User Guide — Multi-Agent UAV LiDAR + MPC

This guide explains how to use the UAV swarm simulation app.

1. Overview

This app demonstrates a complete UAV swarm simulation using LiDAR sensing and Model Predictive Control (MPC). Includes wind and gusts, moving obstacles, energy/battery models, real-time timing, task allocation, coverage analysis, AI suggestions, and full export features.

2. Sidebar Parameters

• World Size, Simulation Steps, Δt (time step), MPC Horizon.
• Drone settings: speed, acceleration, goal radius, damping.
• Environment: wind X/Y, gust sigma, number of drones, number of obstacles, obstacle size and speed.
• LiDAR: range, rays, toggle beams.
• Energy (Wh): sets drone battery capacity.
• Coverage cell size: granularity of coverage heatmap.
• Scenario presets: Warehouse, Urban Canyon, Disaster Mapping.

3. Features

• Multi-agent UAVs with MPC path planning and damped hover.
• Wind and gust simulation.
• Moving obstacles with bouncing dynamics.
• LiDAR ray-casting with fused global mapping.
• Coverage heatmap of environment.
• Energy model with Return-to-Base (RTB) triggers.
• Greedy task allocation for goal assignment.
• Scenario presets for quick demonstrations.

4. Metrics and AI Suggestions

The app displays:
• Total time, latency statistics, coverage percentage, min separation.
• Drone-level stats: distance to goal, avg/peak speed, battery remaining, status.

AI Suggestions:
• Coverage optimization.
• Latency trade-offs.
• Safety (collision risk or wide separations).
• Battery efficiency and RTB triggers.
• Speed tuning recommendations.

5. Export Results

A one-click ZIP export includes:
• trajectories.csv (drone paths)
• metrics.csv (final performance)
• latency.csv (decision times)
• fused_map.csv (LiDAR fused hits)
• run_summary.json (parameters and results)

• trajectories.geojson (mapping-compatible paths)
• plot.png (visual snapshot).

6. Use Cases

• Teaching UAV autonomy concepts.
• Benchmarking MPC scalability.
• Demonstrating LiDAR mapping and fusion.
• Exploring swarm safety, coverage, and efficiency.
• Showcasing AI-assisted UAV decision support.

7. Quick Start

Run with: streamlit run app.py
Adjust sidebar parameters, run simulations, review metrics and suggestions, and export results for further analysis.