

MATLAB EXPO

利用软件在环（SIL）和硬件在环（HIL） workflow 仿真并部署无人机应用

杨超, MathWorks 中国区高级应用工程师



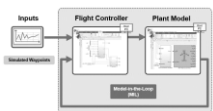
议程



概述



PX4 与 Simulink 的集成



MIL, SIL 和 HIL 工作流



场景仿真



HIL 实现场景仿真



总结与学习资源

驾驶无人机穿越城市街区

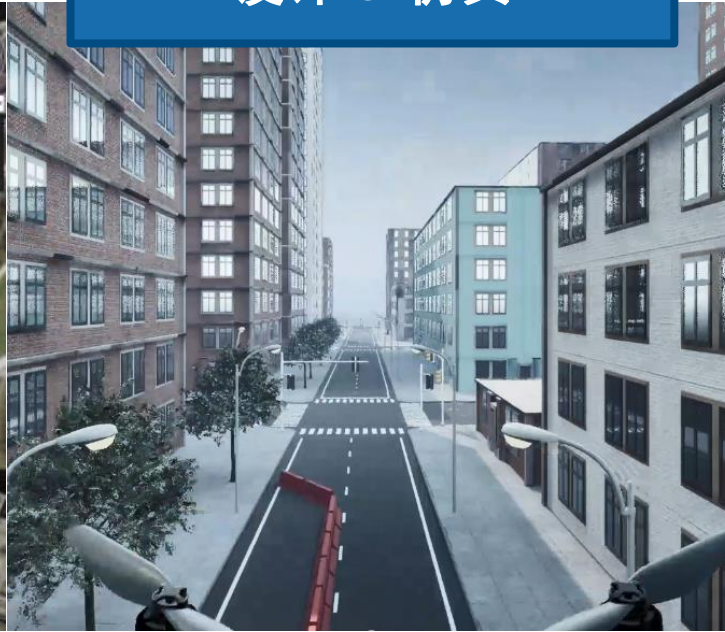


在虚拟场景中进行仿真

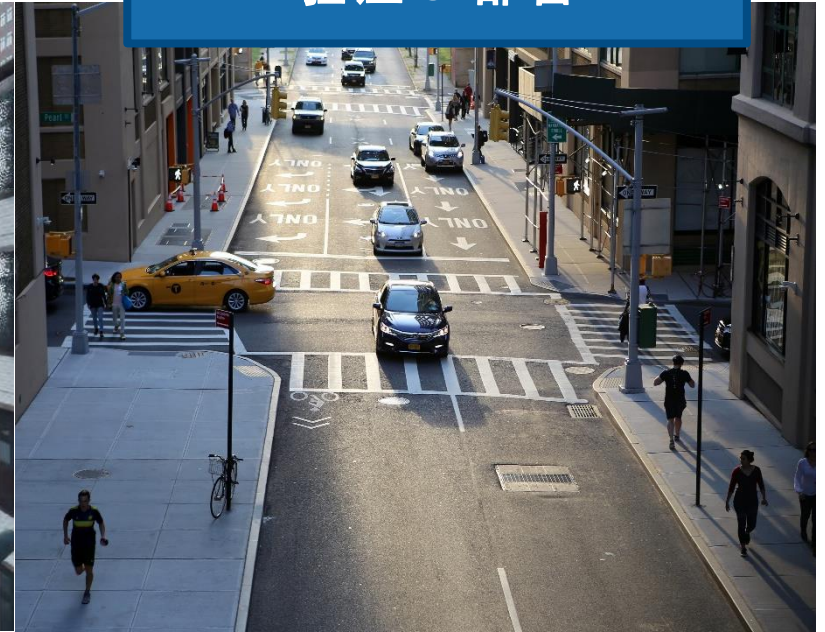
任务规划



设计 & 仿真



验证 & 部署



为无人机仿真构建模块

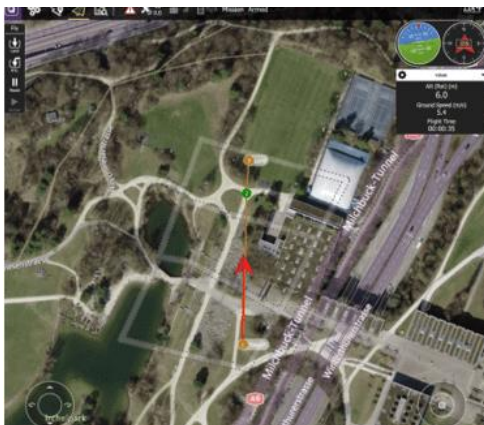
任务规划

为任务生成飞行路径

模拟的航路点



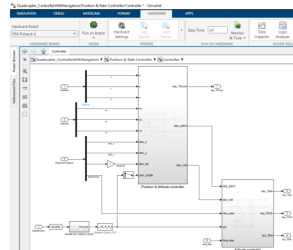
地面控制站



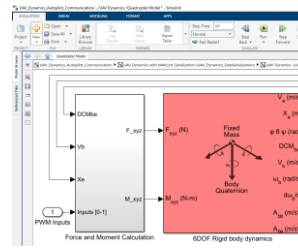
设计 & 仿真

设计飞行控制器并在虚拟场景中仿真被控对象行为

飞行控制器



被控对象模型

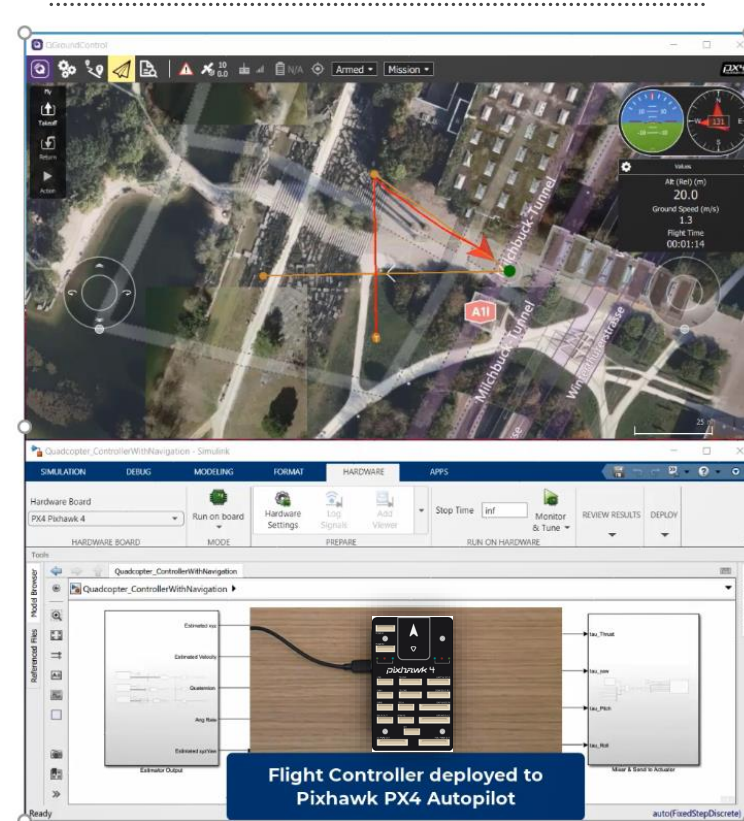


场景仿真

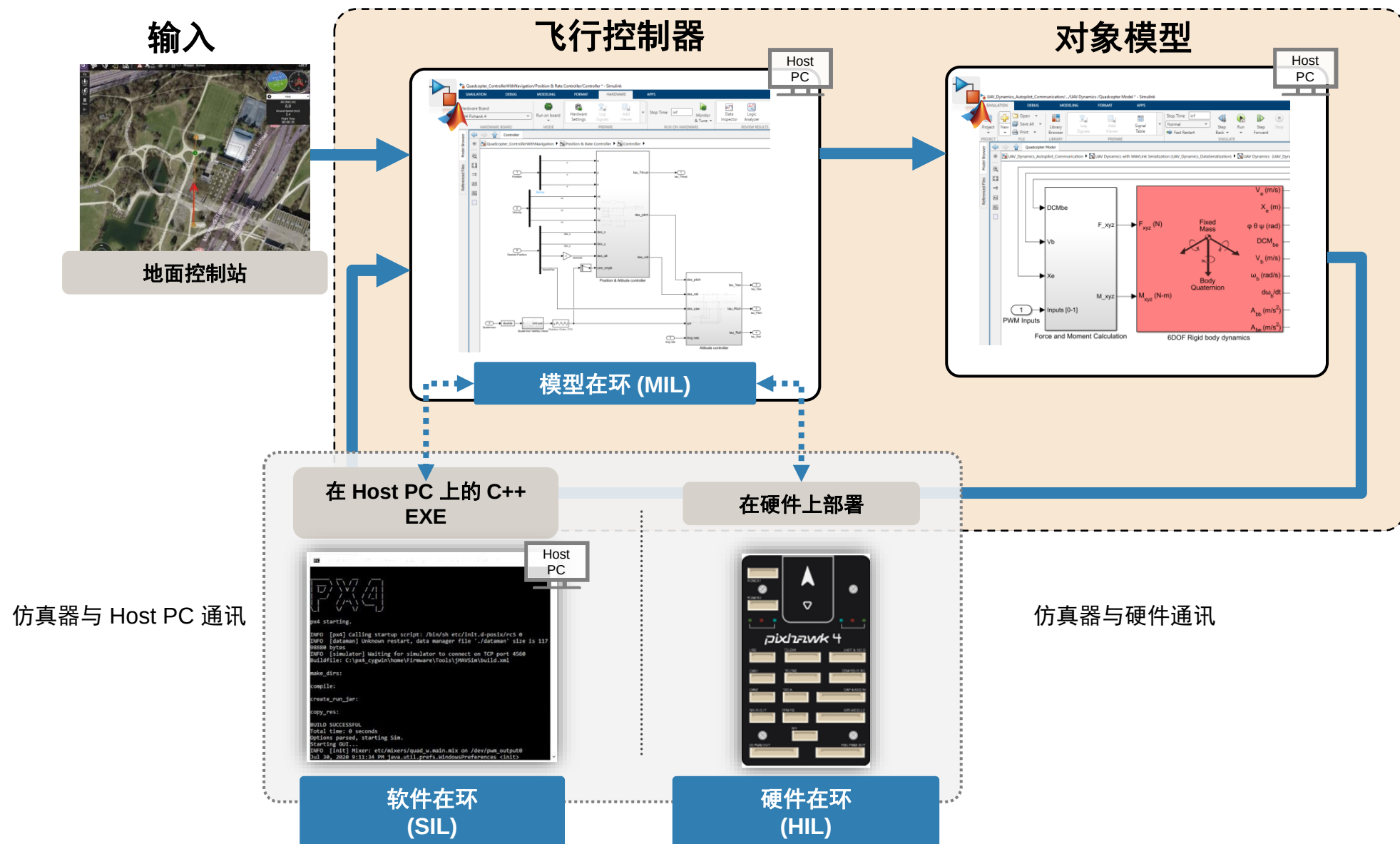


验证 & 部署

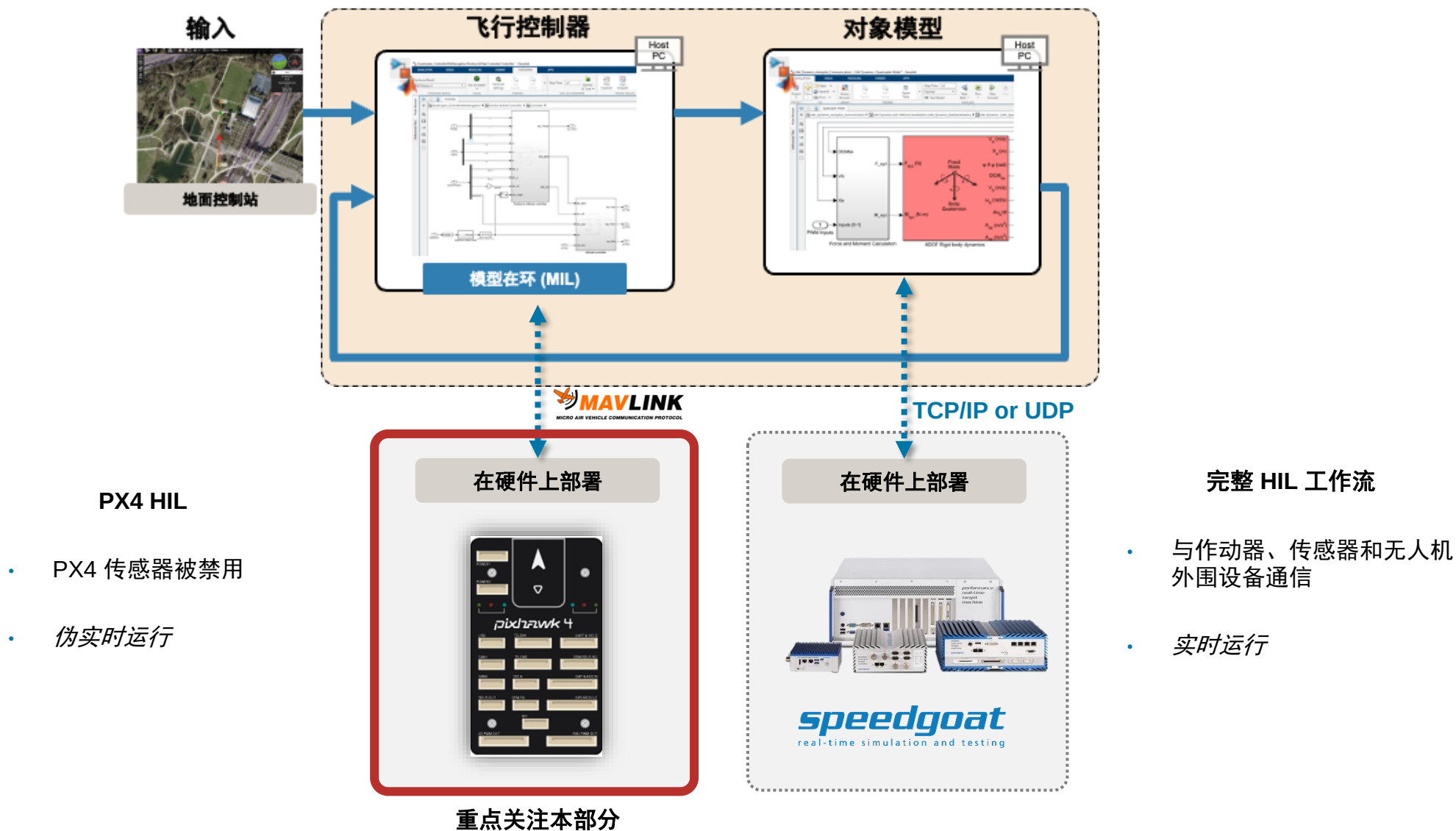
将飞行控制器和自主算法部署到硬件平台



无人机仿真的 MIL, SIL 和 HIL 工作流



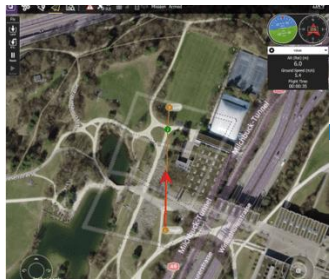
利用 PX4 上部署的飞行控制器实现 HIL





利用无人机仿真 workflow 设计自主算法

输入



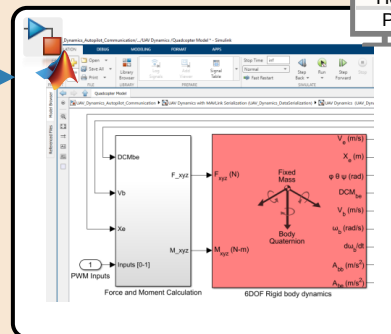
地面控制站

飞行控制器



Host PC

对象模型



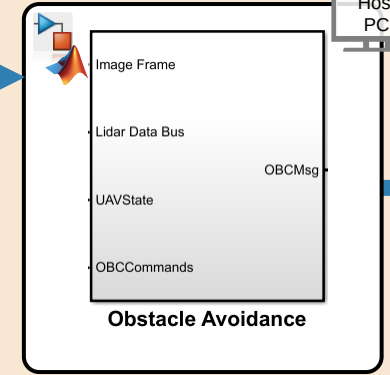
Host PC

场景仿真



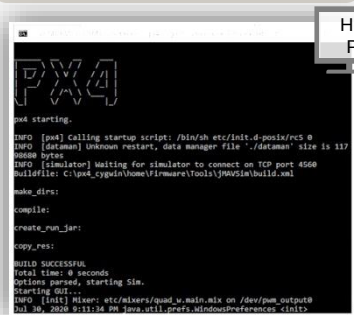
Host PC

机载自主系统



Host PC

在 Host PC 上的 C++
EXE



Host PC

Software-in-the-Loop

在硬件上部署



Hardware-in-the-Loop

在硬件上部署



NVIDIA® Jetson™

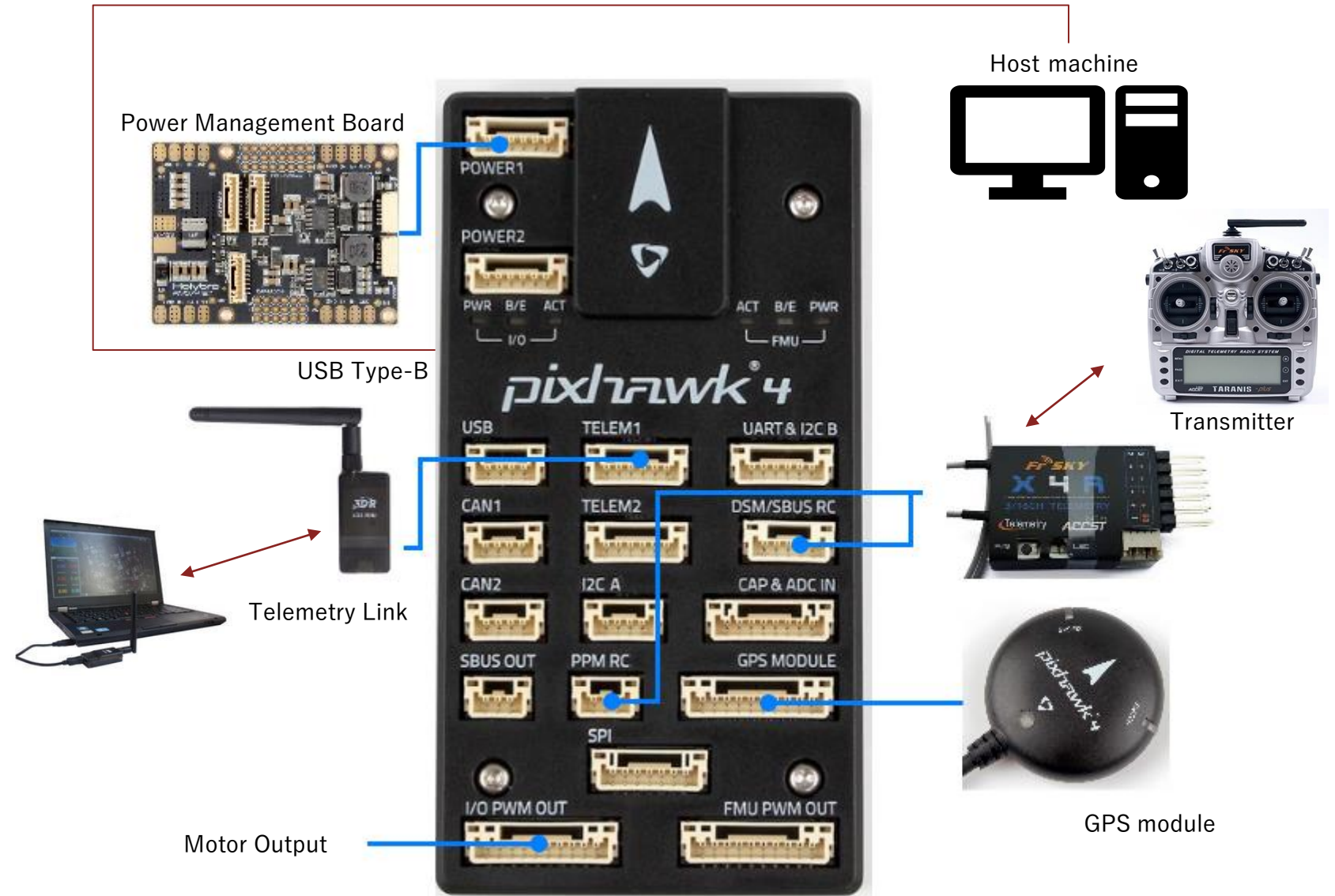
Pixhawk® 概述

On-board sensors:

- Accel/Gyro: ICM-20689
- Accel/Gyro: BMI055 or ICM20602
- Magnetometer: IST8310
- Barometer: MS5611

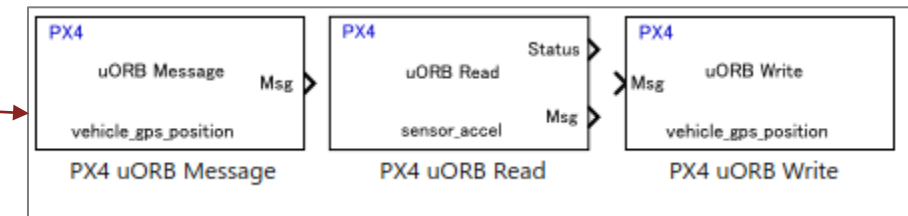
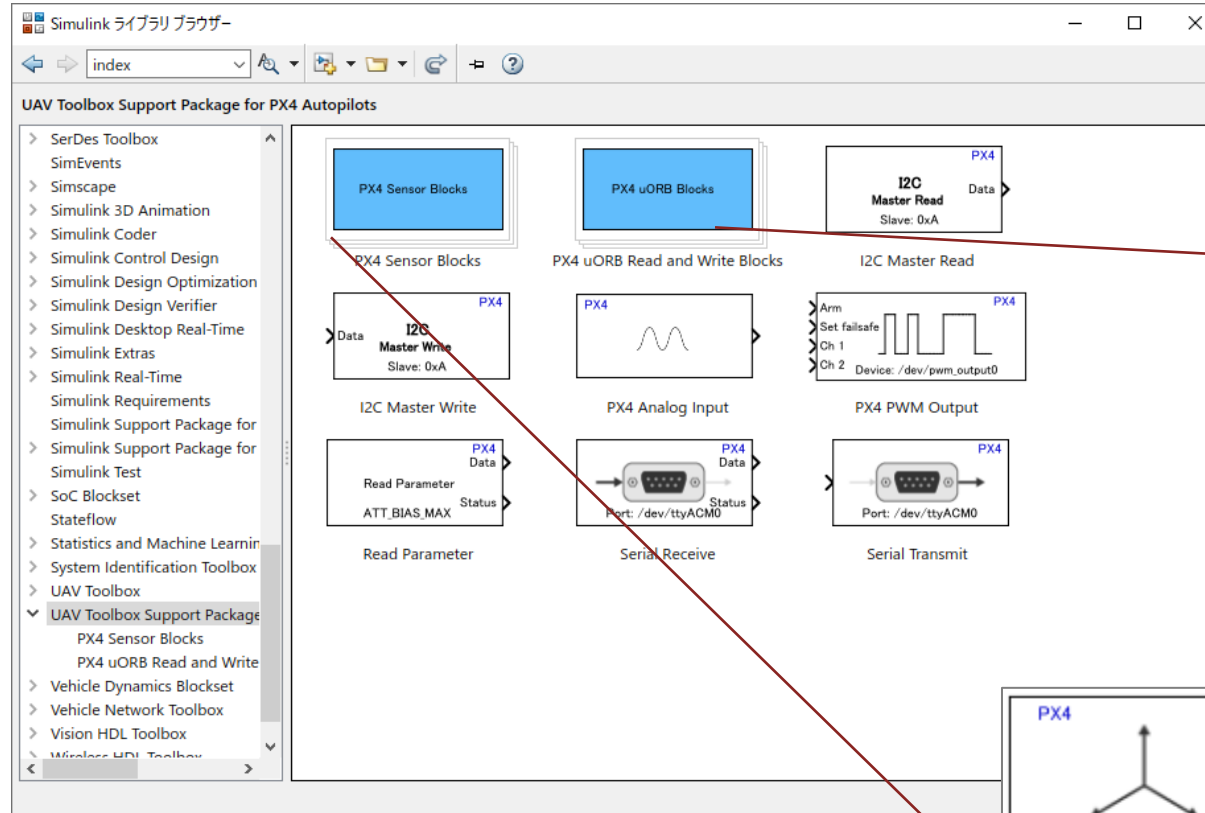
Interfaces:

- 8-16 PWM outputs
- 3 dedicated PWM
- Dedicated R/C
- 5 serial ports
- 3 I2C ports
- 4 SPI buses
- 2 CANBuses

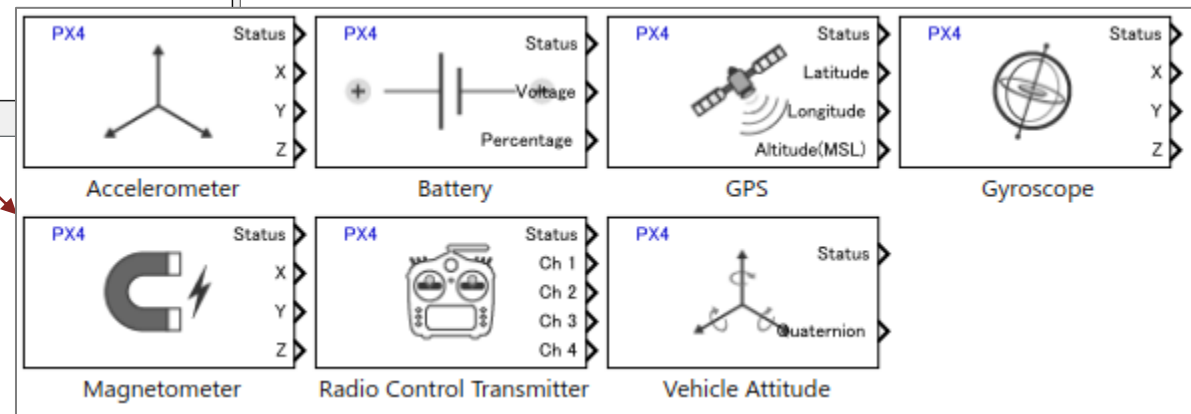


UAV Toolbox Support Package for PX4 Autopilots

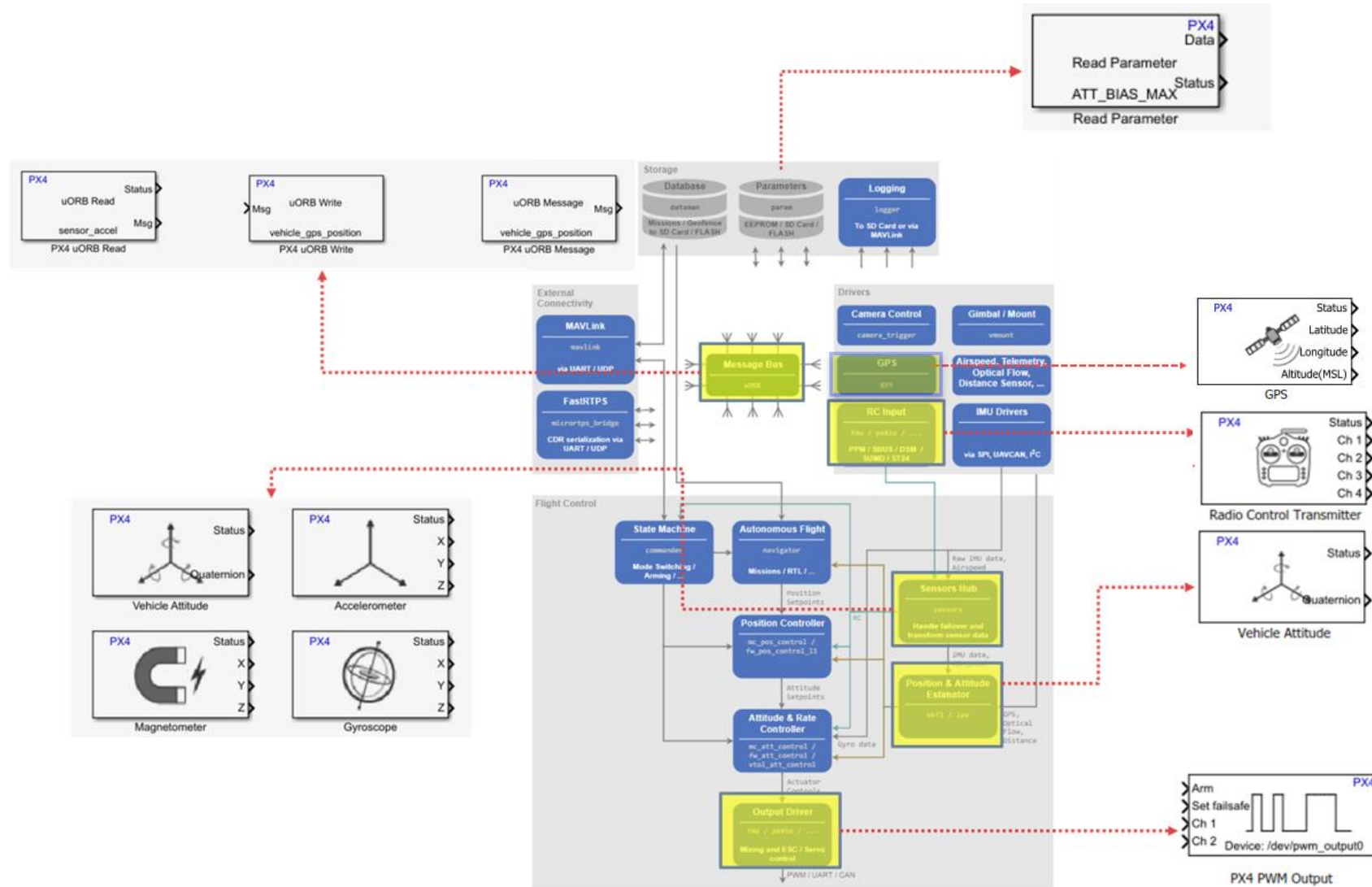
Simulink Block Library



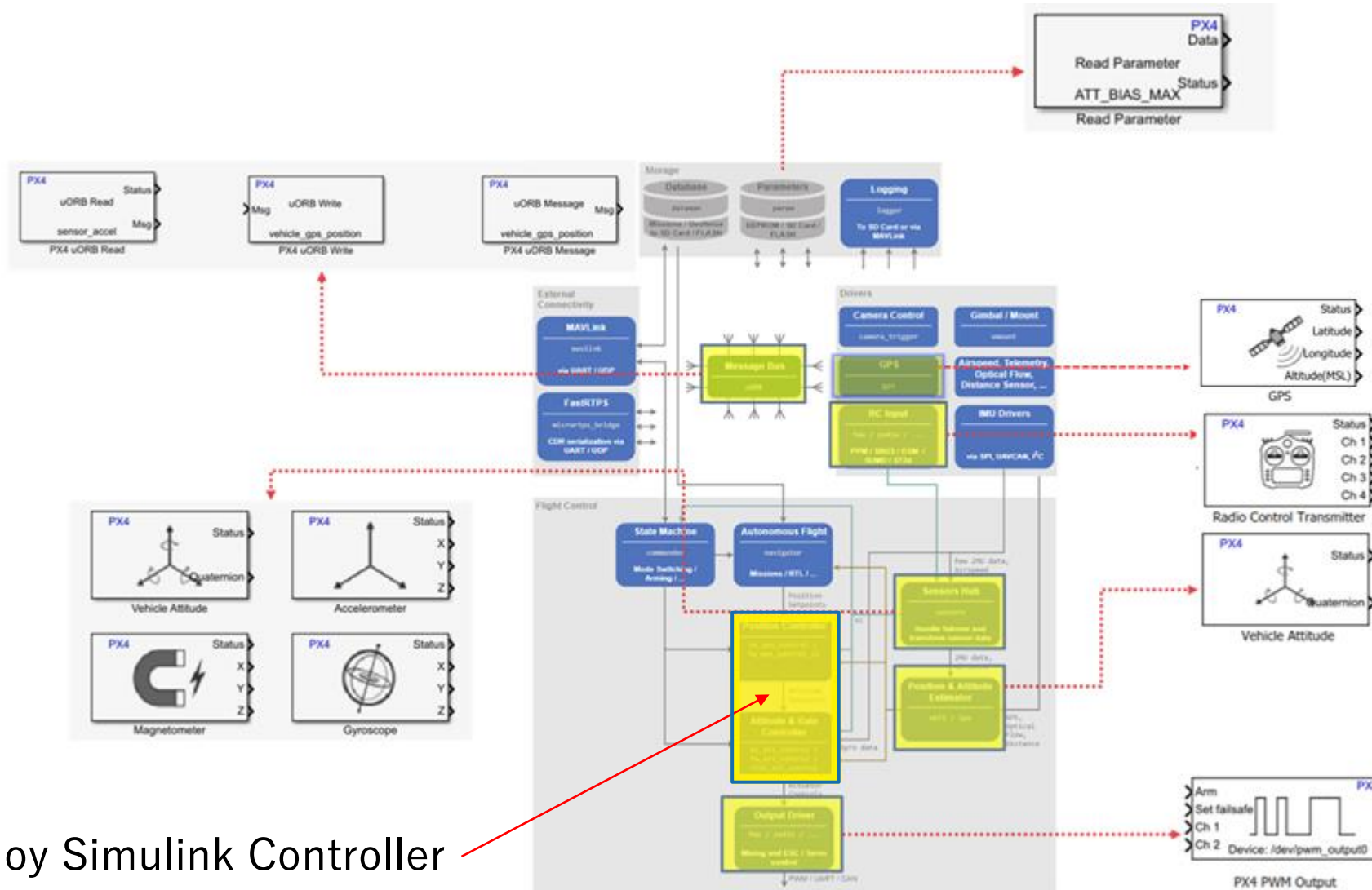
uORB: Asynchronous pub/sub messaging API (middleware)



PX4 Autopilots Support Package 与 PX4 Architecture 的关系

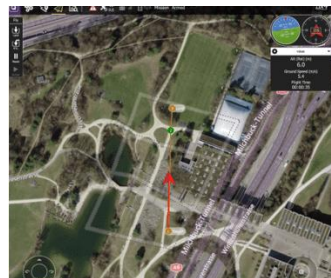


PX4 Autopilots Support Package 与 PX4 Architecture 的关系



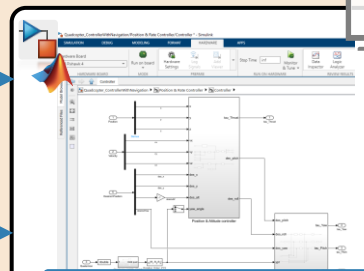
利用 PX4 和 Simulink 实现无人机仿真 workflow

输入



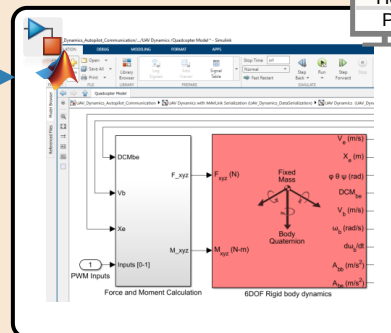
地面控制站

飞行控制器

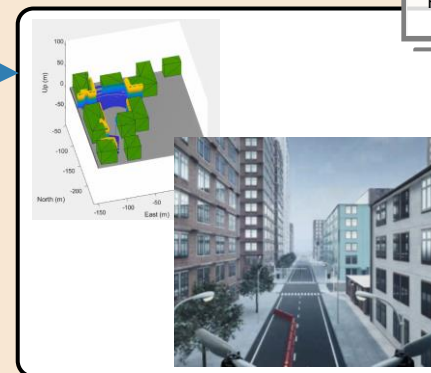


模型在环
(MIL)

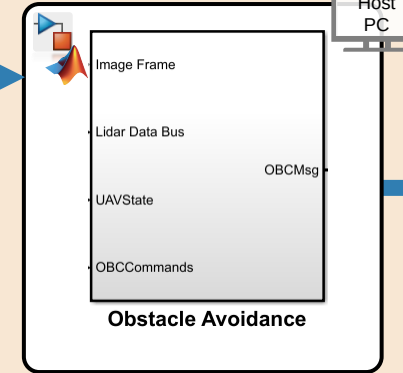
对象模型



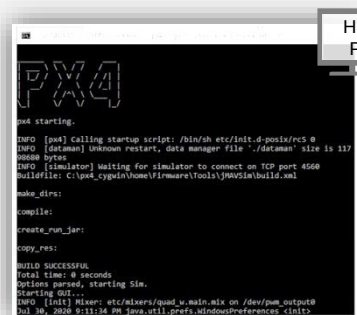
场景仿真



机载自主系统



在 Host PC 上的 C++



软件在环

在硬件上部署



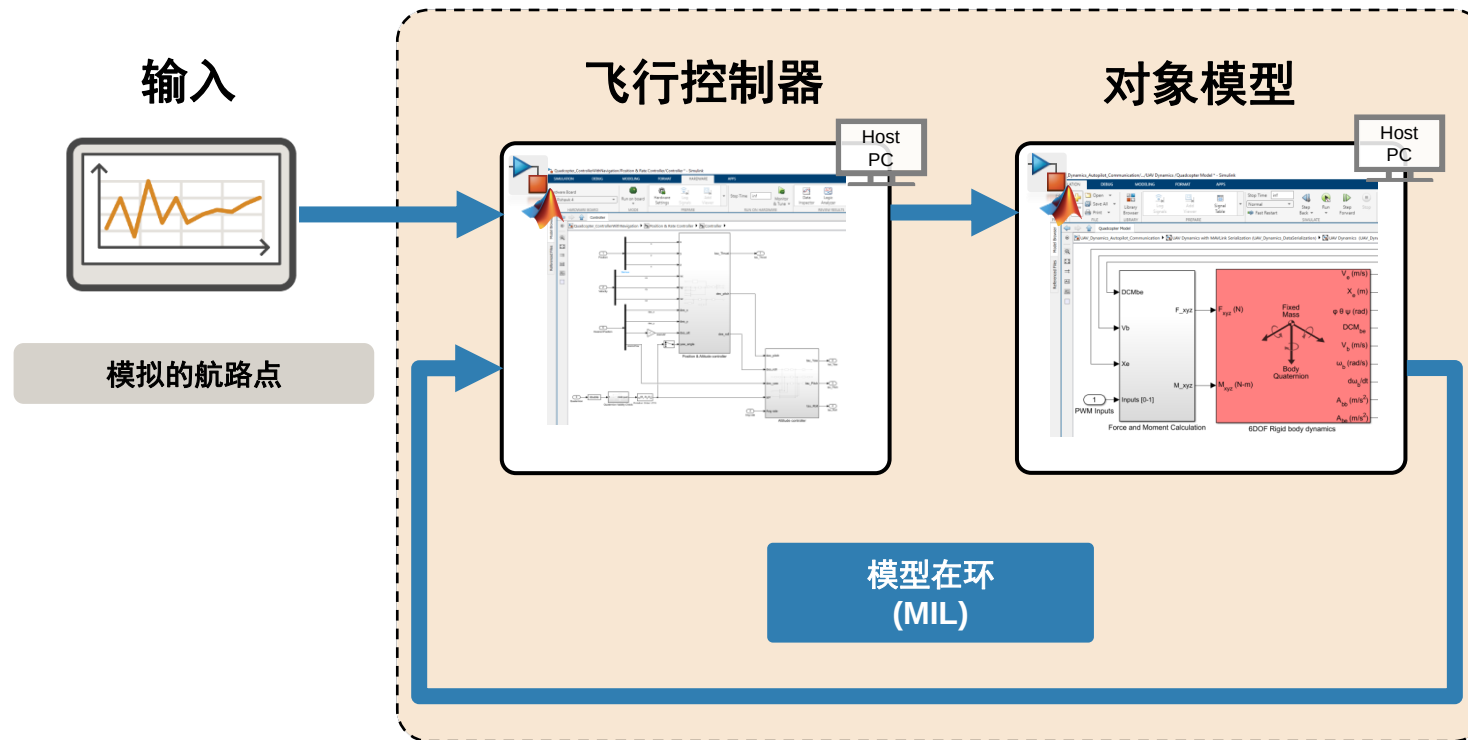
硬件在环

在硬件上部署

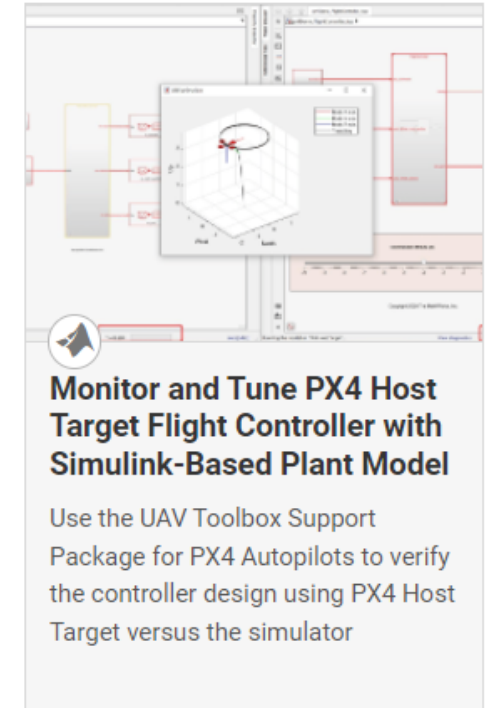
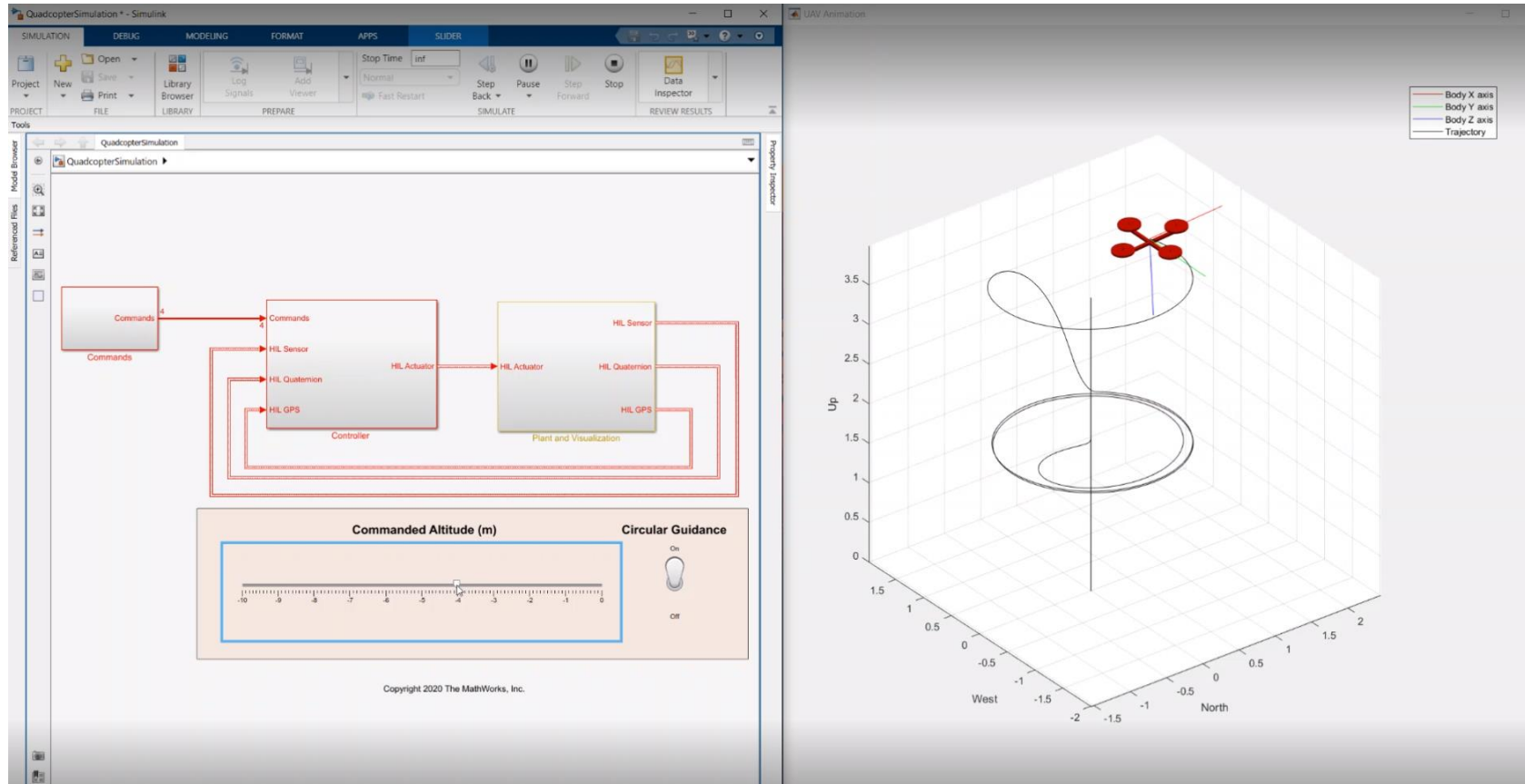


NVIDIA Jetson

模型在环

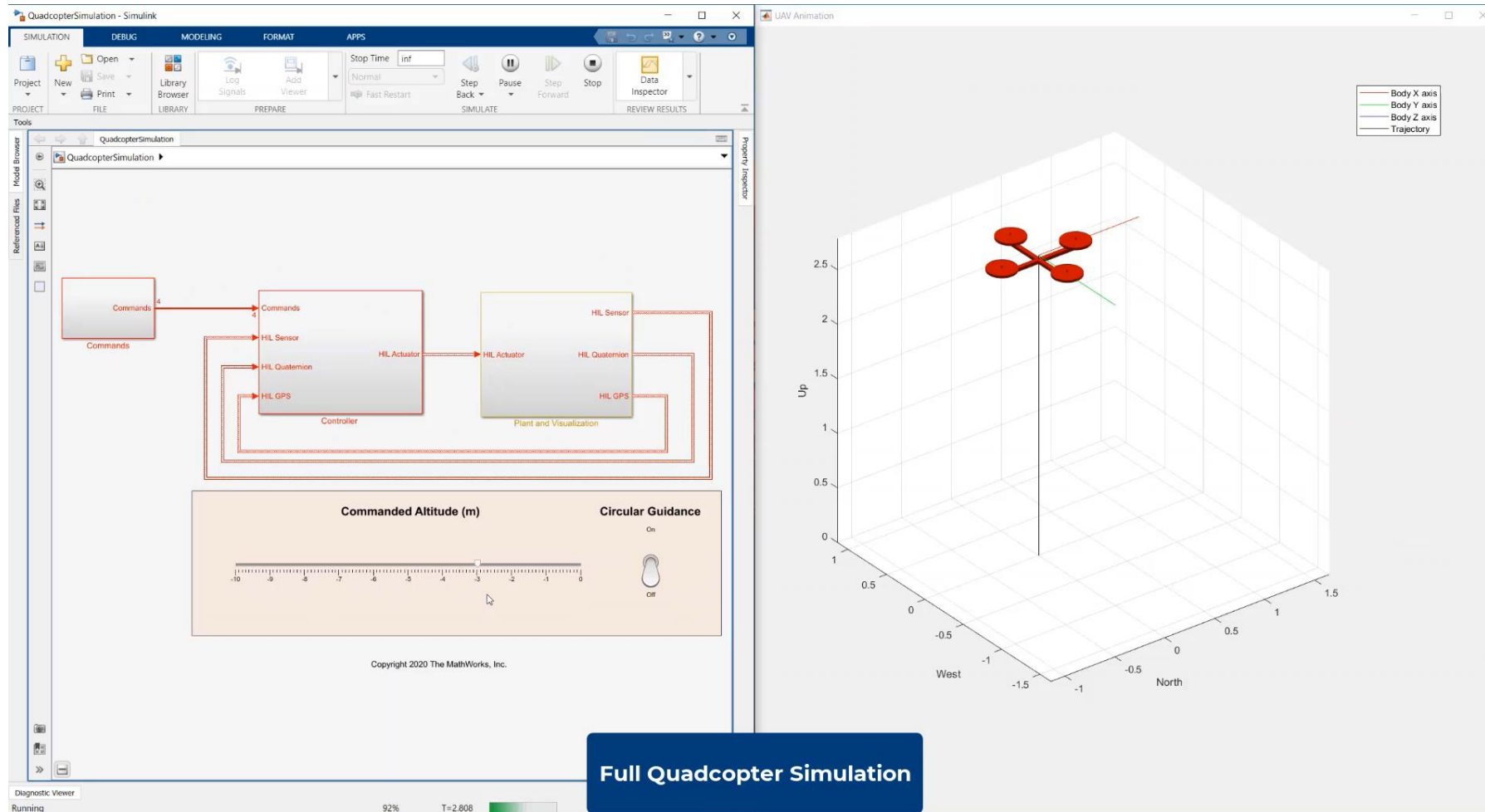


Simulink 中的旋翼机仿真



[Shipping example in UAV Toolbox](#)

Simulink 中的旋翼机仿真

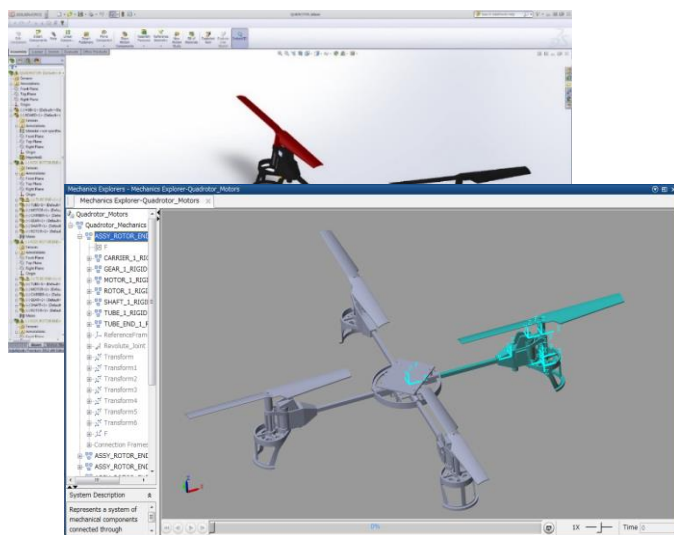


Video included with expo session content package

Simulink 对象建模

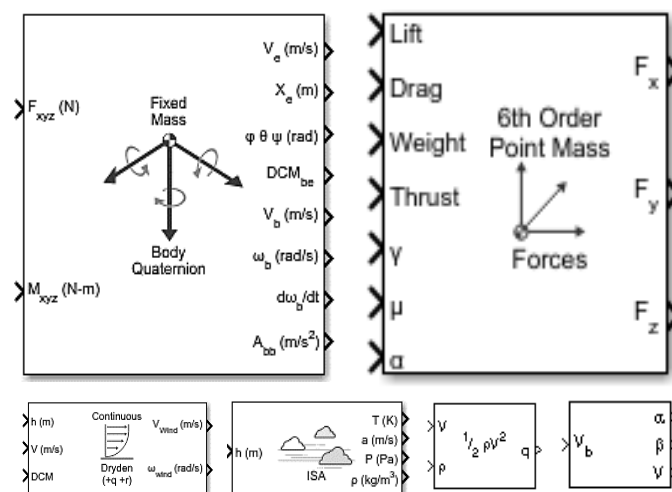
高保真无人机模
型构建

低保证无人
机模型描述



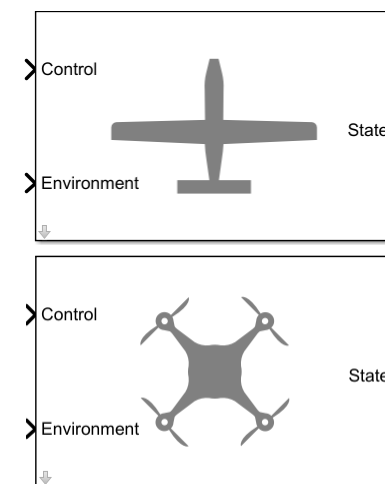
Physical Modeling

Model construction techniques and best practices, domain-specific modeling, physical units



Vehicle Dynamics

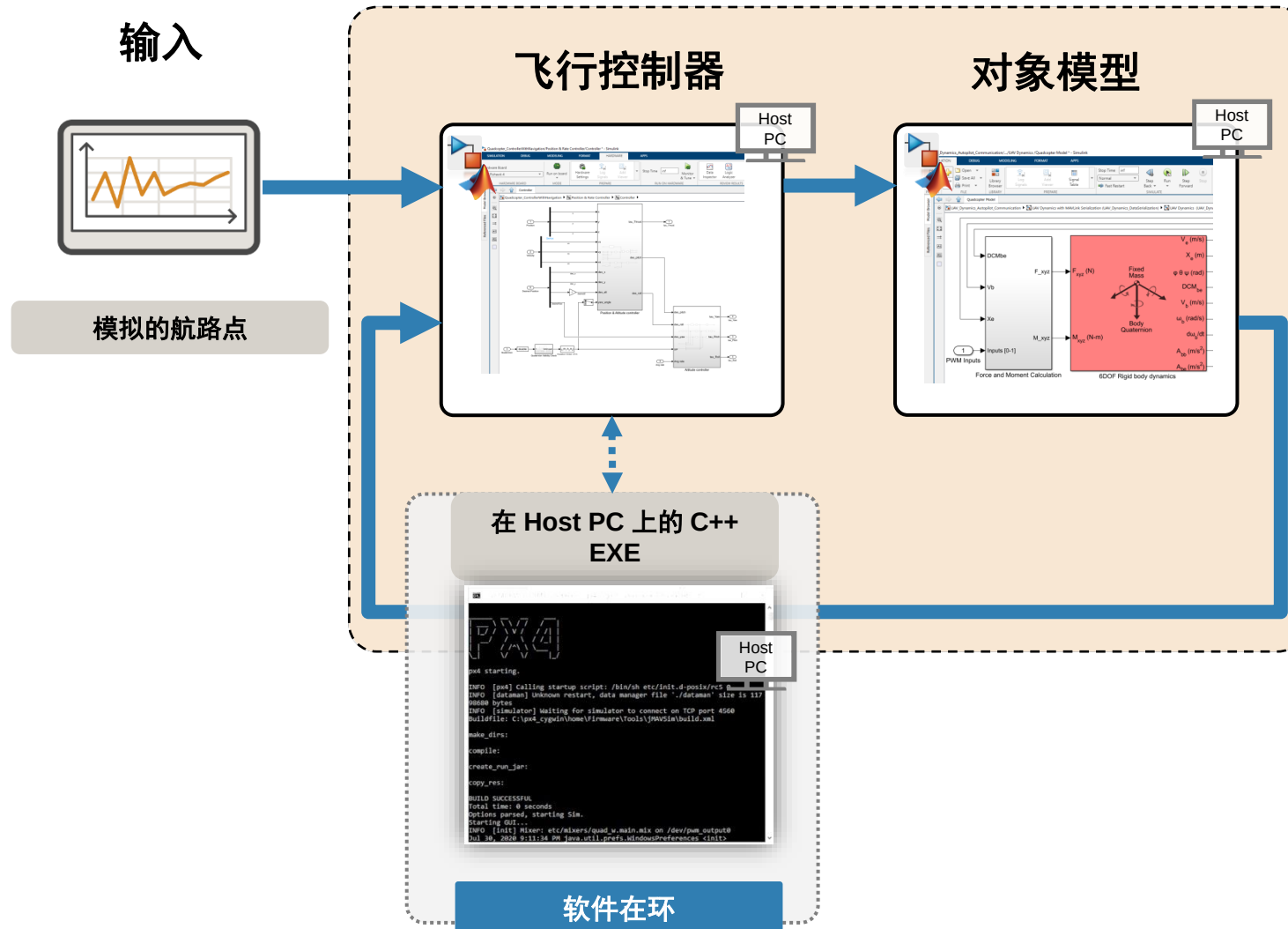
Model aerodynamics, propulsion, and motion of aircraft and spacecraft



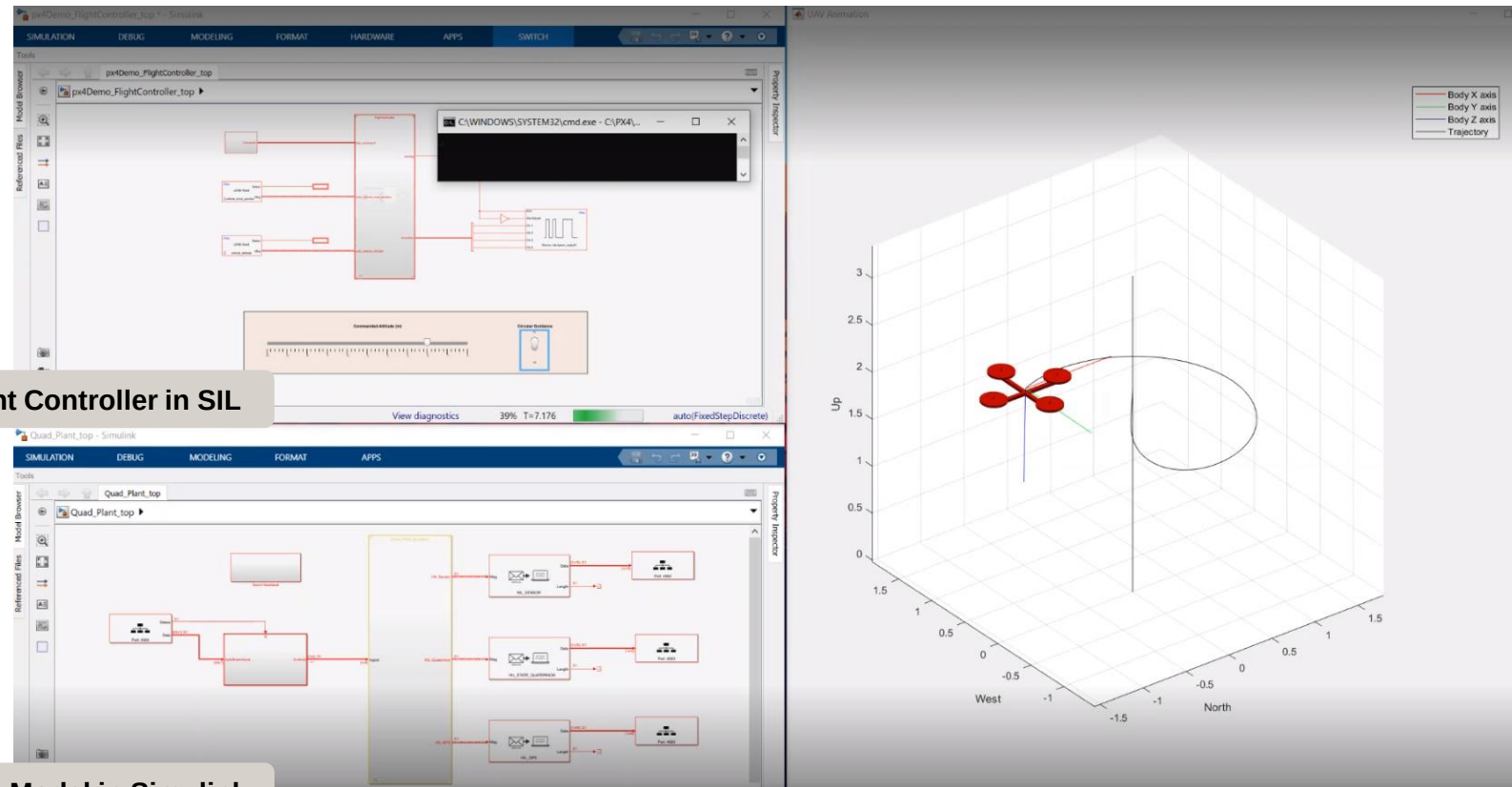
Guidance Model

Reduced-order model for UAV

软件在环 (SIL)

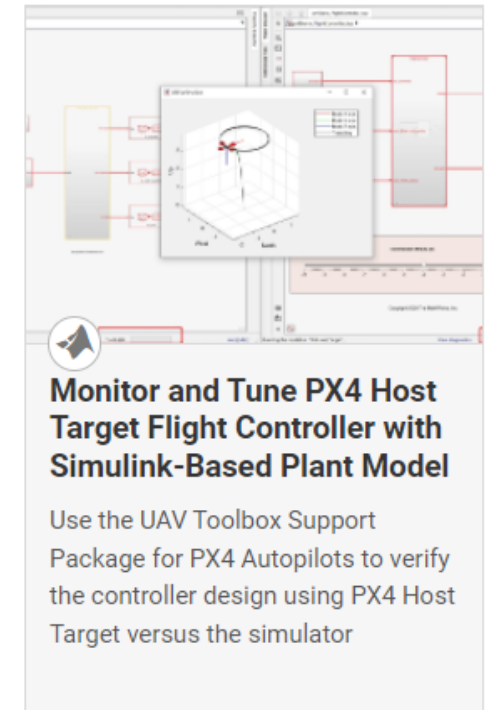


利用 PX4 HSP 和 Simulink 被控对象实现 SIL



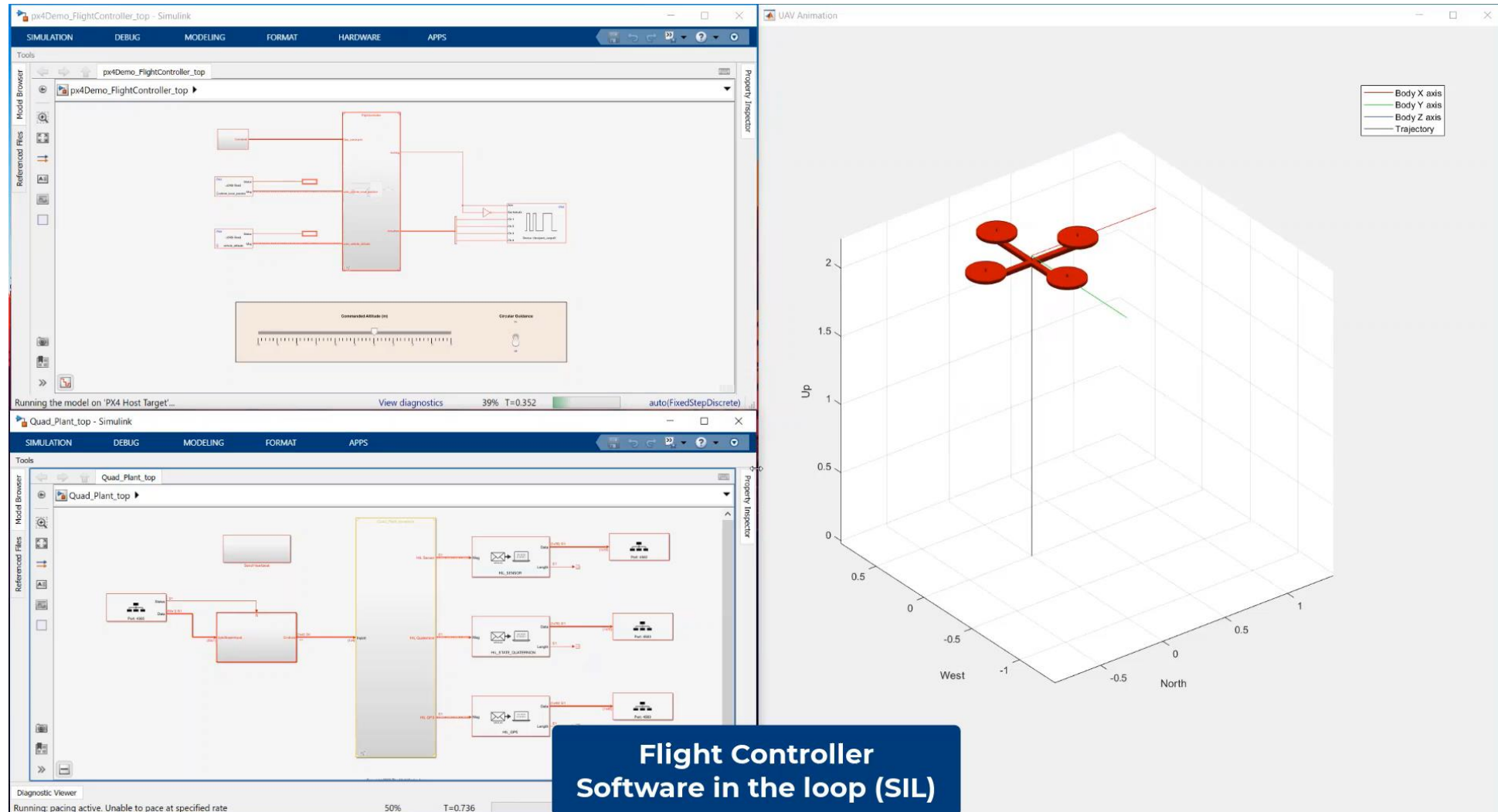
Flight Controller in SIL

Plant Model in Simulink



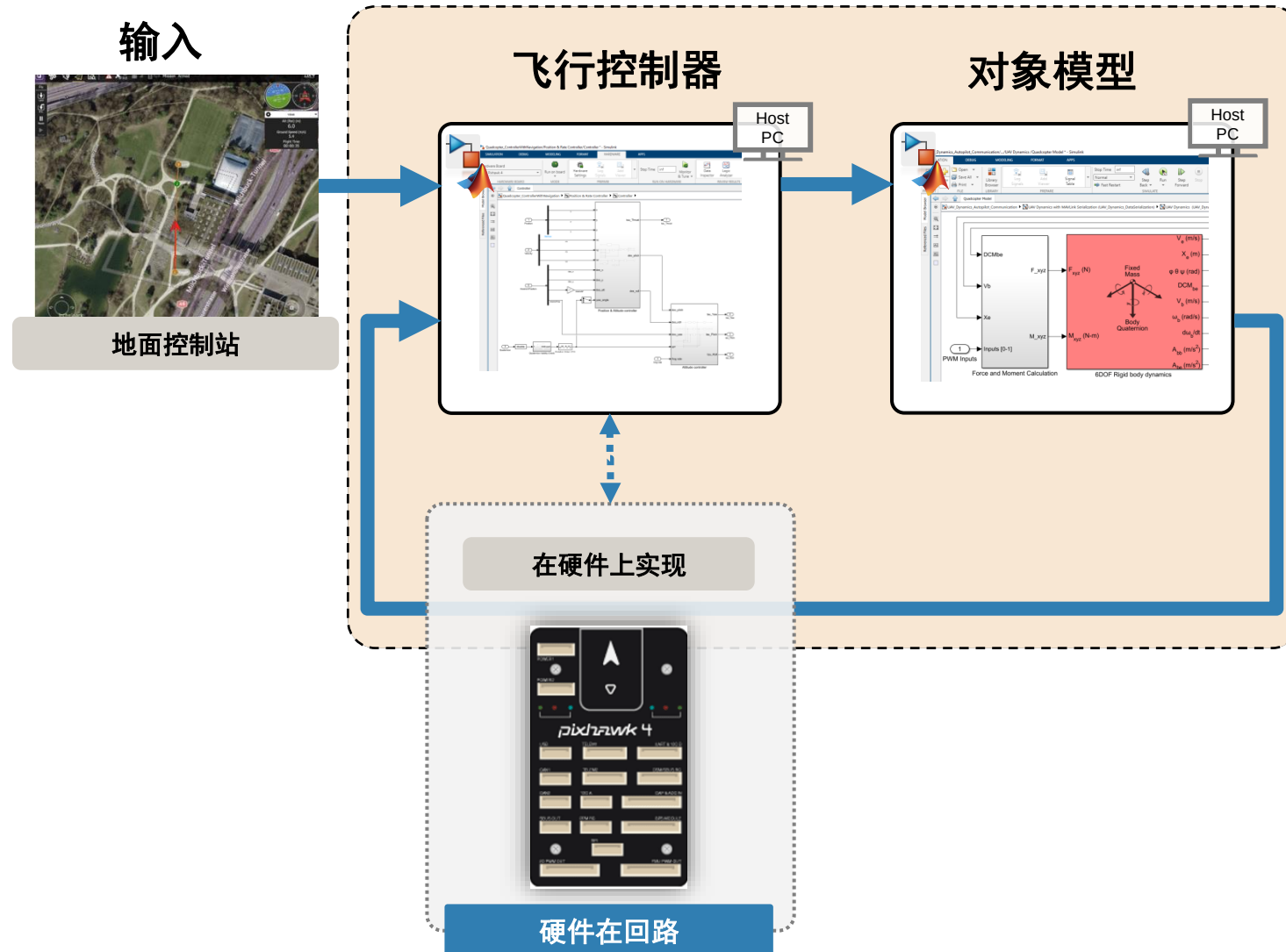
[Shipping example in UAV Toolbox](#)
(See Task 2 in the example)

利用 PX4 HSP 和 Simulink 被控对象实现 SIL

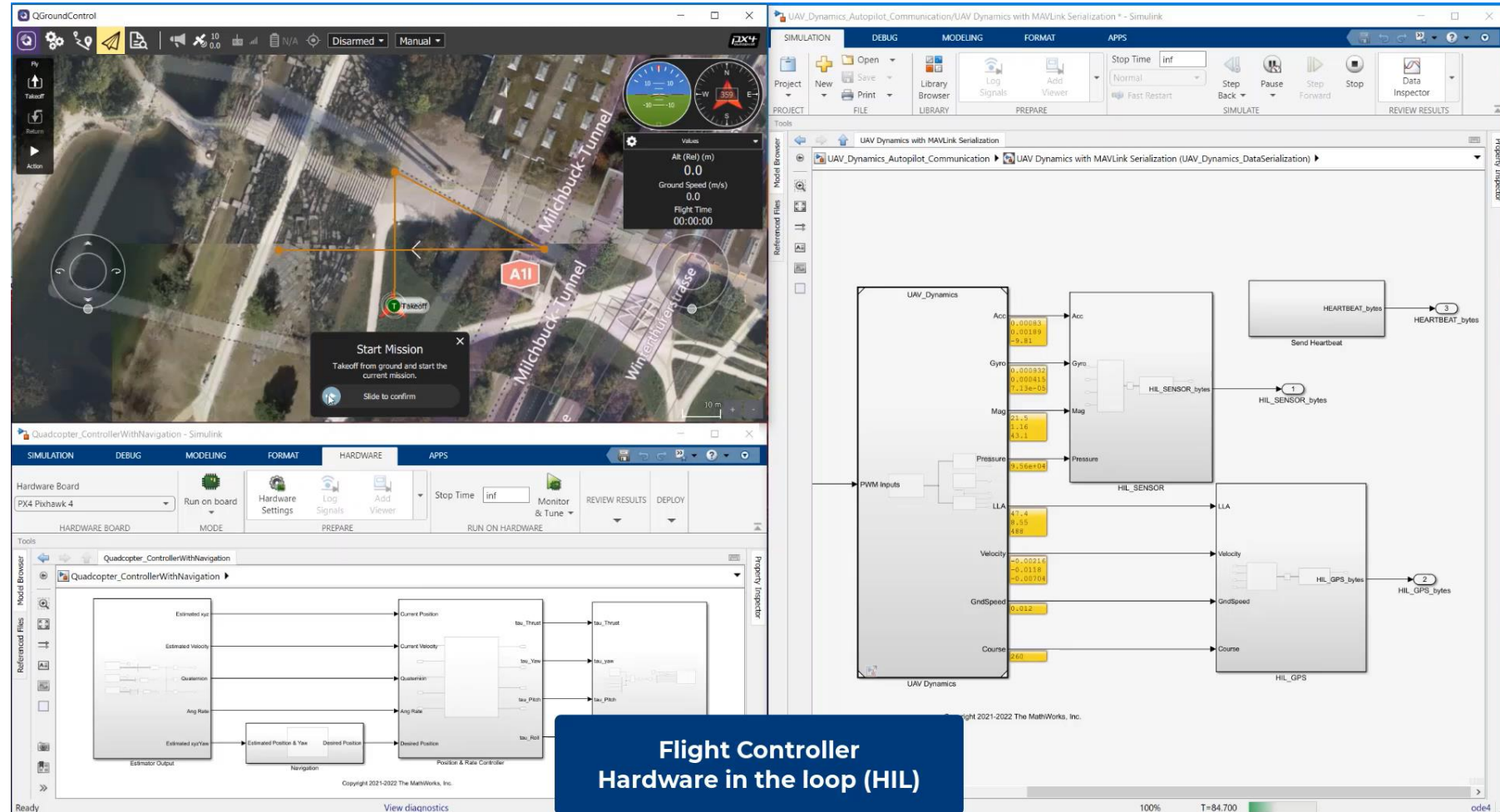


Video included with expo session content package

硬件在环 (HIL)

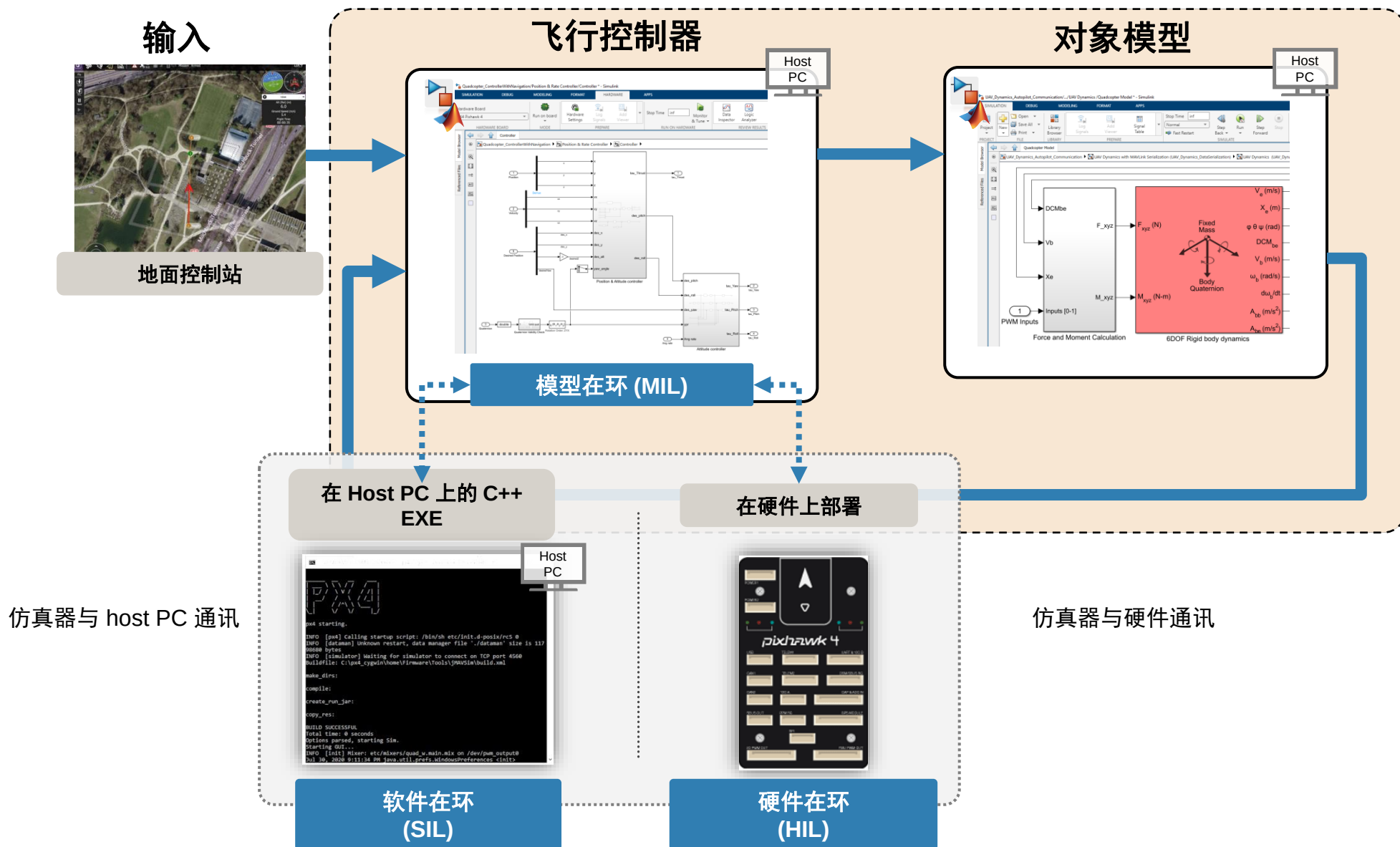


利用 PX4 和 Simulink 被控对象实现 HIL



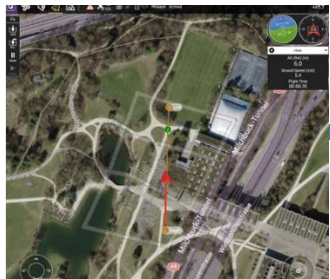
Video included with expo session content package

基于 PX4 和 Simulink 的无人机仿真 workflow



基于 PX4 和 Simulink 的无人机仿真 workflow

输入

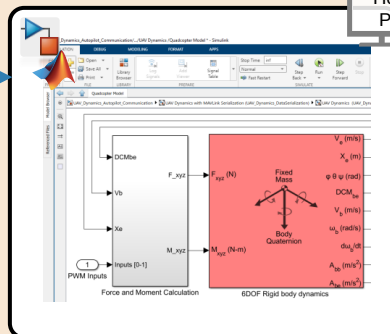


地面控制站

飞行控制器



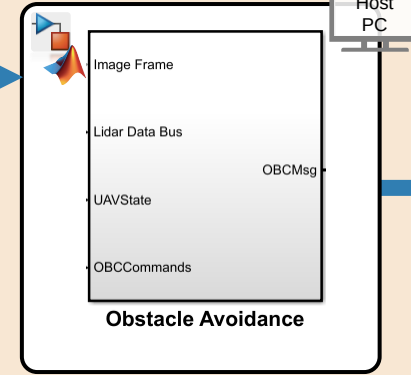
对象模型



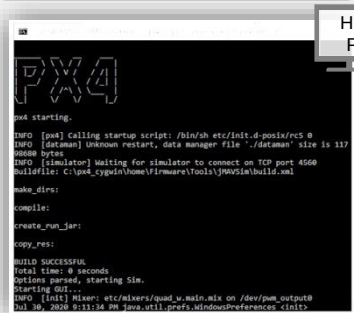
场景仿真



机载自主系统



在 Host PC 上的 C++
EXE



软件在环

在硬件上部署



硬件在环

在硬件上部署

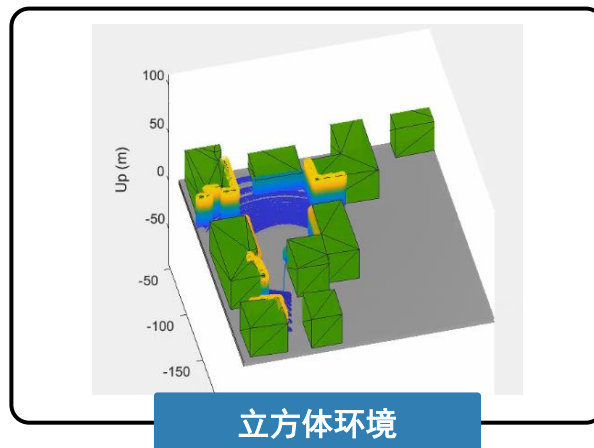


NVIDIA Jetson

闭环自主系统仿真



场景仿真



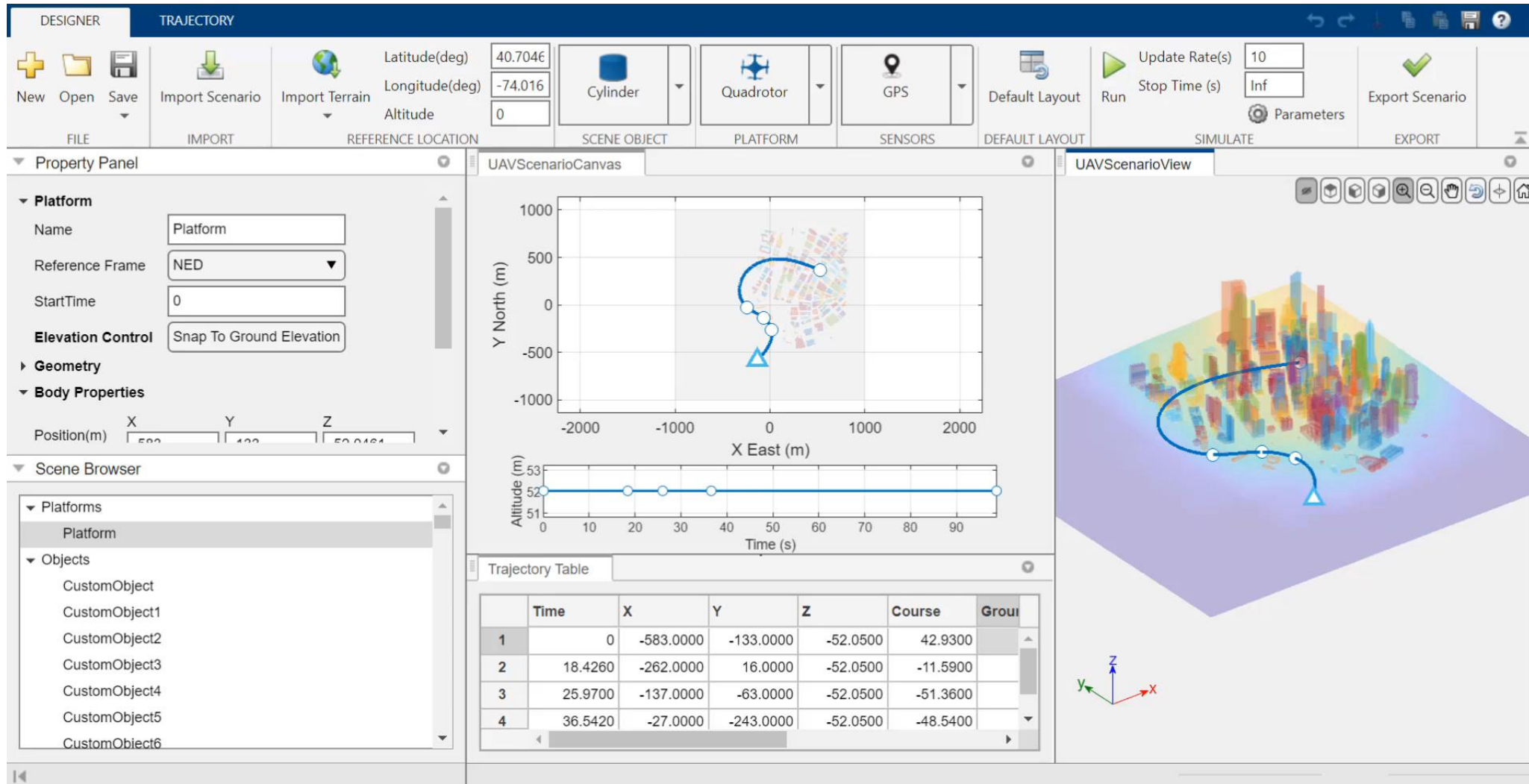
立方体环境



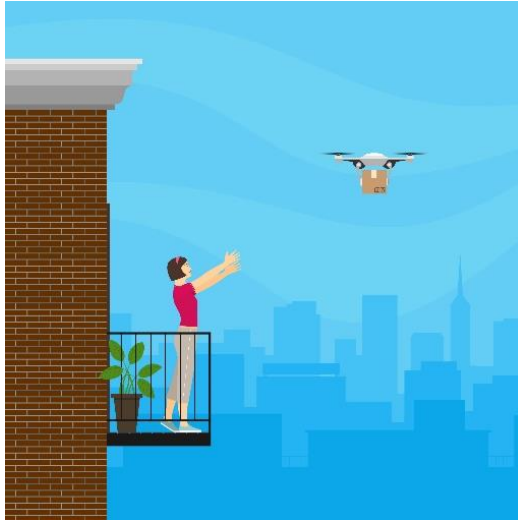
逼真场景环境

创建环境并仿真传感器数据

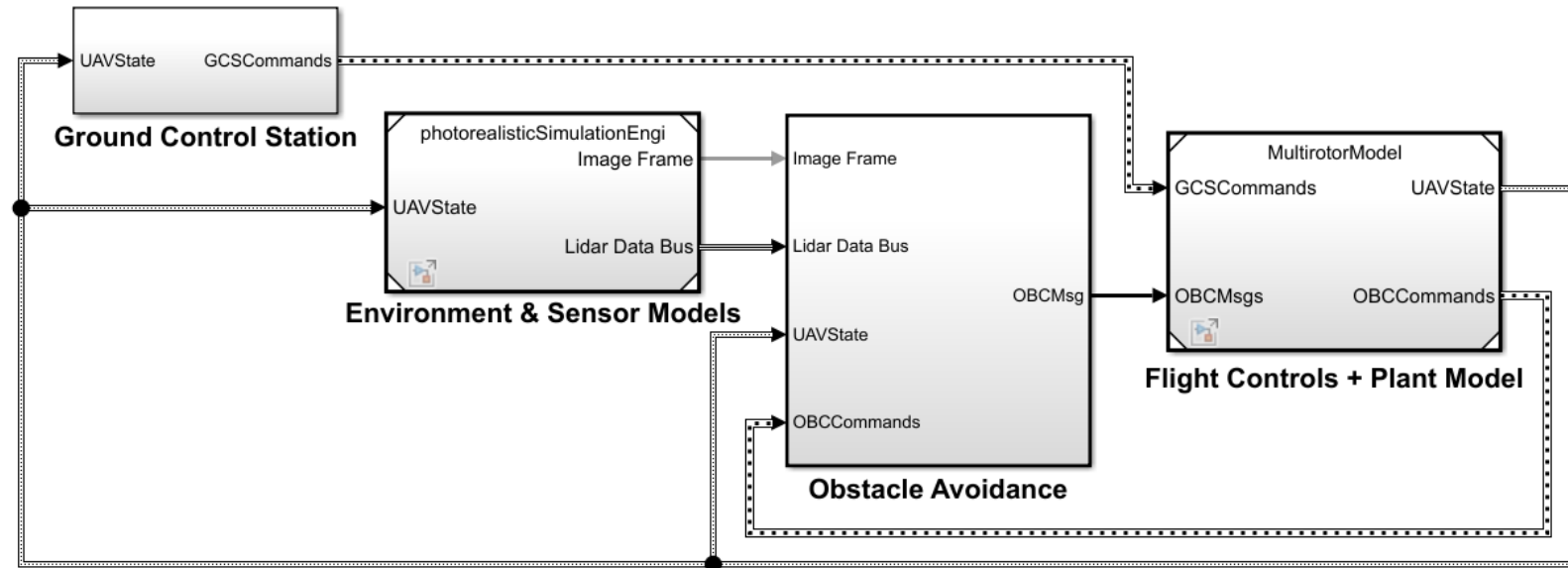
UAV Scenario Designer



将环境集成到全系统仿真

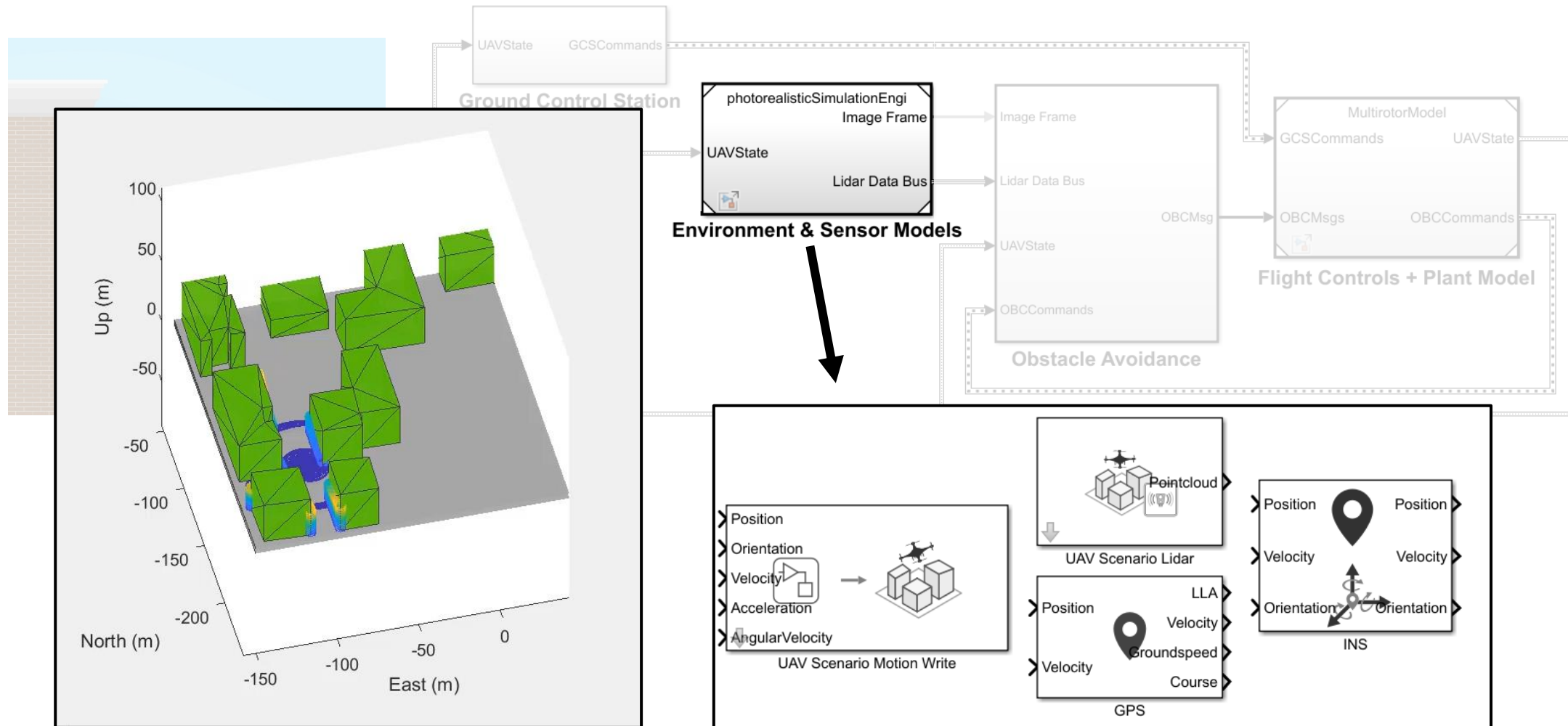


UAV Package Delivery Example

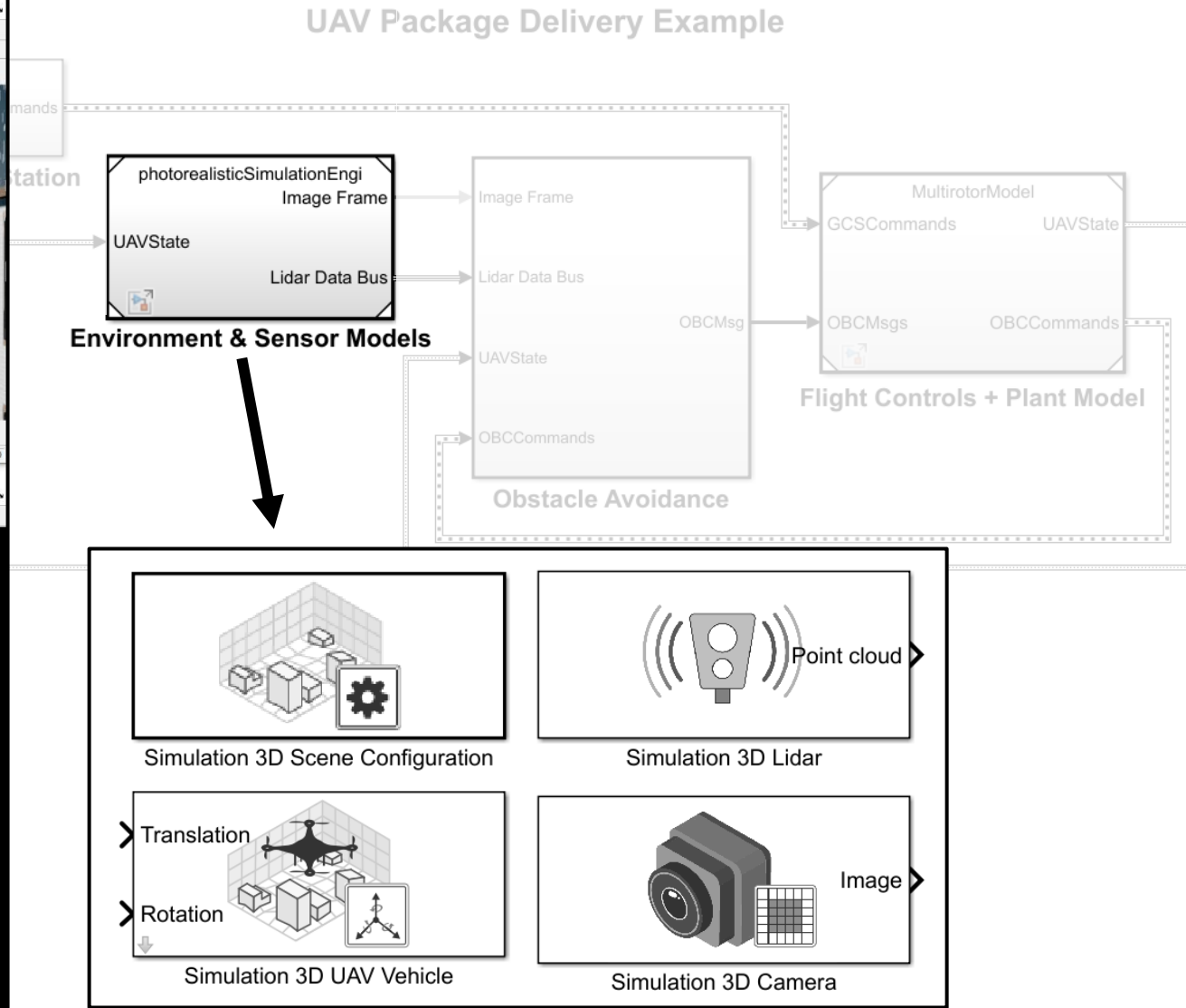
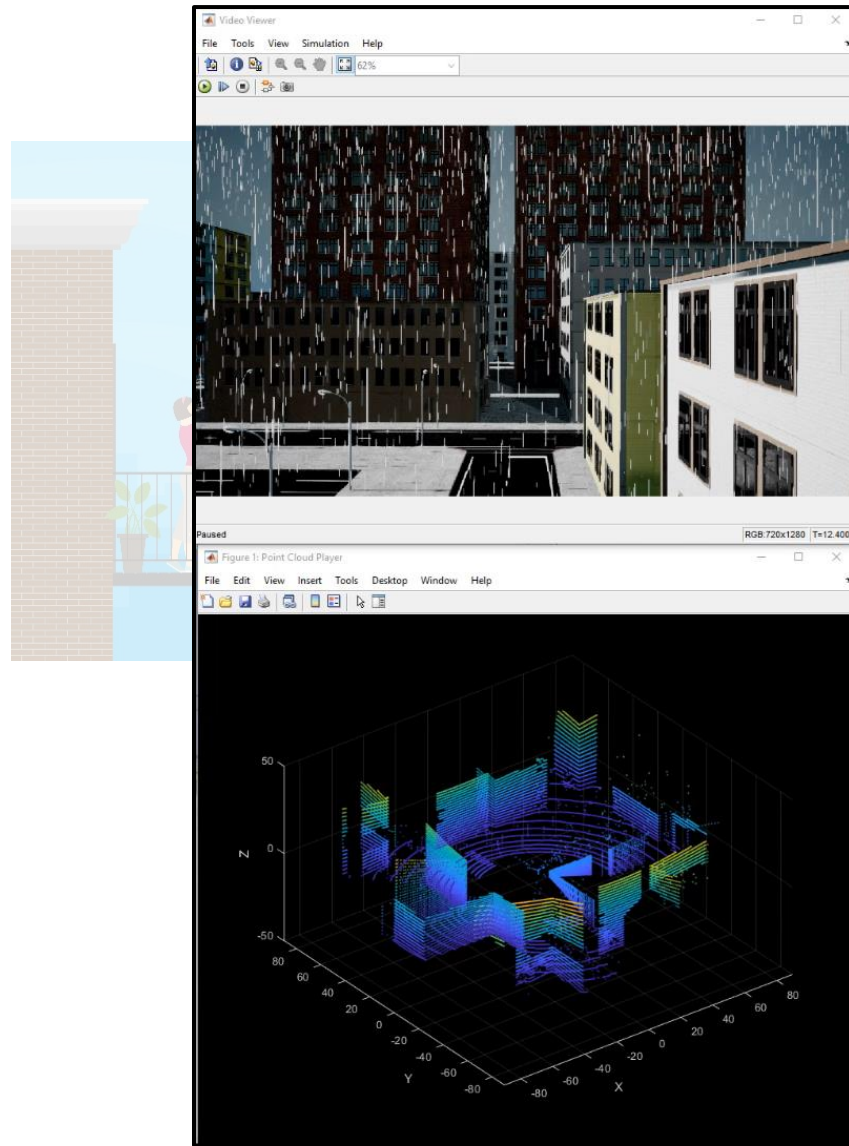


将环境集成到全系统仿真

UAV Package Delivery Example

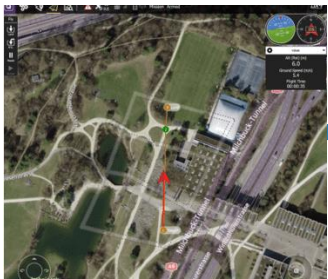


将环境集成到全系统仿真



基于 PX4 和 Simulink 的无人机仿真 workflow

输入

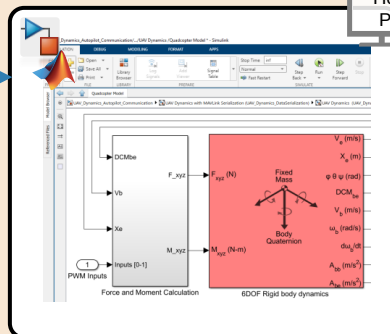


地面控制站

飞行控制器



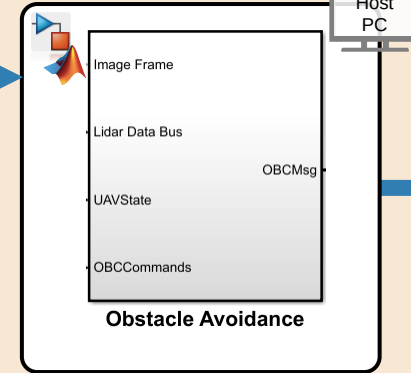
对象模型



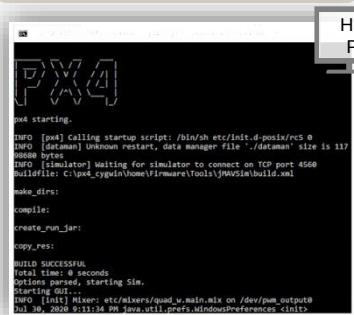
场景仿真



机载自主系统



在 Host PC 上的 C++
EXE



软件在环

在硬件上部署



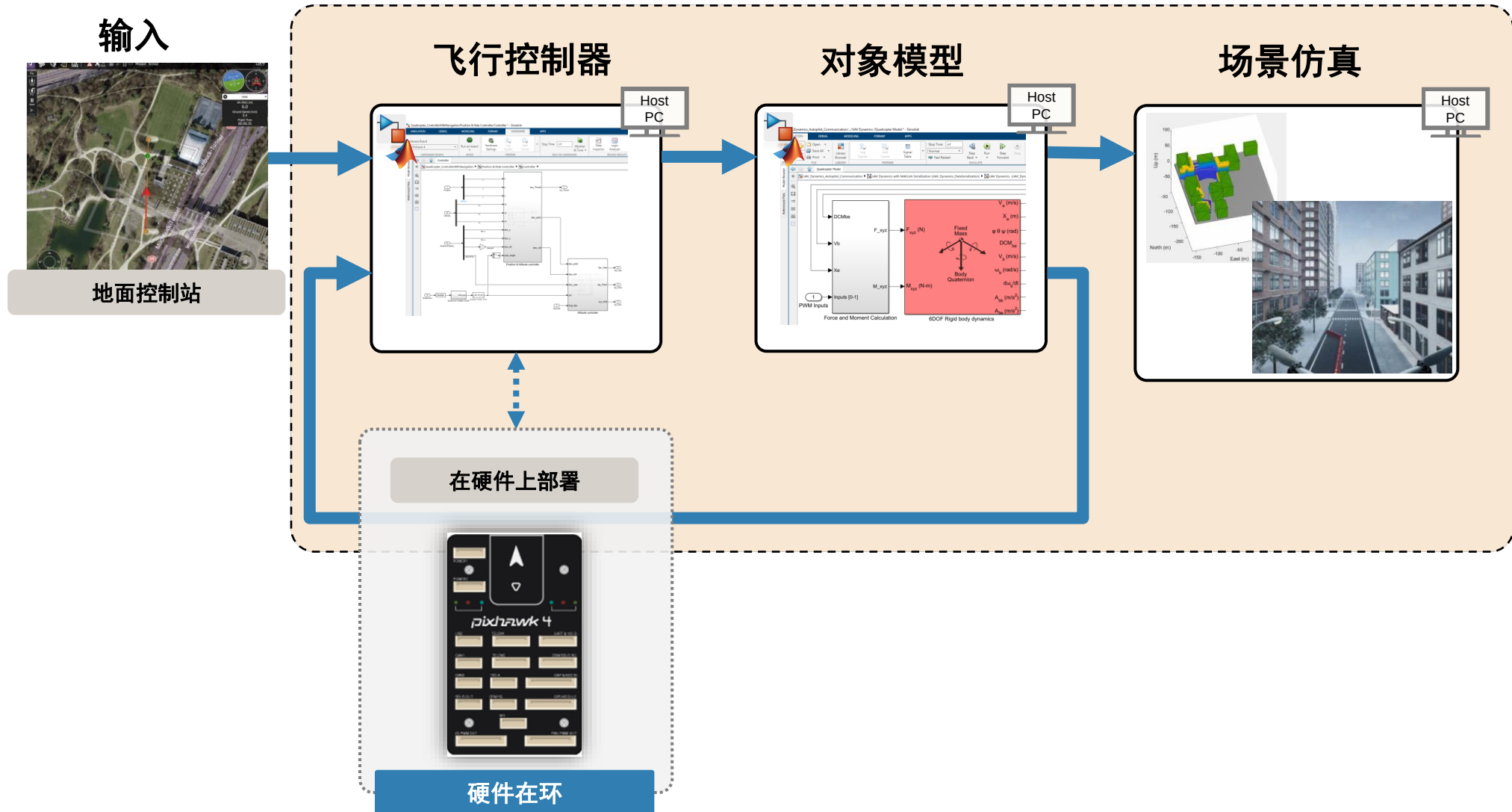
硬件在环

在硬件上部署

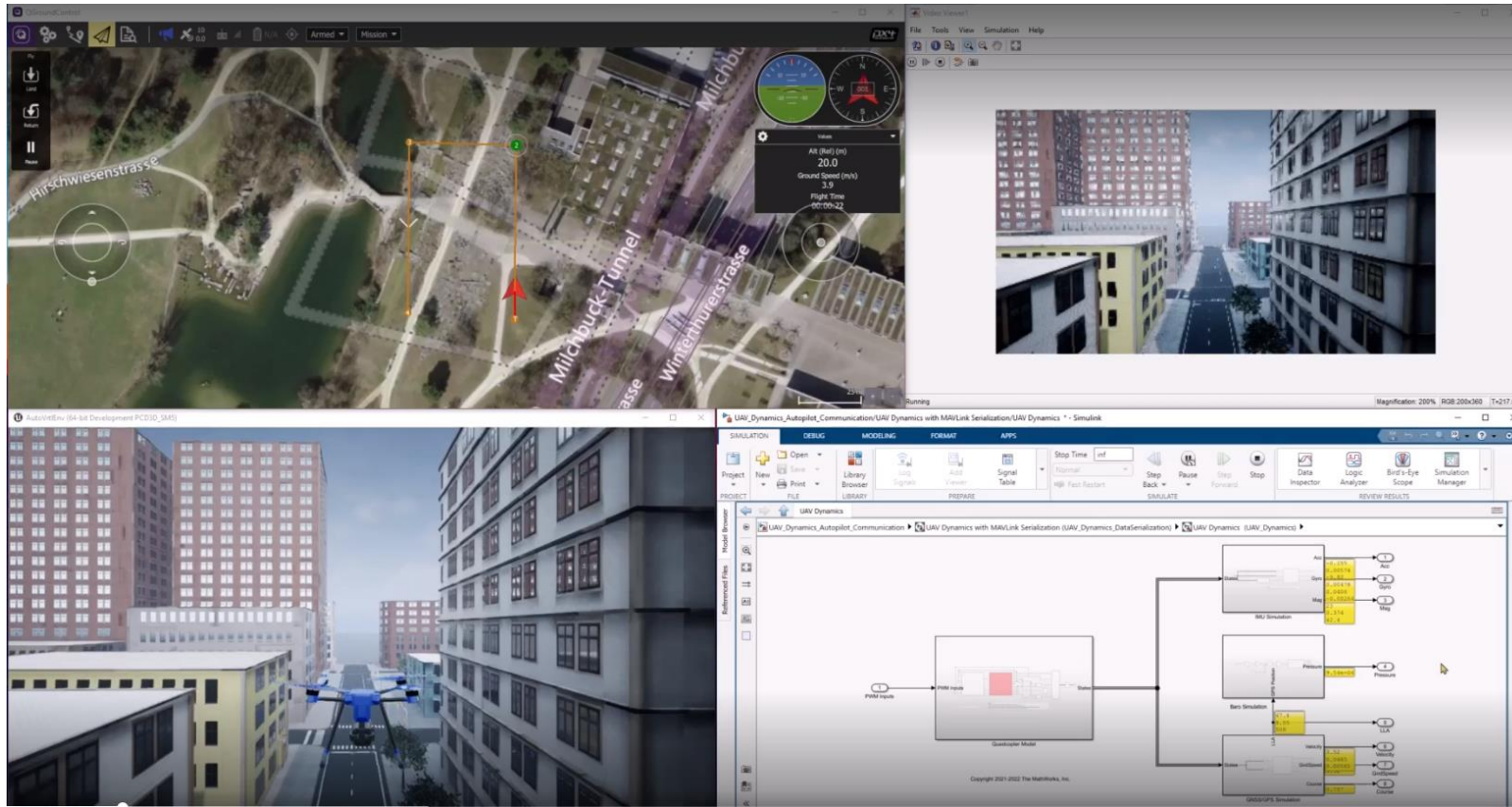


NVIDIA Jetson

HIL 与 场景可视化



HIL 与 场景可视化

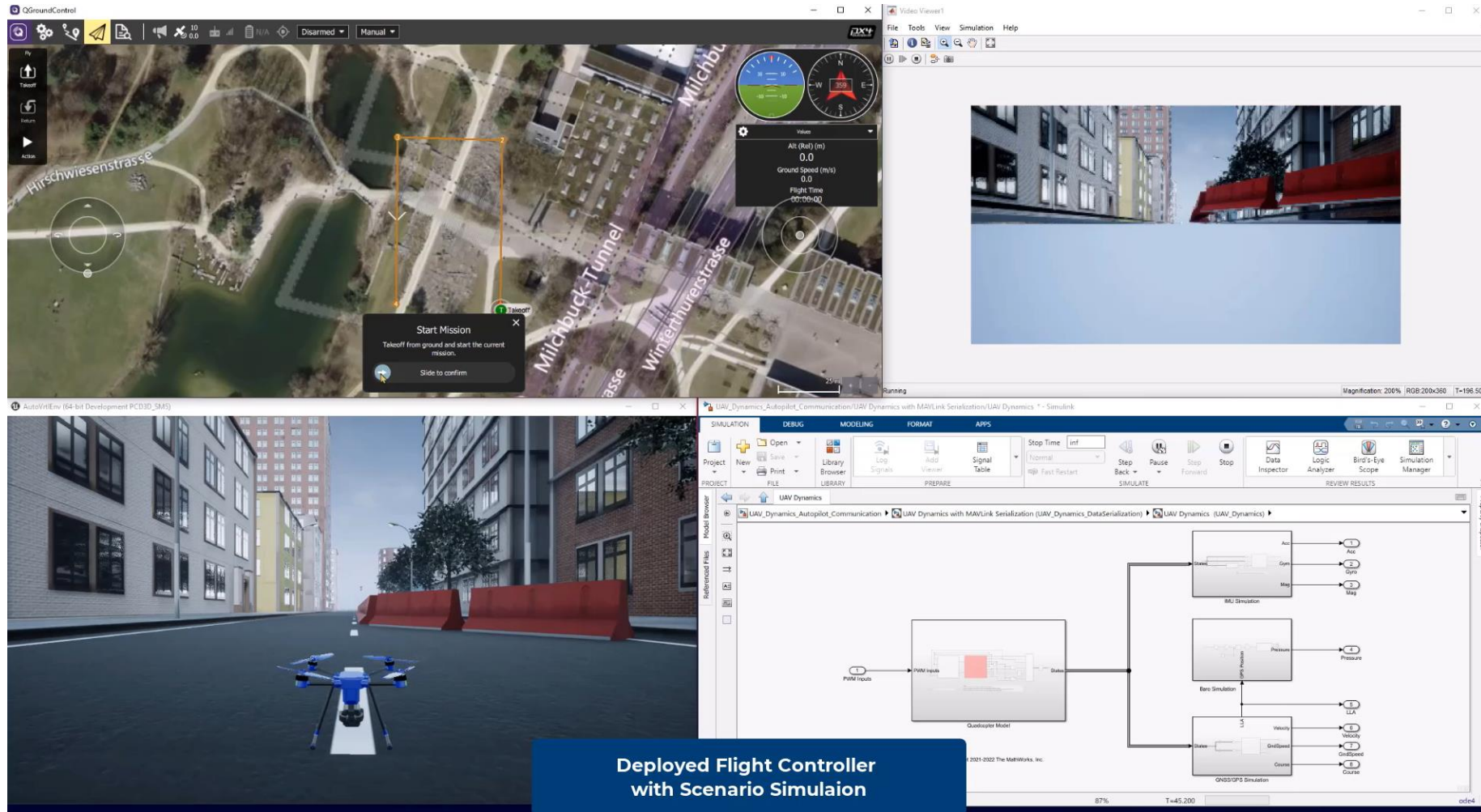


Scenario Simulation and Flight Visualization with PX4 Hardware-in-the-Loop...

Demonstrates 3D scenario Simulation and Flight visualization with PX4 Hardware-in-the-Loop (HITL) and UAV Dynamics contained

[Shipping example in UAV Toolbox](#)

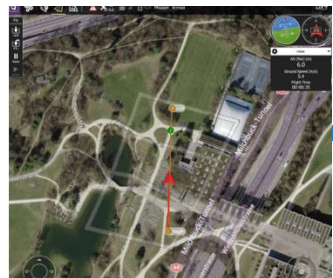
HIL 与 场景可视化



Deployed Flight Controller
with Scenario Simulation

基于 PX4 和 Simulink 的无人机仿真 workflow

输入

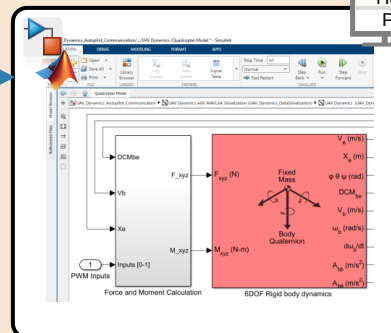


Ground Control Station

飞行控制器



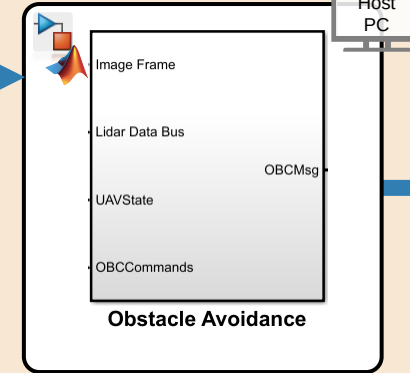
对象模型



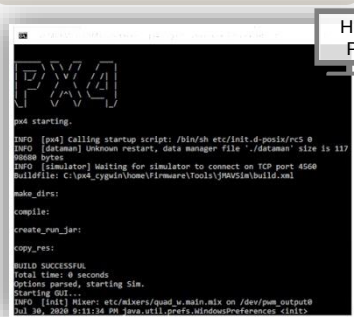
场景仿真



机载自主系统



在 Host PC 上的 C++ EXE



软件在环

在硬件上部署



硬件在环

在硬件上部署



NVIDIA Jetson

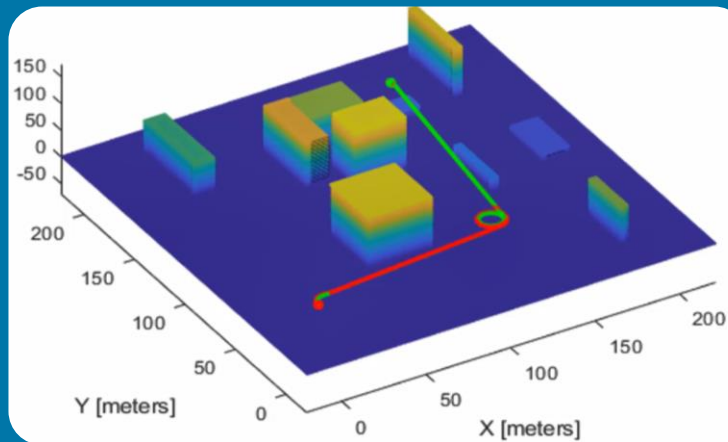
利用 SIL 和 HIL workflow 仿真并部署 UAV 应用

- Why SIL and HIL?
 - 保证飞行安全性
 - 在仿真中测试飞行行为

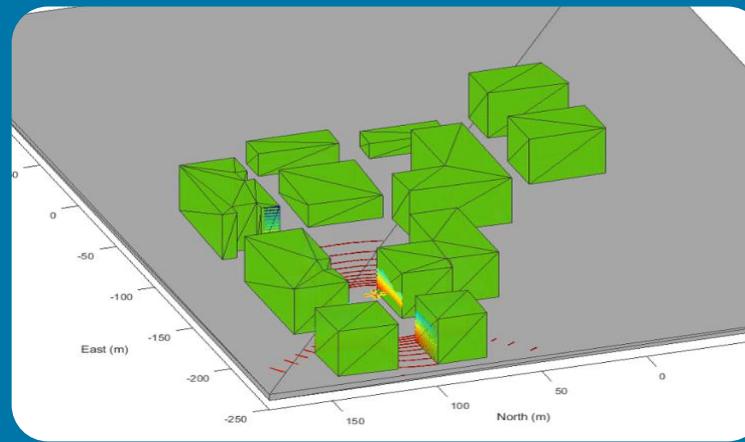
- Why MATLAB & Simulink?
 - 与外部自动驾驶仪集成
 - 为机载计算机生成 C/C++ 代码
 - 利用 MATLAB 和虚幻引擎进行场景仿真

UAV Toolbox

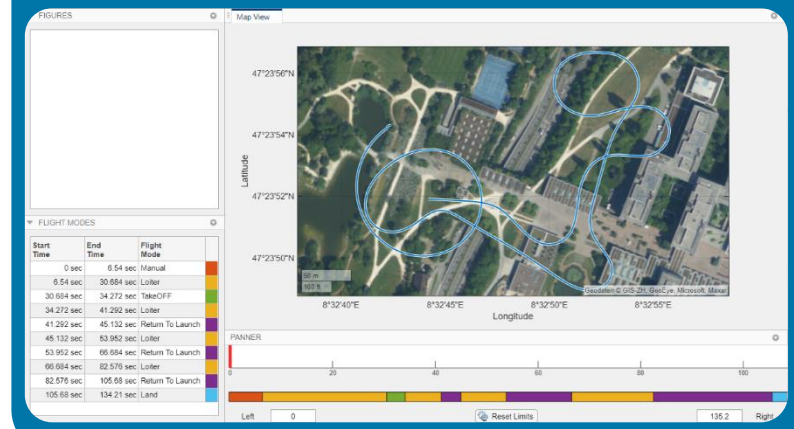
UAV Algorithms for Planning and Control



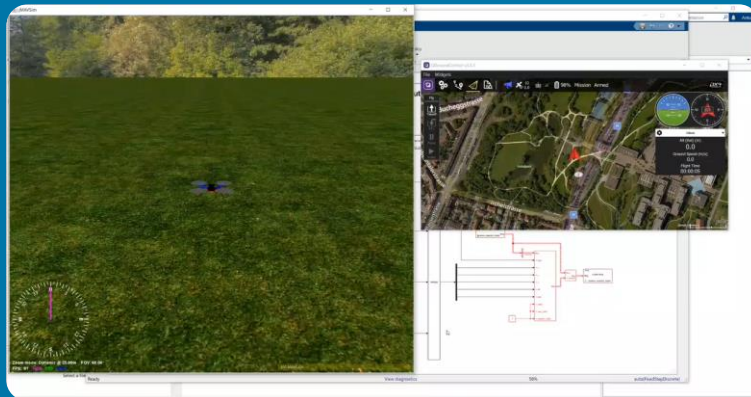
Scenario Design & Low-Fidelity Sensor Simulation



Flight Telemetry Data Analysis Flight Log Analyzer App



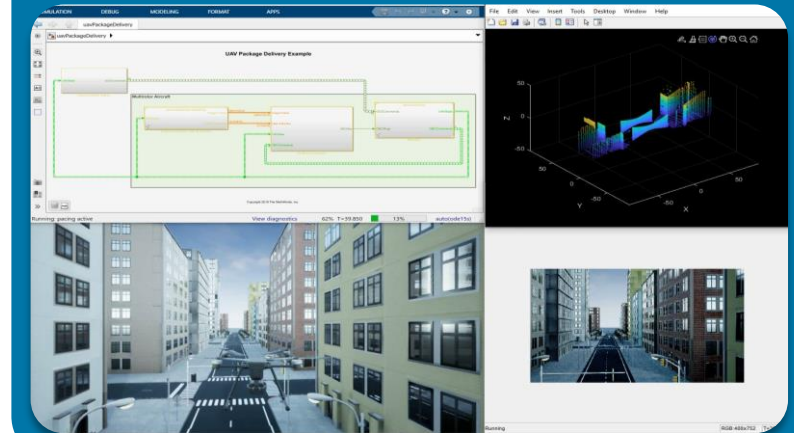
Connectivity and Deployment with MAVLink and PX4



Unreal Engine Co-Simulation with Sensor Models



Reference Applications



更多学习资源

- 产品页面
 - <http://www.mathworks.cn/products/uav.html>
- 产品概览视频
 - <https://www.mathworks.cn/videos/what-is-uav-toolbox-1600154005892.html>
- UAV Toolbox Support Package for PX4 Autopilots
 - https://www.mathworks.cn/help/supportpkg/px4/index.html?s_tid=CRUX_topnav
- 文档
 - <http://www.mathworks.cn/help/uav/>
- 示例
 - <http://www.mathworks.cn/help/uav/examples.html>

MATLAB EXPO

谢谢



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