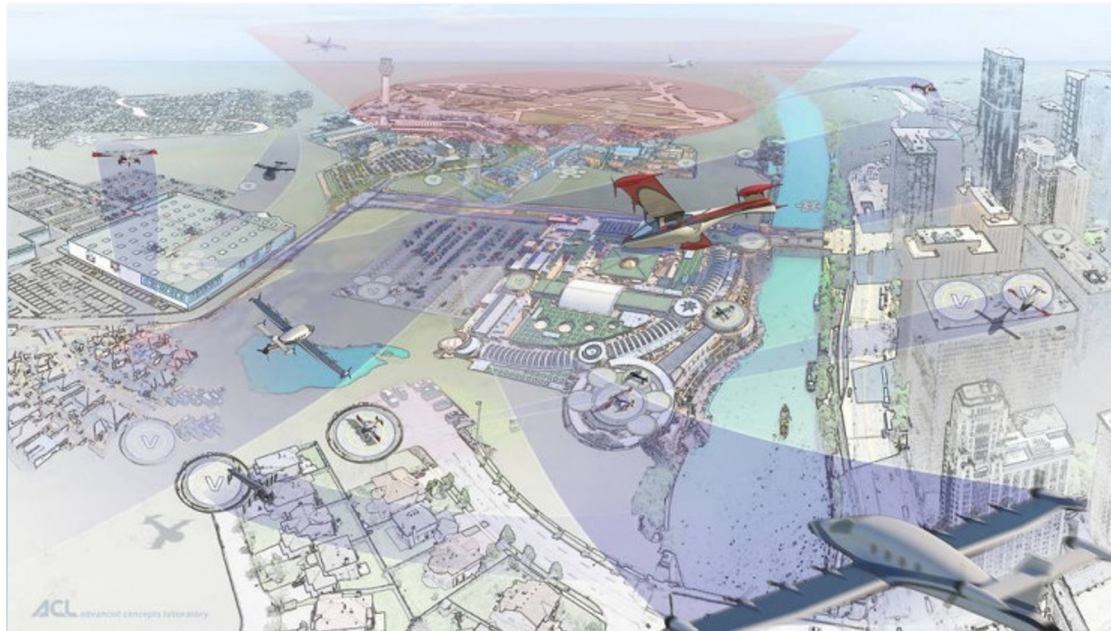


Collaborative Weather Research and Development for Urban Air Mobility



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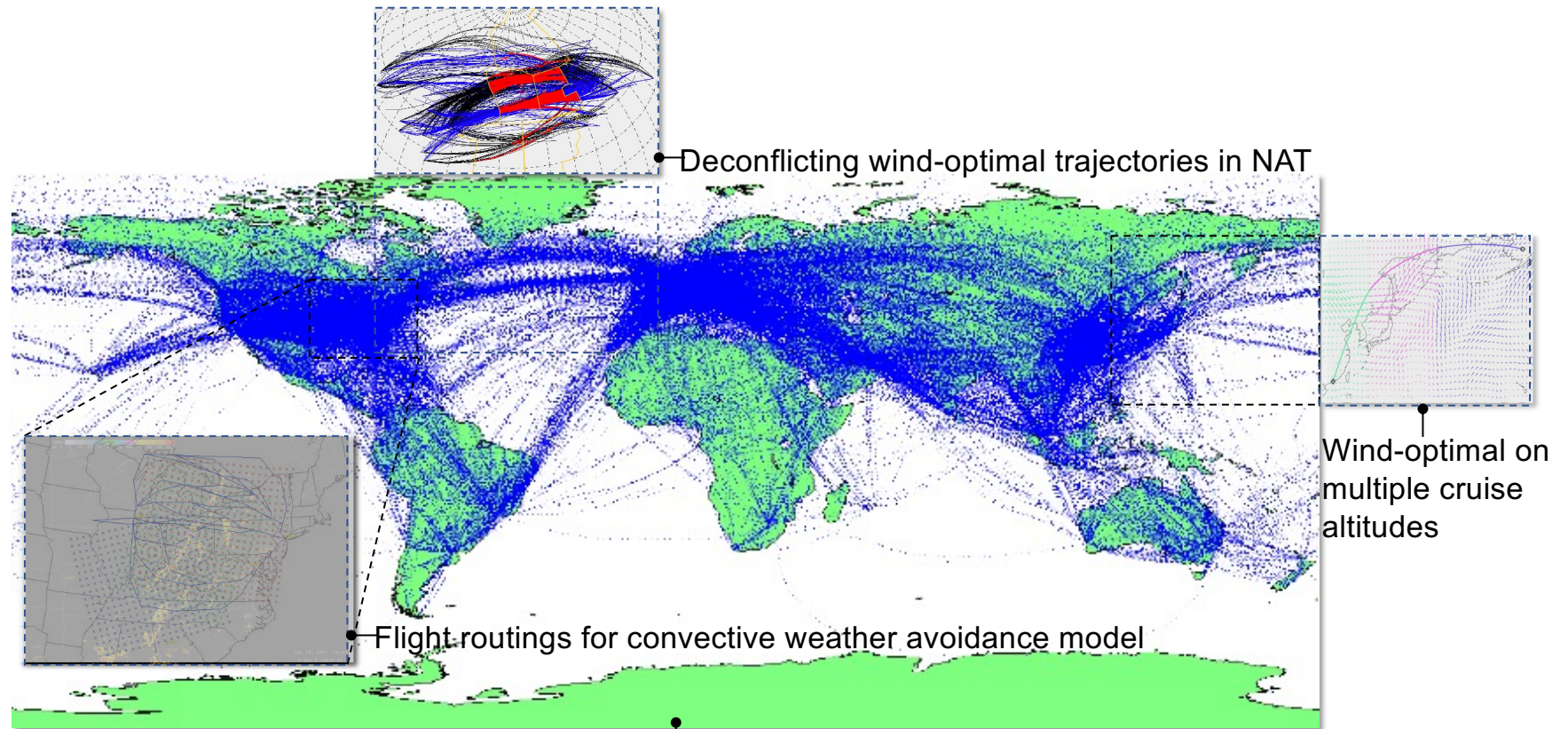


Outline

- Introduction
 - Wind optimal and weather avoidance operations
 - Climate impact and aircraft emissions tradeoff
- Background: Urban Air Mobility (UAM)
- Overview: Collaborative Weather Research and Development
- Impact Analysis for Dallas-Fort Worth Metroplex
 - Input Data
 - Preliminary Results
- Work in Progress
 - Weather Impact Data Analysis
 - Airspace Capacity Analysis



Introduction: Wind Optimal and Weather Avoidance Operations

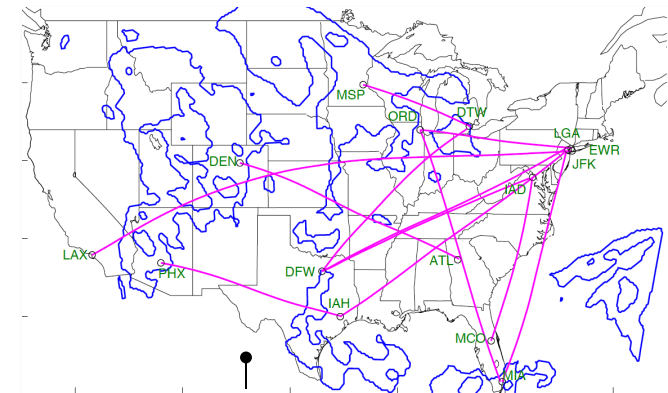
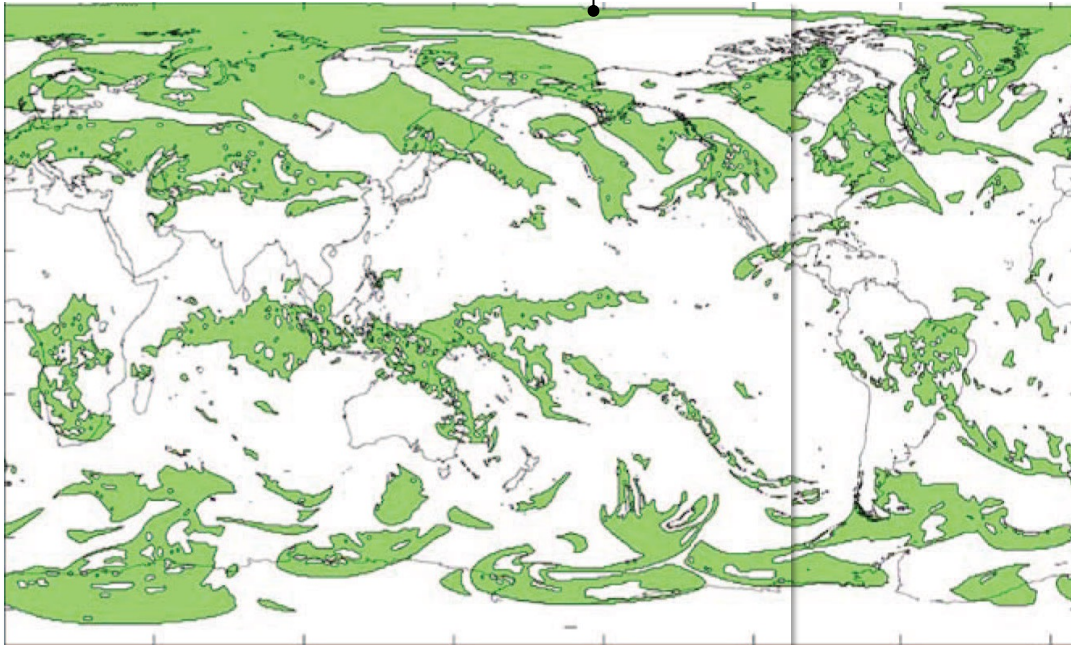


Wind-optimal trajectories worldwide for 26 June 2010

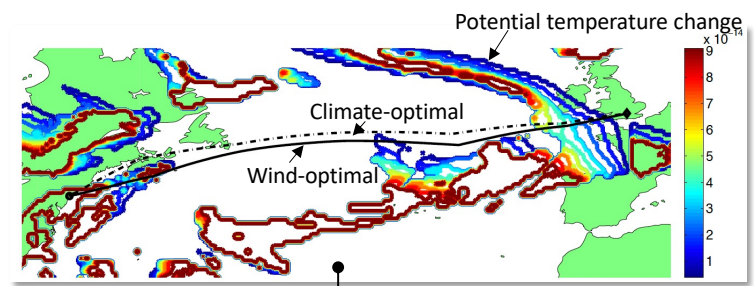


Introduction: Climate Impact and Aircraft Emissions Tradeoff

Persistent contrails favorable regions worldwide for December 31, 2009



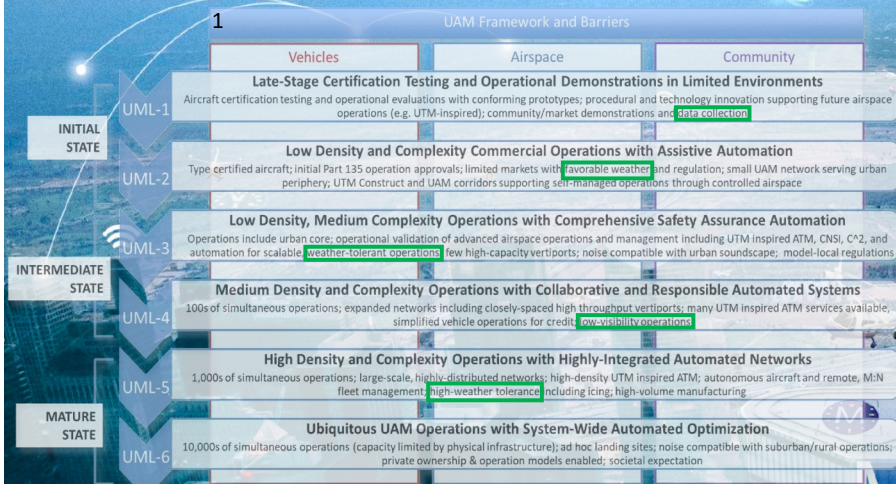
Energy-efficient trajectory design for reducing climate-impact on various timescales



Trajectory design for reducing climate-impact of trans-Atlantic flights

Background: Urban Air Mobility

National Aeronautics and
Space Administration



- 2**
- **Policy and Regulations**
 - Weather Policy at UML-4 evolved from requiring the vehicle operator or pilot to be responsible for the quality of the weather information to the weather data provider.
 - **Weather Data Collection**
 - UML-4 weather data collection will require balancing the need for greater granularity of weather observations, at a micro-climate scale, with the cost of taking those observations.
 - **Weather Data**
 - Weather data meeting performance standards, collected from sensors described above, will be accessible from government, private sector and non-profit entities following a standard set of data performance standards.
 - **Modeling and Forecasting**
 - At UML-4, higher resolution, coupled forecast models are required to capture urban wind and weather effects for safe and cost-effective high-density urban flight operations.
 - **Weather Supplemental Data Service Providers (SDSPs)**
 - Weather Supplemental Data Service Providers are expected to drive innovation and leverage government and commercial weather data sets to produce granular micro weather products and services customized to support UTM and UAM operator operations.

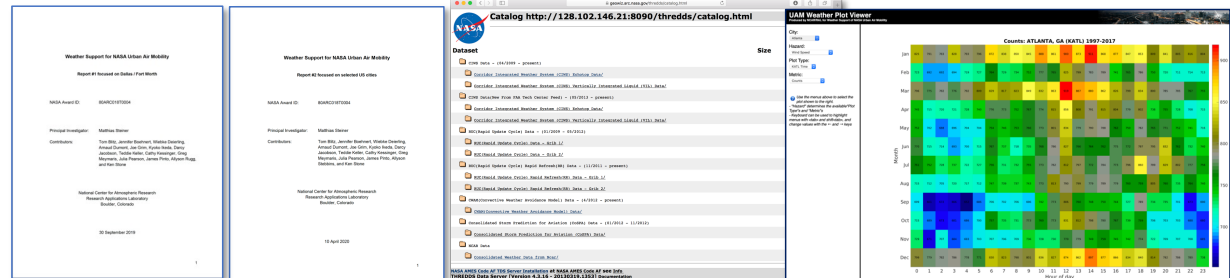
1. National Aeronautics and Space Administration (NASA) UAM Vision Concept of Operations (ConOps) UAM Maturity Level (UML) 4

2. Advanced Air Mobility (AAM) Ecosystem Community Integration Working Group: UAM Weather

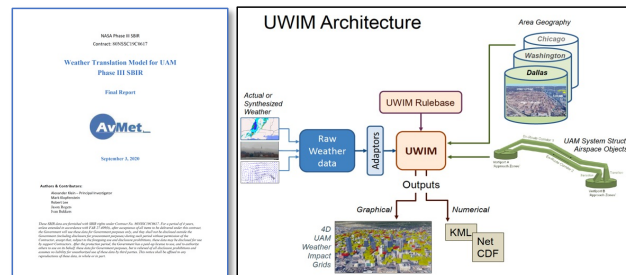
Overview: Collaborative Weather Research and Development



- Data support
 - NCAR project (FY19-20)
 - Initial analysis (FY20-22)



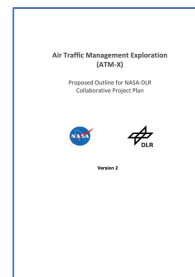
- Impact translation model
 - AvMet SBIR Phase III (FY20)



Summary of known UAM relevant weather impact constraints and rules

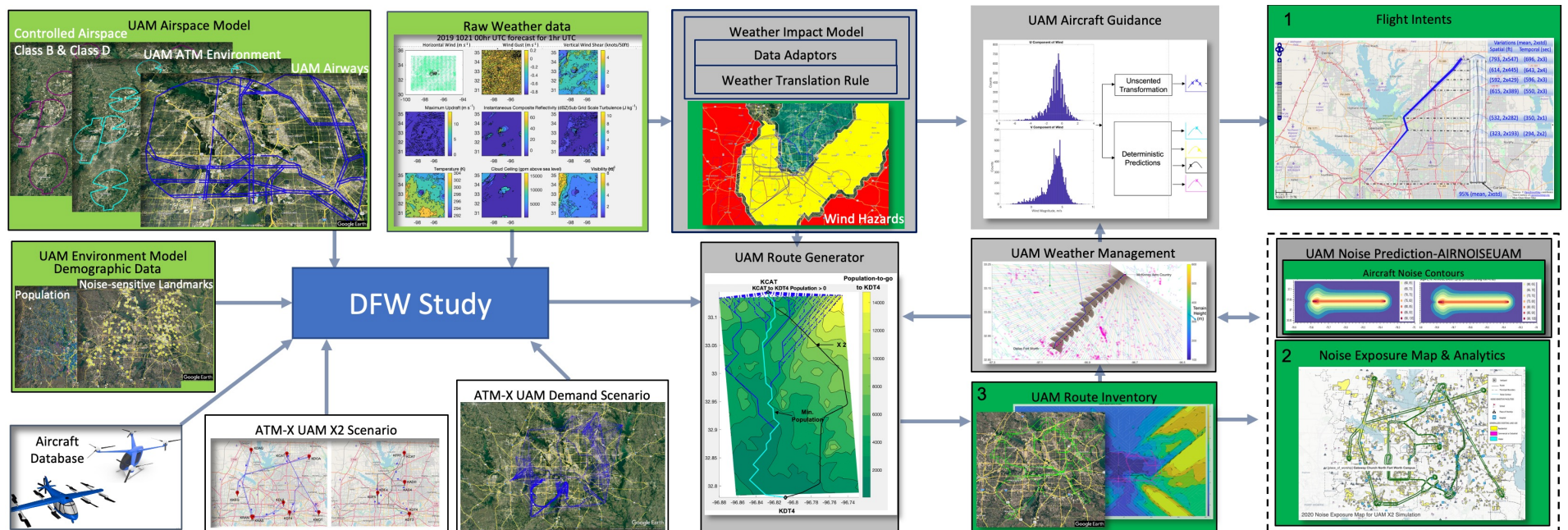
Weather phenomenon	Units	Proposed UAM Weather Thresholds for Specific Weather Phenomena		
		Green	Yellow	Red
Convective weather	dBZ NM	15-30 NM "light" around a 40 dBZ area	10-15 NM "light" around a 40 dBZ area	Within 15 NM of a 40 dBZ area
Freezing drizzle	mm/hr	No freezing drizzle	Freezing drizzle?	Freezing drizzle
Ice	mm/hr	No ice	N/A	Any ice
Snow	mm/hr	Light (< 1 mm/hr)	Light to Mod (1-2.5 mm/hr)	Moderate (> 2.5 mm/hr)
Horizontal Wind speed	kt	Wind < 15 kt ± 5	Wind < 20 kt ± 10	Wind > 25 kt or gusts > 35 kt
Vertical Wind gust	DEVS	< 4	4-6	> 6
Vertical Wind Shear	M/s	< 1.5	1.5 - 2.3	> 2.3
Cloud ceilings	Feet	> 1000 Ft	10-15 kt variation between 50-15 layers	> 15 kt variation between 50-15 layers
Cloud ceilings	Feet	> 1000 Ft	1000-500 Ft	> 500 Ft
Visibility	Statute Miles	> 3 miles above e.g. 1200 Ft	1-3 miles above e.g. 1200 Ft	< 0.5 mile
Rain	mm/hr	< 1 mm/hr	0.5-1 mm/hr	> 1 mm/hr
Temperature	Deg C	< 30°C	30-35°C or -35,-1°C	> 35°C or < -35°C
Relative humidity	Percent	7	7	7

- Impact analysis
 - DLR collaboration (FY21-22+)





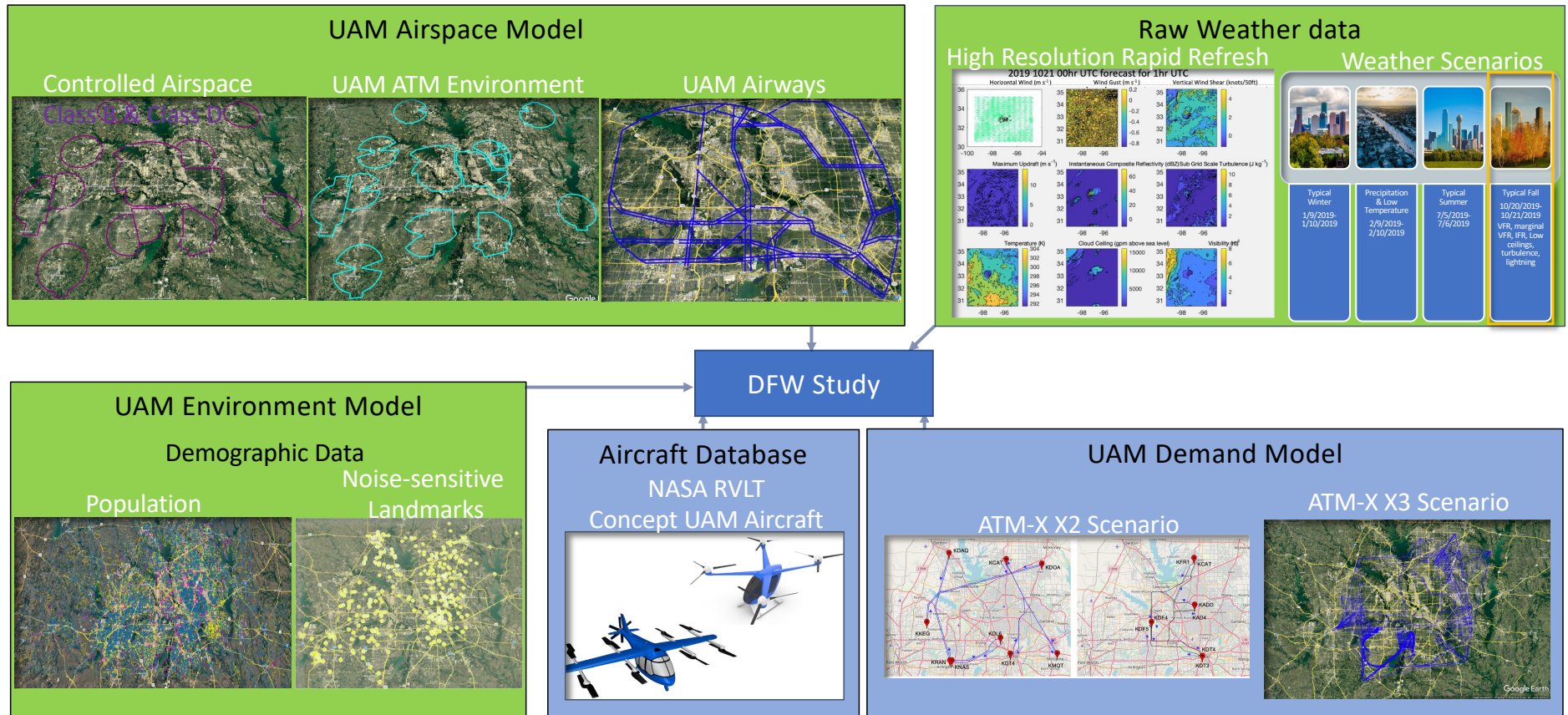
UAM Impact Analysis for Dallas-Fort Worth Metroplex



1. Ng, H., "Strategic Planning with Unscented Optimal Guidance for Urban Air Mobility", 2020 AIAA Aviation Forum
2. Li, Jinhua, Ng, H., Zheng, Y., Gutierrez, S., "Noise Exposure Maps for Urban Air Mobility," 2021 AIAA Aviation Forum
3. Ng, H., Li, Jinhua, Zheng, Y., "Noise Impact Analysis for Urban Air Mobility in Dallas-Fort Worth Metroplex", 2022 AIAA Aviation Forum (to be published)

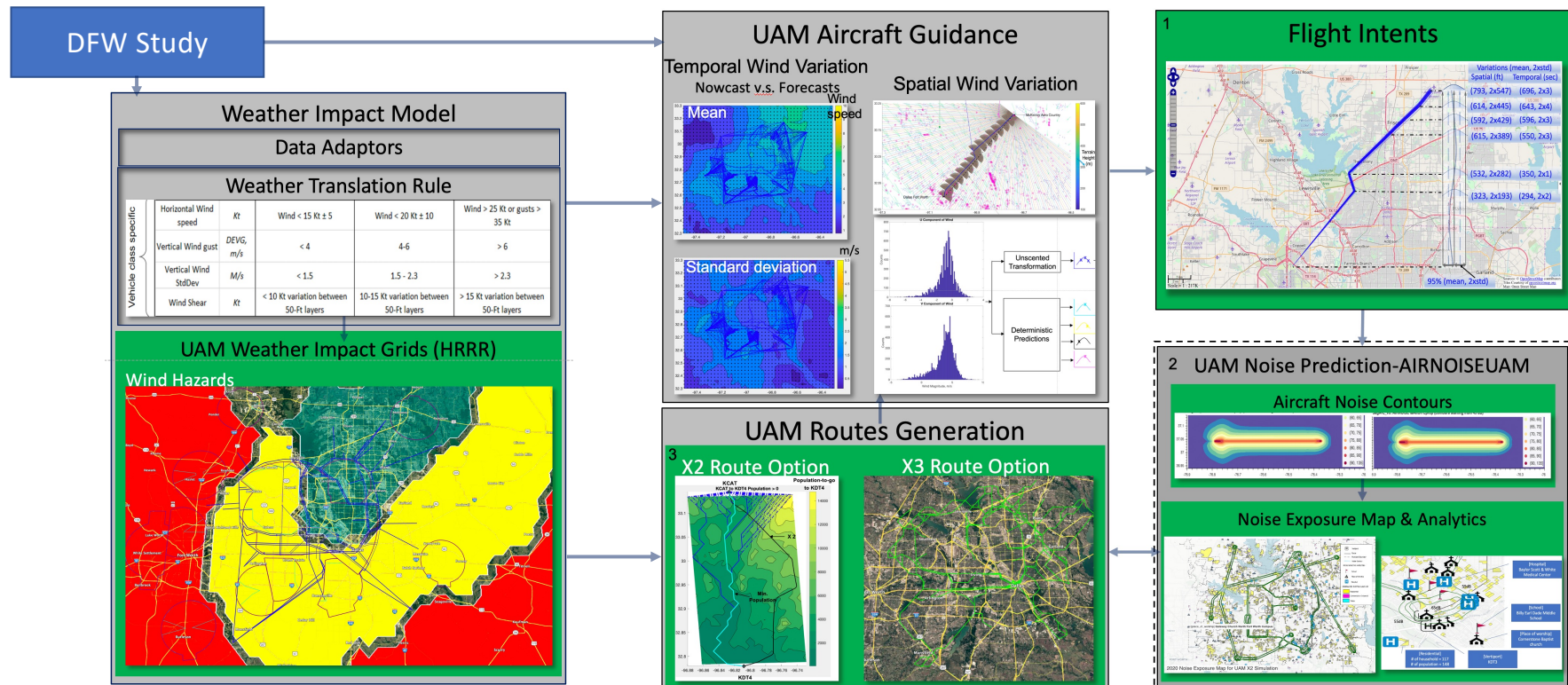


Inputs to UAM Impact Analysis





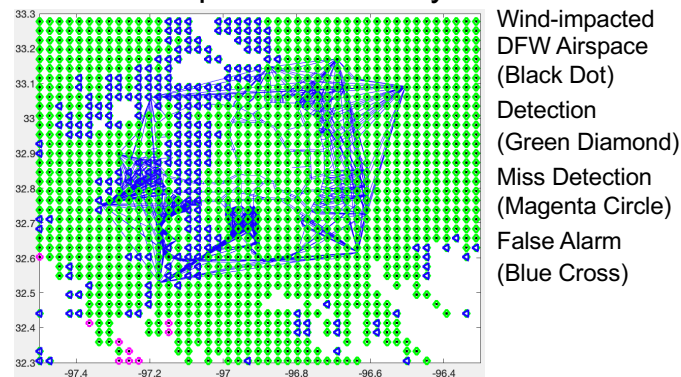
UAM Weather and Noise Impacts-Preliminary Results





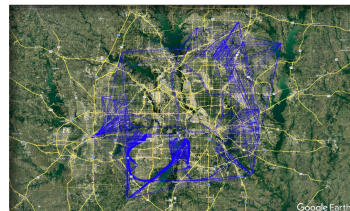
Work in Progress & Discussion

• Weather Impact Data Analysis

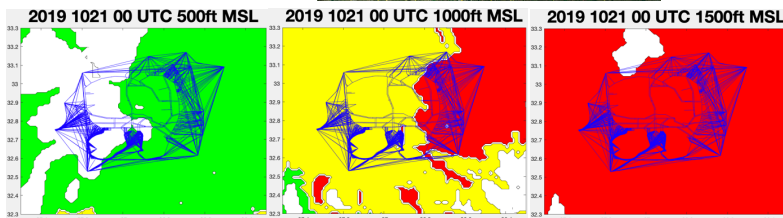


Wind-impacted
DFW Airspace
(Black Dot)
Detection
(Green Diamond)
Miss Detection
(Magenta Circle)
False Alarm
(Blue Cross)

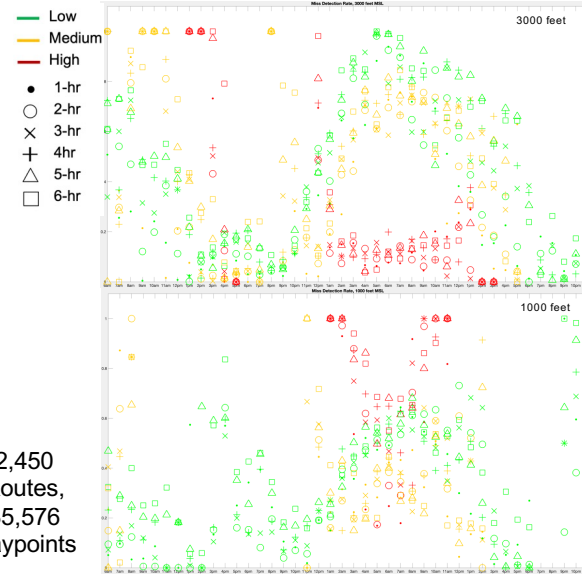
• Airspace Capacity Analysis



2,450
Routes,
35,576
waypoints



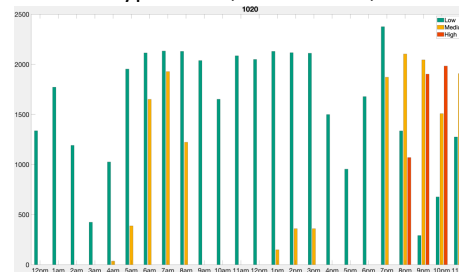
Miss Detection Rate



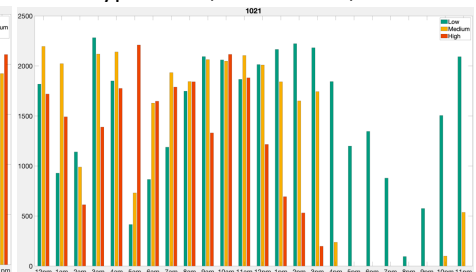
False Alarm Rate



Typical Fall, October 20, 2019



Typical Fall, October 21, 2019





Thank You!

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