CNA

Quantum Cooperative Air Traffic Simulation (Q-CATS)

By 2035, cities will face airspace gridlock due to the rise in operations and the failure of scheduling algorithms. The complexity of coordinating airspace fairly, efficiently, and safely will become increasingly challenging. Current simulators simplify this problem and do not operate effectively at the scales required for future traffic densities. There is a critical need to simulate and test extensible traffic management (xTM) strategies at future-ready scales to ensure public safety.

The project proposes to develop an xTM simulation framework using quantum annealing and agent-based simulation. This enhanced framework, called Quantum Collaborative Airspace Traffic Simulator (Q-CATS), will scale with demand and provide government decision-makers with a tool to make informed xTM decisions. The simulation environment supports optimization algorithms that leverage quantum hardware, decreasing processing time and increasing simulation capacity. Current unmanned traffic management (UTM) systems rely on simplistic heuristics and struggle with performance at high traffic densities. Existing deconfliction models are sub-optimal and do not scale efficiently.

Opportunity: Quantum annealing hardware and quadratic unconstrained binary optimization (QUBO) algorithms will enable Q-CATS to handle future traffic densities. These methods allow rapid combinatorial search and optimization, outperforming classical computers. Quantum-classical hybrid computational methods will ensure scalability with advances in quantum processing power.

If successful, **Q-CATS will allow government stakeholders to test and plan for future operations** and airspace constraints. Regulatory agencies can use the tool to evaluate UTM Service Suppliers (USS) deconfliction protocols, and municipalities can analyze airspace congestion. The project aligns with DOT priorities by enhancing safety, ensuring fairness, and supporting large-scale simulations.

Phase 1: Develop QUBO Algorithm (Year 1)

- Formulate the optimization algorithm and develop a testable QUBO algorithm, Inter-USS integration, and simulation framework.

Phase 2: Integrate Q-CATS with Cloud-Based Quantum Hardware (Year 2)

- Create interoperability with commercial quantum cloud resources, targeting 5,000 binary variable execution on quantum/classical hybrid hardware with runtime < 1 minute, 75% adherence to sector density requirements, and 10% decrease in cancellations and delays.

Phase 3: Pilot Program Deployment and Validation (Year 3)

- Validation of Q-CATS with 2-3 pilot program partners.

Phase 4: Scaling and Packaging (Year 4)

- Scale the simulation capacity to large-city densities, targeting: 5,000 binary variable execution on quantum/classical hybrid hardware with runtime < 30 seconds.

The proposed project aims to address the critical issue of airspace gridlock by developing a scalable, future-ready UAS simulation framework. By leveraging quantum annealing and agent-based simulation, **Q-CATS will provide a powerful tool for government and industry stakeholders to ensure safe, efficient, and fair airspace operations in the future.**