

Weather Needs for Advanced Aerial Mobility and Urban Flight



Jamey Jacob plus many Diverse Hands from the WINDMAP Team

WINDMAP

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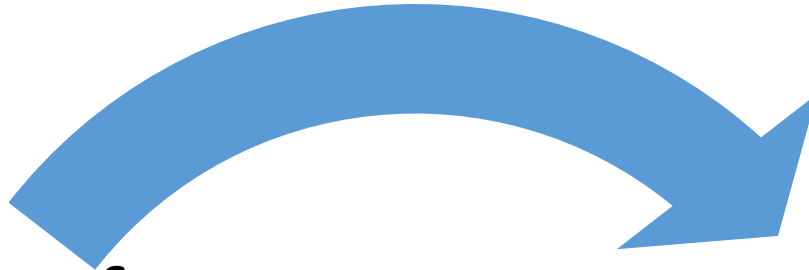


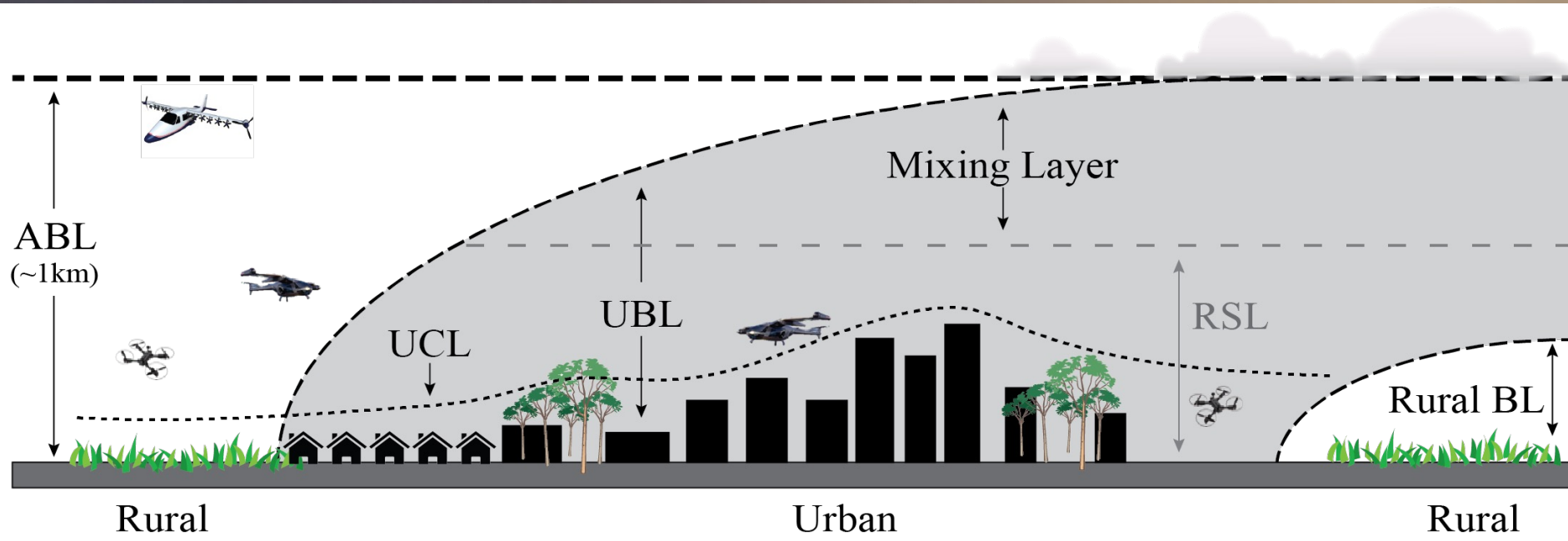
AAM Needs and Benefits



Needs of
AAM for
Enhanced
Weather
Information

Benefits in
Providing
Weather
Observations





Wind

Specific:

- Turbulence
- Wake Vortices
- Shear

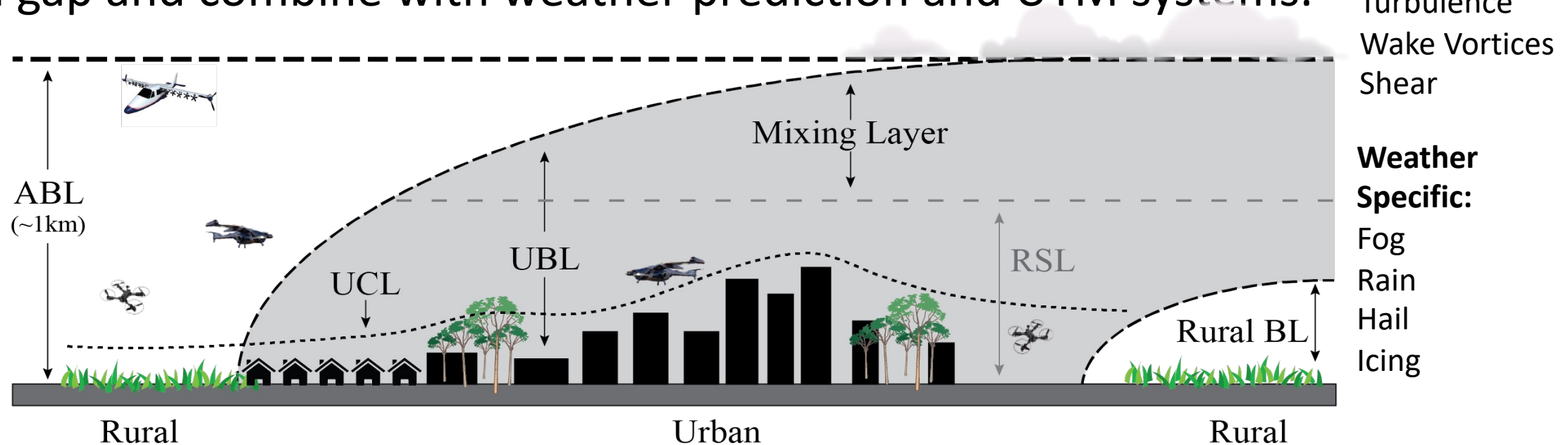
Weather
Specific:

- Fog
- Rain
- Hail
- Icing

Mission: Provide Real-time Weather Awareness for Enhanced UTM Safety Assurance



- Weather creates a variety of barriers to all aircraft operations but in particular drones, which are easily grounded during inclement weather.
- Our goal is to address needs in real-time weather forecasting to improve the safety of low altitude aircraft operations across the AAM space.
- WINDMAP integrate real-time observations from AAM to fill the data gap and combine with weather prediction and UTM systems.



WINDMAP Strategy

In Situ Observations

Novel
Autonomous Systems

Existing
Capabilities



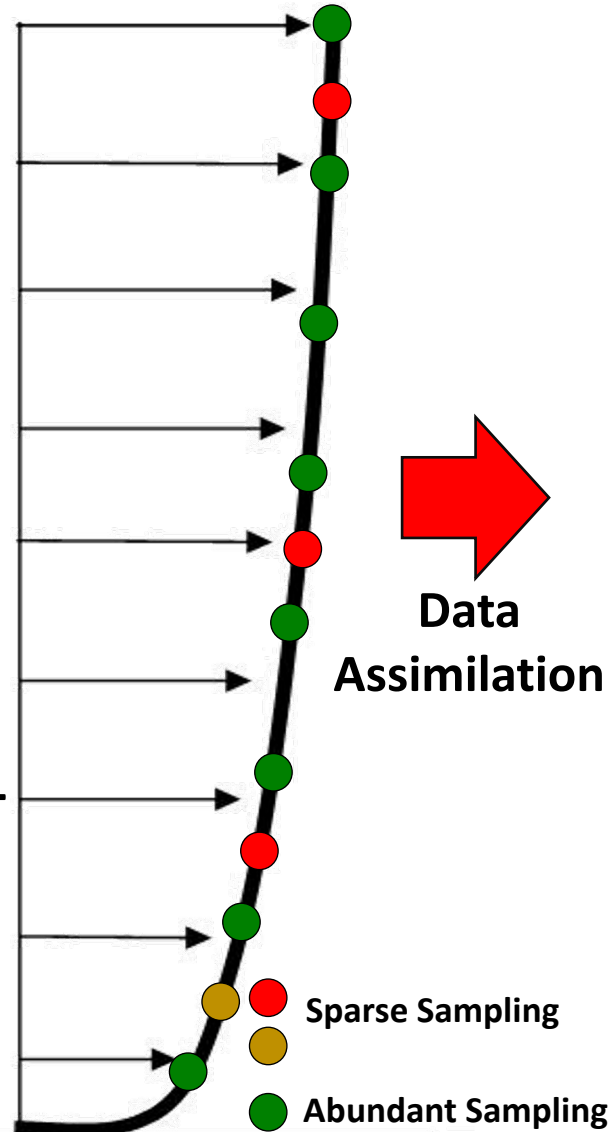
Radiosonde



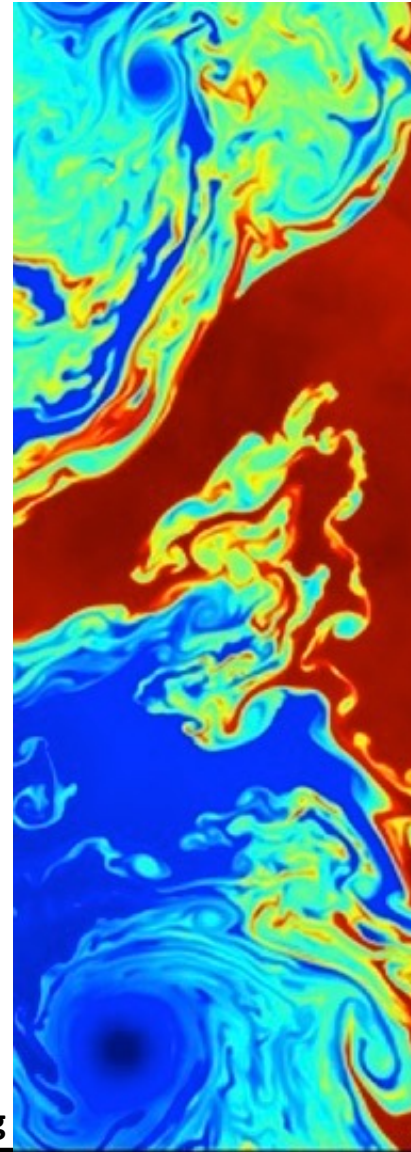
Tower



ABL Spatial Resolution Observations



Models



UTM Safety Assurance

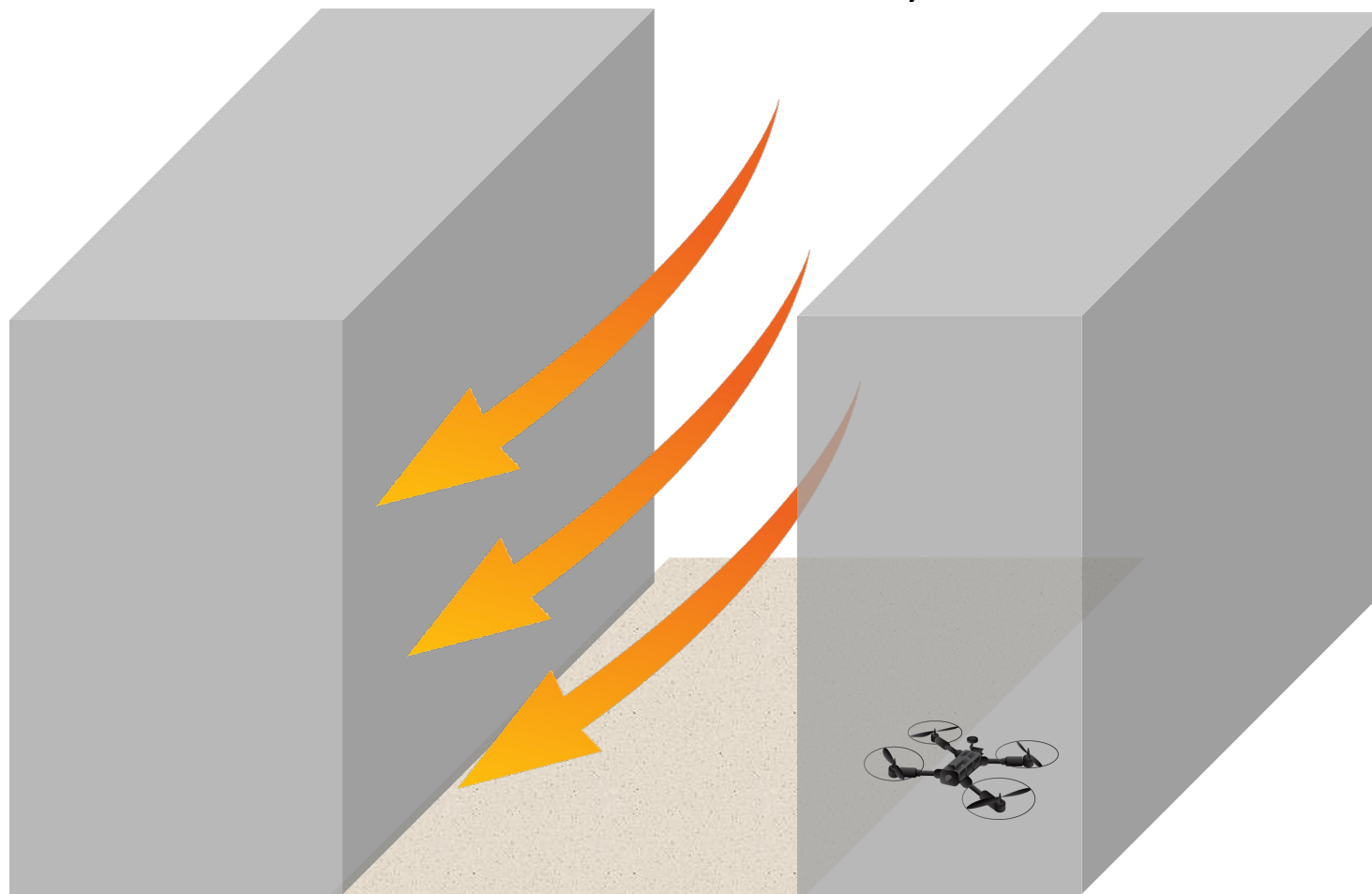


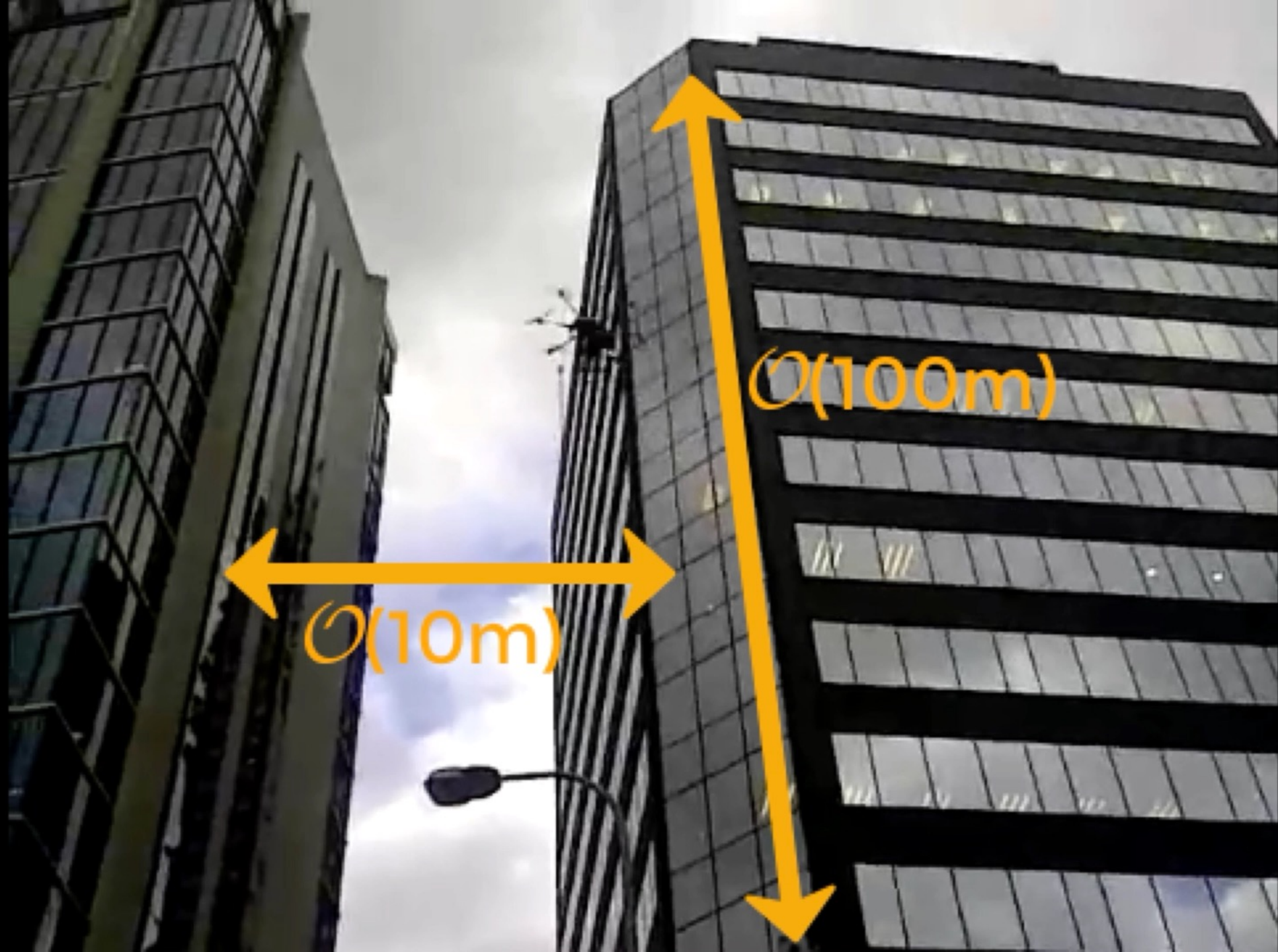
Ops

ATC



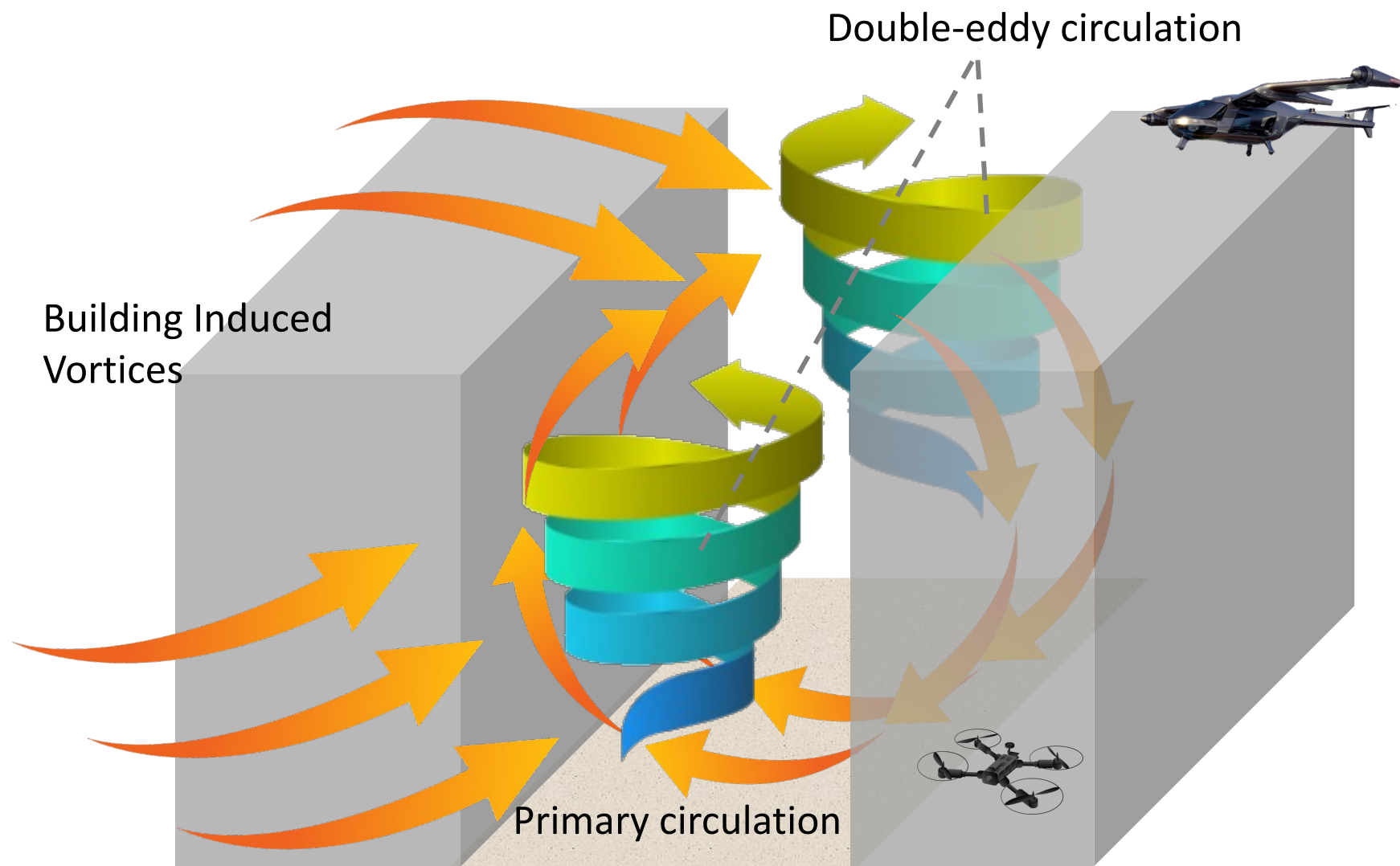
Urban Canyon





$\mathcal{O}(100m)$

$\mathcal{O}(10m)$



Status quo of aviation weather

Designed for *pilots*

Information

Displays

Dissemination

Standardized training

Humans at multiple points in the system

Clustered around airports

Spaced based on crewed aviation flights

AAM weather applications

Diverse stakeholders

Experience

Automation level

Dissemination

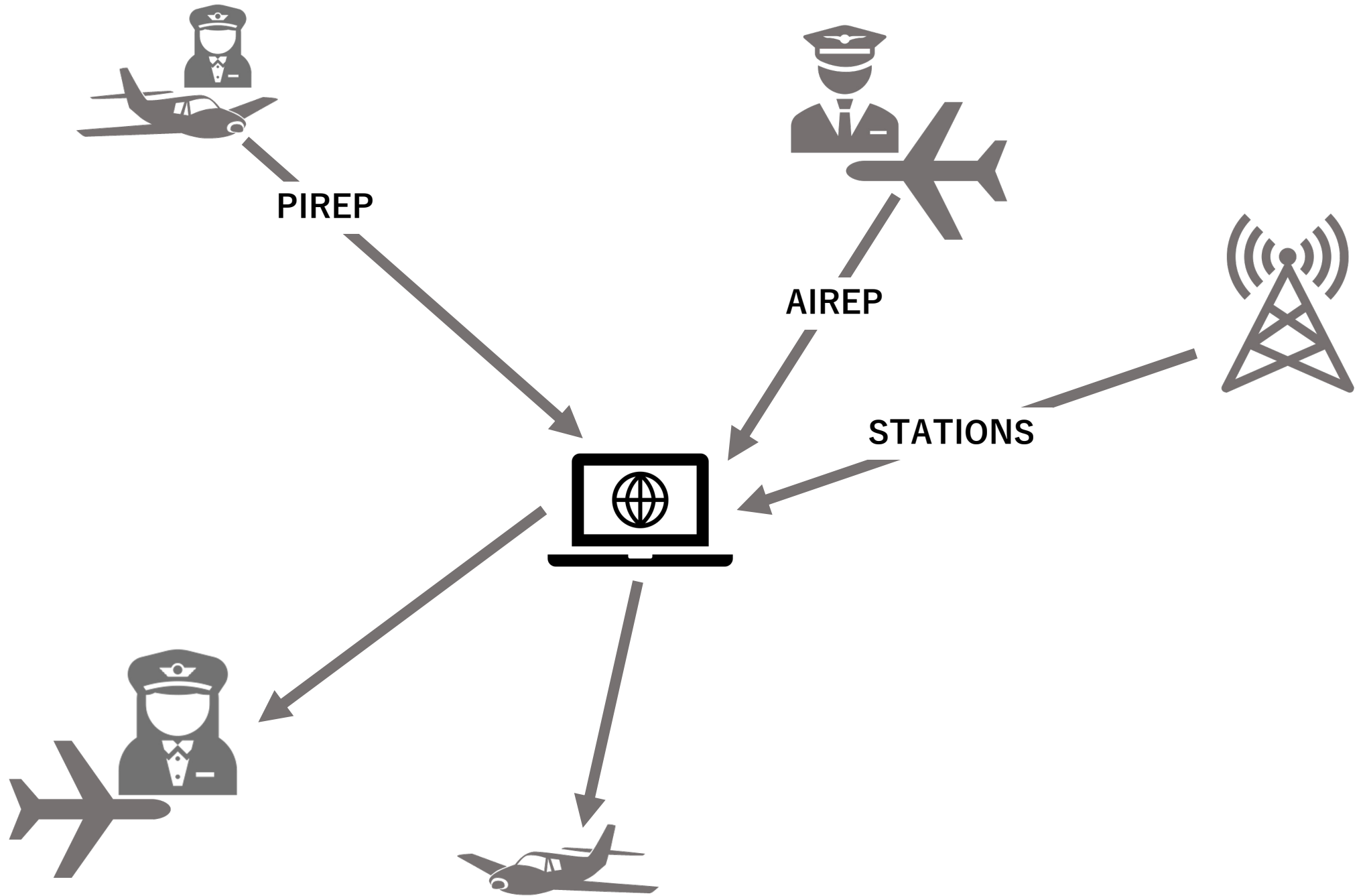
Varied training and experience

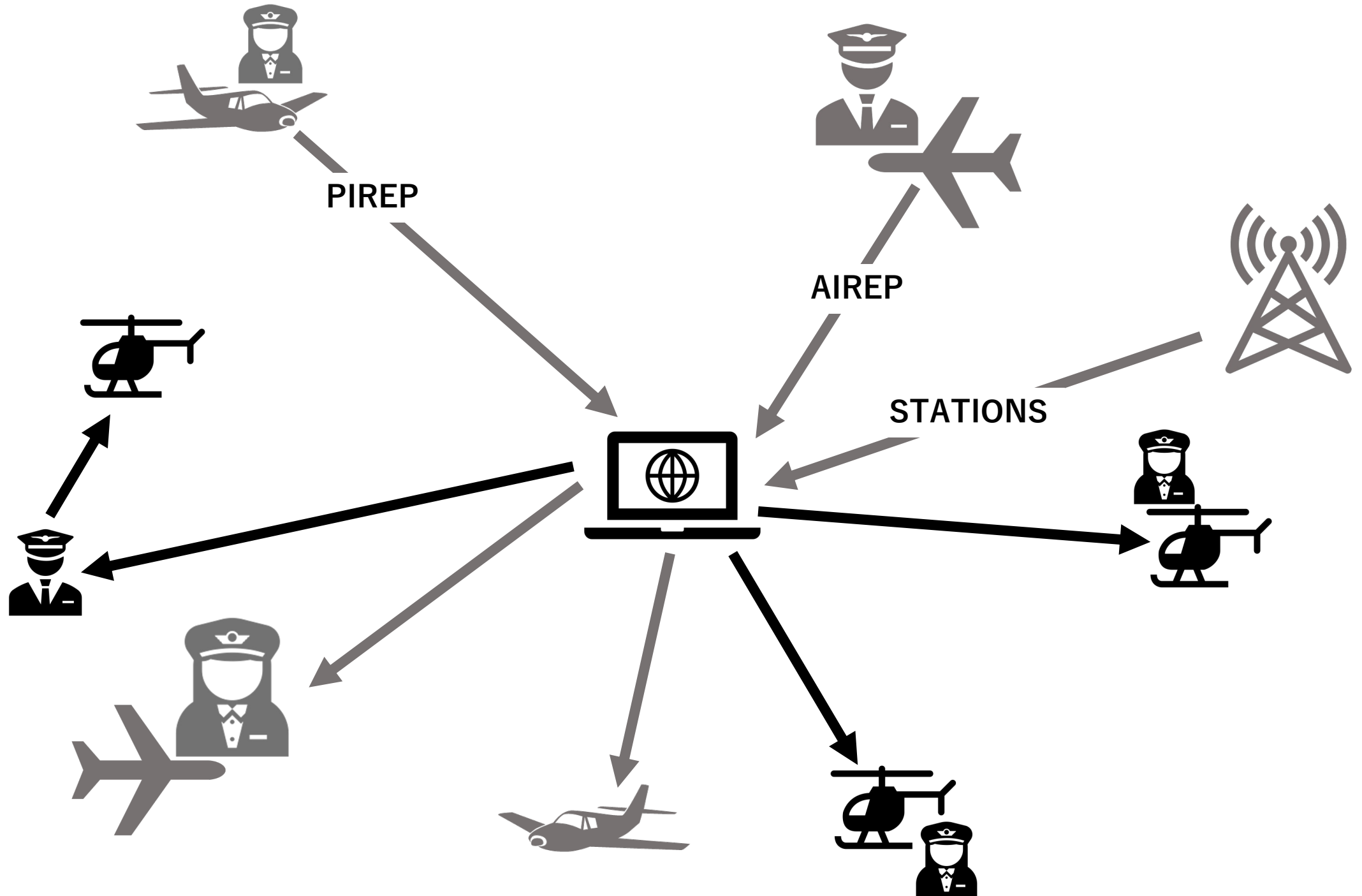
More automation in system

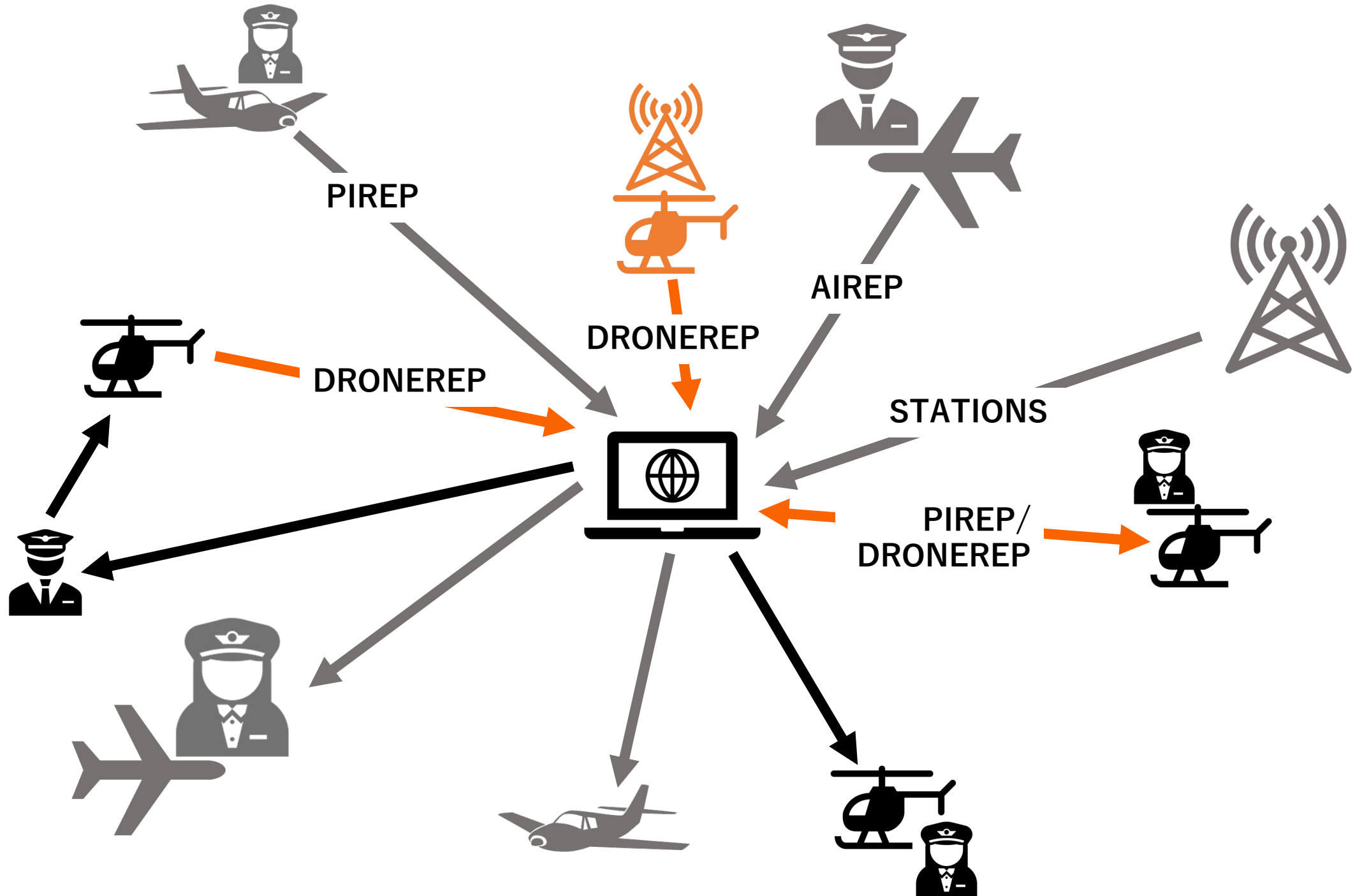
Requires higher diversity of locations

Needs higher resolution in time and space



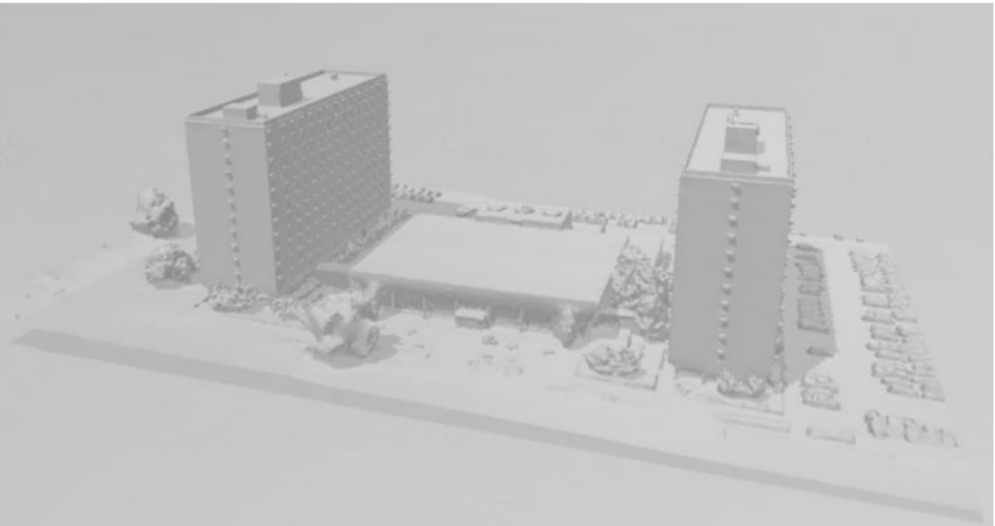






Urban Surrogate Flight Test – OSU Campus

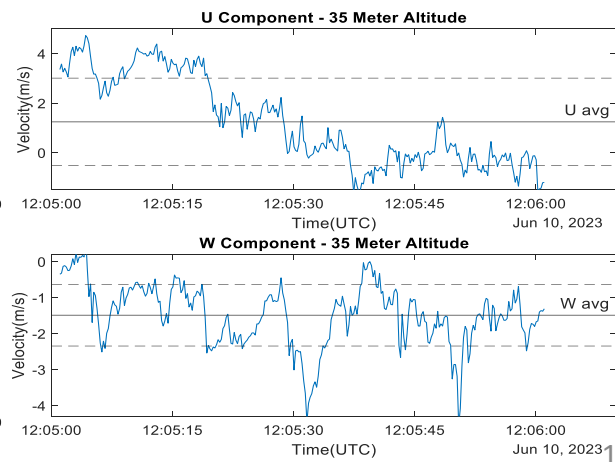
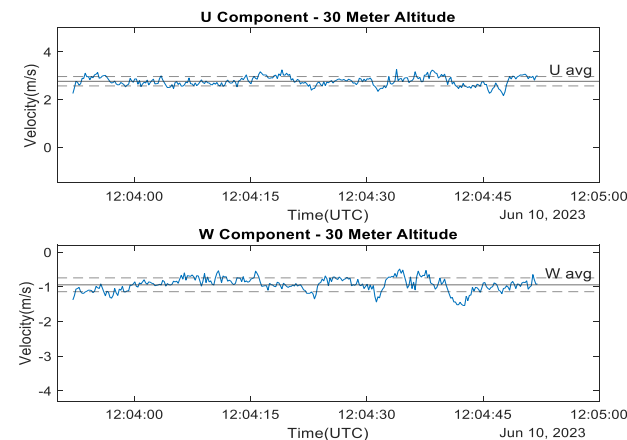
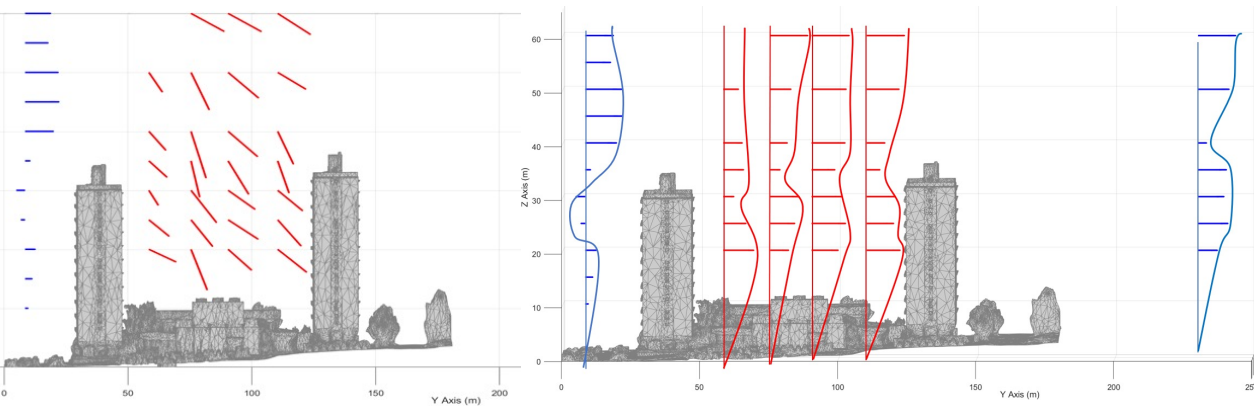
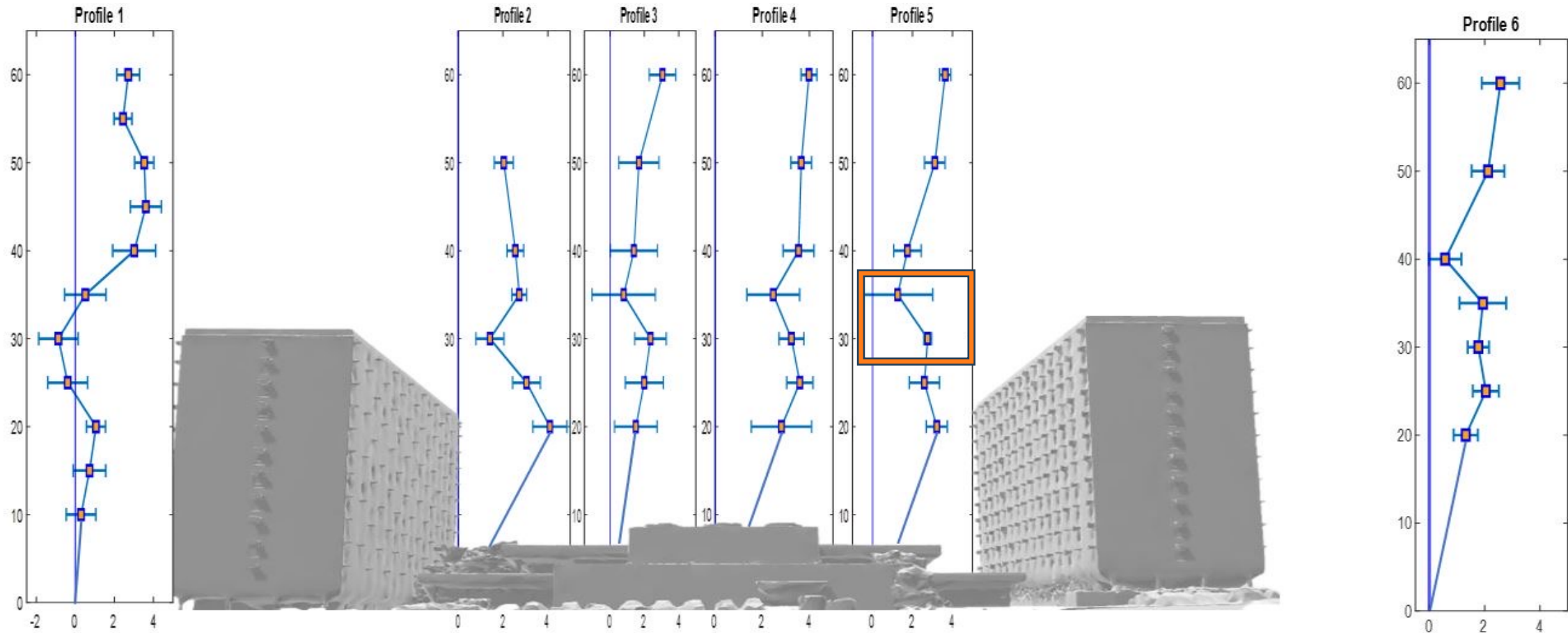
30 m high building – 6 profile locations



100m from building, 10m – 60m profile, 5m increments, 1 minute each altitude – Eagle w/ Tri Sphere 3D

20m – 60m profile, 5m increments, 1 minute each altitude – Eagle w/ Tri Sphere 3D

20m from building, 10m – 60m profile, 5m increments, 5 minute each altitude – SK8 w/ Tri Mini 2D



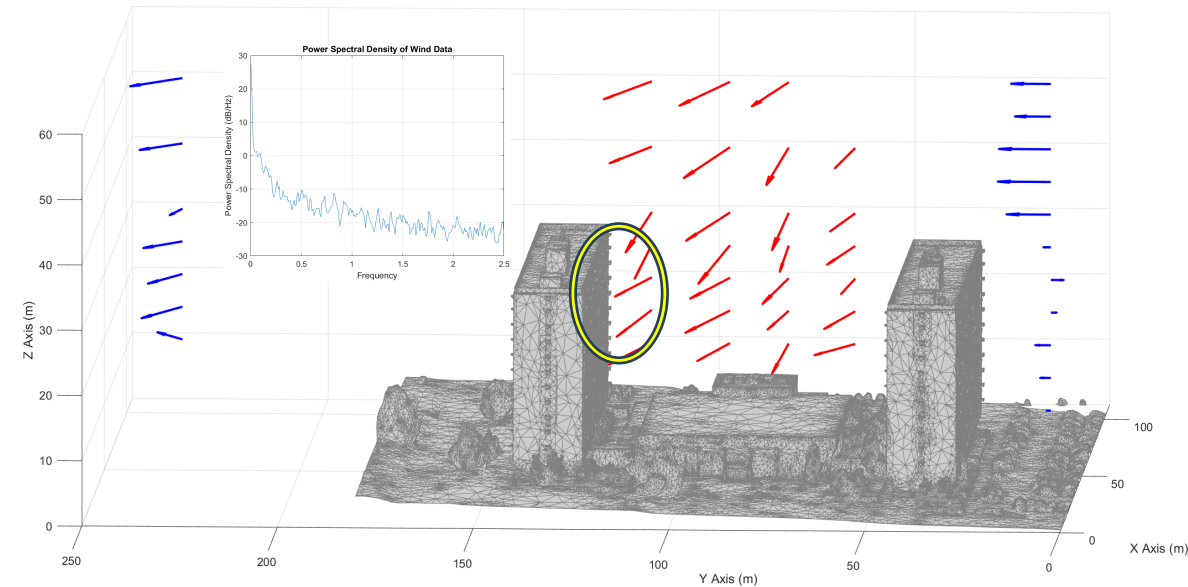
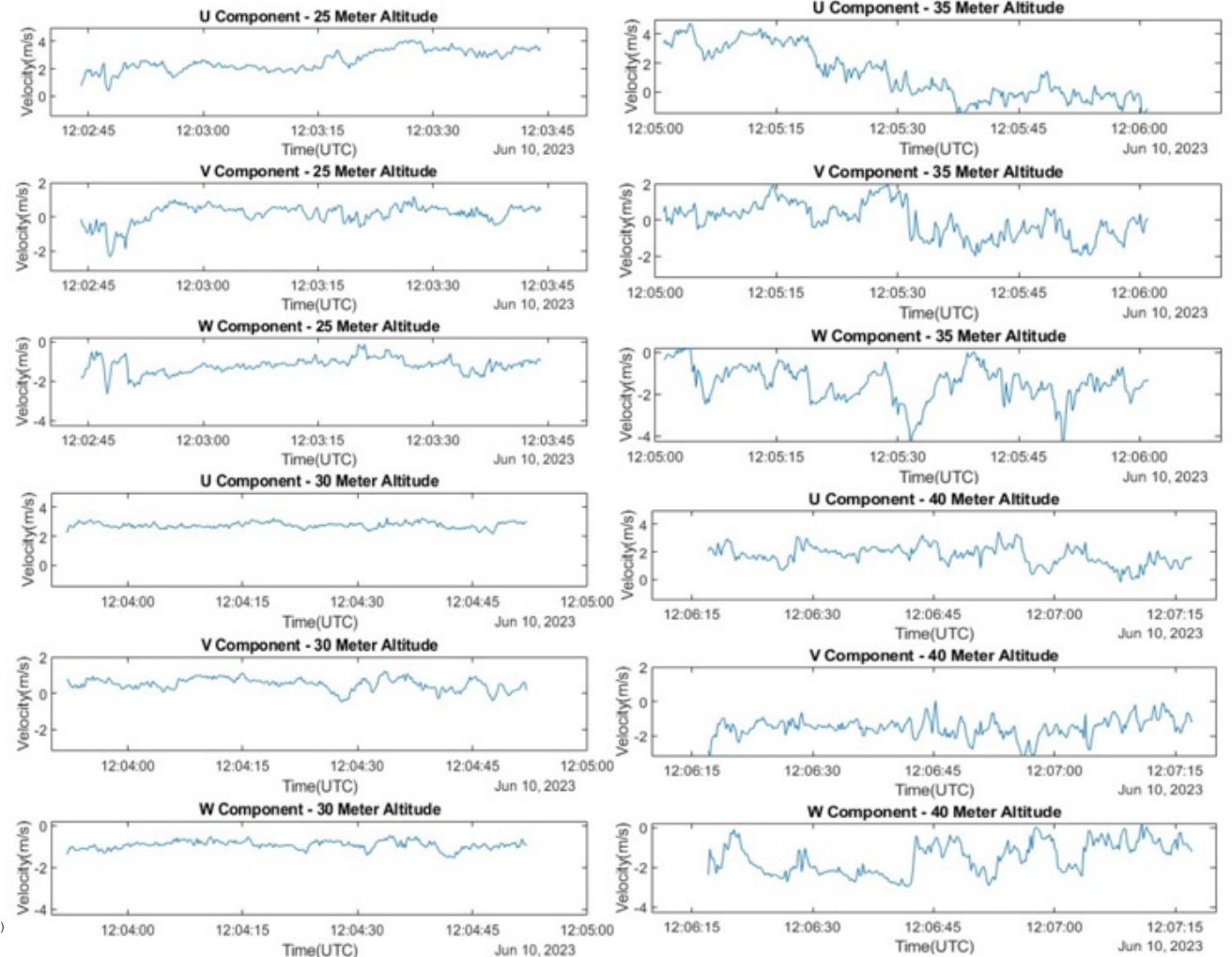
Building Observations

➔ Highest vertical turbulence area analyzed

- 25, 30, 35, and 40-meters of altitude analyzed
- 25- & 30-meters calm and stable
- 35- & 40-meters extremely turbulent

➔ Large spike in vertical velocity

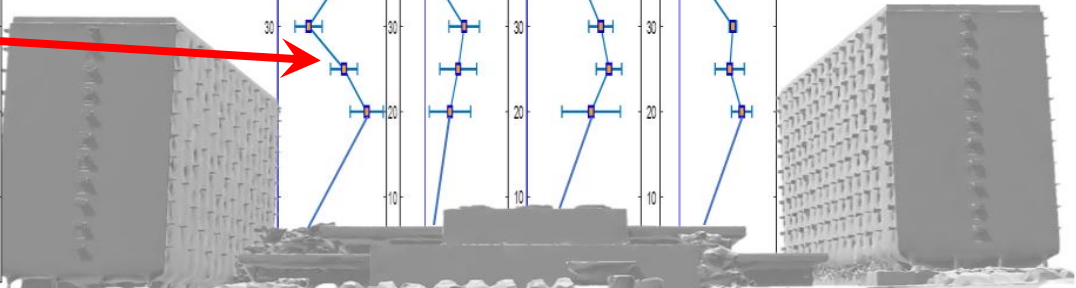
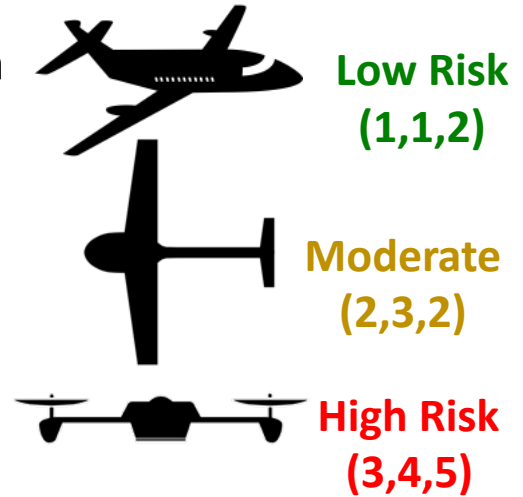
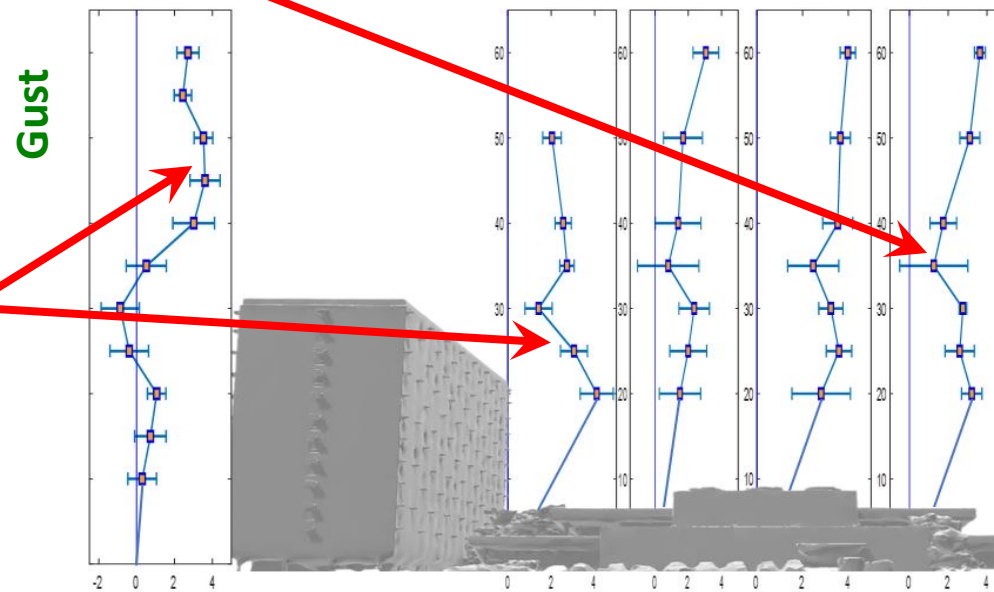
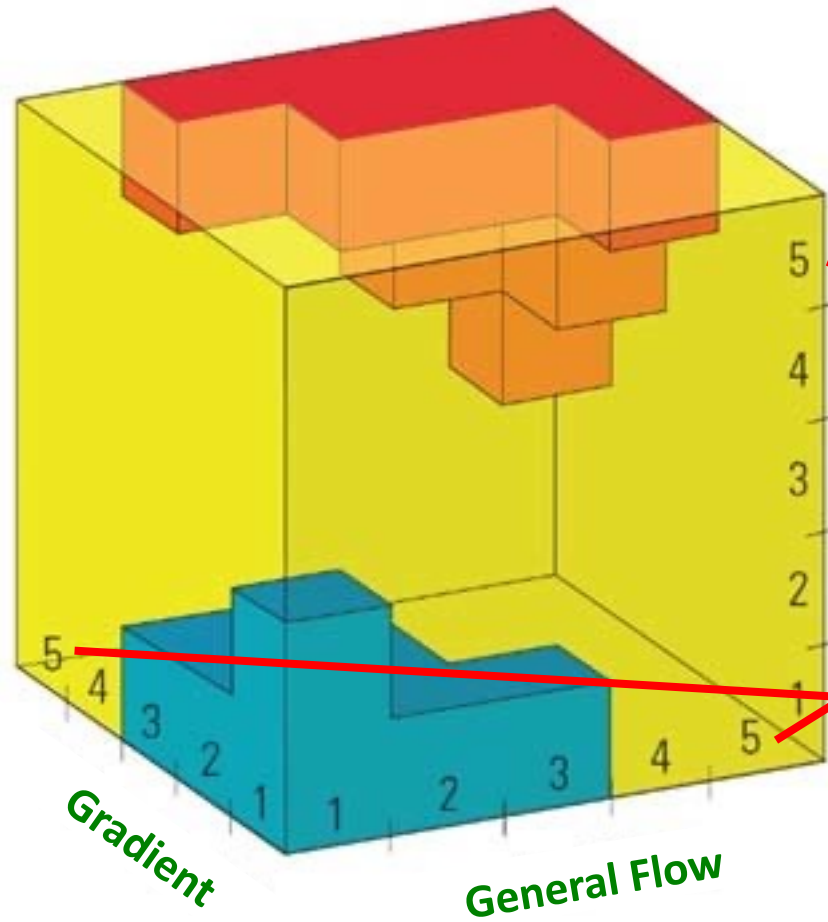
- Unsafe location for UAS operations



Urban Risk Matrix – “G³” Cube



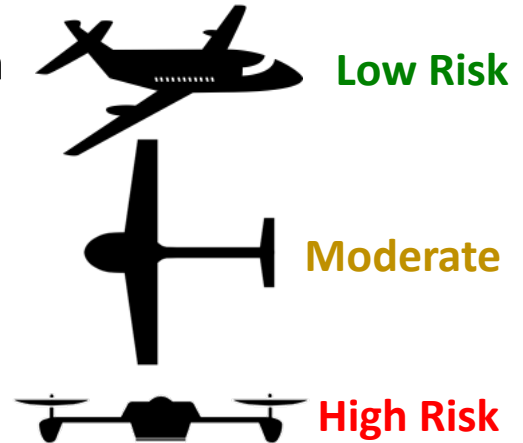
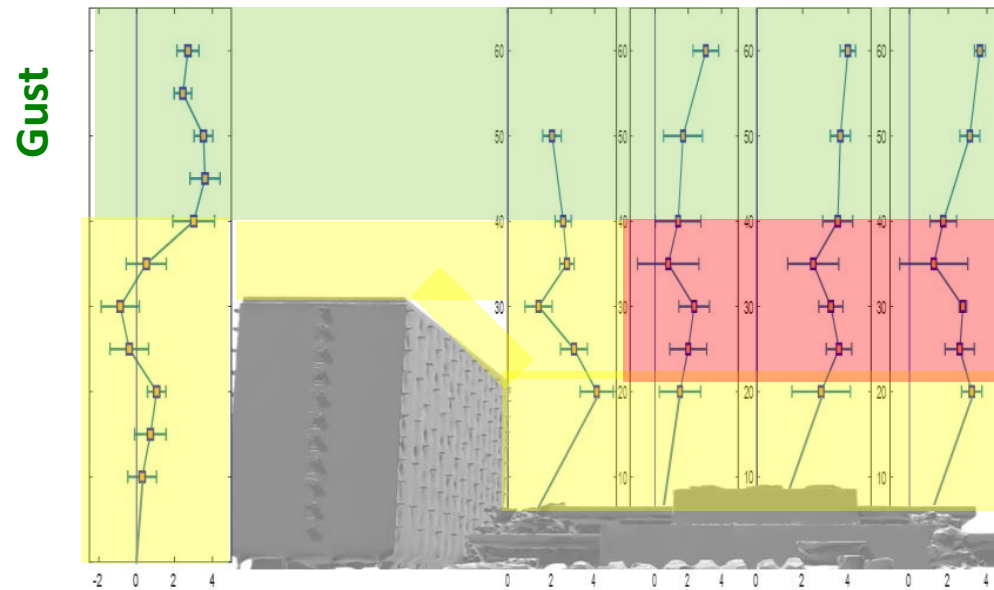
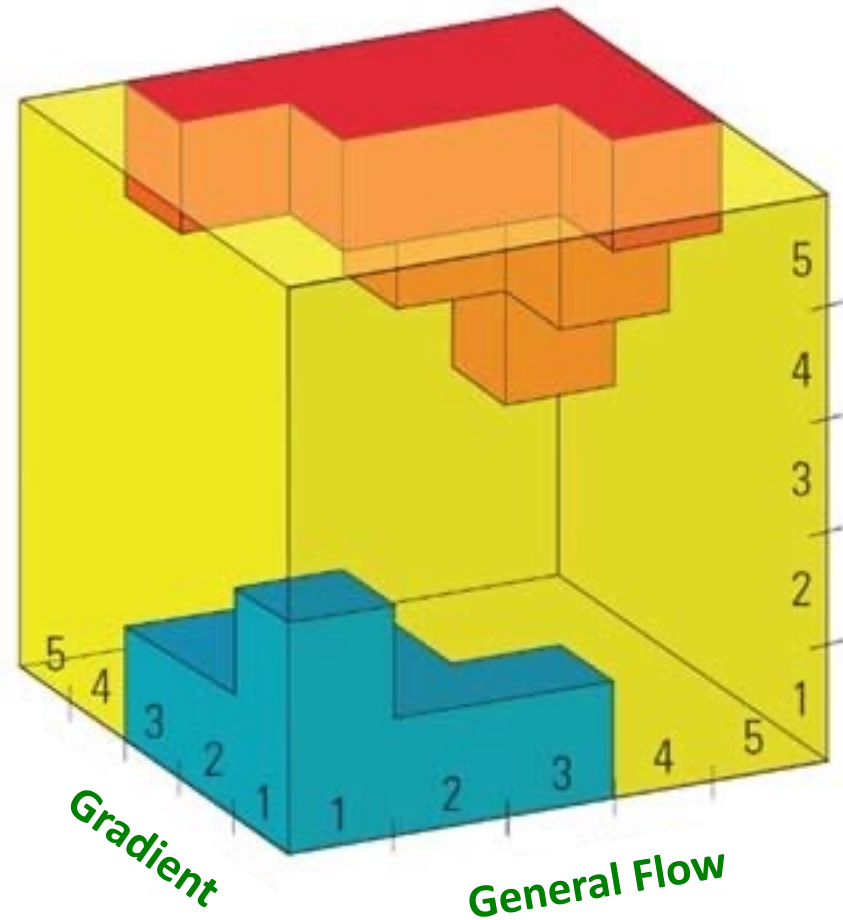
- Based on general freestream flow speed, gust level, and gradient (shear or spatial variation)
 - Similar to Robinson “shake & sharp”
- Heat map provides level of impact on vehicle based on individual vehicle parameters
- Note high gusts and gradients usually require high background flows as well
- Risk profile scales individually on each axis with vehicle



Urban Risk Matrix – “G³” Cube

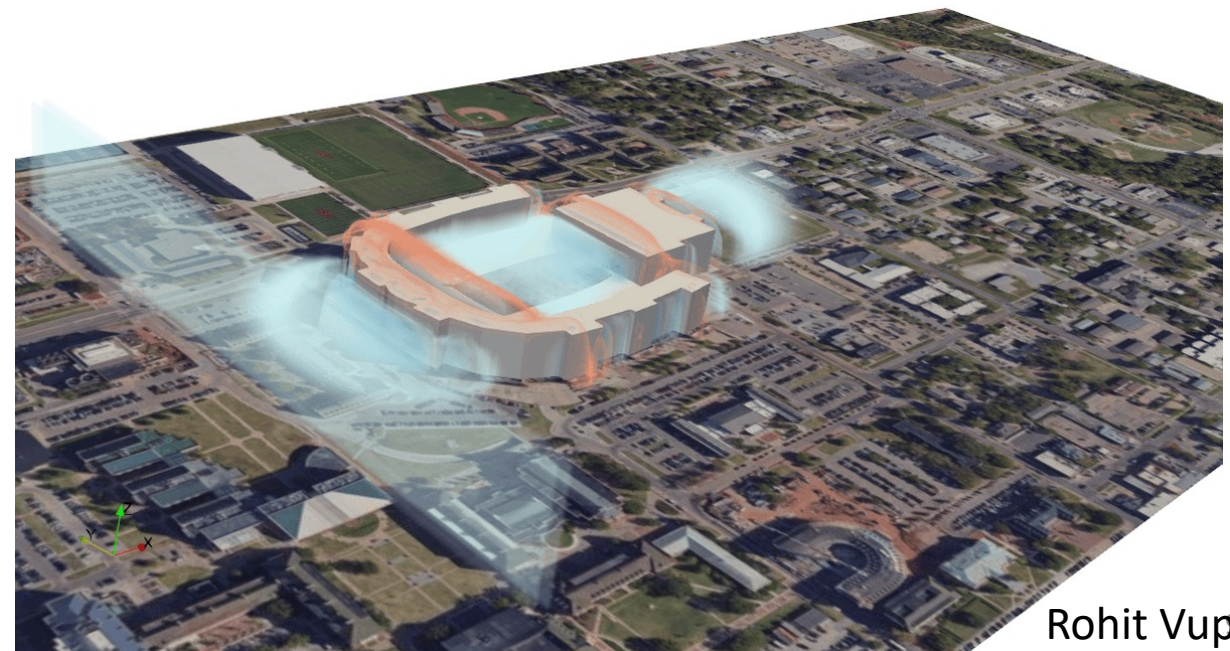
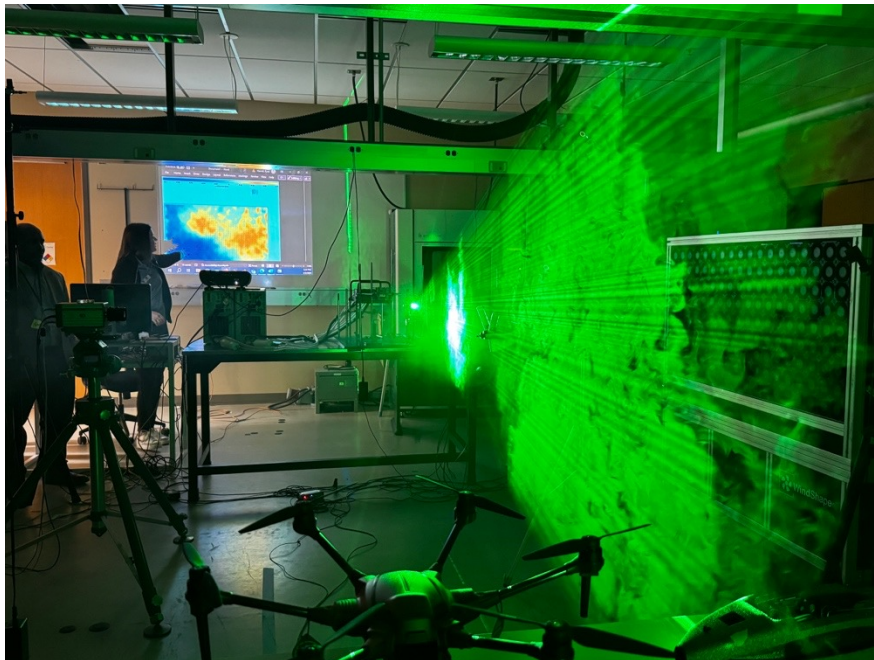


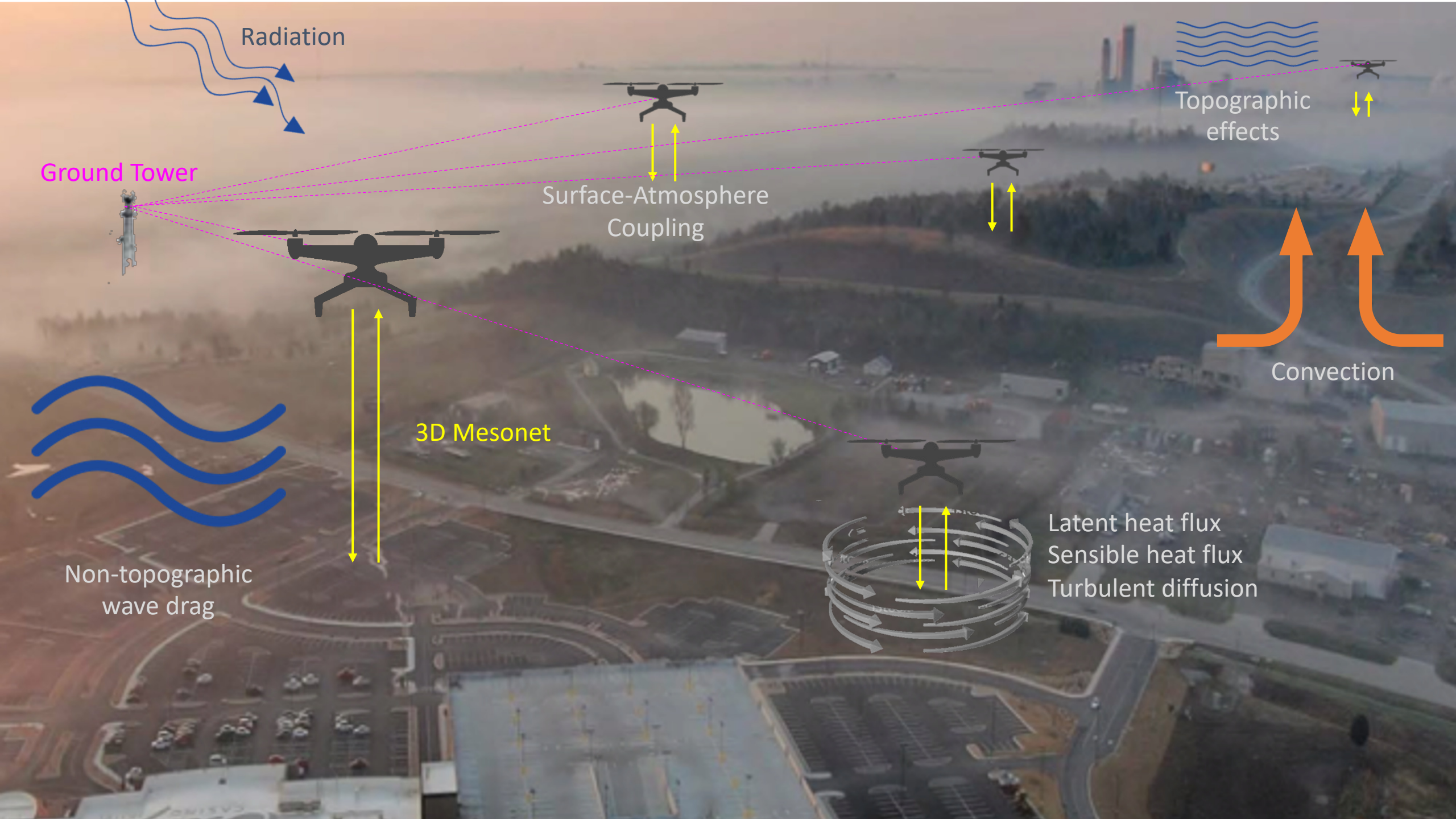
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Next Steps

- Gust shear wind tunnel testing
- Turbulence analysis & heat maps
 - Optimized visualization
 - Target and report risks
- Urban flights
 - CFD validation





Radiation

Topographic effects

Ground Tower

Surface-Atmosphere Coupling

Convection

3D Mesonet

Non-topographic wave drag

Latent heat flux
Sensible heat flux
Turbulent diffusion

Urban Field Campaign

- Diverse urban landscape
- Large centralized high rise
- Close control center proximity
- Predominant N/S wind
- Community receptive to drone use for weather applications

Field Office



Downtown Tulsa

Looking East



667'

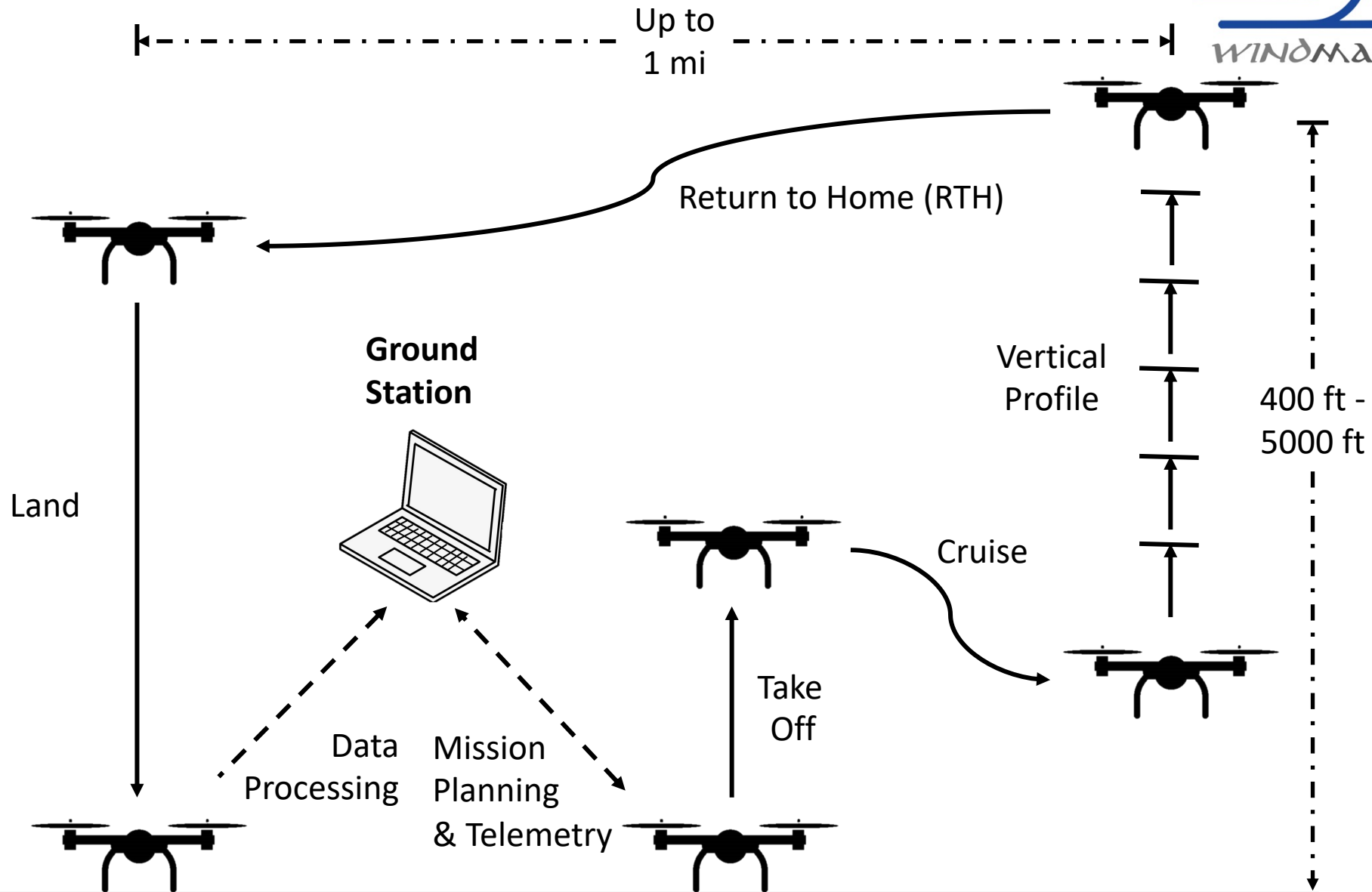
513'

516'

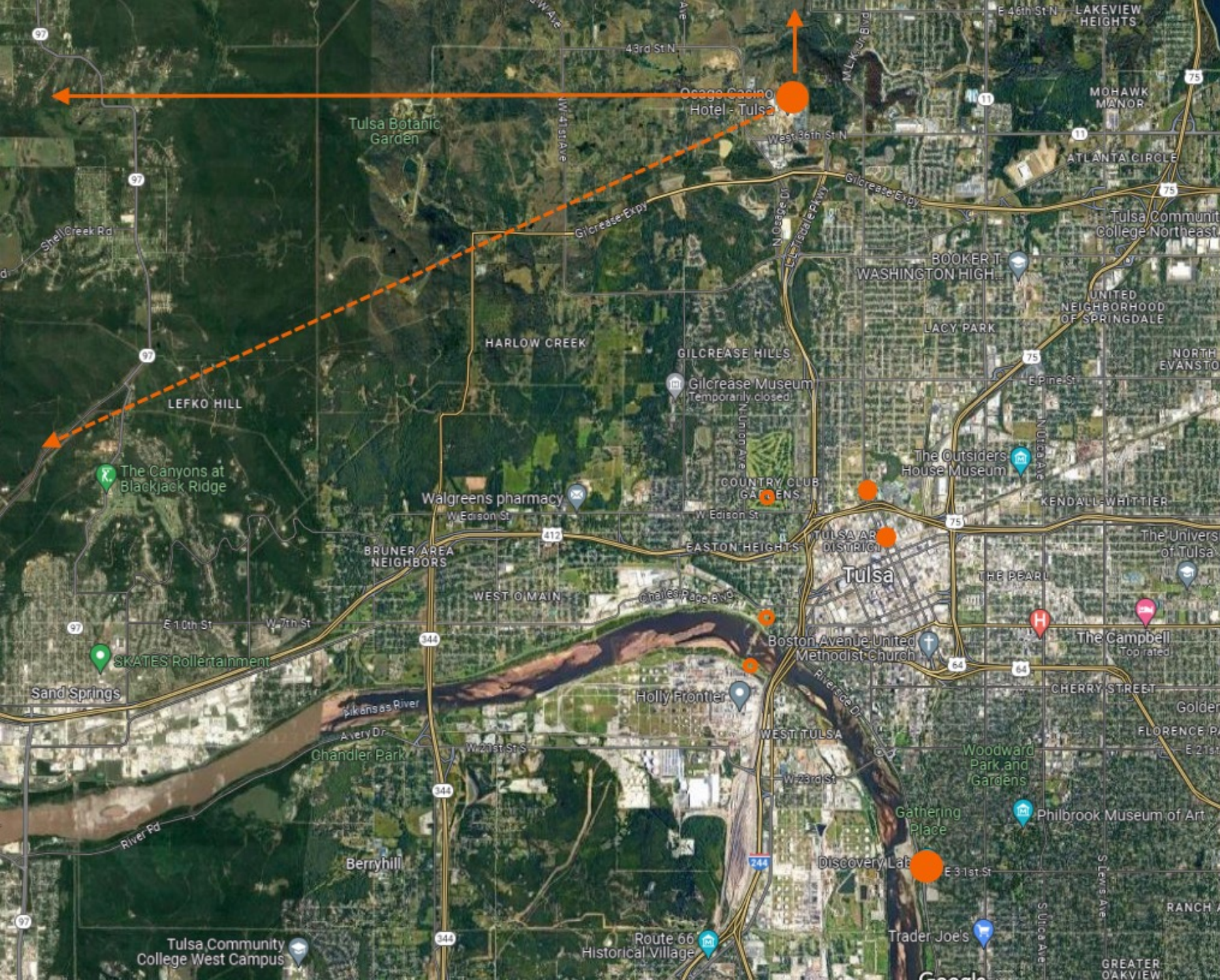
412'

400'

CONOPS



Drone not to scale with City



Scientific Objectives

Validate data and models – Fast Eddy

- TKE profile
- Alt: 50m +
- At least 4 flight teams

Heat Island and Data Representativeness

- Downstream, Cross-stream, Internal
- Thermodynamic measurements
- Profiles in urban area
- Long transects north and west
- Mobile tower of 3+ aircraft

WMO DC

- Alt: 1-2km
- PTU + wind
- Spread out measurements at Mesonet sites across the state

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