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

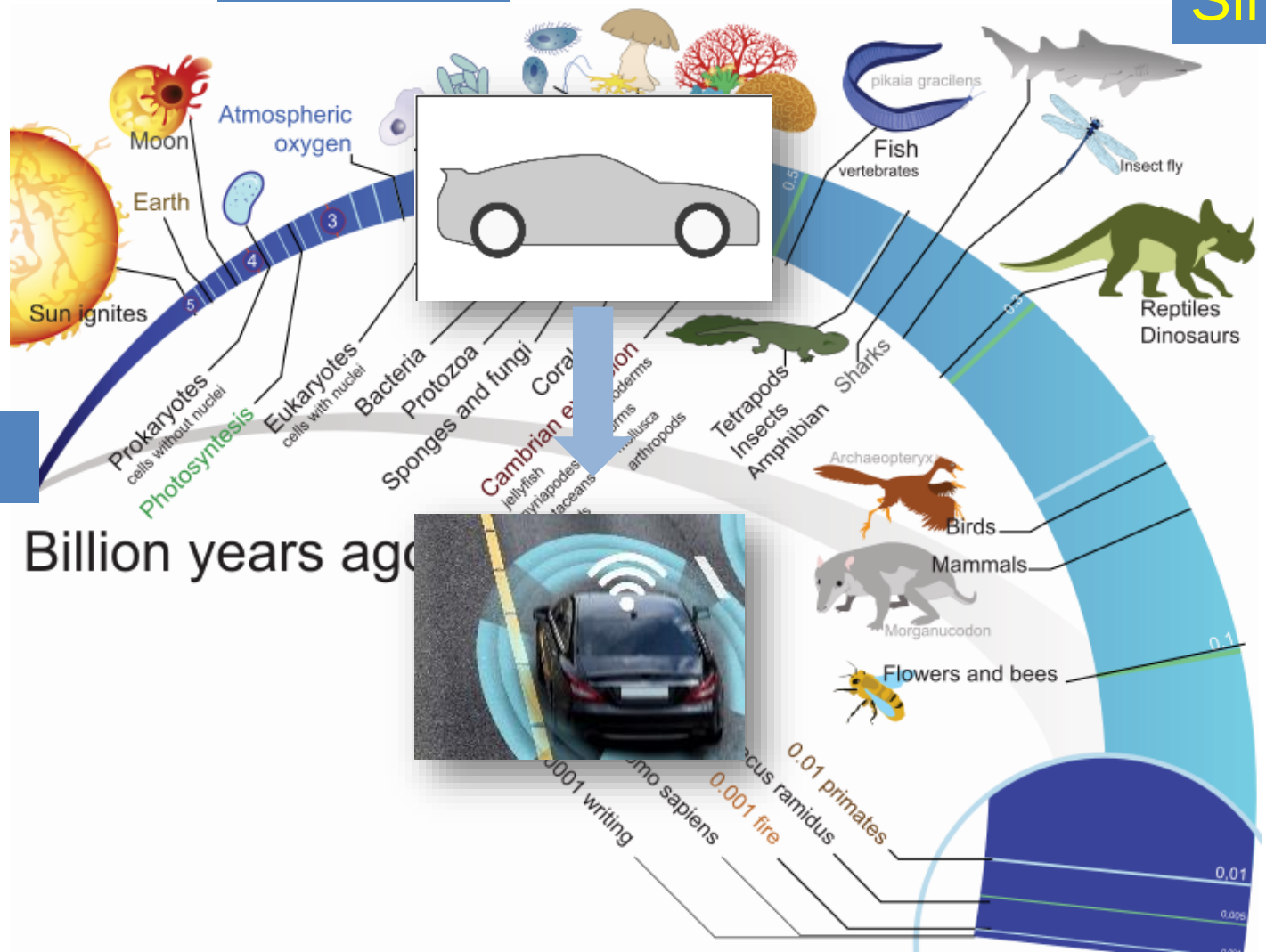
MathWorks®

今天我们的主题：
进化

Stateflow

RTW

Simscape



Coder

Simulab

1990

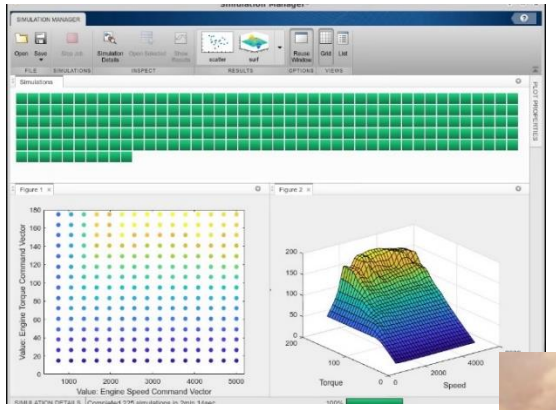
V&V

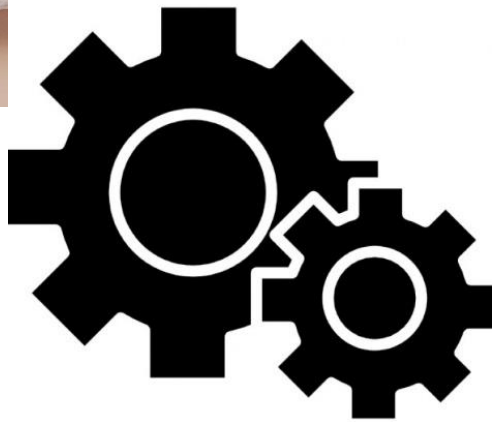
Simulink

R2020a

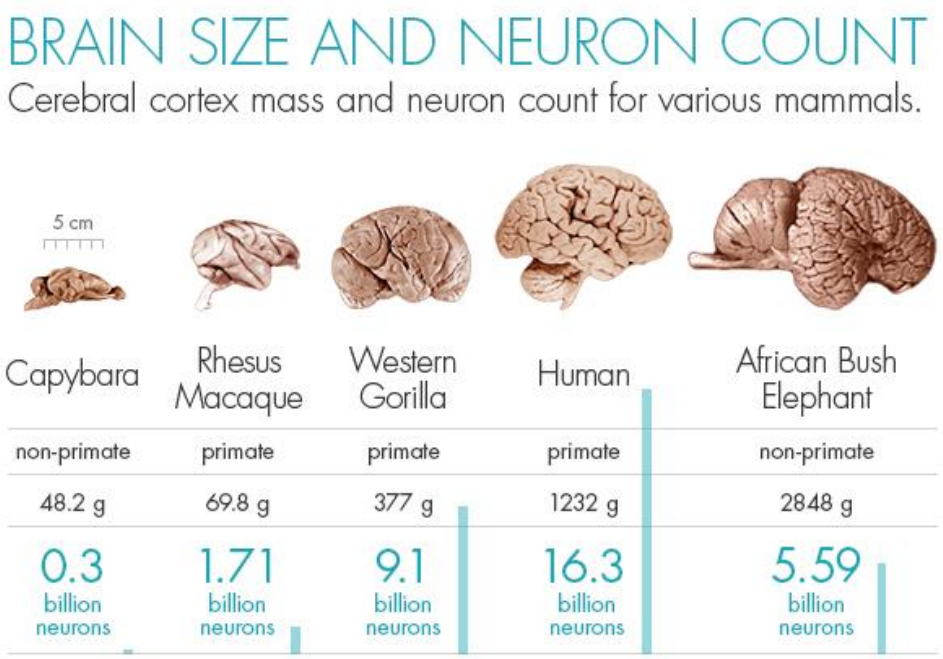
三种进化力量在起作用

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

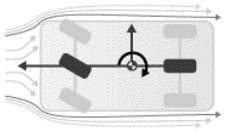


https://www.quantamagazine.org/how-humans-evolved-supersize-brains-20151110/

趋势：扩大仿真能力的需求

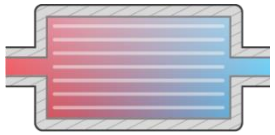
整车仿真

策略：不断演化Simulink，使其成为一流的仿真集成平台

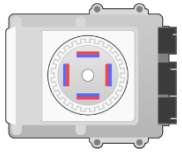


Simscape

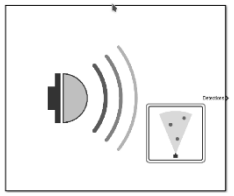
3rd party tool



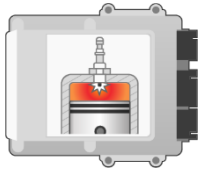
3rd party tool



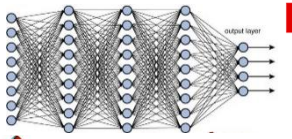
Windows



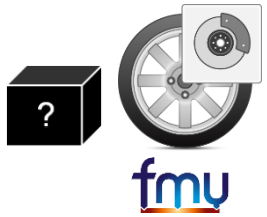
MATLAB

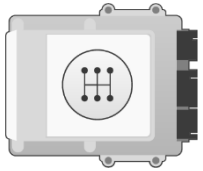


Linux

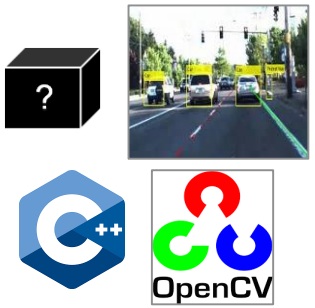


Deep Learning NN



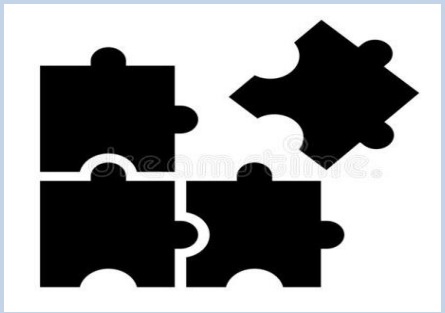


S-Function

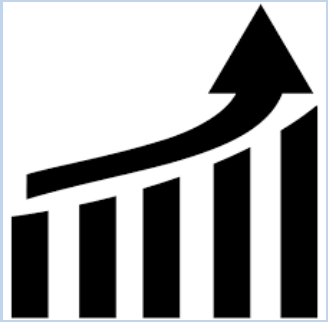


Hand C/C++ Code

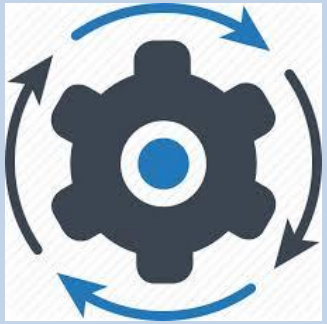
仿真规模的主要挑战



集成

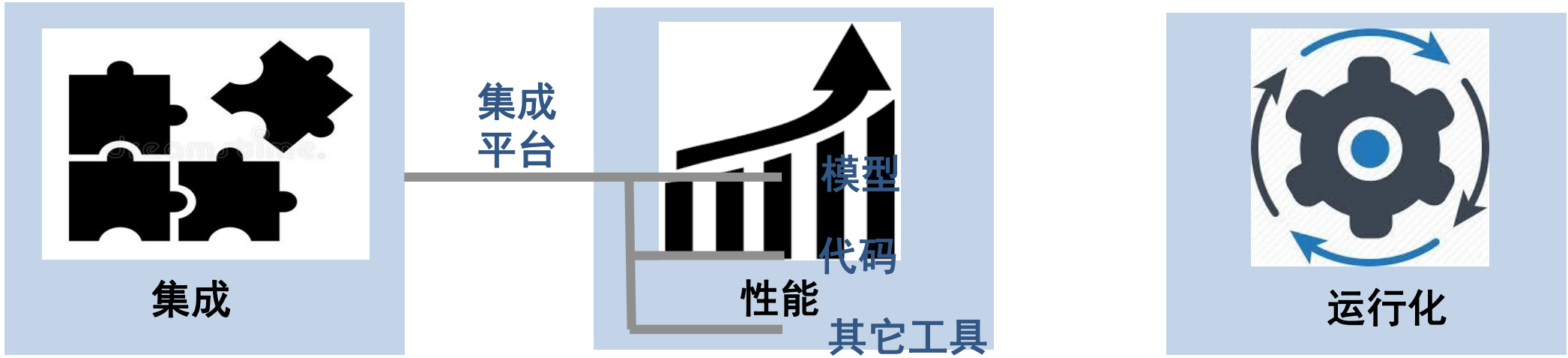


性能



运行化

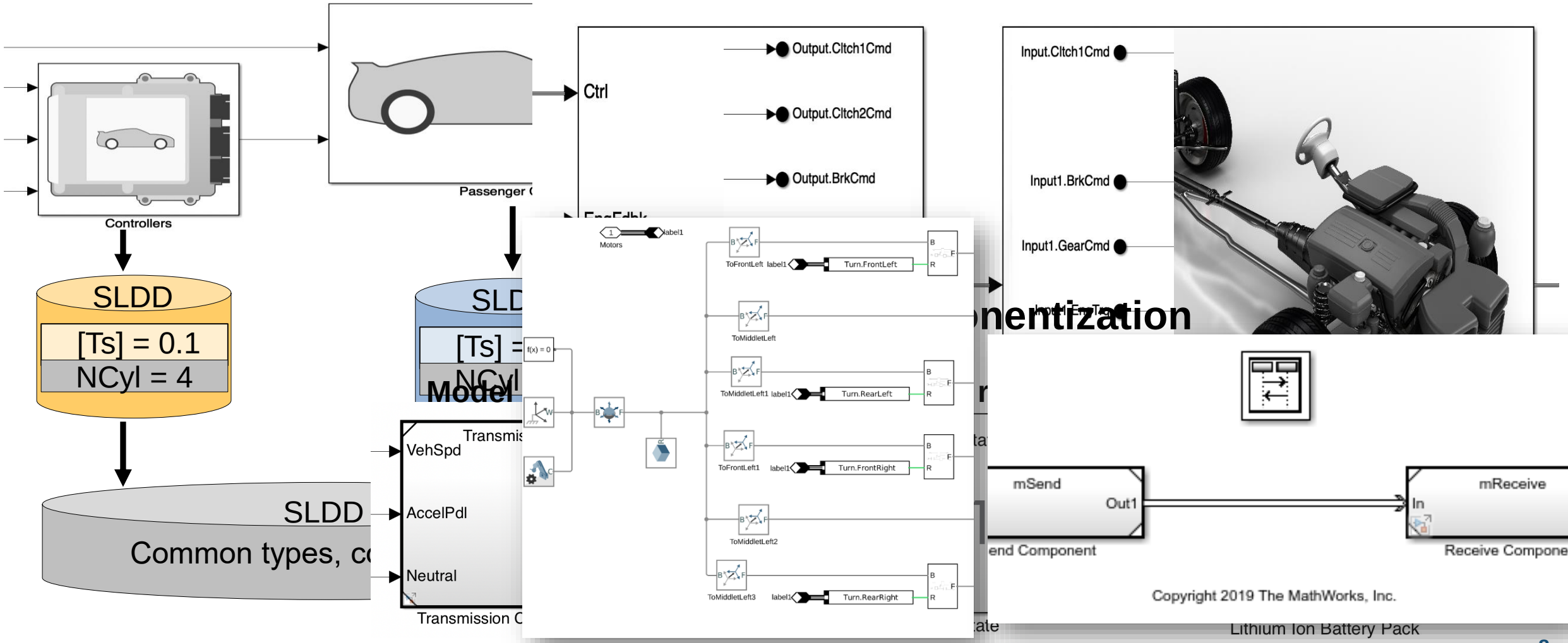
算法与多个仿真接口的集成是关键



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



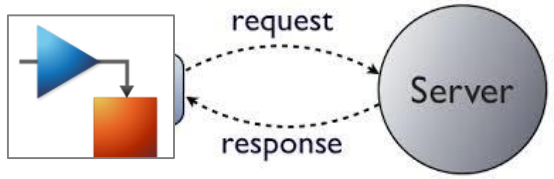
可以轻松地将C / C ++代码引入Simulink

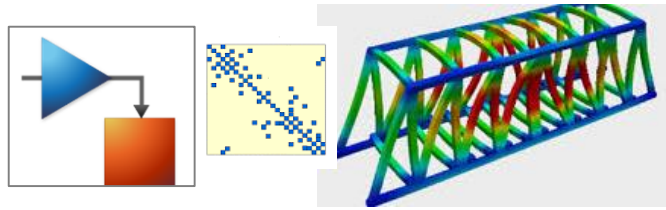
模型

代码

工具

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

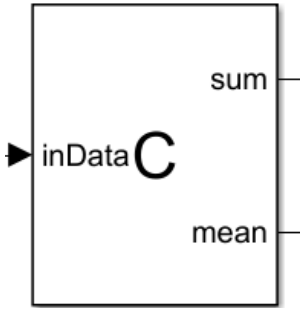




Basic → Advanced

C Caller

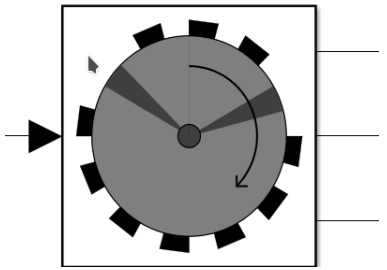
R2018b



C Function

R2020a

S-Function Builder



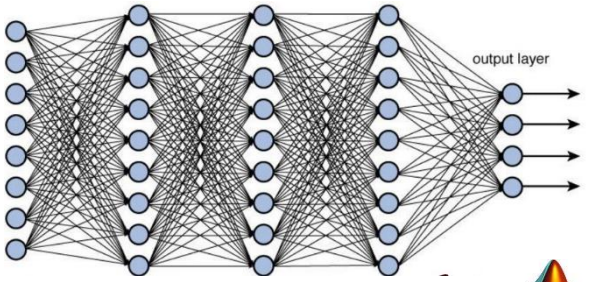
S-Function

可以在Simulink中用MATLAB 算法如Deep Learning Toolbox

模型

代码

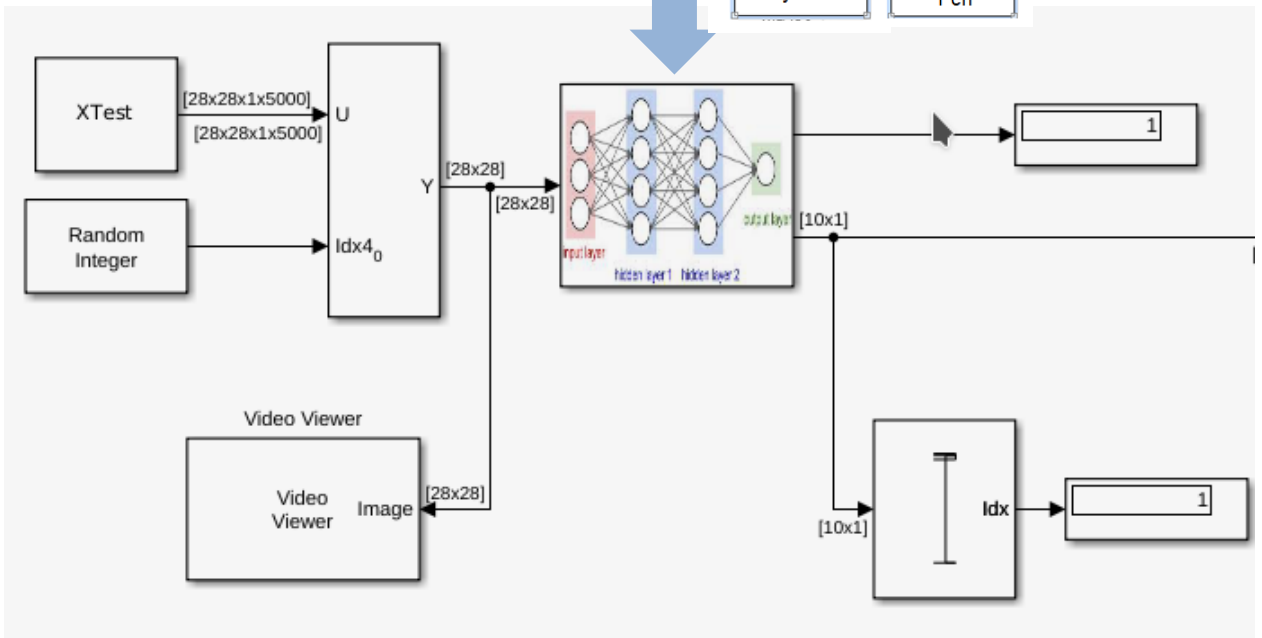
工具



Deep Learning Toolbox

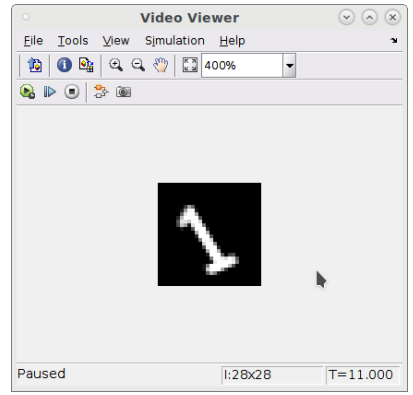
```
classdef DL_load < matlab.System

    properties (Access = private)
        % Trained deep learning model
        DLModel
    end
```

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



Tensorflow-
Keras Importer

R2020a

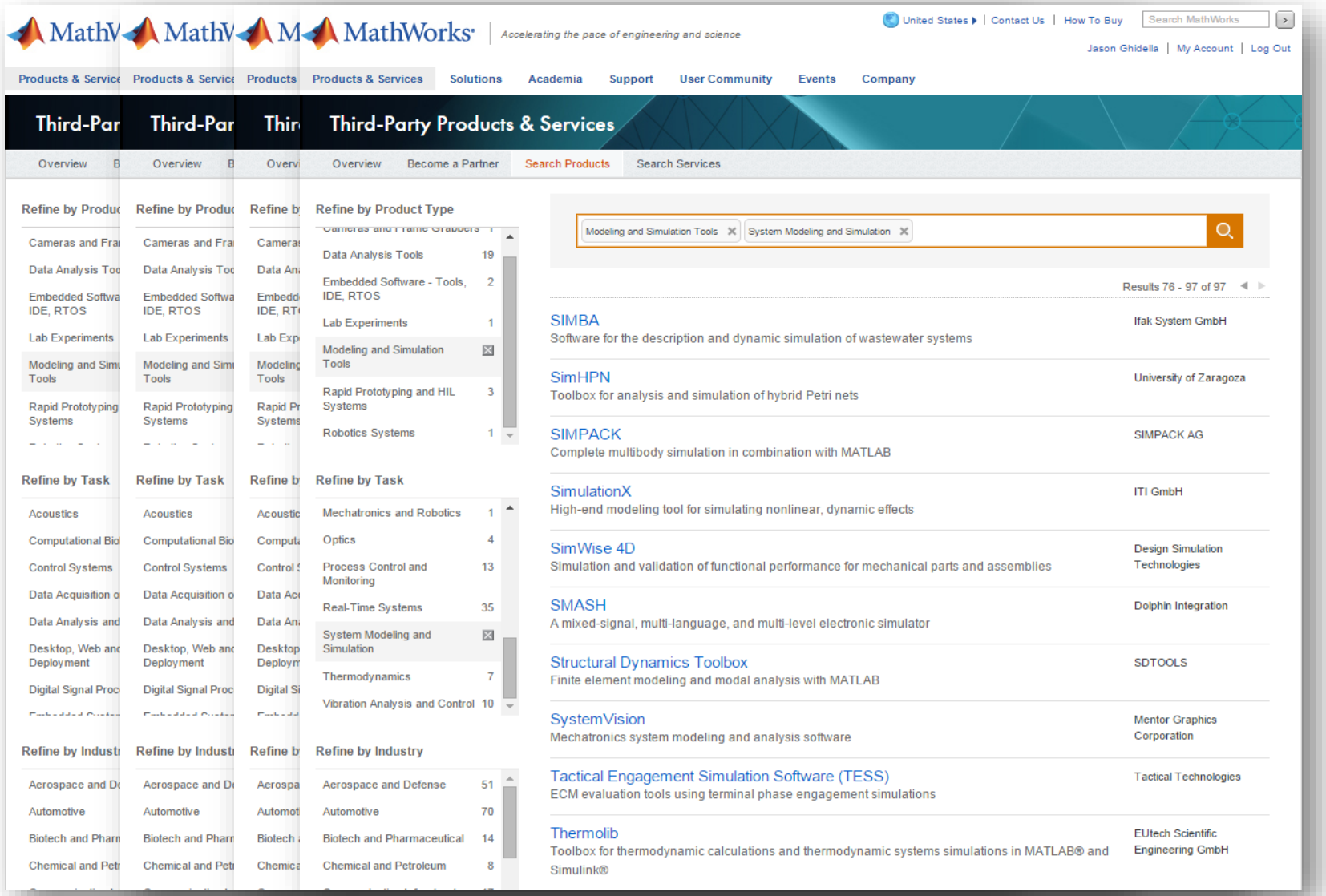


Simulink主要通过S-Function接口为190个连接伙伴产品和服务提供仿真接口

模型

代码

工具



MathWorks Partner

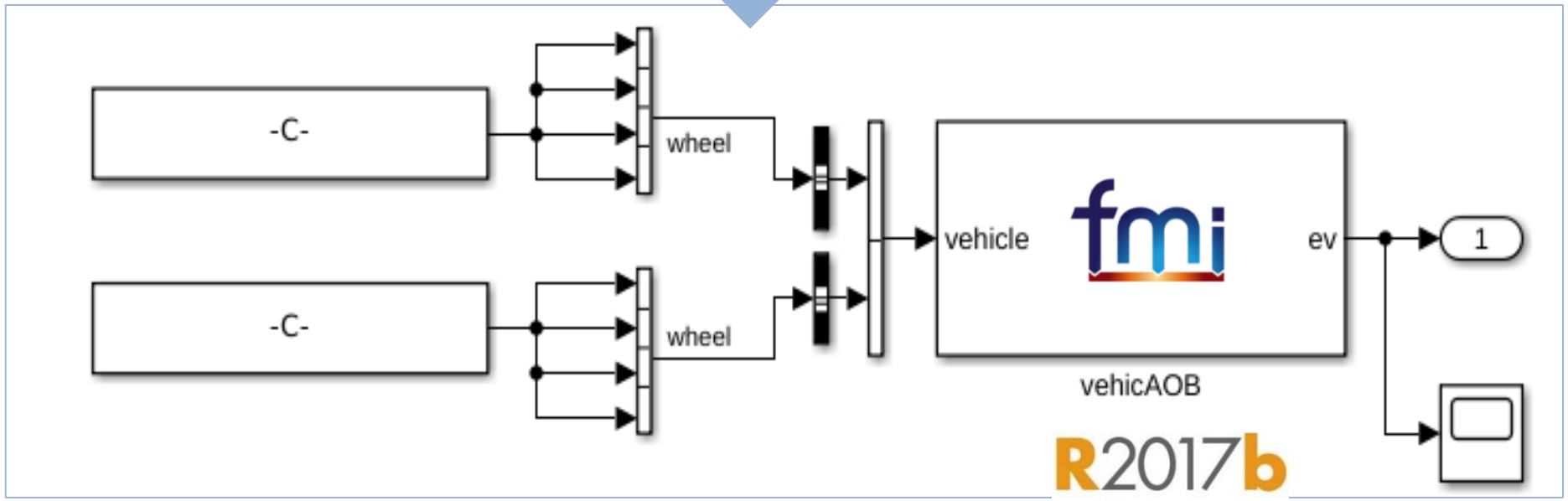
Simulink中使用FMU既简单又富有表现力

模型

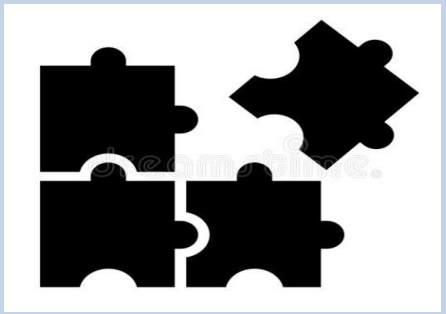
代码

工具

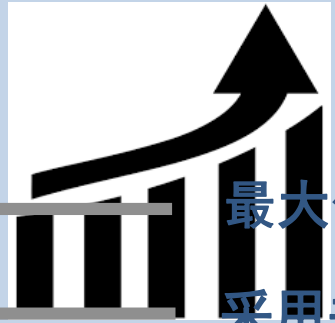
第三方工具



系统级仿真的计算量很大 (昂贵)

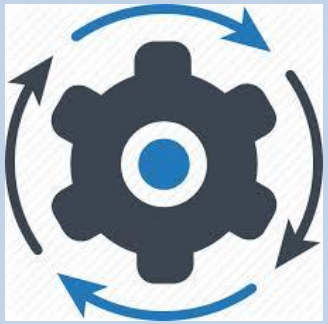


集成模型和组件



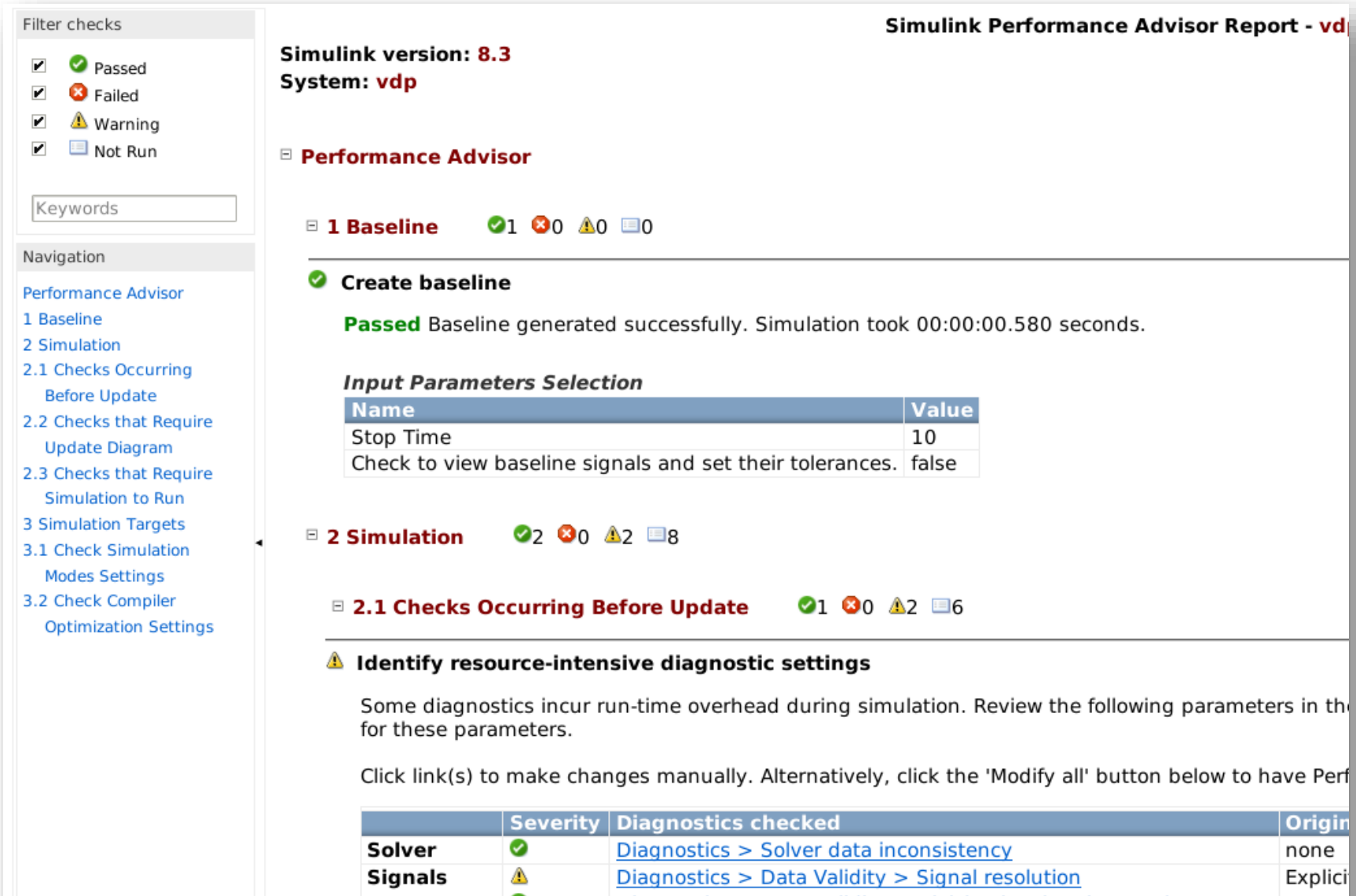
仿真性能

- 最大化单线程性能
- 采用并行化
- 启用大规模仿真运行



运行化

通过发现加速机会来最大化性能：Performance Advisor



- 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

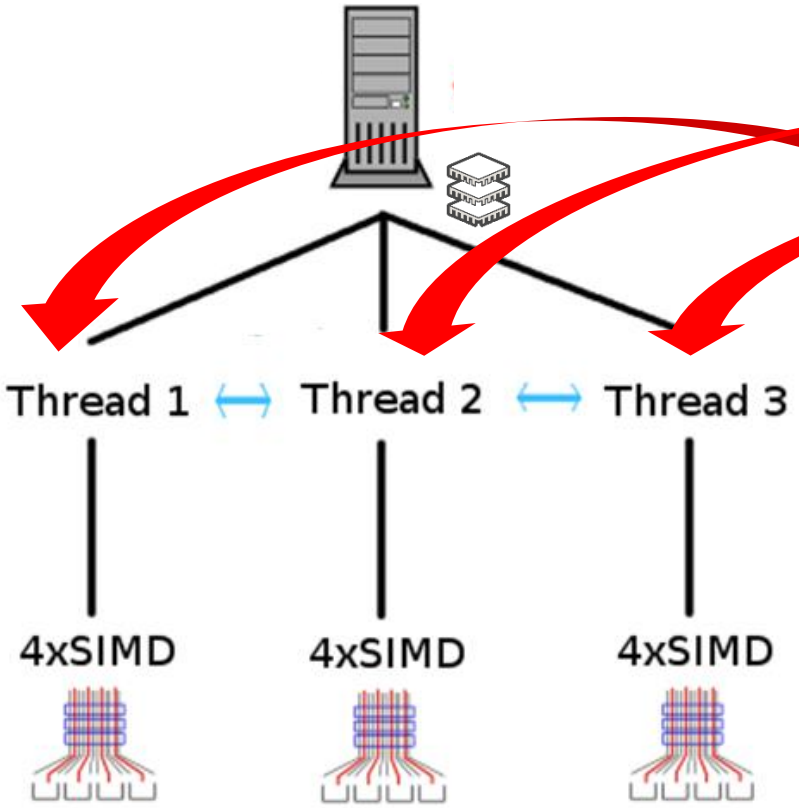
数据流 SIMD

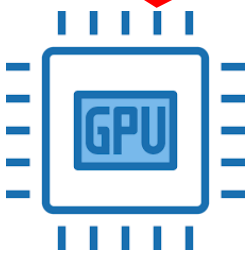
ForEach 子系统的的并行化

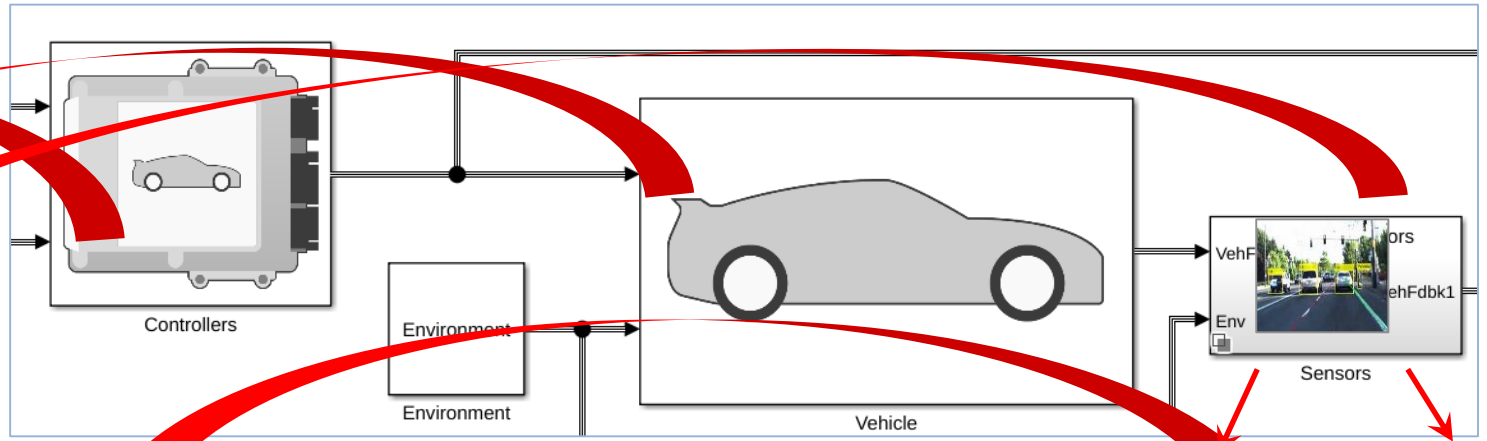
MATLAB 函数 GPU 加速

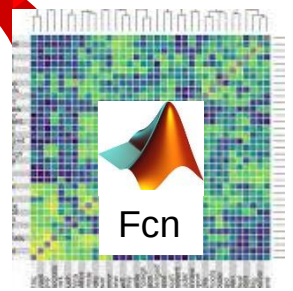
计算集群

FUTURE RELEASE

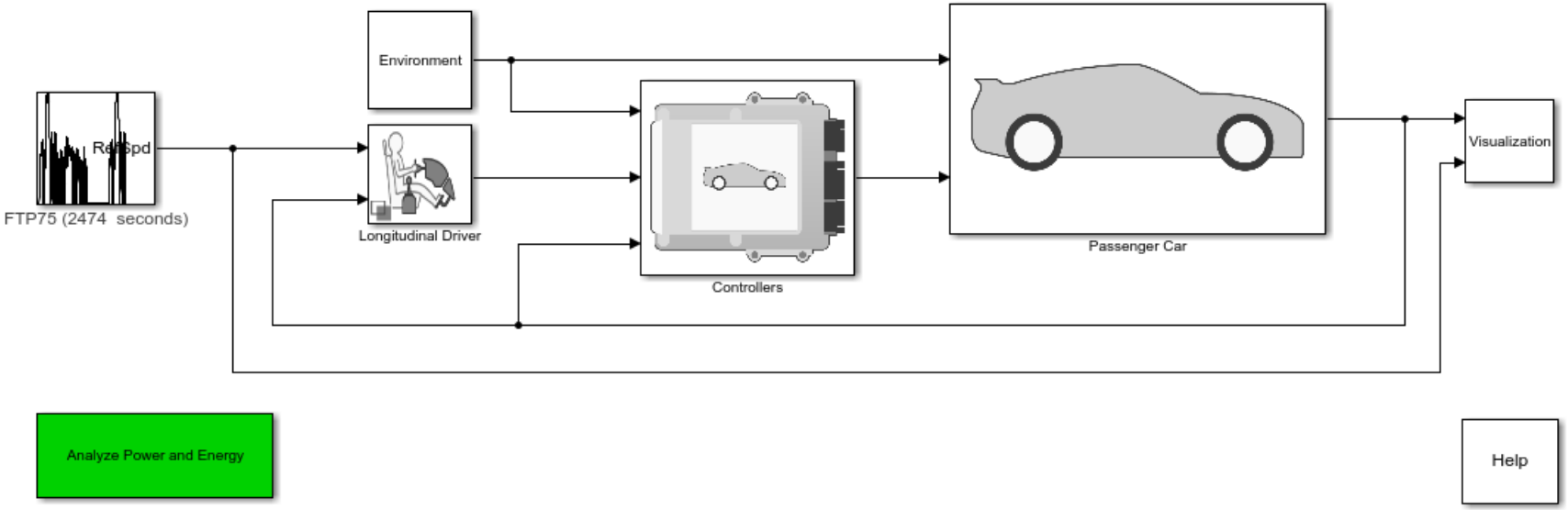


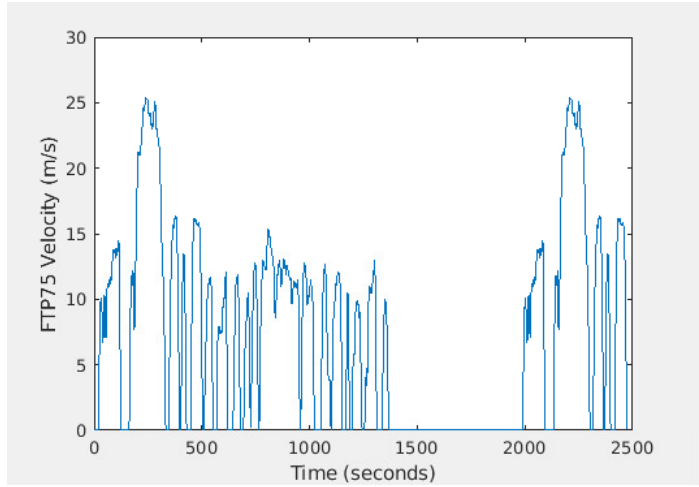






工况设计优化需要大量仿真





驾驶循环

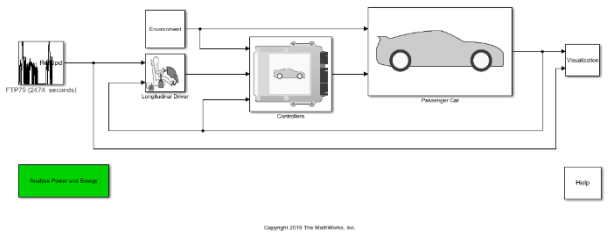
整车模型

100 驾驶循环 × 10 车辆装载 × 10 天气状况

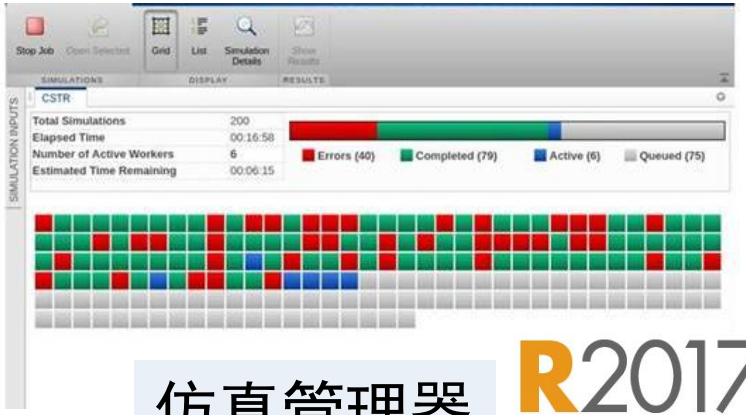
优化传动比

Simulink支持浩大量的仿真工作流程

创建

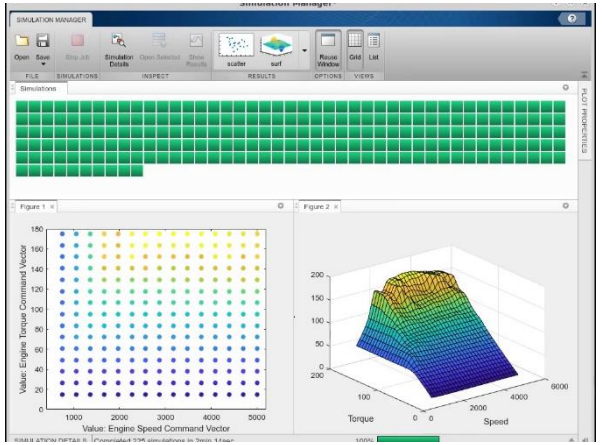


仿真

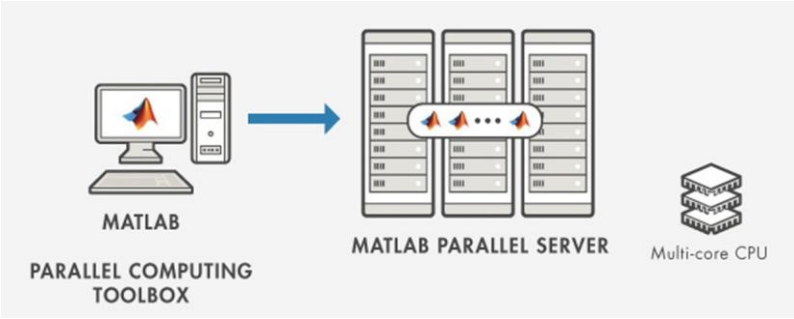


仿真管理器 R2017b

分析



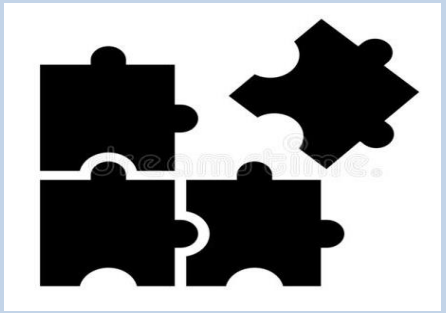
仿真管理器 R2019b FUTURE RELEASE



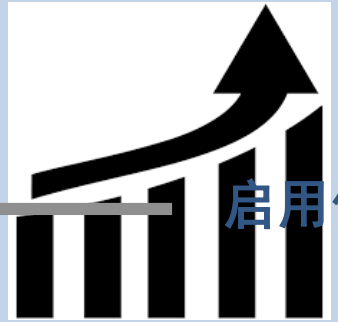
parsim R2017b

batchsim R2018b

将仿真扩展到系统的运行阶段

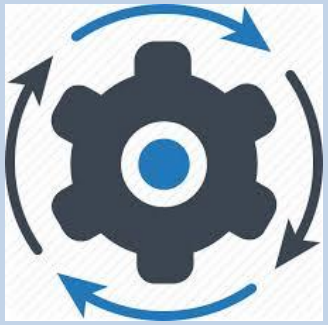


集成模型和组件



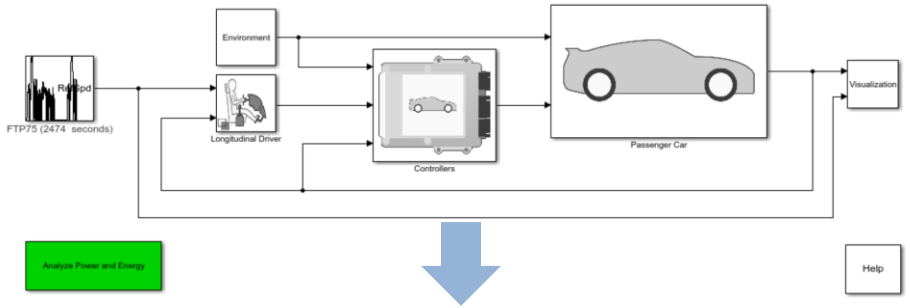
仿真性能

启用仿真部署



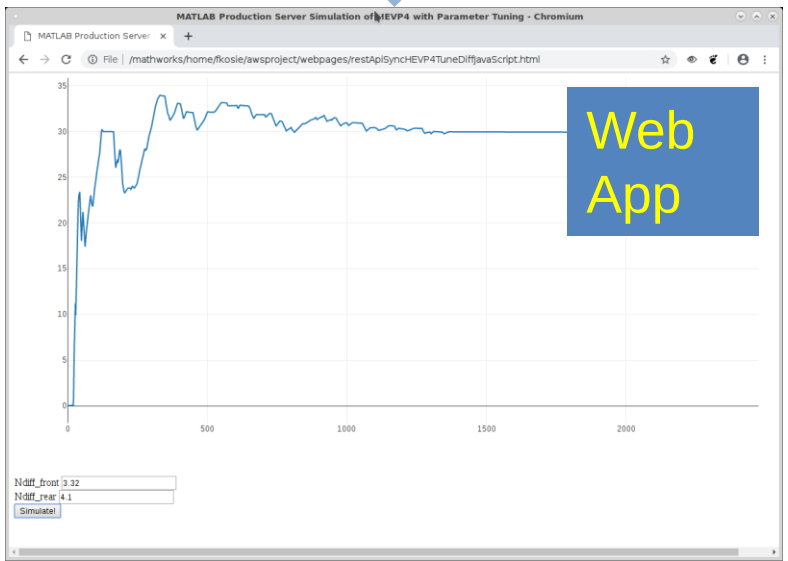
运行化

Simulink Compiler支持仿真部署

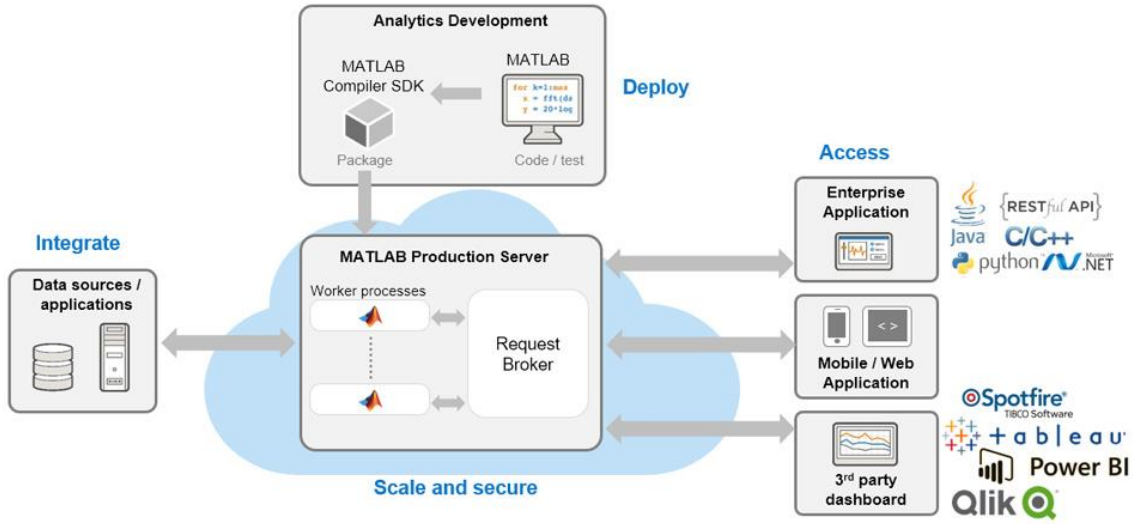


Simulink Compiler

R2020a



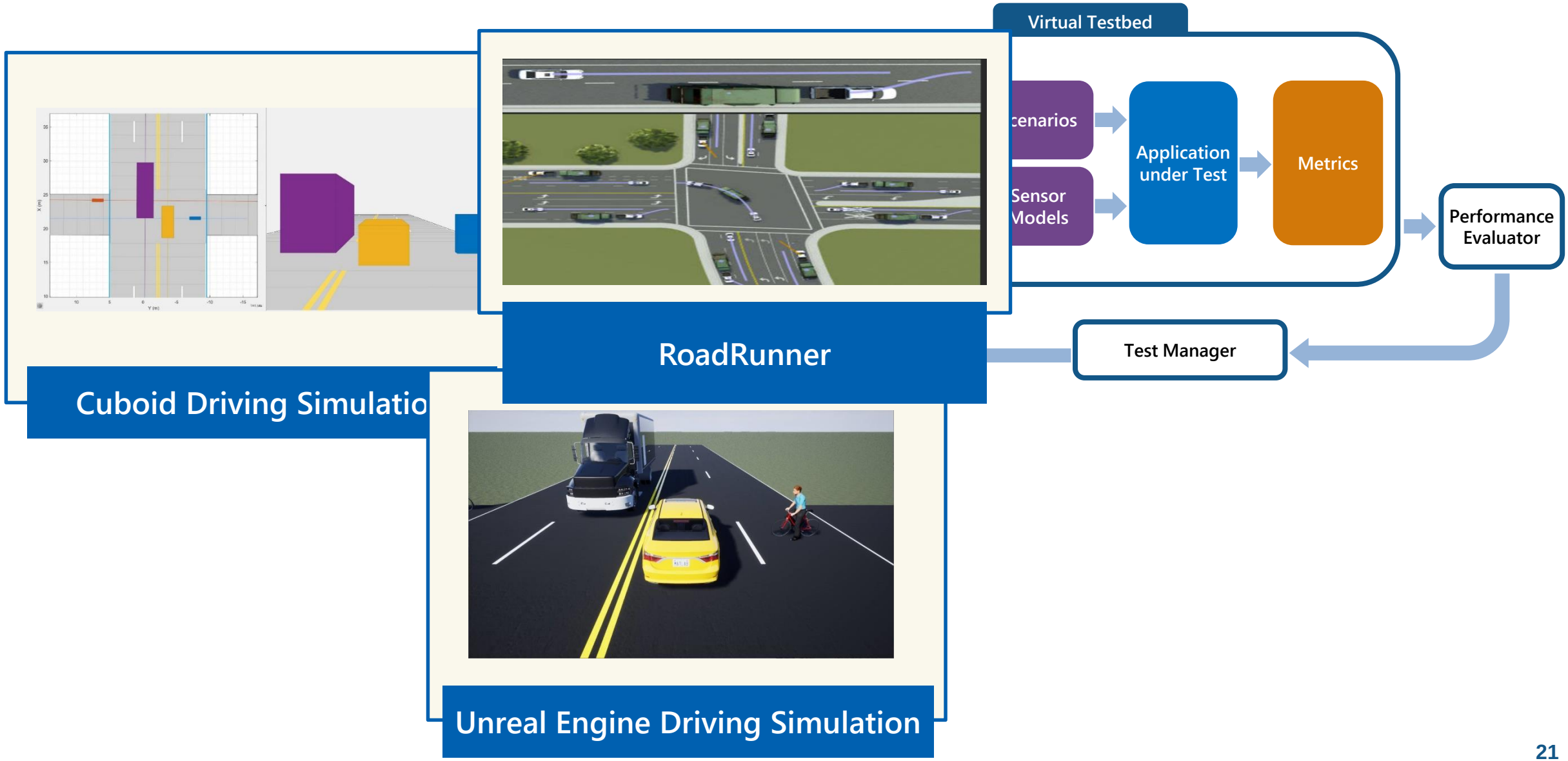
集成为企业级应用



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

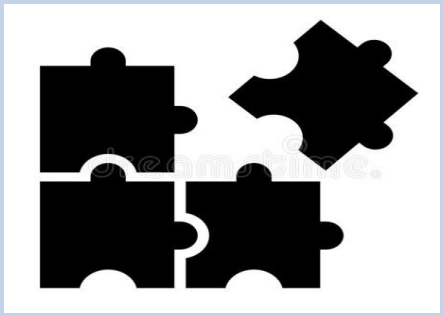
策略：为系统间 (场景) 仿真创建平台



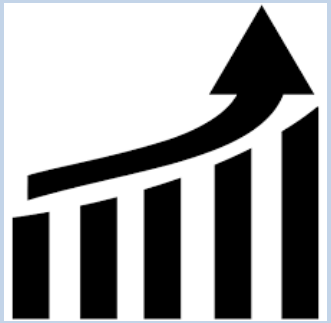
Simulink平台在不断发展以满足扩大规模的仿真需求

整车仿真

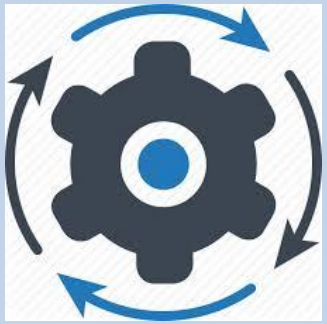
自主场景模拟



集成模型和组件



仿真性能



运行化

场景仿真

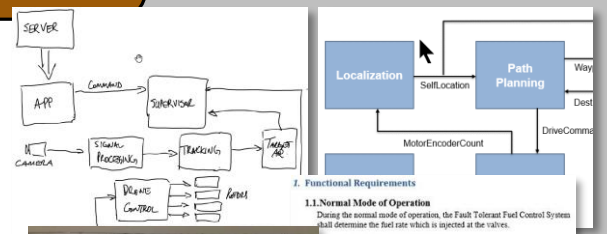
设计复杂性的演变

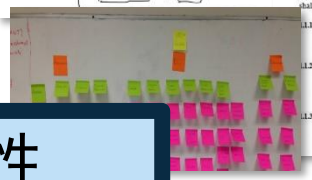
https://en.wikipedia.org/wiki/Tiktaalik


“Not sure you get it…”
Wonder what’s for lunch?

为什么不满意？

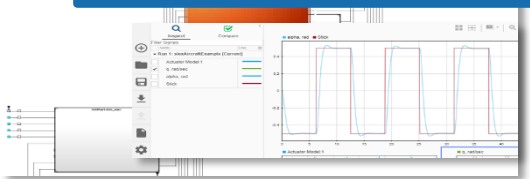
利益者需求





描述性架构

实施

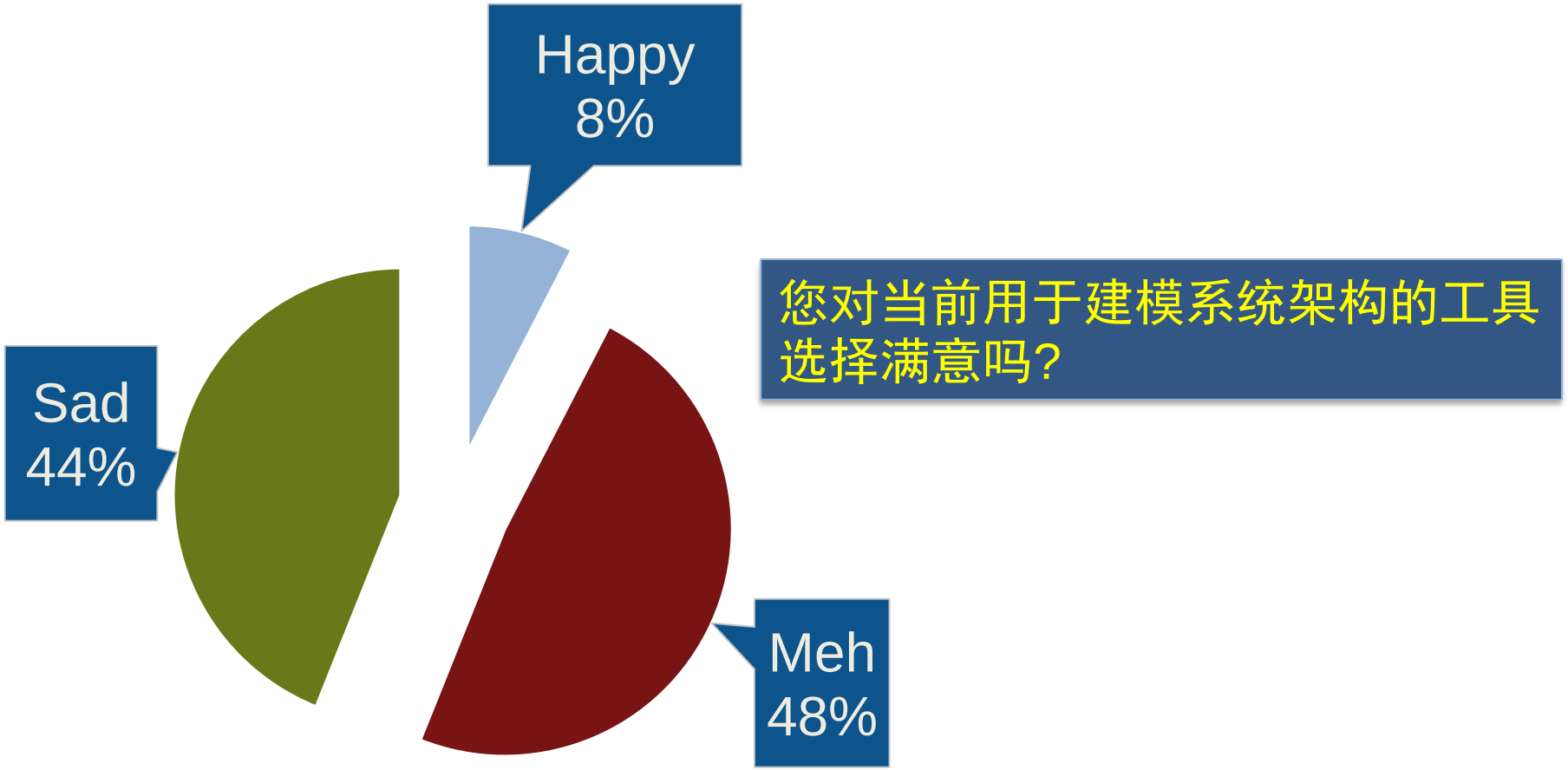


Customer quote:

"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"

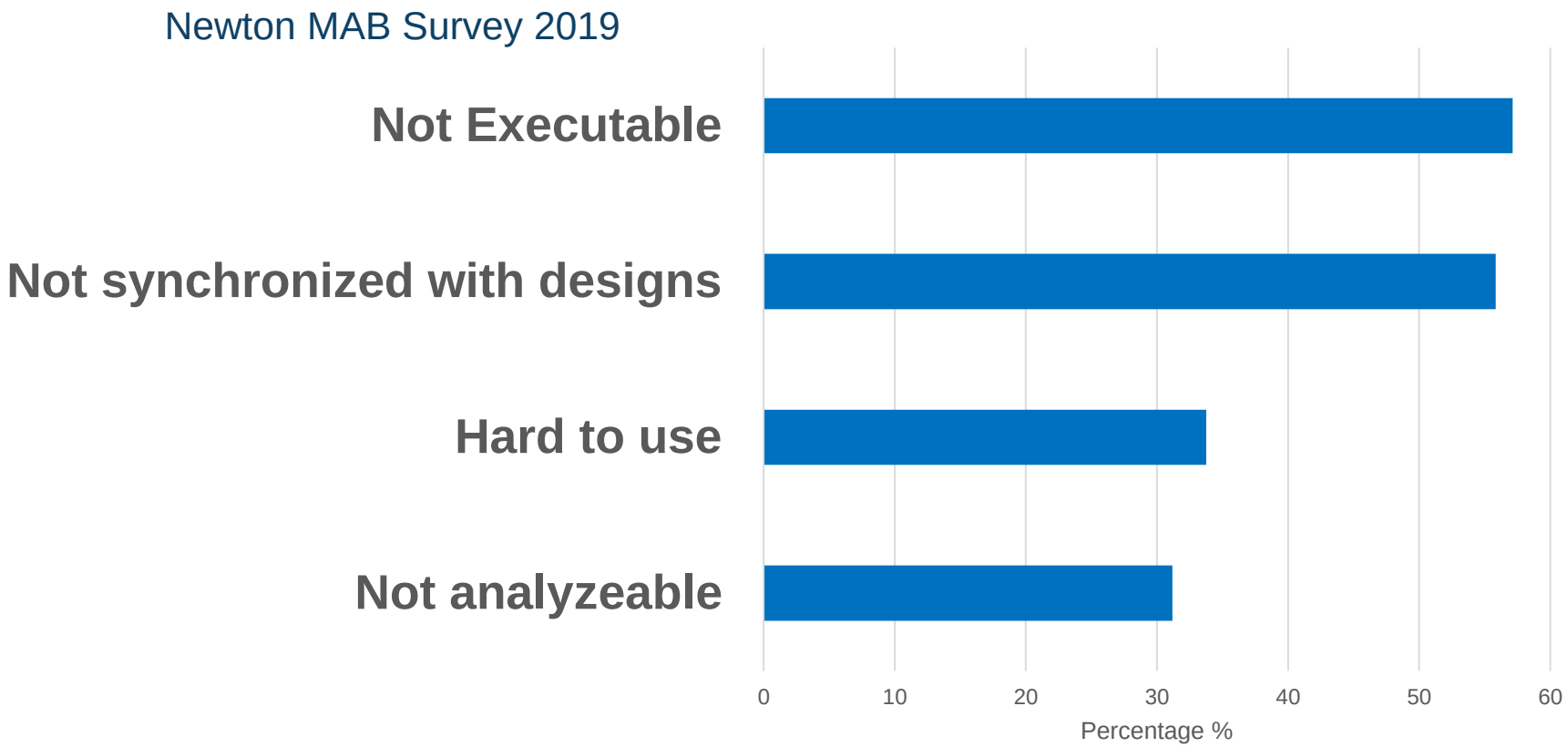
调查 @ *建模系统架构分组会*

Newton MAB - 2018



更具体地说，有哪些痛楚？

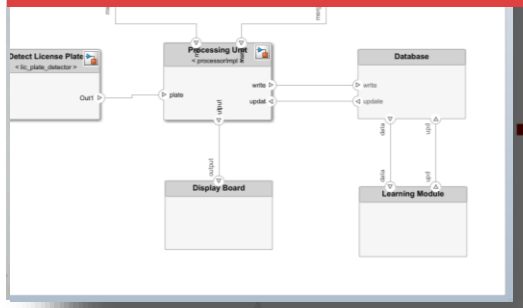
“我们不喜欢当前的系统架构解决方案，因为它们:”

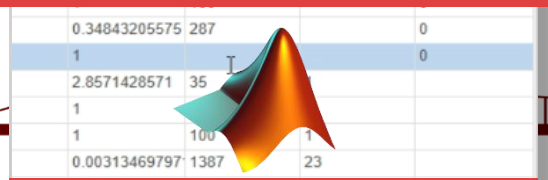


策略：建立适合于MBD的MBSE生态系统

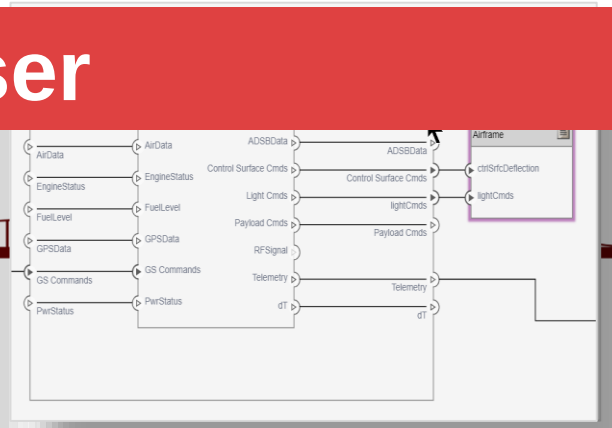
直观　　便于分析　　应对复杂性　　能够实施

System Composer

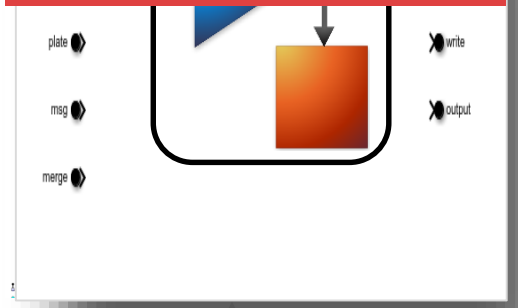




MATLAB

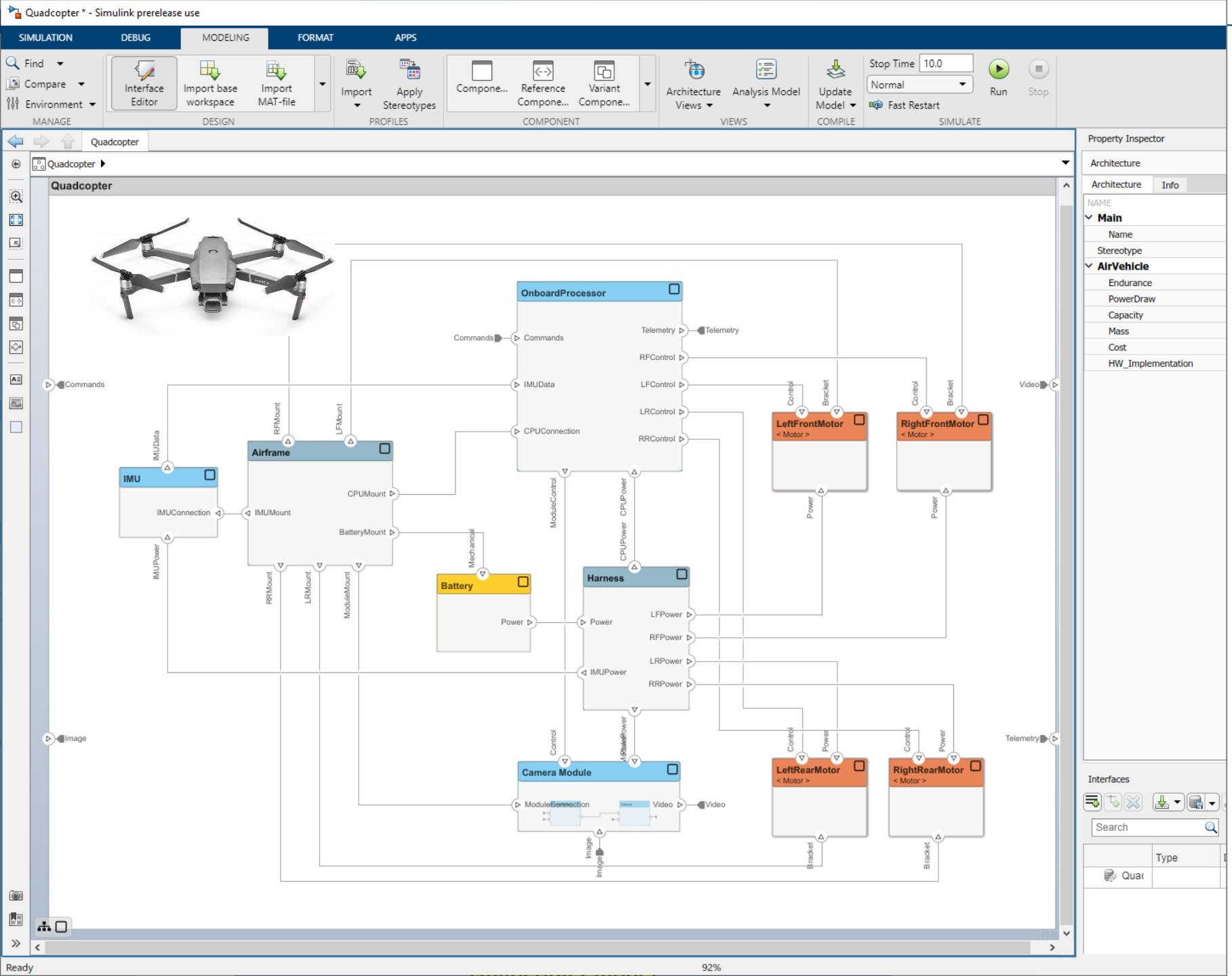


Simulink



需求覆盖率报告和影响分析

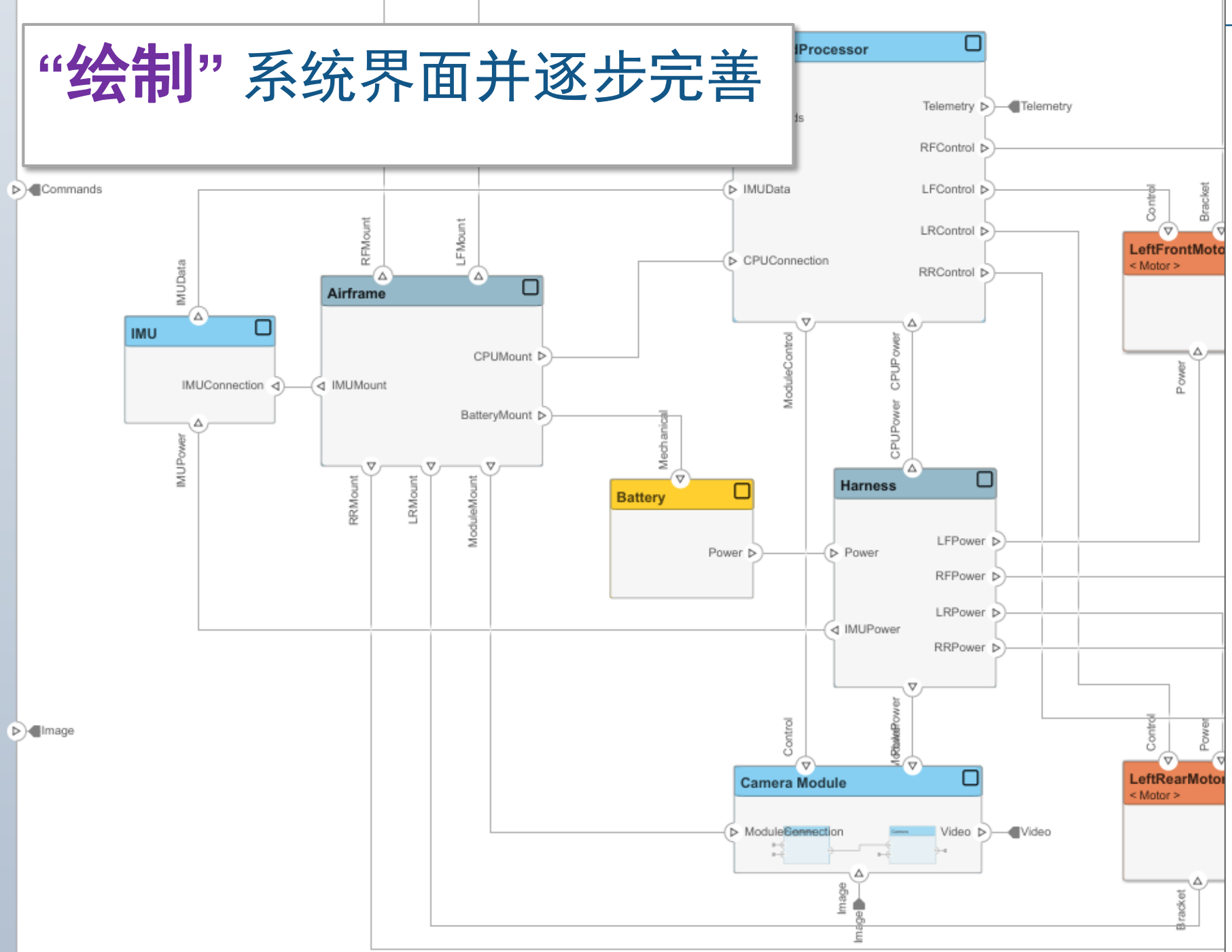
Simulink Requirements



MathWorks

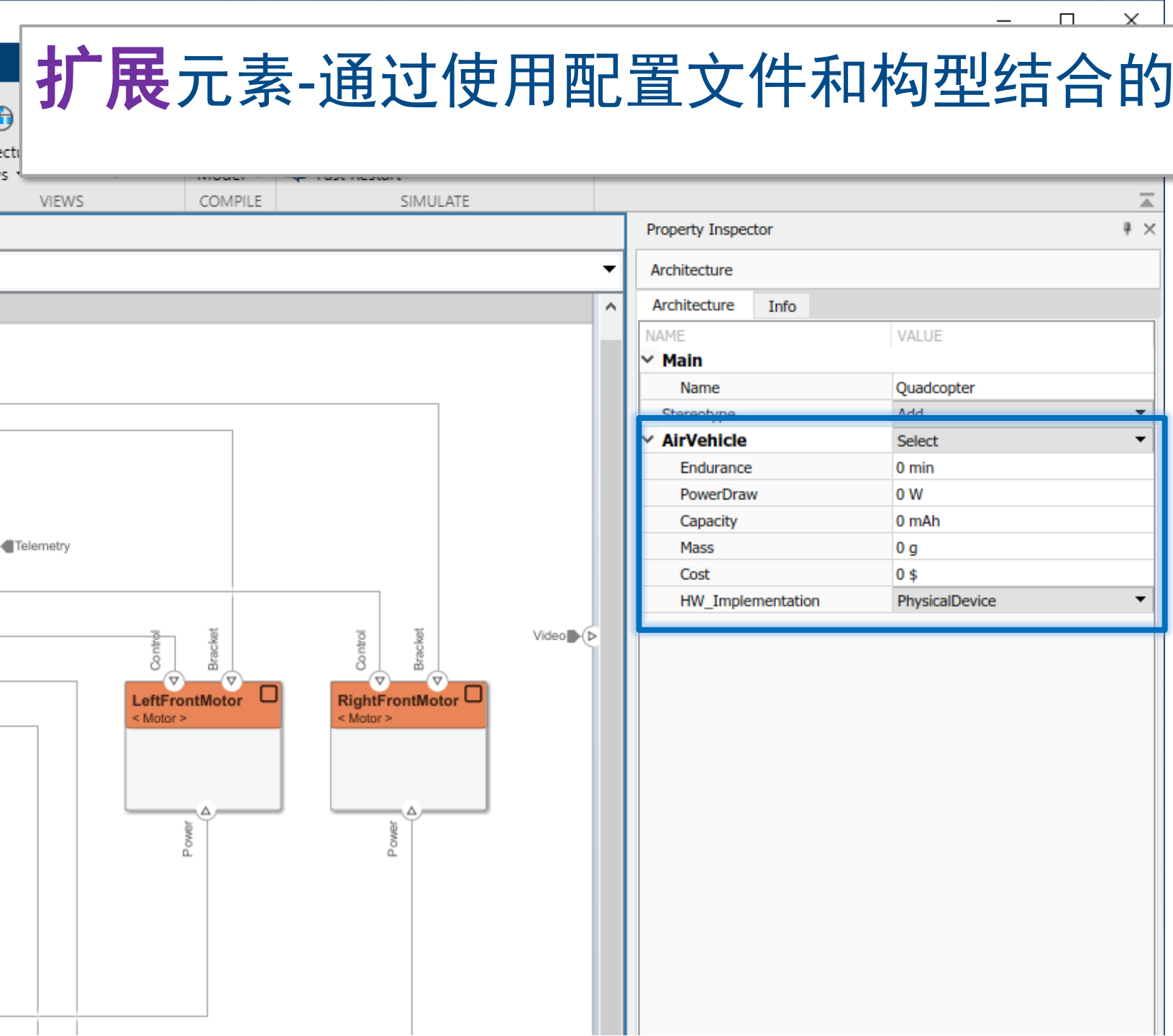
R2019a

“绘制”系统界面并逐步完善



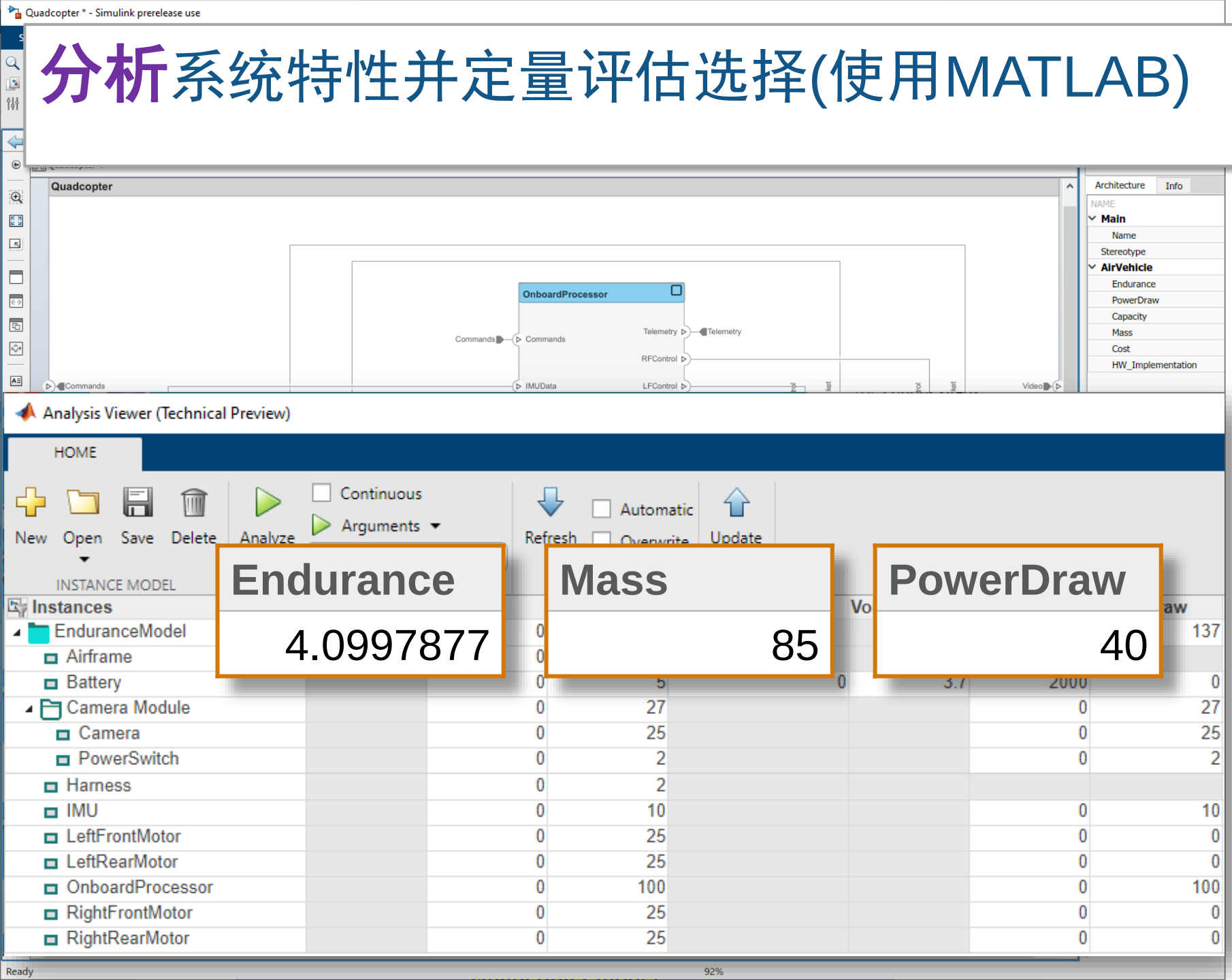
R2019a

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)



Endurance	Mass	PowerDraw
4.0997877	85	40

R2019a

跟踪系统需求
与架构一起完善需求

Requirements - Quadcopter

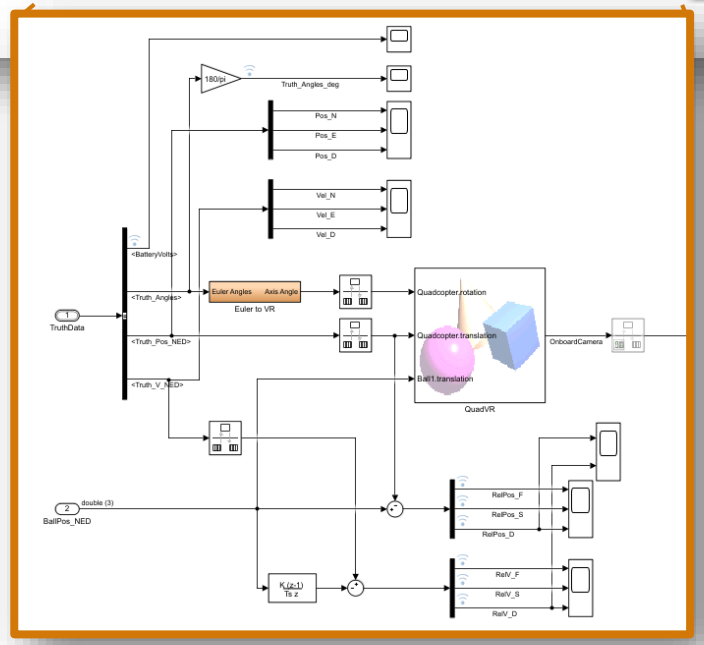
View: Requirements

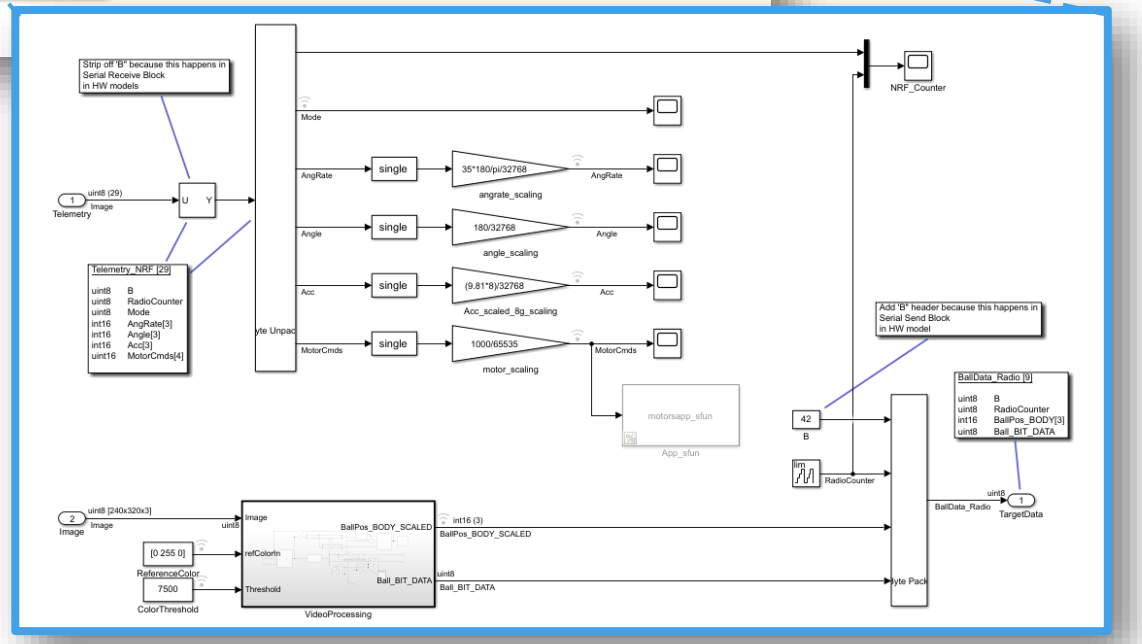
Index	ID	Summary	Implemented
quadcopter			
1	#1	Aircraft Performance	
1.1	#14	Aircraft horizontal velocity	
1.2	#15	Aircraft vertical velocity	
2	#2	Power System	
2.1	#6	Power Source	

R2019a

With Simulink Requirements

关联设计模型与组件并确保接口一致

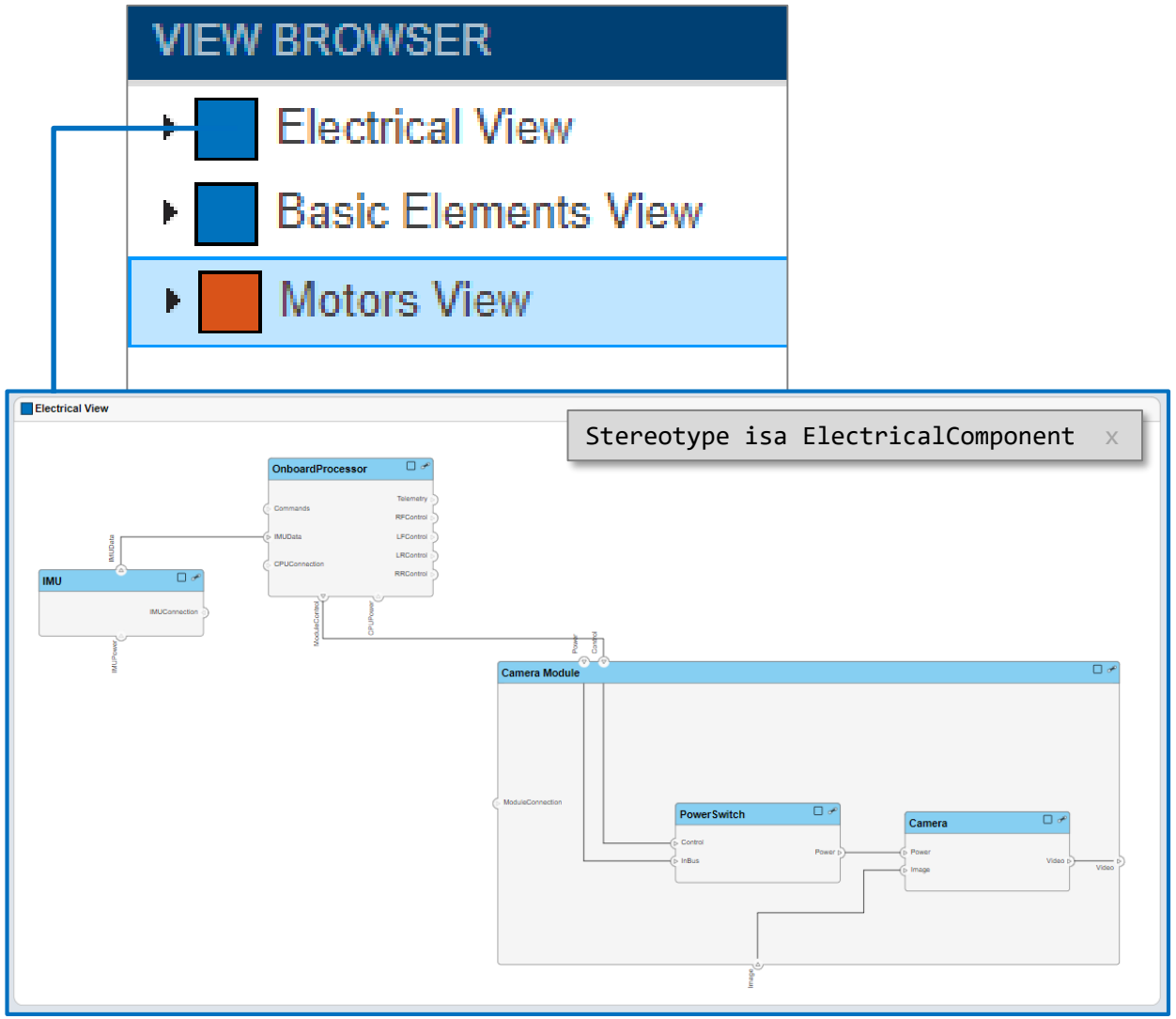




R2019a

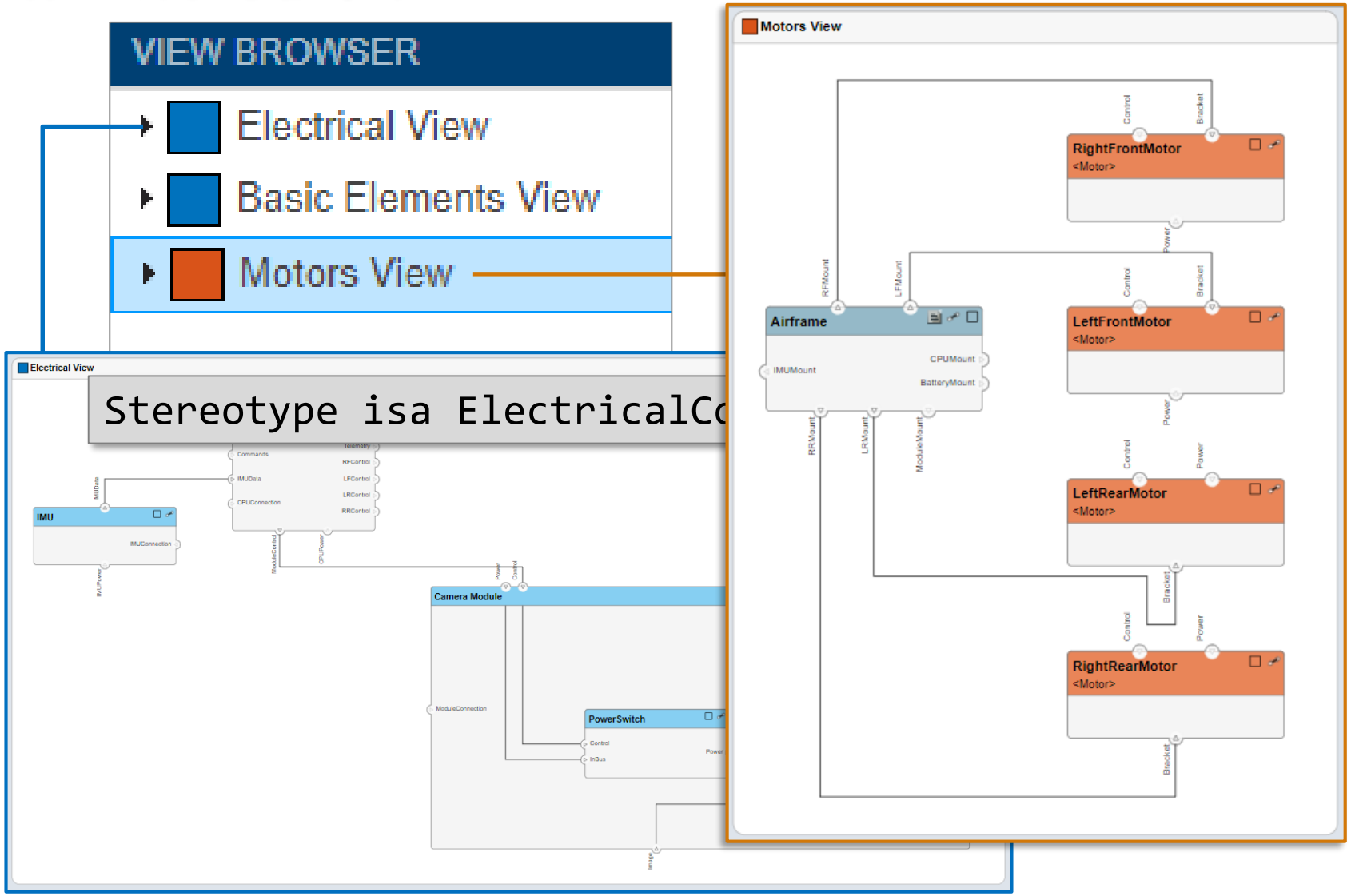
简化复杂性使用过滤器和自动生成的视图

R2019b



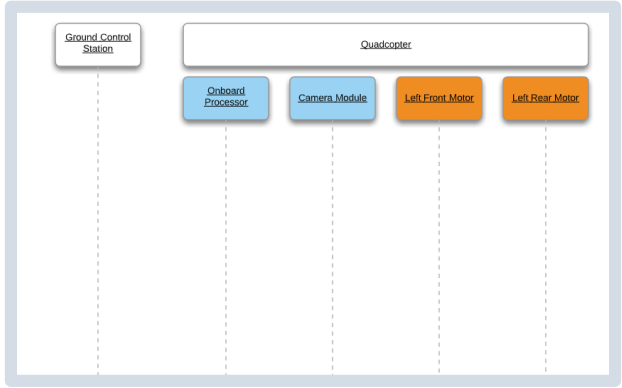
简化复杂性使用过滤器和自动生成的视图

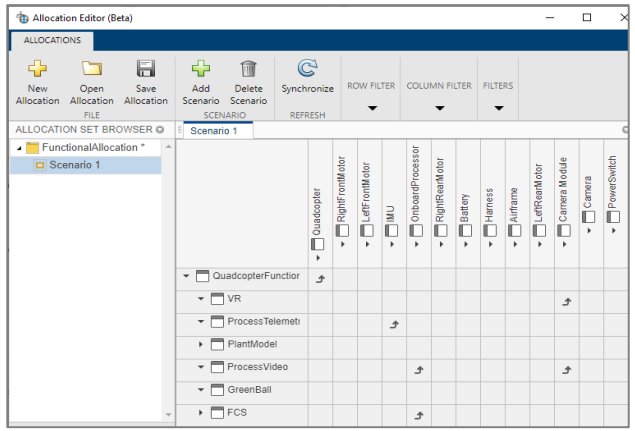
R2019b

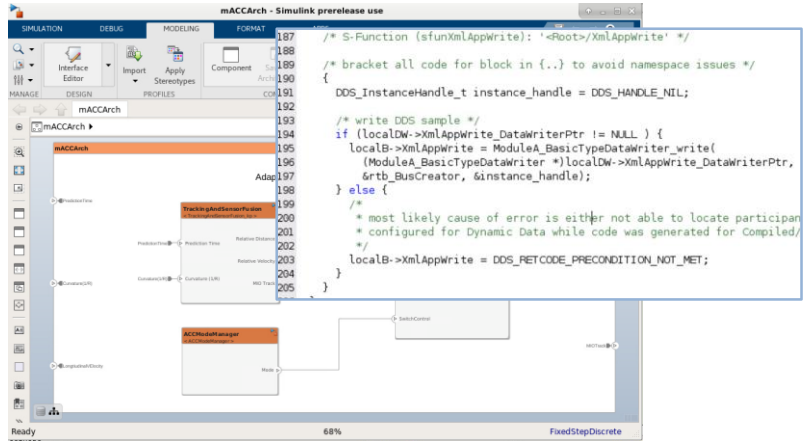


而我们才刚刚开始
即将来临的：

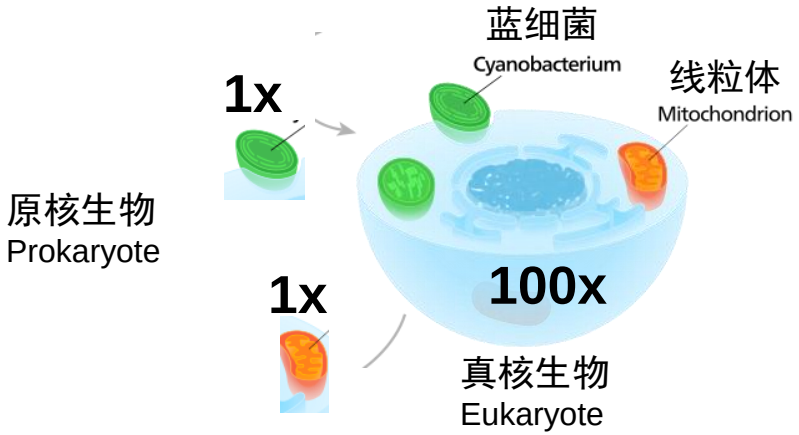
- 使用序列图进行行为建模
- 通过分析(例如逻辑到物理)进行架构分配
- 软件架构建模
  - 链接到AUTOSAR (R2019b)
  - 其它中间件，例如DDS
- 还有更多！





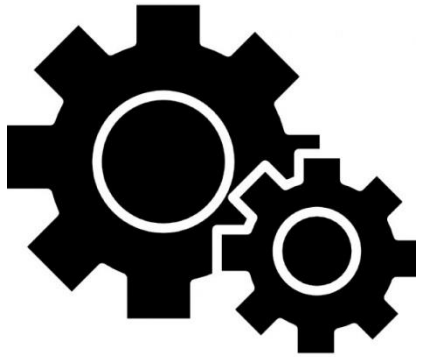


协同工程的演变

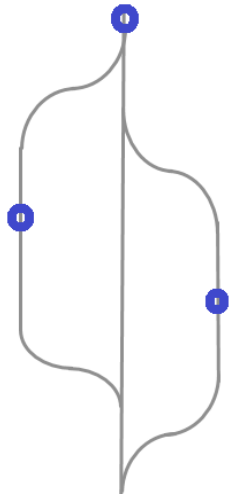


https://en.wikipedia.org/wiki/Symbiogenesis

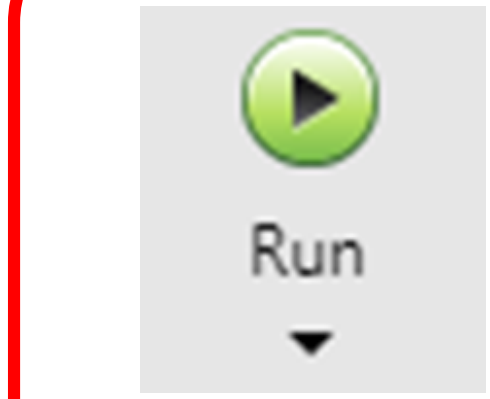
趋势：基于团队的敏捷工作流程的需求增加



共享的团队环境



合作

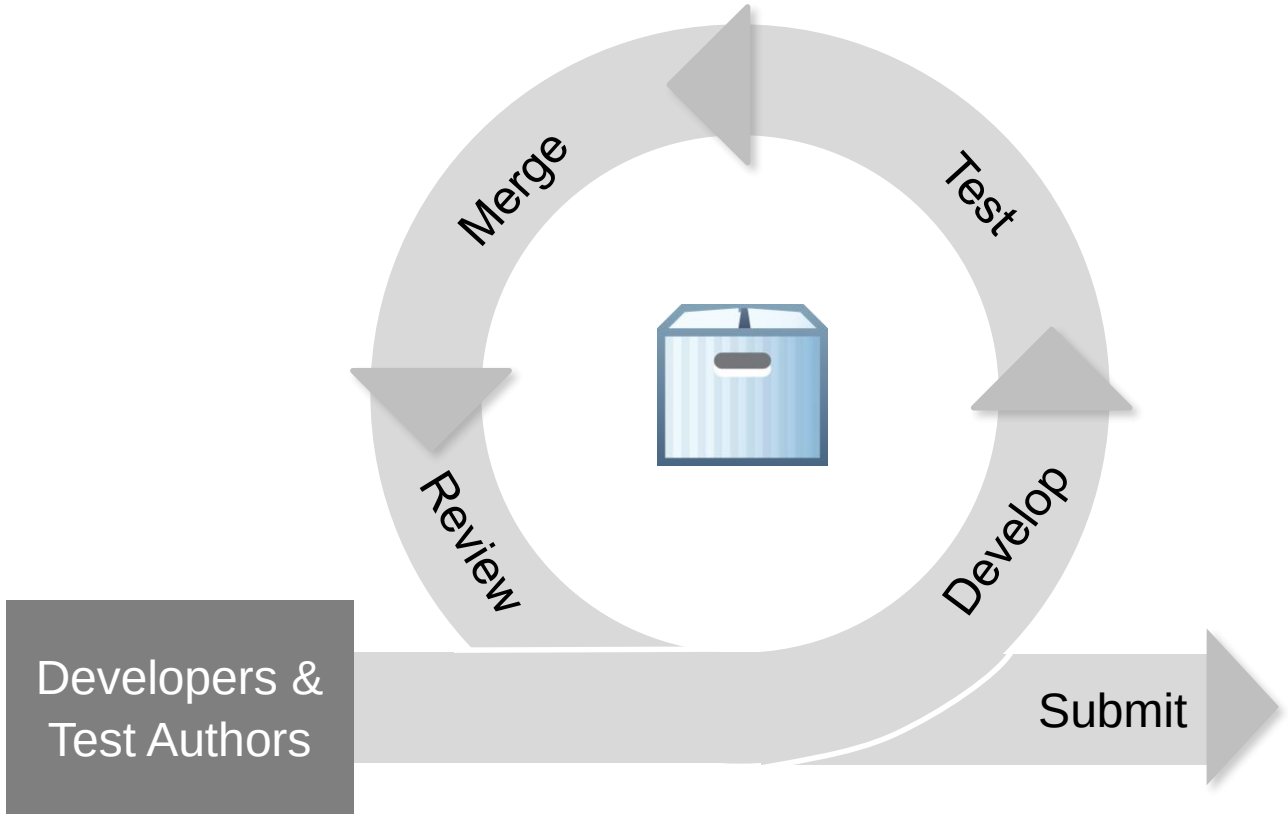


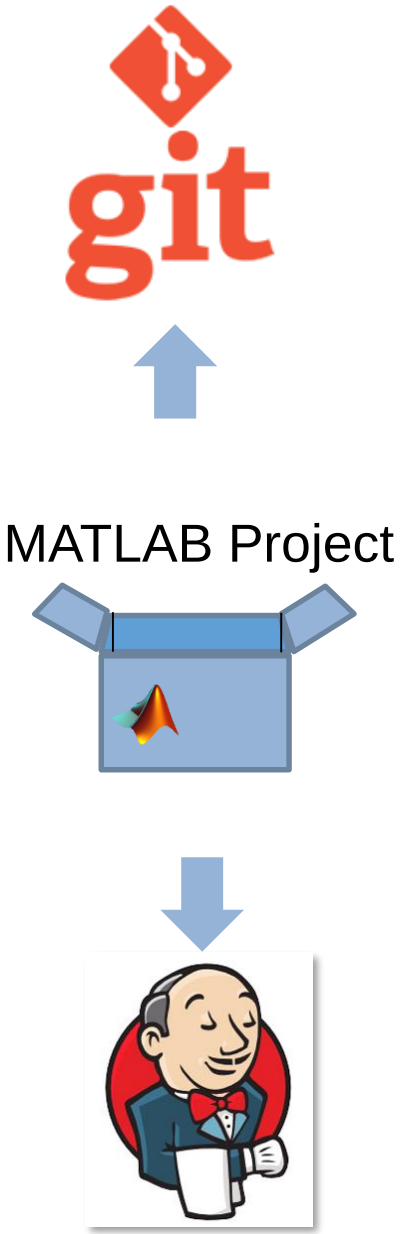
仿真

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



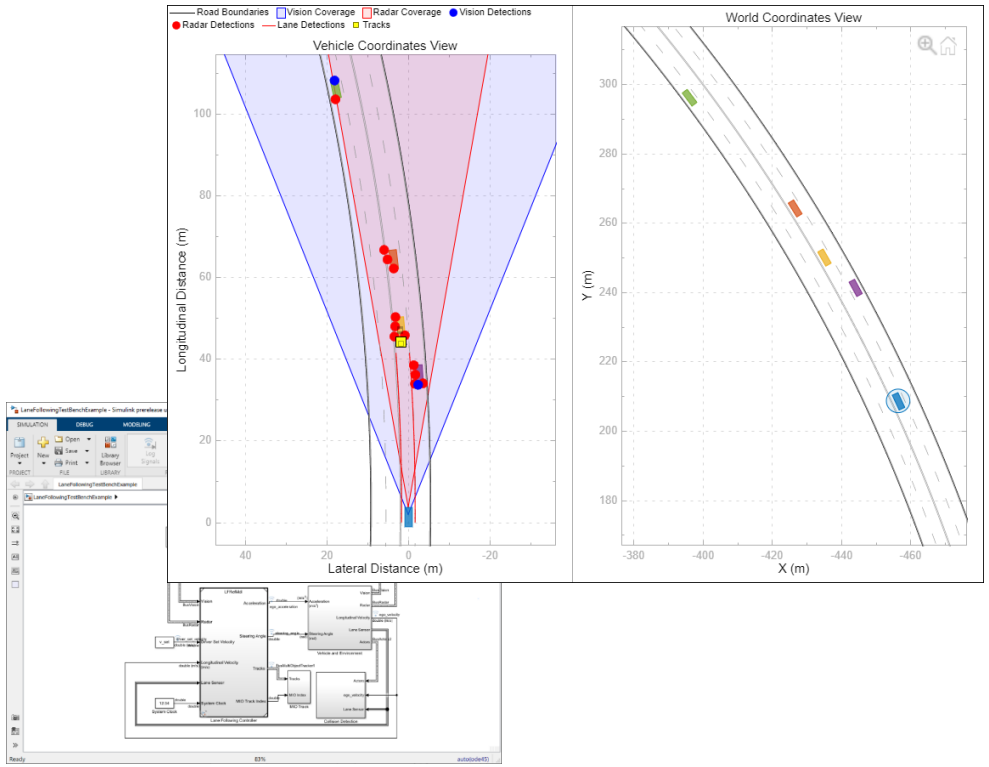


如今我可以在Simulink中进行CI吗?

当然，让我们考虑一个例子

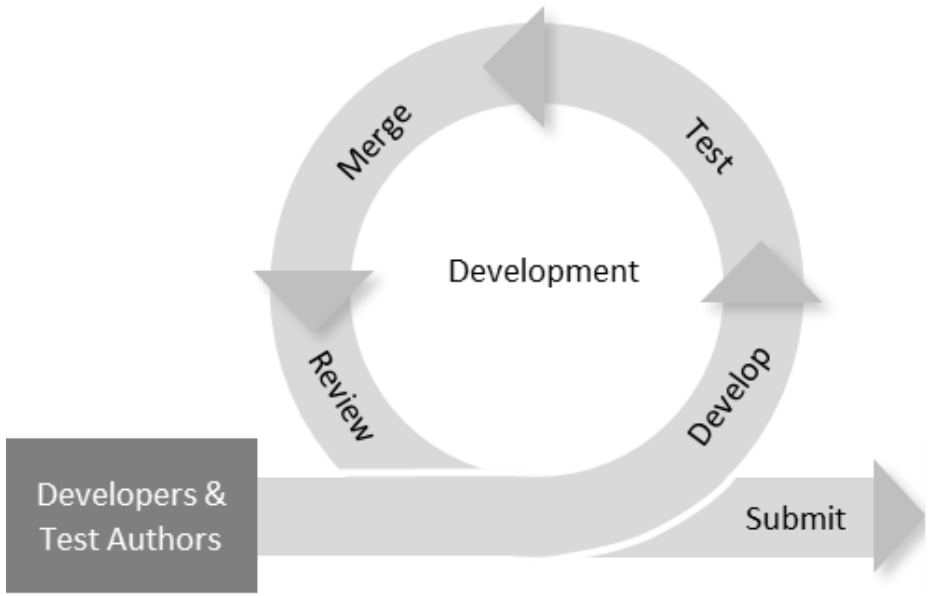
R2019b

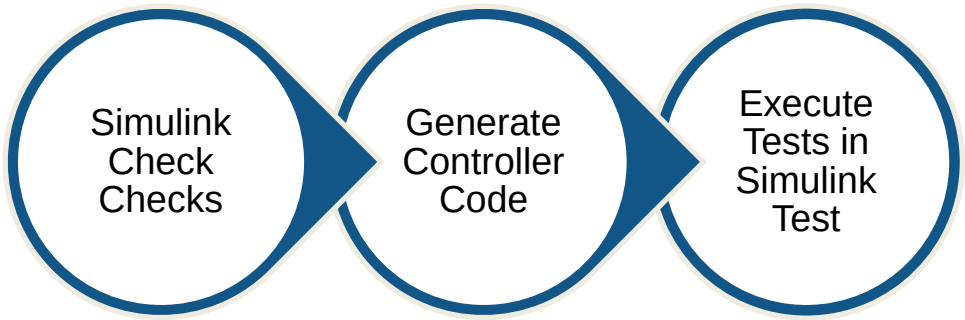
车道跟随辅助示例



- Simulink Check Checks
- SIL Code Generation
- SIL Testing Simulink Test

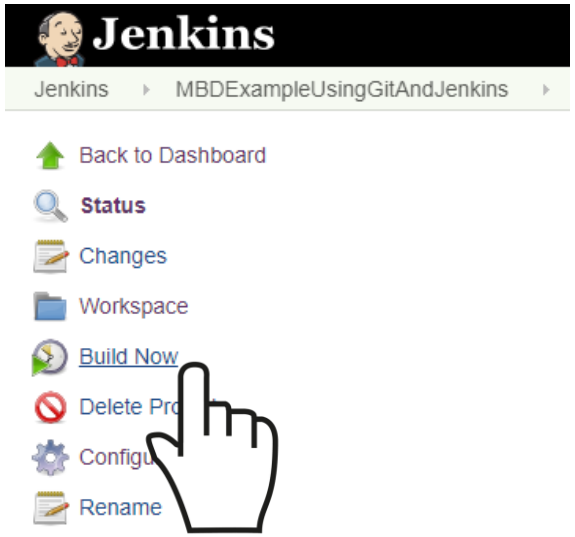
如何将它们都融合在一起?





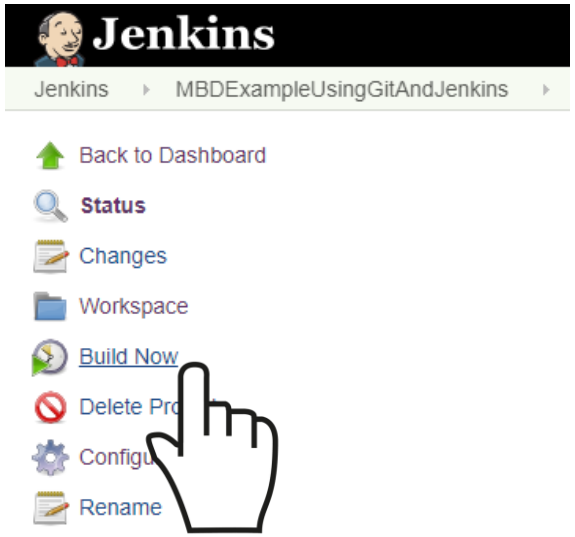
1. 触发

Trigger


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

1.触发

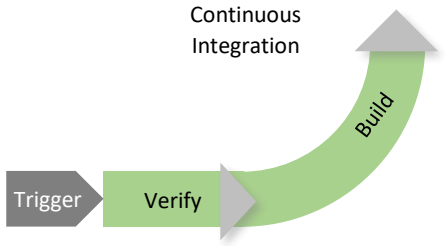
Continuous
Integration

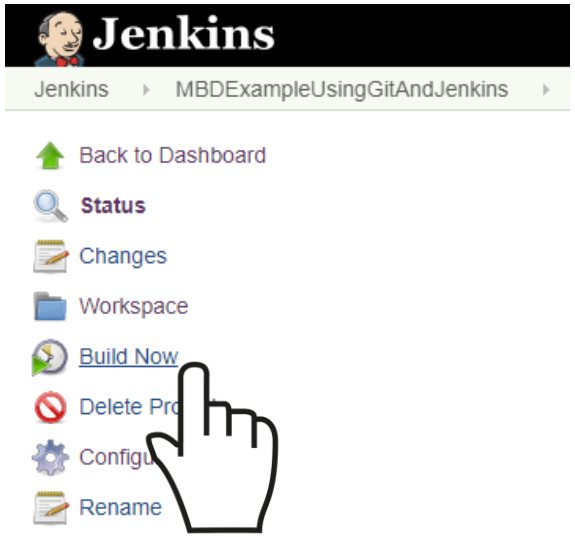



```
Running LaneFollowingModelAdvisorChecks
.
Done LaneFollowingModelAdvisorCheck
```

Simulink Check

1.触发





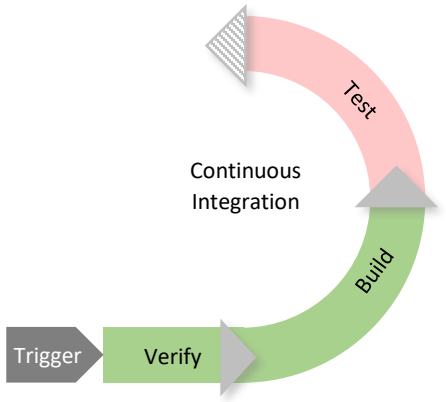

```
Running LaneFollowingModelAdvisorChecks
.
Done LaneFollowingModelAdvisorCheck
```

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

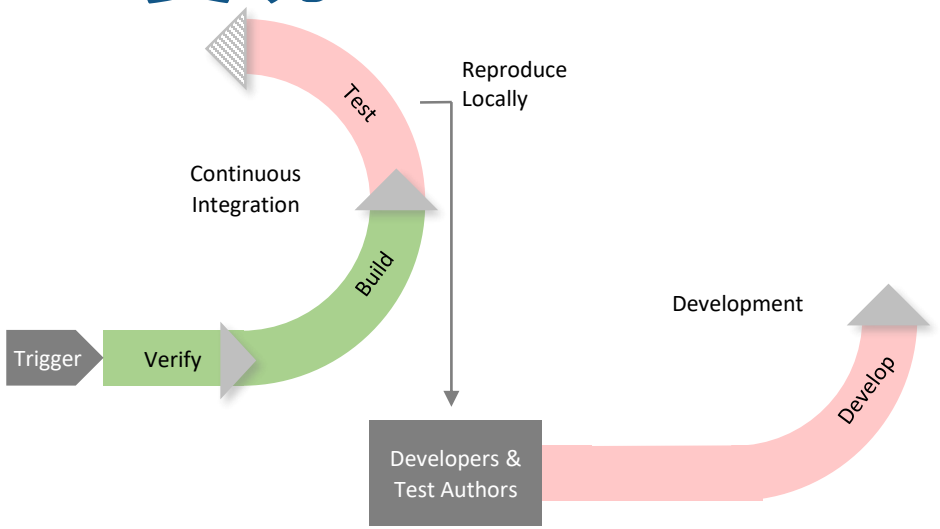
2. 检测

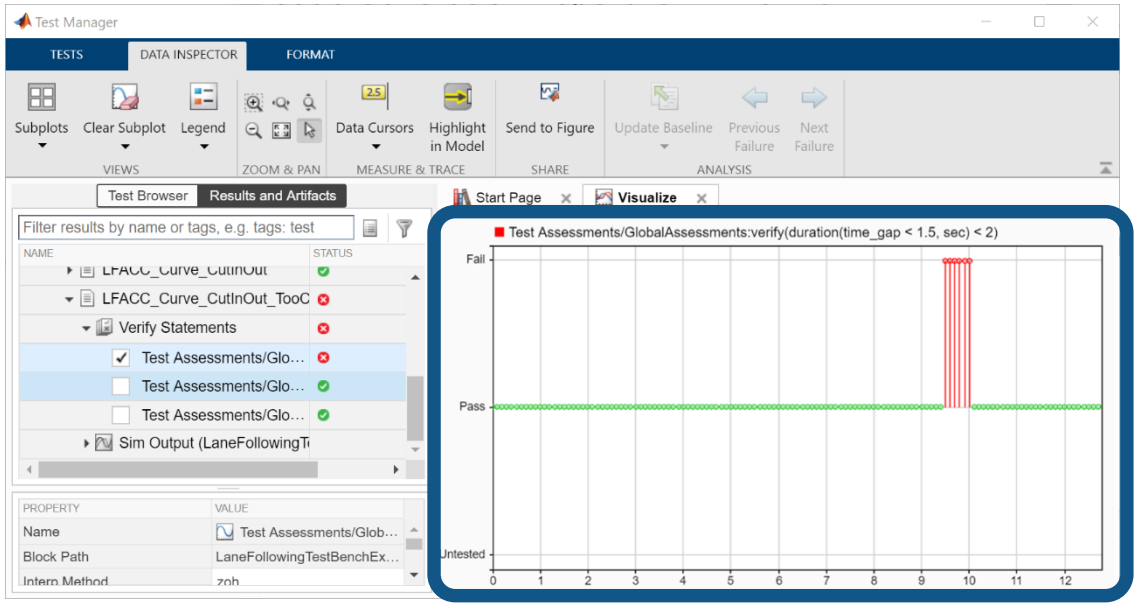



```
Failure Summary:

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

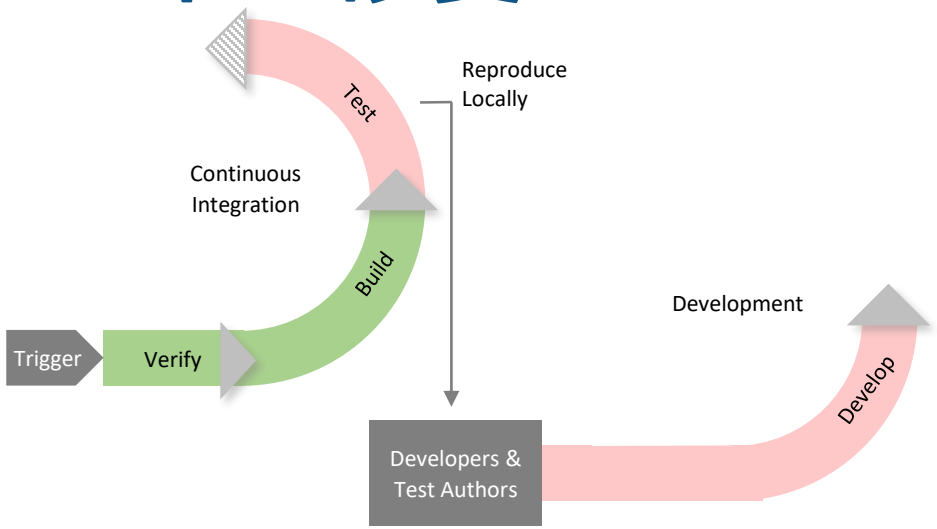
Simulink Test

3. 复现

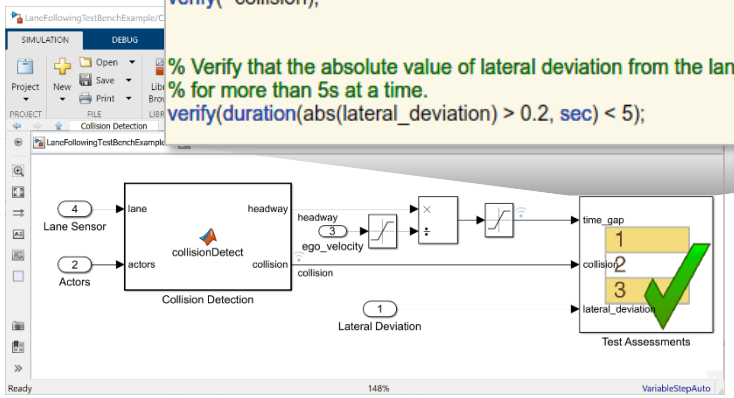

Reproduce
Locally
Test
Continuous
Integration
Build
Trigger
Verify
Development
Develop
Developers &
Test Authors


Test Manager
TESTS
DATA INSPECTOR
FORMAT
Subplots
Clear Subplot
Legend
Data Cursors
Highlight in Model
Send to Figure
Update Baseline
Previous Failure
Next Failure
VIEWS
ZOOM & PAN
MEASURE & TRACE
SHARE
ANALYSIS
Test Browser
Results and Artifacts
Start Page
Visualize
Filter results by name or tags, e.g. tags: test
NAME
STATUS
LFACC_Curve_CutInOut_TooC
Verify Statements
Test Assessments/Glo…
Test Assessments/Glo…
Test Assessments/Glo…
Sim Output (LaneFollowingT
PROPERTY
VALUE
Name
Test Assessments/Glob…
Block Path
LaneFollowingTestBenchEx…
Test Assessments/GlobalAssessments:verify(duration(time_gap < 1.5, sec) < 2)
Fail
Pass
Untested
0
1
2
3
4
5
6
7
8
9
10
11
12

4. 本地修复

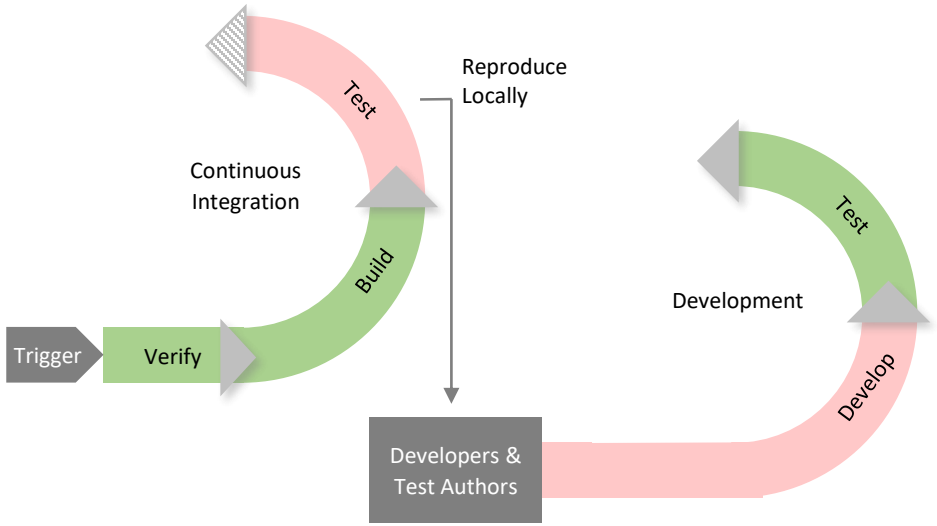


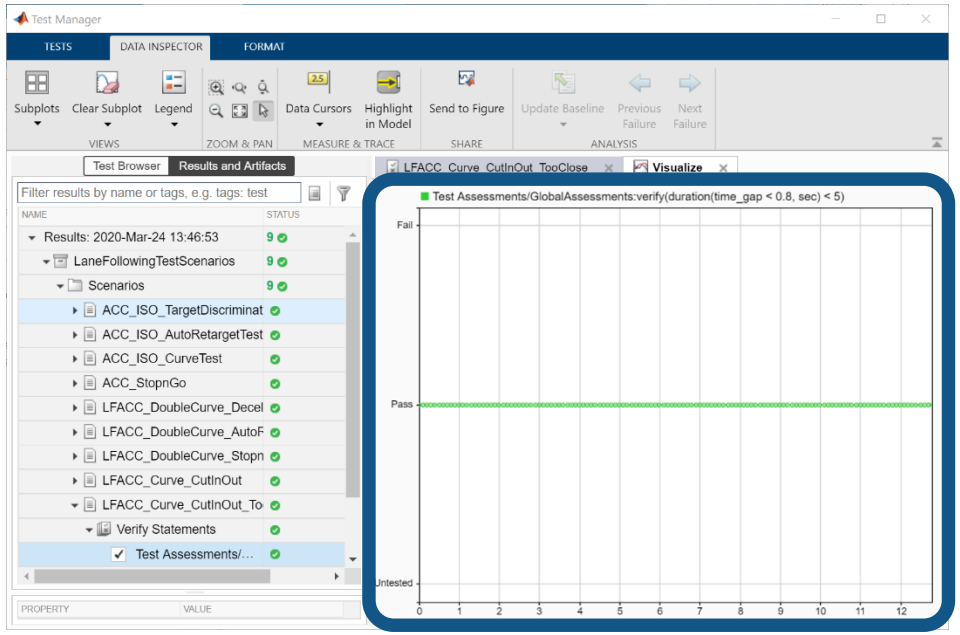

```
GlobalAssessments

% 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);
```



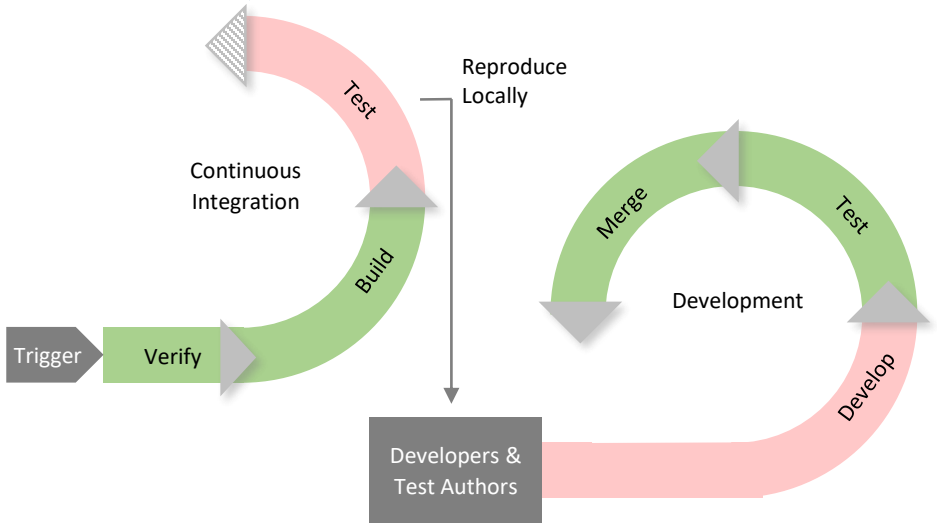

```
GlobalAssessments

% 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);
```

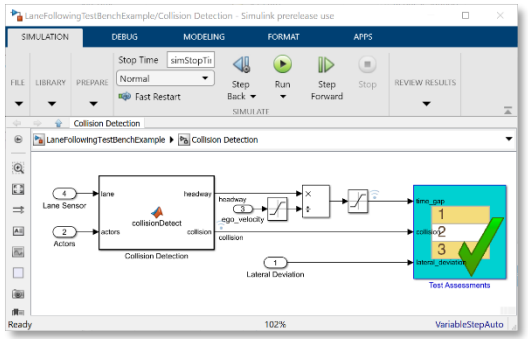
5. 本地测试

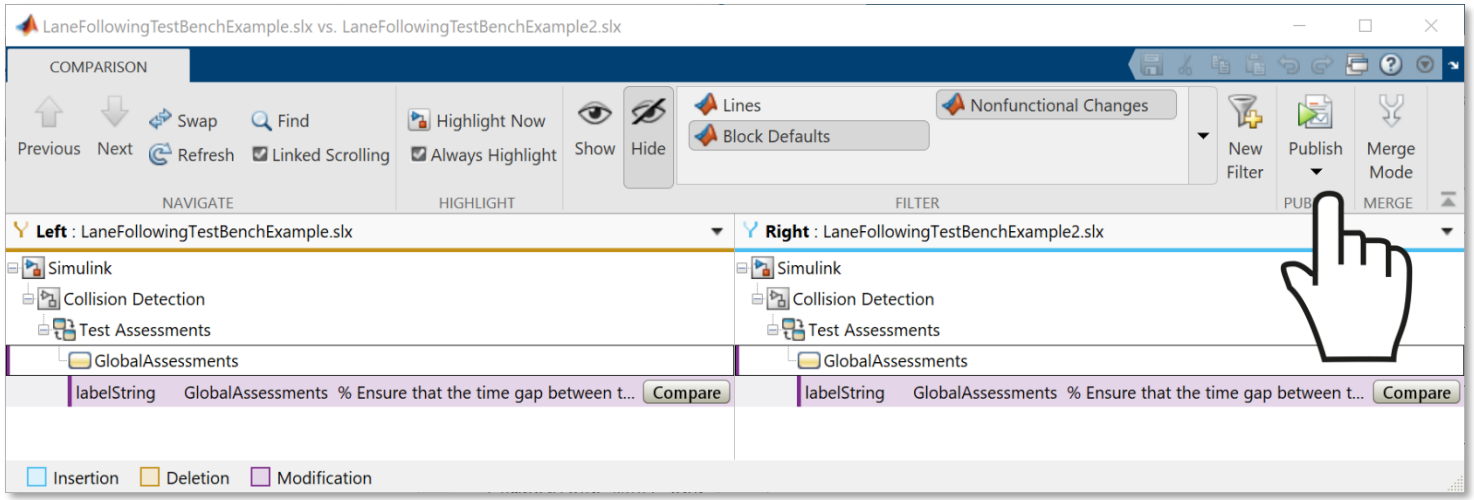

Test
Reproduce
Locally
Continuous
Integration
Build
Trigger
Verify
Test
Development
Develop
Developers &
Test Authors


Test Manager
TESTS
DATA INSPECTOR
FORMAT
Subplots
Clear Subplot
Legend
Data Cursors
Highlight in Model
Send to Figure
Update Baseline
Previous Failure
Next Failure
VIEWS
ZOOM & PAN
MEASURE & TRACE
SHARE
ANALYSIS
Test Browser
Results and Artifacts
Filter results by name or tags, e.g. tags: test
NAME
STATUS
Results: 2020-Mar-24 13:46:53
LaneFollowingTestScenarios
Scenarios
ACC_ISO_TargetDiscriminat
ACC_ISO_AutoRetargetTest
ACC_ISO_CurveTest
ACC_StopnGo
LFACC_DoubleCurve_Decel
LFACC_DoubleCurve_AutoF
LFACC_DoubleCurve_Stopn
LFACC_Curve_CutInOut
LFACC_Curve_CutInOut_To
Verify Statements
Test Assessments/...
PROPERTY
VALUE
LFACC_Curve_CutInOut_TooClose
Visualize
Test Assessments/GlobalAssessments:verify(duration(time_gap < 0.8, sec) < 5)
Fail
Pass
Untested
0
1
2
3
4
5
6
7
8
9
10
11
12

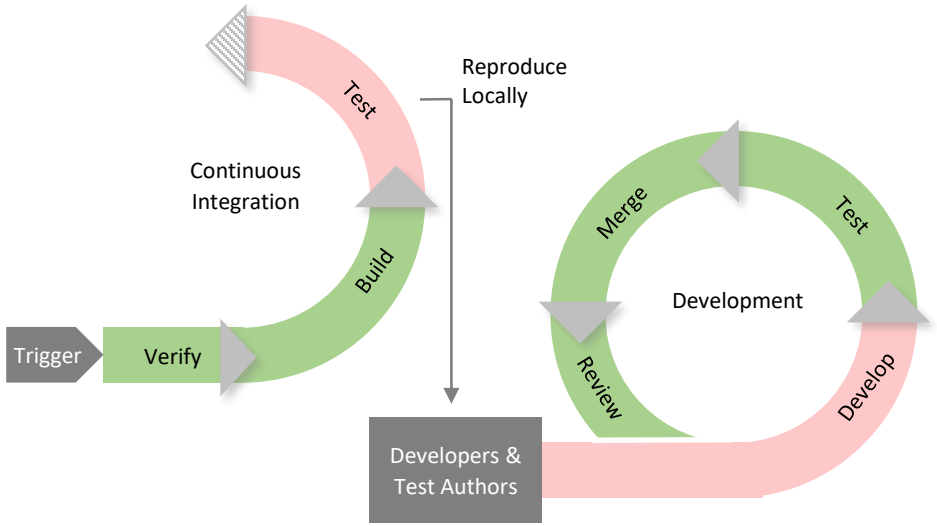
6. 合并

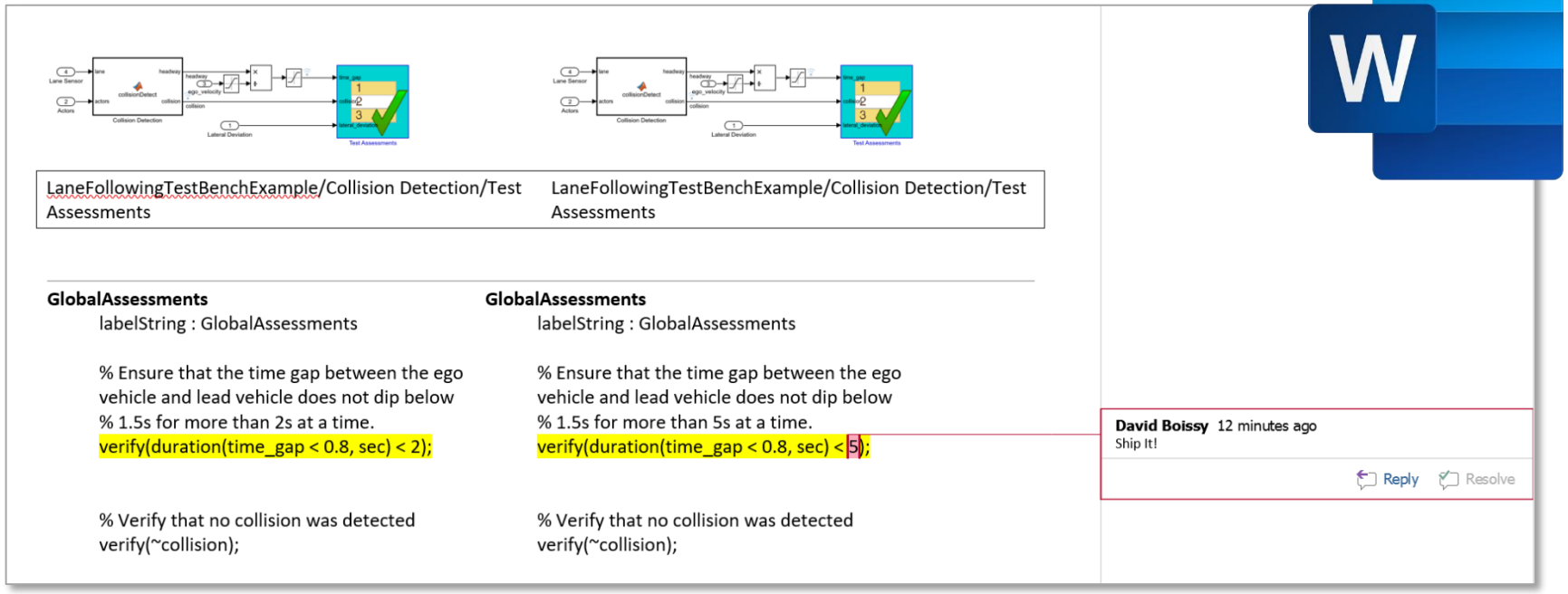

Test
Reproduce
Locally
Continuous
Integration
Build
Merge
Test
Development
Trigger
Verify
Develop
Developers &
Test Authors




LaneFollowingTestBenchExample.slx vs. LaneFollowingTestBenchExample2.slx
COMPARISON
Previous
Next
Swap
Refresh
Find
Linked Scrolling
Highlight Now
Always Highlight
Show
Hide
Lines
Block Defaults
Nonfunctional Changes
New
Filter
Publish
Merge
Mode
NAVIGATE
HIGHLIGHT
FILTER
MERGE
Left : LaneFollowingTestBenchExample.slx
Right : LaneFollowingTestBenchExample2.slx
Simulink
Collision Detection
Test Assessments
GlobalAssessments
labelString
GlobalAssessments
% Ensure that the time gap between t...
Compare
Insertion
Deletion
Modification

6. 审查





LaneFollowingTestBenchExample/Collision Detection/Test Assessments

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);

GlobalAssessments
labelString : GlobalAssessments

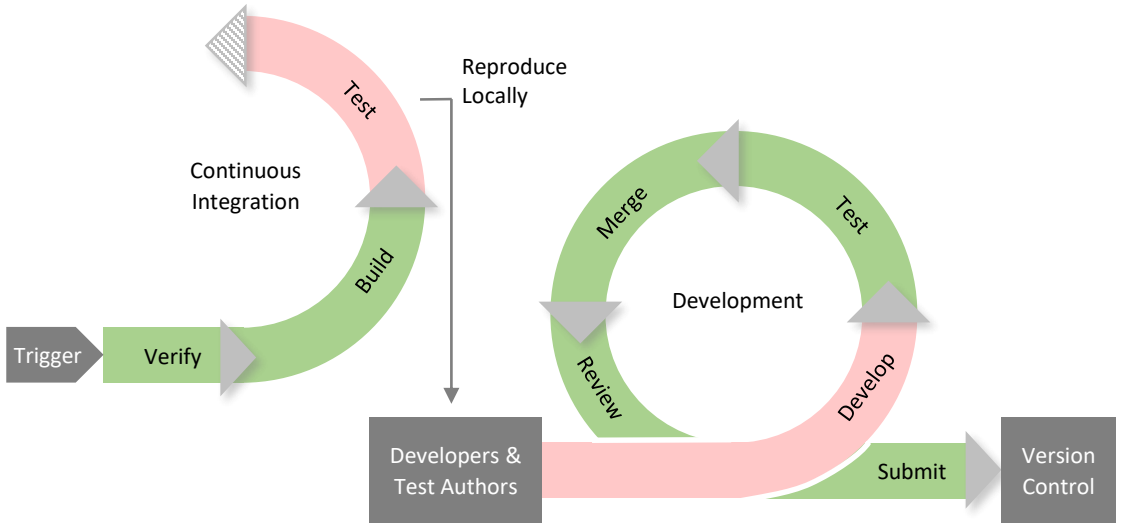
% Ensure that the time gap between the ego vehicle and lead vehicle does not dip below % 1.5s for more than 5s at a time.
verify(duration(time_gap < 0.8, sec) < 5);

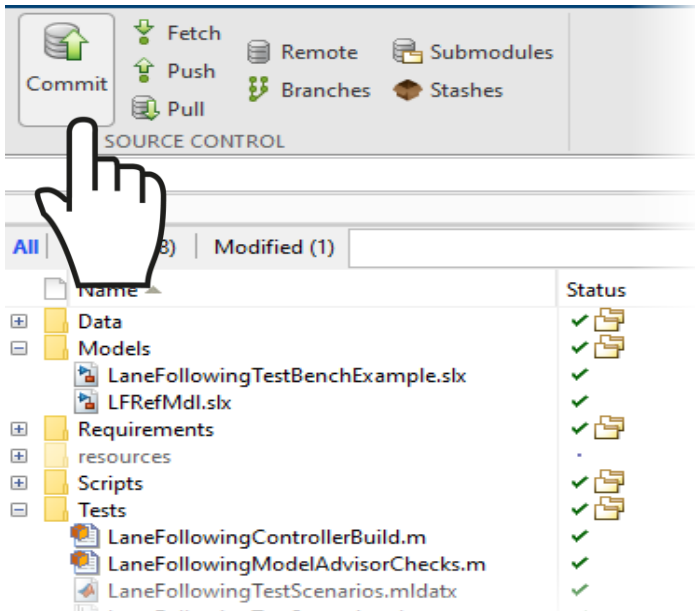
% Verify that no collision was detected
verify(~collision);

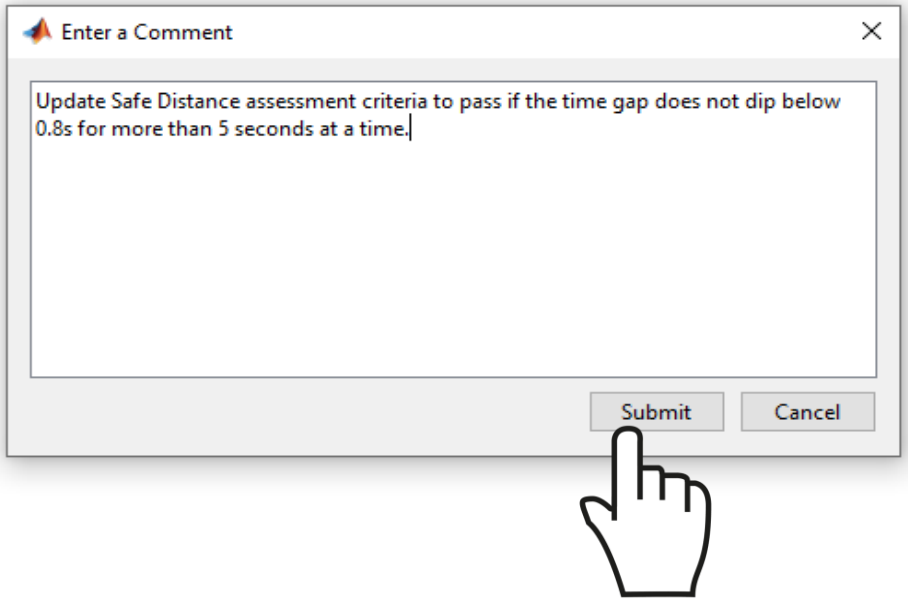
David Boissy 12 minutes ago
Ship It!

Reply Resolve

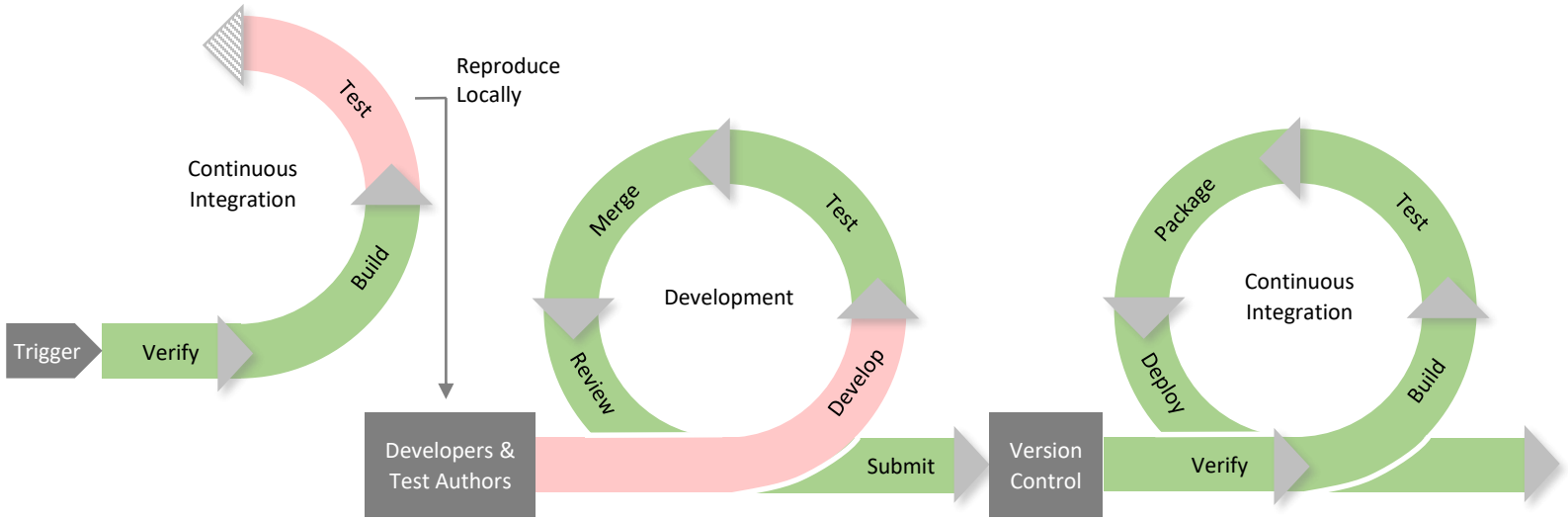
7. 提交


Reproduce
Locally
Test
Continuous
Integration
Build
Trigger
Verify
Merge
Test
Development
Review
Develop
Developers &
Test Authors
Submit
Version
Control


Commit
Fetch
Push
Pull
Remote
Branches
Submodules
Stashes
SOURCE CONTROL
All
Modified (1)
Name
Status
Data
Models
LaneFollowingTestBenchExample.slx
LFRefMdl.slx
Requirements
resources
Scripts
Tests
LaneFollowingControllerBuild.m
LaneFollowingModelAdvisorChecks.m
LaneFollowingTestScenarios.mldatx


Enter a Comment
Update Safe Distance assessment criteria to pass if the time gap does not dip below 0.8s for more than 5 seconds at a time.
Submit
Cancel

8. 验证，生成，测试




```
Finished: SUCCESS
```

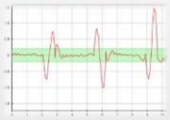
持续集成的成功触手可及

1

工具

Jenkins Plugin

MATLAB Unit

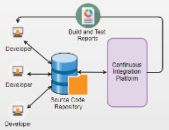


Simulink Test

2

文件资料

Technical Article



Documentation Hub

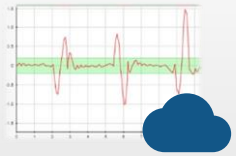
Solutions Page

3

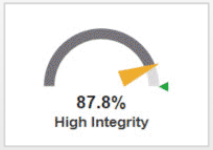
未来

Pipeline

Server Workflows



Test Results Online

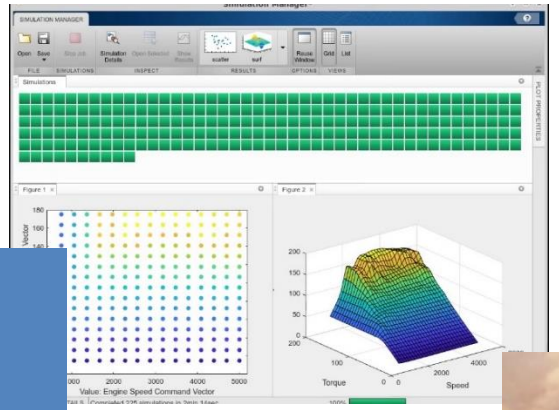


Dashboards

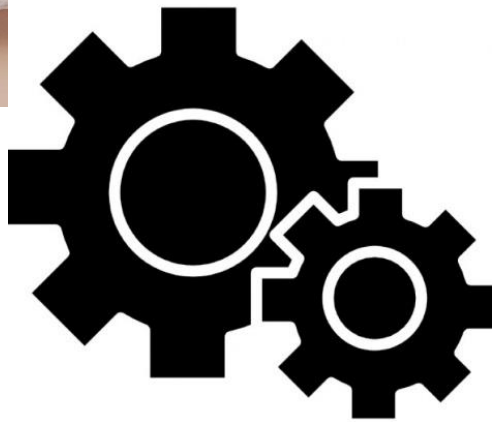
让我们回到塑造平台演变的广泛影响力上

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

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