Robotic Mining Capstone (RMC)

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MISSION

- Design a robot capable of traversing lunar terrain and building a regolith berm.
- Berm construction is essential to protect astronauts and critical lunar structures from radiation and the harsh space environment.
- RMC's robot is engineered to maximize berm volume and employ an efficient regolith storage mechanism.

EXCAVATION

- Composed of eight 3D-printed PLA bucket drums.
- Each drum holds an 80% fill capacity of 0.64 liters of fly ash.
- The drum capacity was predicted using Becker 3D® simulations and verified through physical testing.
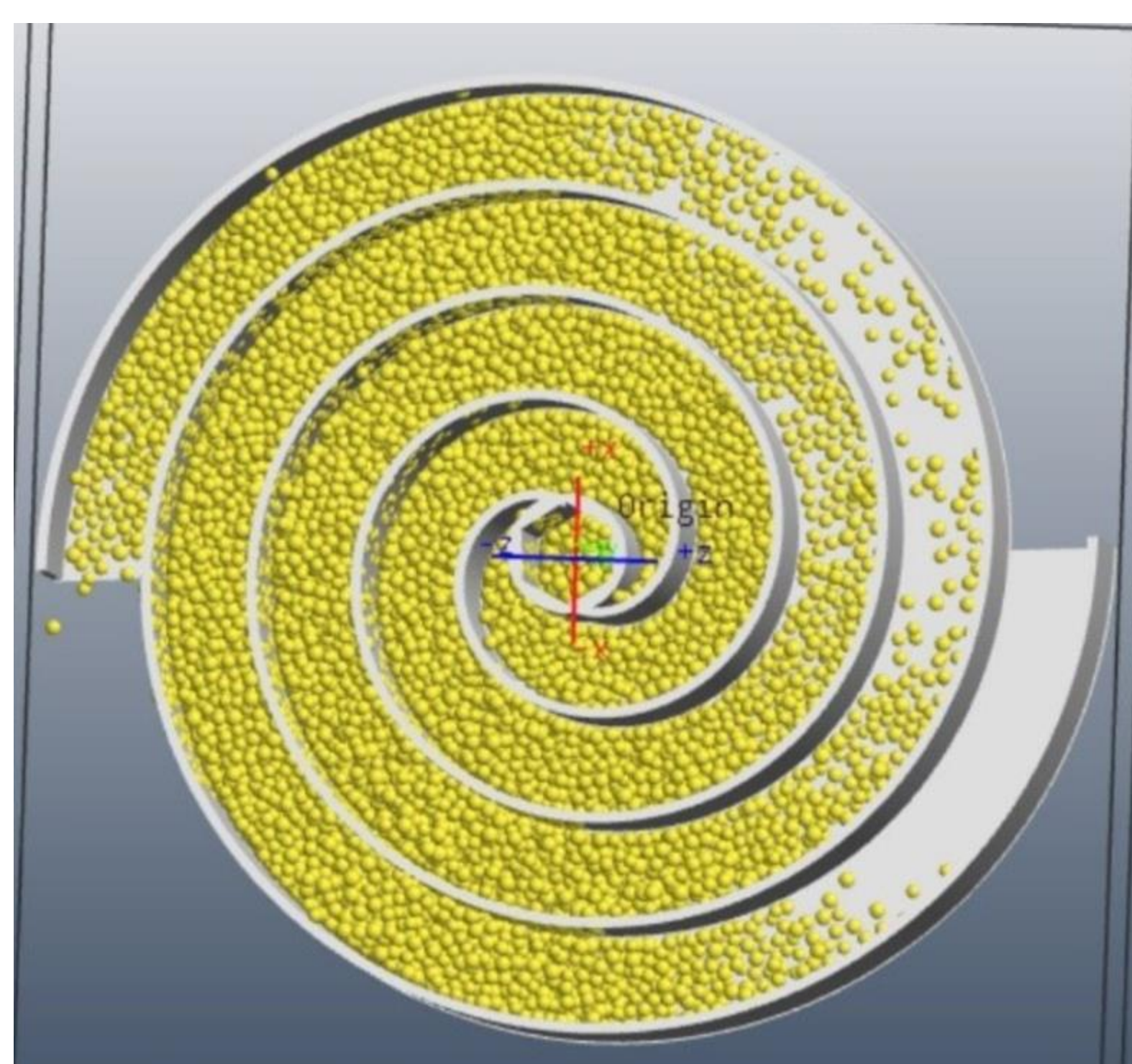
STRUCTURES

- The Ansys® model illustrates the FoS for the wheel, the blue areas denote complete safety while red areas indicate potential failure zones.
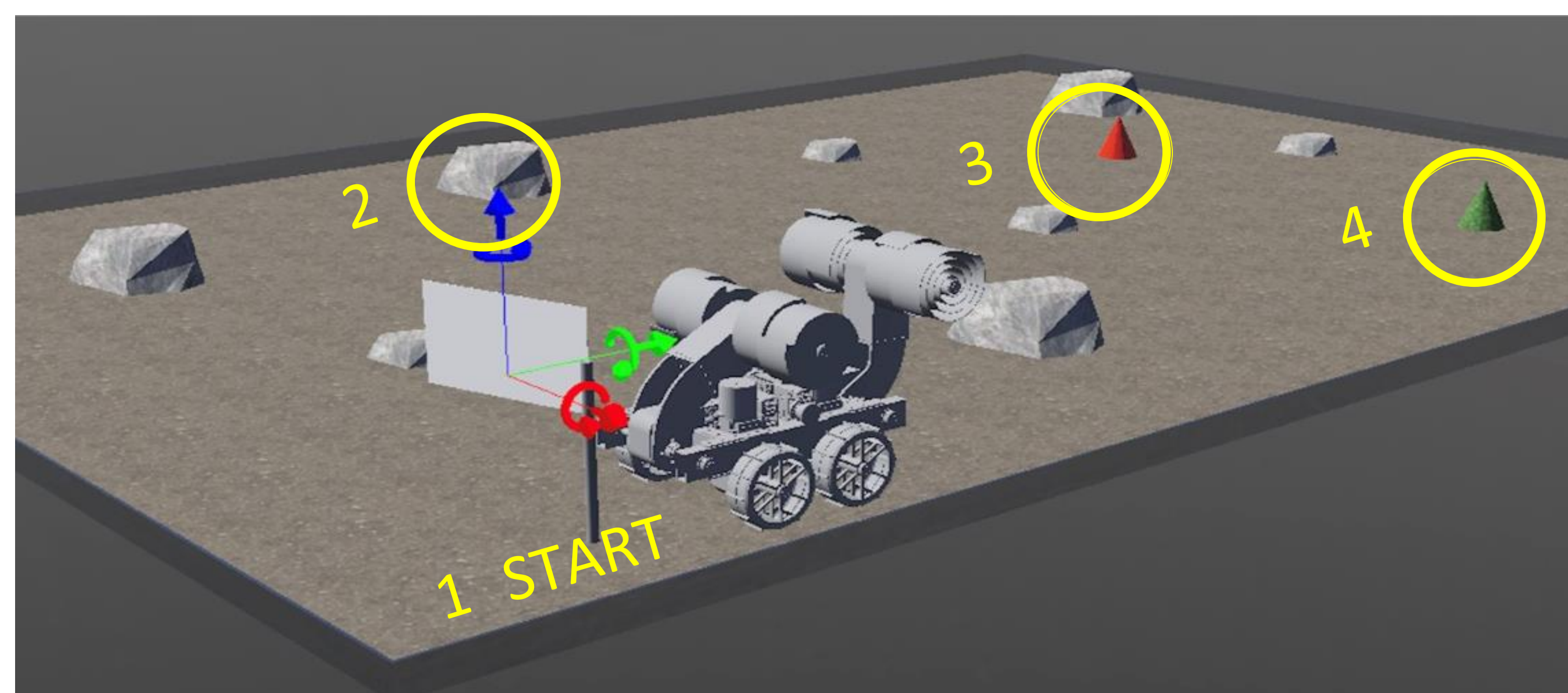

$$F.S. = \frac{Strength\ of\ Material}{Actual\ Stress\ or\ Load} = \frac{\sigma_{ult}}{\sigma_{all}}$$
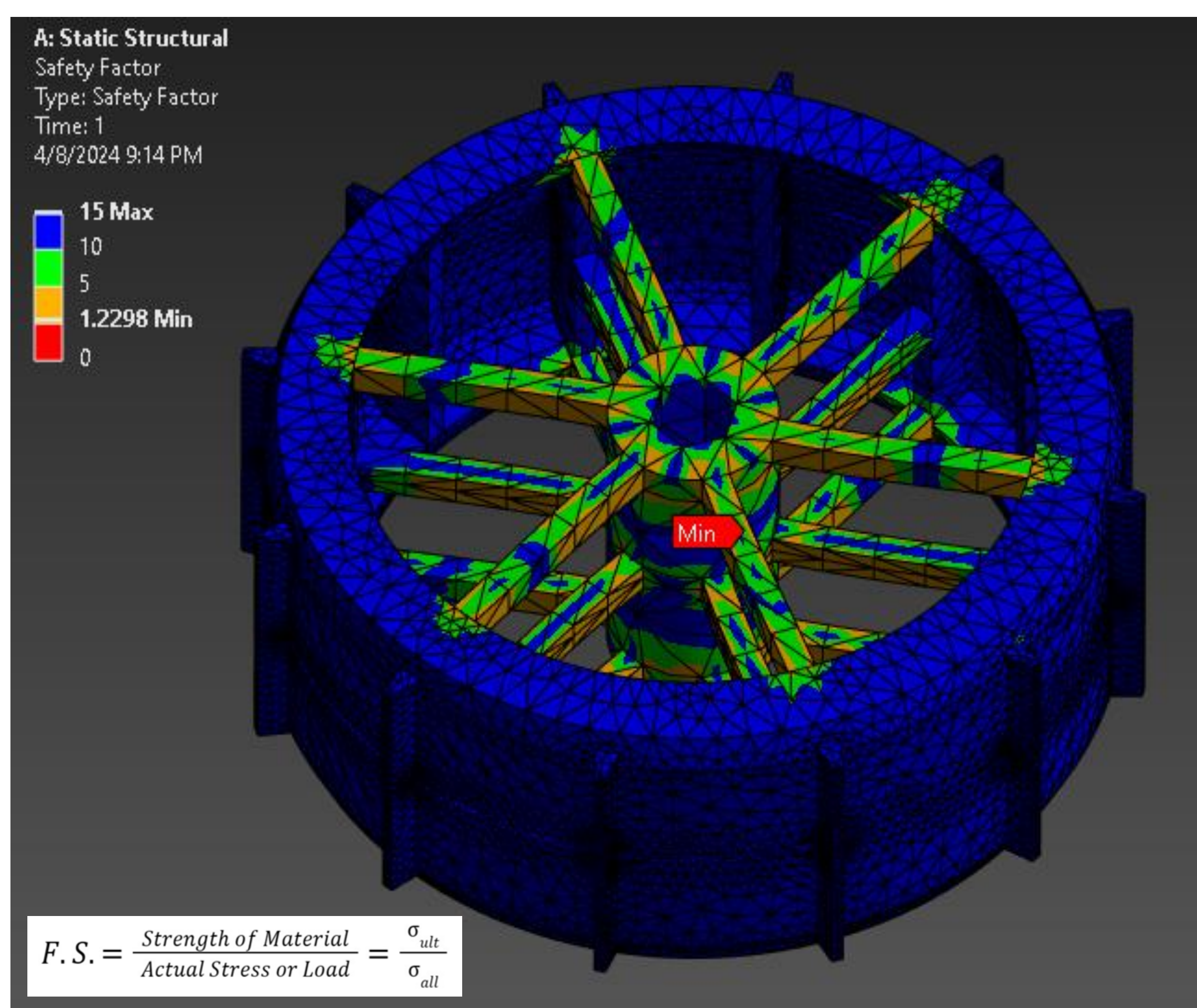
- The minimum FoS recorded is 1.2298.
- The chassis bending stress was predicted using a MATLAB® shear-moment script.

Lunar Robot Model

1. Bucket Drums
2. Electronics Box
3. Lift Arms
4. Chassis
5. Wheels
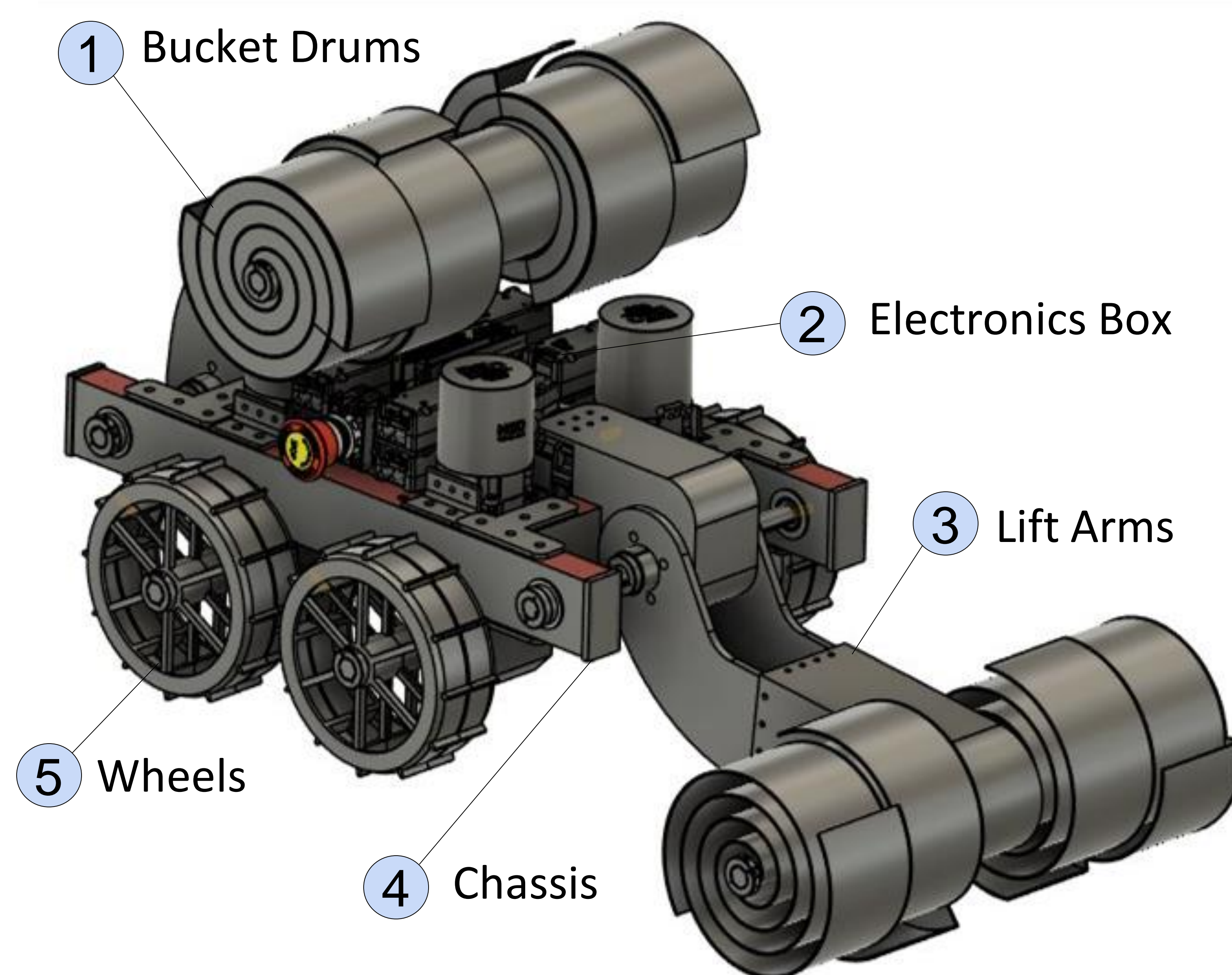
Materials: PLA, Al 6061, Al 6063, and Steel

Step 1: The robot will begin at the starting zone.
Step 2: It will drive through the arena avoiding obstacles.
Step 3: It will reach the mining zone (red cone) and collect regolith.
Step 4: Once full, it will locate the construction zone (green cone) and build the berm.

CONTROLS

Electrical: Electronics Box
1. Emergency shut off
2. Hoist hook
3. Raspberry Pi HAT
4. Motor controller
5. Power distributor
6. Battery 12V 9Ah
7. IMU
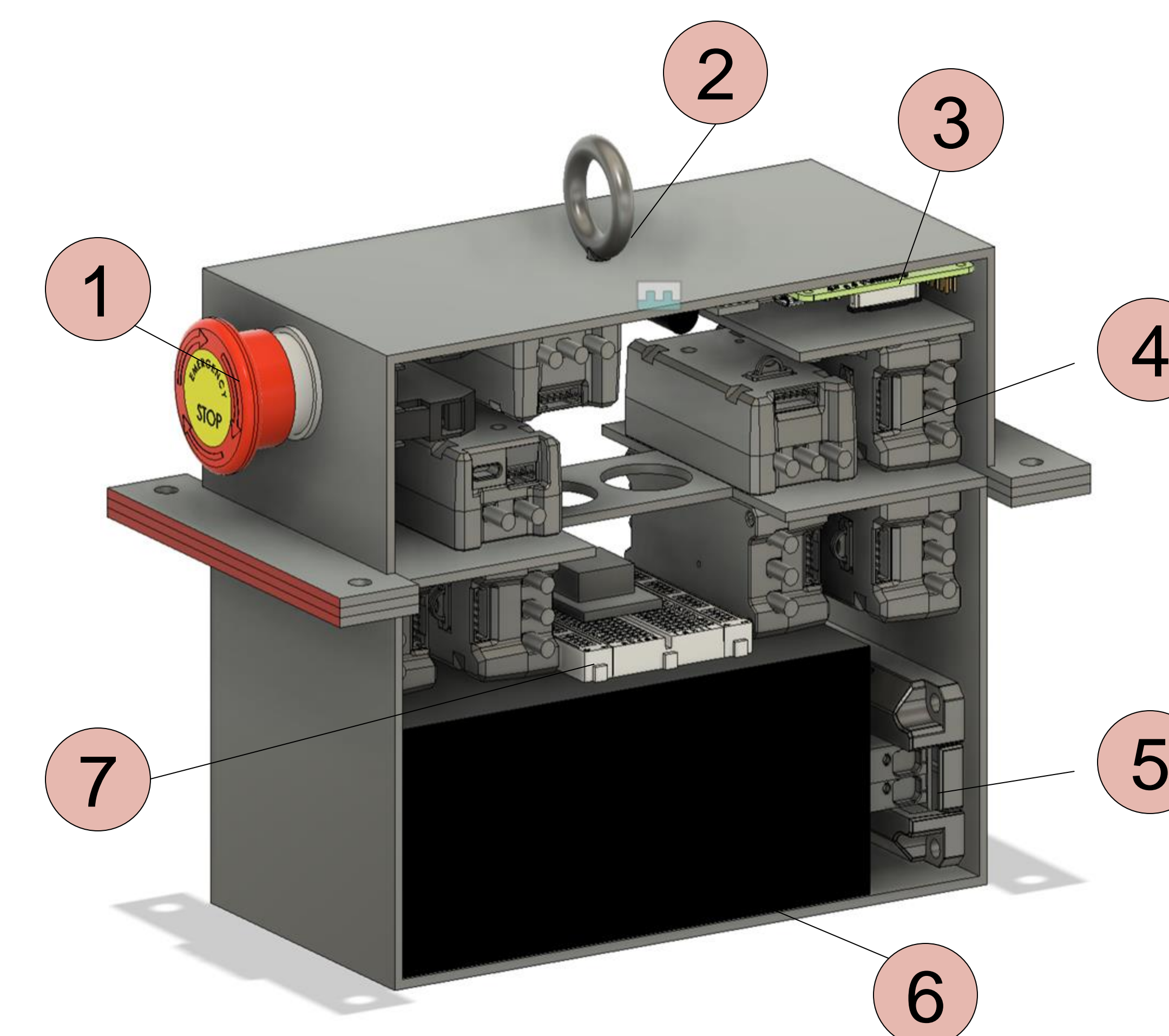
Software:
  Webots®: Simulates mission arena with mock robot to refine the capabilities of the physical prototype.
  Python: Navigation is performed using stored waypoints which appear on the GUI atop a cartesian position grid.
  Becker 3D®: Simulates regolith particle loading and unloading from bucket drums.

RESULTS & FUTURE WORK

Results: Successful manual control for driving and excavating. The robot can build a 0.02 m³ berm in 4 trips.
Future: Refine the robot's autonomous operations script and image processing algorithms.