

MATLAB EXPO 2017

基于模型设计中的验证，确认和测试

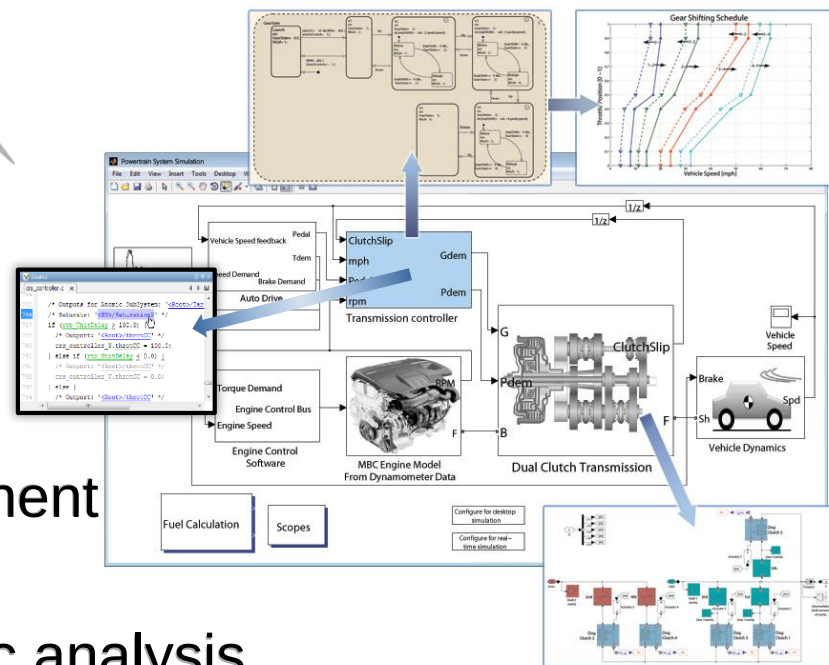
Wu Jing
Application Engineer
MathWorks China

连续的 测试 & 验证

Model & Code

System & Component

Dynamic testing & Static analysis



生产率

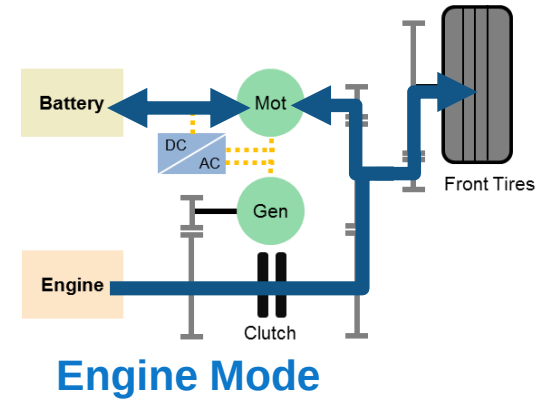
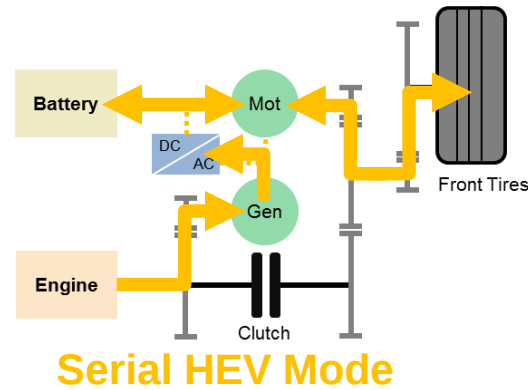
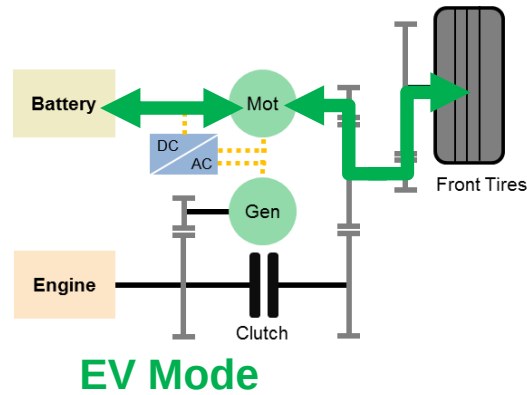
+

质量

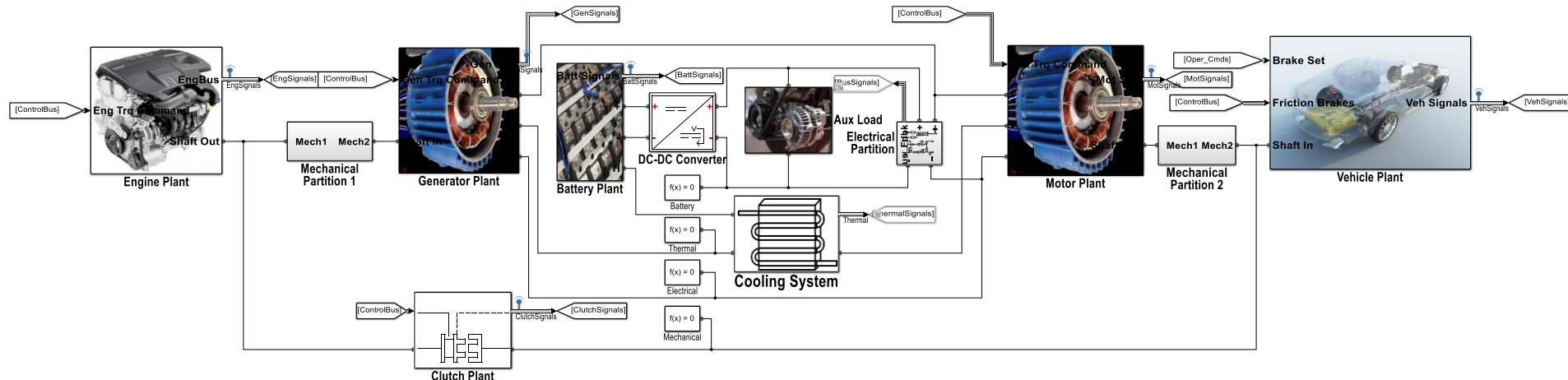
需要验证!

连续的

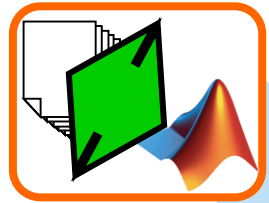
基于模型设计中的多模式混动车设计



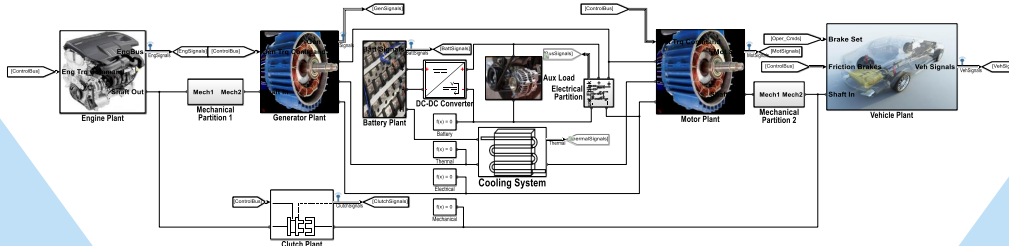
Higuchi, N., Sunaga, Y., Tanaka, M., Shimada, H.: Development of a New Two-Motor Plug-In Hybrid System, SAE 2013-01-1476 (2013)



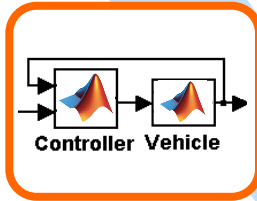
多模式混动车



Define
Requirements



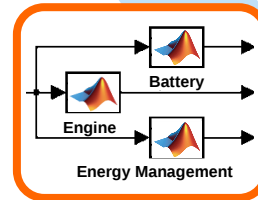
Complete
Integration & Test



System-Level
Specification



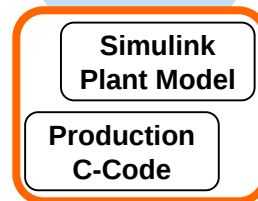
System-Level
Integration & Test



Subsystem
Design



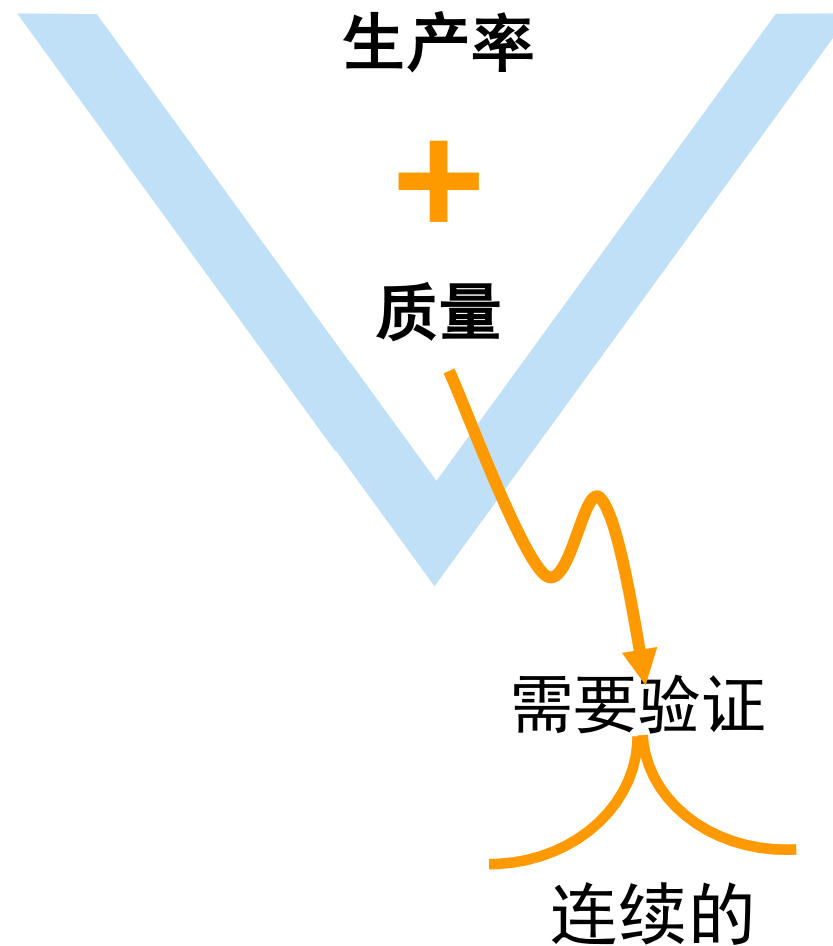
Subsystem
Integration & Test



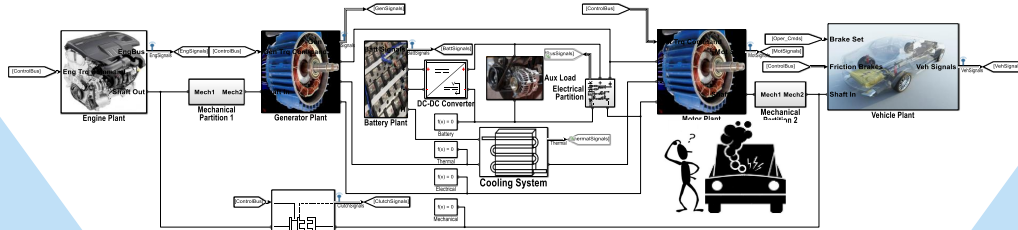
Subsystem
Implementation



连续的测试和验证框架



在仿真层面复现失效



**Confirm the problem
In the Lab/Desktop
Simulation**



Repeat

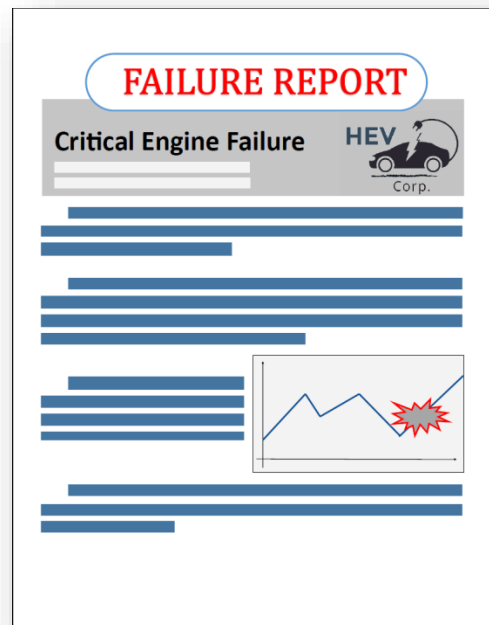
Slice

Fix

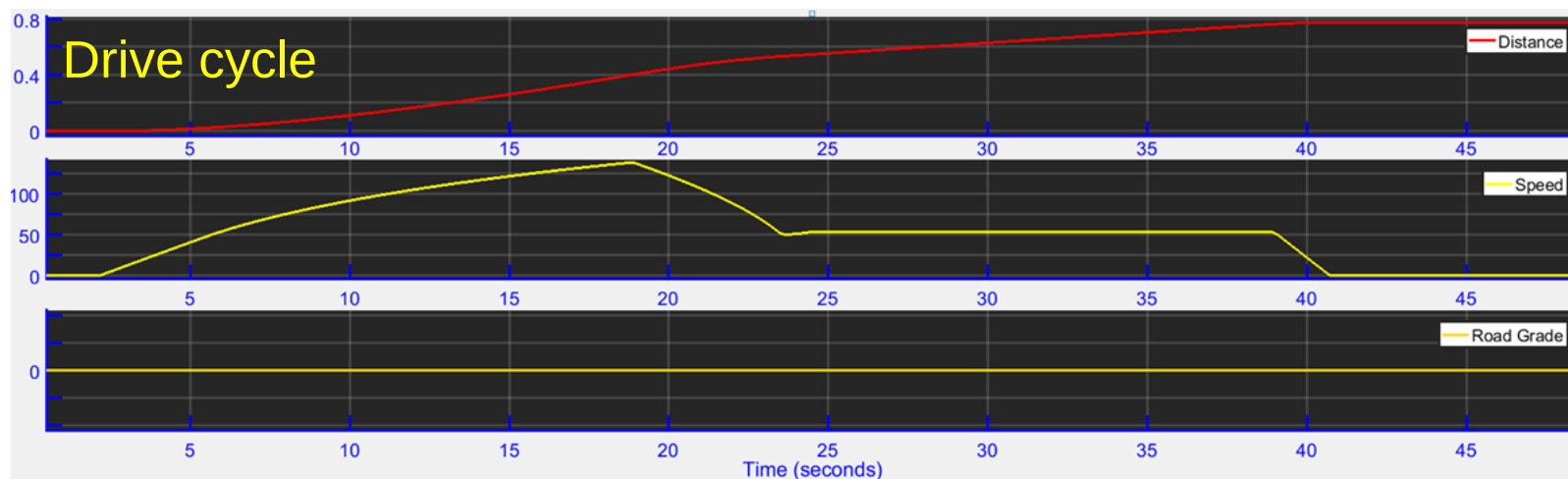
Check

Test

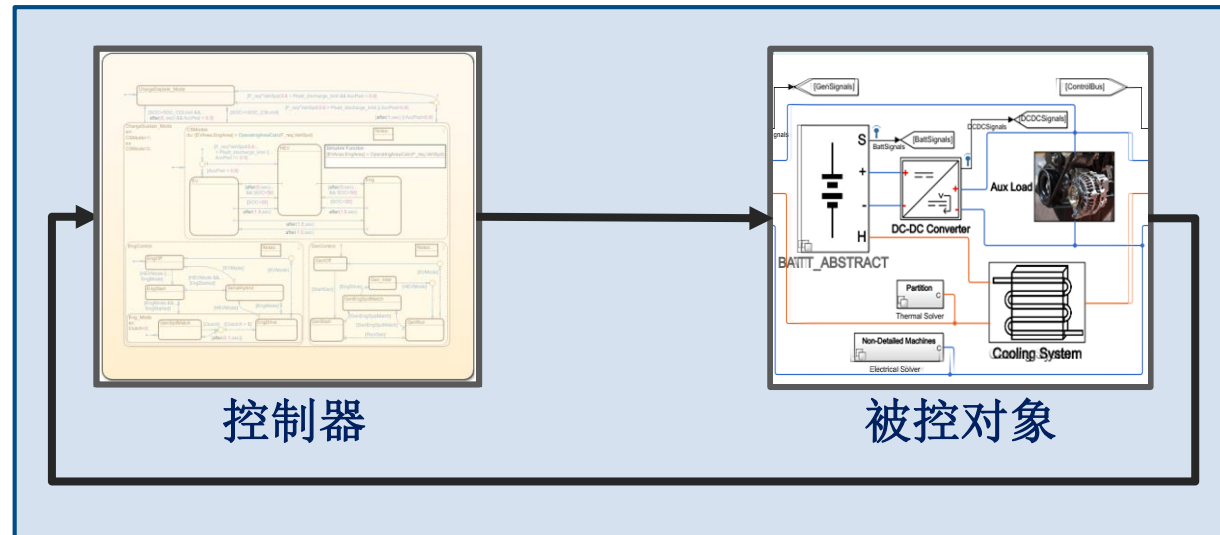
失效报告



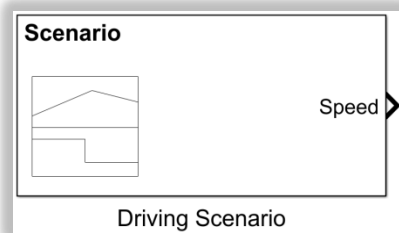
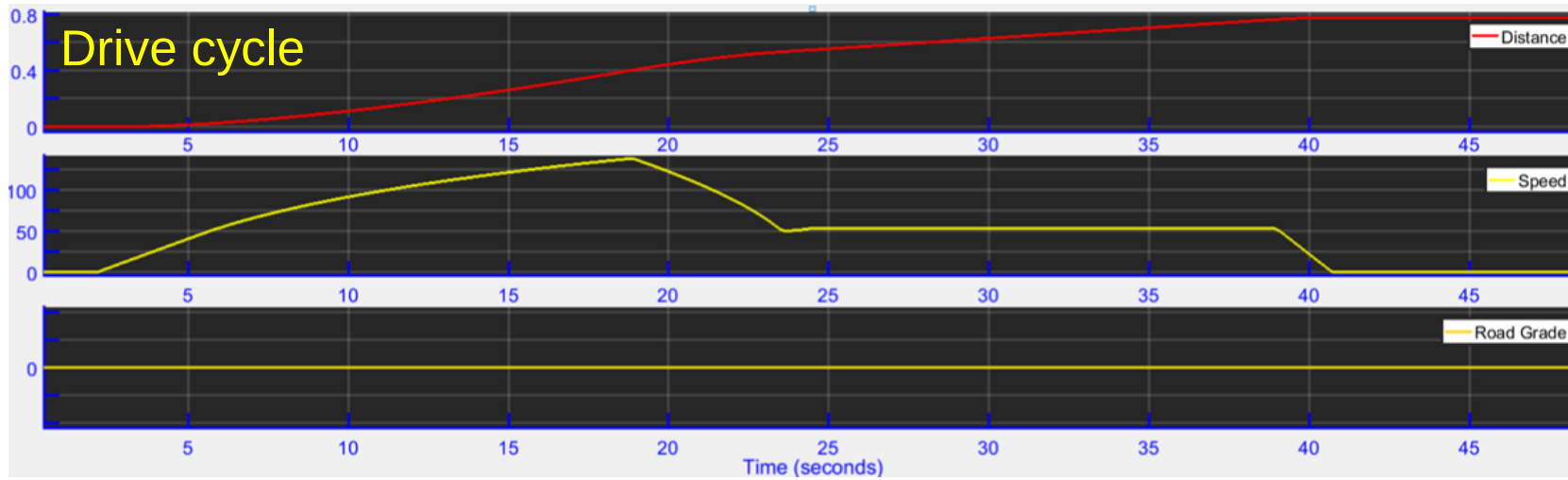
复现失效



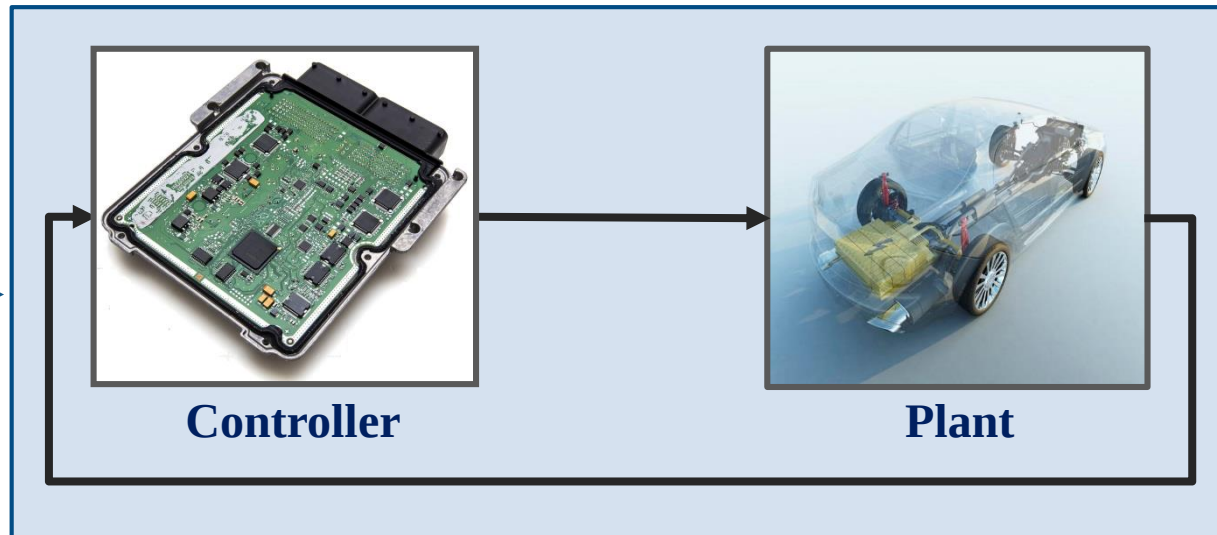
仿真环境



测试建模



Speed



测试建模



Safety Property

Engine RPM must remain within operating bounds limits



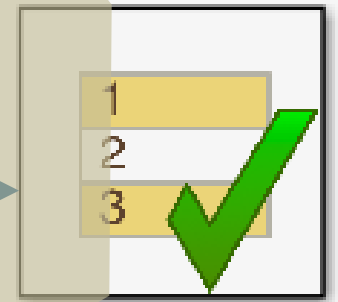
Symbols

Input

1. EngSignals
2. BattSignals
3. GenSignals
4. VehSignals
5. ClutchSignals
6. MotSignals

Step

Assessment

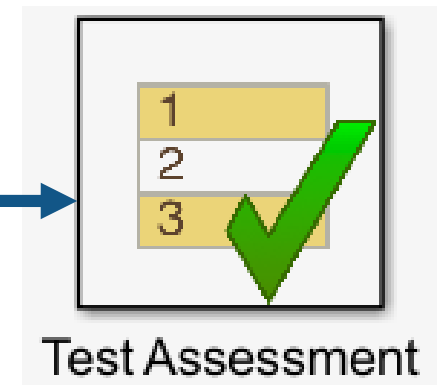
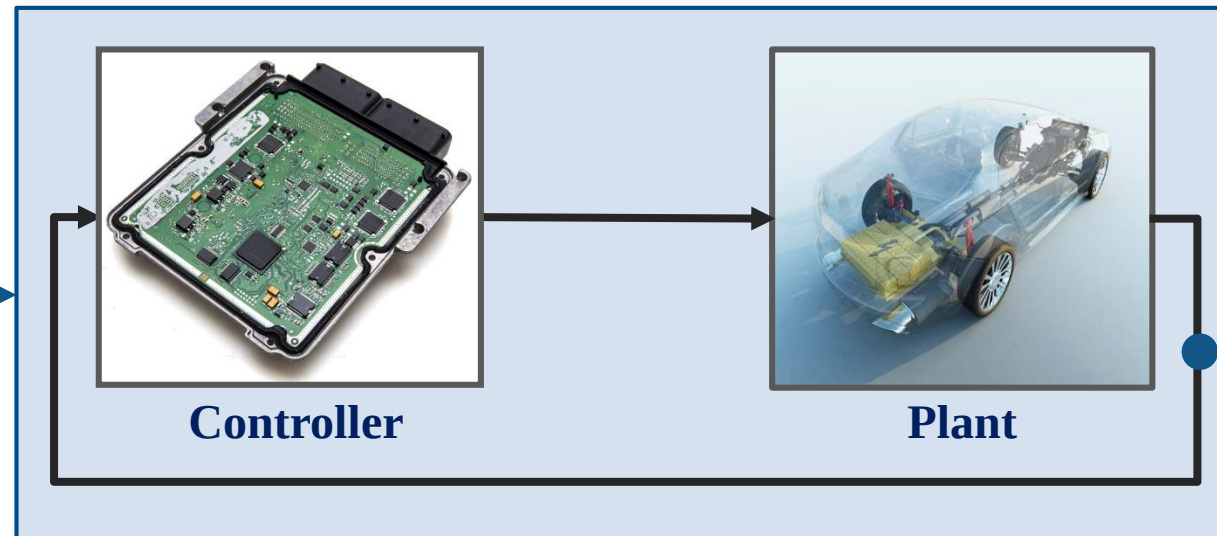
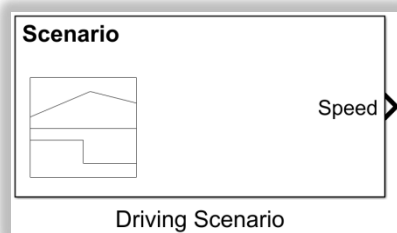
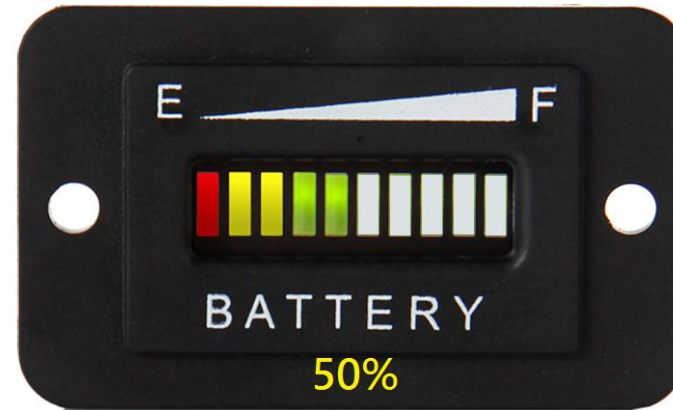


Test Assessment

电池的充电状态

Initial state of charge?

Sweep from 100% to 50%



TESTS

New

Open

Save

Cut

Copy

Paste

Delete

Run

Stop

Parallel

Report

Visualize

Highlight in Model

Import

Export

Help

FILEEDITRUNRESULTSRESOURCES

Test BrowserResults and Artifacts

New Test Suite 1 x

Filter tests by name or tags, e.g.:

HEVM_Test*

New Test Suite 1

PROPERTY	VALUE
Name	New Test S...
Location	C:\work\MabDe...
Hierarchy	HEVM_Test » N...
Enabled	☒
Record Coverage	☐
Tags	type comma or spe

New Test Suite 1

HEVM_Test » New Test Suite 1

Test Suite

TAGS

DESCRIPTION

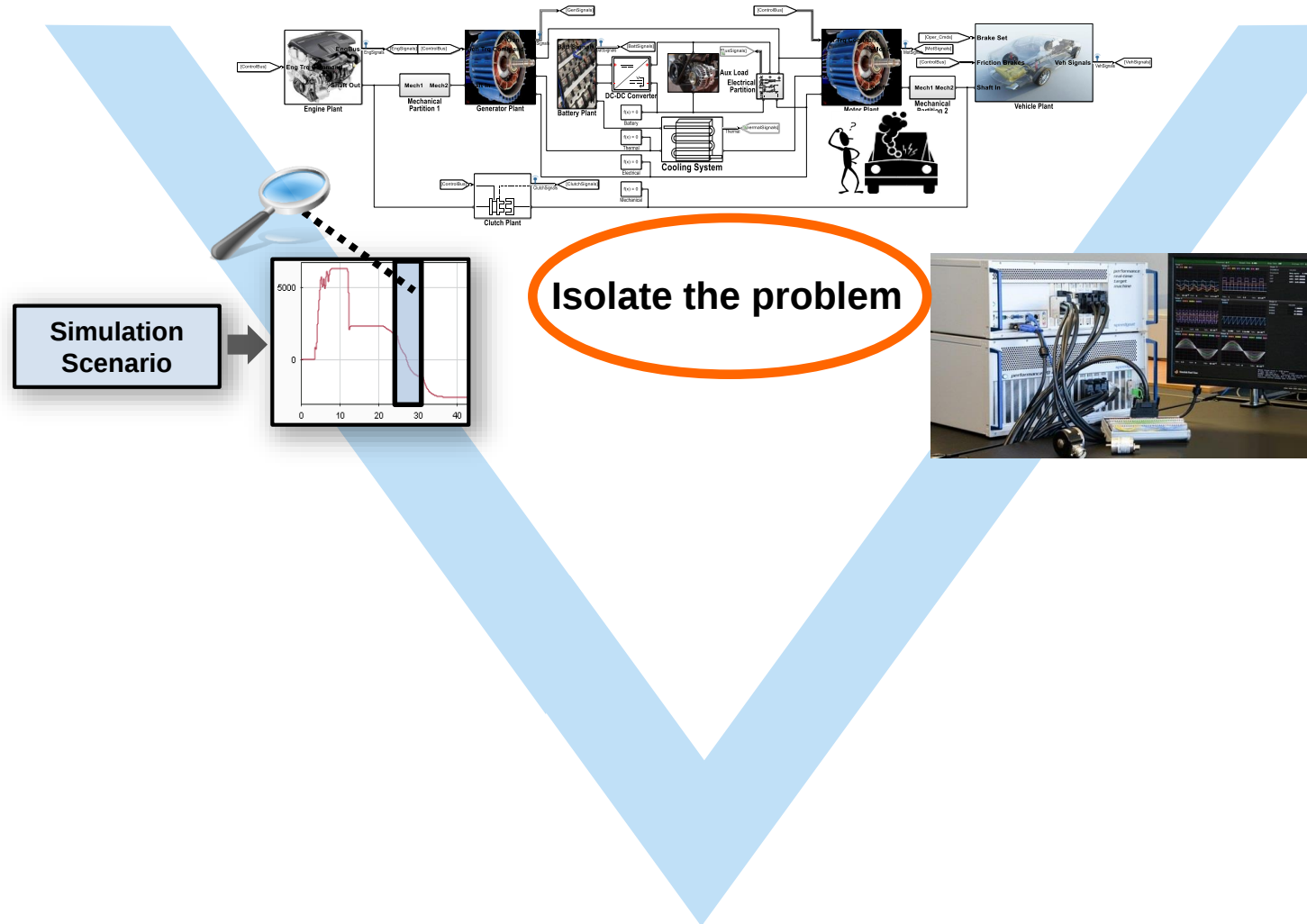
REQUIREMENTS

CALLBACKS?

COVERAGE SETTINGS?

Enabled

模型裁剪: 隔离有问题的设计

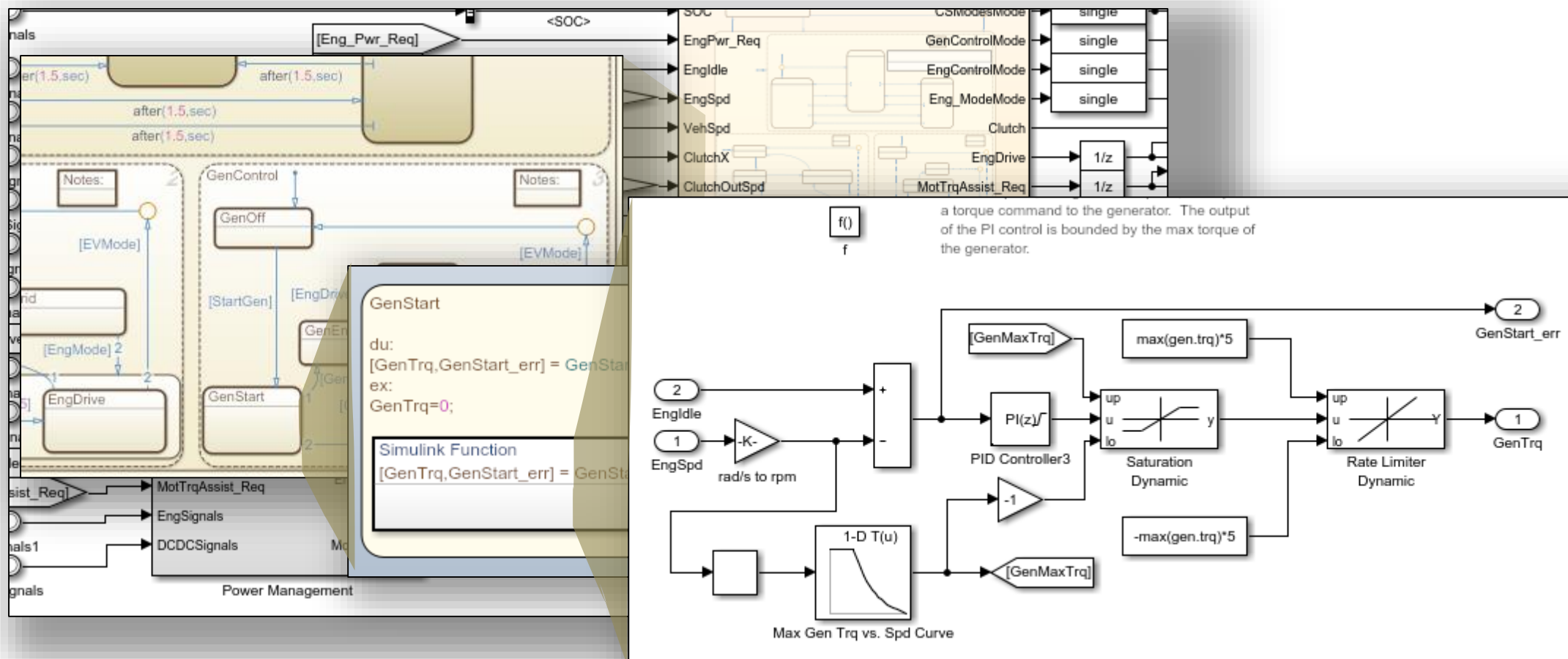


理解系统行为时遇到的挑战

- ## ■ 复杂的被控对象

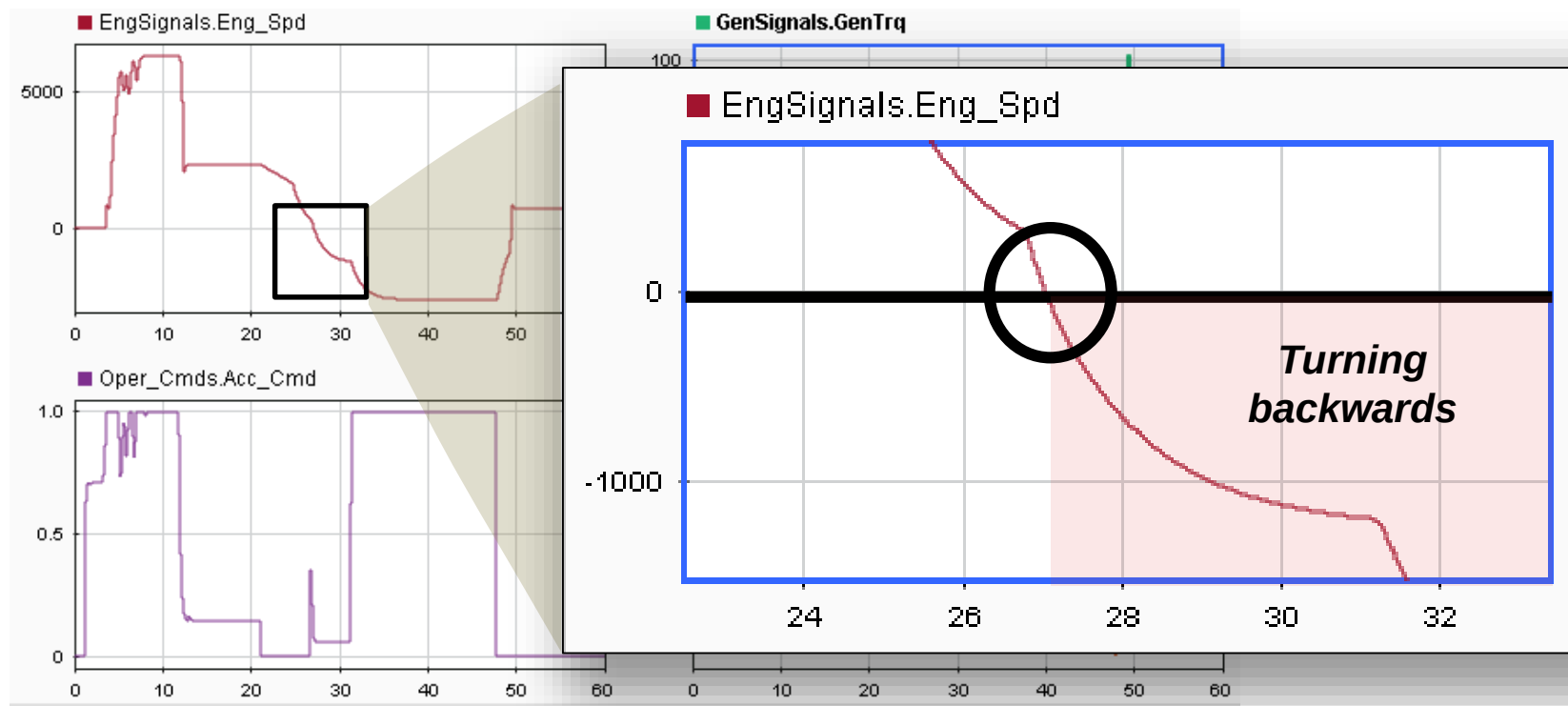
理解系统行为时遇到的挑战

- 复杂的被控对象
- 复杂的控制器

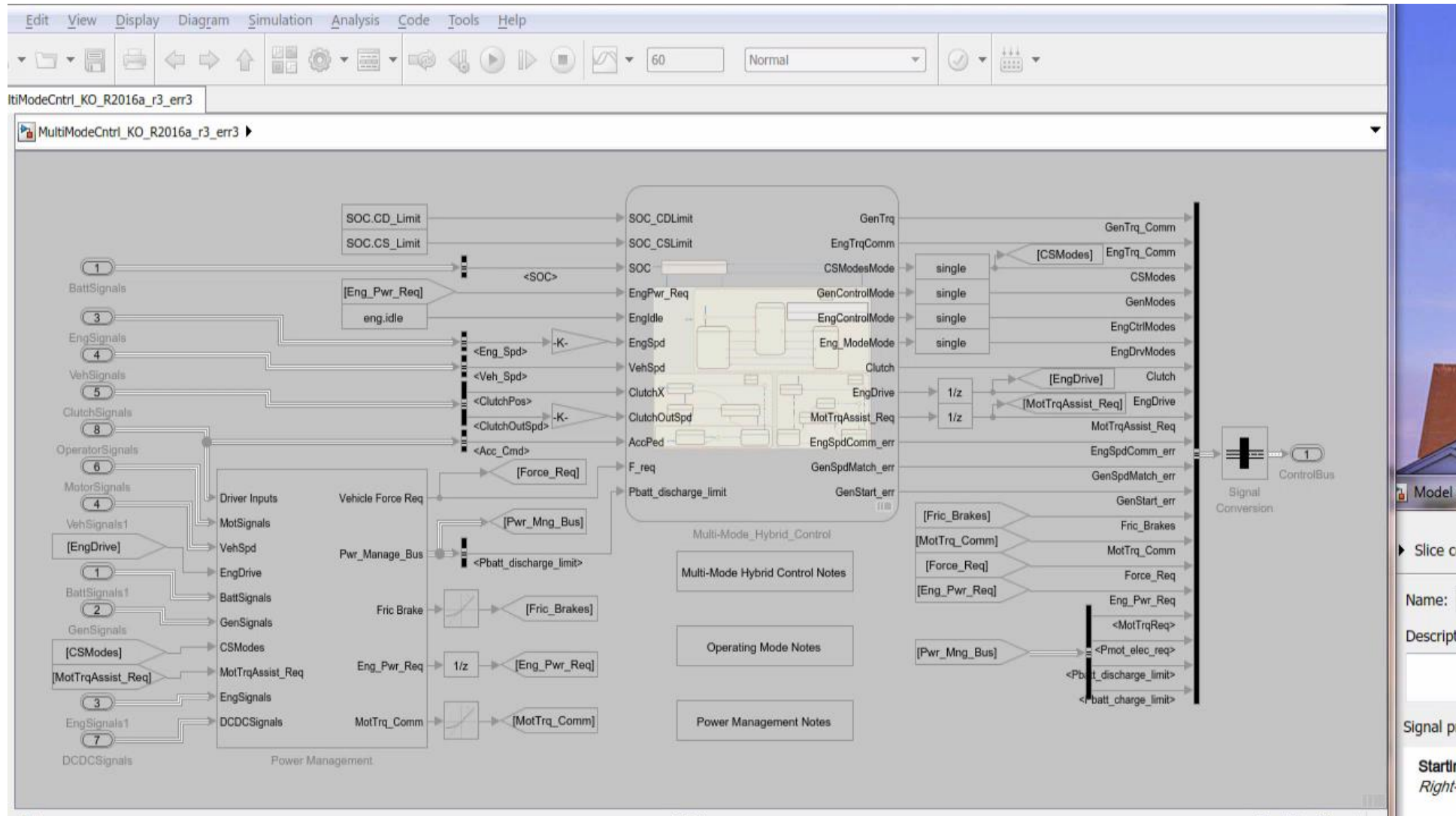


理解系统行为时遇到的挑战

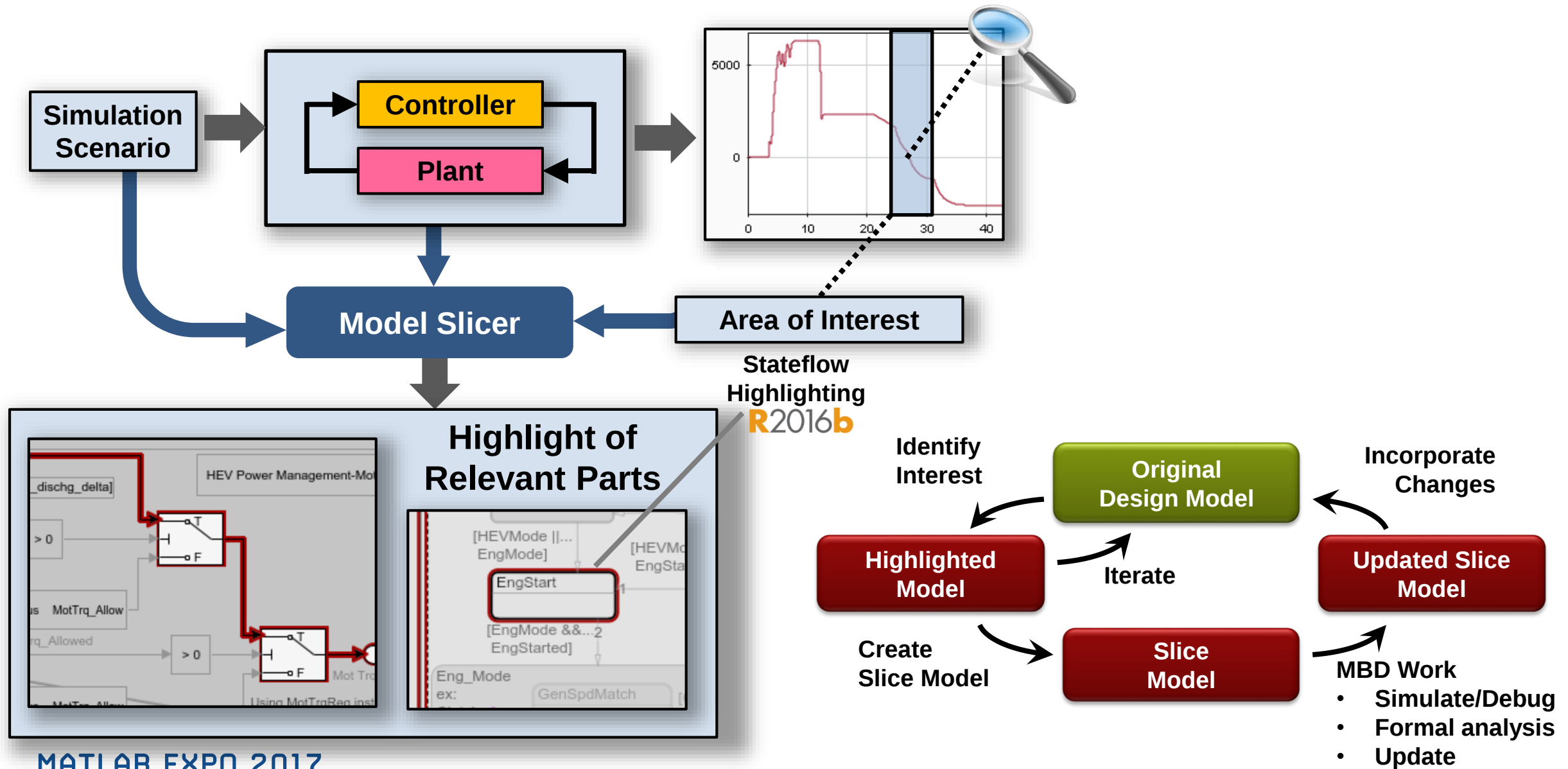
- 复杂的被控对象
- 复杂的控制器
- 复杂的动态



模型裁剪

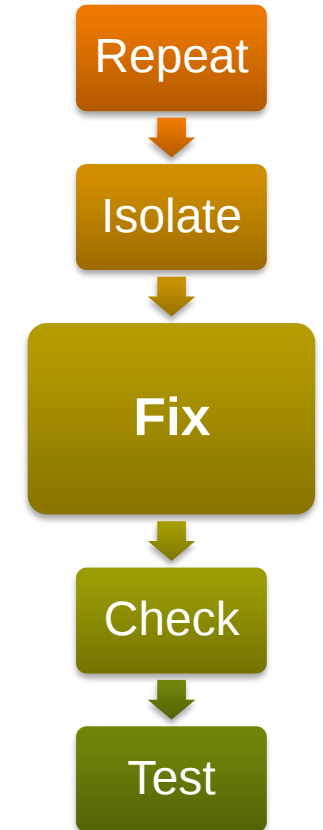
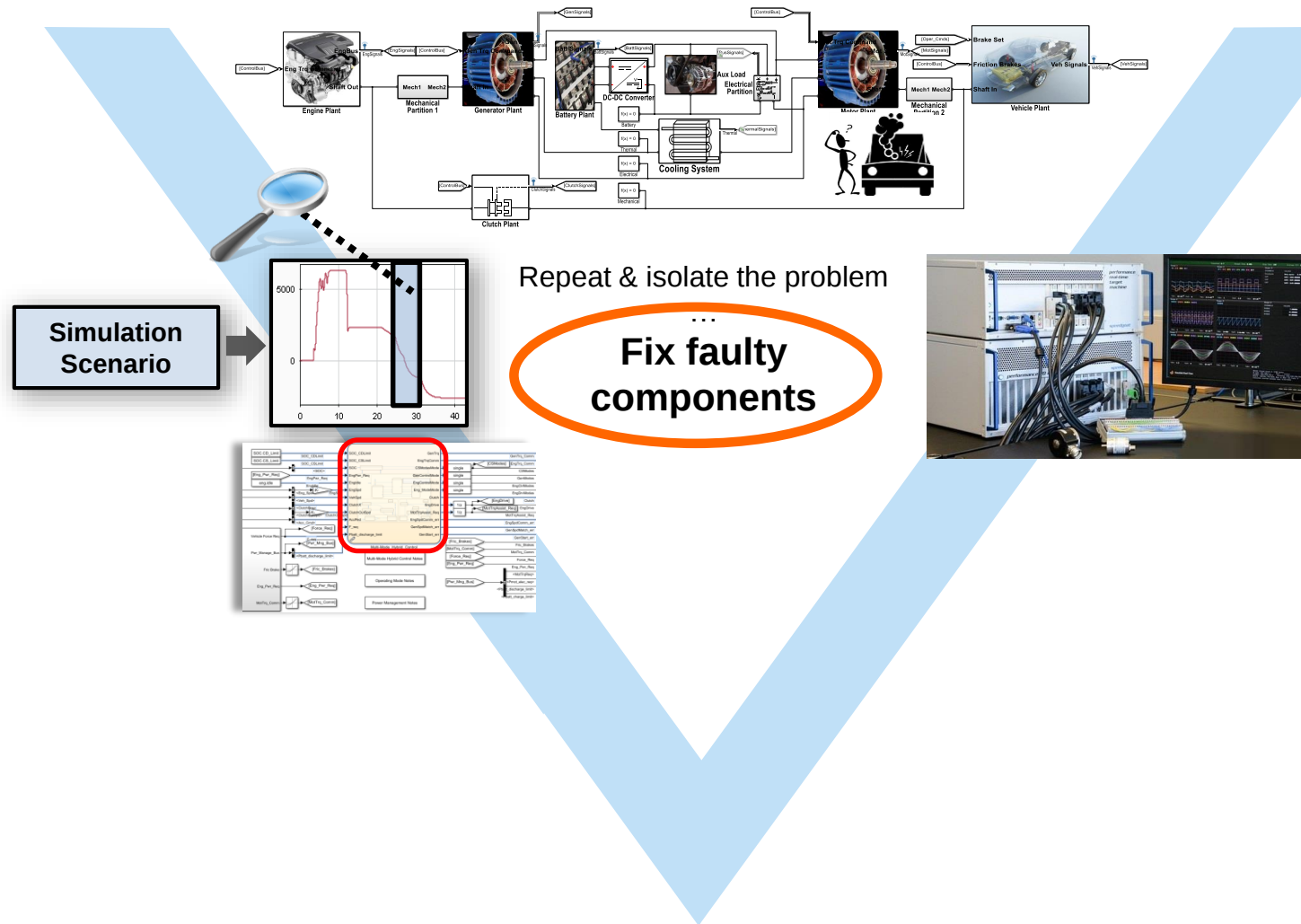


通过Model Slicer隔离有问题的设计



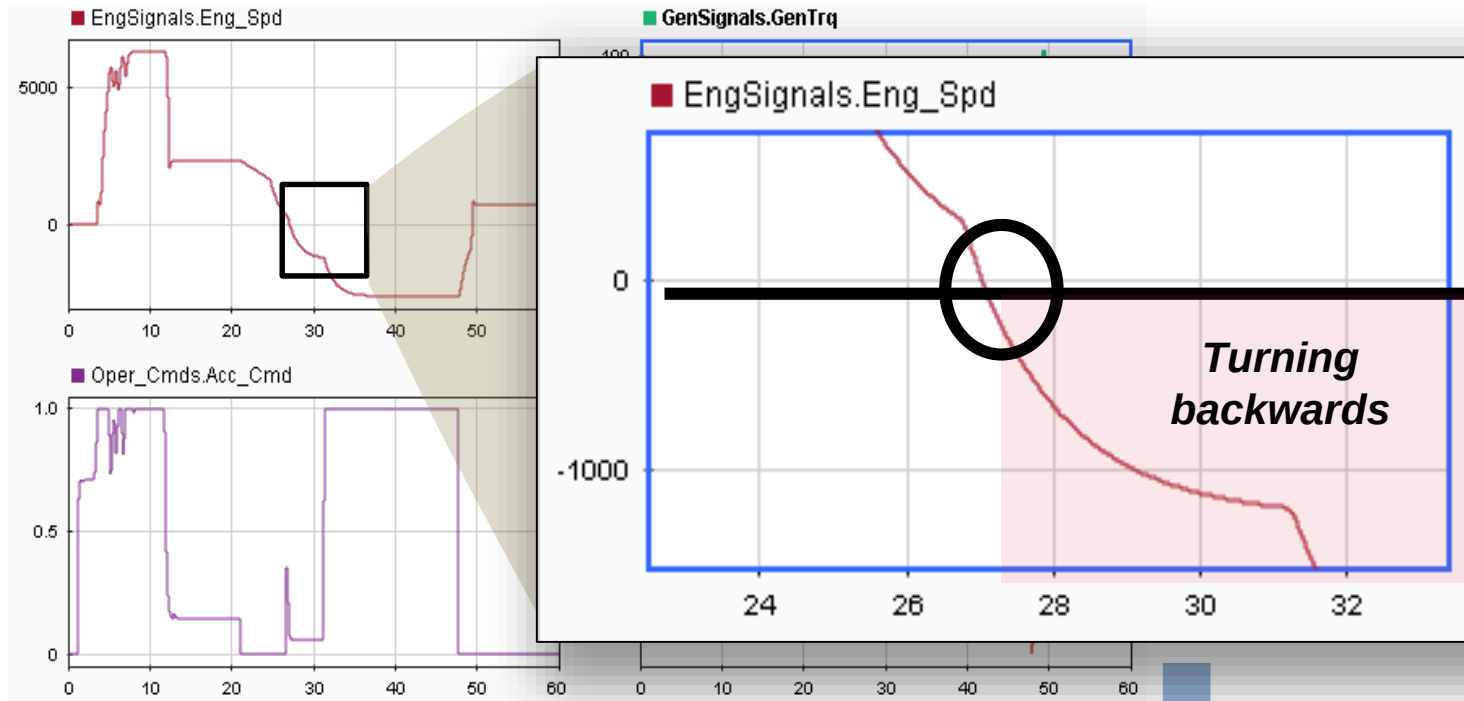
MATLAB EXPO 2017

修复错误与单元测试

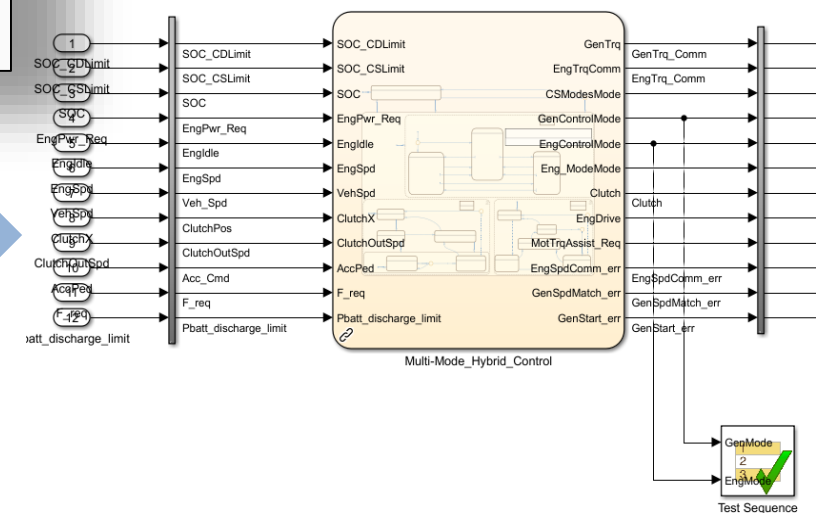


状态同步错误

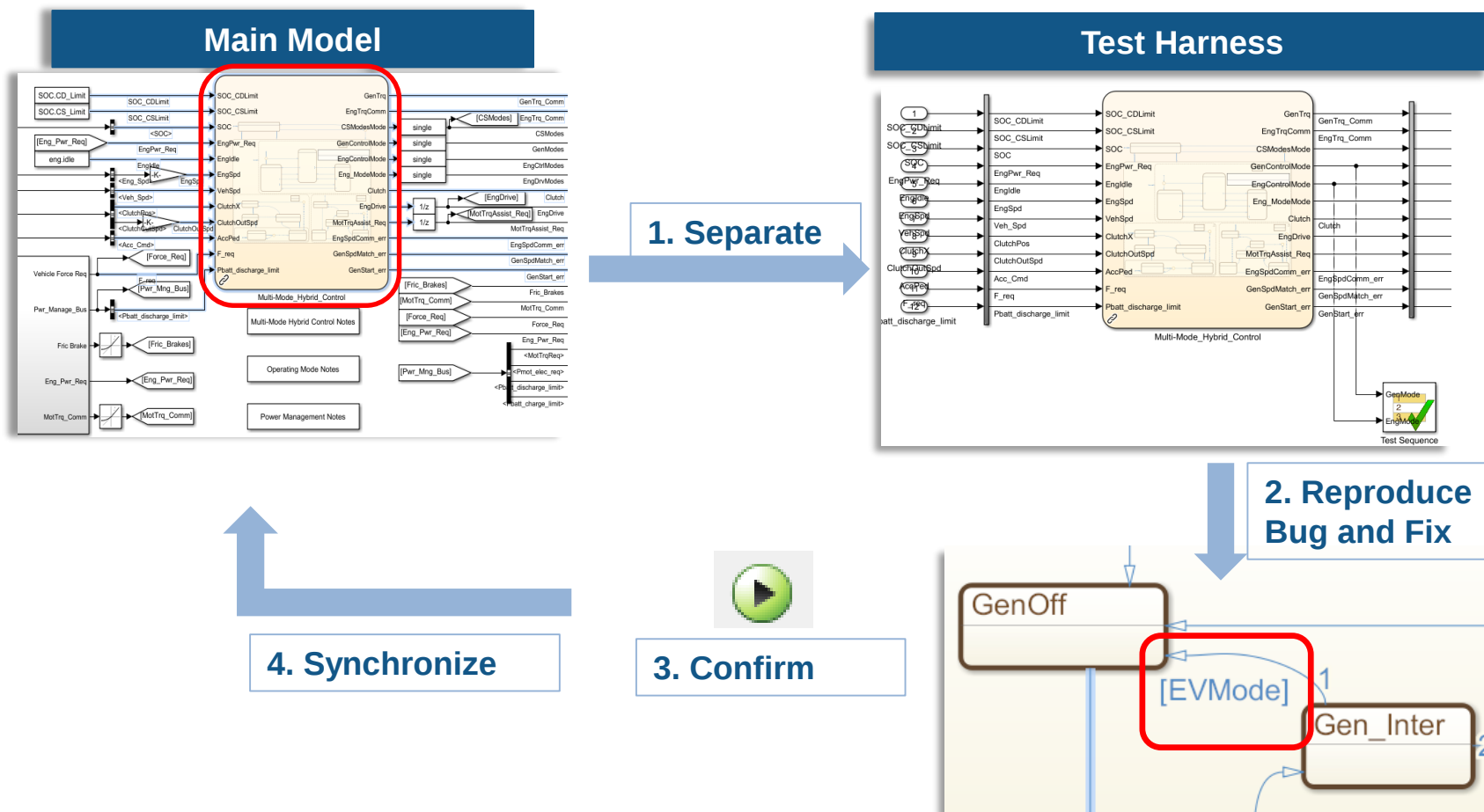
Engine Turning Backwards

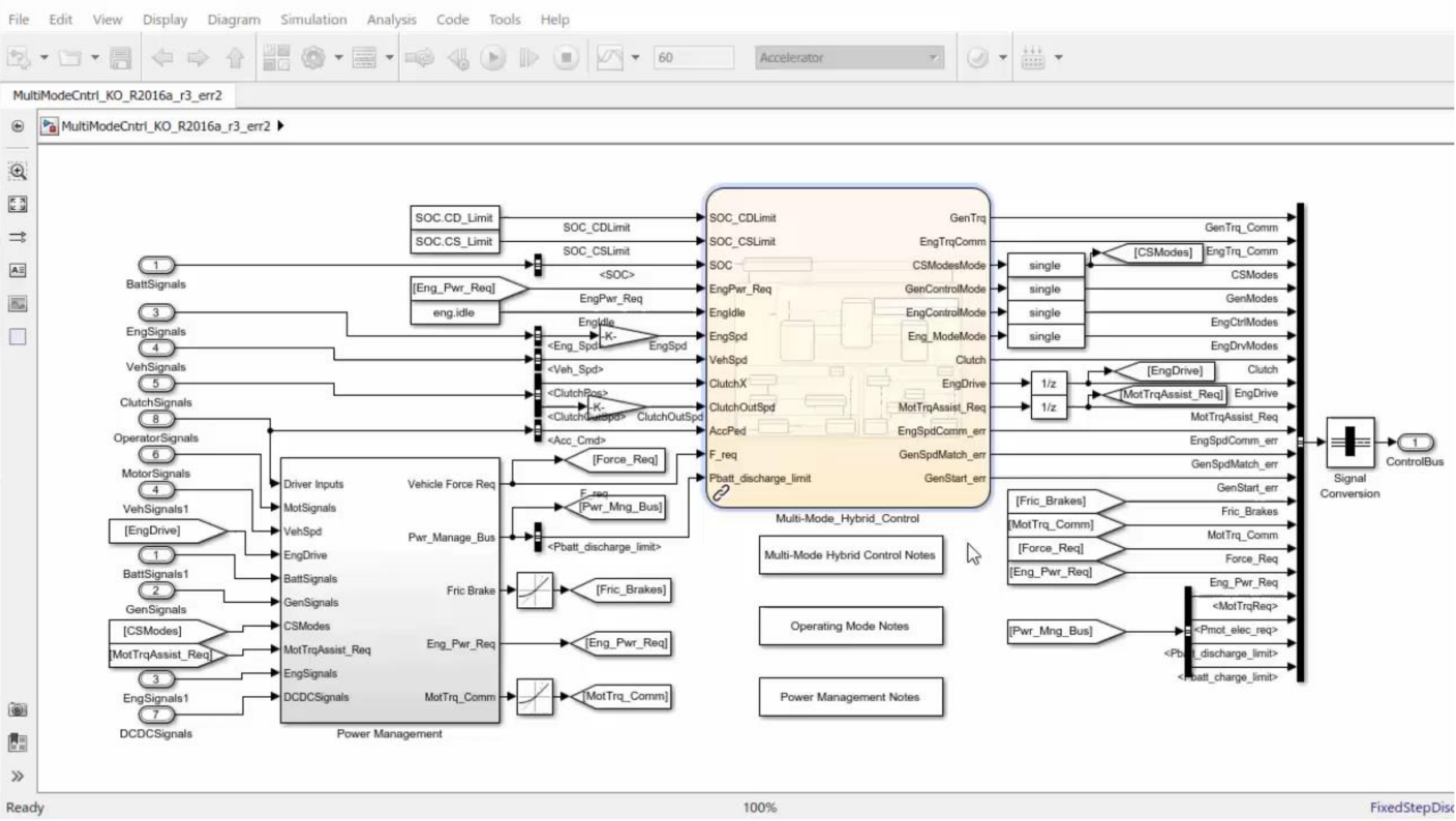


Isolate and Fix



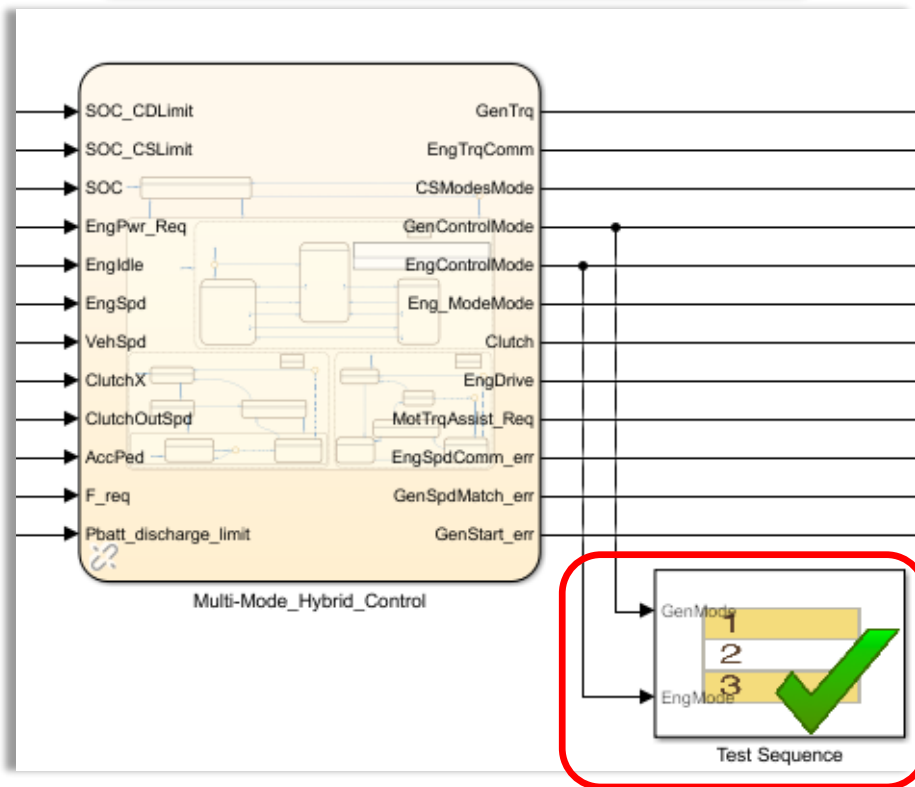
单元测试流程





In-model 验证

Isolate Component in Test Harness



Verification Result streamed to Data Inspector

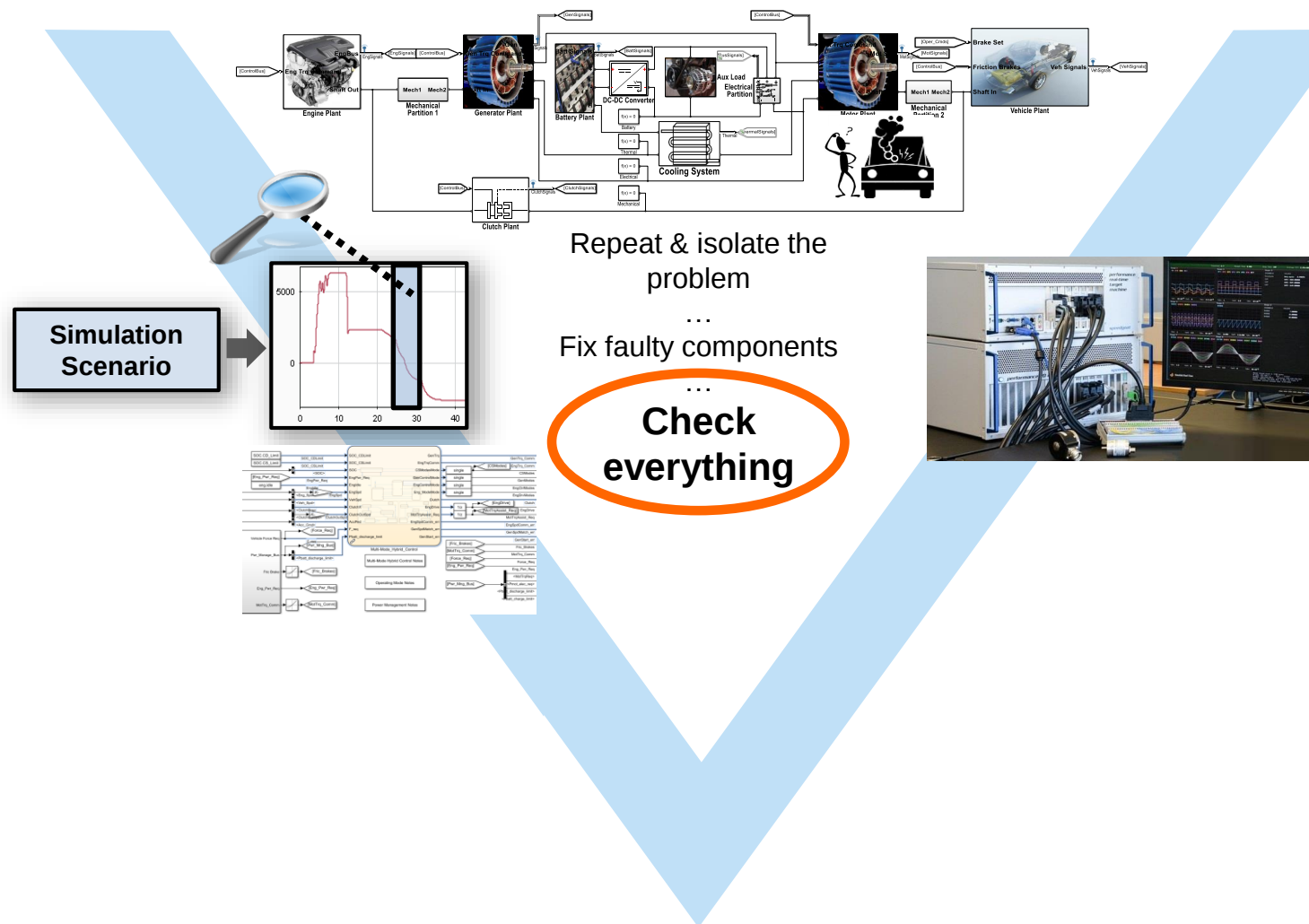


In-model Verification with *verify* keyword

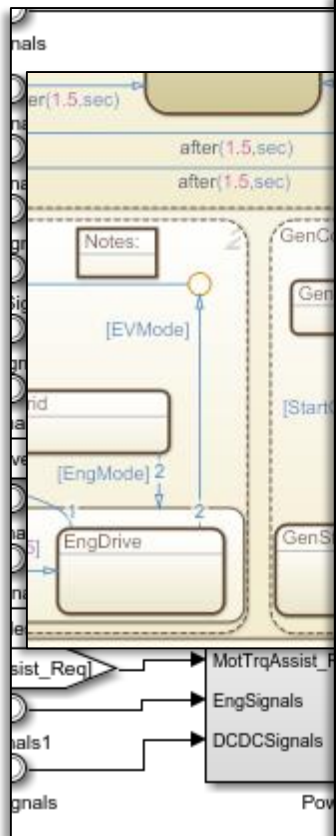
CheckOperatingModes

```
if EngMode == Start
    verify(GenMode ~= Run);
end
```

进一步检查设计错误



利用Static Checking进行鲁棒设计



Static Analysis Capabilities

Simulink Design Verifier

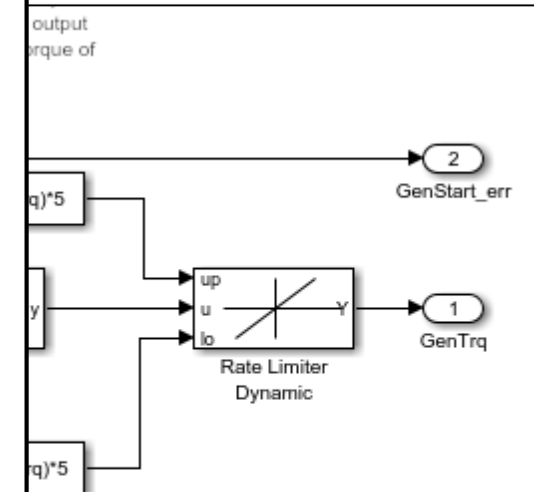
Property
Proving

Design Error
Detection

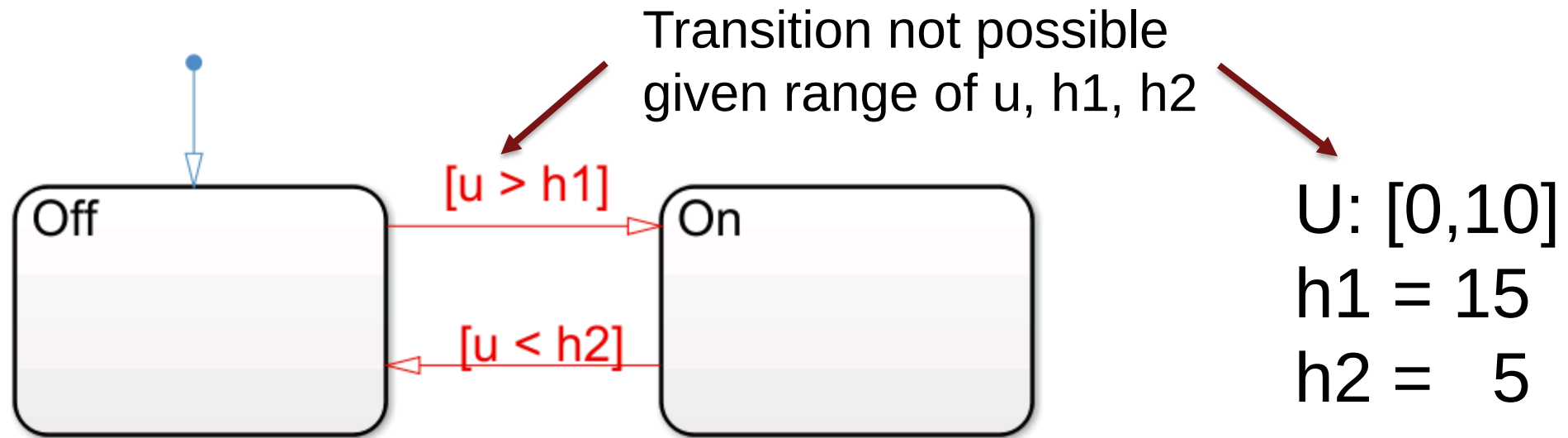
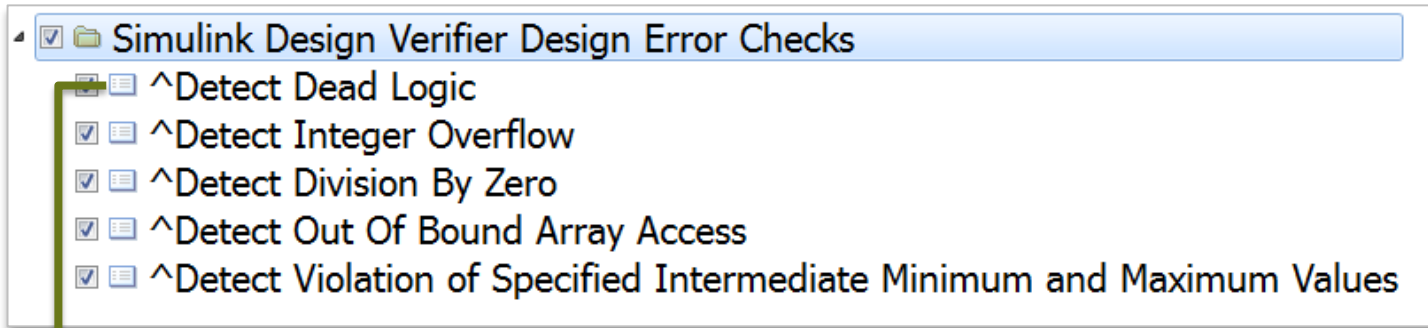
Test
Generation

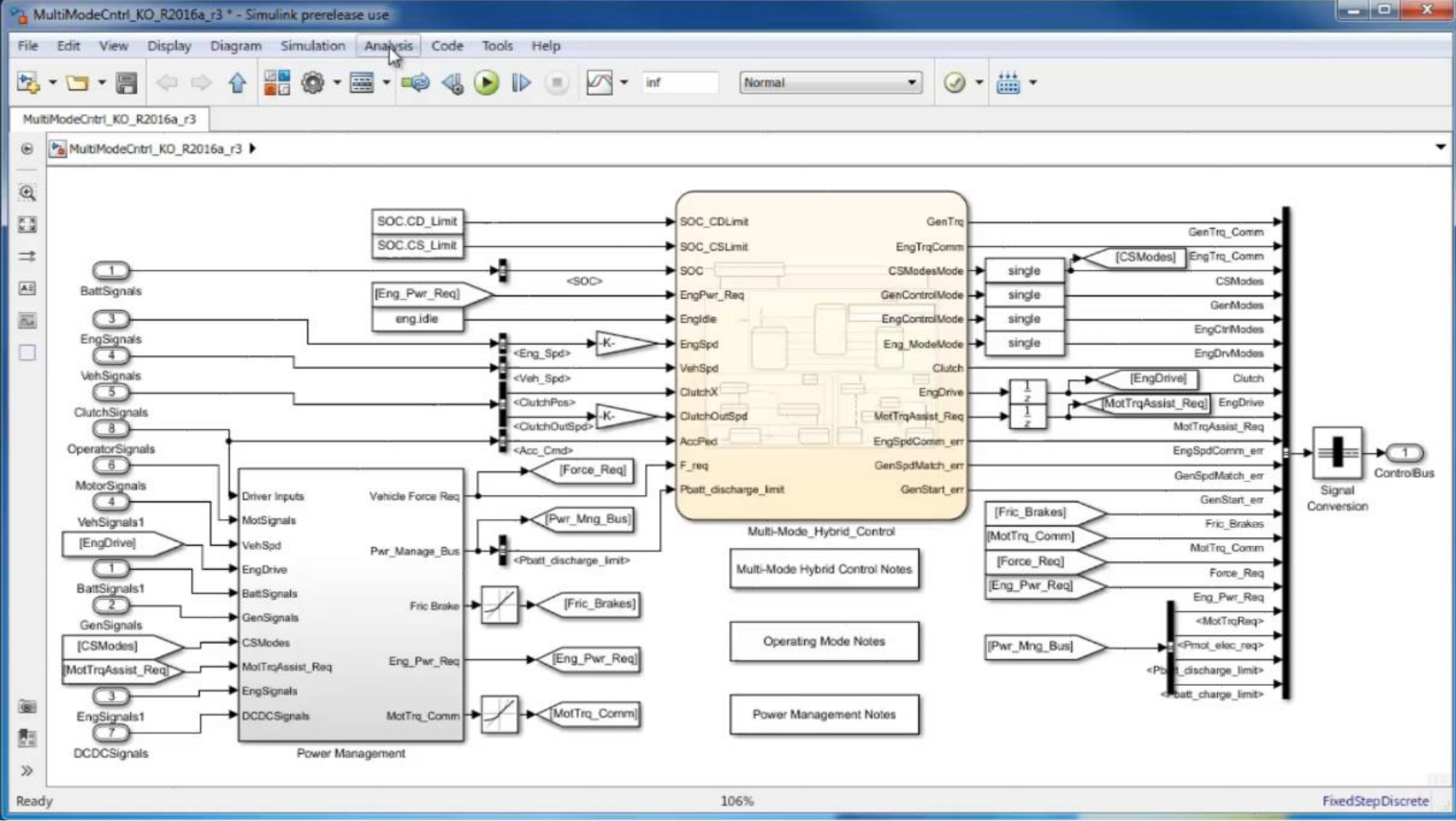
Model Advisor

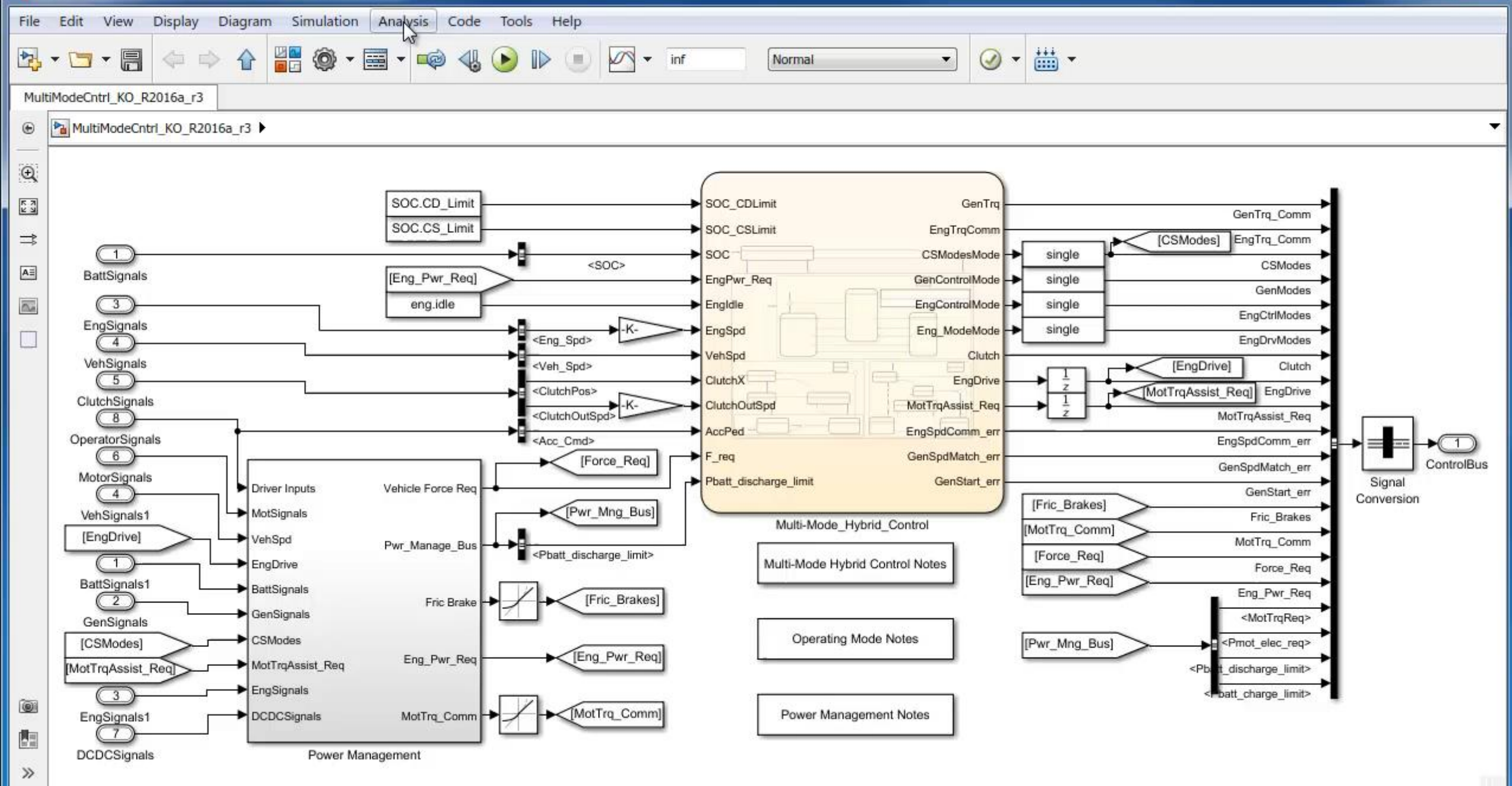
Model Metrics

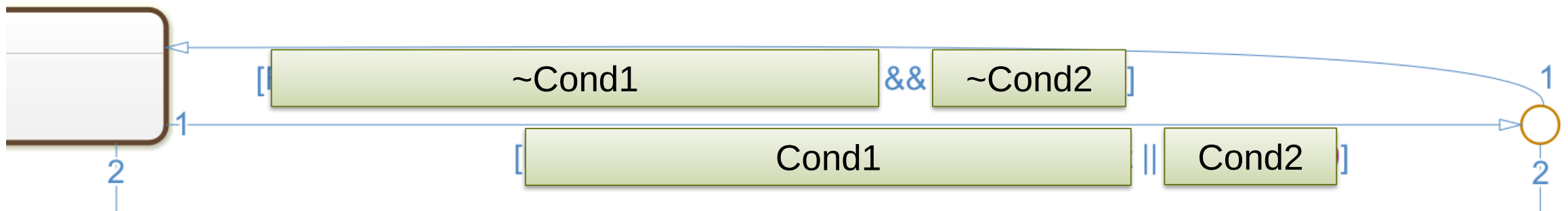


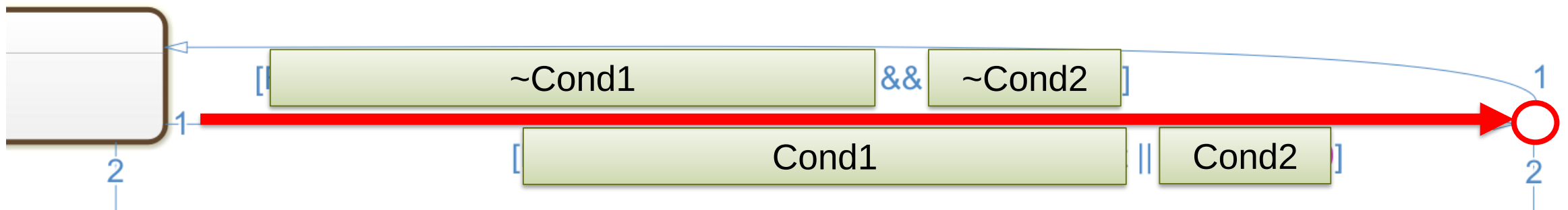
利用Design Error Detection发现隐藏问题

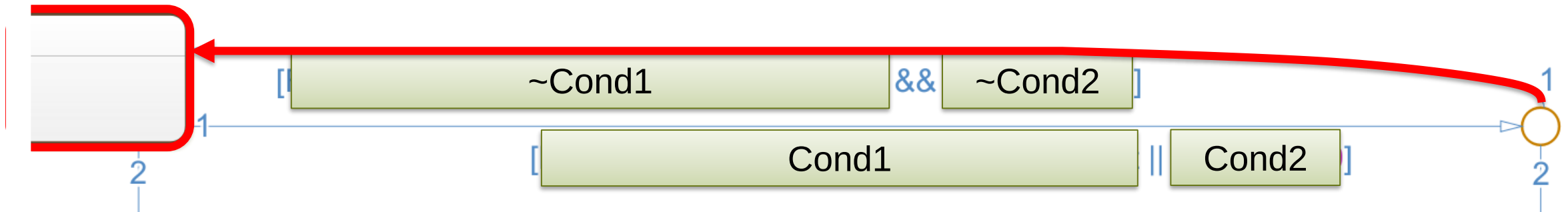


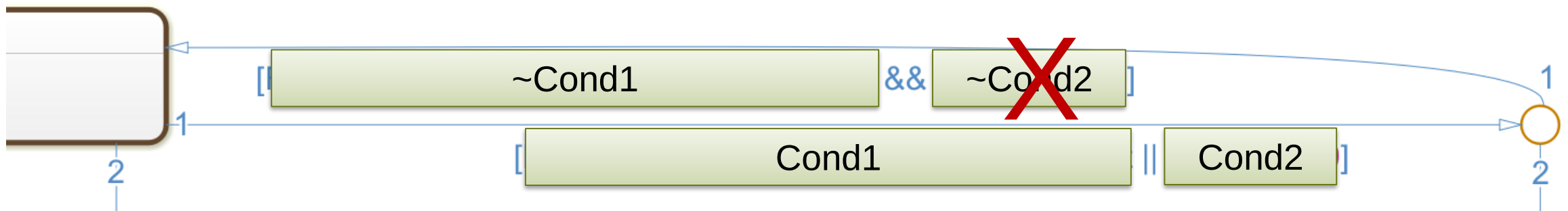












Simulink Design Verifier Results Inspector

[Close results](#)

Design error detection completed normally.
30/473 objectives are dead logic.

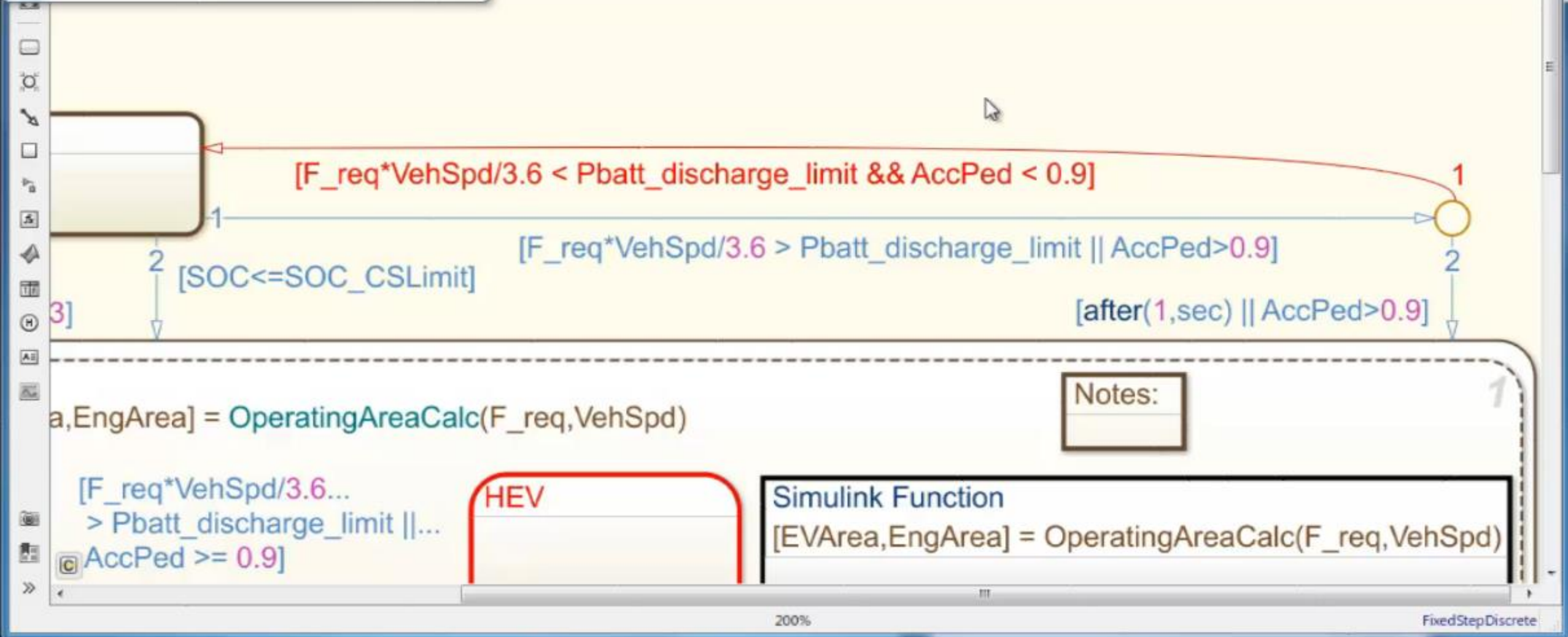
Results:

- Detailed analysis report: [\(HTML\)](#) [\(PDF\)](#)

Control * - Simulink prerelease use

Tools Help

    inf Normal  



[Close results](#)

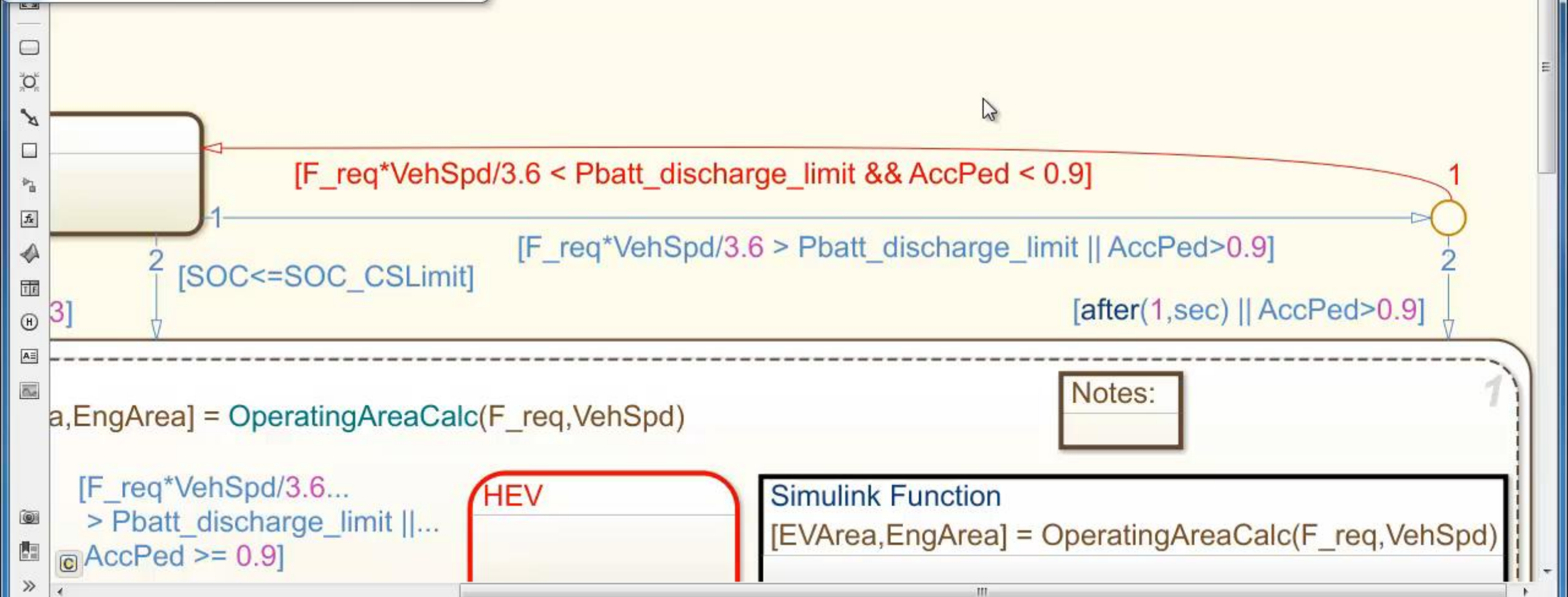
Design error detection completed normally.
30/473 objectives are dead logic.

Results:

- Detailed analysis report: [\(HTML\)](#) [\(PDF\)](#)

Tools Help

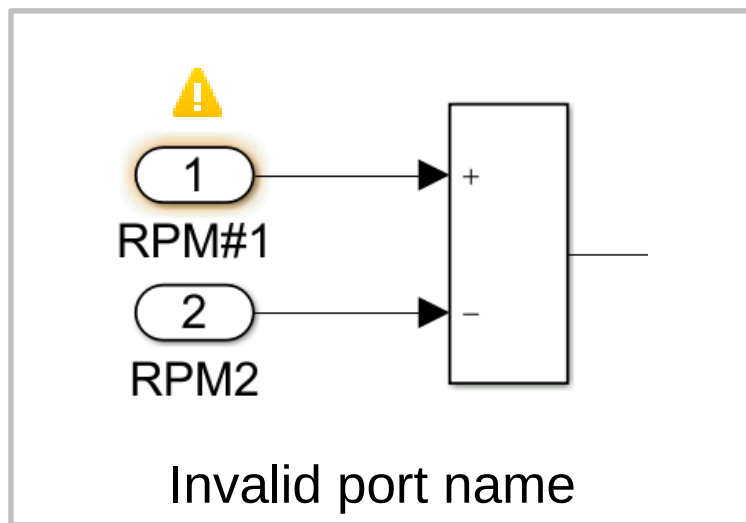
inf
 Normal



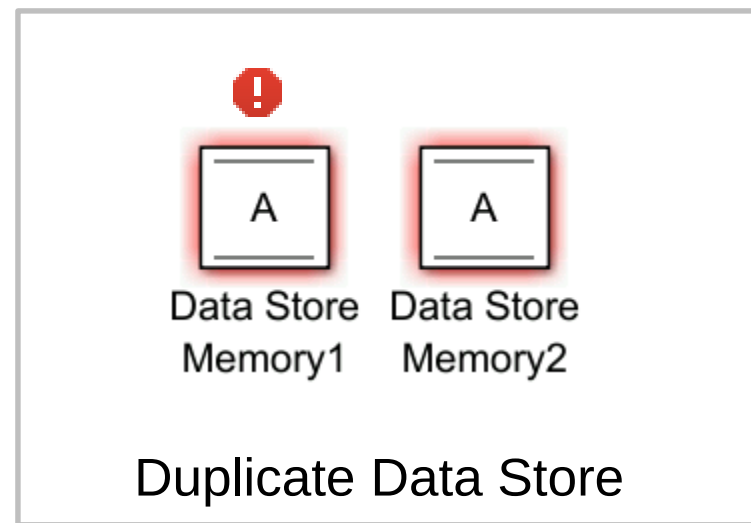
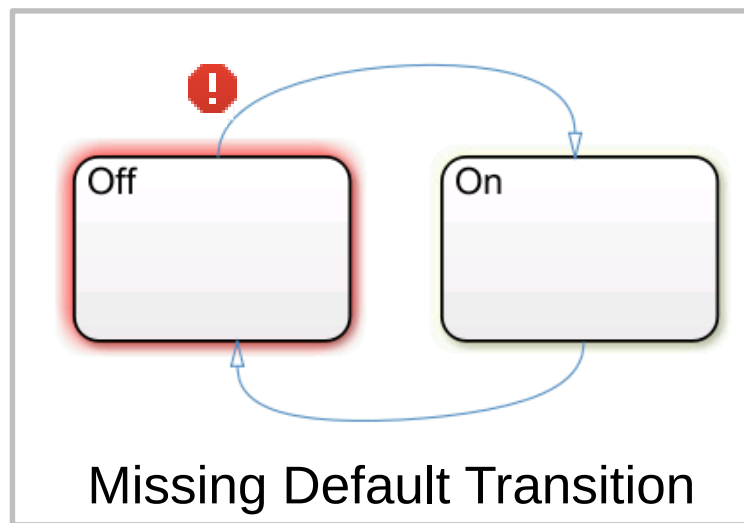
通过‘边做边改’（Fixing-as-you go）预防错误的发生

R2016b

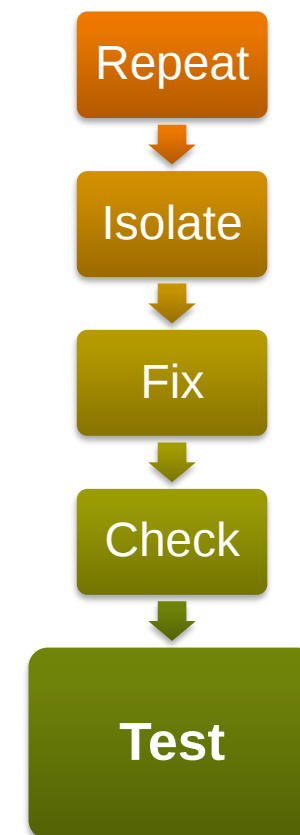
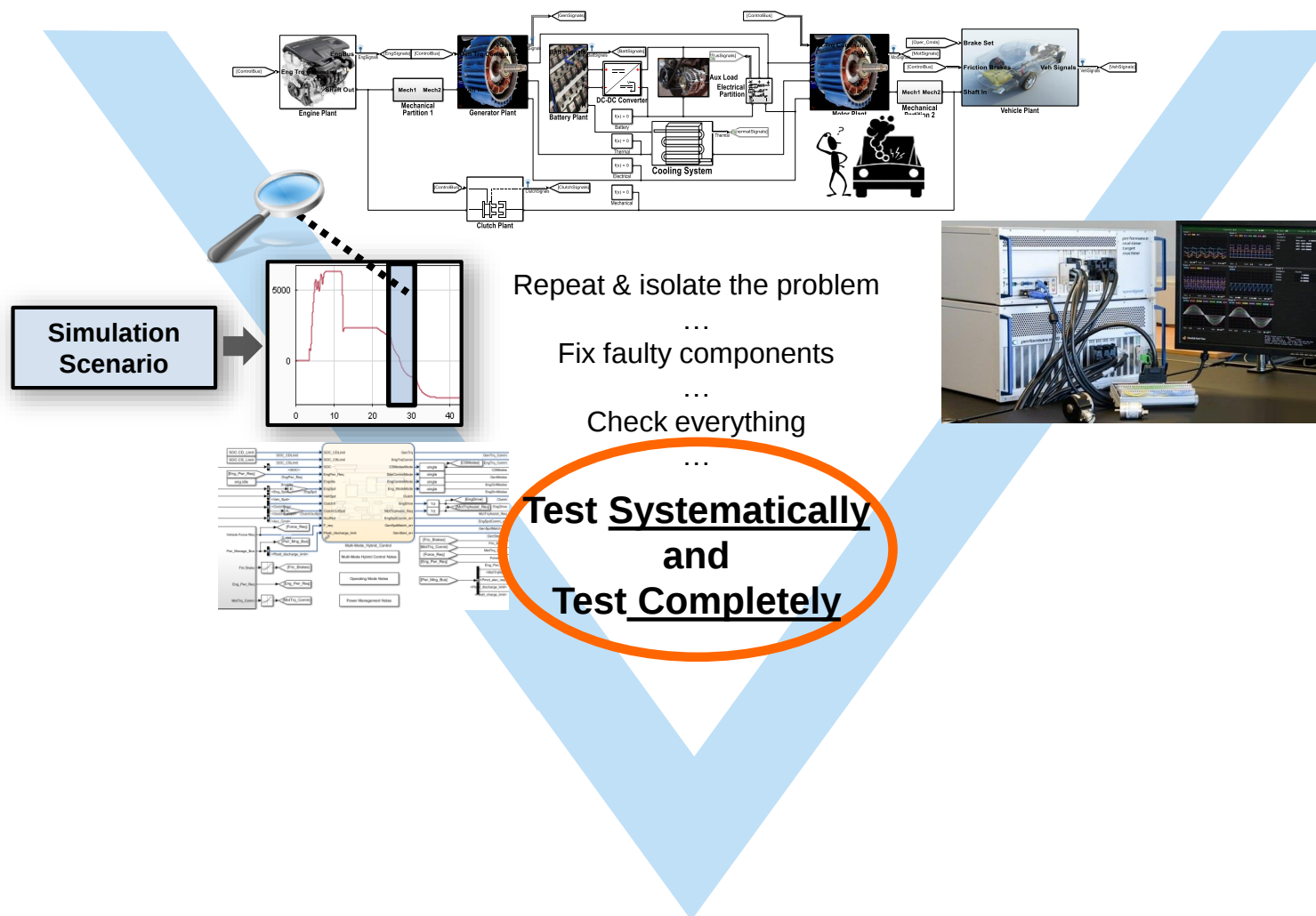
- Edit-time checking
 - Simulink
 - Stateflow
 - Modeling Standards
 - 阻止模块错误
 - 模块和端口名字违背
- 为本单位的标准定制规则



MATLAB EXPO 2017



测试：系统化及完整性





- Unites together a broad set of capabilities
- Simulink Test
- **R2015a**

Test Manager

TESTS

FILE EDIT RUN RESULTS RESOURCES

Test Browser Results and Artifacts

Constant 70 Km/Hr

Filter tests by name or tags, e.g. tag: test

HEV_Control_Regression...
Scenarios
Constant
Constant
Highway

CUSTOM CRITERIA

☒ function customCriteria(test)

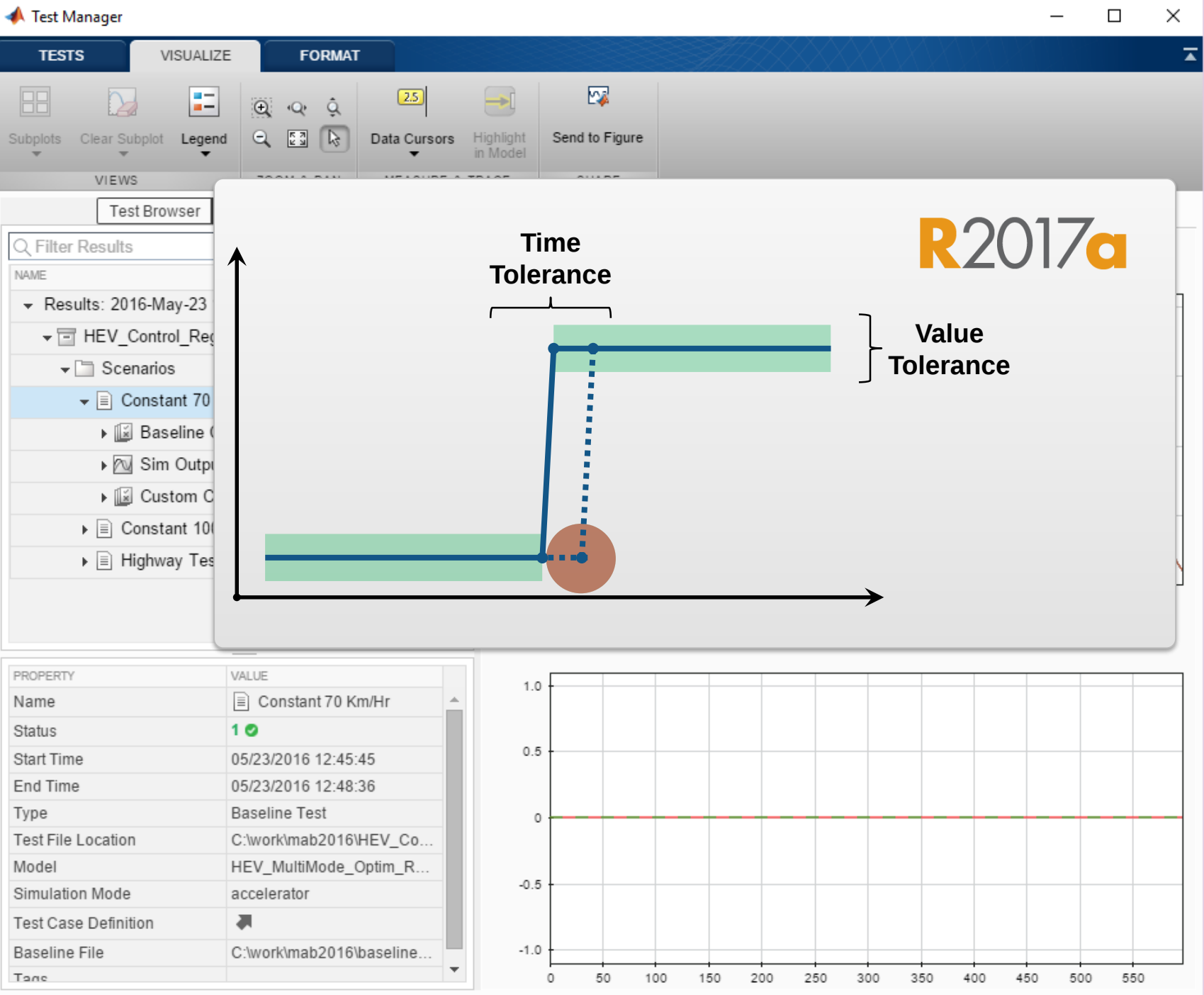
```
1  
2 %% criteria 1: State of charge should not be below 30%  
3 minSOC = min(test.SimOut.get('tmp_racel_logsout').get('BattSignal'));  
4 test.verifyGreaterThan(minSOC, 30, 'SOC should be more than 30%');  
5  
6 %% criteria 2: Voltage should not be less than 250 V after starting  
7 minVoltage = min(test.SimOut.get('tmp_racel_logsout').get('BattSignal'));  
8 test.verifyGreaterThan(minVoltage, 250, 'voltage should be more than 250 V');
```

PROPERTY

Name	
Type	
Model	HEV_MultiMode_Optim_R...
Simulation Mode	[Model Settings]
Location	C:\work\mab2016\HEV_C...
Enabled	☒
Record Coverage	☒
Hierarchy	HEV_Control_Regression...
Tags	type comma or space separa

OUTPUTS
CONFIGURATION SETTINGS OVERRIDES
BASELINE CRITERIA
CUSTOM CRITERIA
ITERATIONS
COVERAGE SETTINGS

MATLAB Script Criteria



TESTS

VISUALIZE

FORMAT

Subplots

Clear Subplot

Legend

Zoom & Pan

MEASURE & TRACE

SHARE

2.5

Data Cursors

Highlight in Model

Send to Figure

Test Browser

Results and Artifacts

Constant 70 Km/Hr

Comparison

AGGREGATED COVERAGE RESULTS

ANALYZED MODEL	REPORT	COMP.	D1	C1	MCDC	EXECUTION
HEV_MultiMode_Optim_R2016a_r3		389	54%	81%	48%	100%
MultiModeCtrl_KO_R2016a_r3_err4		143	76%	62%		
Power_Management_v0		49	91%	97%		

AGGREGATED COVERAGE RESULTS

ANALYZED MODEL	REPORT	COMP.	D1	C1
HEV_MultiMode_Optim_R2016a_r3		389	54%	81%
MultiModeCtrl_KO_R2016a_r3_err4		143	76%	62%
Power_Management_v0		49	94%	100%

PROPERTIES

Name

Status

Start Time

End Time

Type

Test File Location

Model

Simulation Mode

Test Case Definition

Baseline File

Time

05/23/2016 12:45:45

05/23/2016 12:48:36

Baseline Test

C:\work\mab2016\HEV_Co...

HEV_MultiMode_Optim_R...

accelerator

C:\work\mab2016\baseline...

0.5

0

-0.5

-1.0

0

50

100

150

200

250

300

350

400

450

500

550

Report Generated by Test Manager

Title: Test

Author: David Boissy

Date: 24-May-2016 13:05:13

Test Environment

Platform: PCWIN64

MATLAB: (R2017a Prerelease)

完整地测试- Top-It-Off 流程

R2017a

1

- Run Existing Tests
- Aggregate Coverage

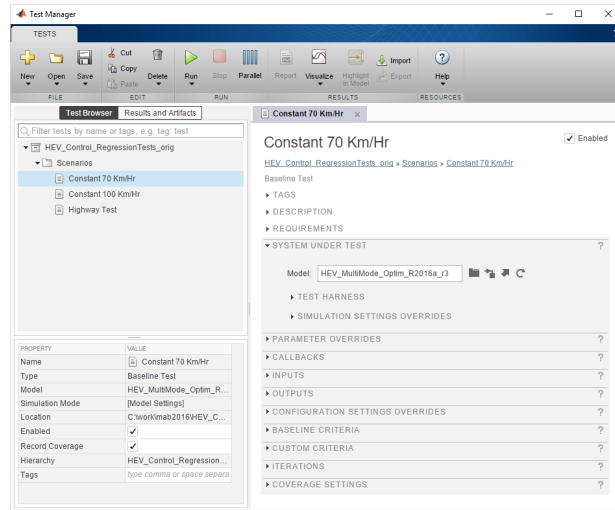
2

- Simulink Design Verifier
- Generate Test Cases

3

- Run New Tests
- Aggregate Coverage

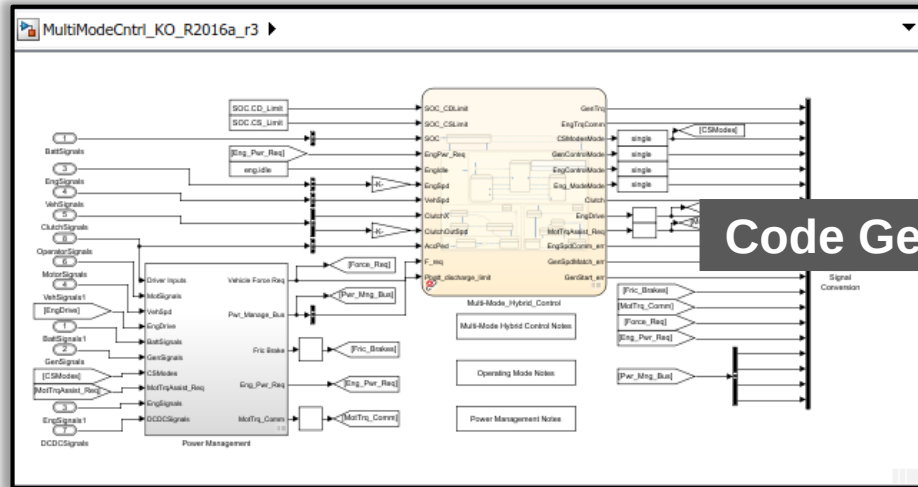
与测试自动化服务器集成



Any continuous integration system that supports
Test Anything Protocol (TAP)

R2016b

代码到模型的验证



Code Generator

```

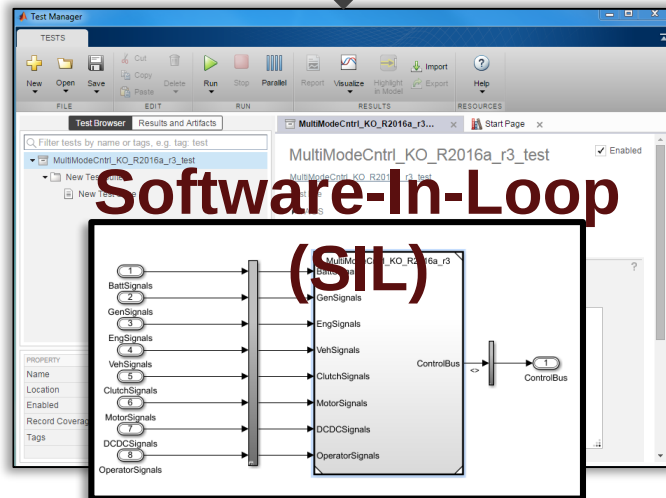
/* Copyright 2007-2013 The MathWorks, Inc. */
#include "version.h"
#include "Fitools/Fitools_all_exports.hpp"
#include "mcs.h"

#include "cg_base/Scope.hpp"
#include "cg_base/Builder/ScopeTypeBuilder.hpp"
#include "cg_base/Builder/TypeFactory.hpp"
#include "cg_base/Factory/TypeFactory.hpp"
#include "cg_base/Type.hpp"
#include "cg_base/Util/cg_pool.hpp"

#include "Fitools/Fitools.hpp"
#include "Fitools/Fitools.hpp"

void TypeFactory::pushPath(const char *str, int
    {
        if (index != -1) {
            Path->append(index+3);
            Path->append(str);
        }
    }
}
    
```

Test Manager



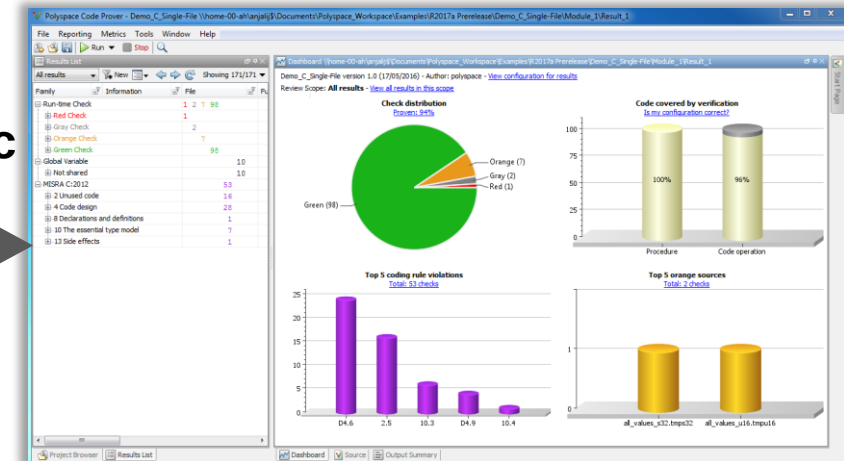
Software-In-Loop

(SIL)

Dynamic

Static

Polyspace



等效性检查及代码覆盖度 (Software-In-Loop)

The screenshot displays the Test Manager application window. The 'TESTS' tab is active, showing a 'Test Browser' on the left and a 'Results and Artifacts' pane on the right. The 'Test Browser' shows a tree structure with 'ControllerRegressionTest' expanded, containing a 'Test suite' which includes 'Scenario 1'. The 'Results and Artifacts' pane shows the configuration for 'Scenario 1', which is an 'Equivalence Test'. The configuration includes sections for 'TAGS', 'DESCRIPTION', 'REQUIREMENTS', 'SIMULATION 1', 'SIMULATION 2', 'EQUIVALENCE CRITERIA', 'CUSTOM CRITERIA', 'ITERATIONS', and 'COVERAGE SETTINGS'. The 'COVERAGE SETTINGS' section is expanded, showing 'COVERAGE TO COLLECT' with checkboxes for 'Record coverage for system under test' and 'Record coverage for referenced models', both of which are checked. Below this, the 'COVERAGE METRICS' section is also expanded, showing checkboxes for 'Decision', 'Condition', 'MCDC', 'Lookup Table', 'Signal Range', and 'Signal Size'. The 'Decision' and 'MCDC' checkboxes are checked, while 'Condition', 'Lookup Table', 'Signal Range', and 'Signal Size' are unchecked.

Test Manager

TESTS

FILE EDIT RUN RESULTS RESOURCES

Test Browser Results and Artifacts

Filter tests by name or tags, e.g. tag: test

ControllerRegressionTest

Test suite

Scenario 1

Scenario 1

PROPERTY VALUE

Name	Scenario 1
Type	Equivalence Test
Simulation 1: Model	HEV_MultiMode_Optim_R2016a_r3
Simulation 1: Harness Name	HEV_MultiMode_Optim_R2016a_...
Simulation 1: Simulation Mode	Normal
Simulation 2: Model	HEV_MultiMode_Optim_R2016a_r3
Simulation 2: Harness Name	HEV_MultiMode_Optim_R2016a_...
Simulation 2: Simulation Mode	Software-in-the-Loop (SIL)
Location	I:\MAR\2016\AbhishekVer\HEVM

Scenario 1

Equivalence Test

TAGS

DESCRIPTION

REQUIREMENTS

SIMULATION 1 ?

SIMULATION 2 [Copy settings from Simulation 1](#) ?

EQUIVALENCE CRITERIA ?

CUSTOM CRITERIA ?

ITERATIONS ?

COVERAGE SETTINGS ?

COVERAGE TO COLLECT

☒ Record coverage for system under test

☒ Record coverage for referenced models

COVERAGE METRICS

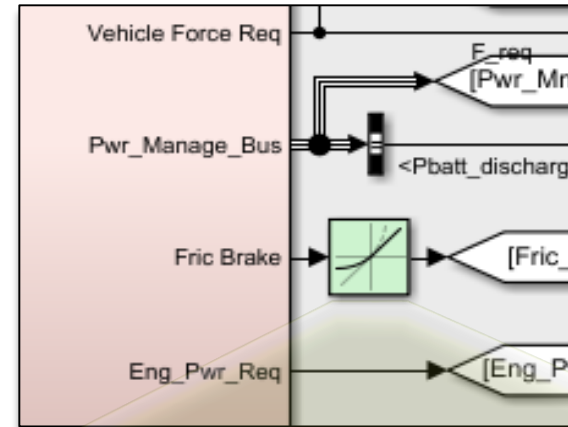
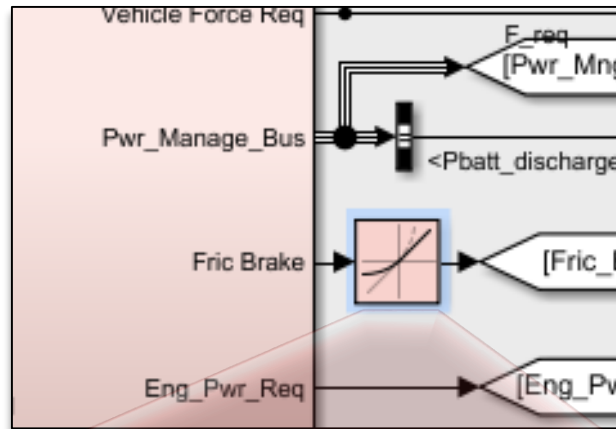
☒ Decision ☒ Condition

☒ MCDC ☐ Lookup Table

☐ Signal Range ☐ Signal Size

Justification for Code Coverage

R2016b



10.28. Decision [ClutchOutSpd > 250.0F](#) (line 2769)

Justify or Exclude

Function: [MultiModeCntrl_KO_R2016a_r3_err2_sil_step](#)
 Model Object: [Rate Limiter3](#)
 Uncovered Links:

Metric	Coverage
Decision (D1)	50% (1/2) decision outcomes

Decisions analyzed:

ClutchOutSpd > 250.0F	50%
false	101/101
true	0/101

Justify

10.28. Decision [ClutchOutSpd > 250.0F](#) (line 2769)

Justified

[\(Remove this rule\)](#)

Function: [MultiModeCntrl_KO_R2016a_r3_err2_sil_step](#)
 Model Object: [Rate Limiter3](#)

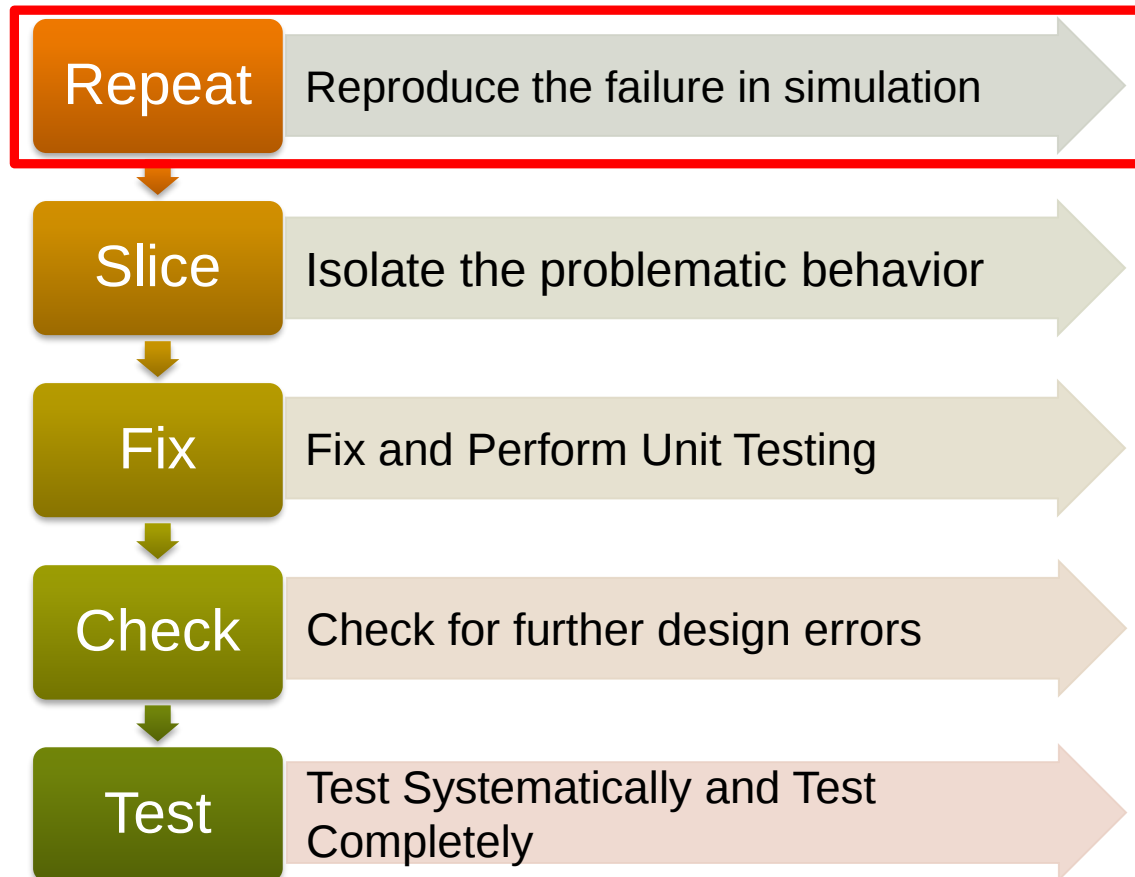
Metric	Coverage
Decision (D1)	100% ((1+1)/2) decision outcomes

Decisions analyzed:

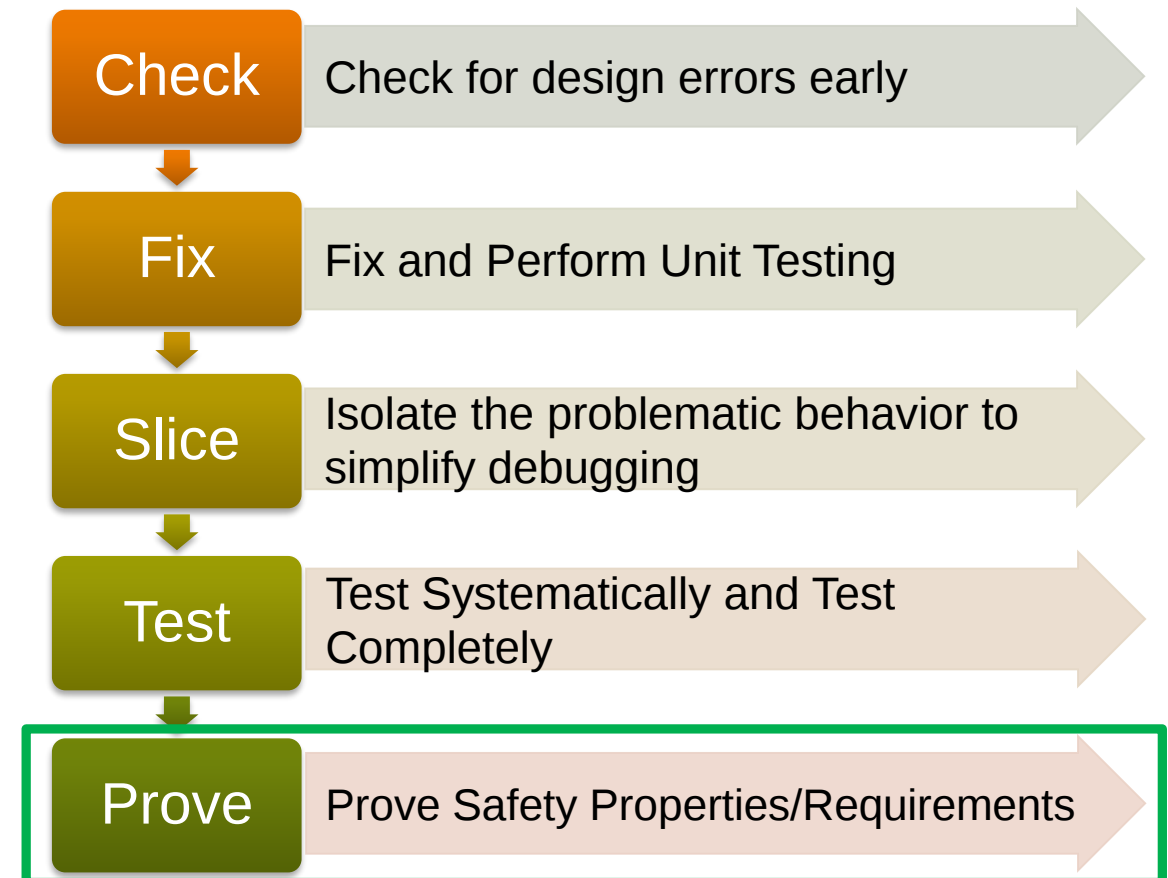
ClutchOutSpd > 250.0F	50%
false	101/101
true	0/101

连续的测试和验证可以帮助...

“Reactively” Reproduce the Field Issues in Simulation



“Proactively” Prove that Implementation satisfies Requirements



基于模型的设计可以帮助...

