

# OPERATION SENTINEL

## Autonomous Perimeter Defense System

**MISSION OBJECTIVE:** Engineer a deployable, National Security-grade autonomous surveillance asset. This roadmap details the critical path from initial architecture to a fully sovereign, privacy-compliant unit capable of operating in GPS-denied environments.

### PHASE 1: THE CORE FOUNDATION (Immediate - Jan 30)

**GOAL:** Validate Core Architecture (PX4-SITL Bridge) & System Design.

#### Milestone 1: API Bridge & Protocol Validation

- **Action:** Verify bi-directional MAVLink communication between Python Mission Control (AirSim API) and PX4 Flight Stack.
- **Metric:** Achieve stable command stream with <10ms round-trip latency.

#### Milestone 2: System Architecture Blueprinting

- **Action:** Define segregation of concerns: Real-time Flight Controller vs. High-Level AI Planner.
- **Deliverable:** High-fidelity Architecture Diagram (ROS 2 / MAVROS node graph).

#### Milestone 3: Compliance Logic & Synthetic Data

- **Action:** Implement strict privacy-safe constraints. Use Synthetic Training Environment (STE) to eliminate PII risks.

#### Milestone 4: Dynamics Verification (Proof of Flight)

- **Action:** Execute initial PID tuning. Verify 'Hold Position' stability under zero-wind.
- **Success Criteria:** <5cm position drift over 60 seconds.

#### Final Step: SUBMIT TECHNICAL ROADMAP

### PHASE 2: THE DATA ENGINE (Jan 31 – Feb 13)

**GOAL:** Scalable Data Pipeline & Procedural Environment Generation.

#### Feb 1 - Feb 5: Procedural Stress Testing

- **Implementation:** Script random map generator (Perlin Noise) to spawn dense obstacle fields.

- **Scale:** Execute overnight headless simulation runs. Accumulate 10,000+ collision events.

### **Feb 6 - Feb 10: High-Frequency Telemetry Pipeline**

- **Implementation:** Configure PX4 ULog streaming to local time-series DB (PostgreSQL).
- **Auditability:** Capture IMU, LiDAR, and Control Actuator outputs at 50Hz for forensics.

### **Feb 11 - Feb 13: LiDAR-Based Navigation**

- **Demo:** Proof of concept flight relying exclusively on Sparse LiDAR (VFH+). No cameras.
- **Milestone:** 'Environment & Data' Submission.

## PHASE 3: FUNCTIONAL ALPHA (Feb 14 – Feb 27)

**GOAL:** Deploy Robust Visuomotor Policy (MVP).

### Feb 14 - Feb 20: Training the Recurrent Policy

- **ML Architecture:** Train PPO agent with LSTM memory cells for state estimation.
- **Dataset:** Utilize 100k+ step synthetic dataset for Behavior Cloning warm-starting.

### Feb 21 - Feb 25: Disturbance Rejection

- **Test Setup:** Inject randomized wind vectors (up to 12 m/s) in Gazebo.
- **Criterion:** Maintain trajectory within 0.5m corridor.

### Feb 26 - Feb 27: Containerization

- **DevOps:** Encapsulate Simulation + Stack into monolithic Docker container.
- **Milestone:** 'Functional Alpha' Submission.

## PHASE 4: SECURITY & ASSURANCE (Feb 28 – Mar 13)

**GOAL:** Safety Critical Systems & Human-in-the-Loop.

### Feb 28 - Mar 5: Hardware Kill Switch

- **Mechanism:** High-priority interrupt thread monitoring physical input.
- **Latency:** Override engagement <50ms.

### Mar 6 - Mar 10: Deterministic Geofencing

- **Logic:** Hard-coded geometric geofence enforcement overriding Neural Net.

### Mar 11 - Mar 13: C2 Dashboard Integration

- **Stack:** React/Flask WebSocket link for real-time threat maps.
- **Milestone:** 'System Security' Submission.

## PHASE 5: THE X-FACTOR (Mar 14 – Mar 20)

**GOAL:** Sovereign Deployment & Production Pitch.

### Mar 14 - Mar 17: Sovereignty Audit

- **Claim:** 100% Local Compute. Zero cloud dependency. Air-gappable.

### Mar 18 - Mar 19: The 'Golden Run'

- **Production:** 4K automated flight logs in high-complexity environments.
- **HUD Overlay:** Post-process video with telemetry overlays.

## **Mar 20: FINAL PITCH**