Returnable Battery Cell Experiments on the Materials on the International Space Station Experiment (MISSE) Follow-On Advanced Platform

Concept Overview

November 2010

Susie N. LaCava
Susie.LaCava@nrl.navy.mil
202.404.3098

Thanks to support from: Bob Skalitzky, Bill Braun, John Vasquez, Rob Walters, and Phil Jenkins, Naval Research Laboratory; J. Christopher Garner, USG

Returnable Battery Experiments Concept

AGENDA

- Introduction
- NaSBE
- MISSE-5 and MISSE Background
- Advanced Platform
- Conclusion / Status

Returnable Battery Experiments Concept

Introduction

- There is interest in the battery community in the return of space-flight batteries/cells
  - Verify ground test data against actual space-flight data
- With the end of the Shuttle missions near, DoD needs a new way of getting low cost DoD experiments to and from the ISS
  - For the last nine (9) years, MISSEs have provided DoD with a "standardized" experiment platform for risk reduction opportunities
  - Opportunity for returnable battery cell experiments

Returnable Battery Experiments Concept

Advantages for Battery Community

- Provide simulated orbit loading over undetermined duration
- Ability to have a quick turn-around for experiments, dependent on scheduled flights to ISS
- Safe return of cells for use in comparison to ground-based controls, including destructive physical analysis
- Low-cost solution
  - Reusable platform at known ISS location
  - Experiment interfaces standardized and controlled by ICDs

Returnable Battery Experiments Concept

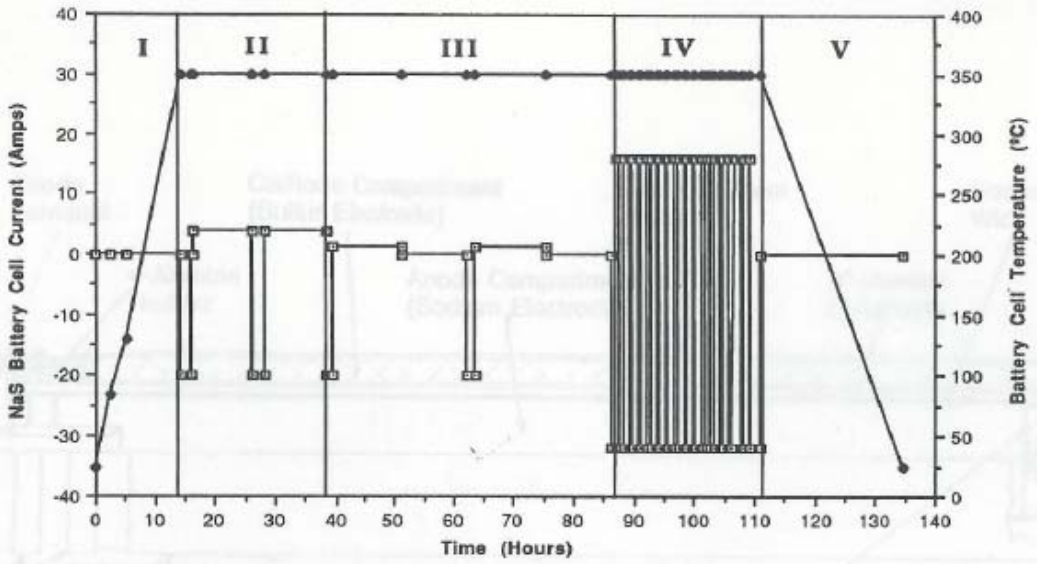
Sodium Sulfur Battery Experiment (NaSBE)

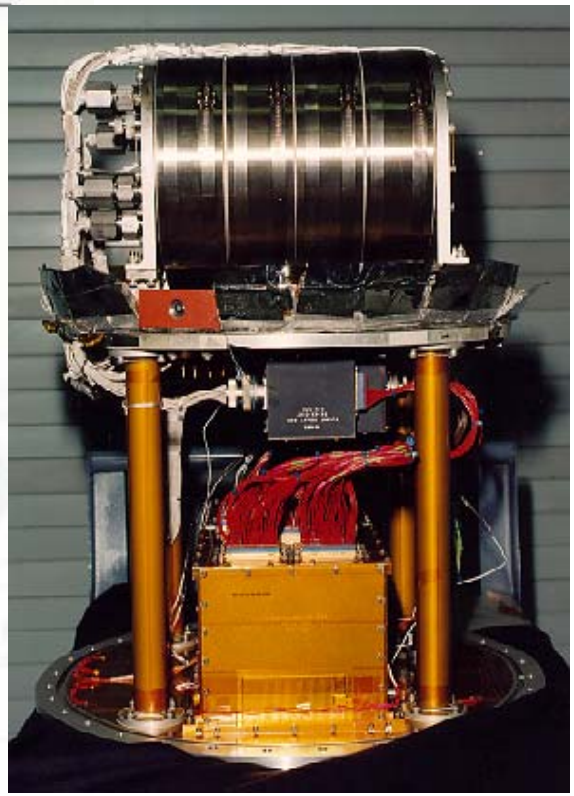
- Primary Objective
  - Demonstration of zero-g operation of the 40 Ah Sodium Sulfur battery cell
  - Post-flight analysis to study fluid dynamics of liquid electrodes
- Launched on STS-87
  - Mission lasted 15 days (19 November 1997 – 05 December 1997)
- Requirements
  - Package 4 NaS battery cells & electronics in “Smart Can” mounted on wake shield facility cross bay carrier (WSF-CBC)
    - Total Experiment Power < 1400W @ 28VDC
    - Total Experiment Mass < 270 lbs including Smart Can
  - Cells launched “cold” and charged
  - Heat cells on orbit to 350°C ± 20°C
  - Record cell voltages, charge/discharge currents, temperature measurements/cell
  - RS-485 communication: Experiment ↔ WSF-CBC
- In Fall 1998, cells were subjected to a DPA by Margot Wasz and Boyd Carter of Aerospace and Jim Degruson of EaglePicher

Returnable Battery Experiments Concept

Sodium Sulfur Battery Experiment (NaSBE)

Experiment Operational Phases



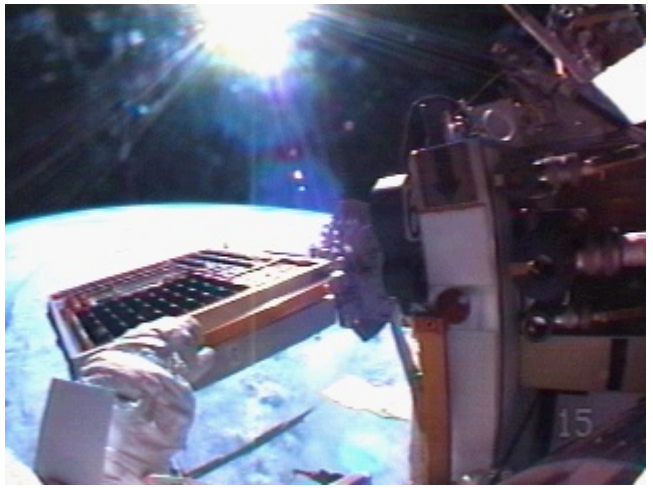


- I Experiment Warm-Up
- II Verification Cycles (2)
  - C/2 = 20 A Discharge to 40 Ah, 5 min OC, C/10 = 4A Charge to 2.5 V
- III Geosynchronus Orbit Cycle (2)
  - C/2 Discharge For 1.2 Hours, C/20 = 2A Charge For 12 Hrs, O.C. For 10.8 Hrs
- IV Low Earth Orbit Cycles (16)/Final Discharge
  - C/1.25 = 32 A Discharge For 0.5 Hrs, C/2.5 = 16 A Charge For 1 Hr
- V Experiment Cool-Down

Returnable Battery Experiments Concept

MISSE-5

- Launched on STS-114 (Return to Flight) 26 July 2005
- Deployed on 03 August 2005
- Retrieved on STS-115 15 September 2006
- Cells were sent back to Yardney for DPA



Astronaut Noguchi Deploys MISSE-5 On the ISS

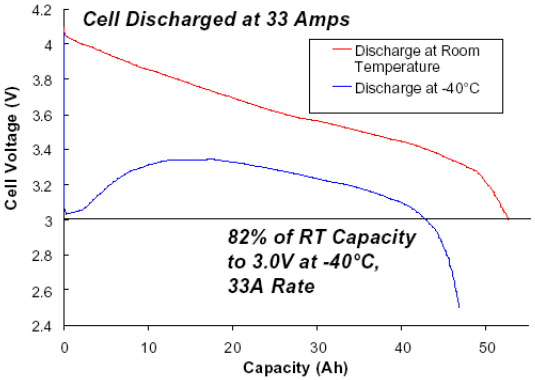
Returnable Battery Experiments Concept

MISSE-5 Energy Storage

- MISSE-5 Energy Storage Requirements
  - FTSCE and PCSat2: 10W at 14VDC (4-Cell Battery)
  - MISSE-5 fixed in position on ISS on Alpha joint
  - Sun angle varies as Beta angle varies
  - Large structures shadow MISSE5 for long periods
  - Originally proposed to use Silver Zinc batteries
  - Concern about length of time between activation and launch

Lithion Inc.
An Ener-Tek Company

Lithium Ion Cell: INCP145/34/138
55 Ah Lithiated Nickel Cobalt Cell



Cell optimized for High Rate operation at Low Temperatures.

Performance Data

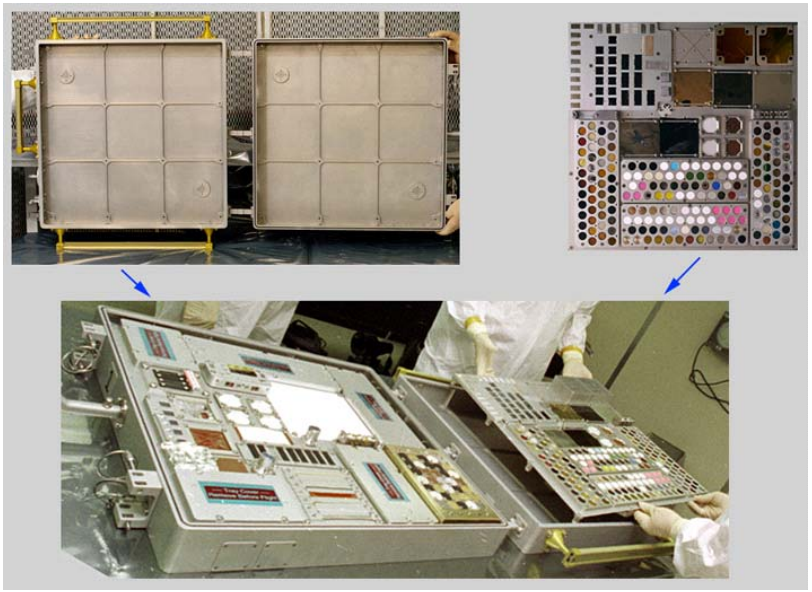
Cathode	:	Lithiated Nickel Cobalt Oxide	Nominal Voltage	:	3.6V
Anode	:	Graphite	Nominal Weight	:	1600 gms
Electrolyte	:	EC:DMC:DEC	Cycle Life	:	> 2000 Cycles
Nominal Capacity	:	55Ah @ C/5	Volumetric ED	:	290 Wh/l
Pulse Current Capability	:	500 Amp (10C)	Gravimetric ED	:	121 Wh/Kg
Sustained Maximum Current	:	150 Amp	Coulombic Efficiency	:	99%
Dimensions	:	5.41" x 1.327" x 5.635"	Fade Rate	:	0.02%/Cycle

Yardney Technical Products, Inc.
82 Mechanic Street, Pawcatuck, CT 06379 (860) 599-1100 – Fax: (860) 599-3903
http:\\www.yardney.com

Returnable Battery Experiments Concept

The MISSE Platform

- Materials on the International Space Station Experiment (MISSE)
  - Passive and active experiments are loaded into a "suitcase"
- Passive Experiment Container (PEC)
  - Approximately 60cm x 60cm x 15cm metal box (2.0ft x 2.0ft x 0.5ft)
  - Experiment is mounted on trays are placed in the PEC
  - The PEC is attached to the ISS and opened on orbit to expose materials to space
  - At the end of the mission, the PEC is closed and retuned to Earth



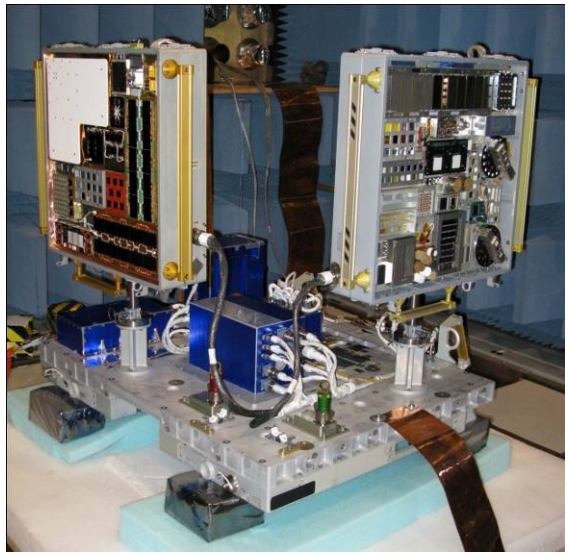
MISSE HISTORY

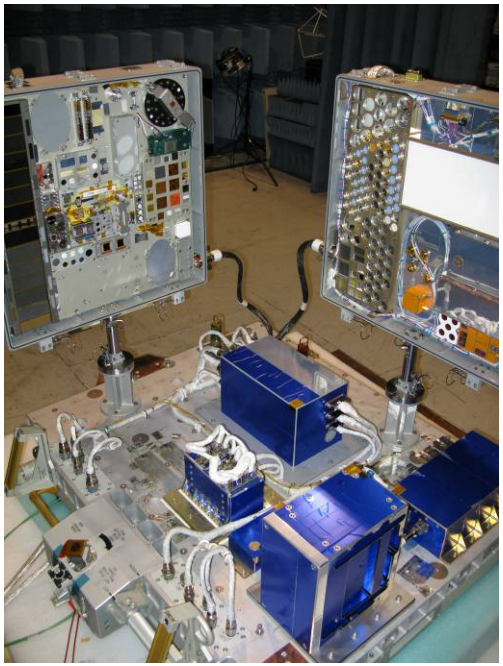
- MISSE-1,-2 (AFRL/ML)
  - Passive material exposures
  - Launched 2001, returned 2005
- MISSE-3,-4 (AFRL/ML)
  - Passive material exposures
  - Launched 2006, returned Aug 2007
- MISSE-5 (NRL)
  - Self-powered with on-board, two-way comms
  - Active solar cell and passive material experiments
  - Launched Aug 2005, returned Sept 2006
- *MISSE-6 (AFOSR/LaRC)*
  - *Uses ISS power with internal data loggers*
  - *Deployed March 2008, returned Sept 2009*
- *MISSE7 (NRL)*
  - *PEC7A (NRL), PEC7B (Boeing). ExPA Experiments (NRL)*
  - *Uses ISS power and data*
  - *Launched 16 Nov 2009, deployed 21 Nov 2009*
- *MISSE-8 (NRL)*
  - *Uses ISS power and data*
  - *Scheduled to launch on STS-134, Feb 2011*

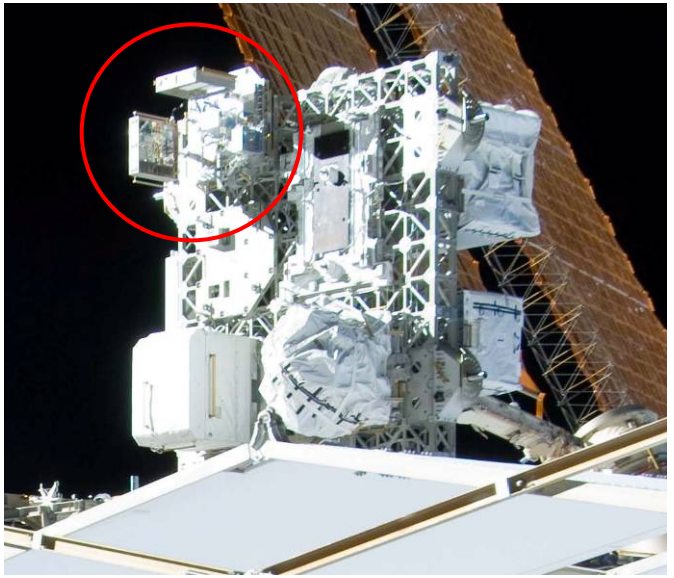
Returnable Battery Experiments Concept

Need for Advanced Platform

- MISSE-1 through MISSE-8 utilized the Shuttle for transport to and from the ISS. Utilize scheduled EVAs to deploy MISSEs.
- With the end of the Shuttle missions near, DoD needs to develop a new platform which will maintain our ability to rapidly deploy, test, and retrieve experiments on the ISS.
- NASA has **no** EVAs (Extravehicular Activities) scheduled for science missions.

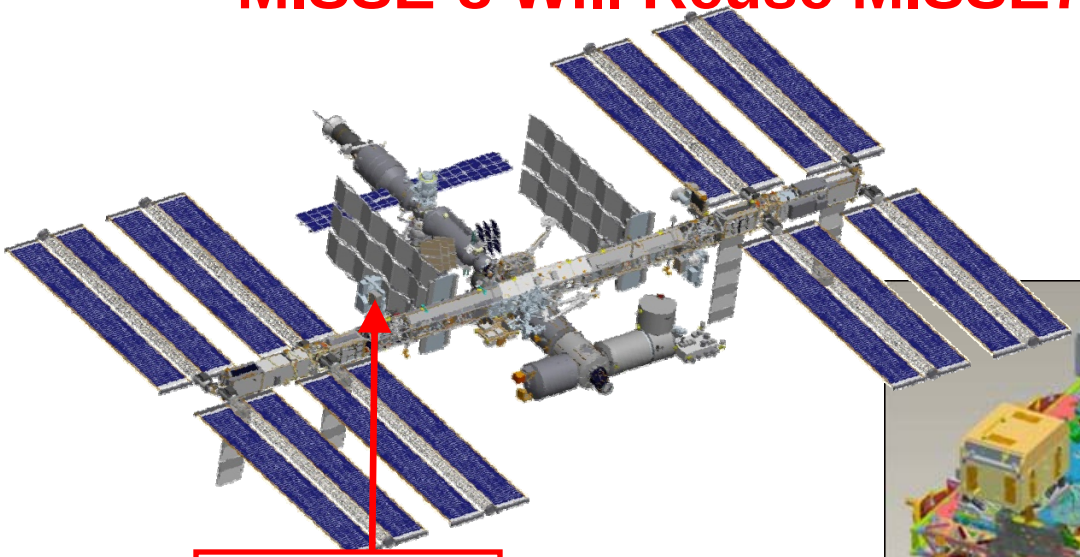




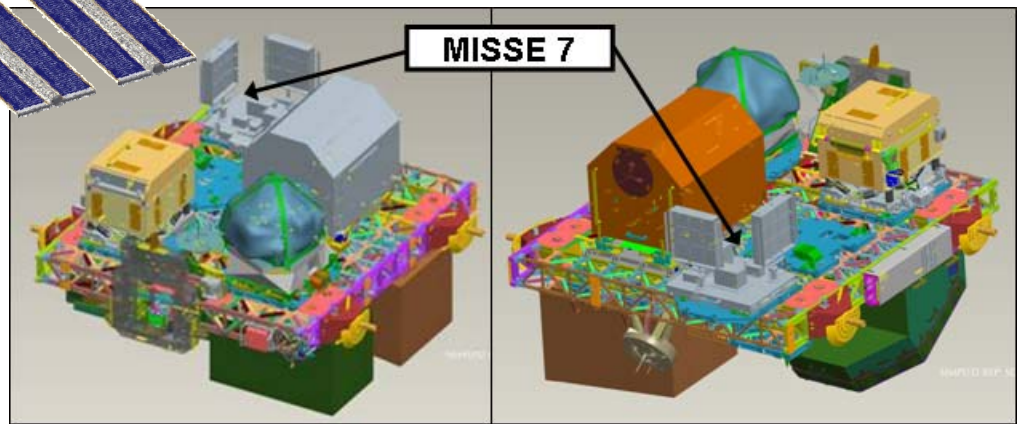


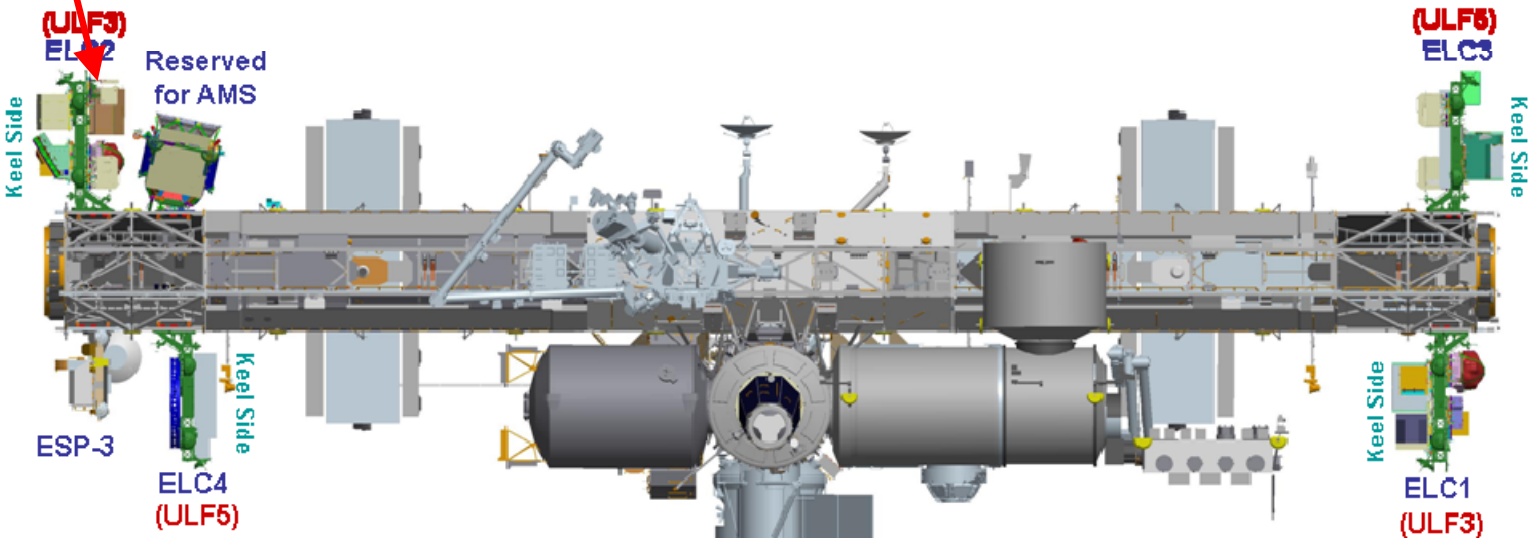
Returnable Battery Experiments Concept

MISSE-8 Will Reuse MISSE7 Location on Station



MISSE7





Returnable Battery Experiments Concept

Advanced Platform Derived Requirements

- EVR-Compatible (Extravehicular Robotics)
- Flexibility to support multiple payloads at multiple locations on ISS
  - ELC/ExPA (Express Logistic Carrier/ExPRESS Pallet Adapter)
  - JEM-EF (Japanese Experiment Module-Exposed Facility)
  - Columbus Module
- Returnable Samples
- Utilize JEM Airlock

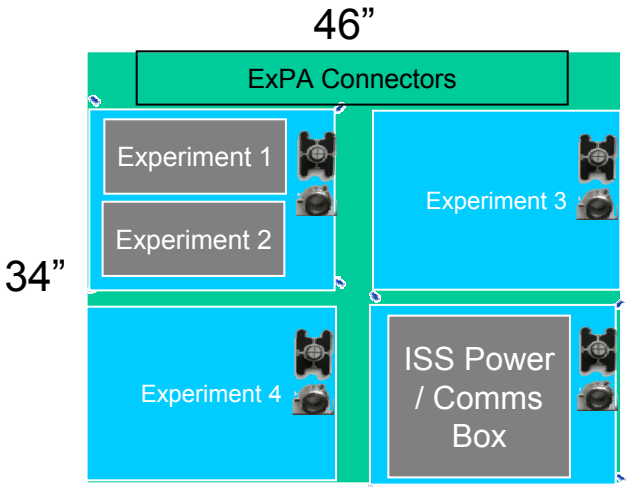
Returnable Battery Experiments Concept

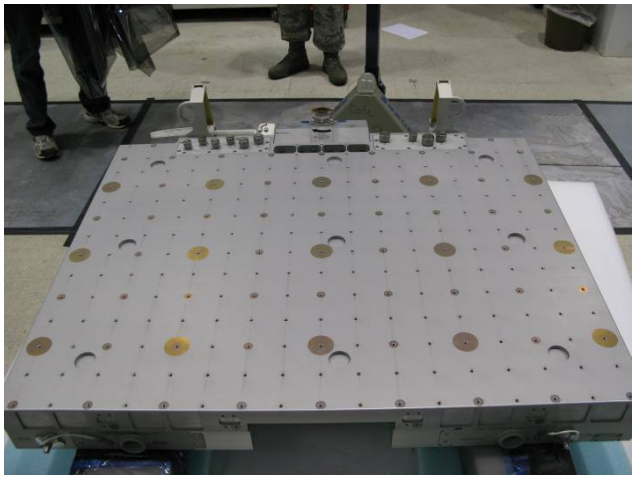
Advanced Platform Points to Consider

- SpaceX Dragon return vehicle more defined and NASA's only option for returning experiments from ISS
  - NASA motivated to make it work
- Robotic capabilities of ISS has increased
  - Previous ISS grapple fixtures large
    - Limit space for experiments

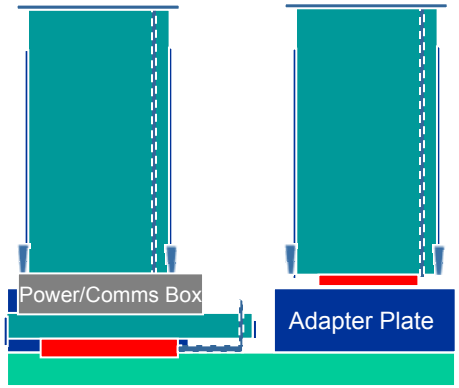
Returnable Battery Experiments Concept

Draft Concept Design





ExPA Flight Platform

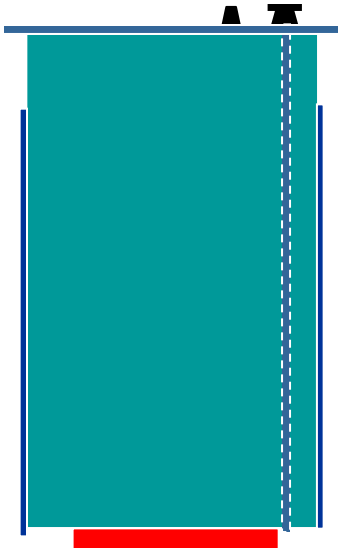


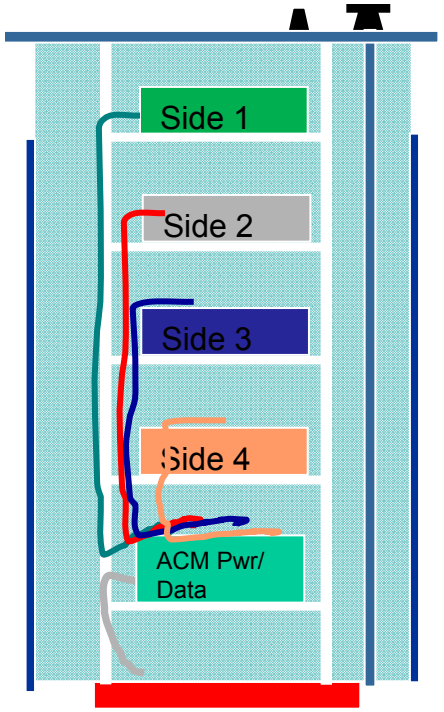
- Utilize the ExPA platform
- Divide ExPA into four (4) sections, three (3) with identical adapter plates for mating experiments to the ExPA via blind-mate connectors for power and data, and one (1) for removable Power/Comms Box
- ExPA paint pattern aids in EVR alignment (not shown)
- Each experiment pallet has simultaneous Ram, Wake, Zenith, and Nadir views depending on its respective neighbors
- Experiment pallets can be independently switched in and out based on experiment needs

Returnable Battery Experiments Concept

Materials Carrier Draft Design

- Initial Concept
  - 14” x 30” x 4 sides
    - About the largest size that will accommodate 2 AMC’s (Advanced Materials Carrier) in the airlock at one time
    - Larger AMC is possible but only one at a time through airlock
  - Micro conical with 7/16” bolt
  - Integral Lid
  - Alignment rails
  - Modified Lightband attachment mechanism
- Alternate Concept
  - 20” x 20” x 10” Carrier
    - Will fit in mid-deck locker
  - Micro conical with 7/16” bolt
  - Integral Lid
  - Alignment rails
  - Revised blind-mate connectors
- Other Alternatives To Be Considered





Returnable Battery Experiments Concept

Conclusion / Status

- Battery community has an opportunity to utilize a platform to conduct battery cell experiments and have them returnable for post-flight analysis

- Currently seeking funding to either perform trade study or develop platform
- Initial discussions with potential experimenters