The Design of a Suitport Logistics Carrier
University of Maryland

Mission Statement
Create a suitport compatible logistics carrier to enable the transfer of pressurized and temperature sensitive goods between a lunar lander and a surface habitat with the assistance of NASA’s lunar rover.

Technical Approach
We propose a design using 8 suitport logistics carriers that greatly reduces human interaction throughout the transport process. The carriers will be lowered from the lunar lander using a davit and placed into the trailer using a robot arm. The trailer will be towed by NASA’s lunar rover for transport to the habitat. Once at the habitat, the trailer’s robot arm will grasp each carrier and connect it to the suitport for unloading. Once the carriers are no longer in use, they will be filled with waste and transported on the trailer for disposal.

Structures & Mechanisms
- Designed 7 standard SPLCs and 1 gas SPLC to maximize logistical efficiency
- Standard SPLC: mass of 39.6 kg, volume of 0.386 m³
- Gas SPLC: mass of 196.6 kg, volume of 0.368 m³
- The standard SPLC transfer container design includes half CTBs, triple CTBs, custom quarter CTBs, and custom CWCs to be held in the end caps
- The layout of the trailer was motivated by the optimal region of manipulability for the robot arm, which is a toroid with an outer radius of approximately 2m
- Terramechanics analysis showed the trailer resistance is larger than the lunar traction force, so the trailer will include grousers and powered rear wheels
- The carriers will be fixed at the handles during launch

Power, Thermal, & Avionics
- Thermal analysis conducted at the south pole and equator during day and night
- By coating the trailer in white paint, a minimal amount of heat transfer is expected
- Most extreme power required for heat gain is during the lunar night at south pole (1.33W per standard SPLC, 1.69W per gas SPLC)
- Patch heater design allows for heat to spread evenly throughout the SPLC internals
- Battery supplies power required during nighttime and solar array provides power required during daytime and charges the battery (power system mass is 287.4 kg)
- Required power during nominal operations (without robot arm usage) is 120.9 W
- Inductive charging between the trailer and carriers eliminates dust contamination and allows for thermal regulation of the SPLCs throughout transport
- Wireless comms system leverages LunaNet to transfer the SPLC monitoring data
- Robotic arm to maneuver the carriers reduces the need for human interaction
- Exploring options for both autonomous and teleoperated control of the robot arm.
- Current implementation allows teleoperation from inside habitat and during EVA.

Mission Plan & Budget
- The SPLC design must be able to hold at least 600 kg of dry goods, 250 kg of water, 50kg of O₂, and 40kg of N₂
- Each lunar lander must have no more than 1800 kg
- The total mass of all SPLCs and their payload must be no greater than 1600 kg per mission
- Mission #1 will carry the trailer, power system, avionics, 1 standard SPLC, 1 gas SPLC, and the davit
- Mission #2 will carry the remaining 6 standard SPLCs and the davit

Underwater Testing
- No more than two astronauts must be able to carry and move the SPLCs if the automated systems malfunction
- Three dive tests were conducted at the Neutral Buoyancy Research Facility (NBRF) at the University of Maryland (UMD) Space Systems Lab (SSL)
- Dive test #1 consisted of divers transporting a single 27-gallon container on their own and with a partner
- Dive test #2 consisted of divers weighted to lunar gravity transporting different configurations of 27-gallon containers to determine the SPLC mass limit. We concluded that 4 SPLCs was the limit.
- Dive test #3 determined the capability of loading and unloading CTBs in different configurations and ensured the astronauts would have the dexterity needed to connect the SPLC to the suitport

Robotic Arm & Crane Testing
- The team designed a 50% scale hardware mockup using the previous 6 SPLC configuration to test the feasibility of completing the CONOPS without any direct human interaction
- This hardware mockup included the lab’s crane equipped with a semi-permanent magnet, a trailer, 6 SPLCs, the NBV robot arm with a 3D printed grapple fixture, and a pneumatically actuated suitport interface
- The robot arm was teleoperated using pre-planned trajectories and cartesian velocity control through joysticks to complete the maneuvers
- This testing proved that our system’s CONOPS can be completed without any direct human interaction and the robot arm provides the dexterity needed to grapple the SPLC and attach it to the suitport

Mission Plan & Budget

<table>
<thead>
<tr>
<th>Mission #</th>
<th>Mass (kg)</th>
<th>Allotted Mass (kg)</th>
<th>Margin (%)</th>
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<tr>
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<td>1800</td>
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- Recognizing recurring and nonrecurring costs, the cost estimate is $678 (M)

Dive Test #2 Results Expanded
Two divers could not adequately carry and maneuver more than three 27-gallon containers, which is equivalent to: 4 SPLCs = 306 kg each = 112 lbs each