TeraSoft
Accelerating your Research & Development

Developing Unmanned Aerial Vehicles (UAV) with MATLAB and Simulink

Sarah Hung
Application Engineer

MathWorks
Authorized Reseller

Increase in UAV Usage

Education

Surveying

Inspection

Delivery

Manual Operations

Autonomous Flight

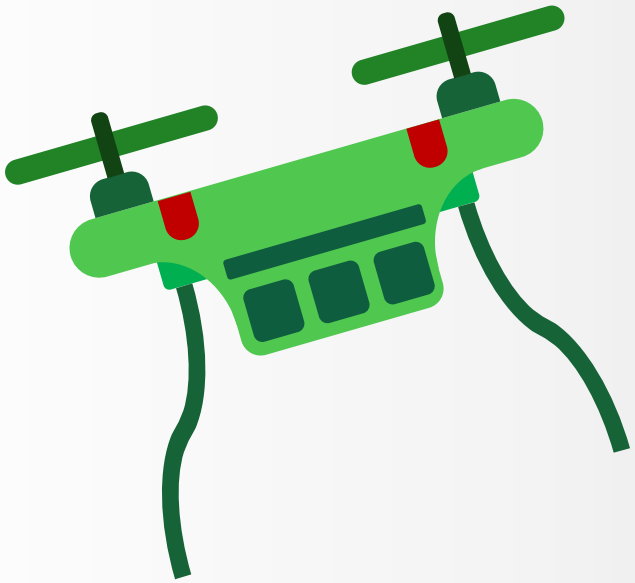
Filming

Measurement

Monitoring

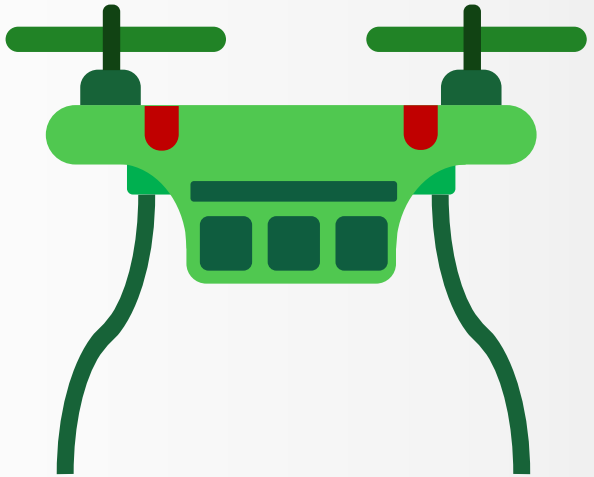
Transport

Challenges in developing autonomous UAV systems & applications



- Complexity of advanced autonomous algorithms
- Need of end-to-end workflows
- Ensuring system quality and reducing flight risk

Solutions for developing autonomous UAV systems & applications

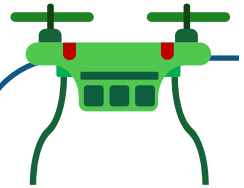


Robust tools and features for designing and testing UAV systems and algorithms

Integrated development environment that covers development from ideas to production

Extensive verification and validation tools to evaluate design quality through virtual testing

Integrated workflows for developing UAV applications



MATLAB®

Simulink®

System Architecture

Model UAV

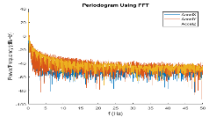
Design Algorithms

Perception

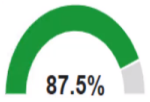
Planning & Decision

Control

Analyze Data



Verification & Validation

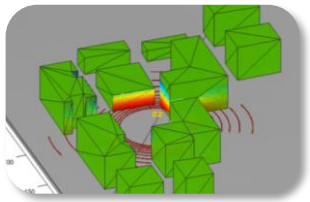


DO-178

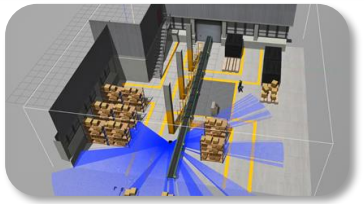
Implement

Connect

Simulate with Sensor Models



Cuboid



Gazebo

Unreal Engine

Deploy to Hardware

PX4®

NVIDIA® Jetson®

Connect

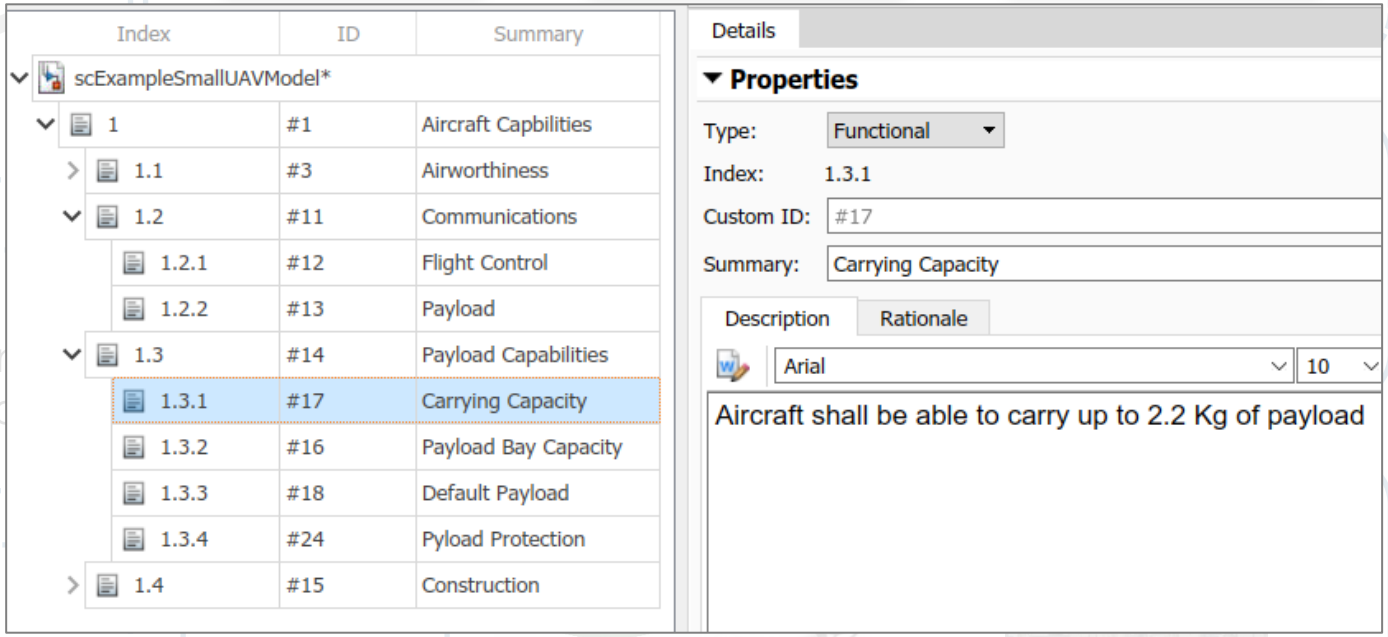
UAV

Ground Control Station

Integrated workflows for developing UAV applications

System Architecture

- System Composer™ for designing and analyzing system and software architecture
- Simulink integration and requirement allocation for traceability



Link

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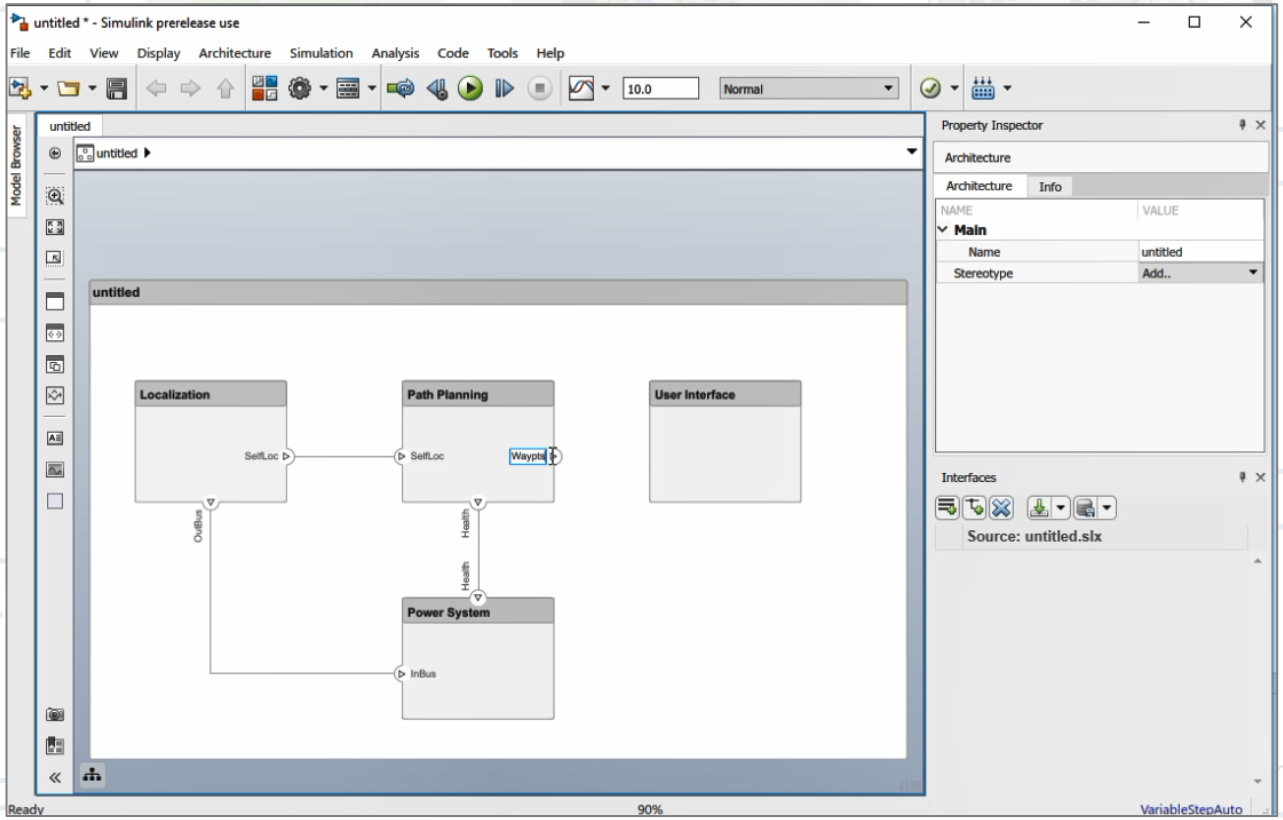

[Link]

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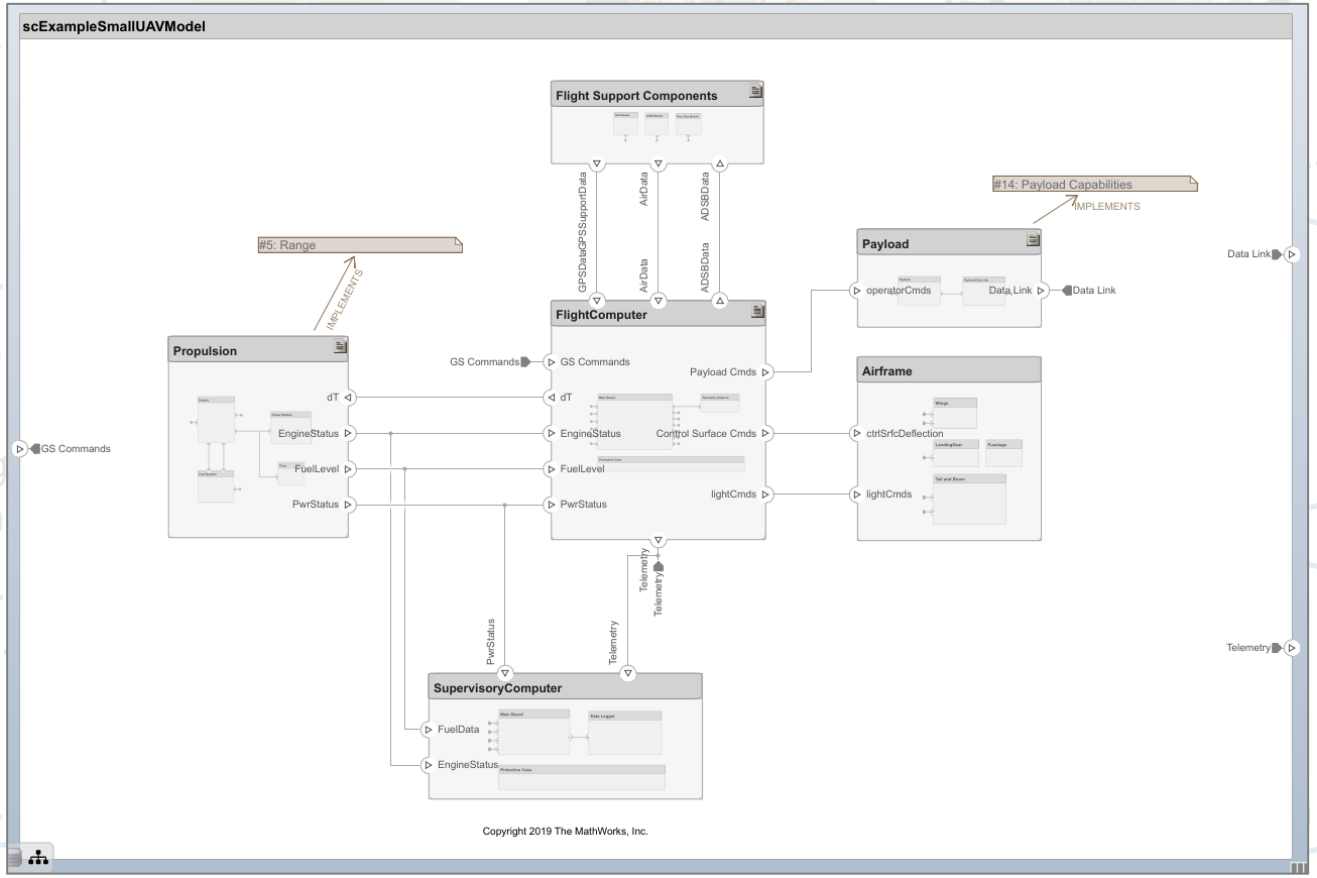

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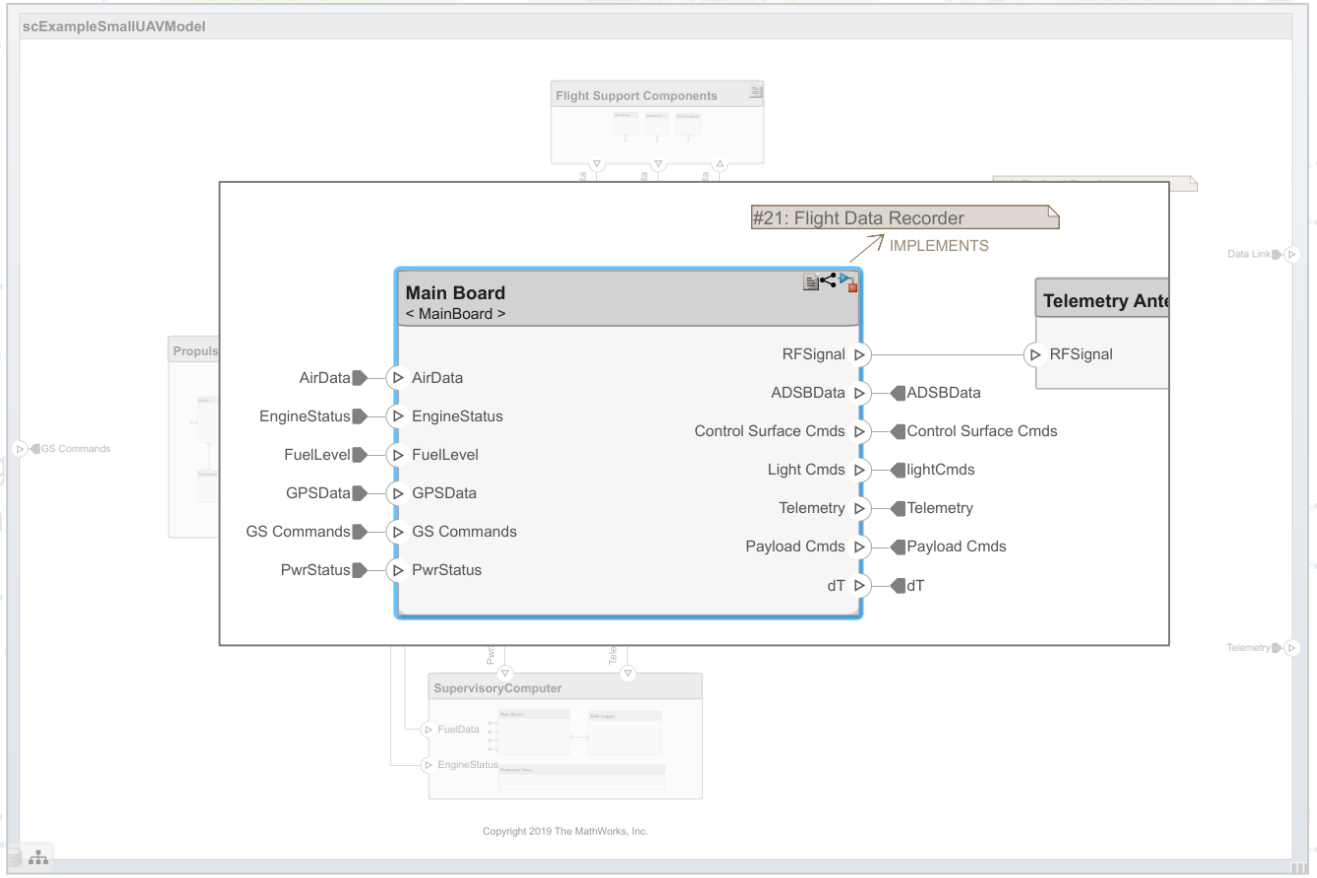

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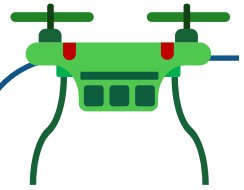
Integrated workflows for developing UAV applications



MATLAB®

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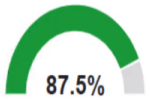
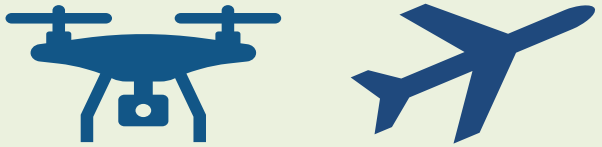
System Architecture

Verification & Validation



DO-178

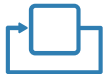
Model UAV



Design Algorithms

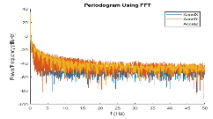
Perception

Planning & Decision

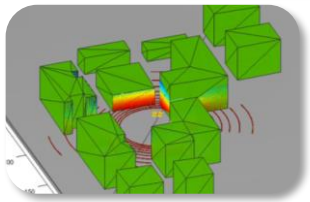


Control

Analyze Data



Simulate with Sensor Models



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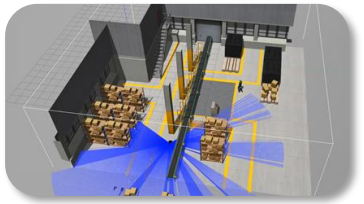

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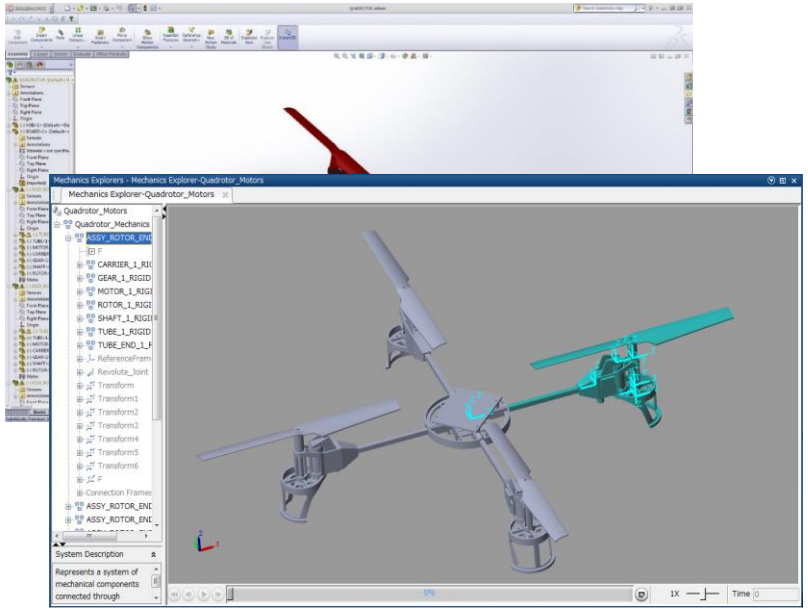
UAV Plant Modeling: Selecting the appropriate fidelity

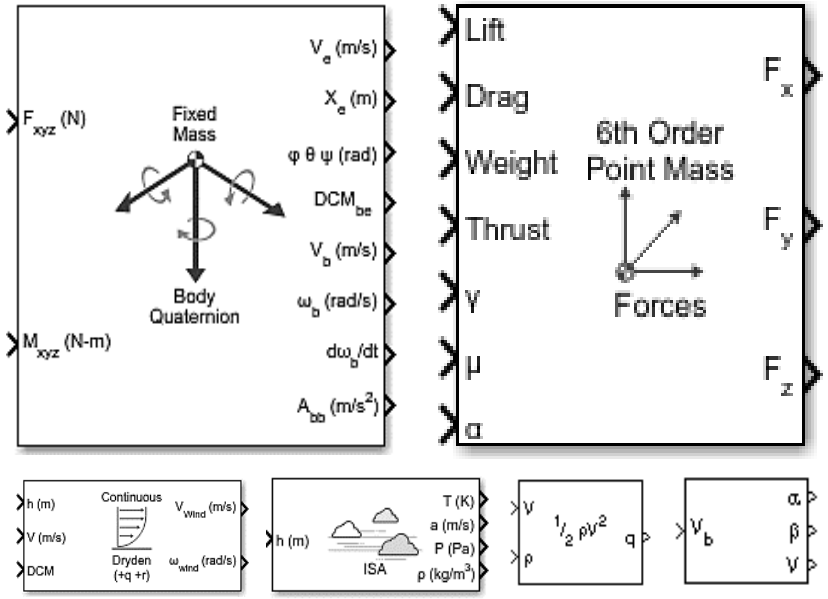
High-Fidelity
Building UAV

Approximate
Programming UAV



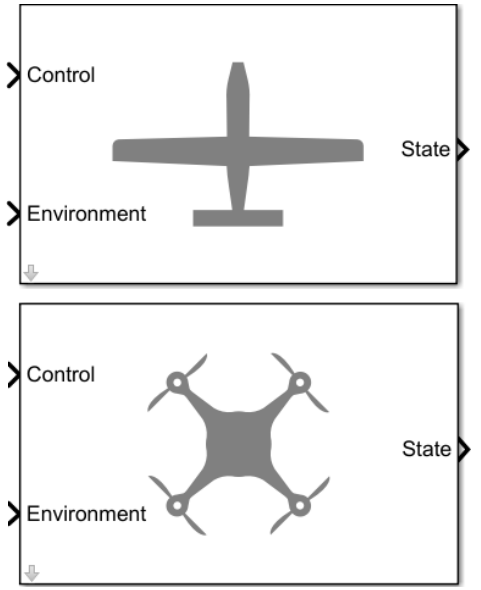
Physical Modeling [Link]

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



Vehicle Dynamics [Link]

Model aerodynamics, propulsion, and motion of aircraft and spacecraft

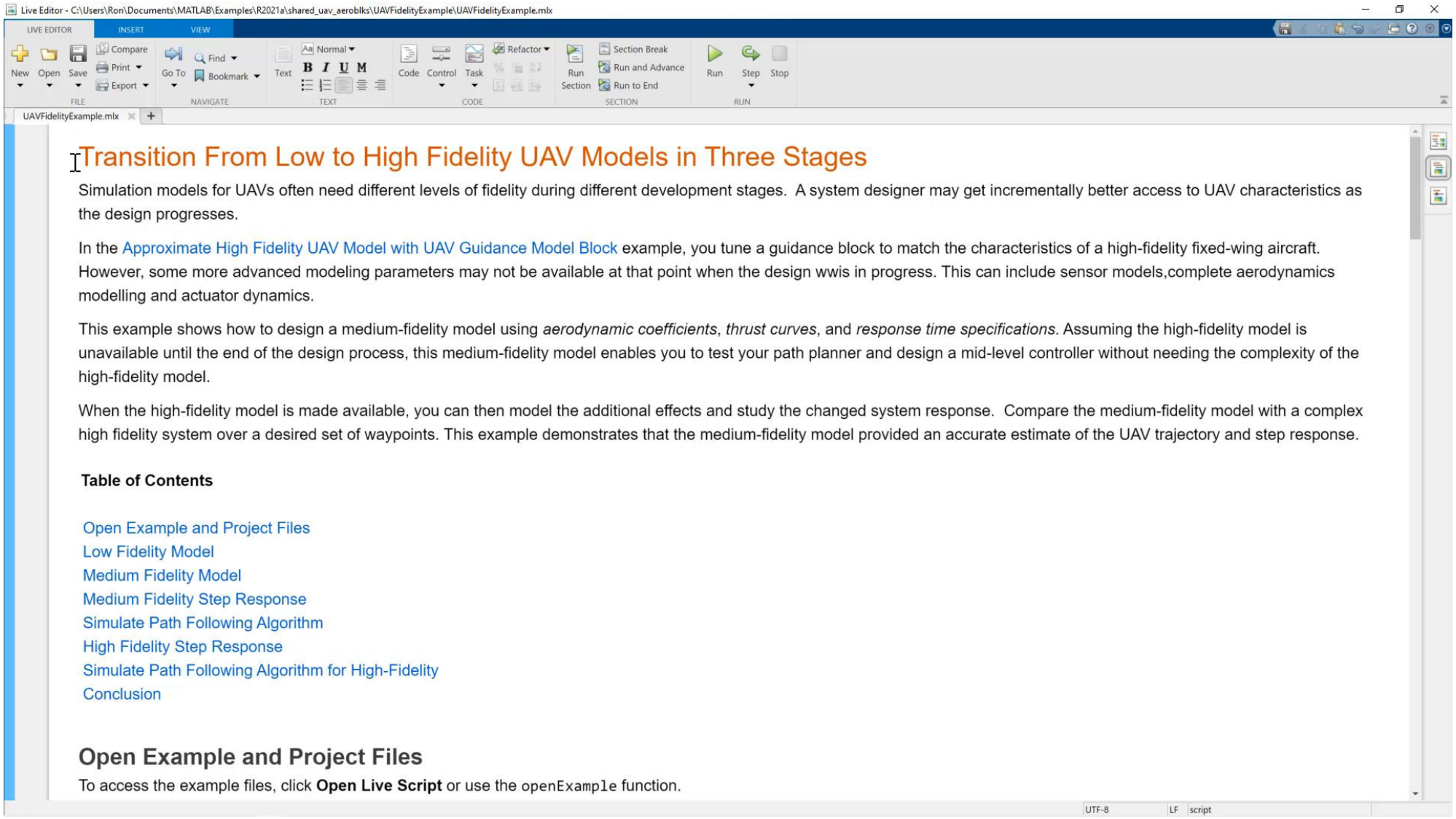


Guidance Model [Link]

Reduced-order model for UAV

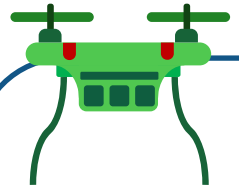
Simscape Multibody, Aerospace Blockset, UAV Toolbox

Transition From Low to High Fidelity UAV Models



Link

Integrated workflows for developing UAV applications



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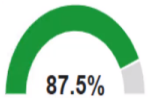
Simulink®

System Architecture

Verification & Validation



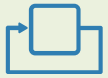
DO-178

Model UAV

Design Algorithms

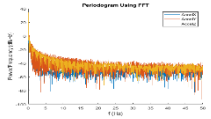
Perception

Planning & Decision

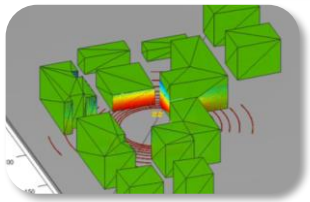


Control

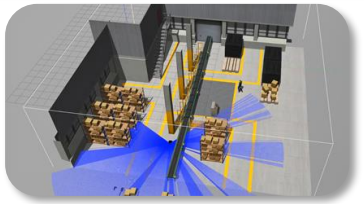
Analyze Data



Simulate with Sensor Models



Cuboid



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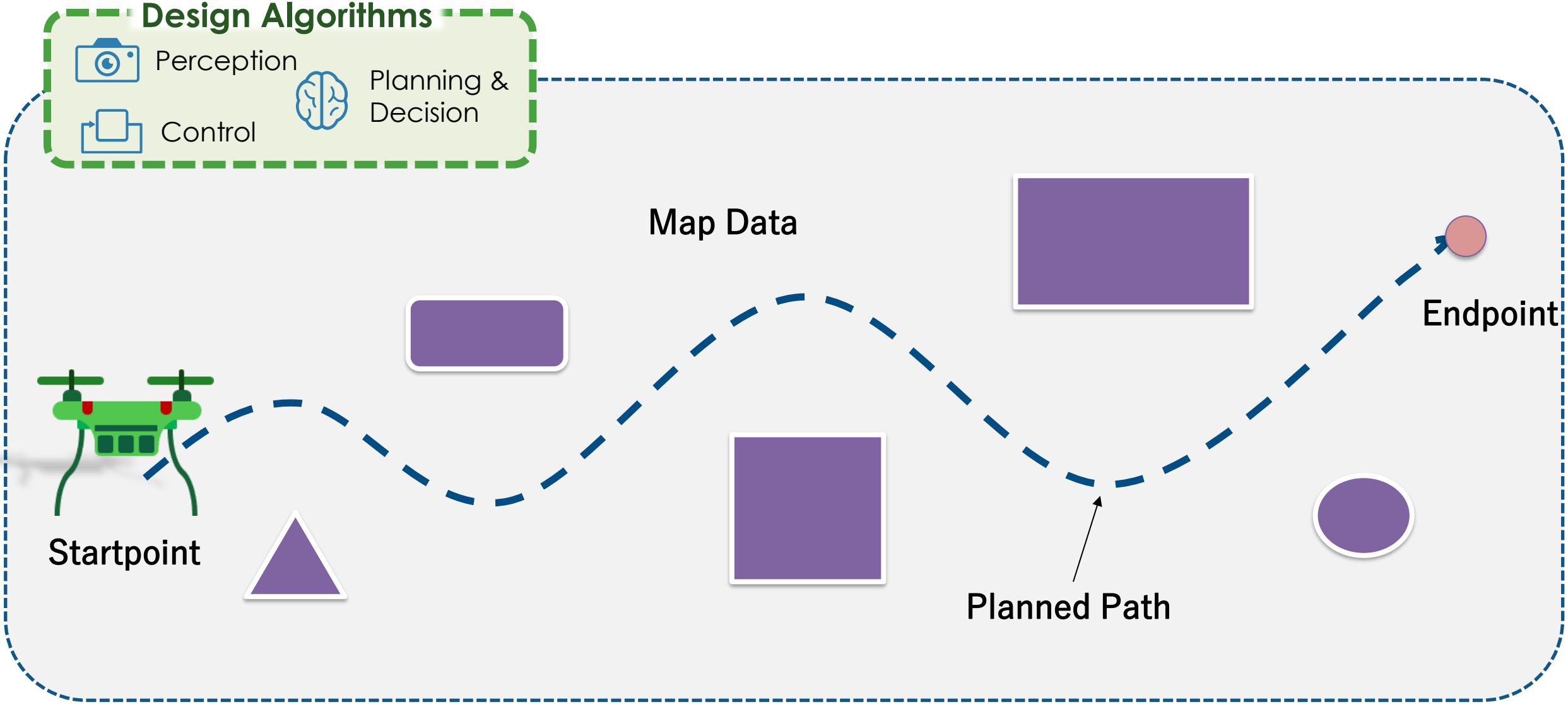
Autonomous UAV Algorithm Development



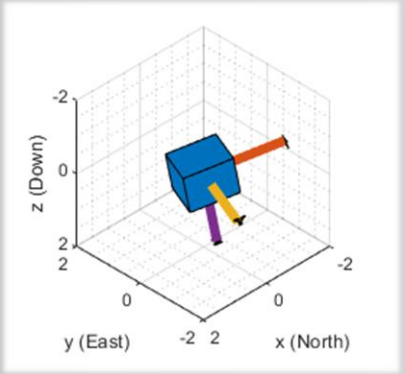
Autonomous UAV algorithm design with robust capabilities

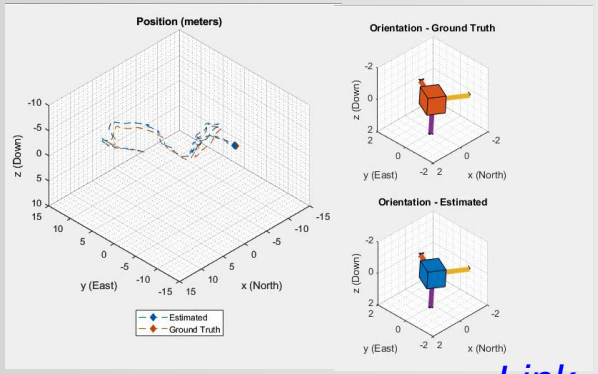
Perception

Planning & Decision

Control

Self Awareness





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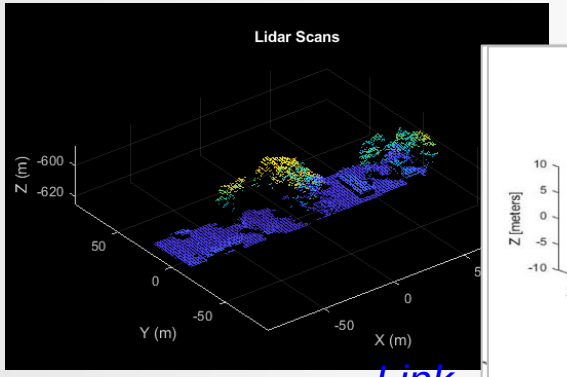

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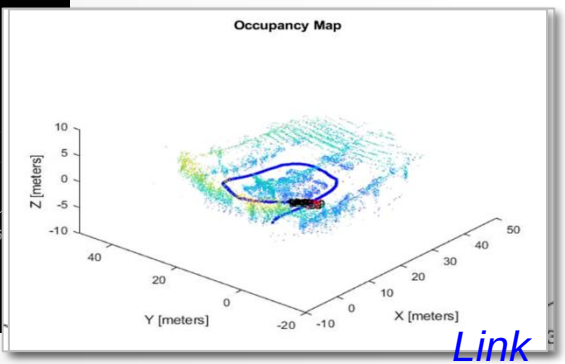
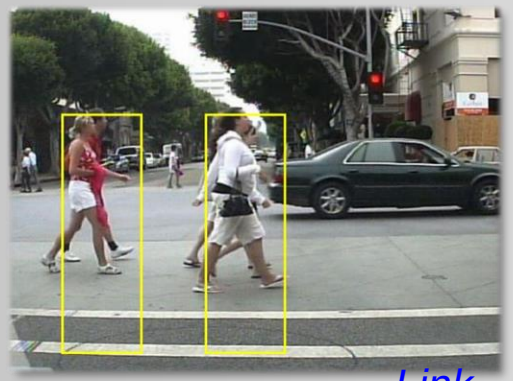


Link

Situational Awareness



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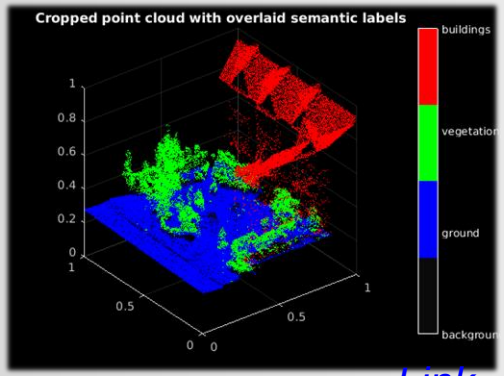

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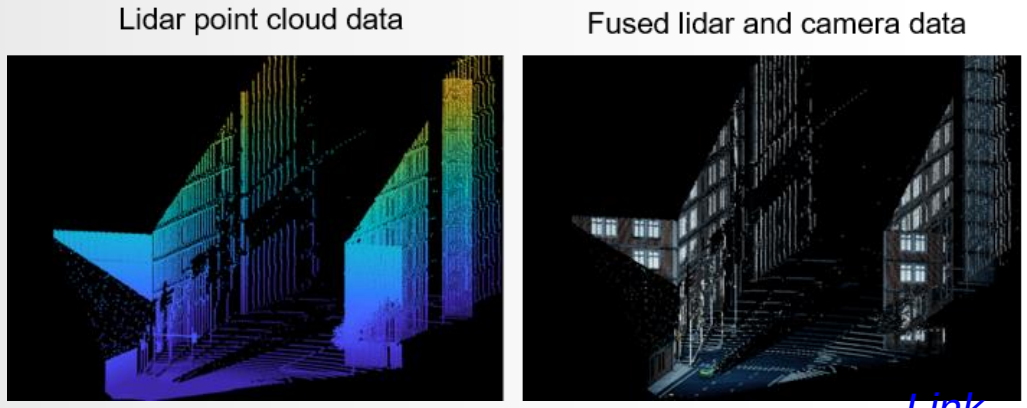
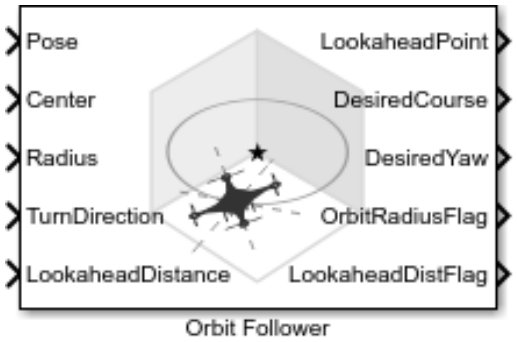


Link

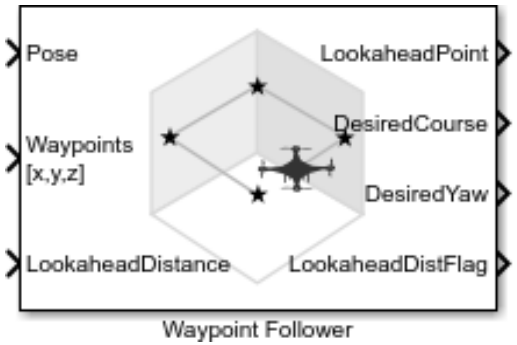
Sensor Fusion and Tracking Toolbox, Lidar Toolbox, Navigation Toolbox, Computer Vision Toolbox, Deep Learning Toolbox

Autonomous UAV algorithm design with robust capabilities

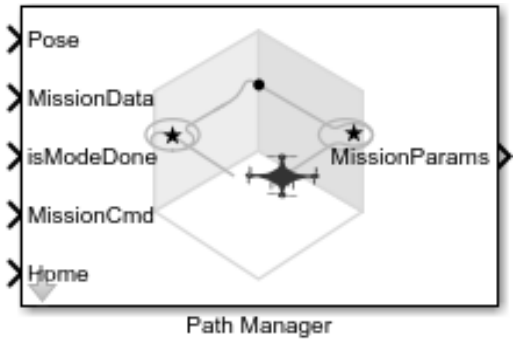
Perception | **Planning & Decision** | Control



Orbit Follower



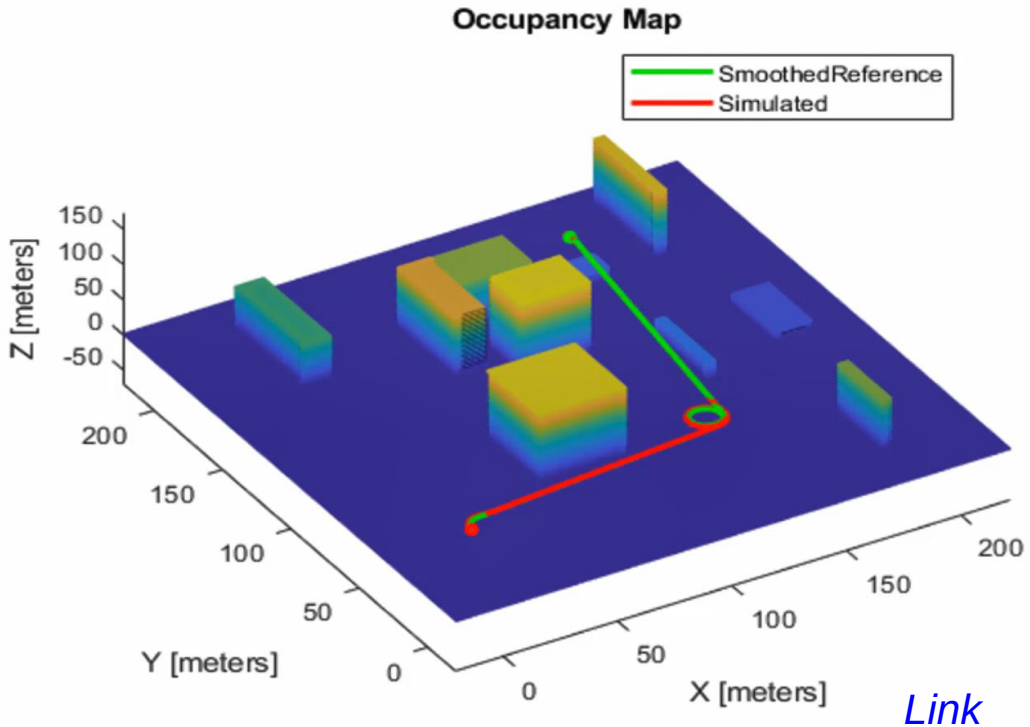
Waypoint Follower



Path Manager

Link

Define UAV missions with waypoint and trajectory-following algorithms



Link

UAV motion planning with advanced path planners

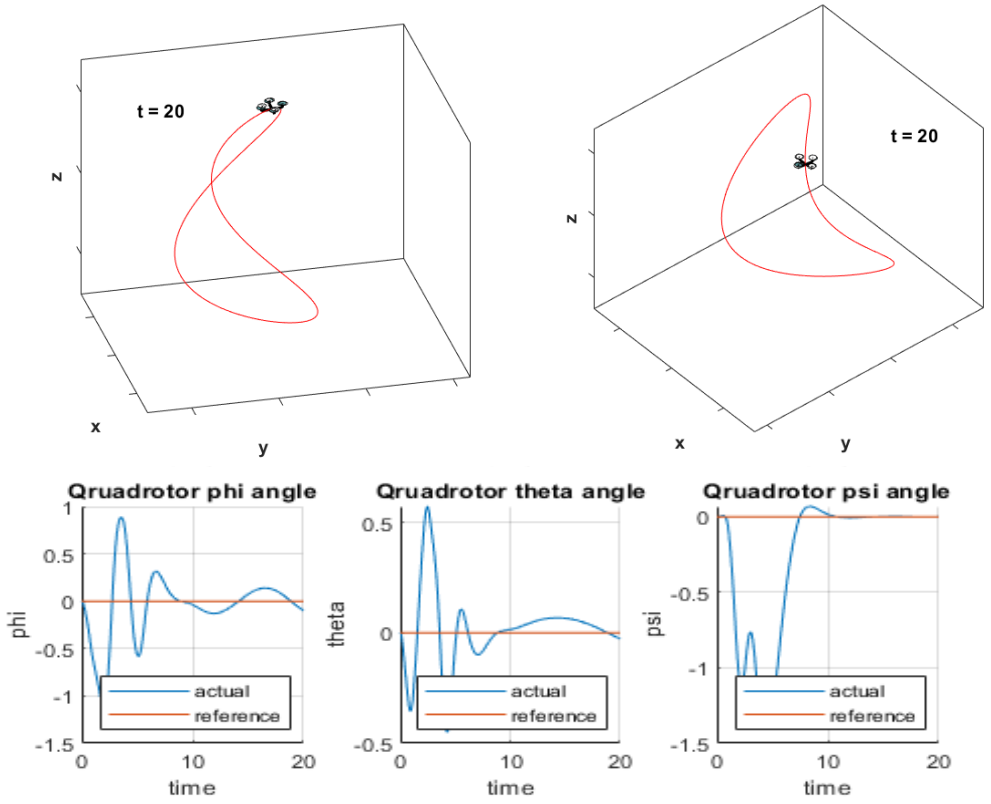
UAV Toolbox, Navigation Toolbox

Autonomous UAV algorithm design with robust capabilities

Perception

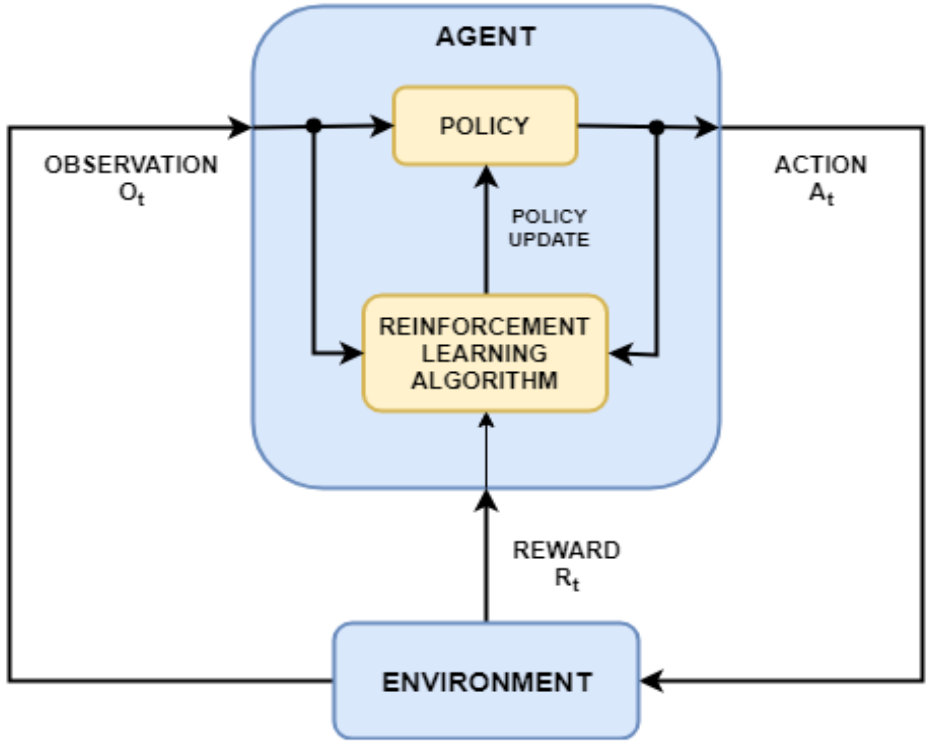
Planning & Decision

Control



Link

Trajectory tracking controller with nonlinear model predictive control (MPC)

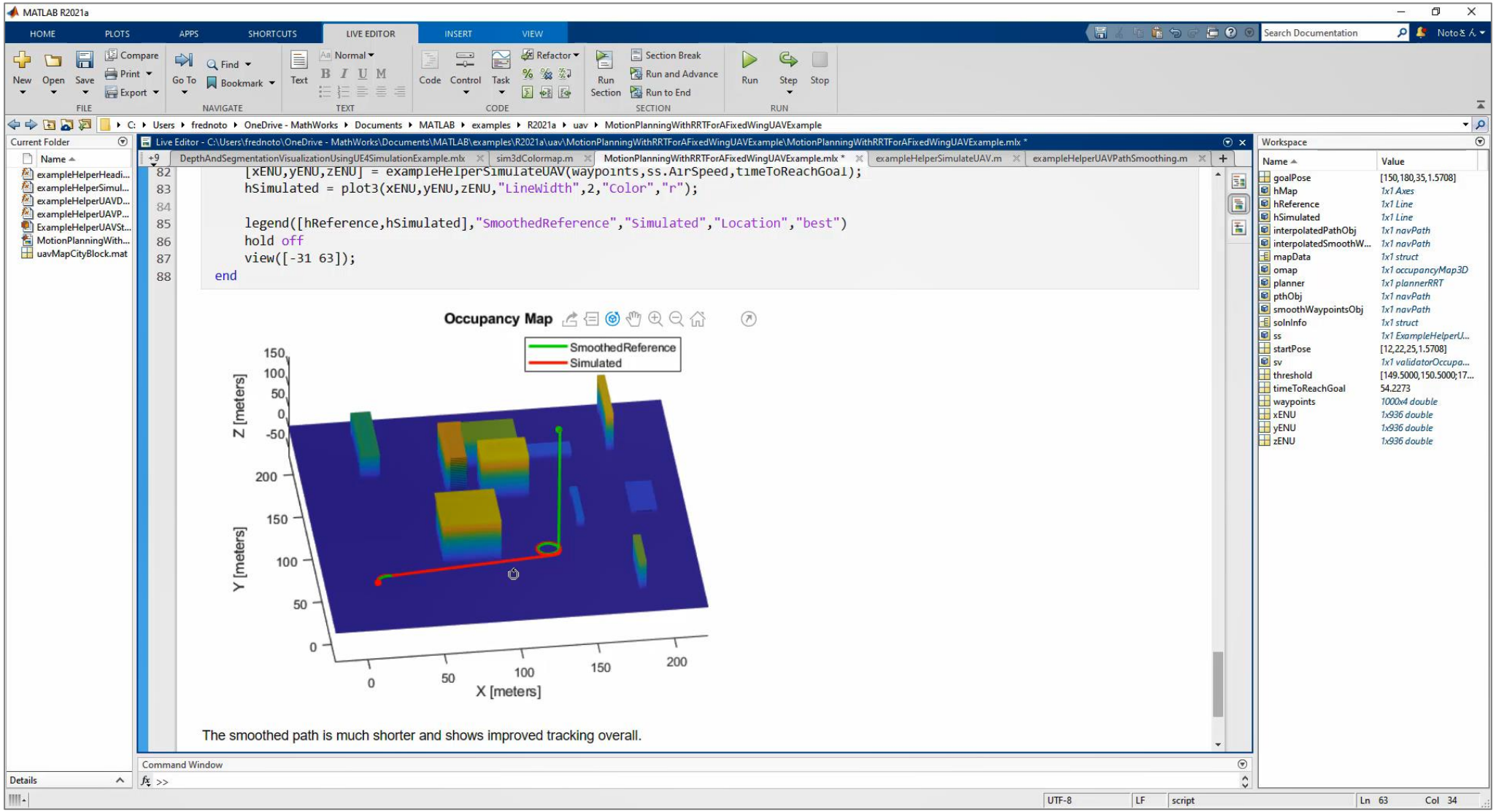


Link

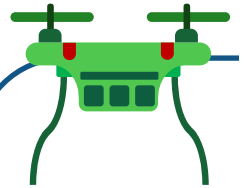
Train policies for trajectory generation using reinforcement learning algorithms

Model Predictive Control Toolbox, Reinforcement Learning Toolbox

Example: Fixed-Wing UAV Motion Planning with RRT



Integrated workflows for developing UAV applications



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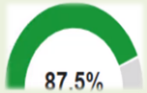
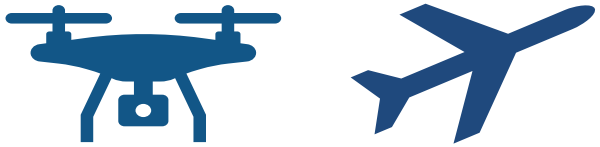


DO-178

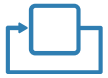
Model UAV



Design Algorithms

Perception

Planning & Decision



Control

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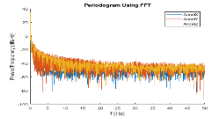

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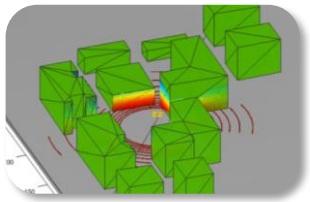

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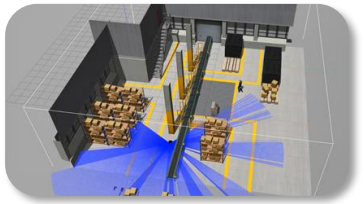

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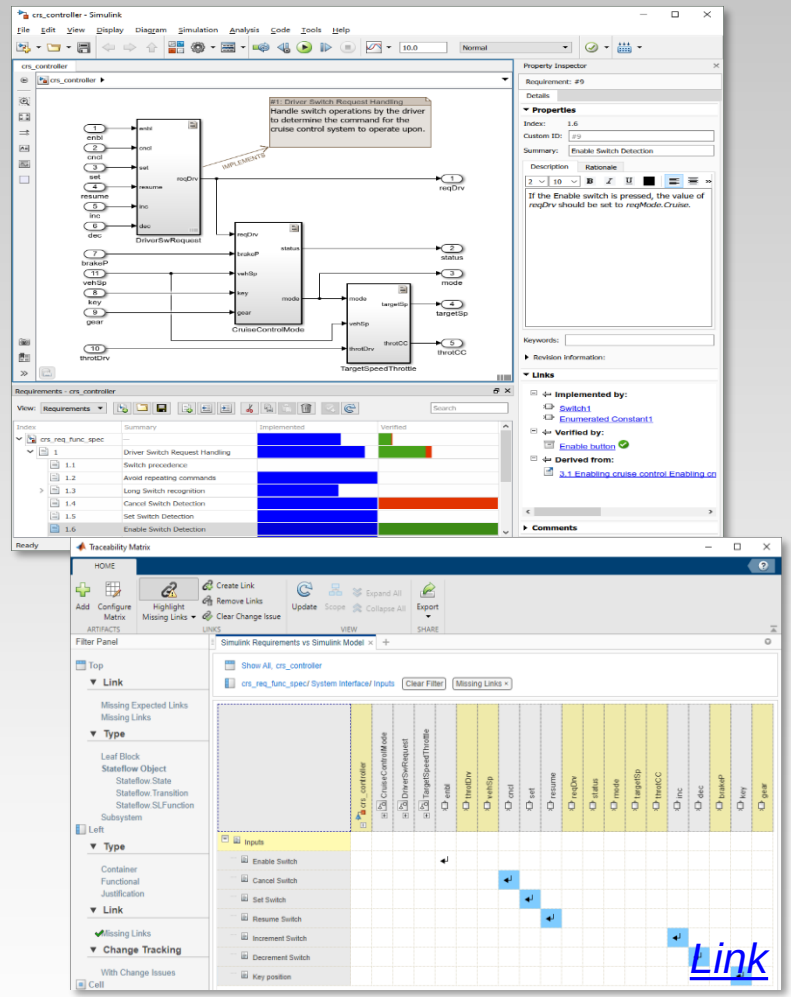
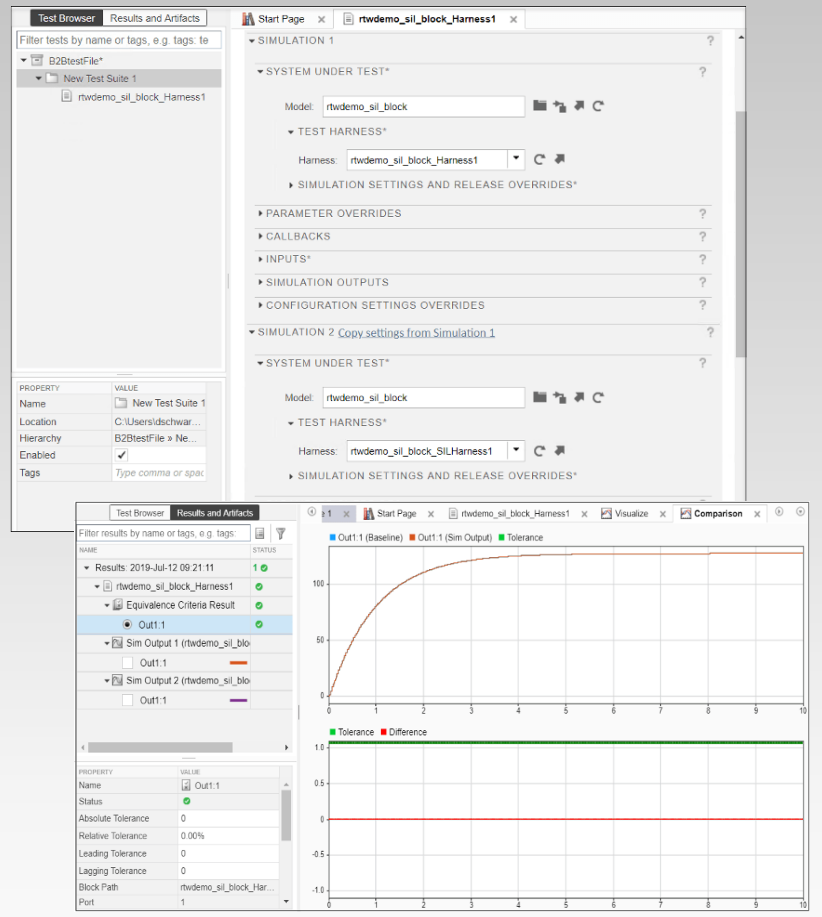
Tracking and automating verification and validation activities

Requirements Traceability



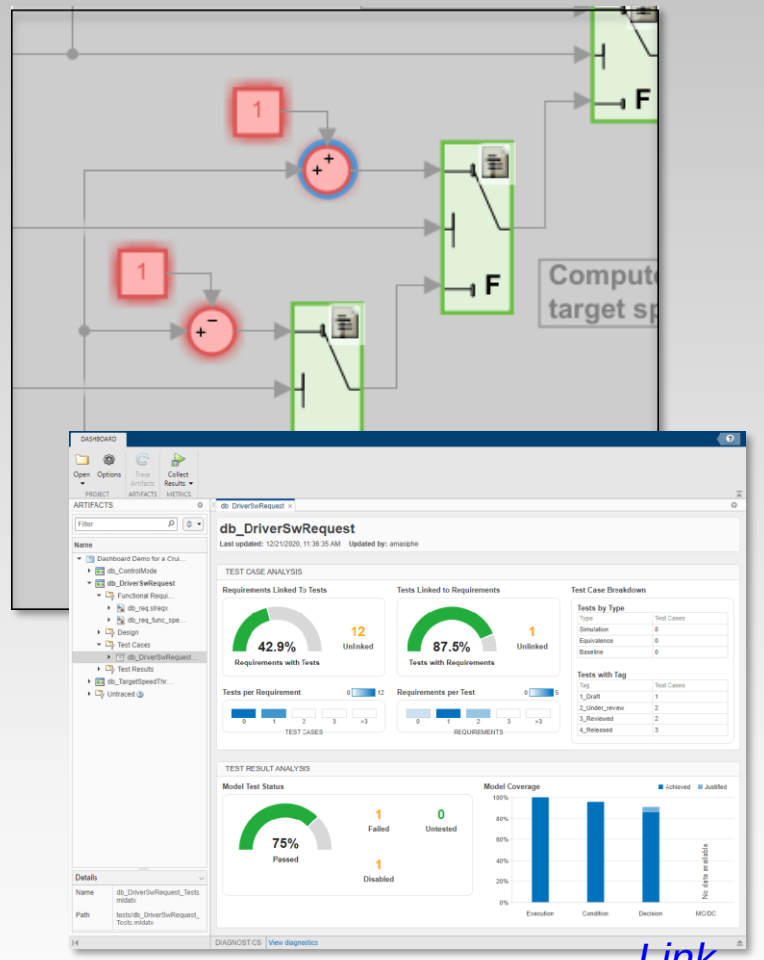
Link

Test Management & Automation



Link

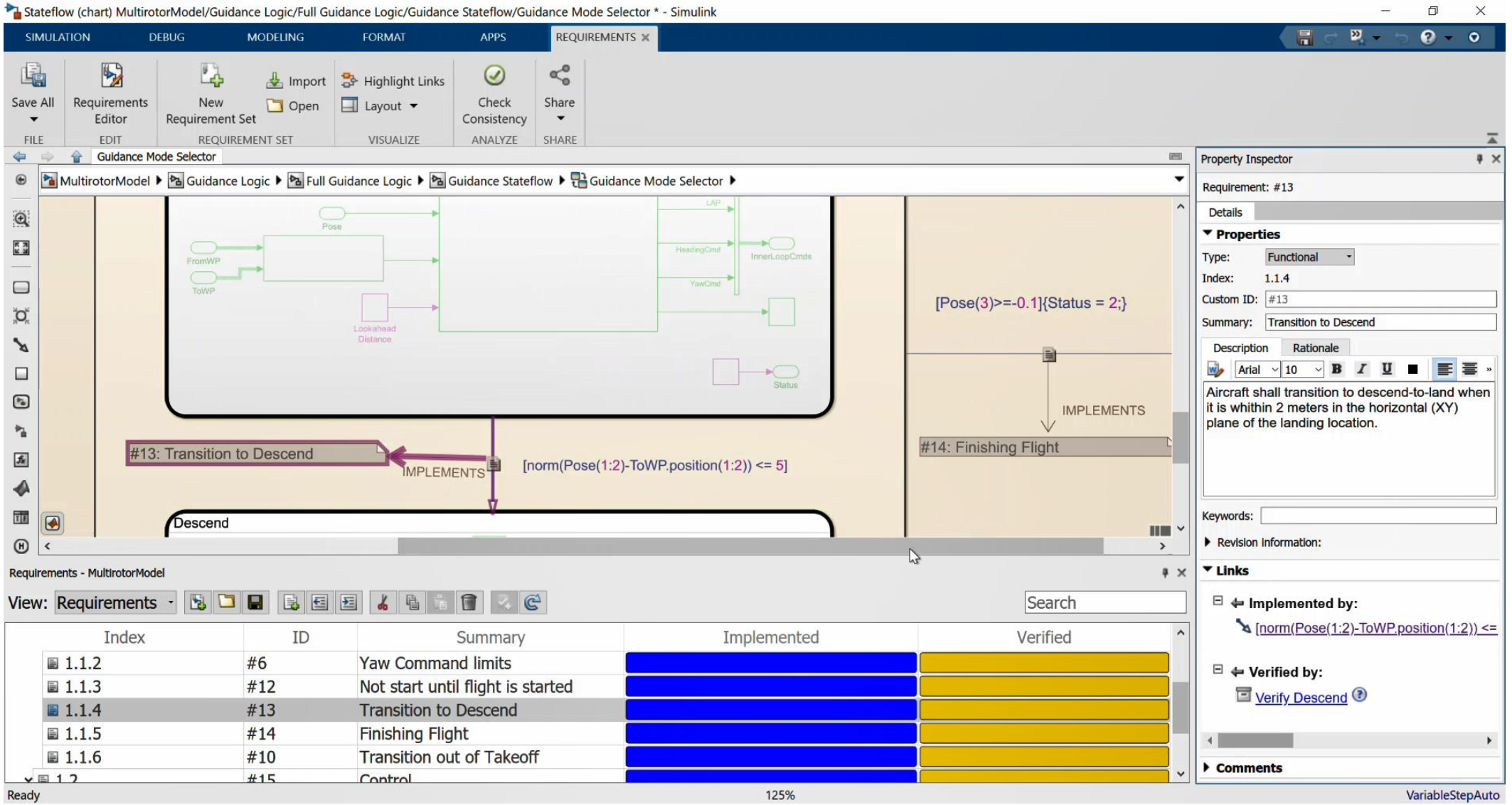
Evaluate Completeness



Link

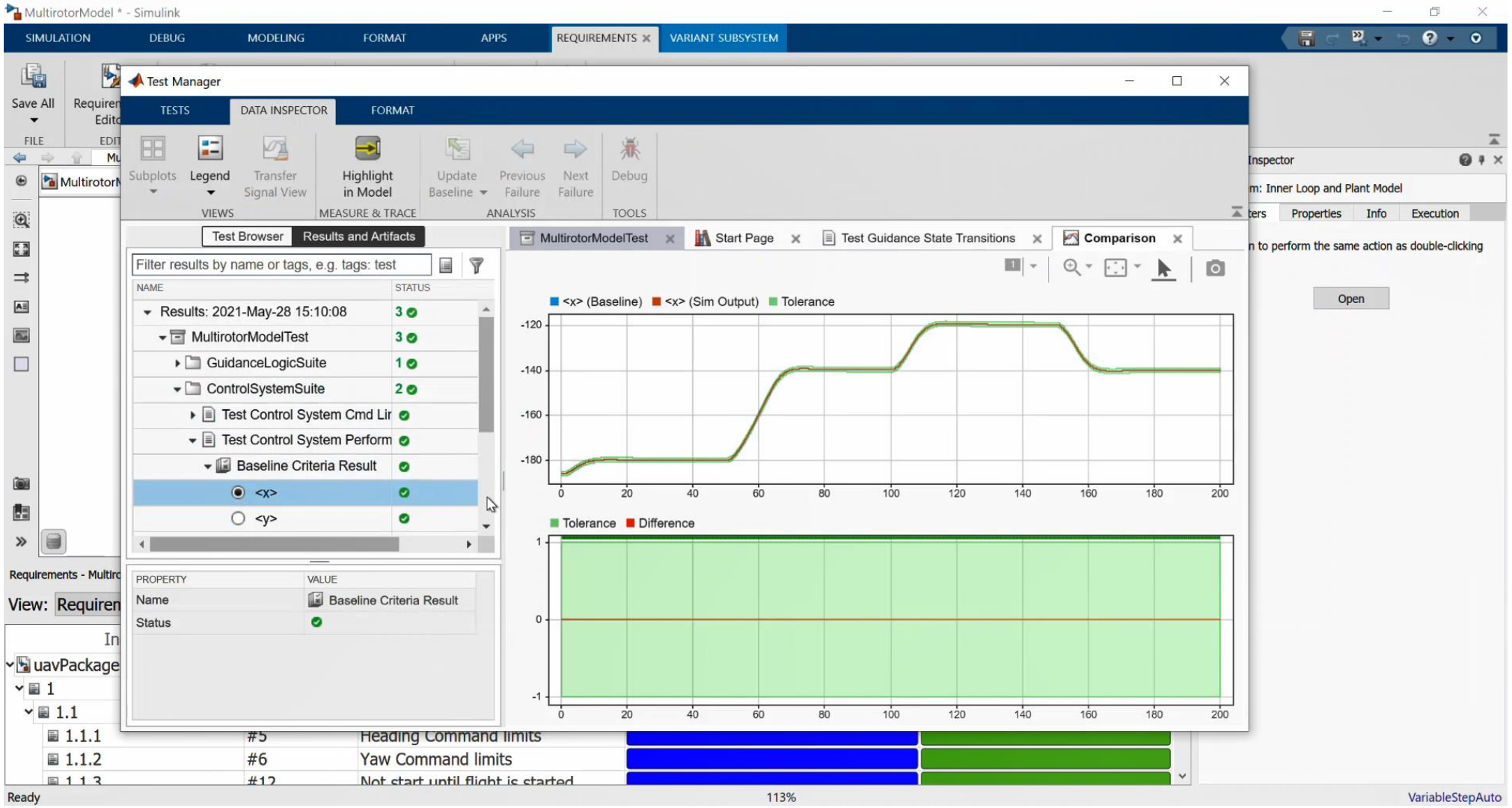
Simulink Requirements, Simulink Test, Simulink Coverage, Simulink Check

Example: Automating UAV testing with requirements linking



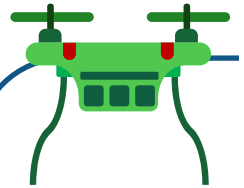
[Link]

Example: Automating UAV testing with requirements linking



[Link]

Integrated workflows for developing UAV applications

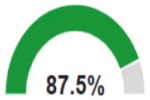


MATLAB®

Simulink®

System Architecture

Verification & Validation



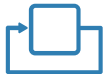
DO-178

Model UAV

Design Algorithms

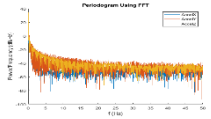
Perception

Planning & Decision

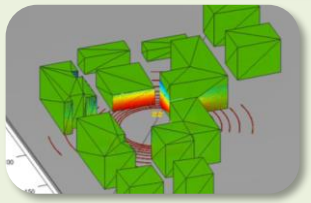


Control

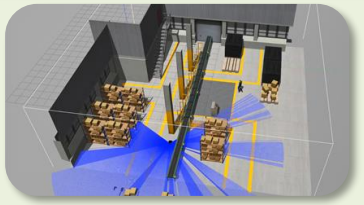
Analyze Data



Simulate with Sensor Models



Cuboid



Gazebo

Unreal Engine

Implement

Deploy to Hardware

PX4®

NVIDIA® Jetson®

Connect

Connect

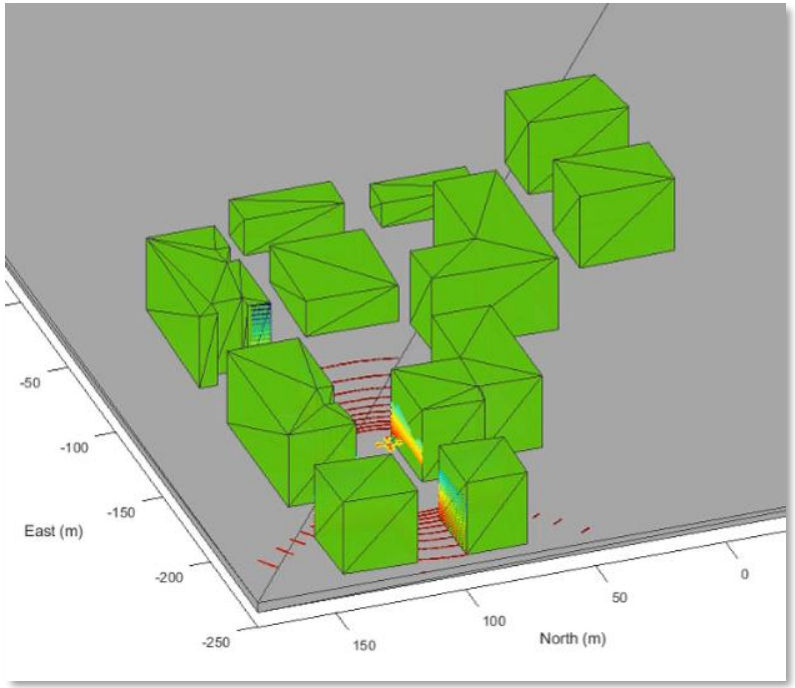
UAV

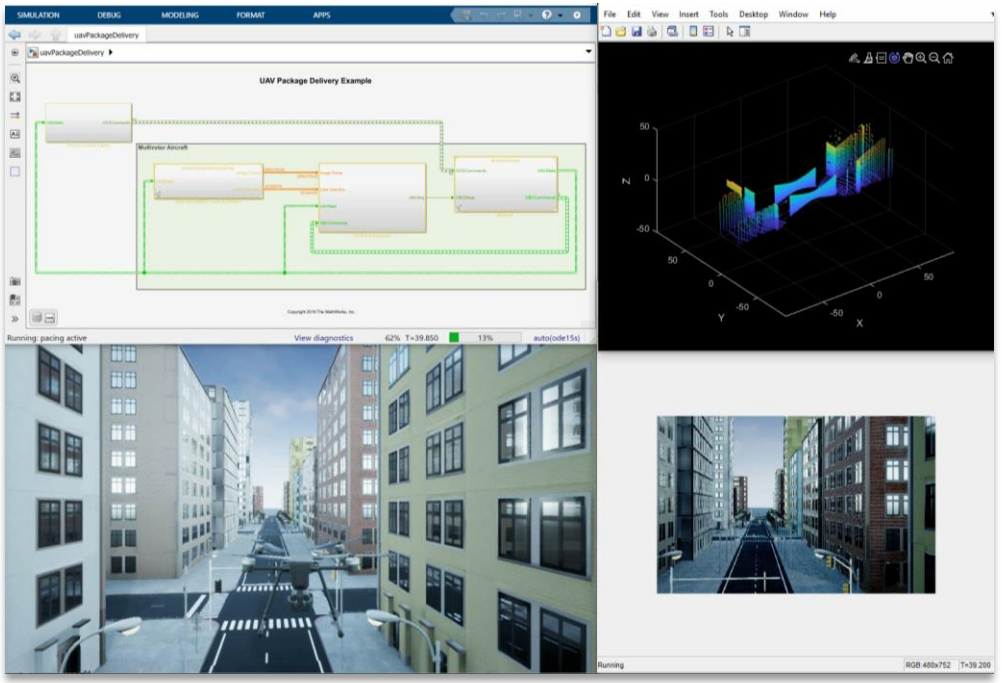
Ground Control Station

Integrated simulations with sensor models

Cuboid
Performance

Unreal Engine®
Photorealistic





Rapidly author scenarios and generate sensor data

UAV Toolbox

Link

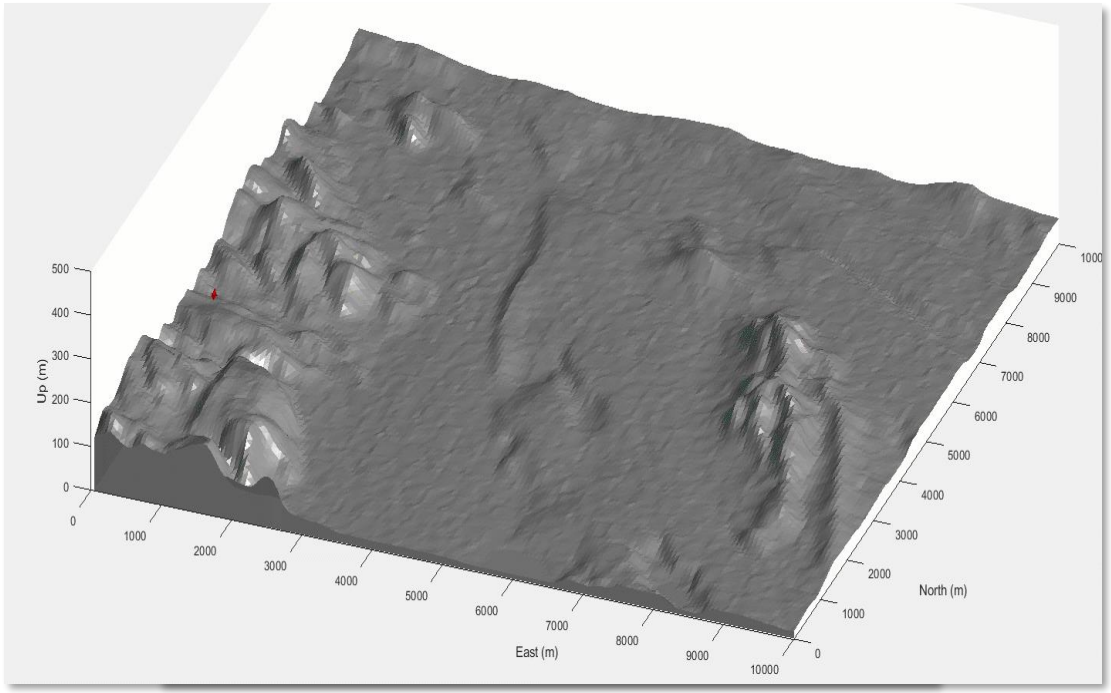
Realistic graphics to test autonomous algorithms in closed-loop simulations

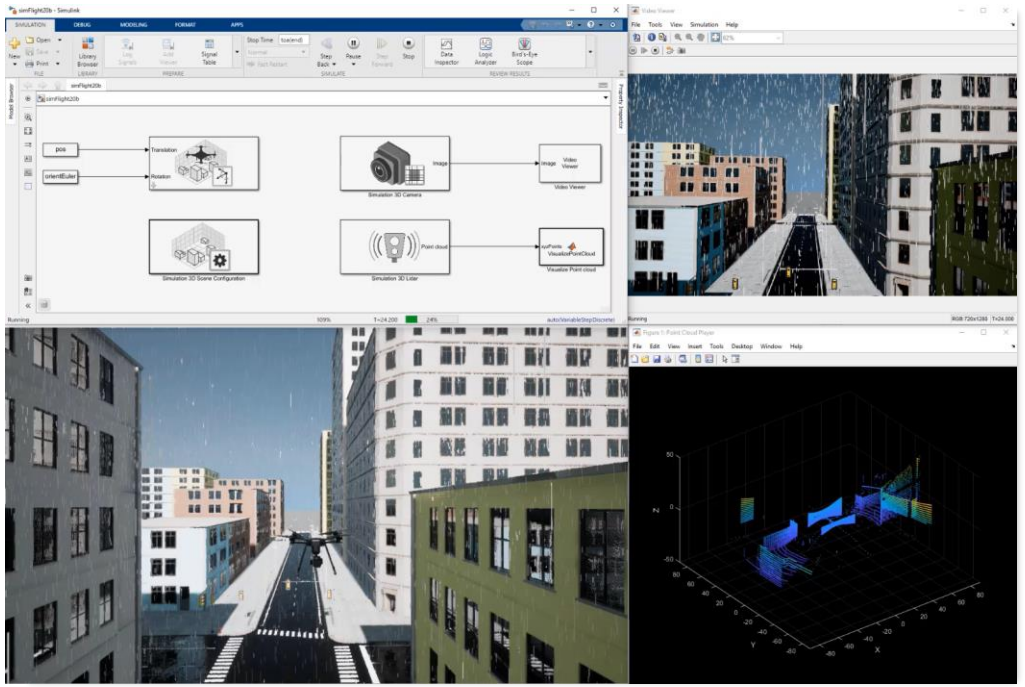
Link

Integrated simulations with sensor models

Cuboid
Performance

Unreal Engine®
Photorealistic





Rapidly author scenarios and generate sensor data

Realistic graphics to test autonomous algorithms in closed-loop simulations

UAV Toolbox

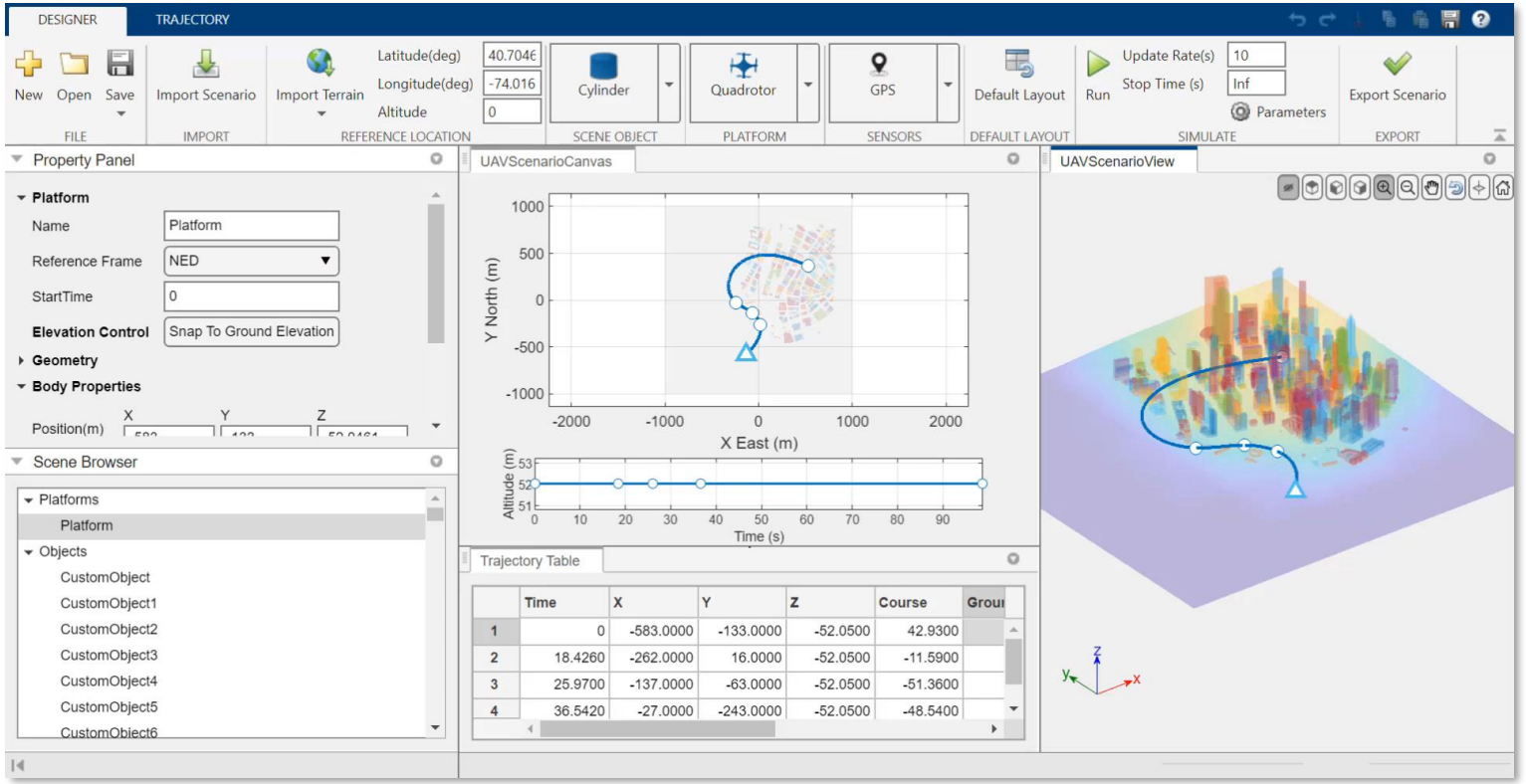
Link

Link

UAV Scenario Designer App

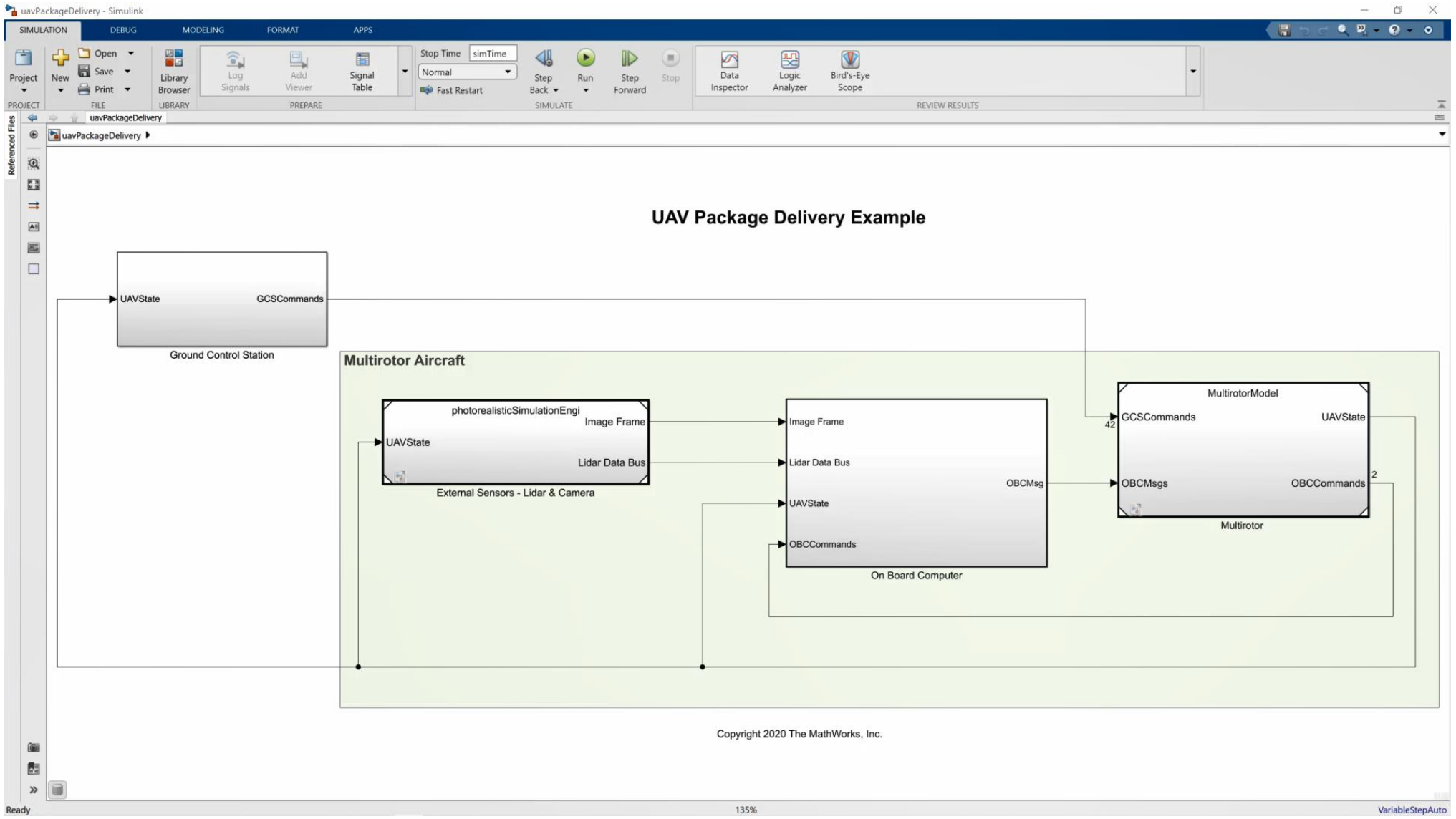
Interactively design and visualize UAV simulation scenarios

- Edit scene terrain, objects, platforms, and sensors
- Create platform trajectories and simulate scenarios
- Import/export UAV scenarios



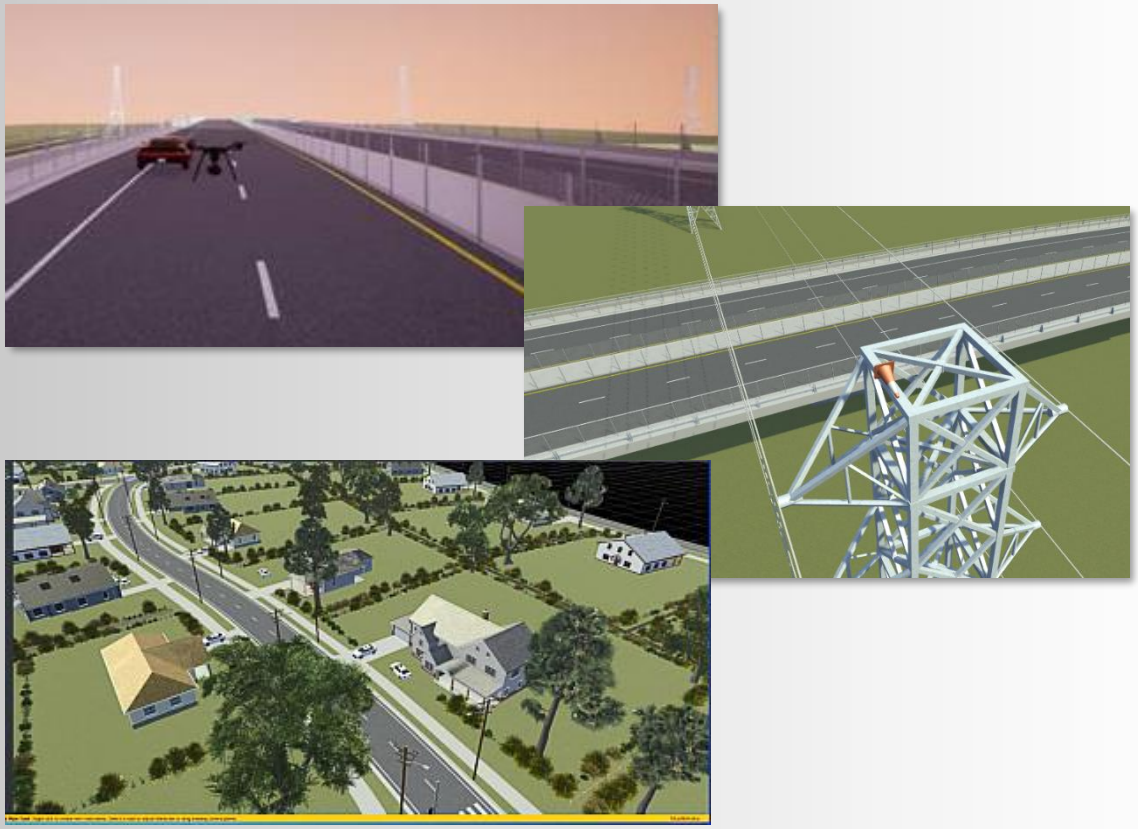
Link

Integrated simulations with sensor models



Create 3D scenes for UAV simulations

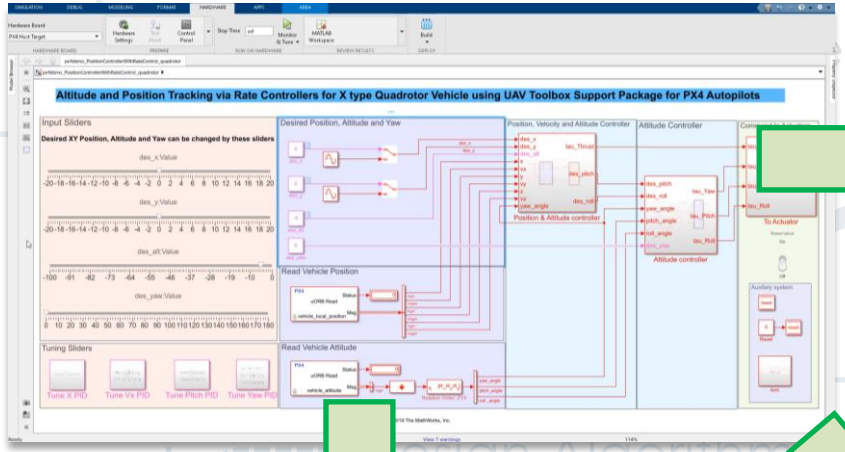
Link



Design 3D scenes for simulating and testing autonomous algorithms

RoadRunner, RoadRunner Asset Library, UAV Toolbox Interface for Unreal Engine Projects

Automatic code generation for hardware implementation



Deploy flight controls to autopilot hardware

Link

Deploy to Hardware

PX4®

NVIDIA® Jetson®

CPU

FPGA

GPU

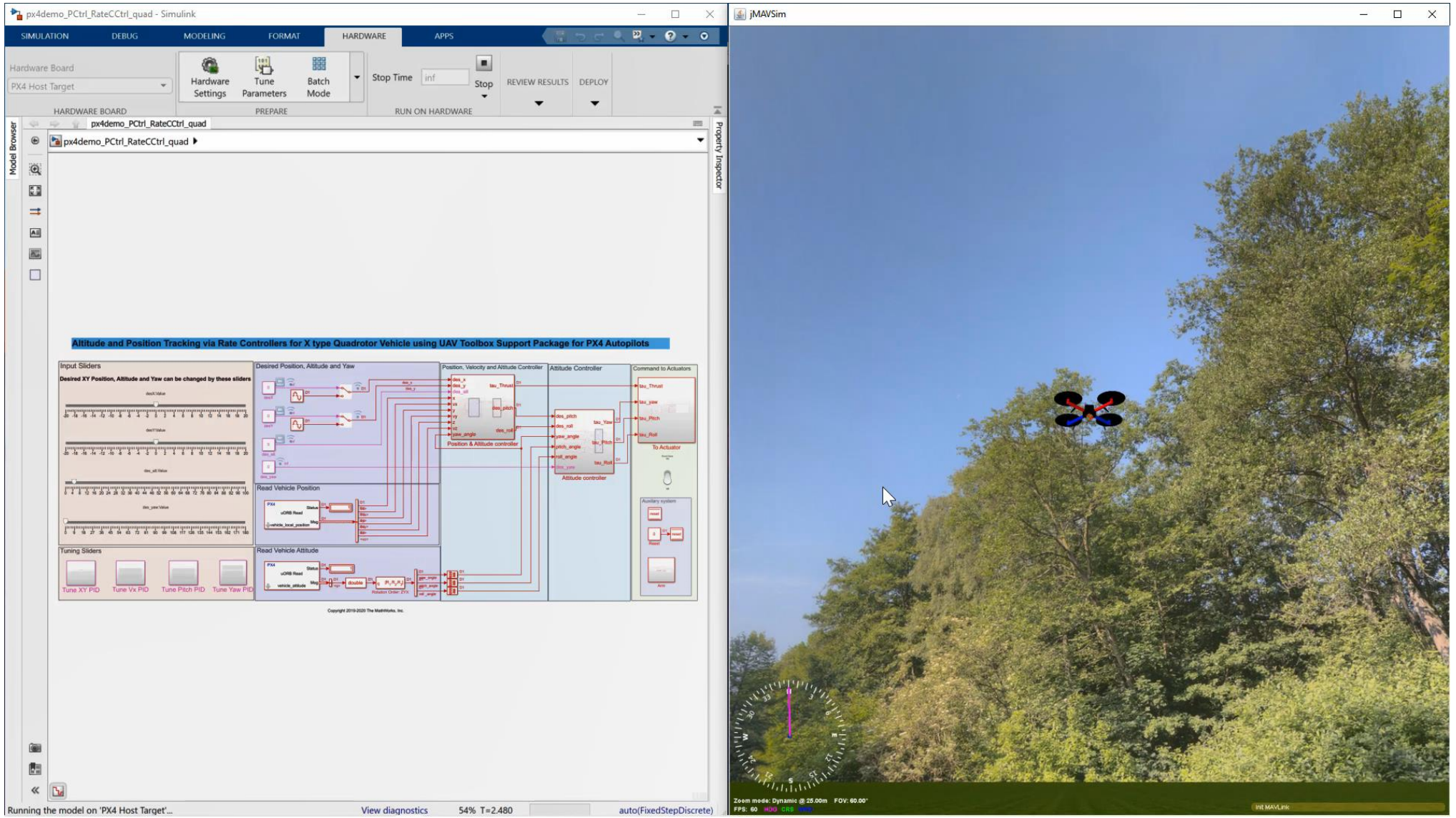
ROS

Deploy autonomous algorithms to onboard computers

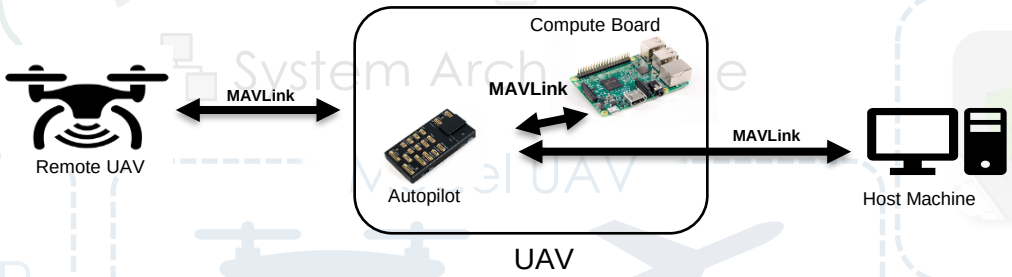
Link

UAV Toolbox, Simulink Coder, Embedded Coder, GPU Coder

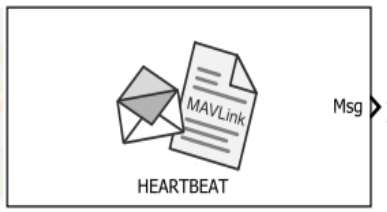
Deploy flight control algorithms to PX4 Host Target

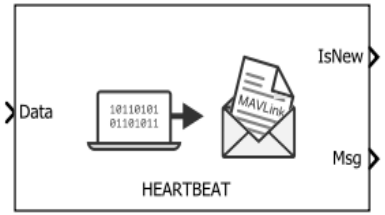


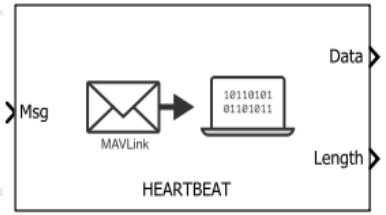
Connecting to UAV hardware through MAVLink protocol



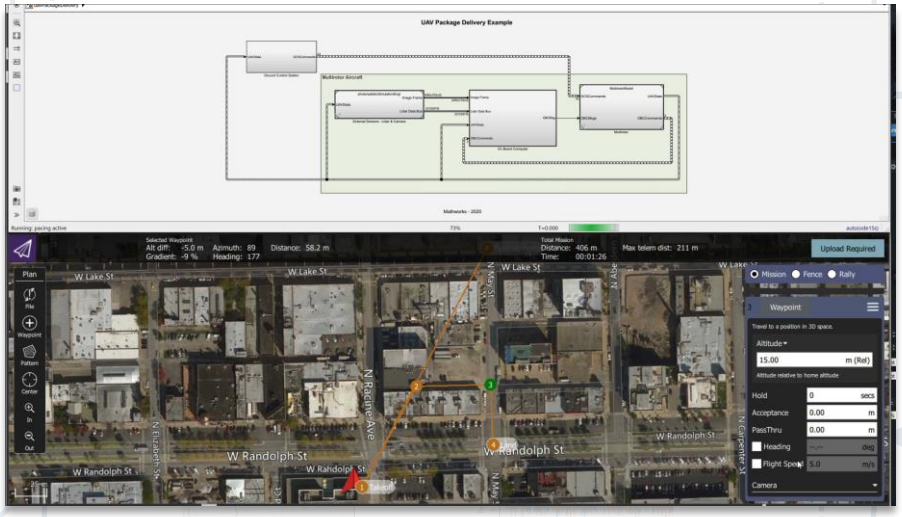
MAVLink Connectivity





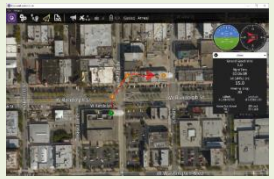


Message Blocks



[Link]

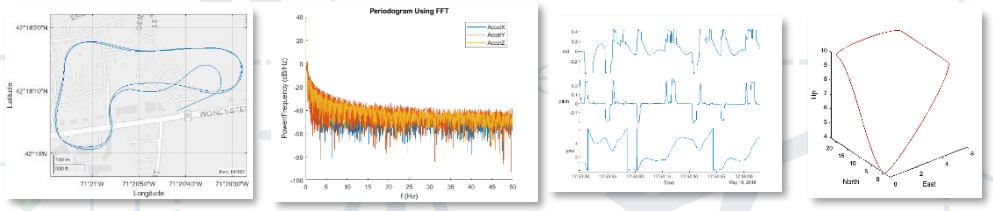
Connect

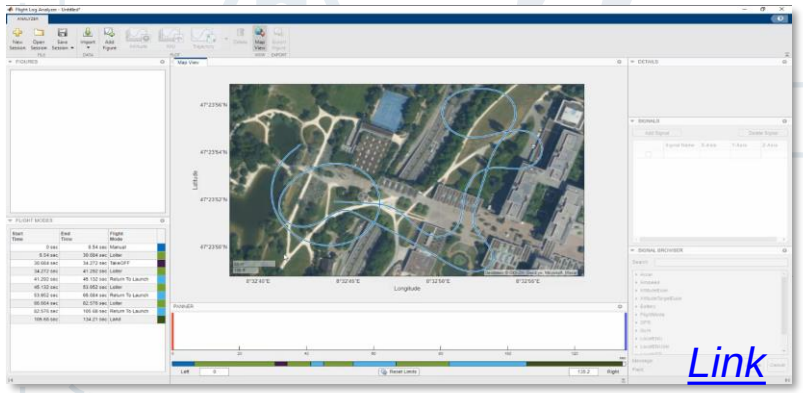


UAV Ground Control Station

Post-flight data analysis

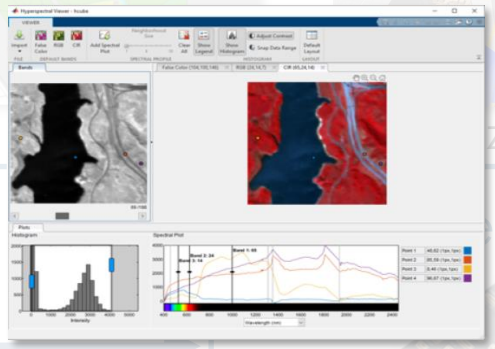
Flight Log Analysis

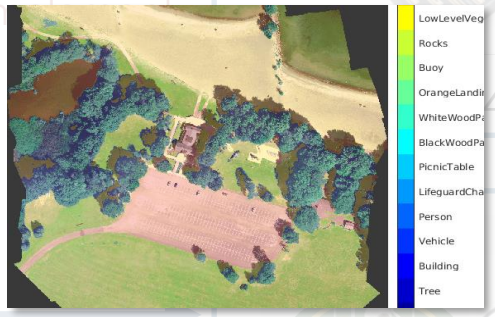




Link

Payload Data Analysis





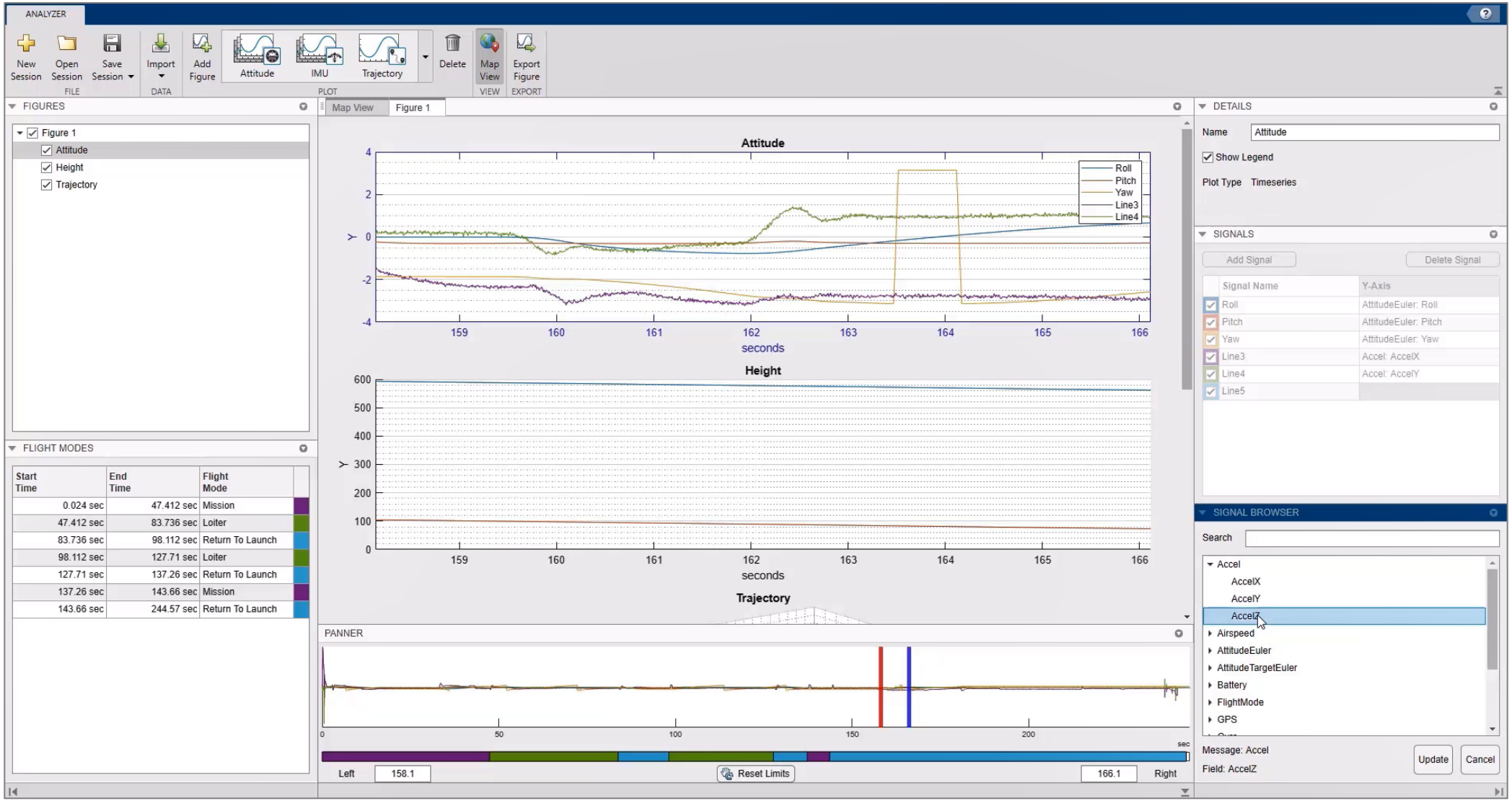
Link

Link

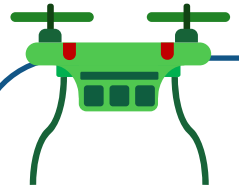
Analyze Data

UAV Toolbox, Computer Vision Toolbox, Deep Learning Toolbox

Example: Flight Log Analysis



Integrated Workflows for Developing UAV Applications

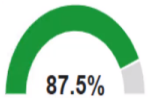


MATLAB®

Simulink®

System Architecture

Verification & Validation



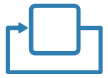
DO-178

Model UAV

Design Algorithms

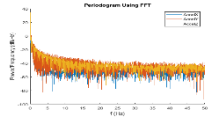
Perception

Planning & Decision

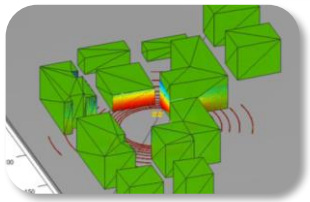


Control

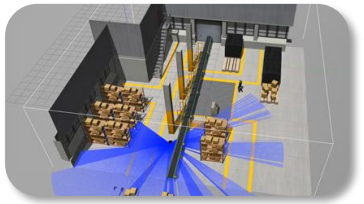
Analyze Data



Simulate with Sensor Models



Cuboid



Gazebo

Unreal Engine

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Deploy to Hardware

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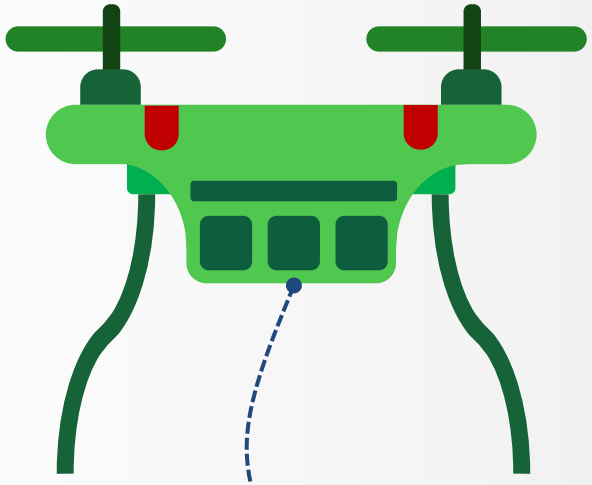
UAV

Ground Control Station

Key Takeaways



Call To Action:

- Download presentation file and investigate linked examples and pages
- Contact us for to learn more details or for trials

Integrated development workflows from prototyping to productization with MATLAB and Simulink

Robust tools/features for autonomous UAV design and simulations with sensor models

Quality through verification & validation tools for traceability, test completeness, and test management/automation

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