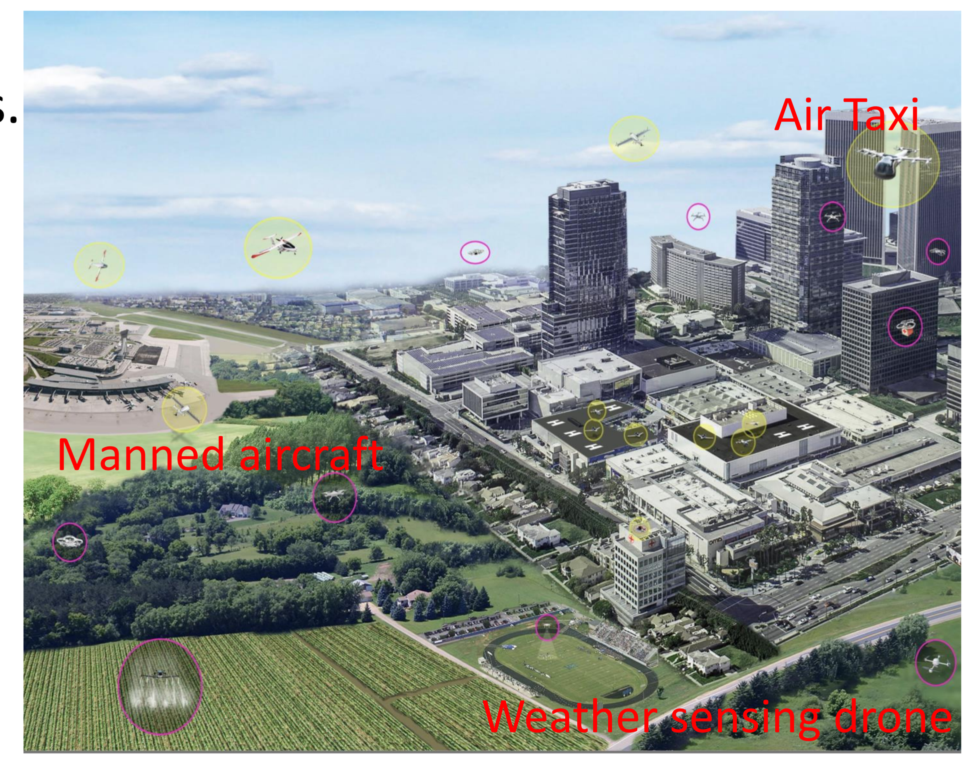
NRI INT: Safe Wind-Aware Navigation for Collaborative Autonomous Aircraft in Low Altitude Airspace

Dr. He Bai[1], Dr. Rushikesh Kamalapurkar[1], Dr. Jamey Jacob[1], Dr. Kursat Kara[1], Dr. Matt Vance [2], Dr. Balaji Jayaraman[3]
[1] Mechanical & Aerospace Engineering, [2] College of Education and Human Sciences, Oklahoma State University; [3]Sci-AI Corporation

Background and Challenges

- Small unmanned aerial systems (sUAS) technologies found many civil, commercial, and military applications.
- Infrastructure, such as NASA UAS traffic management (UTM) for low-altitude airspace management and monitoring is being developed.
- Safety and efficiency of sUAS operations are strongly impacted by low-altitude gusts:
  - Negatively affect pilot operations, reduced flight time, damage
  - Airspace management and allocation made conservative and inefficient

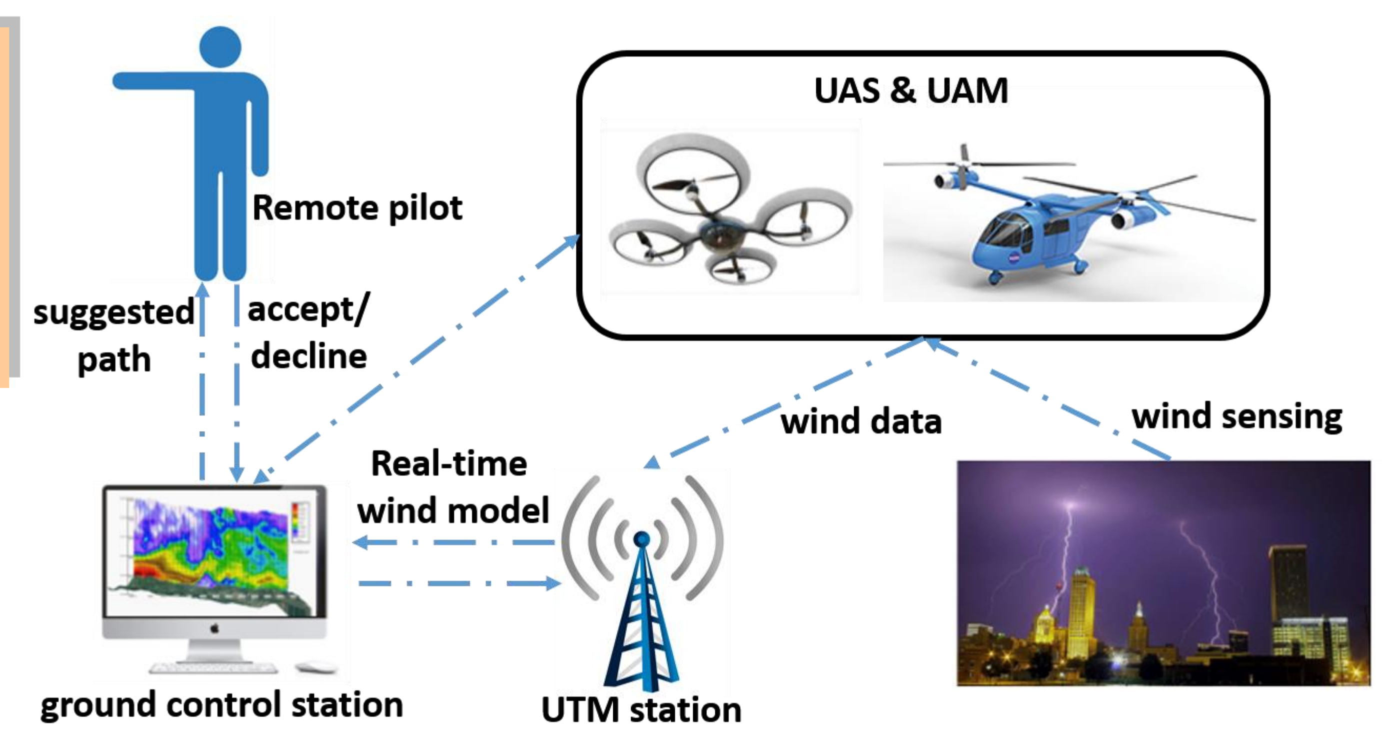


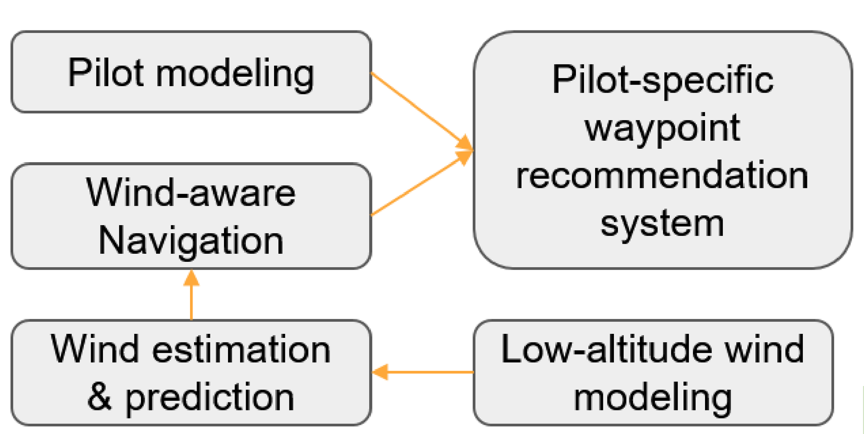
adapted from NASA

Improve safety and efficiency of low-altitude UAS operations

Technical Approach

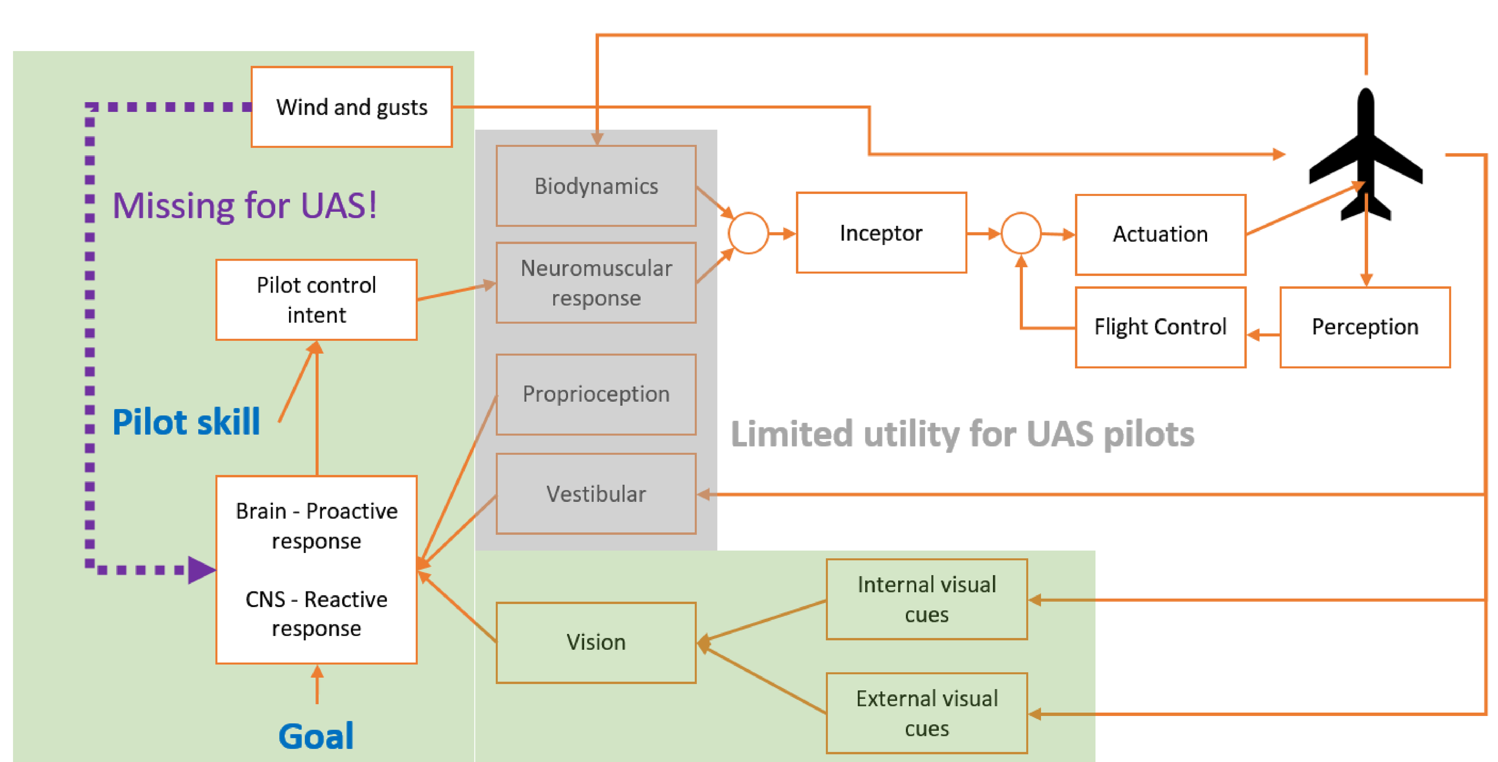
'In-time' or 'real-time' wind field information, communicated effectively to pilots and traffic management, can enhance safety, efficiency, and robustness of future sUAS operations in low-altitude airspace.





Pilot models - Inverse Reinforcement Learning

- Nonlinear vehicle dynamics
- Pilot intent and pilot preferences modeled as the need to minimize a cost function ***J***
- Design experiments and collect input-output data to identify ***J***

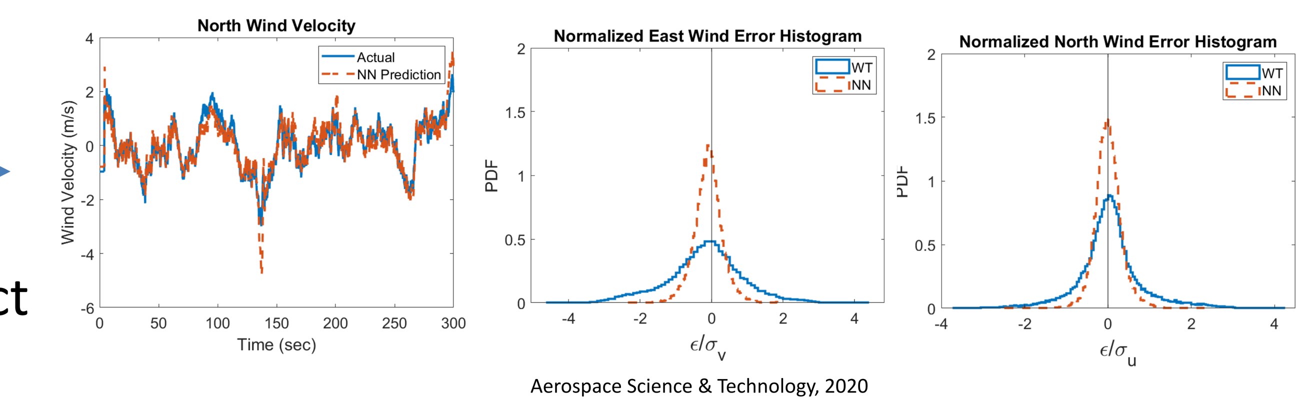


Wind estimation and prediction

- Estimate wind from sUAS trajectories

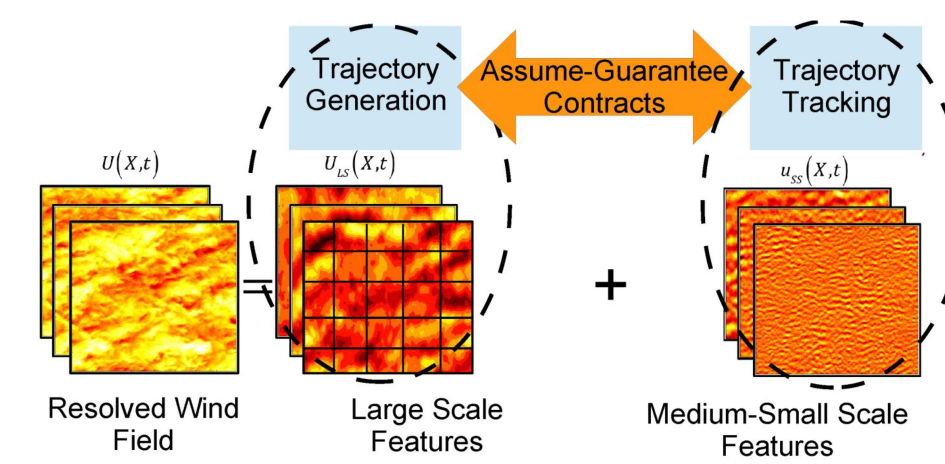
Trajectory deviation → Learned Model → Wind

- Assimilate sUAS wind estimates to predict wind information



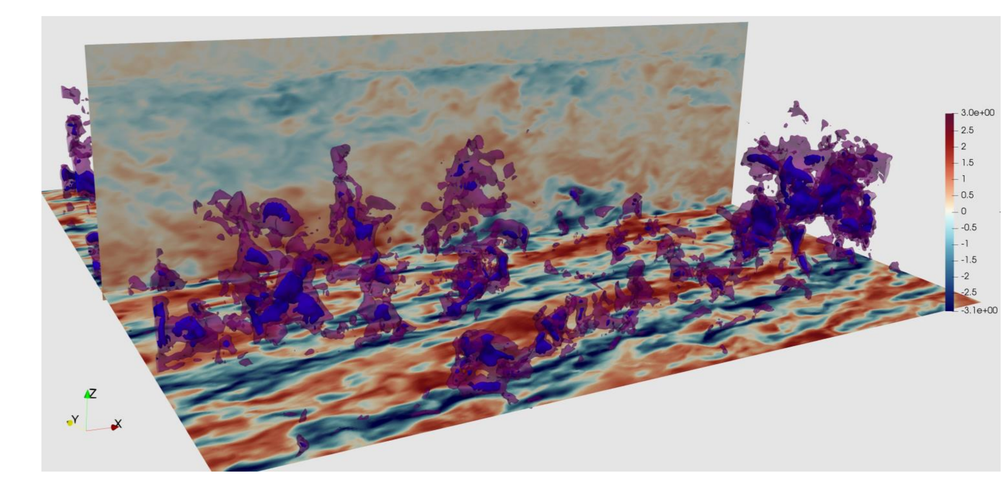
Wind-aware path planning

- Exploit spatiotemporal scale separation in wind field for optimal hierarchical control



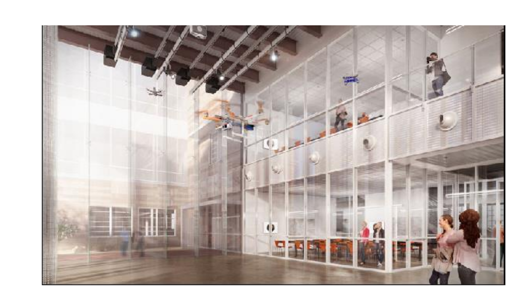
Wind modeling and simulation

- Large-Eddy Simulations (LES) for low-altitude wind with different terrains



Validation plan

- Indoor navigation and pilot modeling
- Outdoor sUAS flight test and data collection



Scientific Impacts

- Challenging problem for sUAS integration into the National Airspace: wind impacts sUAS navigation and pilot operations
- Mapping sensor data to a wind field and then into pilot commands can have impact on other Human Robot Interaction (HRI) applications
- Potential enhancement of low-altitude wind estimation and prediction towards micrometeorology

Broader Impacts

- Impacts on UTM and Urban Air Mobility (UAM) efforts and package delivery, reconnaissance, etc.
- Atmospheric sensing of weather phenomena and turbulent plumes of pollutants/emissions
- Manned pilots and aircraft: No ability to estimate or correct for gusts
- Release matured algorithms on open source software, e.g., QGroundControl
- Oklahoma Louis Stokes Alliance for Minority Participation (OK-LSAMP)
- Development efforts integrated into senior design and class projects

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