# Abstract
# Innovative Air Mobility - Control Center

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IAM-CC is a control center for managing fleets of highly automated or autonomous eVTOL aircraft in dense urban airspace under U-space/UTM rules.

It is projected to integrate 4D trajectory planning, strategic and tactical conflict management, geofence enforcement, vertiport slot scheduling, fleet health monitoring, and real-time visualization, with REST-based interoperability to U-space service providers.

It prospectively includes a simulation suite for aircraft, airspace, vertiports, passenger demand, booking, and U-space services to support validation, training, and demonstrations.

## Front-end architecture:

- Cesium-powered 3D map.
  - Cesium World Terrain, OSM-derived layers, and configurable imagery.
  - GeoJSON/3D tiles overlays for dynamic/static geofences, no-fly zones, obstacles, and population-density heat maps.
- Interactive mission planning.
  - Rubber-band editor for drag-and-drop waypoints with time and altitude constraints.
  - On-map geofence drawing to publish or trial dynamic restrictions.
  - Color-coded trajectory compliance: green (nominal), yellow (caution), red (violation).
- Fleet and health dashboards.
  - Matrix view: columns per aircraft; rows for subsystems (battery, comms, propulsion health, proximity hazards, ground-risk density, vertiport congestion).
  - Color-coded icons highlight excursions from nominal.
  - Aviate panel on selection: attitude, ground speed, altitude, heading, and ranked conflict-resolution suggestions.
- Operator workflow panels.
  - Conflict Resolution panel with ranked mitigations: delay, expedite, reroute, altitude change, slot swap.
  - Vertiport Scheduler with slot availability, congestion forecasts, and automated relief proposals.

## Back-end microservices:

- Path Planning Service.
  - REST endpoints produce candidate 4D trajectories along designated skyways.

    - Uses aircraft performance and energy models, wind and terrain, and integrates geofences and vertiport schedules.
- Conflict Detection Services.
    - Strategic (pre-flight): batch checks against active plans, static constraints, hazards, and demand-capacity rules.
    - Tactical (in-flight): streaming conformance monitoring on telemetry and dynamic geofences; detects trajectory conflicts and deviations.
- Conflict Resolution Service.
    - Generates and ranks deconfliction maneuvers: time shift, route diversion, altitude change.
    - Optimizes for safety, compliance, mission impact, and energy margins.
- Vertiport Management Service.
    - Tracks per-vertiport capacity, pad occupancy, charging resources, and turnaround processes.
    - Issues automated relief actions: delay, expedite, cancel, swap, or redirect to alternates.
- U-space/UTM integration.
    - REST connectors to USSP for mission management, flight authorization, and strategic deconfliction.
    - REST connectors to CIS/CISP for geo-awareness: static/dynamic geofences, NOTAMs, temporary segregated areas, terrain/obstacles, vertiport metadata, and event notifications.
    - Remote ID and identification/tracking data flows as applicable.
- Data and observability (implementation detail).
    - Time-series telemetry ingestion, eventing for alerts, audit logging for legal recording and incident reconstruction.

# Simulation framework:

- UAS simulation.
    - Controlled Airtaxis Simulator: vehicle dynamics and onboard autonomy; accepts trajectory updates and resolution commands; streams telemetry including GPS and battery state.
    - Uncontrolled Traffic Simulator: non-cooperative manned/unmanned traffic on scripted or random routes; emits ADS-B-like or Remote ID-like tracks to tactical detection.
- Vertiport schedule simulation.
    - Time-indexed arrival/departure queues per vertiport in a database.
    - Charging stations, pad occupancy, and turnarounds modeled to predict congestion and trigger scheduler proposals.
- Passenger demand simulation.
    - Synthetic mission requests from temporal, geographic, and historical models.
    - Demand elasticity versus pricing, availability, weather, and events.
- Booking workflow simulator.
    - Emulates booking platforms and dispatch UIs; applies pricing, availability, and cancellation logic.

- U-space service simulators.
    - CISP simulator: registration, Remote ID streams, geo-awareness feeds, terrain/obstacles/vertiport metadata, and event alerts.
    - USSP simulator: mission planning and authorization, strategic deconfliction, dynamic geofence distribution, conformance monitoring, identification/tracking, and traffic information.
    - Optional services: dynamic capacity management, tactical conflict resolution, emergency and contingency management, legal recording, citizen reporting, procedural/collaborative ATC interfaces, and drone AIM for 3D airspace structure governance.

# Operational flow

- Intake mission requests from booking or dispatch.
- Generate candidate 4D trajectories and evaluate energy, time, and capacity constraints.
- Perform strategic deconfliction, obtain flight authorization via USSP, and ensure geo-awareness compliance via CISP.
- Reserve vertiport slots; publish conformance bounds and contingency plans.
- Execute missions with tactical monitoring and on-demand trajectory updates for conflicts, geofences, weather, or health alerts.
- Manage turnarounds and charging; adjust schedules and flows as conditions evolve.

# Compliance and governance

- Align with U-space regulations for airspace designation, U-space services, and conformance monitoring.
- Maintain audit trails for authorizations, advisories, operator decisions, and telemetry for incident reconstruction.

# Non-functional goals

- Scalability for city-scale operations with bursty demand.
- Low-latency decision loops for tactical deconfliction.
- High availability and graceful degradation with operator overrides.
- Configurability to regional U-space/UTM variants.

# Biography

Speaker Given Name

Studies and PhD in Mathematics at the University of Münster, since 2024 researcher on flight guidance of unmanned air systems at the DLR