UAV Strategic Deconfliction System – Overview Document

1. System Overview

The **UAV Strategic Deconfliction System** ensures safe drone operations in shared airspace by detecting **spatiotemporal conflicts** (collisions in 3D space + time). It serves as a **pre-flight validation tool** for drone operators and air traffic managers, verifying mission safety against other scheduled flights.

Key Capabilities

✔ 4D Conflict Detection – Checks X/Y/Z position + time windows
✔ Safety Buffering – Configurable minimum separation distance
✔ Interactive Visualization – 3D static plots + 4D animated trajectories
✔ Scalable Architecture – Modular design for future expansion

2. Technical Implementation

Core Components

Component	Function
Mission Parser	Validates and loads JSON mission files
Trajectory Generator	Interpolates waypoints into continuous paths
Conflict Detector	Checks for spatial + temporal overlaps
Visualization Engine	Generates 3D plots and animations

Algorithm Approach

- **Spatial Checks**: Euclidean distance calculations with safety buffers

- **Temporal Checks**: Time-window overlap detection (±1 sec tolerance)
- **Vectorized Math**: Uses NumPy for performance efficiency

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3. AI Integration

While the runtime system does **not use AI/ML**, development was accelerated via:

- **ChatGPT**: For optimizing algorithms (vectorization, visualization tips, docstring and writing clean code)

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4. Testing & Edge Cases

Testing Strategy

- **Unit Tests** – Core algorithms (e.g., distance calculations)
- **Integration Tests** – End-to-end mission conflict validation

Edge Cases Covered

- Zero-time missions (immediate rejection)
- Single-waypoint flights (treated as stationary)
- Altitude-only conflicts (Z-axis specific detection)

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5. Scaling for Real-World Use

To support **10,000+ drones**, the system would require infrastructure scaling.

Performance Goals

- Latency: <100ms per mission check
- Throughput: 1,000+ mission validations per minute
- Availability: 99.99% uptime SLA

Conclusion

This system provides a robust **foundation for large-scale UAV traffic management**, balancing **accuracy, modularity, and performance**. With future enhancements, it can support both commercial and public airspace management systems.