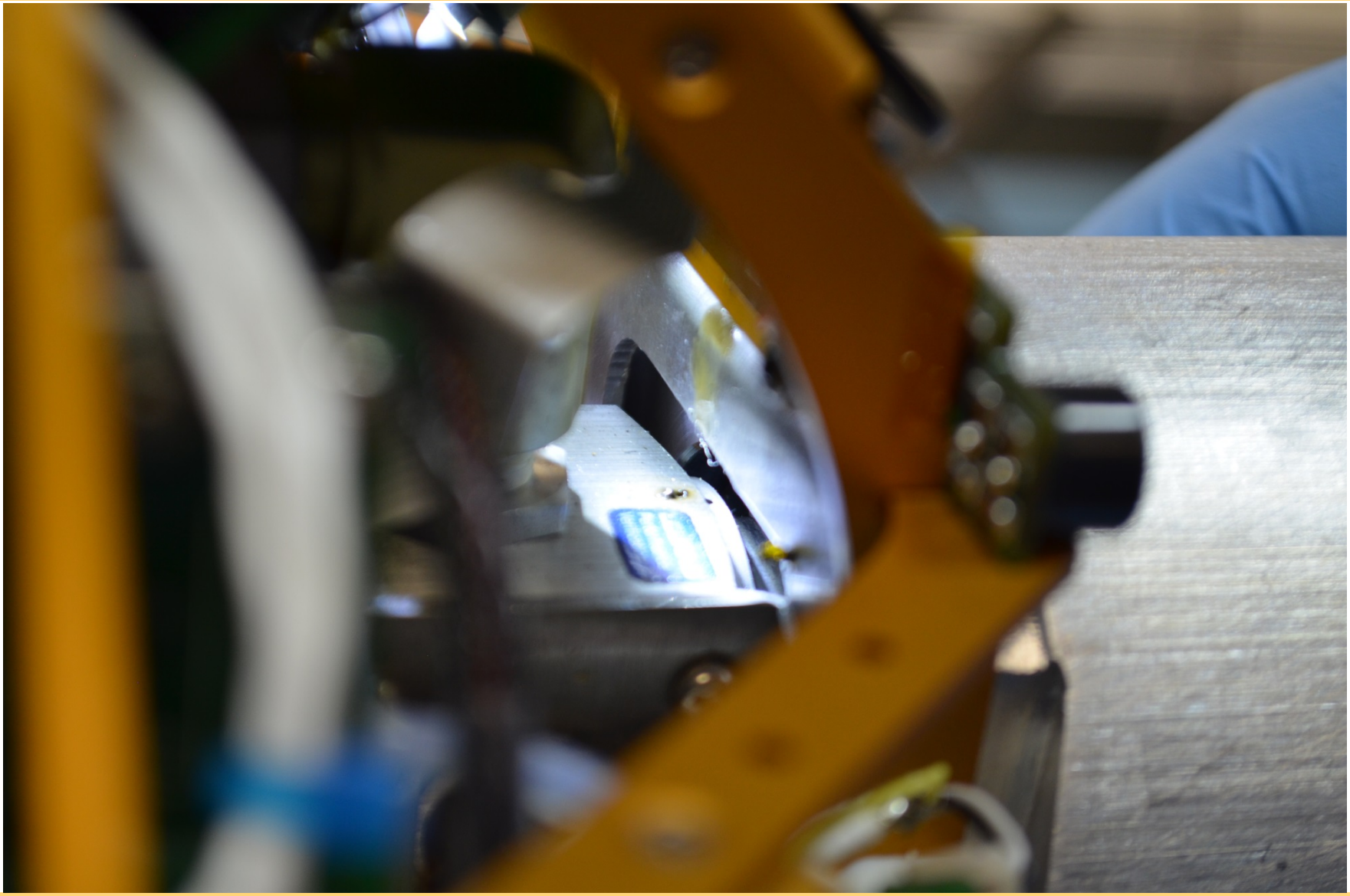
Removal of Shell



What is That?



Flux? Grease?



Meeting #94

- Discovered Pressure system was choked flow and had small gas capacitance giving partial functionality.

- Blue has double operational hours
- ~250 hours vs 150
- Loss of oil
- Brass particulates
- Theory is clogged inlet filter

What Did We Replace?

CAD MAINTAINED. CHANGES SHALL BE INCORPORATED BY THE DESIGN ACTIVITY
ALL SHEETS ARE SAME REVISION LEVEL

CAGE CODE 4KYR6 | DWG NO SPH-A-06-302 | REV - | SHEET 1

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

EXPLODED ISOMETRIC VIEW

EXPLODED RIGHT VIEW

ISOMETRIC VIEW

REVERSE ISOMETRIC VIEW

FIND NO	QTY	CAGE CODE	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MODEL NAME/MATERIAL
6	AR	2VS07	MCM 7346A11 OR EQUIV	THREAD TAPE, PTFE, MILITARY GRADE, 1/4"	NM_TEFLON_TAPE PTFE
5	AR	1UCL7	MCM 1810A315 OR EQUIV	ADHESIVE, THREADLOCKING, LOCTITE 220 (FOR <1/4" DIA.)	PARTS_LIST_LOCTITE_220
4	1	4KYR6	SPH-A-07-303	ASSY, EXPANSION CHAMBER	GS_EXP_CHAMBER_ASY
3	1	4KYR6	SPH-A-07-302	ASSY, GAUGE ADAPTER, LELAND	GS_GAUGE_ADAPTER_ASY
2	1	4KYR6	SPH-A-07-301	ASSEMBLY, GAS SUPPLY	GS_REGULATOR_BODY_ASY
1	4	2W134	PART OF 50033	SCREW, #4-40 X 7/32, PAN HEAD LELAND LTD, PART OF 50033	LELAND_GAUGE_MT_SCREW

PARTS LIST

AURORA PROPRIETARY
THIS INFORMATION IS NOT TO BE DUPLICATED OR DISTRIBUTED TO OTHER PARTIES WITHOUT THE EXPRESS WRITTEN CONSENT OF AURORA FLIGHT SCIENCES CORPORATION.

PREPARED IAW ASME Y14.100-2000
DIMENSIONS/TOLERANCING PER ASME Y14.5M-1994

UNLESS OTHERWISE SPECIFIED:
ALL DIMENSIONS ARE IN INCHES
TOLERANCES: .X ± .10 ANGULAR ±0°30'
.XX ± .02
.XXX ± .005
SURFACE FINISH 63 PER ANSI B46.1
BREAK ALL SHARP EDGES AND DEBURR (R .020)
DIMENSIONS & SURFACE FINISHES APPLY AFTER ANY FINISH, COATING, OR TREATMENT

Aurora FLIGHT SCIENCES
RESEARCH & DEVELOPMENT CENTER
4 CAMBRIDGE CENTER, SUITE 11
CAMBRIDGE, MA USA 02142

APPLICATION

NEXT ASSEMBLY	USED ON
SPH-A-05-302	SPH-1-0000-000

DESIGNER: FAIR

CONFIGURATION STATUS

RELEASE STATUS: RELEASED | DATE: 13-08-20

COPY STATUS: UNCONTROLLED | COPY NO: N/A

FILENAME: GS_REGULATOR_ASY | PROJECT CODE OR CONTRACT NO: S303

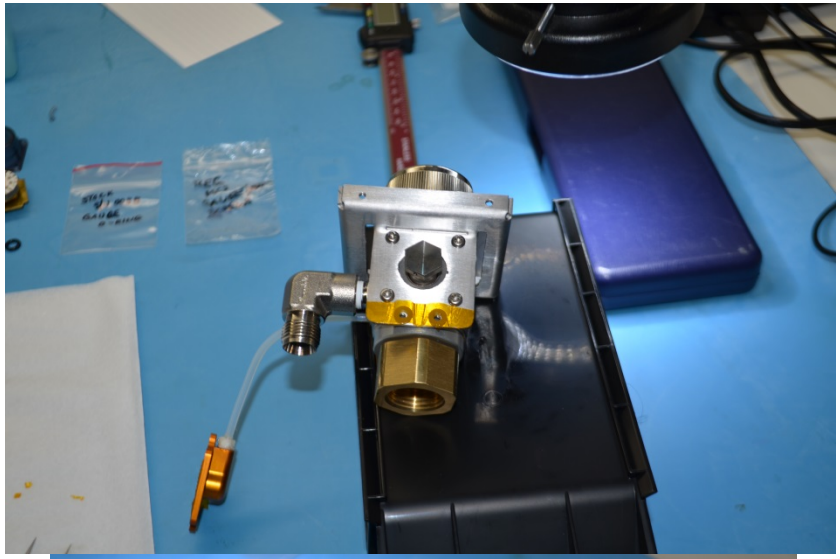
TITLE: ASSY, REGULATOR

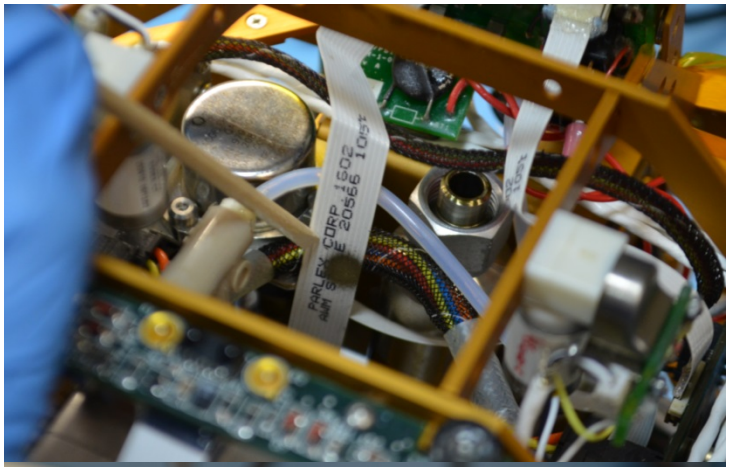
SIZE: D | CAGE CODE: 4KYR6 | DWG NO: SPH-A-06-302 | REV -

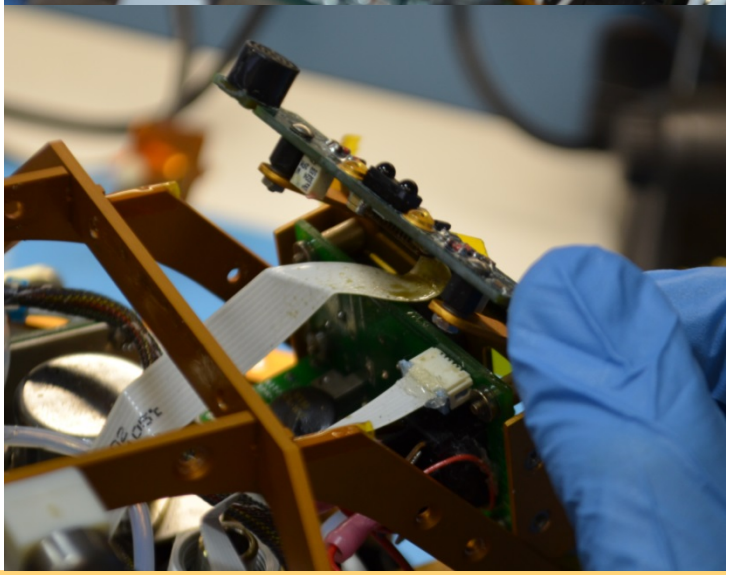
SCALE: 1/1 | DATE: 13-04-02 | SHEET 1 OF 1

Blue Flight Repair

- Discovered Pressure system was choked flow and had small gas capacitance giving partial functionality.



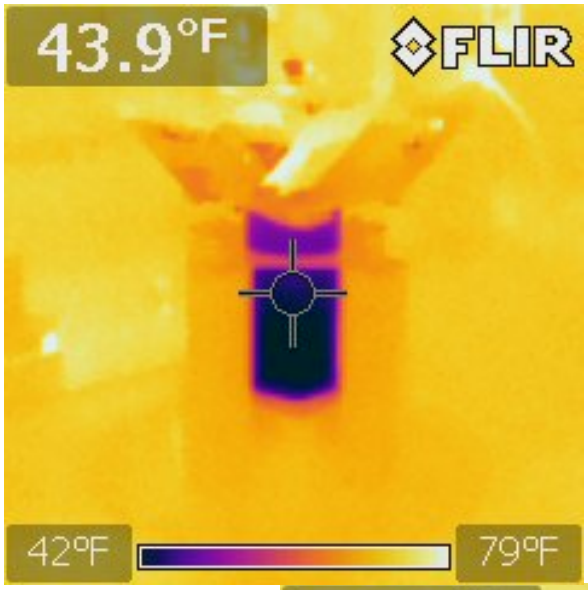


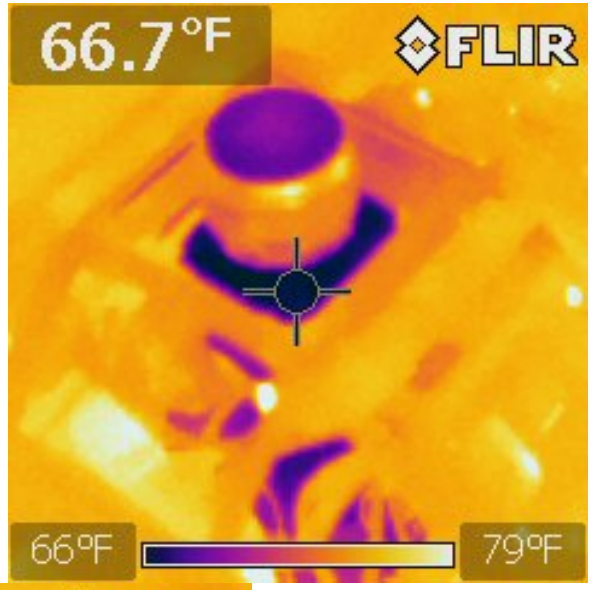


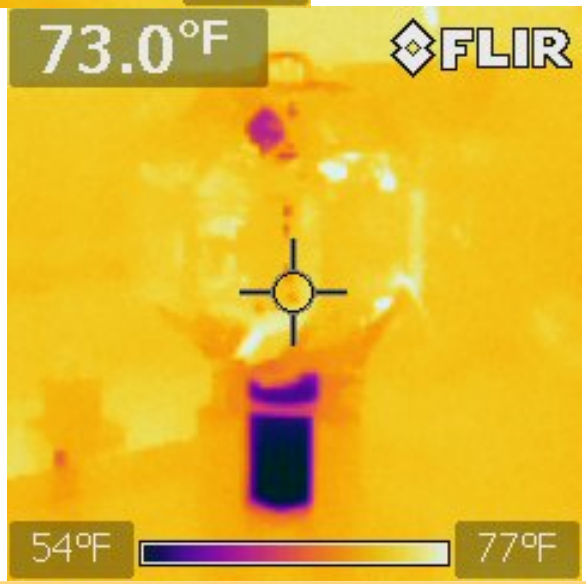
Bench Test Video

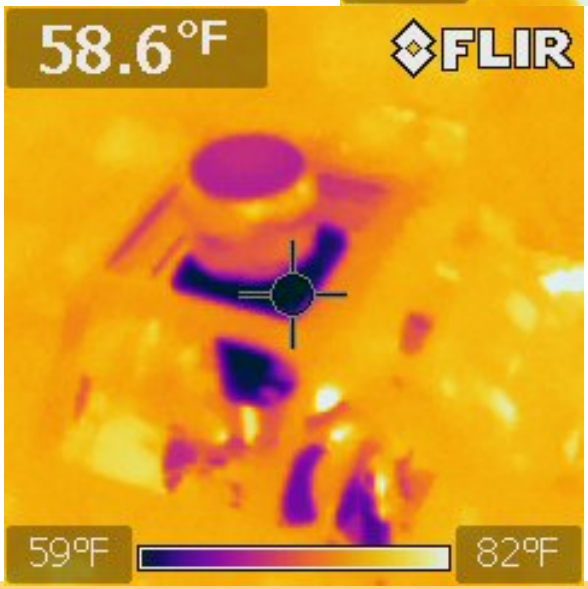
- ~5 Minute Long Video

FLIR View if Installed Regulator

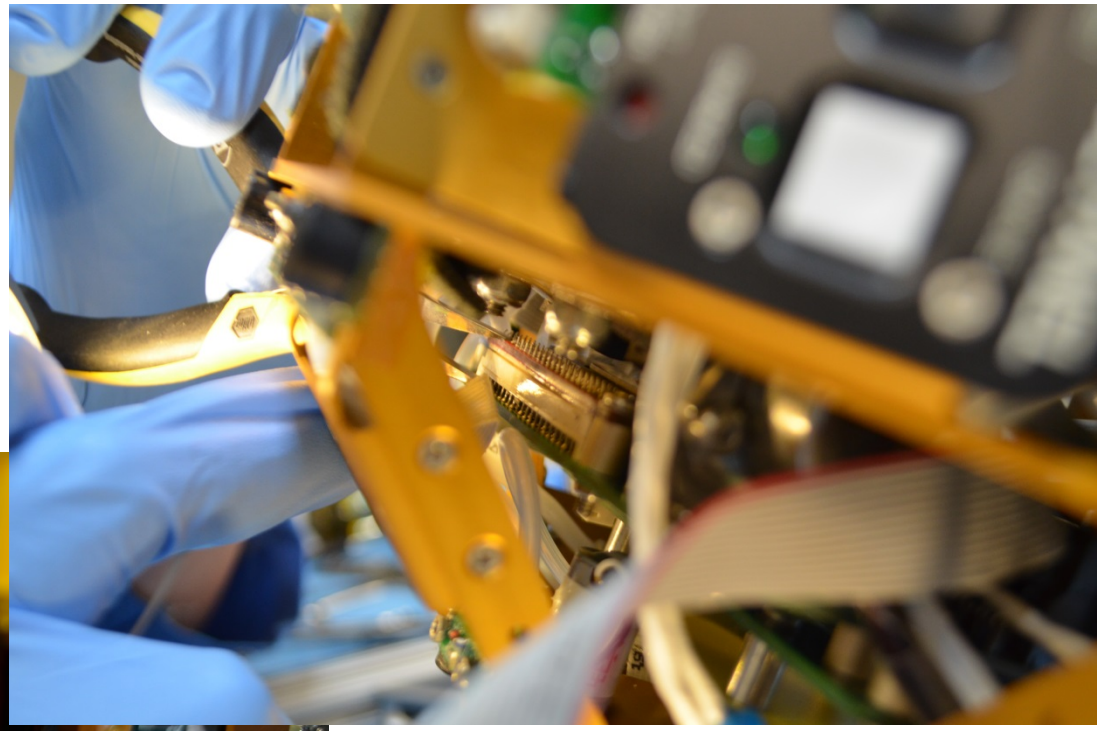


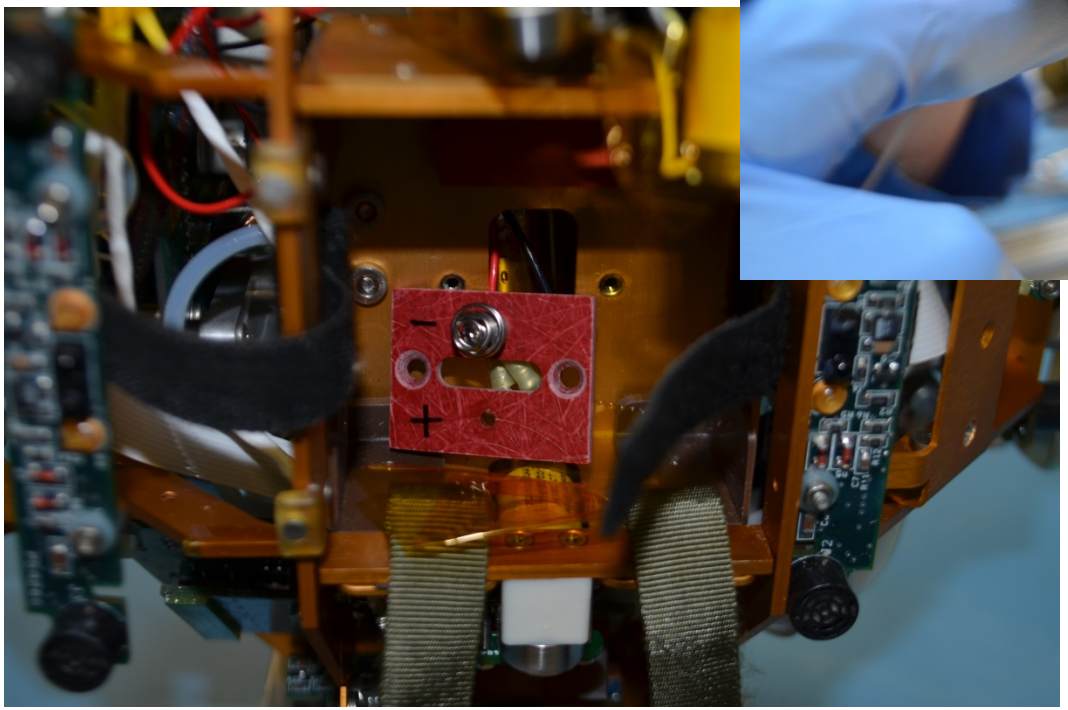




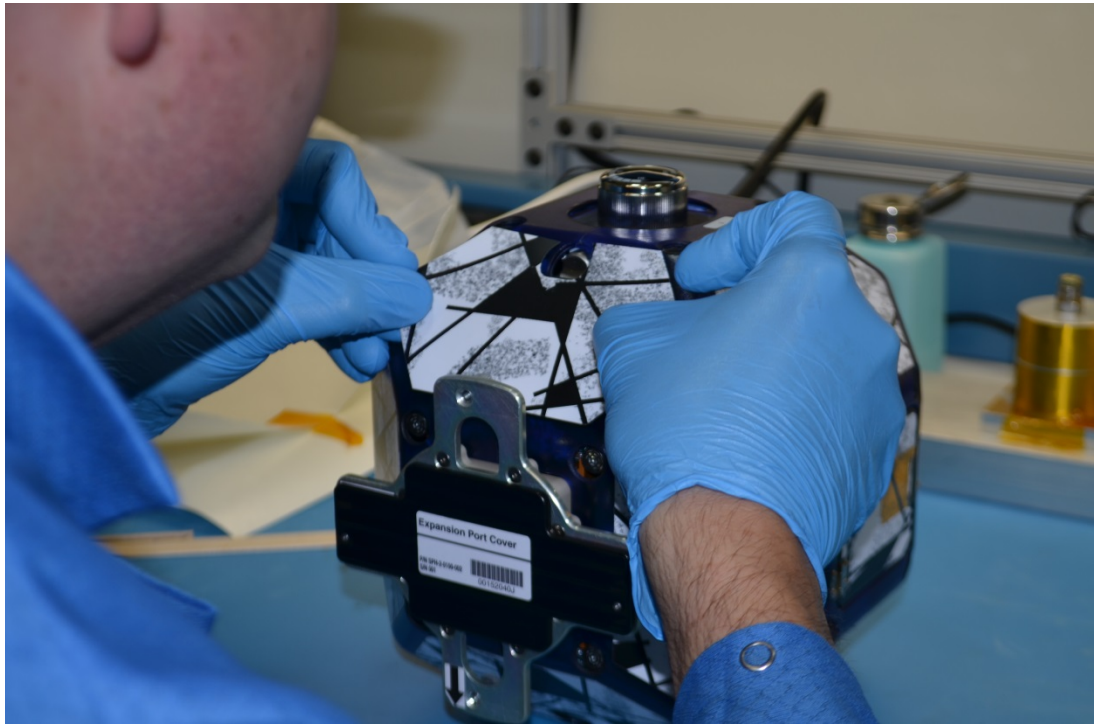


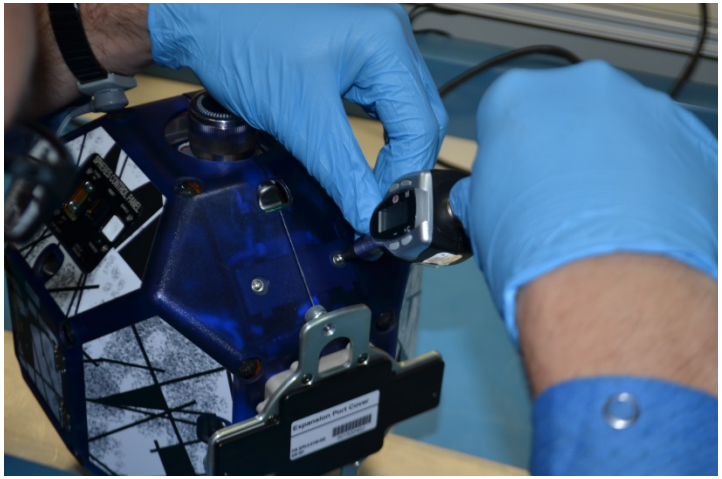
Additional Repairs

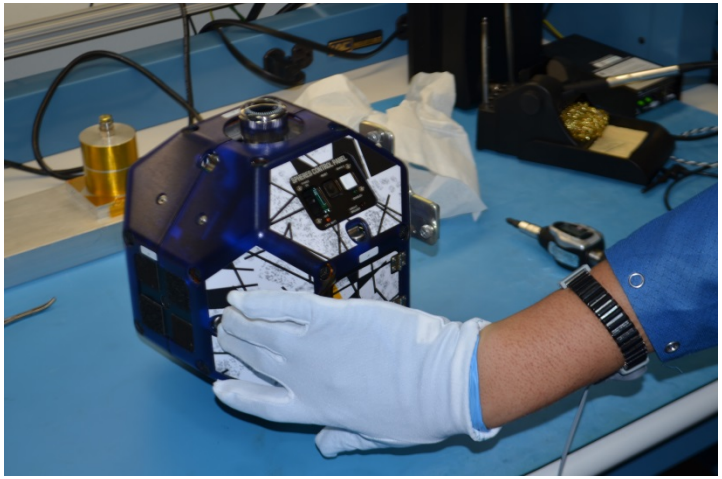




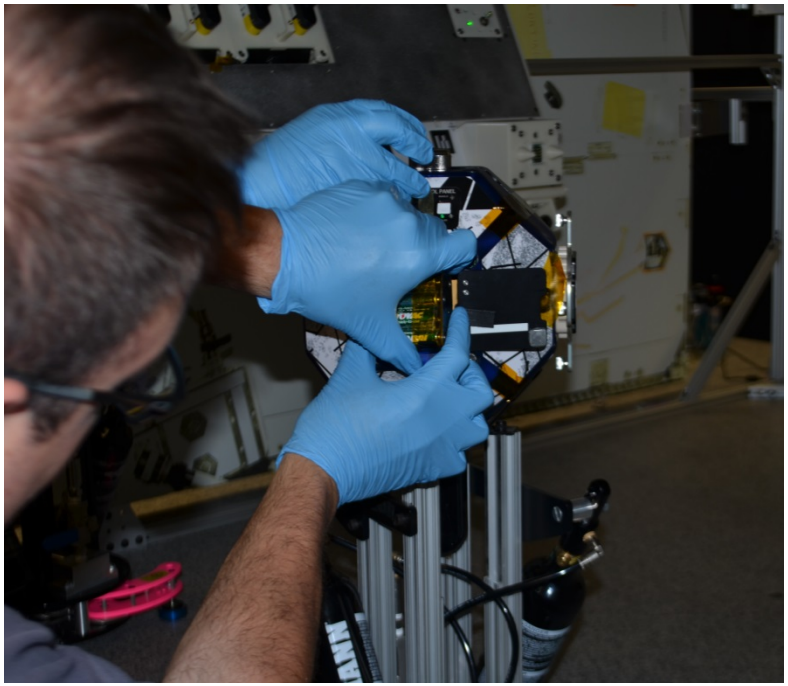
Installing of Shell & Decals

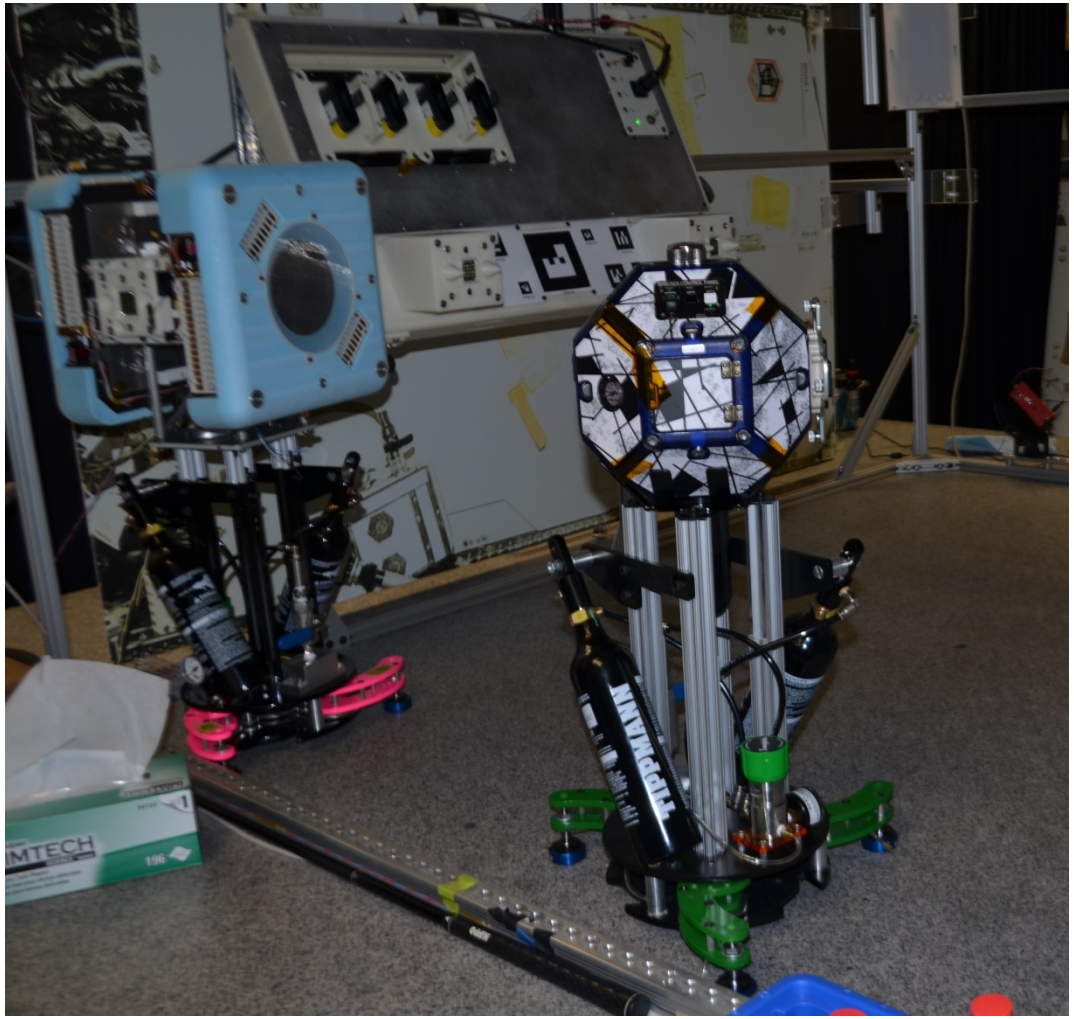






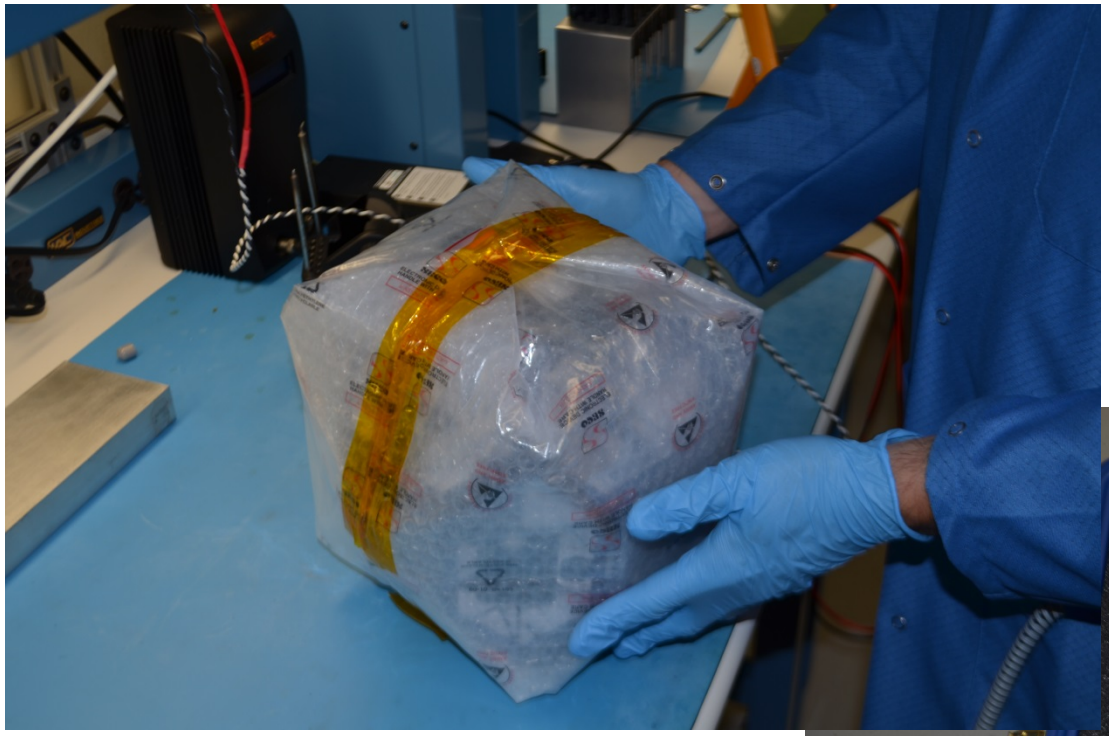
Integrated Function Test

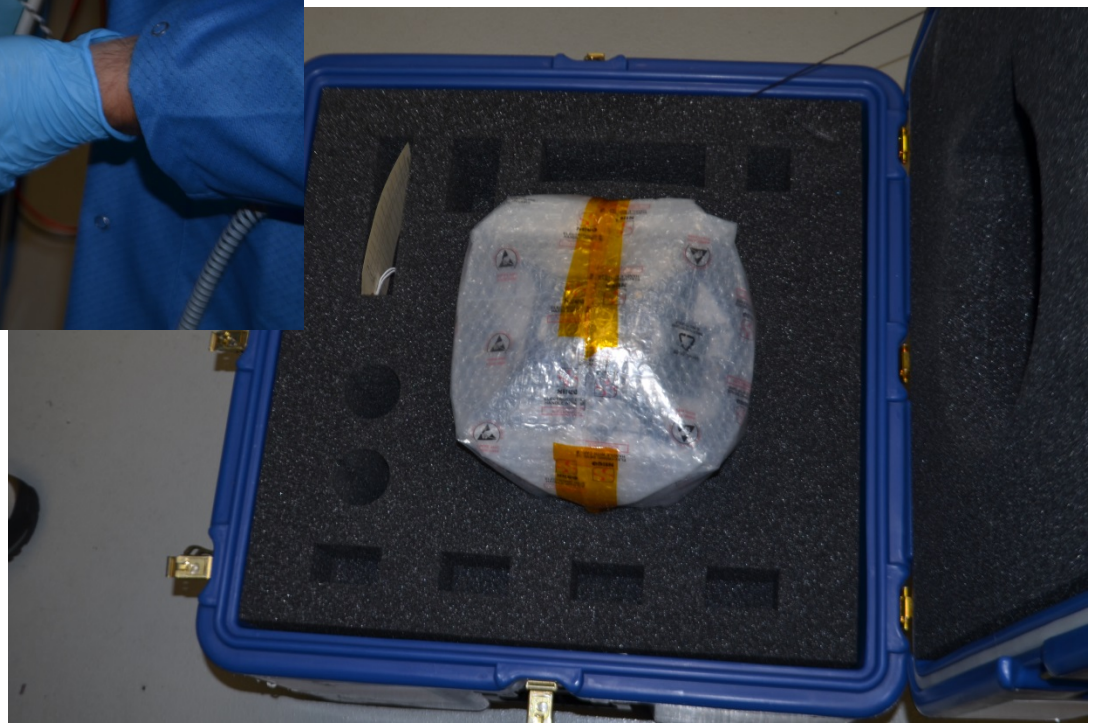


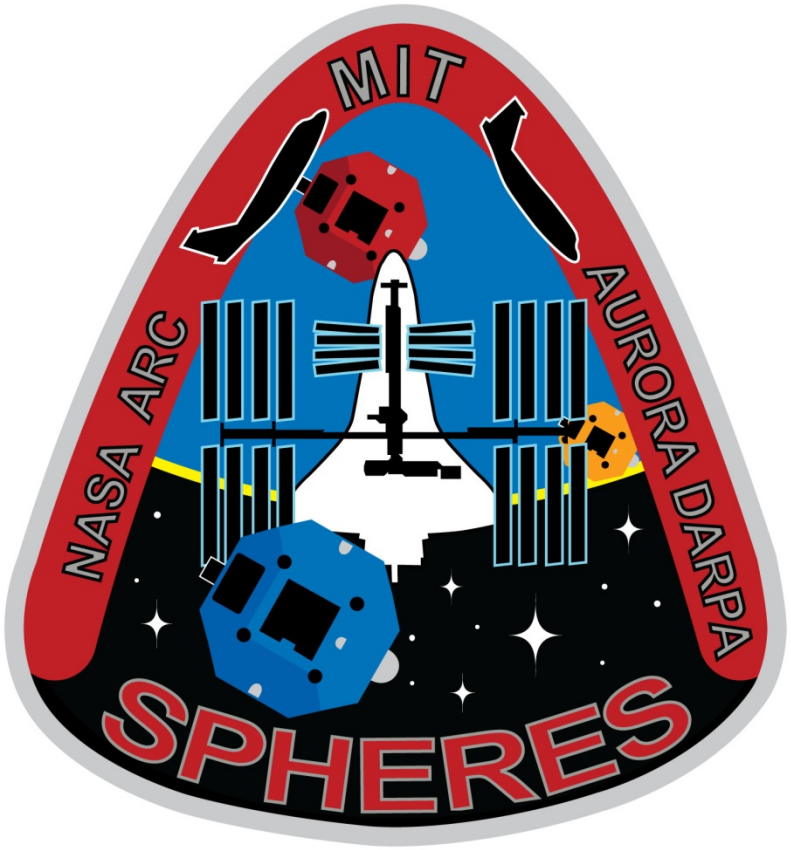


Further Shock Testing

Final Packing and Shipping







PIM Update

PIM Status

- **What integration work has been accomplished since last SPHERES Quarterly Working Group on 07/29/2016?**

  - **Blue satellite returned on SpX-9 (08/26/16), refurbished, and turned over on 10/13/16 for launch on Flight HTV-6 (12/09/16)**
    - Export and safety paperwork all complete; only a few verification requirements left open to address
    - **Awesome** job done by all to get this refurbished so quickly!!

  - **Slosh – launched on Flight Orb-1 (01/09/14)**
    - Slosh on-orbit Test Sessions (TS):
      - TS #7 occurred on 10/07/16; issues encountered with data
      - Voluntary Science session in work
      - Will work on bringing home all hardware on SpX-10…

    - **Slosh Coating – remains as candidate on Flight OA-7 (02/17/16)**
      - RISE Pilot Investigation: completed Sync Point 0/1 on 7/20/16; Sync Point 2 completed on 08/10/16; Sync Point 3 - TBD
        - Issues encountered with tank production and coating
      - Not using SPHERES, however Ames will be assisting with procedures/planning and on-orbit operations

PIM Status--continued

- **Vertigo – launched on Flight 32S (10/23/12)**
  - Qty. 50 Nikon batteries launched on Flight SpX-9 (7/18/16) –batteries worked well during last test session!
  - Any additional Vertigo sessions upcoming?

- **SPHERES Tether Demo – launched on Flight SpX-8 (04/08/16)**
  - Two test sessions planned in Inc. 49/50 (09/07/16- 02/25/17)
    - Science TS #1 and #2 are TBD; crewtime hours have moved from reserved to prime (i.e. session will be hard scheduled).

- **SPHERES Docking Ports – qty. 3 launched on Flight 43S (07/22/15); qty. 3 launched on Flight OA-6 (03/23/16)**
  - One test session planned in Increment 49/50 (09/07/16- 02/25/17)
    - TS #3 – TBD

- **SPHERES Halo - launched on Flight SpX-8 (04/08/16)**
  - Five test sessions planned in Increment 49/50 (09/07/16- 02/25/17)
    - TSs #1-5 – TBD

- **RINGS – launched on Flight HTV-4 (08/03/13)**
  - RINGS battery safety re-certification approved on 10/03/16
  - RINGS hardware usage assessment on-going…expect to hear something by early next year

PIM Status--continued

- **SPHERES Zero Robotics:**
  - Inc. 47/48 (03/03/16-09/06/16): Completed Unit Test, Dry Run, and Finals
  - Inc. 49/50 (09/07/16- March 2017): 3 sessions to occur in early 2017

- **SPHERES Consumables - multiple flights**
  - Flight OA-7 (2/27/16):
    - Qty. 10 rechargeable batteries are manifested; turnover is 11/25/16
    - Verification requirements to be submitted
    - Safety Phase III + Ames integrated SDP to be completed
  - Qty. 10 tanks to launch on TBD flight – will be manifested on first available flight

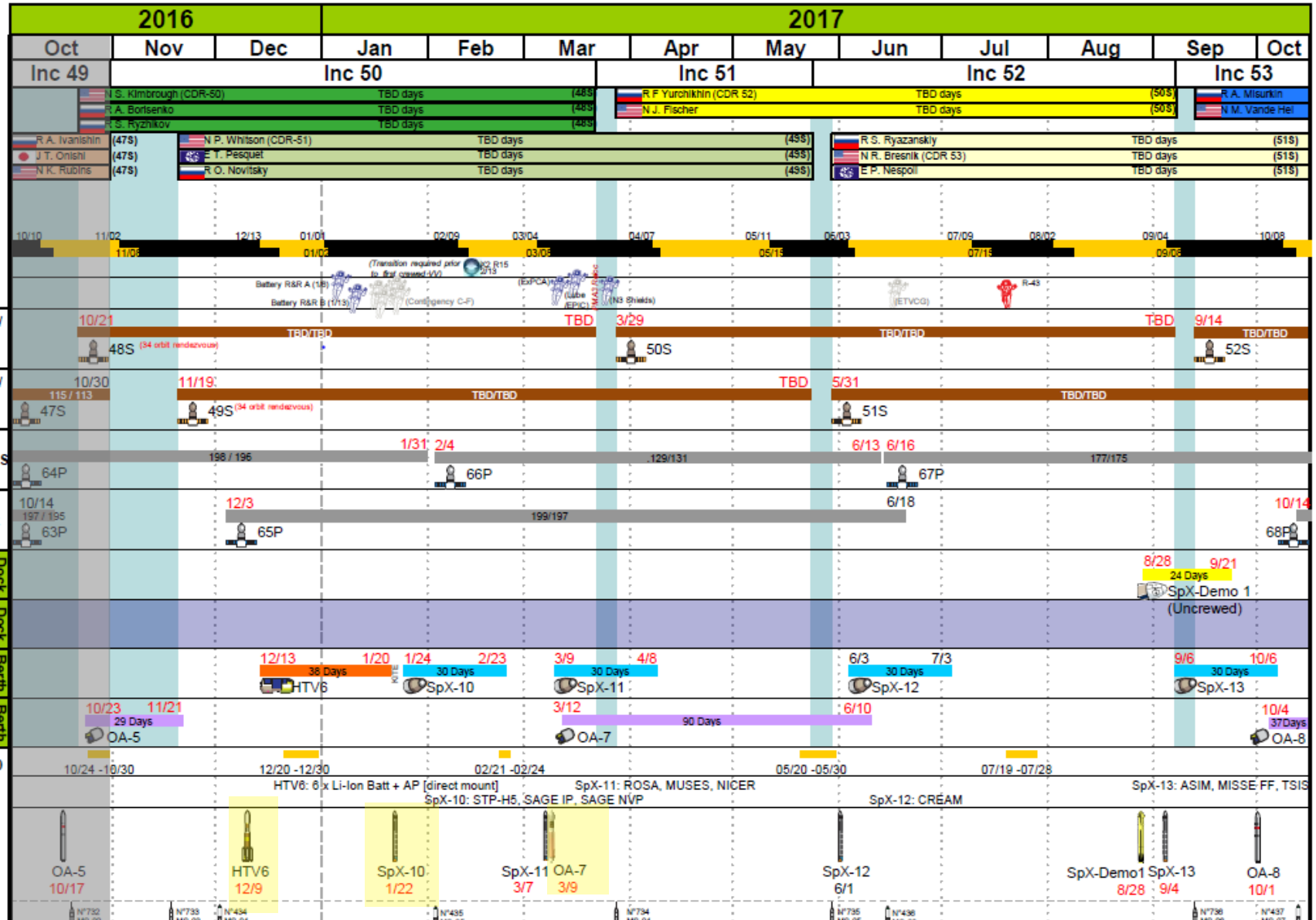
- **Other integration issues/topics:**
  - Discussions being had to use SPHERES inside BEAM module

ISS Flight Plan (in-work version as of 11/08/16)

For current baseline refer to SSP 54100 Multi-Increment Planning Document (MIPD)

ISS Flight Plan
Flight Planning Integration Panel (FPIP)
(Pre-decisional, For Internal Use, For Reference Only)

NASA: OC4/John Coggeshall
MAPI: OP/Irene Chan
Chart Updated: November 8th, 2016
CRs: 15527 (Incs. 53 & 54); 15530 (Incs. 49-51)



Review New Action Items

Adjourn