

2020 MathWorks 中国汽车年会

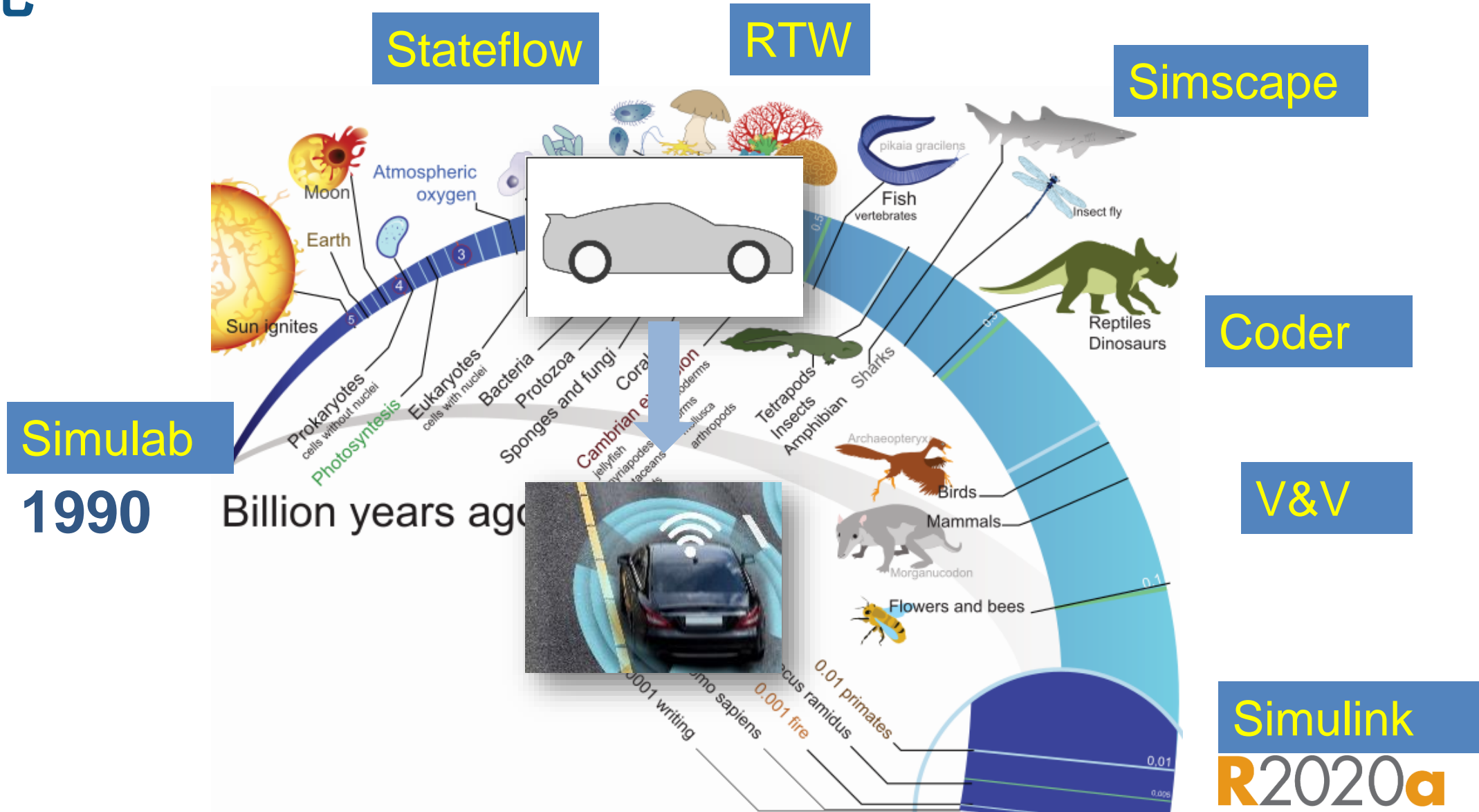
基于模型的工程平台应对
软件开发的复杂性和规模化

张灵惠

MathWorks 亚太区技术项目支持总监

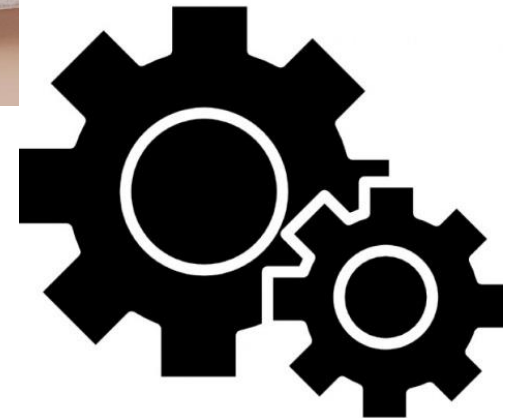
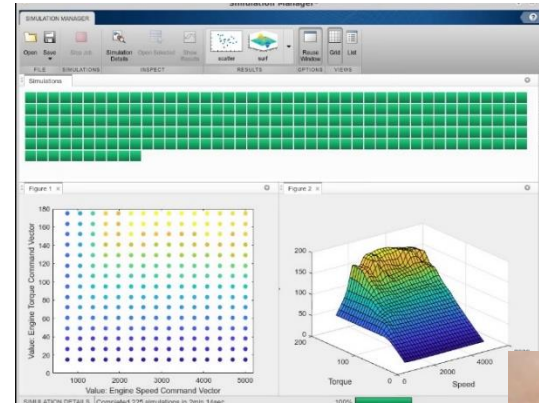


今天我们的主题： 进化



三种进化力量在起作用

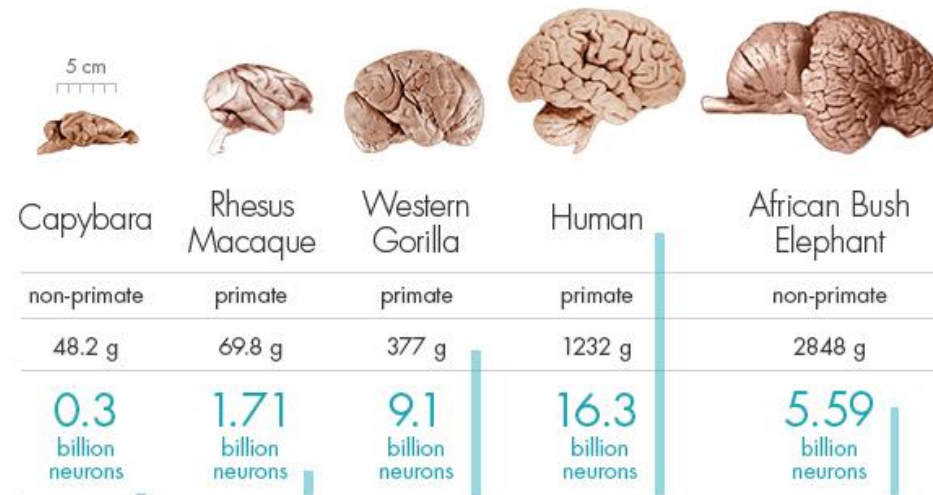
1. 仿真规模化
2. 设计复杂性
3. 协同工程化



仿真规模的演变

BRAIN SIZE AND NEURON COUNT

Cerebral cortex mass and neuron count for various mammals.



<https://www.quantamagazine.org/how-humans-evolved-supersize-brains-20151110/>

趋势：扩大仿真能力的需求

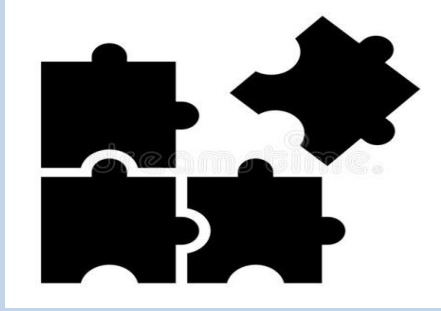


整车仿真

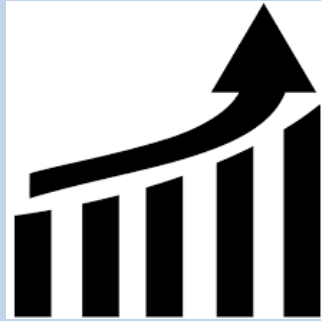
策略：不断演化Simulink，使其成为一流的仿真集成平台



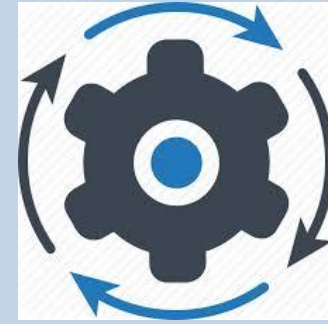
仿真规模的主要挑战



集成

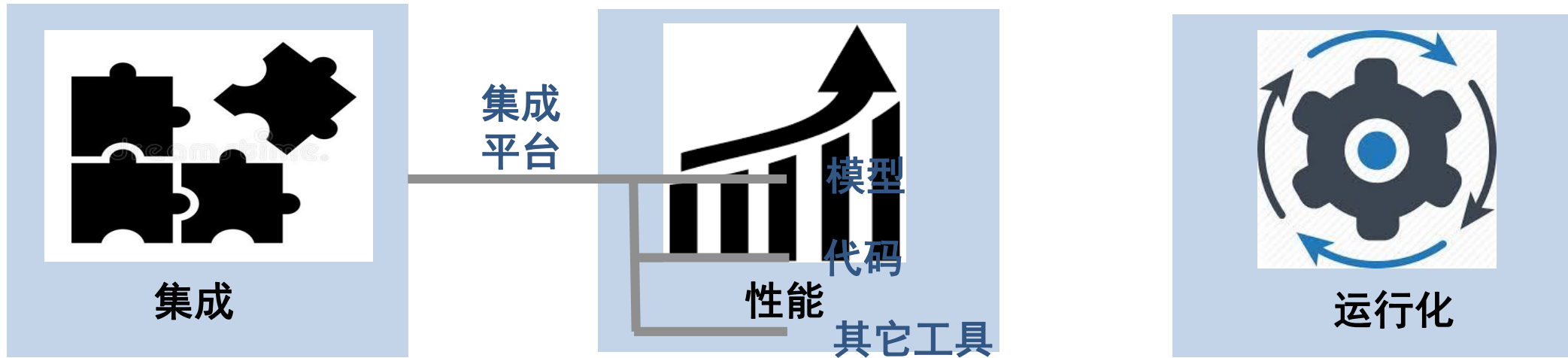


性能



运行化

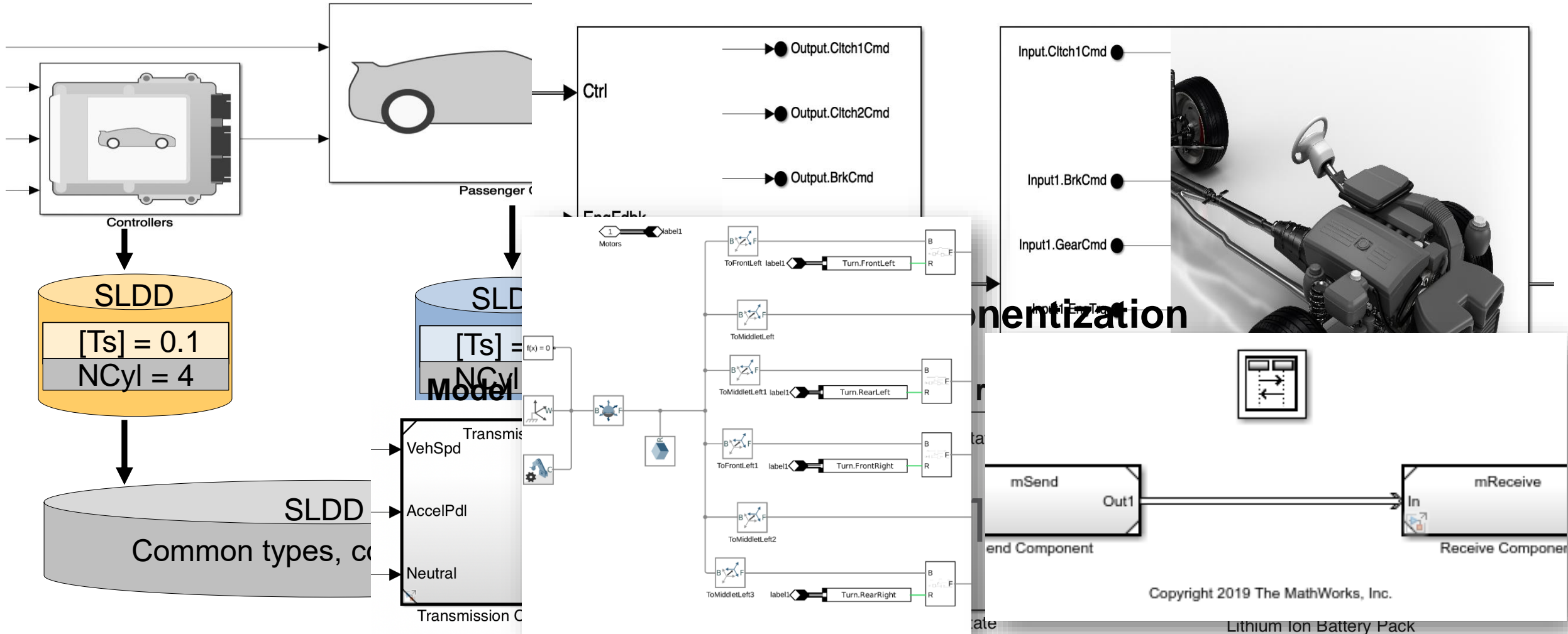
算法与多个仿真接口的集成是关键



对于模型，核心模块化原则是集成的基础

数据封装

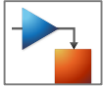
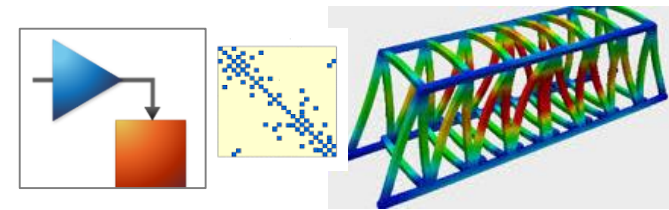
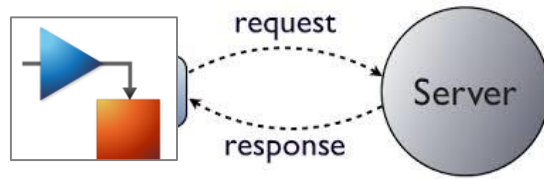
界面管理



可以轻松地将C / C ++代码引入Simulink

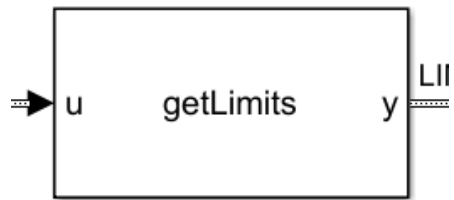
模型
代码
工具

```
void function_name() {
    .....
    .....
}
```

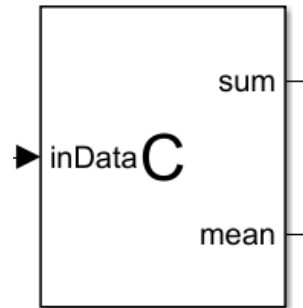
Basic

Advanced



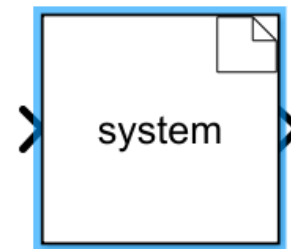
C Caller

R2018b

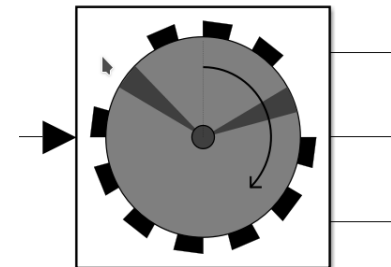


C Function

R2020a



S-Function
Builder



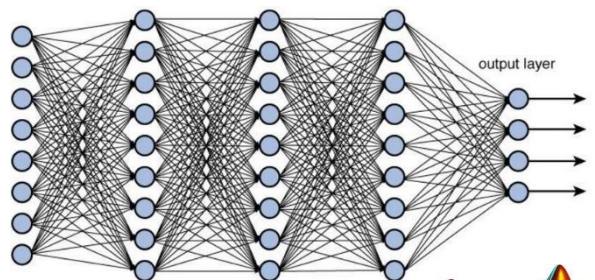
S-Function

可以在Simulink中用MATLAB 算法如Deep Learning Toolbox

模型

代码

工具



Deep Learning Toolbox

```

1 classdef DL_load < matlab.System
2
3     properties (Access = private)
4         % Trained deep learning model
5         DLModel
6     end
7

```

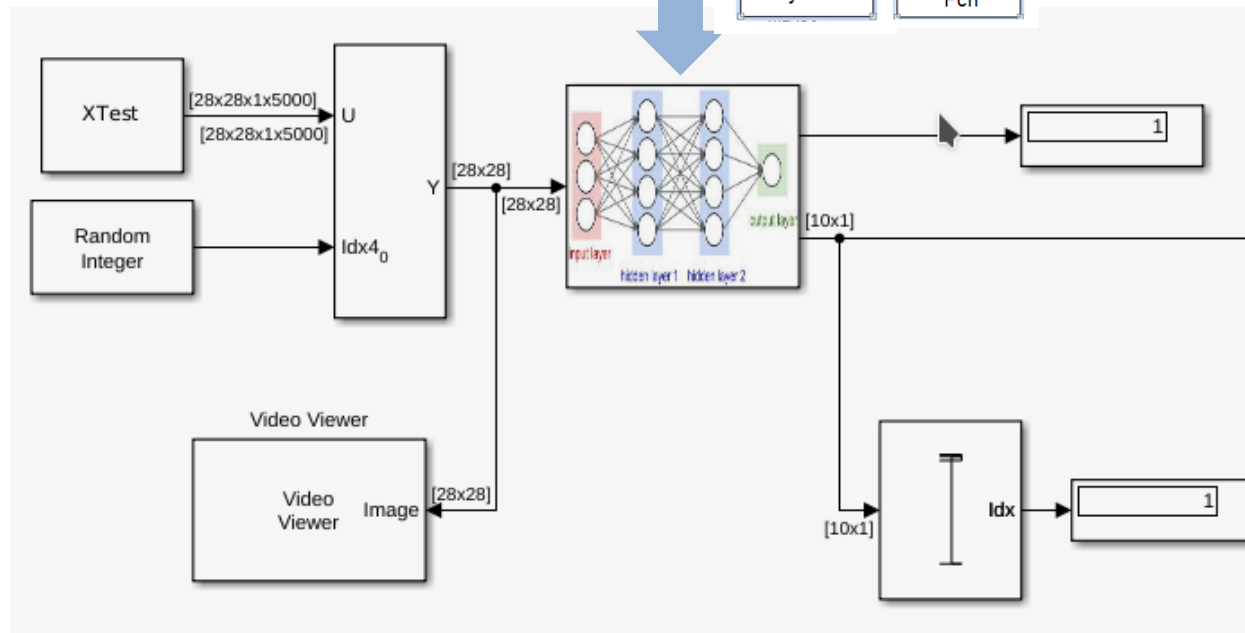
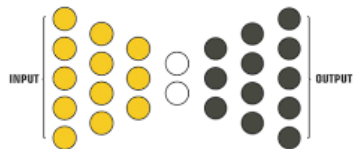
```

obj.DLModel = coder.loadDeepLearningNetwork('mydnn.mat', 'network')

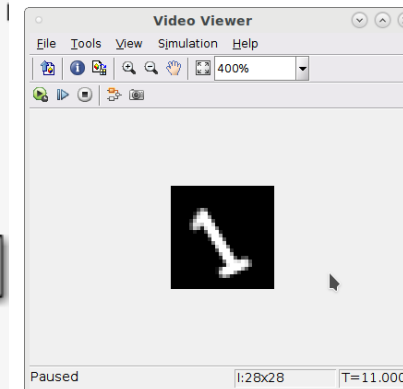
```

Tensorflow-
Keras Importer

K Keras TensorFlow 2.0



R2020a



Simulink主要通过S-Function接口为190个连接伙伴产品和服务提供仿真接口

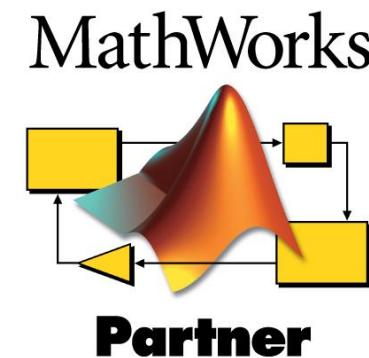
模型

代码

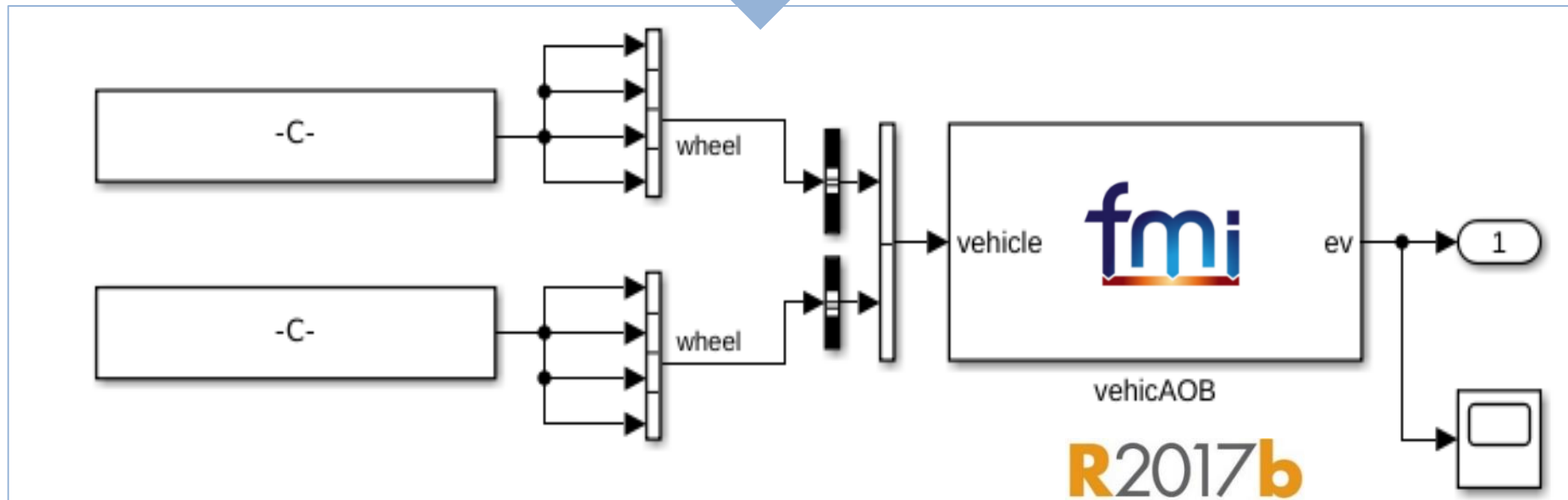
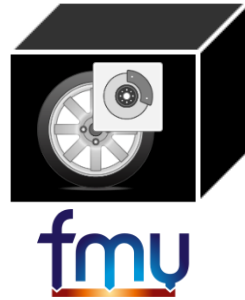
工具

The screenshot displays the MathWorks website's 'Third-Party Products & Services' section. The search results are filtered by 'Modeling and Simulation Tools' and 'System Modeling and Simulation'. The results list various simulation tools and their providers:

- SIMBA**: Software for the description and dynamic simulation of wastewater systems. Provider: Ifak System GmbH.
- SimHPN**: Toolbox for analysis and simulation of hybrid Petri nets. Provider: University of Zaragoza.
- SIMPACK**: Complete multibody simulation in combination with MATLAB. Provider: SIMPACK AG.
- SimulationX**: High-end modeling tool for simulating nonlinear, dynamic effects. Provider: ITI GmbH.
- SimWise 4D**: Simulation and validation of functional performance for mechanical parts and assemblies. Provider: Design Simulation Technologies.
- SMASH**: A mixed-signal, multi-language, and multi-level electronic simulator. Provider: Dolphin Integration.
- Structural Dynamics Toolbox**: Finite element modeling and modal analysis with MATLAB. Provider: SDTOOLS.
- SystemVision**: Mechatronics system modeling and analysis software. Provider: Mentor Graphics Corporation.
- Tactical Engagement Simulation Software (TESS)**: ECM evaluation tools using terminal phase engagement simulations. Provider: Tactical Technologies.
- Thermolib**: Toolbox for thermodynamic calculations and thermodynamic systems simulations in MATLAB® and Simulink®. Provider: EUtech Scientific Engineering GmbH.



Simulink中使用FMU既简单又富有表现力

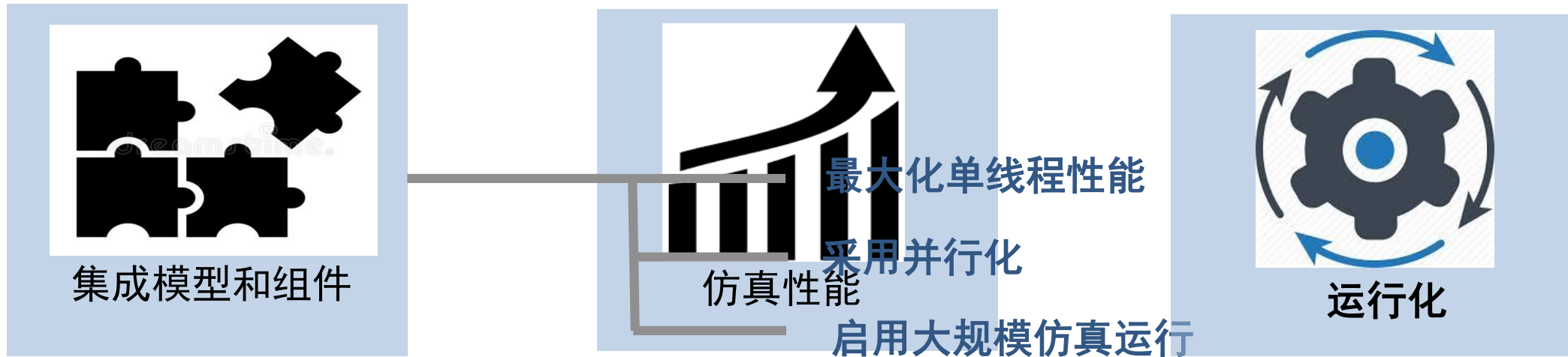


模型

代码

工具

系统级仿真的计算量很大 (昂贵)



通过发现加速机会来最大化性能：Performance Advisor

Filter checks

- ✔ Passed
- ✘ Failed
- ⚠ Warning
- 📄 Not Run

Keywords

Navigation

- Performance Advisor
- 1 Baseline
- 2 Simulation
- 2.1 Checks Occurring Before Update
- 2.2 Checks that Require Update Diagram
- 2.3 Checks that Require Simulation to Run
- 3 Simulation Targets
- 3.1 Check Simulation Modes Settings
- 3.2 Check Compiler Optimization Settings

Simulink Performance Advisor Report - vdp

Simulink version: 8.3
System: vdp

Performance Advisor

1 Baseline ✔1 ✘0 ⚠0 📄0

✔ **Create baseline**

Passed Baseline generated successfully. Simulation took 00:00:00.580 seconds.

Input Parameters Selection

Name	Value
Stop Time	10
Check to view baseline signals and set their tolerances.	false

2 Simulation ✔2 ✘0 ⚠2 📄8

2.1 Checks Occurring Before Update ✔1 ✘0 ⚠2 📄6

⚠ **Identify resource-intensive diagnostic settings**

Some diagnostics incur run-time overhead during simulation. Review the following parameters in the [Diagnostics](#) tool for these parameters.

Click link(s) to make changes manually. Alternatively, click the 'Modify all' button below to have Perf

	Severity	Diagnostics checked	Origin
Solver	✔	Diagnostics > Solver data inconsistency	none
Signals	⚠	Diagnostics > Data Validity > Signal resolution	Explici

- 关于性能的综合建议
- 给出有效的建议！
- 帮助发现注重功能的性能

投资多种并行化技术以提高性能

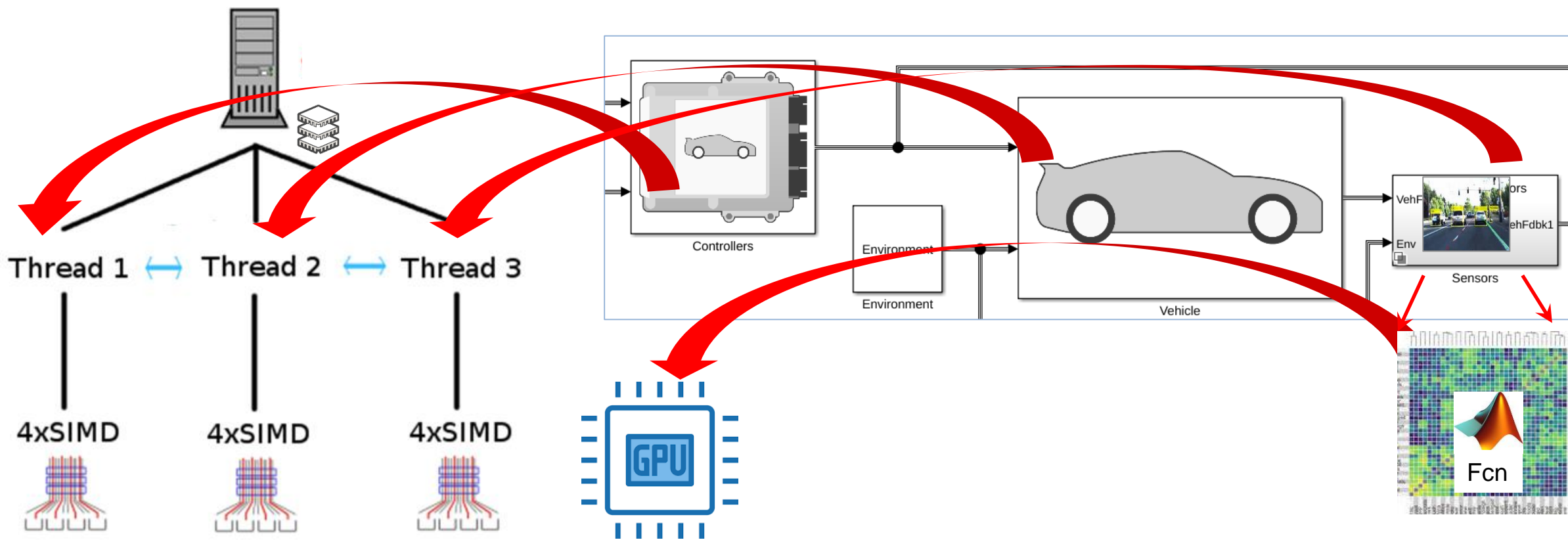
Model block, S-function, FMU 输入

R2018a

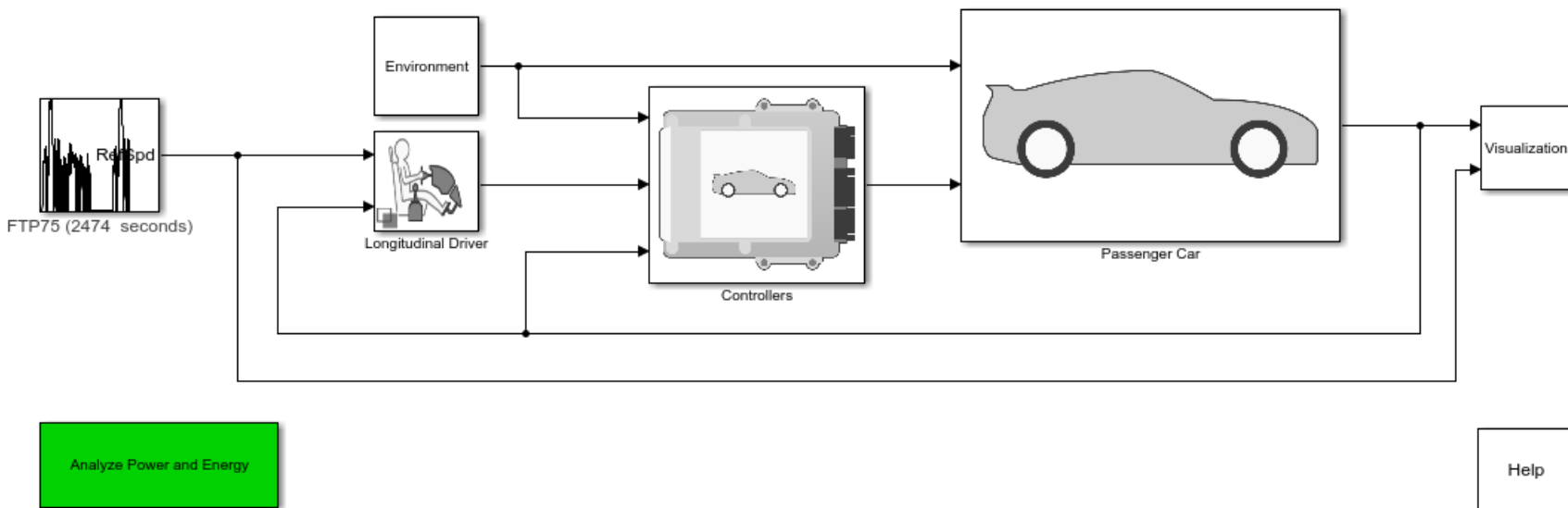
R2018a
数据流 SIMD

ForEach 子系统的并行化
MATLAB 函数 GPU 加速
计算集群

FUTURE
RELEASE

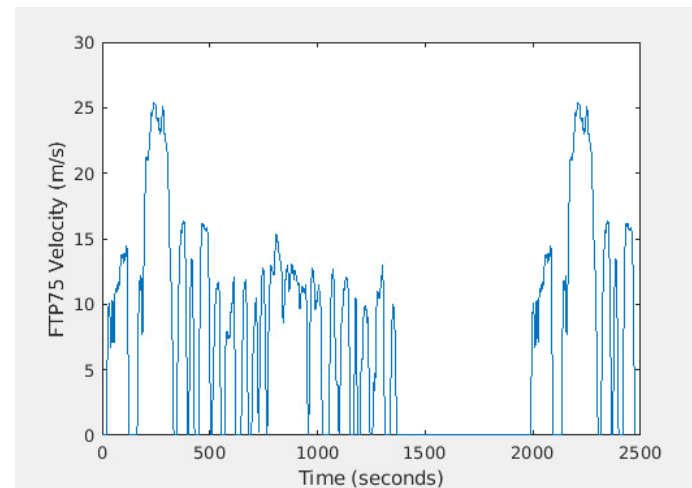


工况设计优化需要大量仿真



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整车模型



驾驶循环

100 驾驶循环

× 10 车辆装载

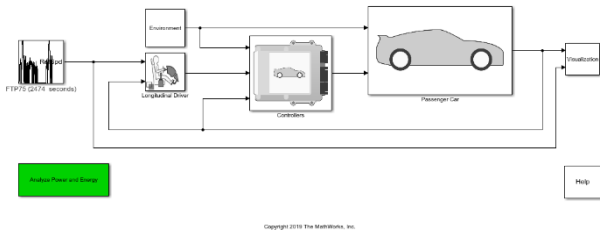
× 10 天气状况

100,000 iterations

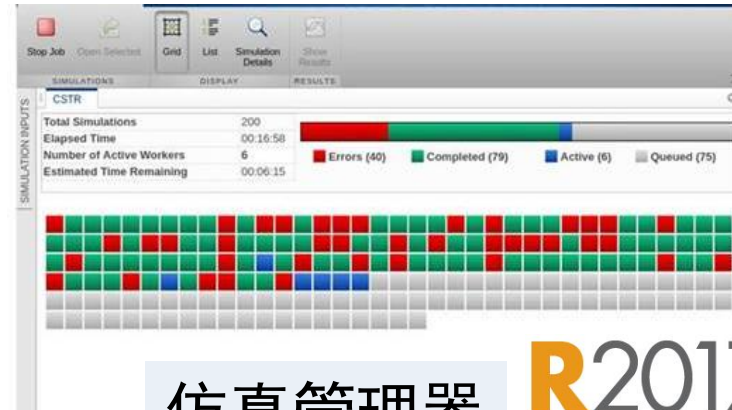
优化传动比

Simulink支持浩大量的仿真工作流程

创建



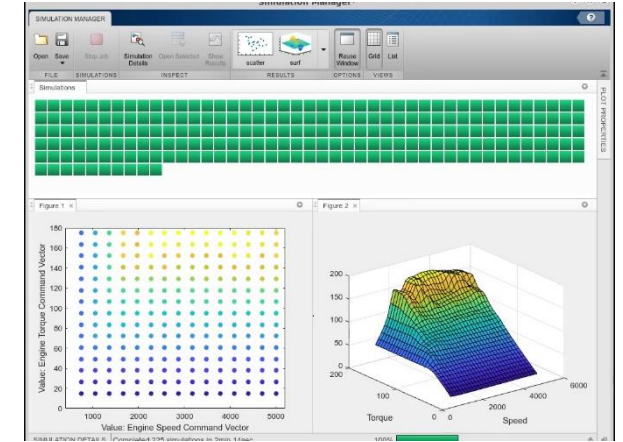
仿真



仿真管理器

R2017b

分析



仿真
管理器

R2019b

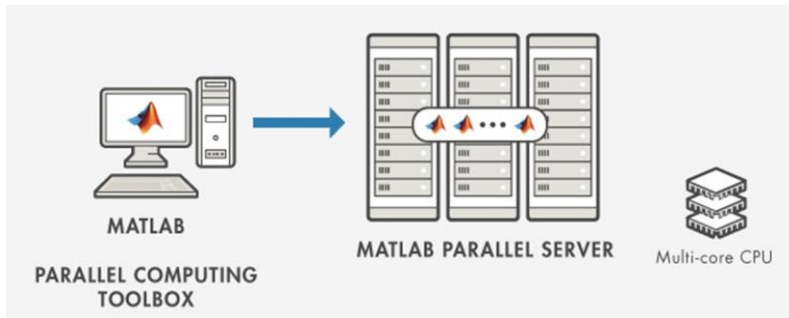
FUTURE
RELEASE

parsim

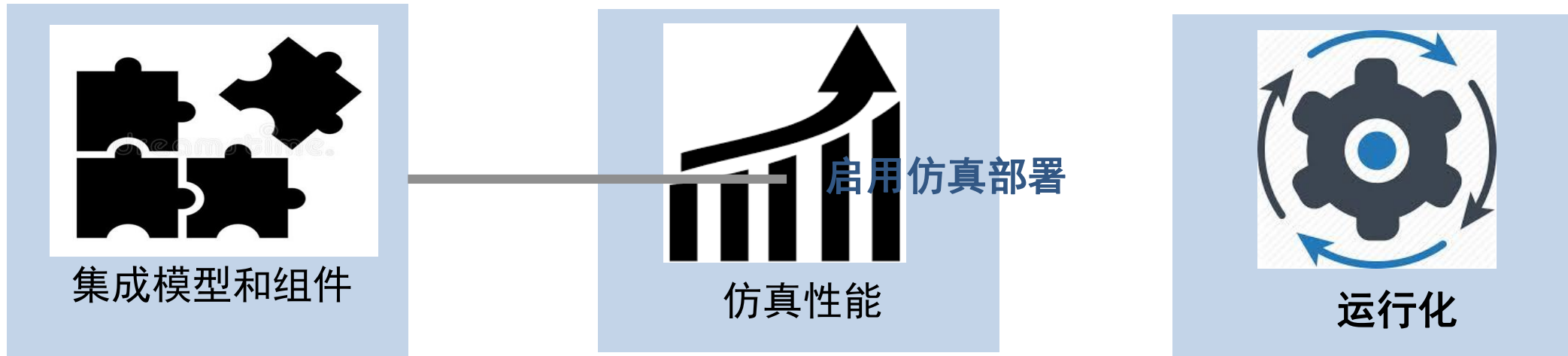
R2017b

batchsim

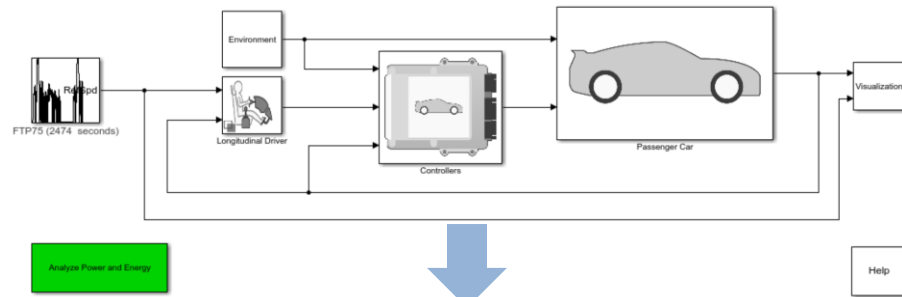
R2018b



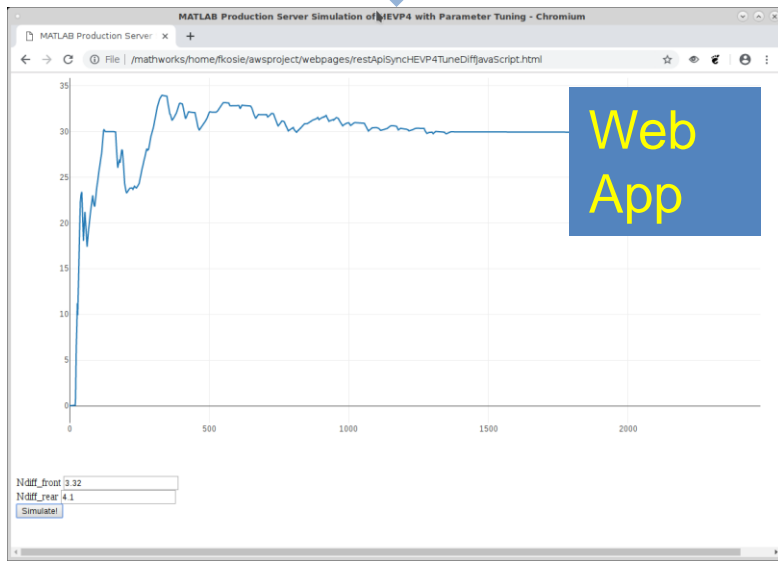
将仿真扩展到系统的运行阶段



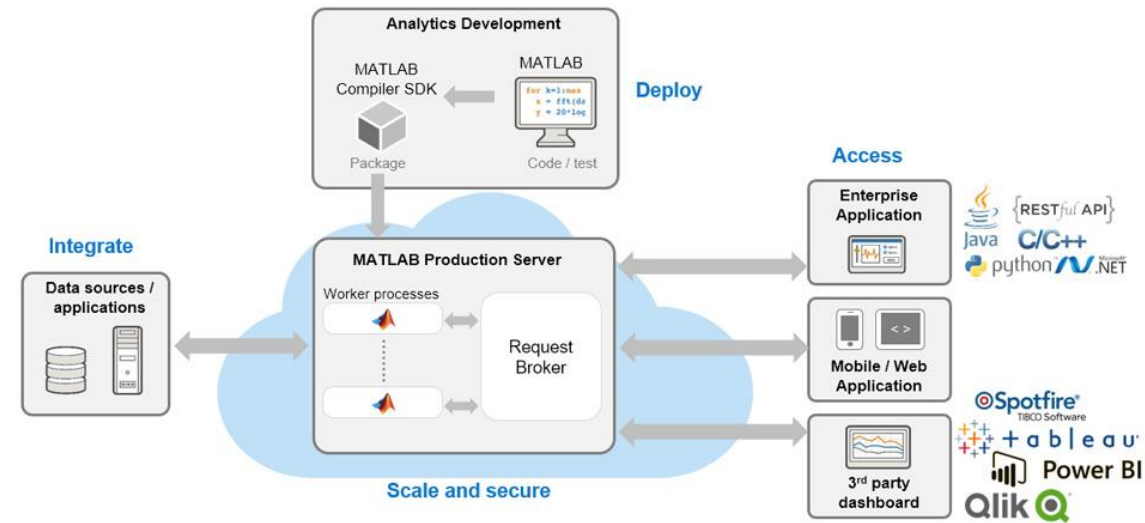
Simulink Compiler支持仿真部署



Simulink Compiler
R2020a



集成
为
企业级
应用

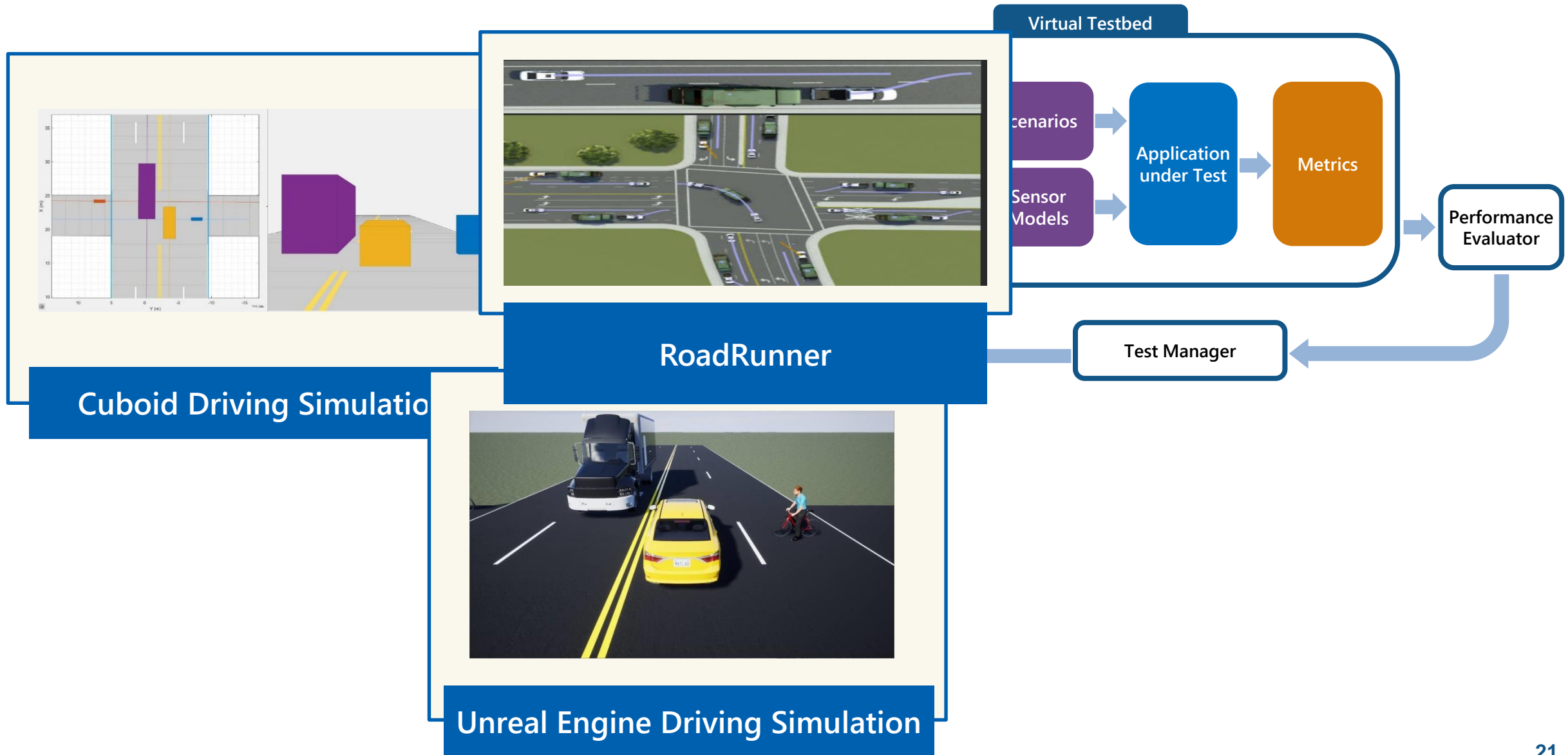


趋势：对具有多个参与者的复杂场景进行模拟的需求在增长



自主场景模拟

策略：为系统间 (场景) 仿真创建平台



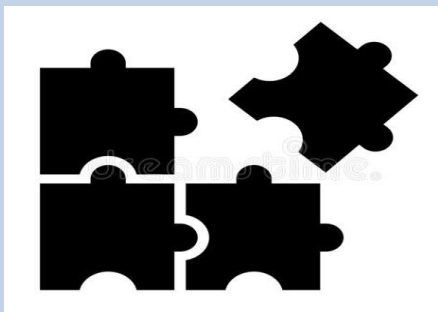
Simulink平台在不断发展以满足扩大规模的仿真需求



整车仿真



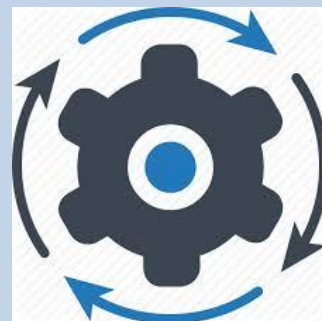
自主场景模拟



集成模型和组件



仿真性能



运行化



场景仿真

设计复杂性的演变



<https://en.wikipedia.org/wiki/Tiktaalik>

发现：行进中的一些失望

MAB 2012系统架构分组会



“Not sure you get it...”

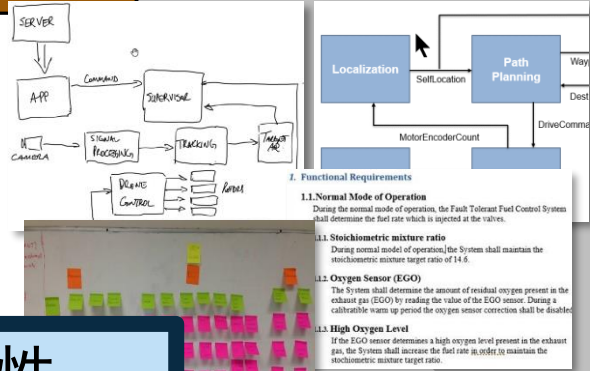
Wonder what's
for lunch?

为什么不满意?

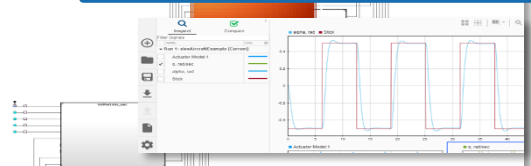
利益者需求

描述性架构

实施

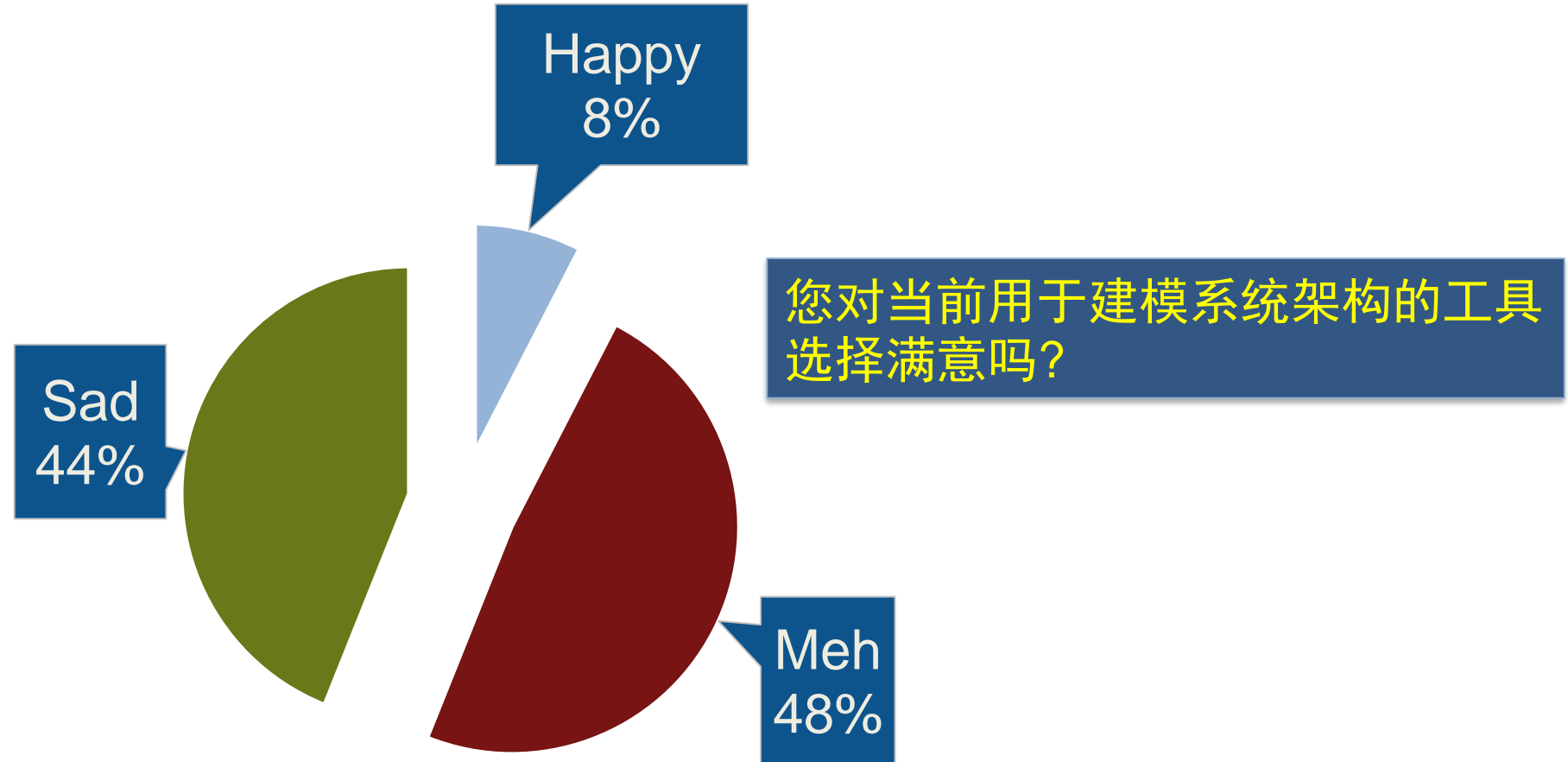


Customer quote:
 “We have tried to build the architecture model in SysML and connect it to the design in Simulink ...
 ... does not work without rework both in the architecture and design worlds whenever a change is needed. It is broken and we need a more integrated approach”



调查 @ 建模系统架构分组会

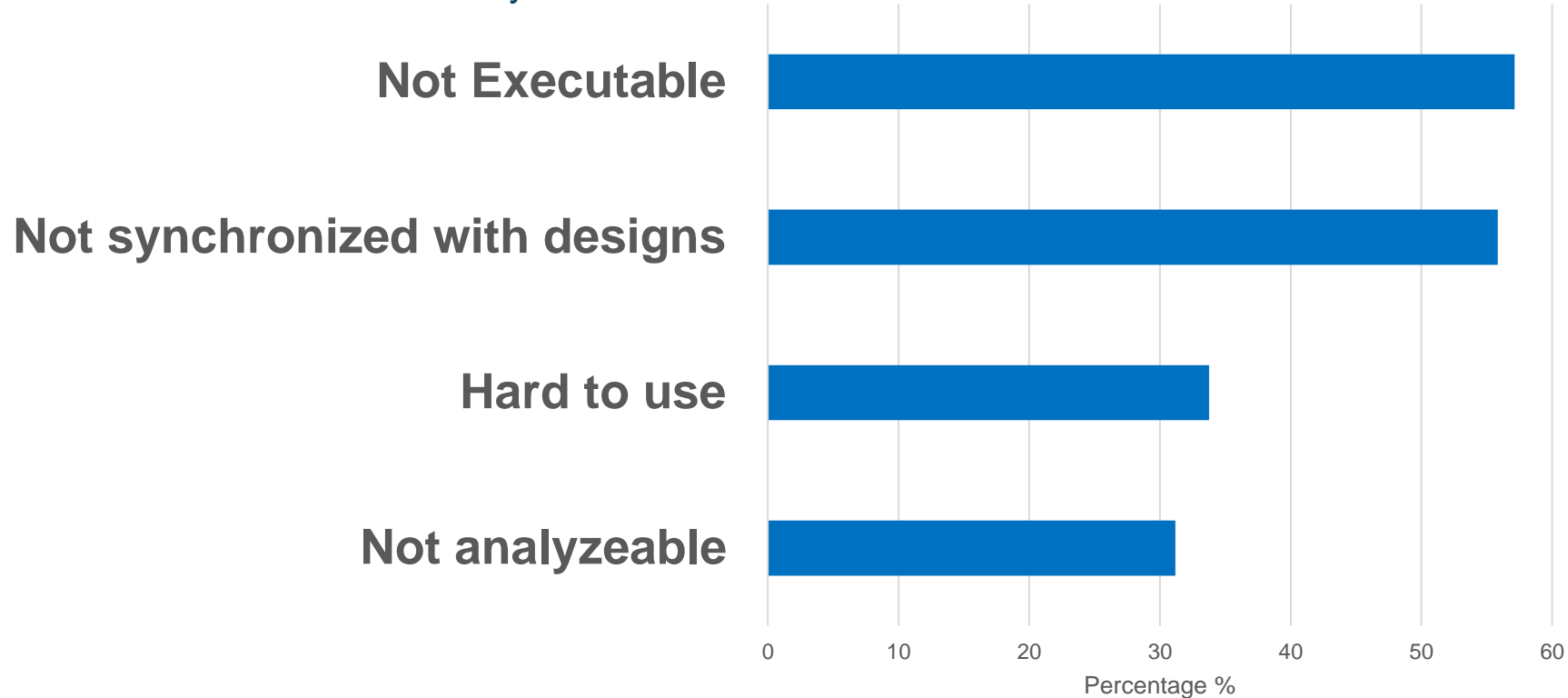
Newton MAB - 2018



更具体地说，有哪些痛楚？

“我们不喜欢当前的系统架构解决方案，因为它们：”

Newton MAB Survey 2019



策略：建立适合于MBD的MBSE生态系统

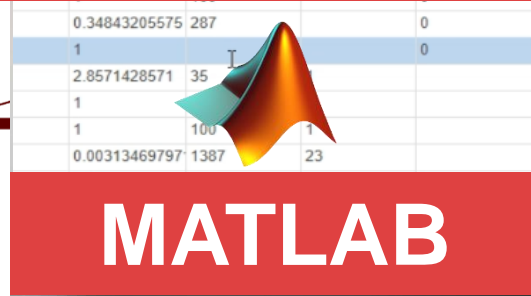
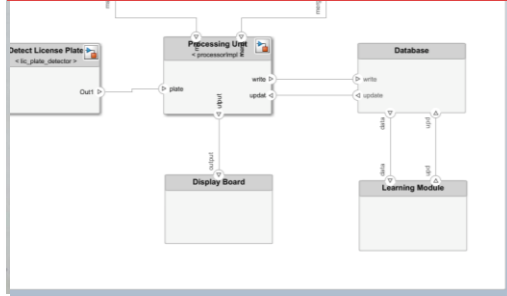
直观

便于分析

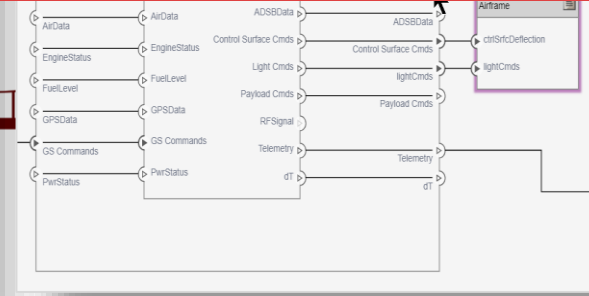
应对复杂性

能够实施

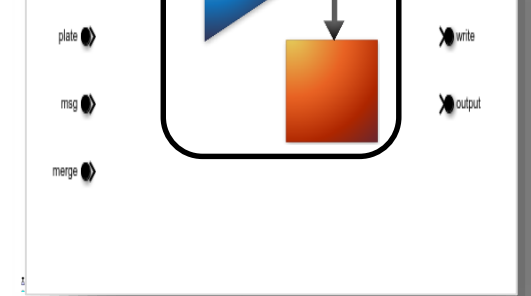
System Composer



MATLAB



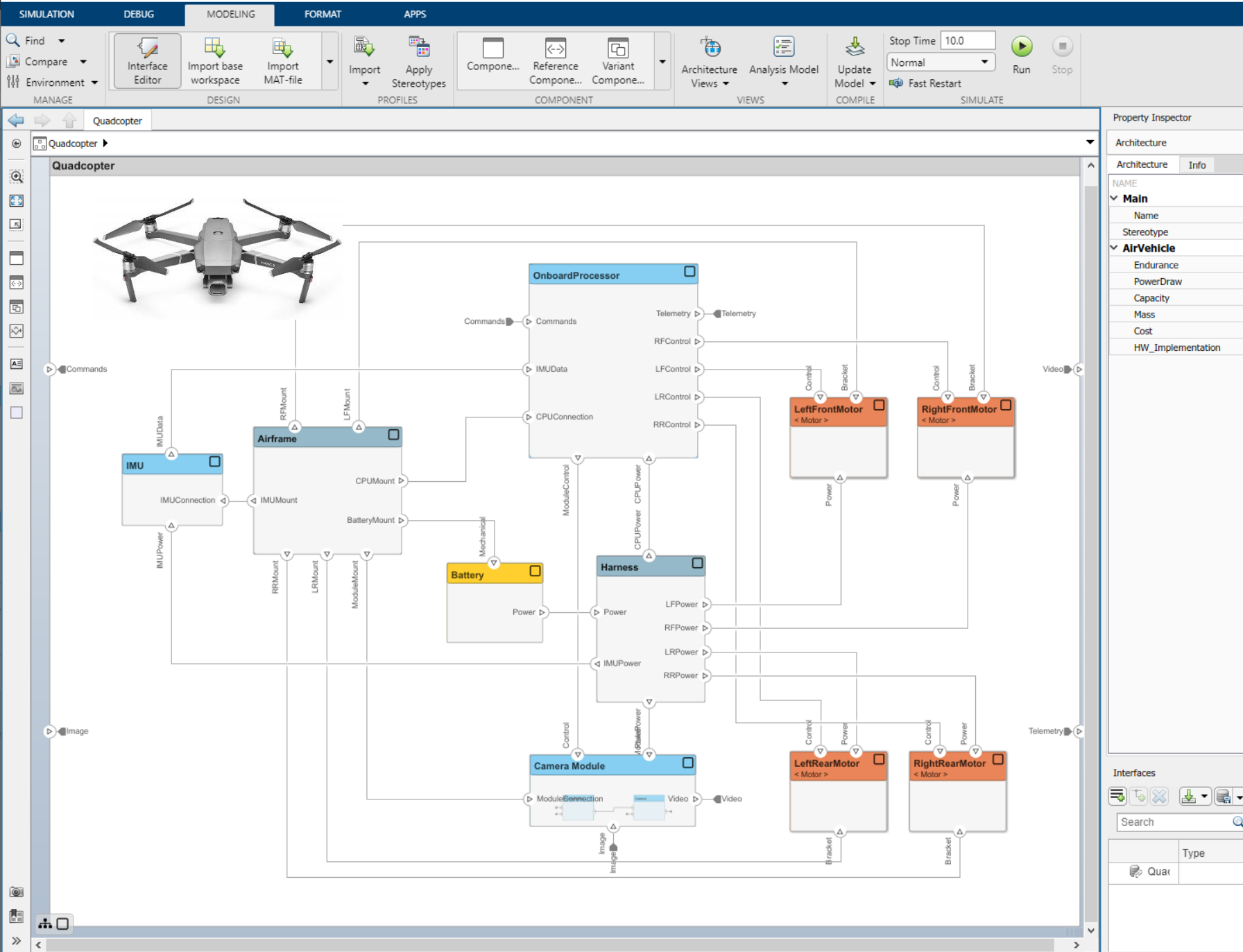
Simulink



需求覆盖率报告和影响分析

Simulink Requirements

Index	Summary	Implemented
> 1.1	Airworthiness	<div style="width: 80%; background-color: blue;"></div>
> 1.2	Communications	<div style="width: 100%; background-color: blue;"></div>
▼ 1.3	Payload Capabilities	<div style="width: 70%; background-color: blue;"></div>
1.3.1	Carrying Capacity	<div style="width: 100%; background-color: blue;"></div>
1.3.2	Payload Bay Capacity	<div style="width: 100%; background-color: blue;"></div>
1.3.3	Default Payload	<div style="width: 100%; background-color: blue;"></div>
1.3.4	Payload Protection	<div style="width: 100%; background-color: blue;"></div>



Property Inspector

Architecture

Architecture Info

NAME

- ▼ Main
 - Name
 - Stereotype
- ▼ AirVehicle
 - Endurance
 - PowerDraw
 - Capacity
 - Mass
 - Cost
 - HW_Implementation

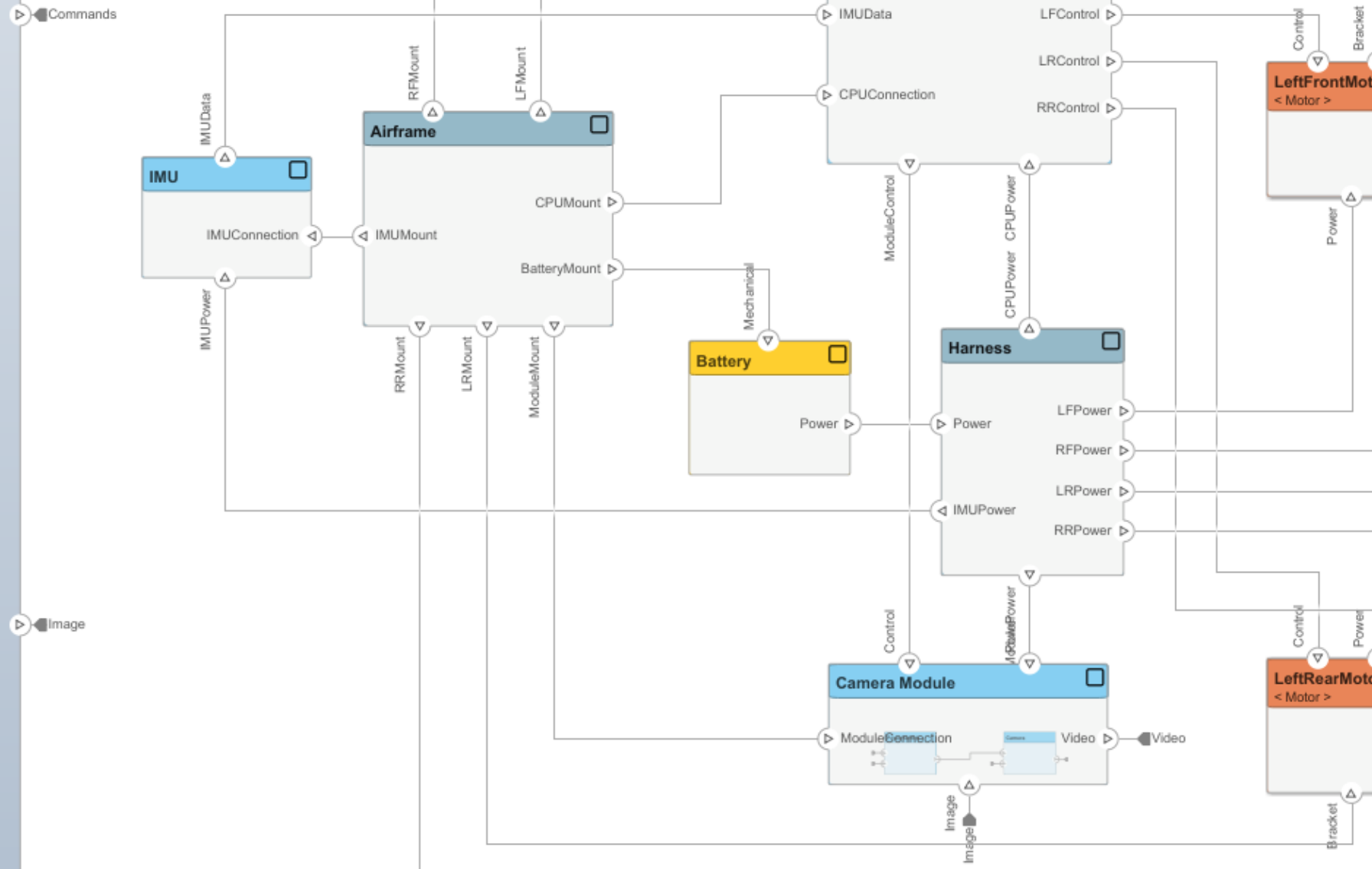
Interfaces

Search

Quar	Type

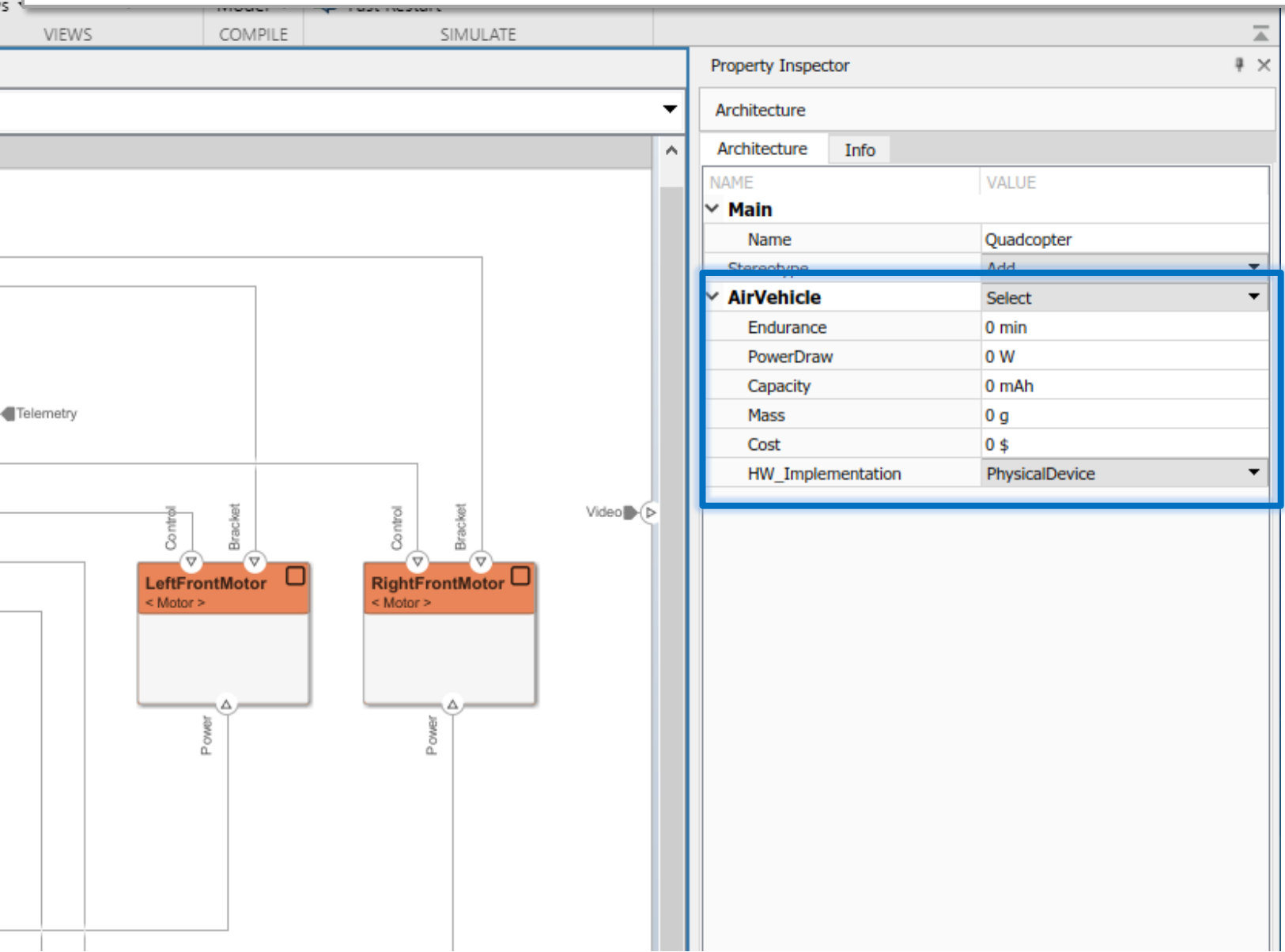
R2019a

“绘制” 系统界面并逐步完善



R2019a

扩展元素-通过使用配置文件和构型结合的自定义元数据



R2019a

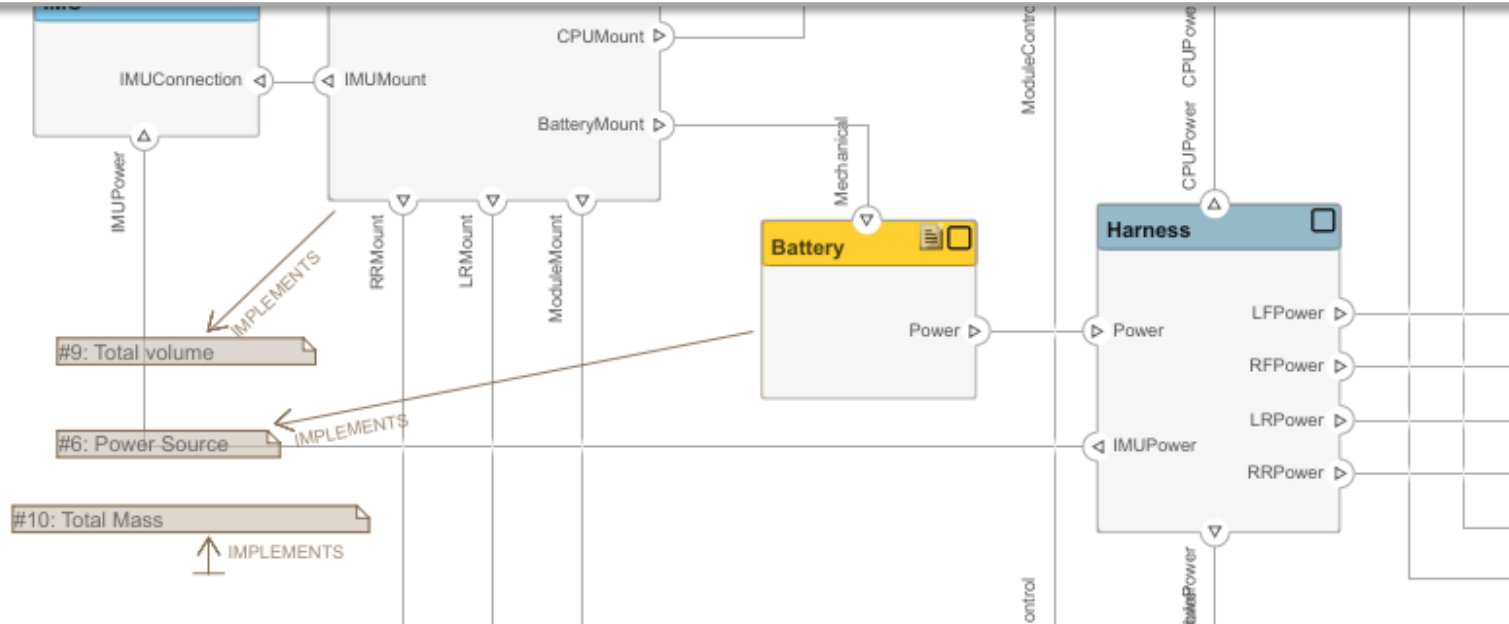
分析系统特性并定量评估选择(使用MATLAB)

The screenshot shows the Simulink Analysis Viewer interface. At the top, a block diagram of a Quadcopter system is visible, featuring an 'OnboardProcessor' block. Below the diagram, the 'Analysis Viewer (Technical Preview)' window is open, displaying a table of quantitative metrics for various system components. Three specific metrics are highlighted with orange boxes: Endurance (4.0997877), Mass (85), and PowerDraw (40).

Instance	Endurance	Mass	PowerDraw
EnduranceModel	4.0997877	85	40
Airframe	0	0	0
Battery	0	5	3.7
Camera Module	0	27	0
Camera	0	25	0
PowerSwitch	0	2	0
Harness	0	2	0
IMU	0	10	0
LeftFrontMotor	0	25	0
LeftRearMotor	0	25	0
OnboardProcessor	0	100	0
RightFrontMotor	0	25	0
RightRearMotor	0	25	0

R2019a

跟踪系统需求 与架构一起完善需求



R2019a

With Simulink Requirements

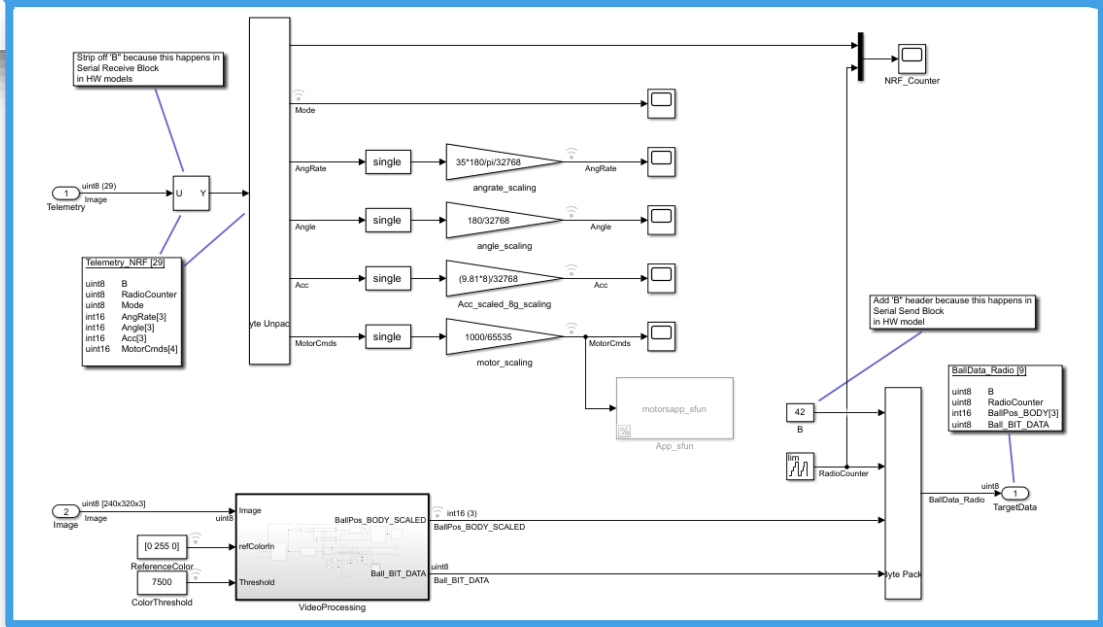
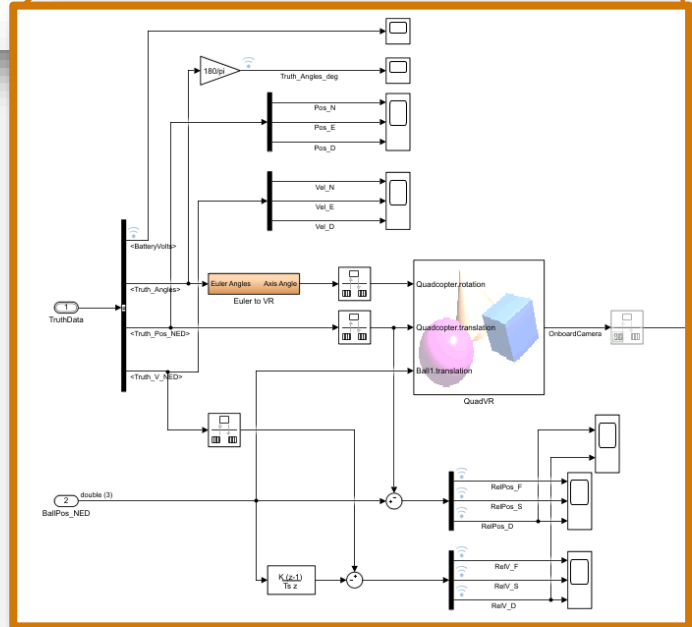
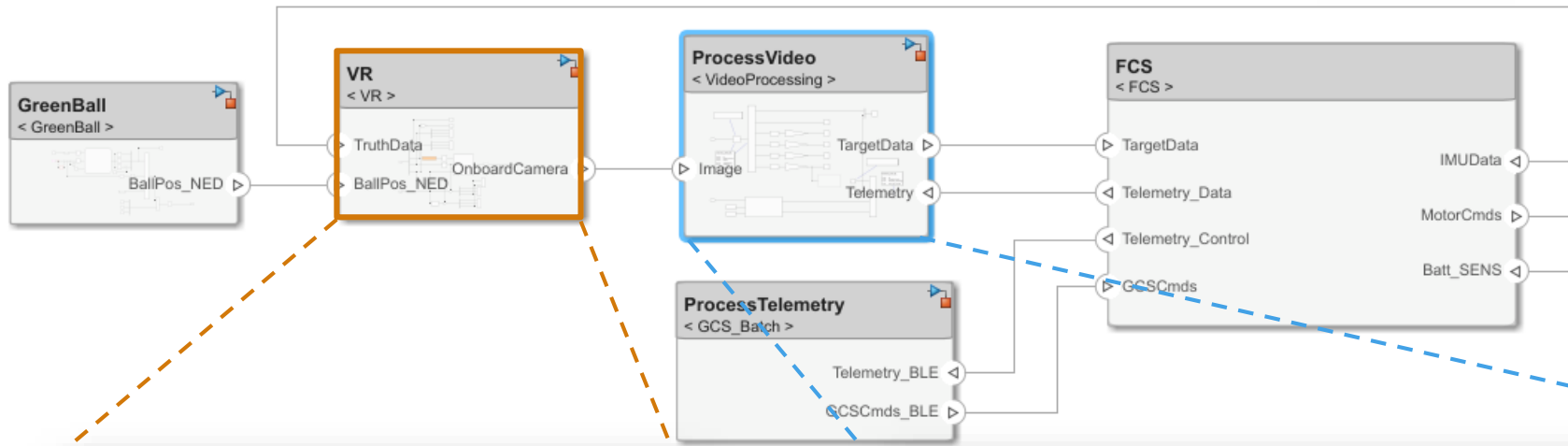
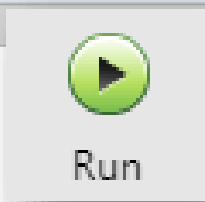
Requirements - Quadcopter

View: Requirements



Index	ID	Summary	Implemented
quadcopter			<div style="width: 10%; background-color: blue;"></div>
1	#1	Aircraft Performance	<div style="width: 0%; background-color: blue;"></div>
1.1	#14	Aircraft horizontal velocity	<div style="width: 0%; background-color: blue;"></div>
1.2	#15	Aircraft vertical velocity	<div style="width: 0%; background-color: blue;"></div>
2	#2	Power System	<div style="width: 10%; background-color: blue;"></div>
2.1	#6	Power Source	<div style="width: 10%; background-color: blue;"></div>

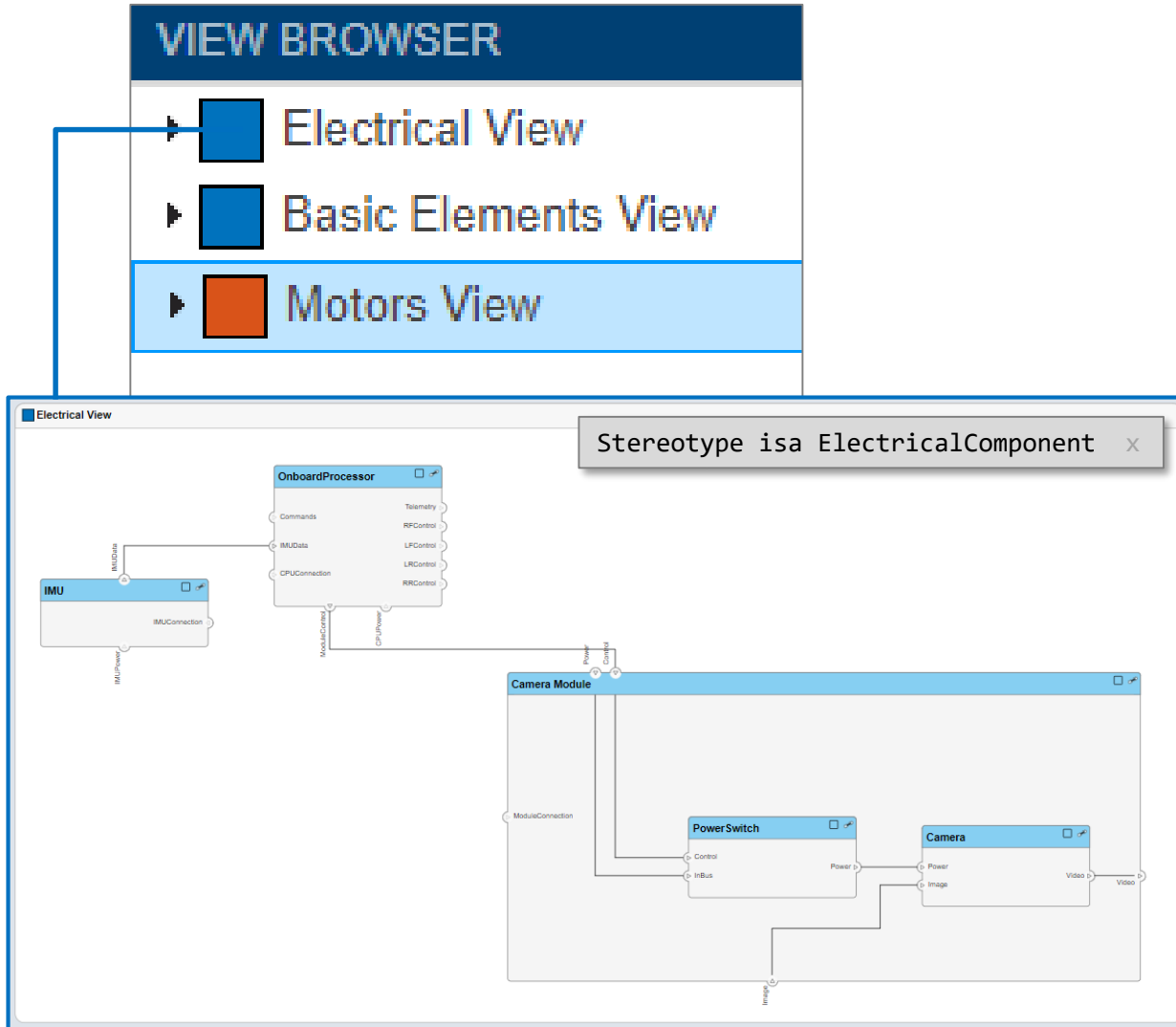
关联设计模型与组件并确保接口一致



R2019a

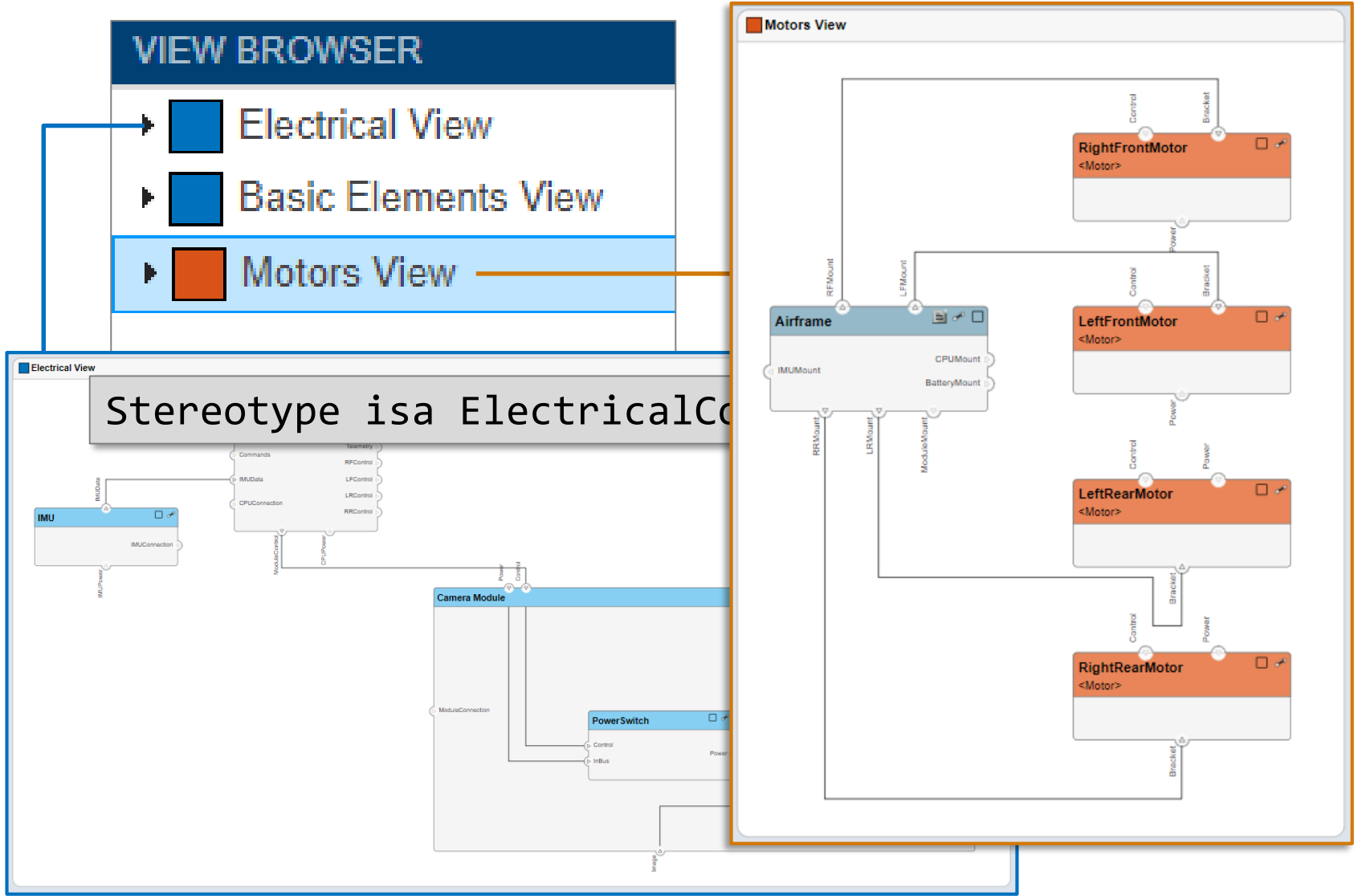
简化复杂性使用过滤器和自动生成的视图

R2019b



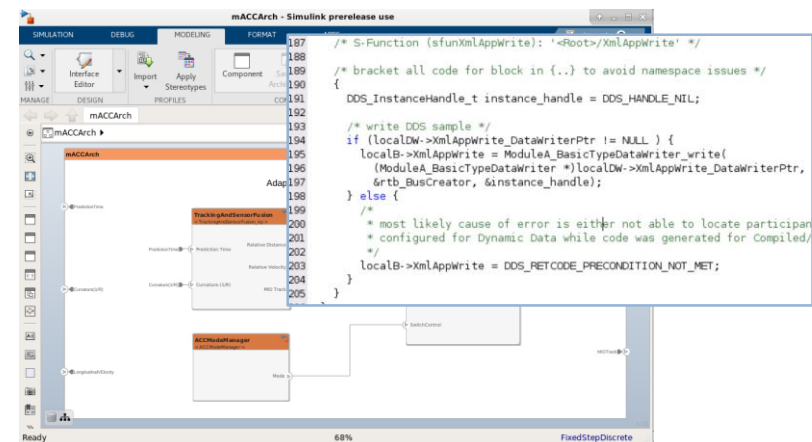
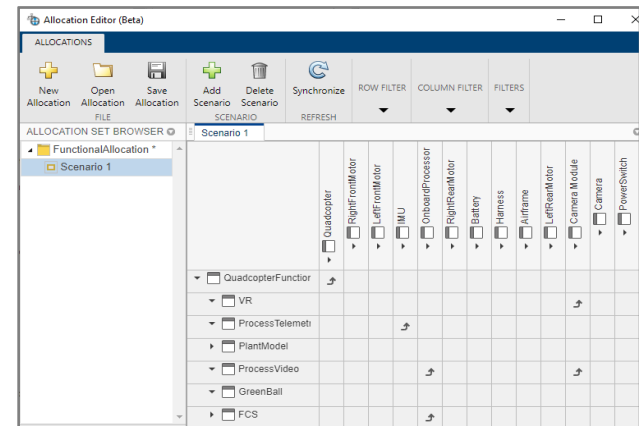
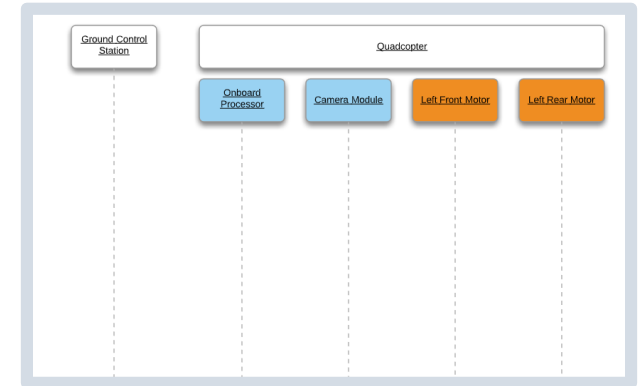
简化复杂性使用过滤器和自动生成的视图

R2019b

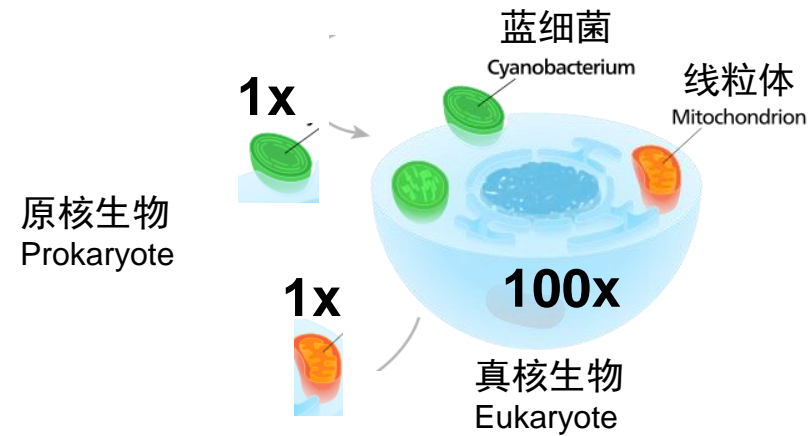


而我们才刚刚开始 即将来临的：

- 使用序列图进行行为建模
- 通过分析(例如逻辑到物理)进行架构分配
- 软件架构建模
 - 链接到AUTOSAR (R2019b)
 - 其它中间件，例如DDS
- 还有更多！

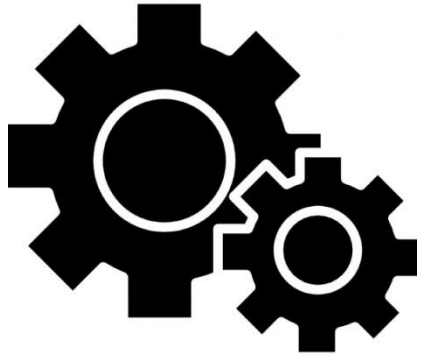


协同工程的演变



<https://en.wikipedia.org/wiki/Symbiogenesis>

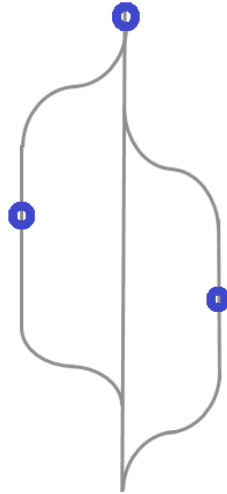
趋势：基于团队的敏捷工作流程的需求增加



共享的团队环境



合作

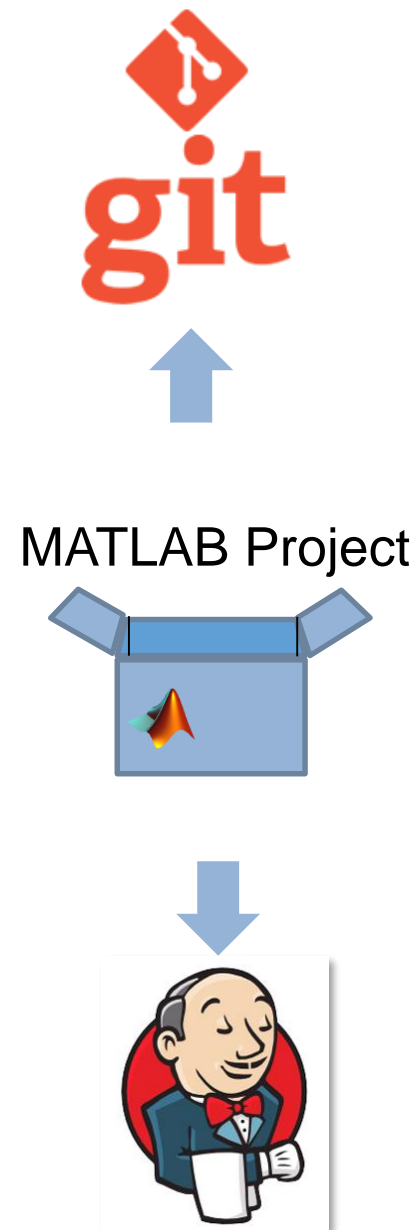
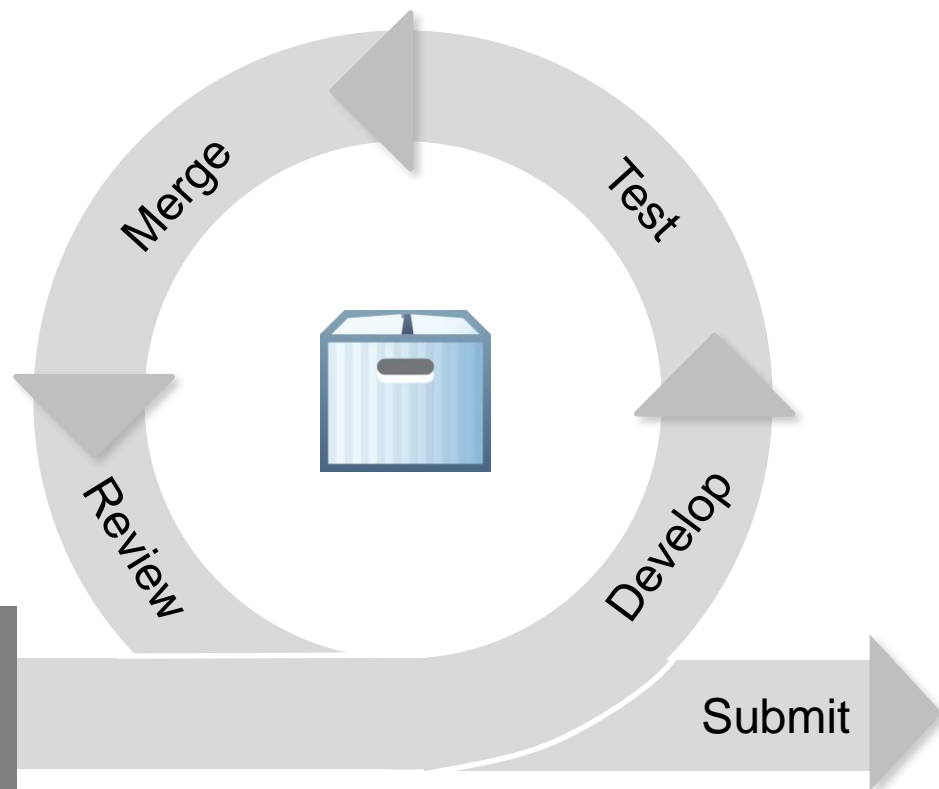


Jenkins

持续的集成与测试



策略：不断的投入以促进持续集成，将其作为敏捷工作流程中的关键要素

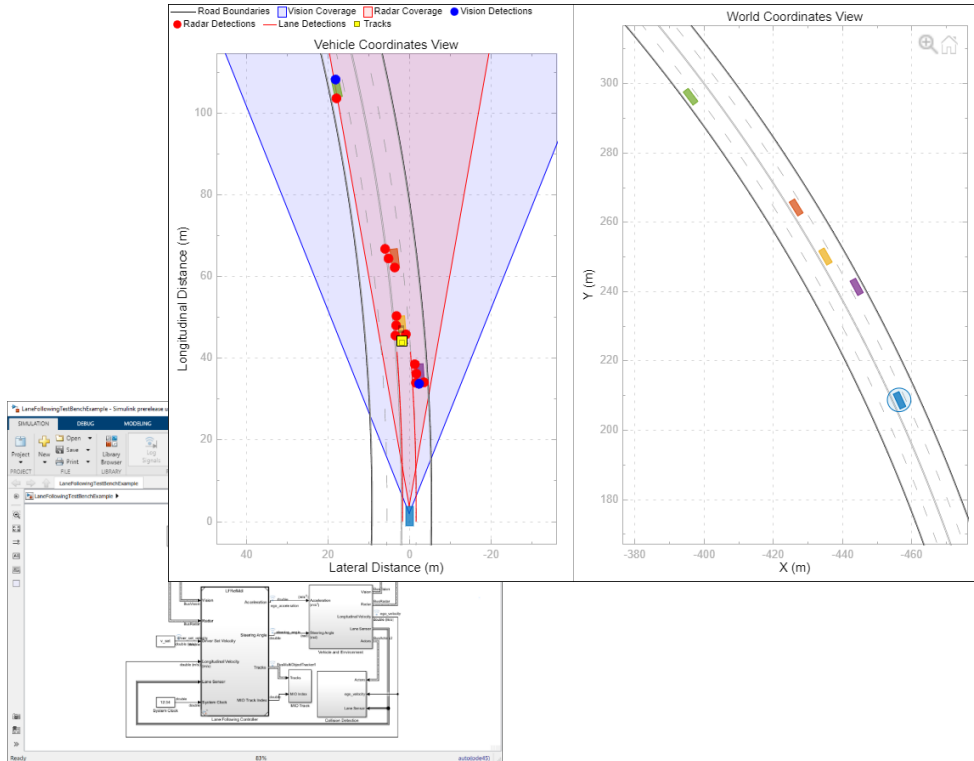


如今我可以在Simulink中进行CI吗？

当然，让我们考虑一个例子

R2019b

车道跟随辅助示例



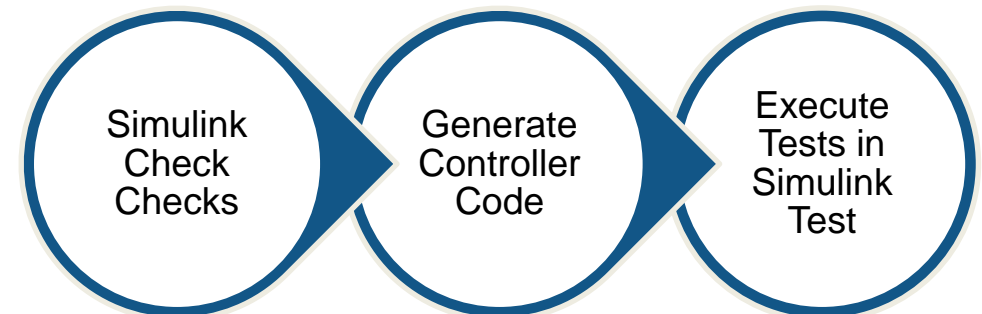
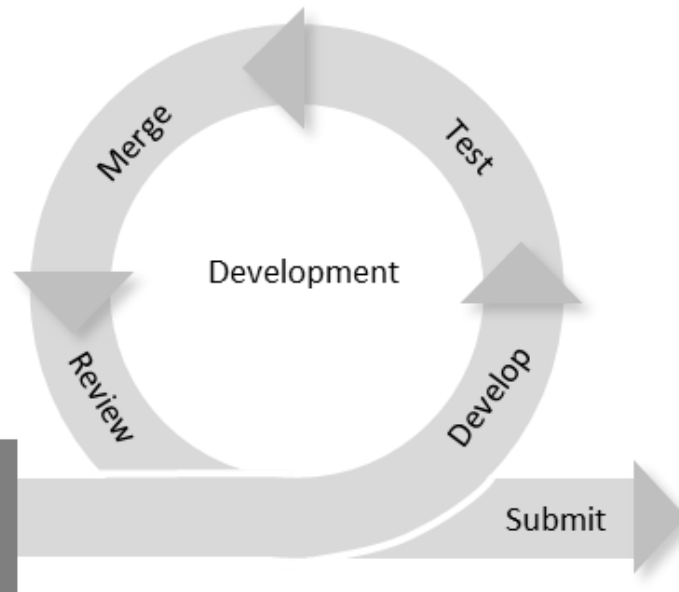
Simulink Check Checks

SIL Code Generation

SIL Testing Simulink Test

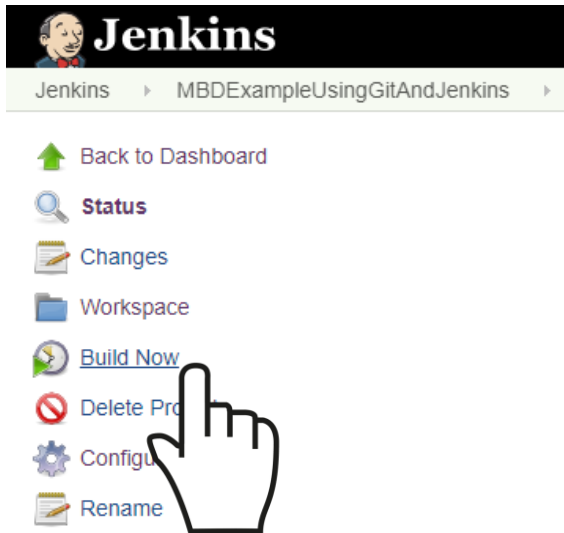


如何将它们都融合在一起？



1. 触发

Trigger

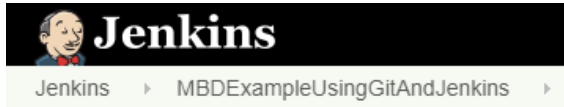


The screenshot shows the Jenkins web interface. At the top, there is a black header with the Jenkins logo and the word "Jenkins" in white. Below the header, there is a breadcrumb trail: "Jenkins > MBDEExampleUsingGitAndJenkins >". A list of navigation options is displayed on the left side, each with a small icon and a text label. The options are: "Back to Dashboard" (green arrow icon), "Status" (magnifying glass icon), "Changes" (notepad icon), "Workspace" (folder icon), "Build Now" (play button icon), "Delete Pro" (red circle with slash icon), "Configu" (gear icon), and "Rename" (notepad icon). A hand cursor is pointing at the "Build Now" button, which is highlighted in blue.

- Back to Dashboard
- Status
- Changes
- Workspace
- Build Now
- Delete Pro
- Configu
- Rename

1.触发

Continuous
Integration



Back to Dashboard

Status

Changes

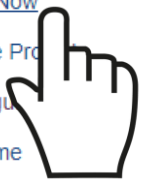
Workspace

Build Now

Delete Pro

Configu

Rename



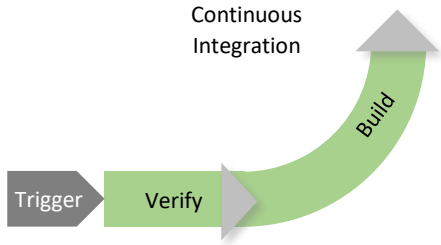
```

Running LaneFollowingModelAdvisorChecks
.
Done LaneFollowingModelAdvisorCheck
  
```

Simulink Check



1.触发



```

Running LaneFollowingModelAdvisorChecks
.
Done LaneFollowingModelAdvisorCheck
  
```

Simulink Check



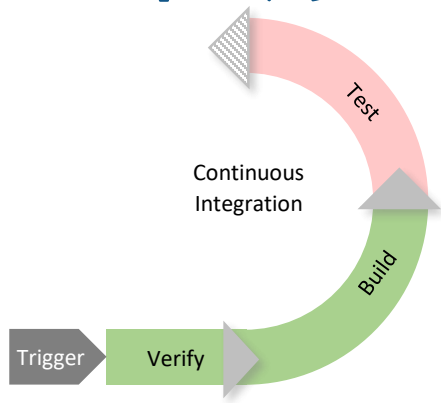
```

## Caching model source code
.....
.....
### Writing header file rtGetNaN.h
### Writing source file rtGetNaN.cpp
### Writing header file rt_defines.h
### Writing header file rt_nonfinite.h
### Writing source file rt_nonfinite.cpp
  
```

Code Generation



2. 检测



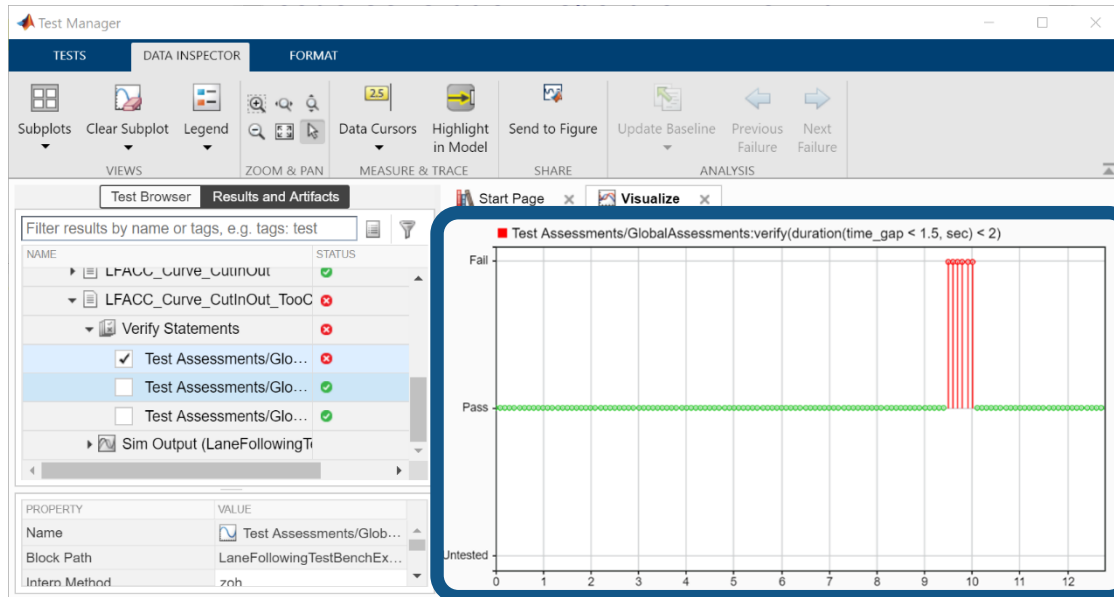
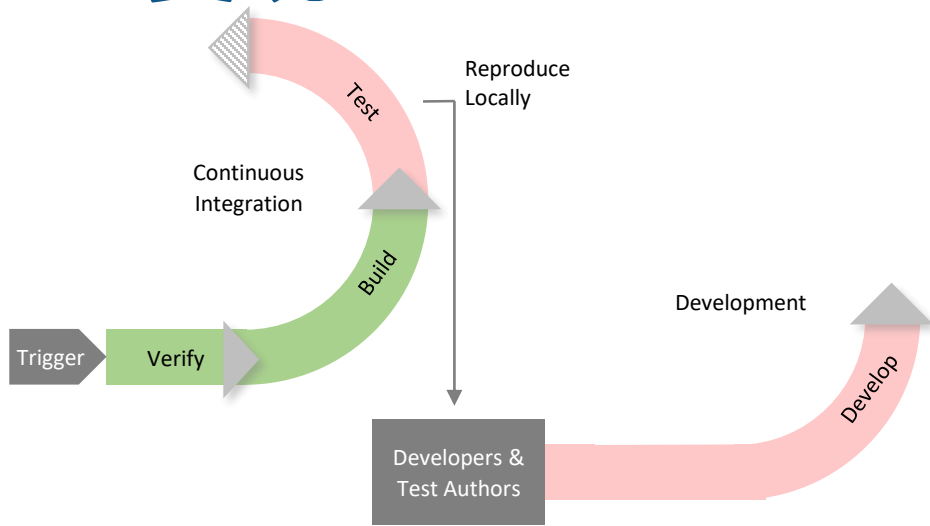
Failure Summary:

Name	Failed	Incomplete	Reason(s)
<pre> LaneFollowingTestScenarios > Scenarios/LFACC_Curve_CutInOut_TooClose ERROR: MATLAB error Exit Status: 0x00000001 Build step 'Run MATLAB Tests' changed build result to FAILURE Finished: FAILURE </pre>	X		Failed by verification.

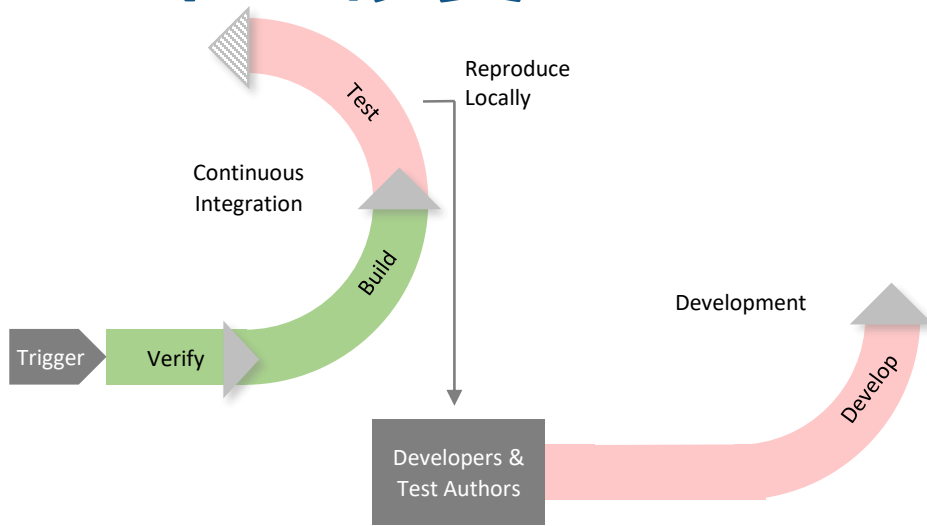
Simulink Test



3. 复现



4. 本地修复

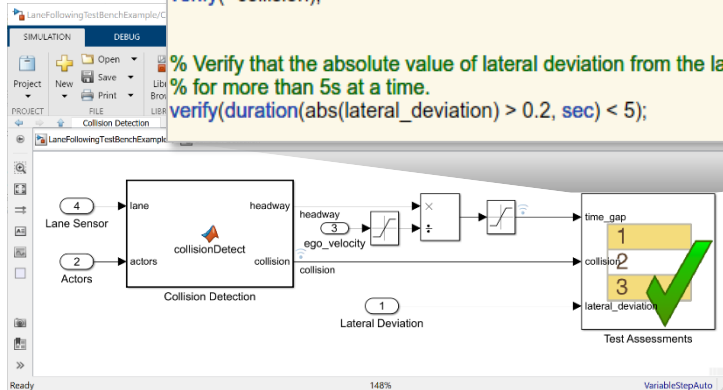


GlobalAssessments

% Ensure that the time gap between the ego vehicle and lead vehicle does not dip below 1.5s for more than 2s at a time.
`verify(duration(time_gap < 1.5, sec) < 2);`

% Verify that no collision was detected
`verify(~collision);`

% Verify that the absolute value of lateral deviation from the lane centerline does not exceed 0.2m for more than 5s at a time.
`verify(duration(abs(lateral_deviation) > 0.2, sec) < 5);`



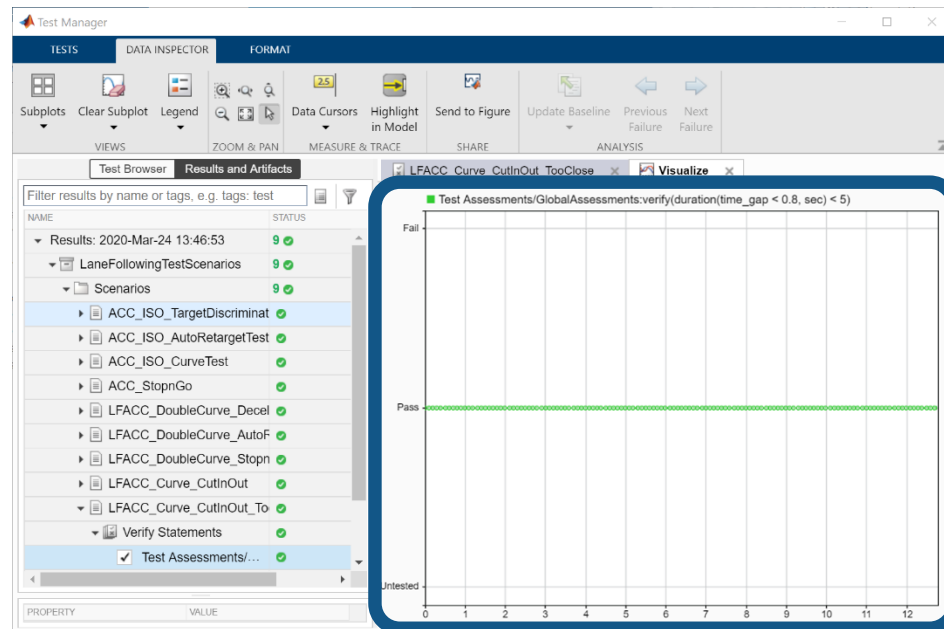
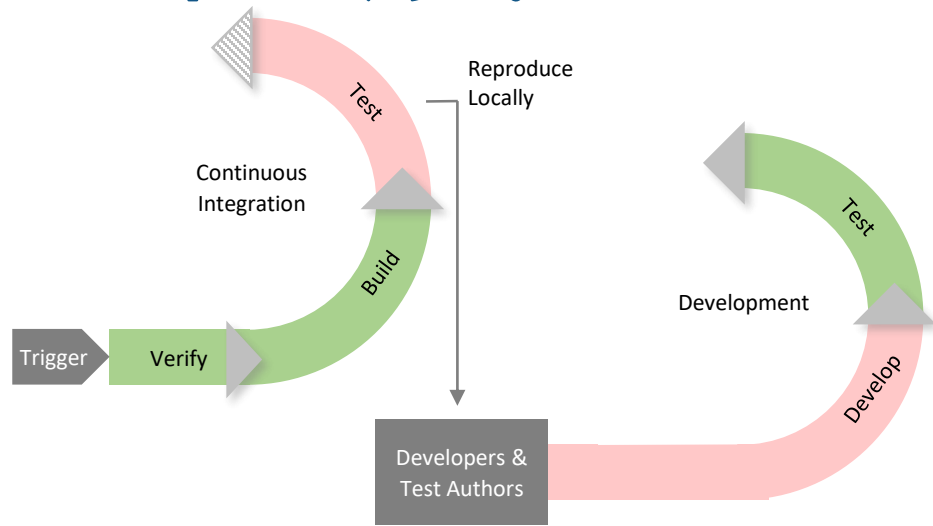
GlobalAssessments

% Ensure that the time gap between the ego vehicle and lead vehicle does not dip below 0.8s for more than 5s at a time.
`verify(duration(time_gap < 0.8, sec) < 5);`

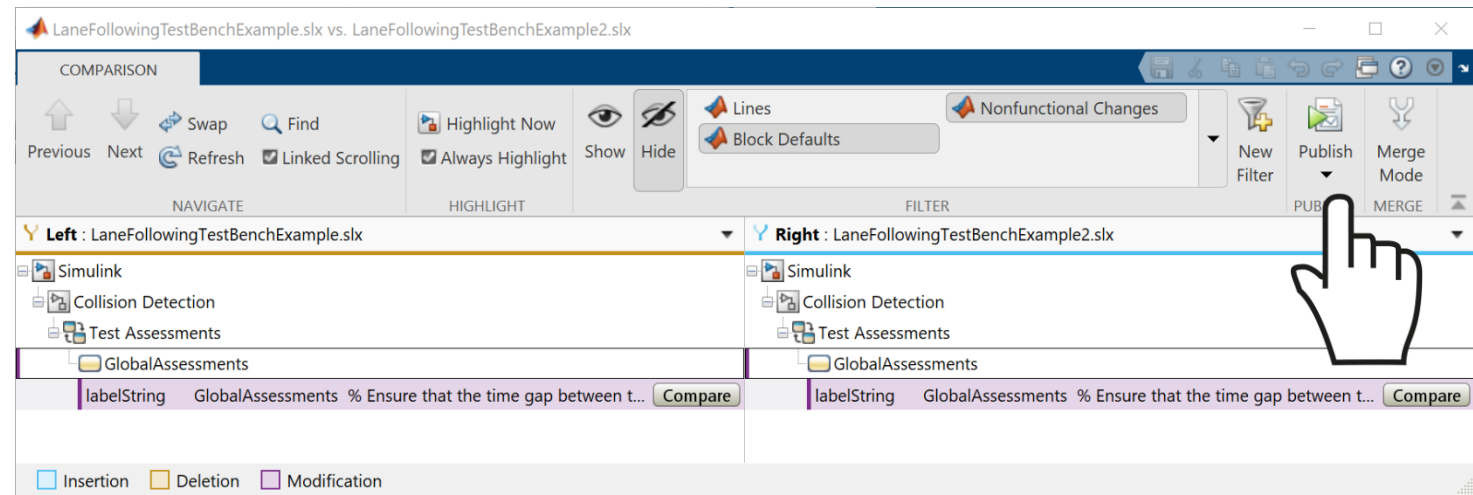
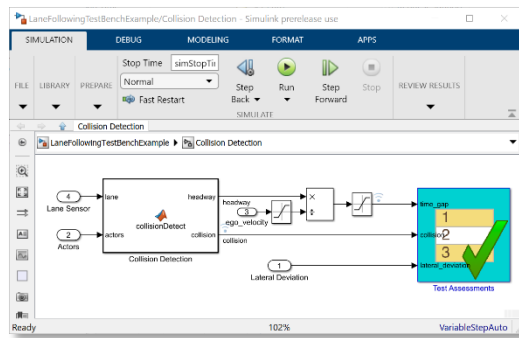
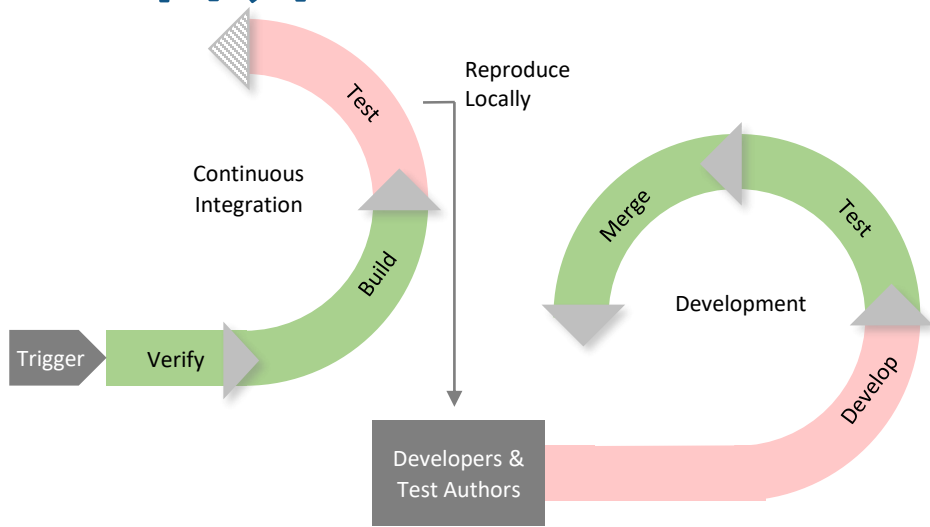
% Verify that no collision was detected
`verify(~collision);`

% Verify that the absolute value of lateral deviation from the lane centerline does not exceed 0.2m for more than 5s at a time.
`verify(duration(abs(lateral_deviation) > 0.2, sec) < 5);`

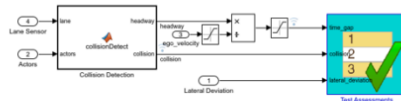
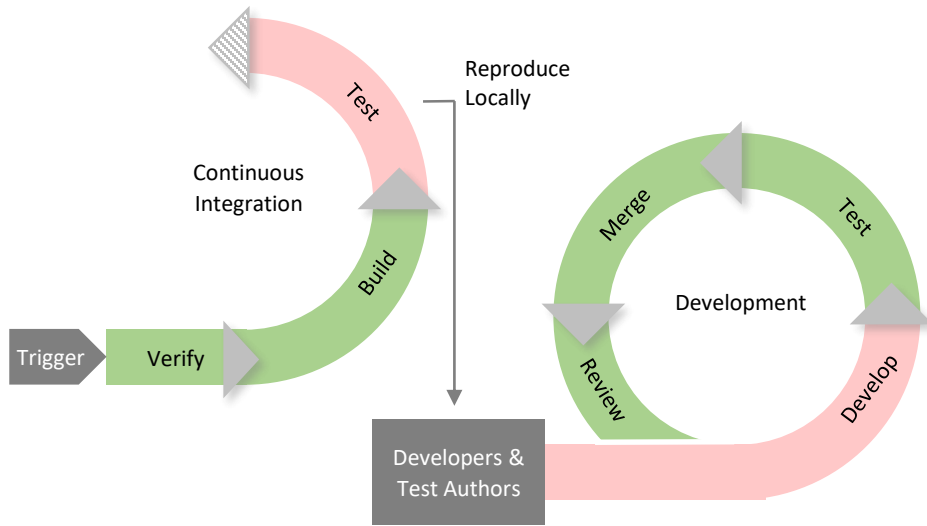
5. 本地测试



6. 合并



6. 审查



LaneFollowingTestBenchExample/Collision Detection/Test Assessments

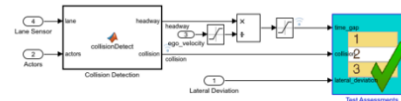
GlobalAssessments

labelString : GlobalAssessments

% Ensure that the time gap between the ego vehicle and lead vehicle does not dip below % 1.5s for more than 2s at a time.

`verify(duration(time_gap < 0.8, sec) < 2);`

% Verify that no collision was detected
`verify(~collision);`



LaneFollowingTestBenchExample/Collision Detection/Test Assessments

GlobalAssessments

labelString : GlobalAssessments

% Ensure that the time gap between the ego vehicle and lead vehicle does not dip below % 1.5s for more than 5s at a time.

`verify(duration(time_gap < 0.8, sec) < 5);`

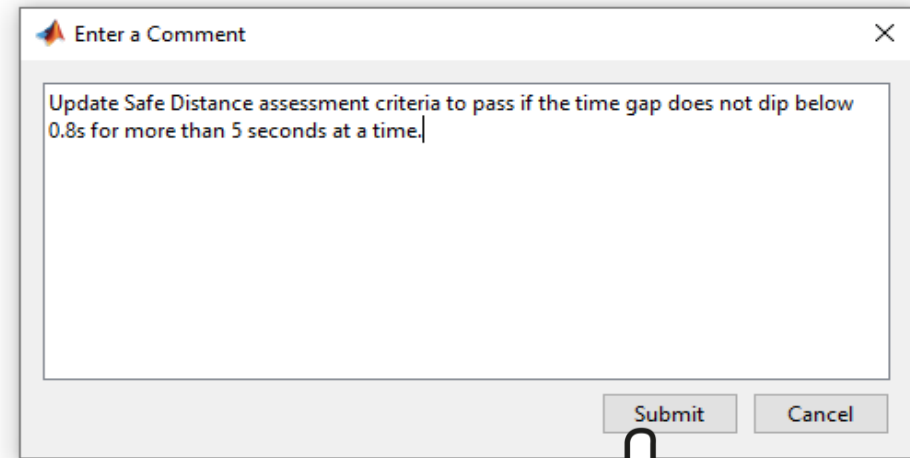
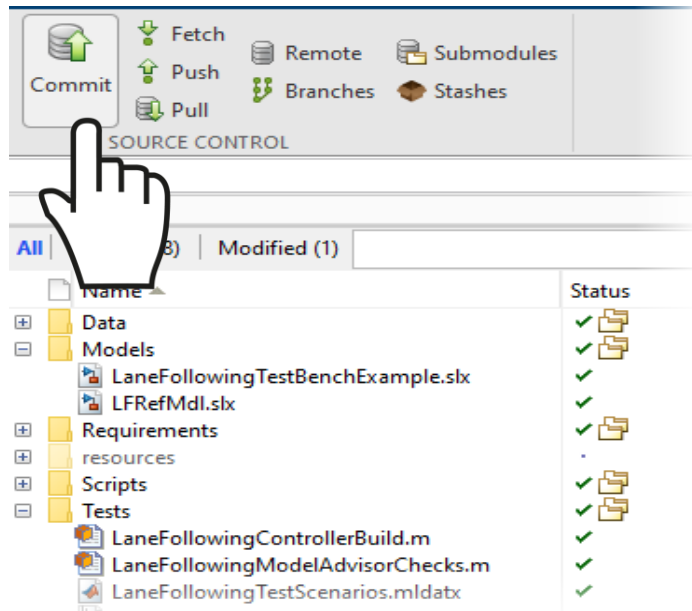
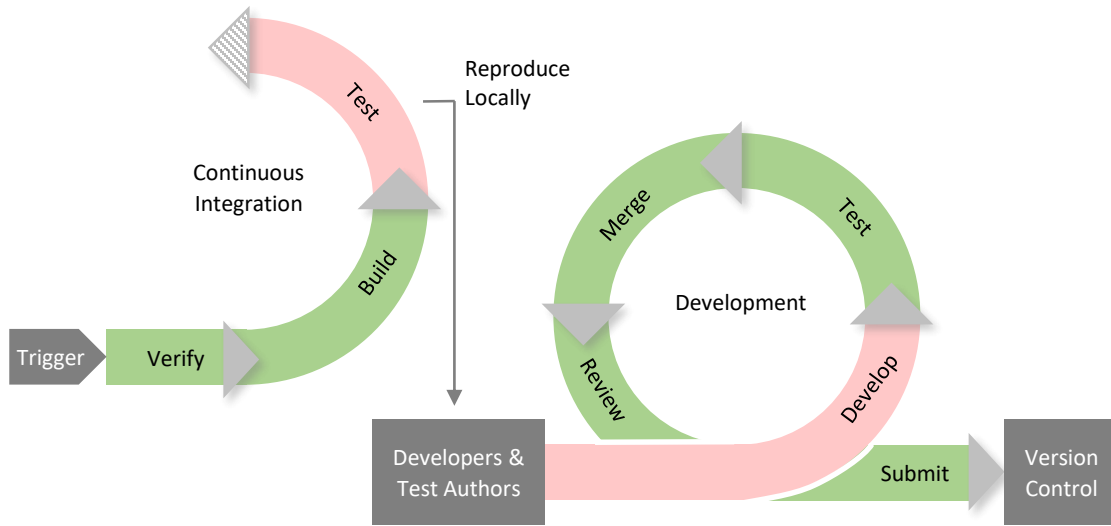
% Verify that no collision was detected
`verify(~collision);`



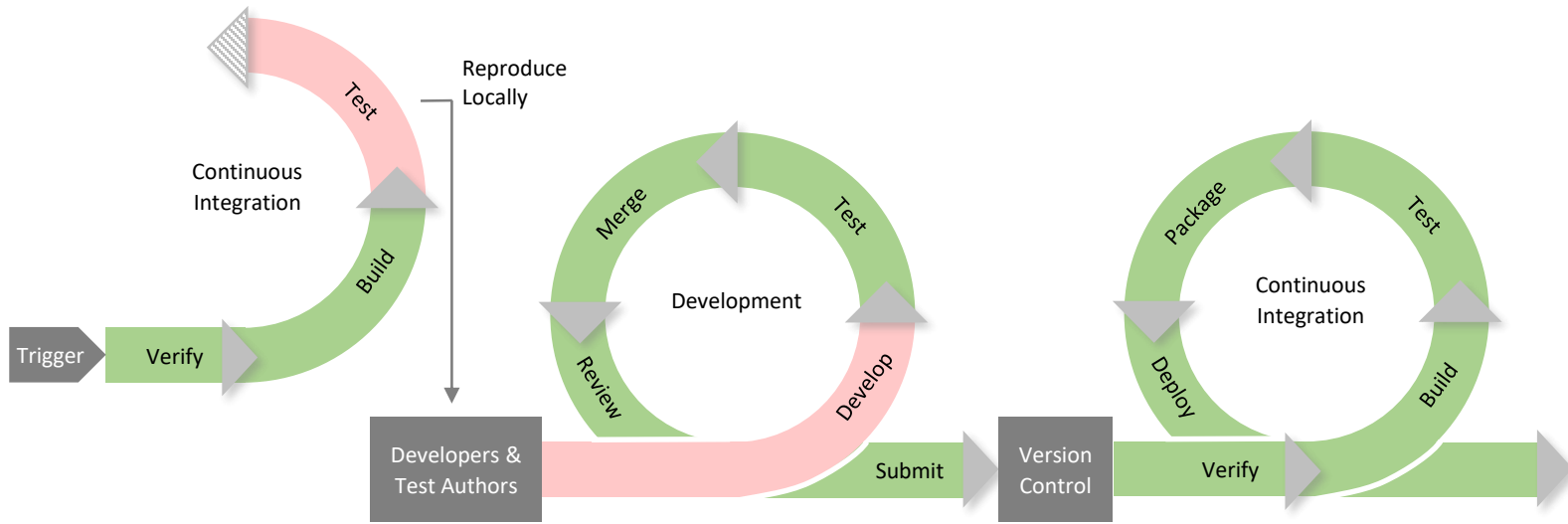
David Boissy 12 minutes ago
Ship It!

[Reply](#) [Resolve](#)

7. 提交



8. 验证, 生成, 测试




Finished: SUCCESS




持续集成的成功触手可及

1

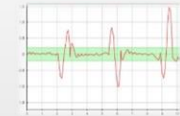
工具



Jenkins
Plugin




MATLAB
Unit



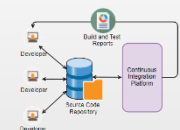
Simulink
Test

2


文件资料



Technical
Article




Documentation
Hub




Solutions
Page

3

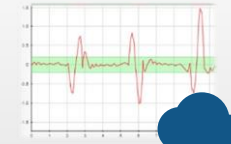
未来



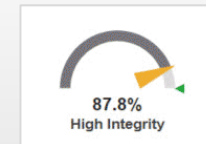
Pipeline



Server
Workflows



Test Results
Online

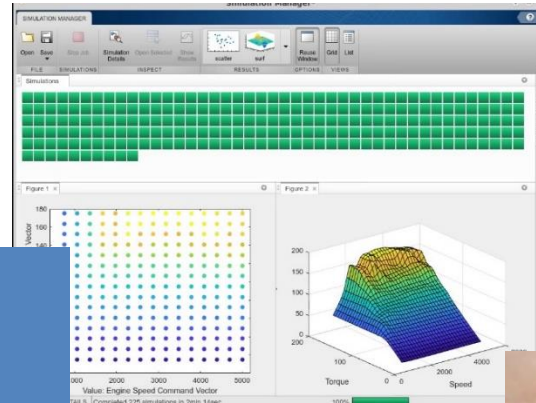


Dashboards

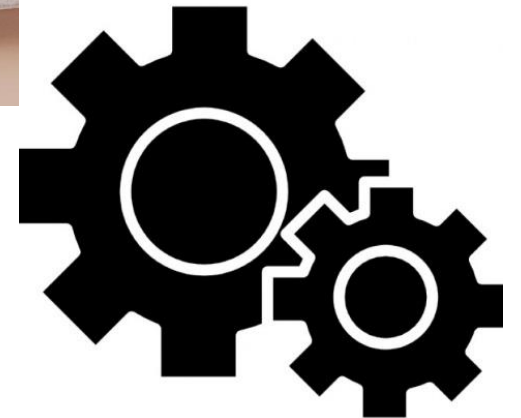
让我们回到塑造平台演变的广泛影响力上

1. 仿真规模化

YOU!



3. 协同工程化



Q&A

有问题请联系我们



lzhang@mathworks.com