AEROSPACE ENGINEERING
TEXAS A&M UNIVERSITY

Capsule Astronautics Refurbishment, Assessment, and Technology (CARAT Team)

Critical Design Review (CDR)

Professor Bonnie J. Dunbar, Advisor
John and Bea Slattery Chair
Aerospace Engineering

4 May 2022

Customer: Mr. Art Dula
Chairman, Excalibur Almaz Company

Mr. Dula founder of Excalibur Almaz, a private spaceflight company, established in 2005

- Use purchased flight-proven heritage hardware from the discontinued Russian Almaz military space station program.
- Configure for human and cargo spaceflight in LEO
- Invest in Education: Mr. Dula loaned Texas A&M University the Excalibur Almaz Engineering Evaluation Unit Mockup (EEUM), a *Form, Fit, and Function* mockup of an Almaz flight vehicle, used for engineering evaluation and/or crew training. Has been in unconditioned storage at the TAMU RELLIS facility for nearly a decade

Excalibur Almaz Flight Capsule

Almaz Engineering Evaluation Unit Mockup (EEUM)

Capsule Astronautics Refurbishment, Assessment, and Technology (CARAT Team)

Critical Design Review (CDR)

Mr. Jonathan Lephuoc, AERO 401/402 Project Manager

4 May 2022

Capsule Astronautics Refurbishment, Assessment, and Technology (CARAT)

Critical Design Review

4 May 2022

Agenda

- The CARAT Team Organization
- PDR and CDR Project Needs
- Requirements Review
- Project Schedule & Budget
- CDR Key Results and Outcomes
  - Configuration Control Documentation/Implementation
  - Computer Aided Design (CAD) Analyses and Modeling
    - Excalibur ALMAZ Capsule/Engineering Evaluation Unit Mockup (EEUM)
    - Spacecraft Onboard Equipment and Payload Storage System (SOEPSS)
  - EEUM Restoration for TAMU Education/Simulation
    - CAD Modeling
    - Structural Restoration
    - Electrical and Environmental Reverse Engineering/Activation
    - New Communication System Implementation

Figure 1. Members of CARAT with project customers Mr. Art Dula and Dr. Bonnie J. Dunbar (Check Presentation)

Figure 2. CARAT team working on the Excalibur Almaz Engineering Evaluation Unit Mockup (EEUM) at RELLIS Aerospace Engineering Hangar

CARAT Organizational Chart

Faculty Advisor & Customer: Dr. Bonnie J. Dunbar

Project Manager: Jonathan Lephuoc

Customer: Mr. Art Dula

Configuration Control: Bri Mason

Structures Lead: Harrison Otto

Structures: Elizabeth Bendrey

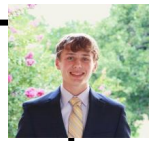
Structures: Kyle Zaiontz

Structures: Garrison Kleman

EECOM* Lead: Gavin Thompson

EECOM: Tanner Law

EECOM: Logan Daigle



EECOM: Brandon Nesbitt

EECOM: Bri Mason

CAD Lead: Kyle Sherrod

CAD: Manuel DeLaRosa

CAD: William O'Brien

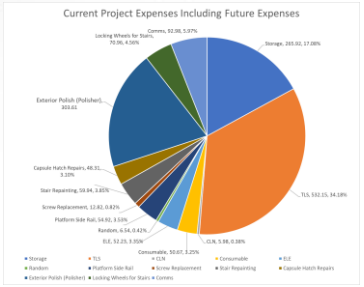
CAD: Jacob Wade

*Electrical, Environmental, Communications

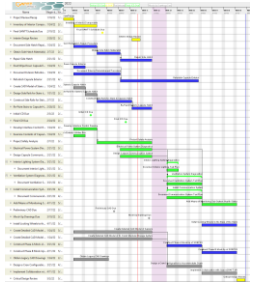
Project Management Processes

Project Management Processes

- Project Manager defined project schedule and project budget with customers
- Team Leads provided Project Manager with weekly updates
- Project Manager and Team Leads provided weekly stand-up meeting updates to advisor/customer
- Project Manager provided Dr. Dunbar with weekly Friday Activity Reports
- Utilized GANTT Project, Microsoft Teams, Microsoft Word, Microsoft Excel, Solidworks
- Standards and Regulations: Followed NASA Procedural Requirements (NPR) 7123.1, Systems Engineering



Project Manager: Jonathan Lephuoc

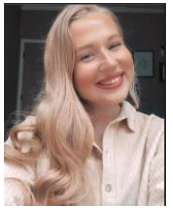


Structures Lead: Harrison Otto

EECOM Lead: Gavin Thompson

CAD Lead: Kyle Sherrod

Configuration Control: Bri Mason



Presenter: Project Manager Jonathan Lephuoc

Customer Needs

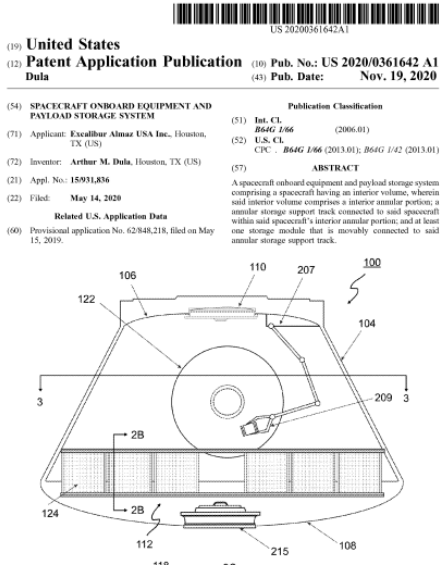
NEED #1:

Using Patent application Number: 15/931,836 by Mr. Art Dula for a payload storage device *Spacecraft Onboard Equipment and Payload Storage System (SOEPSS)*

- Create a CAD model and sub-scale mockup of the storage device
- Identify any potential design flaws or interferences with the Flight Vehicle

NEED #2:

Refurbish and restore the Excalibur Almaz *Form Fit & Function* Engineering Evaluation Unit Mockup (EEUM) which will be used for education and/or research applications within the Texas A&M University Department of Aerospace Engineering.



US 20200361642A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2020/0361642 A1**
Dula (43) **Pub. Date: Nov. 19, 2020**

(54) **SPACECRAFT ONBOARD EQUIPMENT AND PAYLOAD STORAGE SYSTEM**

(71) Applicant: **Excalibur Almaz USA Inc.**, Houston, TX (US)

(72) Inventor: **Arthur M. Dula**, Houston, TX (US)

(21) Appl. No.: **15/931,836**

(22) Filed: **May 14, 2020**

Related U.S. Application Data

(60) Provisional application No. 62/848,218, filed on May 15, 2019.

Publication Classification

(51) **Int. Cl.**
B64G 1/66 (2006.01)

(52) **U.S. Cl.**
CPC . *B64G 1/66* (2013.01); *B64G 1/42* (2013.01)

(57) **ABSTRACT**

A spacecraft onboard equipment and payload storage system comprising a spacecraft having an interior volume, wherein said interior volume comprises a interior annular portion; a annular storage support track connected to said spacecraft within said spacecraft's interior annular portion; and at least one storage module that is movably connected to said annular storage support track.

Figure 3. Payload storage device patent

Figure 4. Initial Condition of the Almaz EEUM with damaged hatch

Figure 5. Initial Condition of the Almaz EEUM Stairs

Presenter: Project Manager Jonathan Lephuoc

SOEPSS System Requirements

Reqmt No.	Requirement	Rationale
SPS-001	The SOEPSS **shall** fit within the dimensions of the spacecraft's interior volume	SOEPSS Must fit within the Almaz EEUM and by extension, Almaz capsule. (From patent)
SPS-002	The SOEPSS **shall** consist of an annular support track connected to the spacecraft	For better security, access, and function, an annular track was determined to be advantageous (From patent)
SPS-003	The SOEPSS **shall** support at least one module that is movably connected to the annular support track	SOEPSS should have modules that rotate around the track (From patent)
SPS-004	The SOEPSS **shall** accommodate the quick and easy loading and unloading of payloads through the hatch	It is important to consider the ground crew who will work with SOEPSS and prevent their strain (From patent)
SPS-005	The SOEPSS **shall** allow convenient access of payloads in flight by either an astronaut or robotic arms	For some experiments, additional interaction may be required once orbit has been achieved. SOEPSS must accommodate this(From patent)
SPS-006	The SOEPSS **shall** include a means of securing modules on the track so they will not move or be damaged during takeoff or landing	The launch of spacecraft subjects structures to intense accelerative and vibroacoustic loads. SOEPSS therefore needs to secure modules for this event (From patent)
SPS-007	The SOEPSS **shall** allow the deployment of modules through the spacecraft hatch by the Zelon arm(s)	Some modules may be deployed from the capsule. SOEPSS must not significantly obstruct the hatch to allow for this (From patent)
SPS-008	The SOEPSS **shall** be separable into segments so that it can fit through the hatch and be assembled inside the spacecraft	SOEPSS will take up a significant amount of the width of the capsule and will not be able to fit through the hatch unless it is segmented

Almaz EEUM Structural Restoration Requirements

Reqmt No.	Requirement	Rationale
STR-001	The Almaz capsule **shall** resist weathering and scrapes	This capsule must be able to resist deteriorating in the hangar in order to be used by subsequent students.
STR-002	The Almaz capsule **shall** be capable of human entry into the capsule	The capsule needs to be accessible from the outside for crew, ground personnel, and engineers to move in and out of the capsule.
STR-003	The stairs to the capsule **shall** support at least 2 people with equipment	The stairs need to be able to support at least 2 people with equipment, since the stairs will be used for maintenance and loading cargo into the EEUM.
STR-004	The hatch to the capsule **shall** withstand the forces of opening and closing without damage	The hatch needs to stay intact when being opened and closed, without shattering or falling apart
STR-005	The hatch **shall** be capable of manual opening from inside the capsule	The crew must be able to open the hatch from the inside for emergency exit and other operations
STR-006	The hatch **shall** be capable of manual opening from outside the capsule	The crew must be able to open the hatch from the outside
STR-007	The stairs to the capsule **shall** be movable by 2 people	The stairs need to be moved around the capsule when working on the capsule
STR-008	The stairs to the hatch **shall** include handrails capable of supporting a human person	The stairs need handrails to ensure the safety of crew walking up the stairs.

Presenter: Project Manager Jonathan Lephuoc

Almaz EEUM Electrical Restoration Requirements

Reqmt No.	Requirement	Rationale
EPS-001	The electrical power system **shall** power the capsule interior lighting.	The capsule interior needs lighting to enable operations. The lighting system is referenced in the RFP.
EPS-002	The electrical power system **shall** power the ventilation fan system.	The capsule interior needs airflow to circulate air supplies and ensure crew safety. The ventilation fan system is referenced in the RFP.
EPS-003	The electrical power system **shall** power the interior communications system.	A communications system is mentioned in the RFP. The interior communications system will need to be powered by the electrical power system.
EPS-004	The electrical power system **shall** be capable of being powered on and powered off	The ground crew should be able to power cycle the system to troubleshoot issues and power off the capsule when not in use.
EPS-005	The electrical power system **shall** be connected to a ground power supply.	If the capsule is stored indoors it will not have the capability to charge by solar power. A power supply from the indoor facility would simplify operations and testing.
EPS-006	The electrical power system **shall** be cooled by the ventilation fan system.	Electrical equipment that produces heat needs to be cooled by airflow to reduce capsule heating.

Presenter: Project Manager Jonathan Lephuoc

Almaz EEUM Ventilation Requirements

Reqmt No.	Requirement / Rationale	Rationale
VEN-001	The ventilation system **shall** control the capsule interior temperature.	Capsule interior temperature will need to be controlled by airflow.
VEN-002	The ventilation system **shall** provide air circulation throughout the capsule.	Air movement throughout the capsule will maintain air quality and temperature.
VEN-003	The ventilation system **shall** cool the electrical power system.	Electrical equipment will produce heat and needs to be cooled.
VEN-004	The ventilation system **shall** be powered by the electrical power system.	All electrical systems inside the capsule are powered by the main power system.

Presenter: Project Manager Jonathan Lephuoc

Almaz EEUM Communications Requirements

Reqmt No.	Requirement	Rationale
COM-001	The communication system **shall** provide voice talk communication between those inside the capsule and outside.	It is imperative that the crew inside the capsule be able to talk to those on the outside.
COM-002	The communication system **shall** be rechargeable if wireless.	It would be beneficial for the microphones and transmitters to be reused and not discarded when the batteries are depleted.
COM-003	The communication system **shall** have a signal strength to be functional when the hatch is closed.	Communication is necessary during all phases of refurbishments, including when the capsule hatch is in the closed position.
COM-004	The communication system **shall** be able to be turned on from inside the capsule.	The capsule crew will need to be able to restart the communication system in case of a failure.
COM-005	The communication system **shall** be able to be cooled by the ventilation system	A ventilation system is mentioned in the RFP. Communication systems that produce heat need to be cooled by air flow to ensure capsule safety.
COM-006	The communication system **shall** not have wires that interfere with the crew's work.	The crew must not be burdened by wires of the system that could tangle the crew or snag on other parts of the capsule.
COM-007	The communication system **shall** be able to allow up to four crew members to communicate at once.	This capability is important if more than one crew member is on the interior of the capsule and needs to communicate rapidly with the outside.
COM-008	The communication system **shall** be able to be turned off from inside the capsule	The capsule crew will need to be able to restart the communication system in case of a failure.

Presenter: Project Manager Jonathan Lephuoc

Project Schedule

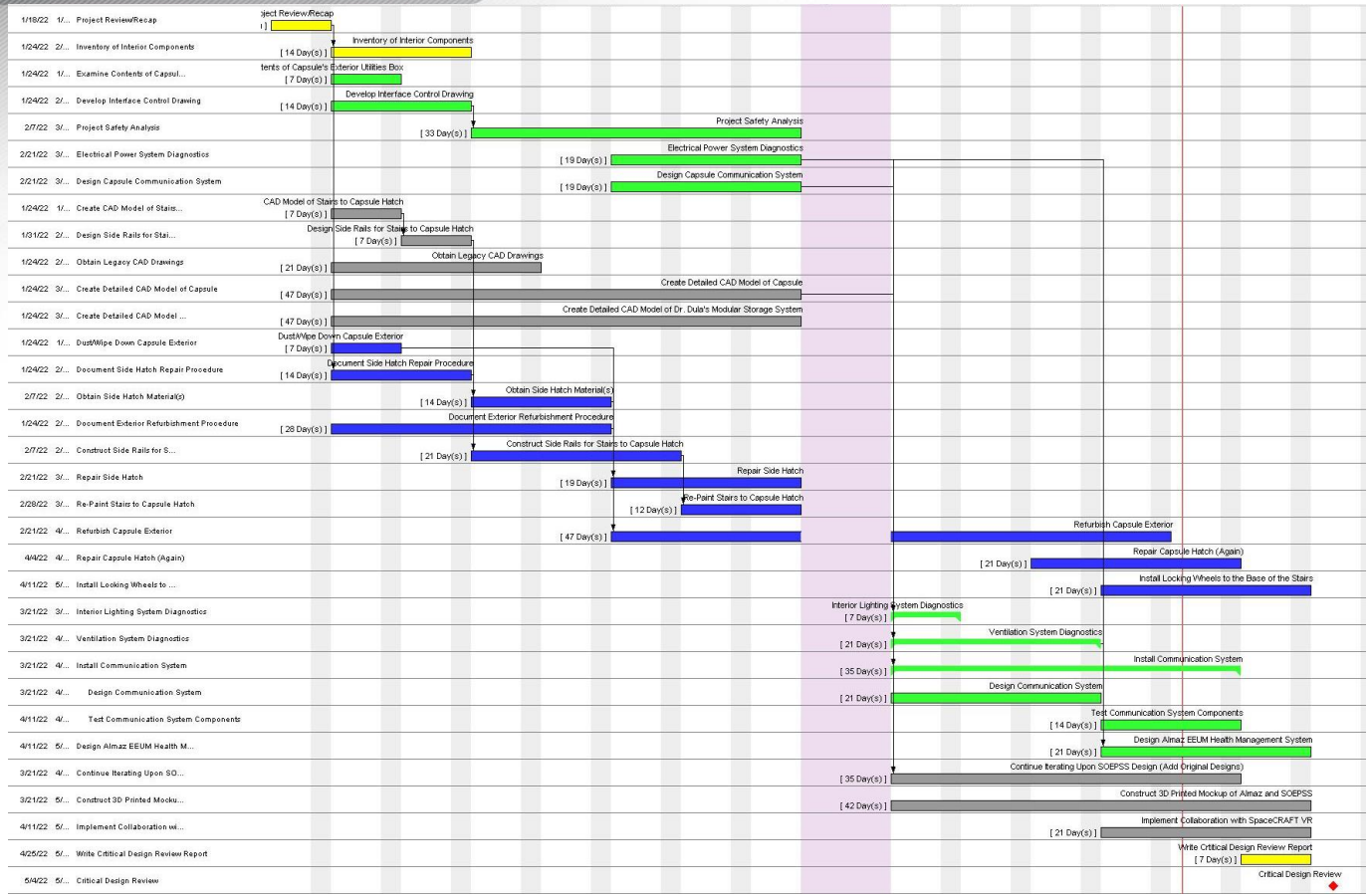


Figure 6. Project Schedule

Presenter: Project Manager Jonathan Lephuoc

Pre-Spring Break Phase: Project Schedule

- Full Inventory of the Almaz EEUM.
- CARAT Project Safety Analysis.
- Creation of the Almaz EEUM CAD models.
- Almaz EEUM Exterior Cleaning.
- Almaz EEUM Stairs Refurbishment.
- **Interim Design Review**
  - **March 3, 2022**

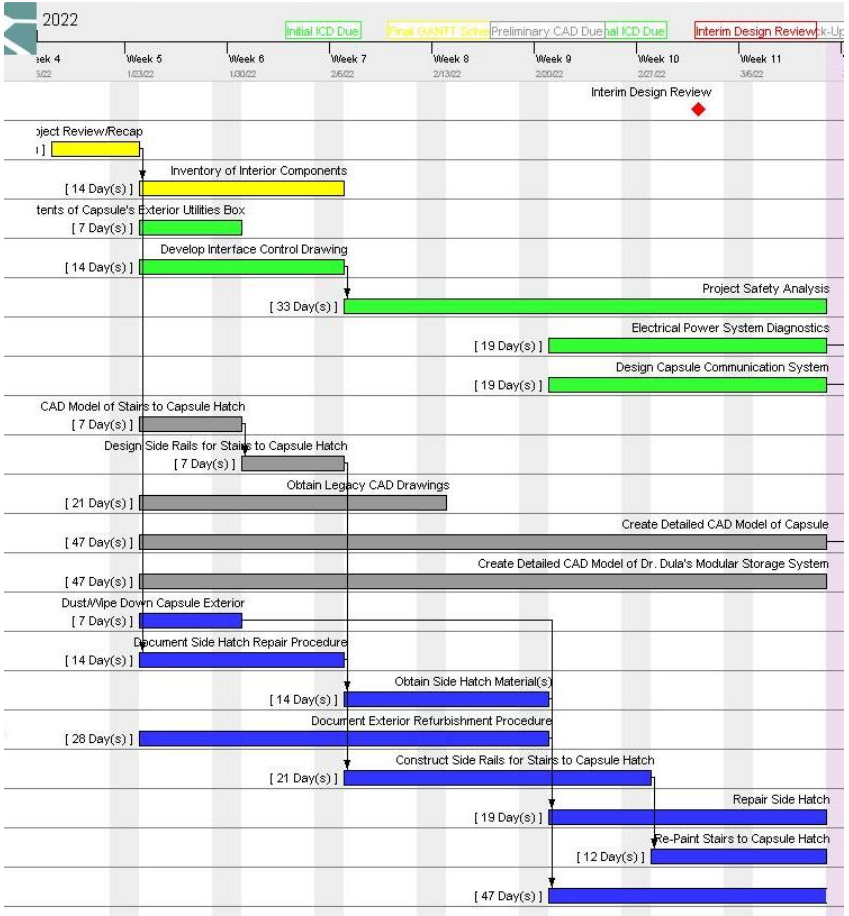


Figure 7. Pre-Spring Break Project Schedule

Presenter: Project Manager Jonathan Lephuoc

Post-Spring Break Phase: Project Schedule

- Completed Almaz EEUM Exterior Refurbishment.
- Repaired Almaz EEUM Hatch.
- Installed Almaz EEUM Communications System.
- Tested Almaz EEUM EECOM Components.
- Finalized EEUM and SOEPSS CADs
- Constructed Sub-Scale Almaz EEUM and SOEPSS Mockups
- **Critical Design Review**
  - **May 4, 2022**

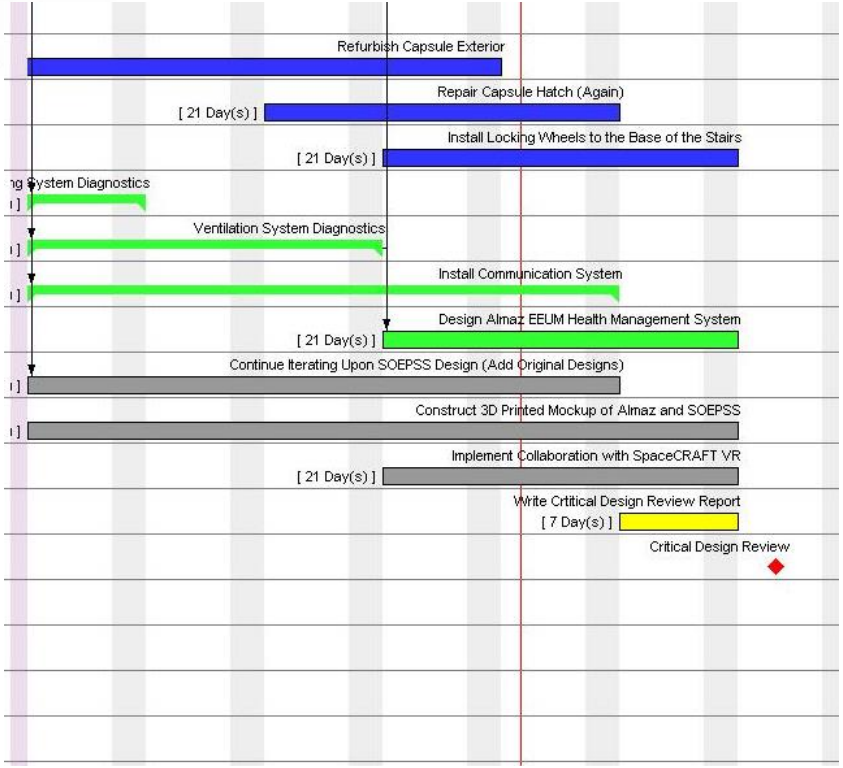


Figure 8. Post-Spring Break Project Schedule

Presenter: Project Manager Jonathan Lephuoc

Project Budget

- **Total Project Budget: $2000.00**
  - $1000 from Texas A&M Aerospace Engineering Dept.
  - $1000 provided by Mr. Art Dula
- **Total Project Expenses**: **$1580.91**
  - **$419.09 Under Budget**

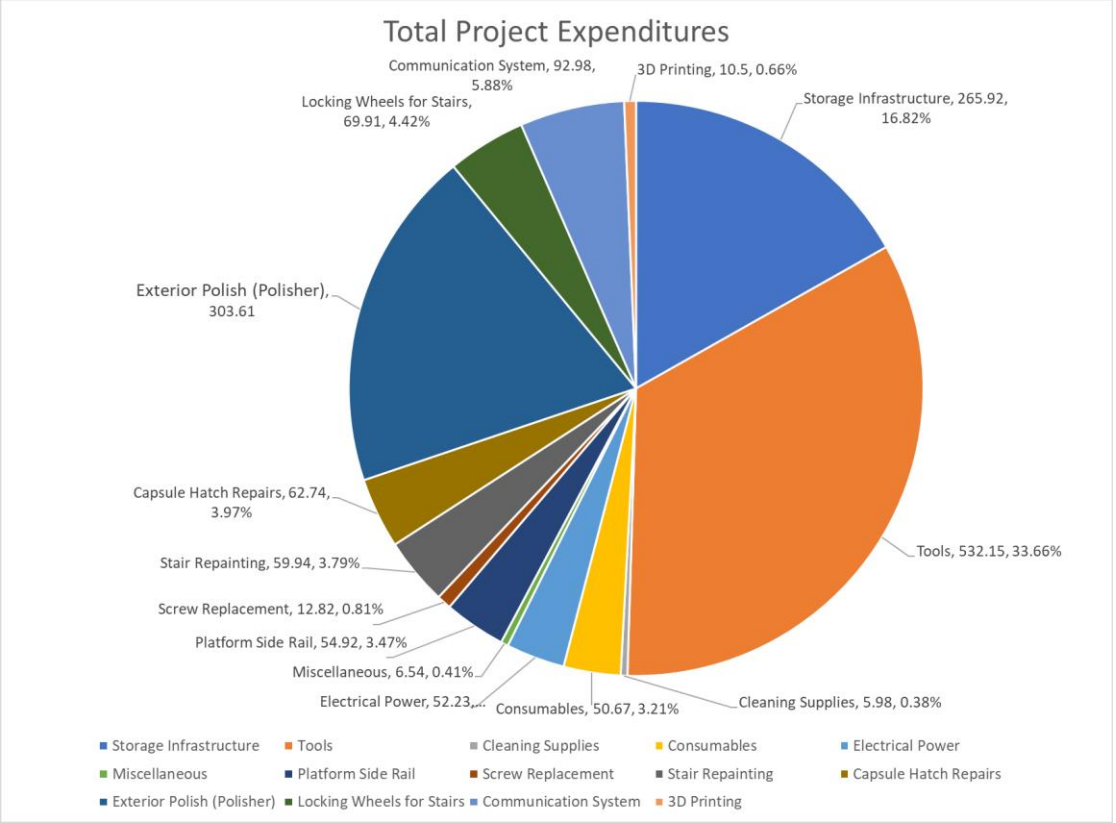


Figure 9. Pie chart displaying project expenditures

Presenter: Project Manager Jonathan Lephuoc

Inventory Management and Configuration Control

Inventory Management

Inventory Management:

- Interior stowage of the Almaz EEUM was inventoried for customer (including mock-ups and seats)
- Established inventory tagging system for all items, including tools, according to item category
- Inventory managed digitally through an Inventory Management Spreadsheet
- Inventory was audited bi-weekly
  - Were able to identify objects inadvertently removed from work site
  - Consumables were replaced as required

Table 1: Item Inventory Categories

Category	Corresponding Latin Code
Structures	STR
Mock-Ups	MOC
Tools	TLS
Electrical Power	ELE
Lighting	LGT
Ventilation	VEN
Human Integration	HUM
COMMS	COM
Cleaning	CLN
Miscellaneous	MSC

Presenter: Configuration Control Lead Bri Mason

Configuration Control

- Document Numbering System was established for document configuration control
- Final official documents are named according to document type, subsystem, and a 3-digit number, all separated by dashes.
- Official document types include ICDs, test procedures, trade studies, correspondences to Mr. Art Dula, and finalized CAD Drawings. (i.e. STR-TP-001, ELE-ICD-001)
- If the document underwent several revisions, the document number has a revision tag (STR-TP-001RevA).
- Created Document Template to unify all official documents

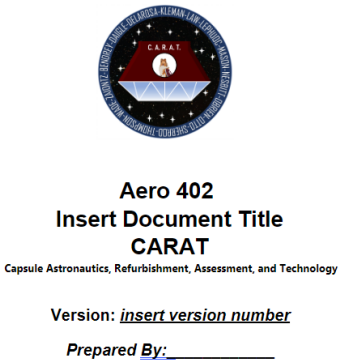


Figure 10: Document Template

Table 2: Project Documents

Number	Document
STR-TP-001	Stair Screw Replacement
STR-TP-002	Platform Railing Procedure
STR-TP-003	Hatch Repair
STR-TS-001	Adhesive Trade Study
STR-TS-002	Polish Trade Study
ELE-TP-001	Capsule Startup Procedure
ELE-TP-002	Capsule Shutdown Procedure
ELE-PSA-001	Project Safety Analysis
ELE-PSA-002	Project Safety Analysis Action List
ELE-ICD-001	Electrical Interface Control Document
ELE-PIC-001	Pictures
GEN-SWP-001	Safe Work Practices

Presenter: Configuration Control Lead Bri Mason

Project Safety Processes

Project Safety

- Met with Dr. David Breeding, Assistant Director of Environmental Health and Safety
- Developed Safe Work Practices
  - Team-wide work safety guidelines were written to comply with industry standards such as the National Electric Code (NEC) and Occupational Safety and Health Administration (OSHA) regulations.
- Completed Project Safety Analysis (PSA)
  - Extensive analysis of project risks and risk mitigations
- Completed Fire Extinguisher, Tool and Shop Safety Trainings - entire team

Table 3: Sample Action Item Assigned by Dr. Breeding

Project Safety Action Item List

Action Number	Required Action	Area/Subject Matter	Response/Course of Action
ACT-PSA-001	**David Breeding** Use in compliance with NEC rules for "temporary flexible cords," per NFPA -70 & 70e.	Extension Cord and Power Adapter Procedures	The team will research the mentioned documents.
ACT-PSA-002	**David Breeding** Note revisions. Please refer to the Texas A&M Safety Manual for clothing/attire requirements. An Engineering Safety Guideline on Safe Attire in Labs & Shops is available for your use. In general, personnel working in Texas A&M labs & shops must wear long pants covering shoes of impervious material with at least ¼ inch thick soles. Shorts, skirts, and other clothing exposing bare skin are prohibited.	Personal Protective Equipment and Clothing	The team has been briefed and will remain in compliance.

Presenter: EECOM Team Lead Gavin Thompson

Need #1 :

Using Patent application Number: 15/931,836 by Mr. Art Dula for a payload storage device, *Spacecraft Onboard Equipment and Payload Storage System (SOEPSS)*

(1) Create a CAD model and sub-scale mockup of the SOEPSS and EEUM

(2) Identify any potential design flaws or interferences of the SOEPSS with the Flight Vehicle

CAD: Capsule Interior

- Modeled the interior to test proper fit and function of SOEPSS module
- Mainly focused on interior space (longerons, side hatch clearance, any protrusions)

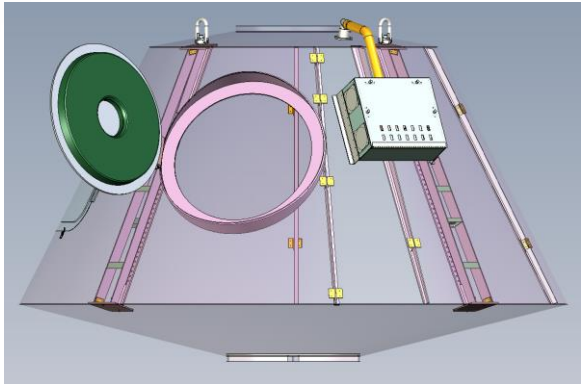


Figure 11: Legacy eDrawings model (provided by Jon Zelon)

Table 4: Excerpt of Table of measurements from Legacy eDrawings

ID Number	Measurement Name	Value (cm)
1	exterior base radius	135.405
2	exterior top radius	71.1135
3	exterior top hatch radius	28.4165
4	exterior bottom hatch radius	33.0525
5	exterior bottom hatch to base height	25.701
6	exterior base to top height	127.202
7	exterior top to top hatch height	7.782
8	exterior top hatch height	2.403
9	exterior bottom hatch height	2.394

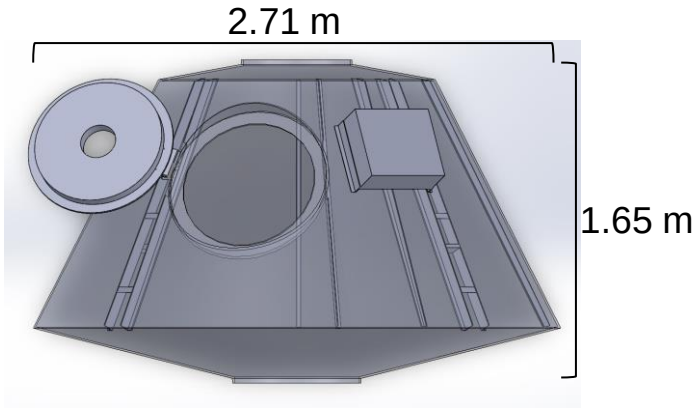


Figure 12: Final SolidWorks model

Presenter: CAD Team Lead Kyle Sherrod

CAD: SOEPPS Designs

- Considered Primary and Secondary Designs
- Following Analysis, our recommendation is:
  - Continue with the primary design as it is a launch capable storage system
  - While the secondary design is simpler, requiring less parts, its lack of supports makes it unable to secure internal payloads, potentially resulting in an unsafe situation.

Primary Design

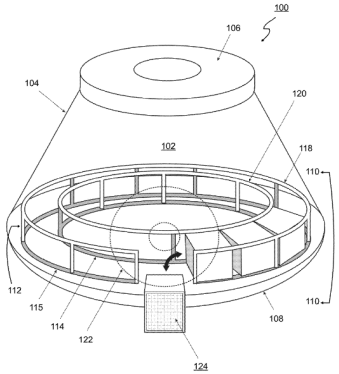


Figure 13: Patented Primary Design

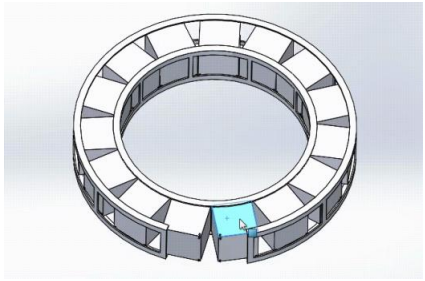


Figure 15: Preliminary Primary Design Model

Secondary Design

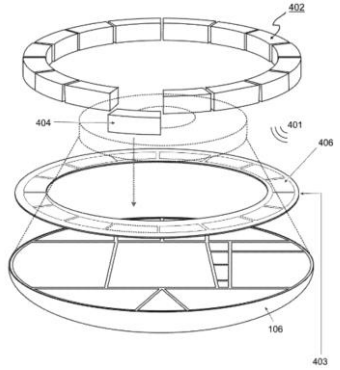


Figure 14: Patented Secondary Design

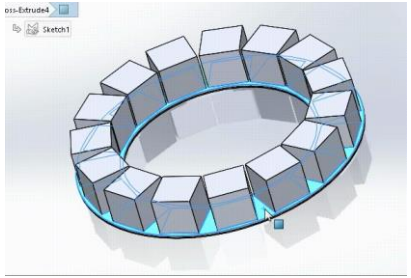


Figure 16: Preliminary Secondary Design Model

Presenter: CAD Team Lead Kyle Sherrod

CAD: ALMAZ Storage System CONOPS

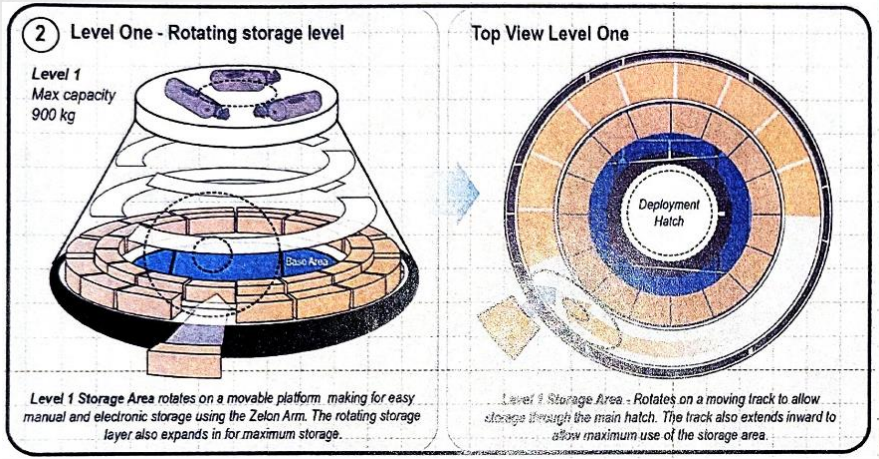


Figure 17: SOEPSS Concept of Operations

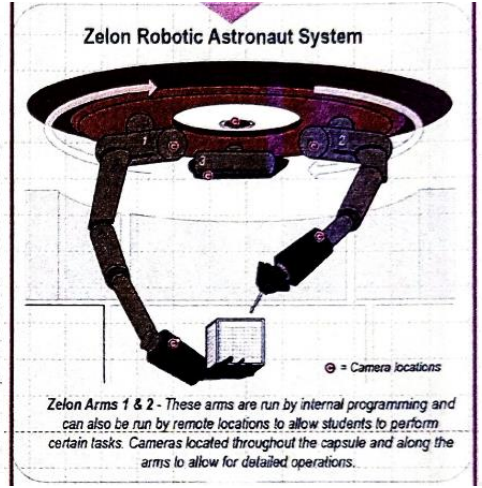


Figure 18: Experiment Box Manipulation via "Zelon" Robotic Astronaut System

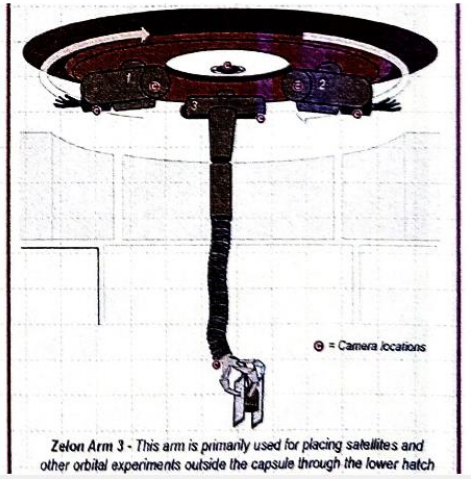


Figure 19: Satellite Deployment via "Zelon" Robotic Astronaut System

Presenter: CAD Team Lead Kyle Sherrod

CAD: SOEPPS Advantages

- Efficient and secure cargo storage
- Accessible during flight
- Space for electrical routing and cooling through the center of the annulus
- Allows for storage and deployment of small satellites

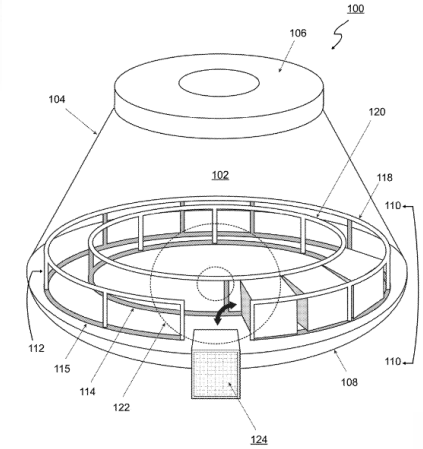


Figure 20: Patent Drawing of SOEPSS

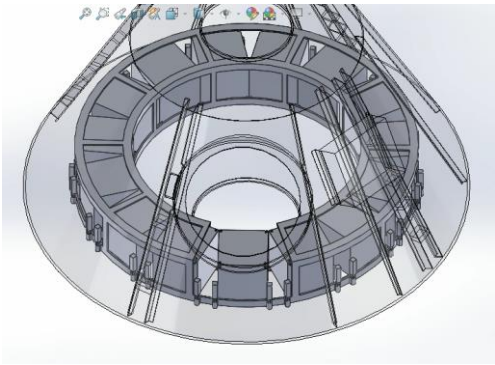


Figure 22: Final CARAT SOEPSS Design

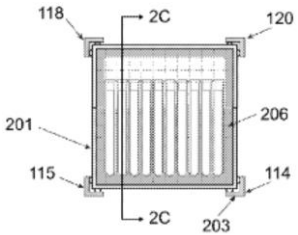
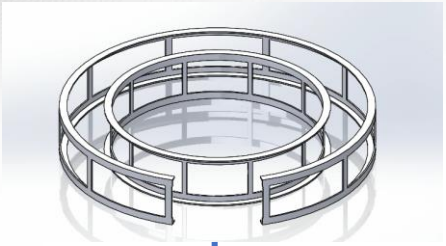


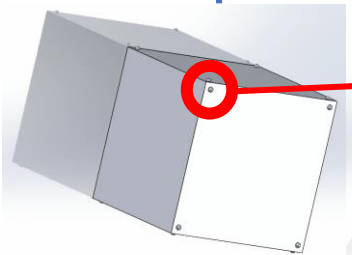
Figure 21: Patent Drawing of Experiment Box

SOEPPS CAD Design Process Flow

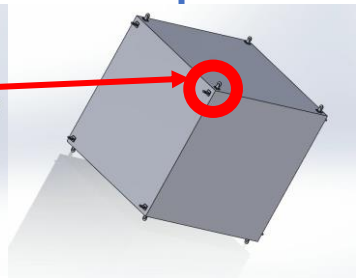
Initial design derived from patent



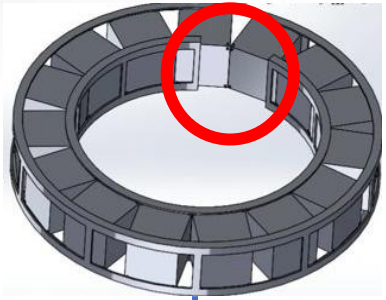
Initial experiment box design from patent (ball bearings)



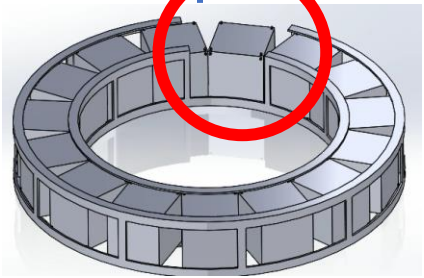
Experiment box with wheels



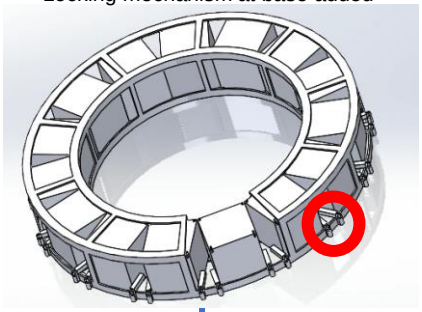
Breach moved to inside to allow better interaction with Zelon arms



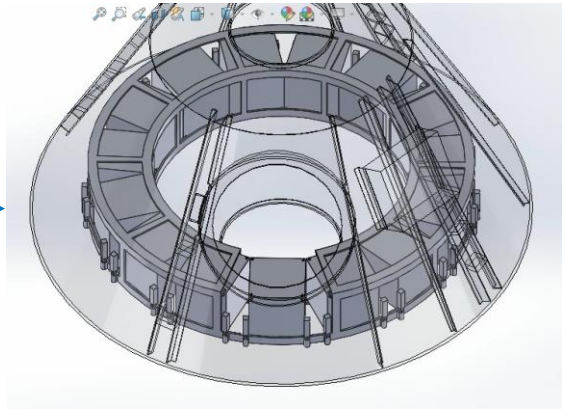
Outer breach readded to allow for easy loading and unloading by both users outside the capsule, and the Zelon arms inside the capsule.



Locking mechanism at base added



Final design implemented into the capsule CAD model



Presenter: Manuel DeLaRosa

SOEPPS Potential Design Flaw

- Observation:
  - Boxes “stuck” on interior rail (not enough clearance from the ball bearings to allow movement)
  - Only 7.6 mm clearance between bearings and inner rail
- Proposed Solution:
  - Add wheels to raise clearance at center of box
  - Increased distance between inner and outer railings

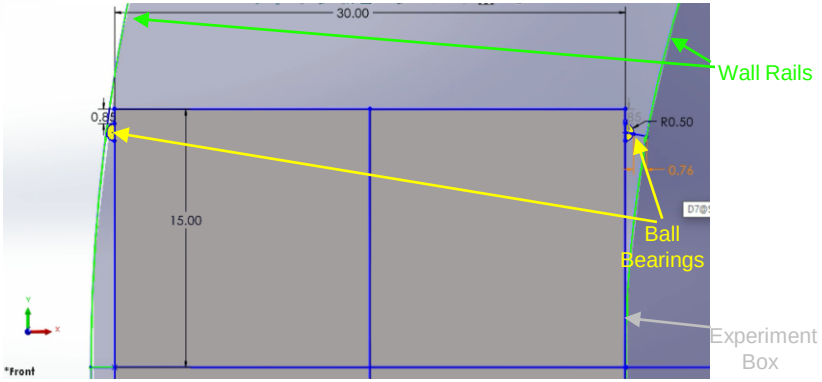


Figure 23: Top View of Box with Ball Bearings (patent design)

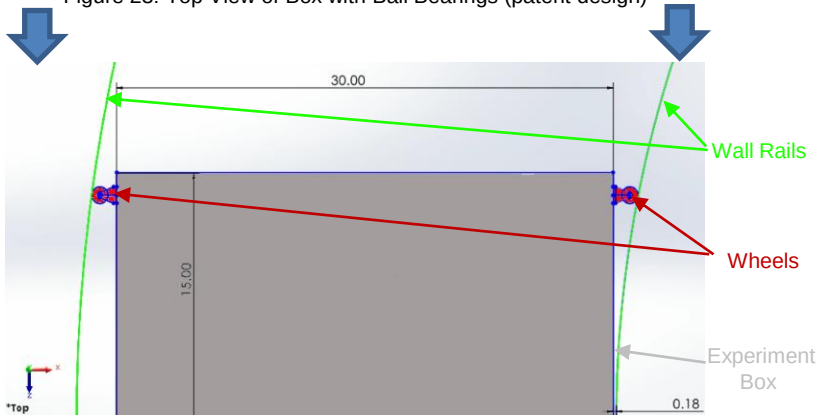


Figure 24: Top View of New Wheeled Box

Presenter: Will O'Brien

CAD: SOEPPS Wheel Design

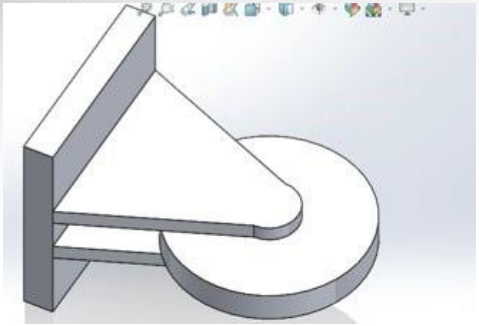


Figure 25: CAD model of Proposed wheel design

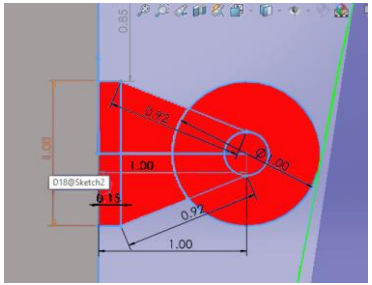


Figure 27: Side Drawing of Wheel (dimensions in cm)

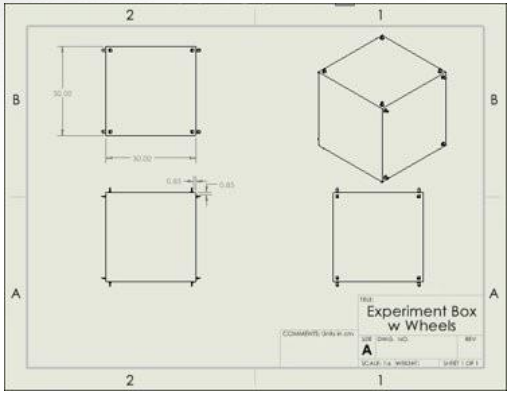


Figure 26: Drawing of Wheeled Box

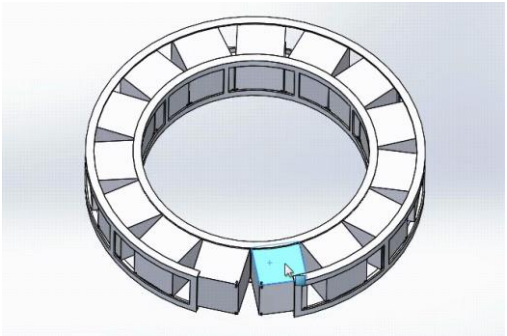


Figure 28: Animation of Primary SOEPSS

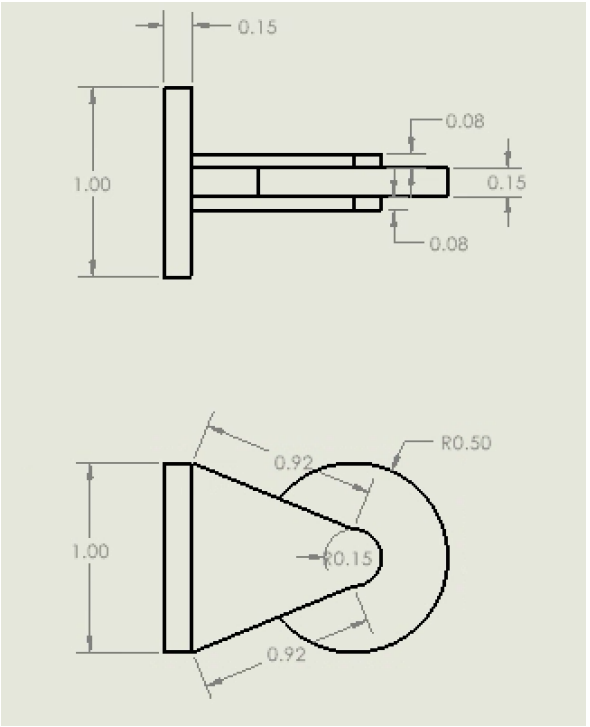


Figure 29: Drawing of wheel

Presenter: Will O'Brien

CAD: SOEPPS Motion Study

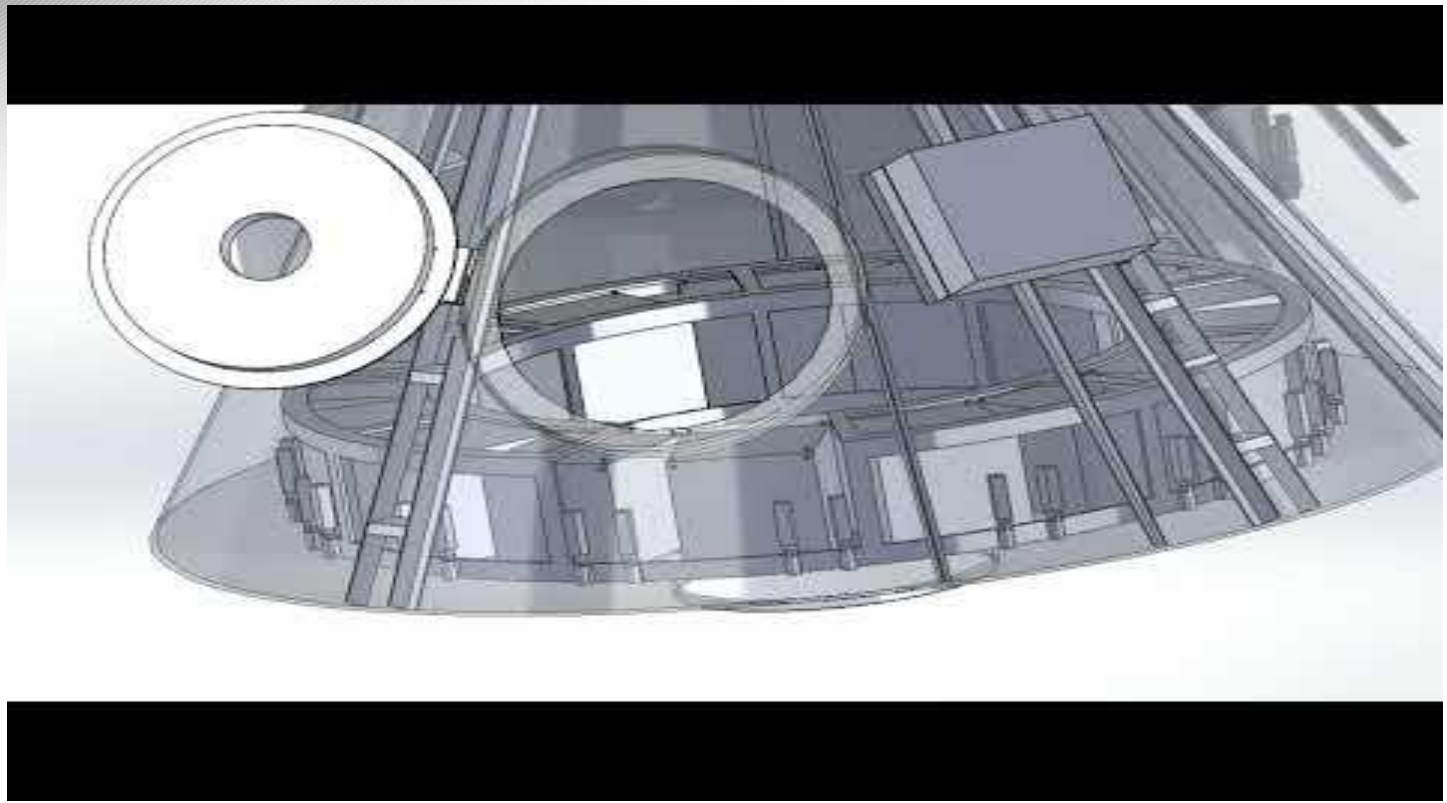


Figure 30: Motion Study of Finalized SOEPSS Design

Presenter: Will O'Brien

CAD: 3D Printed Model

- Models of the Capsule and SOEPSS printed in PLA plastic
- SOEPPS confirmed to fit inside capsule as intended
- Cargo Boxes move freely around the ring

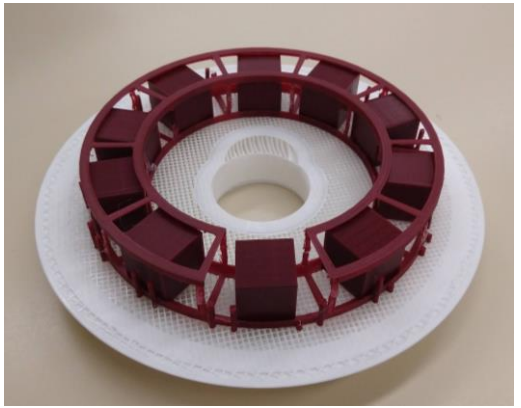


Figure 31: 3D printed subscale mockup of the SOEPSS

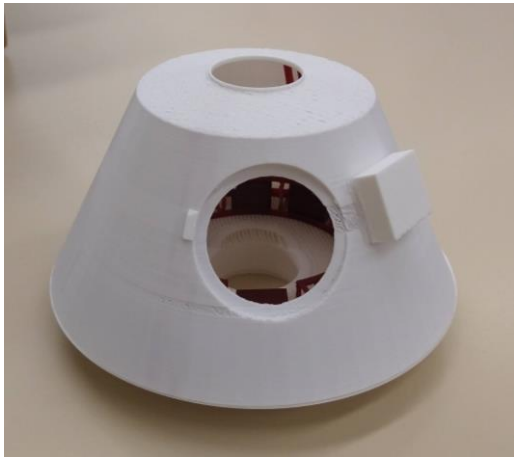


Figure 32: Full 3D printed assembly of the SOEPSS inside of the Almaz capsule

Presenter: Jacob Wade

Need #2:

Refurbish and restore the Excalibur Almaz *Form Fit & Function* Engineering Evaluation Unit Mockup (EEUM) which will be used for education and/or research applications within the Texas A&M University Department of Aerospace Engineering.

Restoration: Tasks and Deliverables

- Restore the EEUM Structure
  - Repair Stairs
  - Repair Hatch
  - Add Wheels to Increase mobility
  - Polish/Refurbish Exterior
- Restore and Repair Electrical System
- Add Communication System

Figure 33. Initial Condition of the Almaz EEUM Stairs

Figure 34. Initial Condition of the Almaz EEUM Exterior and Hatch

Development of Almaz EEUM CAD Models

- Created SOLIDWORKS CAD models of all existing structures
  - The capsule,
  - Capsule Support stand
  - Stairs

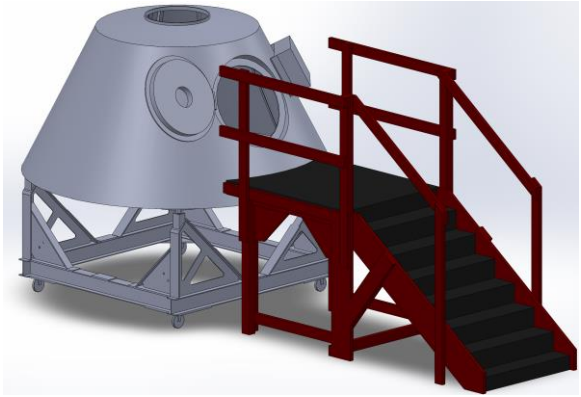


Figure 35: Assembly of CAD Models for Existing Structures

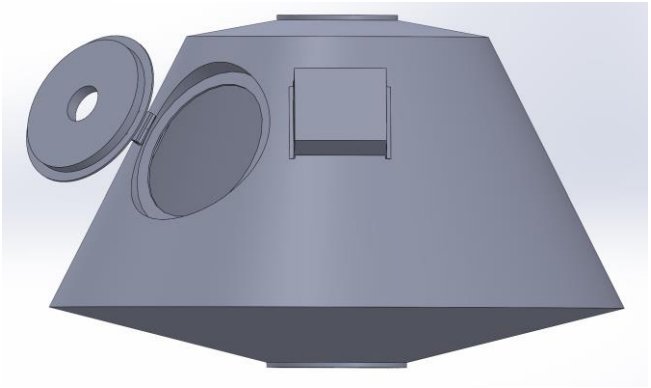


Figure 36: Capsule CAD Model

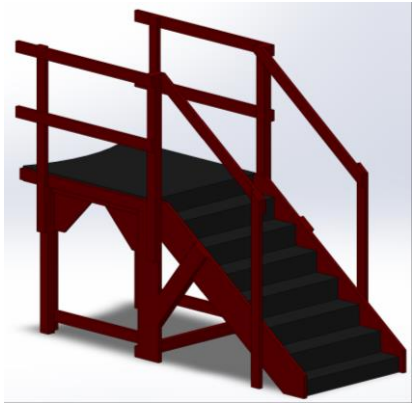


Figure 37: Staircase CAD Model

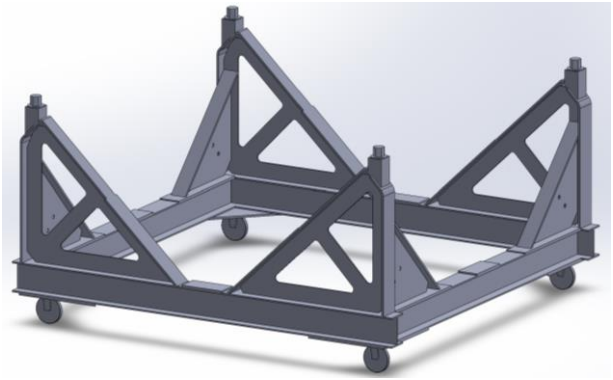


Figure 38: Capsule Stand CAD Model

Presenter: Jacob Wade

EEUM Structural Restoration

Structures and Restoration: Stairs/Platform

- Stairs and Platform
  - Cleaned the stairs/platform
  - Added railings to the platform for safety – Conducted Design Trade Study
  - Repainted the stairs and new railings in Aggie Maroon
  - Installed locking caster wheels onto the base of stairs/platform

Table 5. Completed trade study for platform railings.

Factor	Scale	Single Horizontal Railing	Double Horizontal Railing	Single Horizontal Railing with Diagonal Support
Cost	3 (0 = expensive, 3 = inexpensive)	3	2.4	2.0
Safety	3 (0 = not safe, 3 = very safe)	1.2	2.7	2.1
Integration with Existing Structure	2 (0 = difficult to integrate, 2 = easy to integrate)	0.8	1.8	1.4
Ease of Installation	2 (0 = difficult to install, 2 = easy to install)	1.4	1.6	1.2
Total	10	6.4	8.5	6.7

Figure 39. Completed stairs and platform

Presenter: Structures Team Kyle Zaiontz

Structures and Restoration: Exterior Polishing

- Conducted 2 trade studies
  - To determine the best polishing tools.
  - To address the best polishing results
- Completed coupon tests with an Aluminum 6061 coupon donated from Jacobs at NASA Johnson Space Center.
- The Kobalt cordless polisher with WD-40 was selected as the best combination for exterior restoration.

Figure 40: Before Polishing

Figure 41: After Polishing

Table 6: Trade Study for Exterior Polishing Tool

Item	Price	Rationale
Kobalt Cordless Polisher	$139	This option will be the easiest to move around the capsule with as well as being better ergonomically with two handle configurations.
Craftsman 5 in. Corded Polisher	$149	Parts for the polishing could not be easily found.
Craftsman 10 in. Corded Polisher	$64.98	The two handle design would've been impractical for work on a ladder.
WEN 6 In. Corded Polisher	$22.33	No reviews lead to skepticism on its quality.

Presenter: Structures Team Garrison Kleman

Structures and Restoration: Hatch

- Hatch Repair Trade Study Decisions:
  - To replace or repair? (trade study 1)
  - If repaired, what adhesive? (trade study 2)
    - After testing, decided upon JB Weld Clear Adhesive

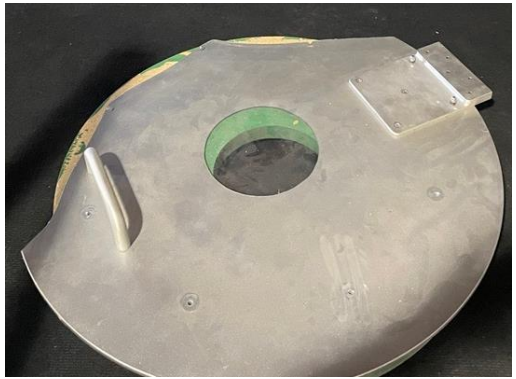


Figure 42. Initial State of the hatch

Figure 43: Epoxy adhesive practical test

Table 7: Repair vs. Replace Trade Study

Factor	Scale	Repair	Replace
Cost	5 (0 = expensive, 5 = inexpensive)	5	1
Risk (of breaking materials)	3 (0 = High risk, 3 = Low risk)	1.2	2.1
Time	2 (0 = Long time, 2 = short time)	1.4	1.4
Total	10	7.6	4.5

Table 8: Adhesive Trade Study

Criteria	Scale	Methacrylate	Epoxy
Cost	4 (0 = Expensive, 0 = Cheap)	0.8	3.6
Risk (of misapplying or another issue)	3 (0 = High risk, 3 = Low risk)	1.2	1.5
Effectiveness	3 (0 = Low strength, 3 = High strength)	2.4	2.7
Total	1.0	4.4	7.8

Presenter: Structures Team Lead Harrison Otto

Restoration: Hatch Failure and Repair

- The first repair attempt failed
- A preliminary failure analysis implied poor bonding surface preparation and mechanical interference with the hatch opening to be the primary issues.
- For the re-repair, the team more thoroughly cleaned the surfaces with isopropyl alcohol and extended the glue's curing time to 456 hours.

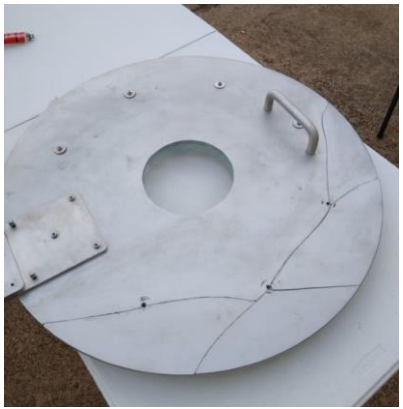


Figure 44: Hatch After Initial Repair

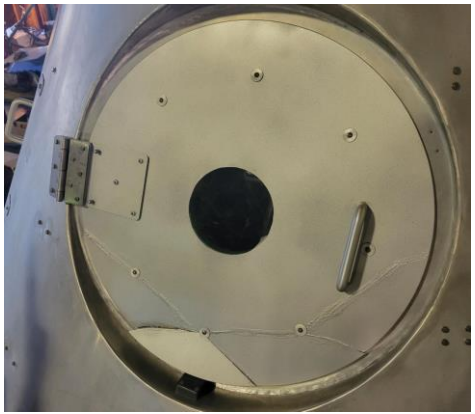


Figure 45: Hatch Broken After Initial Repair

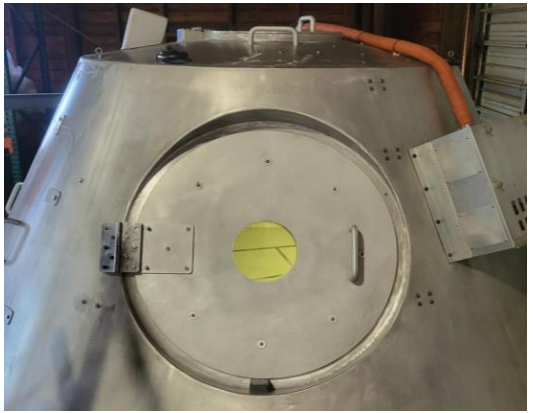


Figure 46. Hatch after final repair and painting

Presenter: Structures Team Lead Harrison Otto

Restoration: Matching Hatch Paint

- Tested multiple similar-to-existing hatch paint colors on plexiglass coupons.
- Compared dried coupons to original paint and conducted trade study.

Table 9. Trade study for the hatch paint.

Factor	Scale	Krylon Metallic Silver	Krylon Metallic Aluminum	Rust-Oleum Silver Wheel
Cost	2 (0 = expensive, 2 = inexpensive)	2	2	1.5
Ease of Application	2 (0 = difficult to apply, 2 = easy to apply)	2	1.5	0
Finishing Match	6 (0 = dissimilar finish, 6= exact finish)	5.5	5	3
Total	10	9.5	8.5	4.5

Figure 47. Hatch spray paint coupon

Presenter: Structures Team Elizabeth Bendrey

EEUM Electrical, Environmental, and Communications (EECOM) Restoration

Overview - EECOM

- Electrical, Environmental, and Communications (EECOM) Tasks and Deliverables
  - Reverse Engineer the Almaz EEUM Electrical System Components
  - Develop an EEUM Interface Control Diagram (ICD)
  - Conduct an EEUM Electrical Power Test
    - Start up and shutdown procedures
  - Develop an EEUM Communications System

Figure 48: Interior of Electrical Box

Figure 49: EECOM Team Lead Gavin in the EEUM after a successful startup procedure

Presenter: EECOM Team Lead Gavin Thompson

Restoration - EECOM (Electrical)

- EEUM Electrical System Verification/Checkout
  - Reverse engineered wire pathing with multimeter
  - Verified electrical continuity from wall outlet to components
  - Confirmed all switches were functional
  - Confirmed safety of electrical system
  - Developed ICD starting with hand drawn schematics

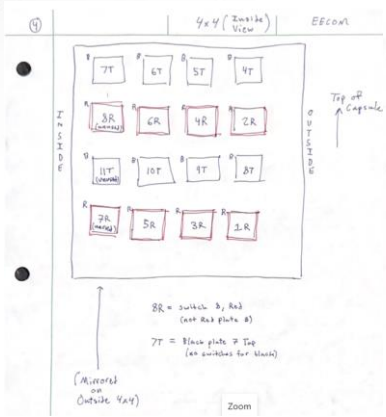


Figure 50: Electrical Box External Ports

Figure 51: Checked Wire Continuity

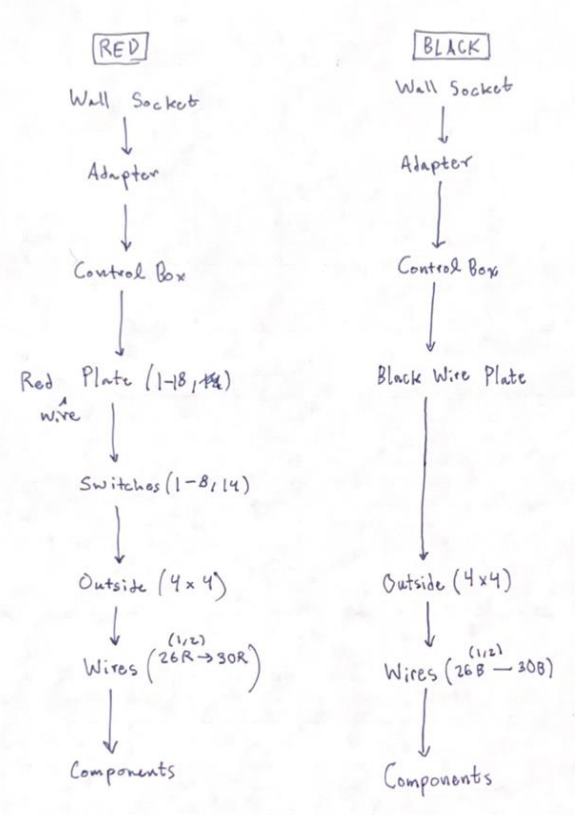


Figure 52: High Level Component Mapping

Presenter: EECOM Tanner Law

EECOM (Electrical)

- Used computer design software "Whimsical" to develop ICD, which was compared against the original ALMAZ User's Manual – Confirmed connections and wire paths

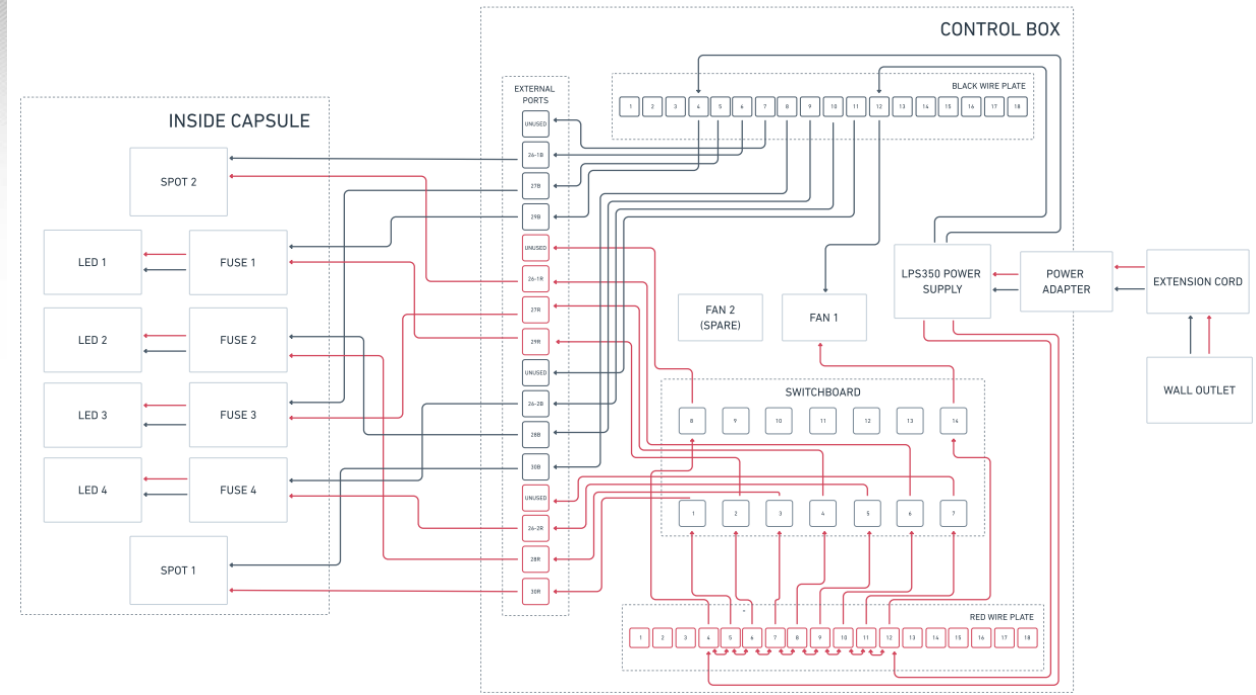


Figure 53: EECOM ICD Version 3.1

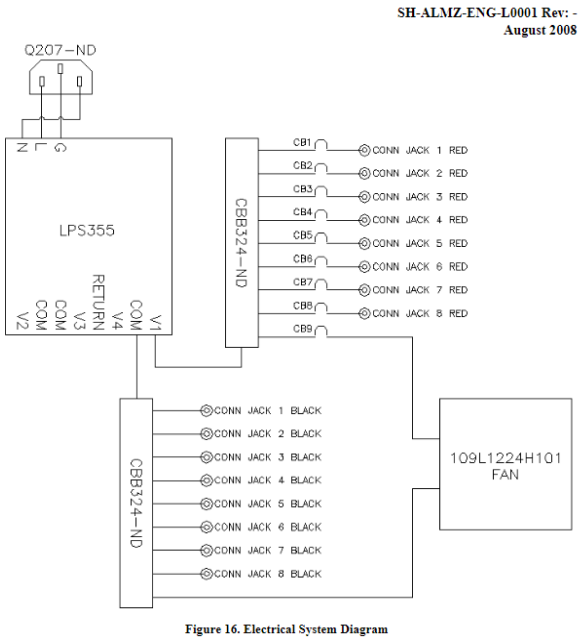


Figure 16. Electrical System Diagram

Figure 54: Original Almaz Electrical System Diagram

Presenter: EECOM Brandon Nesbitt

EECOM (Electrical)

- EEUM electrical power test
  - Created a safety plan and procedures for starting and stopping electrical current to capsule systems
  - Wrote startup and shutdown procedures
- First test procedure was completed on March 2, 2022
  - Validated functionality of each spotlight, LED, and ventilation fan
  - Demonstrated functionality of EEUM to Dr. Dunbar

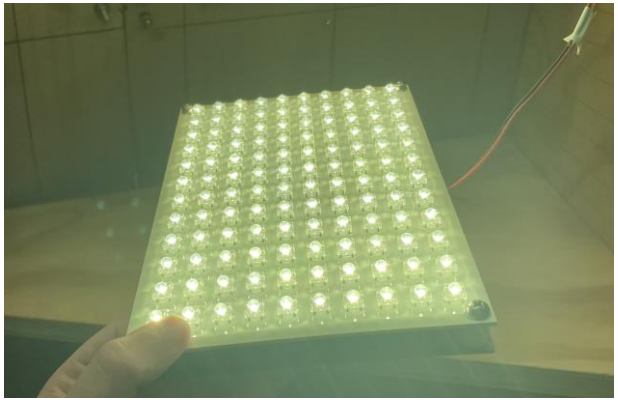


Figure 55: Functioning EEUM LED

Figure 56: Functioning EEUM Spotlight

Presenter: EECOM Team Lead Gavin Thompson

EECOM (Electrical)

Reinstalled Interior Lighting

Figure 57: Before Restoration EEUM LEDs

Figure 58: Before Restoration Adhesive

Figure 59: Restored EEUM LEDs

Before → **After**

Presenter: EECOM Team Lead Gavin Thompson

EECOM (Communications)

Communications Concept of Operations (CONOPS)

- Requirements
  - Wireless Communication between capsule and console
  - Up to 4 Crew members
  - Two modes:
    - (1) Voice actuated, VOX
    - (2) Push to Talk, PTT
  - Battery Powered

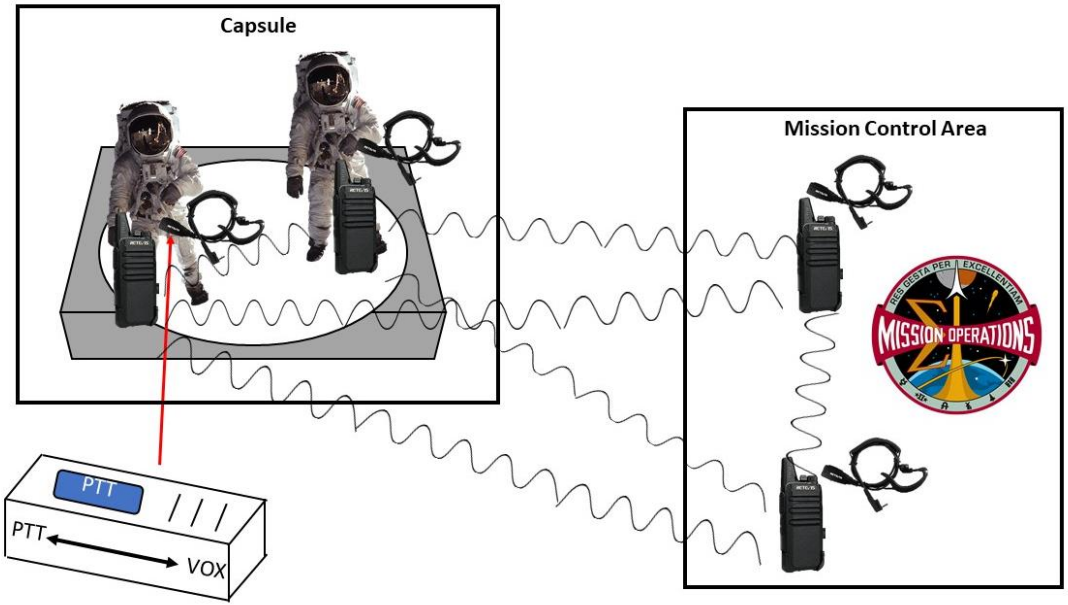


Figure 60: Communication CONOPS

Presenter: EECOM Logan Daigle

EECOM (Communications)

- Capsule Signal Interference Test
  - Initial HAM radio test verified wireless COMM capability through capsule walls

- Two trade studies were conducted to decide between a decentralized or centralized COMM system and a Bluetooth or radio-based frequency

Figure 61: Initial Radio Test

Table 10: System Type Trade Study

Factor	Scale	Centralized	Decentralized
Cost	5 (0 = expensive, 5 = inexpensive)	2	5
Ease of Use	1.5 (0 = difficult to use, 1.5 = not difficult to use)	0.9	1.3
Portability	1.5 (0 = difficult to move, 1.5 = not difficult to move)	1.1	1.5
Sound Quality	1 (0 = poor, 1 = excellent)	1	0.7
Mission Control Awareness	1 (0 = not aware, 1 = very aware)	0.9	0.6
Total	10	**5.9**	**9.1**

Table 11: Product Trade Study

Factor	Scale	Bluetooth System	Radio System
Cost	4.0 (0 = expensive, 4 = inexpensive)	2.5	3.5
Ease of Use	2.0 (0 = difficult to use, 2 = not difficult to use)	1.5	2.0
Complexity	2.0 (0 = complex, 2 = simple)	1.0	2.0
Signal Strength	2.0 (0 = poor, 2 = excellent)	0.5	1.5
Total	10.0	**5.5**	**9.0**

Presenter: EECOM Logan Daigle

EECOM (Communications)

- Selected Communications System
  - Retevis RT22 Walkie Talkies and headsets
  - Utilizes 16 channels in the Family Radio Services (FRS) frequency band (462 MHz to 467 MHz)
  - Provides wireless communication for up to 4 people with handsfree (VOX) capability
  - Operates throughout the hangar in PTT and VOX mode with no interference

Figure 62: Retevis RT22 Walkie Talkies

Figure 63: Retevis EEK016 headset

Presenter: EECOM Logan Daigle

SOEPSS System Requirements Outcomes

Reqmt No.	Requirement	Verification/Validation Method	
SPS-001	The SOEPSS shall fit within the dimensions of the spacecraft's interior volume	Inspection	
SPS-002	The SOEPSS shall consist of an annular support track connected to the spacecraft	Inspection	
SPS-003	The SOEPSS shall support at least one module that is movably connected to the annular support track	CAD Analysis/Simulation	
SPS-004	The SOEPSS shall accommodate the quick and easy loading and unloading of payloads through the hatch	CAD Analysis/Simulation	
SPS-005	The SOEPSS shall allow convenient access of payloads in flight by either an astronaut or robotic arms	CAD Analysis/Simulation	
SPS-006	The SOEPSS shall include a means of securing modules on the track so they will not move or be damaged during takeoff or landing	Inspection	
SPS-007	The SOEPSS shall allow the deployment of modules through the spacecraft hatch by the Zelon arm(s)	CAD Analysis/Simulation	
SPS-008	The SOEPSS shall be separable into segments so that it can fit through the hatch and be assembled inside the spacecraft	Unable to be designed into the SOEPSS within the time constraint	

Presenter: Jonathan Lephuoc

Almaz EEUM Structural Restoration Requirements Outcomes

Reqmt No.	Requirement	Verification/Validation Method	
STR-001	The Almaz capsule shall resist weathering and scrapes	Test	
STR-002	The Almaz capsule shall be capable of human entry into the capsule	Demonstration	
STR-003	The stairs to the capsule shall support at least 2 people with equipment	Demonstration	
STR-004	The hatch to the capsule shall withstand the forces of opening and closing without damage	Demonstration	
STR-005	The hatch shall be capable of manual opening from inside the capsule	Demonstration	
STR-006	The hatch shall be capable of manual opening from outside the capsule	Demonstration	
STR-007	The stairs to the capsule shall be movable by 2 people	Demonstration	
STR-008	The stairs to the hatch shall include handrails capable of supporting a human person	Inspection	

Presenter: Project Manager Jonathan Lephuoc

Almaz EEUM Electrical Requirements Outcomes

Reqmt No.	Requirement	Verification/Validation Method	
EPS-001	The electrical power system shall power the capsule interior lighting.	Test	
EPS-002	The electrical power system shall power the ventilation fan system.	Test	
EPS-003	The electrical power system shall power the interior communications system.	Test	
EPS-004	The electrical power system shall be capable of being powered on and powered off	Test	
EPS-005	The electrical power system shall be connected to a ground power supply.	Test	
EPS-006	The electrical power system shall be cooled by the ventilation fan system.	Inspection	

Almaz EEUM Ventilation Requirements Outcomes

Reqmt No.	Requirement / Rationale	Verification/Validation Method	
VEN-001	The ventilation system shall control the capsule interior temperature.	Inspection	
VEN-002	The ventilation system shall provide air circulation throughout the capsule.	Inspection	
VEN-003	The ventilation system shall cool the electrical power system.	Inspection	
VEN-004	The ventilation system shall be powered by the electrical power system.	Test	

Almaz EEUM Communications Requirements Outcomes

Reqmt No.	Requirement	Verification/Validation Method	
COM-001	The communication system shall provide voice talk communication between those inside the capsule and outside.	Demonstration	
COM-002	The communication system shall be rechargeable if wireless.	Demonstration	
COM-003	The communication system shall have a signal strength to be functional when the hatch is closed.	Demonstration	
COM-004	The communication system shall be able to be turned on from inside the capsule.	Inspection	
COM-005	The communication system shall be able to be cooled by the ventilation system	Inspection	
COM-006	The communication system shall not have wires that interfere with the crew's work.	Inspection	
COM-007	The communication system shall be able to allow up to four crew members to communicate at once.	Demonstration	
COM-008	The communication system shall be able to be turned off from inside the capsule	Inspection	

Project Outcomes

- CAD models and 3D printed sub-scale mockups of the Almaz EEUM and the SOEPSS were created.
  - Satisfied Stakeholder Need #1
- The Almaz EEUM was refurbished and can now safely support multiple people working inside and outside of the capsule.
  - Satisfied Stakeholder Need #2

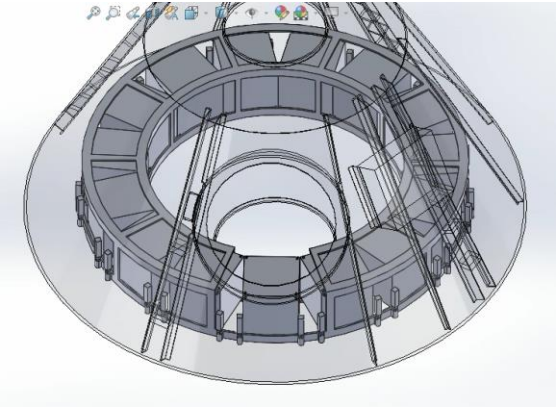


Figure 64: Final CAD Model of the SOEPSS

Figure 65: Final Restored EEUM and EEUM Stairs

Presenter: Project Manager Jonathan Lephuoc

Acknowledgements

- Mr. Art Dula, for providing the Almaz EEUM to Texas A&M and providing $1000 to the project budget.
- Dr. Bonnie J. Dunbar, for serving as the faculty advisor for the AERO 402 team.
- Mr. Jon Zelon, for providing important references and resources regarding the Almaz EEUM.
- Jacobs at NASA JSC, for providing an aluminum 6061 coupon with which to test the Almaz EEUM exterior polishing.
- Mr. Jed Simms, for providing guidance to the team as a former AERO 402 Project Manager as well as serving as the point-of-contact for Jacobs.

Presenter: Project Manager Jonathan Lephuoc

Questions










BACKUP SLIDES

EECOM (Electrical)

- Referencing the EEUM User's Manual
  - Confirmed connections and wire pathing
  - Checked the function of each switch
  - Confirmed presence of extra fan in electrical box

Figure 76: Spare Fan inside Electrical Box

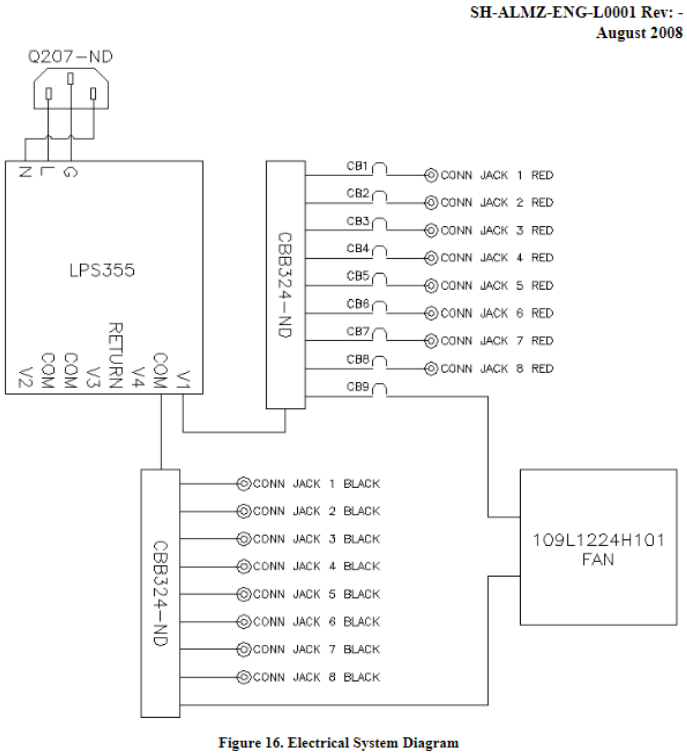


Figure 77: Original Almaz Electrical System Diagram

Restoration - EECOM (Electrical)

- EECOM ICD Diagram Development
  - Confirmed number convention of the capsule
  - Utilized hand-drawn sketches for high level diagrams

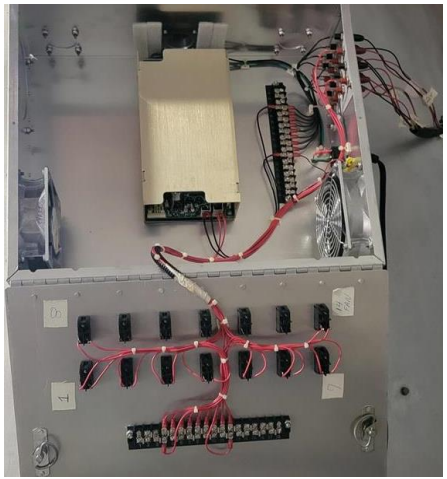


Figure 70: Interior of Electrical Box

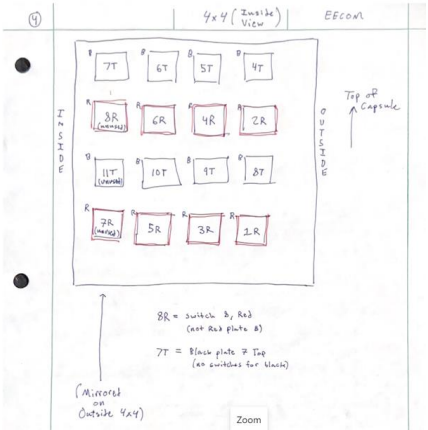


Figure 72: Electrical Box External Ports

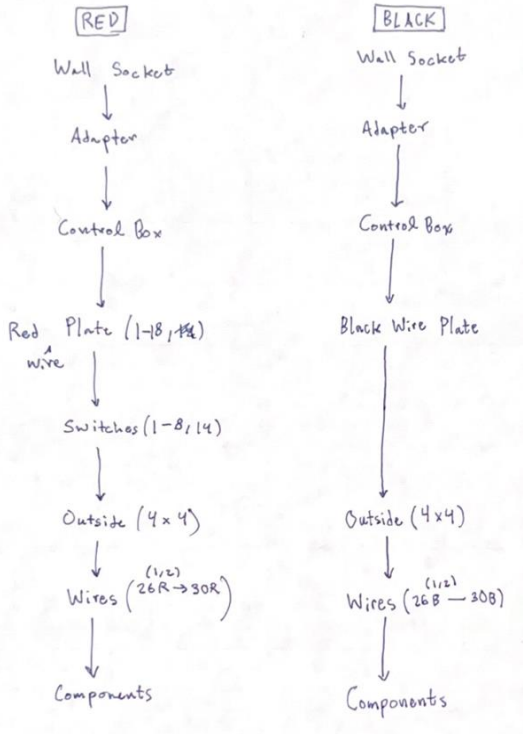


Figure 74: High Level Component Mapping

Restoration: Hatch Final Repair

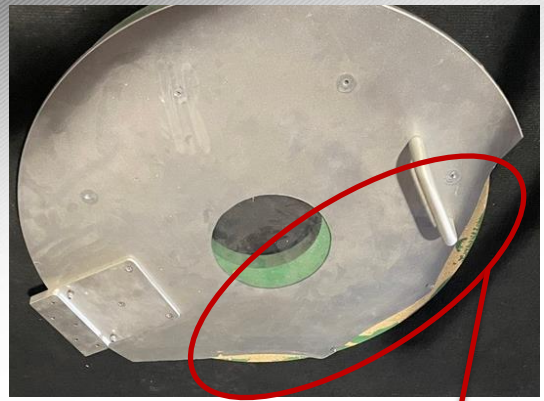


Figure XX. Initial State of the hatch

Figure XX. Initial state of the stairs

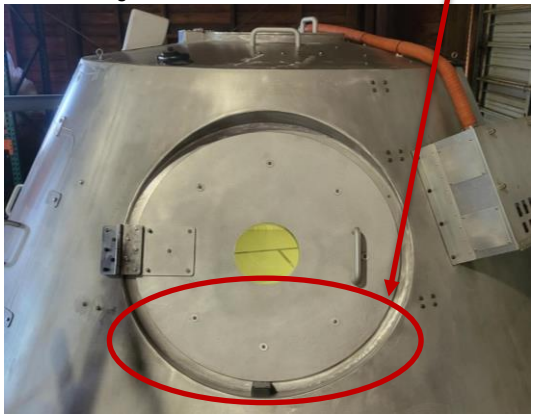


Figure XX. Hatch after final repair

Figure XX. Final state of the capsule and stairs

Presenter: Structures Team Elizabeth Bendrey

CAD: Capsule and Stand Drawings

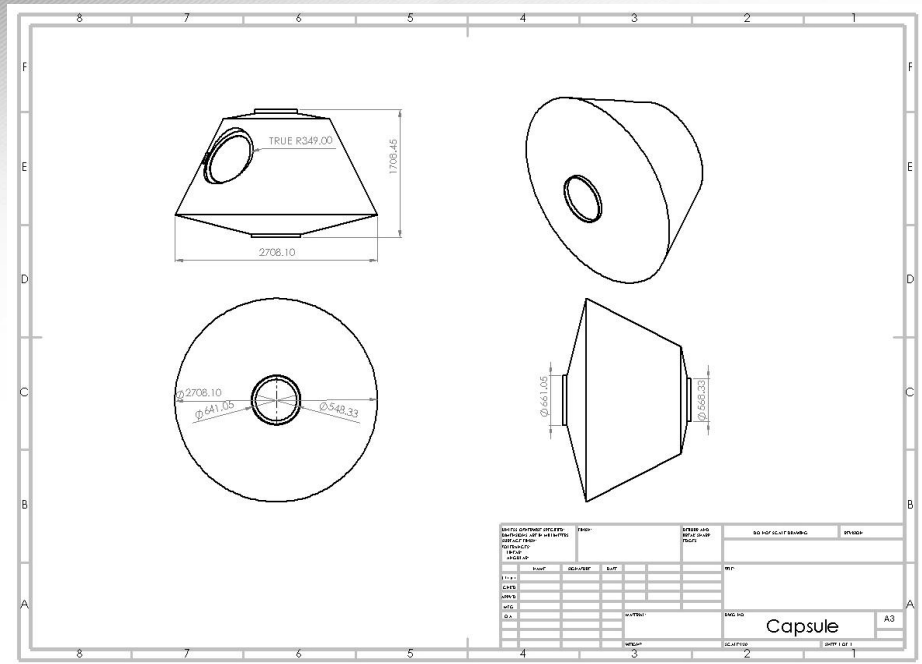


Figure 30: Capsule CAD Drawing

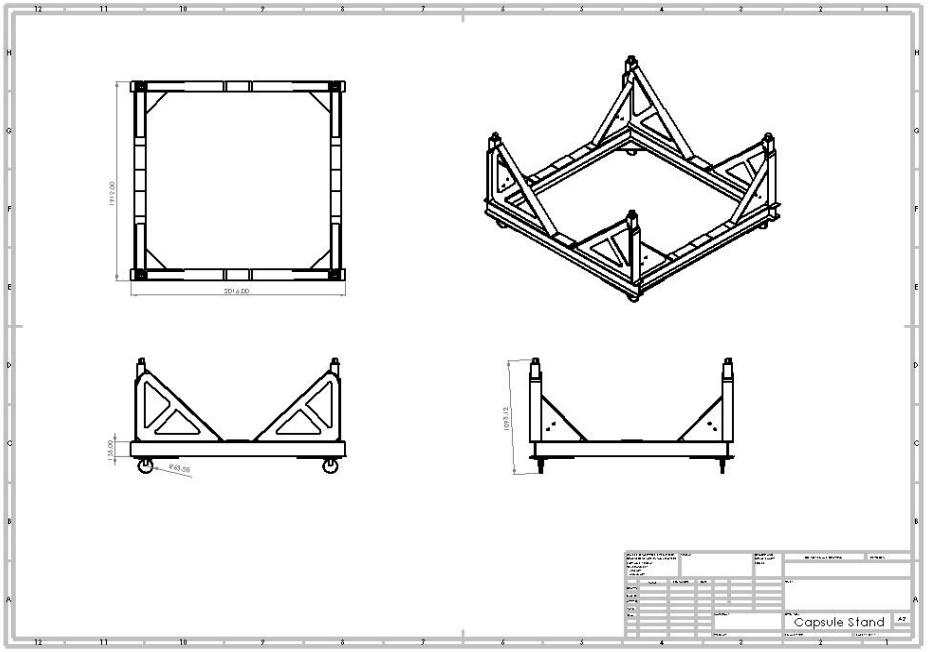


Figure 31: Capsule Stand CAD Drawing

Presenter: Jacob Wade

CAD: Stairs and Hatch Drawings

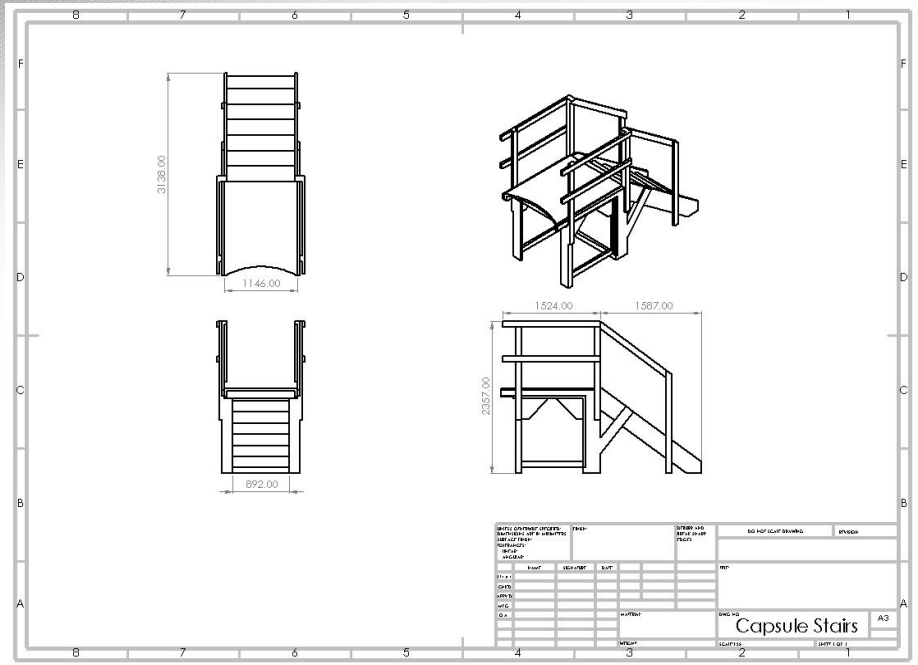


Figure 32: Capsule Stairs CAD Drawing

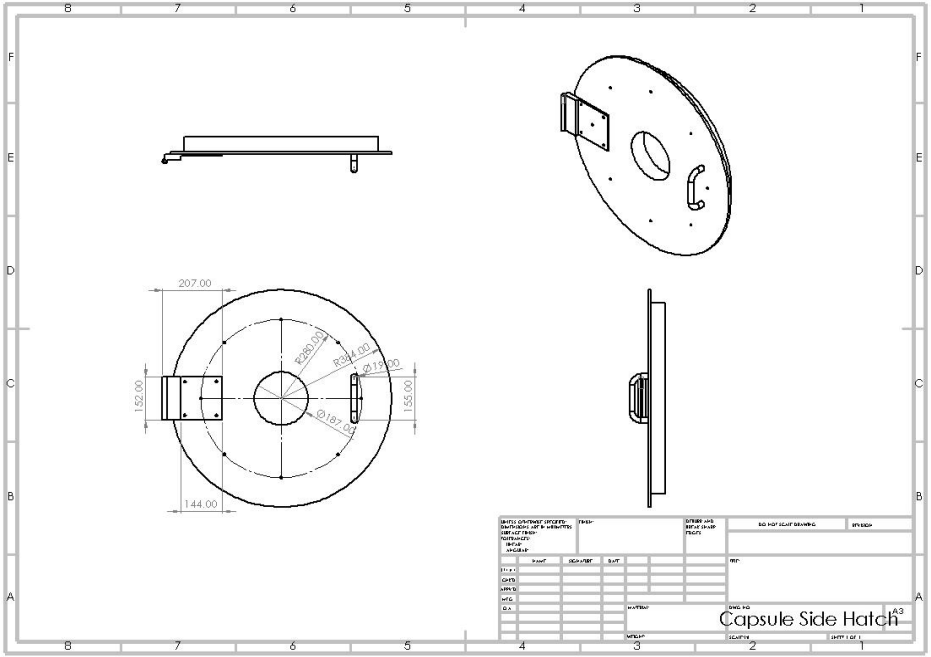


Figure 33: Capsule Hatch CAD Drawing

Presenter: Jacob Wade

Configuration Control

Project Tasks:

- Managing the inventory of all items related to the project using the Inventory Management Spreadsheet.
  - Inputting new items into the inventory as they arrive.
  - Tracking all items that are checked out by a team member and leave the hangar.
- Regularly auditing the inventory.
- Document control.

Presenter: Project Manager Jonathan Lephuoc

Inventory Management & Configuration Control

- **Configuration Control Tasks and Deliverables**
  - Inventory Management
  - Document Control
  - Inventory Audit
  - Full Inventory of the EEUM
  - Identifying everything inside of the EEUM

Presenter: Configuration Control Lead Bri Mason

Inventory Management & Configuration Control

Category Tag	Item Description	Item Quantity	Photo	Item ID will be a 6 character sequence composed of 3 latin characters followed by a dash, followed by 3 numerical digits The 3 latin characters will denote the subsystem that the item applies to: STR for Structures, ELE for
TLS TLS-001	Husky Diagonal Cutters	1		
TLS TLS-002	Husky Pliers	1		
TLS TLS-003	Husky Pliers	1		

Table XX: Inventory Spreadsheet Layout

Item Designation	Item Description	Photo
MOC-001	FFCS II Monoblock	
MOC-002	ACM 408n Beacon Monoblock	

Table XX: Initial Capsule Inventory Document

Presenter: Configuration Control Lead Bri Mason

Inventory Management & Configuration Control

- Inventory managed digitally through the Inventory Management Spreadsheet.
  - Entries contain item ID, item description, and photo
- Inventory was audited bi-weekly and consumable items that were used up were replaced
- A separate document was created detailing customer owned items that initially existed in the capsule.

Presenter: Configuration Control Lead Bri Mason

Inventory Management & Configuration Control

- Inventory Check-In/Check-Out Spreadsheet was created for checking items in and out of the hangar
  - Contains columns for team member name, item ID, item description, check-out date, and check-in date

Team Member Name	Item ID	Item Description	Check Out Date	Check In Date
Harrison Otto	STR-006	Capsule Fragment	1/24/2022	2/9/2022
Elizabeth Bendrey	STR-011	2.5'' Wood Screw for Staircase	1/31/2022	2/9/2022
Elizabeth Bendrey	STR-012	Bag of Capsule Side Panel Hatch Bolts/Nuts	1/31/2022	2/9/2022
Elizabeth Bendrey	STR-006	Capsule Fragment	2/9/2022	2/14/2022
Garrison Kleman	STR-008	Bag of Hatch Screws, Nuts, and Washers	2/9/2022	

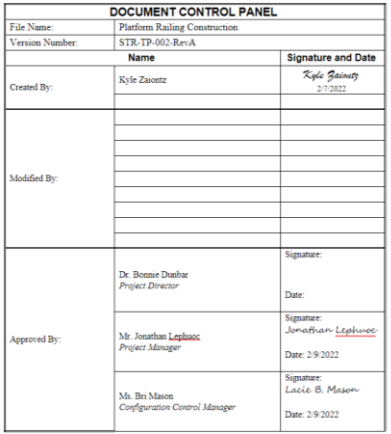
Table XX: Inventory Check In/Check Out

Presenter: Configuration Control Lead Bri Mason

Inventory Management & Configuration Control

- Created Document Template to unify all official documents:
  - Title Page: Displays team logo, team name, document title, and document tracking ID.
  - Document Control Panel: Area to track document version number, creation date, and appr oval.

Figure XX: Document Title Page



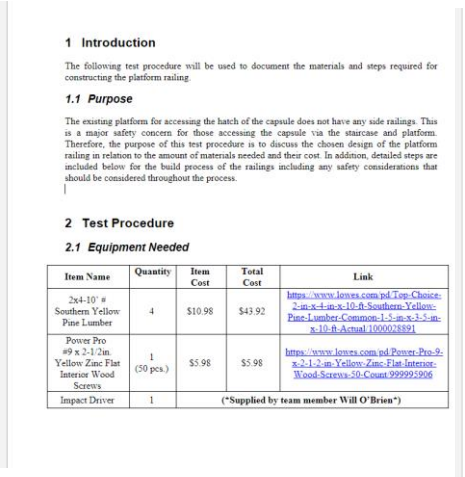
DOCUMENT CONTROL PANEL		
File Name:	Platform Railing Construction	
Version Number:	STR-TP-002-RevA	
	Name	Signature and Date
Created By:	Kyle Zaiontz	Kyle Zaiontz 2/7/2022
Modified By:		
Approved By:	Dr. Bonnie Dunbar, Project Director	Signature: Date:
	Mr. Jonathan Lephuoc, Project Manager	Signature: Jonathan Lephuoc Date: 2/9/2022
	Ms. Bri Mason, Configuration Control Manager	Signature: Lacie B. Mason Date: 2/9/2022

Figure XX: Document Control Panel

Presenter: Configuration Control Lead Bri Mason

Inventory Management & Configuration Control

- Document Template
  - Revision History: Details document lifetime from initial to final version.
- Test Procedures Include Body Template
  - Contains an introduction, statement of document purpose, materials list, detailed procedure, and safety precautions.



1 Introduction

The following test procedure will be used to document the materials and steps required for constructing the platform railing.

1.1 Purpose

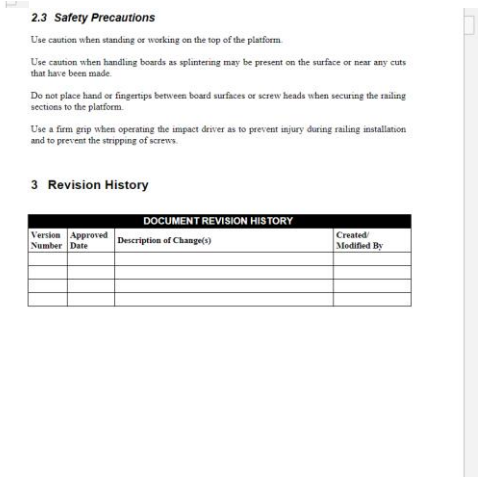
The existing platform for accessing the hatch of the capsule does not have any side railings. This is a major safety concern for those accessing the capsule via the staircase and platform. Therefore, the purpose of this test procedure is to discuss the chosen design of the platform railing in relation to the amount of materials needed and their cost. In addition, detailed steps are included below for the build process of the railings including any safety considerations that should be considered throughout the process.

2 Test Procedure

2.1 Equipment Needed

Item Name	Quantity	Item Cost	Total Cost	Link
2x4-10' # Southern Yellow Pine Lumber	4	$10.98	$43.92	https://www.lowes.com/pd/Top-Choice-2-in-x-4-in-x-10-ft-Southern-Yellow-Pine-Lumber-Common-1-5-in-x-3-5-in-x-10-ft-Actual/1000028891
Power Pro #9 x 2-1/2in. Yellow Zinc Flat Interior Wood Screws	1 (50 pcs.)	$5.98	$5.98	https://www.lowes.com/pd/Power-Pro-9-x-2-1-2-in-Yellow-Zinc-Flat-Interior-Wood-Screws-50-Count/999995906
Impact Driver	1	(*Supplied by team member Will O'Brien*)		

Figure XX: Document Body



2.3 Safety Precautions

Use caution when standing or working on the top of the platform.

Use caution when handling boards as splintering may be present on the surface or near any cuts that have been made.

Do not place hand or fingertips between board surfaces or screw heads when securing the railing sections to the platform.

Use a firm grip when operating the impact driver as to prevent injury during railing installation and to prevent the stripping of screws.

3 Revision History

DOCUMENT REVISION HISTORY			
Version Number	Approved Date	Description of Change(s)	Created/ Modified By

Figure XX: Document Revision History

Presenter: Configuration Control Lead Bri Mason

Inventory Management & Configuration Control

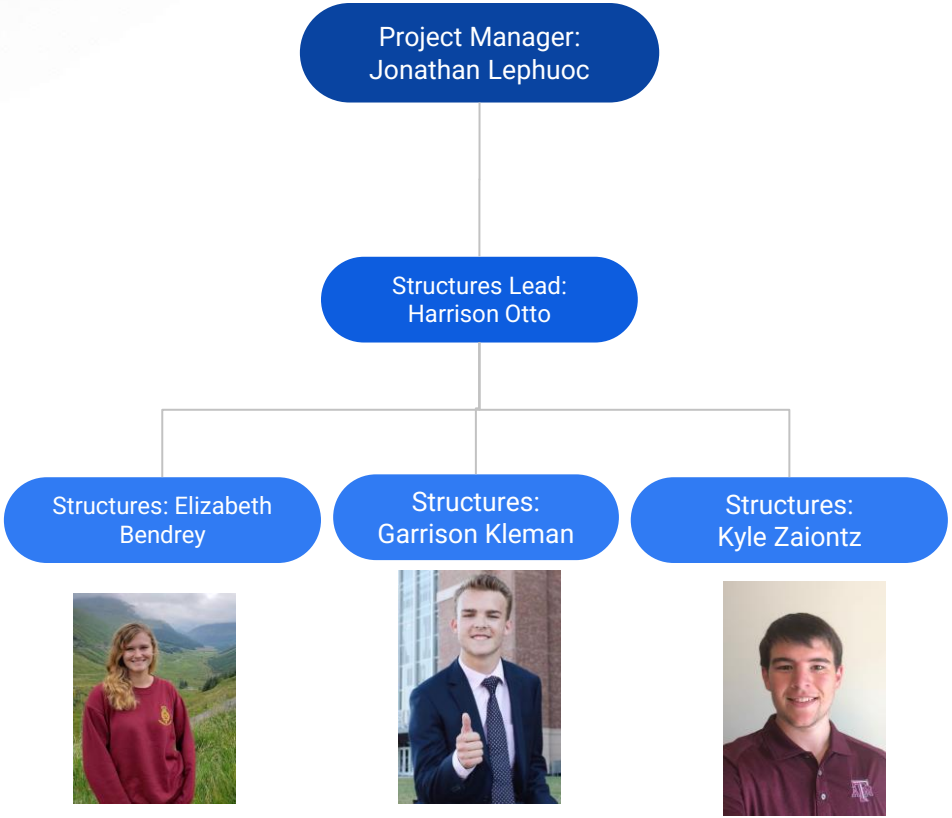
Document Number	Document Title
STR-TP-001	Stair Screw Replacement
STR-TP-002	Platform Railing Procedure
STR-TP-003	Hatch Repair
ELE-TP-001	Capsule Startup Procedure
ELE-TP-002	Capsule Shutdown Procedure
ELE-PSA-001	Project Safety Analysis
GEN-SWP-001	Safe Work Practices
ELE-PSA-002	Project Safety Analysis Action List
STR-TS-001	Adhesive Trade Study
STR-TS-002	Polish Trade Study
STR-TS-003	Tools Trade Study
ELE-ICD-001	Electrical Interface Control Document
ELE-PIC-001	Pictures

Presenter: Configuration Control Lead Bri Mason

Structures Team

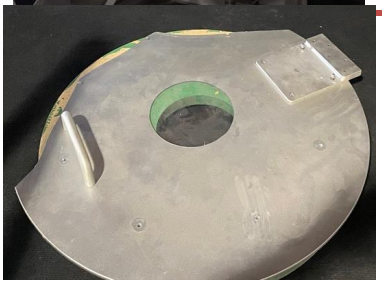
Project Tasks:

- Documenting & executing the exterior cleaning and refurbishment procedures.
- Repairing EEUM side hatch.
- Modifying the side hatch stairs to include side rails for safety.
- Modifying the stairs to have locking caster wheels for safety and ease of transportation.



Presenter: Project Manager Jonathan Lephuoc

Restoration

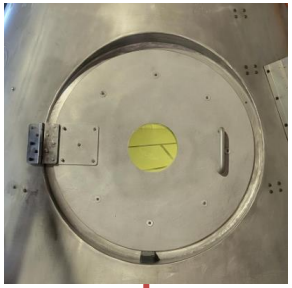


Capsule and Hatch in initial states

Capsule after cleaning

Polished capsule

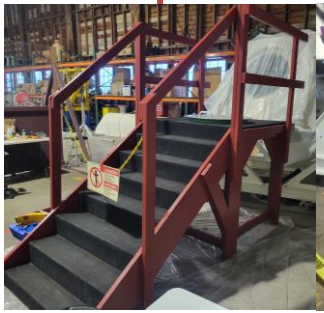
Final repaired hatch



Picture of completed capsule & stairs

Stairs in initial state

Stairs with railings



Painted stairs

Stairs with wheels

Presenter: Structures Team Lead Harrison Otto

Restoration

- Adhesive Study
  - Compared methacrylate to epoxy to decide on epoxy for lower cost, more availability, and higher nominal bond strength
  - Compared JB Weld plastic and clear epoxy through a practical test to decide on the clear option

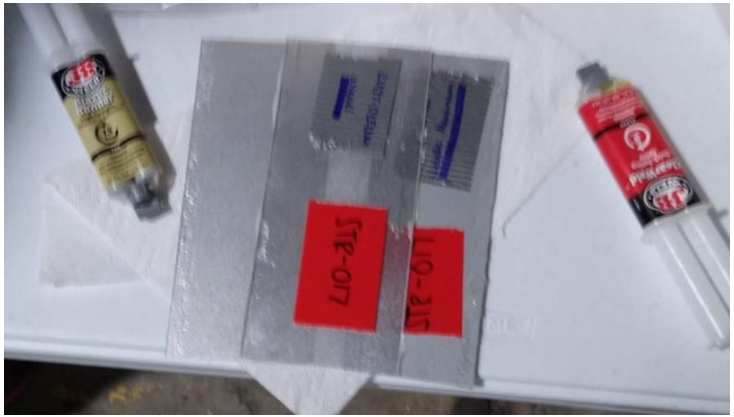


Figure 24: Epoxy Adhesives Tested on Material Coupons

Presenter: Structures Team Lead Harrison Otto

Restoration: Repair vs. Replace Cost Analysis

Cost Analysis

Repair		Replace	
Item	Cost ($)	Item	Cost ($)
Methacrylate Adhesive	69.50[1]	Acrylic Sheet	350.00[2]
Adhesive Gun	77.30[3]	Sand paper	6.77[4]
		Electric drill	Borrow
Adhesive	69.50[5]		
Adhesive Gun	68.00[6]		
Total	137.50 - 146.80	Total	356.77

Figure X: Variable part cost analysis for repairing and replacing the hatch

Structures and Restoration

- Capsule cleaning process
  - Dusted exterior.
  - Wiped the Aluminum surface with Windex on microfiber towels.
  - Wiped with soapy water on microfiber towels.
  - Removed any remaining chemicals from cleaners using damp rags.

Figure X. Capsule before cleaning

Figure X. Capsule after cleaning

Presenter: Structures Team Elizabeth Bendrey

Structures and Restoration

- Almaz EEUM Stairs
  - Evaluated the initial condition of the stairs/platform.
  - Determined a railing would be necessary for the safety of workers or operators.
  - Railing design considerations:
    - Cost
    - Integration with existing structure
    - Assembly methods

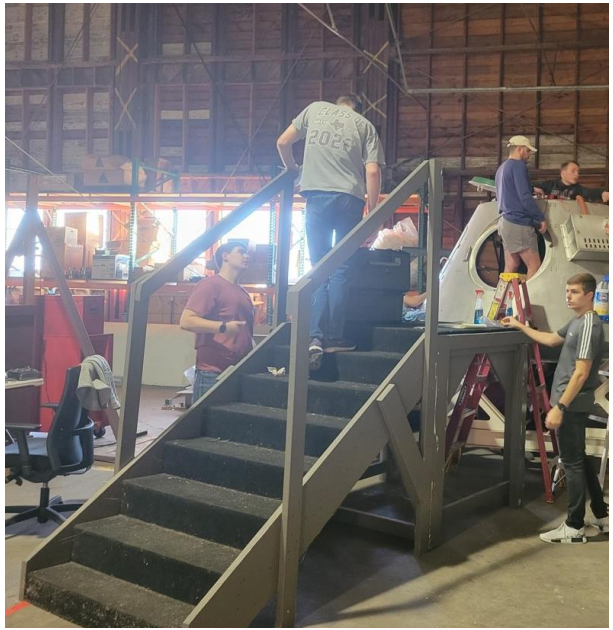


Figure x. Initial Condition of the Platform

Presenter: Structures Team Kyle Zaiontz

Structures and Restoration

- Platform Railing
  - The design consisted of wooden railings and supports which are similar to the original Almaz EEUM platform
  - Created procedure documents including necessary safety precautions.
  - Completed the procedure and assembled the railings.

Figure x. Newly Assembled Railings

Presenter: Structures Team Kyle Zaiontz

Structures and Restoration

- Stairs painting
  - Sanded original paint, then painted the stairs with two layers of maroon paint.

Figure 19. Stairs before repainting

Figure 20. Stairs after repainting

Presenter: Structures Team Elizabeth Bendrey

Structures and Restoration

- Locking Wheels for Stairs
  - Used six locking caster wheels with a safety factor of >2 for five, average weight people on the stairs.
  - Added wood sheets to the bottom to increase surface area for mounting the wheels and to assist with weight distribution

insert image of final EEUM stairs

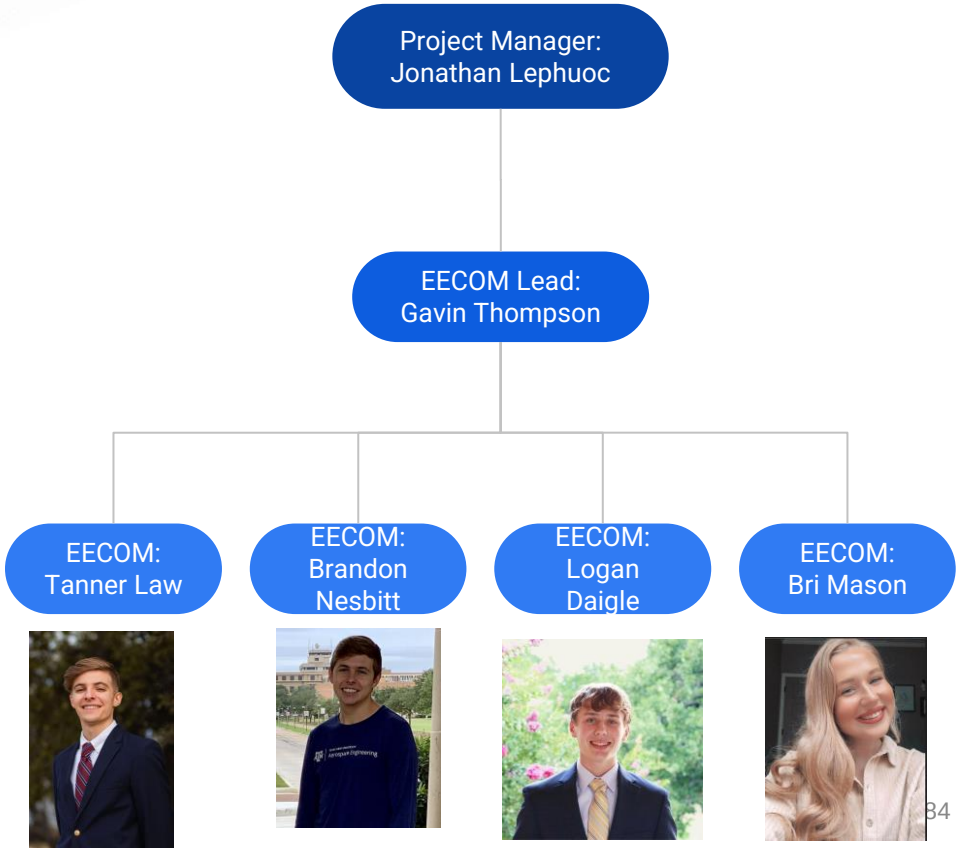
Figure XX: Stairs after addition of wheels

Presenter: Structures Team Lead Harrison Otto

EECOM Team

Project Tasks:

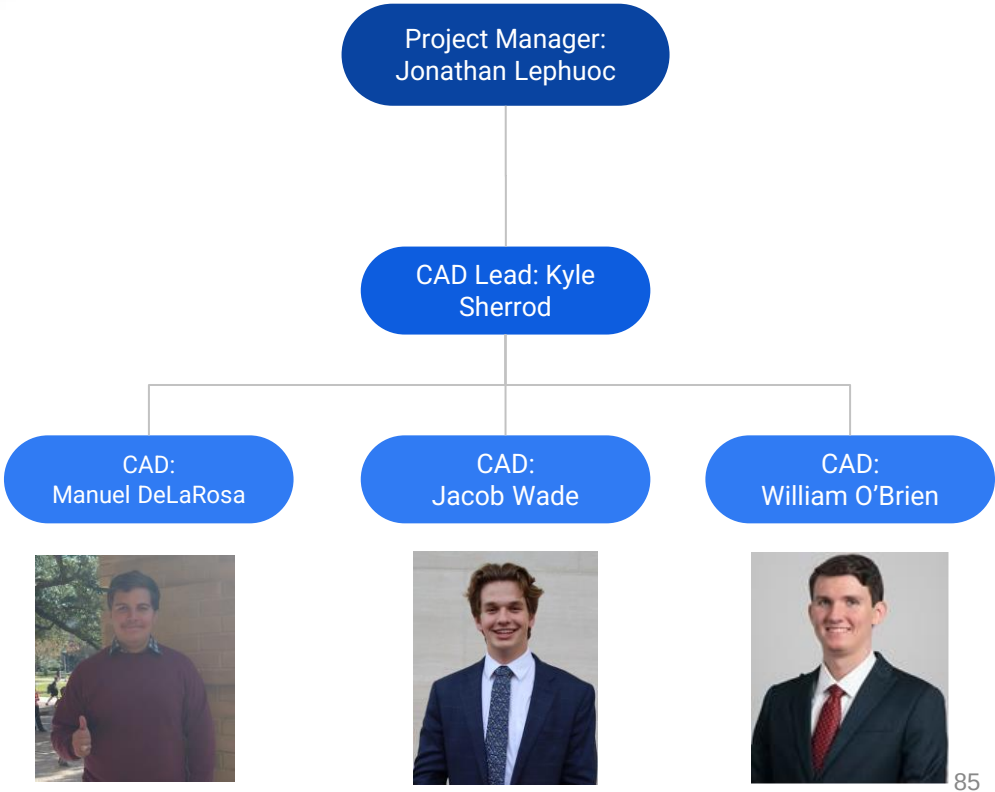
- Creating the Almaz Systems Diagram.
- Assessing the Almaz EEUM electrical, ventilation, and lighting systems.
- Installing a communications system inside of the capsule.
- Designing an Almaz EEUM Health Management System



Presenter: Project Manager Jonathan Lephuoc

CAD Team

- **Project Tasks:**
  - Designing the CAD model of the stairs to the capsule hatch.
    - Designing the side rails for the stairs.
  - Designing the CAD model of the Almaz EEUM
    - Designing the CAD model of the stand upon which the EEUM is mounted.
  - Designing the CAD model for a modular storage system for the Almaz RRV.
  - Constructing a sub-scale mockup of the payload storage device patented by Mr. Art Dula.



Presenter: Project Manager Jonathan Lephuoc

Excalibur Almaz Reusable Reentry Vehicle (RRV)

- High-level concept of operations:
  - Reusable spaceflight vehicle with both manned and unmanned flight configurations.
  - Space tourism to LEO or lunar orbit.
  - Orbital science platform for research, outreach, and/or education

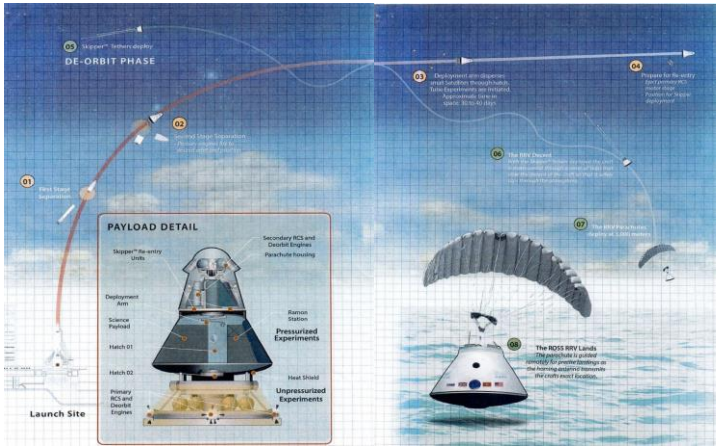
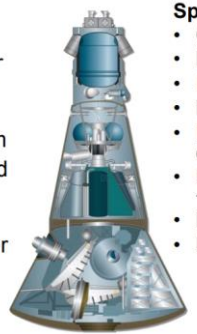


Figure 6: Original Excalibur Almaz RRV CONOPS

Features
- Reusable
- Autonomous or piloted
- Emergency Escape System
- Parachutes and retrorockets
- Can land on ground or water



Specifications
- Crew 3
- Launch: ~8,000 kg
- In Orbit: ~4,200 kg
- Landing: ~4,000 kg
- Internal Volume: ~8 cubic meters
- Habitable Volume: ~4.56 cubic meters
- Length: 3.64 m
- Diameter: 2.79 m

Figure 5 Excalibur Almaz RRV Specifications

Presenter: Project Manager Jonathan Lephuoc

CAD (XX/XX)

- SOEPSS Primary Design
  - Geometric concern of Figure 38 as a cross section
    - Cannot exist as shown in orange since the wheels/ball bearings are parallel to the box edge and therefore cannot both be in the plane
    - Cannot exist as shown in purple because the curvature of the rails is not reflected
    - Cannot exist as shown in blue because the box is not centered with respect to the inner and outer rails

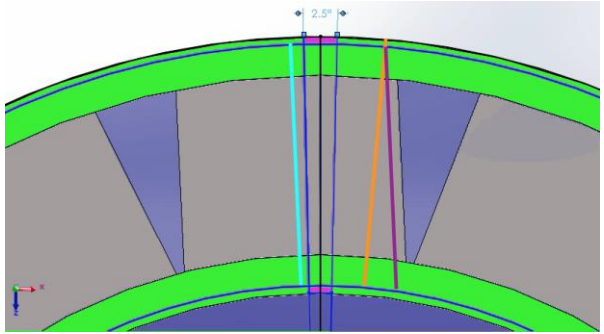


Figure 50: Top View of Possible locations of the cross sectional plane as shown in Figure 38

Presenter: Will O'Brien

*SOEPSS = Spacecraft Onboard Equipment (and) Payload Storage System

CAD

- SOEPSS Design Concern
  - The Environmental Control and Life Support System (ECLSS) significantly protrudes into the lower capsule interior
  - After meeting with Mr. Dula during our IDR presentation, we elected to ignore the ECLSS for the modeling of the SOEPSS

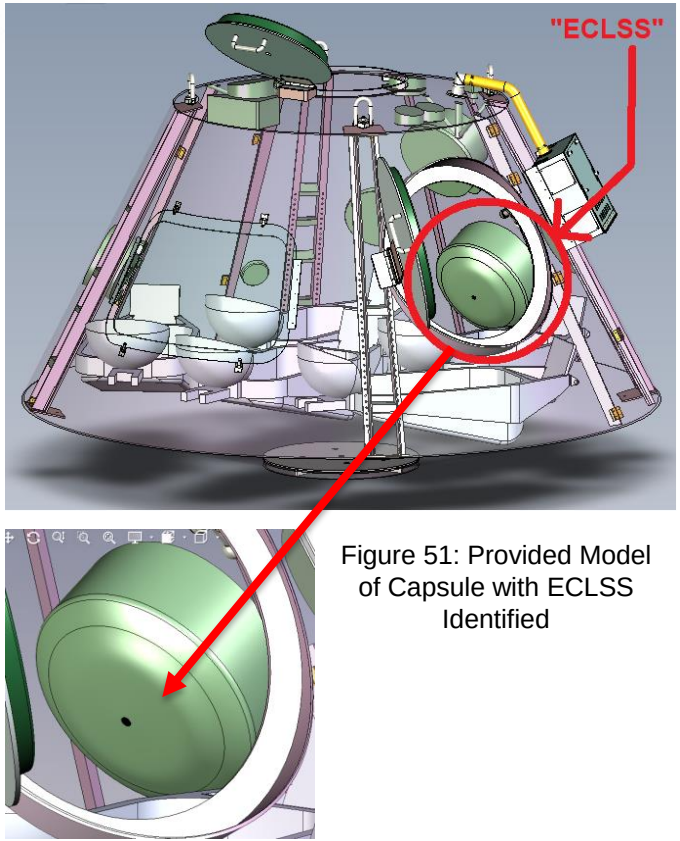


Figure 51: Provided Model of Capsule with ECLSS Identified

Presenter: Manuel DeLaRosa

EECOM

- EECOM Introductions
  - Electrical, Environmental and Communications
- Project Safety Analysis
  - Was created as a preventative measure
  - Holds the team to industry standards
  - Contains all safety, procedures, trainings

Figure 66: Team member in capsule

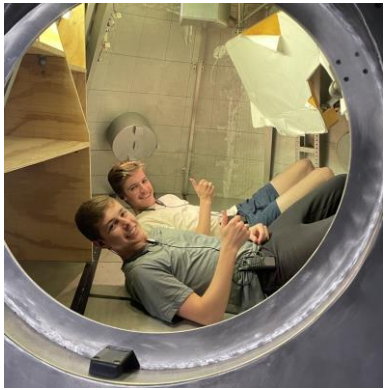


Figure 65: Team members in capsule

Figure 67: Team member in capsule

Presenter: EECOM Team Lead Gavin Thompson

EECOM (Environmental)

- Almaz EEUM Proposed Health Management System
  - Power Draw
  - Power Box Temperature
  - Ventilation Fan RPM
  - Internal/External Temperature
  - Internal/External Pressure
  - Oxygen Level
  - Carbon Dioxide Level

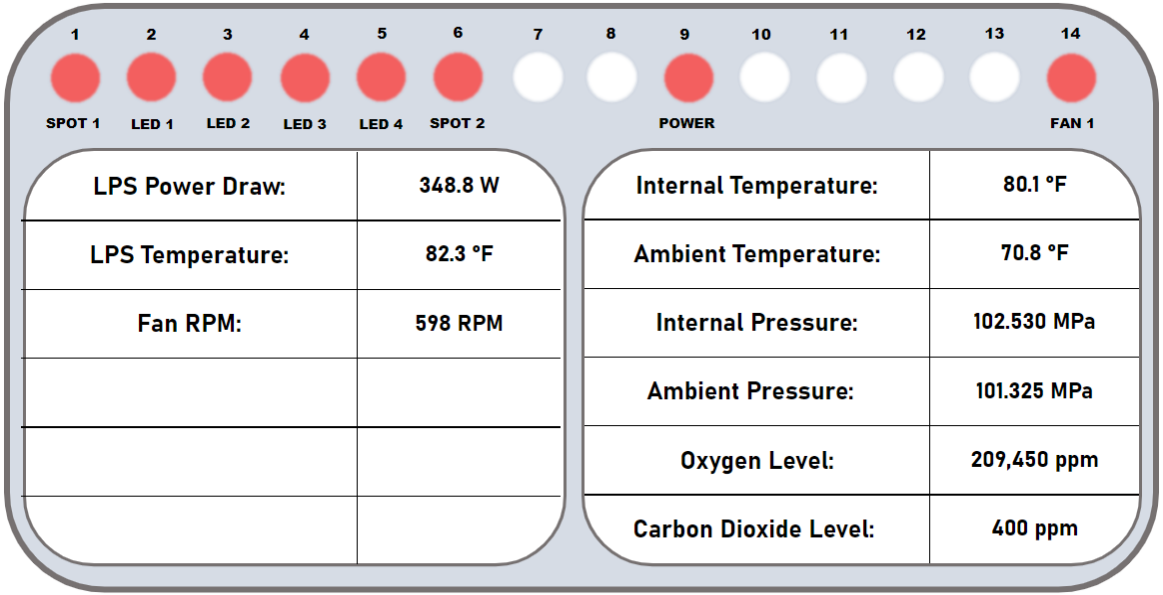


Figure X: Theoretical Health Management System Display

Presenter: EECOM Team Lead Gavin Thompson

EECOM (Environmental)

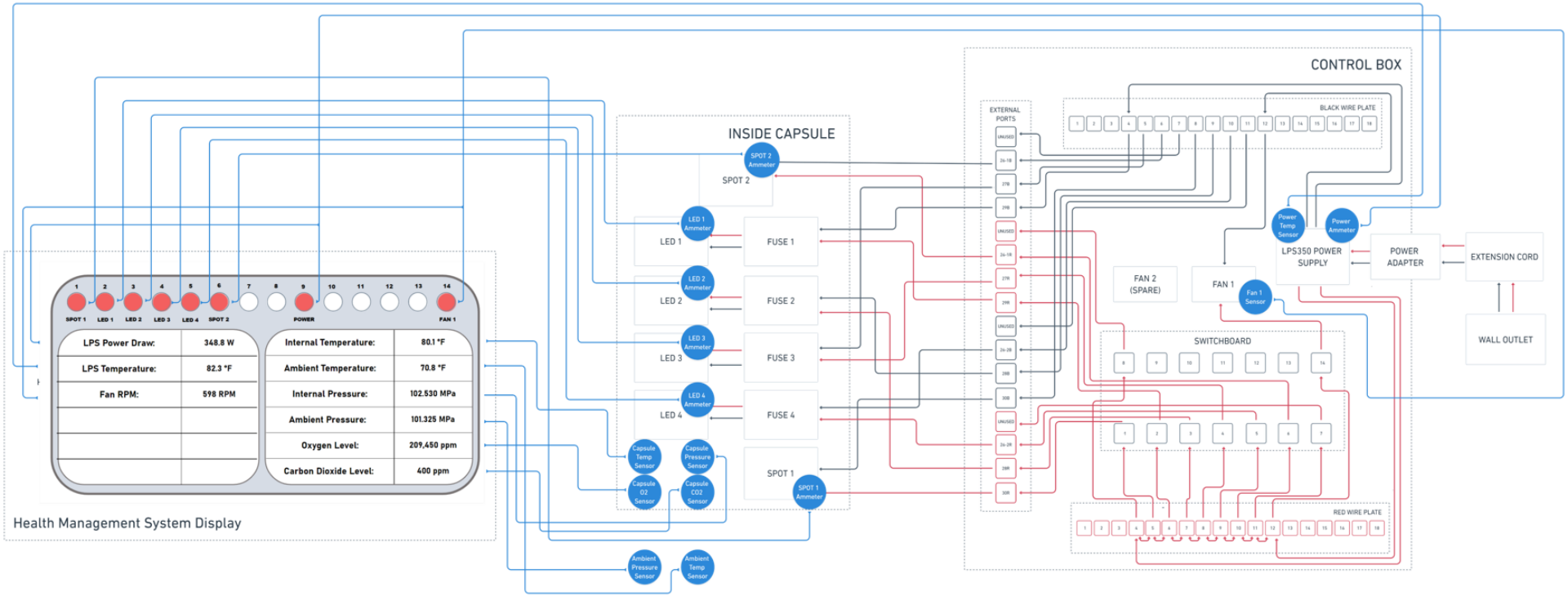


Figure X: Health Management System Interface Control Document Diagram

Presenter: EECOM Team Lead Gavin Thompson