MathWorks
AUTOMOTIVE CONFERENCE 2022
North America

Building a Virtual Vehicle for Large-Scale Simulation Studies

Mike Sasena, MathWorks product manager

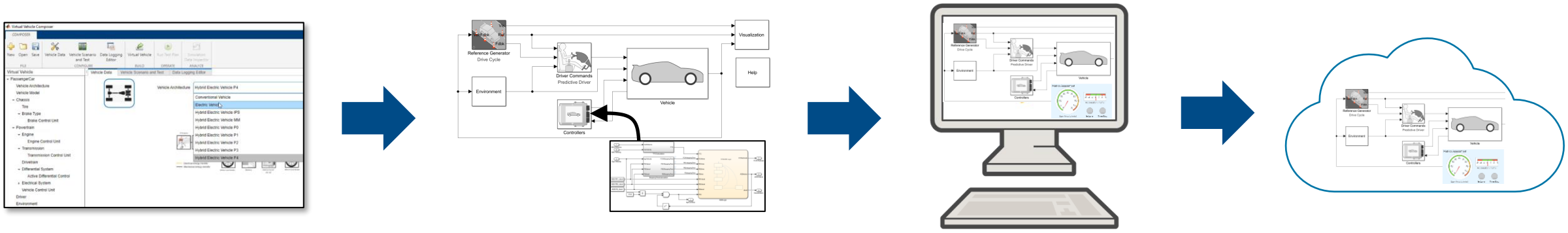
Brad Hieb, MathWorks application engineer

Scott Furry, MathWorks consultant

MathWorks

Key Takeaways

- New **Virtual Vehicle Composer app** makes it easy to build a Virtual Vehicle
- Generated models can be **customized**
- Studies can be performed on **desktop**
- Work can easily be deployed to the **cloud** for large-scale studies



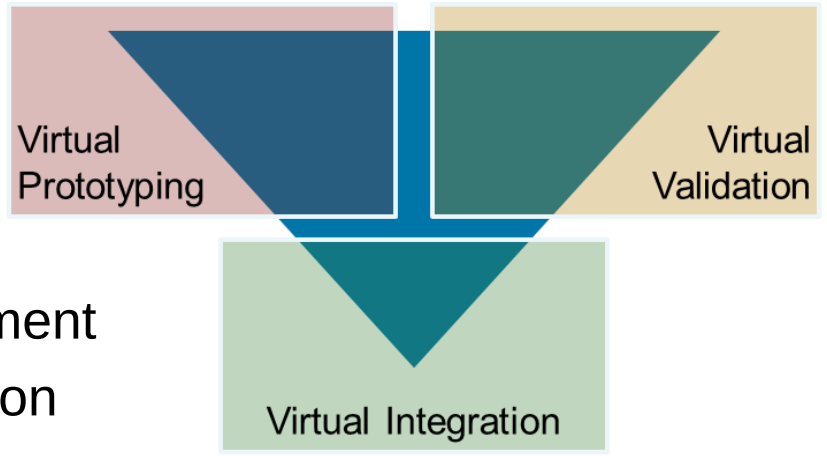
Agenda

- What is a Virtual Vehicle?
- Building a Virtual Vehicle
- Performing desktop studies
- Preparing for large scale studies

Agenda

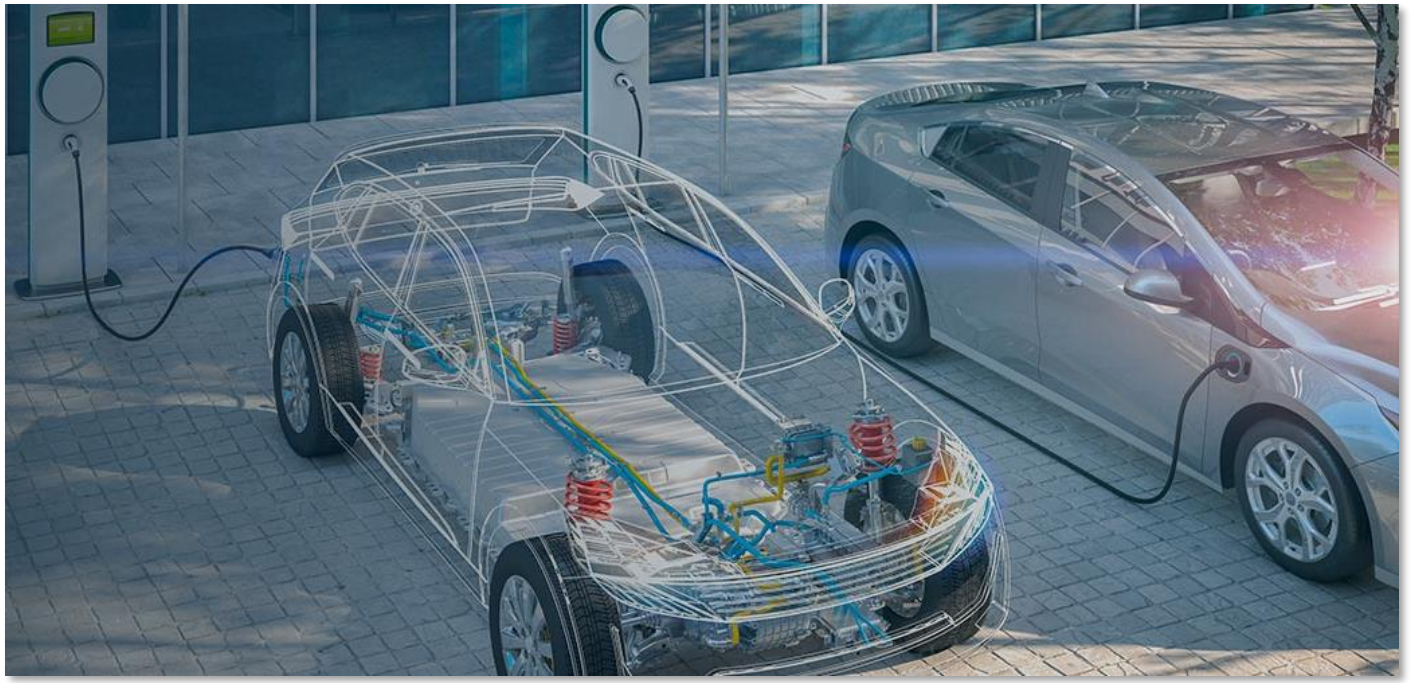
- **What is a Virtual Vehicle?**
- Building a Virtual Vehicle
- Performing desktop studies
- Preparing for large scale studies

What is a Virtual Vehicle?



- Companies are deepening virtual development
  - Increasing reliance on system-level simulation for development
  - Using physical prototypes for confirmation and final validation
  - Focus on powertrain, vehicle dynamics and ADAS / AD

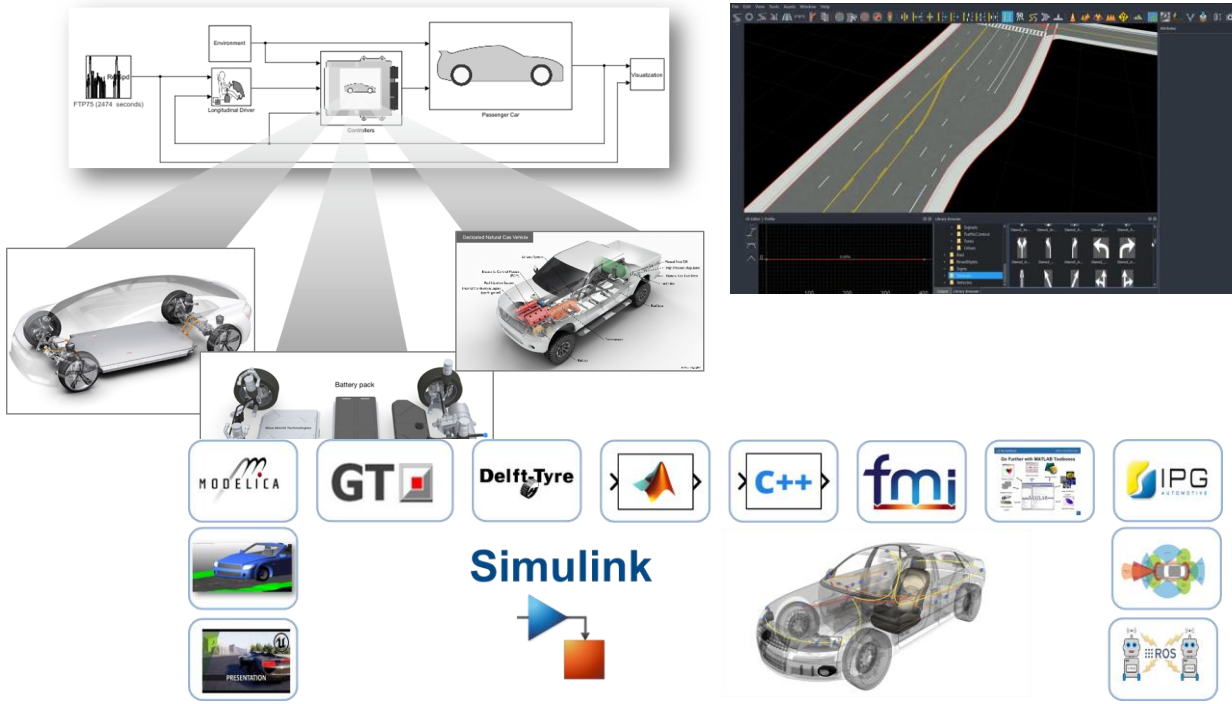
- Common challenges
  - Integration of both **physics** and **software** models
  - Access to “right level” **fidelity** models across organization
  - Deploying models to users who **aren’t tool experts**

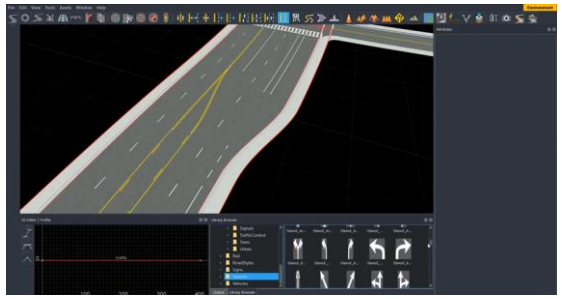


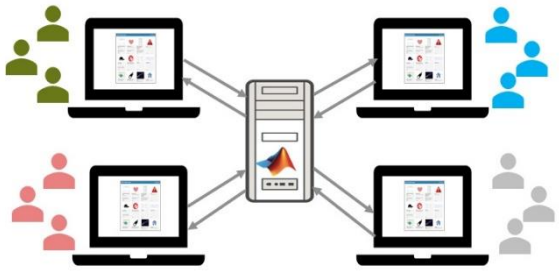
MathWorks Offering for Virtual Vehicle Simulation

Engineering Tools + Application Expertise

Create Vehicle	Integrate Software	Author Scenarios	Simulate & Analyze	Deploy Simulation
Vehicle Templates Subsystem Libraries Modeling Guidelines	C/C++ Interface Reduced Order Models FMU Integration	Scene & Scenarios Open Standards Drive Cycles	Visualization Data Analysis Report Generation	Cloud Integration Datalake Integration HIL Deployment



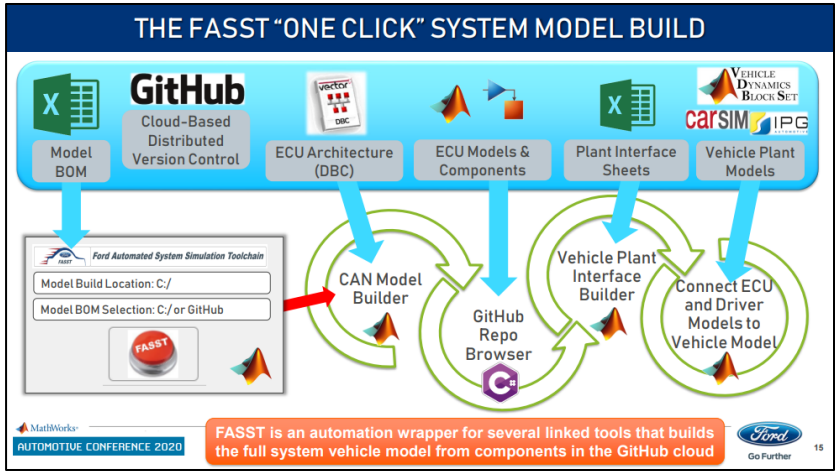




Value proposition:

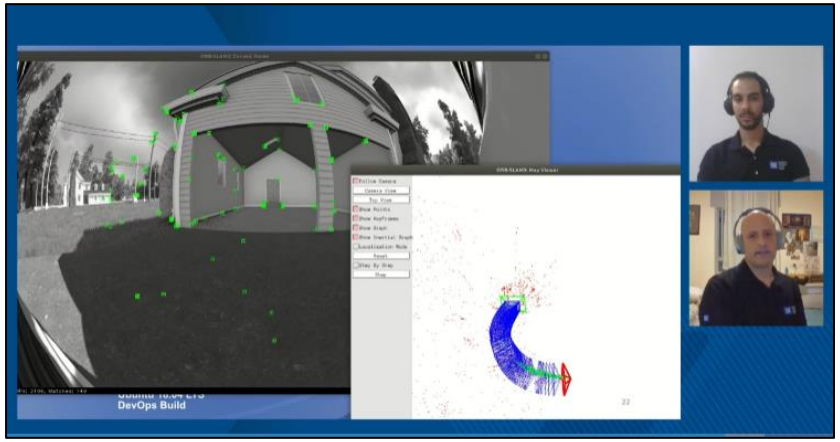
- Proven tools for modeling of physics and software
- Reference applications for reduced time-to-simulation
- Common platform for model reuse
- Solutions for large-scale modeling and simulation
- Flexible platform for growth / new use cases

How Are Companies Building Virtual Vehicles with MathWorks?

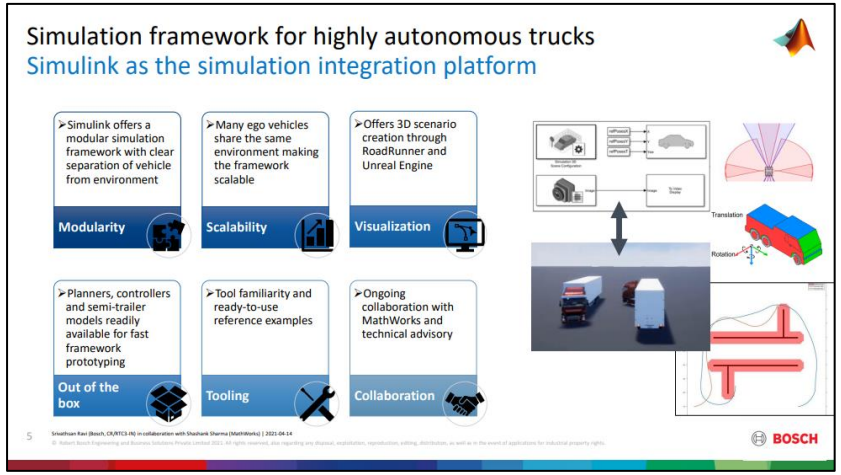


[Ford: Build Virtual Vehicle in minutes]

- Different virtual vehicles are built for different use cases
- Common themes are the automation of model creation, simulation and analysis



[GM: Autonomous parking development]



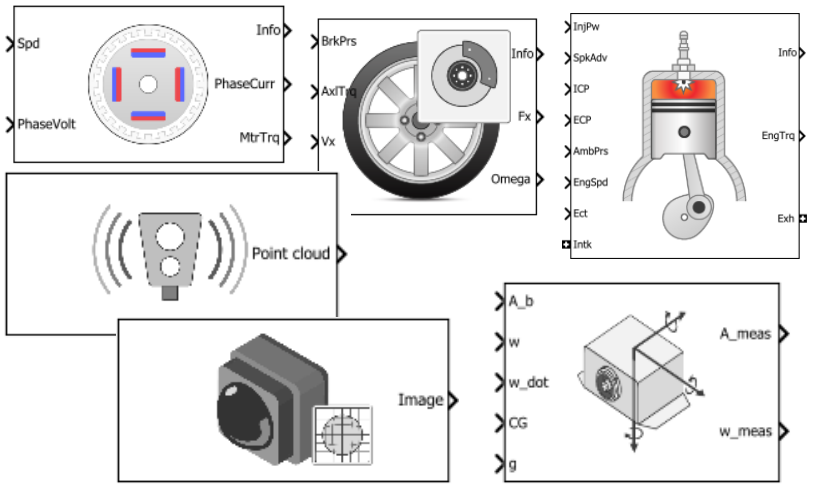
[Bosch: Autonomous truck development]

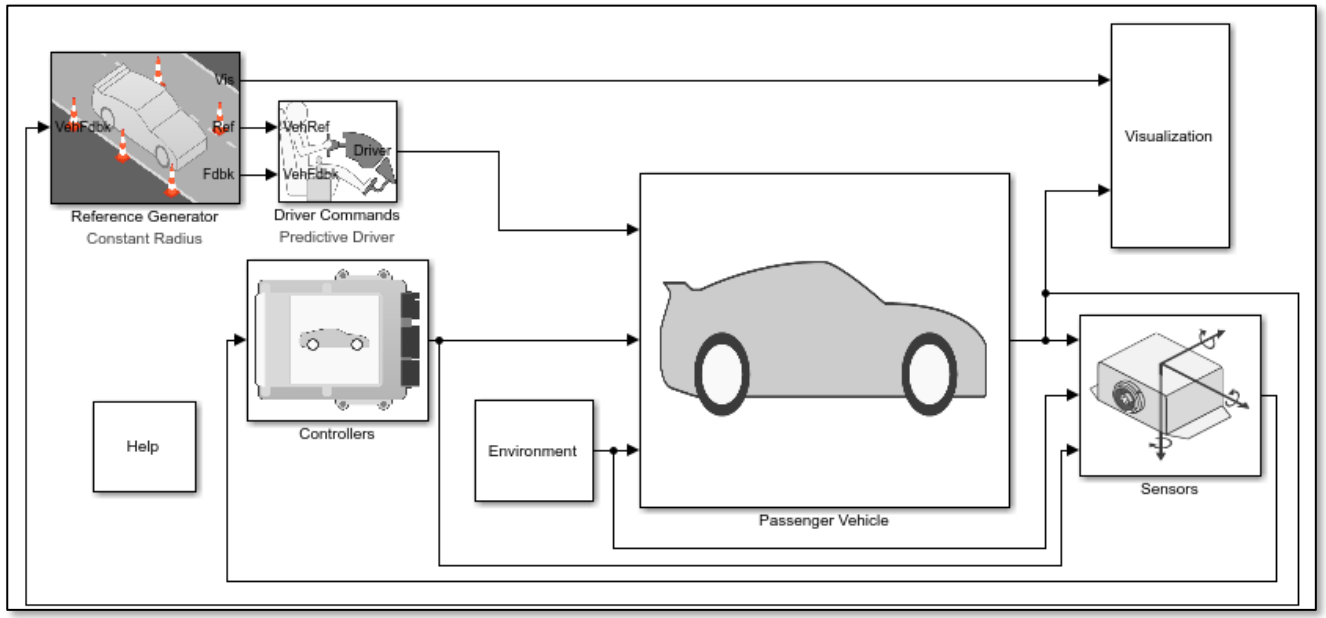
Agenda

- What is a Virtual Vehicle?
- **Building a Virtual Vehicle**
- Performing desktop studies
- Preparing for large scale studies

Building a Virtual Vehicle with MathWorks

- Start with one of our reference applications
- Customize as needed



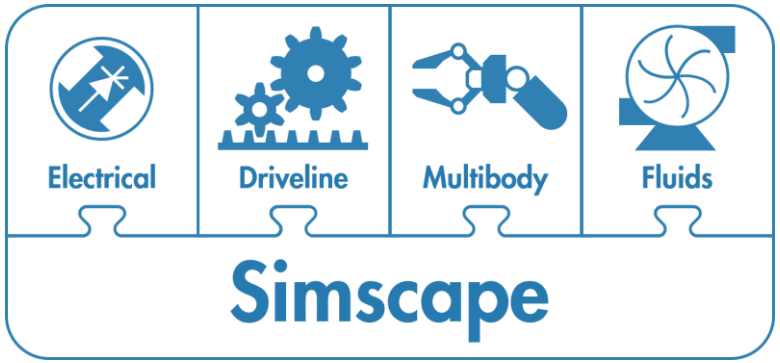


Learn more:

[Powertrain Blockset]

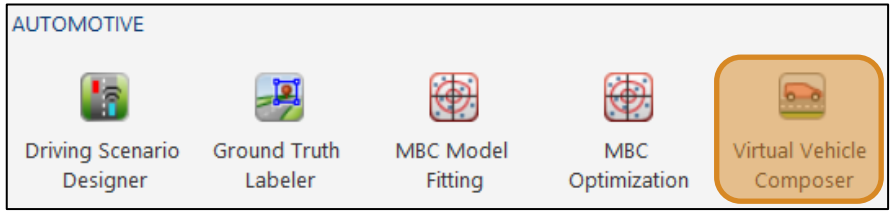
[Vehicle Dynamics Blockset]

[Simscape]

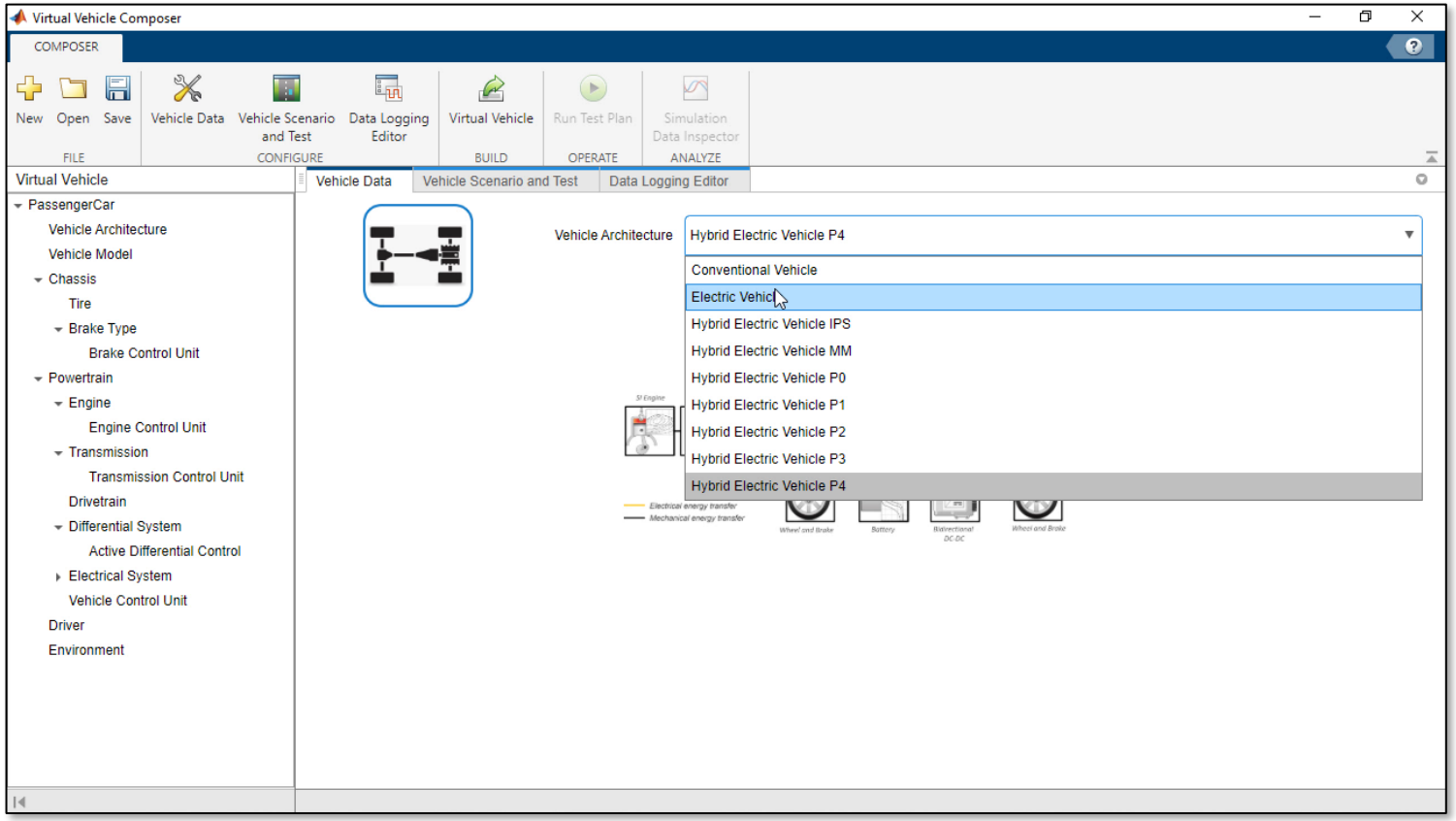


Virtual Vehicle Composer App

New in R2022a



- Unified interface to quickly configure a virtual vehicle model, select test cases and review results
- Available with **Powertrain Blockset** and / or **Vehicle Dynamics Blockset**
- Includes detailed powertrain models, vehicle dynamics and closed-loop controls

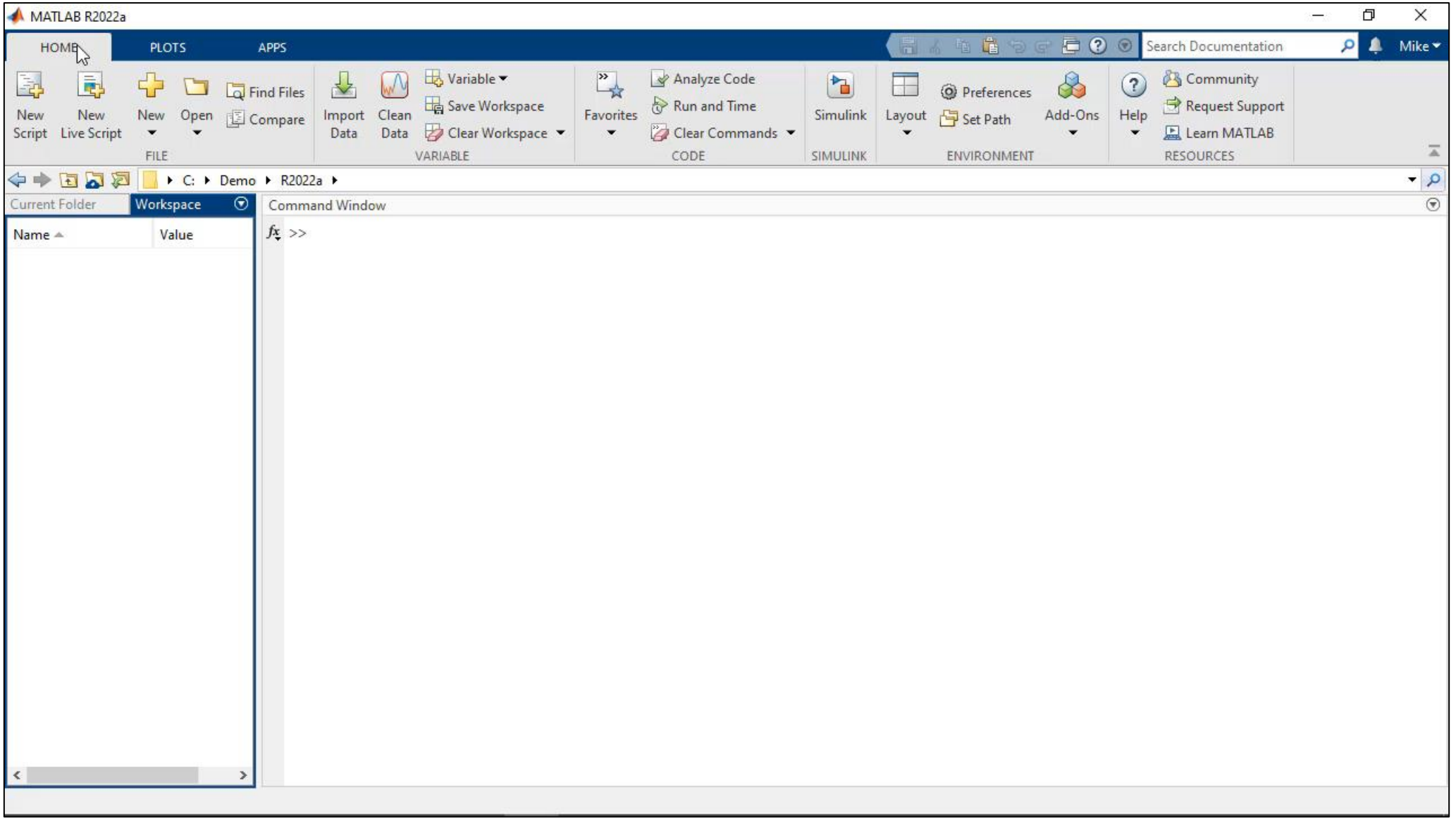


Learn more:

[Virtual Vehicle Composer]

Virtual Vehicle Composer App

New in R2022a

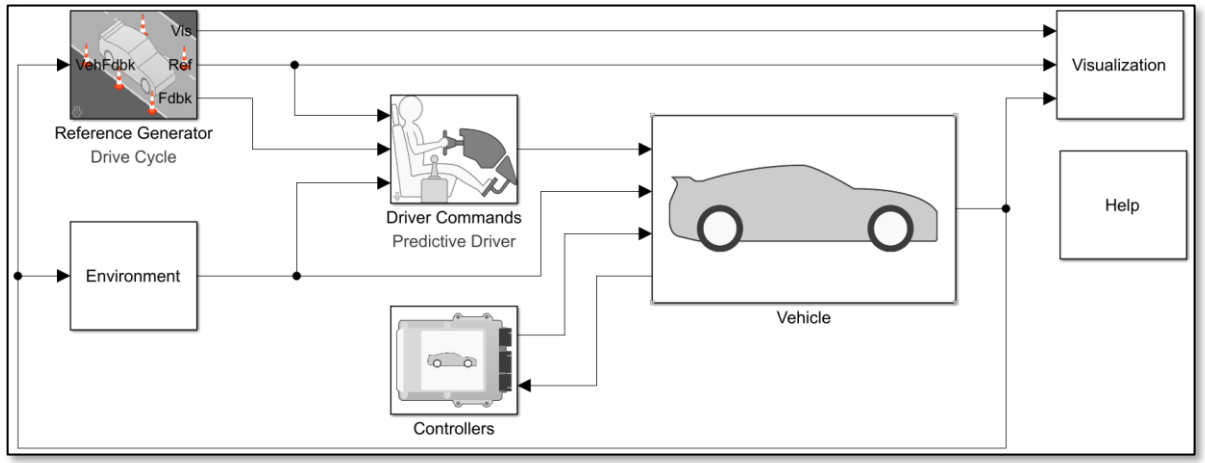


Workflow steps:

1. Start new session
2. Select powertrain
3. Select data
4. Select scenarios
5. Select signals to log
6. Generate model
7. Run test suite
8. Review results

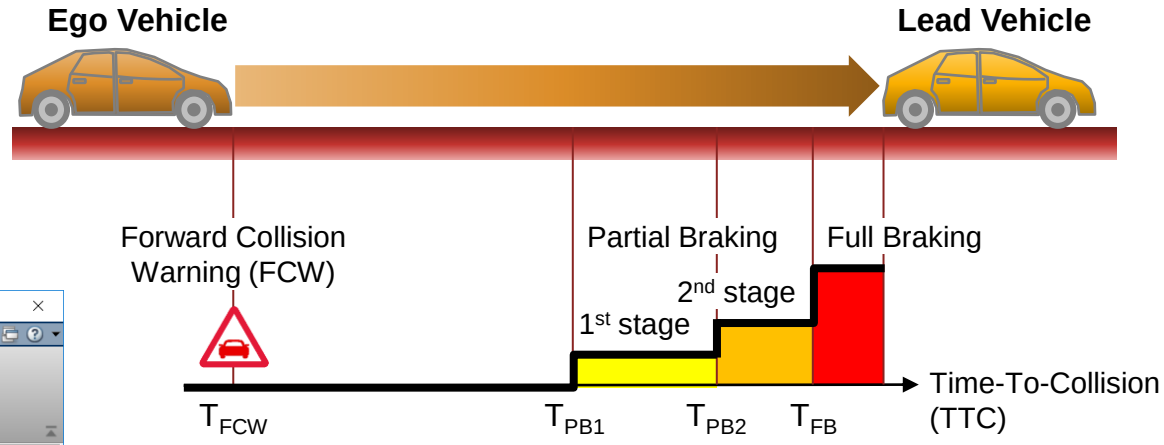
Model Customization

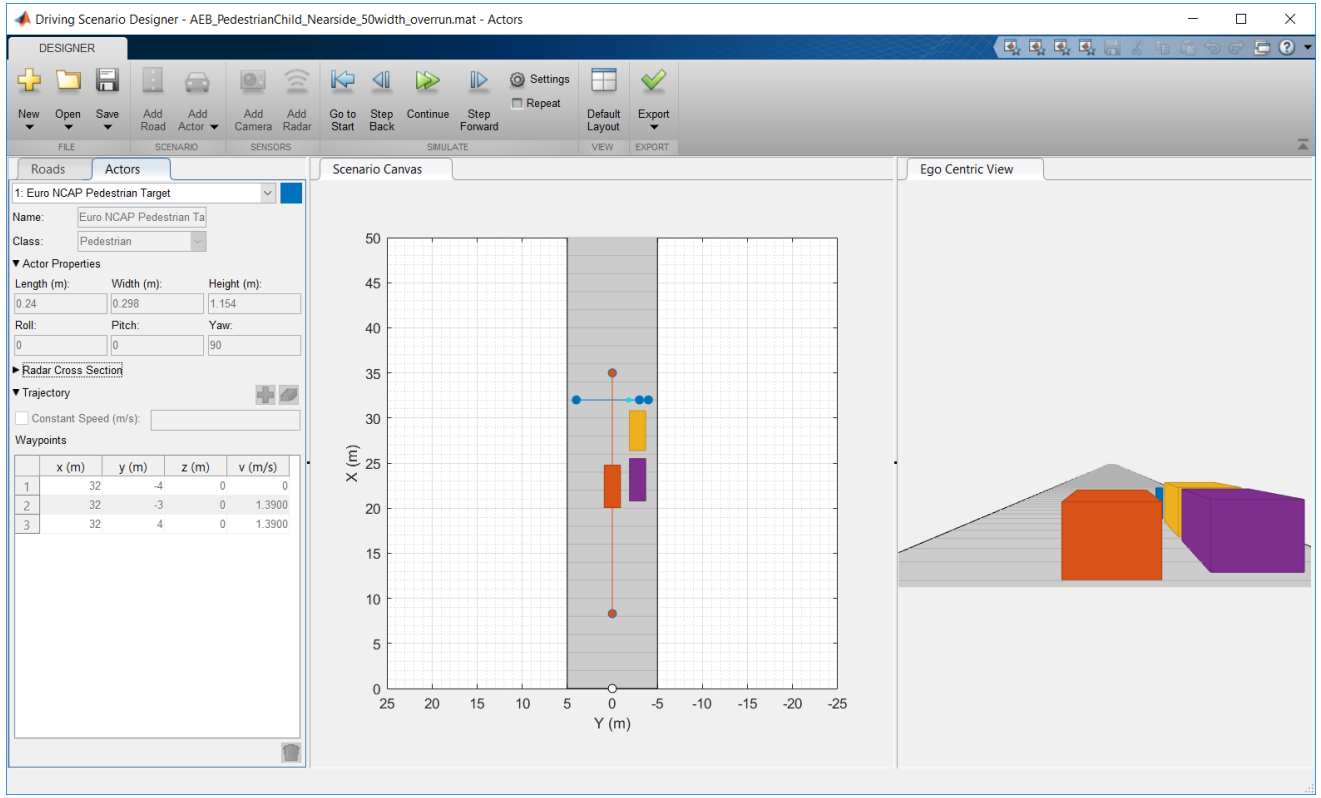
- Virtual Vehicle Composer app gets you a good starting point quickly
- Generated models are open, so you can customize it
  - Add new plant, controller or sensor model features
  - Create custom test scenarios
- Leverage Simulink platform
  - Integrate C code, S-functions, FMU, etc.
  - Perform large scale studies
  - Deploy model (HIL, cloud, etc.)



Autonomous Emergency Braking (AEB)

- If driver fails to apply brakes in time, AEB system engages automatically to avoid or mitigate collision





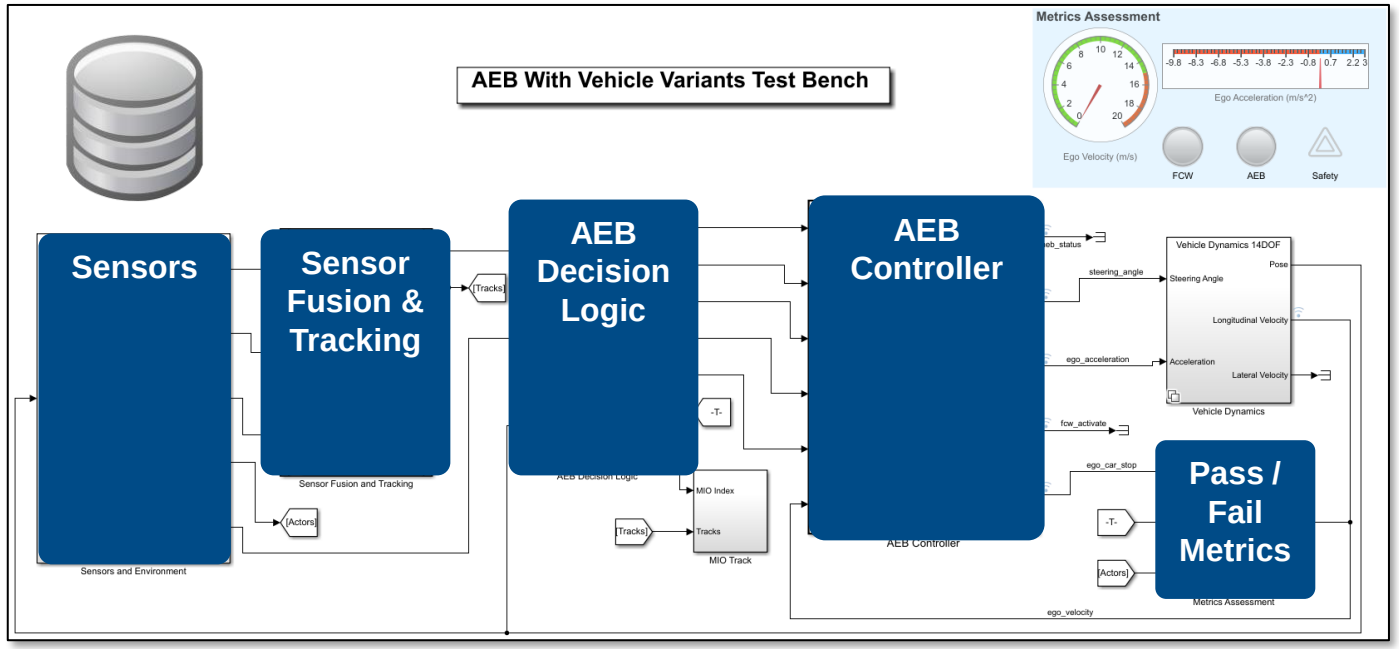
- Driving Scenario Designer can graphically author test scenarios
- Automated Driving Toolbox includes AEB demos for different use cases

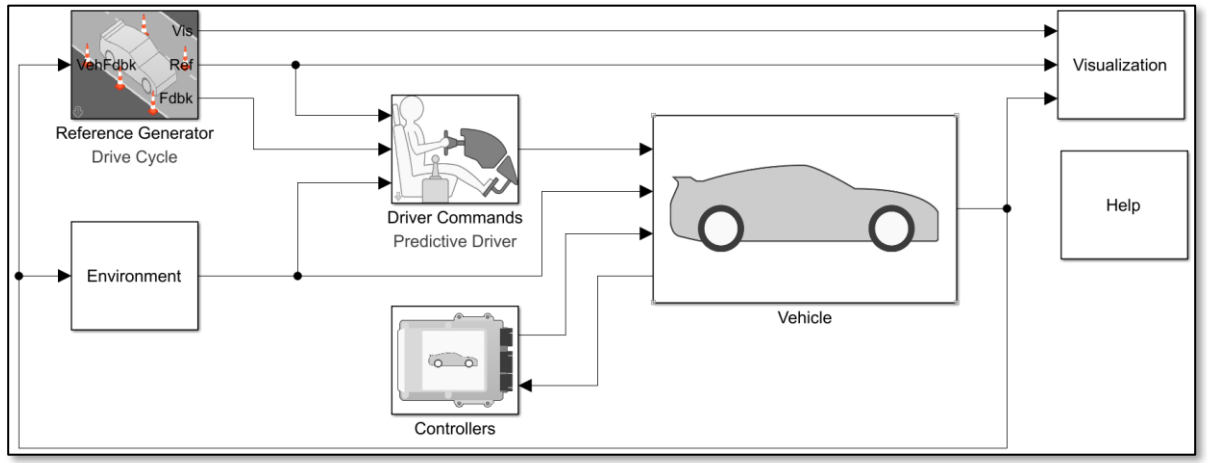
Learn more:

[Automated Driving Toolbox]

[AEB with Vehicle Variants]

Customizing for Autonomous Emergency Braking (AEB)





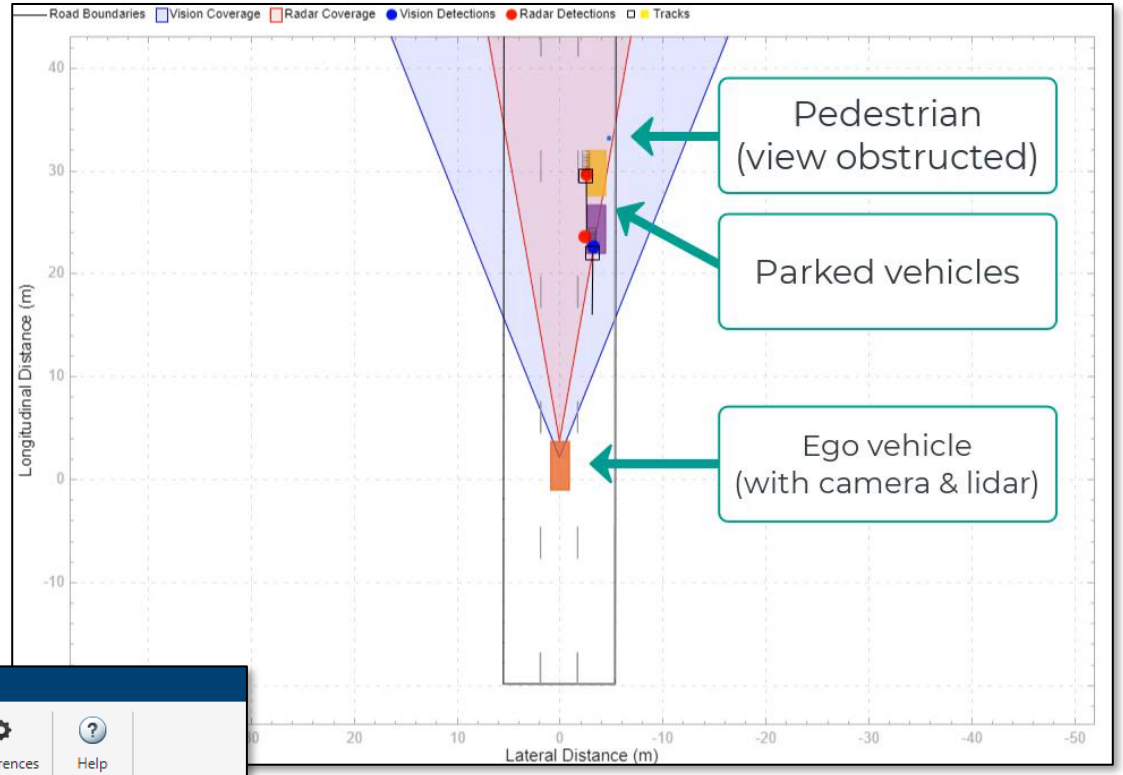
- Start with EV model generated from app
- Incorporate required features from AEB demo:
  - Sensor models
  - AEB control algorithm with brake input override
  - Test scenarios / metrics
- Import data developed for AEB application
  - Vehicle parameters
  - Controller calibrations

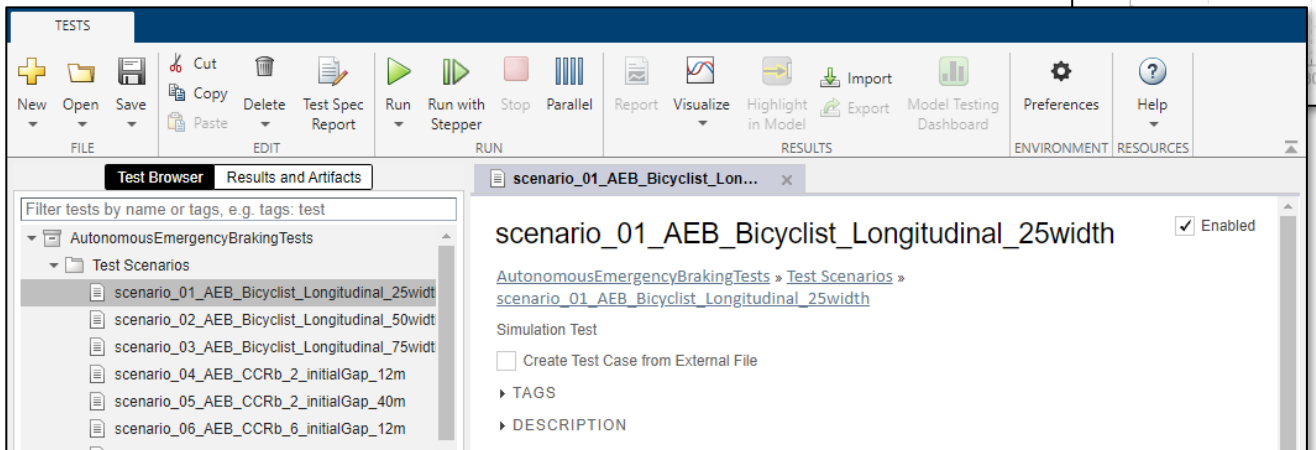
Agenda

- What is a Virtual Vehicle?
- Building a Virtual Vehicle
- **Performing desktop studies**
- Preparing for large scale studies

Setting Up AEB Study

- How robust / optimal is AEB controller?
  - Tests → different scenarios
  - Plant → additional payload
  - Controller → brake application time
    → 2nd stage brake level
- Pail / fail criterion
  - Did AEB bring vehicle to stop before collision?
- Use Simulink Test to manage test suite





Learn more:
[Simulink Test]

Start with Desktop Study

- Start small
  - Full study requires 28 x 16 x 5 x 5 = 11,200 runs
  - Desktop is good for small studies, but won’t scale well

- Desktop as a debugging platform
  - Validate custom model and test scripts perform as expected
  - Perform reduced study before scaling to cloud

Agenda

- What is a Virtual Vehicle?
- Building a Virtual Vehicle
- Performing desktop studies
- **Preparing for large scale studies**

Transitioning from Desktop to Cloud

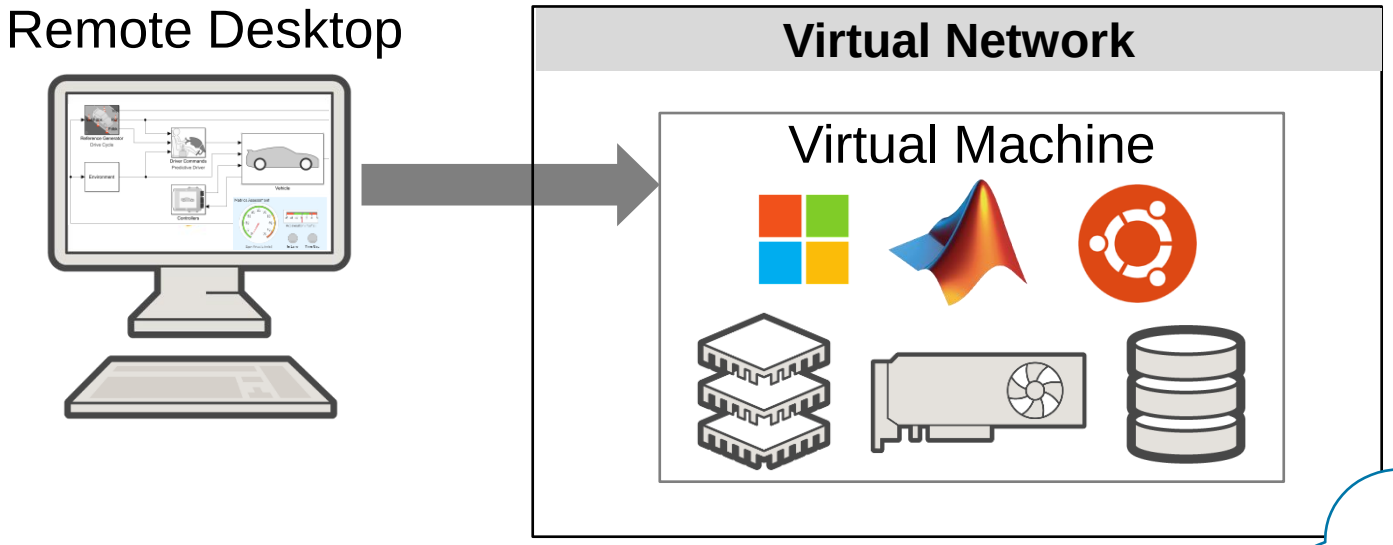
- Why would you want to use the cloud?
  - Offload computational load from your working machine
  - Scale up computing power (RAM, GPU, multi-core CPU, etc.)
  - On-demand access (“elastic computing”)
  - Proximity to cloud-based data repository
- It’s easy to port your code from desktop to cloud-based workflows
  - No need to rewrite your algorithm
  - Supports both Windows and Linux

Learn more:

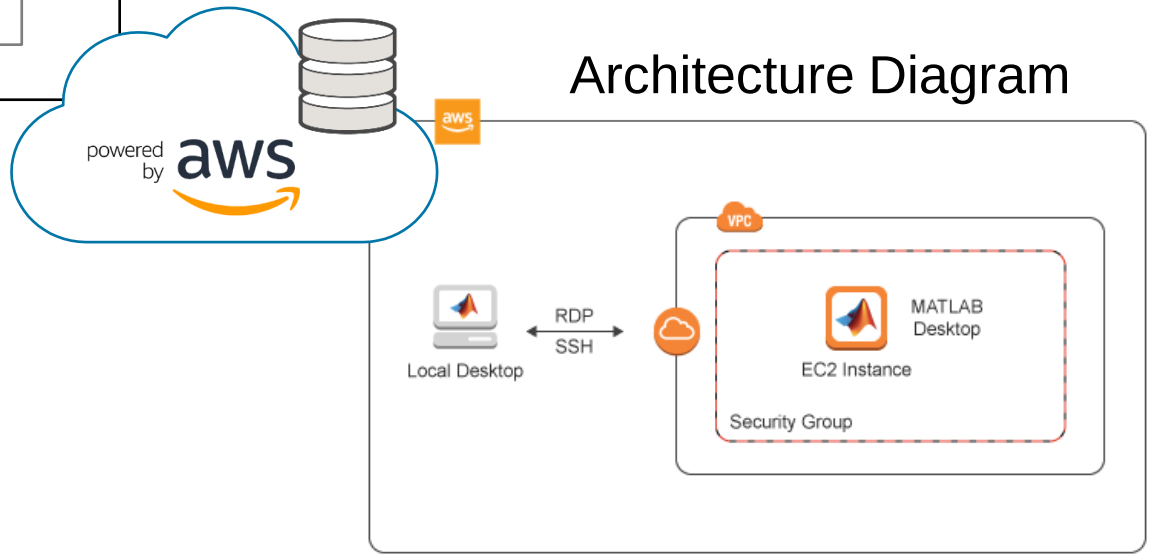
Parallel Computing Toolbox

MATLAB Parallel Server

Leveraging a Prebuilt Cloud Configuration via Reference Architecture



- MathWorks provides Reference Architectures for specific OS and software stacks on Virtual Machines (VM) in the cloud



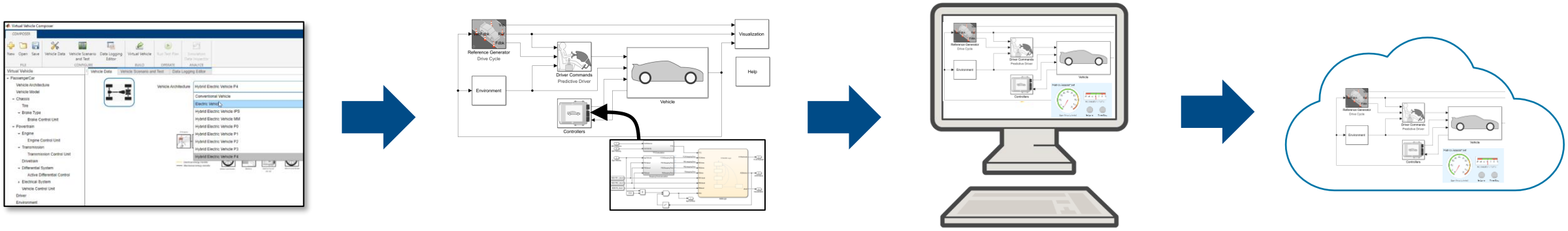
- Select VM with desired hardware setup, then apply Reference Architecture

Learn more:

[MATLAB on Amazon Web Services](#) (AWS)

Key Takeaways

- New **Virtual Vehicle Composer app** makes it easy to build a Virtual Vehicle
- Generated models can be **customized**
- Studies can be performed on **desktop**
- Work can easily be deployed to the **cloud** for large-scale studies



MathWorks Consulting Services Can Support You

Model Architecture

Model assessment
Simulation performance
Interface standardization
…

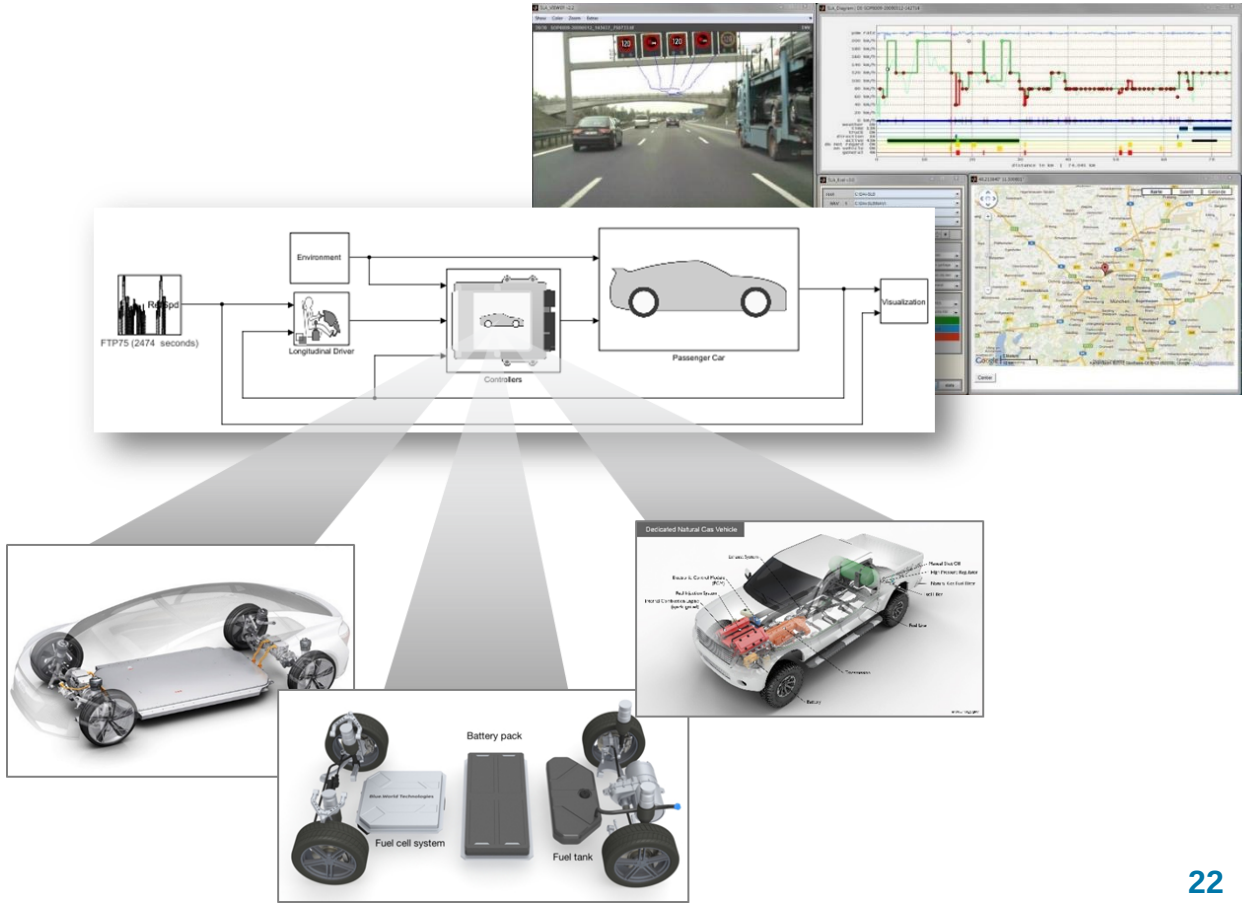
Construction

Build process automation
Database/Repo interface
Model-Building know-how
…

User Experience

GUI driven workflow
Tool compatibility support
Artifact creation
…

- Provide expert-level guidance
- Automate workflows
- Develop custom UI’s



Learn more:
[MathWorks Consulting Services]

MathWorks
AUTOMOTIVE CONFERENCE 2022
North America

Thank you

Mike Sasena: msasena@mathworks.com
Brad Hieb: bhieb@mathworks.com
Scott Furry: sfurry@mathworks.com

© 2022 The MathWorks, Inc. MATLAB and Simulink are registered trademarks of The MathWorks, Inc. See *mathworks.com/trademarks* for a list of additional trademarks. Other product or brand names may be trademarks or registered trademarks of their respective holders.