STEReO/SAFE50 : Advanced Airborne Autonomy For Urban Operations

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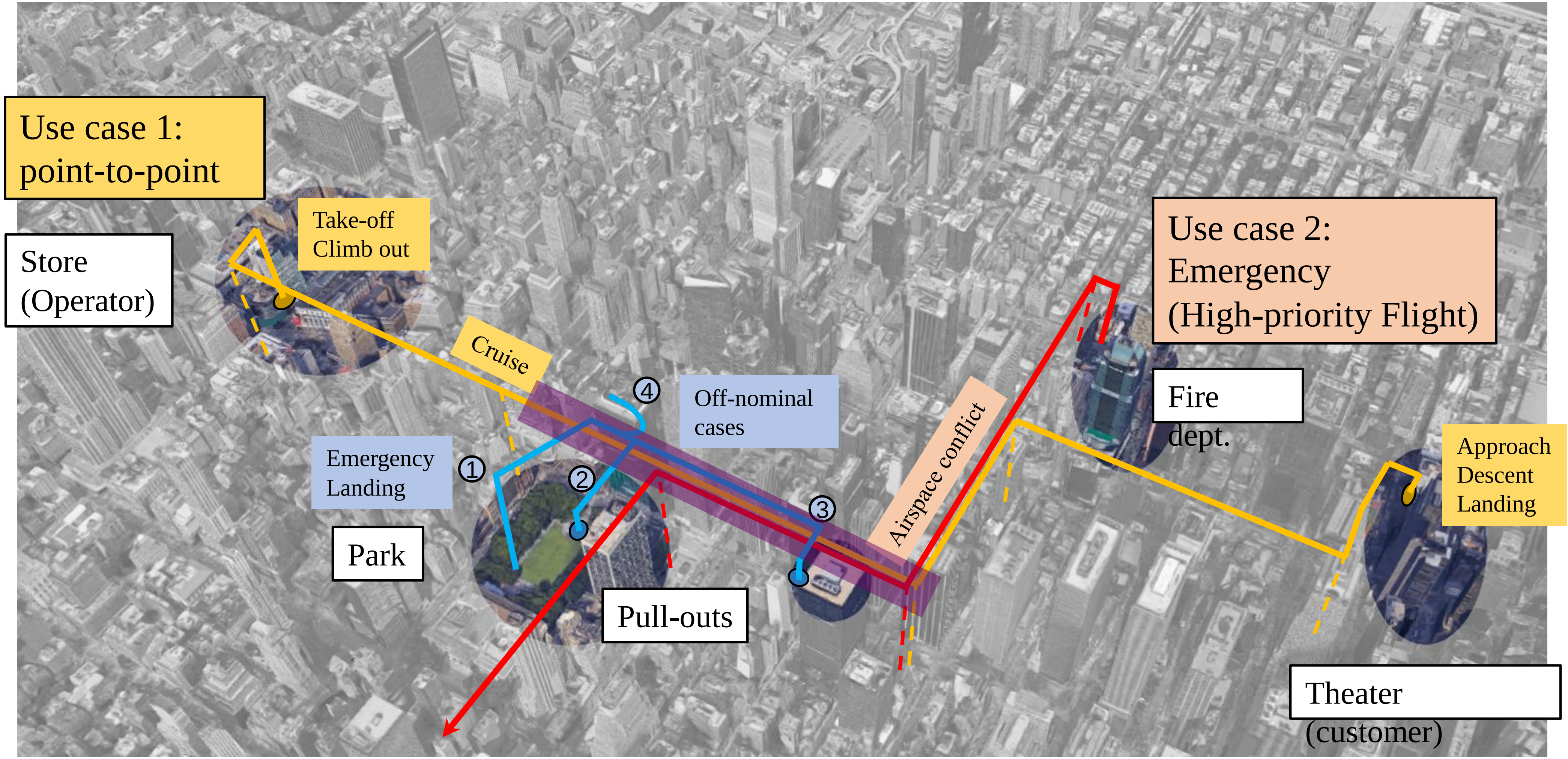
Goals

- Enable High-Density Low-Altitude UTM Operations over Densely-Populated Urban Environments through Advanced Vehicle Autonomy
- Vary the vehicle and autonomy
- Assumes today's technology and infrastructure (fix everything else)
- Evolve the UTM TCL 4 framework as necessary to meet derived requirements

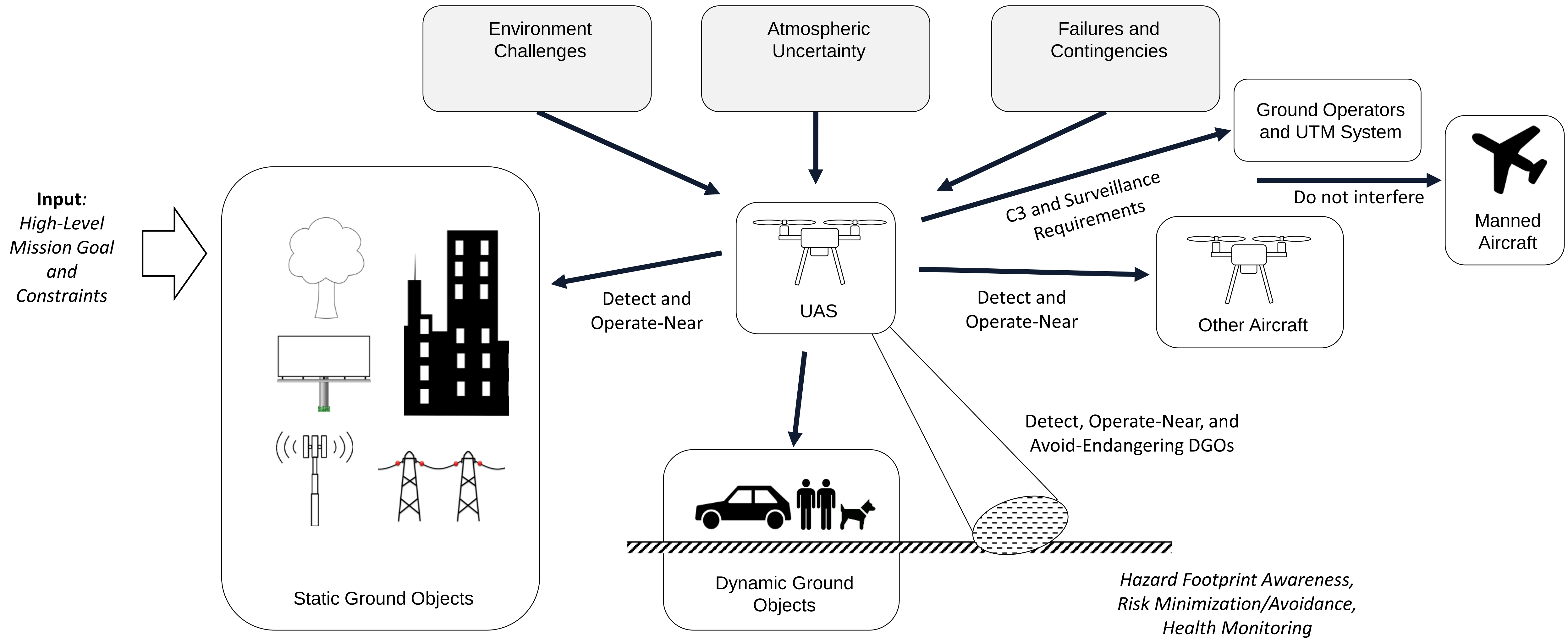
Technical Objectives

- SAFE50 Reference Design Study
- Reference Architectures
- Flight and Simulation Experimentation
  - Feasibility, Characterization, Requirements Derivation, and Validation

SAFE50 ConOps

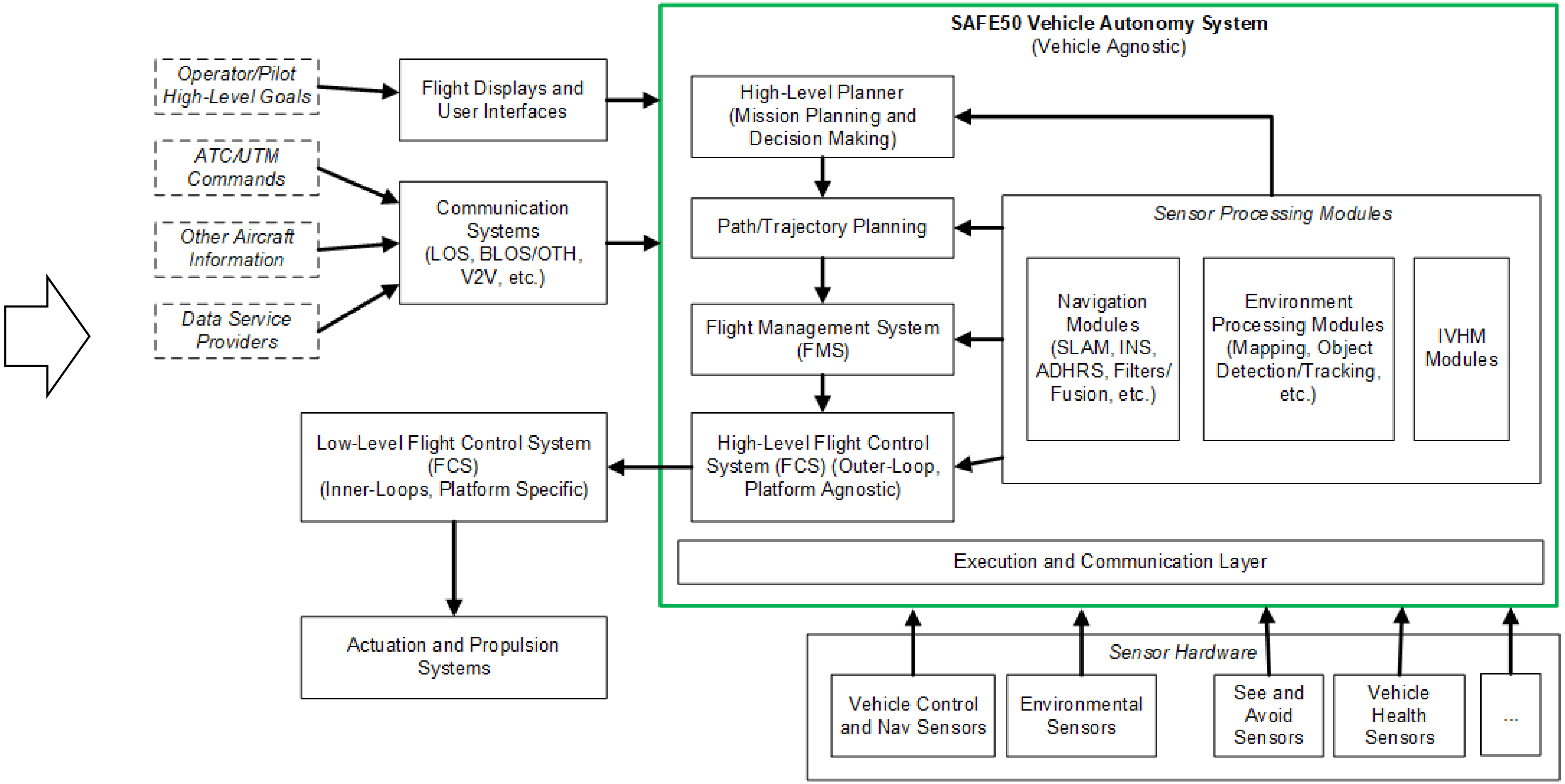


Requirements for Autonomous Operations

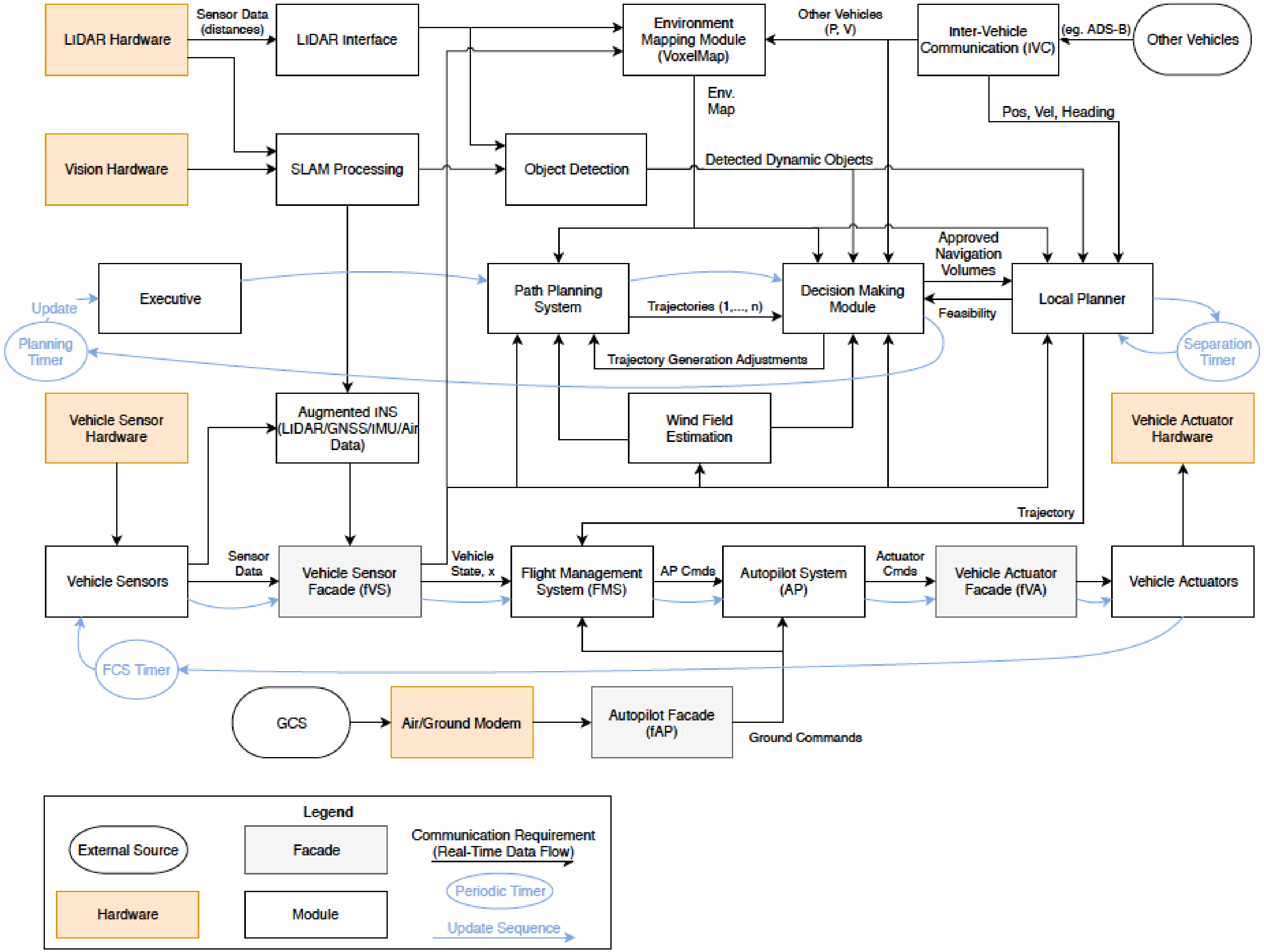


SAFE50 Reference Autonomy System - Conceptual View

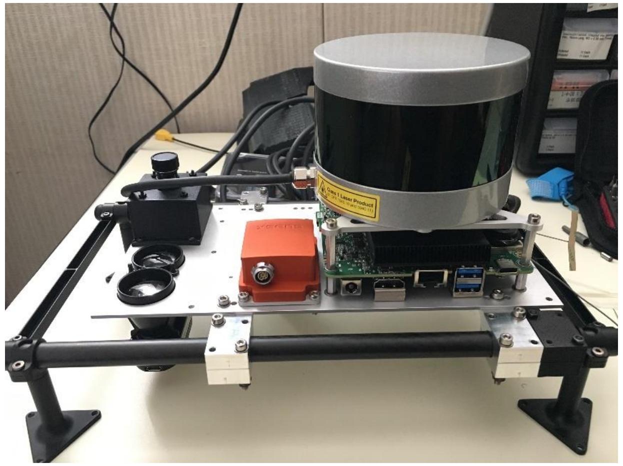
Input: *High-Level Mission Goal and Constraints*



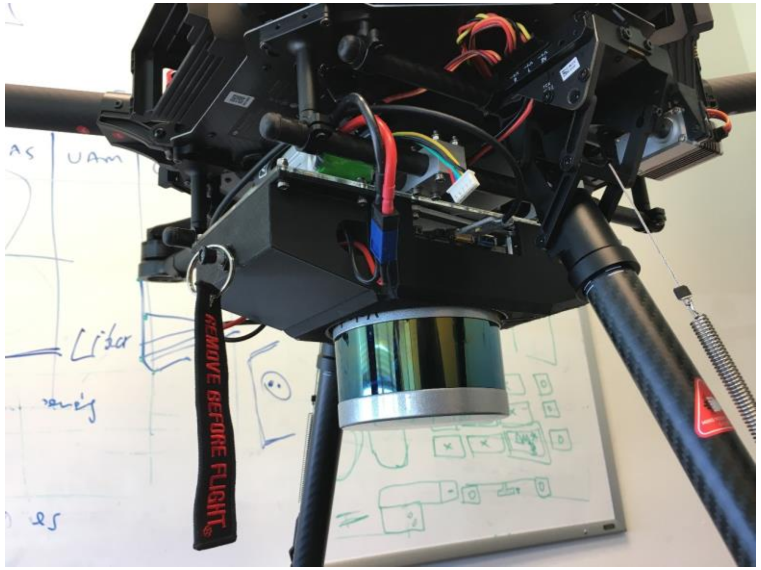
Reflection Simulation Architecture



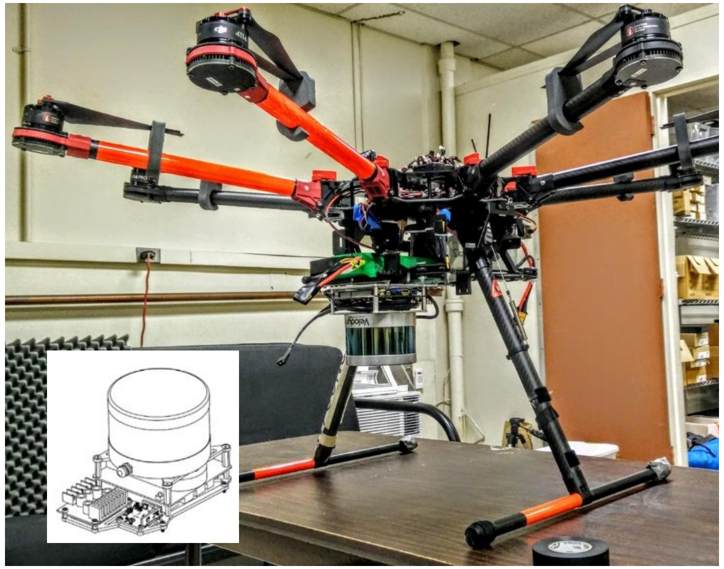
Reference Design Vehicles and Payloads



SAFE50 Gen-2.5 Autonomy Avionics Payload

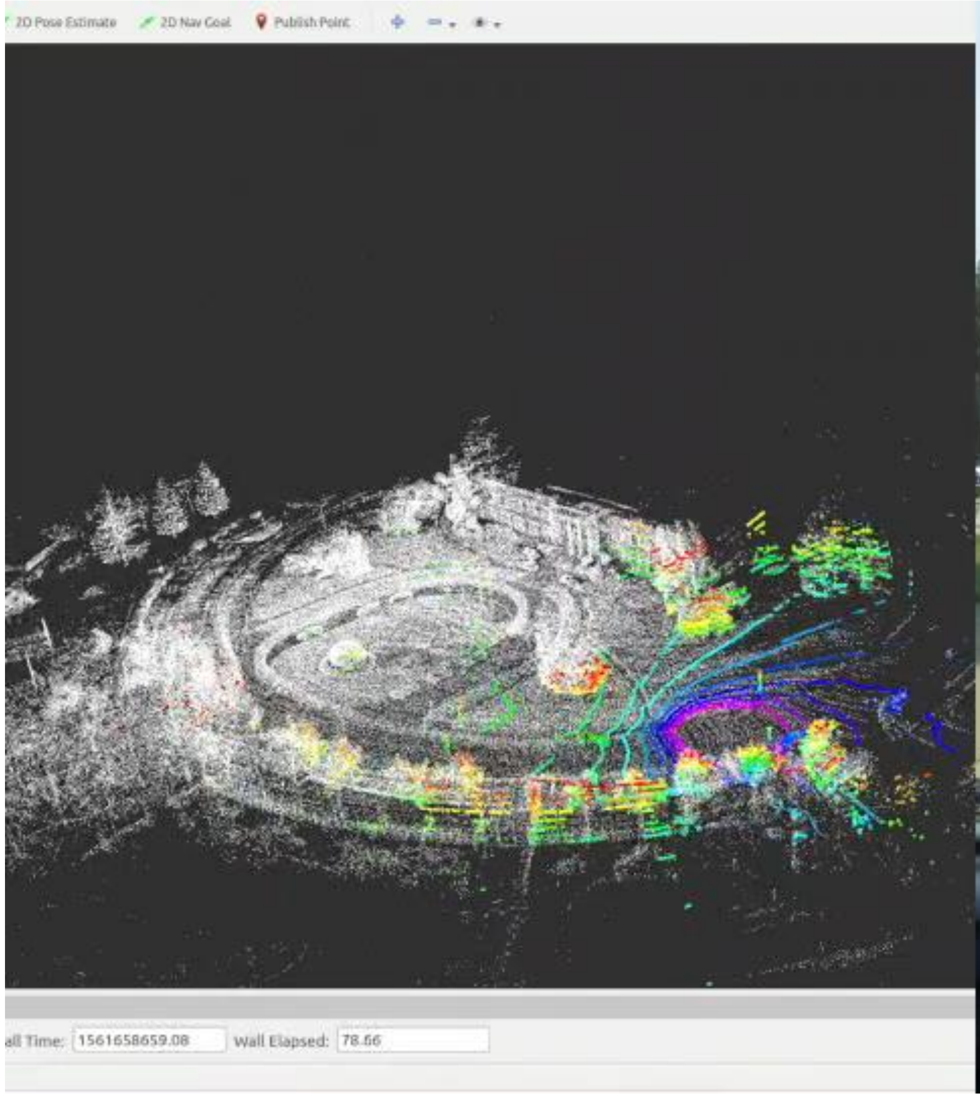


Gen-2 on SAFE50 Multicopter

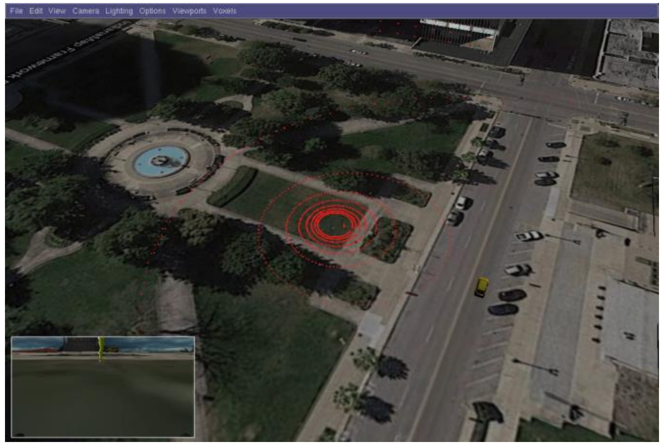


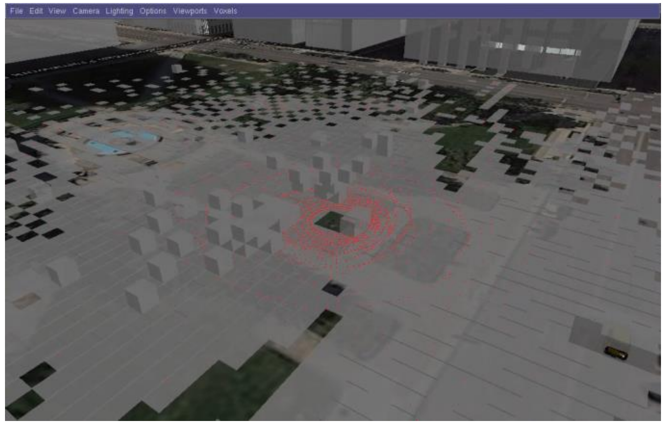
SAFE50 Vehicles (top)
SAFE50 Gen-1 Vehicle System (bottom)

GPS-Free Navigation and Mapping in Constrained Spaces



Autonomous Sensor Fusion, Environment Mapping and Hazard Characterization





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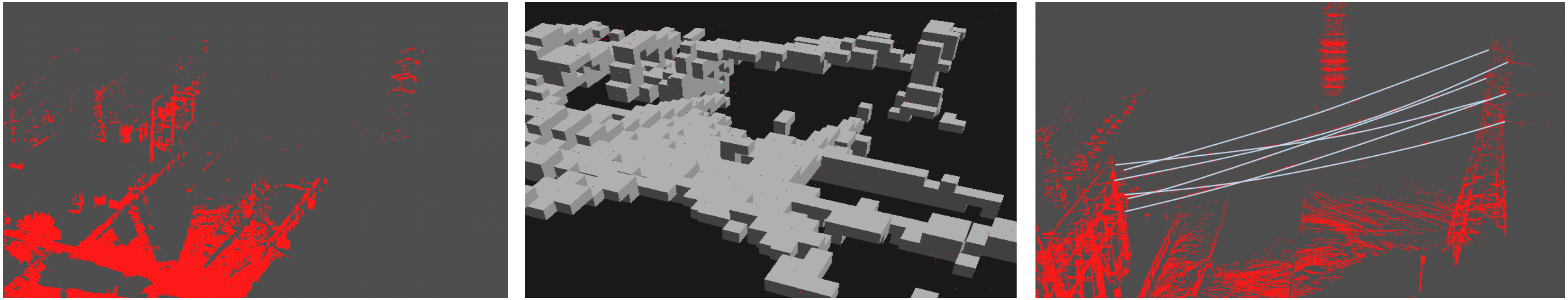
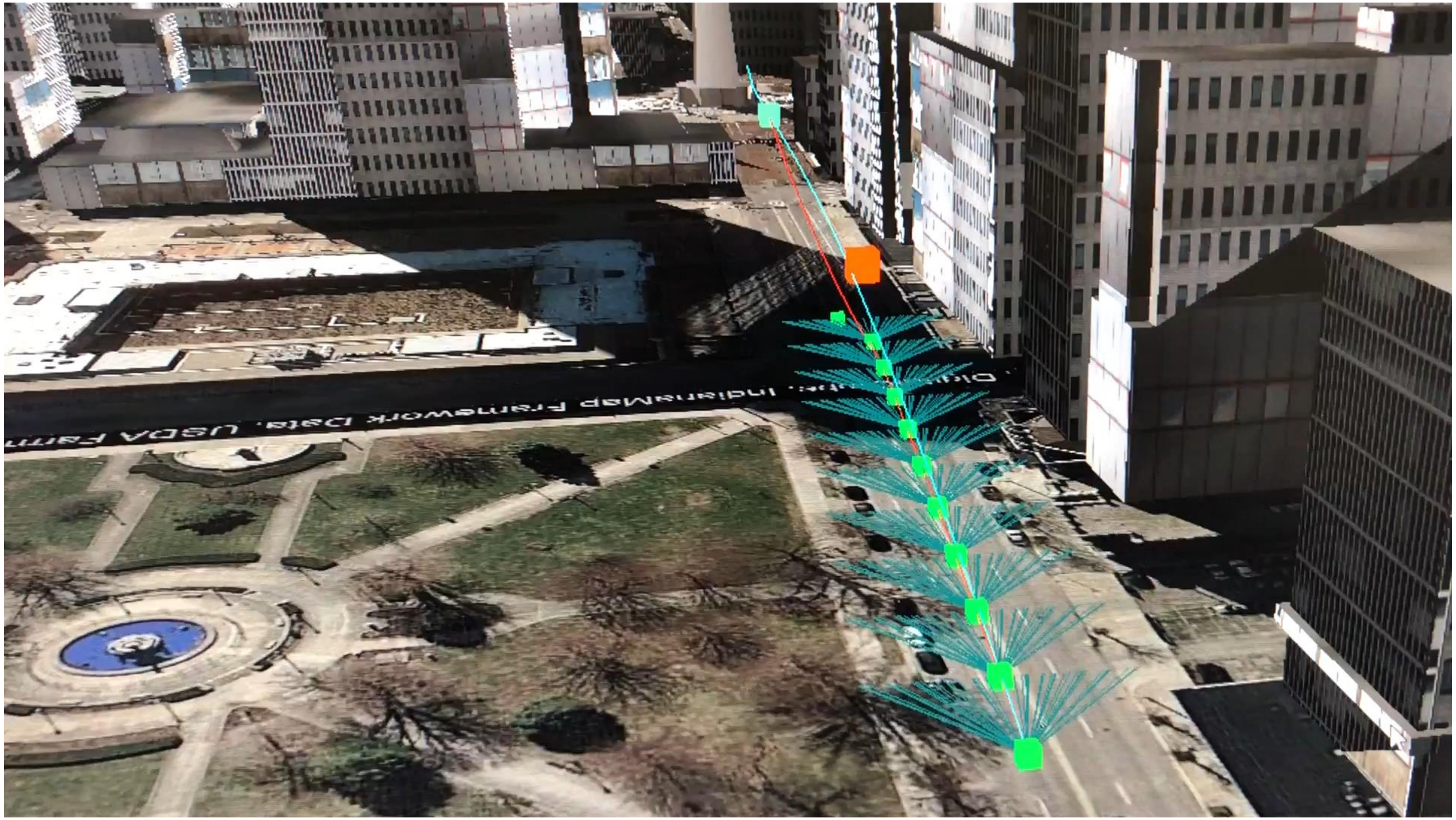
Intelligent Cable and Power Line Detection

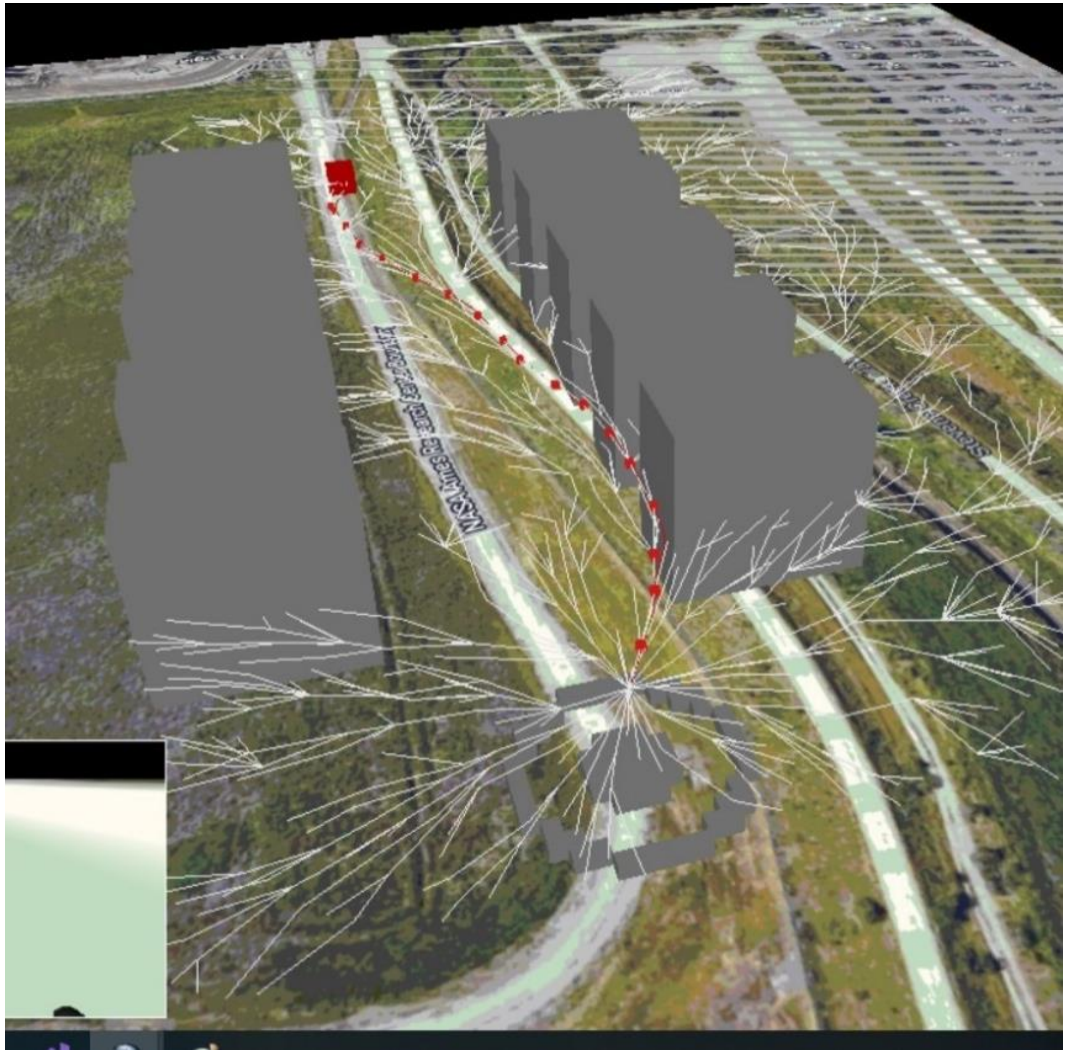


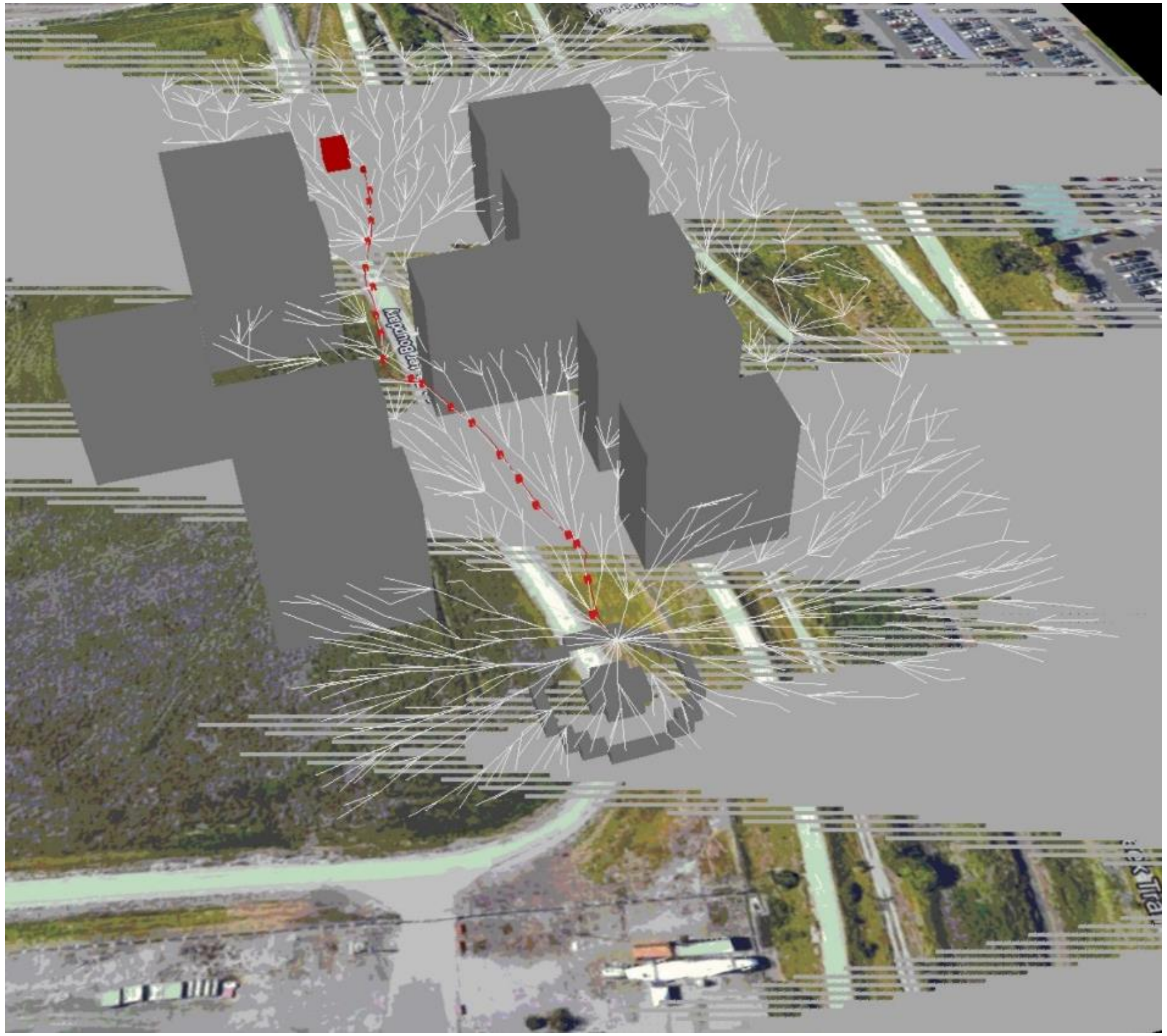
Power Line Identification and Reconstruction through ML/AI - Flight Test Verification Results
Raw LiDAR point clouds (left), voxel processing (middle), reconstructed powerlines at 75m (right).

Real-Time Constrained Trajectory Optimization – Low-Level Planner



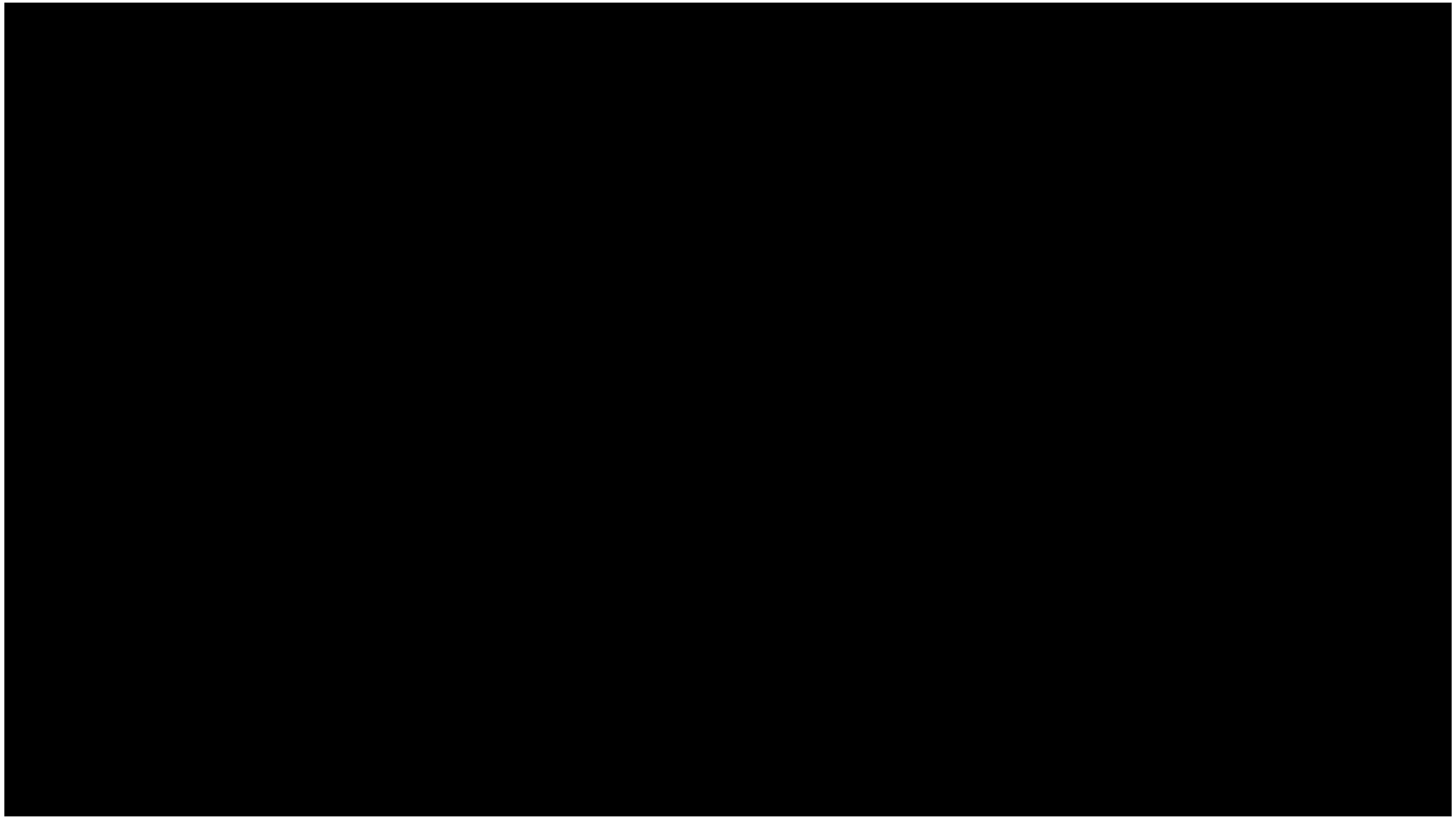
Real-Time Constrained Trajectory Optimization – High-Level Planner



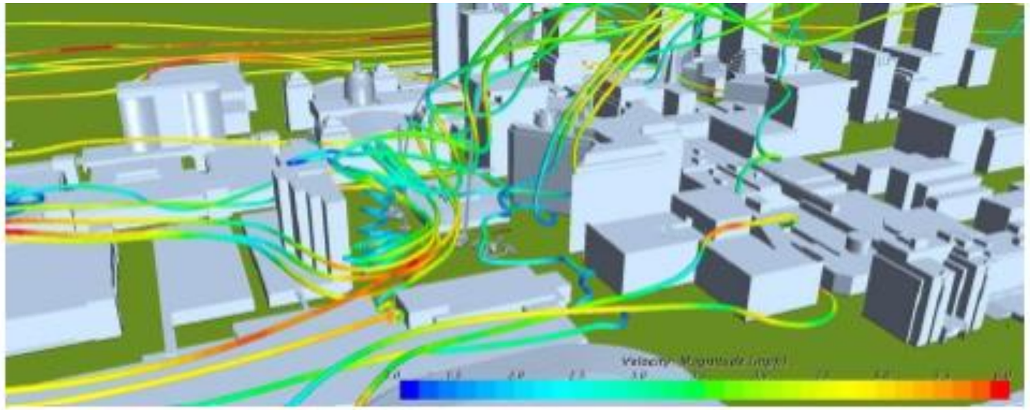


Real-Time Constrained Trajectory Optimization – Volume Conformance

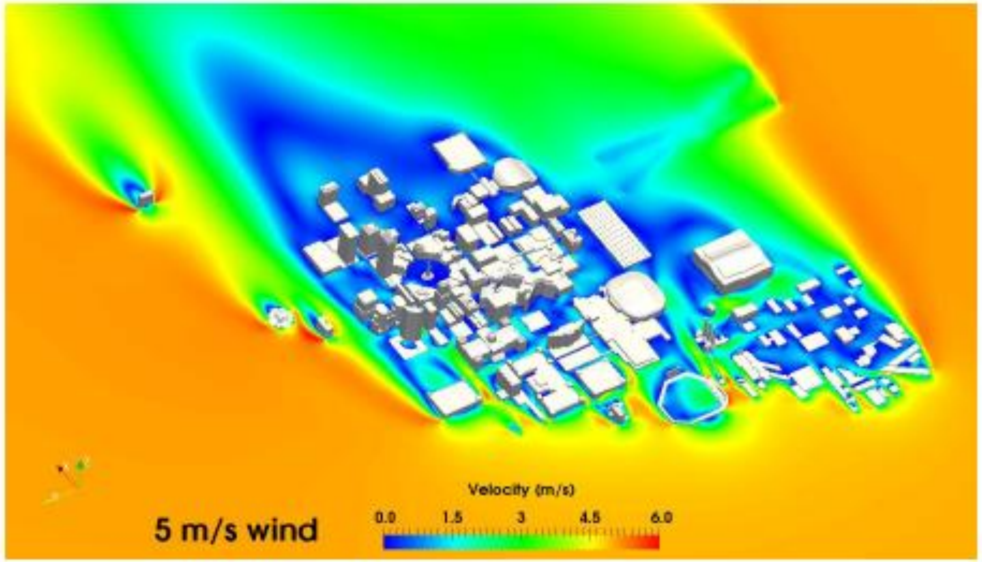
Collaborative Sense and Avoid

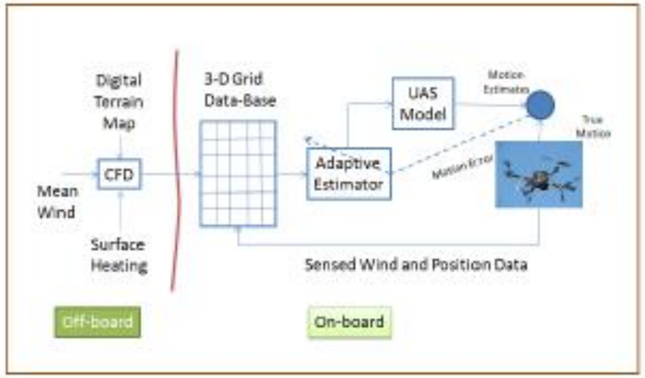


Urban Environment Wind Modeling and Estimation



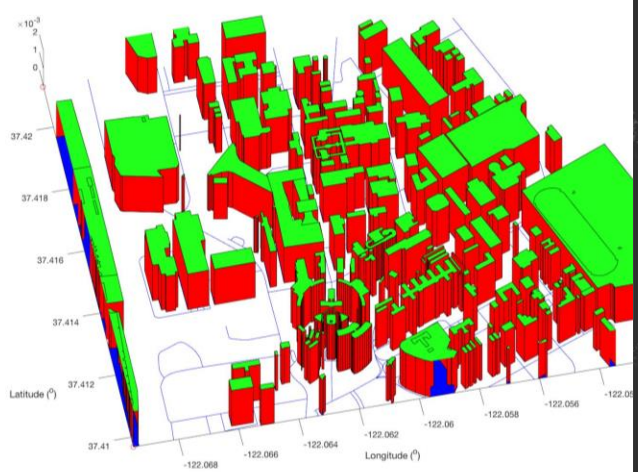
Urban Architecture and CFD Simulation of Wind Profiles.

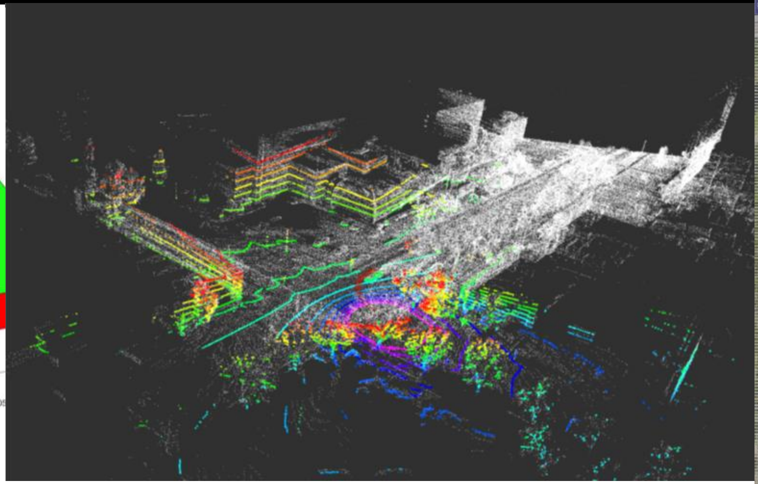


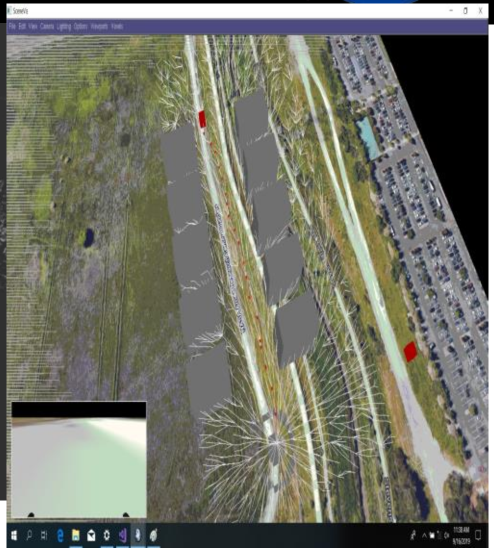


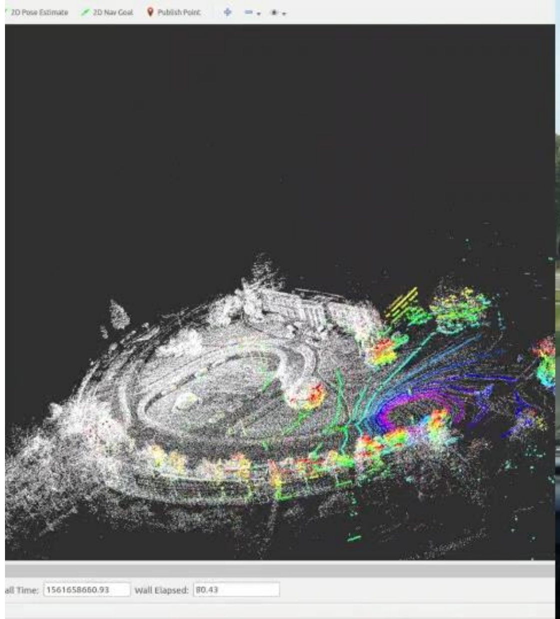
Questions?

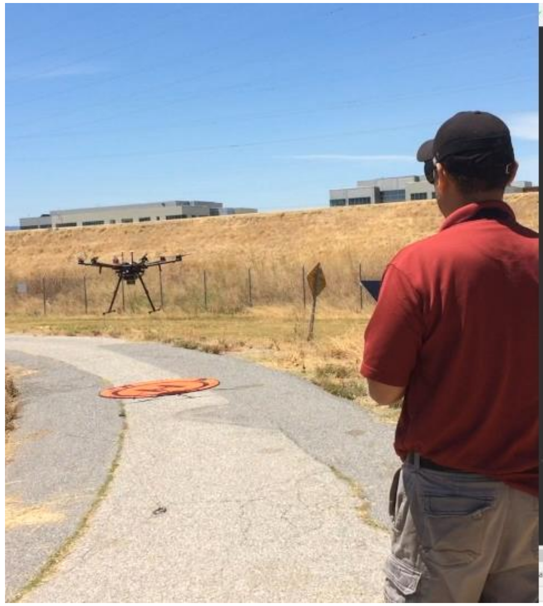
Flight Tests

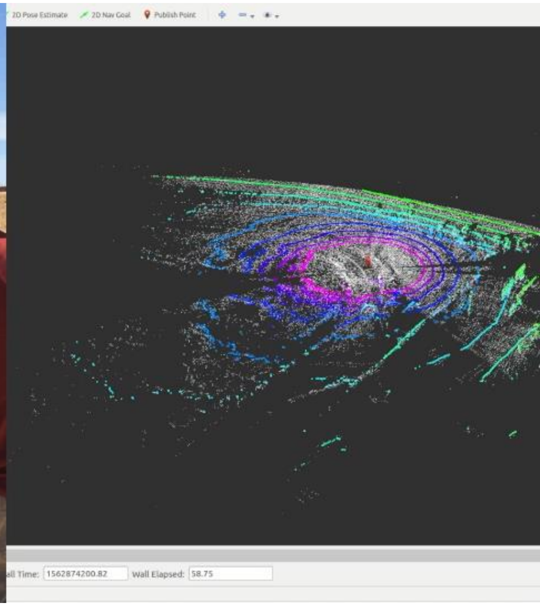












UTM/SAFE50 Project – Safe Autonomous Flight Environment

Goal

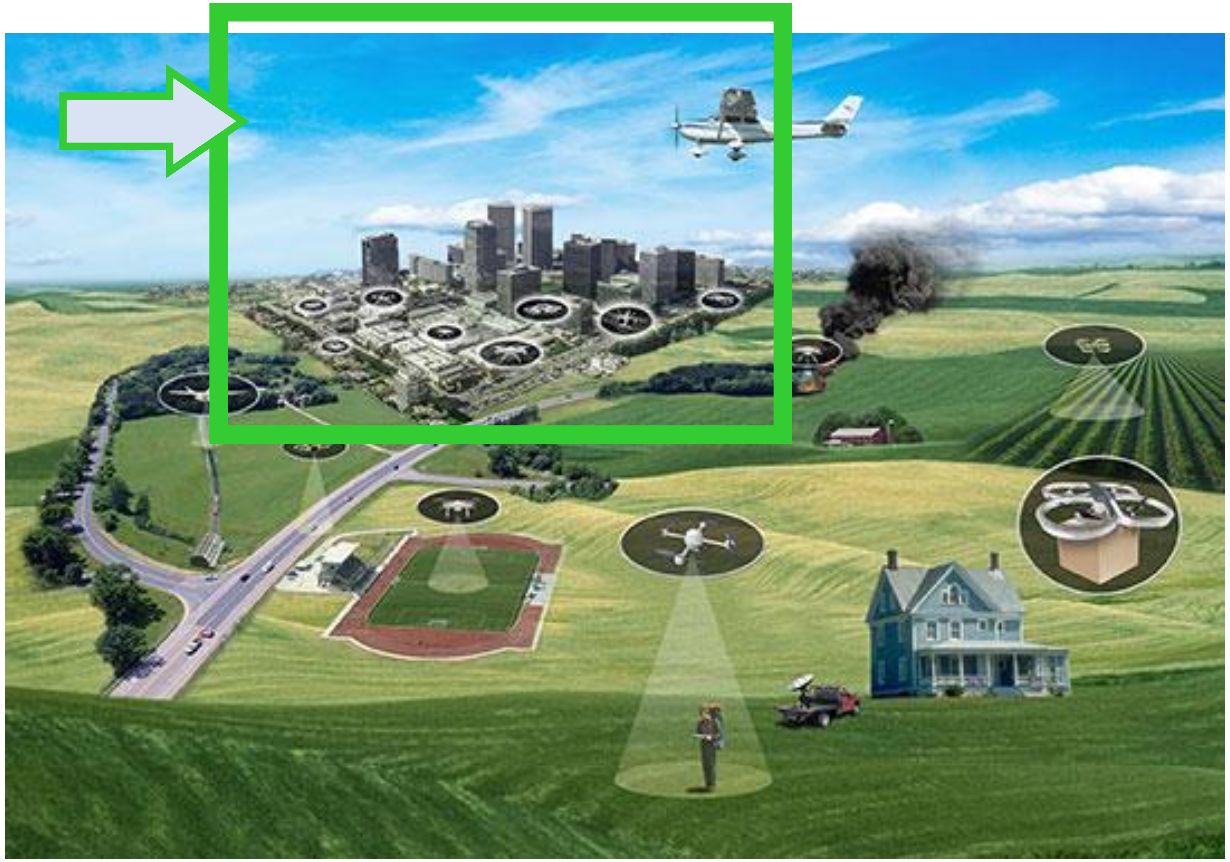
- Enable High-Density Low-Altitude UTM Operations over Densely-Populated Urban Environments through Advanced Vehicle Autonomy

Technical Objectives

- SAFE50 Reference Design Study
    - Comprehensive system-wide design study for autonomous UAS operations (from UTM down to vehicle subsystem level)
    - Design for future generation vehicles and avionics (vary the vehicle system)
    - Assumes today’s technology and infrastructure (fix everything else)
    - Extend UTM TCL-4 framework as necessary to meet requirements and achieve objectives
- SAFE50 Reference Architectures (Vehicle, Avionics, and Flight Autonomy)
    - Software Implementation and Flight Hardware Prototypes
- Feasibility and Validation
    - Modeling and Simulation
    - Simulation and flight test experimental validation

Overview

Safely Enabling Routine High-Density Low-Altitude UAS Operations over Densely-Populated Urban Environments



- Unmanned Aircraft Systems (UAS) Traffic Management (UTM) project seeks to advance concepts towards higher-density operations over densely-populated areas
- UAM and UTM industry partners are actively seeking access to this space
- Anticipated high-demand market with significant economic growth potential
- Non-trivial shift from UTM TCL 4 to high-density urban UAS operations

Challenges for High-Density Urban Flight Operations

- Flight over people, property, and critical urban infrastructure
- Highly constrained spaces within urban canyons
- Operations almost entirely beyond visual and communication line-of-site
- Concurrent operations in high-density air traffic
- Mission designs drive towards larger more-capable vehicles in higher risk categories
- Cluttered and challenging RF environment and GPS degraded/denied
- Urban environment is unpredictable and dynamic
- Complex hazardous atmospheric conditions that are poorly understood
- Many stakeholders with competing needs and desires

Enabling Safe Autonomous UAS Urban Operations

Gaps

Concepts and Standards Gap

- Lack of guidance for FAA rulemaking
- Disparate technologies, assumptions, capabilities
- Lack of industry standards and requirements
- No clear certification path

Knowledge Gap

- Lack of validated system-wide studies
- Poor understanding of vehicle behavior and environmental conditions

Technology Gap

- Current industry platforms in state-of-the-art lack functionality, performance, capabilities and robustness
- Gap between academic research and industry
- Low-TRL research literature technologies for this application

Approach

Perform systems-wide studies to show path towards urban access for UTM through onboard autonomy.

Identify gaps and advance the state of the art in fundamental understanding.

Develop feasible validated reference architectures for advanced vehicles.

Technical Objectives (Vehicle Autonomy Focus)

Conduct system-wide/systems-level reference design study.

Develop high-fidelity environment models. Develop validated flight dynamics models from wind-tunnel experimental data.

Develop and validate SAFE50 reference design vehicle and autonomy architectures.

Enabling Autonomous High-Density Urban UAS Operations.

SAFE50 Design Process