Part 4 Project Plan & Implementation:

<u>Focus:</u> On the sun-tracking implementation of Sunlink II, especially the motor control subsystem and its role in achieving the project's innovation: sunlight-aligned, system-to-system VLC communication.

Approach for Sunlink II (Sun tracking subsystem focus)

Project Vision Recap:

Aim to develop and design a motor-electronics-driven sun tracking system that enables real-time alignment of light communication devices to direct sunlight.
Serving Two Goals:
1. Maintaining optimal alignment for reliable VLC (Visible Light Communication)
2. Enabling scalable multi-node communication across an outdoor area without relying on RF infrastructure.

Core Innovation:

The innovation emphasises– and differentiates from past works in the area like Sol-Fi, Sunlight-Duo, and Edge-Light.

- Real-time mechanical sun tracking for dynamic beam alignment
- Support multi-node directional communication, not fixed point-to-point links.
- Integration of closed-loop control with feedback from photodiode sensors or light intensity readings.
- Application of PID or adaptive gain scheduling to keep the system power-efficient and stable.

Subsystem Focus:

1. Actuation: Motor Choice
2. Sensing: Sun position estimation using photodiode arrays, LDRs, or digital sun sensors
3. Control: PID control algorithm to align device orientation with sun's trajectory.
4. Mechanical Design: Mount and structure for the tracking system. (Duel axis system)
5. Interface & integration: Feed forward to VLC system to enable system-to-system coordination via modulated sunlight/artificial.

Structured Development Plan:

Plan for developing the Project: Broken down into phases and tasks, aligned with our focus and Gantt chart timelines:

Phase One: Planning and research

- Literature Review
- Gaps in existing systems identified
- Unique subsystem focus defined

Phase Two: System Architecture & Component Selection

- Decide on tracking configuration (dual-axis)
- Select Motors: Servo / Stepper / DC + Encoder
- Select Light Sensor Setup
- Choose MicroController
- Power Requirement and Interface Considerations
- Initial design of the mechanical Mount
  [Block diagram, Hardware Selection List, Schematic Draft]

Phase Three: Motor Control & Sensing Development

- Write and tune a PID controller for motor positioning
- Develop a sun position estimation algorithm from sensor data
- Implement motor feedback looping using photodiode readings
- Test basic sun-tracking on bench setup (Lamp/ artificial light set-up)
- Log Angle errors and power usage for analysis
  [Tracking code, logs, plots of tracking error, tuned PID parameters]

Phase Four: Integration with the communication system

- Align the emitter direction with the tracked sun position
- Sync modulation window to tracking accuracy
- Coordinate multiple receiver testing using an emitter
  [System integration prototype, tracking+transmission logs]

Phase Five: Testing, Evaluation & Integration

- Test using full artificial light over long, extended periods
- Analyse data integrity vs misalignment and range
- Compared to the static-angle transmission performance
- Optimise for power efficiency and tracking latency.
  [Plots of alignment vs throughput, sunlight consistency vs BER, energy consumption logs]

Component	Supply Voltage	Source
NEMA 17 Stepper motor	12V	Main Rail
28BYJ-48 Servo Motor	5V	Second Rail
A4988 Driver	12V logic + VM	Main Rail
ULN2003 Driver	5V	Second Rail
MSP430FR2433 MCU	3.3V	Step Down
LDR + Photodiode Sensors	3.3V	Step Down
LC shutter (modulation)	TBD	Second Rail

Function	Interface Type	MCU Connection
Azimuth Motor Control (A4988)	Digital GPIO	Step / Dir pins
Elevation Motor Control (ULN2003)	Digital GPIO	Sequence control
LDR / Photodiode Inputs	Analog (ADC)	4x ADC channels
LC Shutter Control	Digital GPIO / PWM	TBD
Debug / Data Logging	UART	Serial TX/RX
Optional Limit Switches	Digital Input	Interrupt pins