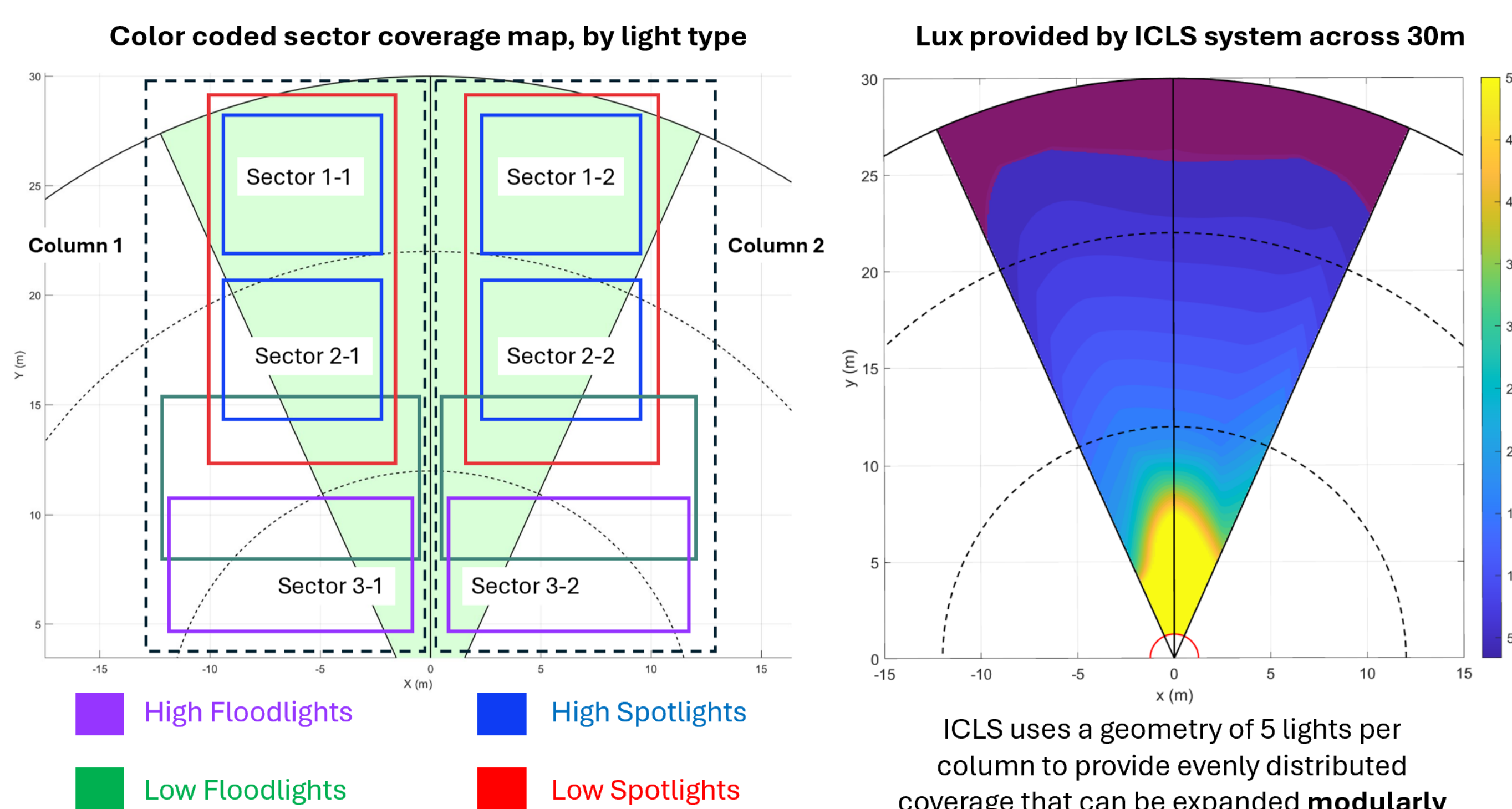
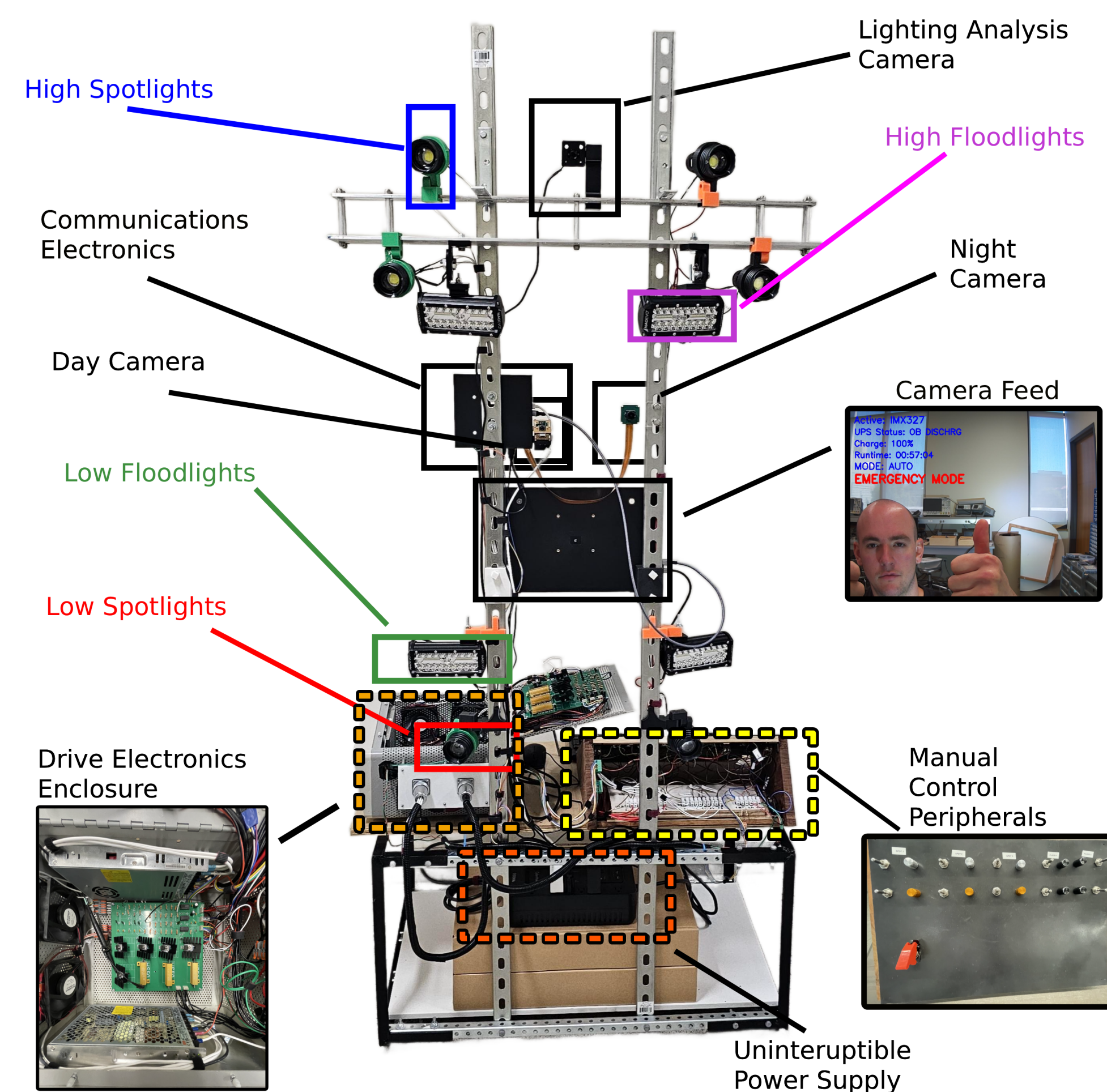


Problem Description

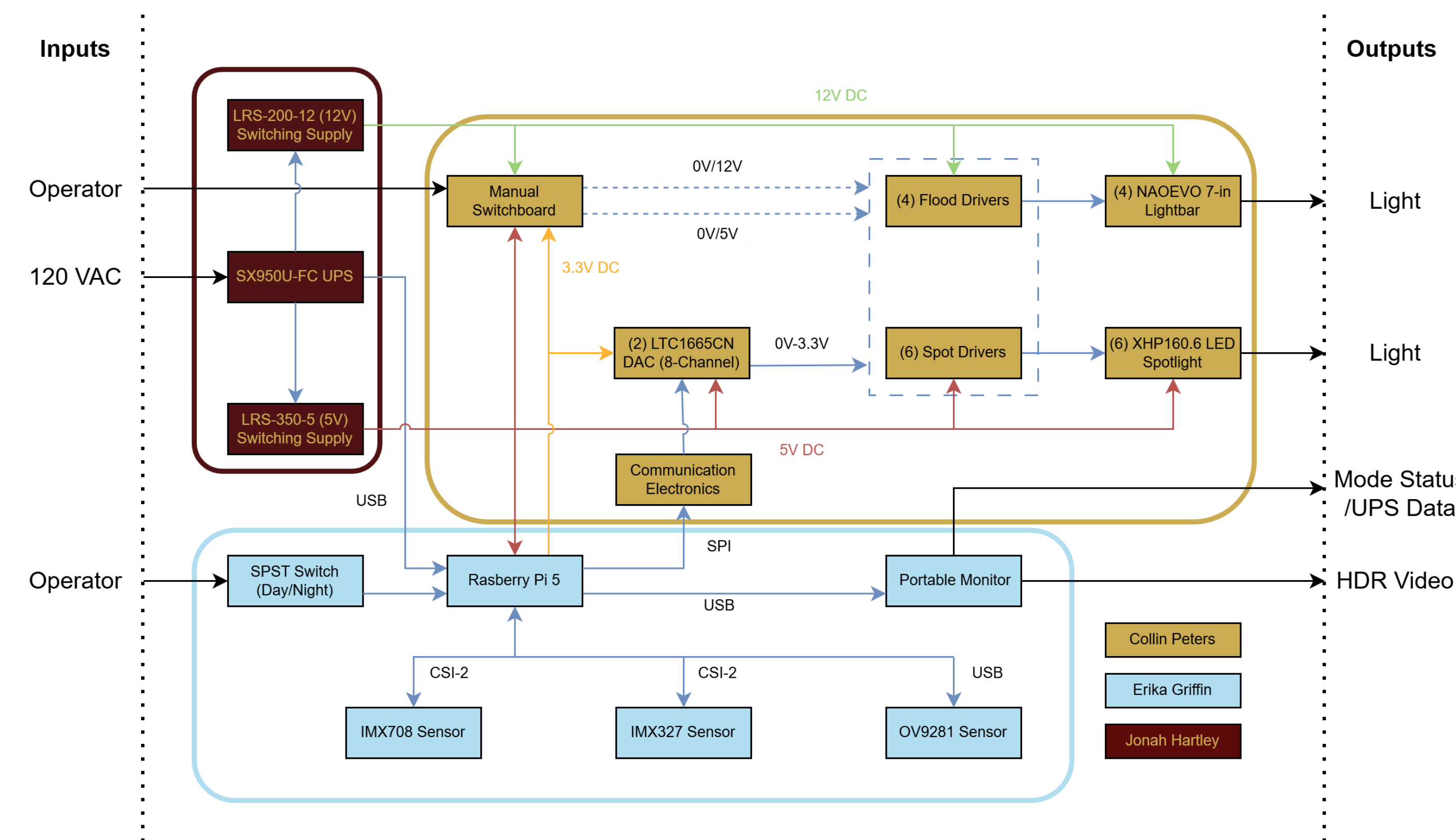
NASA's upcoming missions to the lunar surface present extreme contrast lighting conditions, from brilliant sunlight to deep, dark shadows. Traditional lighting systems force a trade-off between underexposure and power efficiency, while many existing Pulse Width Modulation systems used to drive LEDs are incompatible with video capture. Future exploration also demands real-time monitoring for both astronaut safety and mission efficiency.

Our Solution

- A Raspberry Pi 5 analyzes sector brightness in real time.
- Only the necessary lights are activated to maintain safe illumination.
- Manual override mode gives operators direct control when needed.
- Assumption of 4m/s top rover speed and 2 second required reaction time.
- Reliable power and cooling: UPS backup, emergency-mode, Pi 5 + driver cooling, and stable temps verified for 100-minute operation.



System Architecture & Top-Level Diagram



Real-Time Adaptive Illumination

- Arducam B0332 + HDR/low-light cameras for full-scene analysis
- Real-time sector-based % dark estimation
- Fast control loop activates only needed lights

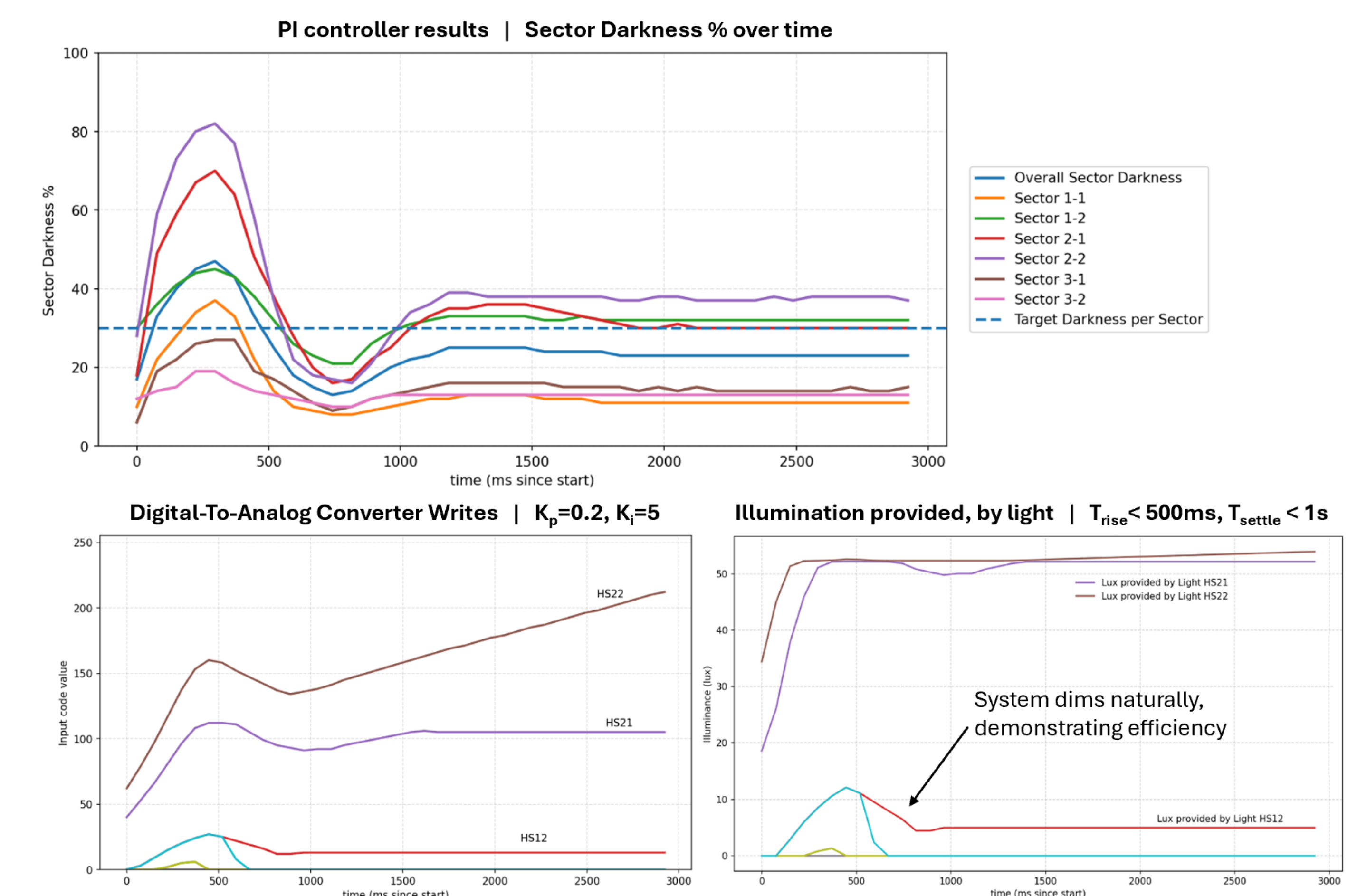


System Identification

- Pseudo-Random Binary Sequence (PRBS)
- Autoregressive Exogenous (ARX) Model (2 Poles, 1 Zero)
- Matlab tuned PI Controller provides smooth, stable lighting adjustments

System Controls & Response

- Effective lighting distance up to 25 meters
- 90 ms single-frame response time
- Under 500 ms rise time for rapid correction
- Energy-efficient: only necessary lights activate



Sector brightness values during a perturbation are displayed above. The system responds with a controlled rise and minimal oscillations before settling.

Meet the Team



Jonah Hartley, Collin Peters (Project Manager), Erika Griffin

Future Work & Acknowledgements

Future Work: MIMO, MPC, Optics

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