Accelerate Aerial Autonomy with Simulink and Microsoft Project AirSim

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MATLAB EXPO

Agenda

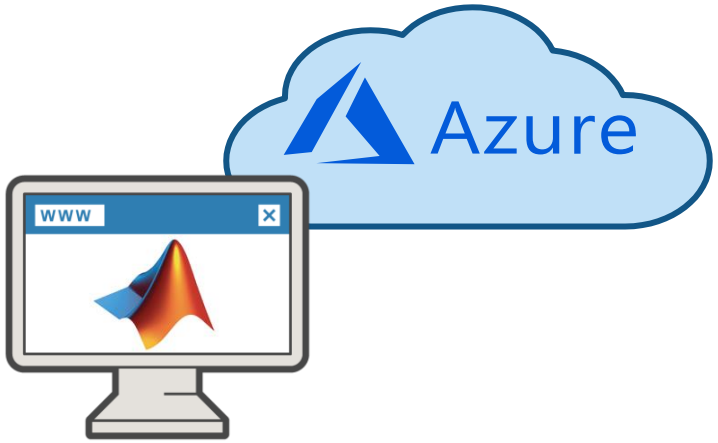
- Microsoft and MathWorks Partnership
- Project AirSim Overview and Use Cases
- Integrating Project AirSim with Simulink
- Workflow Example: Advanced Air Mobility

Microsoft and MathWorks Collaboration

Cloud Computing and Deployment

Deploy and run MATLAB® in Microsoft Azure

- Preconfigured virtual machines for MATLAB
- Supports simultaneous multi-user with MATLAB Production Server
- Scale computations to compute clusters in the cloud



Autonomous System Development

Use Simulink models in high-fidelity simulations

- Integrate Simulink custom aircraft dynamics in autonomous flight simulations
- Support for synchronized simulation
- Generate synthetic sensor data for AI training

Integrated workflows for developing autonomous aerial systems

MATLAB® Simulink®

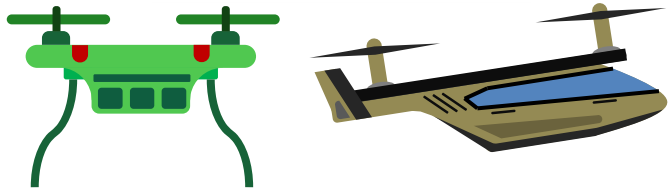
System Architecture

Verification & Validation

87.5%

DO-178

Model System



Design Algorithms

Perception

Planning & Decision

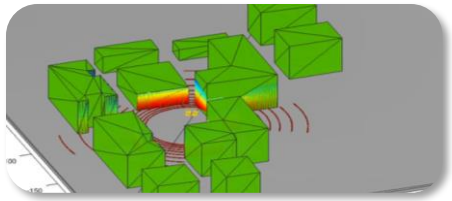
Control

Analyze Data

Implement

Connect

Simulate with Sensor Models



Cuboid

3D Simulator

Deploy to Hardware

PX4®

NVIDIA® Jetson®

Connect

UAV

Ground Control Station

Integrated workflows for developing autonomous aerial systems

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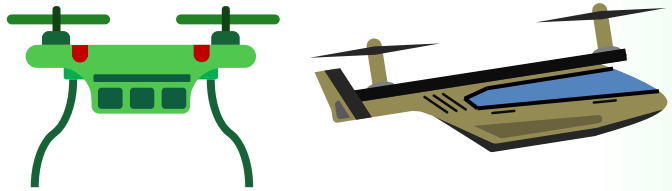


Design Algorithms

Perception

Planning & Decision

Control

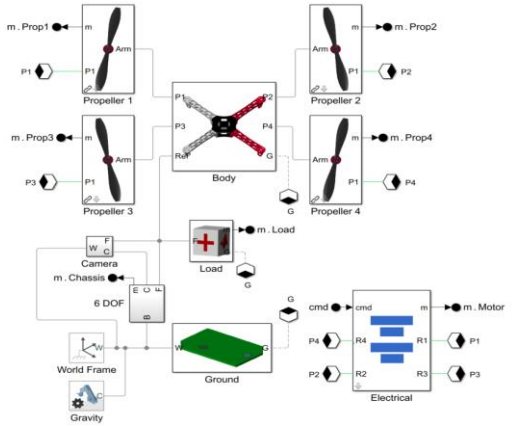
Analyze Data

Vehicle Dynamics + Controls

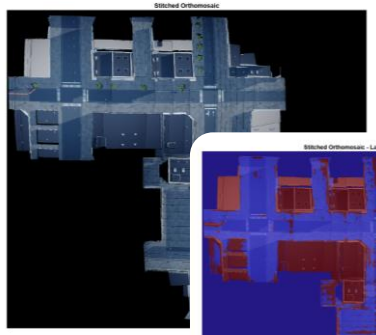
$$\frac{d}{dt}\begin{bmatrix}u\\v\\w\end{bmatrix}_e = \frac{1}{m}\boldsymbol{R}^{E/B}\begin{bmatrix}0\\0\\-T\end{bmatrix} + \begin{bmatrix}0\\0\\g\end{bmatrix} - \boldsymbol{R}^{E/B}\left(\boldsymbol{\omega} \times \begin{bmatrix}u\\v\\w\end{bmatrix}_b\right)$$

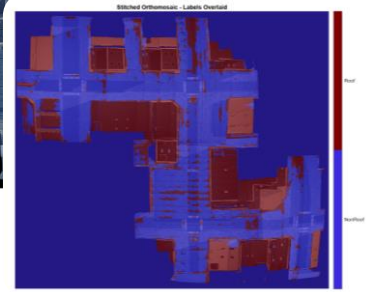
$$\frac{d}{dt}\begin{bmatrix}\phi\\\theta\\\psi\end{bmatrix} = \begin{bmatrix}1 & sin\phi tan\theta & cos\phi tan\theta\\0 & cos\phi & -sin\phi\\0 & sin\phi/cos\theta & cos\phi/cos\theta\end{bmatrix}\begin{bmatrix}P\\Q\\R\end{bmatrix}$$

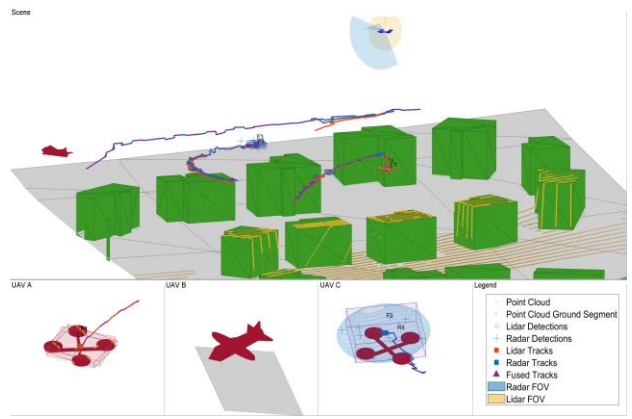
$$\frac{d}{dt}\begin{bmatrix}P\\Q\\R\end{bmatrix} = \boldsymbol{J}^{-1}\left(\begin{bmatrix}\tau_{roll}\\\tau_{pitch}\\\tau_{yaw}\end{bmatrix} - \boldsymbol{\omega} \times (\boldsymbol{J}\boldsymbol{\omega})\right)$$



Autonomous Algorithms

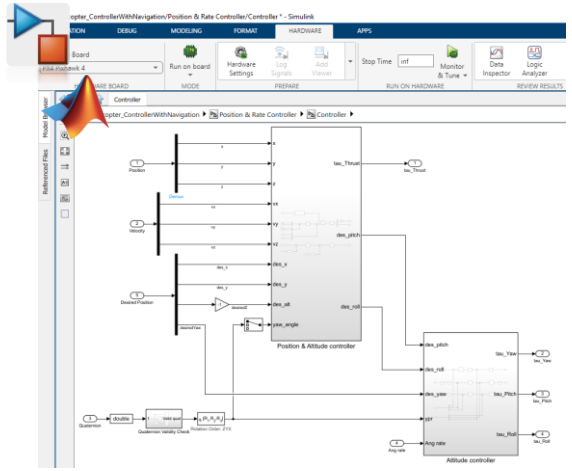




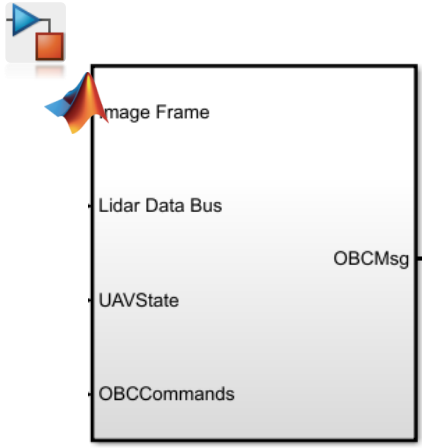


Integrated workflows for developing autonomous aerial systems

Flight Controller

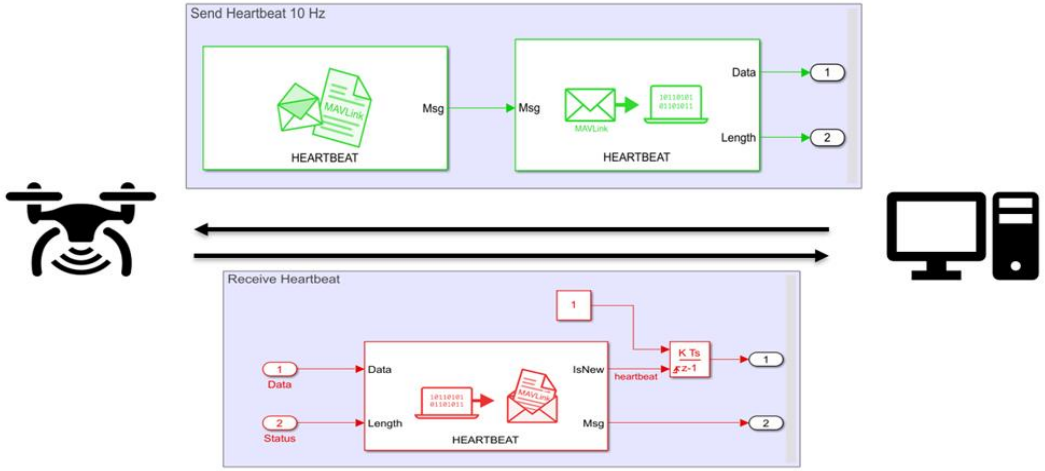


Onboard Autonomy



Obstacle Avoidance

MAVLink Connectivity



Verification & Validation

Simulate with Sensor Models

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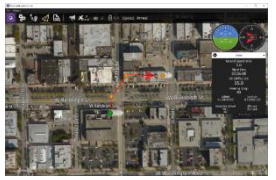
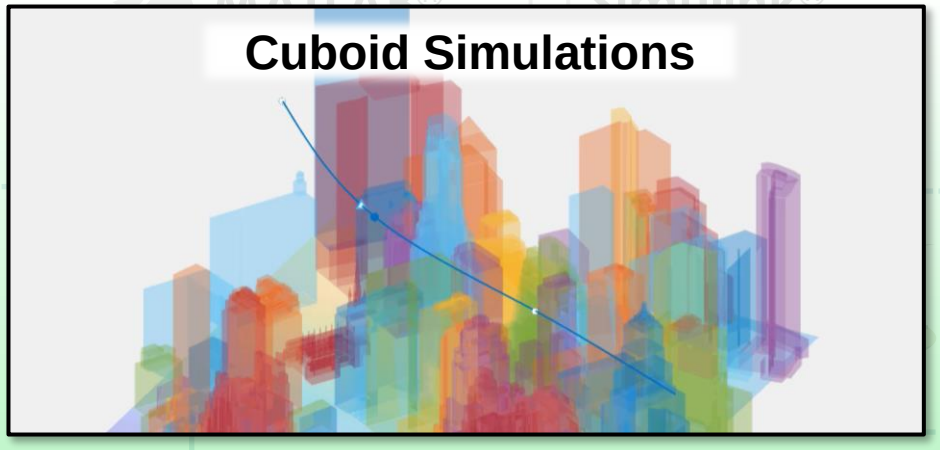
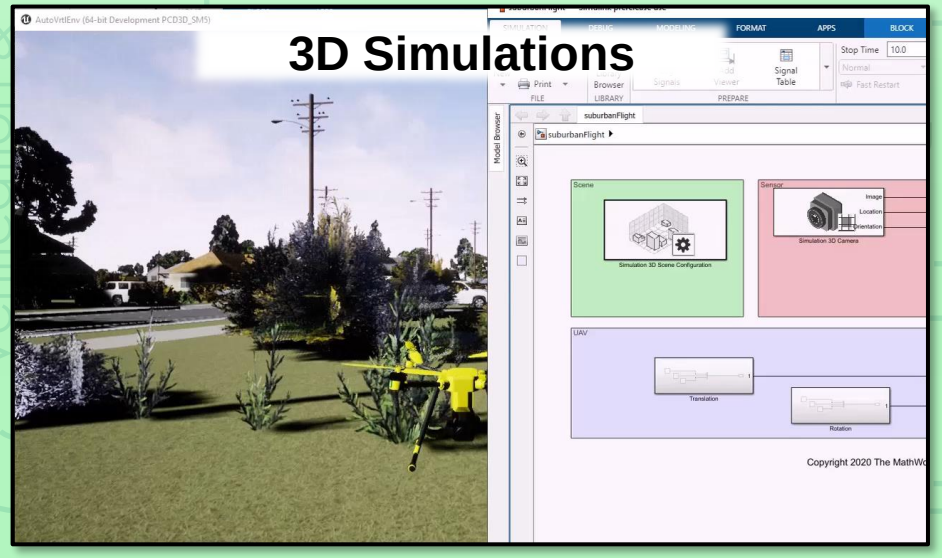


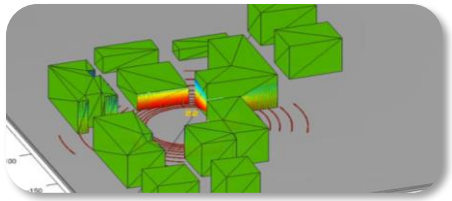
Ground Control Station

Integrated workflows for developing autonomous aerial systems



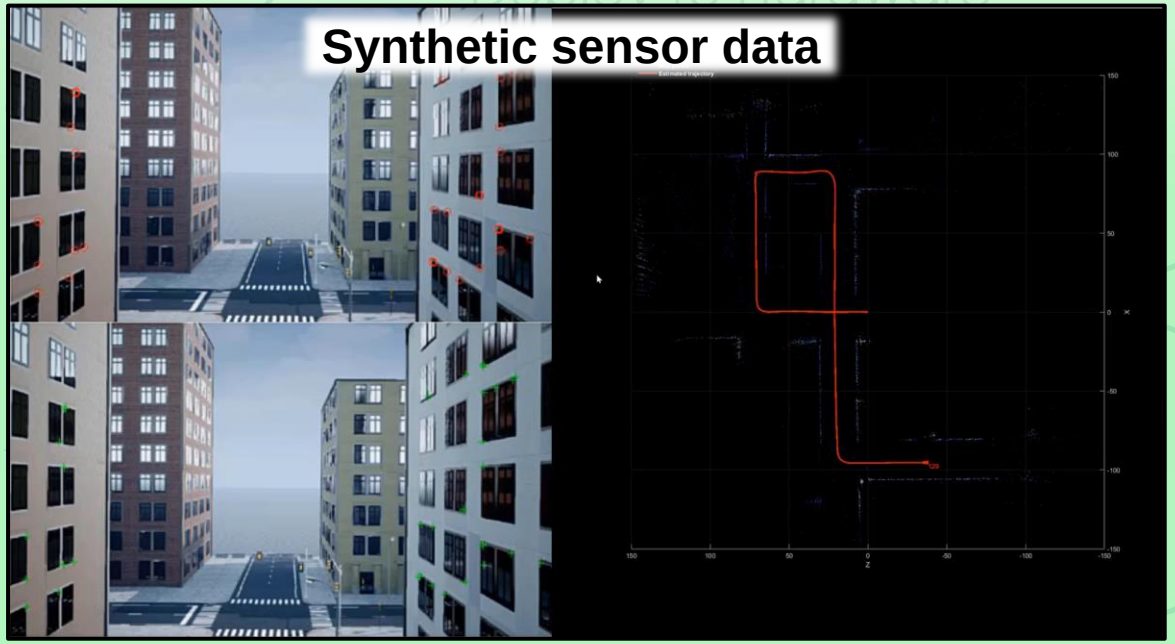


Simulate with Sensor Models



Cuboid

3D Simulator

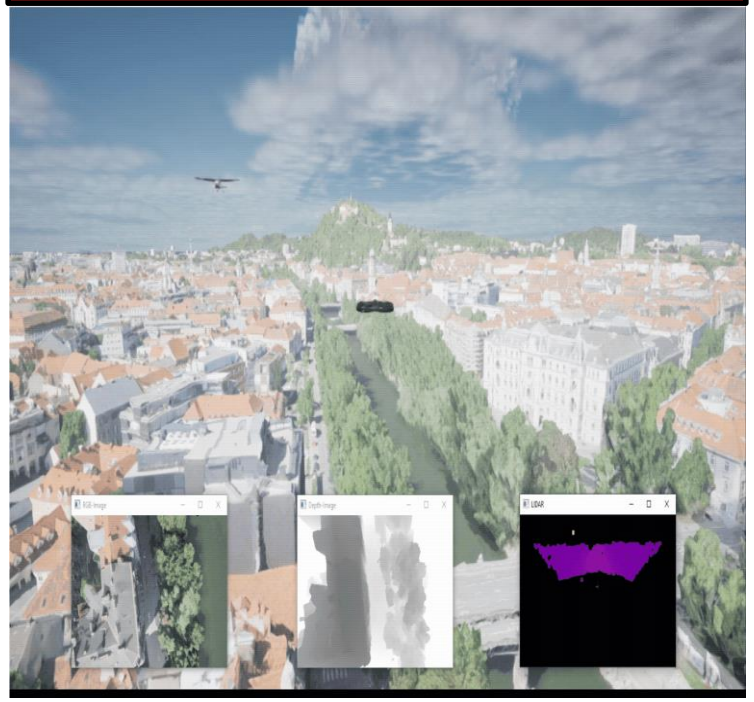


Project AirSim Overview

End-to-end platform for safely creating, training, and validating autonomous agents

AI-first Sim Engine

Accurately simulate agents and sensors in a repeatable and extensible manner

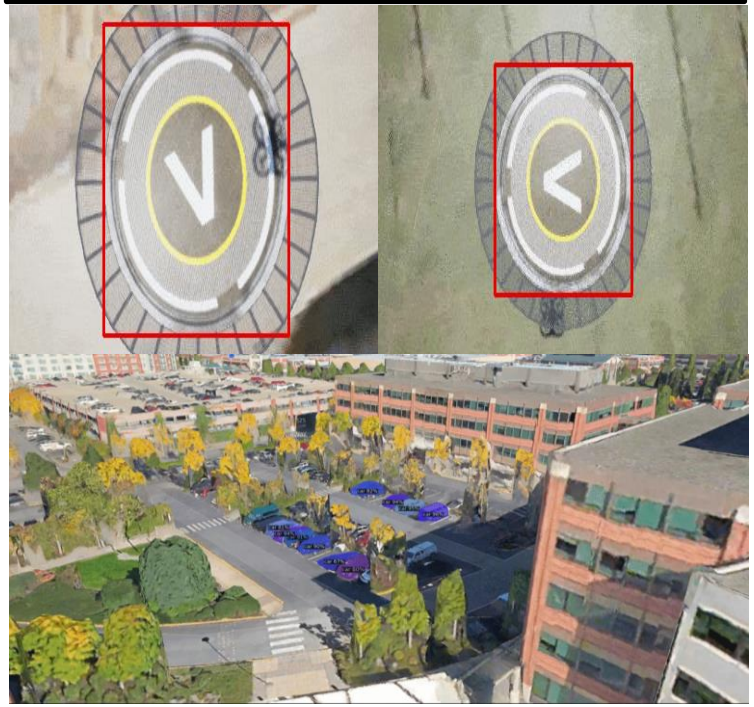


Synthetics Datagen

Capture, store and process AI data from synthetic worlds at extreme scale

Foundational AI Blocks

Accelerate autonomy with MLOps and pre-trained AI Models



Project AirSim Use Cases

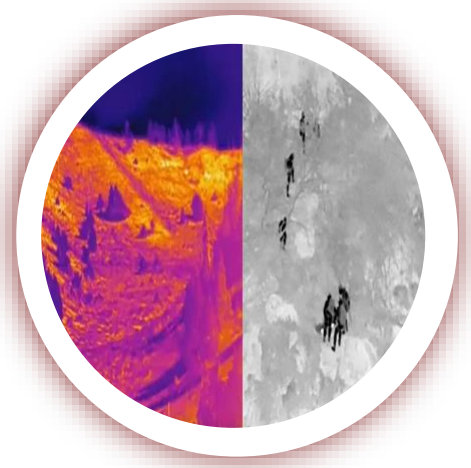
Infrastructure

Last Mile Delivery,
Logistics

Mobility,
Air Taxi

ISTAR

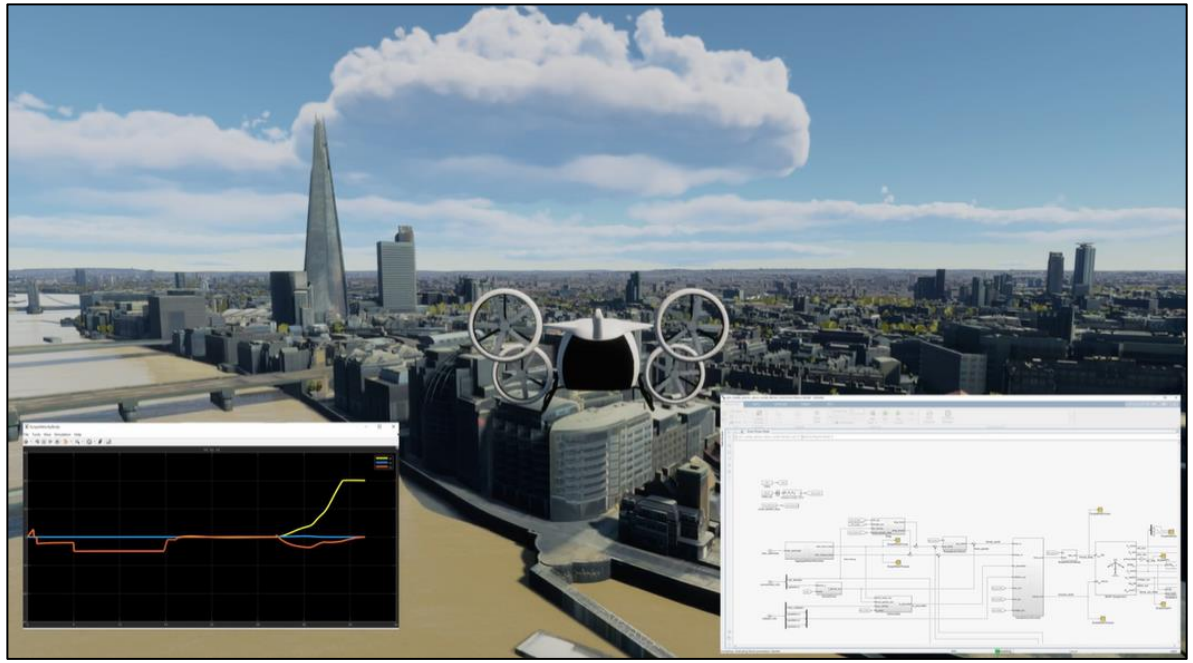
Multi-Agent Drones



Search & Rescue

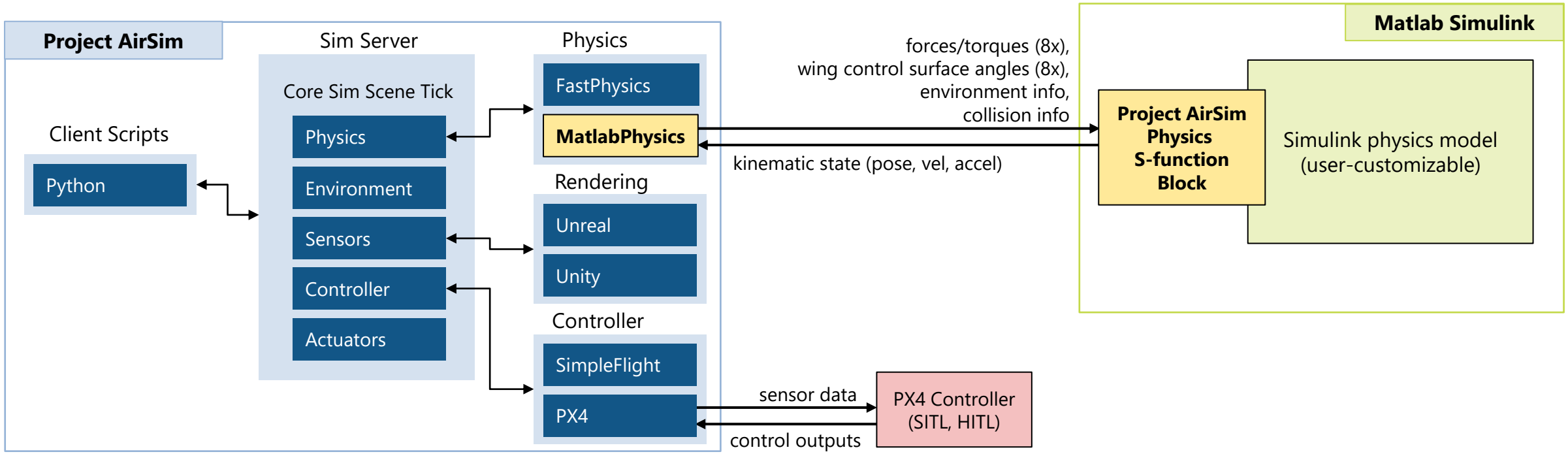
Value of Integrating Simulink and Project AirSim

- Combine the best of both worlds:
  - Simulink brings a deep ecosystem of robust tools for developing control systems and physics models in Model-Based Development workflows
  - Project AirSim brings 3D world rendering and sensor simulation in an easy-to-use autonomous aerial simulation platform, with Bing Maps GIS data and scaling on the Azure cloud
- Leverage aerial multirotor and VTOL dynamics plant models that users are already developing in Simulink, integrated through lock-step co-simulation with Project AirSim.

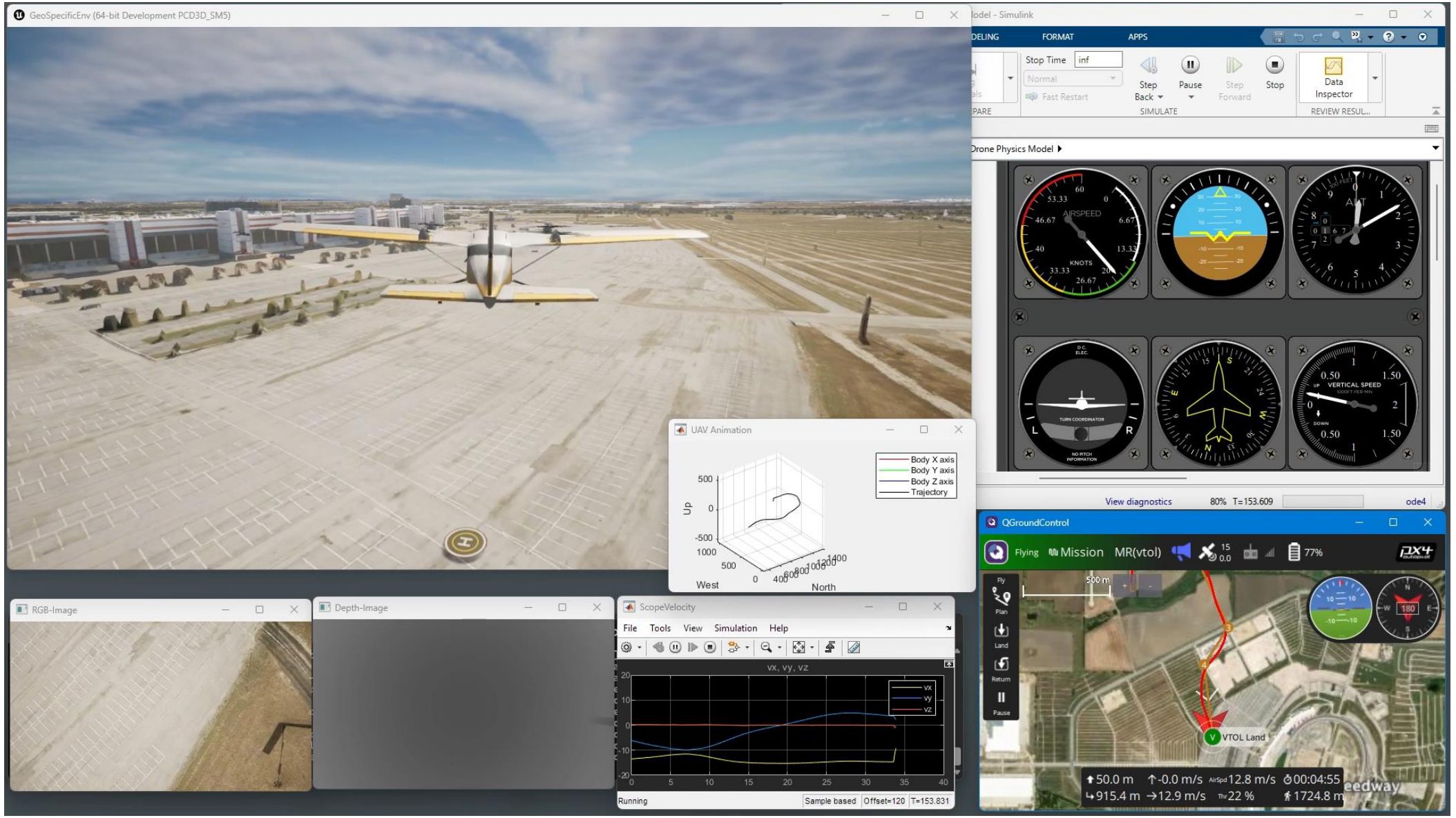


Architecture of Integrating Simulink and Project AirSim

- Initial integration is an **S-function interface to pass physics data** between Project AirSim and Simulink at every time step to allow using a user-customizable Simulink dynamics model instead of the built-in simple FastPhysics model.
- The physics interface data is passed over a request-response TCP connection which can be local or remote, on either Windows or Linux.



Workflow Example: Advanced Air Mobility



Summary

- Microsoft and MathWorks continue to develop the partnership with collaboration in the aerial autonomous systems development space

- Integrating Project AirSim and the Simulink ecosystem can help accelerate aerial autonomy by combining the best of both worlds and enabling new customer workflows

- Additional Integration Opportunities:
  - **Expanding the S-function interface** to other areas (controllers, sensors, actuators, etc)
  - Scaling the integration for containerized **Azure cloud workloads**
  - Developing **custom PX4 controller code** using the MathWorks PX4 toolchain to simulate in Project AirSim
  - Leveraging the **ROS ecosystem** through Project AirSim's ROS bridge and Simulink's ROS support to enable another path for passing data

Accelerate Your Aerial Autonomy Development with Simulink and Microsoft Project AirSim

- Learn more about Microsoft Project AirSim
  - aka.ms/airsim
- Discover more about aerial system development
  - mathworks.com/robotics/uav.html

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Thank you

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