Recent Developments on Photo Realistic Simulation and VTOL Vehicle

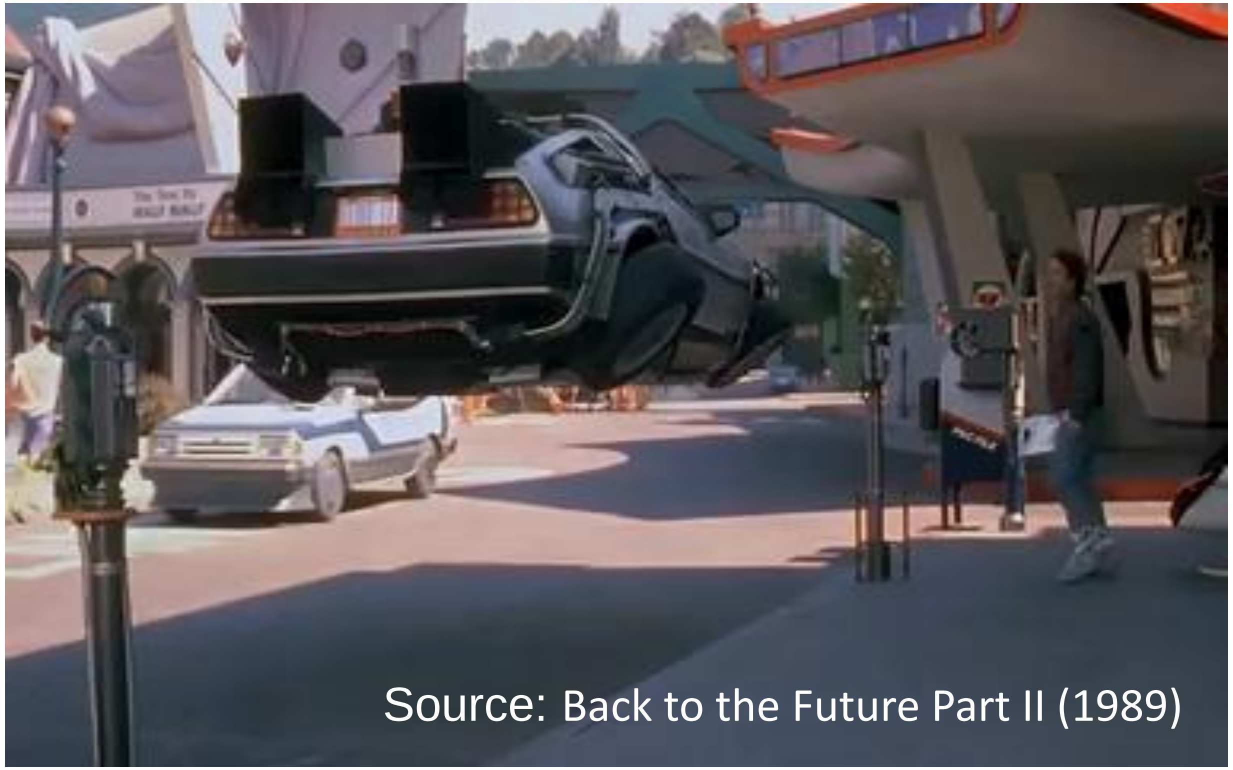
Hyung-Jin Yoon

05/16, 2025

Tennessee Tech
Mechanical Engineering

Vision and Focus

Autonomous Landing of Advanced Aerial Mobility Vehicles in Urban Environments



*Urban Air Mobility (**UAM**) Landing on **Street***

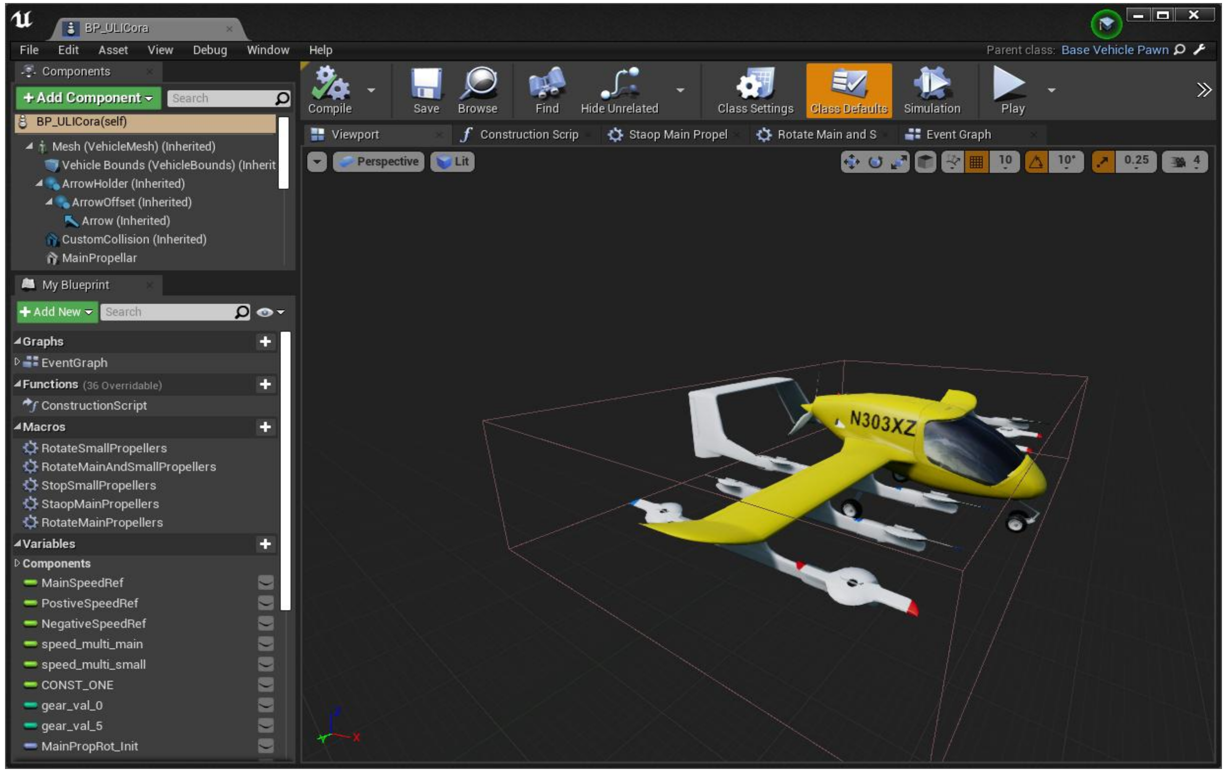
- **Photorealistic Simulation Environment**
  - **High-fidelity visuals** for realistic testing and development
  - Supports real-time sensor and control loop integration
- **VTOL RC Plane Platform**
  - Custom-built to **support GPU payload**
  - Designed for **onboard AI inference** and autonomy testing

Simulation Environment

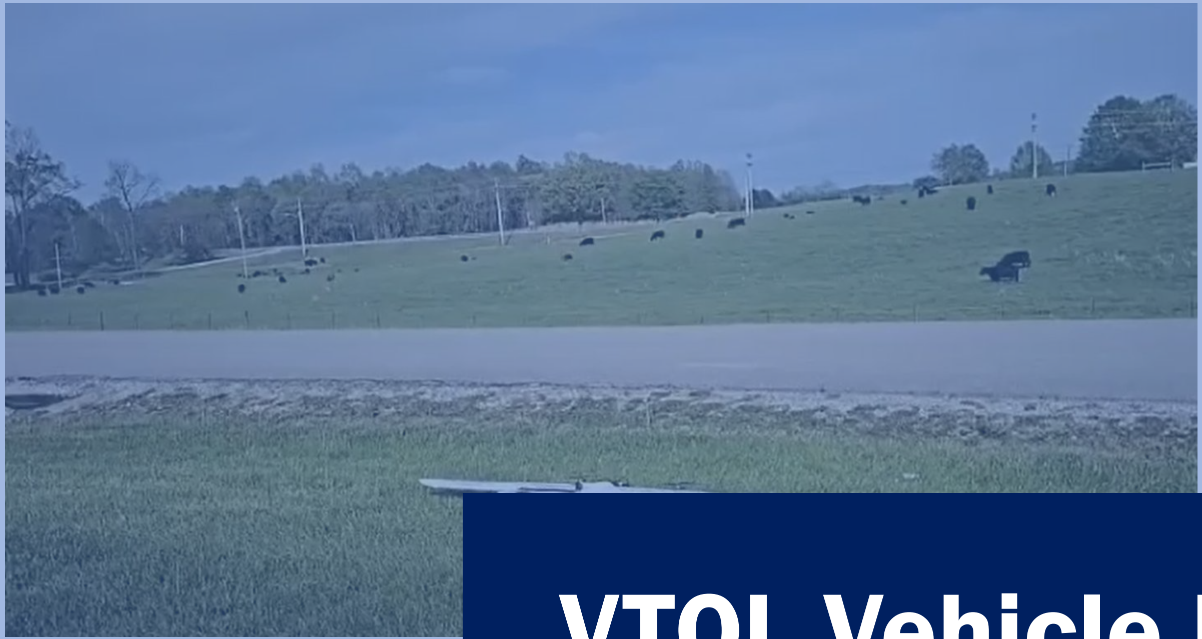
Progress Summary Up to Previous Milestone

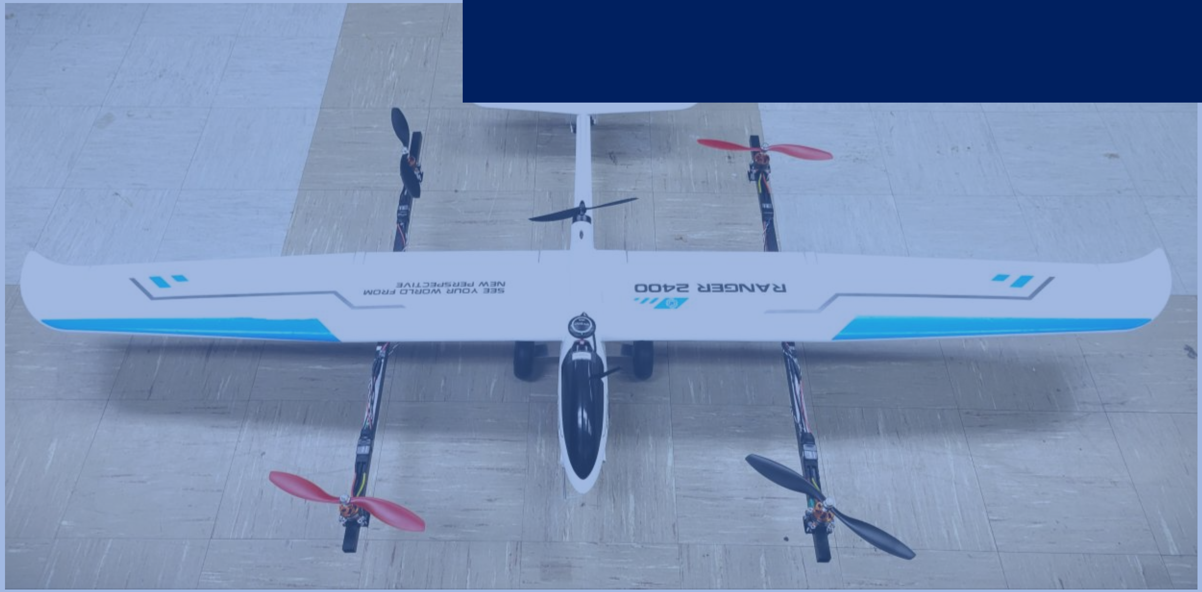
Latest Work: CORA Vehicle Integrated in UE5 CARLA Environment

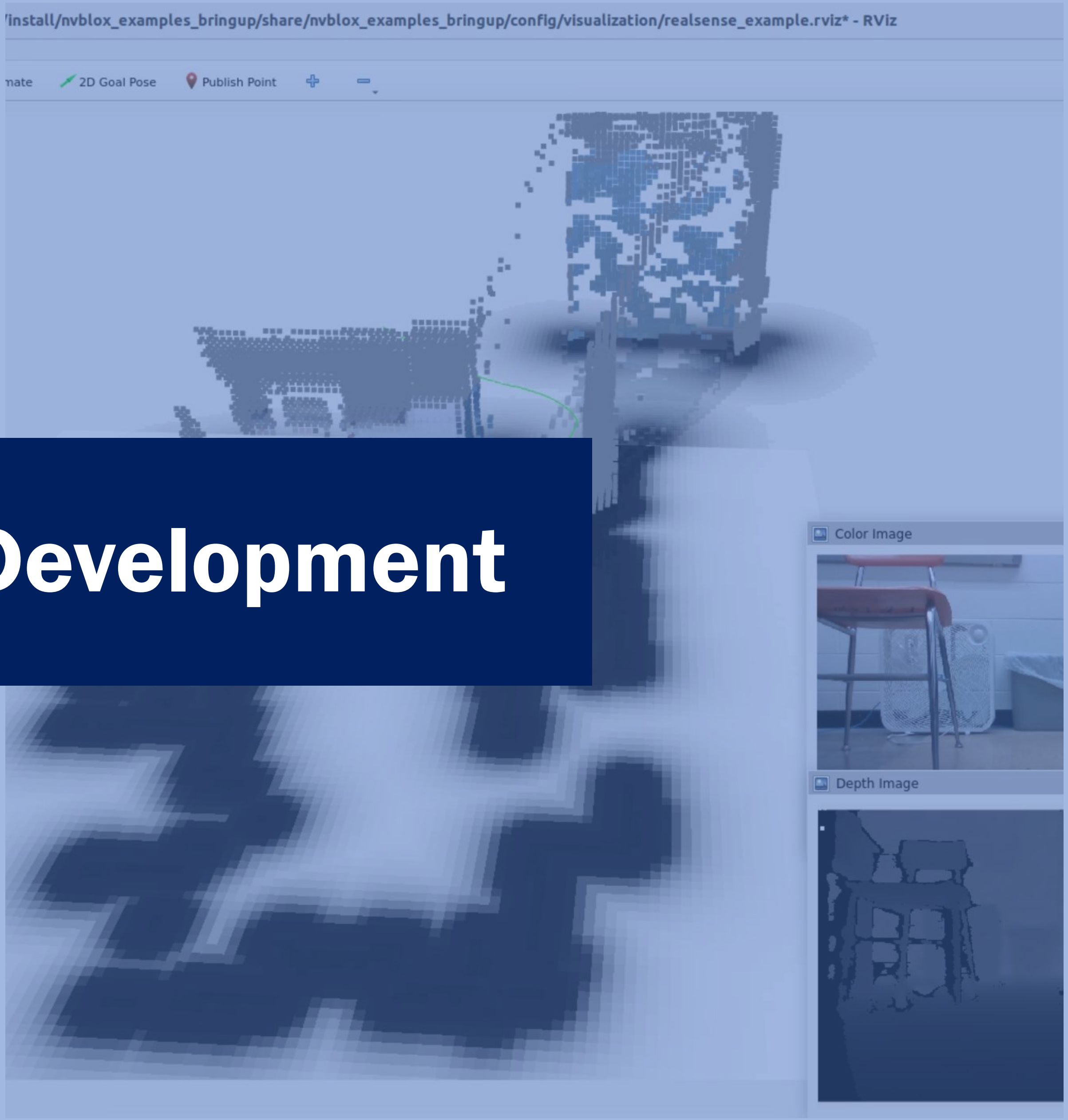
- With the release of **CARLA for UE5**, we have migrated the **CORA model** into the **UE5** simulation.
- This environment is shared via **Docker Hub** by Ashik (from our group) with Ayoosh (Dr. Lui Sha's group) and Mikael (Dr. Hovakimyan's group).



VTOL Vehicle Development

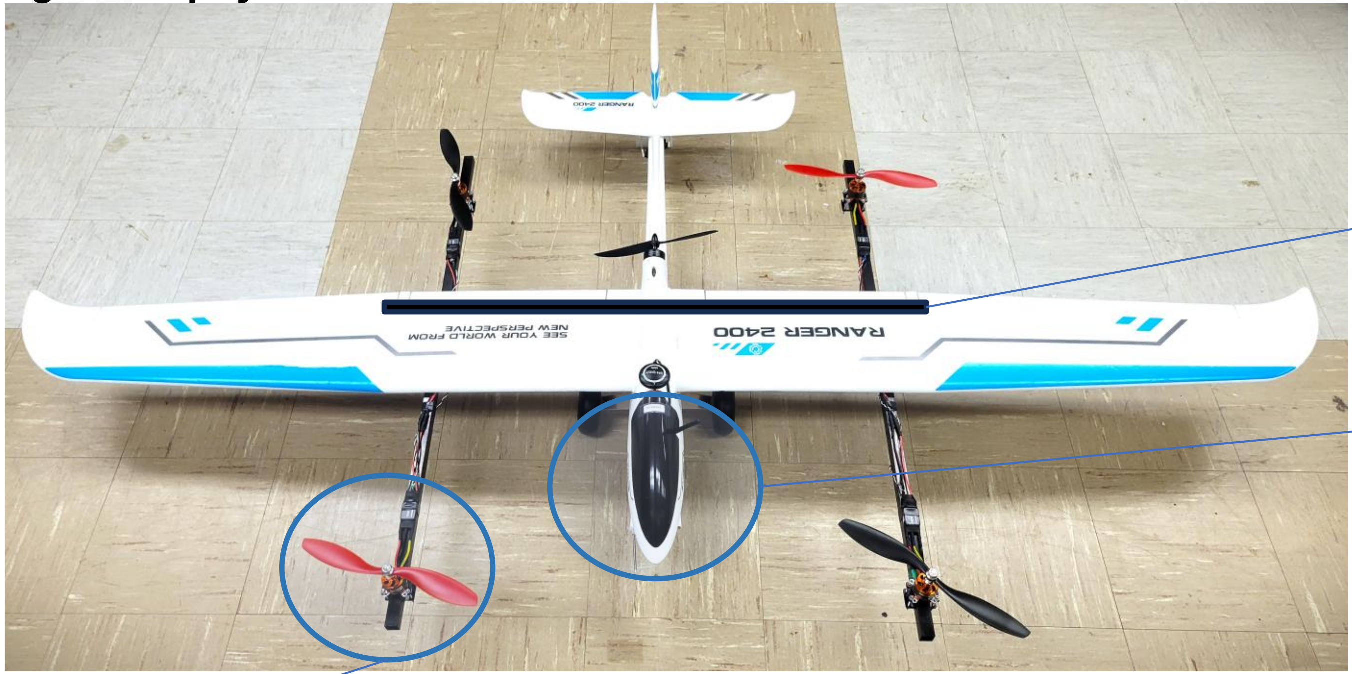






Progress Summary Up to Previous Milestone

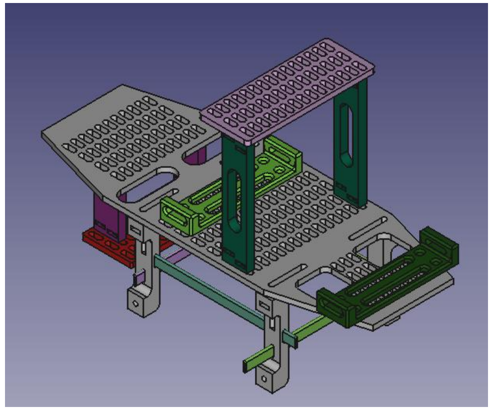
To accommodate a **mobile computer capable (3kg payload)** of running multiple software applications for autonomous operations, we have constructed a VTOL (Vertical Take-Off and Landing) aircraft with a **wingspan of 2.4 meters to support greater payload.**

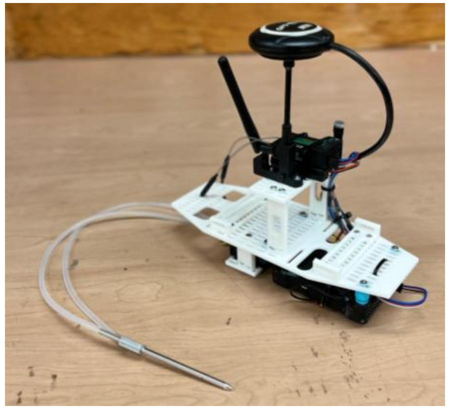


After initial testing that includes **several crashes**, we are **upgrading the vehicle** as follows:

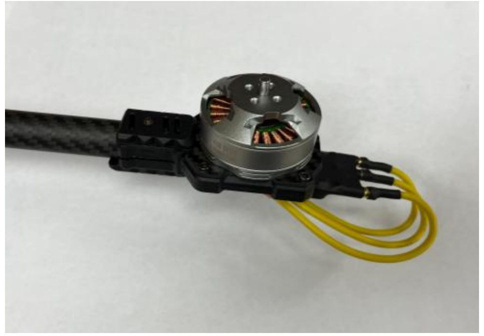
A carbon fiber beam has been added for wing reinforcement to enhance the **stiffness of the frame**.

Avionics carrier is redesigned to improve **space utilization** in the fuselage.

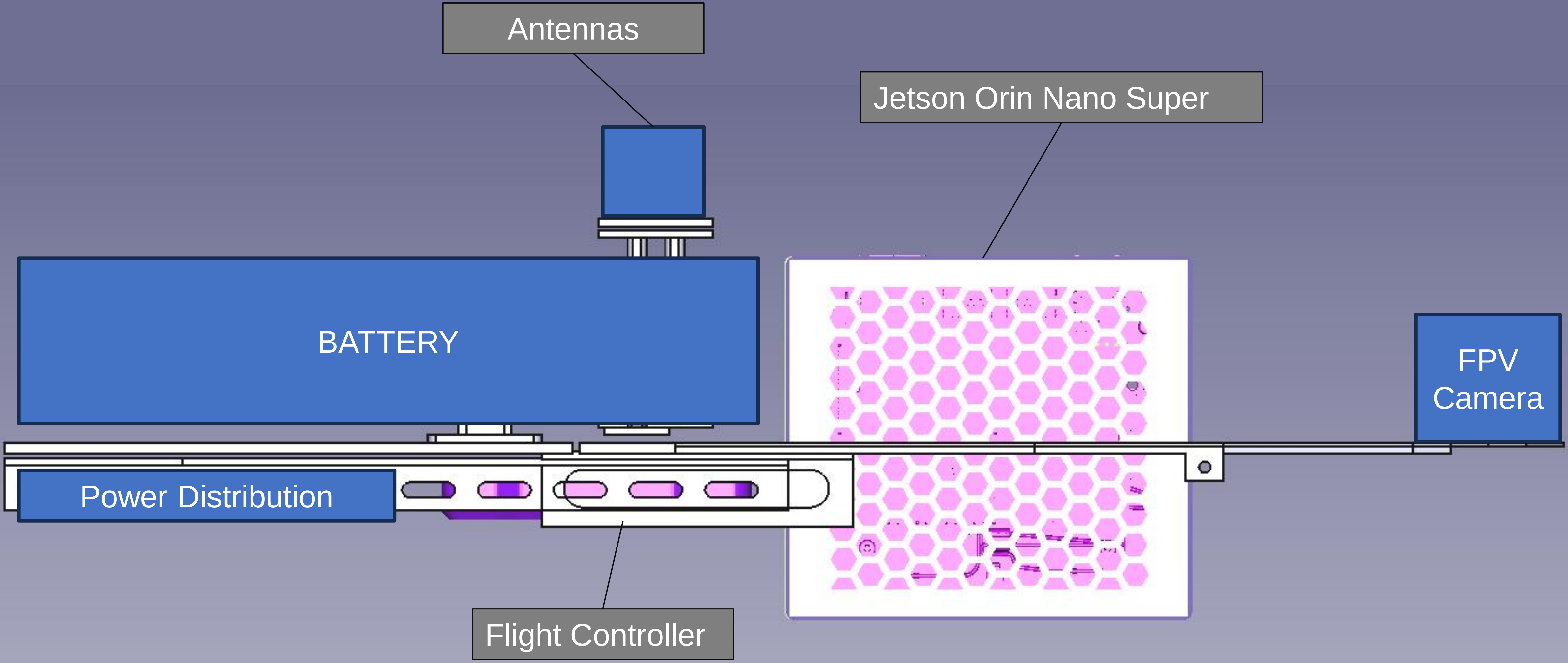




The **propeller, motor, mountings,** and **battery** (upgraded from 4S to **6S**) have been enhanced for improved quality.

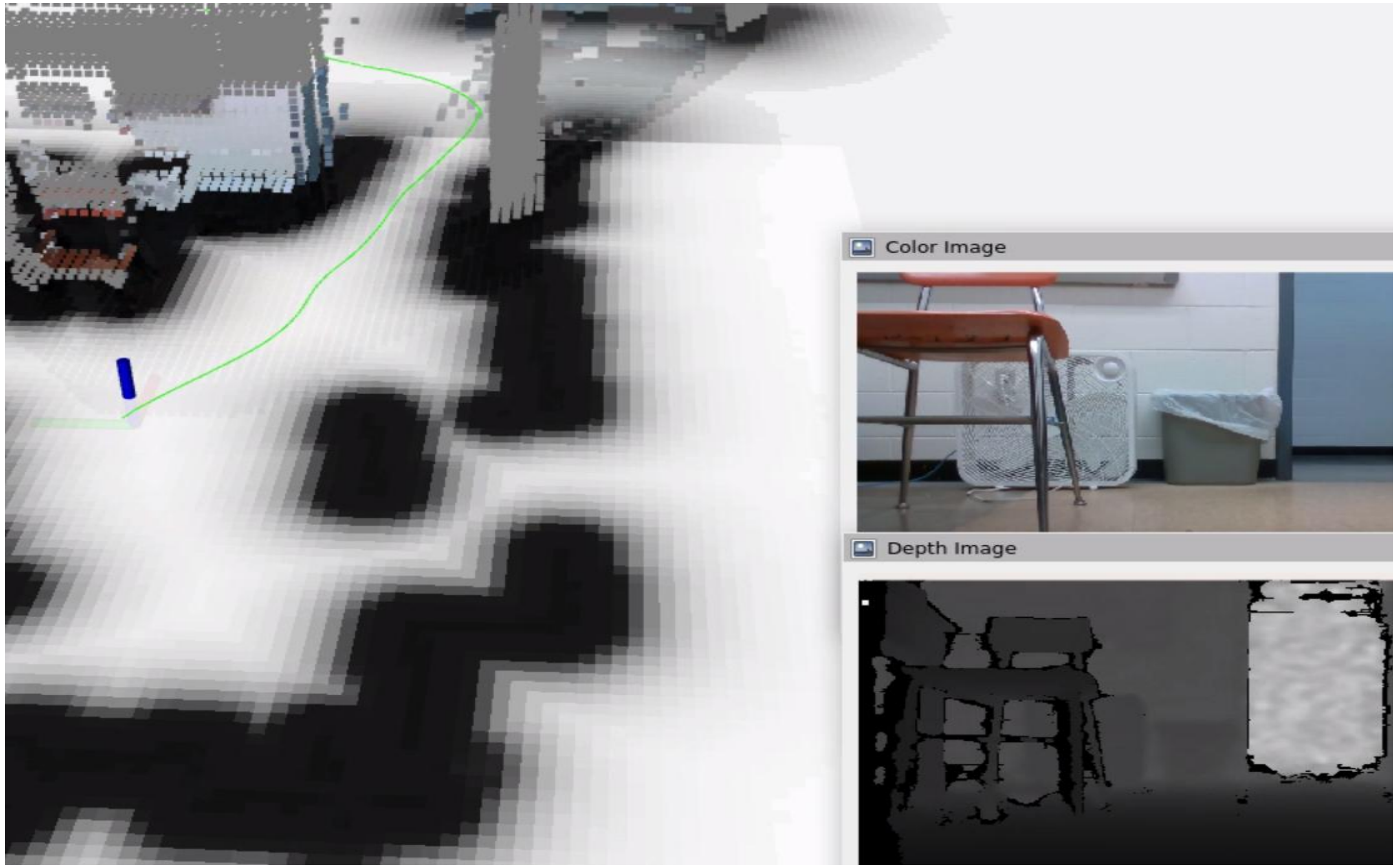


Latest Work: Adding Jetson Orin Nano

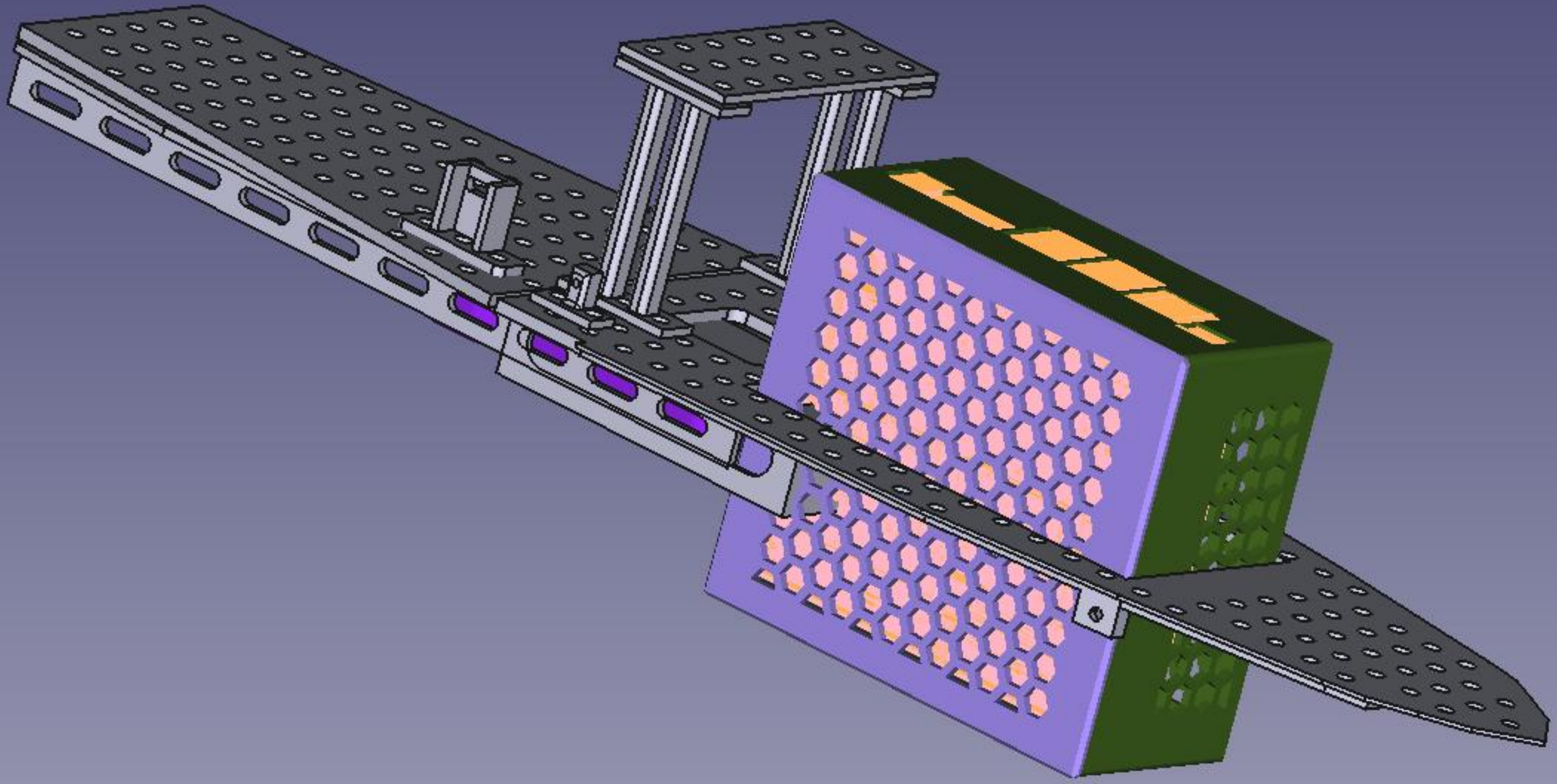


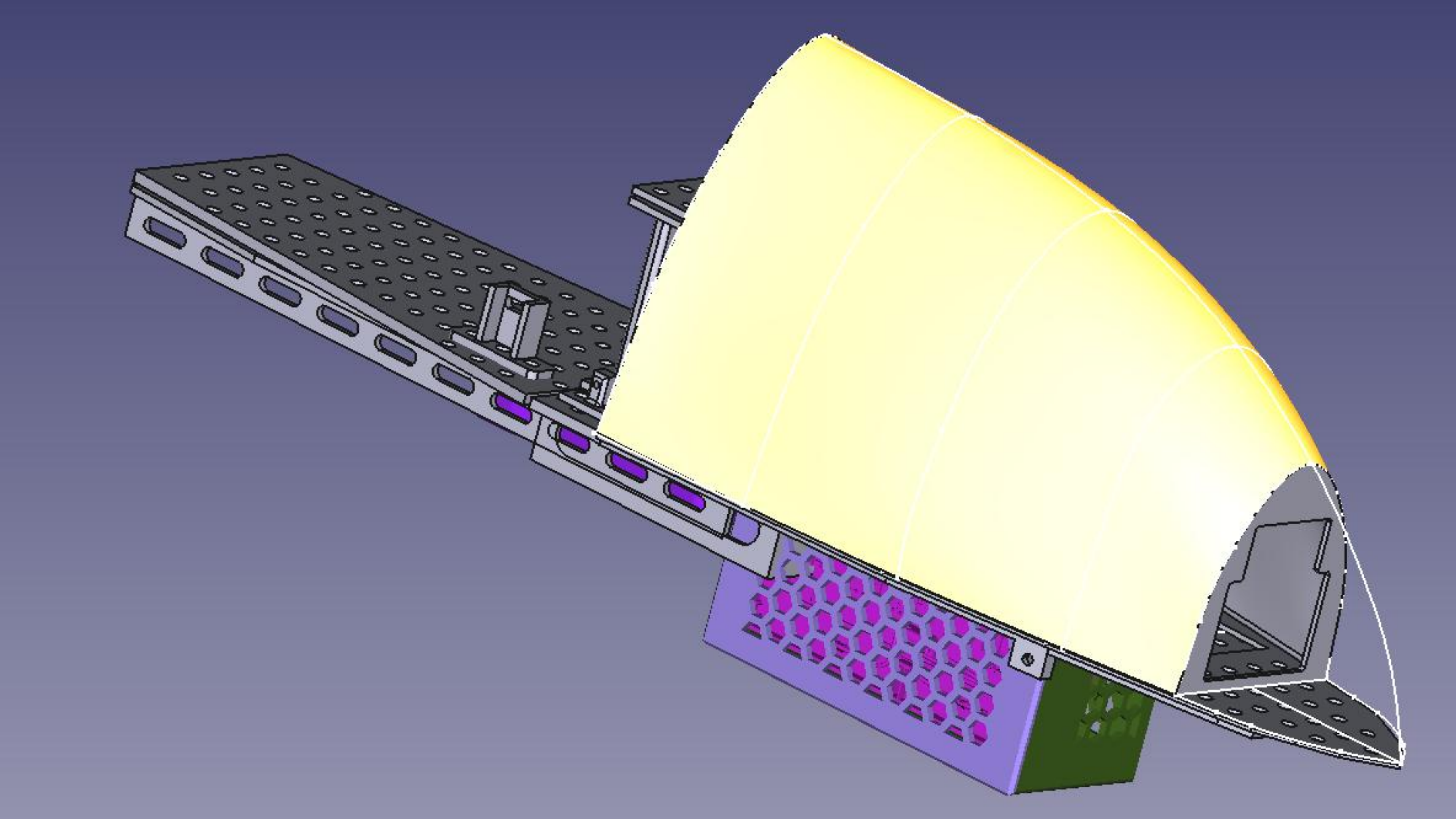
NVIDIA ORIN NANO SUPER – ISAAC ROS – Ground Vehicle

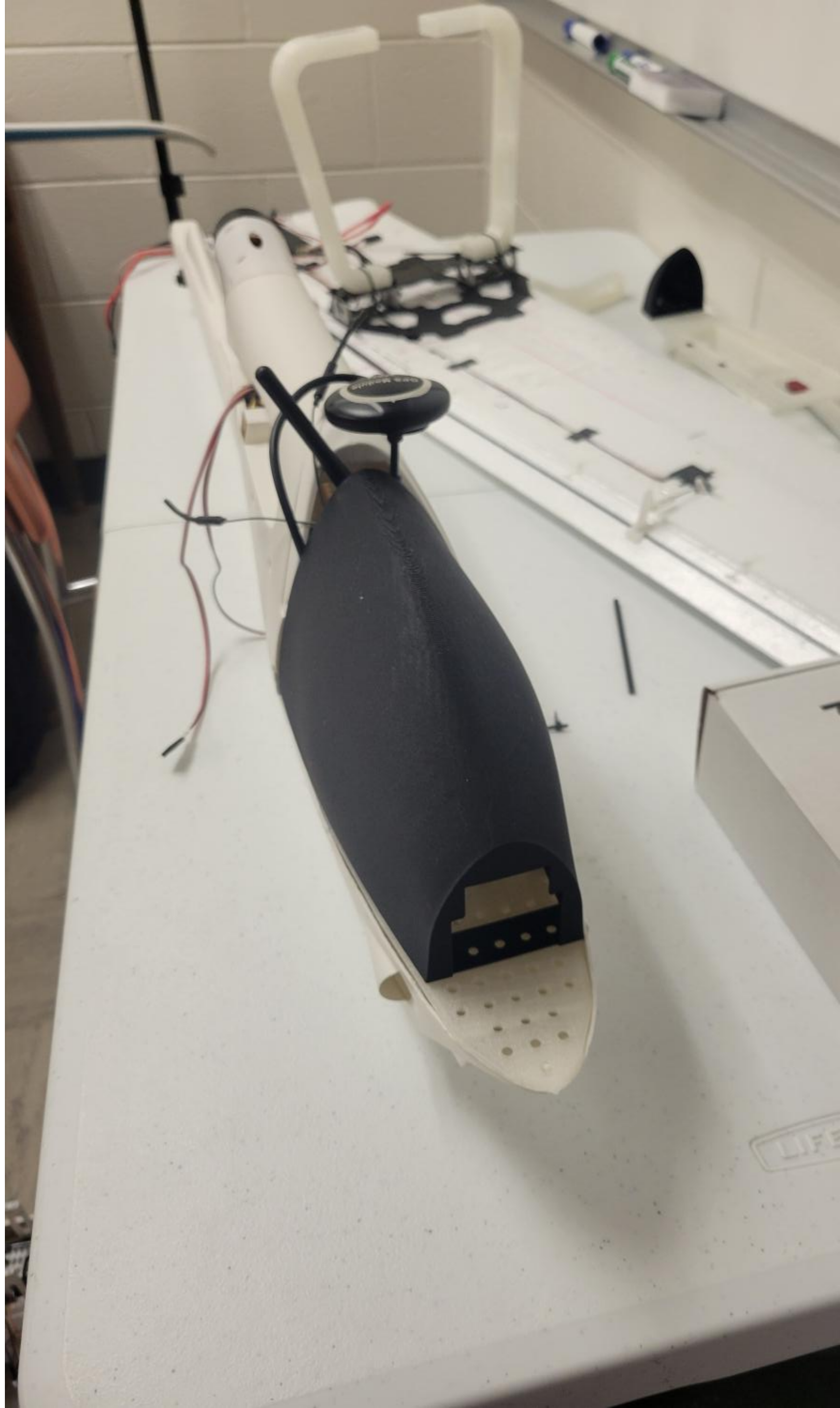
NVIDIA Isaac ROS is a ***GPU-accelerated extension of ROS 2***



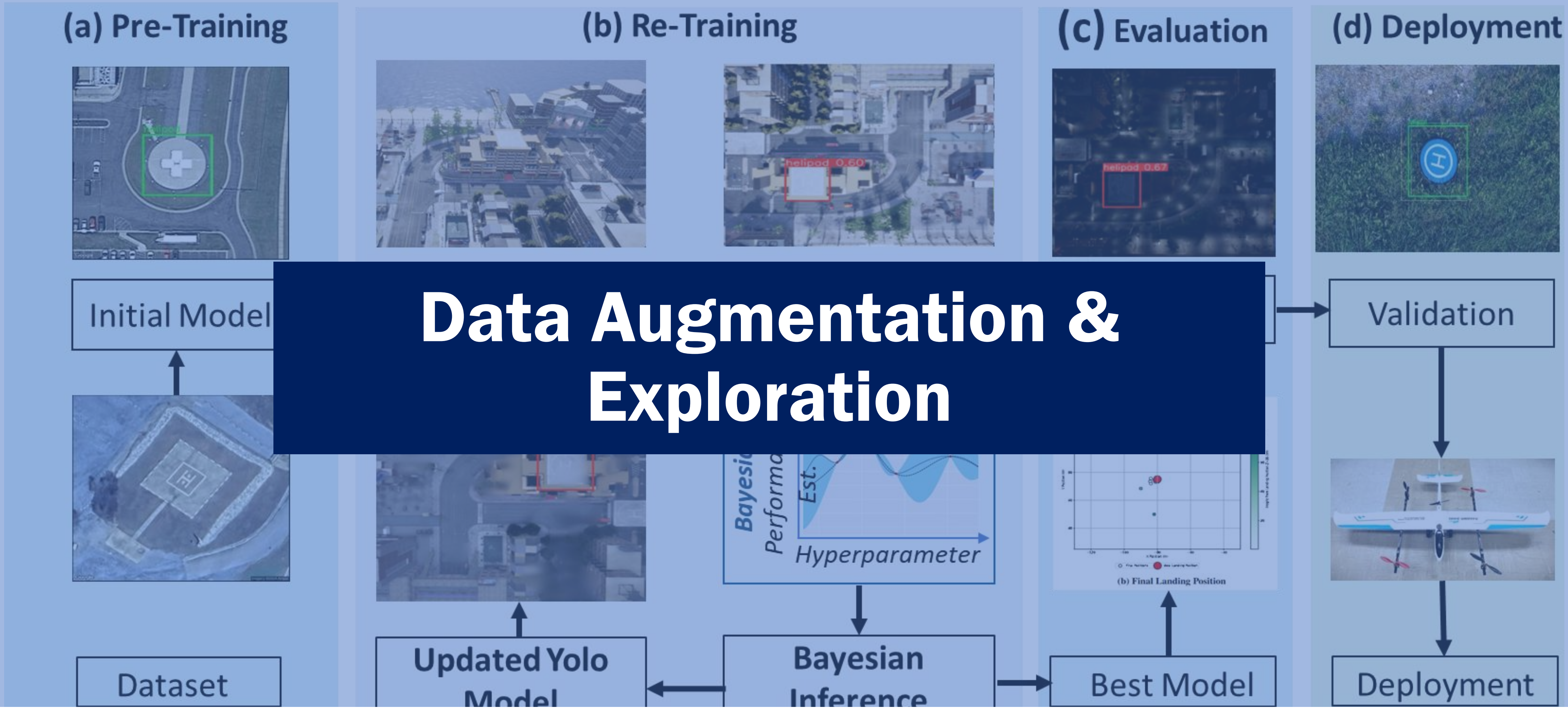
- **Pose and velocity** are estimated via **visual-inertial odometry** from *Realsense* images.
- **NVBlox** builds **3D voxel maps** using *Realsense* point clouds and estimated poses.
- **Nav2** combines **voxel maps** and **2D LiDAR** to form global and local **costmaps**.
- **Global planning** uses a **grid-based** A*-like **algorithm**.
- **Local planning/control** is done with **MPPI** (*Model Predictive Path Integral*) for short-horizon trajectories.







Real-Flight Development in Parallel with ML and Robotics on Orin Nano

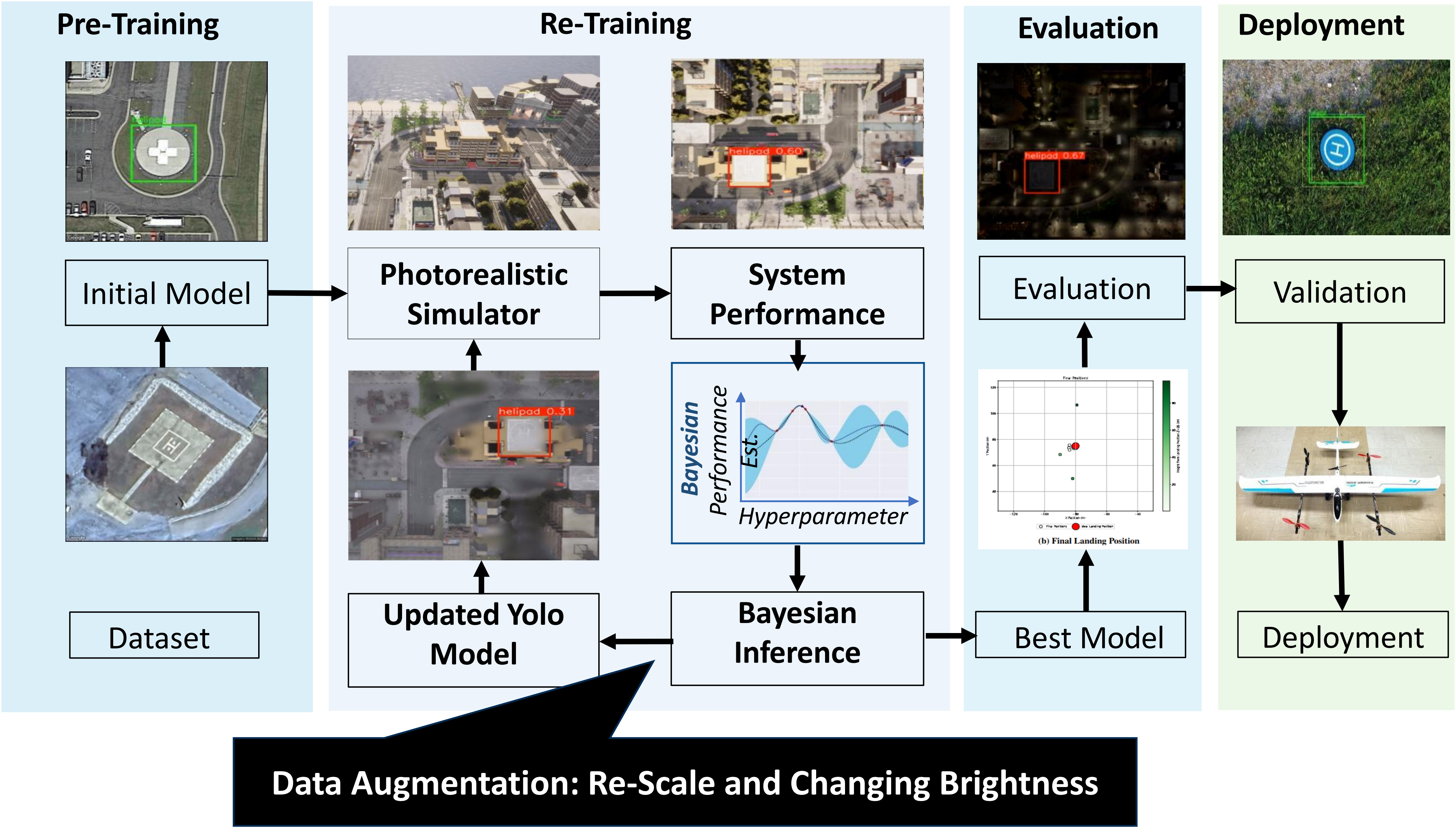


Data Augmentation & Exploration

Rasul, Ashik, Humaira Tasnim, Hyung-Jin Yoon, Ayoosh Bansal, Duo Wang, Naira Hovakimyan, Lui Sha, and Petros Voulgaris. "Bayesian Data Augmentation and Training for Perception DNN in Autonomous Aerial Vehicles." In *AIAA SciTech 2025 Forum*, p. 0933. 2025.

Landings with Random Initial Position and Lighting Condition

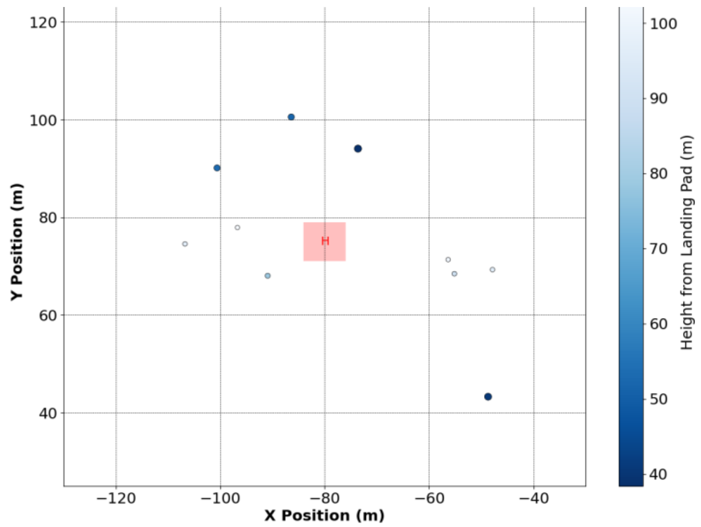
Proposed Framework - Overview



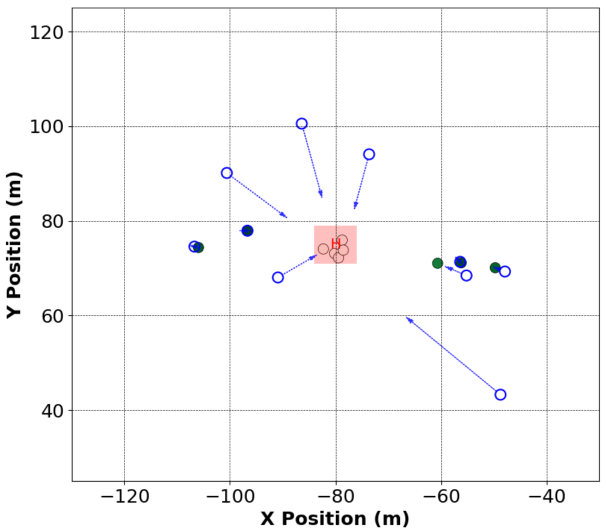
Experiments & Results: Before Optimization

Landing Performance **<u>before Optimization</u>**:

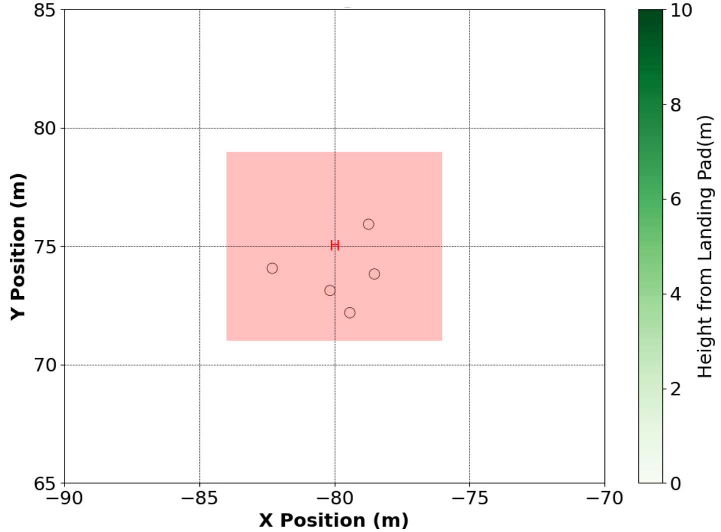
Random Initial Positions



Movement of the VTOL



Zoomed in Helipad

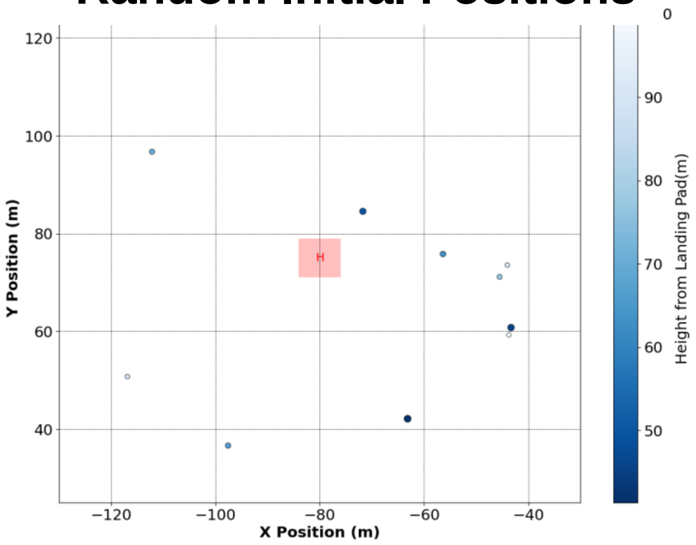


- From **10 initial random coordinates** we recorded landing performance.
- **Successful landing** if the VTOL Reaches **within 4m of Helipad Center in X,Y Plane** and 1m in Z axis.
- **Only 50% Trials could reach the helipad** (Baseline Performance).

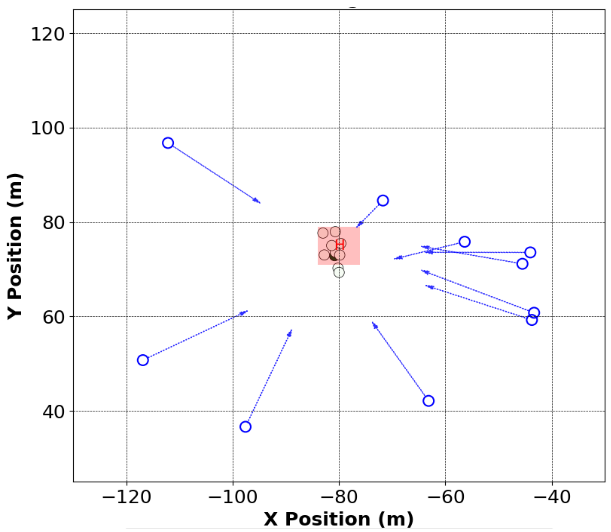
Experiments & Results: After Optimization

Landing Performance **<u>after Optimization</u>**:

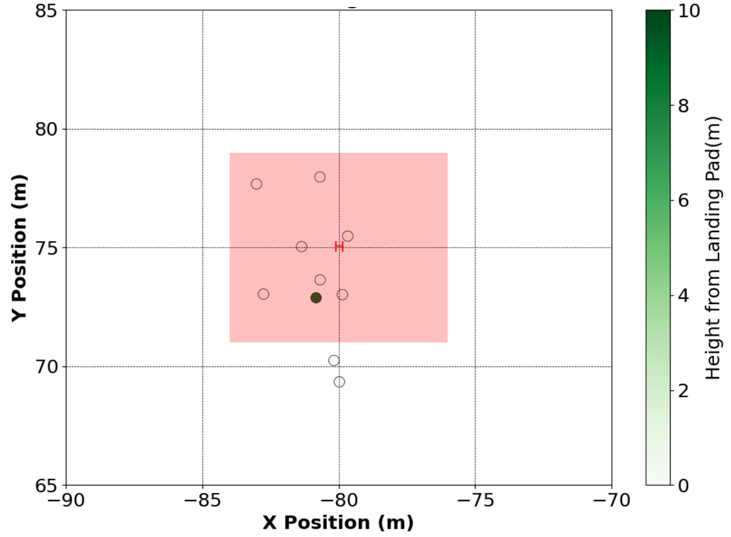
Random Initial Positions



Movement of the VTOL



Zoomed in Helipad



- After optimization we retrained the DNN with best suggested hyperparameter.
- **70% instances, VTOL could reach the helipad**, showing **improvement from the baseline (50% Success Rate)**.

Learning and Control for Autonomous Systems Laboratory (LCASL)

Hyung-Jin Yoon

Humaira Tasnim

- Robotics
- Machine learning
- Bayesian optimization

Ashik E Rasul

- Mobile Robotics- Path Planning
- Machine Learning
- Bayesian optimization

Exchange Students From South Korea

Lim, Young Hyun

Kim, Ji Yu

Developing **VTOL vehicle in Summer 2025**

Thank you (Q&A)