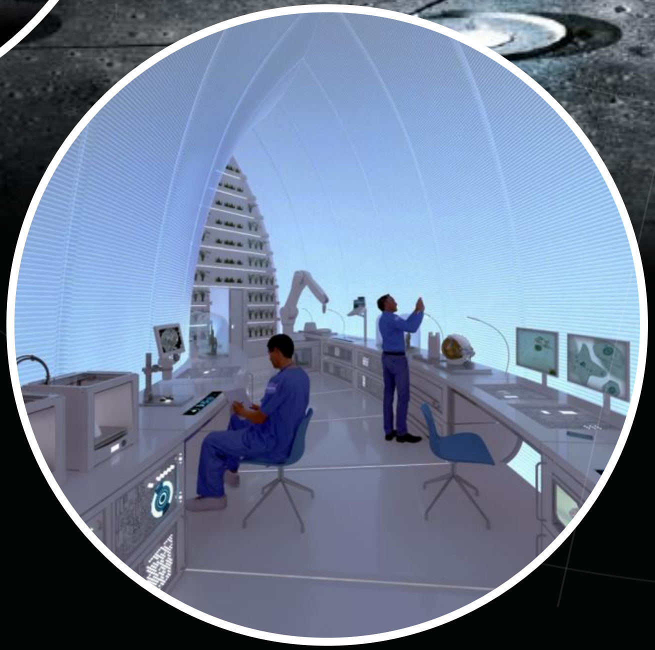
Outfitting

"Converting structural systems into useable systems"



Fully outfitted buildings to support a permanent lunar settlement and vibrant space economy

Outfitting

Draft definition

The process by which a structural system is transformed into a useable system by in-situ installation of subsystems as well as the associated planning and preparation required for this process. Note the structural system can be enclosed, open, submerged or subsurface. To the extent reasonable, these subsystems can be preintegrated into modules and the modules assembled or can be integrated into the structure during the construction process. A fundamental attribute of outfitting is assembly. Thus, outfitting is distinct from deployment because deployment does not require assembly. To the extent reasonable outfitting can be accomplished autonomously, however the specific agents (robotic or human) performing the outfitting are part of the co-design of the overall system .

Steps in the process include planning for and installing: wiring, insulation, lighting, gas or fluid lines (Environmental Control & Life Support System (ECLSS), water, hydraulics, coolants, etc.), elevators & cranes (lifting aids), furniture, etc.

Outfitting

Top Priority Gaps

- **Conductor/Cable and Piping/Tubing (coolant, gasses, hydraulics, etc.) line management and interfaces**
  - Installing, securing, strain-relief, splicing/connecting, CTE management, disconnect, micrometer protection, radiation.
  - Coolant lines: joining, testing, repair (when wet), spill management
  - Why: Common problem across broad class of applications (electrical, fiber, fluids, gases, etc) with different (size, stiffness, bend radius) combinations. Similar approaches can likely be applied to conductors and tubing, but conductors will have unique interference susceptibility that must be managed, tubing may have unique heat transfer and CTE responses that must be managed.

- **Penetration management**
  - Through pressure vessels (Habitats, tanks, etc.)
  - During 3D construction and installation for utilities
  - Why: In overall pressure vessel design, penetrations are a critical requirement but introduce discontinuities resulting in high failure rates in the vicinity of the penetration (i.e. this is the weak point). With planned penetrations, pulling cabling & tubing through what maybe long runs is challenging. Likely also need method to create penetration in situ for unexpected situations, expansion and evolution. In addition, subsequent sealing and validation in-situ is a critical gap.

LSIC Annual Goal

Lunar Infrastructure Repair and Outfitting

A lunar base will inevitably require capabilities in the areas of field repair, in-situ-fabrication of small parts and **outfitting**. We will initiate the development of a roadmap .

Areas of investigation:

- A base will need spare parts. What kind of spare parts are needed / maybe needed?
- What kind of parts are beneficial to be manufactured on lunar surface as opposed to sending from earth?
- What kind of **outfitting inventory** is needed for habitats and landing pad?
- Investigate the use of special purpose robots and their autonomous operation.
- What kind of in-situ fabrication and repair technologies are feasible and necessary?
- Create an industry-government eco-system in this area. A supply-chain framework?
- Propose CLPS activities.

LSIC Annual Goal

Lunar Infrastructure Repair and Outfitting

What are the next steps?

- Define specific concepts (DRM) that will need outfitting and repair and ConOps
  - Landing pads – power, fluid transfer, navigation aids
  - Shelters – power/data cables, fluid transfer
  - Habitats and pressurized structures – power/data cables, fluid transfer, ECLSS, penetrations (windows, hatches, utility pass-thrus)

- Focus on Outfitting – ISM and spares used to support Outfitting and Repair