Autonomous UAV Networks – Digital-Green v2.3
User Guide

Overview

This guide introduces the Autonomous UAV Networks simulator — a research and educational tool that models real-world UAV networking behavior under aerospace-accurate conditions. It integrates International Standard Atmosphere (ISA) physics, aerodynamic power equations, RF propagation (Two-Ray + Rician), and LTE-MCS throughput estimation to simulate resilient airborne networks.

Quick Start

- 1. Launch the app: `streamlit run app.py`.
- 2. Adjust parameters in the sidebar — area, UAV count, frequency, and MAC scheme.
- 3. Click **▶ Run Simulation** to start.
- 4. Monitor the progress bar and live metrics.
- 5. Review visualizations (2D, 3D Orbit, or Animation).
- 6. Export results via the ** Download** buttons for CSV, JSON, or ZIP bundles.

Key Features

• ISA-based atmosphere model for air density and temperature realism.
• Aerodynamic power computation combining induced, parasite, and climb loads.
• Two-Ray + Rician RF propagation for multi-path ground reflection modeling.
• LTE-MCS PHY model or Shannon ideal channel for link throughput estimation.
• TDMA, NOMA, and RSMA MAC presets for multi-access performance testing.
• Integrated jammer and eavesdropper modules for security analysis.
• Dynamic 3D orbit visualization (LEO/MEO/GEO reference rings).
• Expanded export suite: metrics, trajectory, fleet, and configuration data.

Simulation Workflow

Each simulation step evaluates aerodynamic power, link quality, and throughput for every UAV. Kinematic updates incorporate wind vectors, climb rates, and heading changes. Signal-to-Interference-plus-Noise Ratio (SINR) is recalculated dynamically per link. A directed capacity graph determines end-to-end throughput using a “ widest path ” flow heuristic for network efficiency analysis.

Data Export and Analysis

Upon completion, exportable datasets include metrics (throughput, SoC, energy), trajectory, fleet specifications, and final UAV positions. A ZIP bundle consolidates all exports along with the session settings JSON, ensuring reproducibility and compatibility with Python, MATLAB, or Excel workflows.

Troubleshooting & Best Practices

- Ensure Python $\geq$ 3.10 and Streamlit $\geq$ 1.30.
- For large fleets (>25 UAVs), reduce simulation steps or disable animations.
- If simulation halts, use ** Reset Fleet & Reseed** to restart.
- Use consistent random seeds for repeatable studies.
- Keep the terminal open to monitor progress and runtime logs.

Appendix: Mathematical Foundations

Core algorithms employ ISA atmosphere equations, aerodynamic power balance, Two-Ray ground reflection, Rician fading statistics, and LTE Modulation and Coding Schemes. A detailed technical reference is available in the *Aerospace Math Appendix – UAV Networks v2.3* document.