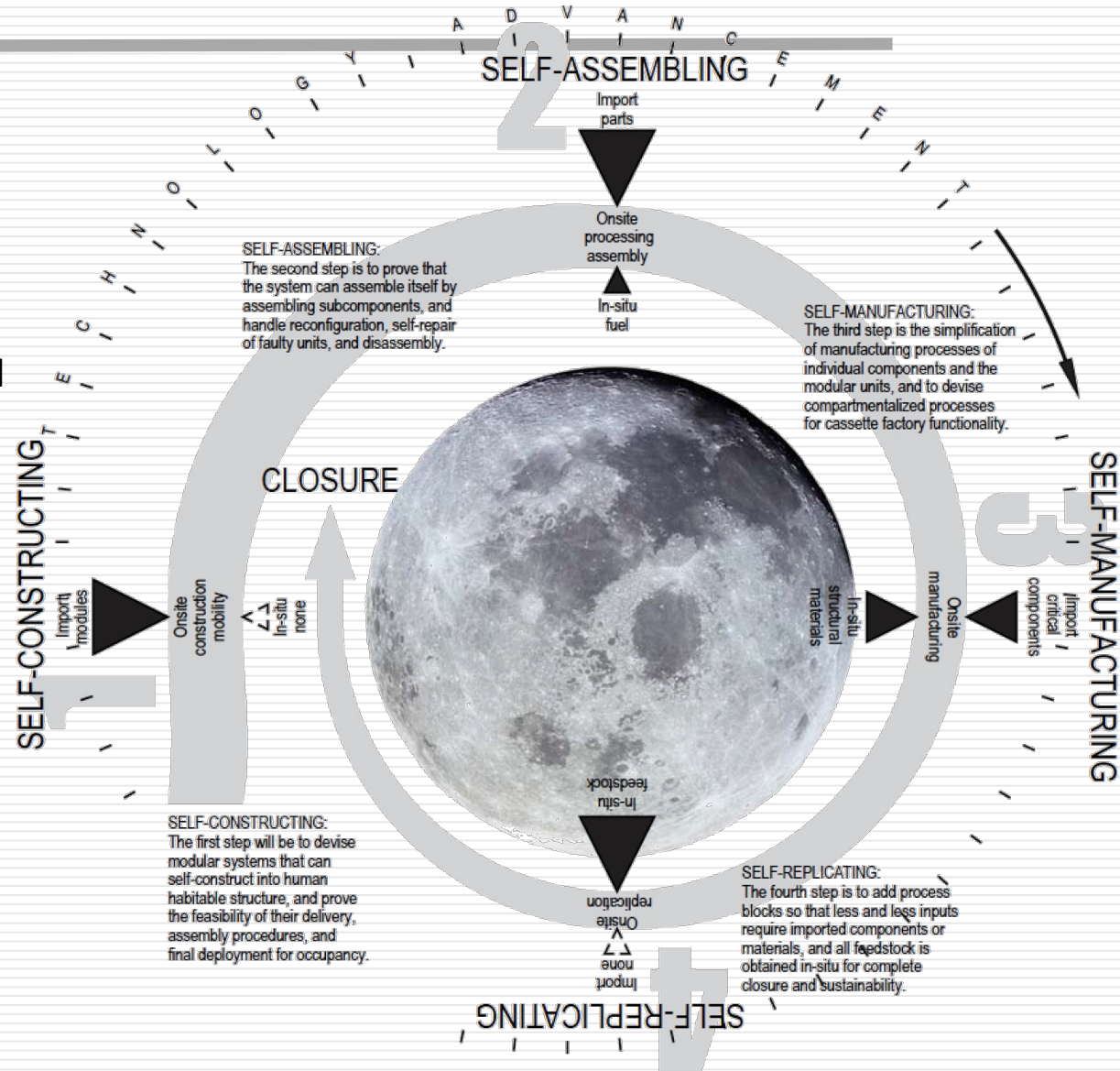
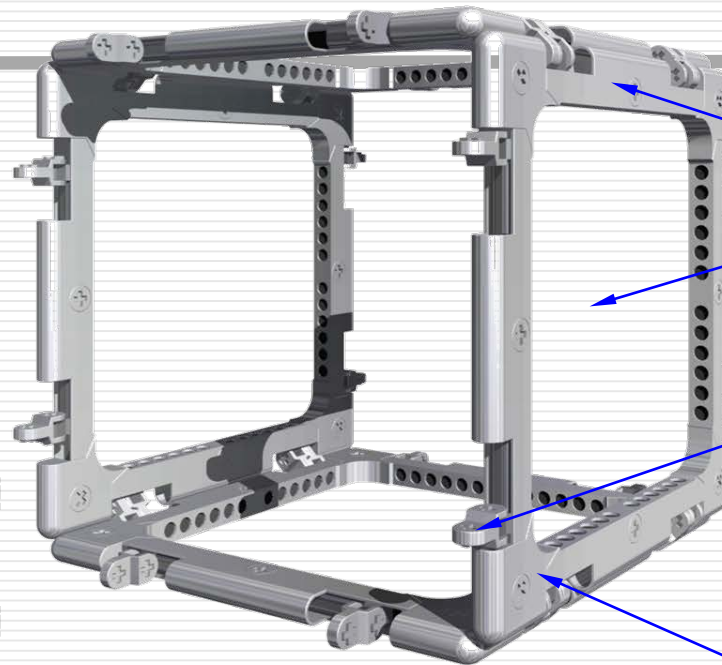
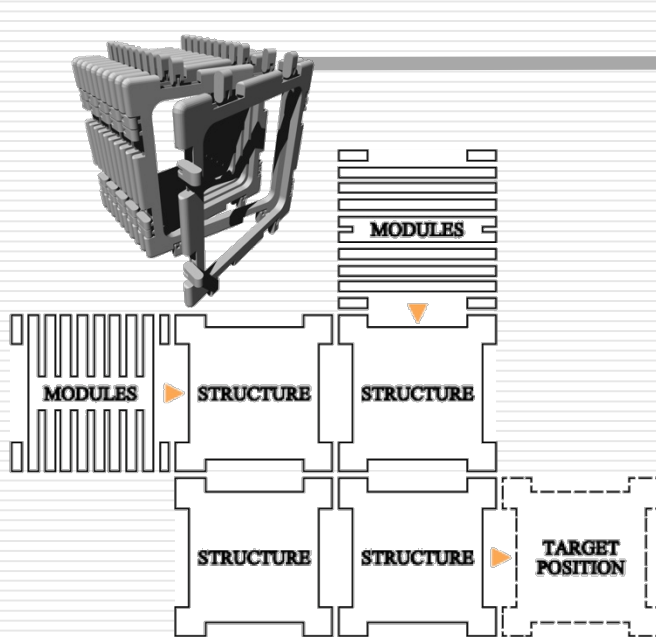
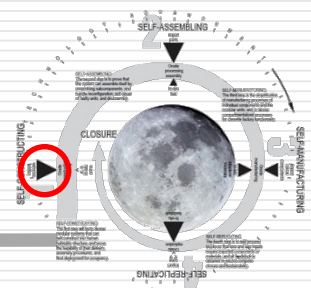


Future Directions: Toward Self-replication?

- Gradual approach to implementation – start right now
- Self-constructing
 - Low-fidelity additive construction
 - Manufacture of limited parts
- Self-assembling
 - Robotic self-assembly
 - Additional additive manufacturing
- Self-Manufacturing
 - Imported “vitamin parts”
- Self-Replicating
 - Fully closed
 - May never need to get here, just get close



Future Directions: Self-constructing



Actuated robotic panel

Gap for payloads

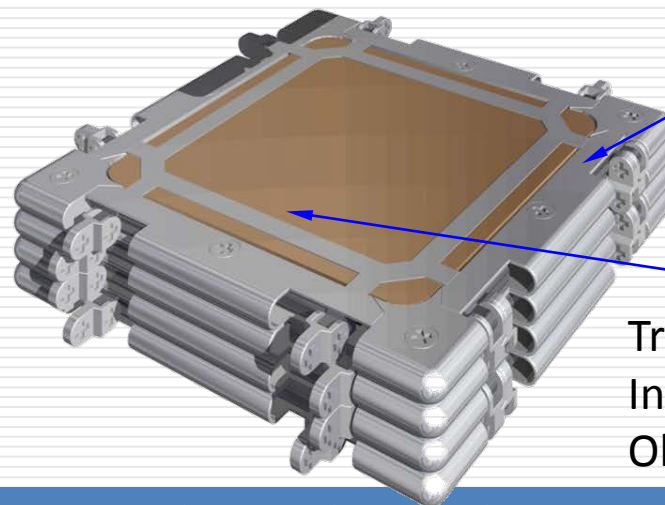
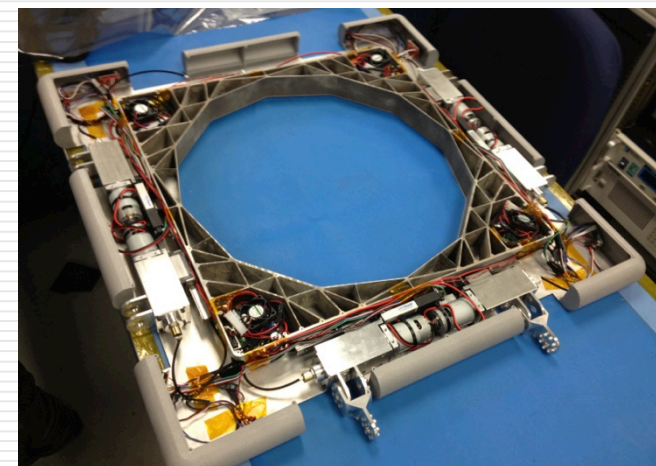
Edge actuators connect power and data in a distributed system

Deployed structure

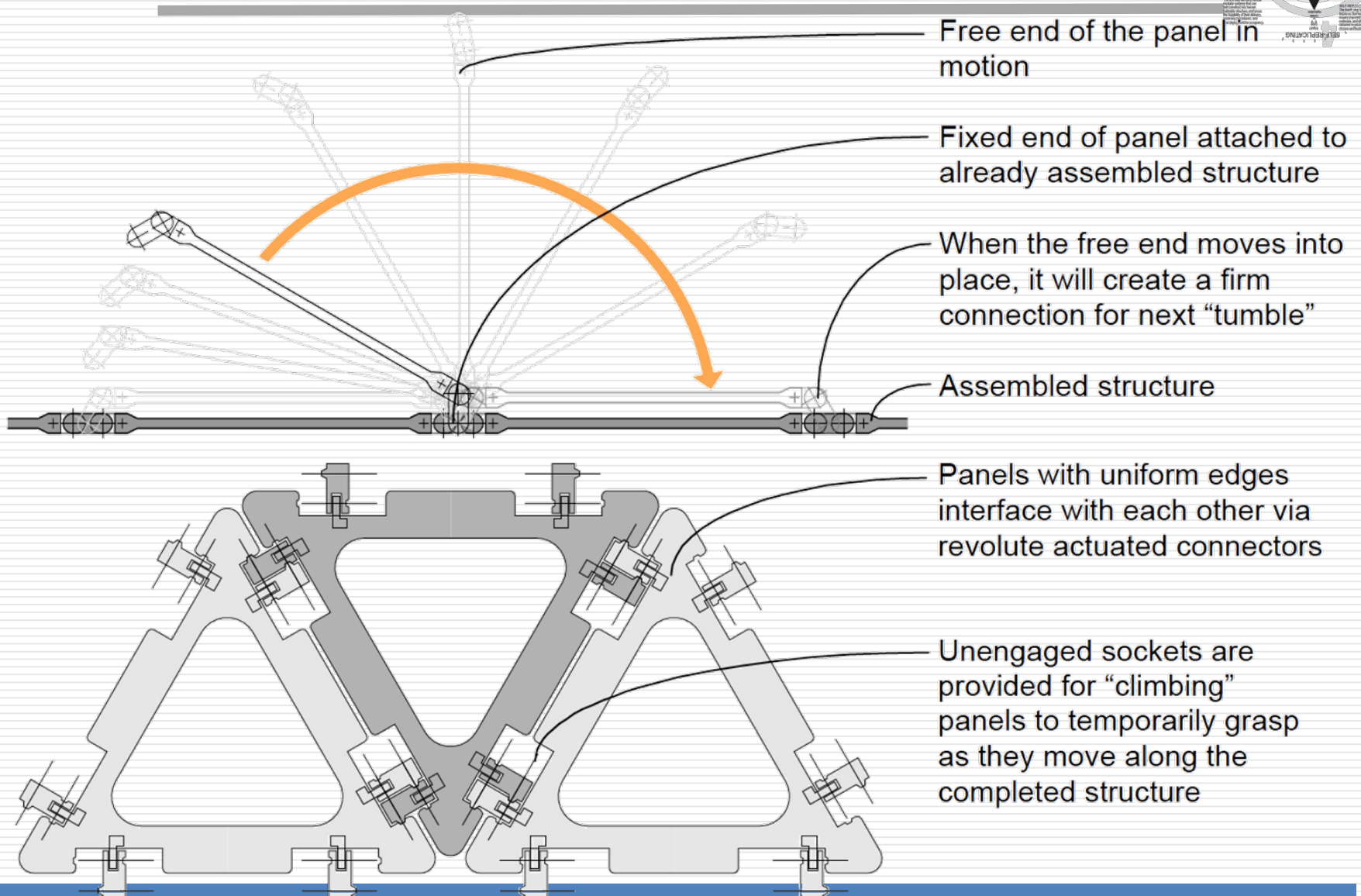
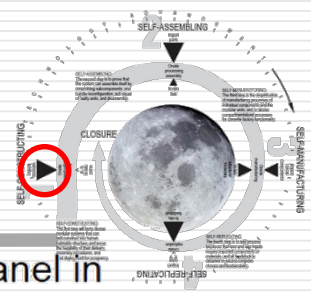
Folded structure (reconfigurable on demand)

Payloads

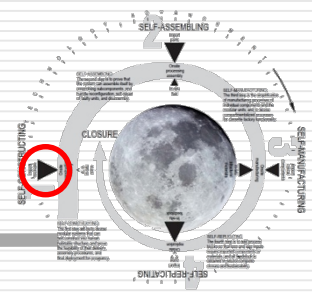
Transformable Robotic Infrastructure-Generating Object Network (TRIGON)



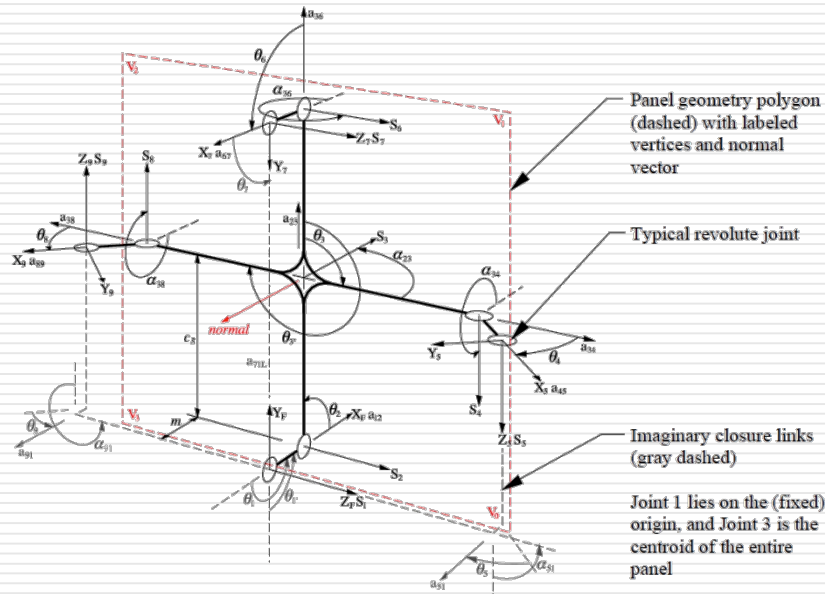
Future Directions: Self-constructing



Future Directions: Self-constructing



- Fully equation-based
- Parametric sizing
- Kinematics / inverse kinematics



c_s = distance to centroid, m = connector manipulator arm length

$\theta_1 = 270 - \theta_2$, $\theta_5 = 90 - \theta_4$, $\theta_7 = 720 - \theta_1 - \theta_2 - \theta_6$,

$\theta_9 = 90 - \theta_8$

$a_{s1} = -a_{12} \sin \theta_2 + a_{45} \sin \theta_4$, $a_{91} = -a_{12} \sin \theta_2 + a_{89} \sin \theta_8$

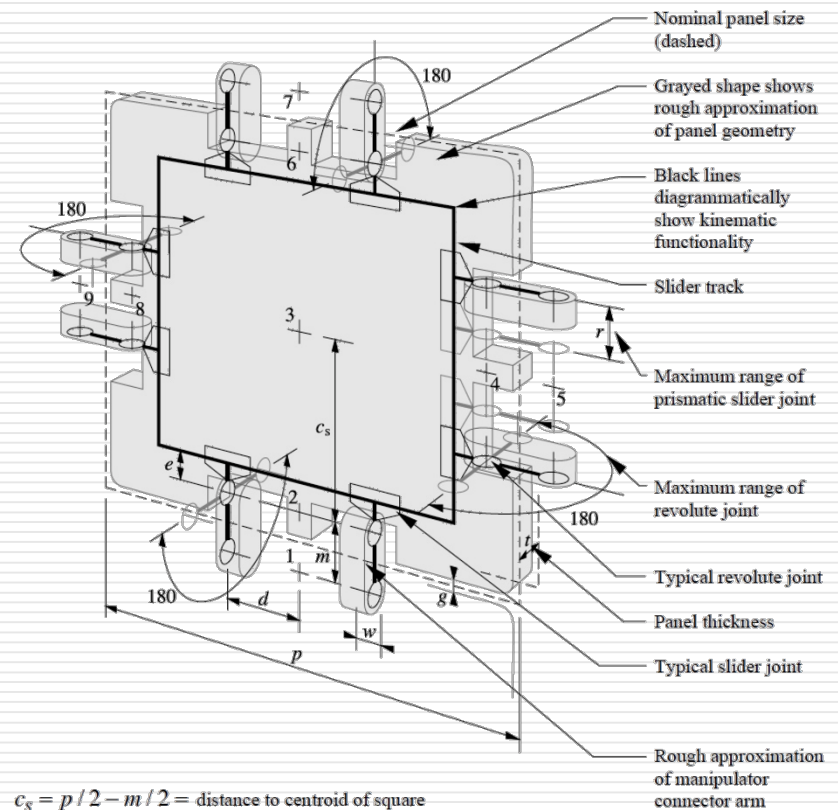
$a_{71} = \sqrt{(a_{12} \sin \theta_2 - a_{67} \sin \theta_6)^2 + (a_{12} \cos \theta_2 + 2c_s + a_{67} \cos \theta_6)^2}$

$S_1 = c_s + a_{45} \cos \theta_4$, $S_{1^*} = c_s + a_{89} \cos \theta_8$, $S_5 = S_9 = c_s + a_{12} \cos \theta_2$

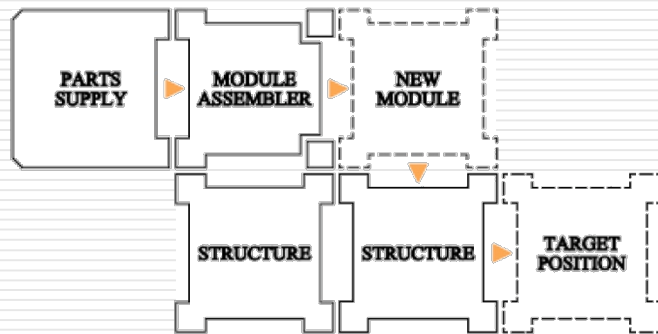
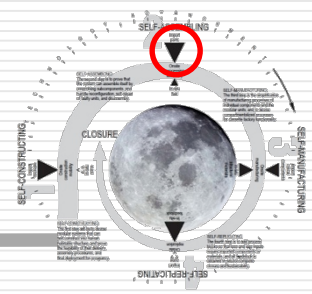
$L = 5$ = links

$J_1 = 4$ = 1DOF jnts

Total DOF = 4



Future Directions: Self-assembling

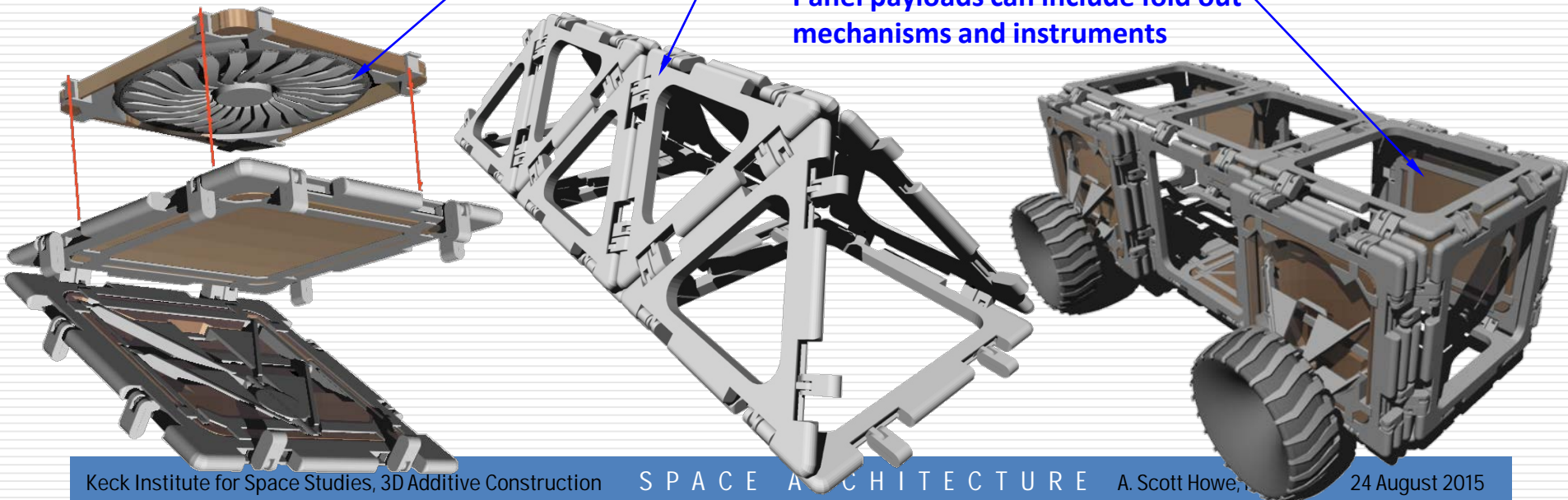


Vitamin Parts: difficult-to-manufacture parts imported from Earth

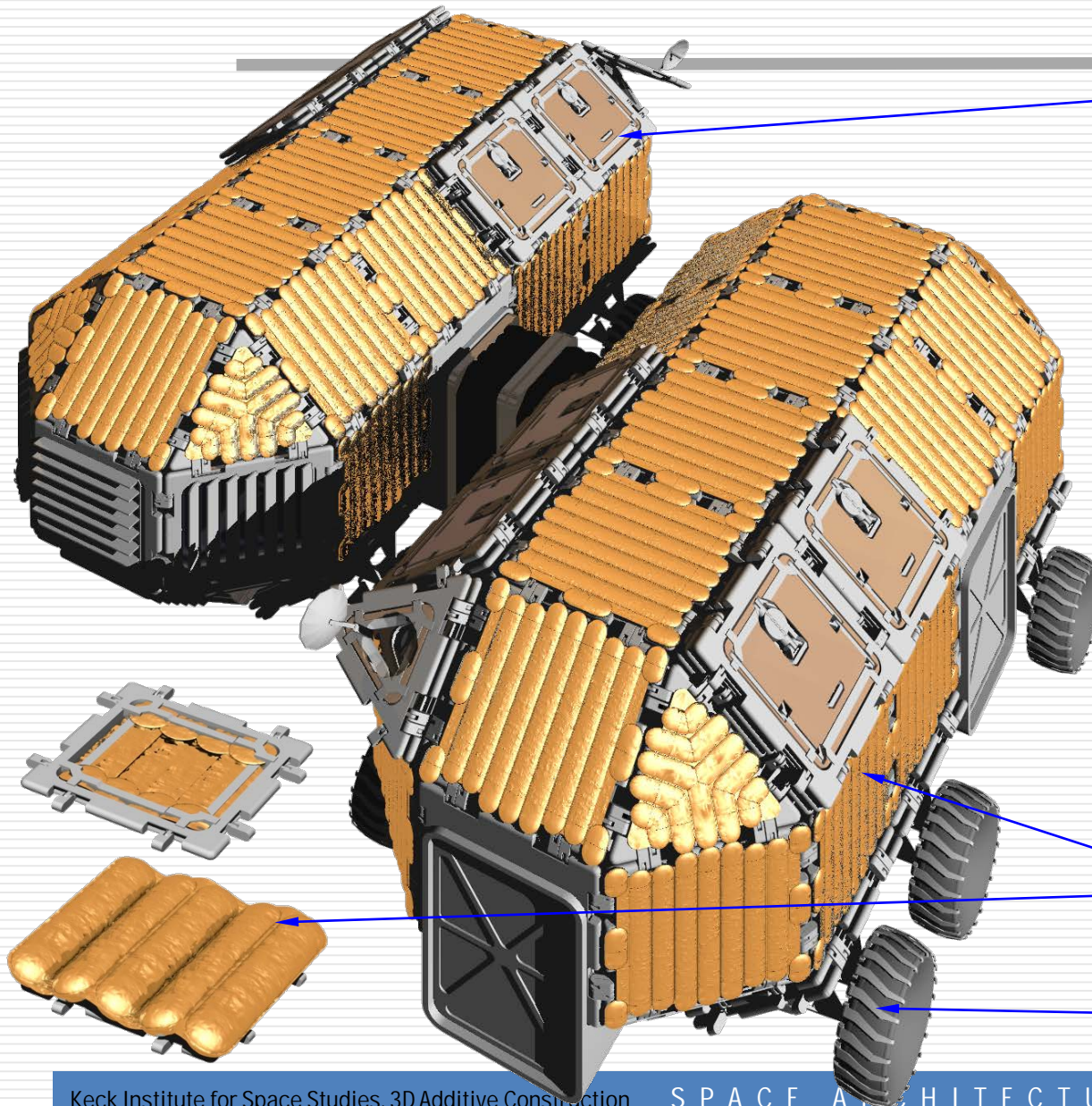
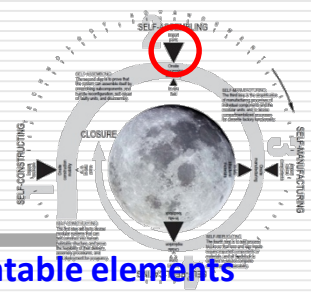
Panels with mechatronics in edges can carry payload in center

Square and triangle panels can be reconfigured on demand into trusses, cylinders, domes, cubes, vaults, and platforms

Panel payloads can include fold out mechanisms and instruments

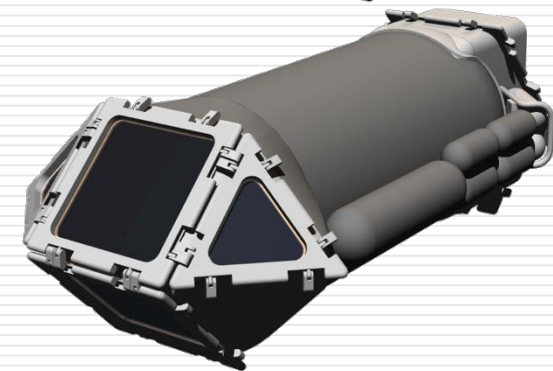


Future Directions: Self-assembling



Modular printable elements

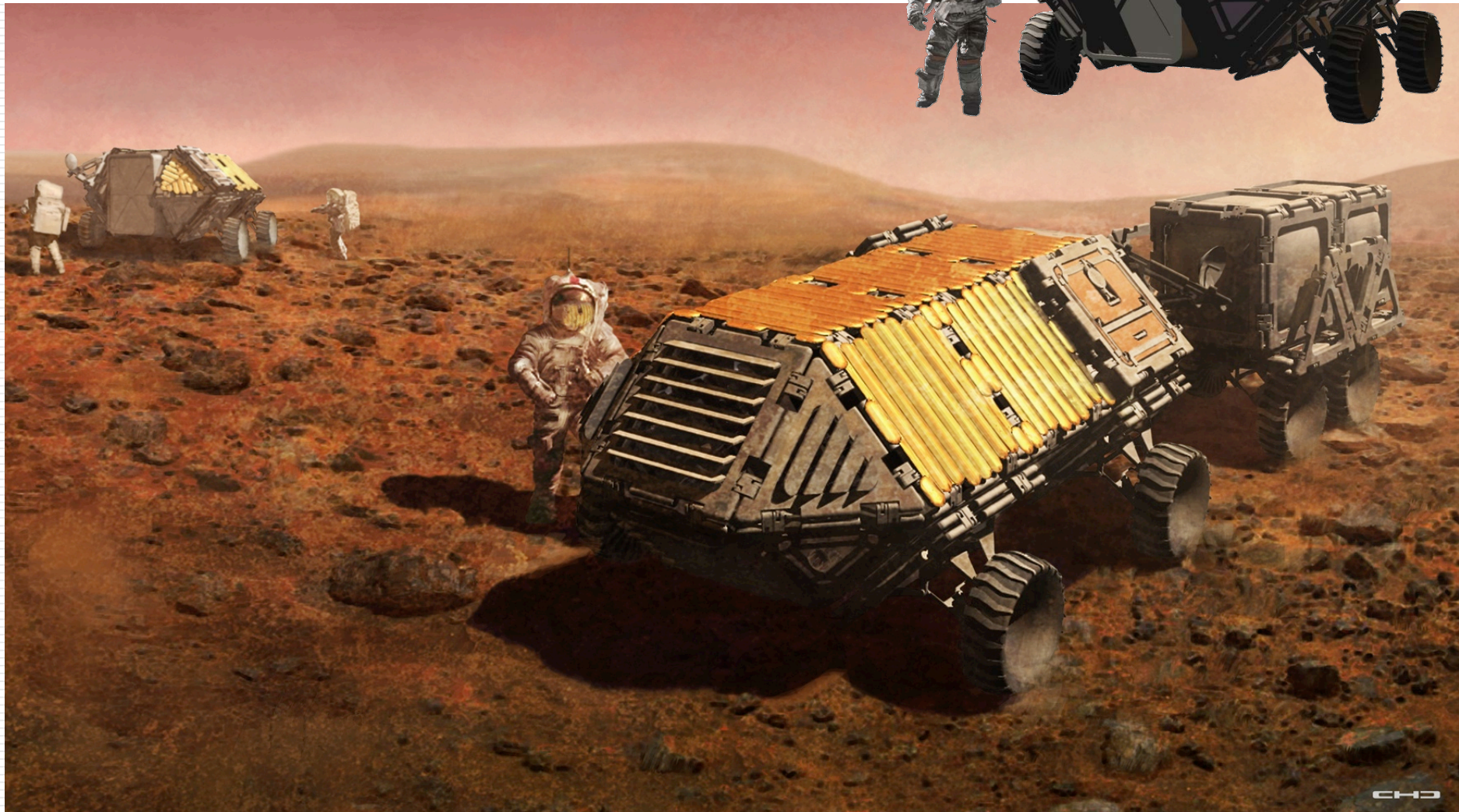
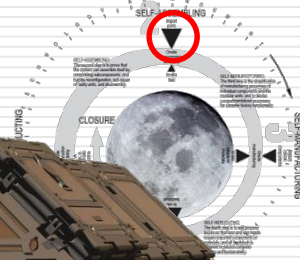
Thin inflatable pressure liner



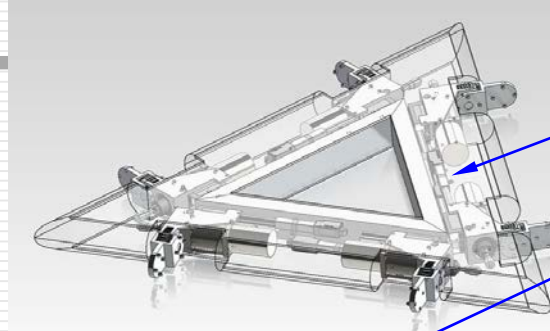
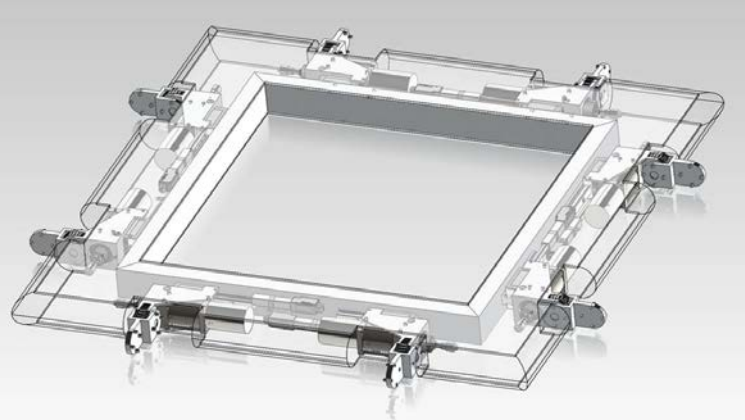
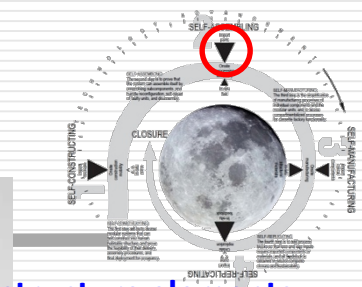
Water or in-situ shielding
carried by hard panel

Deployable wheels and other
mechanical elements

Future Directions: Self-assembling



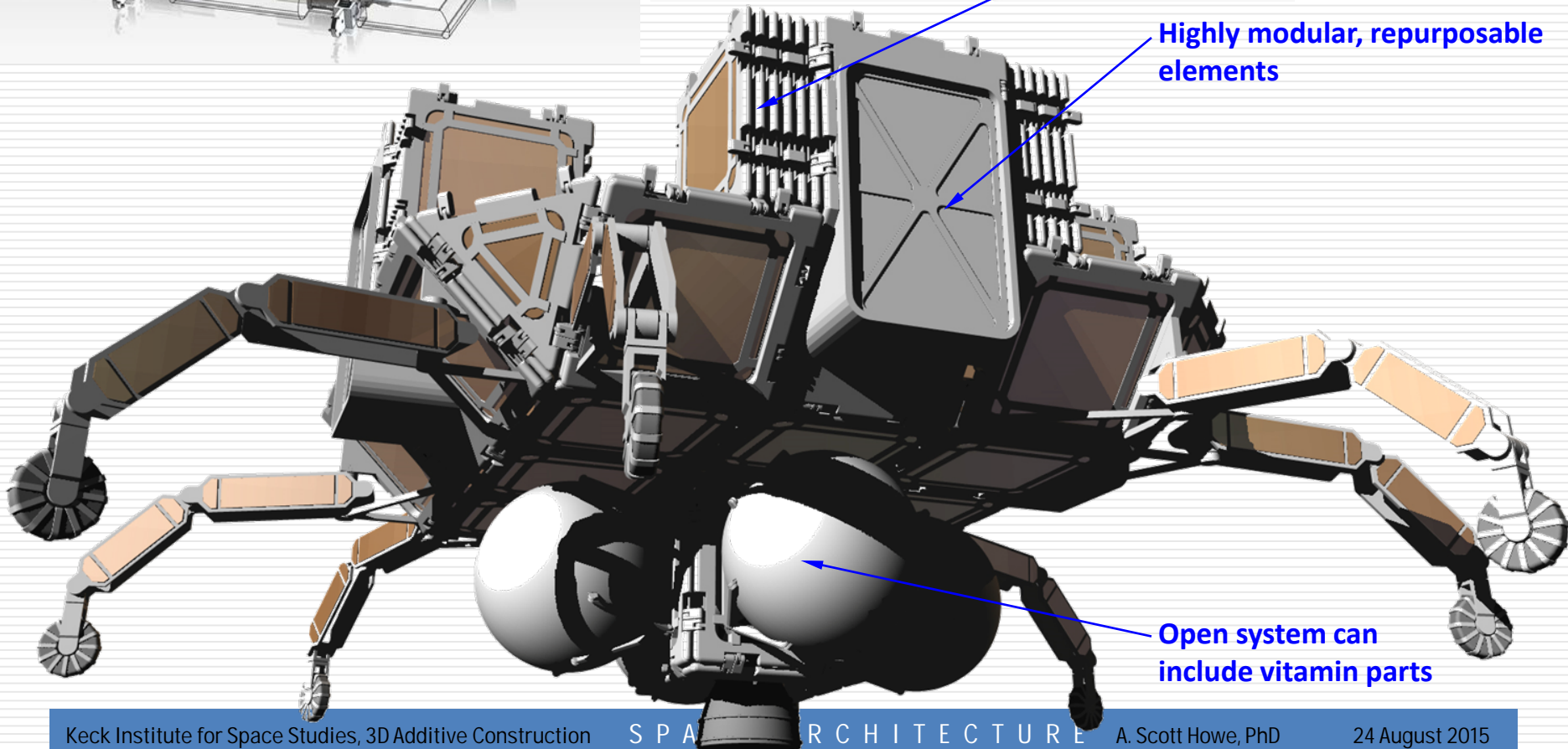
Future Directions: Self-assembling



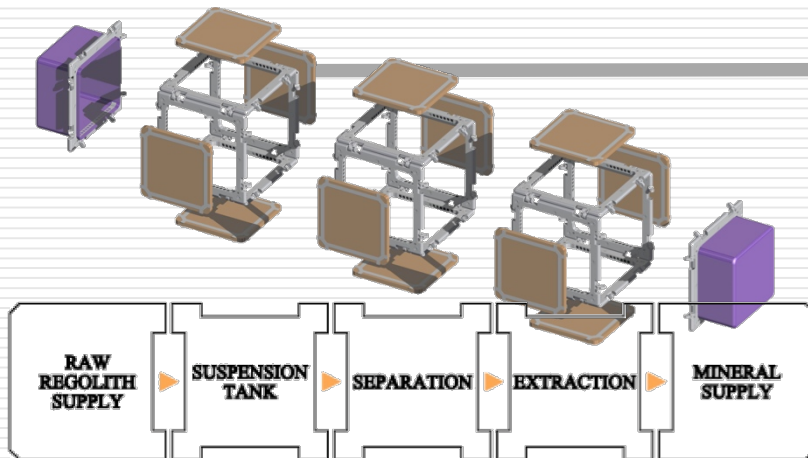
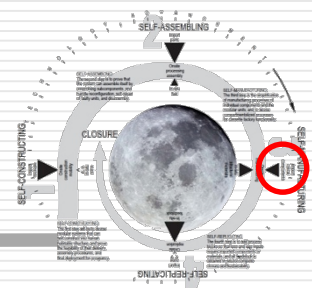
Printable structure elements fitted with actuators

Reusable / reconfigurable robotic panels

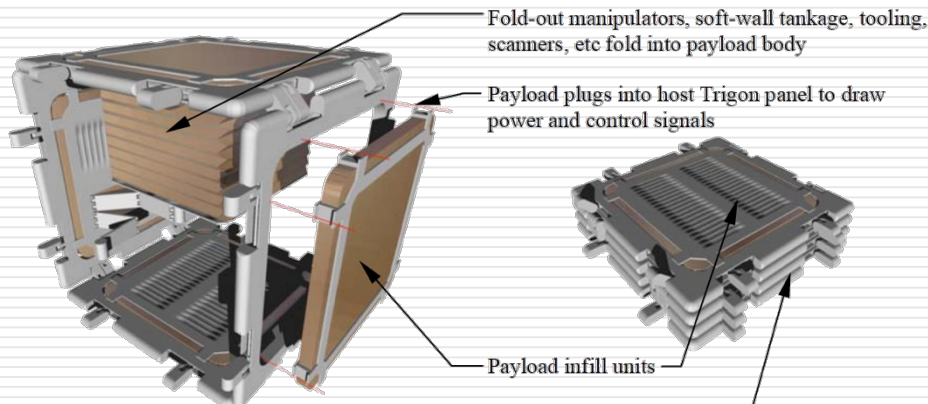
Highly modular, repurposable elements



Future Directions: Self-manufacture

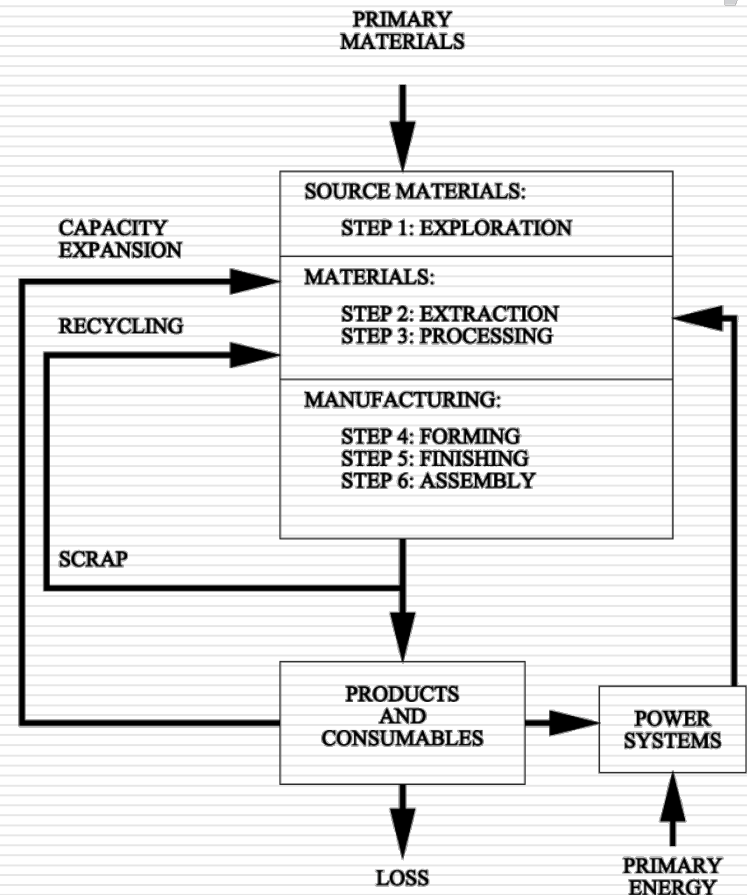


- | PAYLOADS: | PAYLOADS: | PAYLOADS: |
|--------------------------|-------------------------|-------------------------|
| 1: MATERIAL HANDLING | 1: MATERIAL HANDLING | 1: MATERIAL HANDLING |
| 2: DEPLOYABLE TANK | 2: FILTER BELT | 2: SCANNER / INSPECTION |
| 3: MOBILITY / SEPARATION | 3: PLATING / ENTRAPMENT | 3. MINERAL RECEPTACLES |
| 4. DEPLOYABLE TANK | 4. ELECTRODES | 4. MINERAL RECEPTACLES |

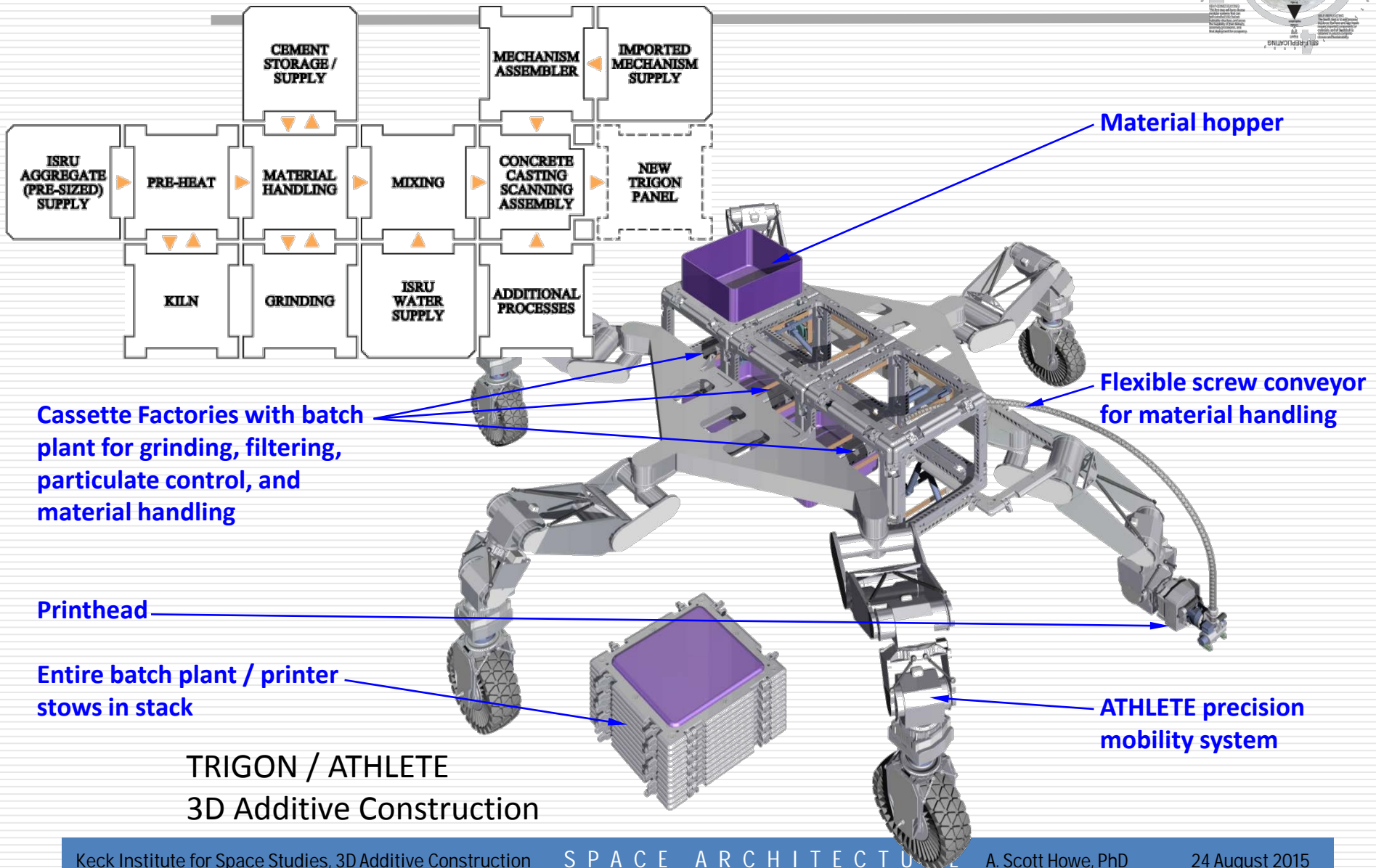
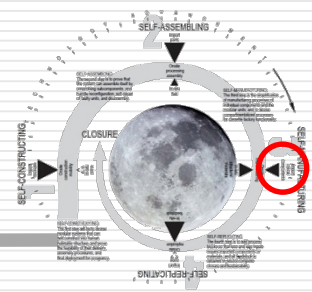


Cassette Factories

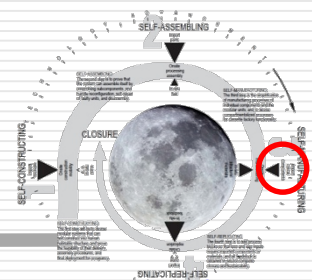
Cassette factory stores into four self-assembling panel stack



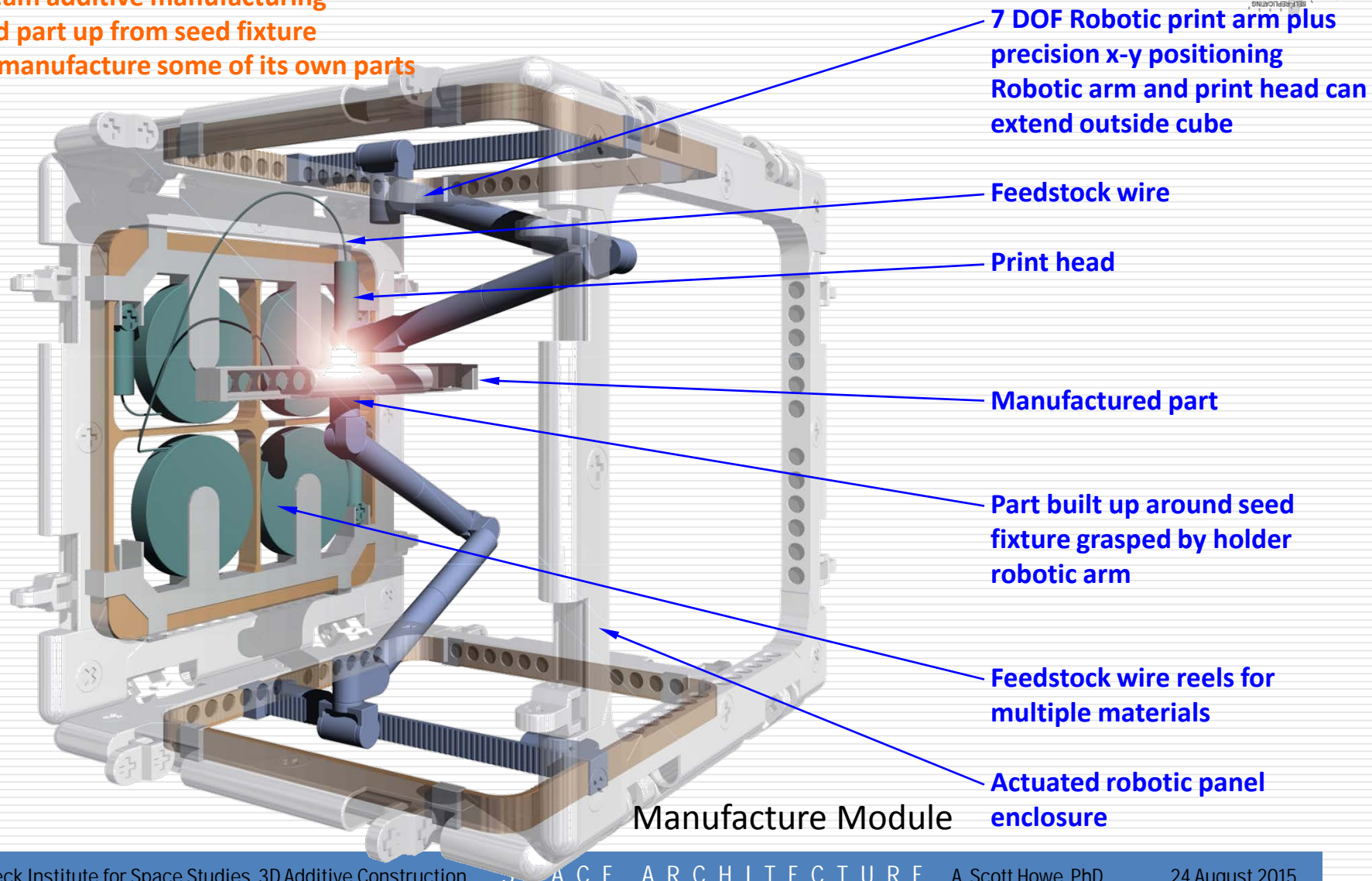
Future Directions: Self-manufacture



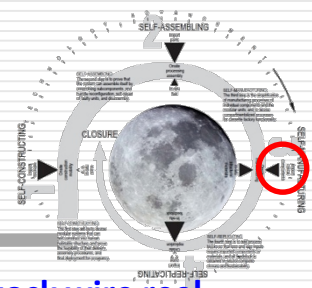
Future Directions: Self-manufacture



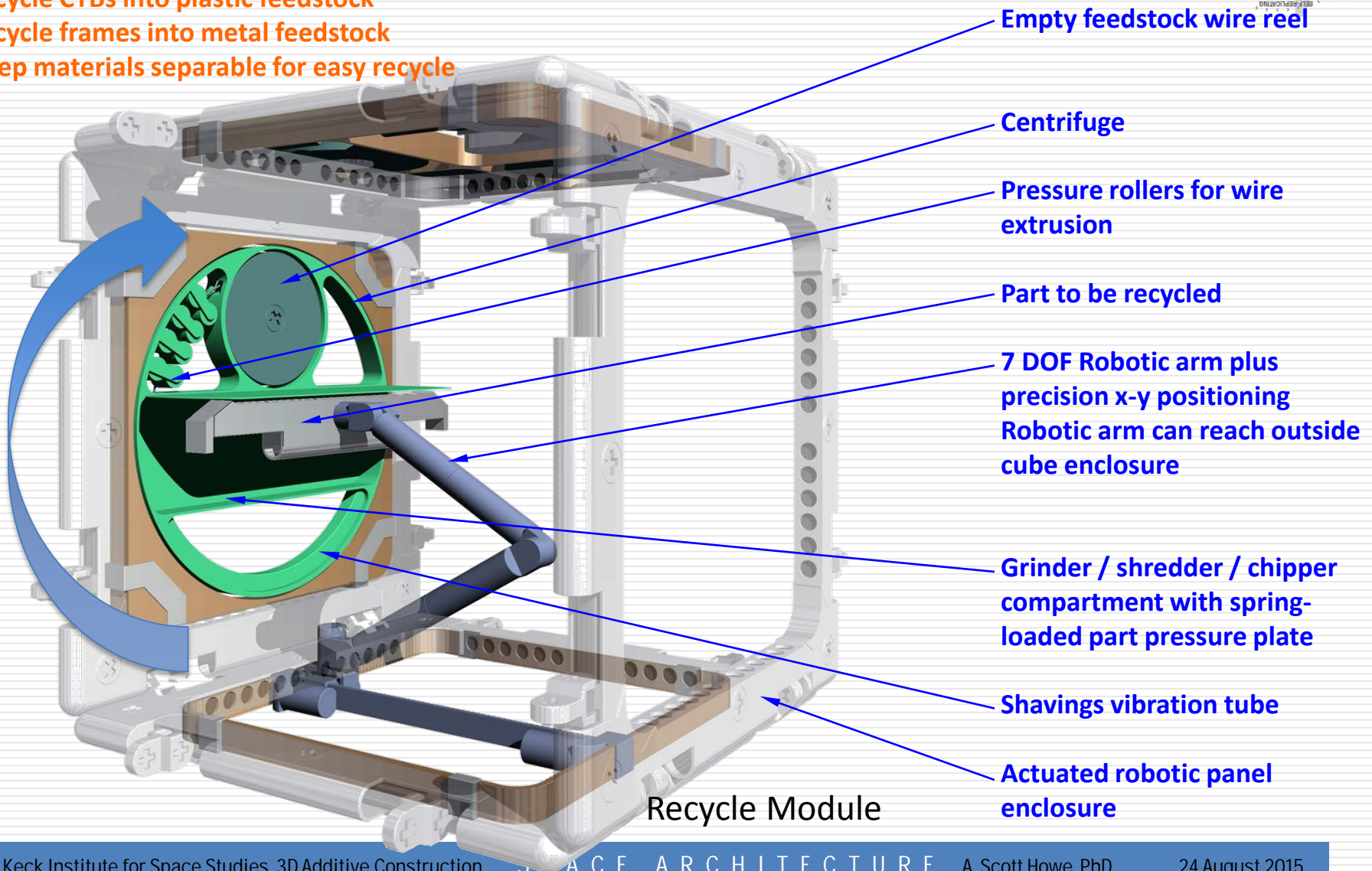
- e-beam additive manufacturing
- build part up from seed fixture
- can manufacture some of its own parts



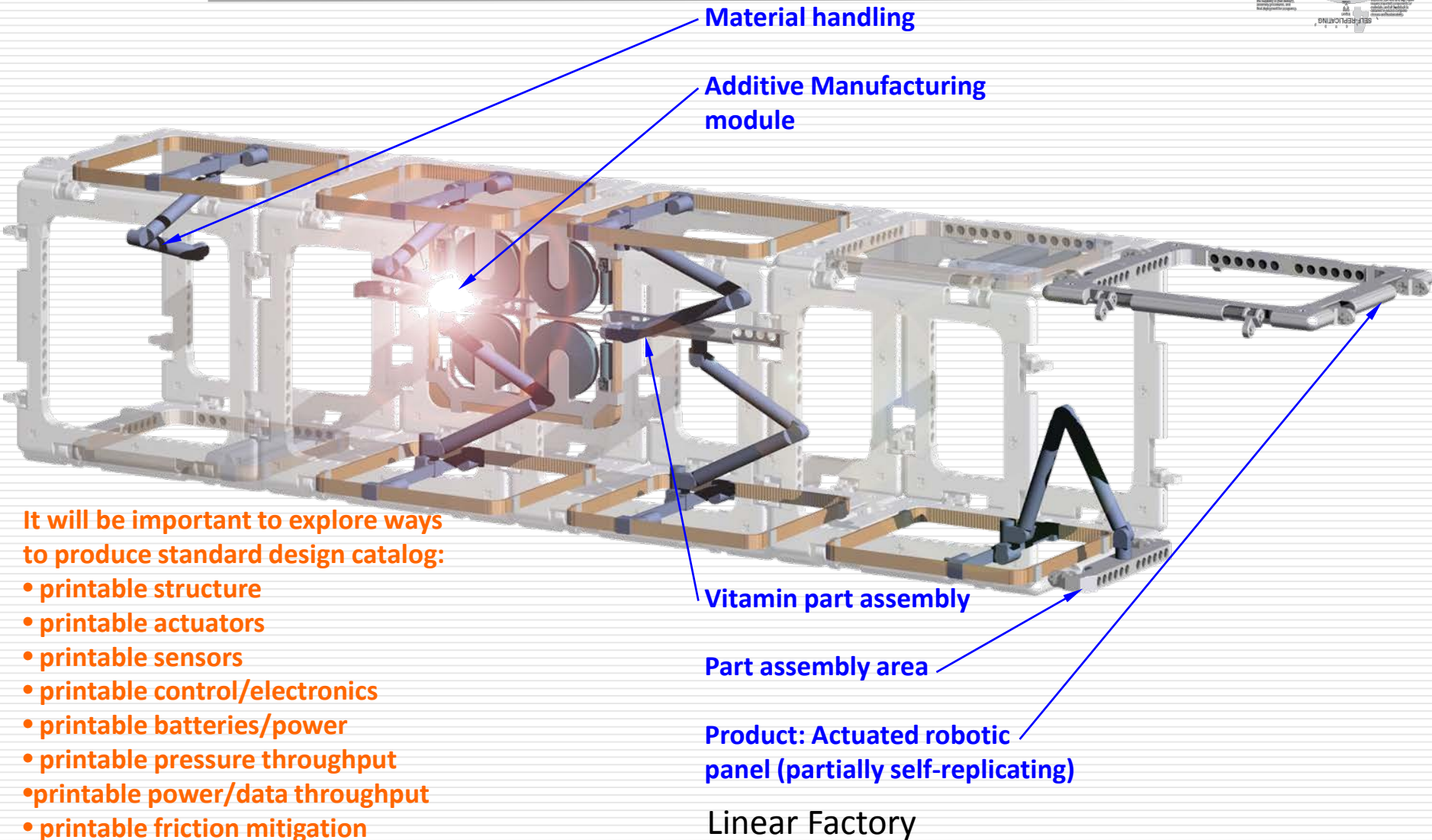
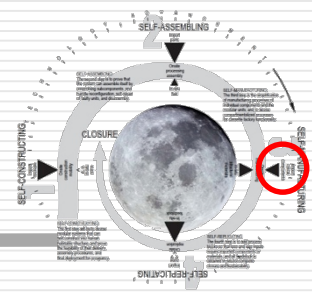
Future Directions: Self-manufacture



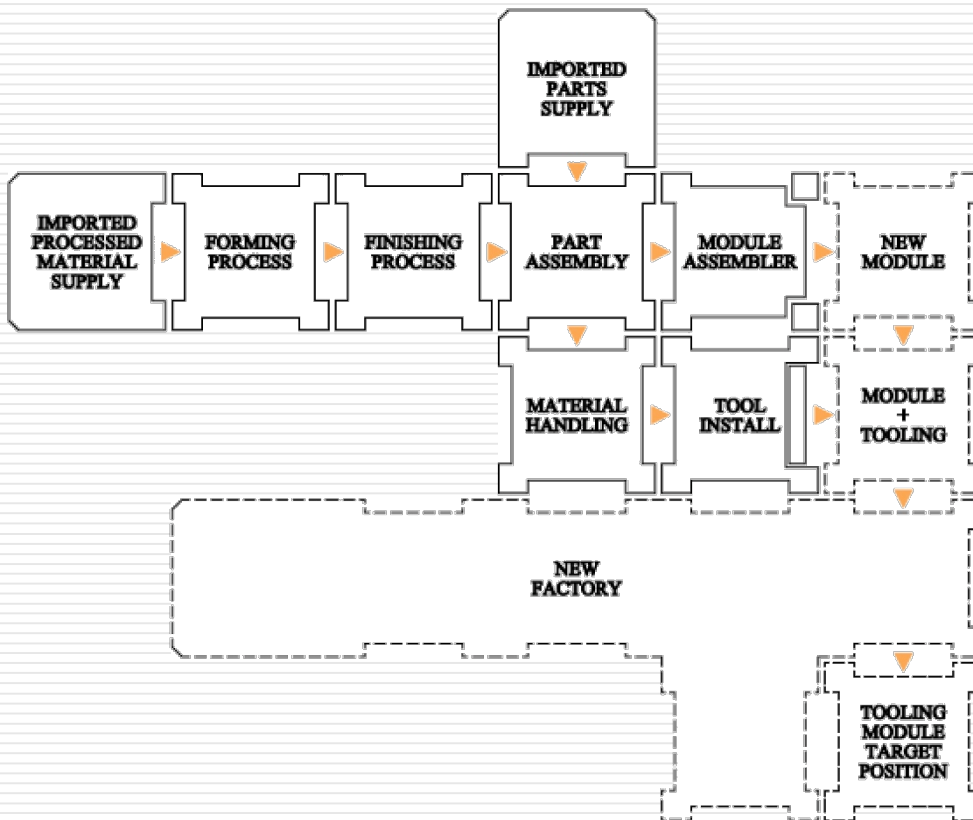
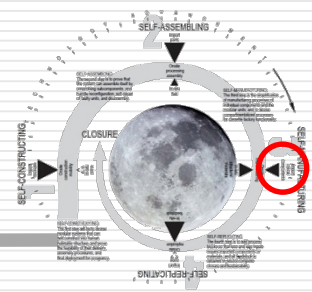
- recycle CTBs into plastic feedstock
- recycle frames into metal feedstock
- keep materials separable for easy recycle



Future Directions: Self-manufacture



Future Directions: Self-manufacture



Additive
Manufacturing
module

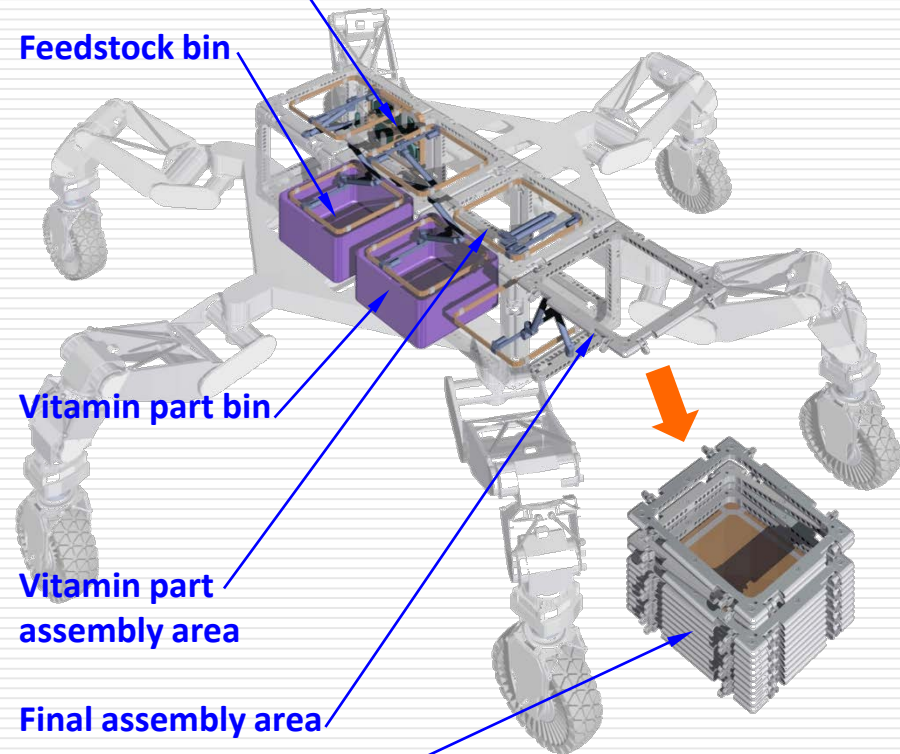
Feedstock bin

Vitamin part bin

Vitamin part
assembly area

Final assembly area

Product: Actuated
robotic panel
(partially self-
replicating)



Future Directions: Self-replication

- May never need to get here, just get close
- Aim for fully closed

