Acoustic Multipurpose Cargo Transfer Bag Abstract

The Logistics Reduction (LR) project within the Advanced Exploration Systems (AES) program is tasked with reducing logistical mass and repurposing logistical items. Multipurpose Cargo Transfer Bags (MCTB) are designed to be the same external volume as a regular cargo transfer bag, the common logistics carrier for the International Space Station. After use as a cargo bag, the MCTB can be unzipped and unfolded to be reused. This Acoustic MCTBs transform into acoustic blankets after the initial logistics carrying objective is complete.

CR 014398

Acoustic Multipurpose Cargo Transfer Bag Overview

Sponsoring Org/Office Code: *AES LR & OB*
Date: *Nov 18, 2015*

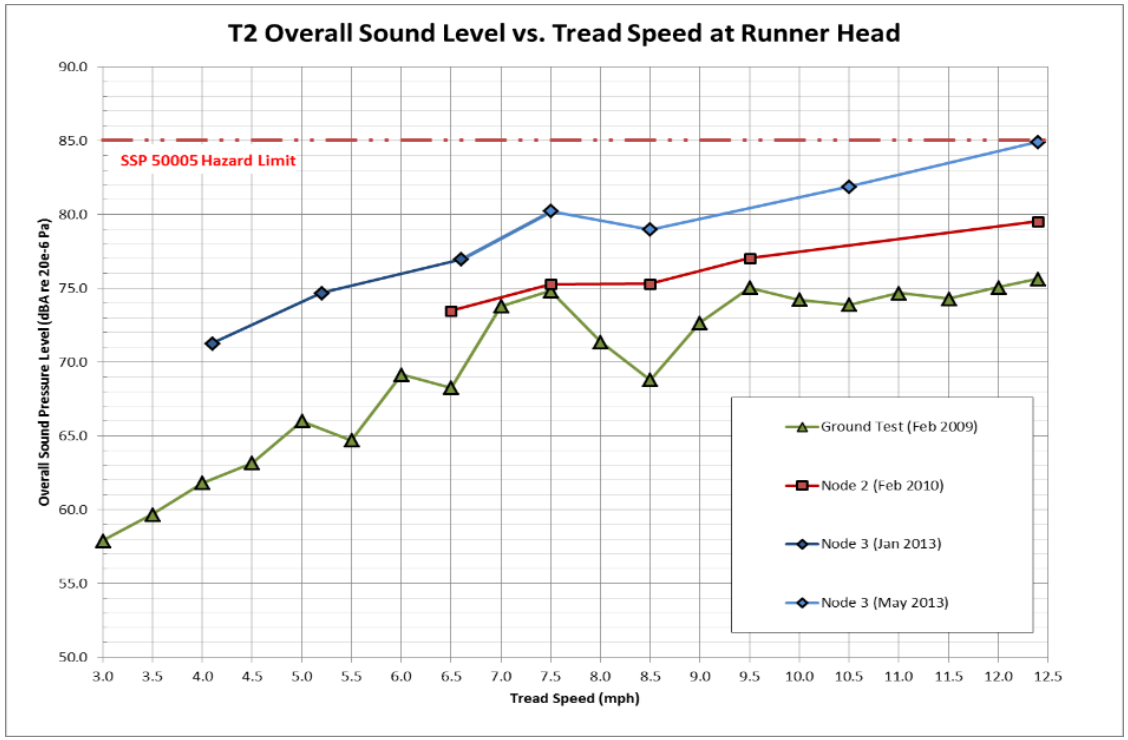
Shelley Baccus

Purpose/Agenda

- **Purpose:** The purpose of this presentation is to obtain approval through the DAA system for the external release of information regarding the Acoustic Multipurpose Cargo Transfer Bag

Project Background – T2 Sound Level

- Ground acoustic testing of the T2 treadmill rack was conducted as part of the flight certification testing in February 2009, and on-orbit measurements of the T2 rack were made after it was installed in the temporary location in Node 2 and the current location in Node 3
- Because the current sound level at high speed reaches the hazard limit, the T2 has been added to the Noise Hazard Inventory, and hearing protection has become mandatory above 10 mph per the Noise Constraint Flight Rule 13-152

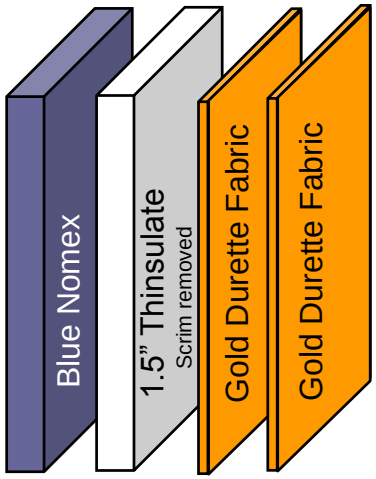


Project Background – Acoustic Testing

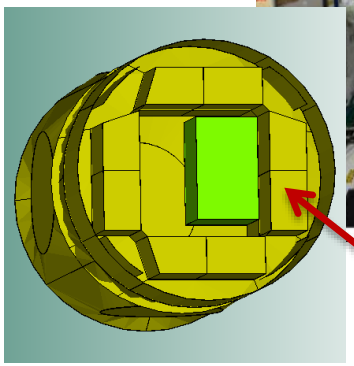
- The Acoustics Office (SF) has completed over 100 impedance tube normal incidence absorption measurements with different material layups to determine the best option
- The preferred layup was determined to be blue Nomex™, Thinsulate™, and two layers of gold Durette fabric implemented in a dual layer acoustic treatment
- Acoustic modelling of Node 3 showed that **implementing the proposed acoustic MCTBs on two walls in Node 3 reduces the noise by ~3 dBA at different tread speeds measured at the runner's head location**
- Since dBA is measured on a logarithmic scale, a 3 dBA reduction is a halving of the sound energy

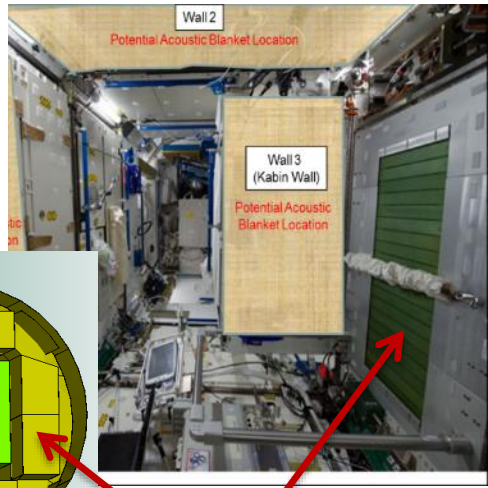
Impedance tube used for measurements

Material part numbers:
Blue Nomex 60650 ROY
Thinsulate: AU 6020-6-60
Gold Durette Fabric: F400-6



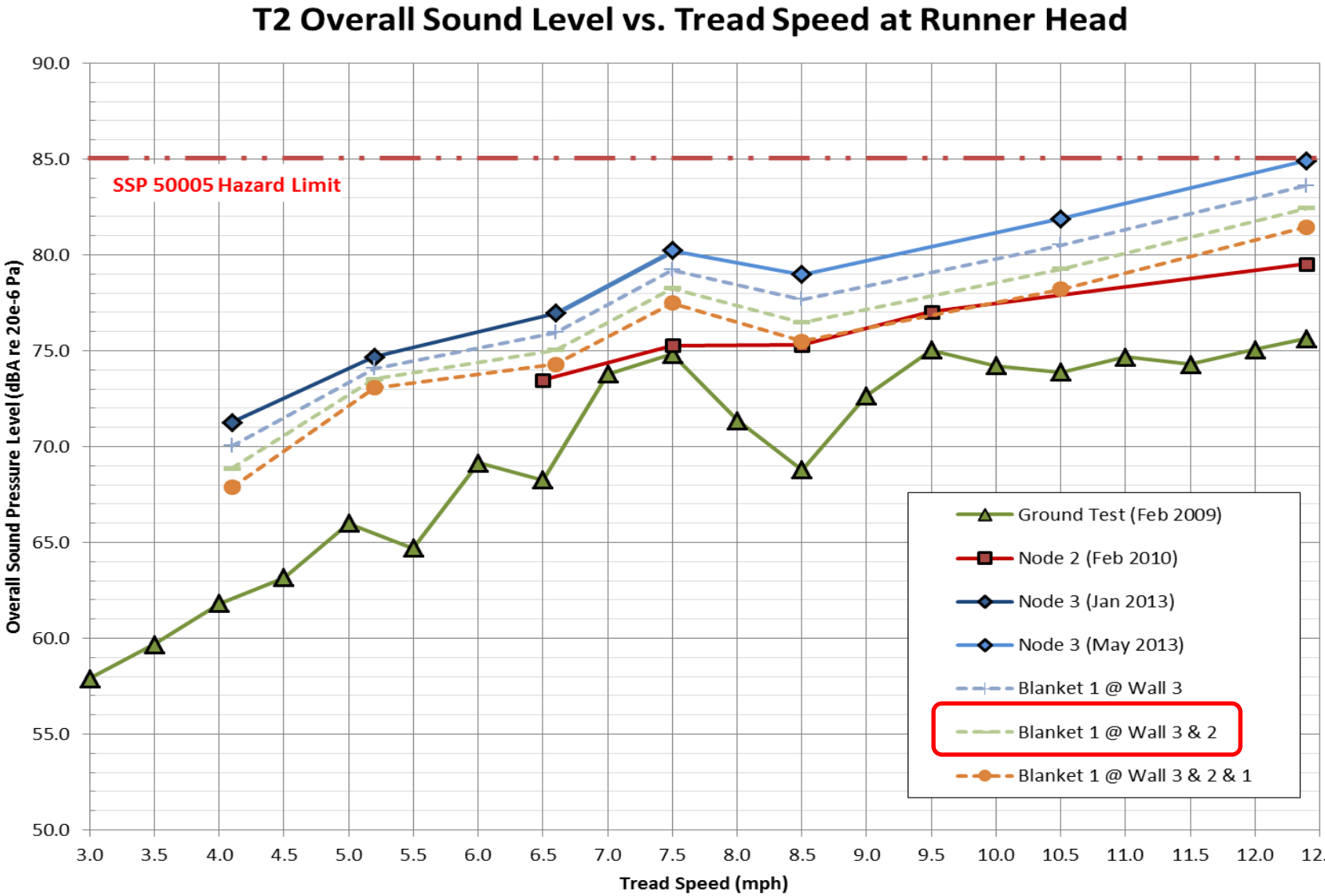
Acoustic Material Layup
Deployed in dual layer





T2
Treadmill

Project Background – Acoustic Modeling



Project Background – Multipurpose Cargo Transfer Bag Solution

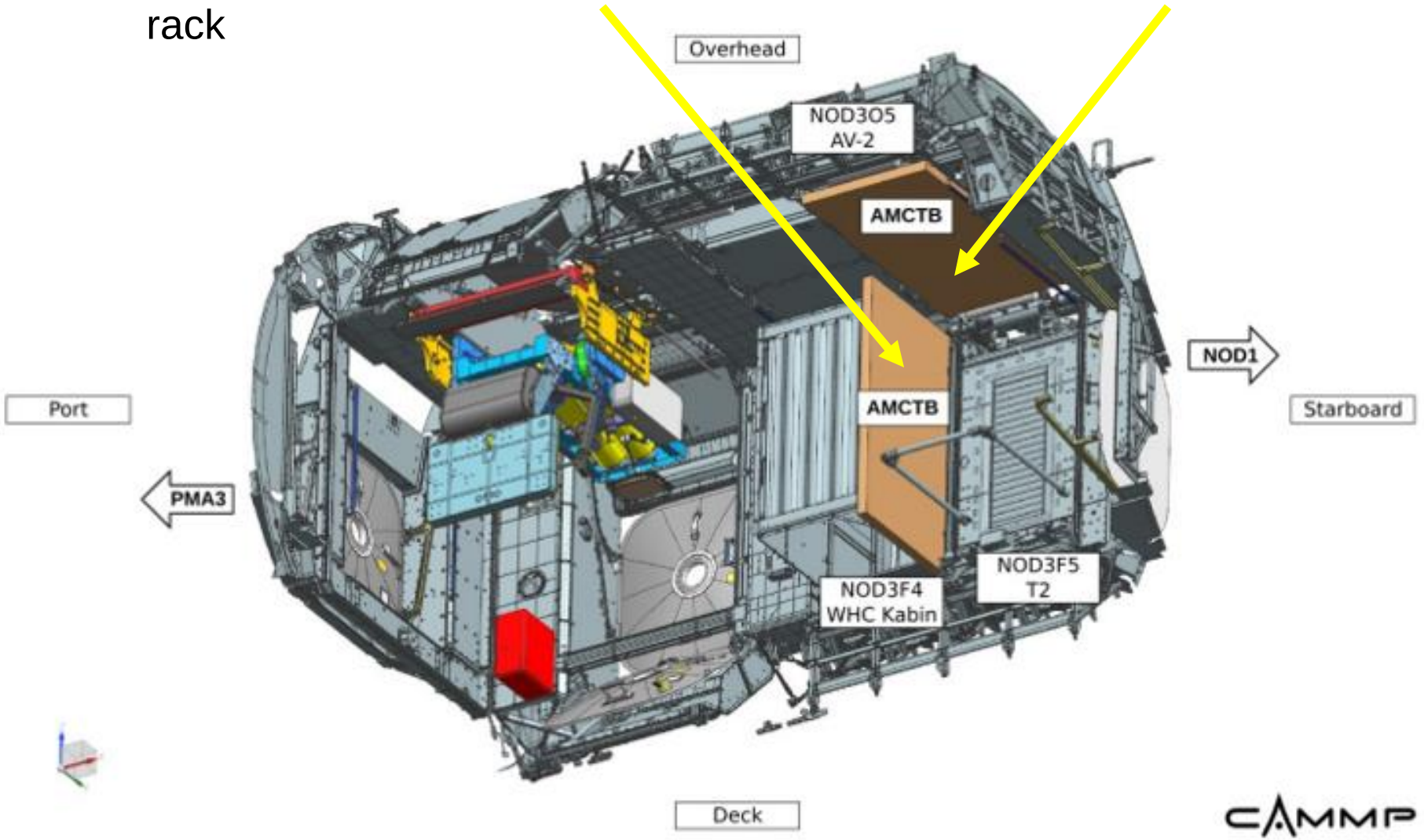
- The Logistics Reduction (LR) project within the Advanced Exploration Systems (AES) program is tasked with reducing logistical mass and repurposing logistical items
- The LR team has developed the Multipurpose Cargo Transfer Bag (MCTB), which can be reconfigured to serve other purposes after providing their primary logistical function
- The technology demonstration of the MCTB will be launched as a CTB and will then be reconfigured into an acoustic blanket
- The Acoustic MCTB (AMCTB) has been designed with a material layup specifically designed to absorb sound

Project Background

- NASA's Crew and Thermal Systems Division (EC) designed, built and certified four Acoustic MCTBs as **Experimental Flight Hardware** using the Class 1-E process
  - Two AMCTBs will be mounted to the WHC Kabin
    - Part name: Acoustic Multipurpose Cargo Transfer Bag
    - Part number(s): SEG39138646-301, S/N: 1001, 1002
    - OpNom: Acoustic 2.0 CTB
  - Two AMCTBs will be mounted to the Avionics 2 Rack
    - Part name: Acoustic Multipurpose Cargo Transfer Bag, Avionics 2 Rack
    - Part number(s): SEG39138647-301, S/N: 1001, 1002
    - OpNom: Acoustic 2.0 CTB AV-2
- Project analysis/documentation included requirements and verifications, stress memo, materials cert, safety/SRP documents, test data, and installation procedures
- Testing included load testing (handle, zipper, and corner coupons), and an T-60 acoustic absorption test

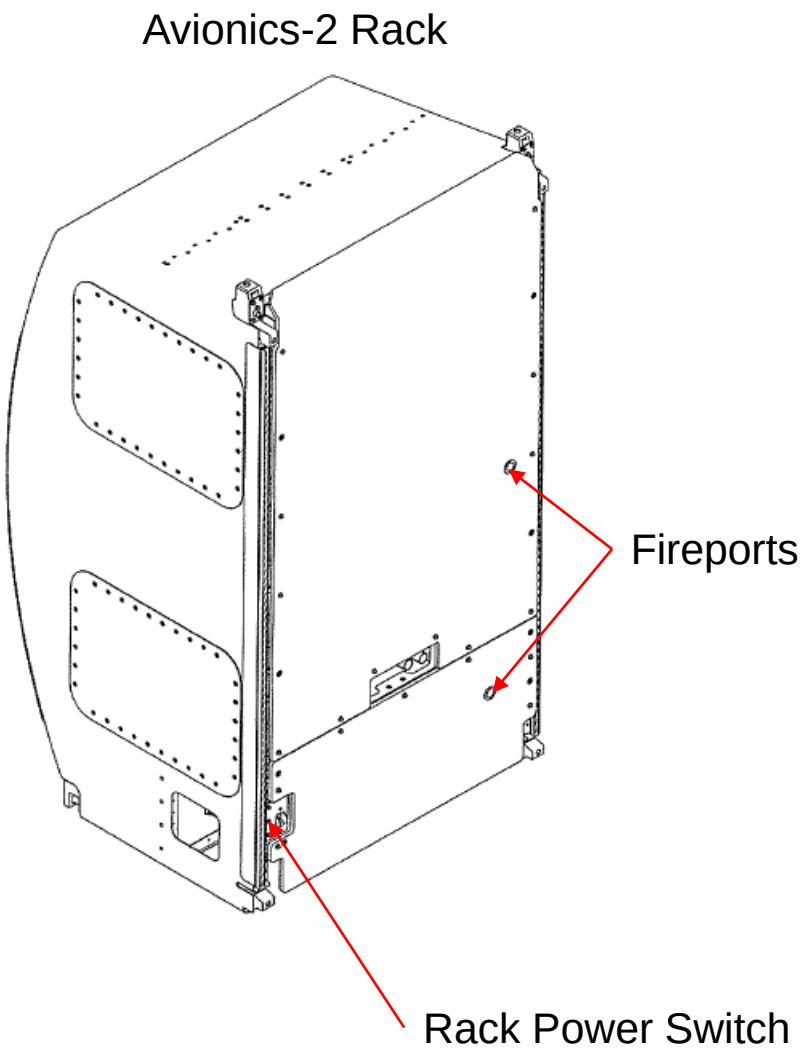
Project Background
AMCTB Installation in Node 3

- This image shows that the Acoustic MCTBs will be installed on the Waste & Hygiene Compartment Kabin wall and the Avionics-2 rack



Project Background – Concept of Operation

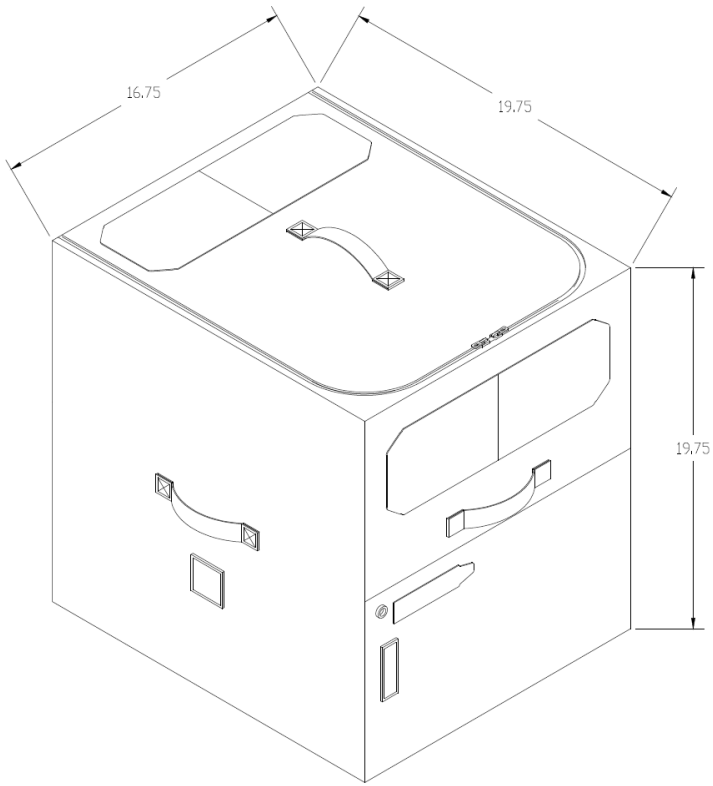
- After being launched as Cargo Transfer Bags, the crew would:
  - Remove the bag contents
  - Unzip the MCTBs into flat panels
  - Attach two layers of MCTBs together using Velcro and snaps
  - Adhere the treatment to the wall using Velcro
- Total crew time for integration = ~30-45 min
  - This does not include removing bag contents or acoustic testing after integration
- There will be holes/patches on the MCTBs that will be used on the Avionics-2 rack to allow access to the two fireports and rack power switch.
- Bungees can be used to secure the MCTBs, if necessary, but should be minimized as compression may reduce the effectiveness of the acoustic treatment
- On-orbit acoustic testing shall be performed at the runner's head location to quantify noise levels before and after installation
  - This will be done as a part of the nominal SLM survey - no additional crew time is needed

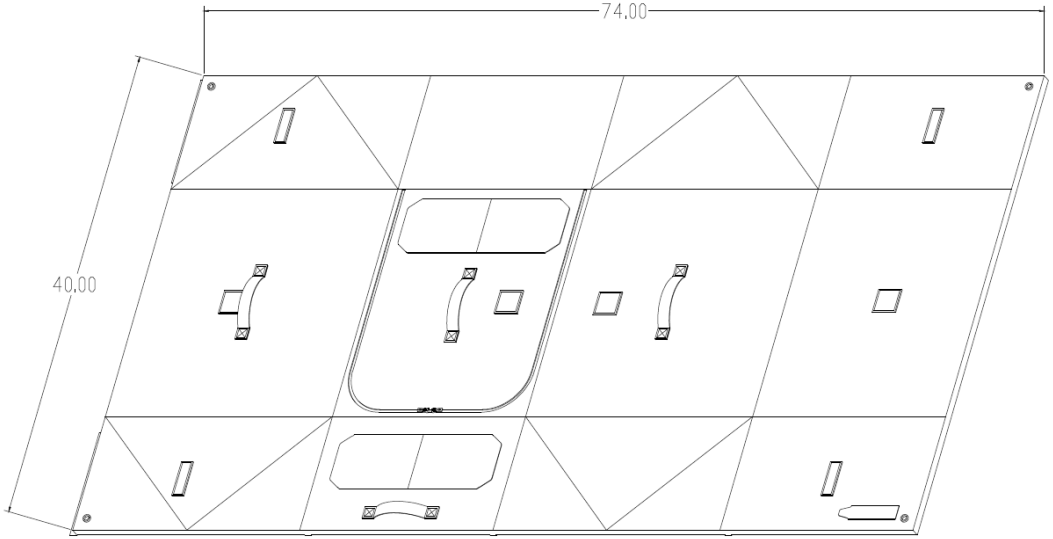


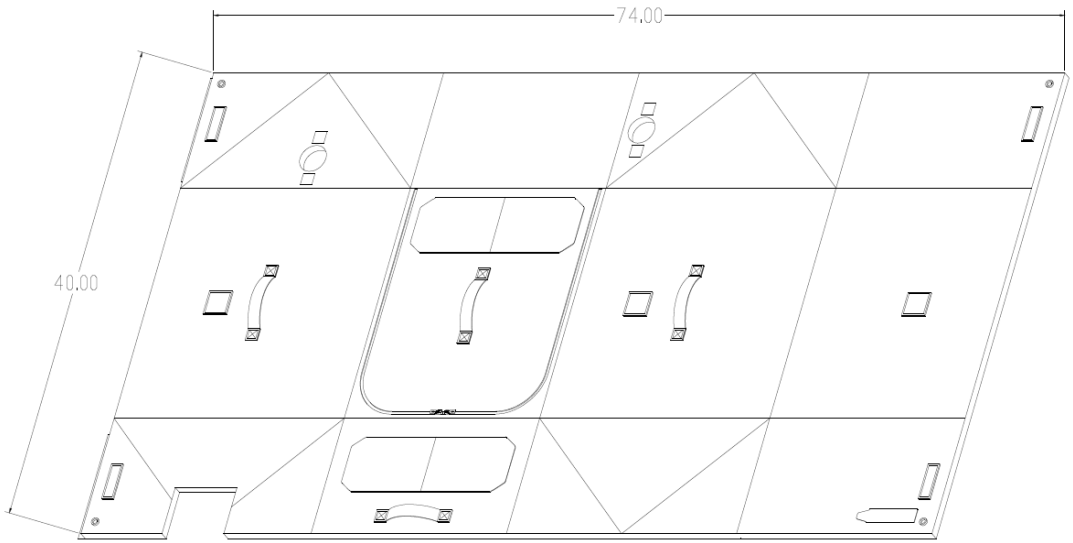
Schedule

- Change Directive signed – January 8
- Processing plan draft routed – January 28
- Kick off – February 6
- Requirements TIM – March 3
- Design TIM – April 21
  - Actions due COB April 27
- Safety Phase 0/I/II – May 5
- Hardware fabrication – May-June
- Verifications – June-July
- Safety Phase III Out-of-Board – July
- Acoustic MCTBs Delivered to CMC for Orb-4 – July 28
- **Achieved the AES Milestone to develop and deliver Acoustic MCTB for flight to support an ISS technology demonstration by July 30**

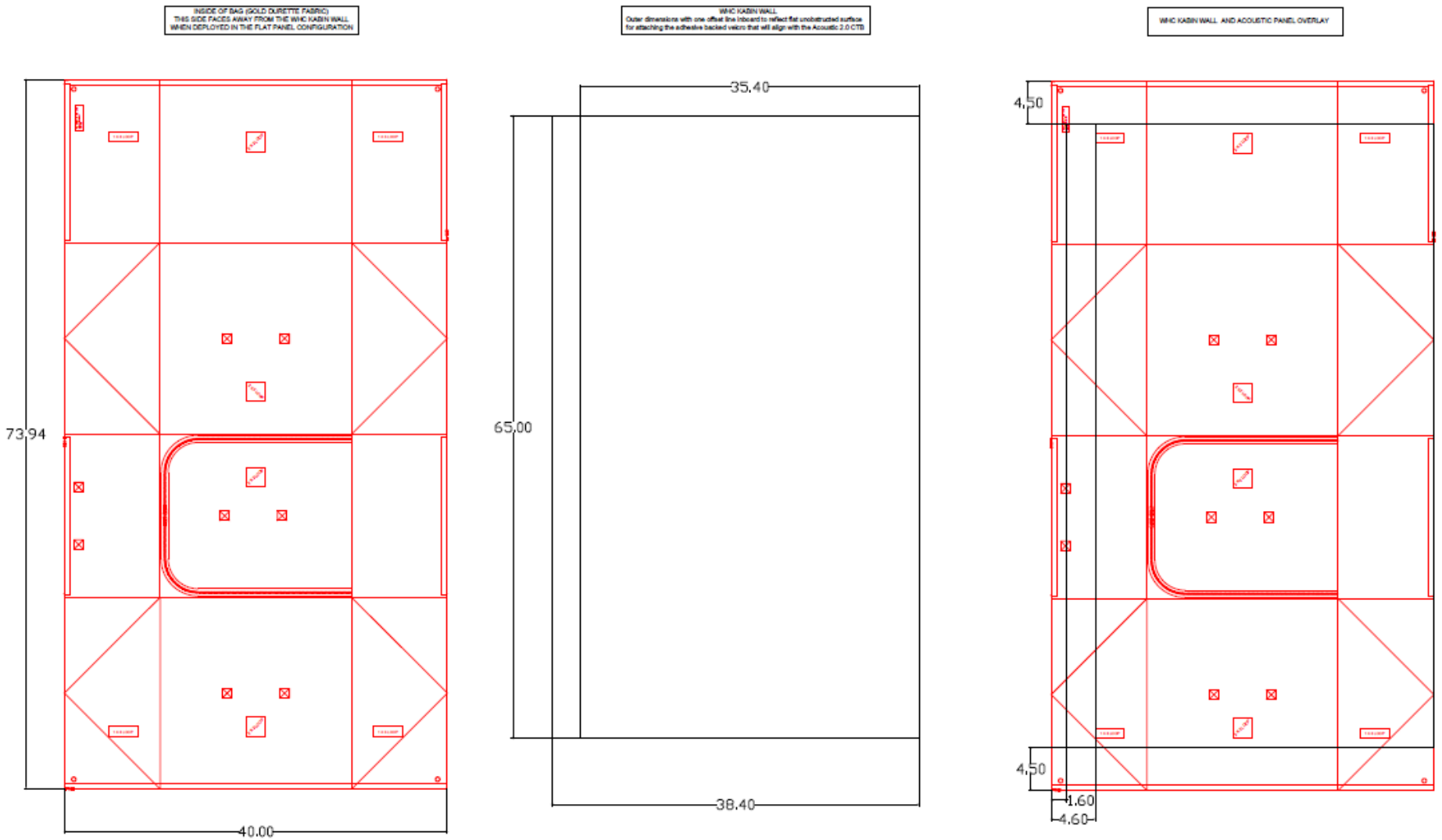
Design



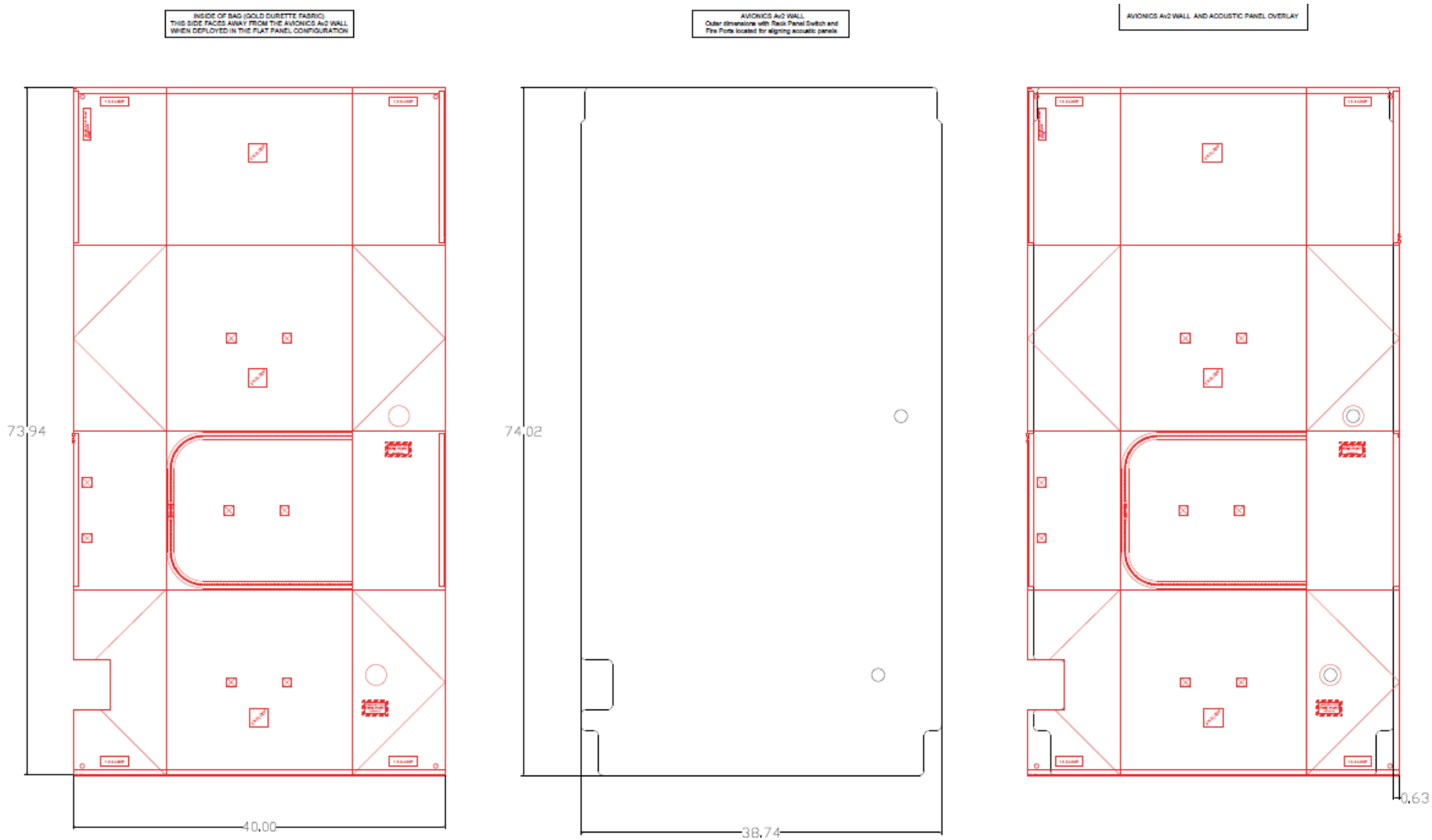




Design – AMCTB for WHC – Overlay



Design – AMCTB for Av2 Rack – Overlay



Design

Acoustic MCTB in bag form (closed and open) and as an acoustic blanket




WHC AMCTB



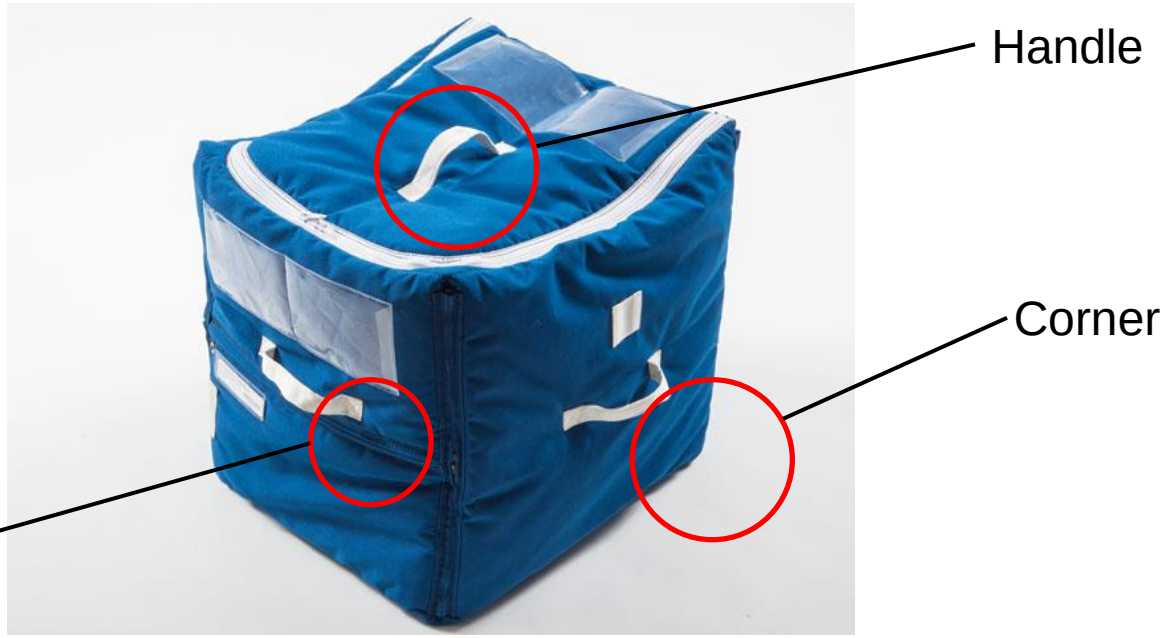
AV-2 AMCTB

Design – Coating

- The crew office was concerned about the AMCTB getting dirty in Node 3 due to the proximity to exercise and bathroom activities
- The NASA JSC Microbiology Laboratory stated that the Acoustic MCTBs would likely grow microbes and would be added to the quarterly microbial swab sampling
- The project investigated coating the fabric with Scotchgard
  - Coating the gold Durette fabric resulted in no strength degradation
  - Coating the blue Nomex resulted in strength degradation, so the Nomex was not coated
  - Weight of Scotchgard after drying was not high enough to warrant a toxicity concern

Load Testing

- 3 different components/regions of the Acoustic MCTB were load tested to meet stress requirements
  - Zippers
  - Corners
  - Handles



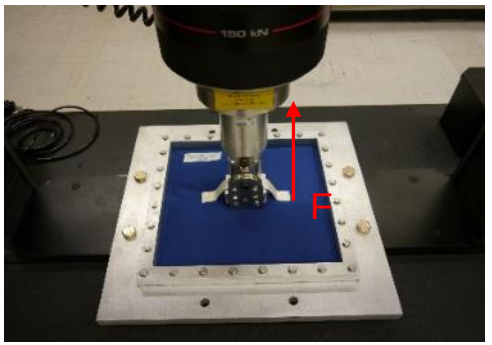
Load Testing

- Test coupons representing each test regions of the Acoustic MCTB with the same materials layup, dimensions, and construction were built for load testing
- Scope of testing:
  - 6 different types of coupon/test configurations
  - Minimum of 2 tests per test configuration
- Common test parameters:
  - Quasi-static loading at a test speed of 3 in/min
  - Test to failure
  - Measure the maximum load value at failure

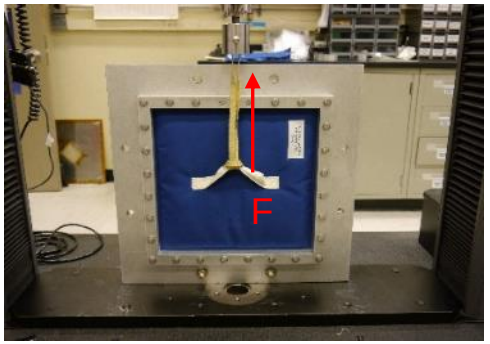
Load Testing – Handles

- 1 type of “Handle” test coupon with 3 load test configurations

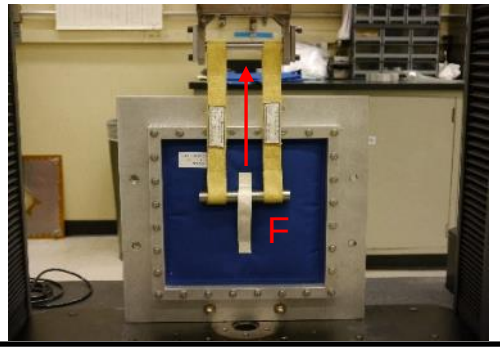
Normal load Pull Test -



Horizontal Shear load Pull Test -



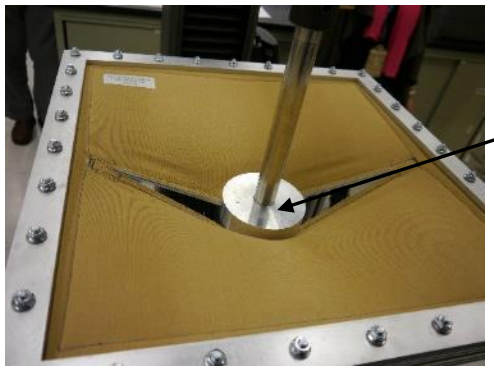
Vertical Shear load Pull Test -



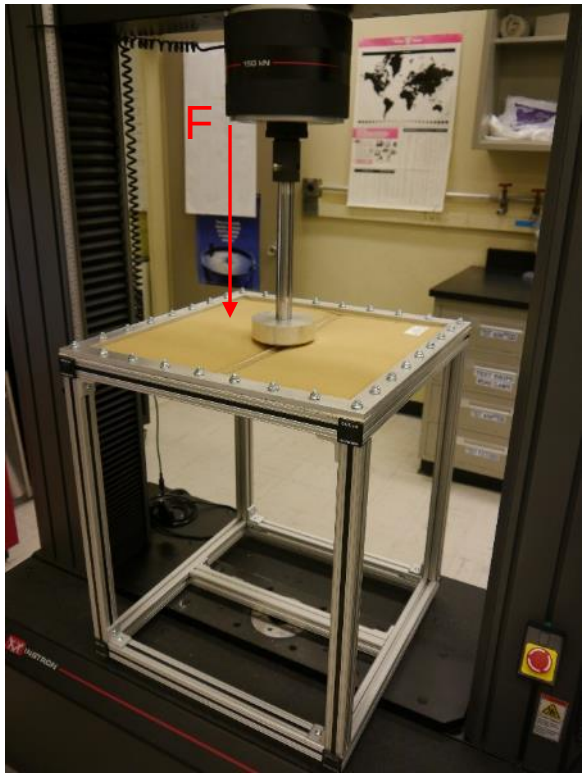
Load Testing – Zippers

- 1 type of “Zipper” test coupon and load test configuration

Zipper Position

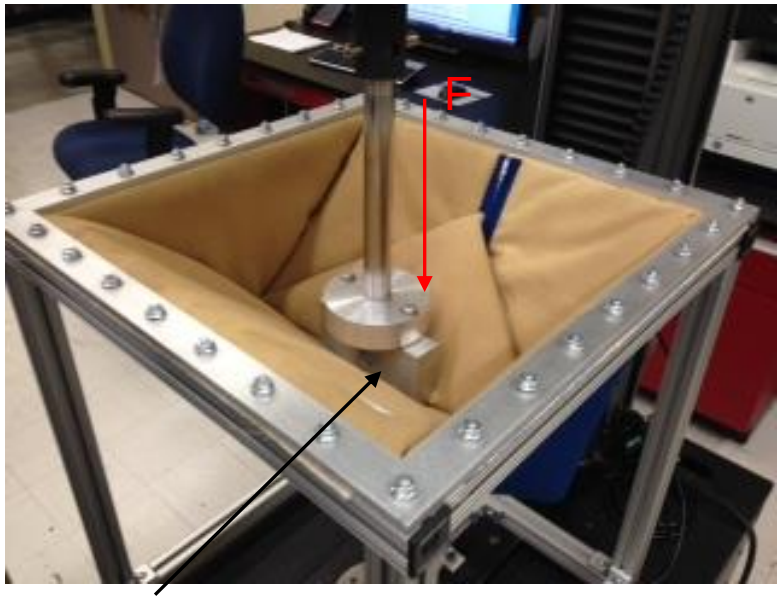


5” Diameter Plunger



Load Testing – Corner

- 2 type of “Corner” test coupons and 1 load test configuration
  - Corner-001, S/N 001 coupon has a Rack Power Switch cutout plus two cutouts for fire ports
  - Corner-001, S/N 002 coupon has only a Rack Power Switch cutout
  - Corner-002 coupon is standard with no cut-outs



6.5” (L) x 1.5” (W) x
3.25” (H) 45-Degrees
Angle Wedge Plunger

Load Testing

- Load testing results

AMCTB Component	Test Coupon Type	Test Configuration	Maximum Load (lbf)			
			Requirement	Test 1	Test 2	Test 3
Handle	Handle-001	Normal - Pull	>144.0	814.9	789.30	729.56
		Vertical Shear		720.6	661.4	632.9
		Horizontal Shear		446.1	484.8	491.4
Zipper	Zipper-001	Normal - Push	>1446.6	1697.0	1966.4	
Corner	Corner-001*	Normal - Push	>723.3	1187.5	1391.4	
	Corner-002*			1267.8	1325.7	

- Corner-001, S/N 001 coupon has a Rack Power Switch cutout plus two cutouts for fire ports
- Corner-001, S/N 002 coupon has only a Rack Power Switch cutout
- Corner-002 coupon is standard with no cut-outs

Structural Analysis and Fracture Assessment

- Structural Analysis and Fracture Assessment Approach
  - AMCTB was test verified for strength
  - Fracture Control Assessment was performed
- Design Loads
  - Analysis focused on the loads induced by bag contents during launch
  - Maximum resultant load factor of 20.1g for launch load (without pre-determined orientation) was used
  - Factor of Safety of 2.0 on ultimate was used (per NASA_STD_5001A, 4.2.7.2 for criticality 3)
  - Launch load on zipper
    - Each zipper shall be able to maintain structural integrity when subjected to a load of 1446.6 lbf
  - Handle Pull load (Ground Handling and On-Orbit)
    - Each handle shall be able to maintain structural integrity when subjected to a load of 144 lbf
  - Launch load on corner
    - Each corner shall be able to maintain structural integrity when subjected to a load of 723.3 lbf
  - Kick load
    - The bag shall be able to maintain structural integrity when subjected to a load of 250 lbf. These loads are enveloped by zipper/corner coupon load testing and are not analyzed separately

Structural Analysis and Fracture Assessment

- Materials and Temperature
  - Each Bag was made with one layer each of Blue Nomex and Thinsulate and two layers of Gold Durette fabric
  - The bag will be subjected to maximum launch temperature of +122° F
  - No or very minimal reduction in breaking strength of Nomex at +122° F
- Fracture Assessment
  - Assessment was done for MCTB only
  - Structural integrity was verified using test and analysis
  - No parts identified as fracture critical
  - MCTB was analyzed for structural containment of the internal contents
  - Contents inside the bag are categorized as non-fracture critical contained

Structural Analysis and Fracture Assessment

- Minimum Margin of Safety Summary

Part Name	Material	Critical Load Condition*	Failure Mode	Limit Load	Margin of Safety	Comments
Zipper	Plastic	Compression Load	Tension	1122.4 lbf	+0.51 (u) tension ultimate	Max payload that can be carried by the bag without affecting the integrity of the zippers (for enveloped launch loads) is **108.9 lbf**
Handle	Nomex	Pull Load	Shear	144.0 lbf	+2.1 (u) shear ultimate	Max payload that can be carried by the bag without affecting the integrity of the handles (for ground handling/on-orbit loads) is **223 lbf**
Corner	Nomex	Compression Load	Tension	561.2 lbf	+1.12 (u) tension ultimate	Max payload that can be carried by the bag without affecting the integrity of the corners (for enveloped launch loads) is **152 lbf**

*Compression load is defined as a push load from inside of bag towards outside of bag

- The maximum payload for launch on **Progress / Soyuz is 223 pounds.**
- The maximum payload for launch on **ATV / HTV is 108 pounds.**
- The maximum payload for launch on **Dragon is 132 pounds.**
- The maximum payload for launch on **Cygnus is 108 pounds.**

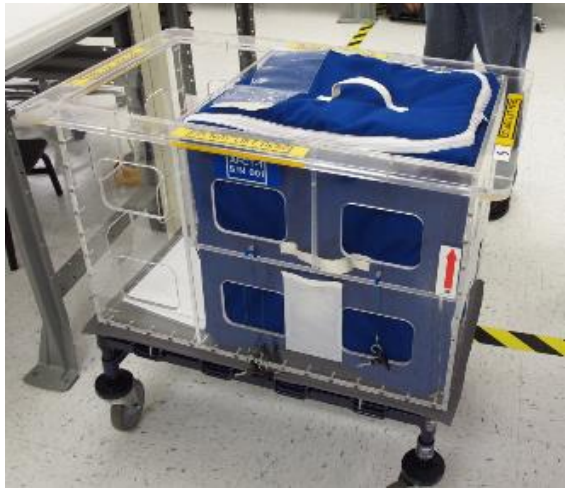
Summary and Conclusion

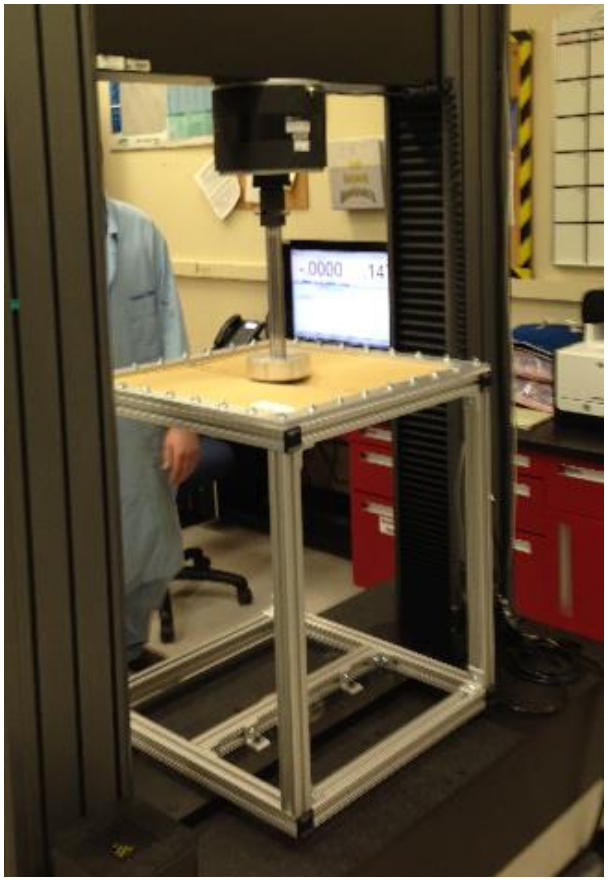
- Four Acoustic Multipurpose Cargo Transfer Bags were designed and developed in 2015 to support two purposes:
  - Demonstrate that logistics items (a cargo transfer bag) can repurposed to serve other functions (an acoustic blanket)
  - Reduce the sound level around the T2 treadmill
- The Acoustic MCTBs were delivered to CMC in July and will be launched on Orb-4, currently planned for December 3, 2015

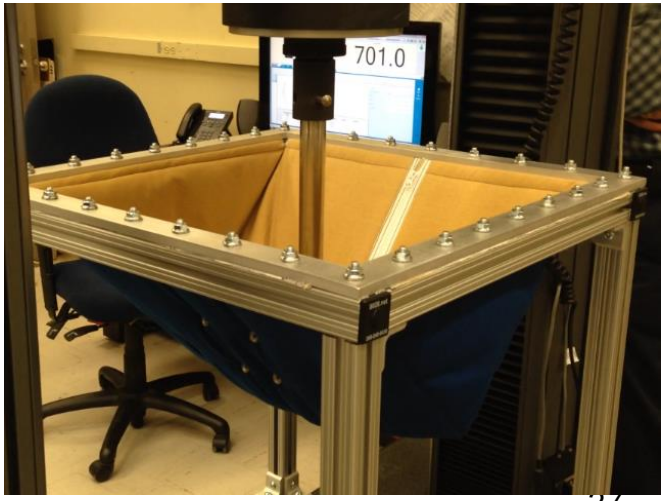
Back-up Slides

Additional Images

- Upper left – T-60 acoustic reverberation test
- Lower left – Fit check structure used for all CTBs at the cargo facility
- Middle and right – load testing in the EC Advanced Materials Lab with the Instron machine







People pictures

- Left – Team members during load testing
- Middle – Installing the prototype in the B9 mockup for a test fit
- Right – PM and PE with AMCTBs

Class 1-E

- In October 2014 a team consisting of ISS, EA, SA, NA, JA, and BA representatives met and defined a new class of hardware to be called Experimental Flight Hardware in an effort to simplify the hardware development process for non-critical flight hardware
- JSC Policy Directive 7120.9 is the guiding directive in this effort to utilize the experimental capabilities of the International Space Station (ISS) in its capacity as a science laboratory and test bed for future exploration
- This project has been selected as one of the pilot projects for the Class 1-E process
- Our project experiences will help to shape the JPR

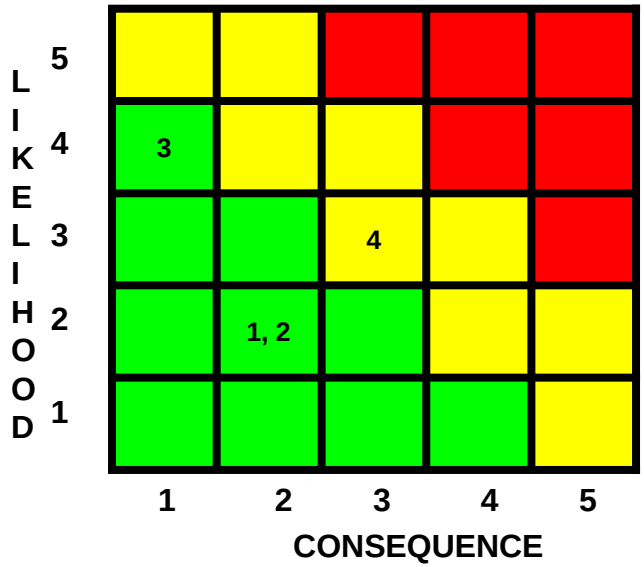
Class 1-E

- In order for Class I-E projects to become more lean, agile and responsive, Class I-E projects shall:
  - Be exempt from JSC Procedural Requirements (JPR) 8500.4 JSC Drawing Manual
  - Be exempt from institutional work instructions and procedural requirements documents requiring configuration management, the identification and tracking of parts, and assembly processes, test processes, shipping and receiving for hardware development, control of nonconforming products, and mitigation of counterfeit parts or materials (except for safety critical components).
  - Use uncontrolled hardware processes for testing
  - Process hardware through Logistics utilizing uncontrolled hardware handling processes (e.g. hardware may bypass Bond Room 421 during shipping and receiving activities).

Class 1-E

- To ensure that Class I-E projects do not cause issues with the operation of the space vehicle and to ensure that risk is controlled consistent with the funding authority, Class I-E projects shall:
  - Comply only with applicable safety and interface requirements defined by the space vehicle office and hardware/software functional requirements defined by the funding authority
  - Define and maintain a project file that include verification data, configuration data, and anomaly data
  - Meet the facility requirements for safety of operations during test activities
  - Demonstrate test safety and facility readiness during Test Readiness Reviews
  - Conduct reviews of design
    - As requested by the space vehicle program to ensure proper integration
    - As requested by the funding authority to ensure functional operation
  - Deliver
    - At least one Top Assembly drawing and a drawing release with a single authorizer
    - Safety, Interface, Unique Functional Verification Records
    - Final Article with JSC part number and labeled as Class I-E in block 10 of JF 911, JSC Projects Parts Tag.

Integration Risks



- Likelihood:
  - 1 - Very Unlikely
  - 2 - Unlikely
  - 3 - Possible
  - 4 - Likely
  - 5 - Very Likely
- Abbreviations:
  - C – Cost Consequence
  - P – Performance Consequence
  - Saf – Safety Consequence
  - Sch – Schedule Consequence

1 – Material billowing/inadequate restraint (P L2xC2)
Mitigation – Use bungees and/or additional Velcro

2 – Acoustically ineffective (P L2xC2)
Mitigation – Test and model prior to deployment

3 – Microbial buildup – Located next to the treadmill and Waste and Hygiene Compartment, there is a likelihood for microbial buildup. (Saf L4xC1)
Mitigation – Change out acoustic treatments when necessary. Can also add Scotchgard.

Note: Microbiology noted that any micro growth would likely be an aesthetic concern, but a low risk for crew-health. The acoustic MCTBs can easily be added as a sampling location for microbial growth.

4 – Lack of Avionics-2 rack information may make MCTBs unusable as an acoustic treatment – Topo has no KOZs defined for Av-2, ISS/TASI has not confirmed that found drawings of Avionics-2 rack are correct/current.) (P L3xC3)