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A GROUND SUPPORT BIO-BARRIER (GSB) FOR RECONTAMINATION PREVENTION

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Agenda

1. Introduction
   - Background Information
2. Statement of Work
   - Requirements for the design
   - GSB Information and Assumptions
3. Ground Support Biobarrier (GSB)
   - Design Iterations
   - The Final Design
   - Meeting Planetary Protection (PP) requirements
   - Meeting Contamination Control (CC) requirements
   - Assembly Procedures
4. Conclusion
5. Acknowledgements

Background Information

What is Planetary Protection?

- To protect the planets (and science) by preserving them as a target of biological exploration—including forward (outbound) and backward (Earth return) missions
  - Prevent false positive findings by life detection missions

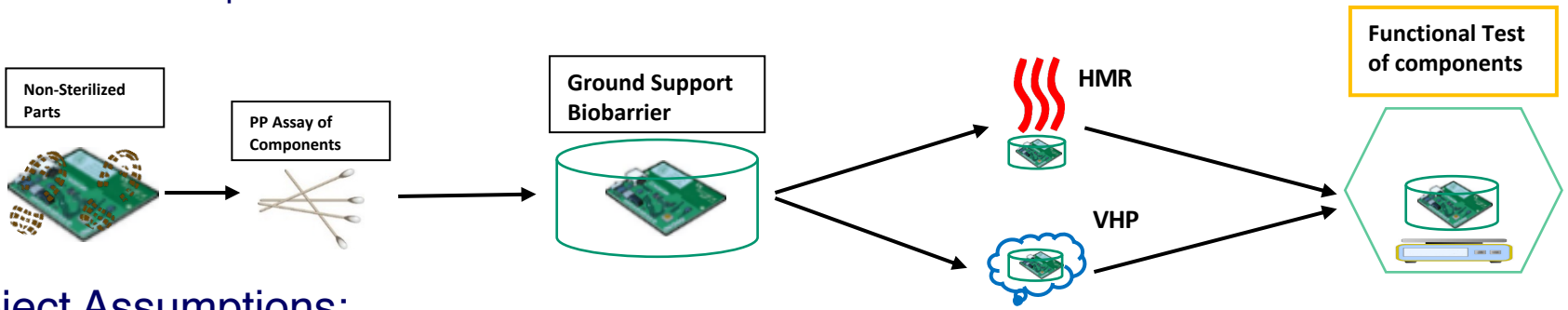
Meeting the Biological Cleanliness requirement for Mars and Icy satellites:

- In order to meet the PP requirements
  - Spacecraft components need to be cleaned / microbially-reduced and protected from recontamination
  - Biological cleanliness is a key / driving requirement throughout the entire lifecycle of the project—from Pre-Phase A until spacecraft disposal.
- Need:
  - A Ground Support Biobarrier (GSB) to prevent recontamination during hardware testing (which is often not performed in a cleanroom environment or includes hardware movement through a dirty environment)
    - Benefit: Microbial reduction processes performed prior to testing avoid the need to conduct additional microbial reduction processes post-testing, which can save weeks of schedule impact

GSB Information and Assumptions

What is the Ground Support Biobarrier?

- A GSB prevents recontamination of microbially-reduced parts during:
  - Environmental/functional testing
  - Transportation



Project Assumptions:

- Parts will be microbially-reduced while inside the Ground Support Bio-Barrier (GSB) by going through Heat Microwave Reduction (HMR) or Vapor Hydrogen Peroxide (VHP)
- GSB will only open inside an aseptic clean room to ensure that parts are not recontaminated after cleaning / microbial reduction
- The GSB design is scalable to accommodate parts/components of different sizes

Key Driving Requirements

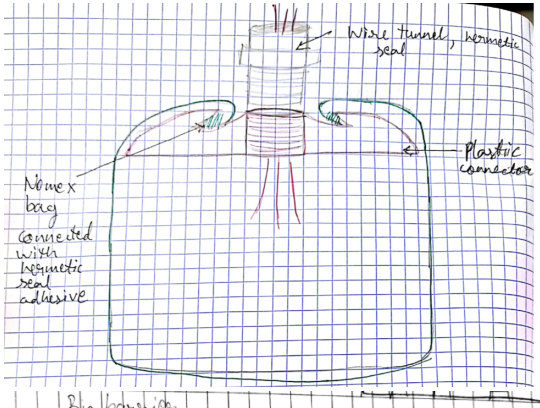
- PP Requirement
  - The interior of the GSB shall maintain a cleanliness level equivalent to 300 spores/m^2 followed by a 4 order-of-magnitude microbial reduction process
- CC Requirement
  - The GSB shall comply with the applicable contamination control plan
    - (For this study Mars 2020 CC plan was used)
- Biological Seal Requirement: The GSB shall meet the Constraints for Biobarriers per NPR 8020.12D Appendix
- The GSB shall withstand temperature range of -50C to +125C
  - Allows heat microbial reduction (HMR) of hardware inside GSB
- The GSB shall be compatible with four cycles of a VHP process using the standard NASA-approved protocol (providing 6 order-of-magnitude reduction)
  - Allows Vapor Hydrogen Peroxide (VHP) microbial reduction of hardware inside GSB
- The GSB shall withstand the dynamic loads specified in Project Environmental Requirements Document
- The GSB shall meet the Project/JPL transportation and handling requirements
- The GSB shall meet the Project electrostatic discharge (ESD) requirements

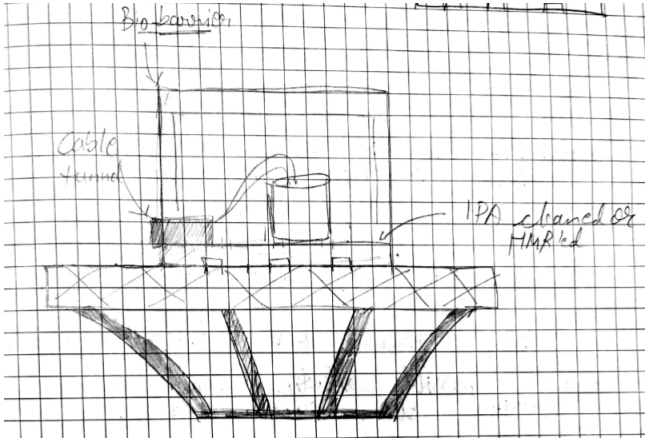
Key / Driving Requirements

Requirement	Compliance Approach	Verification Method
The interior of the GSB shall maintain a cleanliness level equivalent to 300 spores/m^2 followed by a 4 order-of-magnitude microbial reduction process	Perform one of the NASA approved microbial reduction protocols such as HMR and VHP	Inspection (bio-assay)
The GSB shall comply with Mars 2020 project Contamination Control Plan	Maintain GSB seal. During thermal-vacuum test, provide an exit opening such that internal volatiles can escape to an external cold finger and quartz crystal microbalance (QCM)	Inspection (visual)
The GSB shall meet the Constraints for Biobarriers per NPR 8020.12D Appendix	Design a tortuous path at metallic interfaces not hermetically sealed. Conduct leak test and install HEPA filters (99.97% of 0.3 µm particles filtered)	Leak test/filter test
The GSB shall withstand temperature range of -50C to +125C	Design using materials that can withstand the temperature with outgassing properties that also meet the project's CC Plan	Design
The GSB shall be compatible with four cycles of a VHP process using the standard NASA-approved protocol (providing 6 order-of-magnitude reduction)	Design using materials that can withstand exposure to VHP for the required amount of time, without having any adverse effect to the structure.	Design
The GSB shall withstand the dynamic loads specified in Project Environmental Requirements Document.	By Design/Calculations/Modeling	Dynamic test
The GSB shall meet the Project/JPL transportation and handling requirement	By Design. Secondary container shall have a HEPA filter to maintain zero pressure change	Analysis
The GSB shall meet the Project ESD requirements	Select materials that are electrically dissipative as prescribed in the ESD requirement (or Faraday cage implementation)	Electrical continuity test

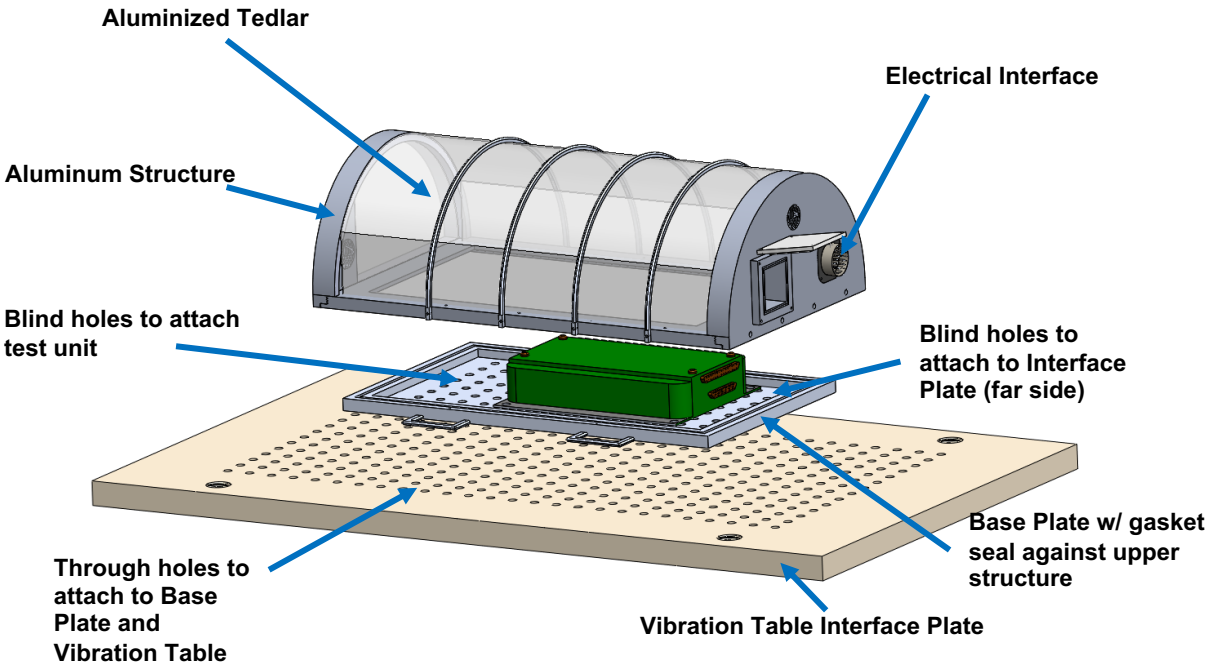
Initial Design Iterations

- Separate design for Thermal-Vacuum test and Dynamic test
  - *Pros:*
    - *The design is optimized for each test*
  - *Cons:*
    - *Multiple types of GSB are needed*
    - *Increased cost*
    - *Must transfer hardware from one GSB to another for each test*
- Single bag design for all test (using a Nomex-PTFE bag with a faraday cage)
  - *Pros:*
    - *A single design could be used for all tests*
  - *Cons:*
    - *Difficulty in Nomex-PTFE construction*
    - *Increased CC unknowns during testing (pre-conditioning and particulate entrapment)*

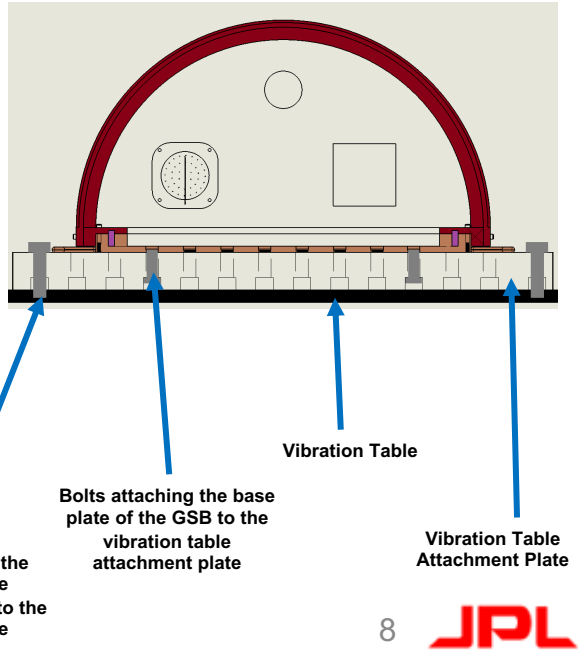




Current Design – THE GSB

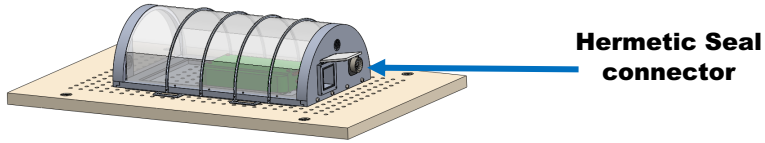


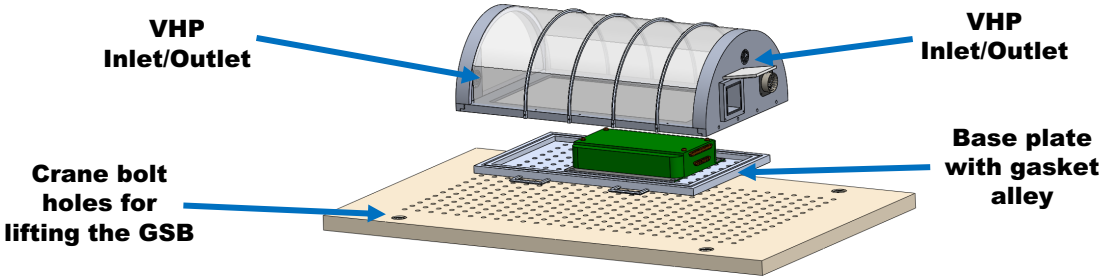
Section View Showing Attachments Between Base Plate, Vibration Table Attachment Plate and Vibration table

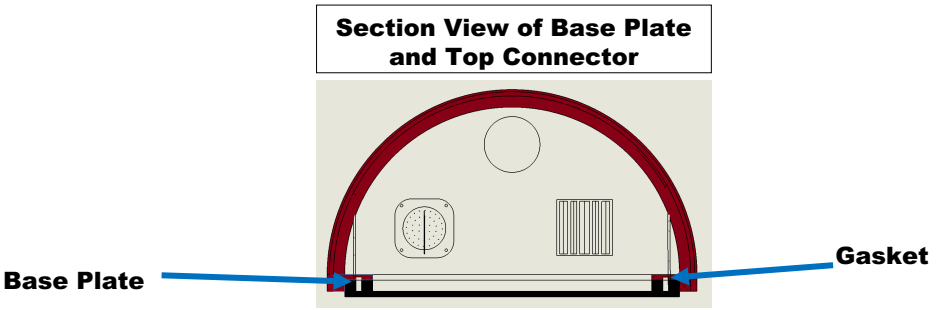


PP Considerations

- Hermetic seal cable connector for electrical connection to the test unit
- VHP Inlet and Outlet in order to use VHP sterilization on parts inside the GSB
- Gasket between GSB top cover and base place for hermetic seal enclosure

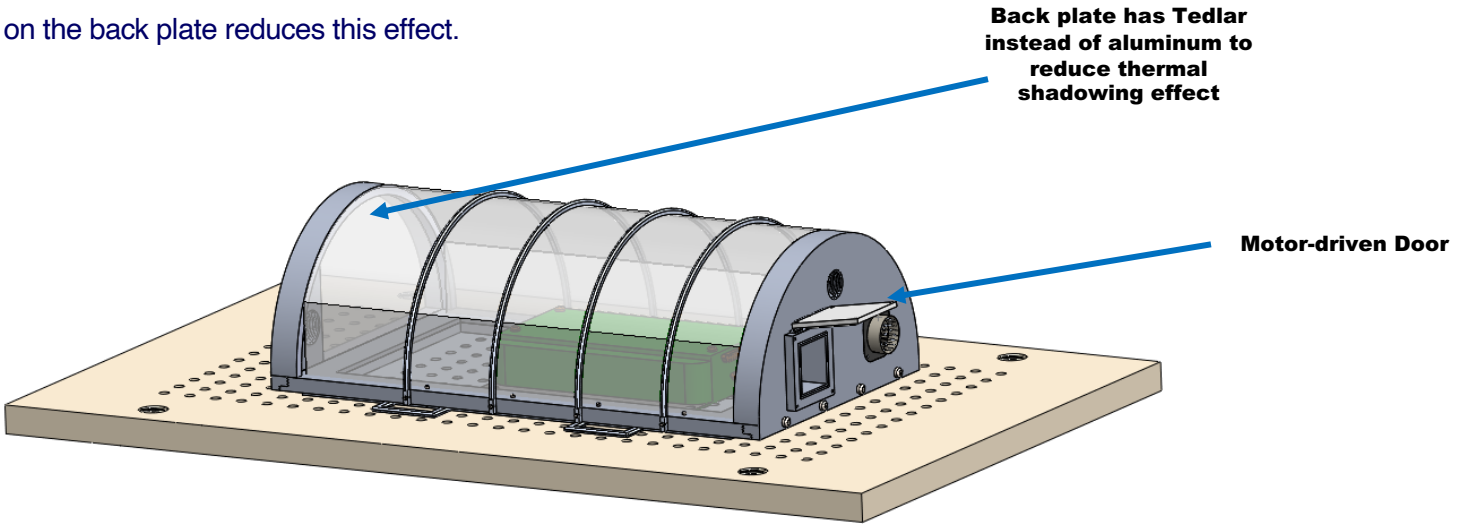




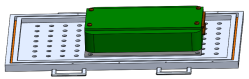


CC Considerations

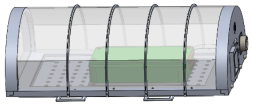
- A motor actuator door opens during Thermal-Vacuum test to allow volatiles to leave the GSB
- A spring-loaded fail safe mechanism will close door in case of motor failure
- Shadowing effect
  - Uneven spread of temperature profile on the test article caused by obstruction between the heat radiator and the test article.
  - Tedlar on the back plate reduces this effect.



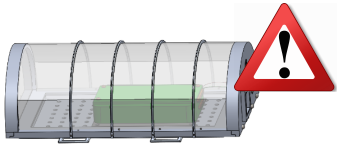
Vibration Test Assembly/Utilization

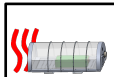


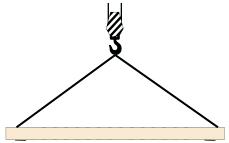
Test article is attached to the base plate of GSB



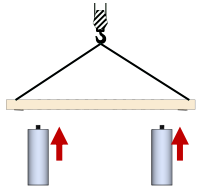
Top cover of the GSB is attached to create a hermetically sealed interior



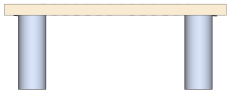
	The GSB and its content may go through microbial reduction using Heat Microbial Reduction technique
	The interior of the GSB may go through microbial reduction using Vapor Hydrogen Peroxide

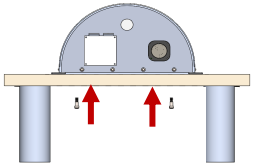


Vibration Table Attachment (VTA) is prepared using lifting crane

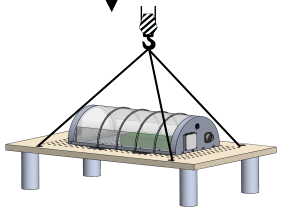


Attach legs to convert VTA to assembly table

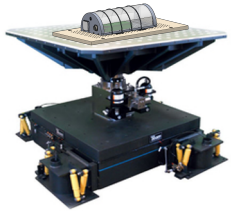




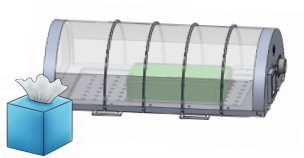
The GSB is attached to the VTA using bolts and the through holes in the VTA



Assembly is lifted to remove the pegs from underneath the VTA



The GSB and the VTA is attached to the vibration table



Outside of the GSB is cleaned using IPA wipes inside the clean room airlock

The GSB gets moved to an aseptic clean room

#Similar procedure for Acoustic and Shock testing

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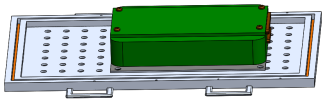
Thermal Vacuum Assembly/Utilization



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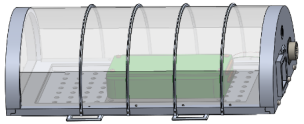

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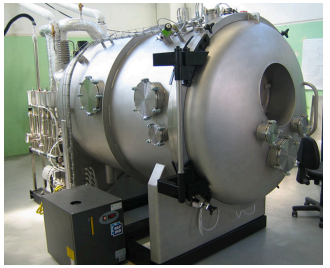
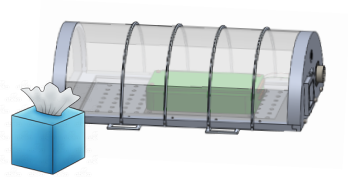
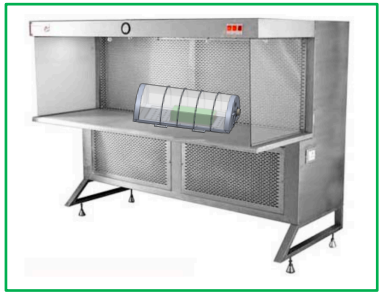


The GSB is moved inside the thermal vacuum chamber where the latch door of the GSB is opened for the volatiles to escape. Once it goes through the required CC and PP bake out, the latch door is closed and the GSB is moved out



Outside of the GSB is cleaned using IPA wipes inside the clean room airlock



The GSB gets moved to an aseptic clean room

Conclusion

- All the requirements for the GSB design were met.

Requirement	Met?	
The interior of the GSB shall maintain a cleanliness level equivalent to 300 spores/m^2 followed by a 4 order-of-magnitude microbial reduction process	✓	
The GSB shall comply with Mars 2020 project Contamination Control Plan	✓	
The GSB shall meet the Constraints for Biobarriers per NPR 8020.12D Appendix	✓	*
The GSB shall withstand temperature range of -50C to +125C	✓	
The GSB shall be compatible with four cycles of a VHP process using the standard NASA-approved protocol (providing 6 order-of-magnitude reduction)	✓	
The GSB shall withstand the dynamic loads specified in Project Environmental Requirements Document.	✓	*
The GSB shall meet the Project/JPL transportation and handling requirement	✓	
The GSB shall meet the Project ESD requirements	✓	

* Pending verification test

Pending Work

Pending Work Not Covered in This Study

- Detailed structural analysis to size the GSB parts and fastener selection
- Final material selection
- Finalize labyrinth seal design
- Leak test
- Details for motor to actuate the CC door
- Detailed design of fail/safe feature in case motor fails (this needs to be included in the package)
- Details of interface for VHP in/outlet
- Vibration testing of the design
- T-VAC testing
  - CC QCM, cold finger, and outgassing analysis included

Acknowledgement

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