



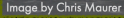
# MYCOTECTURE OFF PLANET: EN ROUTE TO THE MOON AND MARS

★ Why? Because humans need habitats for protection, especially off planet. Traditional approaches: Bring them (e.g., spacecraft or massive 29k kg habitat for nominal Mars. New approaches use in situ resource utilization (ISRU): robotic construction of regolith or ice houses rely on intense construction operation; pros and cons of materials (Tables 1).

- ★ **How?** We propose using mycolecture; fabrication based on fungal mycelia to grow structures (table, chair, rover shell, garage) AND habitats. Currently being explored in "green architecture" because low mass, inexpensive, psychological benefits of natural materials, adaptable to site at destination, potentially self-healing, multiple uses, sustainable, compostable. Many of same benefits off planet.

	Rigid Monomers	Inflexible / degradable modules	Roughly 20 printing possibilities	Regulating factor remaining	Low substrates	Materials in use	Growing interest
Interactions / Examples	<ul style="list-style-type: none"><li>Desamido polyamides</li><li>Desamido polyurethanes</li><li>Desamido polyesters</li><li>Desamido polyethers</li></ul>	<ul style="list-style-type: none"><li>Polycaprolactone</li><li>Polylactide</li><li>Polycarbonate</li><li>Polycarbonate</li></ul>	<ul style="list-style-type: none"><li>Polycaprolactone</li><li>Polylactide</li><li>Polycarbonate</li><li>Polycarbonate</li></ul>	<ul style="list-style-type: none"><li>Polycaprolactone</li><li>Polylactide</li><li>Polycarbonate</li><li>Polycarbonate</li></ul>	<ul style="list-style-type: none"><li>Polycaprolactone</li><li>Polylactide</li><li>Polycarbonate</li><li>Polycarbonate</li></ul>	<ul style="list-style-type: none"><li>Polycaprolactone</li><li>Polylactide</li><li>Polycarbonate</li><li>Polycarbonate</li></ul>	<ul style="list-style-type: none"><li>Polycaprolactone</li><li>Polylactide</li><li>Polycarbonate</li><li>Polycarbonate</li></ul>
Stress	very high	medium	medium	medium	medium	high	low
Force for construction	medium	small	high	medium	high	high	medium
Flexibility / Creep behavior	small	small	medium	medium	small	high	high
Adaptivity in construction	none	small	small	small	small	none	medium
Infrastructure preparation	medium	medium	high	high	high	high	medium
Production protection	low	low	high	high	high	high	medium
Stability	high	medium	medium	low	low	low	medium
Availability on Earth	high	high	medium	low	low	medium	medium

## The vision



Lynn J. Rothschild, NASA Ames Research Center, PI  
Chris Maurer, redhouse studios (architect)  
James W. Head III, Brown University (mission planning)  
Rolando Perez, Ginger Buck, Kiran Mahurkar, Blue Marble Space Institute of Science (mycology/symbio)  
Jessica Snyder, Blue Marble Space Institute of Science (engineering, payload)  
Debbie Senesky, Evan Isbell, Kat Kornegay, Stanford University (material testing)  
Monika Lipińska, University of Newcastle (architect); Liquifier  
Maikel Rheintsdörfer, Hannah Krivic, McMaster University (planetary simulator)  
Radames J.B. Cordero, Melatech (melanin)  
David Cadogan, President Moonprint Solutions (inflatables)  
Alan Cassell, Rachel Ticknor, NASA Ames Research Center (payload design)  
Philippe Amstislavski, University of Alaska (mycelial foams)

- ★ Purpose: Continue focus on ultimate goal of habitats on Mars.
- ★ This proposal: Plan Hadley Max 500 day DRMs to mimic mars long stay.
- ★ Combine Brown University science, engineering and Apollo expertise to design traverse and plan integration of mycotecture.
- ★ Accomplishments year 1:
  - ✓ Regional Geologic Map Published.
  - ✓ Regions of Geologic Interest (ROI) defined.
  - ✓ Mission Architecture Requirements Defined (Initial Base, Evolutionary Base, Remote Science Bases, 'Pony Express' Stations, Lava Tube Environments, etc.). Used to define specific inflatable designs. Redhouse has created the architectural concepts
  - Upmass Problem Resolved using Mycoarchitecture and Inflatable Structures.
  - Feed-forward to Mars!!
  - Almost 20 abstracts, presentations by students at LPSC. Five Papers in Final Draft form.

- ★ Purpose: Initial tests of mycotecture on the lunar surface.
- ★ This proposal: prepare for a lunar payload
- ★ Combine science and engineering desires with expertise of NASA Ames Mission Design Center.
- ★ Accomplishments year 1:
  - ✓ Starship hosted payload workshop at NASA Ames. Internal proposals submitted. Results: Mycotecture not well suited as an early mission payload. Will revisit for later mission opportunities that can host more complex payloads
  - ✓ ROSES-25 PRISM call: Planning a payload for a CLPS lunar surface experiment investigating the growth of NIAC Black in the Lunar environment. Science requirements being defined.

# Starlab



- ★ Purpose: Initial tests of mycotecture in LEO aboard commercial space station.
- ★ This proposal: prepare to produce paneling, prototype to specs, possibly include furniture
- ★ Leverage science and engineering expertise of this team with needs of Starlab to design structures and help raise funding to have this integrated.
- ★ Accomplishments year 1:
  - ✓ Multiple interactions with OSU Starlab team including invited presentation at the 3rd Workshop for Commercialization of Research in Low-Earth Orbit April 23-24, 2025
  - ✓ Dedicated meeting with Larry Traxler, VP Hilton as well as Liquifer on designs for crew living quarter; Redhouse produced multiple designs for crew quarters
  - ✓ Key takeaway: if materials are to be used in space station, they must be flight qualified. New major focus is flammability and outgassing testing to meet standards. Preliminary lab tests; flight certification tests planned for year 2. Much interest in designs and panelling if we can flight qualify.
  - ✓ Initiated discussions with Vast as well for integration into Havens

- ★ Purpose: continue to develop technology
- ★ This proposal: - fungal strain, radiation exposure, material testing, etc.
- ★ Leverage science and engineering expertise of this team with needs of Starlab and lunar payload to design, build and test prototype structures
- ★ Accomplishments year 1:

- Key note of melanin-pigmented public publication Cordero, Mauer, Rothschild, ... 2025: Radiation Protection and Structural Stability of Fungal Melanin Poly(lactic Acid) Biocomposites in Low Earth Orbit. NASA 1922 [18] <https://doi.org/10.2471/18122>, follow up experiment at Brookhaven National Lab scheduled for October 2025. Both redhouse and NASA Ames teams are developing melanin-infused composites and aerogels for testing insulation and radiation attenuation for Starlab/space station and Moon/Mars applications.
- NASA Ames: Preparing coupons for flammability and off-gassing testing at White Sands Test Facility, Developing superior self-extinguishing materials. Producing test coupons for radiation shielding testing at NASA Space Radiation Laboratory at Brookhaven National Lab. Developing alternate rapid growth protocols
- ✓ Testing multiple composites and hydrogel approaches for strength, flexibility, radiation resistance, planetary conditions, and initial tests of flammability.
  - ✓ Planetary simulator environmental testing of mycofoam samples (made in Alaska) under various conditions: 1) Cold (-20 °C) and 2) warm (+30 °C) lunar conditions with UVABC, 3) ISS conditions (21 °C, white light), and 4) extreme cold (liquid N<sub>2</sub>). Both living (rehydrated) and non-living (dried) samples were treated and imaged under the microscope before being sent to Stanford for further mechanical testing. Continue to test melanin degradation in UV.
  - ✓ Stanford: stress strain tests (compressive strength and elastic modulus),
  - ✓ Moonprint developing inflatable: Developing inflatable system for mycelium growth; Baseline material layup based on proven space systems; Prototype program in process to demonstrate system functionality.
  - ✓ Addition of Prof. Philippe Amatslavski who brought in mycelial foam work for insulation.

- ✓ Rothschild presented to Congress or request of National Security Commission on Emerging Biotechnology (April 2025)
- ✓ Rothschild keynote speaker at "Biomaterials", California College of the Arts (Feb), ASM (June), Gordon Conference (July) and inaugural UK ARBIA symposium (London May 2025)
- ✓ Head presented to NAS-NRC "Key Non-Polar Destinations Across the Moon to Address Decadal-level Science Objectives with Human Explorers: Panel on Human and Biological Science" (Aug 2025)
- ✓ Supported media requests including filming NHK "Human Journey" Episode: "Journey to the Moon and Mars" and podcast "The future is fungi"
- ✓ Supported Museum of Science and Industry/NIAC "From Science Fiction to Science Fact", July 2025
- ✓ redhouse built world's first free standing mycelium structure as "NASA Spinoff" MycoHab.
- ✓ Upcoming: Present at Hermes "Innovation Day" (Paris Sept 2025)
- ✓ Student involvement: NASA Brown, Stanford, Ohio State

# Earth

