LIRA SYSTEM OVERVIEW

Lunar Sample Box

Lunar Isolation and Return Assembly (LIRA)
Lunar Sample Box

Artemis III Lunar Sample Container System

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MISSION OBJECTIVE

The LIRA system provides two-layer sample containment for lunar EVA operations. The two part system provides an extra layer of protection in case one of the seals fails. This system maintains sample integrity during transport from the lunar surface to Earth.

SYSTEM ARCHITECTURE

Two-Part System

Collection Bag : Portable sealed container carried on astronaut waist during EVA - Holds one baseball-sized rock sample - Bayonet lock seal with elastic backup

Storage Box : Rover-mounted sealed container - Holds two bags (stacked vertically) - EPDM rubber seal with 4 clamps

Containment Chain

Surface → NASA tools pick up sample Sample → Placed in LIRA bag → Bayonet seal engaged Bag → Placed in LIRA box → Box clamps secured Box → Stored in habitat Box → Returned to Earth → Opened in LRL

The two part system provides an extra contamination barrier. Two layers better than one.

INTERFACES

AxEMU : Spacesuit Bag attaches to LEFT waist D-ring via carabiner - Design accounts for pressurized glove dexterity (15-20 lbs grip strength) - Bayonet lock sized for gloved operation

NASA Sampling Tools : Tongs (30 - 45 cm) or scoop used exclusively - Tools carried on RIGHT waist D-ring - Sample never touched by gloves

Rover : Platform Box mounts to rover - Platform must be level (within 5 degrees) - Box removed via paracord handle

Mission Control : Voice logs transmitted via AxEMU 4G/LTE - Sample tracking database maintained - Chain-of-custody recorded

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TECHNICAL SPECIFICATIONS

Collection Bag

Dimensions : Diameter: 115 mm - Height: ~300 mm

Materials : Outer: Nylon fabric - Middle: Merino wool (puncture resistance) - Inner: Stainless steel mesh - Seal: Rubber O-ring - Lid: 3D-printed bayonet lock (PLA)

Seal Mechanism : Bayonet J-lock (~25 degrees rotation) - O-ring compression (semi-hermetic)

Temperature Range : -40°F to +180°F (O-ring limit)

Reusability : 200-500 cycles (O-ring and bayonet mechanism limit)

Limitations : Nylon is flammable (not fire-resistant) - Wool absorbs moisture (dry environment only) - Poor petroleum resistance

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Storage Box

Dimensions : 15,24 cm W × 15,24 cm D × 30,48 cm H - Wall thickness: 0,1905 cm (14 gauge)

Materials : A569/A1011 Carbon Steel (ASTM A36) - Seal: EPDM foam - Cushioning: 3D-printed hexagonal tiles + steel wool - Handle: Kevlar-core paracord - Tether: 15 cm Kevlar lanyard (>100 lbs breaking strength)

Capacity : 2 bags stacked vertically (one on top of other)

Latching System : 4 compression clamps (stainless steel)

Temperature Range : EPDM seal: -40°F to +250°F (LIMITING COMPONENT) - Steel structure: -40°F to +540°F - System operational range: -40°F to +250°F

Reusability : 50-75 cycles (EPDM foam seal limit)

System Performance

Containment Type : Semi-hermetic (not gas-tight) - Prevents bulk regolith entry - Allows slow gas permeation over time

Sample Constraints : Maximum size: 3 inches diameter - Maximum per box: 2 samples (separate bags, stacked)

OPERATIONAL PROCEDURES

Pre-EVA Preparation (Habitat)

Teflon seal films removed (bare hands, before EVA) - O-rings and EPDM foam inspected - Bayonet mechanism tested (full 25 degree rotation) - Tethers inspected (no fraying) - All 4 clamps tested with double welding gauntlets

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Sample Collection

1. **Sample Identification** : Astronaut identifies sample (≤3 inches diameter) - Assesses terrain and work position
2. **Bag Opening :** Bag detached from LEFT waist D-ring : Bayonet lid rotated 25° counterclockwise - Lid released - Hangs on
3. **Sample Collection :** (CRITICAL: No Glove Contact) NASA tongs or scoop retrieved from RIGHT waist - Sample gripped with tool only - Sample lowered into bag - Tool withdrawn without touching seal area
4. **Bag Sealing** : Tethered lid retrieved - Lid aligned and pressed down - Rotated 25° clockwise (feel engagement click) - Visual verification (attempt to lift lid - should not move)
5. **Voice Logging :** "Sample [NUMBER] sealed in bag [ID]" - Transmitted to Mission Control via 4G/LTE
6. **Return to Rover :** Bag reattached to LEFT waist D-ring - Astronaut traverses to rover

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Sample Storage

1. **Box Opening :** 4 clamps released in opposing pairs: Clamp 1 (Front-Left) → Clamp 3 (Rear-Right) Clamp 2 (Front-Right) → Clamp 4 (Rear-Left) - Opposing sequence prevents seal warping
2. **Lid Placement :** Lid lifted via paracord handle - Hangs on 15 cm tether - Placed inverted on rover platform (seal-side up)
3. **Bag Insertion** (VERTICAL STACKING) - First bag: Placed on bottom Positioned upright Cushioning separator placed on top - Second bag: Lowered onto separator Stacked vertically on first bag Both bags upright
4. **Box Sealing** : EPDM seal inspected (visual only, no touching) - If dust present: Brush with glove edge, outward motion - Lid replaced (level, even contact) - 4 clamps secured in opposing pairs (same sequence as opening) - Visual verification (lid flush, no gaps)
5. **Voice Logging** : "Box [ID] sealed, [1 or 2] bags stored"

Post-EVA Handling

Transport : Boxes carried via paracord handles - Maintained vertical (6×6 base down)

Storage : Boxes stored vertically in habitat - Maintained at 65-75°F - Not opened until Earth return (LRL processing)

DESIGN TRADE-OFFS AND LIMITATIONS

Material Choices

Steel vs Aluminum/Titanium Choice: Carbon steel (A569/A1011) Weight: 6-8 lbs (1.8-2.9× heavier than aerospace alloys) - Why: Machinable, cost effective - Trade-off: Heavier but manufacturable with available tools

EPDM vs Indium Blade Seal Choice: EPDM foam Lifespan: 50-75 cycles (vs 100+ for Viton) - Why: Cost $5-15 vs $20-50, available in standard sizes - Trade-off: Shorter life but sufficient for mission profile - Limitation: EPDM is system limiting component for actual hermetic seal

Nylon vs Fire-Resistant Fabric Choice: Nylon outer layer - Limitation: Melts at 420°F (not fire-resistant) - Why: Available, lightweight, cost effective - Trade-off: Must keep away from heat sources

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Containment Performance

Semi-Hermetic vs Hermetic Choice: Semi-hermetic seals (O-ring and EPDM foam) - Function: Prevents water entry, allows slow gas permeation - Limitation: Not suitable for lunar sample return (requires hermetic)

Reusability Limits

EPDM Seal: 50-75 cycles - O-ring: 200-500 cycles - Bayonet: 200-500 cycles - Clamps: 200+ cycles

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Operational Constraints

Sample size: Maximum 3 inches diameter Box capacity: 2 samples (in separate bags) Temperature: -40°F to +250°F (EPDM limit) Environment: Lunar vacuum and regolith dust Gravity: Designed for 1/6 Earth gravity

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EMERGENCY PROCEDURES AND SAFETY

Emergency Scenarios

- **Bayonet Lock Failure :** Engage backup elastic strap closure - Mark bag as compromised - Continue mission (elastic provides containment)
- **Oversized Sample :** Remove sample using NASA tools - Return to surface at collection location - Select smaller alternative (≤3 inches)
- **Clamp Failure** : (One of Four) Use remaining 3 clamps in modified opposing pattern - Verify seal integrity visually - Mark box at failed clamp location
- **Seal Damage** : Assess severity (minor dust vs major tears) - Seal to best of ability - Mark container "SEAL COMPROMISED" - Continue mission (partial containment better than total loss)
- **Tether Failure :** Hold lid carefully (do not let contact lunar surface) - Complete sealing procedure - Secure loose component

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Safety Philosophy

No Direct Glove-to-Sample Contact : NASA tools used exclusively - Sample never touched by gloves - Tool does not contact bag seal surfaces

Visual Inspection Only : Seals never touched with gloves - Dust brushed with glove edge (outward motion) - No grinding particles into seals

Buddy Verification : Partner confirms bayonet lock engagement - Partner verifies all 4 clamps latched - Second set of eyes on seal integrity

Redundant Closures : Box is primary seal, Bayonet lock on bag assembly is backup seal - If Box fails, Bayonet lock on bag assembly provides containment

Partial Containment Preferred : Compromised seal better than no seal - Damaged container better than lost sample - Continue mission, mark clearly, report to Mission Control

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PROJECT STATUS AND DOCUMENTATION

HUNCH Project Scope

LIRA Delivers: Collection bag with sealing mechanism - Storage box with clamps and Bag assembly - Integration with AxEMU suit and rover

NASA Provides: Sampling tools (tongs, scoops) - Sample tracking systems - Tool carriers and mounting hardware - Mission planning

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Testing Completed

Water Submersion Test : Box submerged to verify seal integrity - Video documentation available via QR code

Prototype Validation : Physical mockup demonstrates bayonet lock operation with gloves - Two bags stacking vertically in box - Clamp operation and opposing sequence - Tether function and length

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Design Iterations

Version 1.0: Initial cardboard mockup

Version 2.0: Two-part system established

Version 3.0: AxEMU integration

Supporting Documentation

Comprehensive Protocol : Complete operational procedures - Detailed emergency scenarios - AxEMU compatibility analysis - Material comparison tables - Maintenance schedules

Test Videos : Water submersion seal test - Bayonet lock operation demonstration

All documentation accessible via QR code.

Team and Timeline

Design Team : Logan Allen - Nick Basi - Orhan Ozdemir

KEY TAKEAWAYS

Problem: Lunar sample contamination from various reasons.

Solution: Two-layer containment with NASA tool interface

Hardware: Collection bag (portable) + Storage box (rover-mounted)

Innovation: Separation of handling and containment with two part system

Performance: Semi-hermetic seals, -40°F to +250°F, 50-75 cycle life

Trade-offs: Steel is heavier but manufacturable, EPDM is shorter-lived but cost-effective

Safety: Redundant closures, buddy verification, partial containment > sample loss

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For complete technical documentation and operational procedures refer to the LIRA Operational Protocol

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END OF DOCUMENT