SURFACE PAYLOAD AUTONOMOUS ROVER eXPLORER (SPARX)

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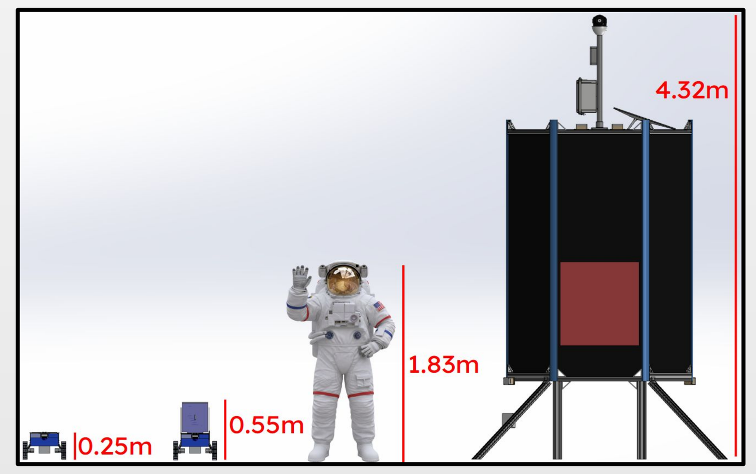
Problem Definition:

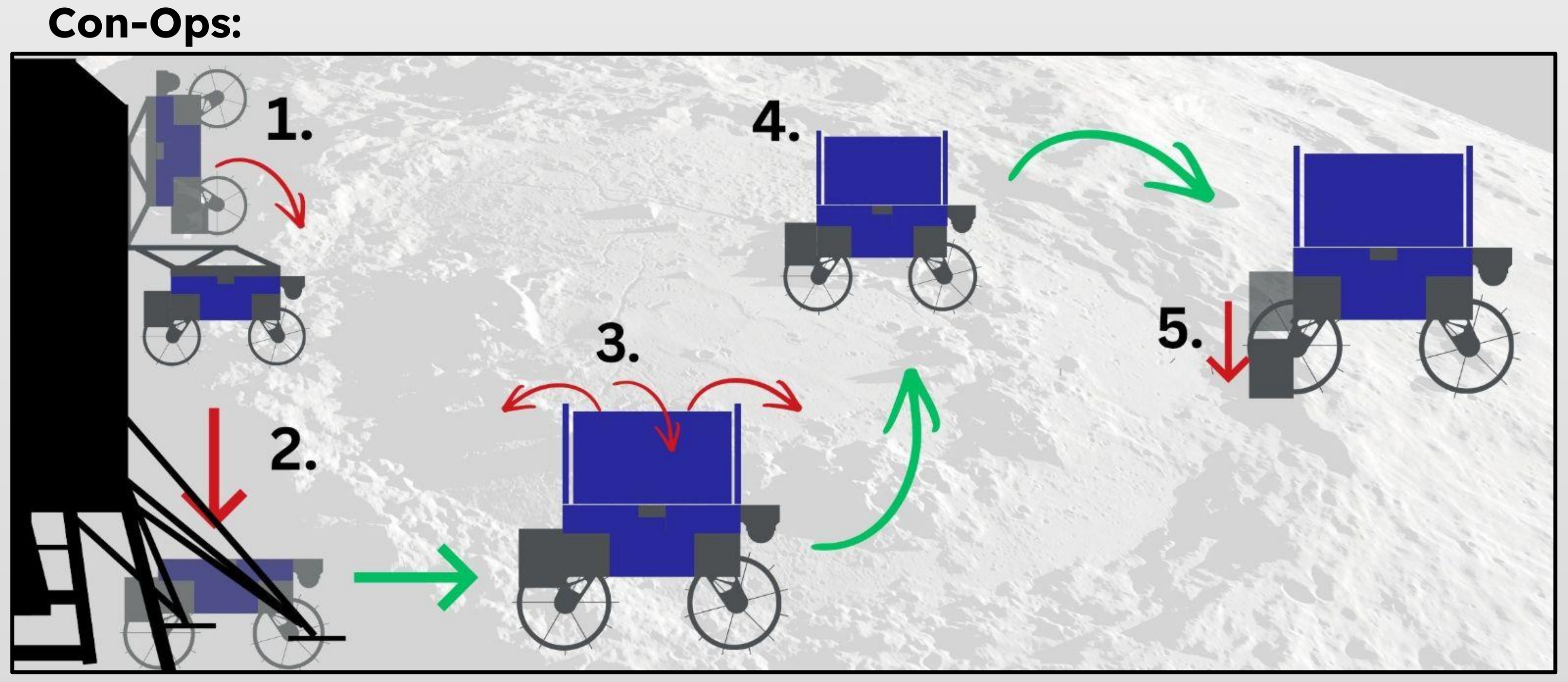
Design a **semi-autonomous** Commercial Lunar Payload Services (CLPS) class **lunar rover** for Intuitive Machines capable of **delivering payloads** within a one kilometer radius of the landing site over the course of **one lunar day**.

Mission Objectives:

- SPARX shall survive launch and transit to lunar surface
- SPARX shall be able to operate for one lunar day (14 Earth days)
- SPARX shall be to traverse the lunar surface
- SPARX shall be able to relay data to Earth
- SPARX shall be able to store and deploy payloads
- SPARX shall be able to integrate with Eclipse lander



Con-Ops:



Key:

1. SPARX deployment system actuates away from the IM lander
2. Frangibolts fire and SPARX drops to the lunar surface
3. SPARX deploys four solar panels
4. SPARX traverses using a combination of live navigation and a pre-planned path
5. SPARX navigates to predetermined way-points to conduct science missions and deploy its payload

Path Planning & Autonomy:

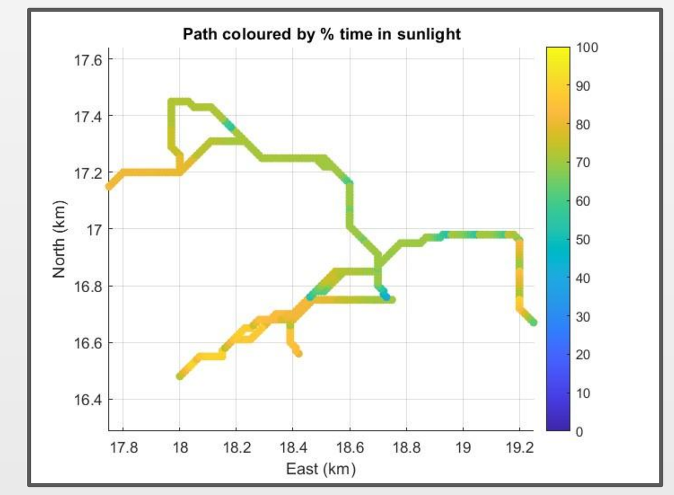


Figure 1: Solar Exposure along global path

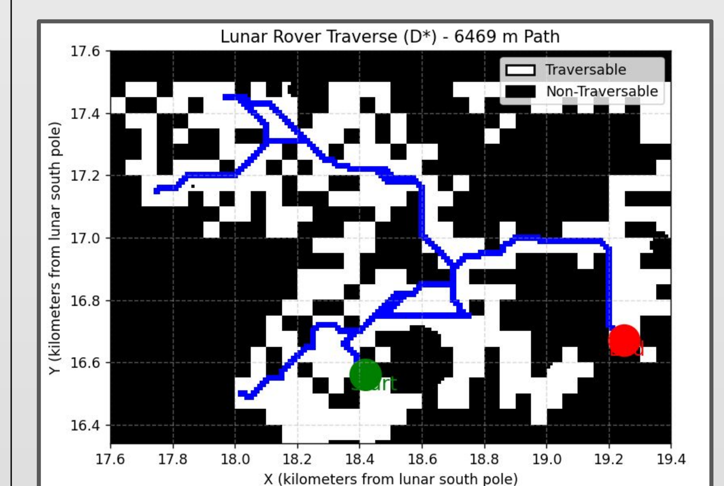


Figure 2: Planned Path w/ all considerations

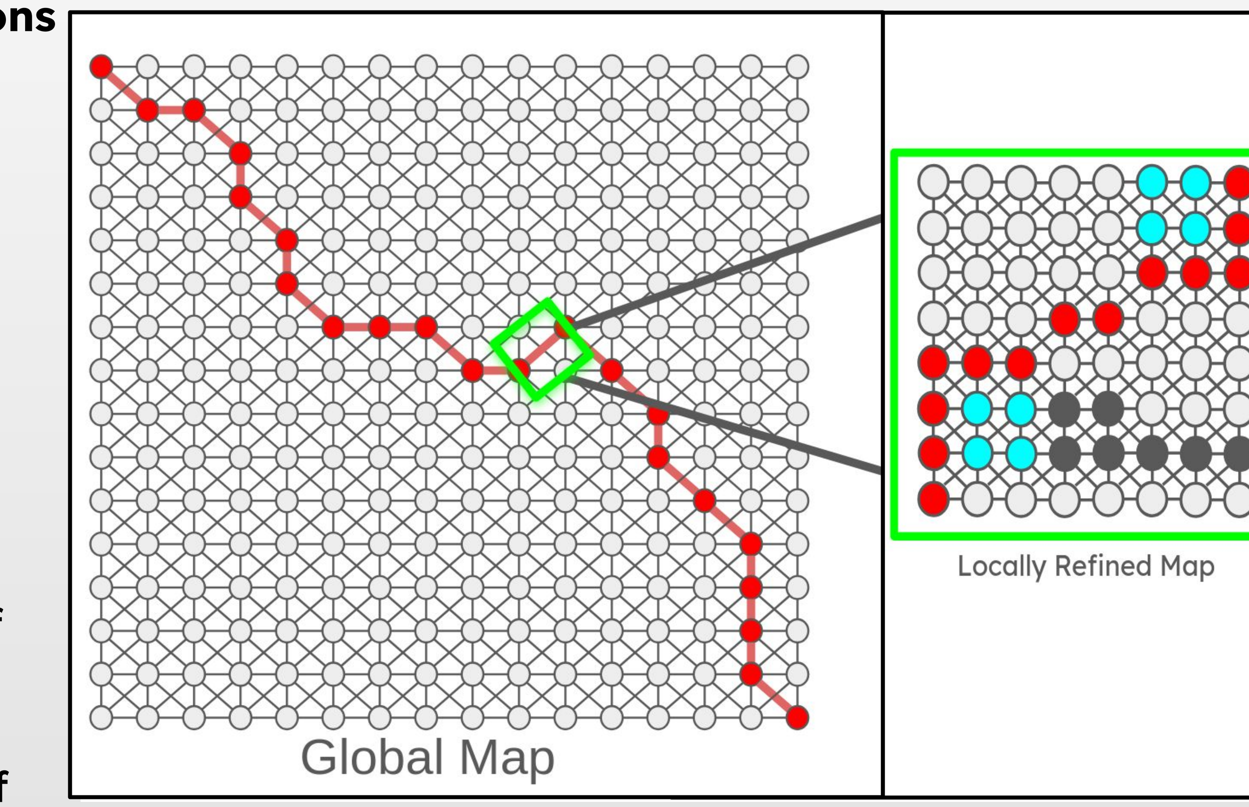
Mission Region Considerations

- ±10° incline/decline
- Sunlight exposure for 340 hours
- Line of sight to lander

Evaluate Lunar DEM data for global path [fig. 1 & 2]

Waypoint Navigation

- Multiple payload dropoff zones
- Mission zone within 1 km of lander
- Path taken intentionally follows illuminated areas of the terrain



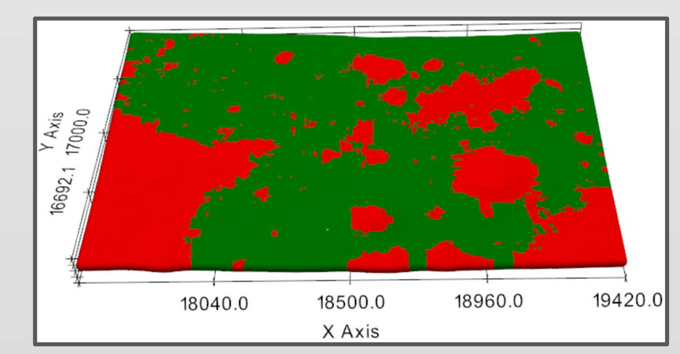


Figure 3: Line of Sight Map

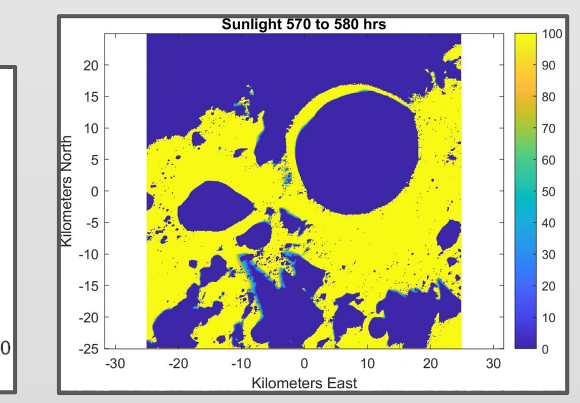


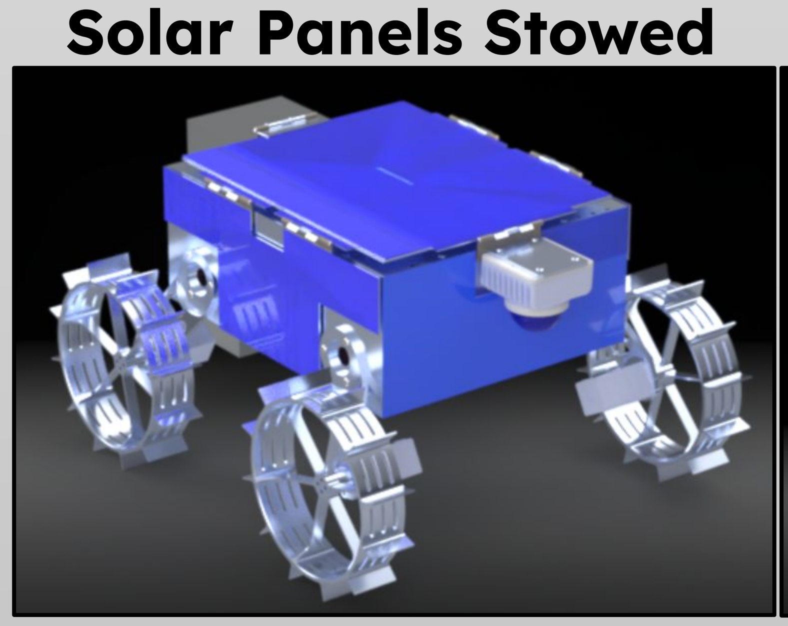
Figure 4: Illumination Map

Decide path [fig. 2] by overlapping line of sight maps [fig. 3] and solar exposure [fig. 1] to create a traversable C-Space for the rover. Determine mission start dates based on illumination map [fig. 4]

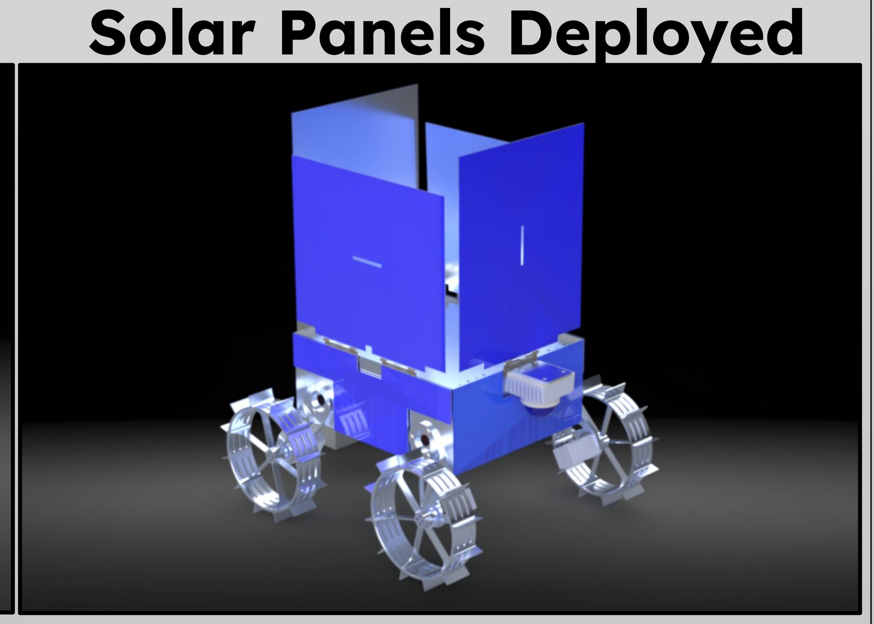
Mechanical Design:

- Deployable solar panel array
- 7075-T6 Aluminum components
- FEA Analysis performed within strict safety factor requirements
- Custom wheels with grousers for traversing lunar terrain
- Frangibolts and Hi-Lok fasteners

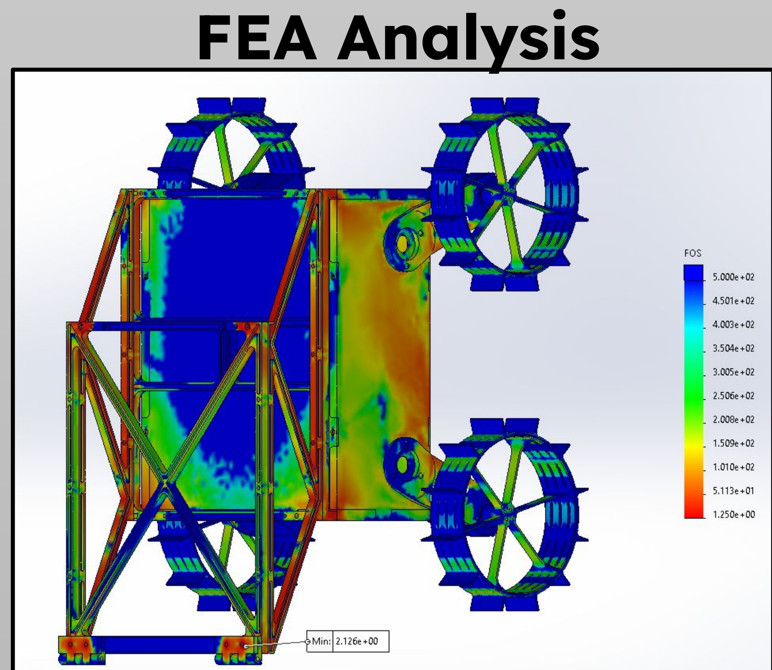
Solar Panels Stowed



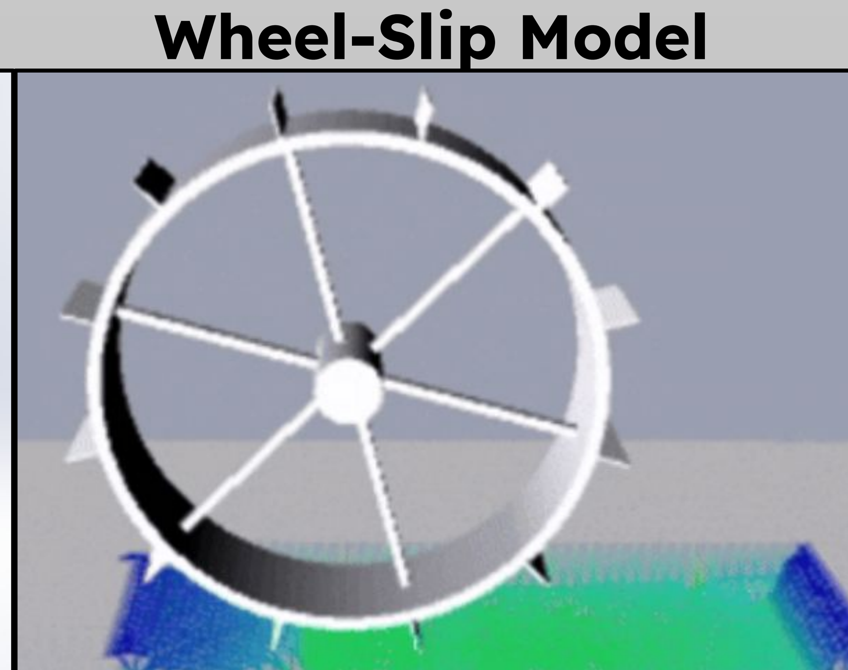
Solar Panels Deployed



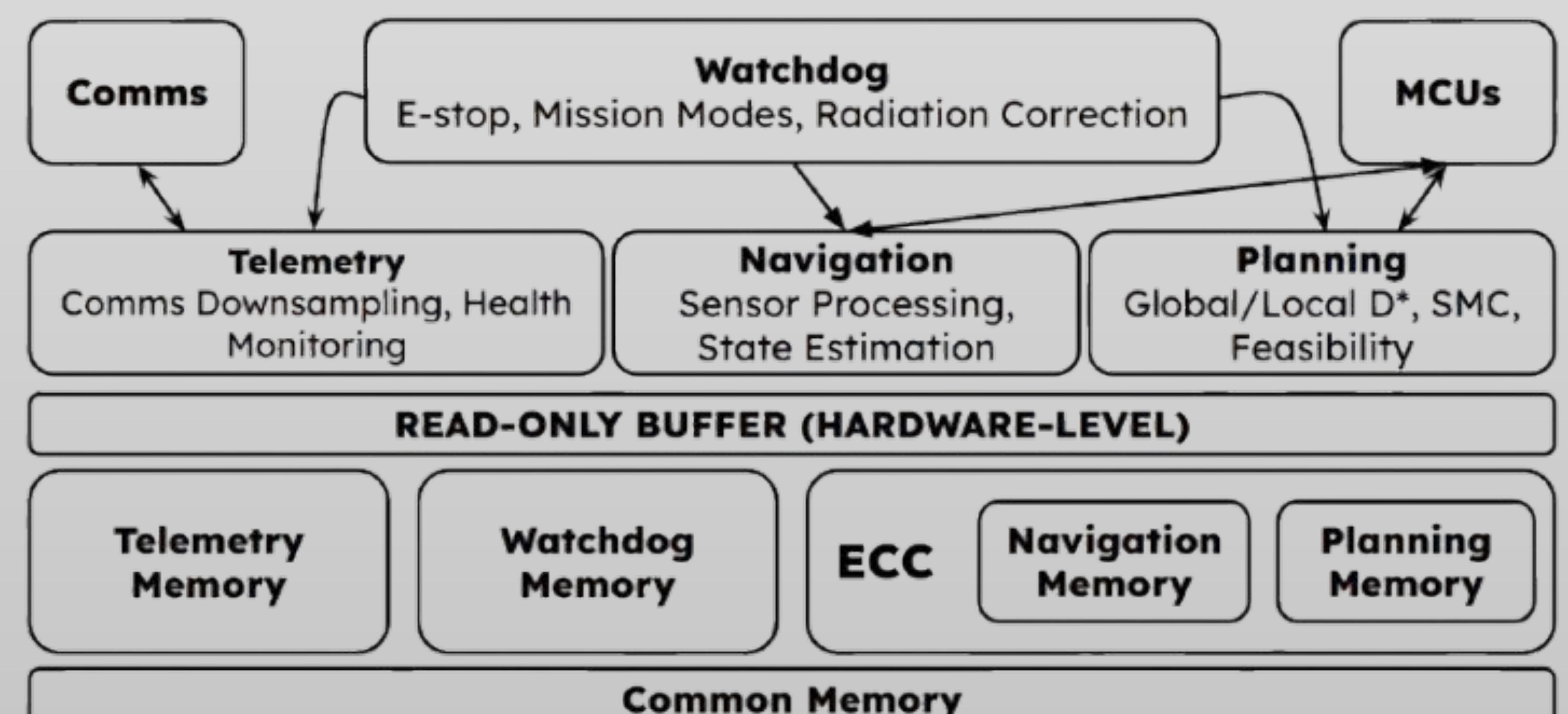
FEA Analysis



Wheel-Slip Model



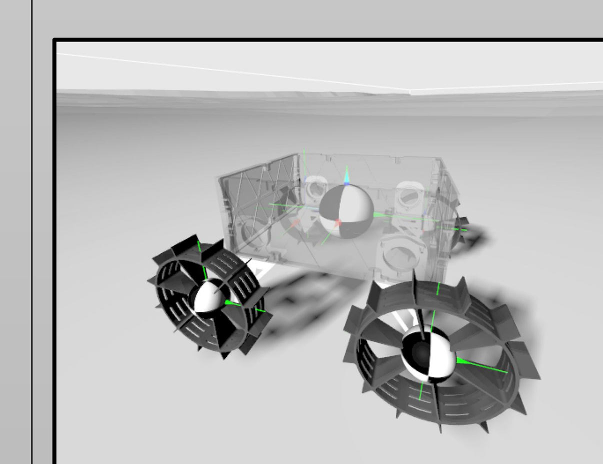
Avionics & Controls:



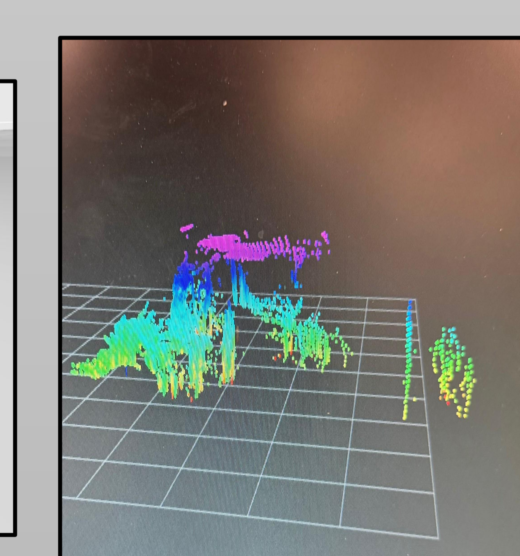
- Quad-core computer -> 4 independent processes
- Global Path Planning:
  - D* Lite graph path algorithm to waypoints within global map resolution
- Local Path Planning:
  - D* Lit graph path algorithm between global map points
  - Local obstacle avoidance w/ LiDAR
- Spline Generation:
  - Local path -> smooth cubic spline trajectory
  - Smooth reference trajectory for control
- 6 sensors for navigation, obstacle avoidance
  - IMU, RF ranging, LiDAR, Sun Sensors
- Multiplicative EKF + TRIAD algorithm:
  - Quaternion attitudes alongside gyro bias
  - TRIAD: IMU gravity vector + sun sensor pointing vector -> attitude estimate
- Translational EKF for {x, y, z, vx, vy, vz}:
  - MEKF attitude estimate treated as measurement
- Sliding Mode Controller:
  - Trajectory-keeping smoothed control robust to varying slip conditions

SPARX-Earth:

ROS2 Simulation



LIDAR Sweep



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