

# Highlights of DoD Research on the ISS

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# Executive Summary

- The Department of Defense has flown over 270 Experiments on NASA's Human Spaceflight Vehicles on the Space Shuttle and the International Space Station
- The Space Test Program has used every human spaceflight launch vehicle or spacecraft for launch and operations
- The Space Test Program accomplishes its mission through a small, cost effective, highly successful team working together with NASA and the International Partners



# DoD Human Spaceflight Payloads Office

- Mission Statement: The DoD Space Test Program-Houston office is the single face to NASA for all DoD payloads on the International Space Station, and other human-rated launch vehicles, both domestic and International Partner
  - *Provide timely space flight for DoD payloads*
    - Assure payload is ready for flight and completes mission objectives
    - Provide project management support to complete the NASA safety and integration processes
    - Provide technical integration support to maximize the efficiency and effectiveness of payload design, schedule, and cost

***Mission:***

***To fly payloads***



# DoD Team at Houston

- Houston is unique...
- Manned aspect brings great flexibility but also unique safety requirements
- Constant high level of interaction with NASA required
- “Hands on” approach
- Small unit, many projects, “experiment to data” in relatively short period
- Return of items from space



**Fabrication  
and Testing**



**Training**



**Launch Site  
Processing**



**Operations**

DoD personnel are engaged across all these functions



# DoD Firsts in Human Spaceflight

- 1st DoD payload on Shuttle mission STS-4 in 1982
- 1st internal DoD payload on Mir
- 1st internal payload on ISS (MACE II, 2000)
- 1st external payload on ISS (MISSE 1&2, 2001)
- 1st U.S. payload on RSA Progress re-supply vehicle (SPHERES, 2003)
- 1st U.S. payload on ESA's Columbus module (MISSE-6, 2008)
- 1st payload on 1st launch of HTV and H-IIB rocket (RAIDS/HICO, 2009)
- 1st U.S. payload on JAXA's JEM-EF (RAIDS/HICO, 2009)
- 1st (and 2nd and 3rd) Express Logistics Carrier payloads (MISSE-7 in Nov 2009, STP-H3 and MISSE-8 in May 2011)
- 1st payload to collect space vehicle reentry data (REBR, Mar 2011)



MACE II – First Internal ISS payload  
Flew in 2000  
Operated by Susan Helms  
Studied vibration cancelation



# 112 Missions with DoD Experiments

## 31 ISS Science Expeditions Since Oct 2000



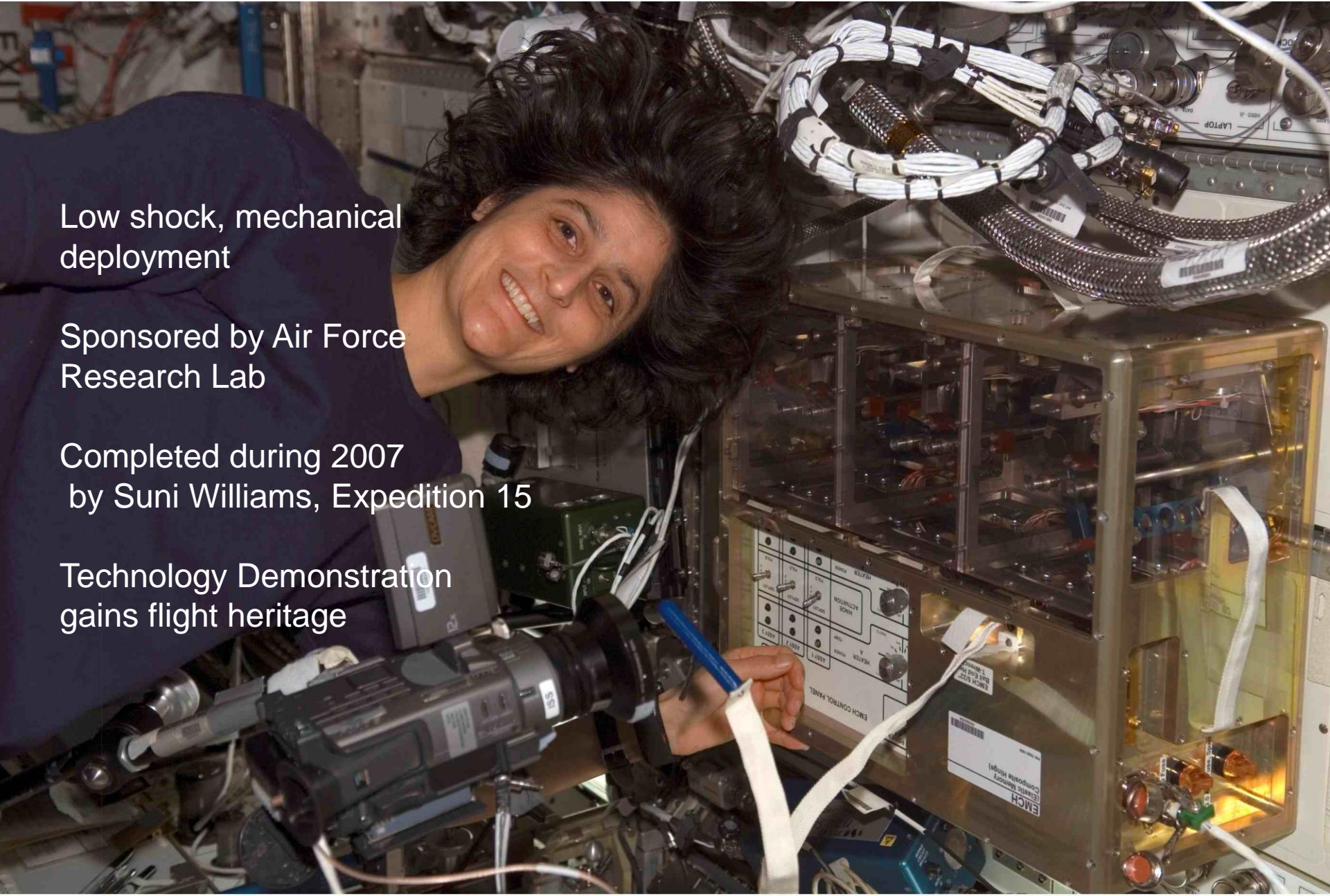
# Elastic Memory Composite Hinge

Low shock, mechanical  
deployment

Sponsored by Air Force  
Research Lab

Completed during 2007  
by Suni Williams, Expedition 15

Technology Demonstration  
gains flight heritage





# DoD on the ISS

**MISSE-8**

ELC-2

Launched May 11, return  
SpaceX



**STP-H3**

(MHTEX, VADER, DISC, Canary)

ELC-3

Launched May 11



**CSAC**

US Lab

Launched 30 Oct 11



**HREP**

(HICO, RAIDS)

JEM-EF

Launched Sep 09



**STP-H4**

(SWATS, GLADIS, MARS, ATT, iMESA-R)

(3 NASA Rideshare Expm't)

ELC-1

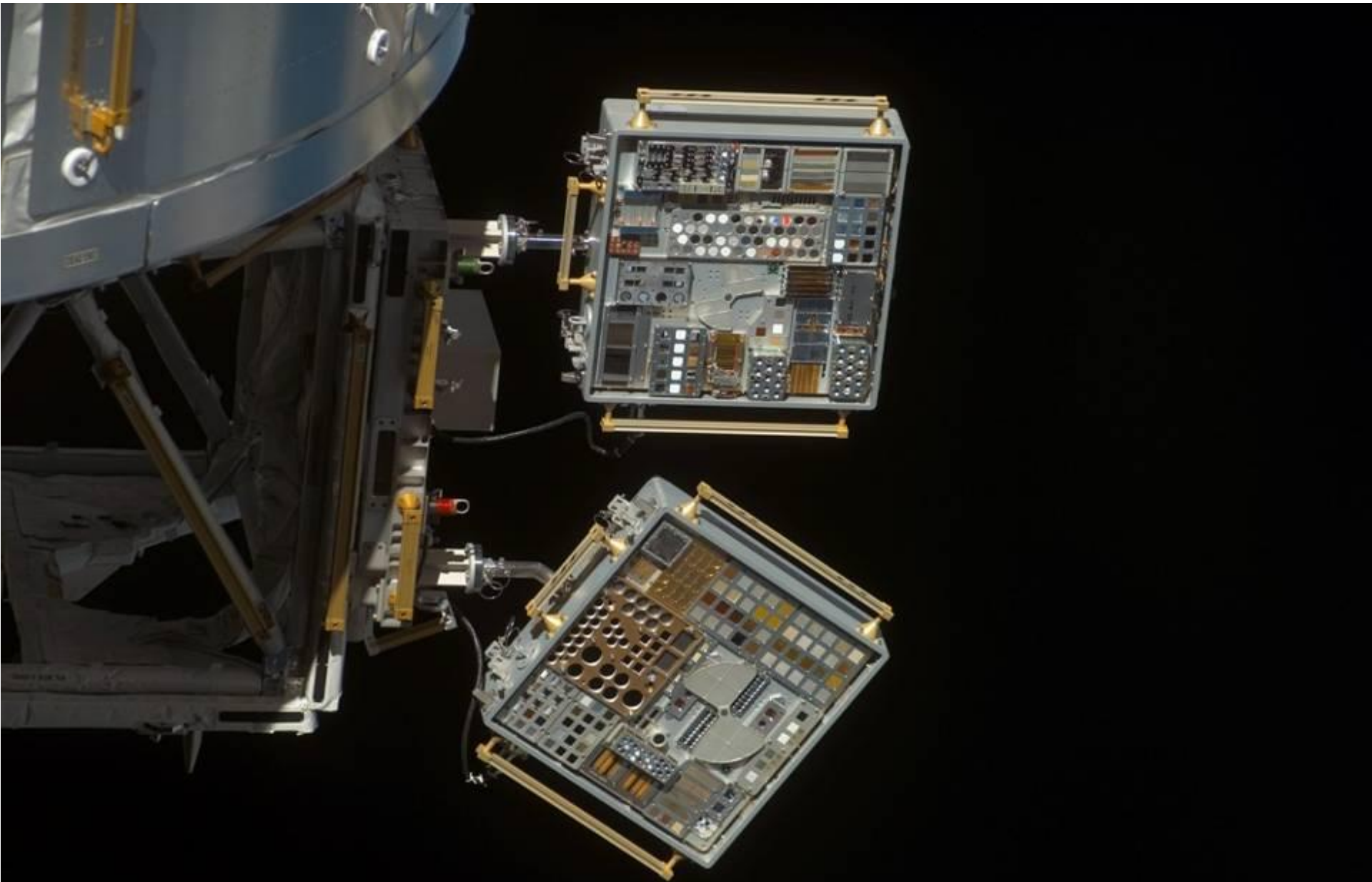
Launches Jun 13



*Pressurized Payloads in work:  
REBR-2 (HTV-3) and ATV-3,  
InSPIRE VBN & EMFF*

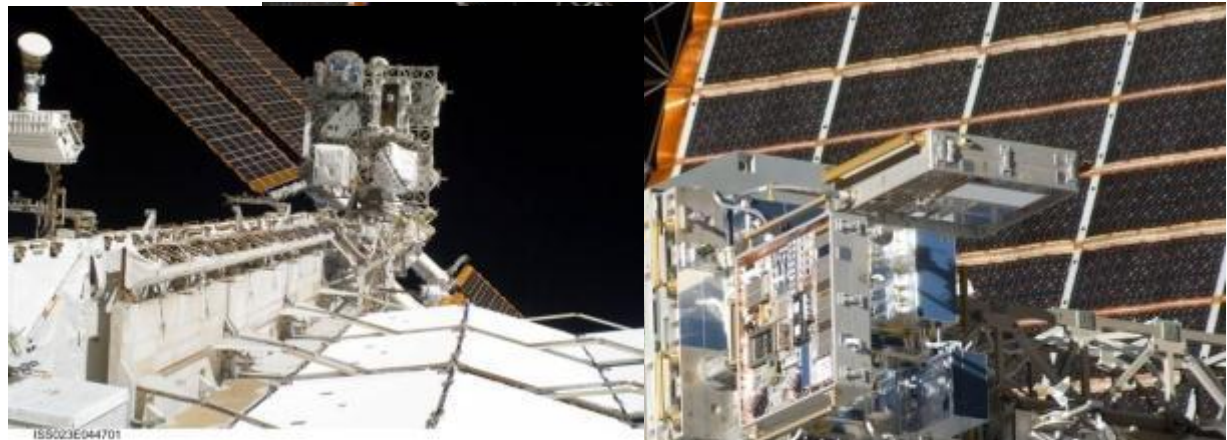
*Deployable Payloads in work:  
DANDE, CUSat, TetherSat, BK1, NPS-SCAT,  
ESP-LDQ, TORC (hosted on AggieSat)*

# Materials International Space Station Experiment 6 on European Space Agency's Columbus Module



# MISSE-7

- MISSE 7 was launched to the ISS on STS-129
  - *1st ELC Payload*
- Primary Operations by NRL with STP Backup
- PECs returned on STS-134

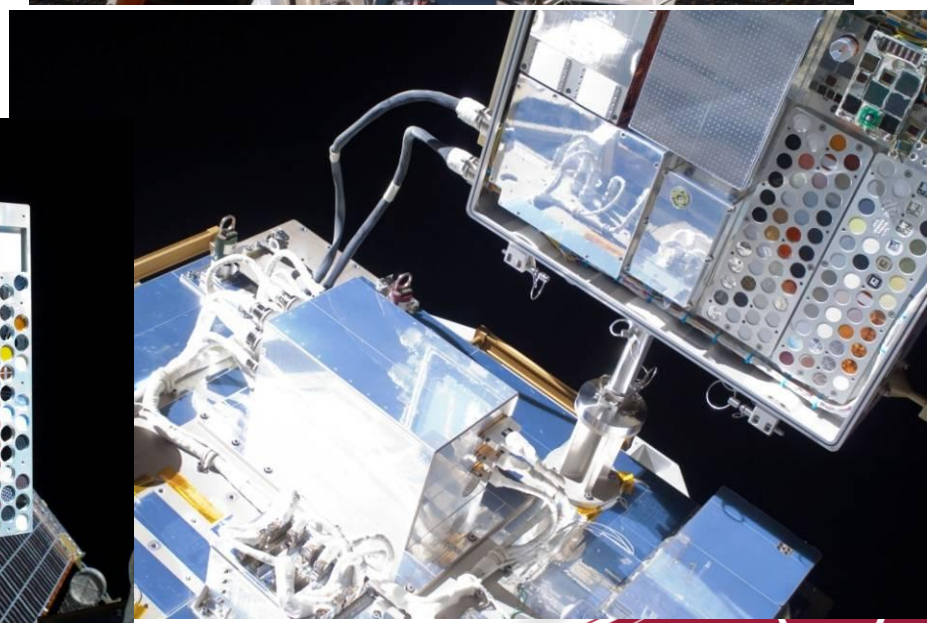
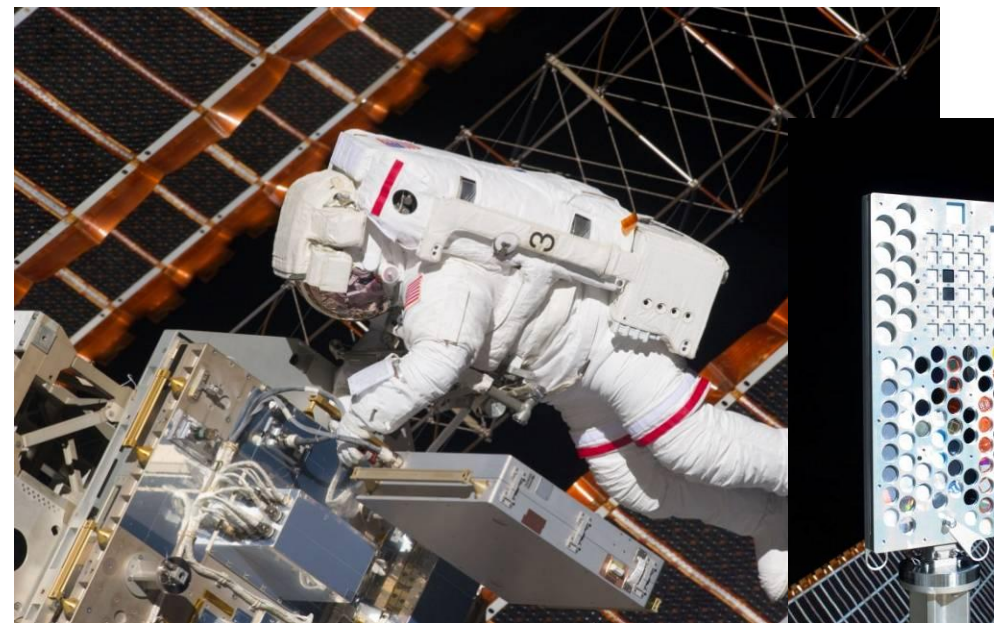


# MISSE 7 Installed



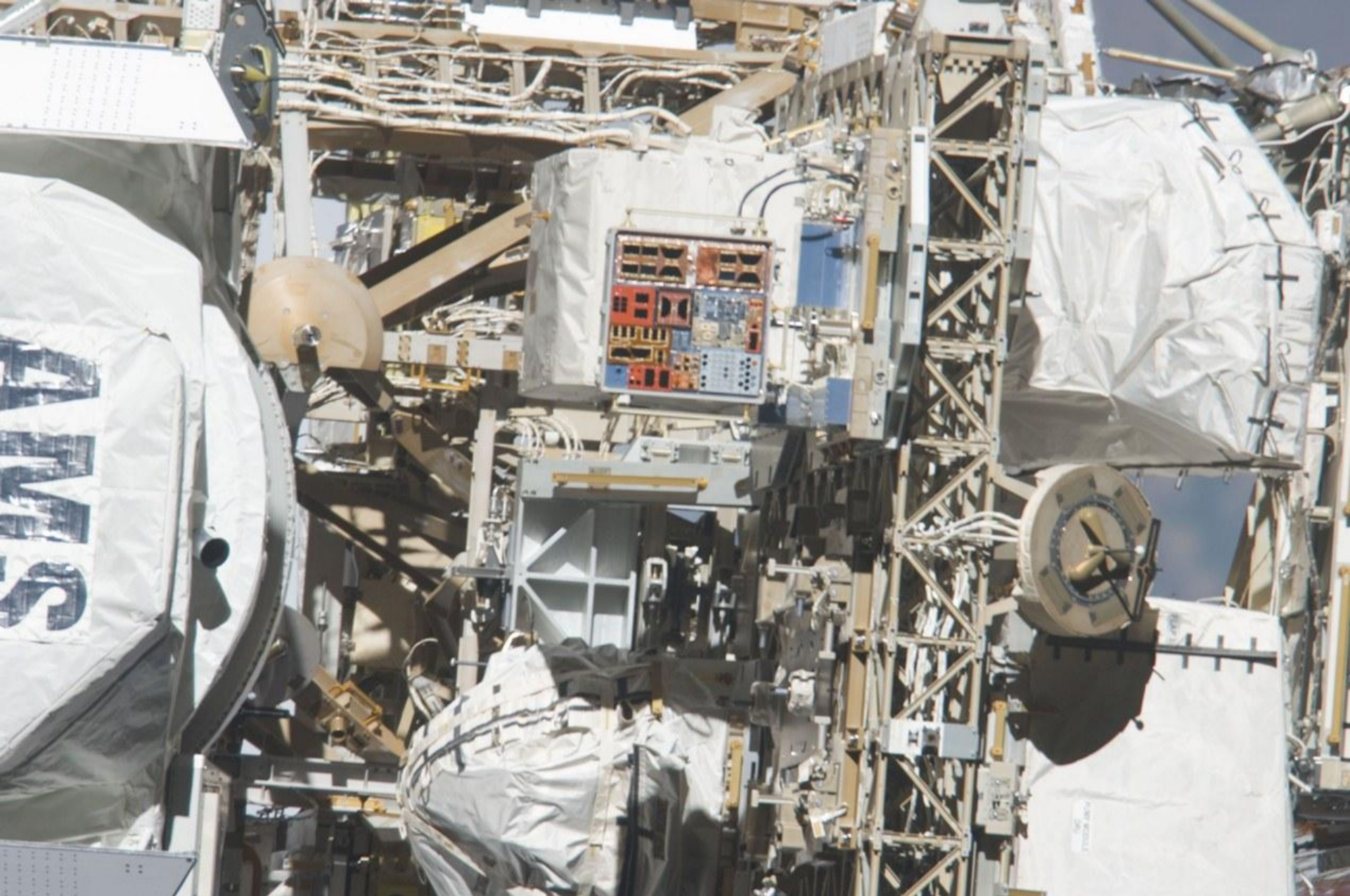
# MISSE 8

- Launched on STS-134; PEC installed
- Aerospace's ORMATE installed during STS-135 to prevent contam
- Preparing for Retrieval in 2013
  - *Manifesting contamination control bags, desiccant, oxygen absorber*
  - *Launch Aug 2012, return Dragon*
- Schedule Conflict: EVA after return Flt



# Materials International Space Station Experiment 8

## MISSE 8



# MISSE Impact to Operational Programs

## MISSE 1-5 (2001 – 2006)

- One PEC
- Battery power
- No data downlink
- EVA install and retrieval
- 100% passive



**Avg. Cost: \$ 7M**  
**(Total cost, 5 missions \$35M)**

**Value Output: \$ 600M+**

## MISSE 6A & 6B (2008 - 2009)

- Two PECs
- ISS power
- No data downlink
- EVA install and retrieval
- 60% active

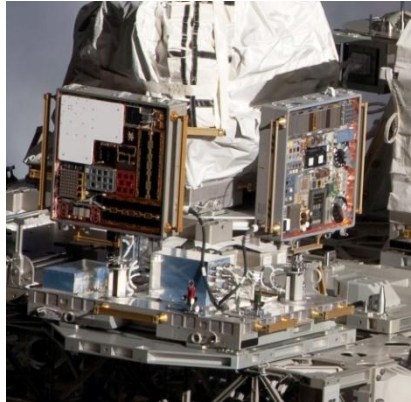


**Cost: \$ 15M**

**Value Output: \$ 34M**  
**Est'd to date**

## MISSE-7 (PEC 7A & PEC 7B) (2009 – 2011)

- Two PECs
- ISS power
- Data downlink
- EVA install and retrieval
- 70% active

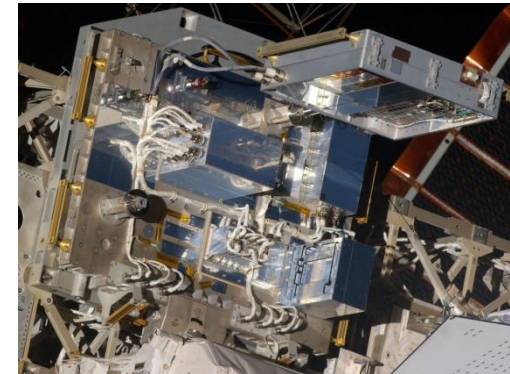


**Cost: \$ 17M**

**Value Output: \$ 300M+ Est'd**

## MISSE-8 (PEC 8 & ORMatE (Optical Reflector Materials Expt)) (2011-TBD)

- One PEC & One ORMatE
- ISS power
- Data downlink
- EVA install and retrieval
- 80% active



**Cost: \$ 10M**

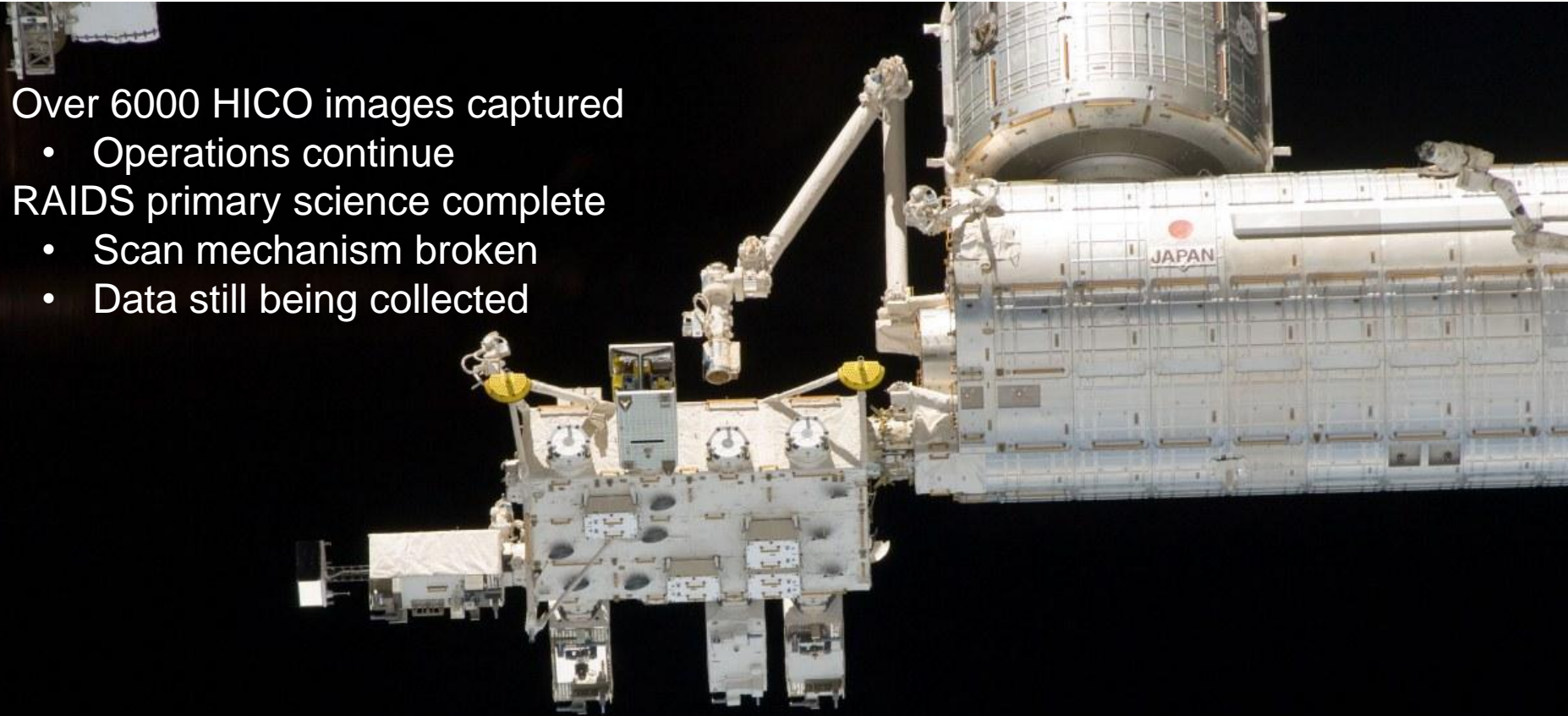
**Value Output: \$ 240M+ Est'd**

Boeing survey showed a value (benefit by extended satellite life or improved performance) of \$634M for 23 experiments conducted on MISSE 1-6



# Hyperspectral Imager Coastal Oceans – Remote Atmospheric and Ionospheric Detection System HICO - RAIDS

- Over 6000 HICO images captured
  - Operations continue
- RAIDS primary science complete
  - Scan mechanism broken
  - Data still being collected



NRL has twice extended operations.



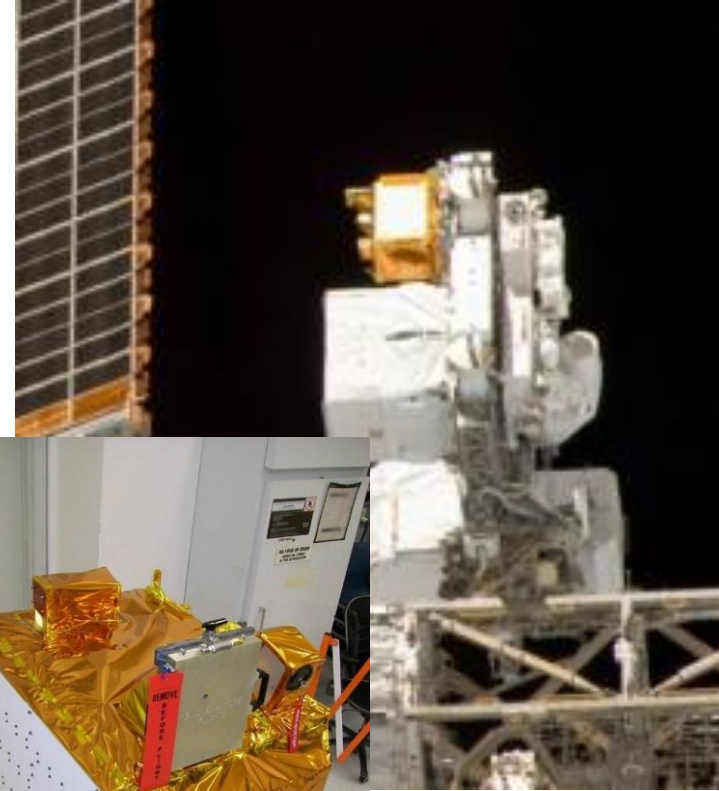
# HICO-RAIDS

- Launched 11 Sep 09 on first flight of H2B rocket, from Tanegashima, Japan
  - *Sponsor: Office of NAVAL Research*
  - *HICO – Hyperspectral Imager for the Coastal Oceans*
  - *RAIDS – Remote Atmospheric and Ionospheric Detection System*
- 1st US payload on H2B Transfer Vehicle (HTV) and Japanese External Facility
- Aerospace and NRL built RAIDS
- Aerospace performed Stress and Thermal analyses
- DoD interfaces routinely with NASA and Japan Aerospace Exploration Agency (JAXA) for payload operations
- Received Rotary's 2010 National Stellar Award



# STP-H3 Completes 1<sup>st</sup> Year of Ops on ISS

- MHTEX (AFRL)
  - *Flight qualification of advanced Capillary Pumped Loop without starting pump*
  - *Demo'd long duration steady state operation*
  - *Major builder using MHTEX-proven design in next sat*
- Canary (USAFA)
  - *Observed 70+ events including Space Shuttle, Soyuz, Progress, ATV, HTV and Dragon vehicle dockings and undockings*
  - *Validated theory of plasma signatures in space environment*
- VADER (AFRL)
  - *Tested 10 Variable Emissivity Devices*
    - One observed to be damaged on orbit
    - Others mixed performance
  - *Aerogel Thermal Blanket performance data continues to be collected*
- DISC (NRL)
  - *Collect over 100 Star Tracker images*
  - *Proven concept of miniature star tracker*

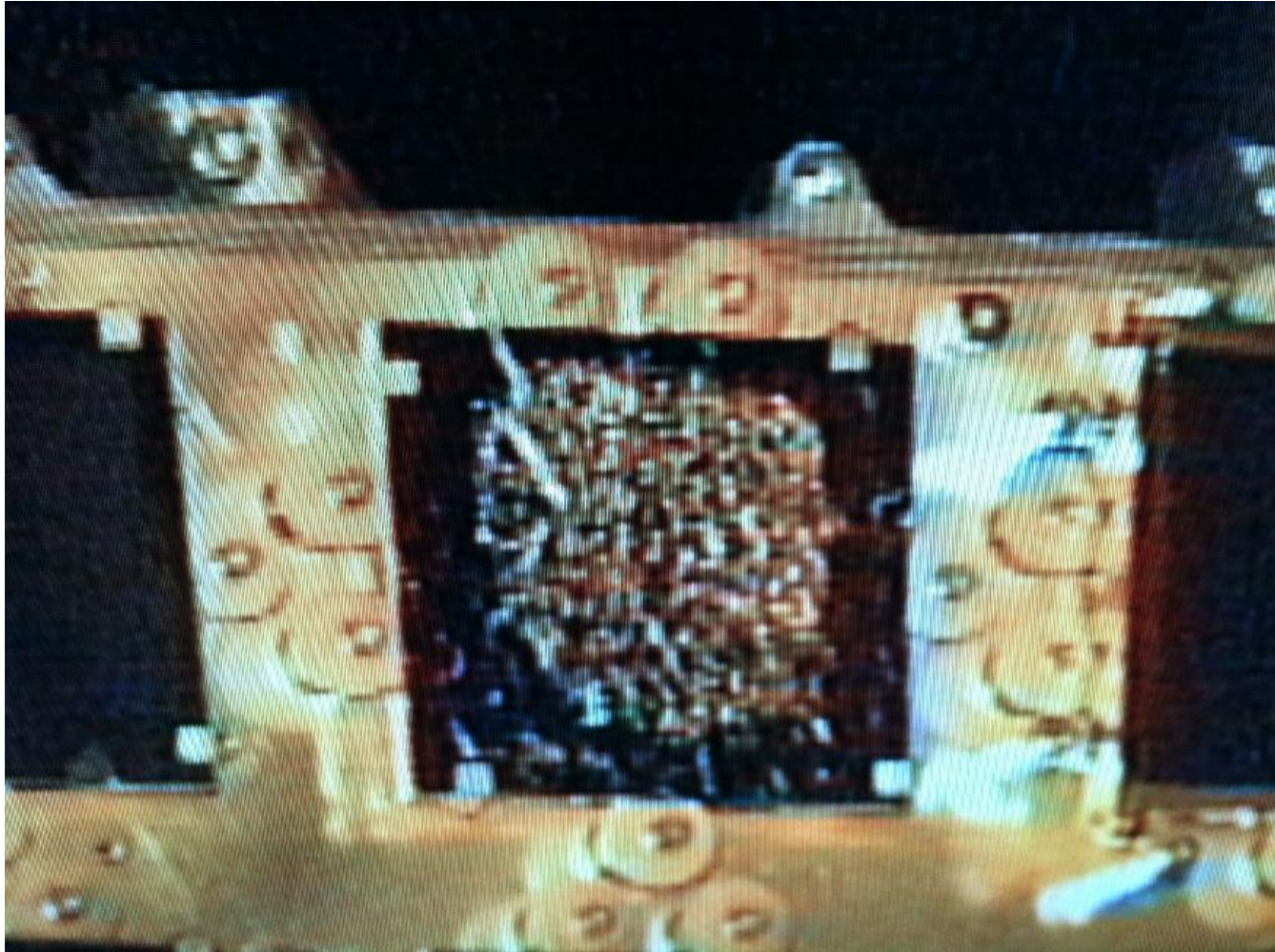


Primary experiment objectives have been met



# ISS Survey Photo of VADER

(Variable emissivity device #3)

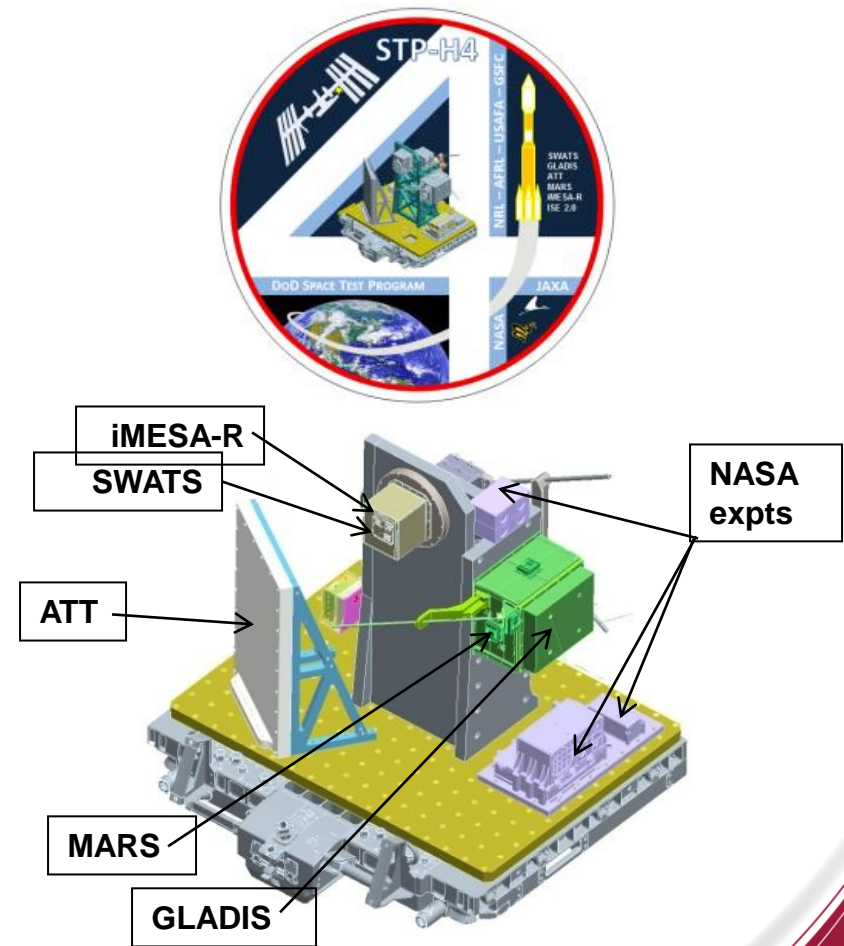


ISS inspection capability is extremely useful to investigate anomalies

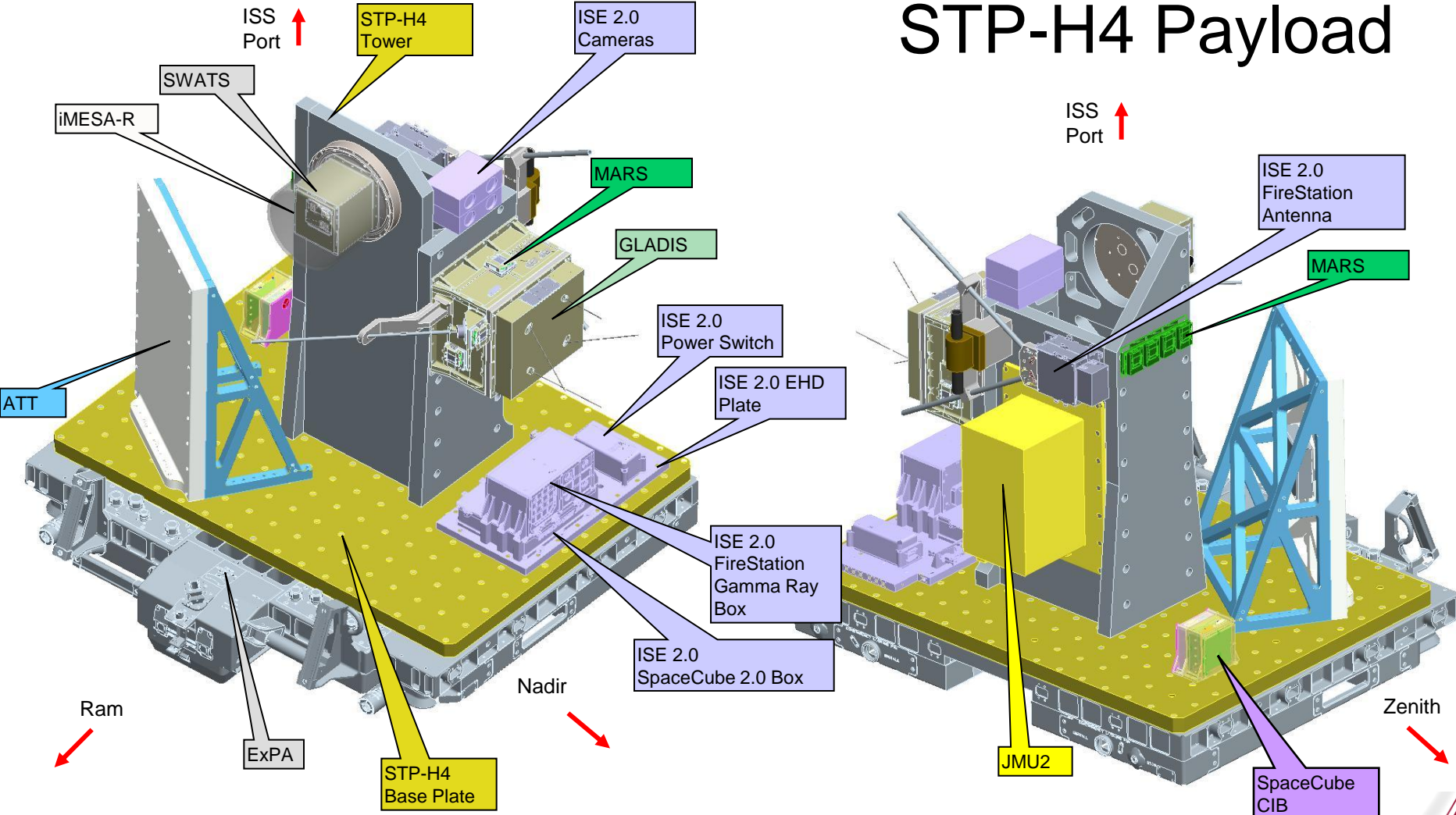


# Space Test Program- Houston 4

- ELC payload complement with 5 DoD expts and 3 reimbursable NASA expts
- Top level Science Objectives:
  - **SWATS (NRL)** – Space Weather
  - **GLADIS (NRL)** – Information Dominance (AIS Receiver & Data Exfiltration Transceiver)
  - **ATT (AFRL)** – Thermal Control
  - **MARS (AFRL)** – 3D Radiation Modeling
  - **iMESA-R (USAFA)** – Space Weather
- Manifested: May 2011
- Launch Vehicle: HTV-4, June 2013



# STP-H4 Payload



**STP's MEIT, NRL and GSFC** are designing, fabricating, assembling all FSE and, integrating and testing the total assembly. **Aerospace STP Houston** is playing critical roles of mission assurance, quality assurance and engineering analysis.

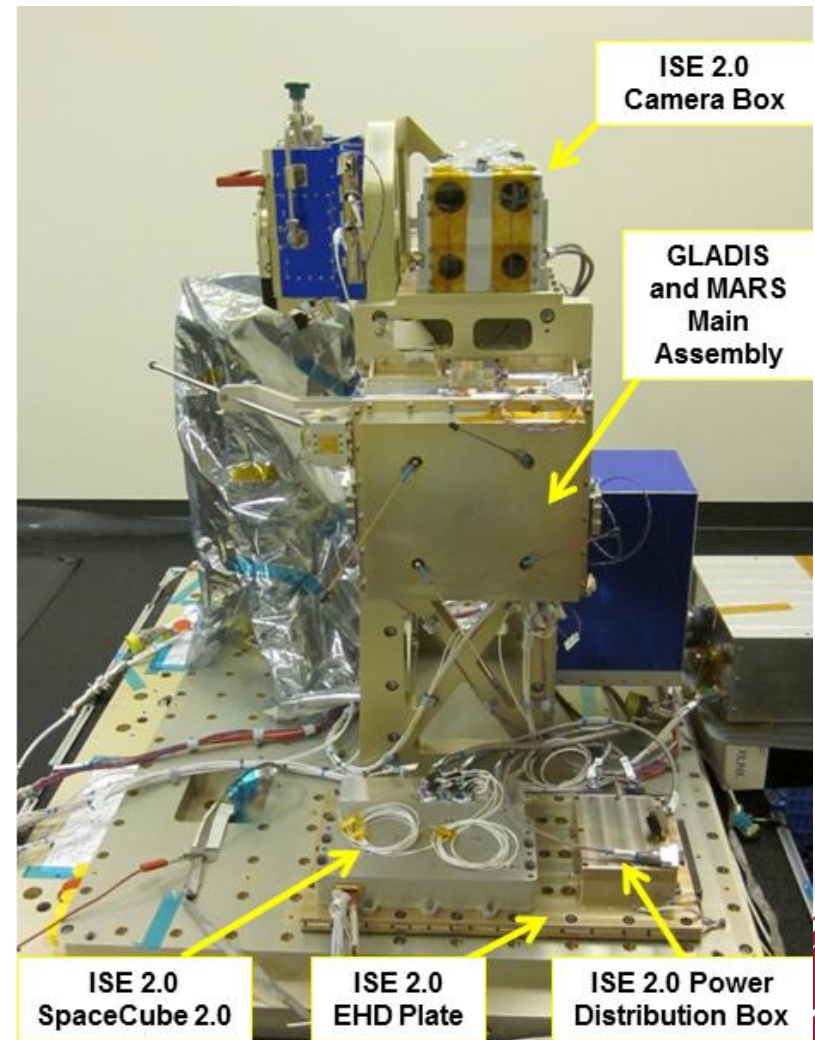
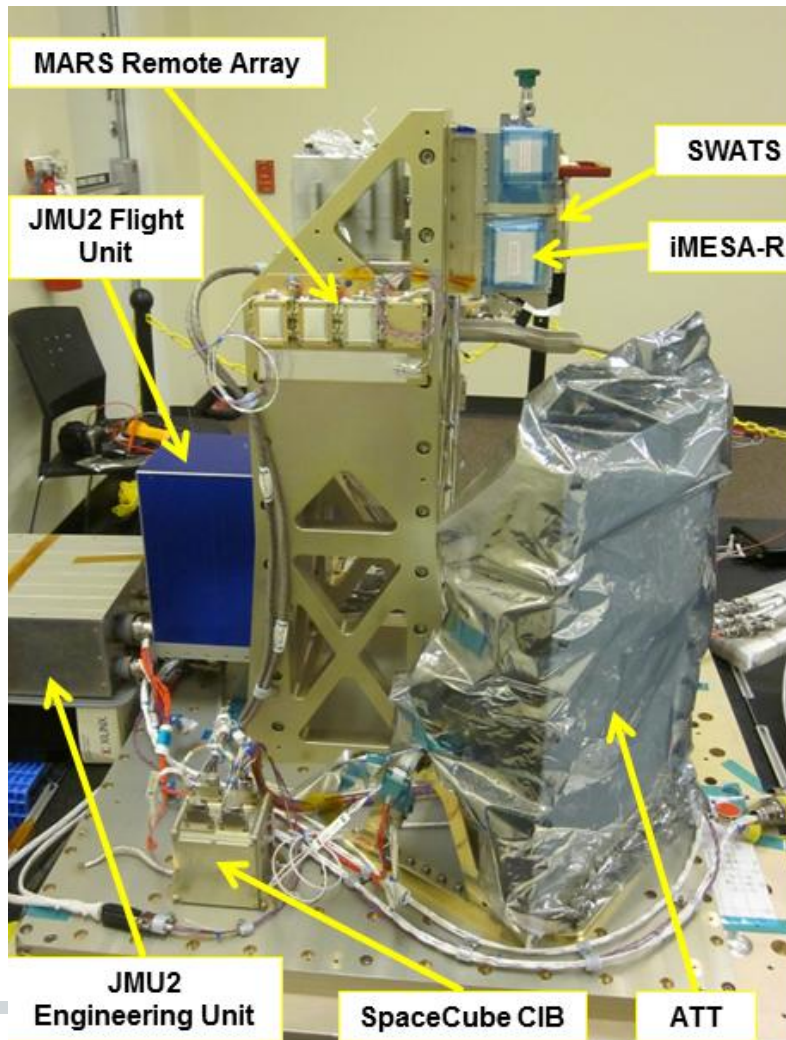


# STP-H4 Experiments

- STP-H4 payload complement includes 5 DoD exp'ts and 3 NASA exp'ts
  - *SWATS – Small Wind And Temperature Spectrometer (NRL)*
    - SWATS acquires simultaneous co-located, in-situ measurements of atmospheric density, composition, temperature and winds
    - iMESA-R (Integrated Miniaturized Electrostatic Analyzer-Reflight, USAFA) is integrated into SWATS, enabling synergistic co-located density and temperature measurements between the instruments
  - *GLADIS – Global Awareness Data-Exfiltration International Satellite Constellation Concept (NRL)*
    - GLADIS will demonstrate co-channel interference mitigation (antenna design) by receiving the Automatic Identification System (AIS) vessel tracking signal while simultaneously providing two way communications to widely distributed Maritime Domain Awareness sensor arrays
  - *MARS – Miniature Array of Radiation Sensors (NRL)*
    - MARS consists of an array of sensors that monitor the total dose radiation on the host spacecraft for 3-D radiation modeling
    - NASA JSC is a co-investigator on MARS, and the MARS experiment includes NASA JSC provided radiation shielding on some of the MARS sensors
  - *ATT – Active Thermal Tile (AFRL)*
    - ATT is a quick-insert thermal control device that is modular, reconfigurable, and fully scalable to a wide array of component sizes
  - *ISE 2.0 – ISS SpaceCube Experiment 2.0 (NASA GSFC)*
    - *SpaceCube 2.0: A small, powerful data processing module with multiple HD cameras to demonstrate new algorithms, including “Radiation Hardened By Software” algorithms and Earth “event detection” algorithms*
    - *EHD: A thermal plate prototype to demonstrate Electro Hydro-Dynamic (EHD) pumping of liquids in micro-channels for advanced thermal control*
    - *FireStation: Measures the optical lightning flash, the radio signatures of lightning, and the gamma rays and electrons produced in terrestrial gamma ray flashes*



# STP-H4 as of 23 May 2012



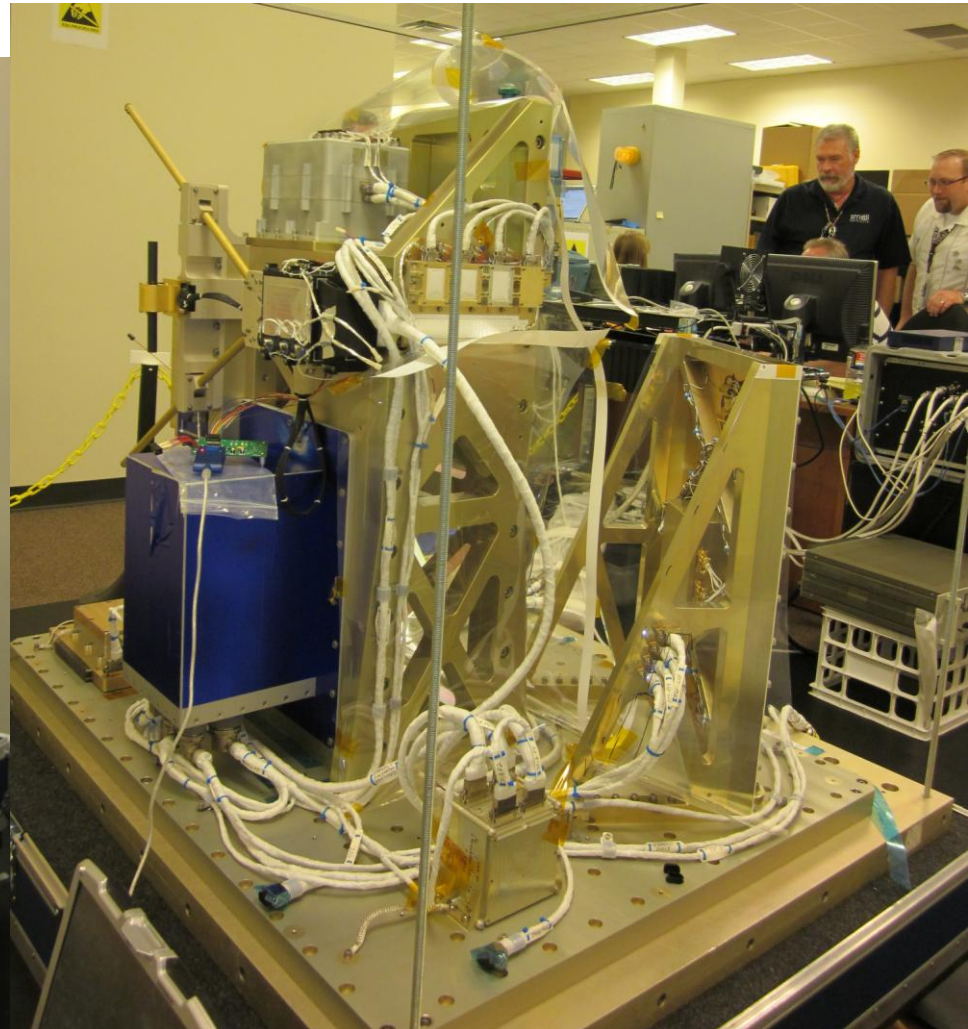
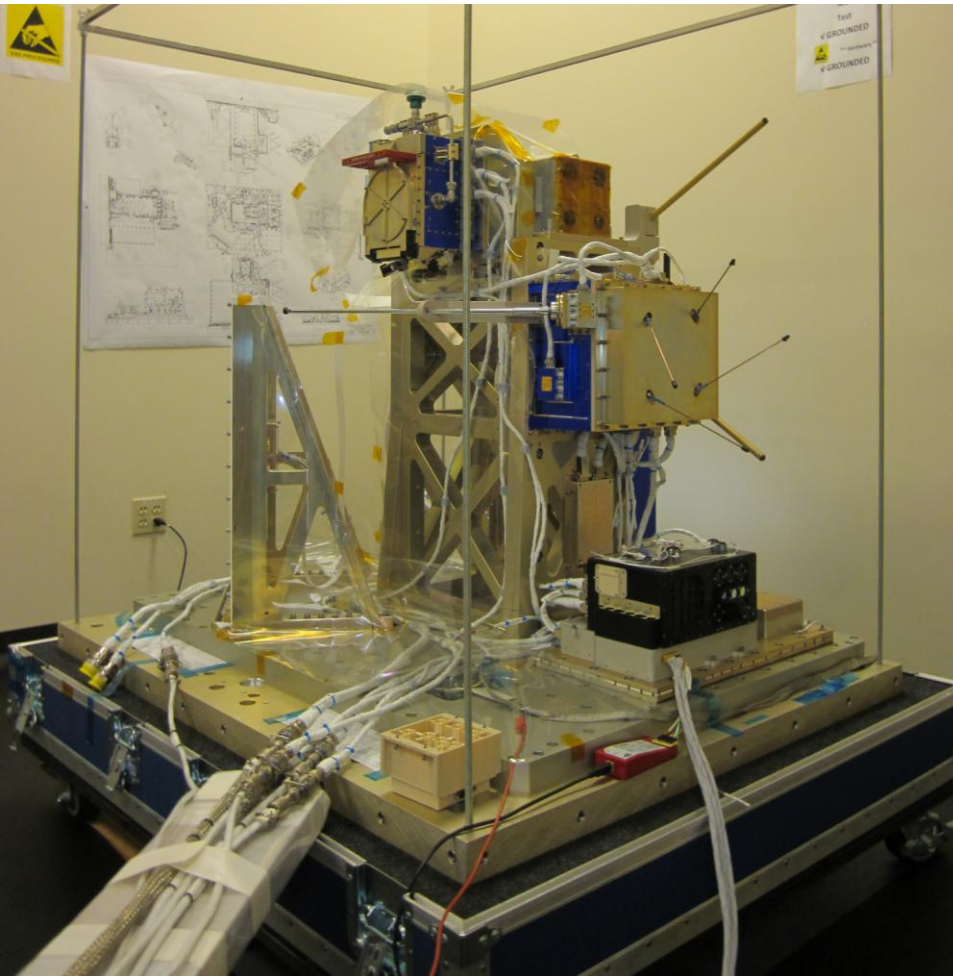
# STP-H4 as of 22 June 2012

## All Payloads installed

Next: software integration  
Phase 3 Safety Reviews  
Vibration, EMI at JSC

Thermal at NASA Langley  
MLI installation  
ISS Interface Test at KSC

Shipment to Tanegashima  
Installation on JEM EP  
Launch mid-2012



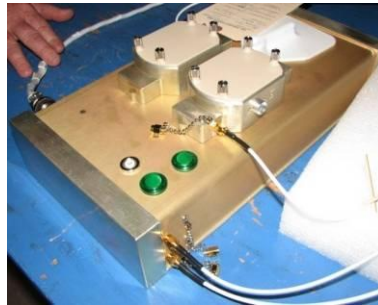


# SPHERES Expansion Port and Chip Scale Atomic Clock

## Experiment Description

### • Top level Science Objectives:

- CSAC – Develop ultra-miniaturized, low-power, atomic time and frequency reference units in microgravity environment
- Expansion Port – Second RS-232 port added for follow-on SPHERES payloads

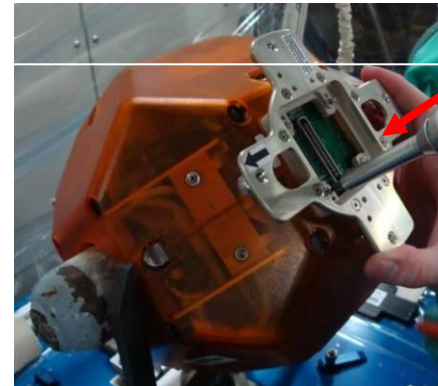


## Experiment Status

- **Launch Date:** 45P
- **Status/Issues:**
  - Expansion Port installed Feb 2012
  - Clocks powered on, 21 Feb
  - Circuit breaker opened 25 Feb
  - Determined Atomic Reference Clock has internal short on 26 June

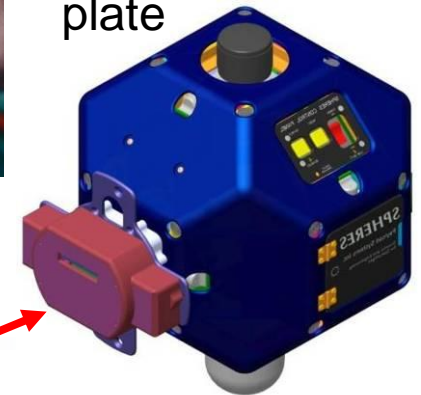
## Experiment Sponsor

- DARPA

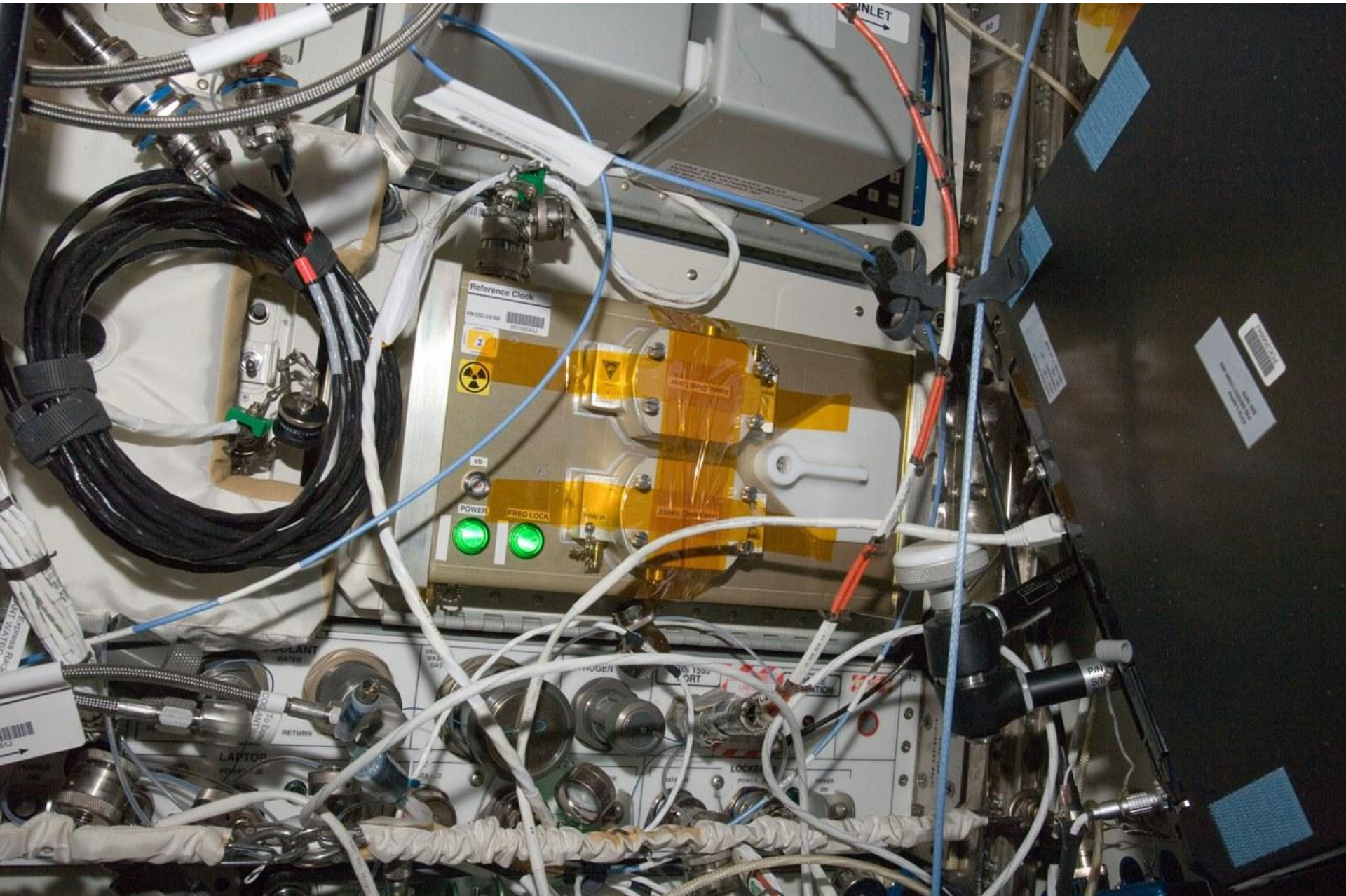


Expansion  
port  
mounting  
plate

CSAC  
Module

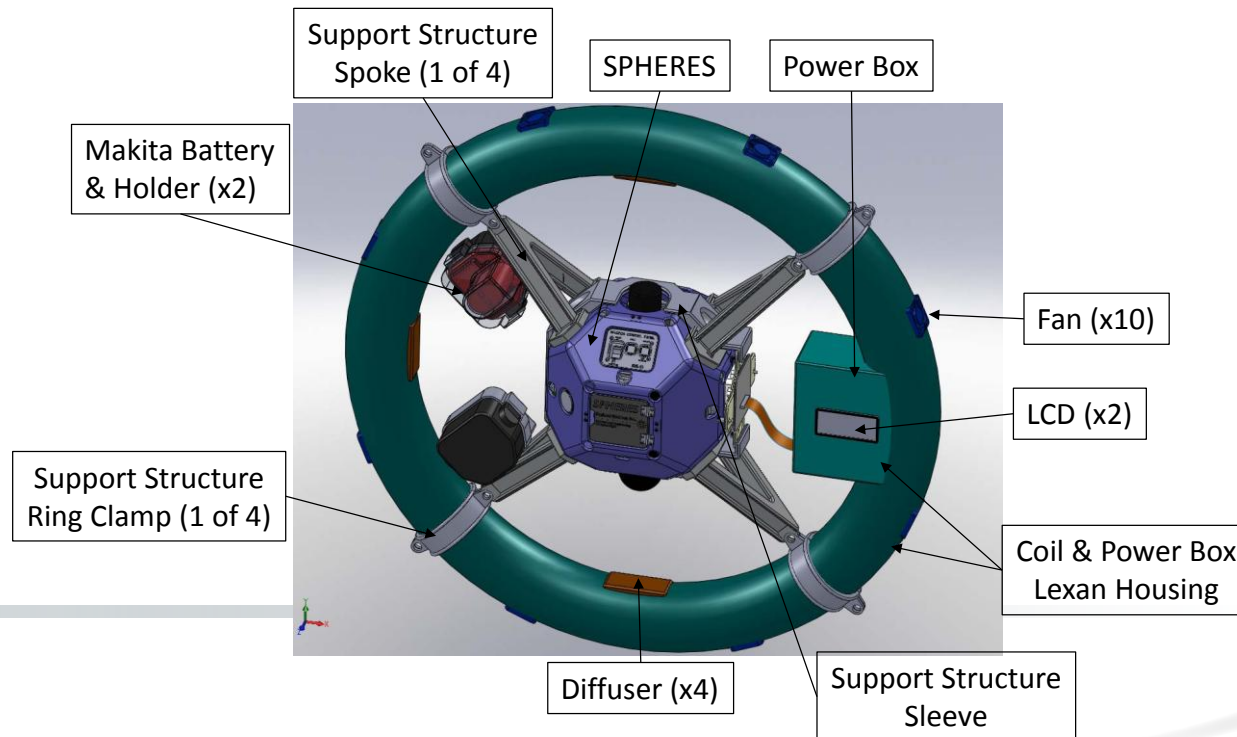


# CSAC Installed on ISS Express Rack Locker 7



# SPHERES RINGS (U of MD)

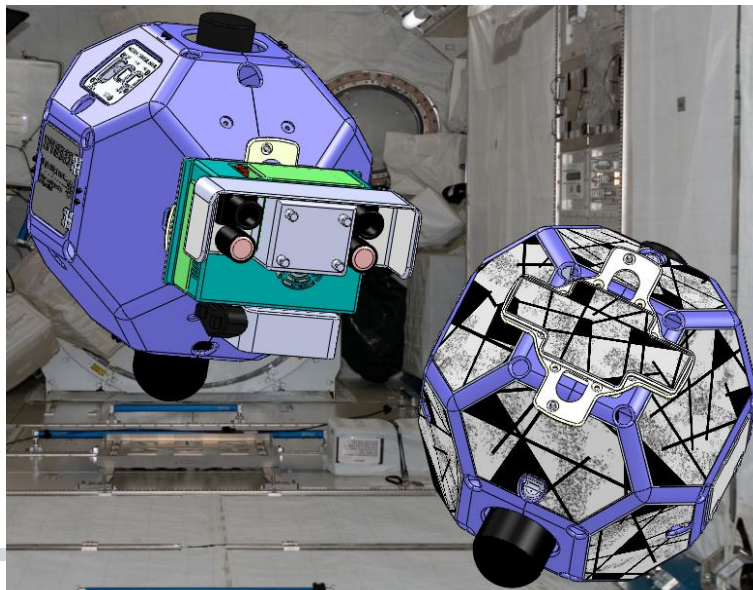
- Resonant Inductive Near-Field Generation System (RINGS)
  - *The RINGS payload will demonstrate six Degrees of Freedom (DOF) maneuvers using Electromagnetic Formation Flight (EMFF) control algorithms.*
  - *The second objective is to demonstrate a hybrid EMFF/Wireless Power Transfer (WPT) design by inductively coupled coils at resonance which will improve power coupling.*



# SPHERES VERTIGO (MIT)

## 3D optical identification and navigation

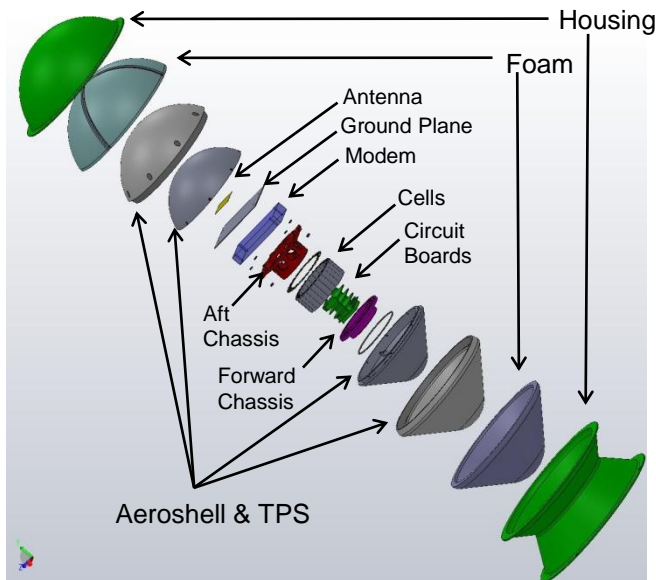
- Visual Estimation and Relative Tracking for Inspection of Generic Objects (VERTIGO)
  - *The VERTIGO payload objective is to develop computer vision based navigation and mapping algorithms capable of building a three-dimensional map of another object and performing relative navigation solely by reference to this three-dimensional model.*



# Reentry Breakup Recorder (REBR)

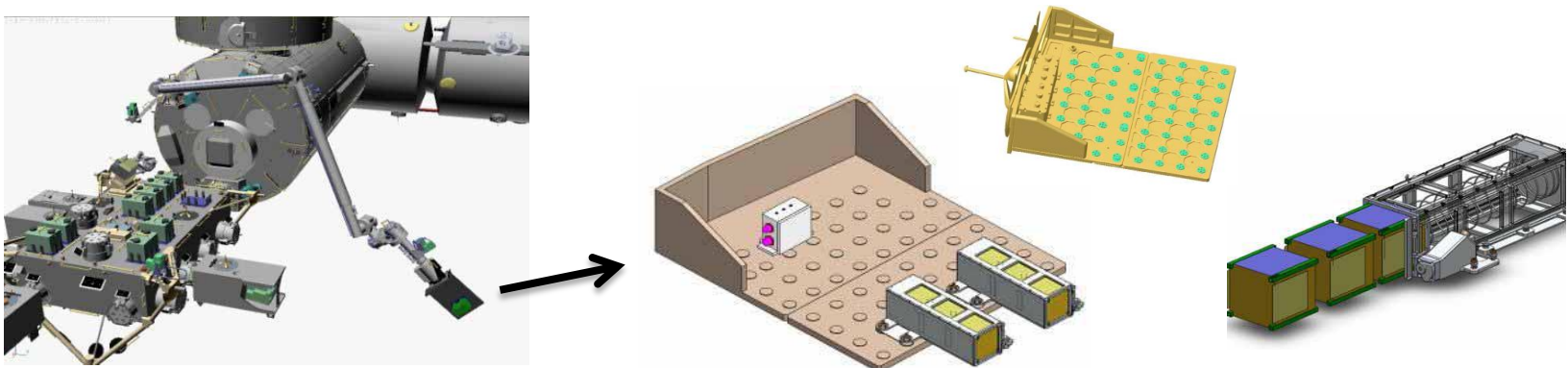


- REBR is a partnership between Aerospace, AF Safety Center, SMC, STP, NASA/Ames, and NASA/Goddard
- Lightweight, self-contained, autonomous, survivable, locatable recording device that is:
  - *Solid state sensors, low-power data recorder to collect data*
  - *Internal GPS sensor to provide location*
  - *Light-weight, rugged heat shield material to protect recorded information*
  - *Satellite phone to send recorded information and location near real-time*
- Attached to host vehicle, sleeps until atmospheric reentry
- Wakes up and records data prior to and during breakup
- Transmits data via Iridium satellite system
- Hardware retrieval not required

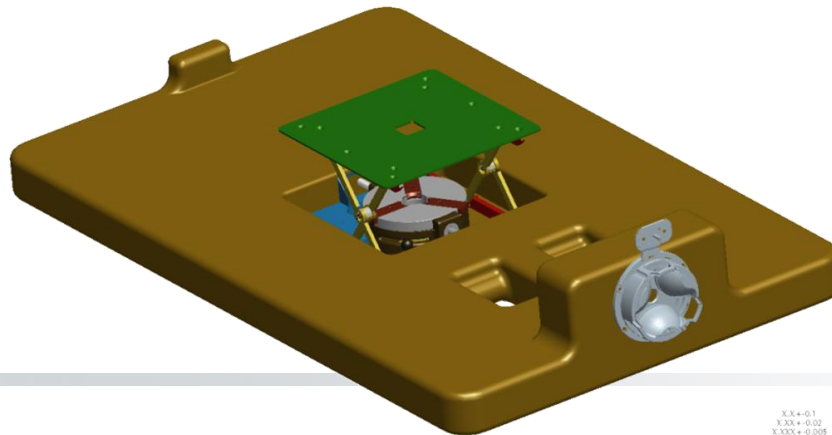


# Satellite Deployment from ISS and ISS launch vehicles

- In addition to deploying off of ISS launch vehicles, DoD will use the 3U cubesat deployment system being developed by JAXA



- DoD is partnering with JSC engineering to develop a deployment system for larger satellites



X.X + 0.1  
X.XXX + 0.02  
X.XXXX + 0.005  
ANG + 0.5



# DoD Zero-G Mission

## *IsoTherm, ASETS, Z-PRIME, Peregrine*

### Mission Description

- **Description:** 4 experiments on 2 Zero Gravity Parabolic Test Flights
  - Flight Dates: June 16<sup>th</sup> & August 25<sup>th</sup> 2012
  - Location: Ellington Field, Houston, TX
- **Vehicle:** Zero Gravity Corp. Boeing 727

### Experiment Description

- **IsoTherm:** *Iso-grid, Thermal-Structural Panel*
  - Thermal Control (electro-hydrodynamic pumps)
- **ASETS:** *Advanced Structurally Embedded Thermal Spreader*
  - Thermal Control (pulsating heat pipe)
- **Z-PRIME:** *ZBLAN Production In a Microgravity Environment*
  - Microgravity Production of Fiber Optics
  - Consists of two independent test facilities: Puller and Quencher
- **Peregrine**
  - Deployable membrane based optics system

### Experiment Sponsors

- **IsoTherm** – Air Force Research Lab
- **ASETS** – Air Force Research Lab
- **Z-PRIME** – Air Force Research Lab
- **Peregrine** – US Air Force Academy

Zero-G



# Closing

- The DoD has accomplished wide-ranging and significant experiments and payloads aboard the International Space Station and its many launch vehicles, foreign and domestic
- The members of the DoD Human Spaceflight Payload Division wish to thank the highly professional and dedicated engineers and managers across NASA who have worked together to accomplish these many advances in science and technology
- The DoD Human Spaceflight Payload Division truly appreciates the tremendous opportunities given by NASA and the International Partners
- The Mission continues....

