Advanced Space Suit Project

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ADVANCED EXPLORATION SYSTEMS
FY16 MID-YEAR REVIEW
FY16 Mid-Year Review Agenda

- Project Objectives
- FY16 Milestone Status
- FY16 Accomplishments
- Collaboration Across AES Projects
- Partnerships and Customers
- Technology Infusion from STMD
- Education and Public Outreach
Project Objectives

• To mature technologies and capabilities that will enable future EVA exploration systems for any of the proposed design reference missions

• To produce real cost, performance, and reliability data through building and testing high-fidelity systems, culminating in a flight demonstration on ISS of an Advanced EMU (AEMU) in the early 2020’s

• After 4 ½ years of support from AES, EVA development efforts are transitioning from technology development for future exploration missions to support of a potential near-term EMU replacement effort
FY16 Milestone Status

- Due to budget cuts and changing priorities, Z-2 vacuum chamber testing will not be performed

- Instead, NBL testing of Z-2 will now begin this year (originally planned for FY17)
  - Testing will characterize Z-2 functionality for micro-gravity EVA to address pressure garment architecture questions

<table>
<thead>
<tr>
<th>FY16 Milestone</th>
<th>Status</th>
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<tr>
<td>Complete Z-2 suit manufacturing and vendor acceptance testing (Delayed FY15 Milestone)</td>
<td>Complete 3/8/16</td>
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<tr>
<td>Complete Portable Life Support System (PLSS) 2.5 Electrical Live Loads Test (7/29/16)</td>
<td>On Track</td>
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<tr>
<td>Complete Z-2 Vacuum Chamber Testing (9/30/16)</td>
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<tr>
<td>Initiate Z-2 Neutral Buoyancy Laboratory Testing (New Milestone – 9/30/16)</td>
<td>On Track</td>
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FY16 Accomplishments – Pressure Garment Subsystem (PGS)

Received Z-2 Prototype Hardware
- One size upper torso and brief
- One size pair of boots with sizing inserts
- Three sizes of lower arms
- Three sizes of lower legs
- Four protective visors
- Two cover layer options
- Dedicated donning stand
- Associated documentation for use and maintenance

Completed in-house verification checks and modifications of Z-2
- Installed integrated audio system (built on CSSS contract)
- Completed suit structural/leakage verification
- Installed simplified ventilation assembly
- Verified mounting location for Feedwater Supply Assembly (FSA)
- Installed data port pass-thru to support CO2 washout testing
FY16 Accomplishments – PGS

CO2 Washout Test Preparation
- Completed 4 Z-2 test subject fit-checks
- Completed facility checkouts
- Completed test plan
- Testing scheduled for May

NBL Test Preparation
- Completed draft test plan and presented to the Integrated EVA Requirements Working Group
- Began design of Mini-Workstation interface to Z-2
- Evaluated pool ingress/egress options with NBL safety divers
- Coordinated initial test run dates with the NBL and initiated test procedure development with the EVA flight controllers
- Planning for 15 runs beginning in September
FY16 Accomplishments – PGS

Z-2 Test Subject Fit-checks and Familiarization
Continued to Refine PLSS 2.5 Design

- Incorporated findings from Interim Design Review (dual seals for thermal loop)
- Modified packaging to relocate batteries away from Oxygen tanks
- Added detail to packaging including plumbing, wiring, and brackets
- Performed component level testing of various components (Vista and JPL CO2 sensors, Mini-ME backpressure valve, regulator backflow)
- Completed requirements and began procurement of Oxygen tanks
- Began detailed team review of FMEA
FY16 Accomplishments – PLSS

Continued Preparations for PLSS 2.5 Electrical Live Loads Test
• Refined objectives and test hardware configuration
• Designed and procured harnesses and breakout boxes
• Performed stress analysis of backplate design and began manufacturing
• Determined process for orbital welding of Titanium water lines
• Completed preparations for the new PLSS component acceptance lab
FY16 Accomplishments – Power Avionics and Software Subsystem (PAS)

Completed assembly of PAS 2.0 Caution and Warning System (CWS), Display and Control Unit (DCU), Communication & Informatics

- Completed fabrication and checkout of the custom carrier printed circuit boards for each assembly
- Connected them to the Field Programmable Gate Array (FPGA) boards and verified proper operation of each interface
- Fabricated and functionally tested the Power Management and Distribution (PMAD) custom Crit 1 & Crit 3 printed circuit boards
- Fabricated and functionally tested DCU simulator
- Completed the enclosure fabrication and internal harness wiring for each
FY16 Accomplishments – PAS

Began PAS 2.0 Integrated Testing

- Objective is to demonstrate PAS subsystem performance and verify functionality
  - Power loading, processor throughput, inter-assembly functional operations, and inter-assembly messaging
- Completed the CWS to Crit 1 PMAD and Informatics to Crit 3 PMAD Integration Test Procedure
  - Power distribution, fault protection, and data transfer function from Crit 1 PMAD to CWS and from Crit 3 PMAD to Informatics
  - Completed checkout of the power distribution to all interfaces including the PLSS controllers
  - Utilized the Display and Control Unit (DCU) simulator to control switching
FY15 Accomplishments – SE&I

• Baselined multiple Project level documents
• Prepared EVA Strategy and Int EVA Dev plan
• Completed assessment of Z-Suit don/doff using ISS EMU Don/Doff Assembly (EDDA)
• Built mockups and prepared test plan for upcoming PLSS to PGS Interface test
Collaboration between Advanced Space Suit and AMPS has continued for the development of a PLSS 2.5 battery

- On schedule to deliver 10 breadboard battery packs, the harness and charger in May for the PLSS Live Loads test
- Performed Thermal Runaway Propagation (TRP) testing of battery module design with support from NESC and JSC battery group
Partnerships and Customers

- **ISS Program**
  - Participating in development of requirements for any future EVA space suit system including:
    - Level 1 requirements, operational concept for demonstration of systems on ISS, exploration environments definition, EVA design and construction standards applicability, NASA Standard 3001 applicability to EVA
  - Constellation Space Suit Systems (CSSS) contract
    - Received over 300 hardware items as part of the CSSS contract close-out
      - Will be integrating hardware into component test plans in FY17 as part of the Integrated EVA Development plan
    - Working with the EVA Management Office to catalog and make available via a controlled technical library, all data deliverables from the eight year effort

- **Human Research Program**
  - Integrated EVA Test Plan
    - Working with the EVA community to identify all EVA human performance gaps and the data required to close them. Will prioritize the gaps and develop an integrated strategy for funding requests and test planning and execution.
**STMD: High Performance EVA Glove (HPEG)**

- Completed design reviews and began manufacturing of glove prototypes
- Gloves will be delivered this summer and undergo testing
  - Two pairs of Gas Pressurized gloves
  - One pair of Mechanical Counter Pressure Gloves
- Conducted suited testing with the first Space Suit RoboGlove (SSRG) prototype
  - Design upgraded for further testing
- Received approval from the Crew Office and ISS for NBL testing of sensor suite this summer
Education and Public Outreach

• Hosted 8 Lab tours including FUSION
• Presented ~12 Space Suit presentations to various public groups (classroom and digital events)
• Conducted interviews on the future of space suit development/Z-2 with 9 different media outlets
• Initiated Z-2 PAO kick-off
  – Updating #SuitUp website with new Z-2 test graphics
  – Utilizing social media to share information about the suit and upcoming NBL testing
  – Planning a Media Day in early May to provide media teams access to AES engineering team and in-person demonstrations of the suit
• International Conference on Environmental Systems (ICES)
  – Planning committee, session chairs, and authors/presenters of 17 papers
Questions?