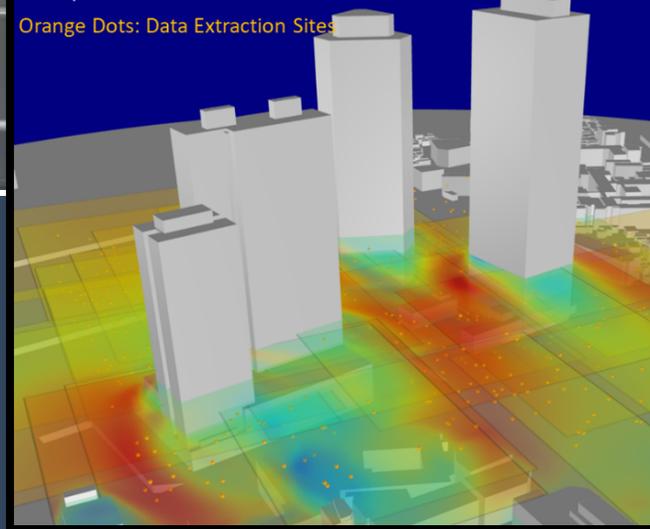# "WHOSE REALITY?"
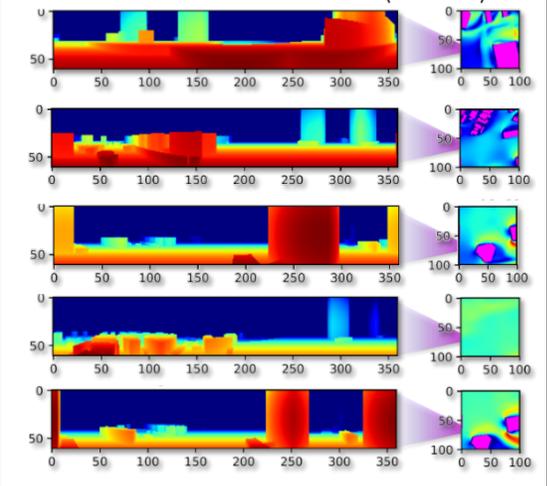## TRUSTING AUTONOMY IN UAS/AAM WEATHER

ANDY THURLING, NUAIR CTO

25 APRIL 2022

Example Wind field simulated with CFD

Orange Dots: Data Extraction Sites

LiDAR imagery of surrounding buildingscape
and associated local wind field (from CFD)

WING LOADINGS AND INERTIAS

UAS flying qualities:
- Low wing loading
  - "*Sticks to the Air*"
- Small rotational inertias
  - "**Susceptible to <u>very small-scale</u> air currents**"
- Makes for interesting HQ – Perf. & Workload

Aircraft	Wingspan (feet)	Approx. Weight (pounds)	Wing Loading (psf)
Boeing 747	211'	>735,000	150
Cessna 172	36'	2450	14.7
ScanEagle (Insitu)	10'	40	3.3
Puma (AV)	9'	15	~2
Helios (AV)	247'	2320	~1

NUAIR
MAKING FUTURE SKIES SAFER

AAM AND UAS SHARE COMMON CHARACTERISTICS

- Maybe not as <u>low wing/rotor loads</u>, but still lower than traditional aircraft

- Lower <u>rotational moments of inertia</u> than large aircraft

- <u>Tightly coupled control and lift devices</u>

- Need to precisely follow 4D flight path

- Just add Turbulence!
  - Wake from buildings and other obstructions
  - Vortex shedding difficult to predict
  - Wake from other UAM vehicles, probably heterogenous

- **Machine-to-Machine with no "carbon-based" backup**

- *Need - Safe high-density weather-tolerant operations in metropolitan areas, including proximity to urban structures, urban canyons, and micro-weather*

NUAIR
MAKING FUTURE SKIES SAFER

WEATHER IMPACTS TO AAM AUTOMATION SYSTEM

- Over 60% of current flight delays caused by weather-related events

- Thunderstorms, fog, and icing - will restrict vertiport operations

- Icing around a vertiport will impact ground taxiing of aircraft as well as takeoff and landing procedures
  - How do you deice on a rooftop vertiport?

- PSU manages the airspace
  - Manage point in space approaches due to many constraints - one is weather
  - May use third party supplemental data service providers (SDSPs) for weather

NUAIR®
MAKING FUTURE SKIES SAFER

WEATHER IN THE VERTIPORT AUTOMATION SYSTEM

- Tactical management and Strategic management when a weather event occurs or is forecasted
  - Rerouting to another airport or introducing delays such as vectors, speed reductions, and holding, but
  - May not be available for AAM, since a weather-related delay at one vertiport will likely cause delays at other vertiports in the local area

- UML-4 throughput projections have time slots as short as 30 seconds
  - Shorter flight times and small buffer times

- Rerouting passengers to vertiports outside of the local area would result in longer ground travel times, impacting the time saving goal of UAM

- Weather can cause <u>cascading delays</u> across numerous flights – unless we manage them!

NUAIR

MAKING FUTURE SKIES SAFER

AI/ML AND TRUSTED AUTONOMY IN WEATHER

- ML/AI can be wrong (fooled)
  - Highly Dependent on Training Data Sets
  - Who defined what was "good"?

- Autonomy can fail in ways that are hard to understand

- We understand human mistakes, but AI/ML makes "different" mistakes
  - Watson "Chicago" answer on Jeopardy
  - Microsoft Tay
  - Bread through bars works. Water, not so much!
  - Tesla signage
  - Tesla (again) '...the "learner driver" metaphor holds for some of FSD's issues, but falls apart when the technology engages in indisputably non-human behaviour.' (Guardian)
  - Uber self-driving

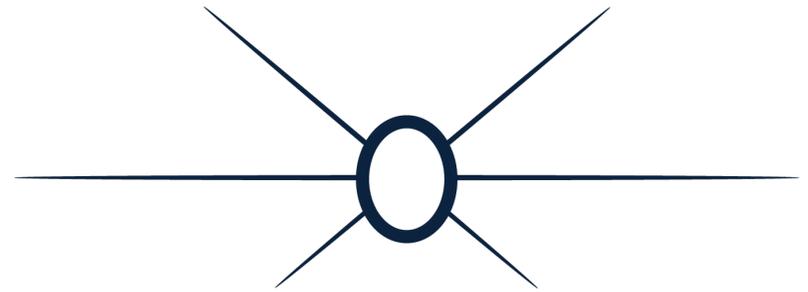- How do we accommodate this in weather FOREcasts and NOWcasts?

WEATHER AND AUTOMATION WITH A HUMAN OVER THE LOOP, WHAT NEEDS TO HAPPEN IF THE LINK GETS LOST?

- If Lost Link, then the aircraft will have to make smart decisions without human oversight

- Making the right decision requires trusted sensor input and interpretation of available information

- Does this lead to different "levels" of weather information and thus automation capabilities and interfaces to the appropriate human in/on/over the loop?
  - Strategic – Network impacts
  - Operational – Local traffic effects
  - Tactical – Get my vehicle to my next point safely

- Should AI and ML try to mimic what a human forecaster or pilot in the cockpit would do?

NUAIR
MAKING FUTURE SKIES SAFER

DISCUSSION

- *Should* AI and ML try to mimic what a human forecaster or pilot in the cockpit would do?

- The remote pilot in command (RPIC) may not act fast enough to intervene if something goes off-nominal
  - RPIC may not even recognize initially that something goes wrong

- And automation can fail in ways that a human does not appreciate or anticipate

- Crawl/Walk/Run graduation process for AI/ML with testbeds?
  - ***First*** Tactical – Get my vehicle to my next point safely, ***then***
  - Operational – Local traffic effects, ***then***
  - Strategic – Network impacts

- I think these could be different problems – Let's Discuss!

NUAIR
MAKING FUTURE SKIES SAFER