Accelerating Physical AI Development with MATLAB, Simulink, and Agentic AI

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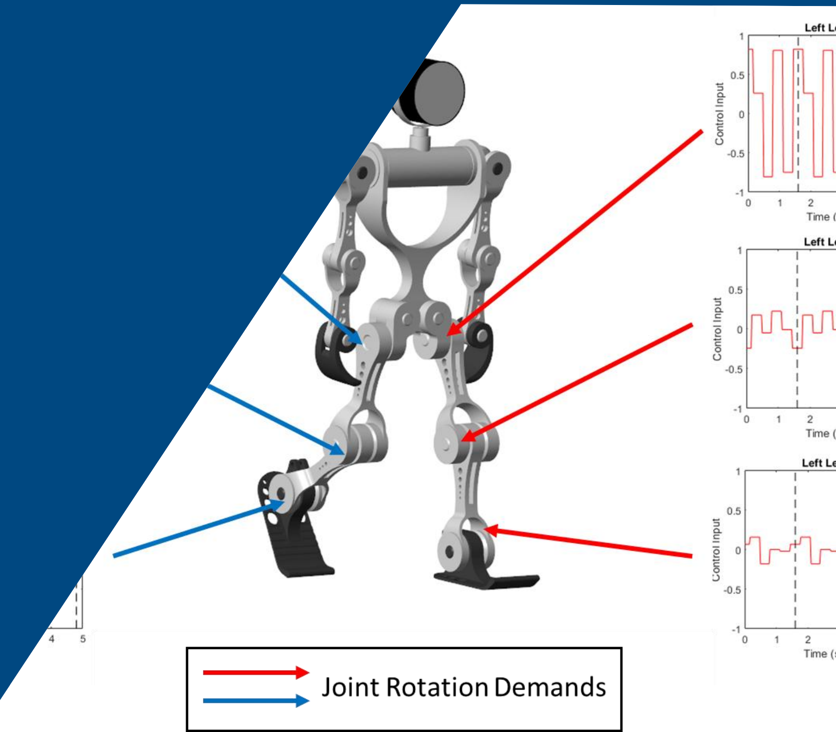


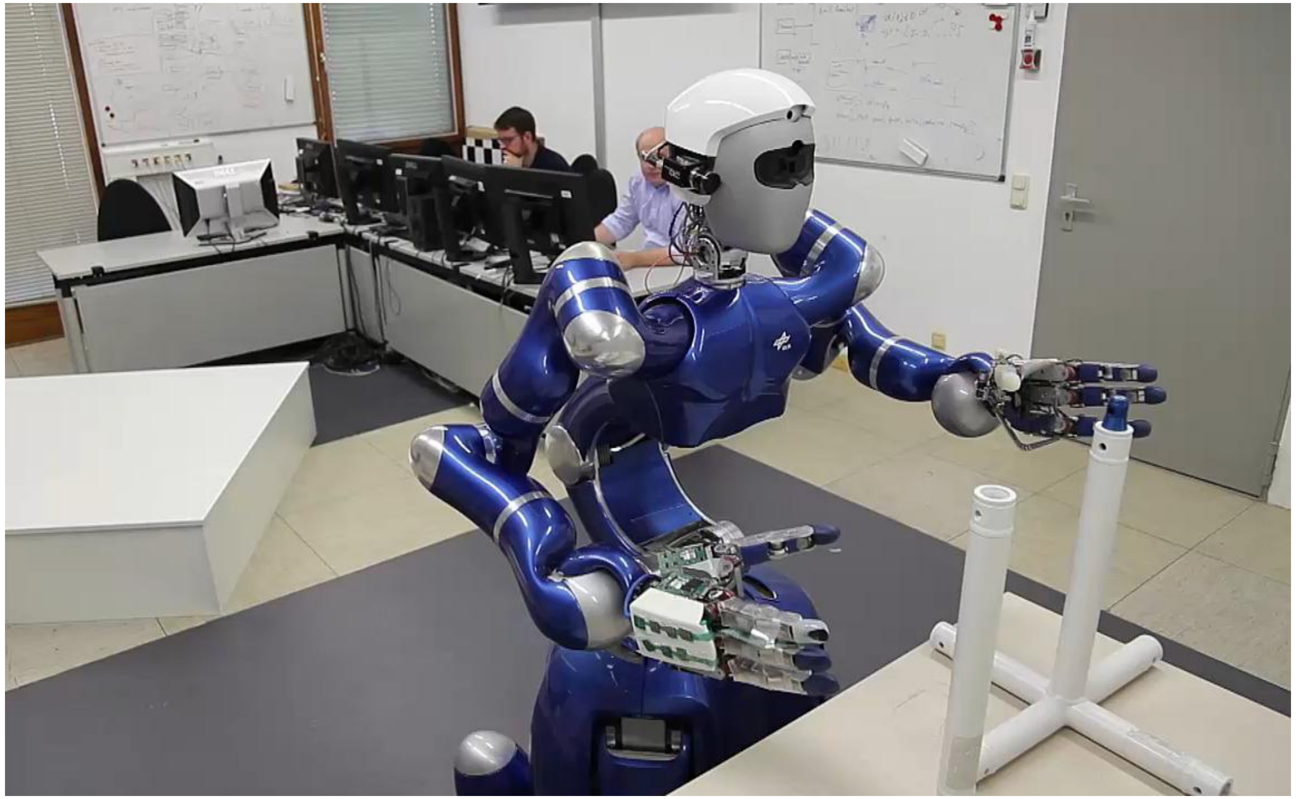
Meet Agile Justin

Built by the German Aerospace Center, Using Model-Based Design

Stereo Vision and RGB-D Camera

53 Degrees of Freedom

Full Body Real-Time Control System

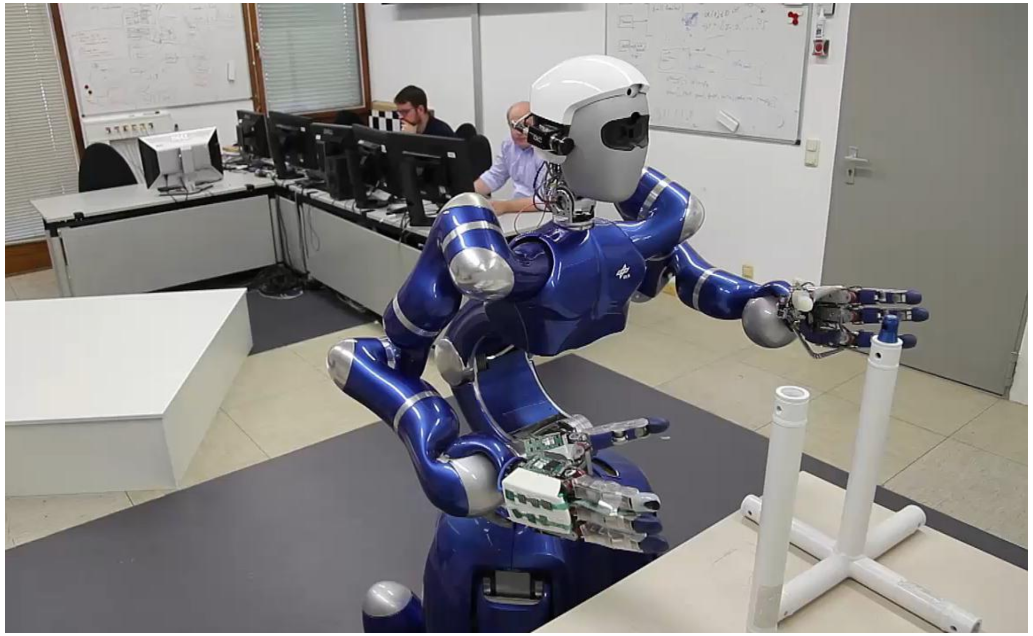


Credit:
Berthold Bäuml -- Head of Autonomous Learning Robots Lab
DLR, Robotics and Mechatronics Center (RMC)
MathWorks' DCRG project

Meet Agile Justin

Built by the German Aerospace Center, Using Model-Based Design

"For a throwing motion, Justin's controllers coordinate 20 degrees of freedom to produce an optimal TCP trajectory," says Bäuml. "We did this work in one afternoon using MATLAB, Simulink, and Optimization Toolbox."



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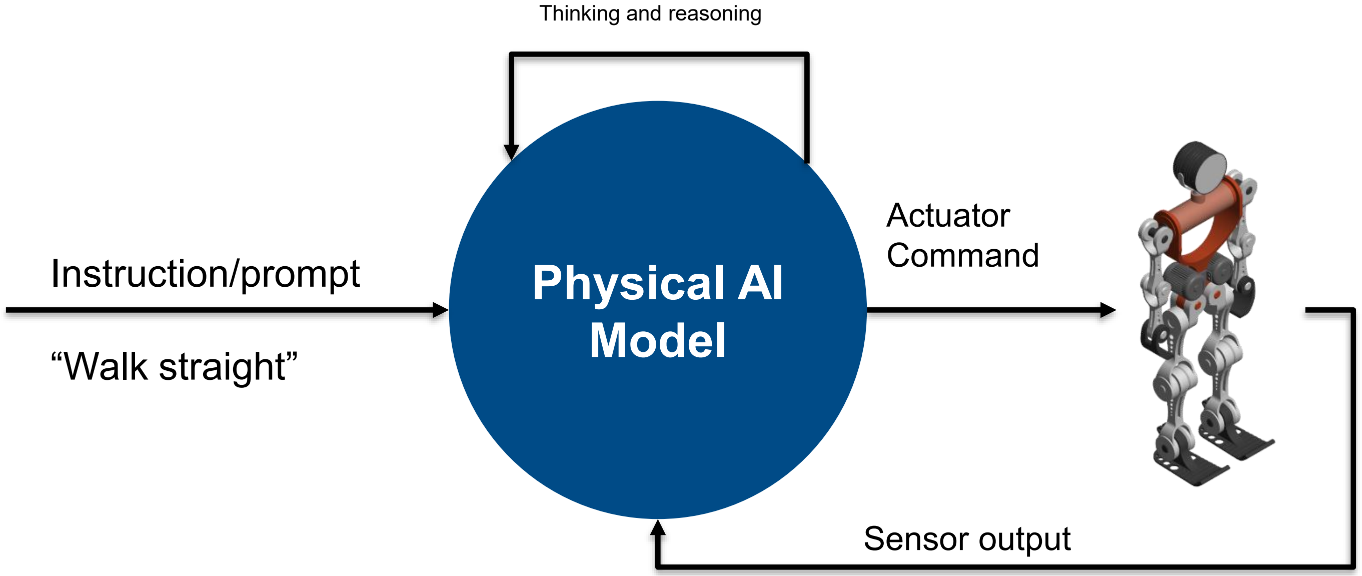
What is Physical AI?

Systems that perceive and understand the physical world and can act on it. Physical AI is the general term for such systems

Covers every area where digital systems and reality intersect, including robotics, autonomous driving, and industrial control

Perceive　Perception	**Reason　Thinking and reasoning**	**Act**
Perceive and model the environment using cameras, LiDAR, and sensors	Understand the situation and determine the best action for the goal	Act directly on the physical world with actuators and robots



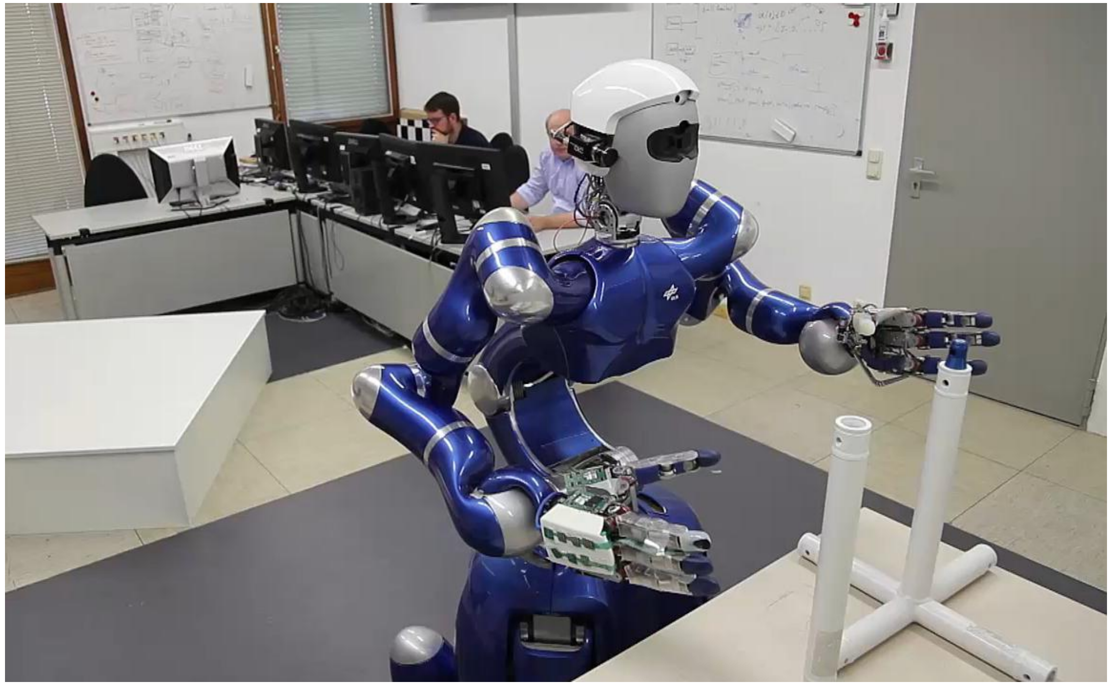
Physical AI systems are systems that can Sense, Think, and Act

Perception

Sensor Fusion

Planning

Controls



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MathWorks' DCRG project

Physical AI systems are systems that can Sense, Think, and Act

Example: Autonomous Driving Vehicle

Perception

↓

Sensor Fusion

↓

Planning

↓

Controls

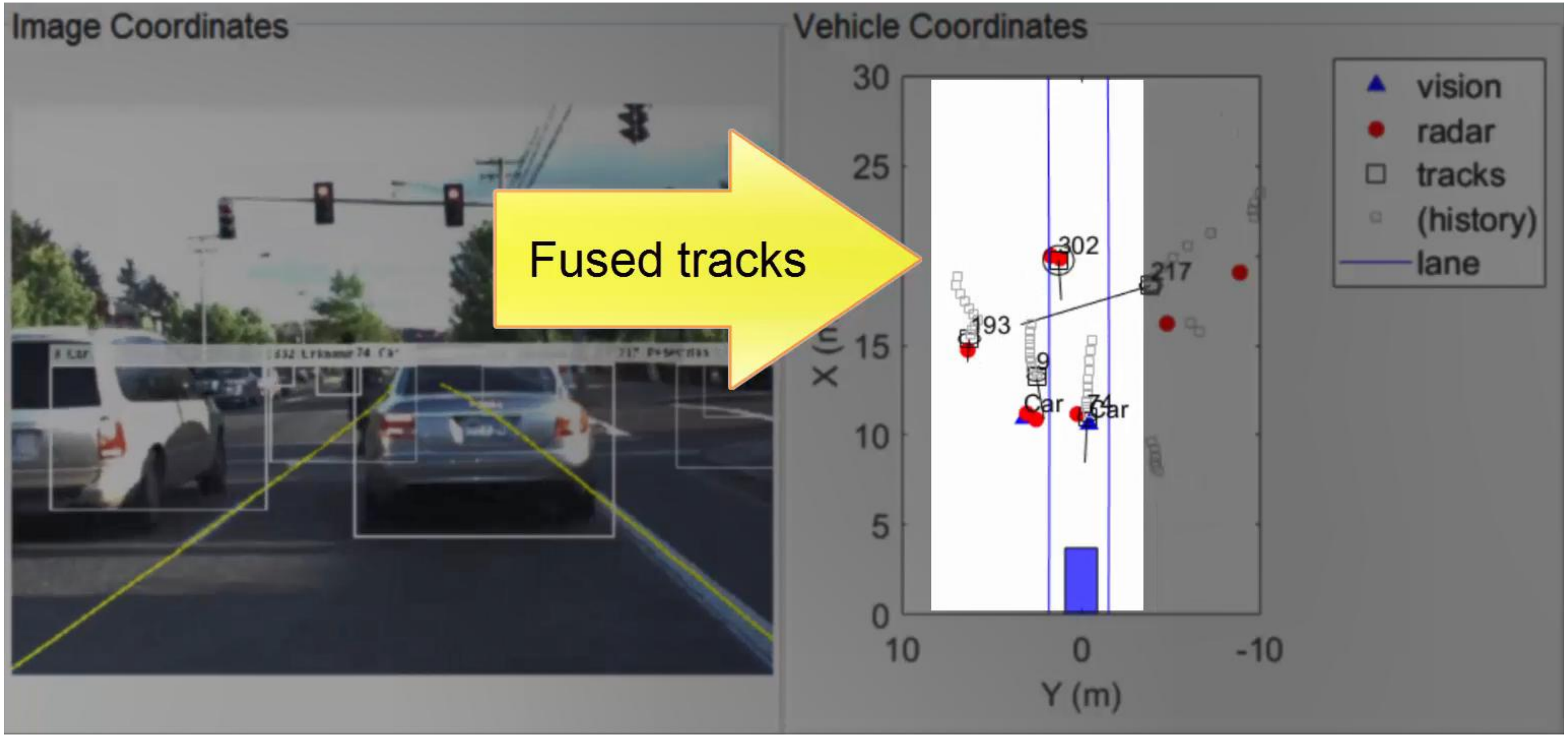
Perception systems understand the environment

Perception

Sensor Fusion systems combine information from multiple sensors and predict future states

Perception

Sensor Fusion

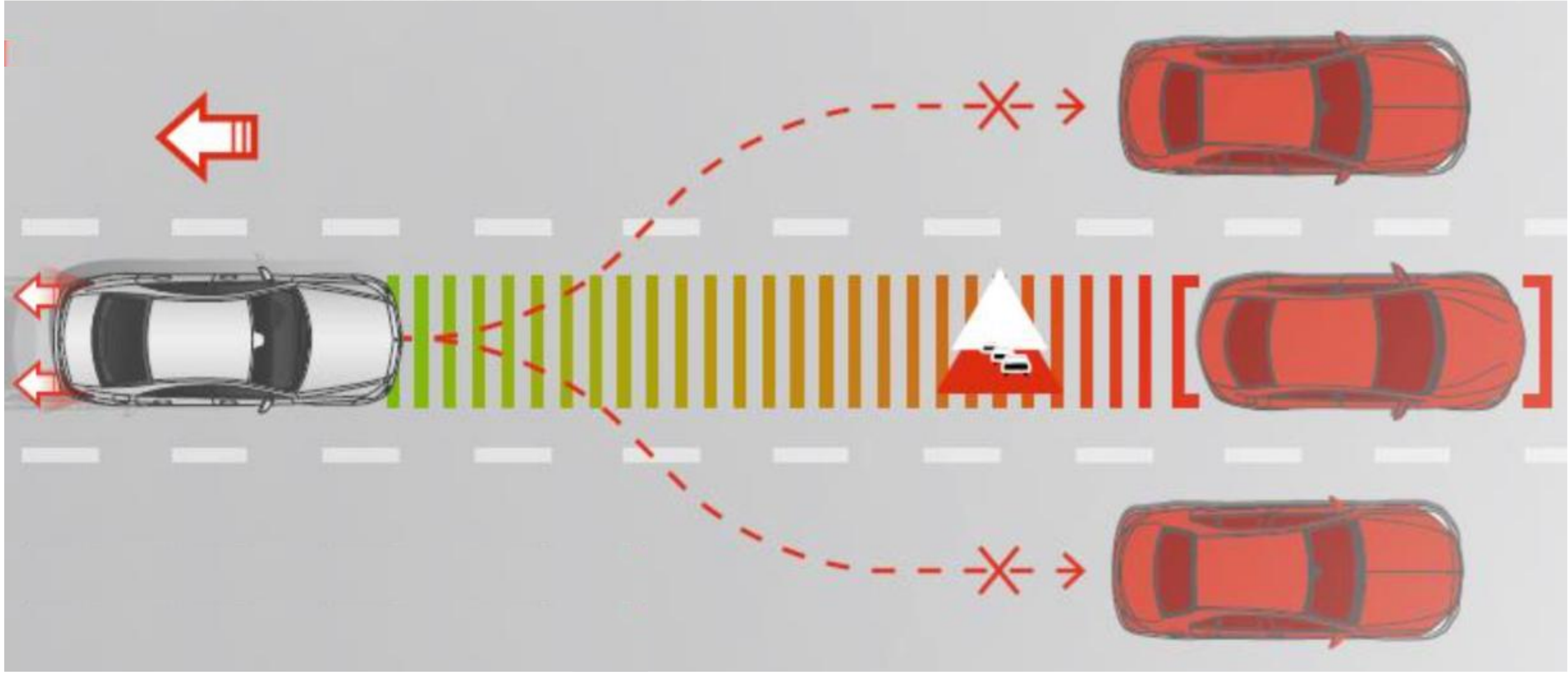


Decide on what the system needs to do

Perception

Sensor Fusion

Planning



Execute the correct control signals for the system to follow the plan

Perception

↓

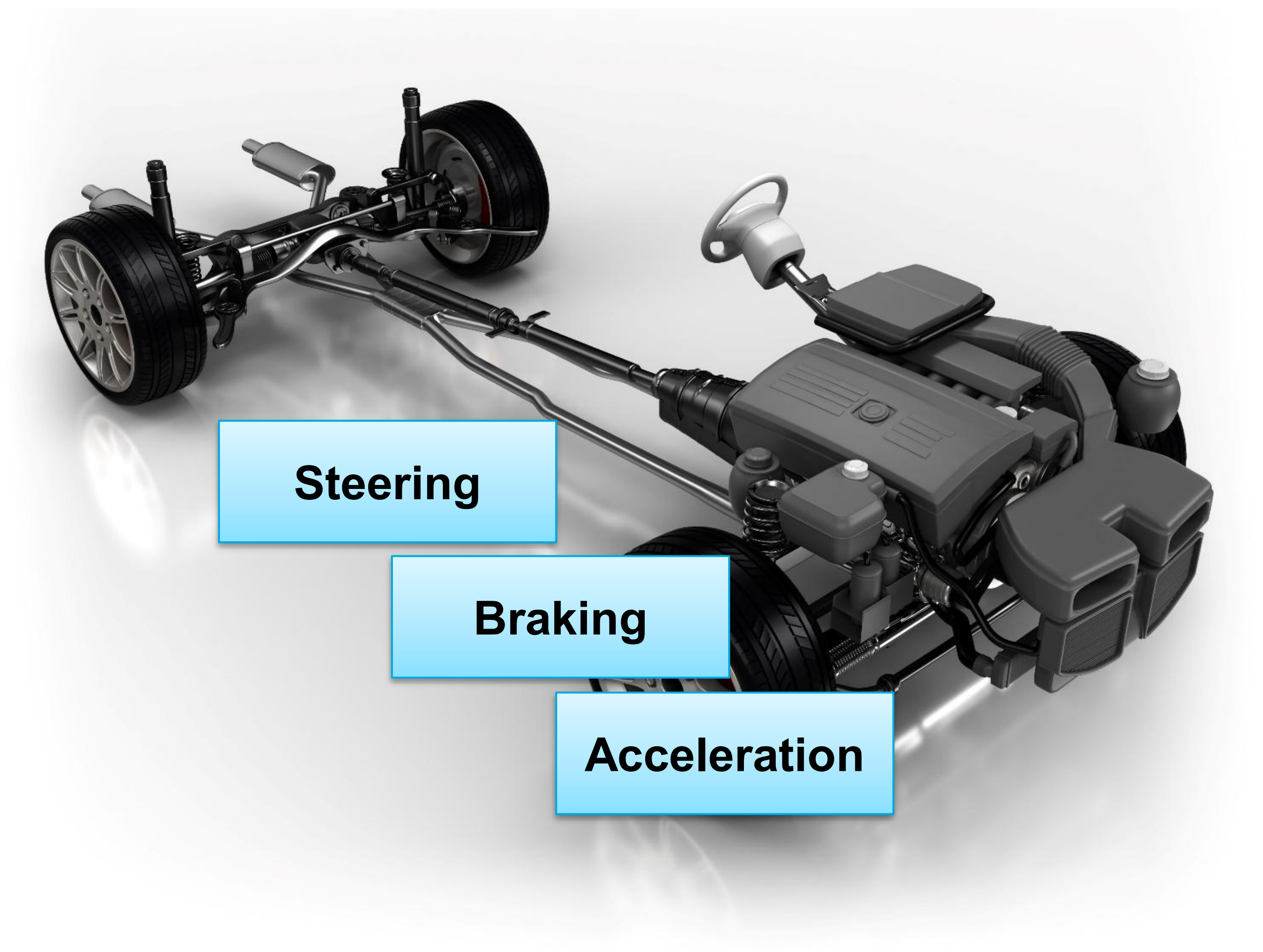
Sensor Fusion

↓

Planning

↓

Controls



Parts of an Automated Driving System

Perception

↓

Sensor Fusion

↓

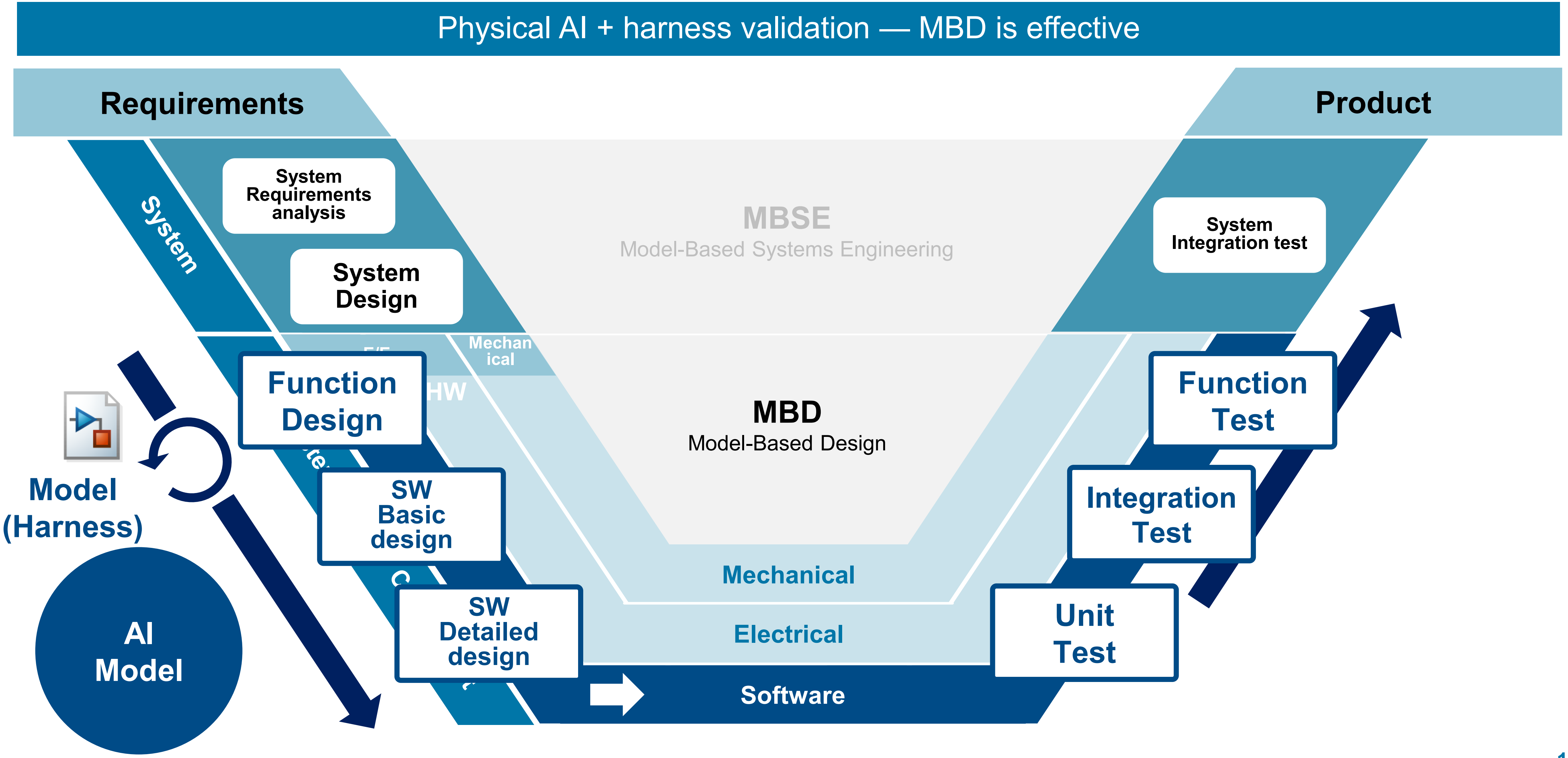
Planning

↓

Controls

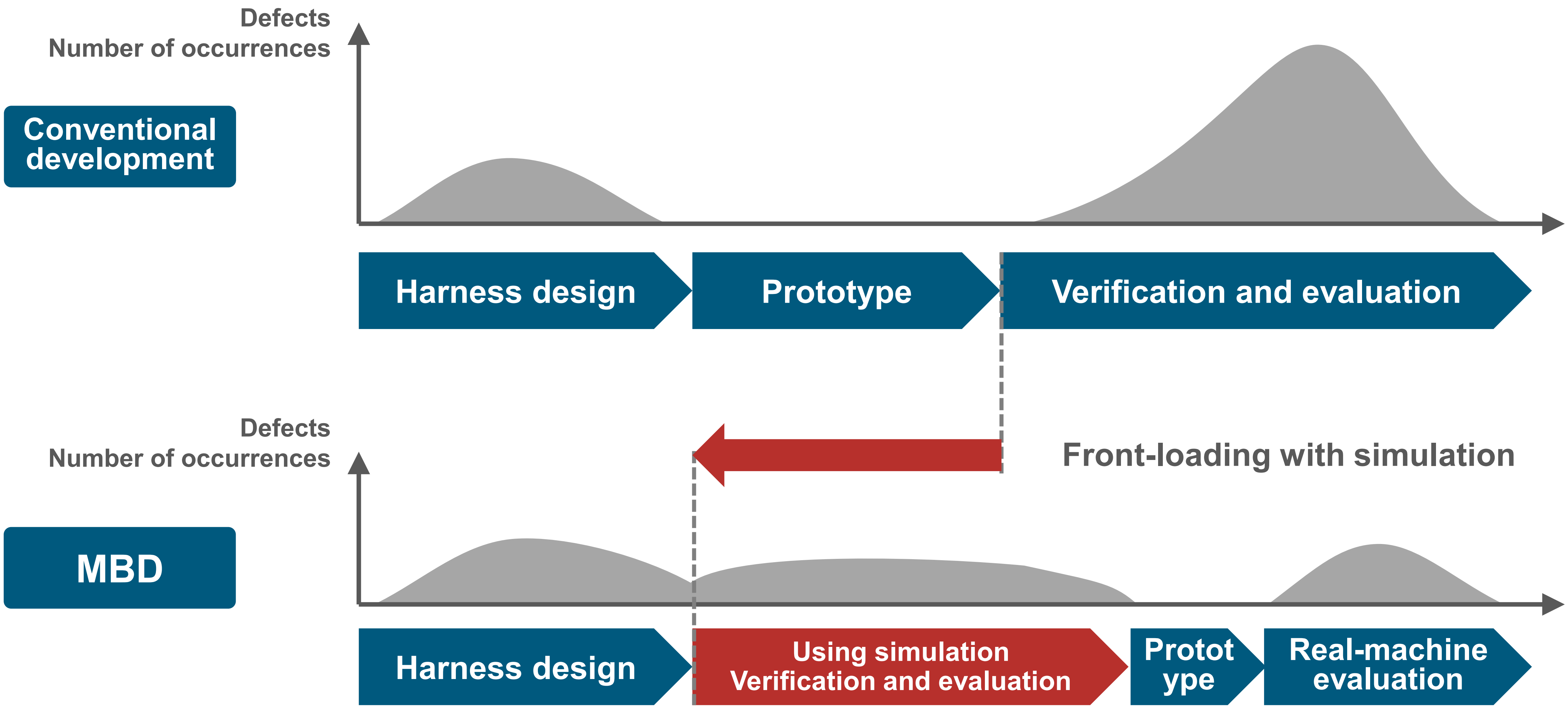
MathWorks

Physical AI through Model-Based Design

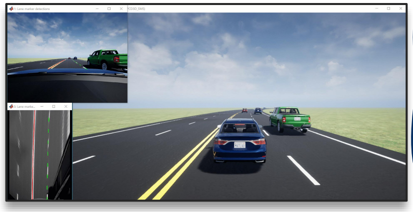


MBD reduces rework risk with simulation

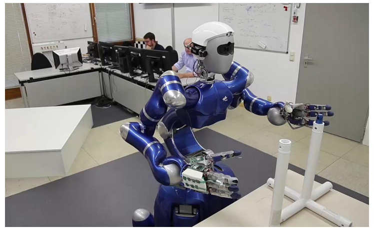
Reduce rework cost by finding defects early through simulation



Build Reliable Physical AI Systems with Model-Based Design

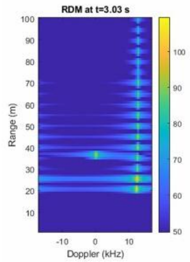


Automated Driving



Robotics

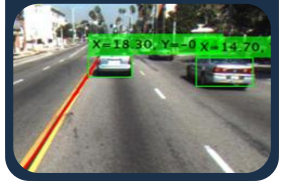
UAVs



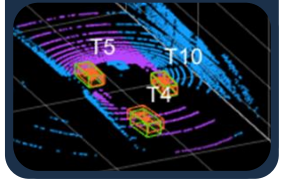
RADAR

Inertial Position

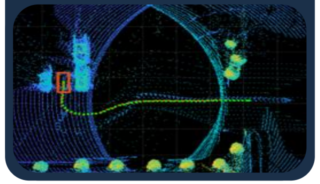
Detection



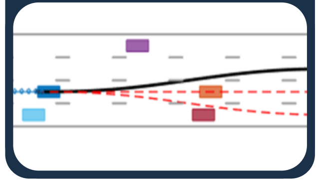
Tracking

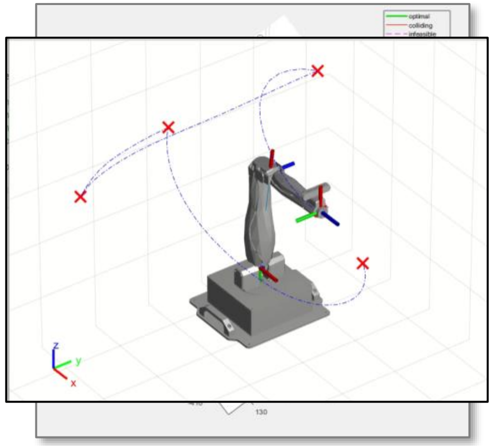


Localization



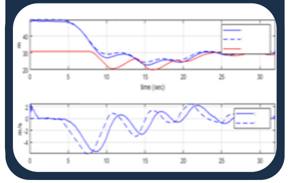
Planning





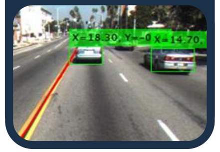
Trajectories and Speed

Controls

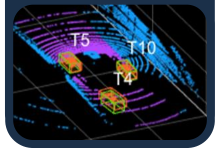


Rule Based Physical AI Systems

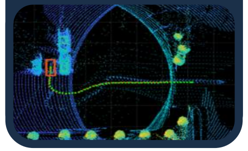
Detection



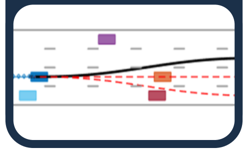
Tracking

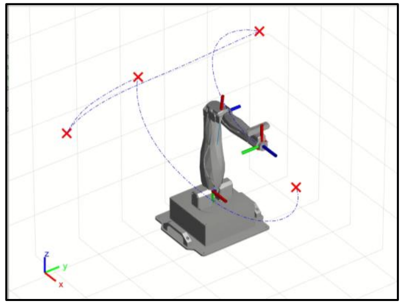


Localization



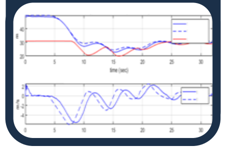
Planning





Trajectories and Speed

Controls



- Coordinate

AI

Deep Learning Models

New Vehicle that has not been seen before

"Pick Up the Carrot from the Floor and Place it in the Dustbin

Tasks for Physical AI Systems are getting more Generalized

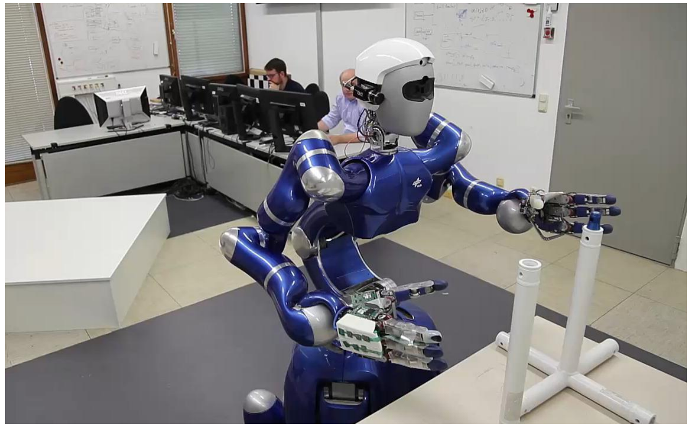
Perception

Sensor Fusion

Planning

Controls

Level 4 Automated Driving



General Purpose Humanoid Robot

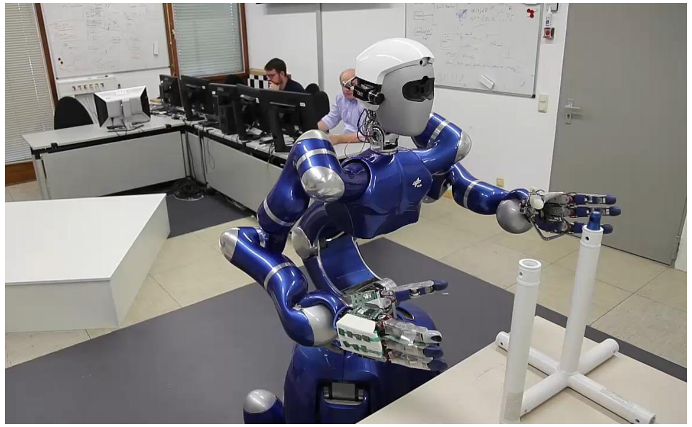
Algorithms are becoming complex for more difficult tasks

Vision Language Action Models are capable of handling these diverse tasks

Vision Language Action Models

Controls

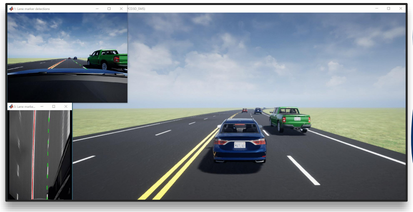
Level 4 Automated Driving



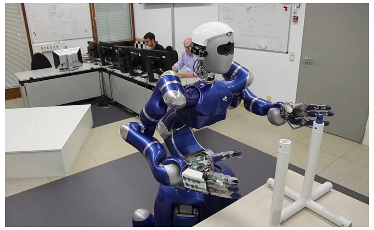
General Purpose Humanoid Robot

Vision Language Action Model based Physical AI

Multi Modal Transformers trained for diverse operating conditions

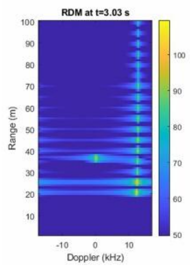


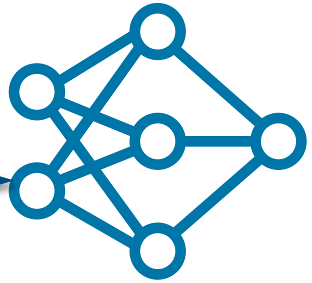
Automated Driving



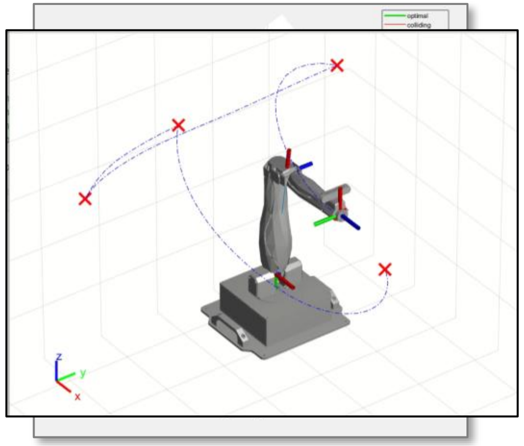
Robotics

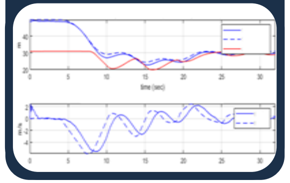
UAVs





Vision Language Action Models





Controls

"Pick up the Discolored object"

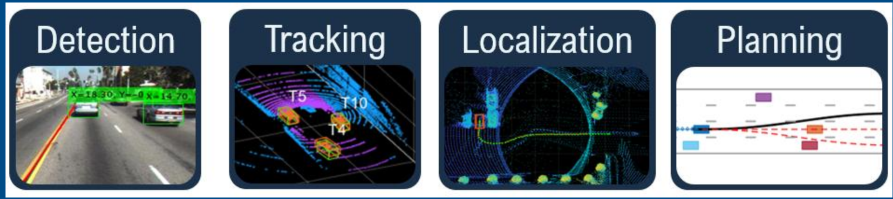
Natural Language

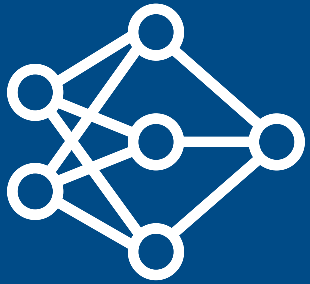
"Object is Moving on the Conveyor Belt"

Reasoning output

Plant → Sensors → Environment → Algorithms

Trade-Offs between the two approaches



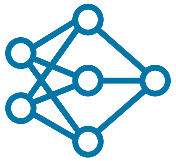


Rule-Based Physical AI	Vision Language Action Models
Deterministic – Easy to explain outputs by analyzing code	Need to rely on the reasoning output for explainability
Runs on CPUs – Lower Power and Cost	Needs Powerful GPUs – Higher Power and Cost
Need to clearly define Operational Range	Handles Edge Cases Better – Natural Language
Eg : Pick and Place Robots; ADAS Level 2	Eg: Robotics (Isaac-GROOT), L4 Automated Driving (Alpamayo)
Needs Lots of Testing	Needs Lots of Testing

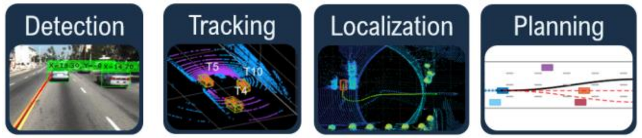
How Reliable is your system?

1. Robustness
2. Repeatability
3. Edge Cases

Identify bugs early in the development cycle with **Simulation**

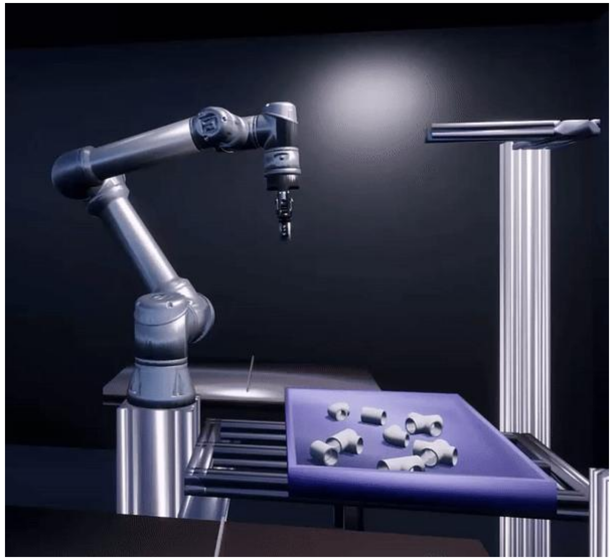


Vision Language Action Models



Controls

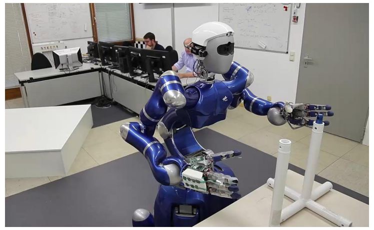
Level 4 Automated Driving



General Purpose Humanoid Robot

Build Reliable Physical AI Systems with Model-Based Design

Automated Driving

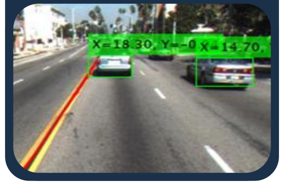


Robotics

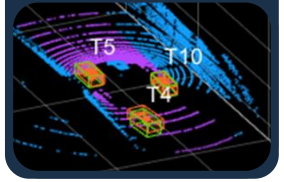
UAVs

Algorithms

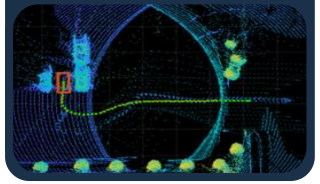
Detection



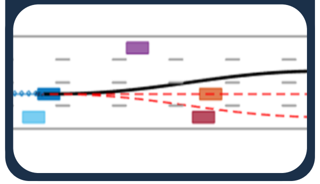
Tracking



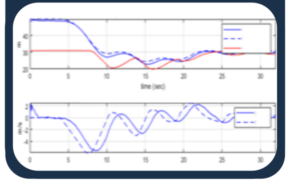
Localization



Planning



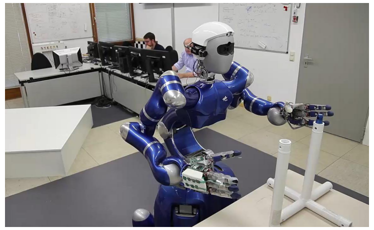
Controls



Vision Language Action Models

Components that affect the performance of a physical AI system

Automated Driving



Robotics

UAVs

Plant → Sensors → Environment → Algorithms

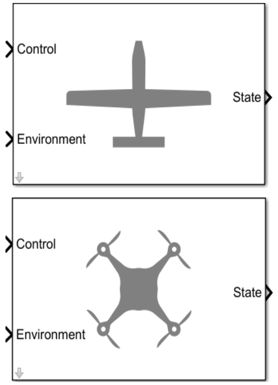
Plant | Sensors | Environment | Algorithms


Automated Driving


Robotics

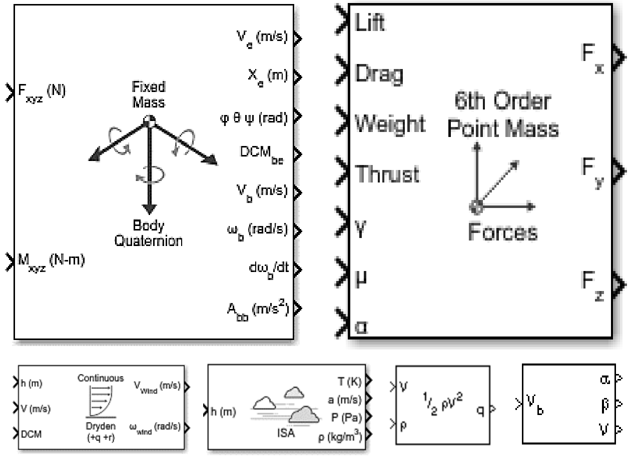

UAVs

Lightweight — **Chose Plant Model Fidelity Based on the application** — **High-Fidelity**



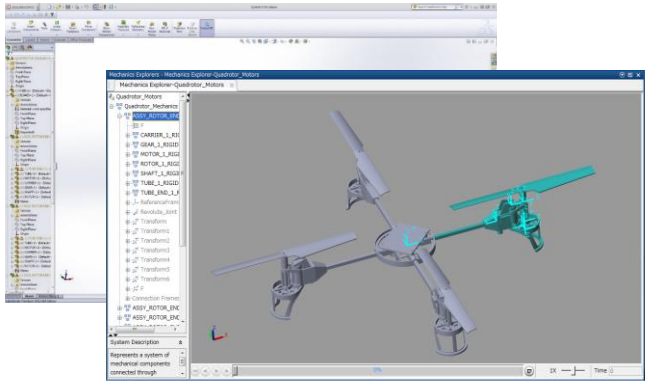
Guidance Model

Reduced-order model for UAV



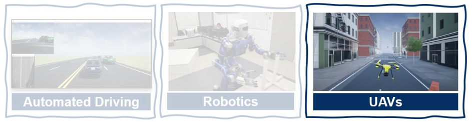
Vehicle Dynamics

Model aerodynamics, propulsion, and motion of aircraft and spacecraft



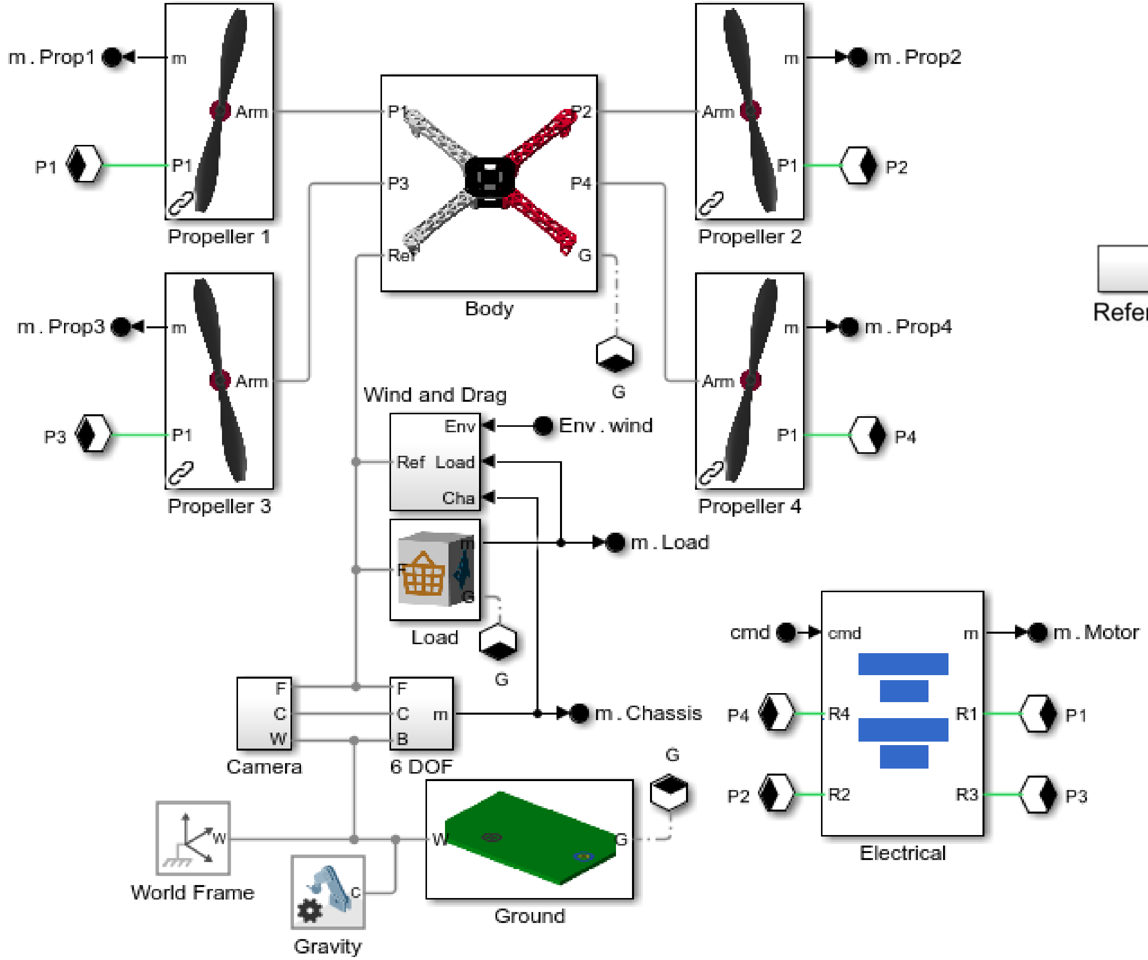
Physical Modeling

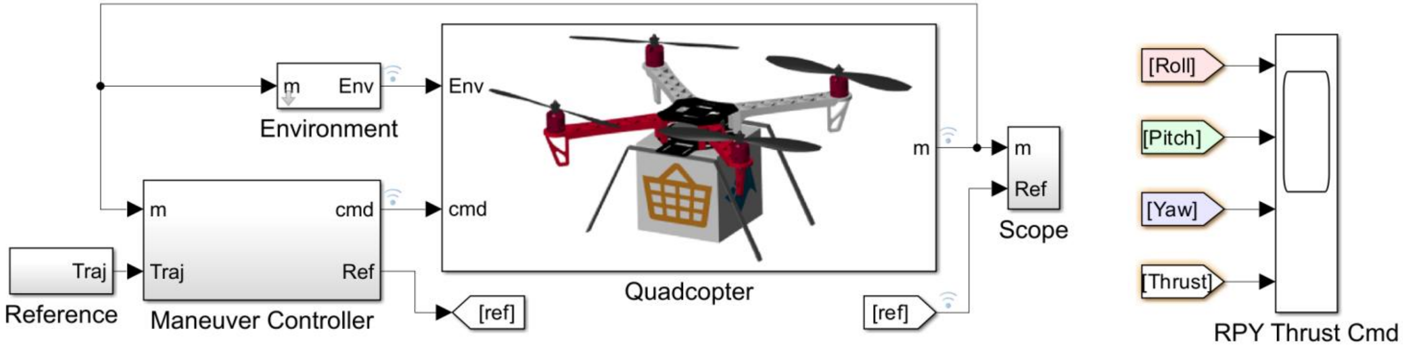
Model construction techniques and best practices, domain-specific modeling, physical units



Plant | Sensors | Environment | Algorithms

Simscape Multibody enables the simulation of multi-body dynamics using physical connections and CAD-based geometry



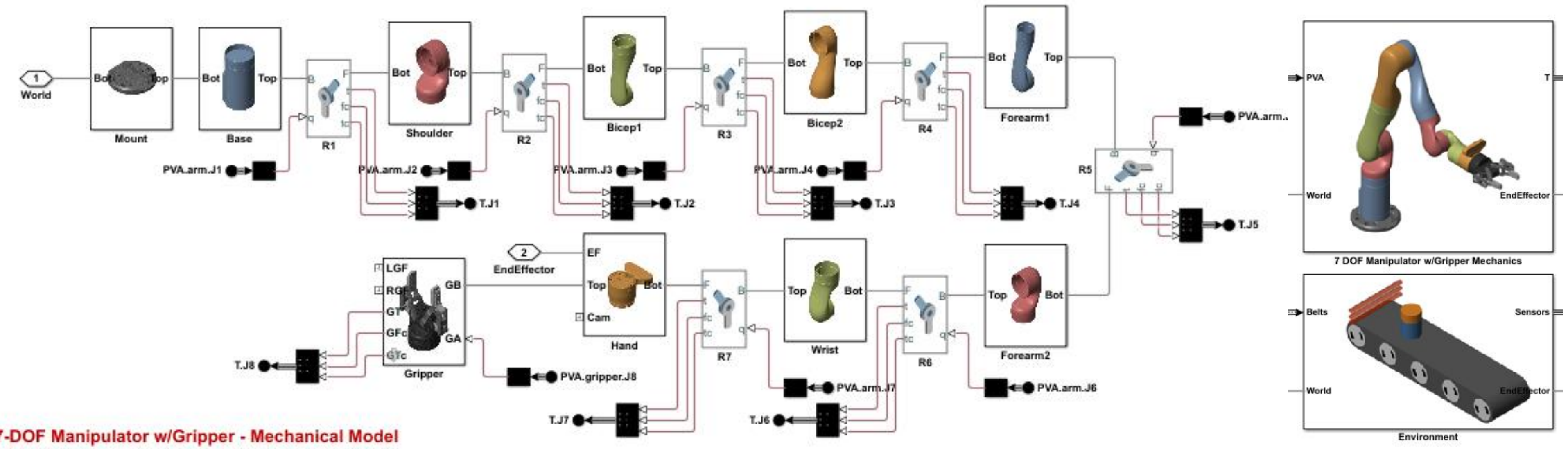


Plant | Sensors | Environment | Algorithms

Automated Driving

Robotics

UAVs

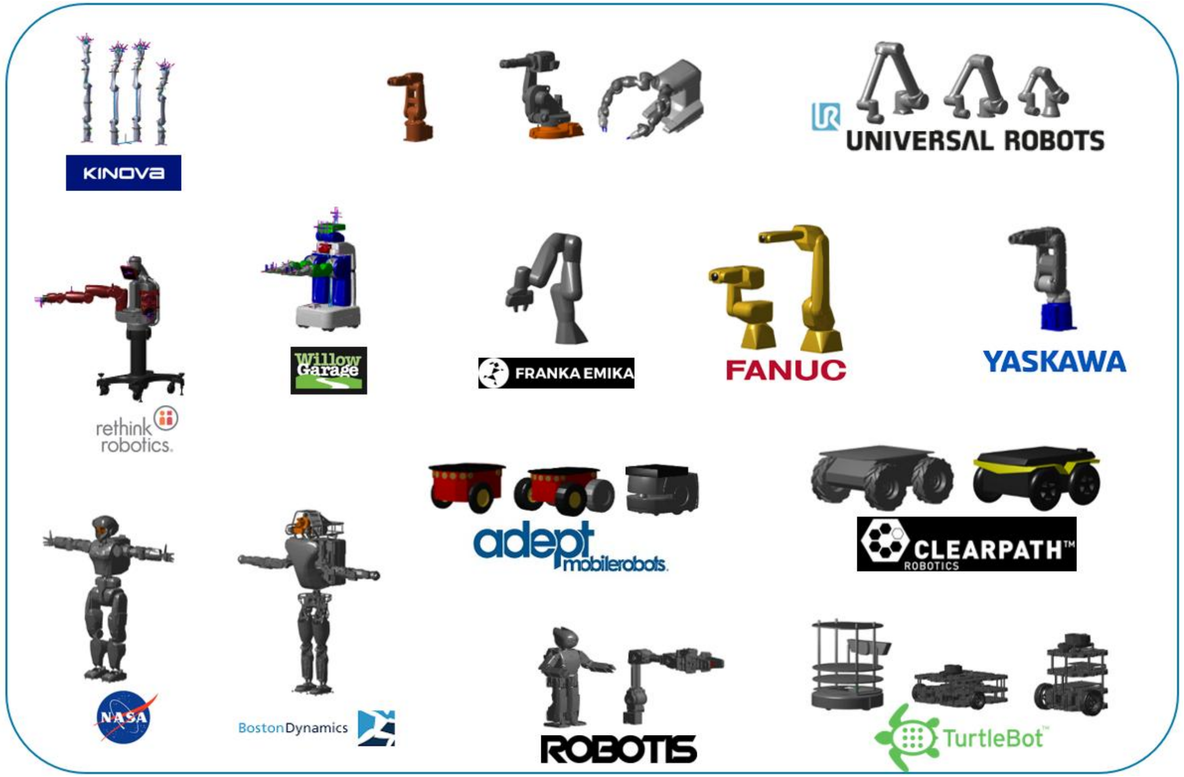


7-DOF Manipulator w/Gripper - Mechanical Model
Motion actuation - Position/Velocity/Acceleration profile

Plant › Sensors › Environment › Algorithms

Additional manipulators and mobile robots added to robot model library

- New manipulators, humanoids, and mobile robots from industry and academia
- Brings total to over 50 models from 18 manufacturers
- Added kinematic data and lightweight simulation models to make getting started easier



Plant | Sensors | Environment | Algorithms

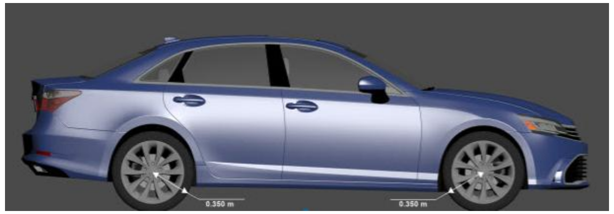
Automated Driving

Robotics

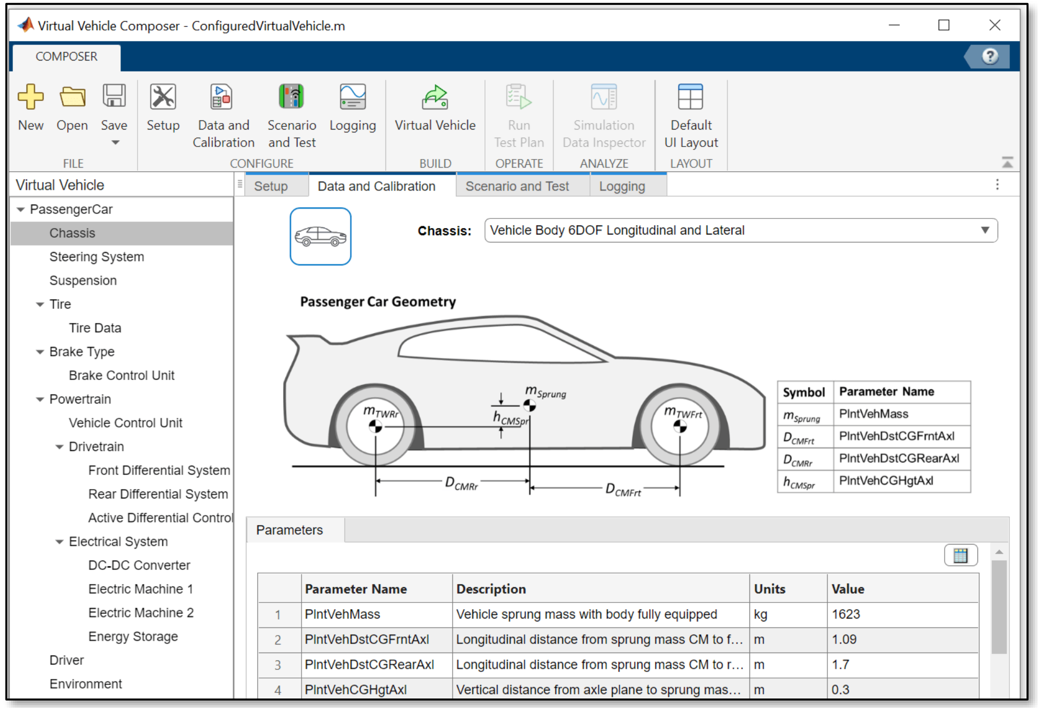
UAVs

Virtual Vehicle Composer

Build a vehicle model with the Vehicle's Parameters



- 3-DOF Passenger vehicle
- **14-DOF passenger vehicle**
- Motorcycle
- Tractor-Trailer commercial vehicle




Automated Driving


Robotics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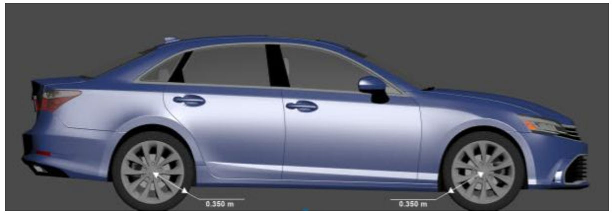

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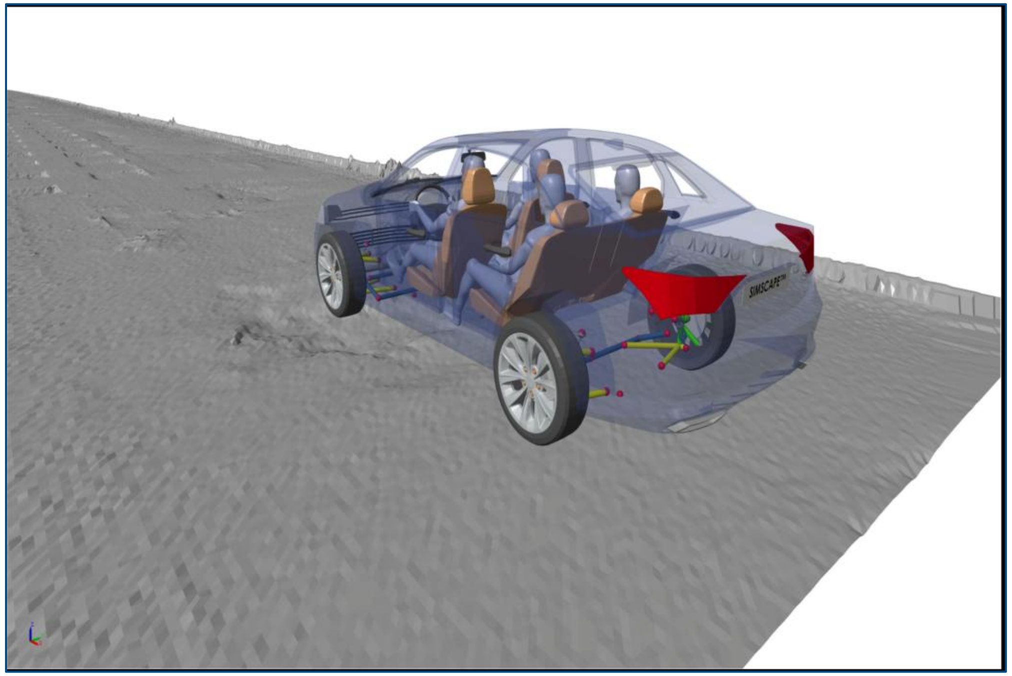
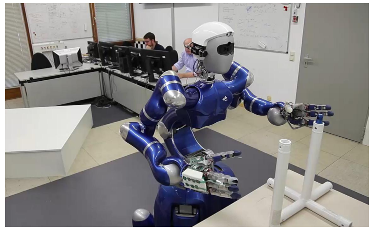


Components that affect the performance of a physical AI system

Automated Driving



Robotics

UAVs

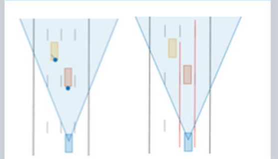
Plant → Sensors → Environment → Algorithms

Sensor Models

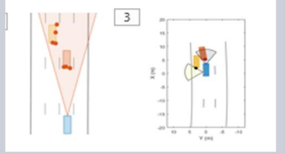
Plant → Sensors → Environment → Algorithms

Probabilistic sensors

Vision
(Lane and detections)

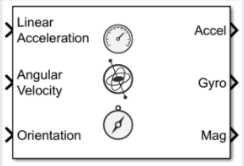


Radar and Ultrasonic Detections



Parametrizable, Code generatable

Inertial Sensors



IMU

GNSS

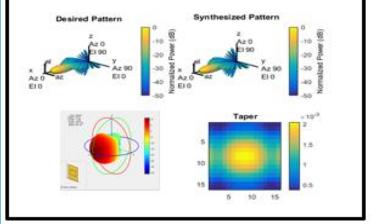
Monocular Camera

Fisheye Camera

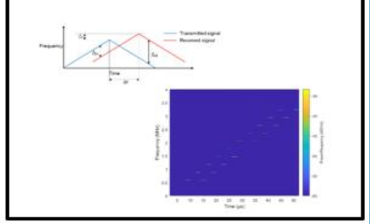
- Monocular, Fisheye
- Photo-realistic images
- Varied weather conditions

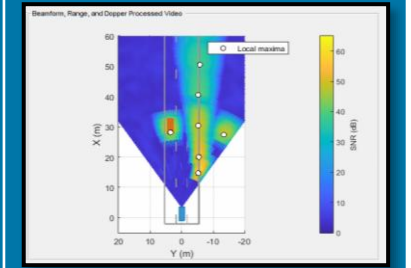
Modelling Radar Transceiver Characteristics

Antenna/RF

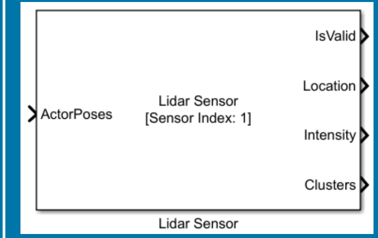


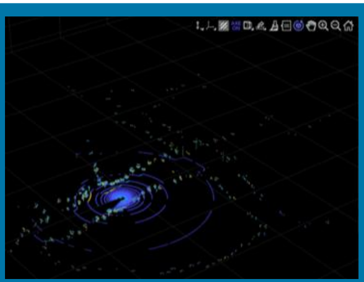
Waveforms





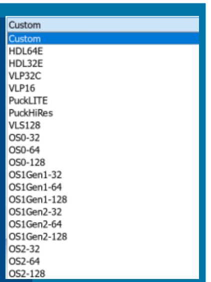
Lidar sensor model





Supported Sensor models:

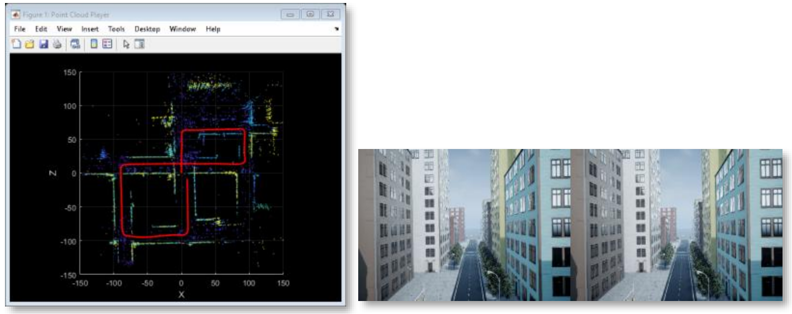
Velodyne®
Ouster®
Custom



Plant → **Sensors** → Environment → Algorithms

Sensor Models

Choosing the Appropriate Sensor Model for the System that is being built



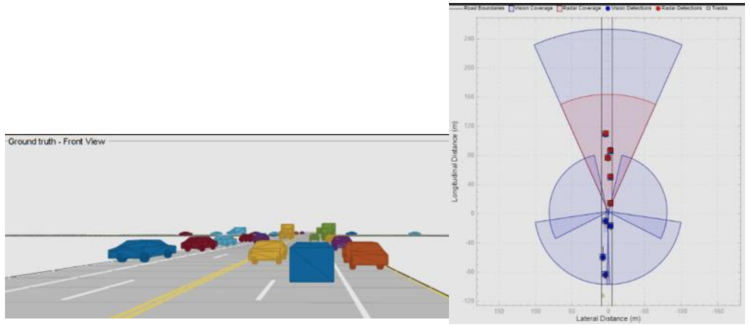
[Stereo Visual SLAM for UAV Navigation in 3D Simulation]

Needs RGB Camera Frames

Simulation Camera

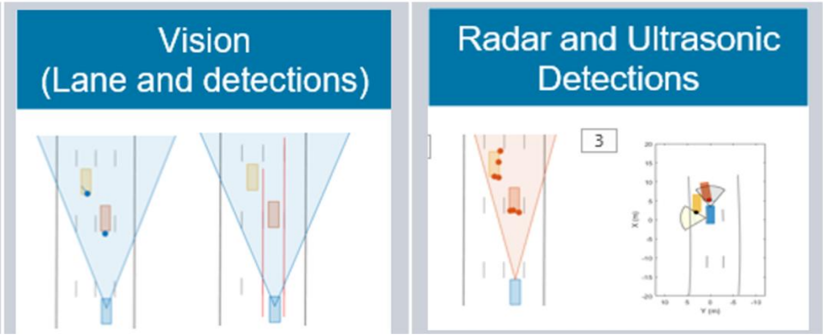
+

Simulation Camera



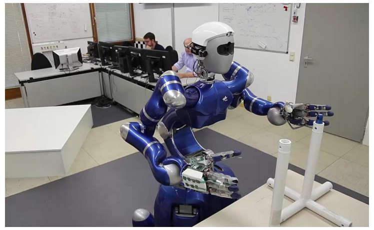
[Surround View system for an Automated Driving Vehicle using Off-The Shelf Sensors]

Final Processed Sensor outputs with Realistic Noise



Components that affect the performance of a physical AI system

Automated Driving



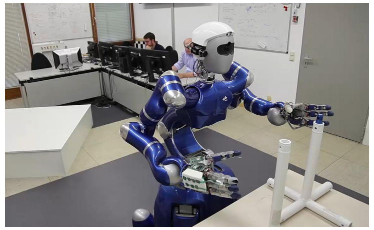
Robotics

UAVs

Plant → Sensors → **Environment** → Algorithms

Plant | Sensors | **Environment** | Algorithms

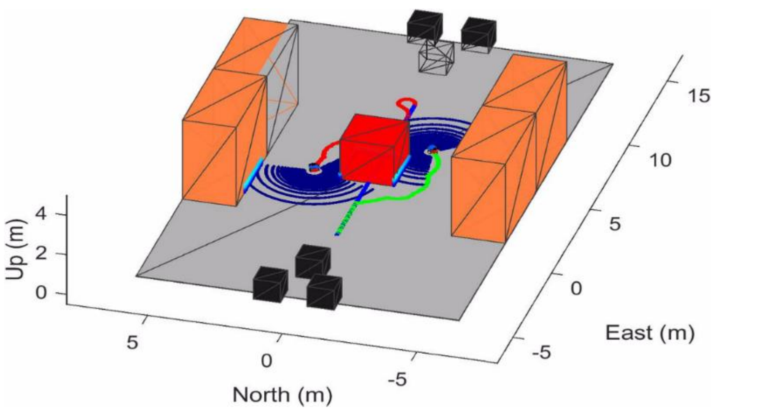
Automated Driving



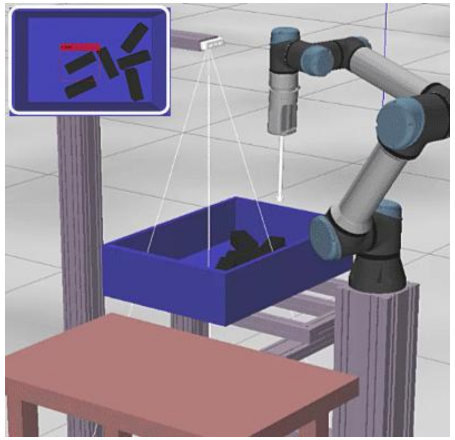
Robotics

UAVs

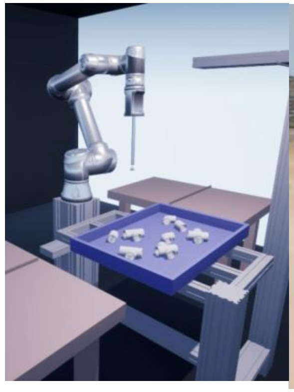
Cuboid Scenario ⟷ **Third Party Simulators** ⟷ **Unreal Engine**



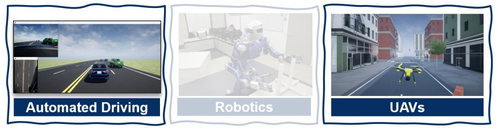
Rapid scenario creation and desktop testing



Co-simulate with External simulators



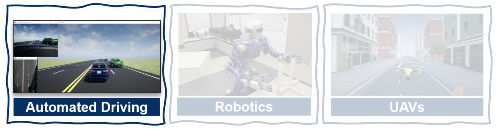

High-Fidelity Game Engine simulator



Plant | Sensors | Environment | Algorithms

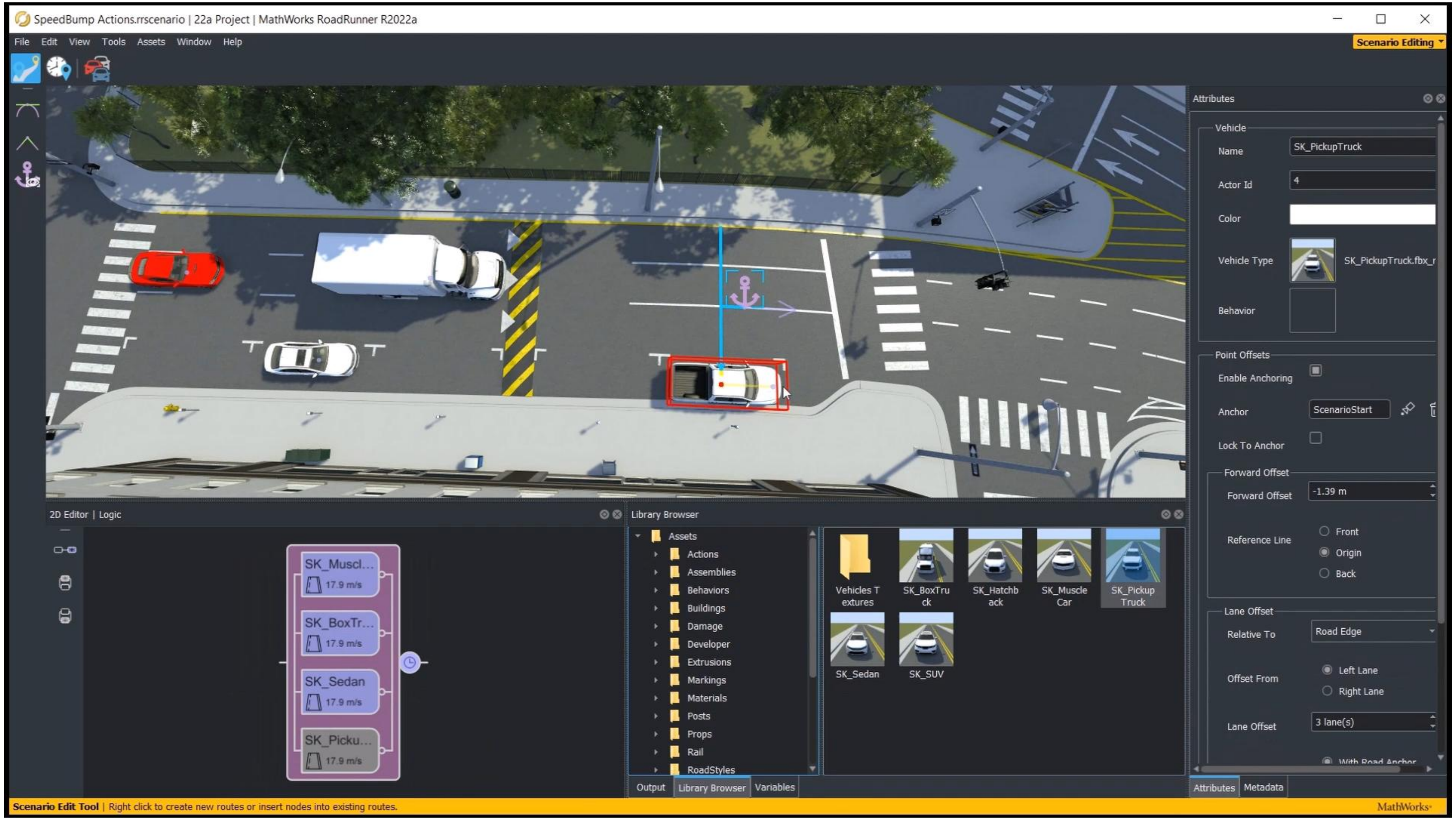
Create Realistic Urban Environments with RoadRunner

- Author realistic 3D roads for common driving simulators
- Interactively create roads, lanes, and intersections
- Create bridges, elevated intersections, and tunnels
- Import data from map services (Here HD, Tom tom, Apollo, …
- Import, export, and validate ASAM OpenDRIVE
- Create snappable templates

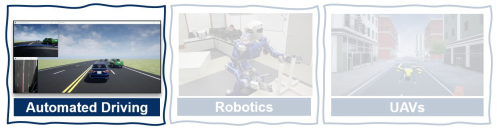


Plant → Sensors → **Environment** → Algorithms

Model Traffic for Automated Driving Simulation



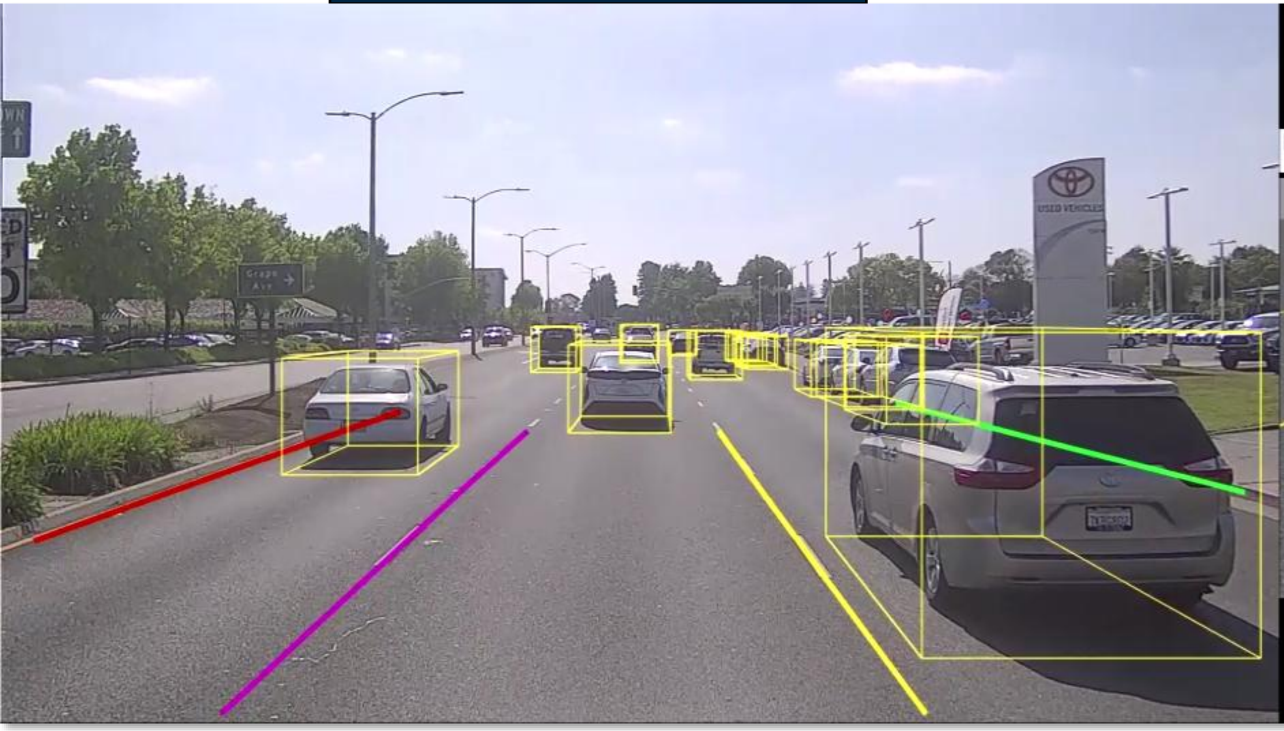
- Add vehicles and pedestrians
- Draw trajectories
- Specify actions and logic
- Visualize logic execution
- **Programmatically author scenarios**
- Import and Export trajectories from ASAM OpenSCENARIO
- Export to third Party Simulators



Plant | Sensors | **Environment** | Algorithms

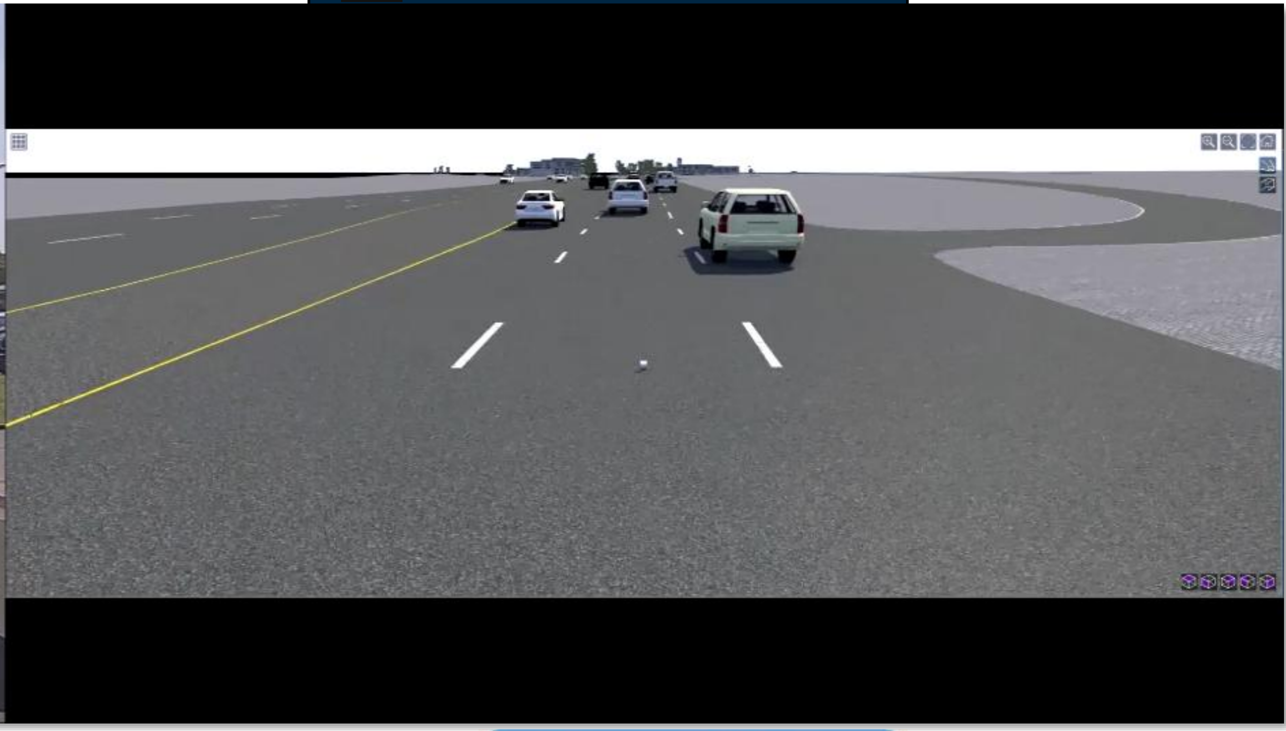
Generate Traffic Scenarios from recorded Vehicle Data

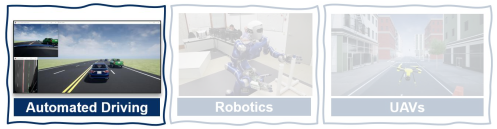
Real World Sensor data



GPS IMU Lidar Camera Radar

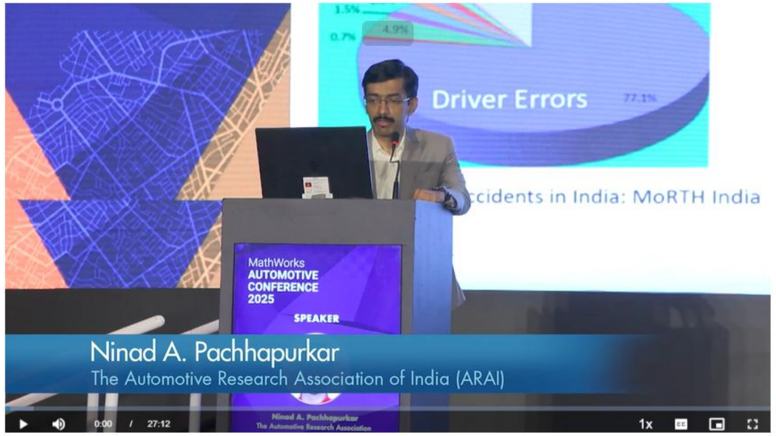
RoadRunner Scenario





Plant | Sensors | **Environment** | Algorithms

Automotive Research Association of India(ARAI) Enables Virtual Testing of ADAS Application with Real-World Simulation Scenarios



Description | Full Transcript | Related Resources

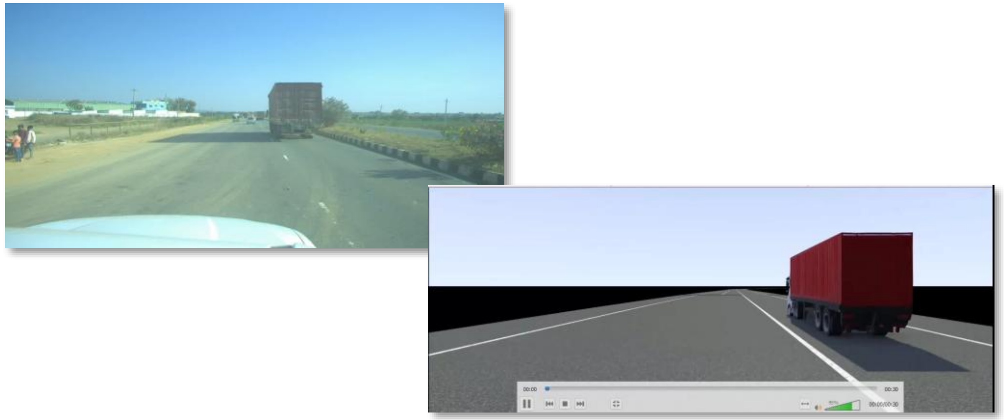
Developing India-Specific Virtual Scenarios from Real-World Data – ADAS Use Cases

Ninad A. Pachhapurkar, The Automotive Research Association of India (ARAI)

ADAS enhances road safety by assisting drivers with real-time alerts and automated responses to potential hazards. With increasing traffic density and accident rates, these systems are essential for reducing human error and improving driving efficiency. However, ADAS validation is inherently complex due to the need for consistent performance across diverse driving scenarios and environmental conditions. In India, this complexity is heightened

Show more

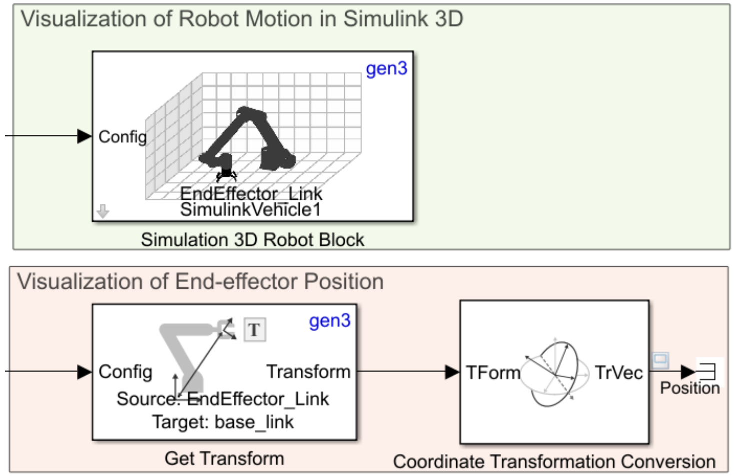
Published: 29 Jul 2025

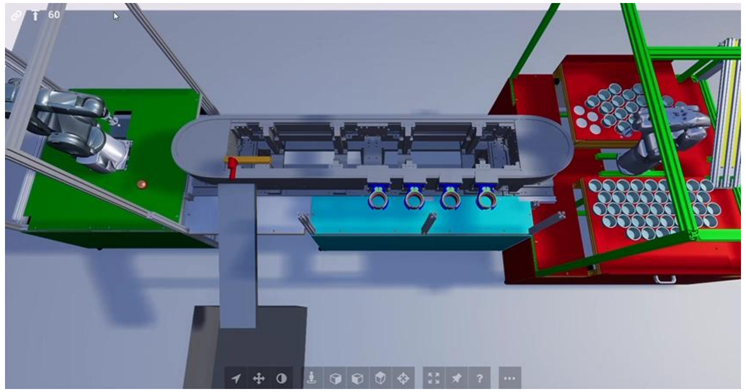


[Developing India-Specific Virtual Scenarios from Real-World Data – ADAS Use Cases - MATLAB & Simulink]()

Co-Simulate with the Unreal Engine with Simulink 3D Animation

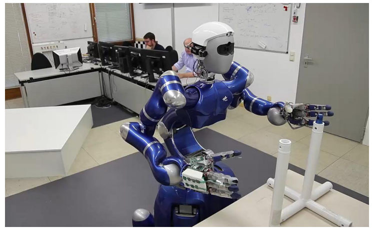
- Use Simulink 3D Robot Block to simulate manipulator motion and grasp workflow and mobile robot in Unreal Engine
- Use Simulation 3D Scene Configuration Block for 3D simulation environment





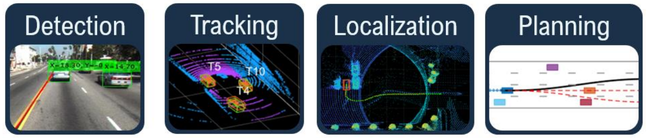
Components that affect the performance of a physical AI system

Automated Driving



Robotics

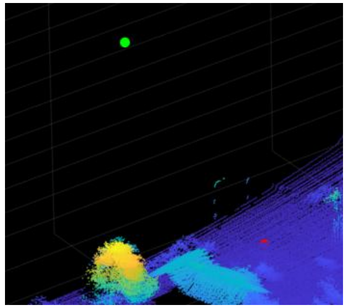
UAVs

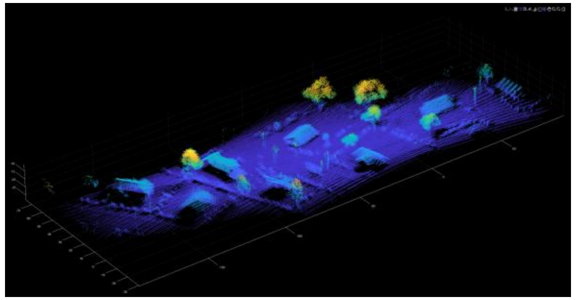


Plant → Sensors → Environment → Algorithms

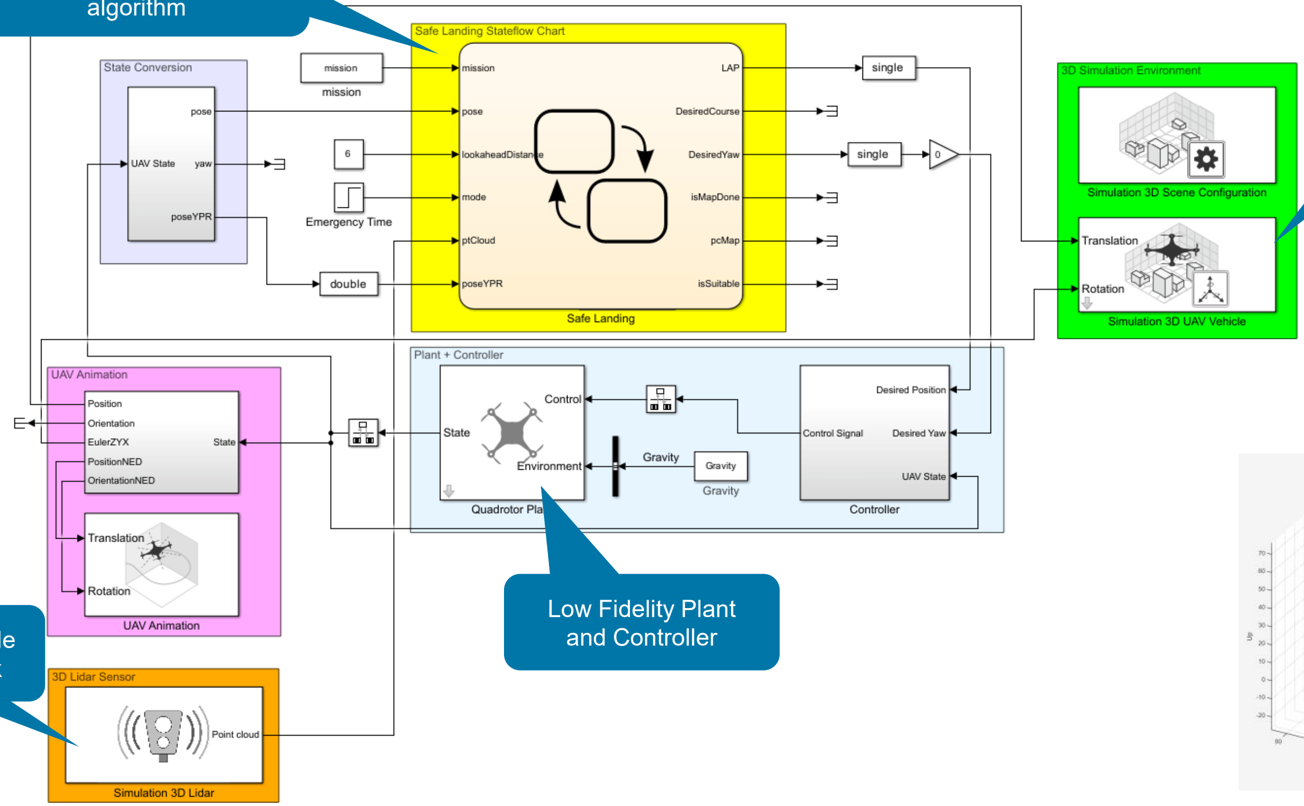
Find a safe spot to land a UAV using a LiDAR

Model-Based Design for Algorithm Development and Simulation





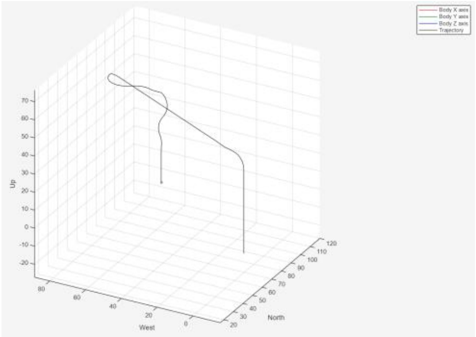
Scenario with integrated landing zone detection algorithm



Unreal Based Visualization

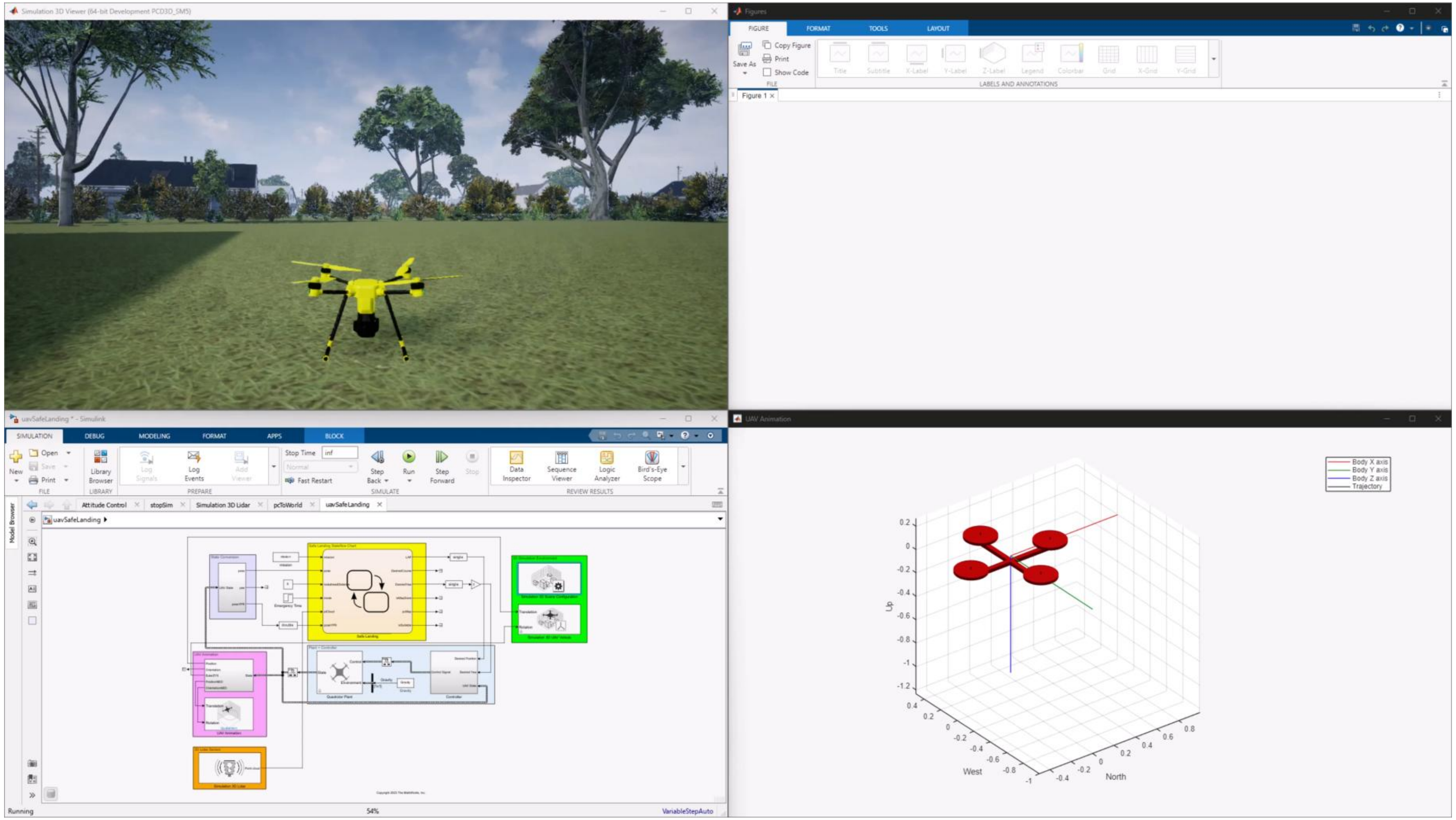
Customizable Lidar Block

Low Fidelity Plant and Controller



Find a safe spot to land a UAV using a LiDAR

Simulation Accelerates the development time



MathWorks

AI

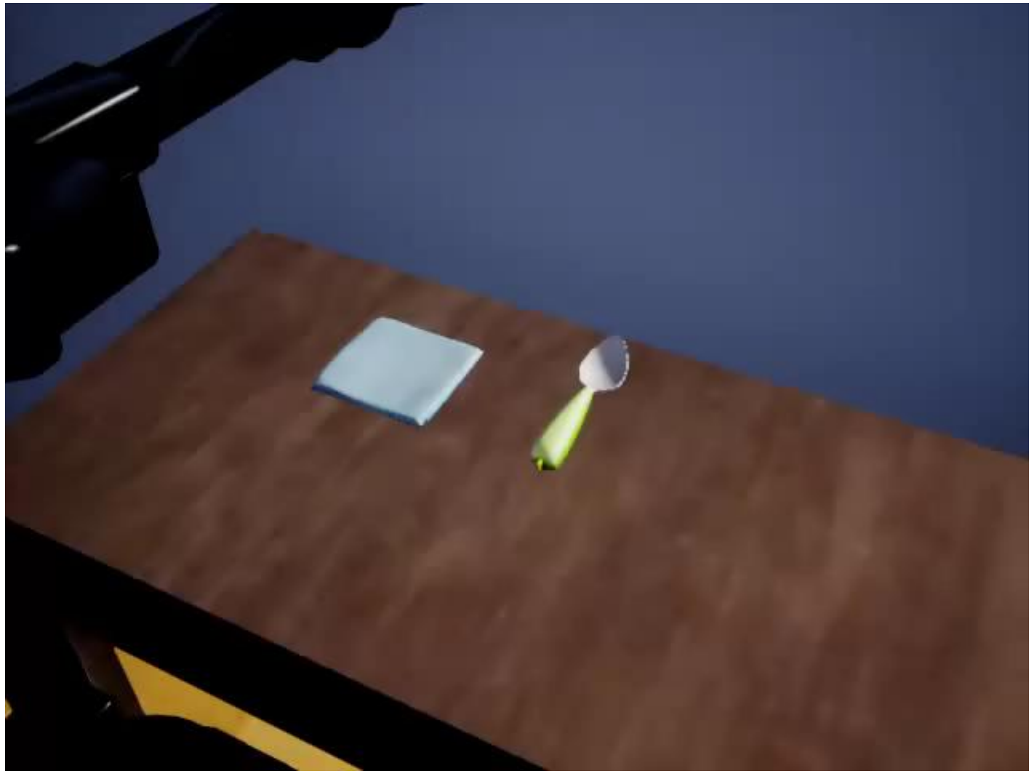
Plant → Sensors → Environment → Algorithms

Pick and Place Robotic arm

Integrate VLA Model in Simulink for Simulation and Testing

“Move the Spoon to the Towel”

Simulation



AI

Plant → Sensors → Environment → Algorithms

Pick and Place Robotic arm

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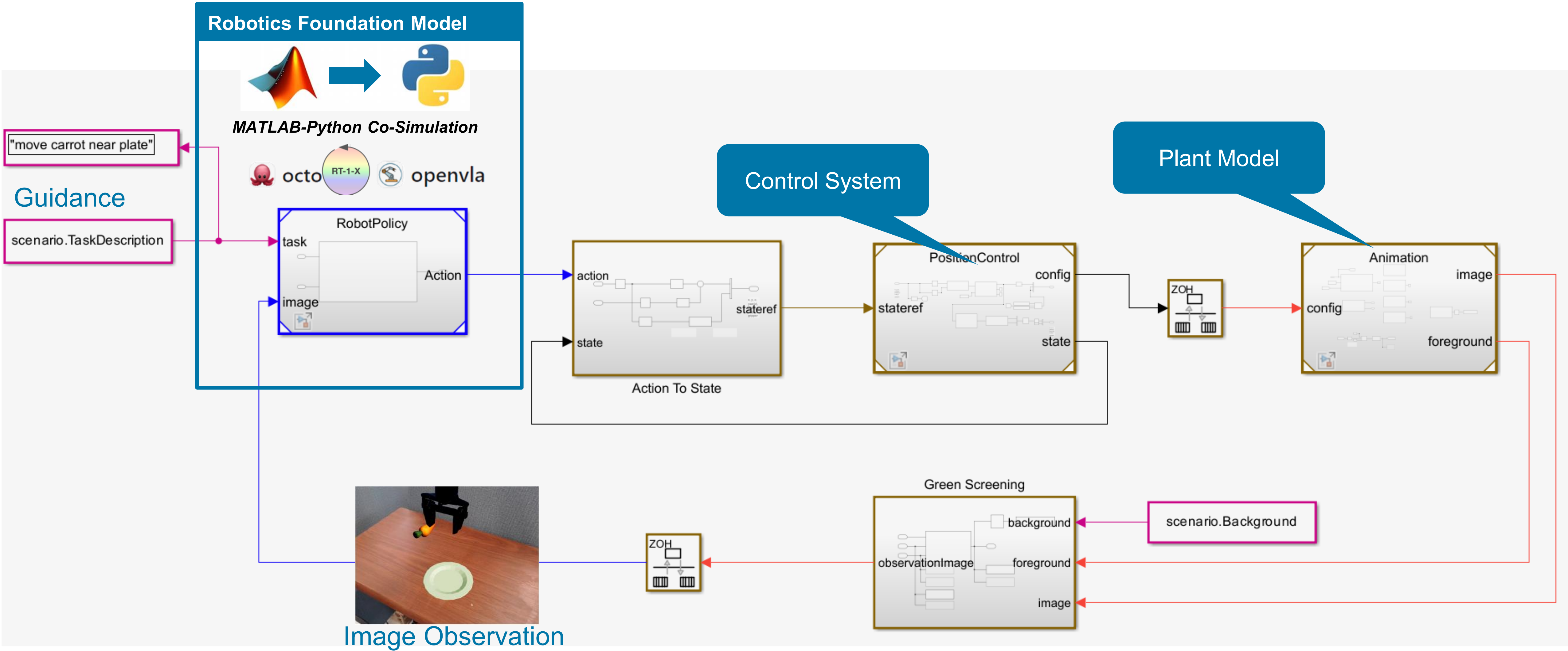
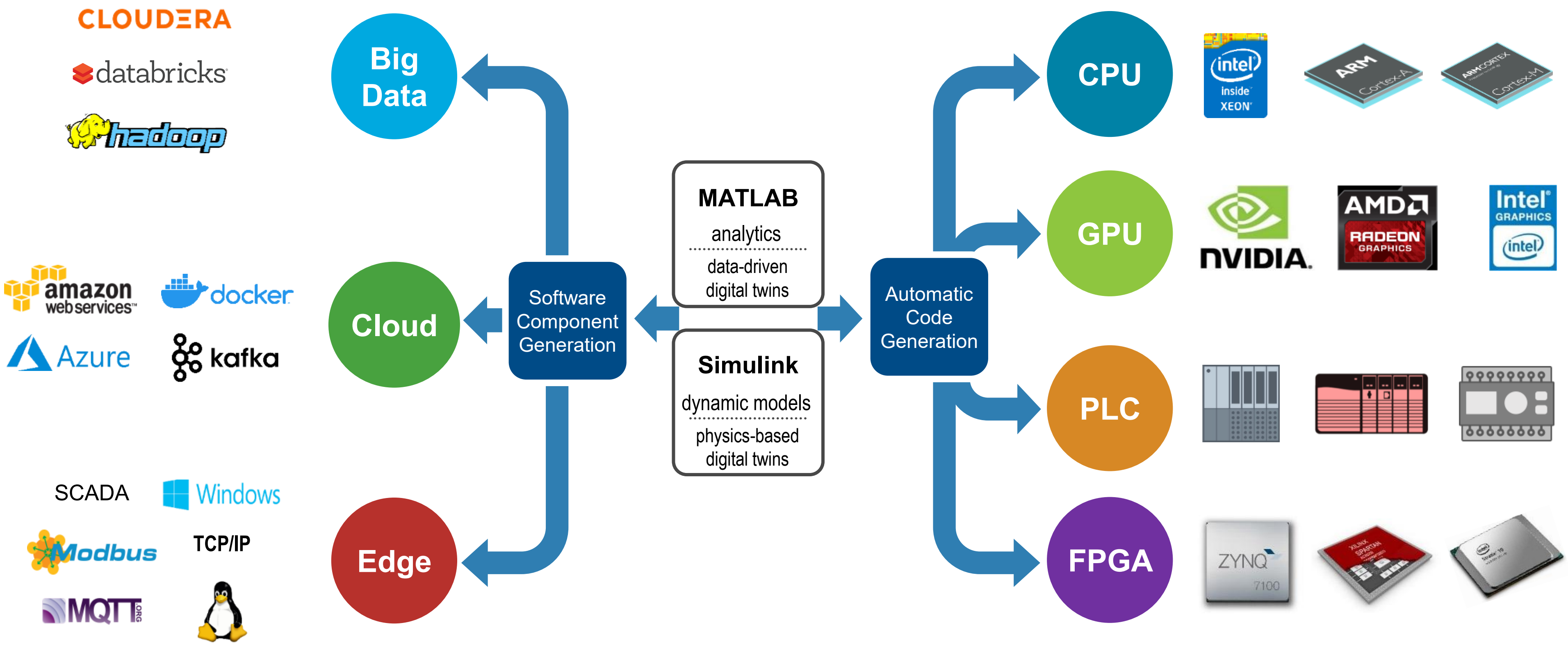
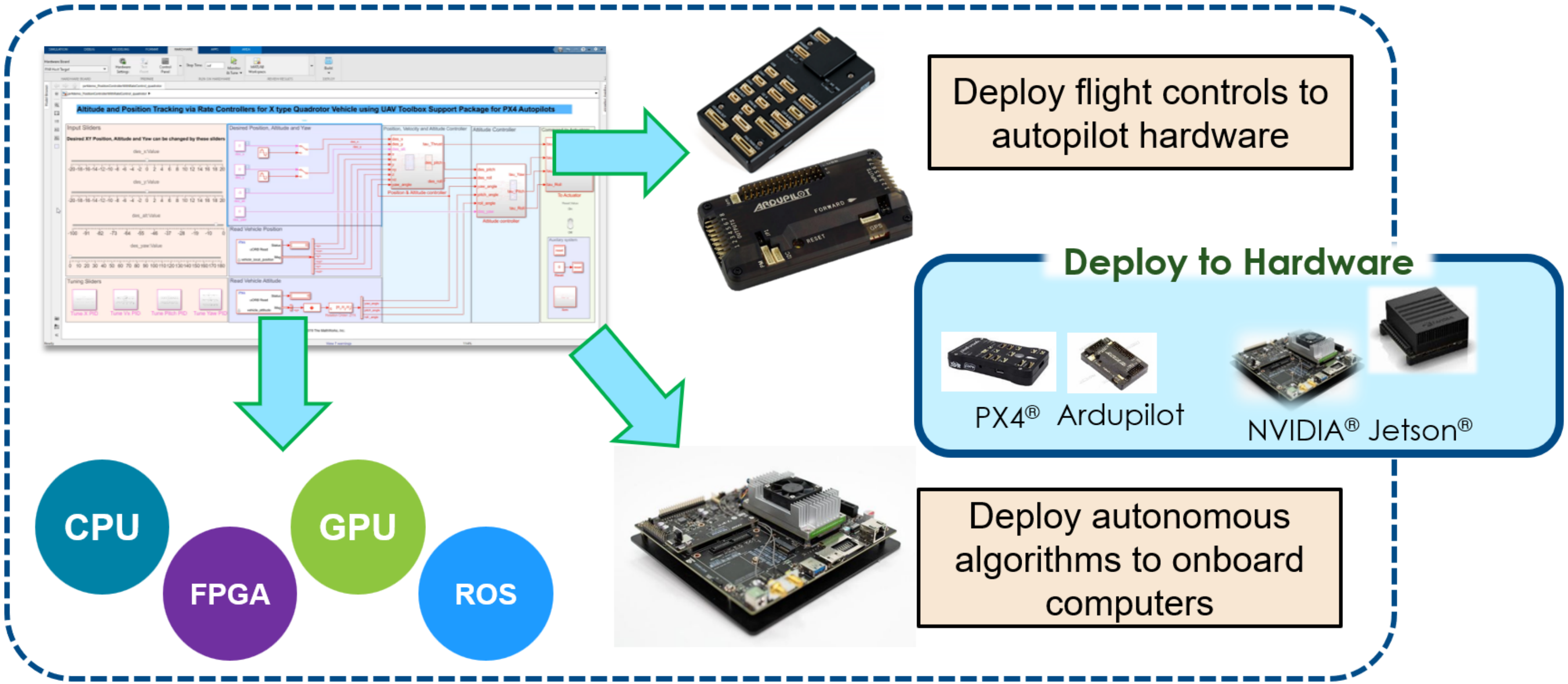


Automate code generation for **prototyping** and **production**

Reliable and high performance, with flexible choice of targets

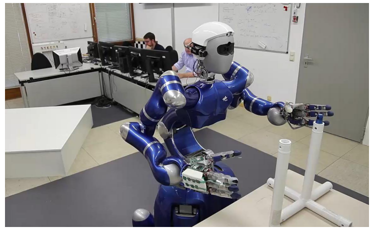



AI
Detection
Tracking
Localization
Planning
UAVs
Plant
Sensors
Environment
Algorithms


Altitude and Position Tracking via Rate Controllers for X type Quadrotor Vehicle using UAV Toolbox Support Package for PX4 Autopilots
Deploy flight controls to autopilot hardware
Deploy to Hardware
PX4®
Ardupilot
NVIDIA® Jetson®
Deploy autonomous algorithms to onboard computers
CPU
FPGA
GPU
ROS

Build Reliable Physical AI Systems with Model-Based Design

Automated Driving



Robotics

UAVs

Plant → Sensors → Environment → Algorithms

Create Simulation Environments and many Test Cases ⇄ **Develop, Test and Validate the System in Simulation**

Agentic AI

GenAI is one of the **most rapid and transformative** technology shifts

Creates code instantaneously

Can use software tools

Understands multiple domains

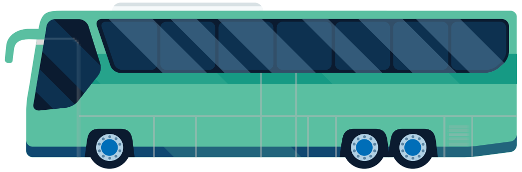
Shift from use of **AI Tools to AI Agents** is turbocharging productivity

Chatbots
"Answer this"

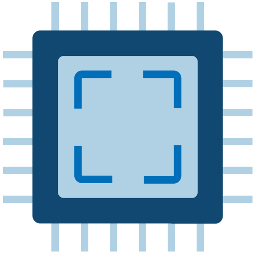
Copilots
"Work with me"

Agents
"Do it for me"

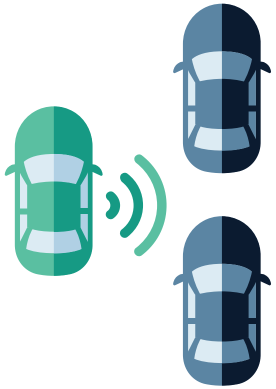
Systems increasingly operate in **safety-critical, regulated environments**



Require safety and certification



Are complex and multi-domain



Interact with the physical world

AI is accelerating **innovation** but does not remove **accountability**.

Generative AI has **practical limitations in production**

Black Box

Non-Deterministic

Inconsistent Quality

Traceability Gap

Scalability

Primary Barriers to Generative AI in Production

Safety-Critical Applications

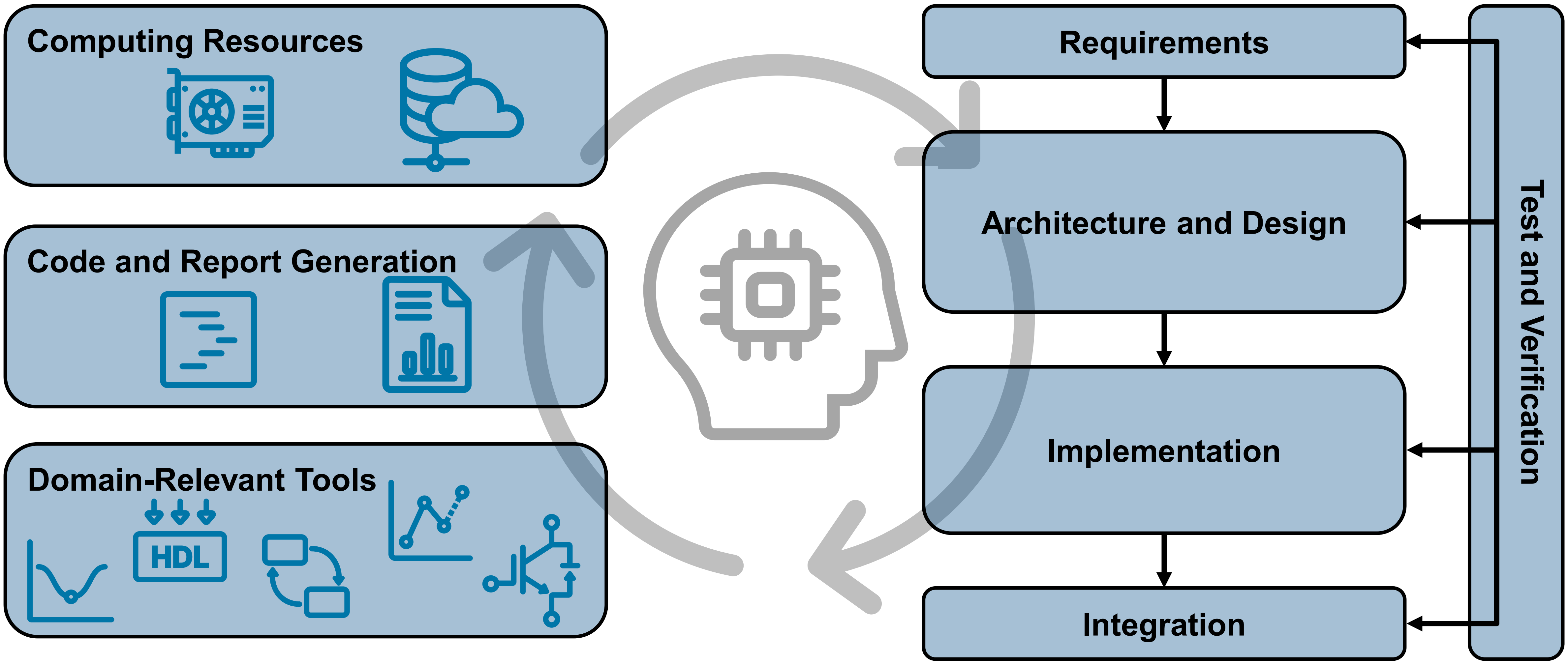
Data Security and Access

Validation of Results

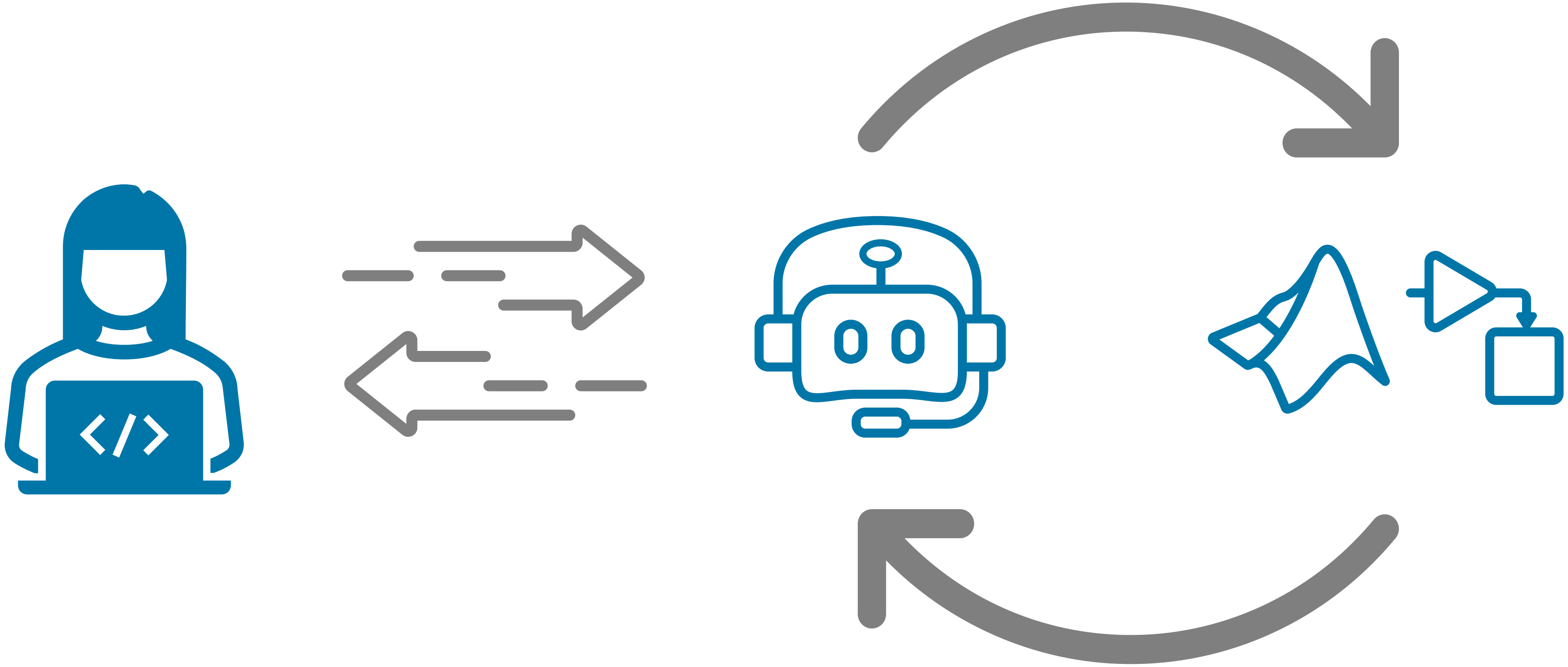
Upskilling Friction

The question is no longer *whether AI is used* in engineering and science, but whether it is used *responsibly*, *predictably*, and *verifiably*.

AI-enabled systems will **require skills and access to tools**



Agentic AI enables access to **trusted engineering and science tools**



Accelerate your MATLAB and Simulink productivity with GenAI

Agentic Workflows

External GenAI Agents

use MATLAB or Simulink with external Agents via MCP or VS Code

Build Agents in MATLAB

call LLMs from MATLAB code

AI Assistants

MATLAB and Simulink Copilots

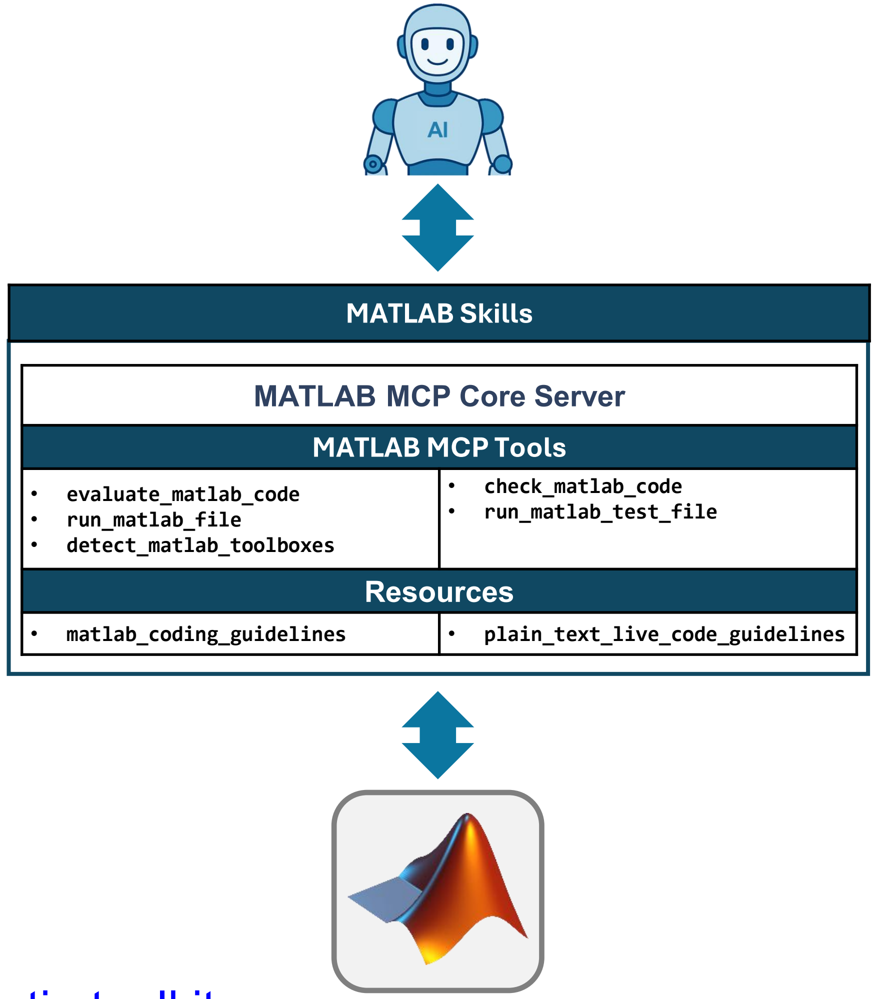
optimized for MATLAB and Simulink

MATLAB Agentic Toolkit

Connect trusted MATLAB capabilities to AI agents to make engineering and scientific workflows agent-ready

- A **free, open-source** local MCP server that connects GenAI assistants to a **locally licensed** MATLAB, enabling intelligent automation and code execution

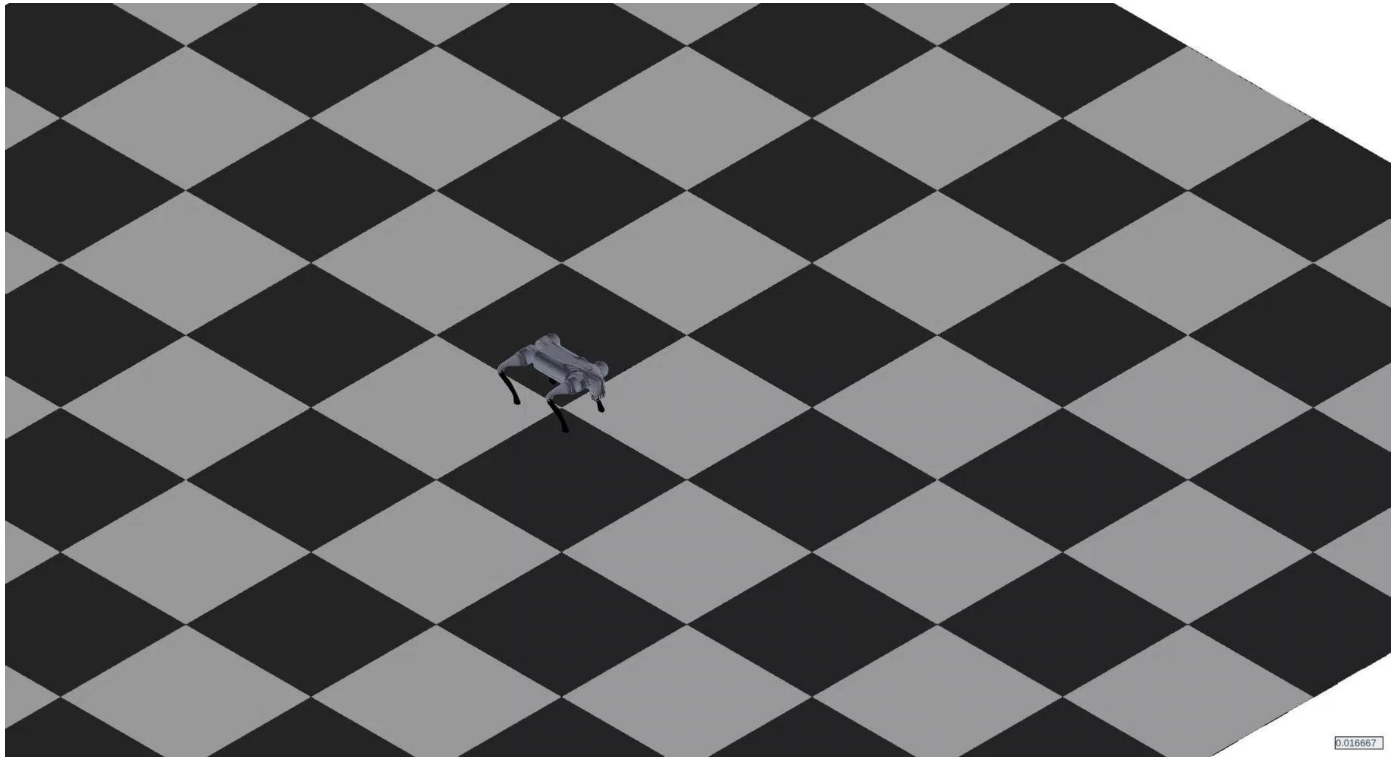
- Expert Skills Catalog encode MATLAB best practices, guiding AI in testing, debugging, and code modernization.



https://github.com/matlab/matlab-agentic-toolkit

A quadruped controller development example — built end-to-end by the Agentic Toolkit

- Built in 2 days vs. ~2–4 weeks (est.) by hand!



A NON-TRIVIAL PHYSICAL-AI TASK

SBS-MPPI controller — K=64 rollouts, N=25 horizon, 50 Hz on a 12-DoF quadruped.

Full stack — CPU MATLAB → GPU Coder MEX → Embedded Coder SIL.

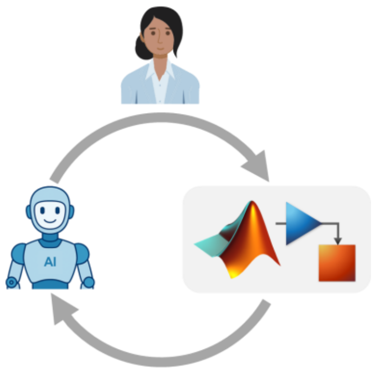
Written from spec — not ported from existing code.

Closed-loop on Simscape Multibody — stand, walk, strafe, turn. No fall.

Bring Generative AI into your workflow

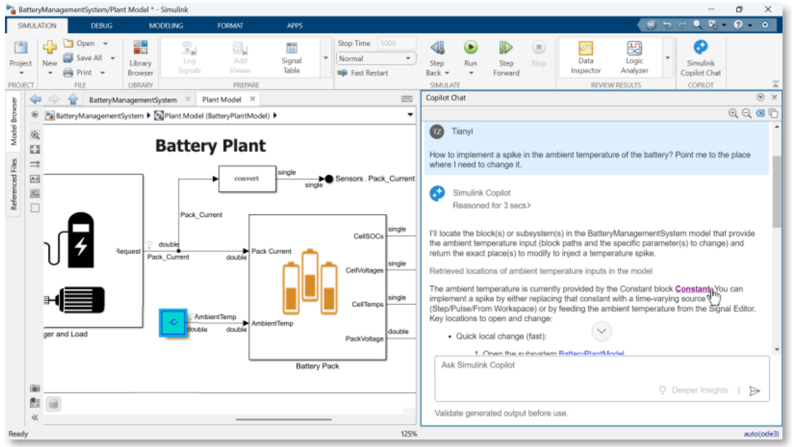
Two Pathways to AI-augmented Model-Based Design

Today's focus



Simulink Agentic Toolkit

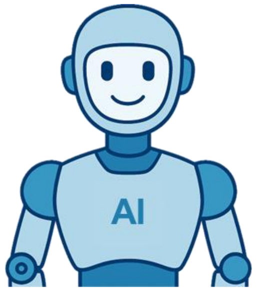
- Connect Simulink to agentic workflows
- Fastest route to agentic capabilities
- Flexibility of bringing your own agent/LLM infrastructure



Simulink Copilot

- Best integrated GenAI within Simulink
- No context switching
- Turnkey solution with minimal setup required

Agentic Toolkit equips agents to engineer models, not just code



MCP Tools

Agent Capability	Tool Name	Purpose
Understand	`model_overview`	Explore model architecture
	`model_read`	Understand model behavior
	`model_query_params`	Inspect any model parameter
	`model_resolve_params`	Resolve workspace variables
Change	`model_edit`	Build and modify models
Verify	`model_test*`	Verify models by creating & running tests

SKILLS

MATLAB MCP Core Server

*requires Simulink Test

Test-driven throughout, with a review gate at every boundary

- Human review at four phases boundary – you stay in control

PHASE A · DAY 1

Algorithm + closed-loop model

Agent translates your design doc into codegen-clean MATLAB and a Simulink closed-loop harness, with unit tests at each layer.

`→ 44 tests passing`

PHASE B · DAY 2

GPU Coder MEX

Agent applies the right kernel pragmas, regenerates, and uses a parity test it wrote itself to verify the MEX matches the CPU reference.

`→ 22.1× verified speedup`

PHASE C · DAY 2

End-to-end demo

Closed-loop omnidirectional walking on Simscape Multibody. Agent diagnoses and fixes gait edge cases on its own.

`→ 26 s clip, no fall`

PHASE D · DAY 2

Embedded Coder SIL

Agent wires the deployable harness, migrates Rate Transitions to the top model, enables profiling, and reports step-time stats.

`→ Fits the 20 ms budget`

Three reasons to put the Agentic Toolkit on your next robotics project

01

~2–4 weeks of work (est.), compressed into ~2 days

End-to-end controllers — algorithm, Simulink model, GPU MEX, Embedded Coder SIL — from a blank project, with human review gates at every phase boundary.

02

Test-driven and codegen-clean — without you enforcing it.

44 unit + integration tests, 22.1× GPU MEX with parity verification, ERT-clean MATLAB on the first commit. The skills set the rhythm.

03

Your toolbox knowledge compounds.

`AGENTS.md` plus cross-session memory means every project starts smarter than the one before. The toolbox knows what you taught it last time.

MathWorks is embracing the pace of GenAI
Example: MATLAB MCP Server release timeline on GitHub

Agentic AI comes to MATLAB!

- Coding Guidelines
- Lazy load of MATLAB
- Optimized binaries

- One-click install on Claude Desktop
- Connect to existing MATLAB sessions
- Define custom MATLAB MCP tools

Oct 31, 2025 | Dec | Jan ‘26 | Feb | Mar | Apr | Future

Initial Release v0.1

- Live Code Guidelines
- nodesktop display mode

MathWorks®

MathWorks GenAI Roadmap

May | Jun | Jul | Aug | Sep | Oct | Nov | Dec

R2026a → R2026b →

MATLAB Copilot	Bring you own key (OpenAI)	LLM Model Update	Agentic Mode
MATLAB MCP Server	Improved extensibility	Improved CI & Test workflows Support for Sandboxed Execution	Support for other products i.e. Polyspace, Roadrunner
MATLAB Agentic Toolkit	Connect Agents to MATLAB Skills turn LLMs into MATLAB experts	New, domain specific skills	
Simulink Copilot	Understand models Search semantically Troubleshoot errors Automate predefined tasks	LLM Model Update	Agentic Mode
Simulink Agentic Toolkit	Connect Agents to Simulink Skills turn LLMs into Simulink experts	New, domain specific skills	

Thank you!