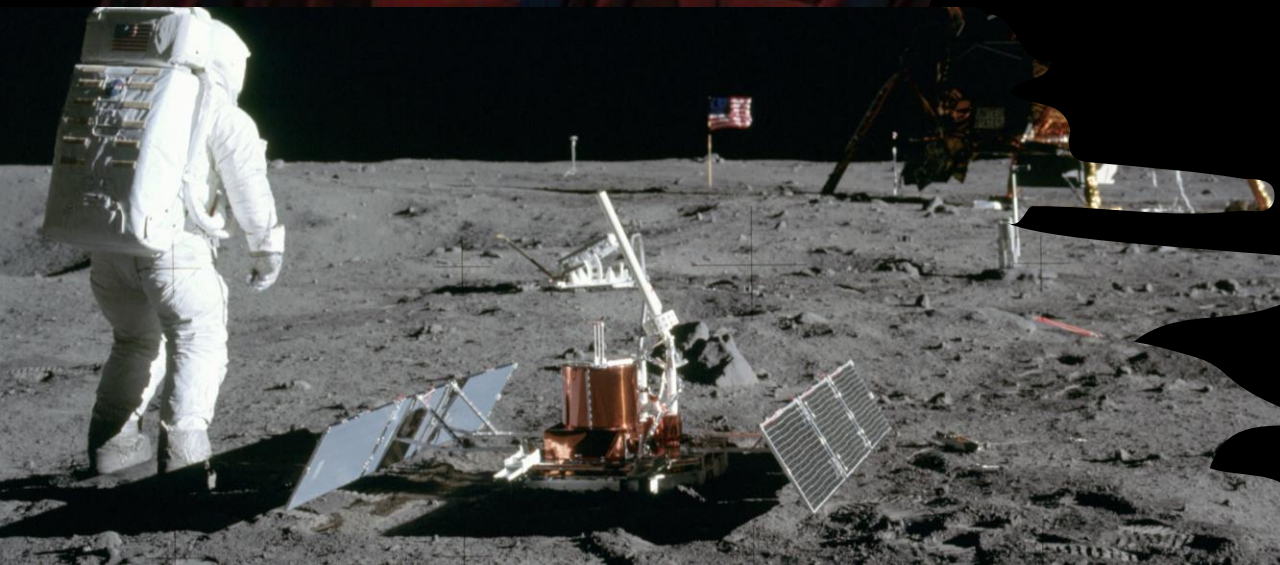
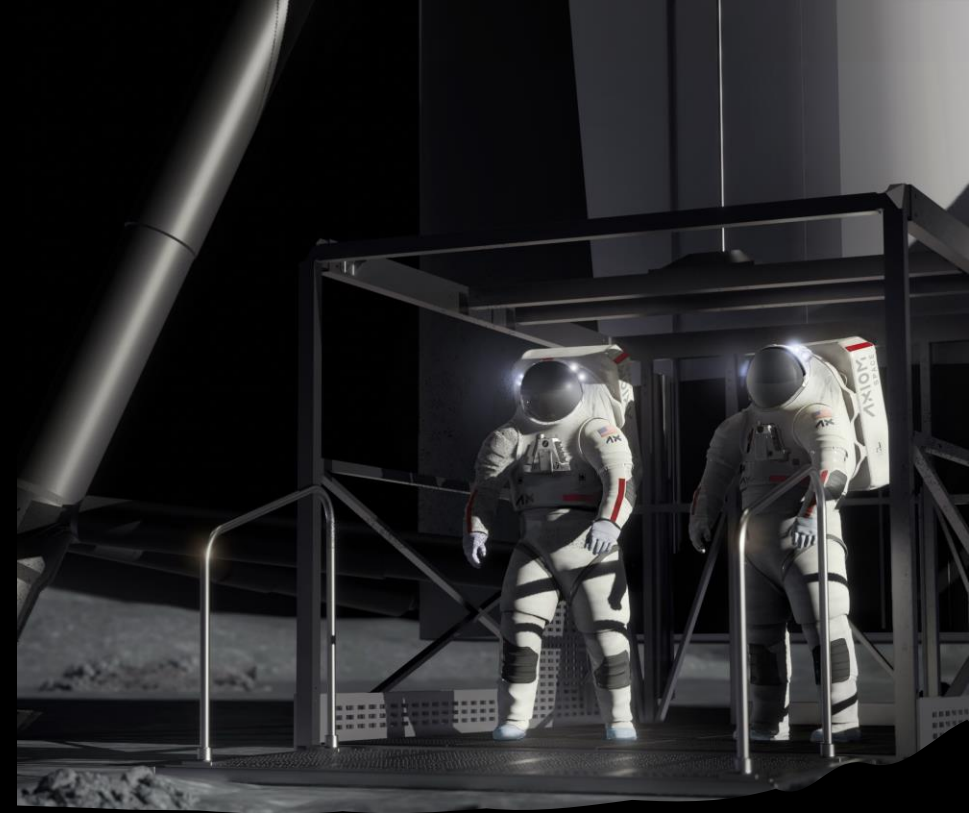


Lunar Sunflower

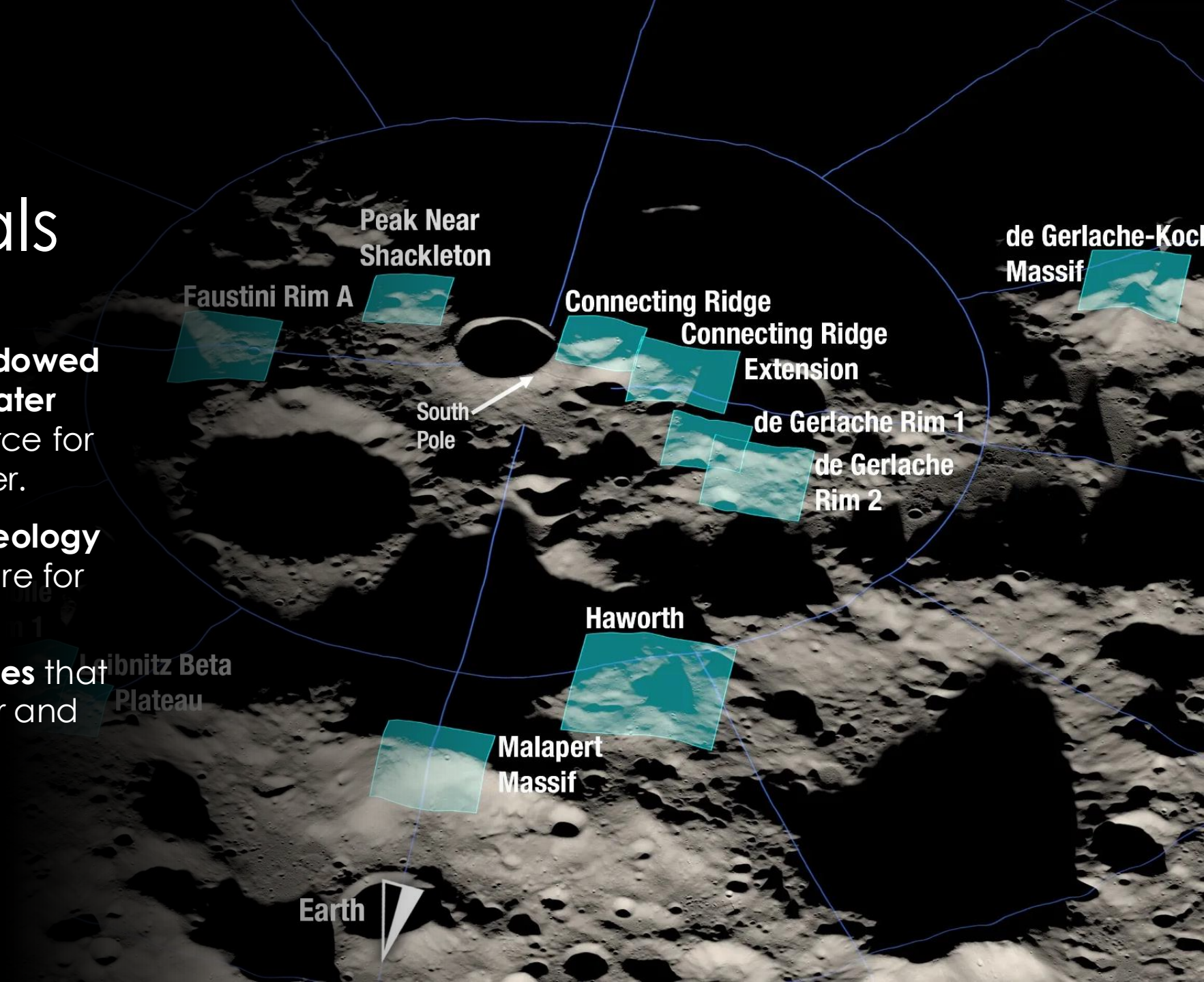
A Sun Tracker Inspired by The Artemis Program for
The 2025 NASA Space Apps Challenge



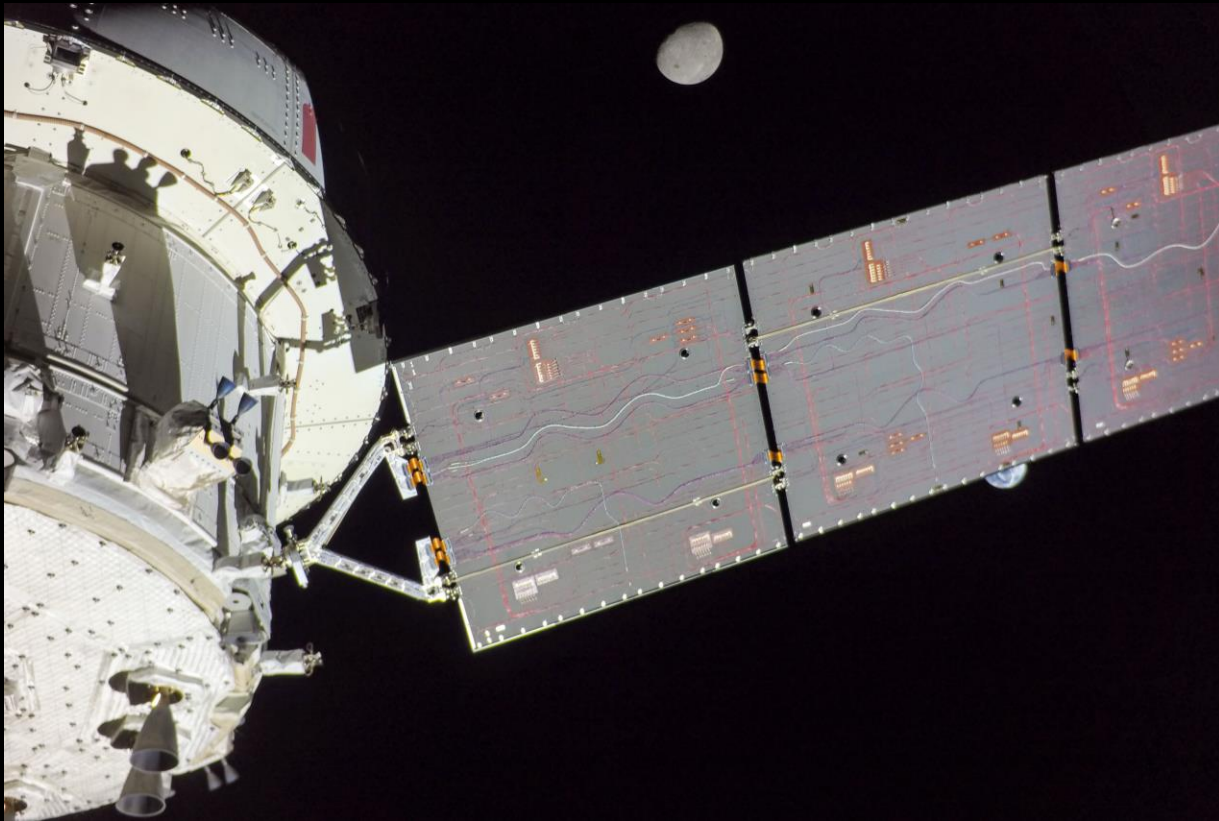
*We made it to the
moon once, and we
plan to go back.*

Artemis III Mission Goals

- Landing astronauts near **permanently shadowed craters** to search for **water ice**, a key future resource for fuel, oxygen, and water.
- **Studying the Moon's geology and radiation** to prepare for longer missions.
- And **testing technologies** that will support future lunar and Martian exploration.

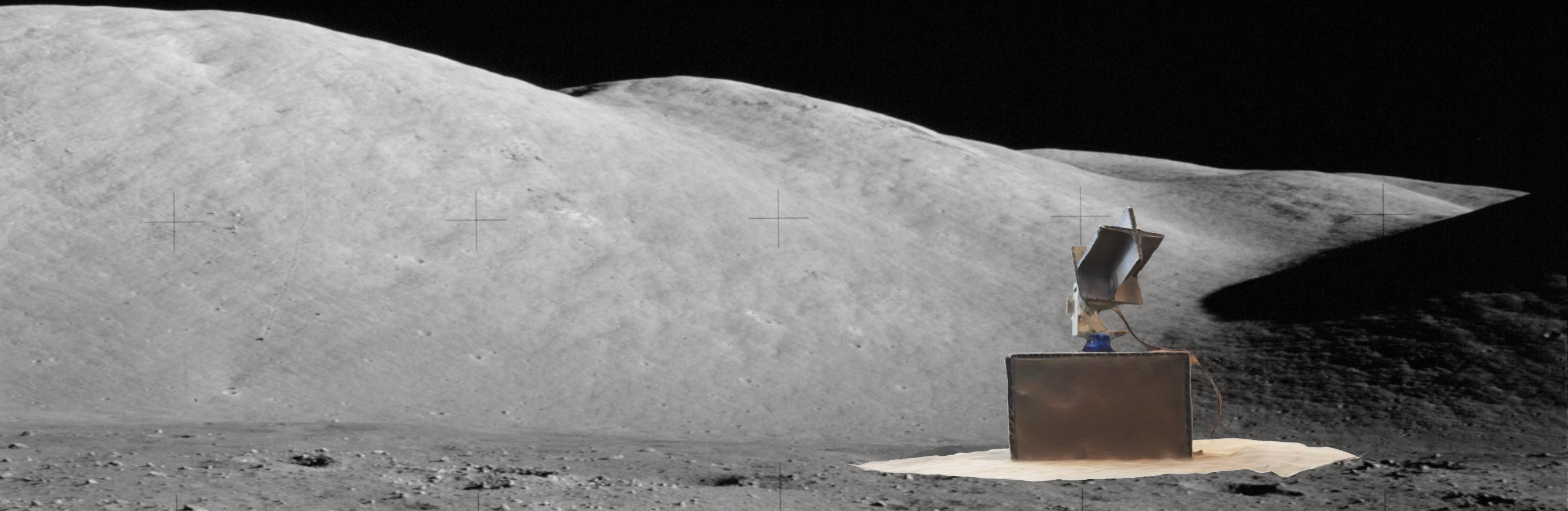


Solar power keeps our crew **alive** and
systems powered



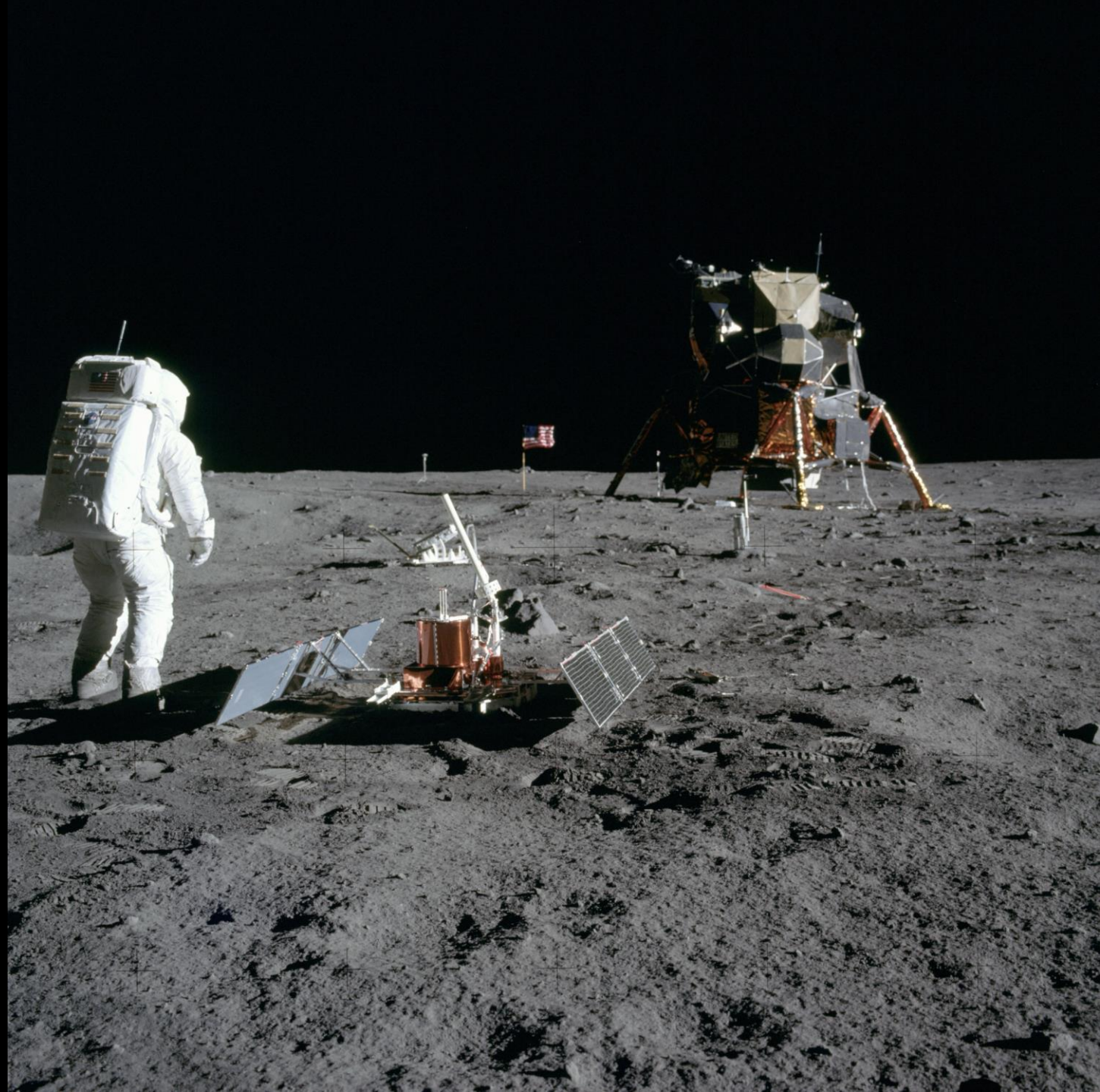
Lunar Sunflower's Design Goals

- Autonomous tracking anywhere in the sky above 15° from the horizon
- Implementation of fail-safes to improve reliability
- Maximize power harnessed



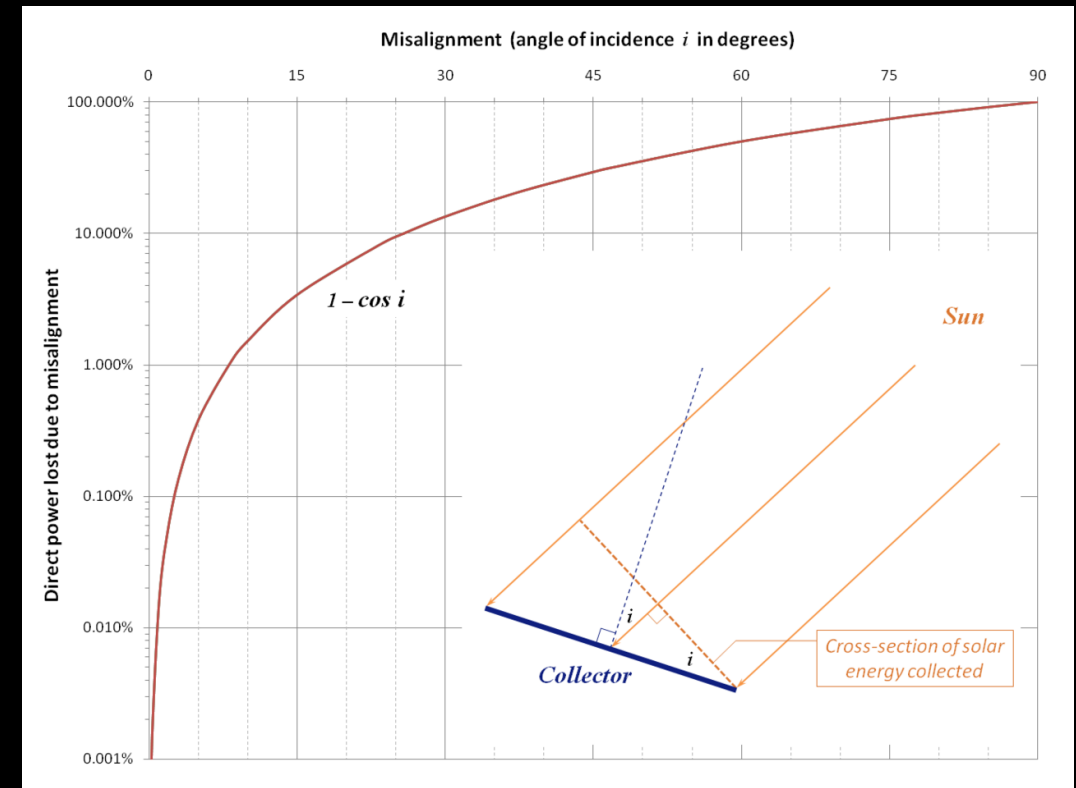
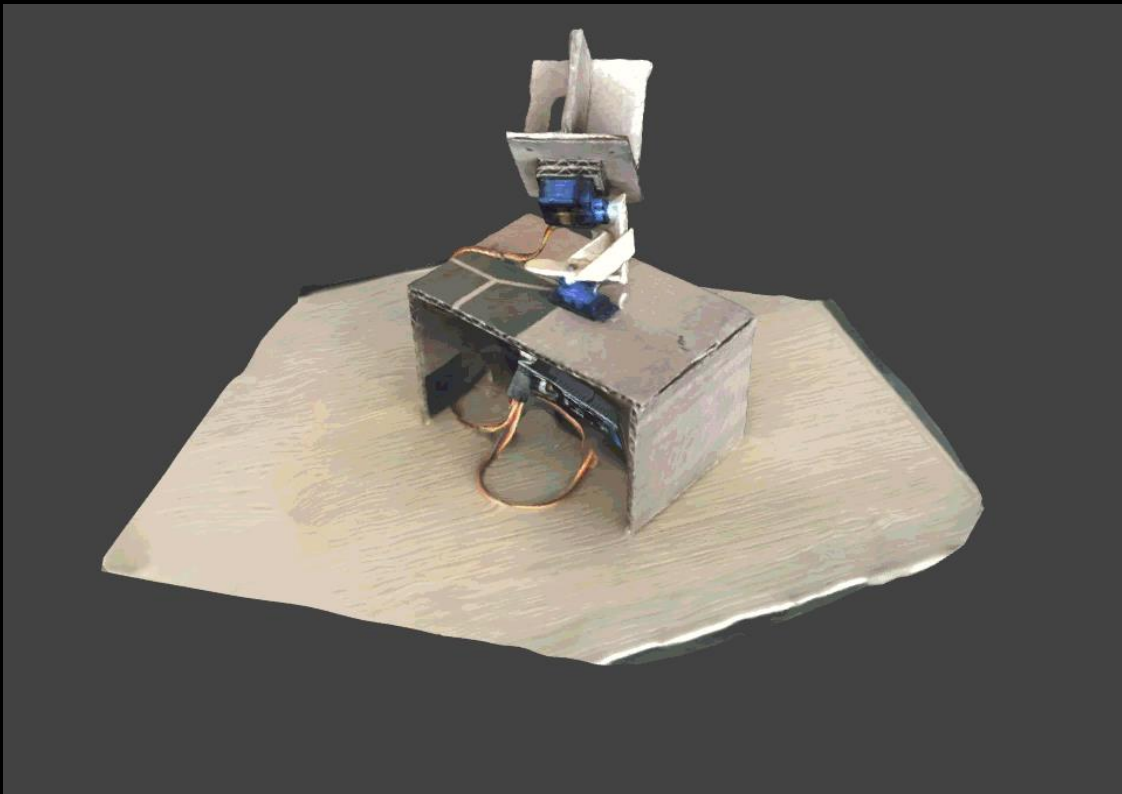
Design Constraints

- All parts must be contained within a 300 mm cubic volume.
- Equipment available:
 - 1x Arduino Uno R3
 - 3x 5g servo motors
 - 8x AA batteries + battery holder
 - Assorted jumper wires
 - 4x Photoresistors + assorted resistors
 - Popsicle sticks
 - Cardboard
 - Cardstock
 - Hot glue
 - Duck tape
- 48 hours to show proof of concept



Tracking Mechanism

- Solar panel efficiency depends on the incident light angle; beyond 15°, **power loss rises nonlinearly**.
- Assumes **zero dispersion** and perfectly collimated sunlight.
- Four photoresistors in a cross-pattern measure sunlight intensity.
- A central shadow structure gives directional cues; **shadow on a sensor shows misalignment**.
- **When the shadow is centered, the panel faces the sun optimally.**

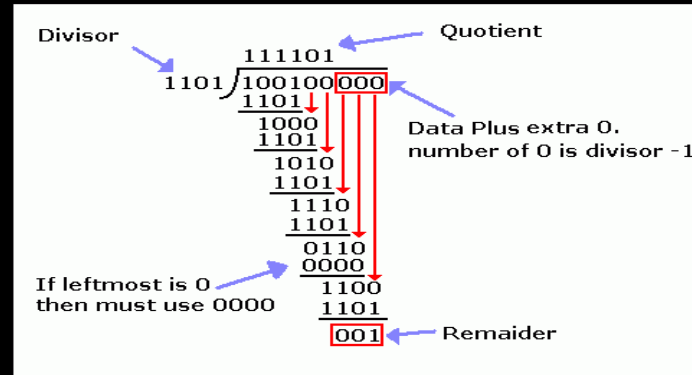


Control and Reliability

HAMMING CODES (EDAC)

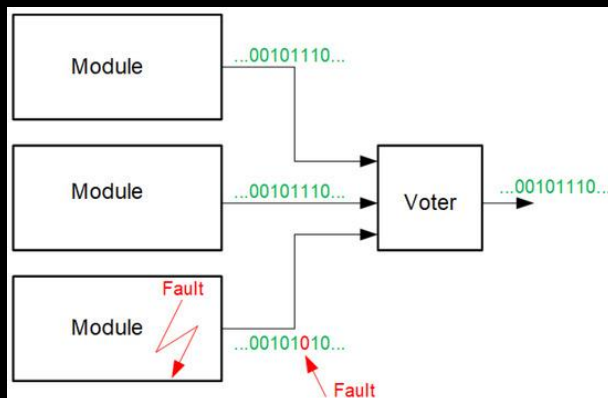
Bit #	1	2	3	4	5	6	7
Transmitted bit	p_1	p_2	d_1	p_3	d_2	d_3	d_4
p_1	Yes	No	Yes	No	Yes	No	Yes
p_2	No	Yes	Yes	No	No	Yes	Yes
p_3	No	No	No	Yes	Yes	Yes	Yes

CRC CHECKS FOR MOTOR COMMANDS



WATCHDOG
(must be fed treats)

TRIPLE MODULE REDUNDANCY



HARDENED STATE MACHINE

✗ Vulnerable

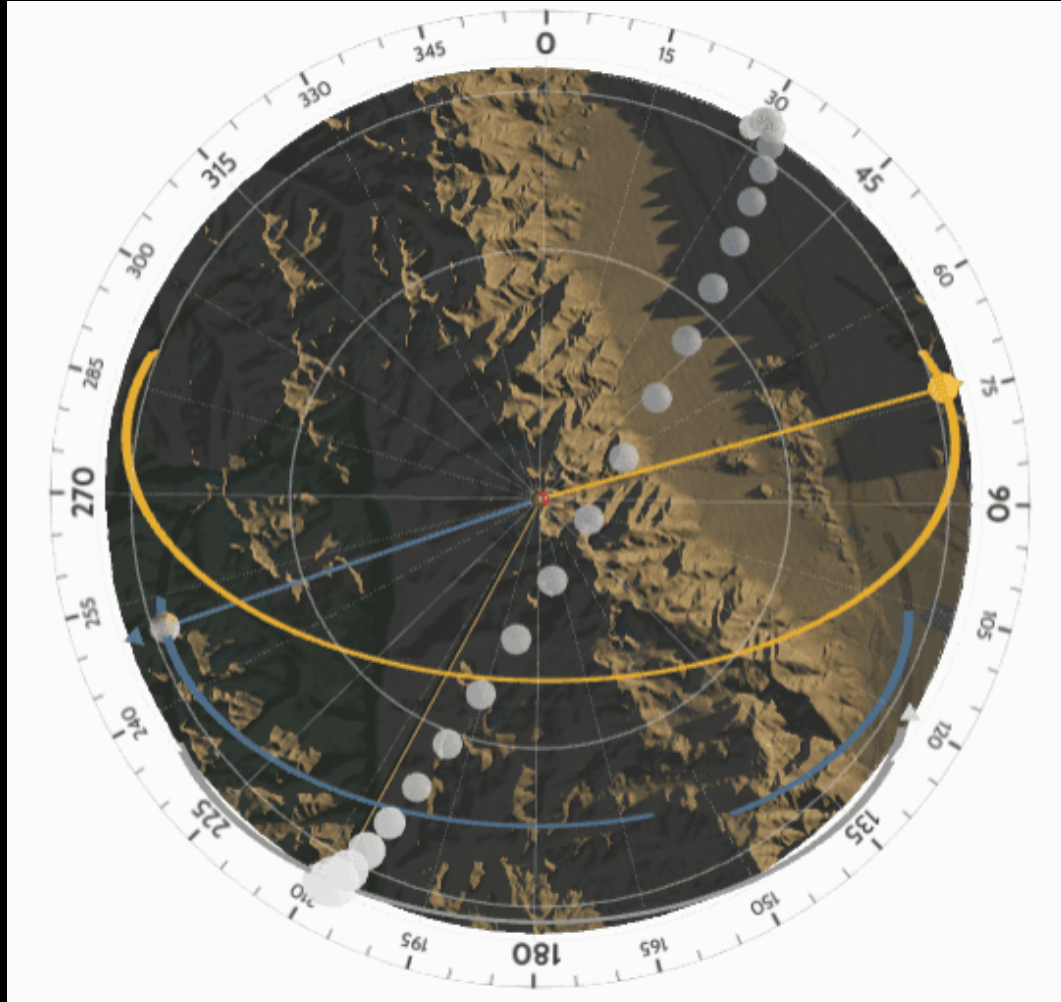
```
enum state {  
    IDLE,  
    TRACKING  
};  
state current = IDLE;
```

✓ Hardened

```
struct {  
    state s;  
    state s_complement;  
    uint16_t checksum;  
} hardened_state;
```

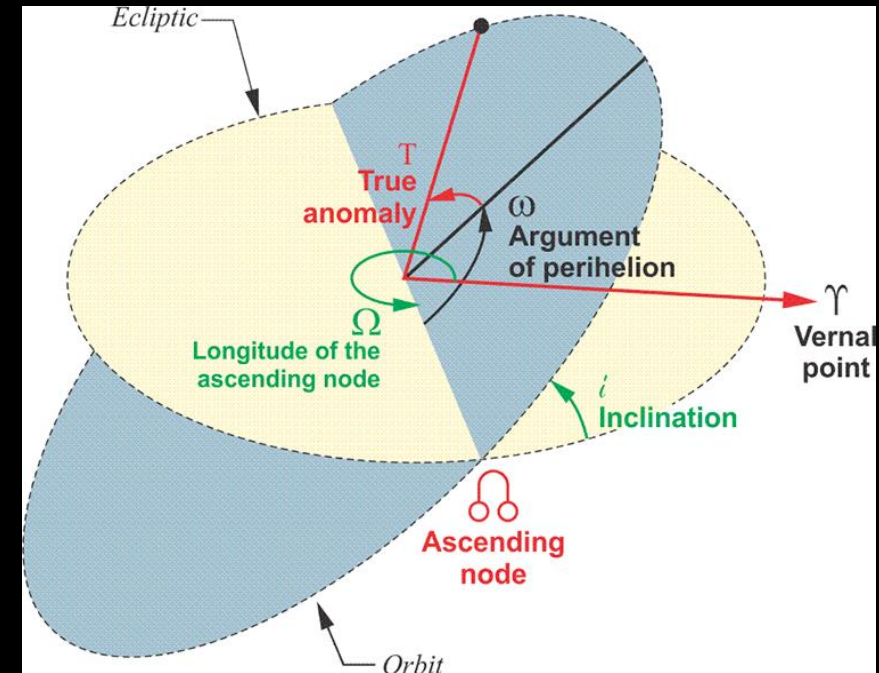


Control and Reliability

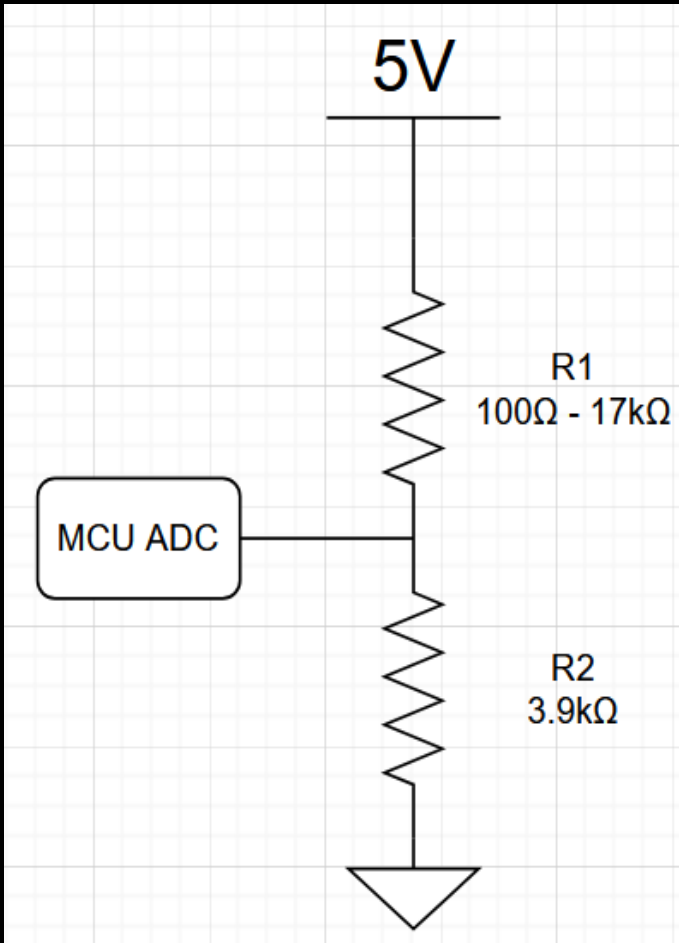


Ephemeris Based Tracking

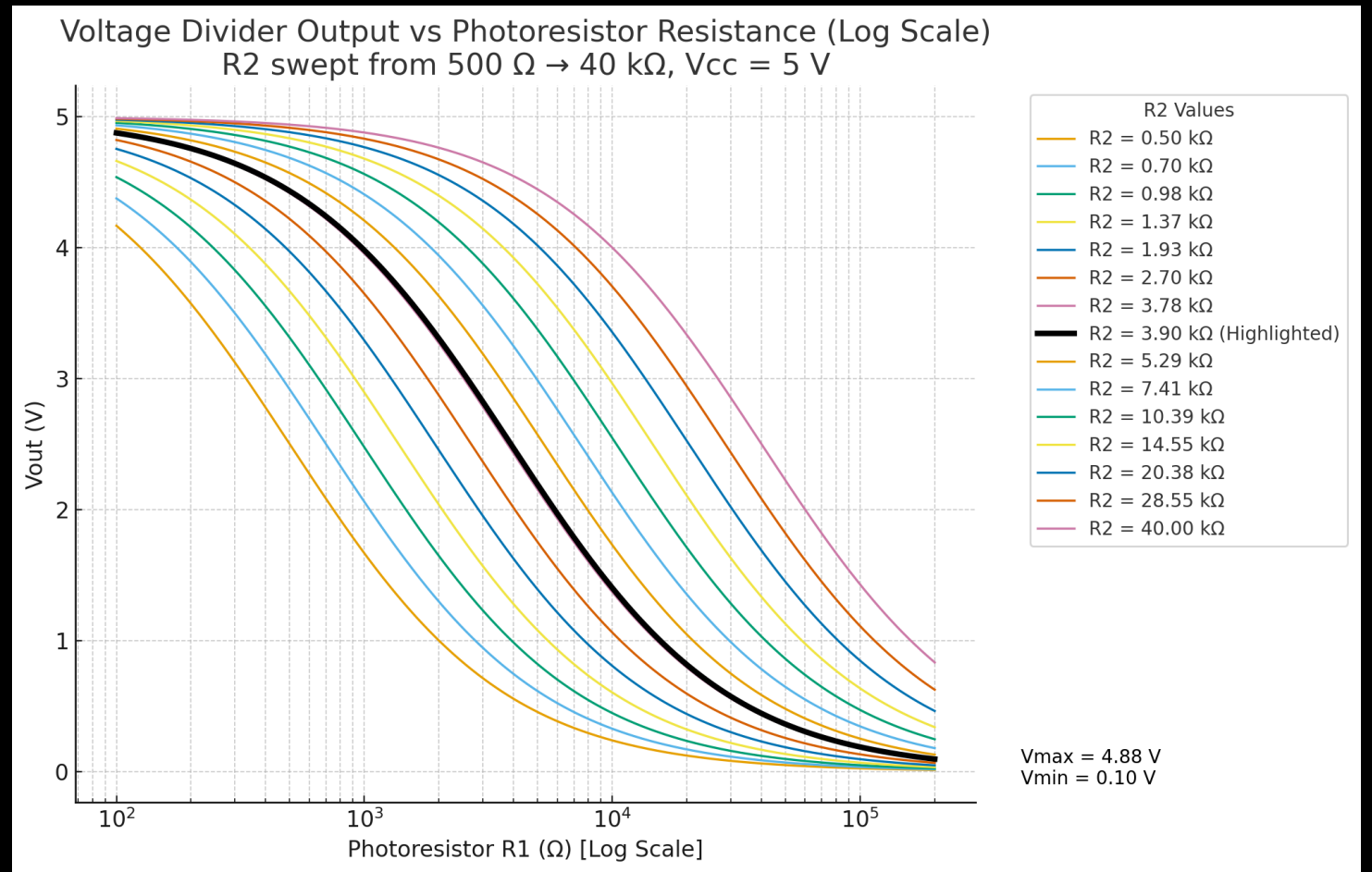
In case of photoresistor failure tracker falls back to robust lookup table of



Electrical Efficiency



Voltage Divider with ADC



Sweep of Photoresistor and $R2$ Values

Troubleshooting and Improvements

- Conducting a cost benefit analysis to **determine if the additional efficiency provided by a 2-axis system is worth the additional complexity** and weight increase
- Ensuring **secure wiring** to prevent signal or power issues
- **Optimize flash storage** usage to fit a more accurate ephemeris of the moon for prolonged sun tracking
- **Introduce Sleep Mode** for operations on the moon



Thank you

