

MathWorks
**AUTOMOTIVE
CONFERENCE 2019**

Simulink Test를 이용한 Powertrain
Blockset 기반의 동적 검증

홍혁기

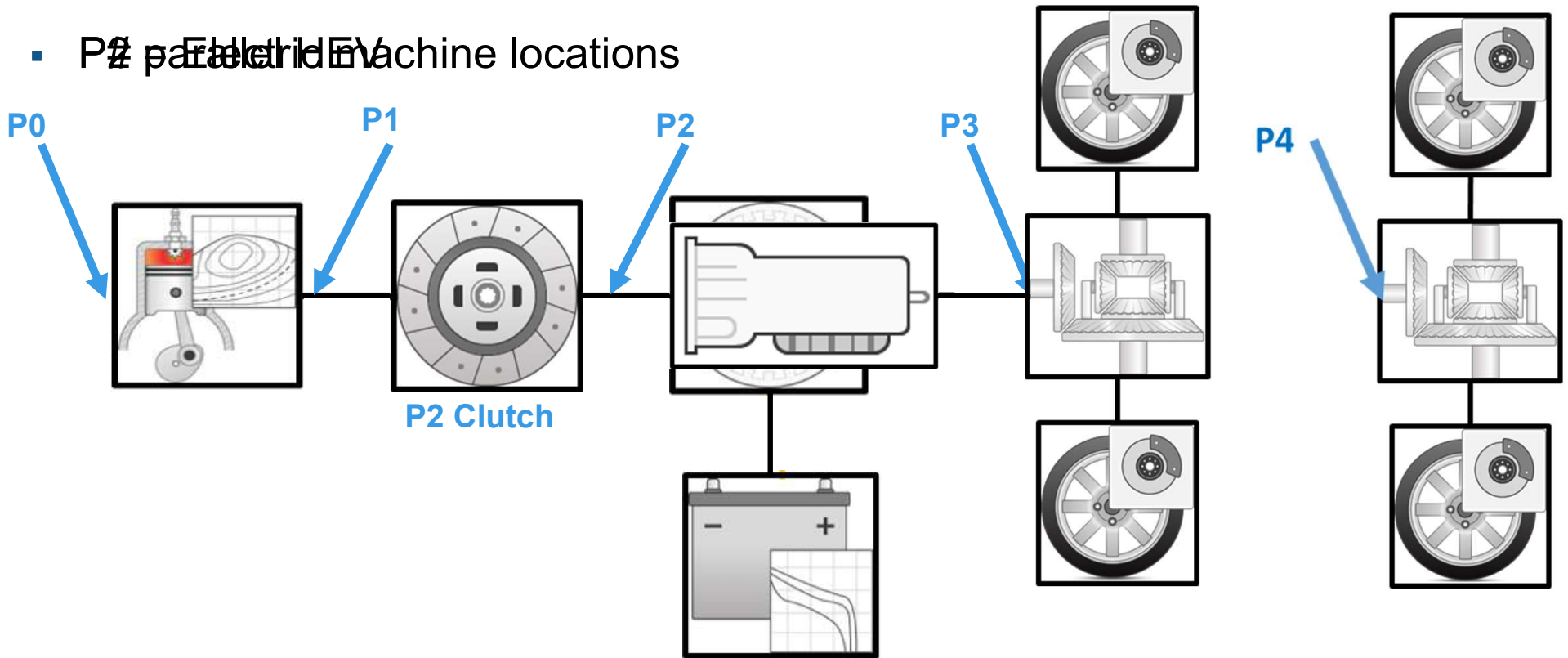


Agenda

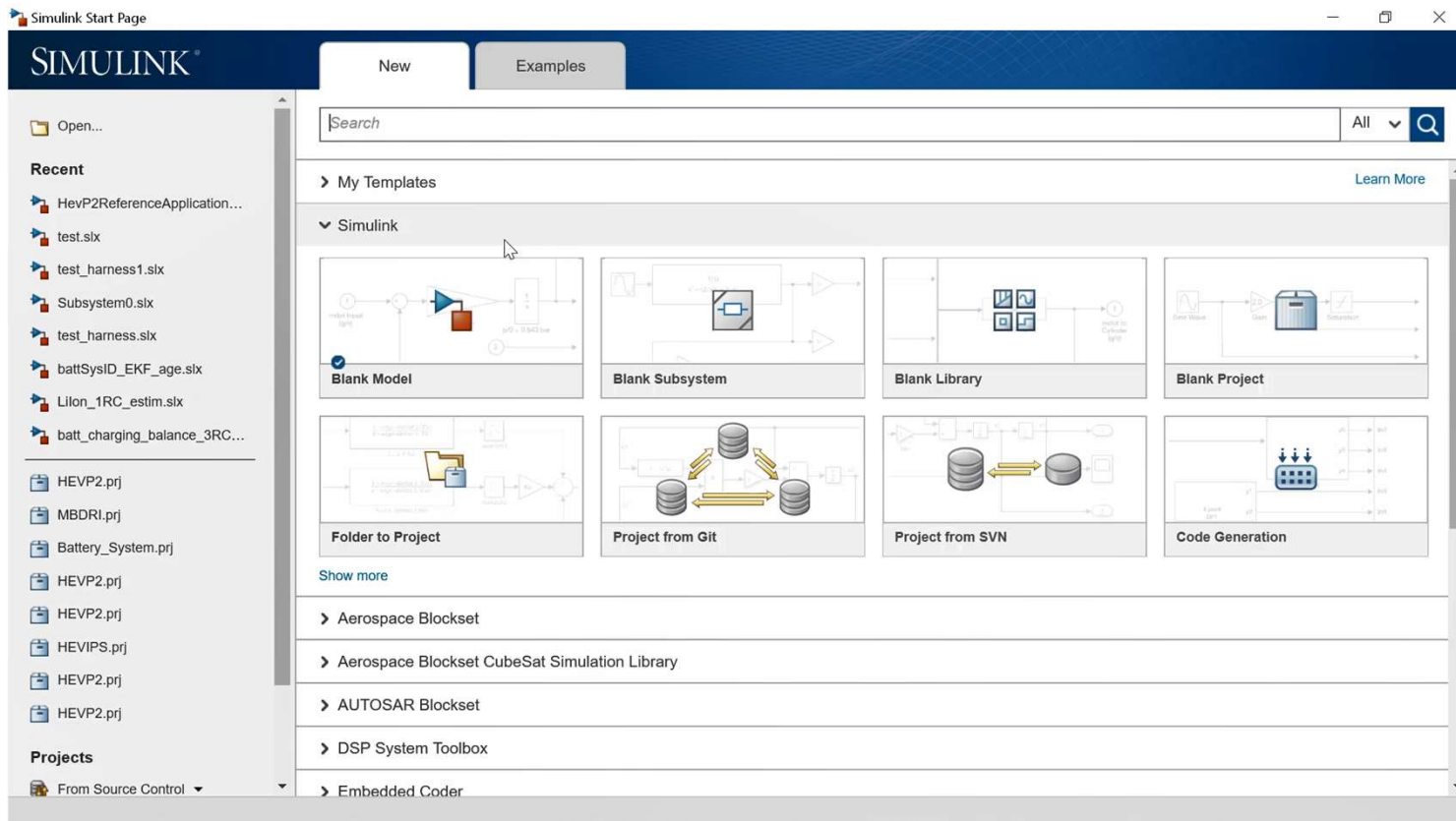
- HEV P2 Model
- Requirement Management in the Simulink Environment
- How to implement VnV Activities using Simulink Test with HVE P2 Model
 - Case1 : HVE P2 Performance
 - Case2 : HVE P2 Fuel Economy

Nomenclature for HEV Topology

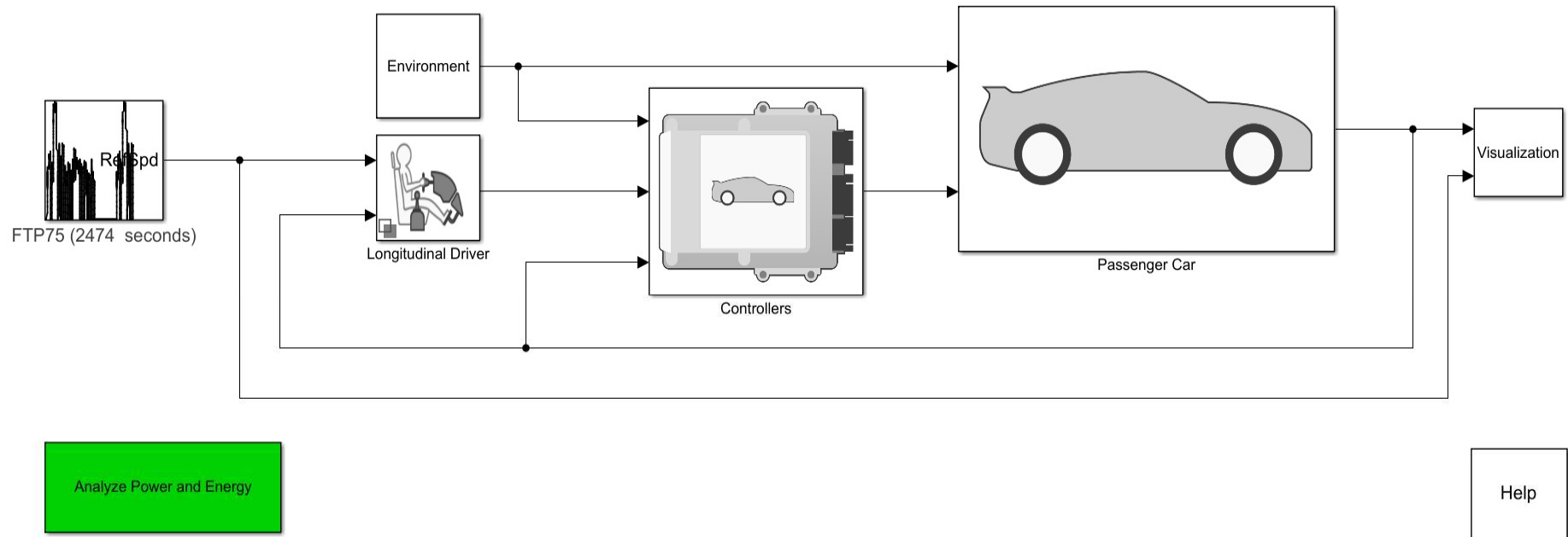
- P₂ parallel HEV machine locations



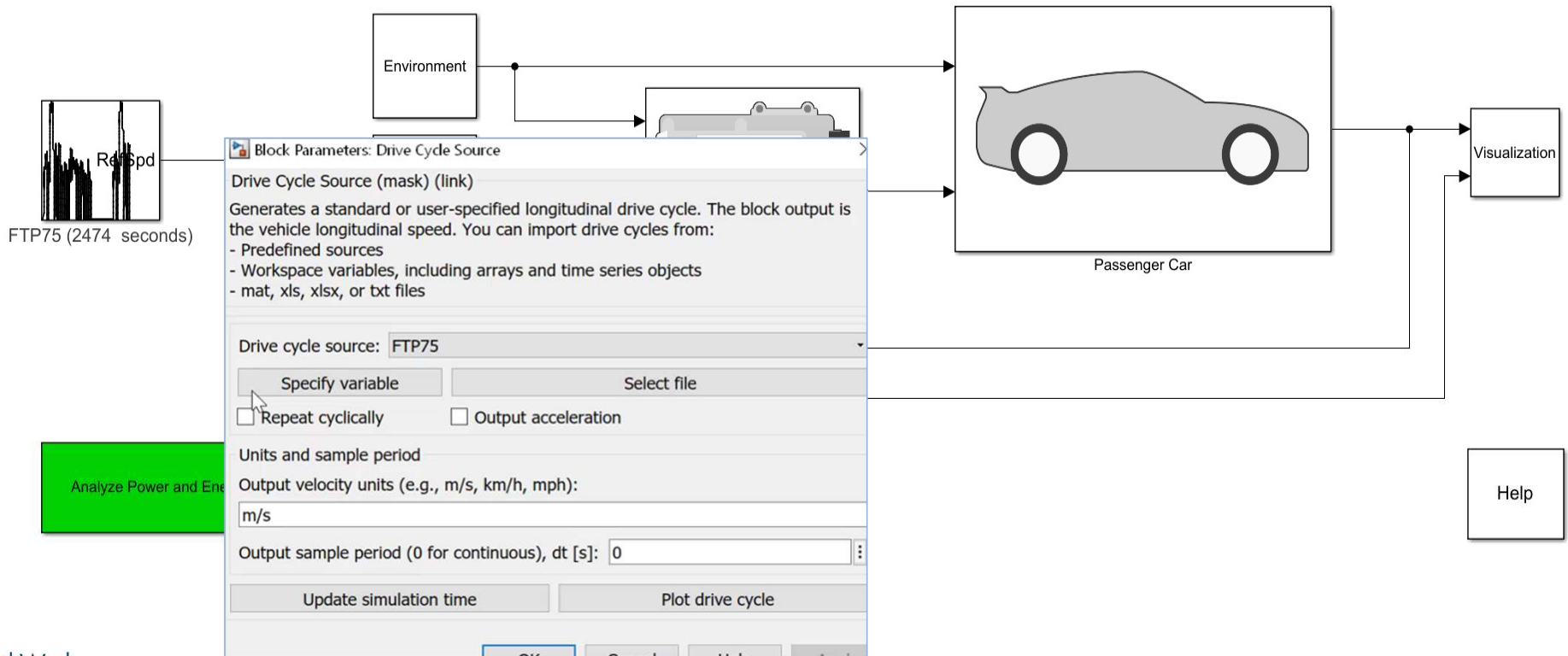
HevP2Reference Application



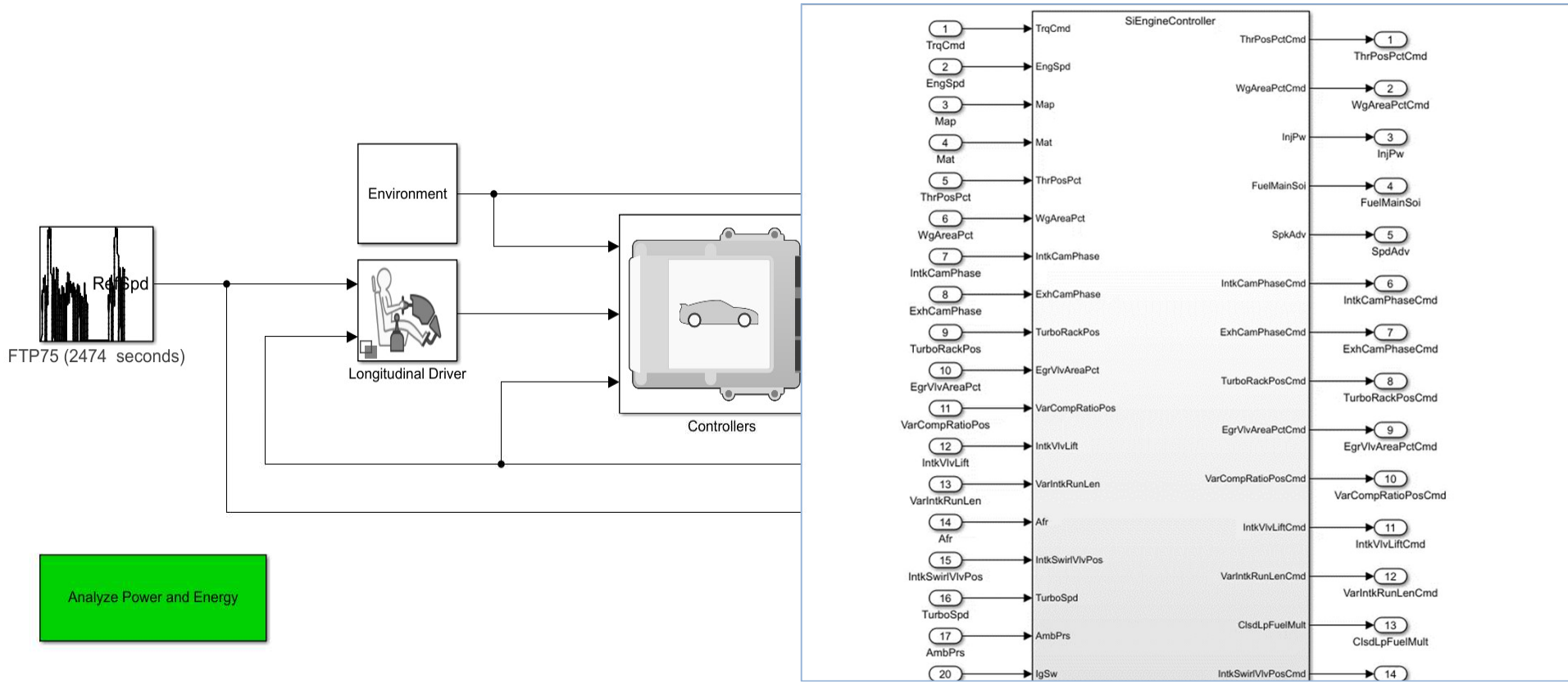
HevP2Reference Application



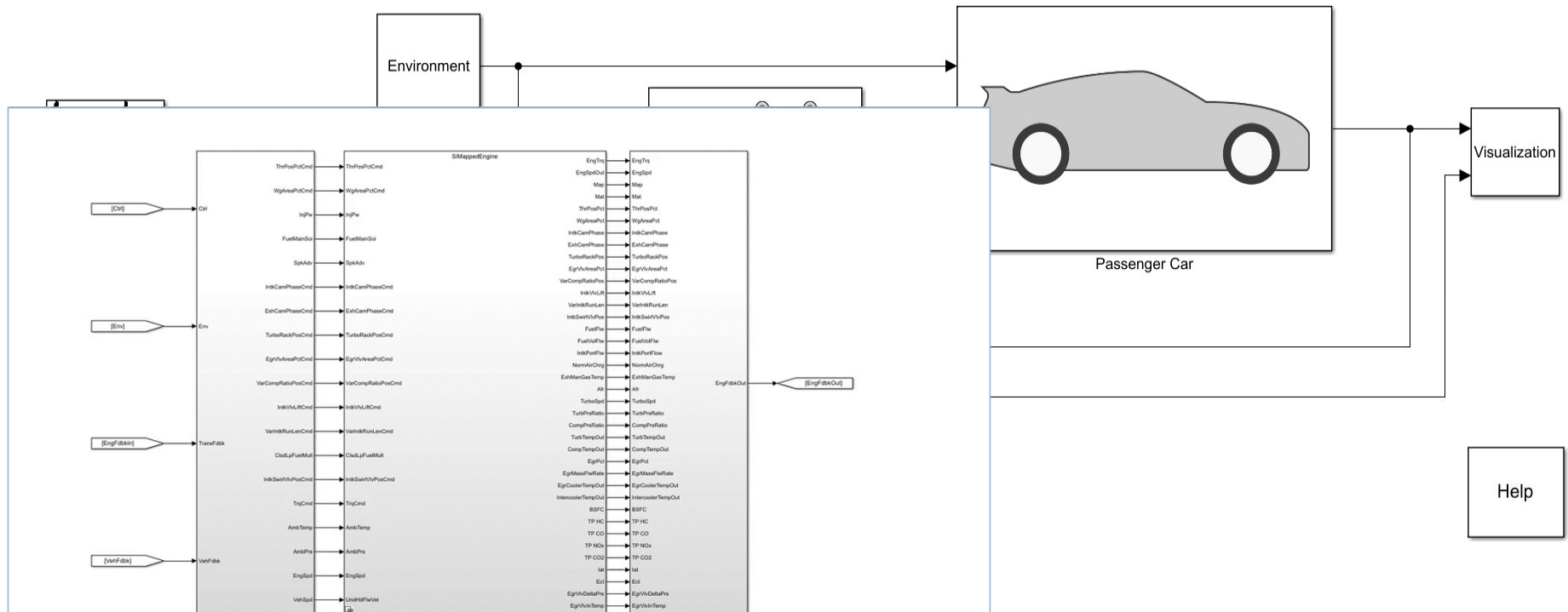
HevP2Reference Application



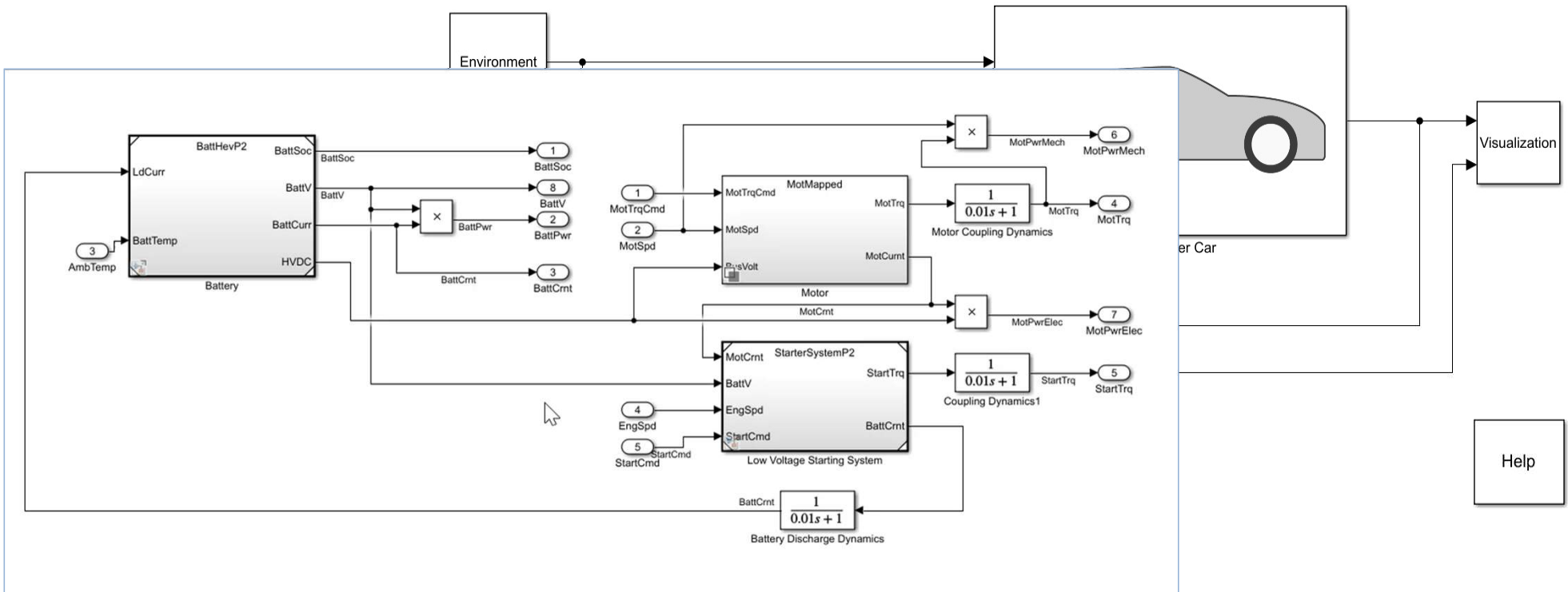
HevP2Reference Application



HevP2Reference Application



HevP2Reference Application

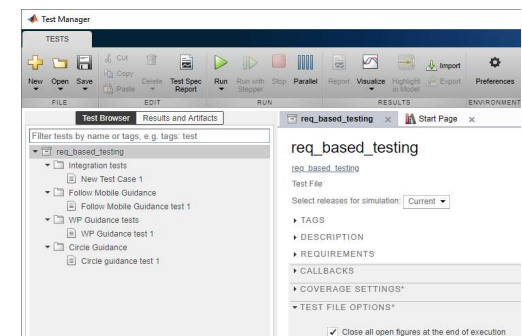
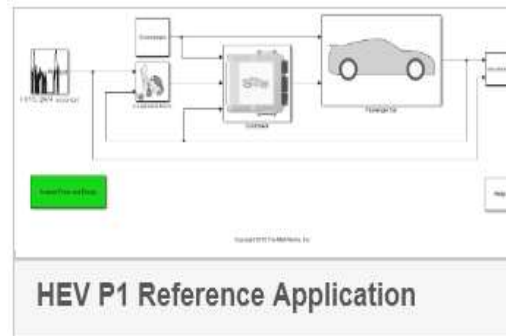
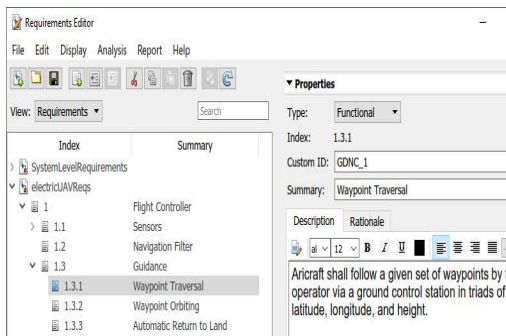


Powertrain Blockset / Simulink Test Collaboration

- Plus
 - Provide starting point for engineers to build good plant / controller models
 - Provide open and documented models
 - Provide very fast-running models that work with popular HIL systems

- Needs
 - Systematic V&V workflow using Powertrain Blockset
 - Repeatable and Automatic Process

Model Based Design for Powertrain Blockset

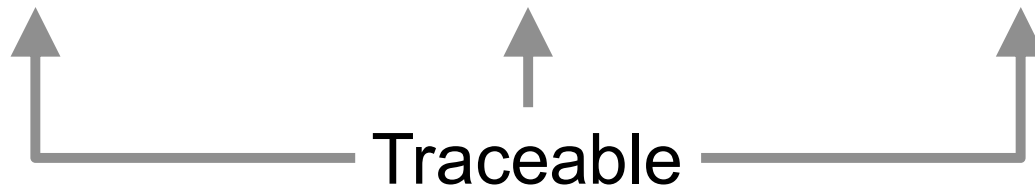
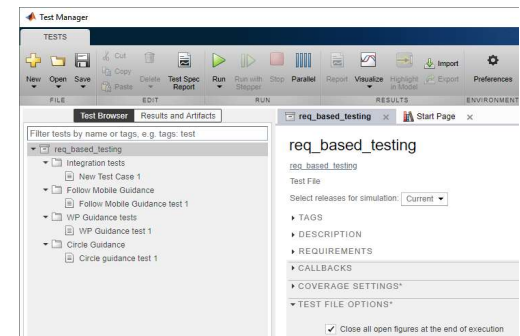
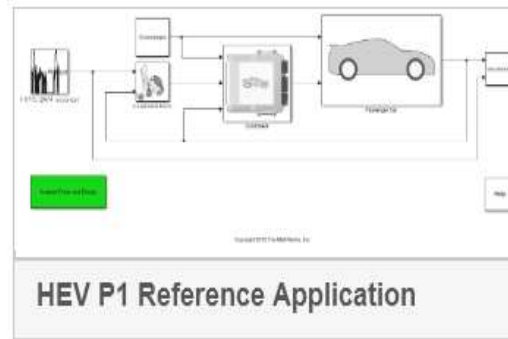
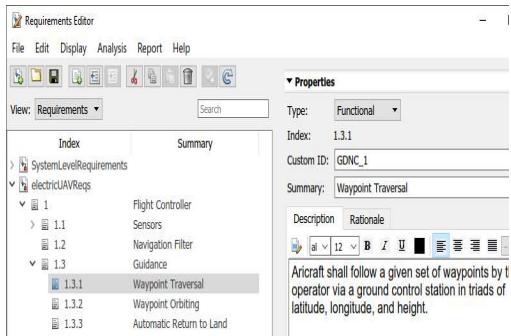


- Simulink Requirement
 - Test Requirement Authoring
 - Test and Modeling Status Check

- Powertrain Blockset
 - Vehicle modeling
 - Simulation

- Simulink Test
 - Test Authoring and Automation
 - Execution and Report Generation

Model Based Design for Powertrain Blockset



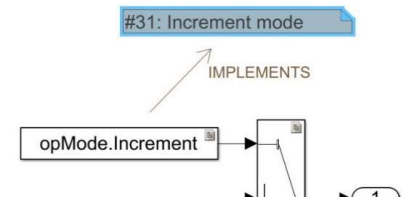
Author Requirements in Simulink

The screenshot shows the Requirements Editor window. On the left is a tree view of requirements under 'BMS_Requirements'. The main area displays the details for requirement '3 BMS Architecture and module specifications'. The 'Properties' section shows it is a 'Functional' requirement with index '3'. The 'Description' and 'Rationale' tabs are active, showing a graph and a diagram of battery cells. The 'Revision information' section shows SID: 24, Revision: 1, and creation details.

This screenshot shows a requirement detail view for 'Cancel Switch Detection'. It includes a 'Description' and 'Rationale' section with the text: 'If the Cancel switch is pressed, the value of reqDrv should be set to reqMode.Cancel.' Below this is a 'Dashboard image' showing a car's control panel with 'CANC', 'SET+', 'RES', and 'SET-' buttons.

Author

Track



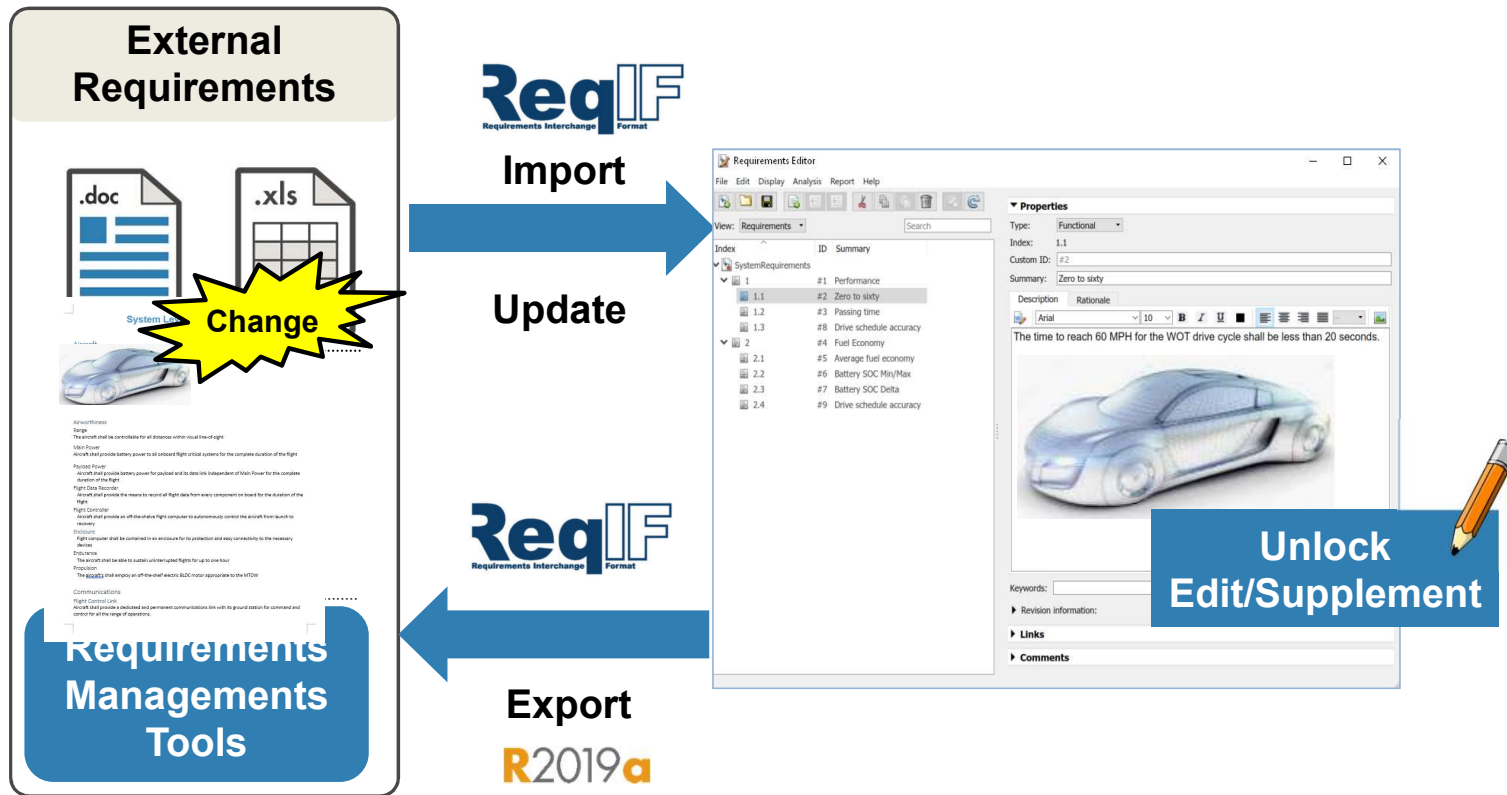
This screenshot shows an issue notification: 'Issue: Destination Changed.' It includes a table with the following data:

Stored:	Revision: 15
Actual:	Revision: 18

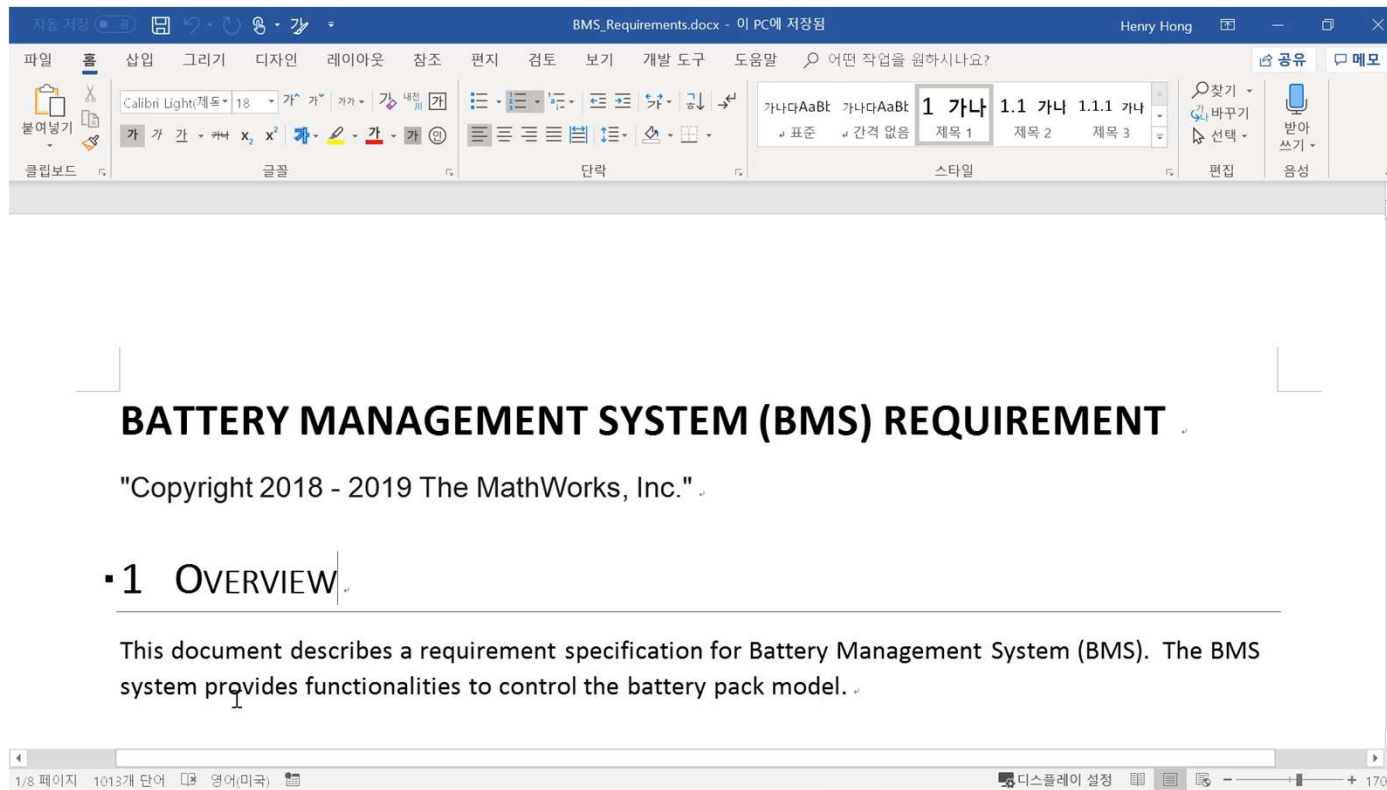
Below the table is a 'Clear Issue' button.

Manage

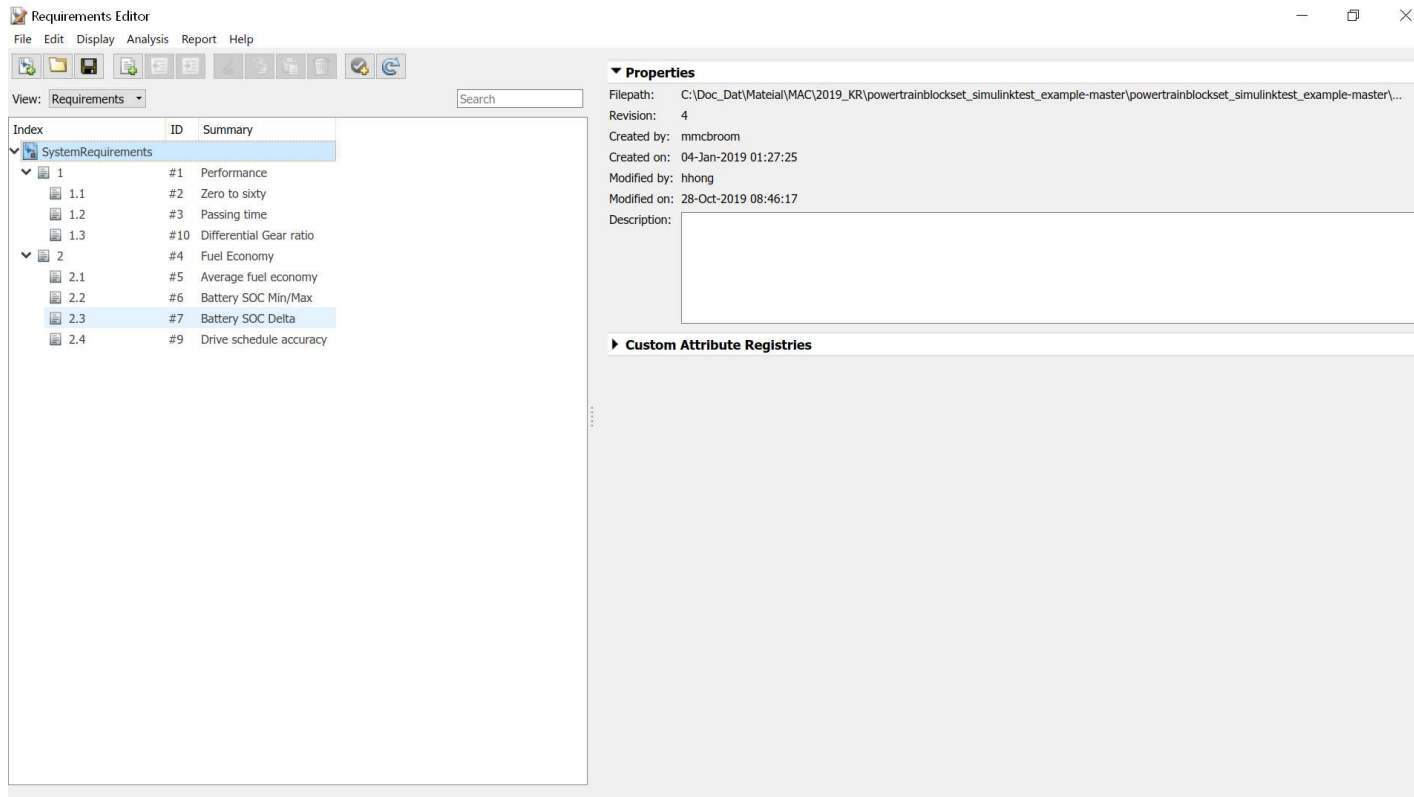
Import and Export with External Tools



Import External Requirements



HEV P2 Test Requirement



The screenshot shows the Requirements Editor application window. The main area displays a tree view of requirements under 'SystemRequirements'. The 'Properties' panel on the right shows details for the selected requirement.

Index	ID	Summary
SystemRequirements		
1	#1	Performance
1.1	#2	Zero to sixty
1.2	#3	Passing time
1.3	#10	Differential Gear ratio
2	#4	Fuel Economy
2.1	#5	Average fuel economy
2.2	#6	Battery SOC Min/Max
2.3	#7	Battery SOC Delta
2.4	#9	Drive schedule accuracy

Properties

Filepath: C:\Doc_Dat\Mateial\MAC\2019_KR\powertrainblockset_simulinktest_example-master\powertrainblockset_simulinktest_example-master\...

Revision: 4

Created by: mmcbroom

Created on: 04-Jan-2019 01:27:25

Modified by: hhong

Modified on: 28-Oct-2019 08:46:17

Description:

Custom Attribute Registries



View: Requirements Search

Index	ID	Summary
SystemRequirements		
1	#1	Performance
1.1	#2	Zero to sixty
1.2	#3	Passing time
1.3	#10	Differential Gear ratio
2	#4	Fuel Economy
2.1	#5	Average fuel economy
2.2	#6	Battery SOC Min/Max
2.3	#7	Battery SOC Delta
2.4	#9	Drive schedule accuracy

Properties

Filepath: C:\Doc_Dat\Mateial\MAC\2019_KR\powertrainblockset_simulinktest_example-master\powertrainblockset_simulinktest_example-master\
Revision: 4

TESTS

Test Browser Results and Artifacts

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

- HEVP2
 - Performance
 - WOT
 - Fuel Economy
 - FTP75
 - HWFET
 - US06

Test Suite

PROPERTY	VALUE
Name	Fuel Economy
Location	C:\class\powertrainblockset_simulinkte...
Hierarchy	HEVP2 » Fuel Economy

Start Page

Getting S

RECENT FILES

- [HEVP2](#)



View: Requirements Search

Index	ID	Summary
SystemRequirements		
1	#1	Performance
1.1	#2	Zero to sixty
1.2	#3	Passing time
1.3	#10	Differential Gear ratio
2	#4	Fuel Economy
2.1	#5	Average fuel economy
2.2	#6	Battery SOC Min/Max
2.3	#7	Battery SOC Delta
2.4	#9	Drive schedule accuracy

▼ Properties

Type: Functional
 Index: 1.1
 Custom ID: #2
 Summary: Zero to sixty

Description Rationale

Arial 20 B I U

The time to reach 60 MPH for the WOT drive cycle shall be less than 20 seconds.

Keywords:

► Revision information:

▼ Links

► Comments



View: Requirements

Search

Index	ID	Summary
SystemRequirements		
1	#1	Performance
1.1	#2	Zero to sixty
1.2	#3	Passing time
1.3	#10	Differential Gear ratio
2	#4	Fuel Economy
2.1	#5	Average fuel economy
2.2	#6	Battery SOC Min/Max
2.3	#7	Battery SOC Delta
2.4	#9	Drive schedule accuracy

▼ Properties

Type: Functional

Index: 1.2

Custom ID: #3

Summary: Passing time

Description Rationale

Arial 20 B I U

The time to accelerate from 40 to 60 MPH in the WOT drive cycle shall be less than 5 seconds.

Keywords:

▶ Revision information:

▼ Links

▶ Comments



View: Requirements

Search

Index	ID	Summary
SystemRequirements		
1	#1	Performance
1.1	#2	Zero to sixty
1.2	#3	Passing time
1.3	#10	Differential Gear ratio
2	#4	Fuel Economy
2.1	#5	Average fuel economy
2.2	#6	Battery SOC Min/Max
2.3	#7	Battery SOC Delta
2.4	#9	Drive schedule accuracy

▼ Properties

Type: Functional

Index: 1.3

Custom ID: #10

Summary: Differential Gear ratio

Description Rationale

Arial

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Two types of variants should be applied.

- Variant1 : 3.0
- Variant2 : 3.32

Keywords:

▶ Revision information:

▼ Links

▶ Comments



View: Requirements Search

Index	ID	Summary
SystemRequirements		
1	#1	Performance
1.1	#2	Zero to sixty
1.2	#3	Passing time
1.3	#10	Differential Gear ratio
2	#4	Fuel Economy
2.1	#5	Average fuel economy
2.2	#6	Battery SOC Min/Max
2.3	#7	Battery SOC Delta
2.4	#9	Drive schedule accuracy

▼ Properties

Type: Functional
Index: 2
Custom ID: #4
Summary: Fuel Economy

Description Rationale

Arial 20 B I U

The following requirements shall be met for the FTP75, US06 and HWFET drive profiles.

Keywords:

► Revision information:

▼ Links

► Comments



View: Requirements

Search

Index	ID	Summary
SystemRequirements		
1	#1	Performance
1.1	#2	Zero to sixty
1.2	#3	Passing time
1.3	#10	Differential Gear ratio
2	#4	Fuel Economy
2.1	#5	Average fuel economy
2.2	#6	Battery SOC Min/Max
2.3	#7	Battery SOC Delta
2.4	#9	Drive schedule accuracy

▼ Properties

Type: Functional
Index: 2.1
Custom ID: #5
Summary: Average fuel economy

Description Rationale

Arial 20 B I U

The average fuel economy at the end of the drive profile shall be 32 MPG.

Keywords:

► Revision information:

▼ Links

► Comments



View: Requirements

Search

Index	ID	Summary
SystemRequirements		
1	#1	Performance
1.1	#2	Zero to sixty
1.2	#3	Passing time
1.3	#10	Differential Gear ratio
2	#4	Fuel Economy
2.1	#5	Average fuel economy
2.2	#6	Battery SOC Min/Max
2.3	#7	Battery SOC Delta
2.4	#9	Drive schedule accuracy

▼ Properties

Type: Functional

Index: 2.2

Custom ID: #6

Summary: Battery SOC Min/Max

Description Rationale

Arial

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The battery state of charge shall be greater than 20% and less than 90% for the entire drive cycle.

Keywords:

▶ Revision information:

▼ Links

▶ Comments



View: Requirements

Search

Index	ID	Summary
SystemRequirements		
1	#1	Performance
1.1	#2	Zero to sixty
1.2	#3	Passing time
1.3	#10	Differential Gear ratio
2	#4	Fuel Economy
2.1	#5	Average fuel economy
2.2	#6	Battery SOC Min/Max
2.3	#7	Battery SOC Delta
2.4	#9	Drive schedule accuracy

▼ Properties

Type: Functional

Index: 2.3

Custom ID: #7

Summary: Battery SOC Delta

Description Rationale

Arial

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The absolute value of the difference between the battery state of charge at the start of the drive profile and the end of the drive cycle shall be less than 1%.

Keywords:

▶ Revision information:

▼ Links

▶ Comments



View: Requirements

Search

Index	ID	Summary
SystemRequirements		
1	#1	Performance
1.1	#2	Zero to sixty
1.2	#3	Passing time
1.3	#10	Differential Gear ratio
2	#4	Fuel Economy
2.1	#5	Average fuel economy
2.2	#6	Battery SOC Min/Max
2.3	#7	Battery SOC Delta
2.4	#9	Drive schedule accuracy

▼ Properties

Type: Functional
Index: 2.4
Custom ID: #9
Summary: Drive schedule accuracy

Description Rationale

Arial 20 B I U

The actual vehicle speed shall be no more than 2 mph greater than the scheduled vehicle speed within 1 second of the given time.

Keywords:

▶ Revision information:

▼ Links

▶ Comments

Simulink Test

Test Harness

The screenshot shows a Simulink Test Harness environment. At the top, a window titled 'Test Harness' displays a block diagram with a red dashed box highlighting a specific component. Below it, a window titled 'Main Model' shows a larger system diagram with a red dashed box highlighting the same component. A blue callout box with a red arrow points to the component in the 'Main Model' window, containing the text 'Component under test'.

Test Manager

The screenshot displays the Simulink Test Manager interface. It features a central window with a test results table and a 'Test Results' plot. Below the main window, a smaller window titled 'Report Generated by Test Manager' is visible, showing a list of test results with columns for Name, Author, Status, and Date.

Test Sequence

The top part of the block shows a diagram of a test sequence. It consists of a box labeled 'Test Sequence!' with three numbered steps: 1. 'gear', 2. 'speed', and 3. 'brake'. A green checkmark is placed over the 'brake' step. Below the diagram is a screenshot of the 'Test Sequence' editor window, which shows a table of test steps and transitions.

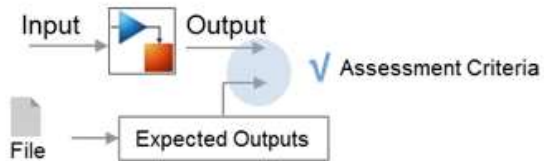
Step	Transition	Next Step
1	1. after 10 ms	Step 2
2	2. after 10 ms	Step 3
3	3. after 10 ms	End

Test Case Templates

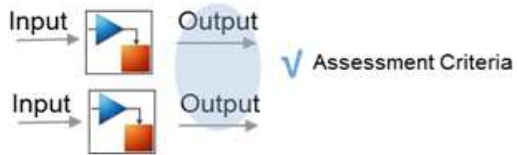
❖ Simulation Testing



❖ Baseline Testing : Regression Test



❖ Equivalence Testing



❖ Temporal Assessment

R2019a

EN	NAME	ASSESSMENT	REQUIREMENT
<input checked="" type="checkbox"/>	Assess...	At any point of time ...	
		trigger: <empty>	
		delay: with no delay ...	
		response: <empty>	

Icon	Description
	whenever is true
	becomes true
	becomes true and stays true for at least
	becomes true and stays true for at most
	becomes true and stays true for between

Logical Assessments	
	Bounds check Check min/max bounds for signals and
	Custom Check if a custom expression holds true for all time steps

Temporal Assessments	
	Trigger-response Check for a signal response once a trigger has been detected

Simulink Test Configuration

TESTS

FILE: New, Open, Save; EDIT: Cut, Copy, Paste, Delete; RUN: Run, Stop, Debug, Parallel; RESULTS: Report, Visualize, Highlight in Model, Export; ENVIRONMENT: Preferences; RESOURCES: Help

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

- HEVP2*
 - Performance
 - WOT**
 - Fuel Economy
 - FTP75
 - HWFET
 - US06

PROPERTY VALUE

Name	WOT
Type	Simulation Test
Model	HevP2ReferenceAppli...
Simulation Mode	[Model Settings]
Location	C:\class\powertrainblo...
Enabled	<input checked="" type="checkbox"/>
Hierarchy	HEVP2 » Performance...
Tags	Type comma or space se

WOT Enabled

HEVP2 » Performance » WOT

Simulation Test

Select releases for simulation: Current

Create Test Case from External File

Traceability
Model and Harness
Simulation Iteration with Parameter Change

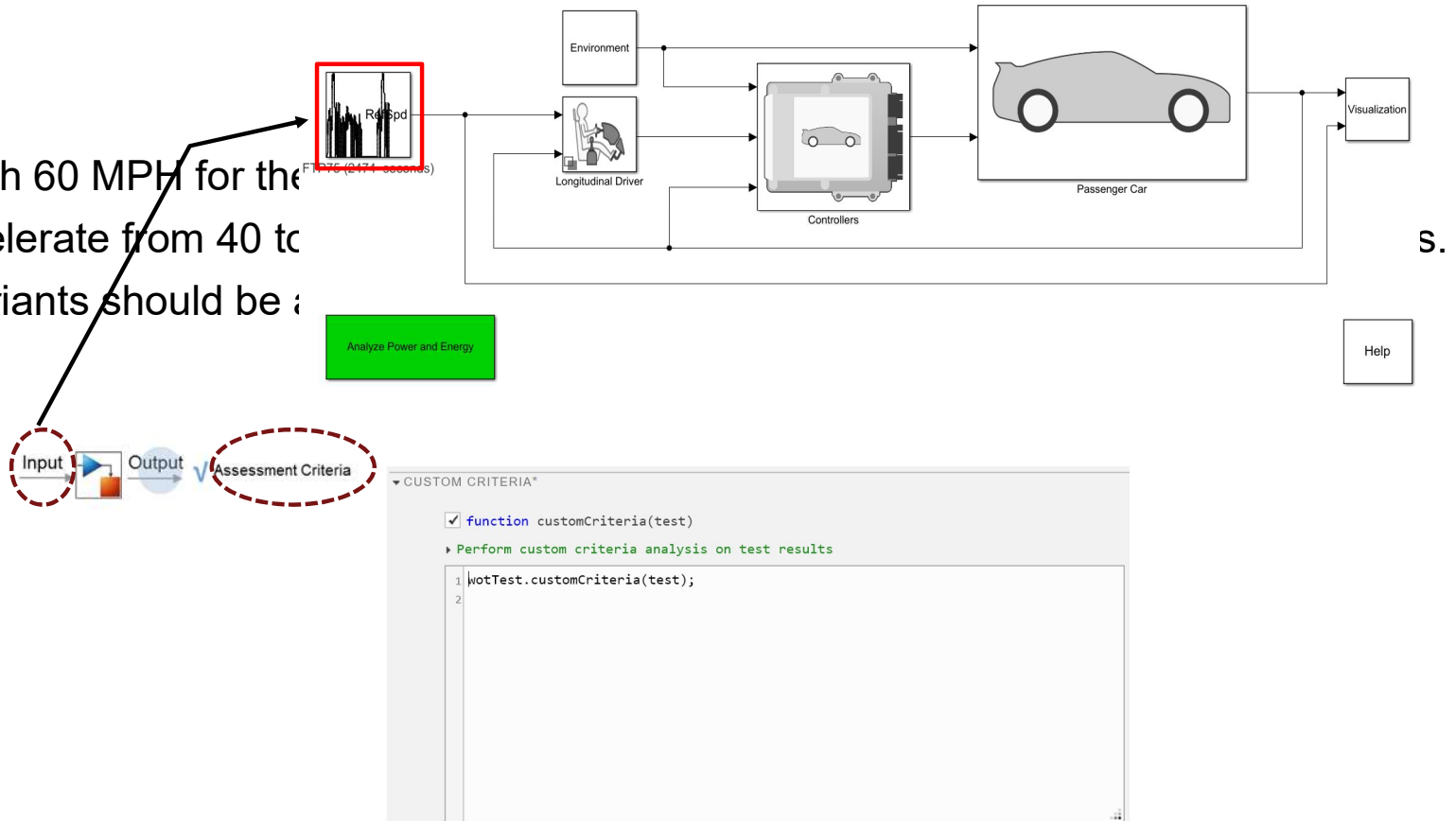
Simulation Input : Excel/Mat
Measurement

Criteria check
MCDC, Condition...

- TAGS
- DESCRIPTION
- REQUIREMENTS*
- SYSTEM UNDER TEST* ?
- PARAMETER OVERRIDES* ?
- CALLBACKS ?
- INPUTS ?
- SIMULATION OUTPUTS* ?
- CONFIGURATION SETTINGS OVERRIDES ?
- ITERATIONS* ?
- LOGICAL AND TEMPORAL ASSESSMENTS* ?
- CUSTOM CRITERIA* ?
- COVERAGE SETTINGS* ?

Dynamic Test 1 - Performance

- Requirement
 - The time to reach 60 MPH for the
 - The time to accelerate from 40 to
 - Two types of variants should be
- Configuration
 - Test Template




Dynamic Test 1 - Performance

- Requirement

- The time to reach **60 MPH** for the WOT drive cycle shall be less than 20 seconds.
- The time to accelerate **from 40 to 60 MPH** in the WOT drive cycle shall be less than 5 seconds.
- **Two types of variants should be applied. (Variant1 : 3.0 / Variant1 : 3.32)**

- Configuration

- Test Template 
- Test Measurement
 - Target Speed
 - Actual Speed
- Parameter Variant Control
 - Parameter Override

PARAMETER OVERRIDES*

PARAMETER SET / WORKSPACE VARIABLE	OVERRIDE VALUE	SOURCE	MODEL ELEMENT
<input type="checkbox"/> Parameter Set 1			
<input checked="" type="checkbox"/> Parameter Set 2			

+ Add Refresh Export Delete

```
function customCriteria(test)
```

```
try
```

```
    vs = test.sltest_simout.logout.get(1).Values;
```



```
    % speed till that actual speed reaches target
```

```
    vIndex = find(vs.Data>60,1);
```

▼ CUSTOM CRITERIA*

function customCriteria(test)

▶ Perform custom criteria analysis on test results

```
1
2  wotTest.customCriteria(test);
```

```
    % drive cycle shall be less than 20 seconds.
```

```
    WOT_0_60_MAX_TIME, sprintf('0-60 test\n'));
```

```
    vIndex = find(vs.Data>40,1);
```

```
    if isempty(vIndex)
```

```
        v40Time = Inf;
```

```
    else
```

```
        v40Time = vs.Time(vIndex);
```

```
    end
```

```
    % Requirement 2
```

```
    % Requirement: Passing Time 60 MPH in the WOT drive cycle shall be less than 5 seconds.
```

```
    test.verifyLessThan(v60Time-v40Time, wotTest.WOT_40_60_MAX_TIME, sprintf('40-60 passing test\n'));
```

Dynamic Test for HevP2Reference Application

The screenshot shows the Test Manager application window. The main area displays the configuration for a test named 'WOT'. The test is enabled and is a simulation test. The configuration includes sections for TAGS, DESCRIPTION, REQUIREMENTS*, SYSTEM UNDER TEST*, PARAMETER OVERRIDES*, CALLBACKS, INPUTS, SIMULATION OUTPUTS*, CONFIGURATION SETTINGS OVERRIDES, ITERATIONS*, LOGICAL AND TEMPORAL ASSESSMENTS, CUSTOM CRITERIA*, and COVERAGE SETTINGS*.

Test Browser

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

- HEVP2*
 - Performance
 - WOT**
 - Fuel Economy

PROPERTY VALUE

PROPERTY	VALUE
Name	WOT
Type	Simulation Test
Model	HevP2ReferenceApplication
Simulation Mode	[Model Settings]
Location	C:\class\powertrainblockset...
Enabled	<input checked="" type="checkbox"/>
Hierarchy	HEVP2 » Performance » W...

WOT Enabled

HEVP2 » Performance » WOT

Simulation Test

Select releases for simulation:

Create Test Case from External File

▶ TAGS

▶ DESCRIPTION

▶ REQUIREMENTS*

▶ SYSTEM UNDER TEST* ?

▶ PARAMETER OVERRIDES* ?

▶ CALLBACKS ?

▶ INPUTS ?

▶ SIMULATION OUTPUTS* ?

▶ CONFIGURATION SETTINGS OVERRIDES ?

▶ ITERATIONS* ?

▶ LOGICAL AND TEMPORAL ASSESSMENTS ?

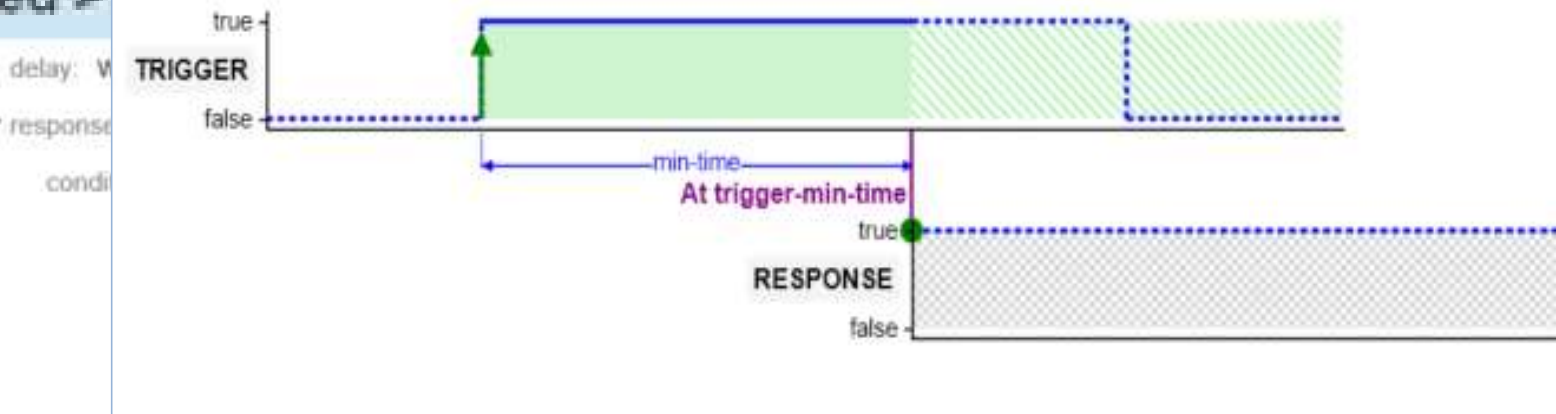
▶ CUSTOM CRITERIA* ?

▶ COVERAGE SETTINGS* ?

Temporal Assessment

LOGICAL AND TEMPORAL ASSESSMENTS*			
EN.	NAME	ASSESSMENT	REQUIREMENTS
<input checked="" type="checkbox"/>	Assessment1	At any point of time ...	Zero to sixty (SystemRequirements#2)

► At any point of time, if `actaul_speed > 0` becomes true and stays true for at least 10.6 seconds then, starting from end of min-time, with no delay, `actaul_speed >`



Temporal Requirement Change

Requirements Editor

File Edit Display Analysis Report Help

View: Requirements Search

Index	ID	Summary
SystemRequirements		
1	#1	Performance
1.1	#2	Zero to sixty
1.2	#3	Passing time
1.3	#10	Differential Gear ratio
2	#4	Fuel Economy
2.1	#5	Average fuel economy
2.2	#6	Battery SOC Min/Max
2.3	#7	Battery SOC Delta
2.4	#9	Drive schedule accuracy

Properties

Type: Functional

Index: 1.1

Custom ID: #2

Summary: Zero to sixty

Description Rationale

Arial 20 B I U

The time to reach 60 MPH for the WOT drive cycle shall be less than 20 seconds.

Keywords:

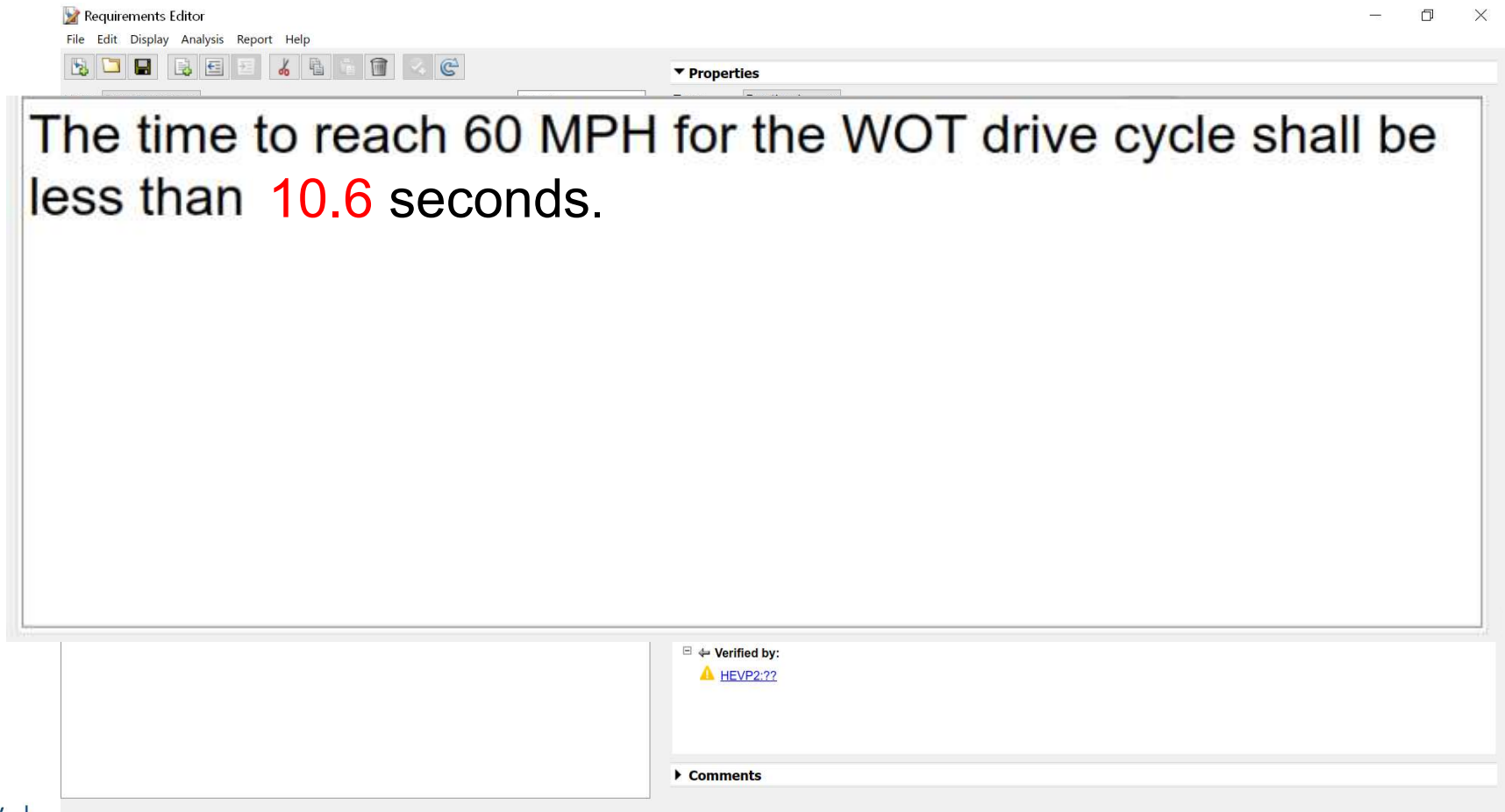
Revision information:

Links

Verified by: HEVP2:??

Comments

Temporal Requirement Change



The screenshot shows the Requirements Editor application window. The title bar reads "Requirements Editor" and the menu bar includes "File", "Edit", "Display", "Analysis", "Report", and "Help". A toolbar with various icons is visible below the menu. The main content area, titled "Properties", contains the text: "The time to reach 60 MPH for the WOT drive cycle shall be less than 10.6 seconds." The value "10.6" is highlighted in red. At the bottom right, there is a "Verified by:" field with a yellow warning triangle icon and the text "HEVP2:??". Below that is a "Comments" section with a right-pointing arrow.

Test Assessments: Formalize and execute requirements **R2019a**

Zero to Sixty

The speed shall at least reach 60MPH after 10.6 sec passes

When <condition 1> is true,
Then <condition 2> must be true for some time

Simple concept

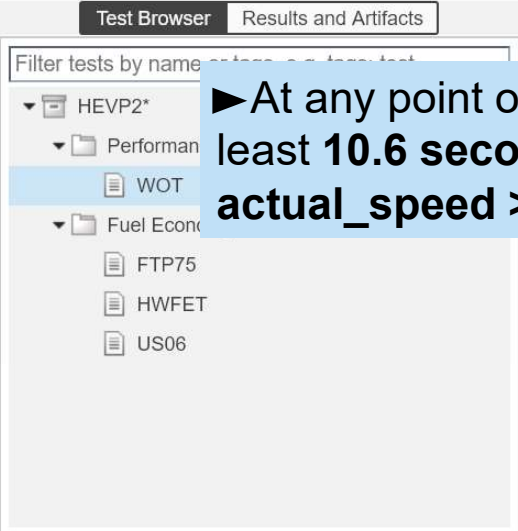
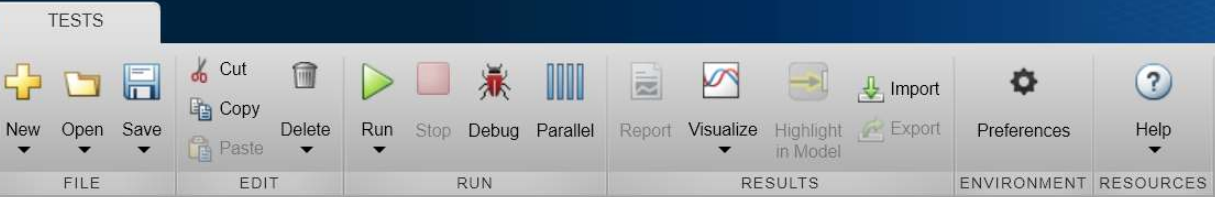
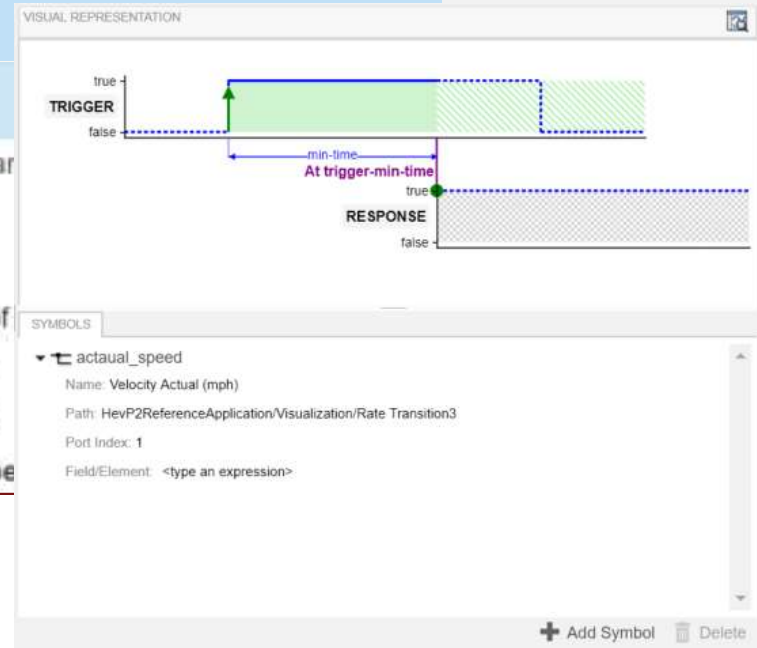
$$(|x_1 - x_2| \geq x_3)^{\varepsilon} \wedge \square_{[0,t_1)}(|x_1 - x_2| \geq x_3) \rightarrow \square_{[0,t_2)}x_4$$

Hard to formalize

MTL logic

Temporal Assessment

► At any point of time, if $tv > 0$ becomes true and stays true for at least **10.6 seconds** then, starting from end of min-time, with no delay, **actual_speed > 60** must be true



PROPERTY	VALUE
Name	WOT
Type	Simulation Test
Model	HevP2ReferenceAppli...
Simulation Mode	[Model Settings]
Location	C:\class\powertrainblo...
Enabled	<input checked="" type="checkbox"/>
Hierarchy	HEVP2 » Performance...
Tags	Type comma or space se

Temporal Assessment

Assessment1

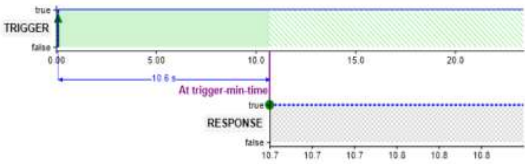
ASSESSMENT

► At any point of time, if `actual_speed > 0` becomes true and stays true for at least **10.6 seconds** then, starting from end of min-time, with no delay, `actual_speed > 60` must be true

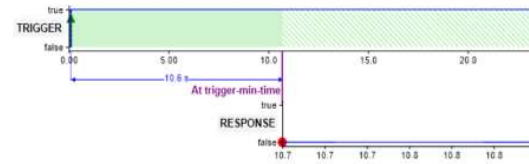
SYMBOLS

- `actual_speed`

Expected Behavior



Actual Result



Explanation

- Assessment 'Assessment1' failed when triggered at 0.1 s.
- Trigger condition '`actual_speed > 0`' is true at 0.1 s.
 - Expected response condition to be true at 10.7 s.
 - i.e. at 'end of min-time' of trigger.
 - Expected 'with no delay, `actual_speed > 60`' must be true to be true at 10.7 s, actual value is false.

EXPRESSION TREE

► Assessment1: At any point in time, if `(actual_speed > 0)` becomes true and stays true for at least 10.6 seconds then, starting from end of min-time (after 10.6 seconds has elapsed), with no delay, `(actual_speed > 60)` must be true

PLOTS

Plot showing assessment status over time (0 to 600 s):

- 0.1 s: Untested
- 0.1 s to 20 s: Fail
- 20 s to 589.3 s: Pass
- 589.3 s to 589.4 s: Untested
- 589.4 s to 600 s: Untested

Dynamic Test for HevP2Reference Application

The screenshot shows the Test Manager application window. The main area displays the configuration for a test named 'WOT'. The test is enabled and is a simulation test. The configuration includes sections for TAGS, DESCRIPTION, REQUIREMENTS*, SYSTEM UNDER TEST*, PARAMETER OVERRIDES*, CALLBACKS, INPUTS, SIMULATION OUTPUTS*, CONFIGURATION SETTINGS OVERRIDES, ITERATIONS*, LOGICAL AND TEMPORAL ASSESSMENTS, CUSTOM CRITERIA*, and COVERAGE SETTINGS*.

Test Browser

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

- HEVP2*
 - Performance
 - WOT**
 - Fuel Economy

PROPERTY VALUE

PROPERTY	VALUE
Name	WOT
Type	Simulation Test
Model	HevP2ReferenceApplication
Simulation Mode	[Model Settings]
Location	C:\class\powertrainblockset...
Enabled	<input checked="" type="checkbox"/>
Hierarchy	HEVP2 » Performance » W...

WOT Enabled

HEVP2 » Performance » WOT

Simulation Test

Select releases for simulation:

Create Test Case from External File

▶ TAGS

▶ DESCRIPTION

▶ REQUIREMENTS*

▶ SYSTEM UNDER TEST* ?

▶ PARAMETER OVERRIDES* ?

▶ CALLBACKS ?

▶ INPUTS ?

▶ SIMULATION OUTPUTS* ?

▶ CONFIGURATION SETTINGS OVERRIDES ?

▶ ITERATIONS* ?

▶ LOGICAL AND TEMPORAL ASSESSMENTS ?

▶ CUSTOM CRITERIA* ?

▶ COVERAGE SETTINGS* ?

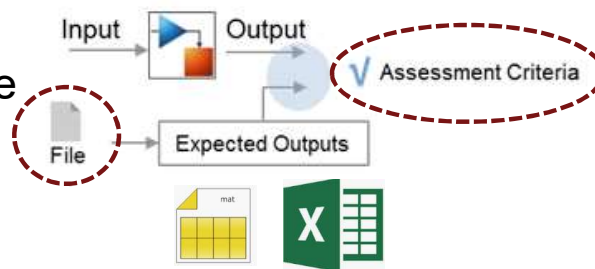
Dynamic Test 1 - Fuel Economy

- Requirement

- The average fuel economy at the end of the drive profile shall be 32 MPG.
- The battery state of charge shall be greater than 20% and less than 90% for the entire drive cycle
- The absolute value of the difference between the battery state of charge at the start of the drive profile and the end of the drive cycle shall be less than 1%.
- The actual vehicle speed shall be no more than 2 mph greater than the scheduled vehicle speed within 1 second of the given time.

- Configuration

- Test Template
- Test Measureme
 - Target Speed
 - Actual Speed
 - SOC
 - MPG



```

CUSTOM CRITERIA*
[ ] function customCriteria(test)
  Perform custom criteria analysis on test results
1 mpgTest.customCriteria(test);
2
    
```



```
function customCriteria(test)
    fuelEconomy = test.sltest_simout.logout.get(1).Values.Data;
    soc = test.sltest_simout.logout.get(2).Values.Data;

    % Requirement : Average fuel economy
    test.verifyGreaterThan(fuelEconomy(end), 32, 'Fuel Economy');

    % Requirement : SOC Min/Max
    soc_min = min(soc);
    test.verifyGreaterThan(soc_min, 20, 'Min of SOC');

    soc_max = max(soc);
    test.verifyLessThan(soc_max, 90, 'Max of SOC');

    % Requirement : SOC delta
    test.verifyLessThan(abs(soc(end)-soc(1)), mpgTest.SOC_DELTA, 'State of Charge Delta');
```

Printed at the Test Report
as Test Case Title

```
1 mpgTest.customCriteria(test);
2
```

PROPER

Name	
Type	Baseline Test
Model	HevP2ReferenceAppli...
Simulation Mode	[Model Settings]
Location	C:\class\powertrainblo...
Enabled	<input checked="" type="checkbox"/>
Hierarchy	HEVP2 » Fuel Econo...
Tags	Type comma or space sej

Dynamic Test for HevP2Reference Application

The screenshot displays the Test Manager application window. The interface is divided into several sections:

- TESTS:** A menu bar at the top with options like New, Open, Save, Cut, Copy, Delete, Run, Stop, Debug, Parallel, Report, Visualize, Highlight in Model, Export, Preferences, and Help.
- Test Browser:** A tree view on the left showing a hierarchy of tests: HEVP2* > Performance > WOT, and HEVP2* > Fuel Economy > FTP75 (selected), HWFET, and US06.
- Property Table:** A table at the bottom left showing properties for the selected test:

PROPERTY	VALUE
Name	FTP75
Type	Baseline Test
Model	HevP2ReferenceApplication
Simulation Mode	[Model Settings]
Location	C:\class\powertrain\blockset...
Enabled	<input checked="" type="checkbox"/>
Hierarchy	HEVP2 » Fuel Economy » ...
- FTP75 Configuration:** The main right-hand pane shows the configuration for the selected test:
 - FTP75** (Enabled)
 - Path: HEVP2 » Fuel Economy » FTP75
 - Type: Baseline Test
 - Select releases for simulation: Current
 - Create Test Case from External File
 - REQUIREMENTS*:** A list of requirements including:
 - Average fuel economy (SystemRequirements#5)
 - Battery SOC Delta (SystemRequirements#7)
 - Drive schedule accuracy (SystemRequirements#9)
 - SYSTEM UNDER TEST*:**
 - Model: HevP2ReferenceApplication
 - TEST HARNESS
 - SIMULATION SETTINGS OVERRIDES
 - PARAMETER OVERRIDES
 - CALLBACKS*

Key Takeaway

- Verification and Validation Process for Powertrain System
- Flexible and Automatic Verification and Validation
- Various Range of Applications

The screenshot displays three overlapping windows from the MathWorks software suite:

- Test Manager:** Shows a hierarchical tree of tests under 'req_based_testing', including 'Integration tests', 'Follow Mobile Guidance', 'WP Guidance tests', and 'Circle Guidance'.
- Requirements Editor:** Shows a 'Requirements' view with a tree structure containing 'SystemLevelRequirements' and 'electricUAVReqs'. The 'Properties' pane on the right shows details for a requirement: Type: Functional, Index: 1.3.1, Custom ID: GDNC_1, and Summary: Waypoint Traversal.
- Simulation Diagram:** A block diagram titled 'req_based_testing' showing the system architecture. It includes blocks for 'Environment', 'Longitudinal Driver', 'Controllers', and 'Passenger Car'. Signal lines connect these components, with labels like 'RWS', 'RHS', 'LH', 'RH', '23021', '23022', '23023', and '23024'. A text box on the right explains: 'All follow a given set of waypoints by the use of a ground control station in triads of longitude, and height.'

Thank you!