

MATLAB EXPO 2019

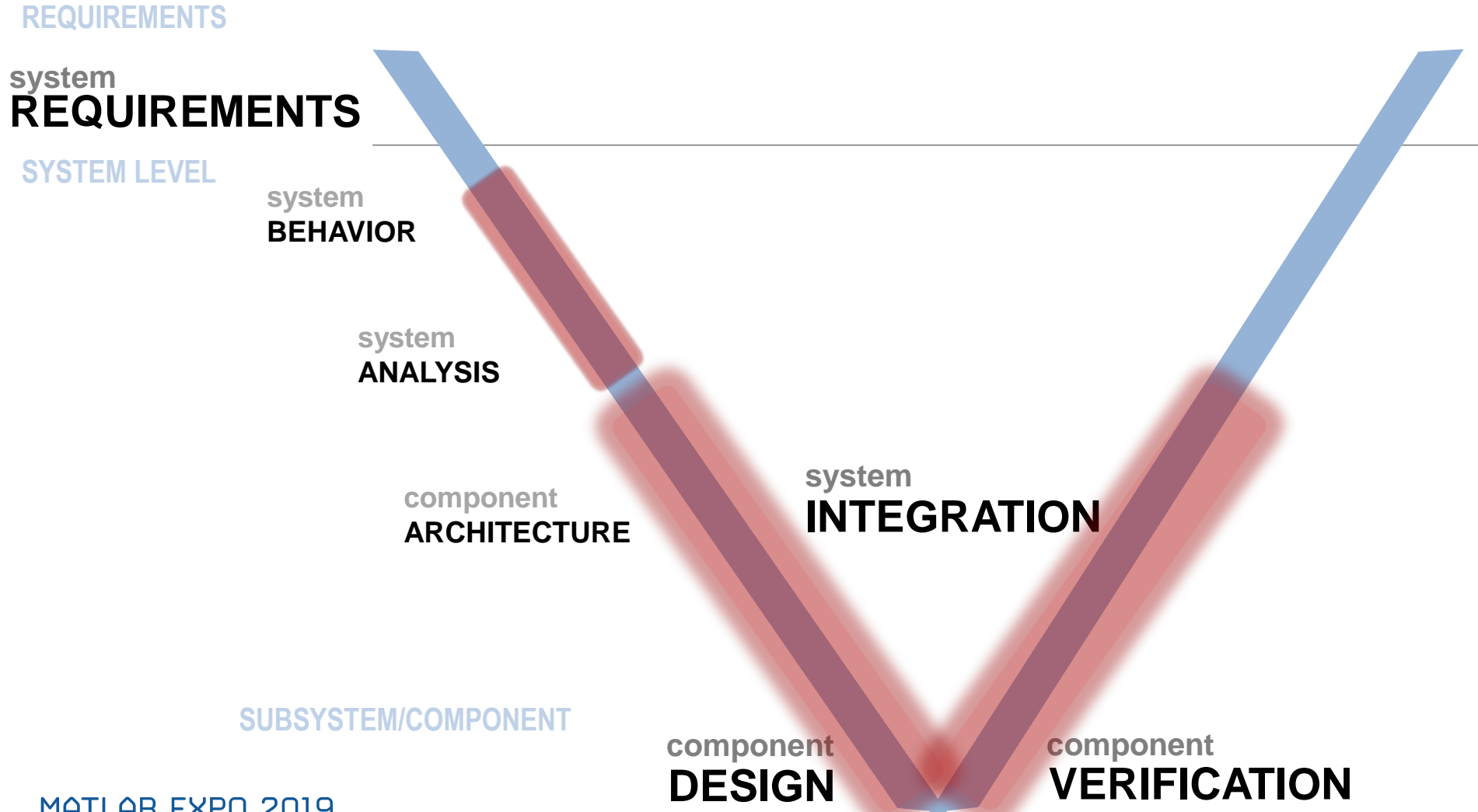
Simulink 기반 Legacy C/C++
Code 통합, 결과 시각화 및 검증
방안

유성재



Model-Based Design

Systematic use of models **throughout** the development process



Legacy Code? Hand-written code?

```

template<class InputString, class Out
bool unhexlify(const InputString& in
    if (input.size() % 2 != 0) {
        return false;
    }
    output.resize(input.size() / 2);
    int j = 0;
    auto unhex = [](char c) -> int {
        return c >= '0' && c <= '9' ? c - '0' :
            c >= 'A' && c <= 'F' ? c - 'A' + 10 :
            c >= 'a' && c <= 'f' ? c - 'a' + 10 :
                -1;
    };
    for (size_t i = 0; i < input.size(); i += 2) {
        int highBits = unhex(input[i]);
        int lowBits = unhex(input[i + 1]);
        if (highBits < 0 || lowBits < 0) {
            return false;
        }
        output[j++] = (highBits << 4) + lowBits;
    }
    return true;
}
    
```

Hand Code

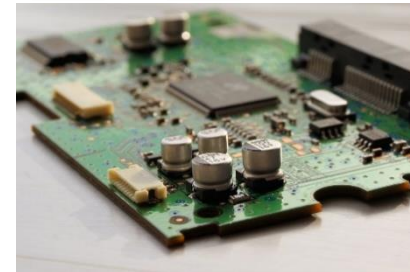
Components Under Development

Internal Libraries



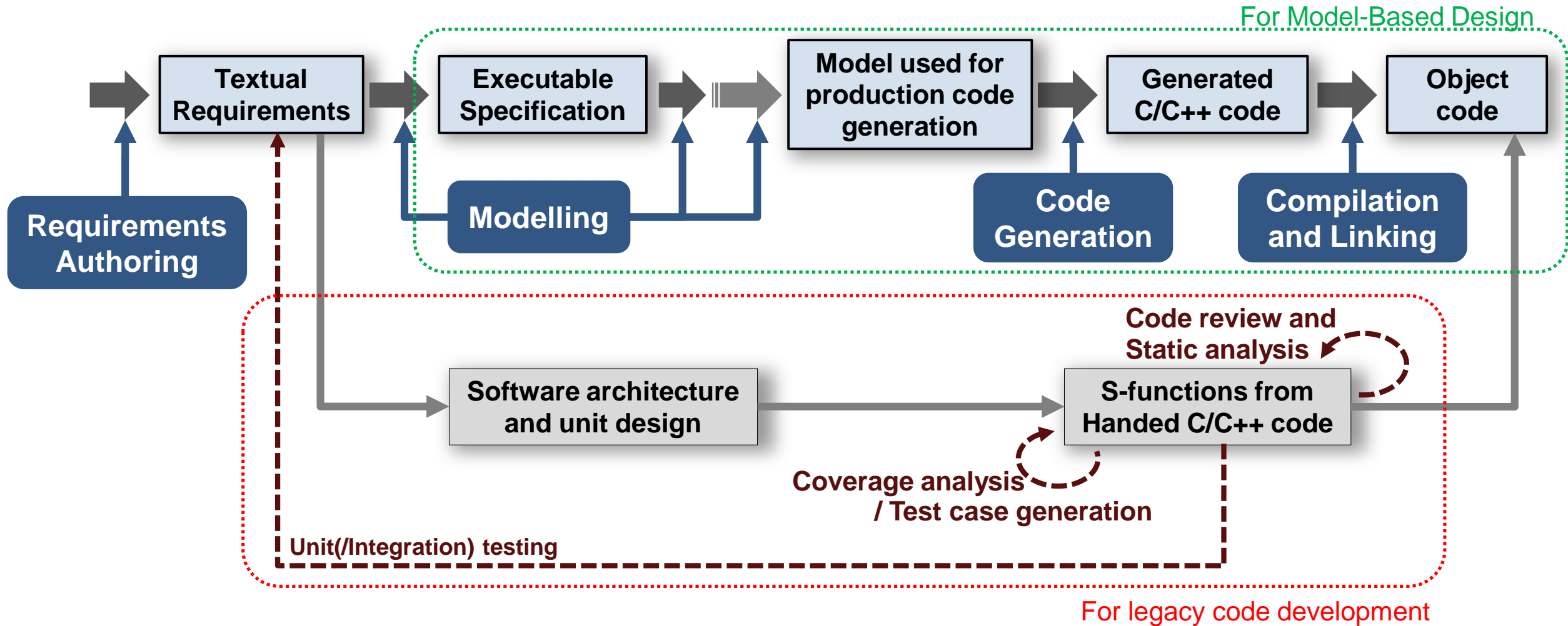
Verified Components

Vendor Libraries

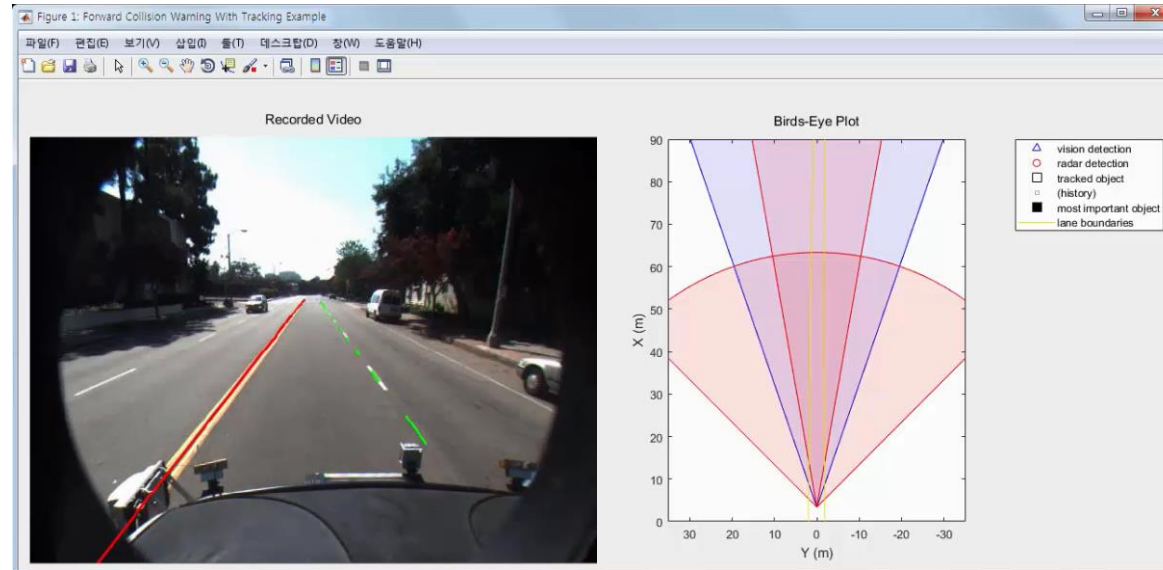
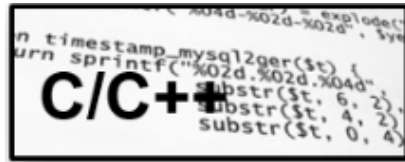


Device Drivers

MBD with Legacy Code!



Challenge?



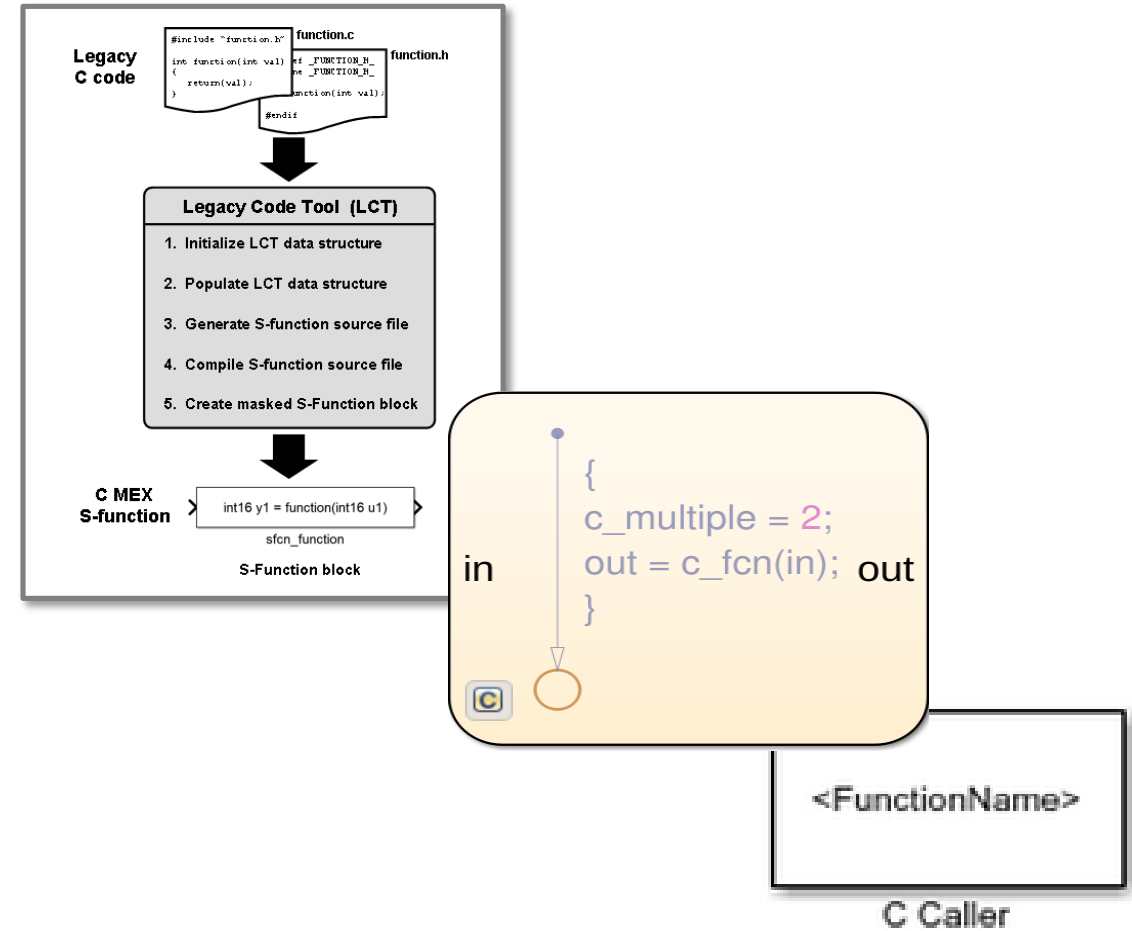
| File Contents/Complexity | Test 1 | | | | |
|---|----------|-----------|----------|---------------|------|
| | Decision | Statement | Function | Function call | |
| 1. mExportFunction.c | 4 100% | 100% | 100% | 100% | 100% |
| 2. ... function1 | 2 100% | 100% | 100% | 100% | -- |
| 3. ... mExportFunction_initialize | 1 -- | 100% | 100% | 100% | 100% |
| 4. ... mExportFunction_terminate | 1 -- | 100% | 100% | 100% | -- |

Agenda

- **Legacy code integration using Simulink**
- Visualization using Simulink
- Verification with legacy code

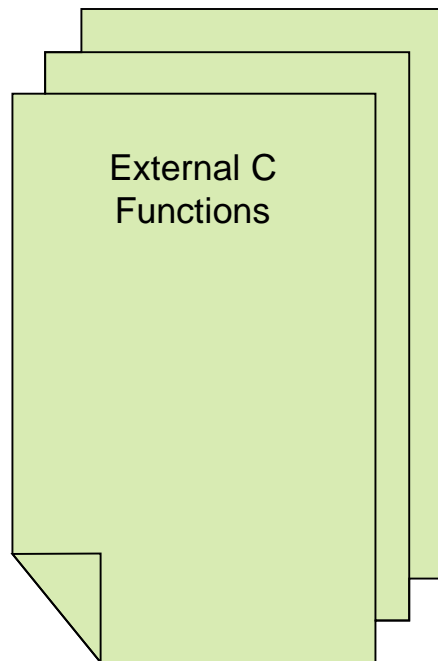
How to Import Legacy Code

- Legacy Code Tool
- Legacy code integration in Stateflow
- C Caller Block

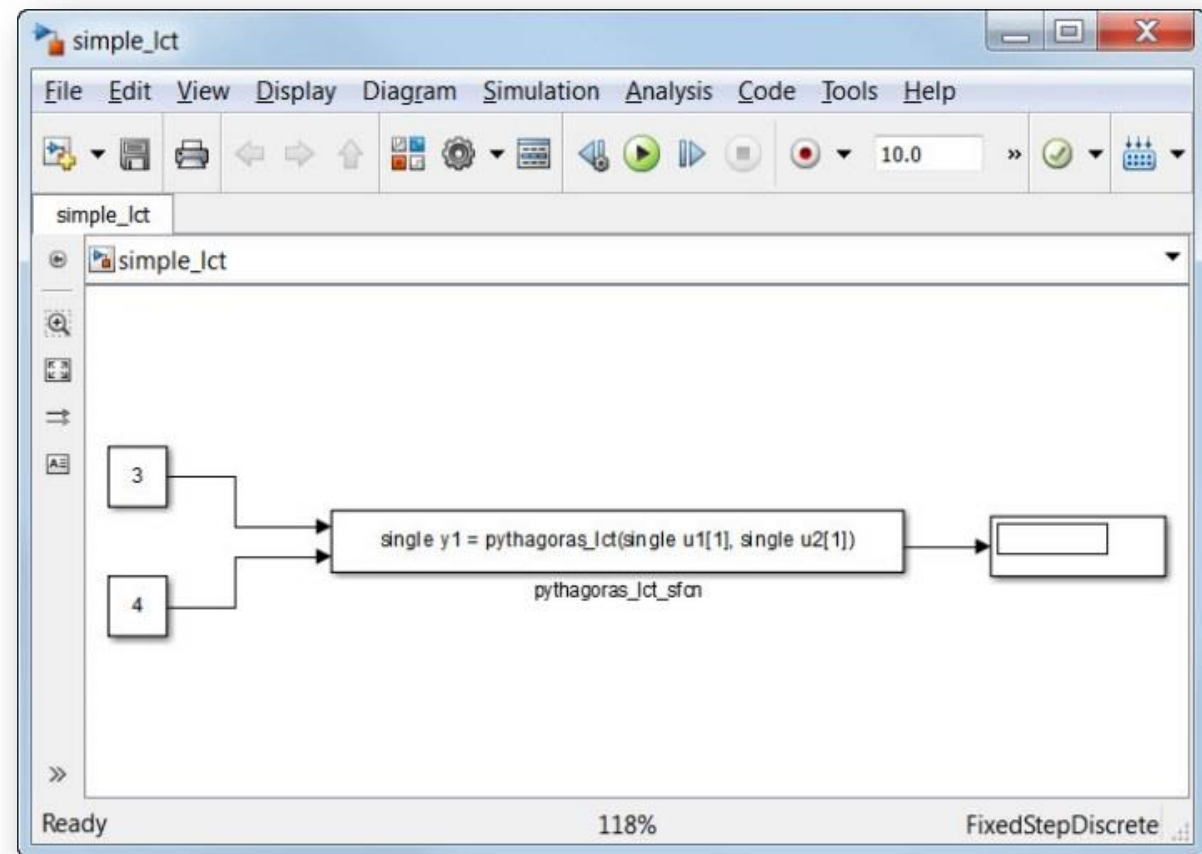


What legacy C code integration in Simulink means?

- Legacy Code Tool enables existing C code to be used in Simulink models

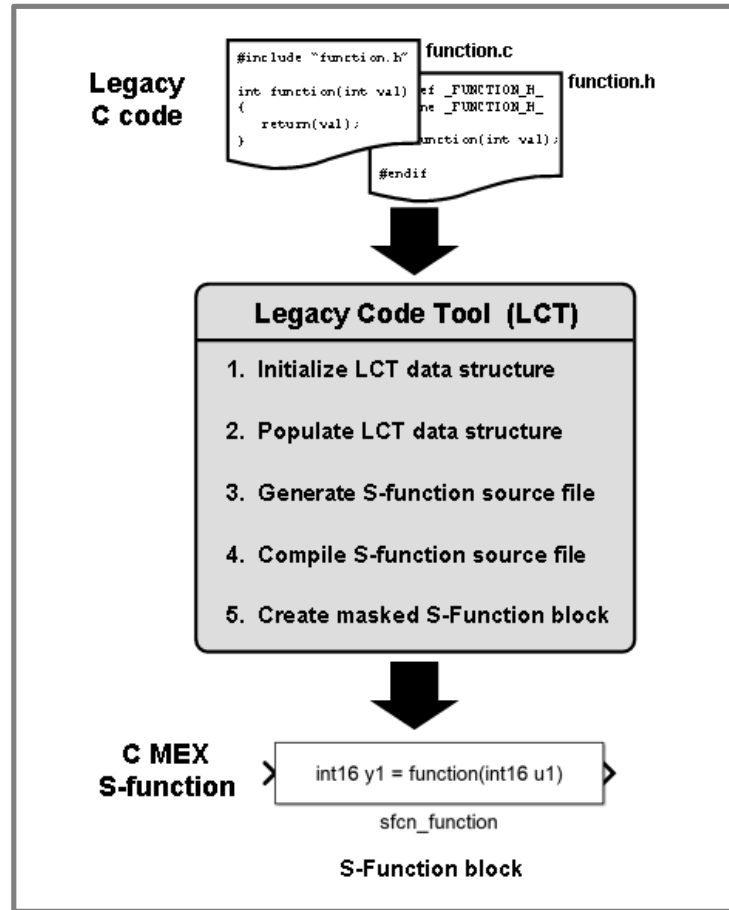


Generating
S-function

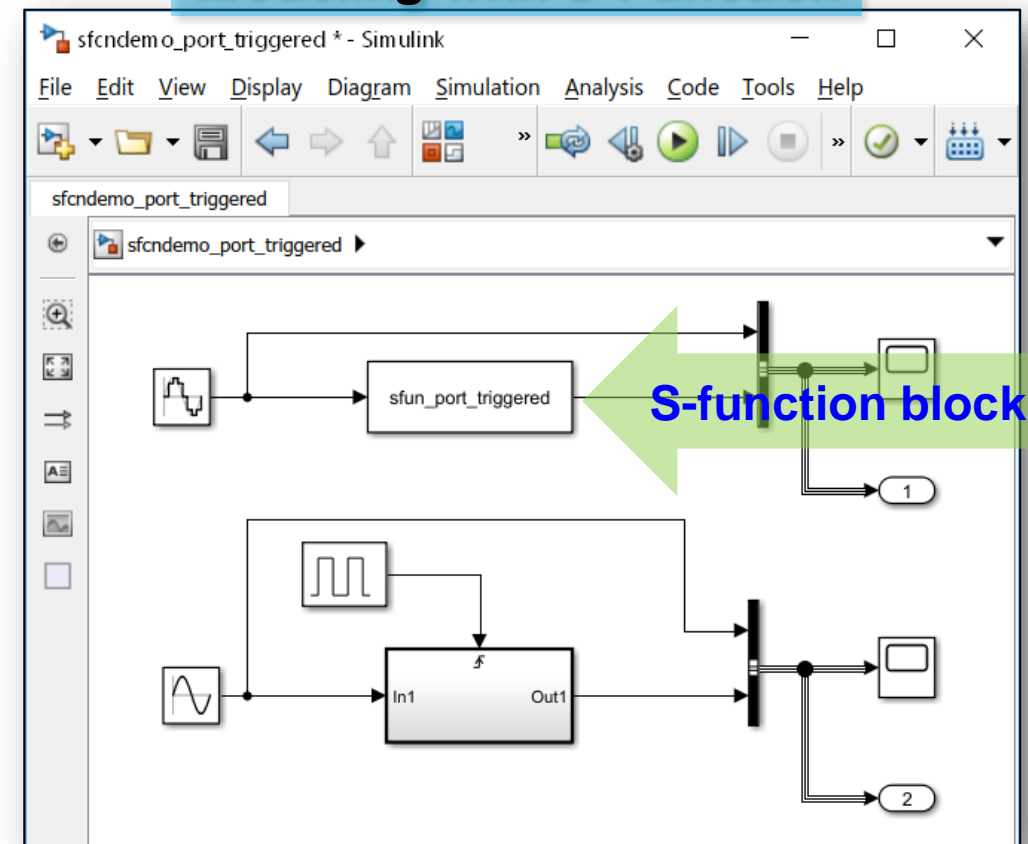


How to use Legacy Code Tool?

- General procedure for using Legacy Code Tool



Modeling with S-Function



Maintenance Problem...

Legacy code

```

/*cruise controller main runnable*/
void CrsCtrlerMain(void)
{
    boolean_t l_ulIncSetLong;
    boolean_t l_ulDecSetLong;

    /* setting increase button is pressed for long time */
    if (ulIncSw == TRUE)
    {
        if (u8IncCnt >= 50)
        {
            l_ulIncSetLong = TRUE;
        }
        else
        {
            u8IncCnt = u8IncCnt + 1;
            l_ulIncSetLong = FALSE;
        }
    }
    else
    {
        u8IncCnt = 0U;
        l_ulIncSetLong = FALSE;
    }

    /* setting decrease button is pressed */
    if (ulDecSw == TRUE)
    {
        if (u8DecCnt >= 50)
        {
            l_ulDecSetLong = TRUE;
        }
        else
        {
            u8DecCnt = u8DecCnt + 1;
            l_ulDecSetLong = FALSE;
        }
    }
    else
    {
        u8DecCnt = 0U;
        l_ulDecSetLong = FALSE;
    }
}
    
```

Wrapper code

```

#include "CrsCtrl_Wrapper.h"

void CrsCtrl(boolean_t u1, boolean_t u2, boolean_t u3, boolean_t u4, boolean_t u5, boolean_t u6,
            uint16_t u7, uint8_t u8, uint8_t u9, int32_t u10, int32_t u11,
            uint8_t *y1, boolean_t *y2, uint8_t *y3, int32_t *y4, int32_t *y5)
{
    u1Enb1Sw = u1;
    u1Cnc1Sw = u2;
    u1SetSw = u3;
    u1ResumeSw = u4;
    u1IncSw = u5;
    u1DecSw = u6;
    s16BrakeP = u7;
    u8Key = u8;
    u8Gear = u9;
    s32ThrotDrv = u10;
    s32VehSpd = u11;

    CrsCtrlerMain();

    *y1 = enumReqDrvOut;
    *y2 = u1StatusOut;
    *y3 = enumModeOut;
    *y4 = s32TargetSpdOut;
    *y5 = s32ThrotCcrOut;
}
    
```

Script file

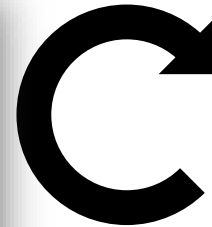
```

def.SourceFiles = {'CrsCtrl_Wrapper.c', 'CruiseCtrlr.c'};
def.HeaderFiles = {'CrsCtrl_Wrapper.h', 'CruiseCtrlr.h'};
def.IncPaths = {[defaultDir, '%files#legacycode'}];
def.SrcPaths = {[defaultDir, '%files#legacycode'}];

%def.StartFcnSpec = 'void sbr_initialize(void)';

def.OutputFcnSpec = ['void CrsCtrl(boolean_t u1, boolean_t u2, boolean_t u3, boolean_t u4, boolean_t u5, boolean_t u6,...
                    'int16_t u7, uint8_t u8, uint8_t u9, int32_t u10, int32_t u11,...
                    'uint8_t y1[1], boolean_t y2[1], uint8_t y3[1], int32_t y4[1], int32_t y5[1]'];

def.Options.supportCoverageAndDesignVerifier = true; %necessary for code coverage analysis and test case generation
def.Options.isMacro = true;
% Generate the C-MEX S-function
legacy_code('sfcn_cmex_generate', def);
legacy_code('rtwmakecfg_generate', def);
    
```



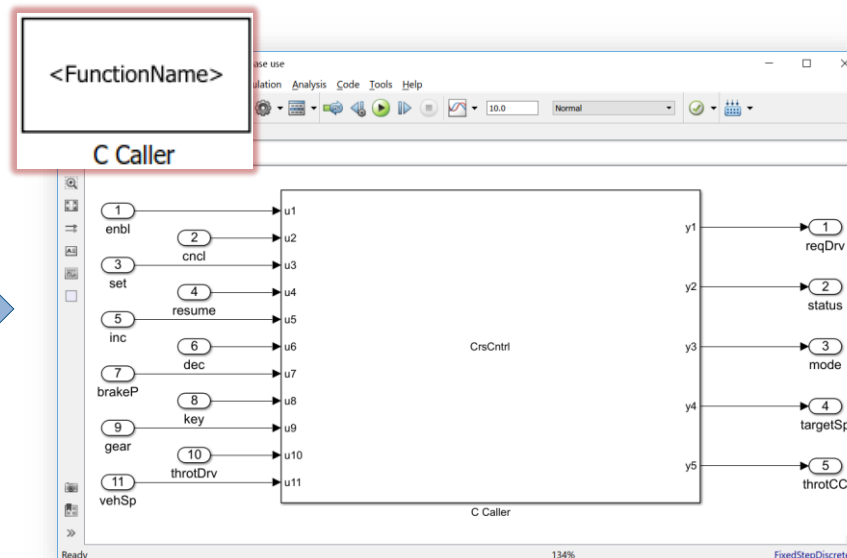
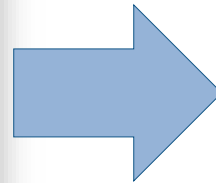
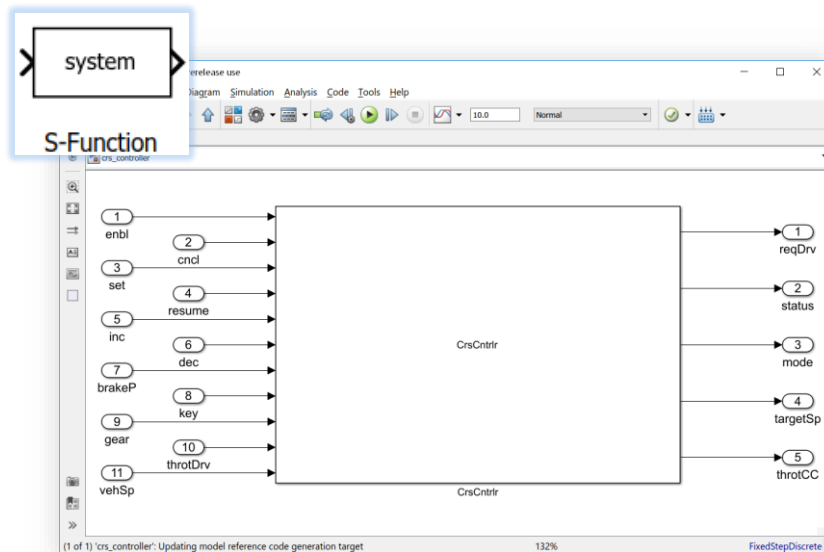
If any changes in code

Modeling

The top screenshot shows a Simulink model window titled 'untitled * - Simulink prerelease use'. It displays a block diagram with a 'CrsCtrlr' block. The bottom screenshot shows the MATLAB script file 'crs_controller' being used for code generation. The script file defines the block's inputs and outputs, including 'enbl', 'cnc1', 'set', 'resume', 'inc', 'dec', 'brakeP', 'key', 'gear', 'throtDrv', 'vehSp', 'reqDrv', 'status', 'mode', 'targetSp', and 'throtCC'.

Introducing C Caller Block

C Caller Block makes it easier to call C Functions in Simulink
→ It works for simulation and Code Generation

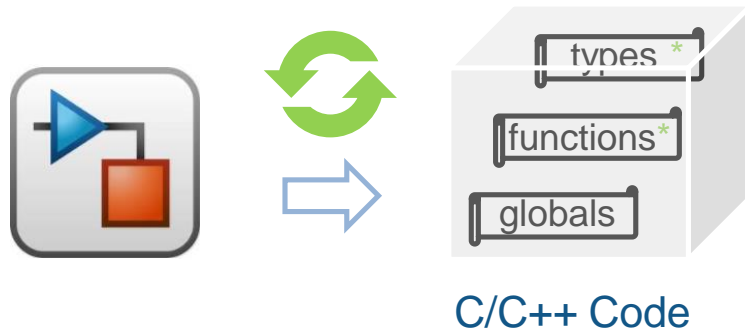


Key Features

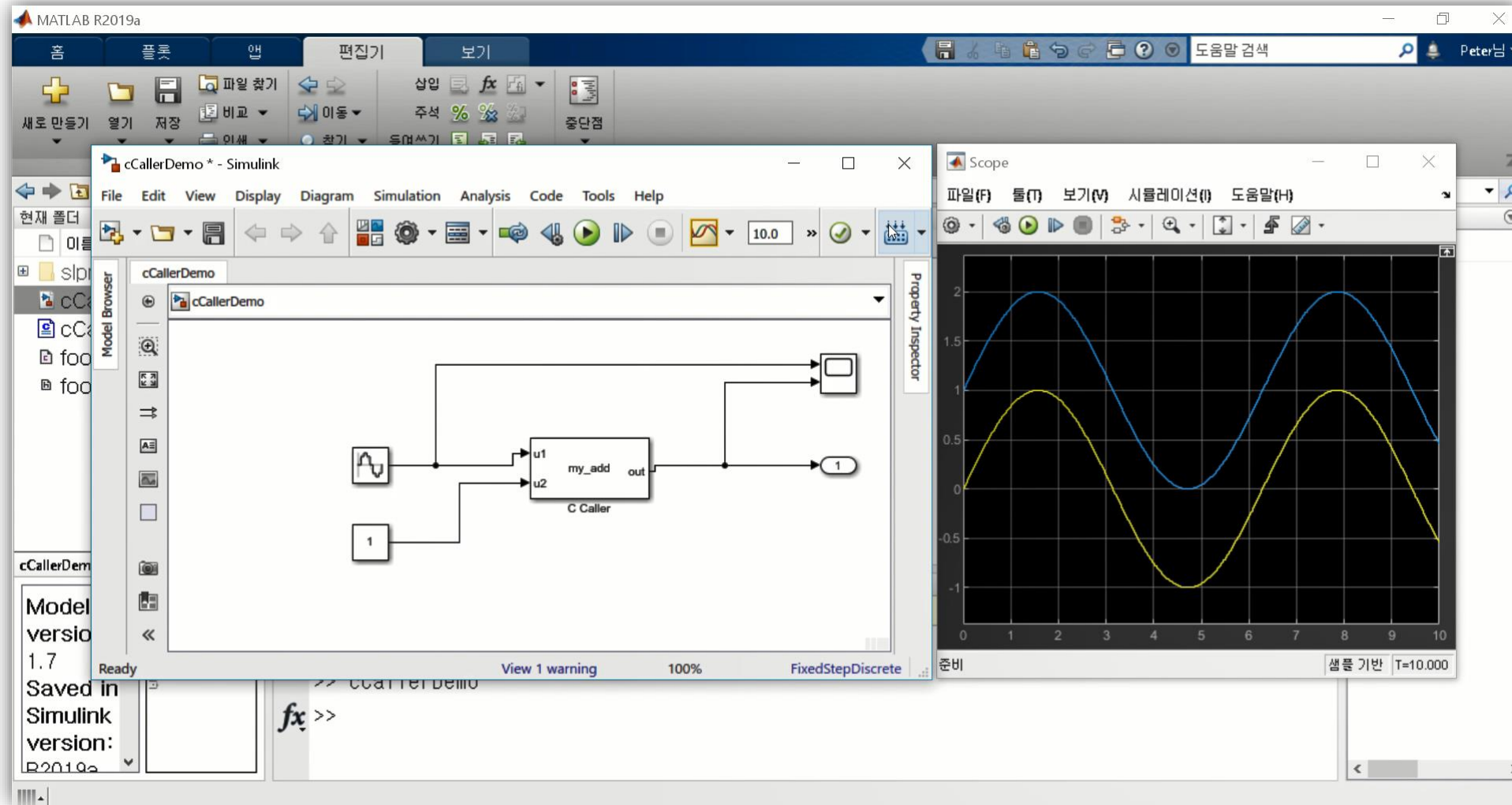
- Automate the process



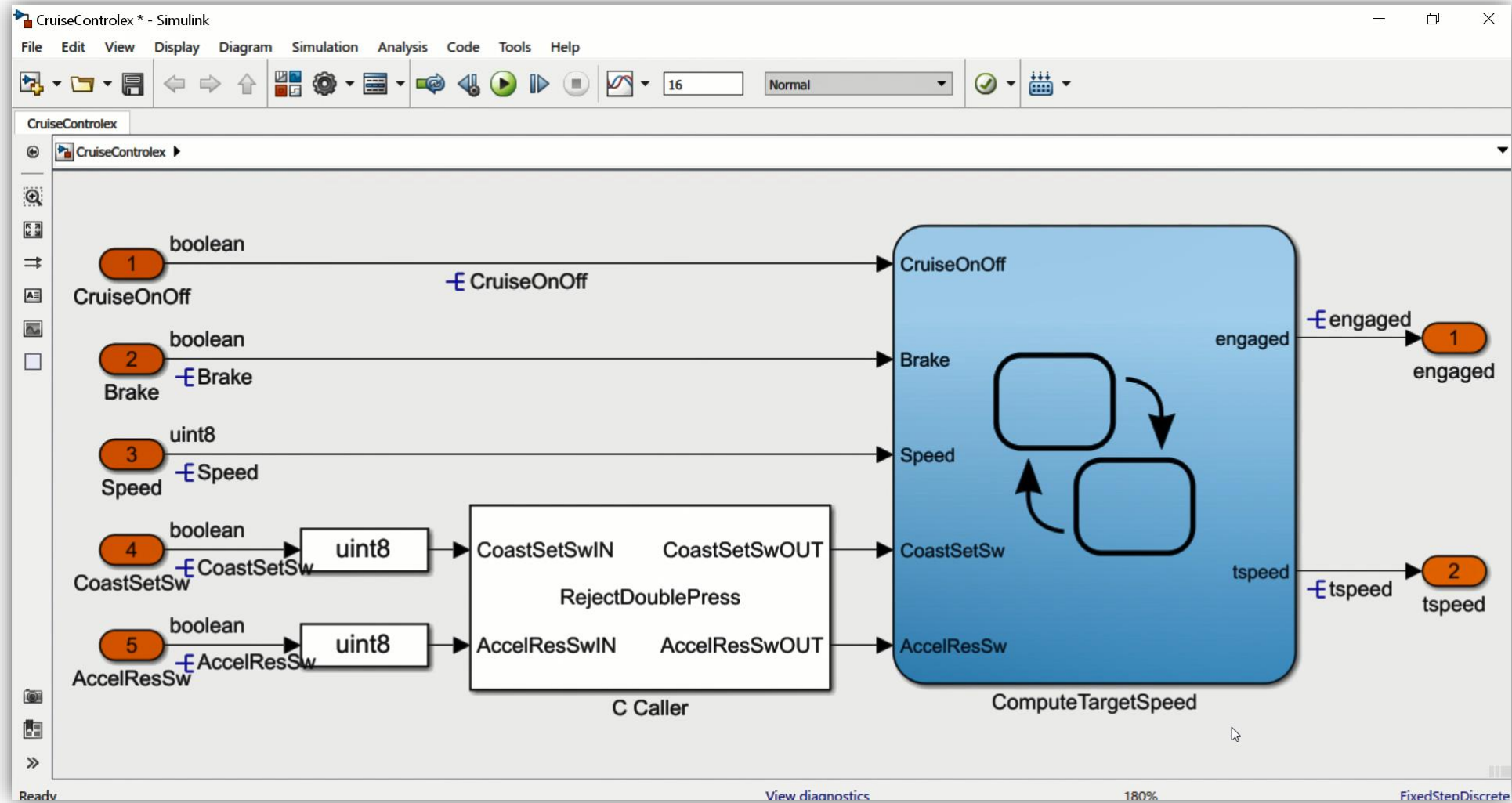
- Synchronize with custom code changes



Demo: Simple C Caller



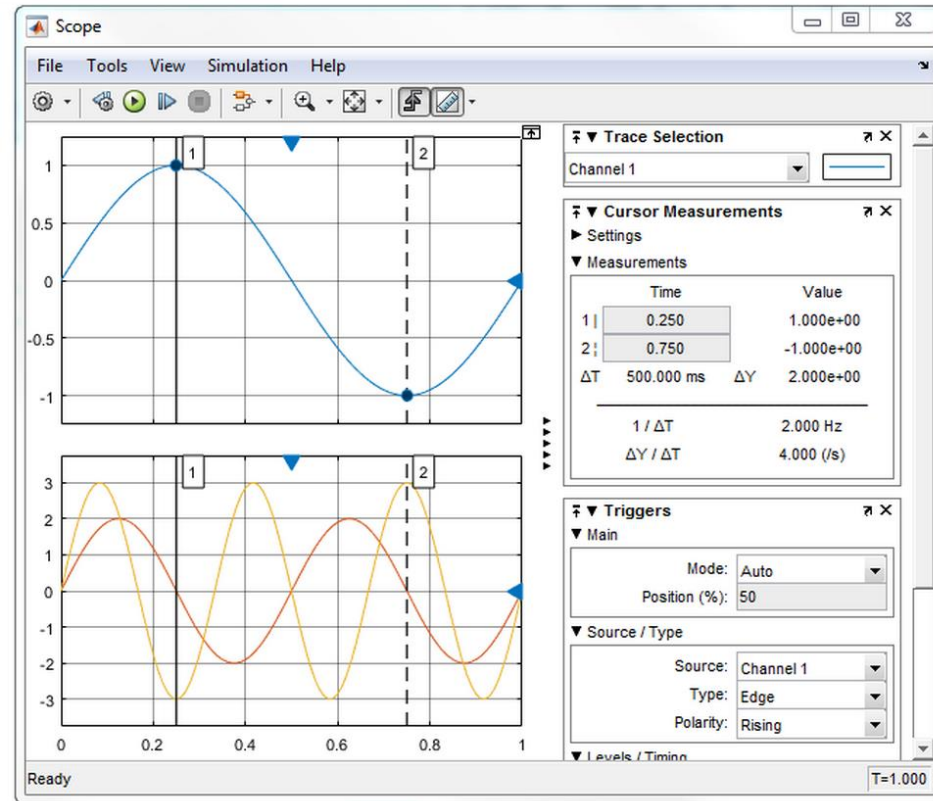
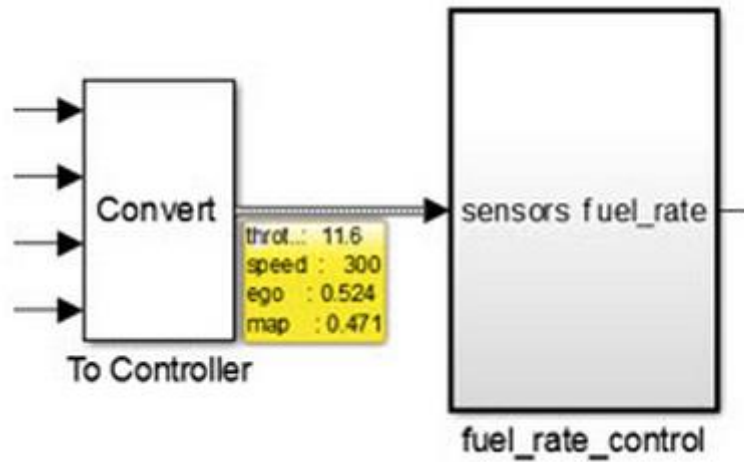
Demo: Integrate C code with Simulink Model



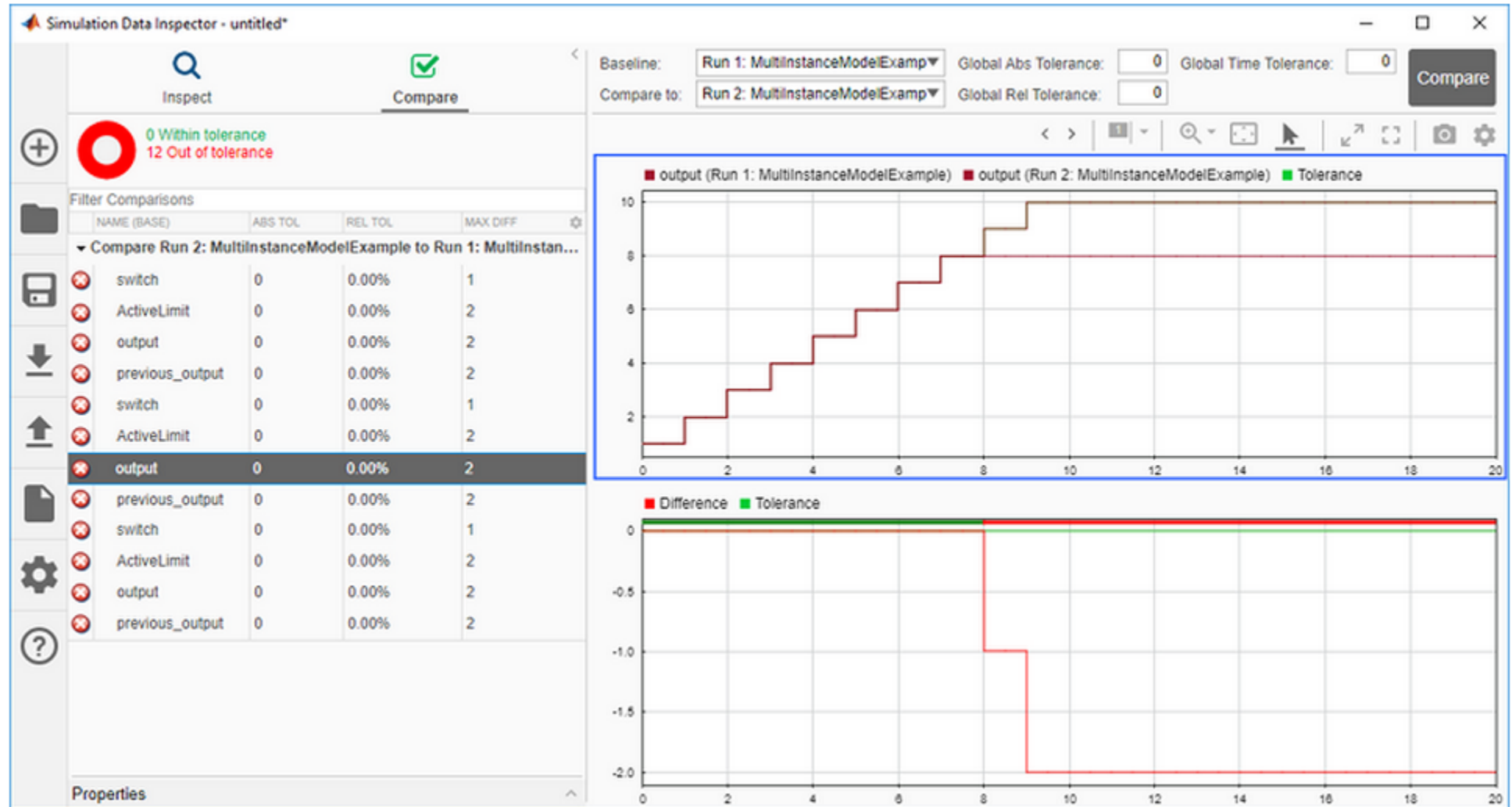
Agenda

- Legacy code integration using Simulink
- **Visualization using Simulink**
- Verification with legacy code

Visualize Simulation Data

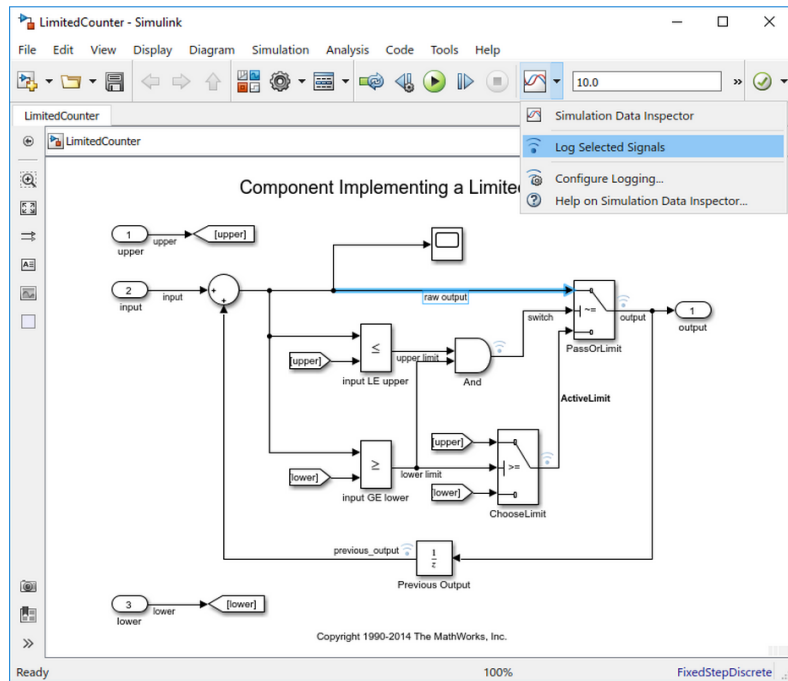


Visualize Simulation Data



Visualize Simulation Data

1



2

Configuration Parameters: MultiInstanceModelExample/Configuration (Active)

Search

Solver

Data Import/Export

Math and Data Types

Diagnostics

Hardware Implementation

Model Referencing

Simulation Target

Load from workspace

Input: [t, u]

Initial state: xinitial

Connect Input

Save to workspace or file

Time: tout

States: xout

Output: yout

Final states: xFinal

Signal logging: logsOut

Data stores: dsmout

Log Dataset data to file: out.mat

Single simulation output: out

Format: Structure with time

Save complete SimState in final state

Configure Signals to Log...

Logging intervals: [-inf, inf]

Simulation Data Inspector

Record logged workspace data in Simulation Data Inspector

Additional parameters

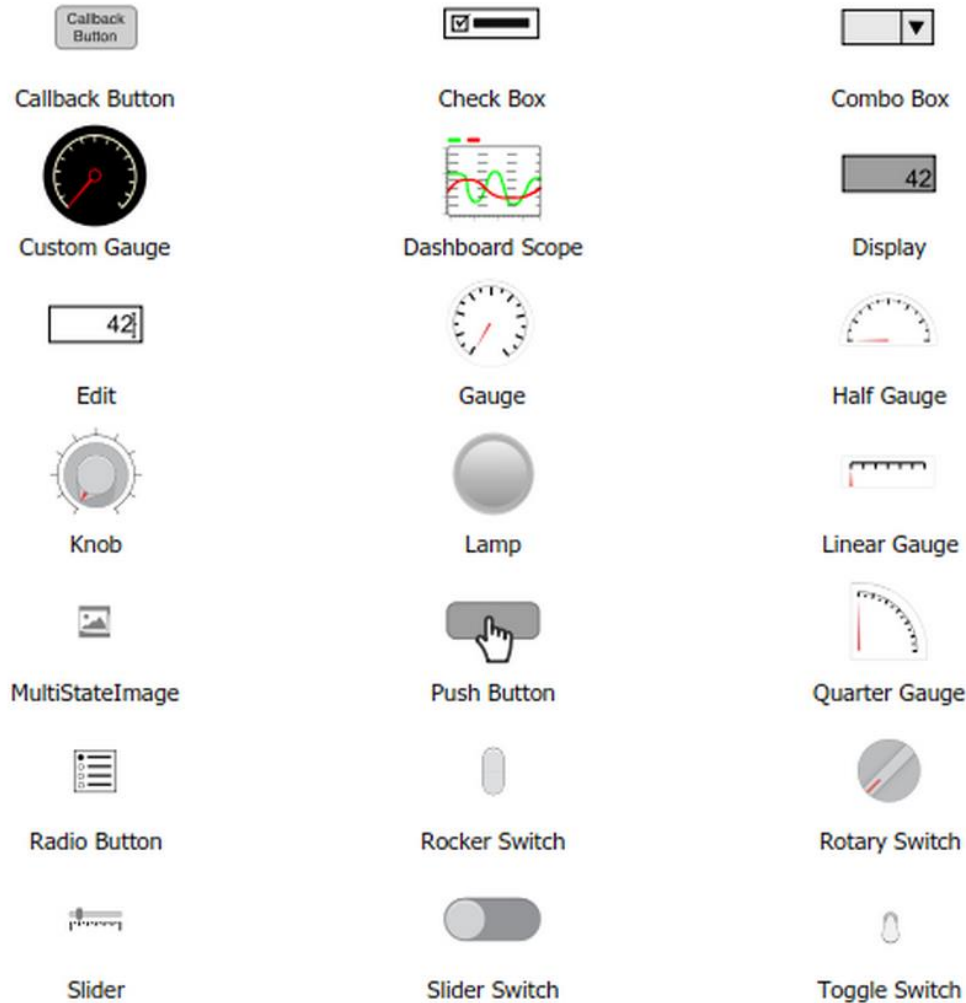
OK Cancel Help Apply

3

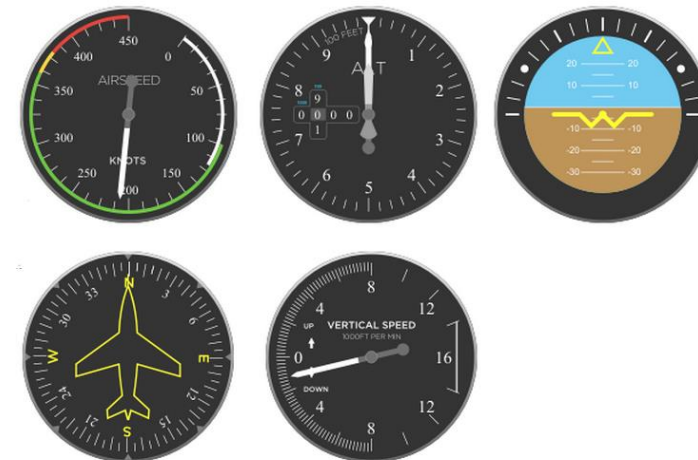
Help

20

Tune and Visualize Your Model with Dashboard Blocks

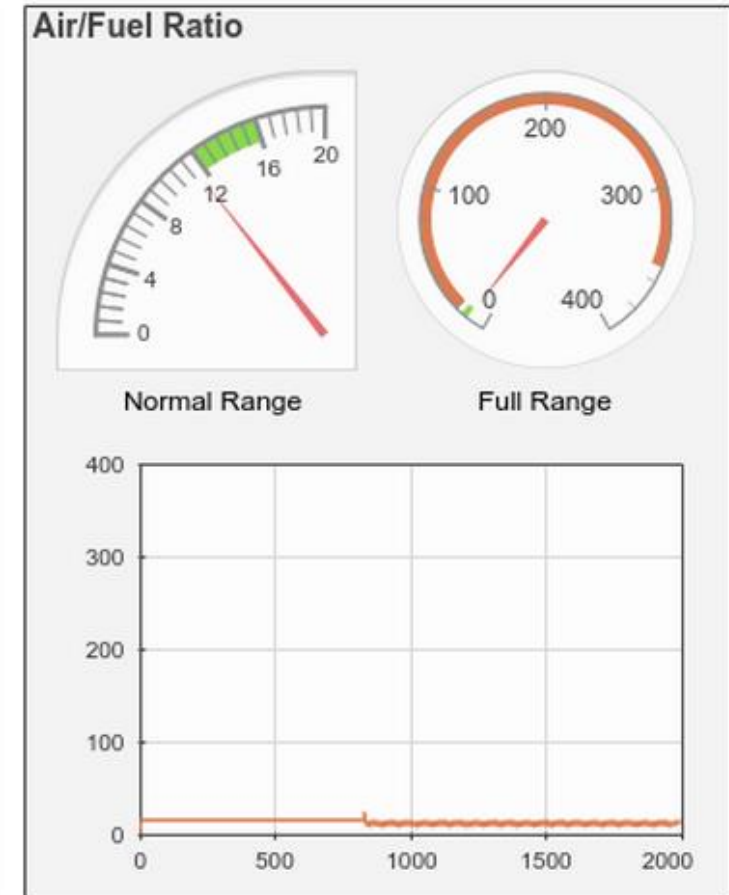
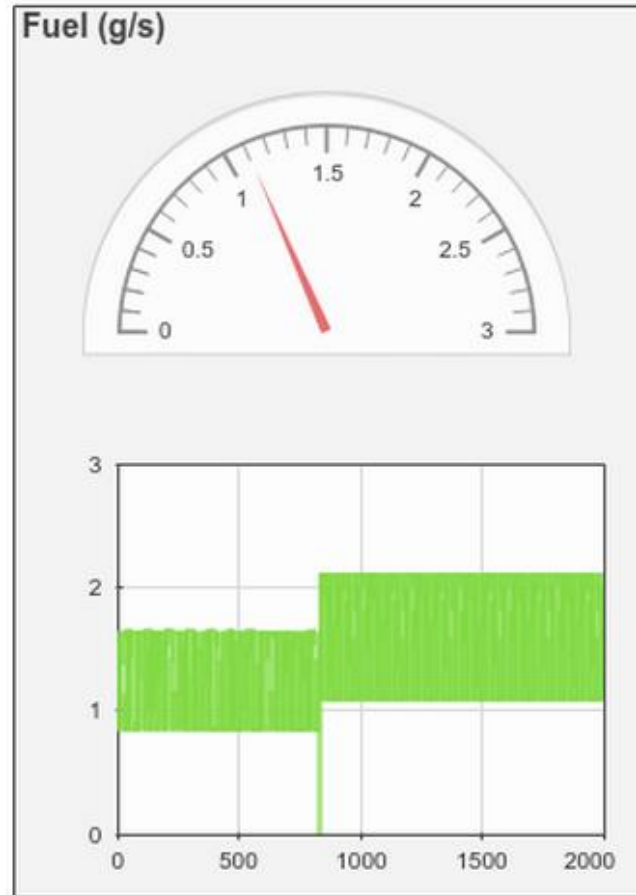
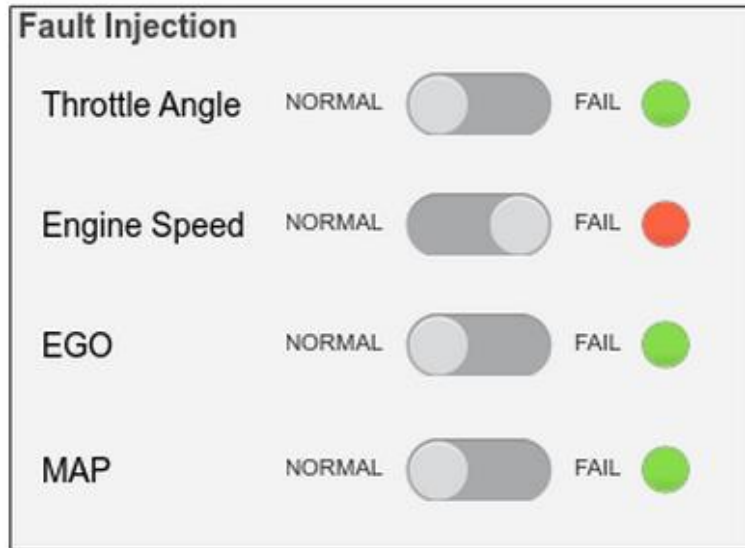


Custom Gauge

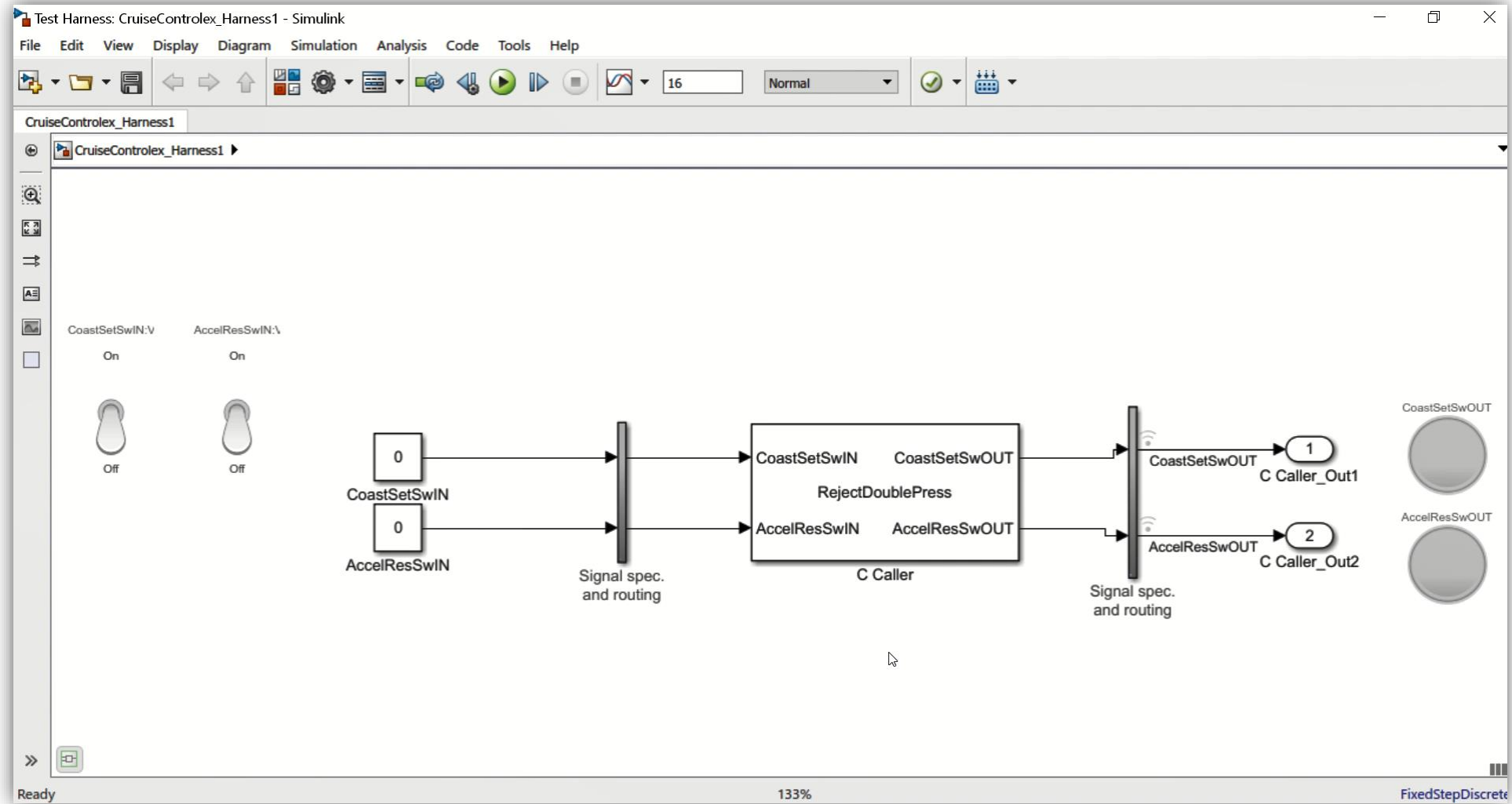


Flight Instrument Gauges
- Aerospace Blockset -

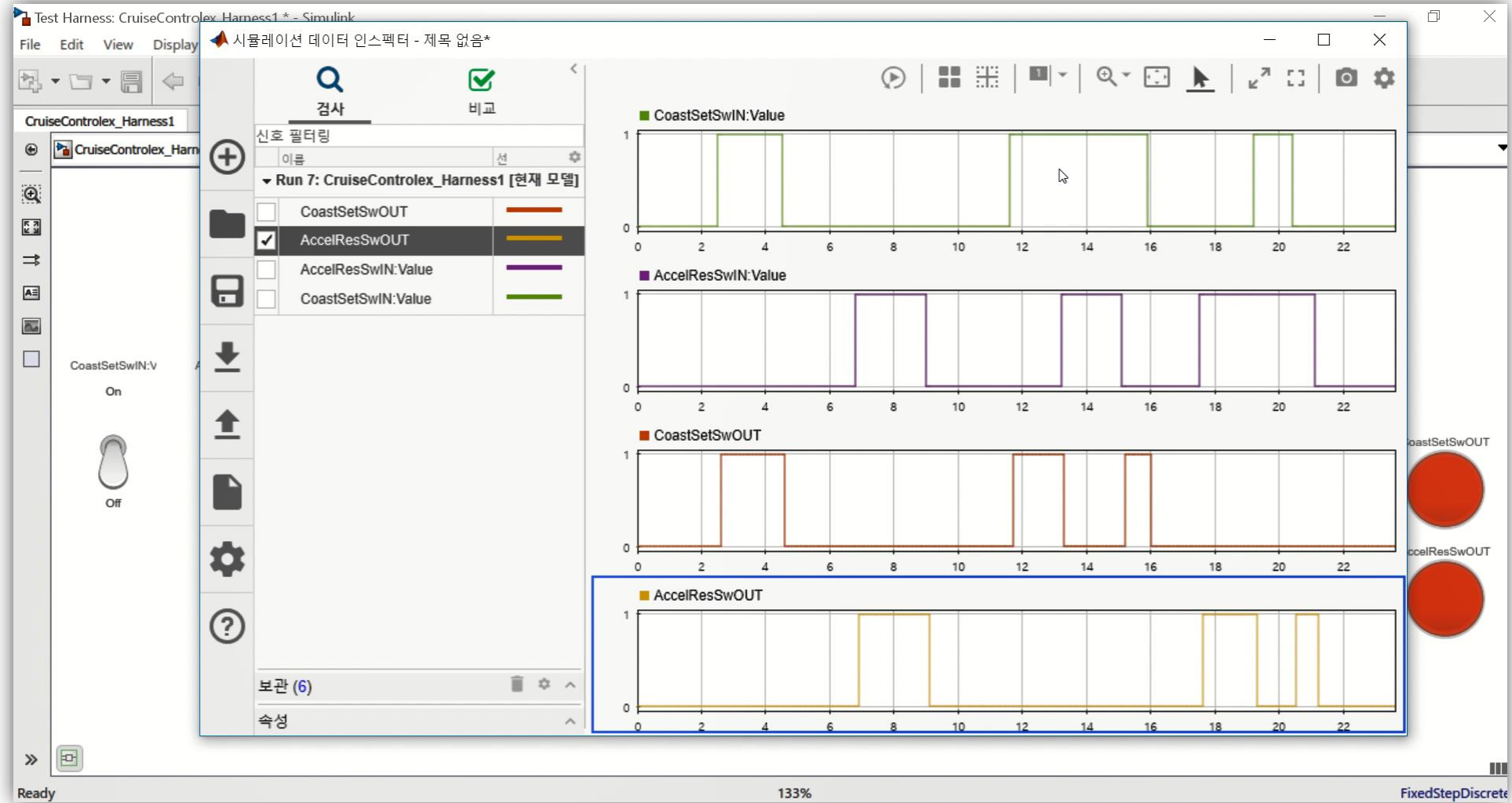
Tune and Visualize Your Model with Dashboard Blocks



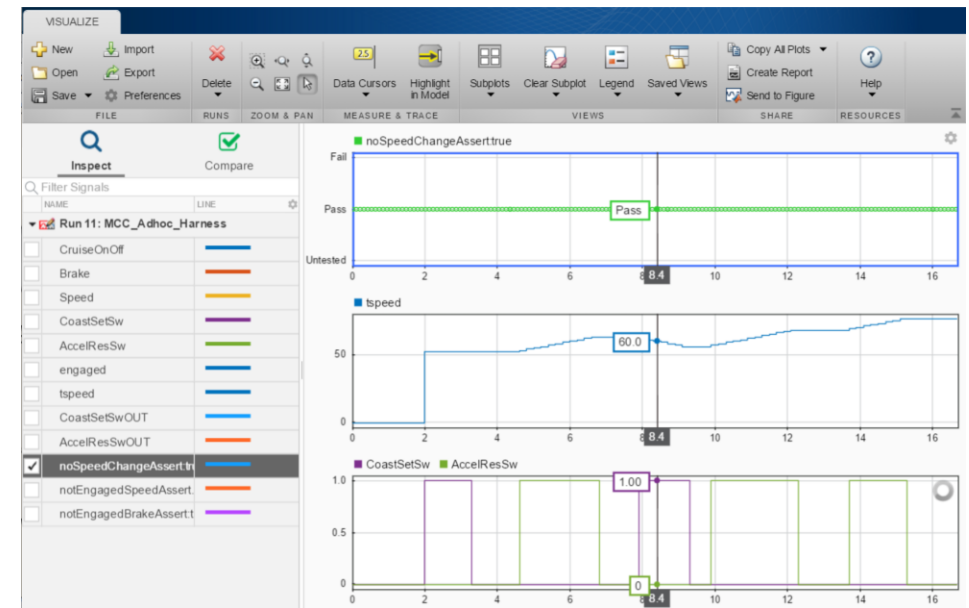
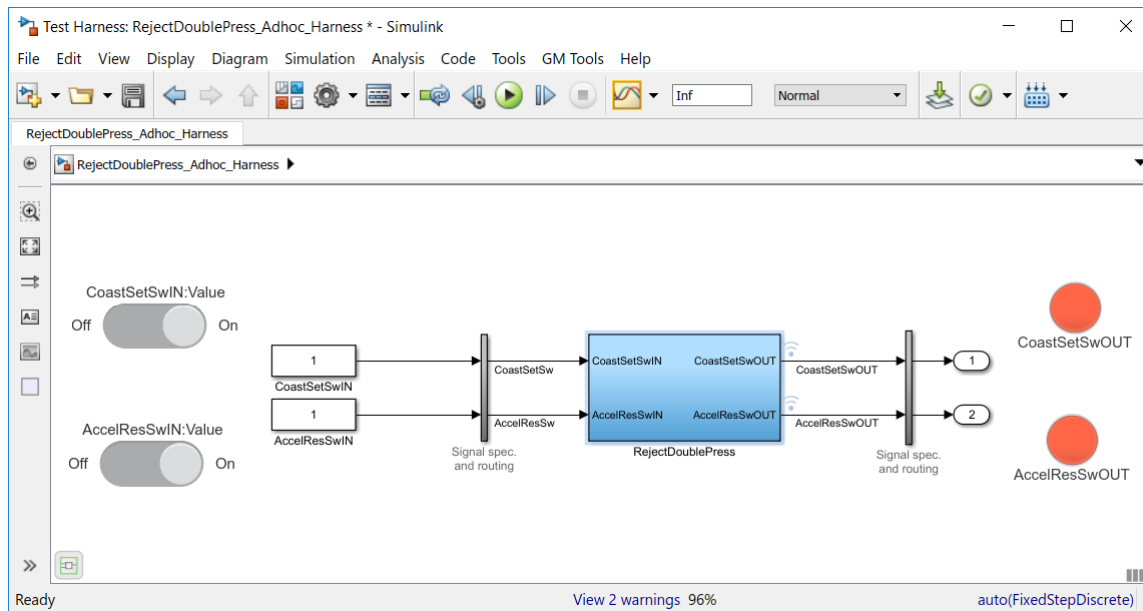
DEMO : Test harness creation with Dashboard



DEMO : Visualize Input and Output data



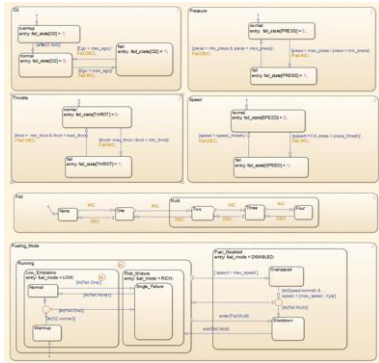
Visualization Summary



Agenda

- Legacy code integration using Simulink
- Visualization using Simulink
- **Verification with legacy code**

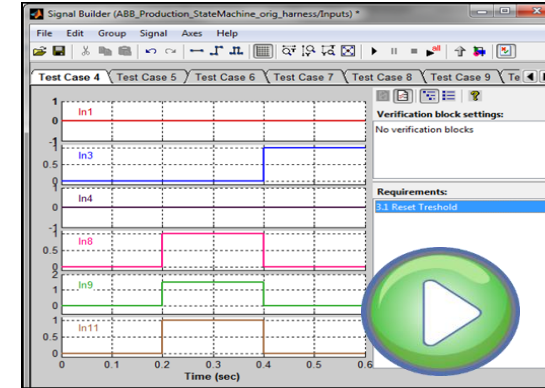
Test Case generation



Design Logic

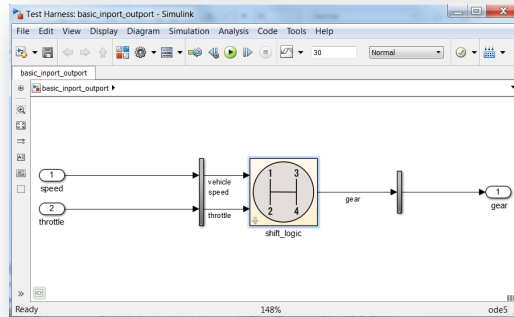
| | D1 | C1 |
|---------------------------|--------|------|
| 1. Step_00_logic | 51 83% | 83% |
| 2. ... safety_logic | 50 83% | 83% |
| 3. SF: safety_logic | 49 83% | 83% |
| 4. SF: Fail | 12 59% | NA |
| 5. SF: Multi | 6 18% | NA |
| 6. SF: Fueling_Mode | 18 85% | 75% |
| 7. SF: Fuel_Disabled | 4 83% | 75% |
| 8. SF: Running | 10 80% | NA |
| 9. SF: Low_Emissions | 4 75% | NA |
| 10. SF: O2 | 5 100% | NA |
| 11. SF: Pressure | 5 100% | 100% |
| 12. SF: Speed | 4 100% | 75% |
| 13. SF: Throttle | 5 100% | 75% |

Existing test coverage



Test Cases

Test case generation



| | D1 | C1 |
|---------------------------|---------|------|
| 1. Step_00_logic | 51 100% | 100% |
| 2. ... safety_logic | 50 100% | 100% |
| 3. SF: safety_logic | 49 100% | 100% |
| 4. SF: Fail | 12 100% | NA |
| 5. SF: Multi | 6 100% | NA |
| 6. SF: Fueling_Mode | 18 100% | 100% |
| 7. SF: Fuel_Disabled | 4 100% | 100% |
| 8. SF: Running | 10 100% | NA |
| 9. SF: Low_Emissions | 4 100% | NA |
| 10. SF: O2 | 5 100% | NA |
| 11. SF: Pressure | 5 100% | 100% |
| 12. SF: Speed | 4 100% | 100% |
| 13. SF: Throttle | 5 100% | 100% |

100% coverage

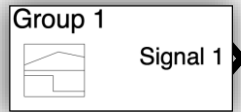
Systematic Functional Testing with Simulink Test

Test Case

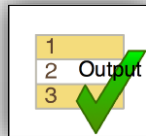
Inputs



MAT file (input)

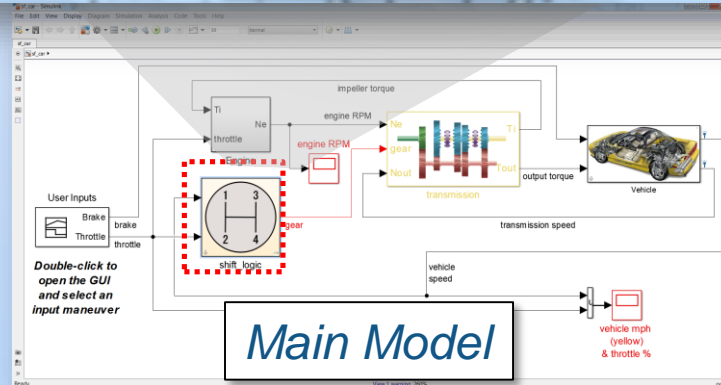
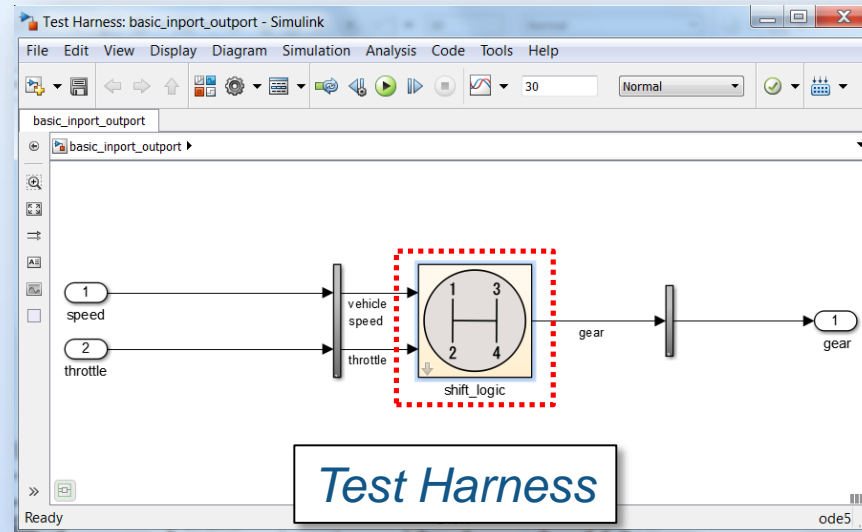


Signal Builder



Test Sequence

and more!



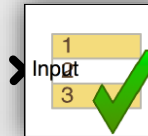
Assessments



MAT file (baseline)

```
function customCriteria
Perform custom criteria
test.verifyThat(test.sl
```

MATLAB Unit Test



Test Assessment

and more!

DEMO : Code Coverage with C caller

The screenshot displays the MATLAB Test Manager interface. The 'Test Browser' shows a list of test results, with 'New Test Case 1' selected. The 'Results and Artifacts' pane shows the test case details, including the code being tested: `verify(tspeed==50);`. The 'COVERAGE RESULTS' table provides a detailed breakdown of code coverage for the analyzed model and its components.

| ANALYZED MODEL | REPORT | COMPLEXI... | DECIS... | COND... | MDCD | EXEC... |
|---------------------|--------|-------------|----------|---------|------|---------|
| CruiseControlex | ➔ | 31 | 47% | 31% | 6% | 100% |
| RejectDoublePress.c | ➔ | 2 | 67% | 67% | 17% | 86% |

The background shows a Simulink model with several components highlighted by orange circles and numbered 1 through 5:

- 1: CruiseOnOff
- 2: Brake
- 3: Speed
- 4: CoastSetSw
- 5: AccelResSw

On the right side, a signal trace shows the 'tspeed' signal, which is labeled with a circled '2'.

DEMO : Coverage Report

웹 브라우저 - Custom Code Coverage Report for RejectDoublePress.c

Custom Code Coverage Report for RejectDoublePress.c

위치: file:///C:/Users/peteryoo/AppData/Local/Temp/tp2ec77113_296e_4503_9192_a420f85028e4/tpc9f0c91_36b3_47ca_b212_e3406085b8c4.html

Decision on

Condition on

MCDC on

MCDC mode masking

Relational Boundary off

Tests

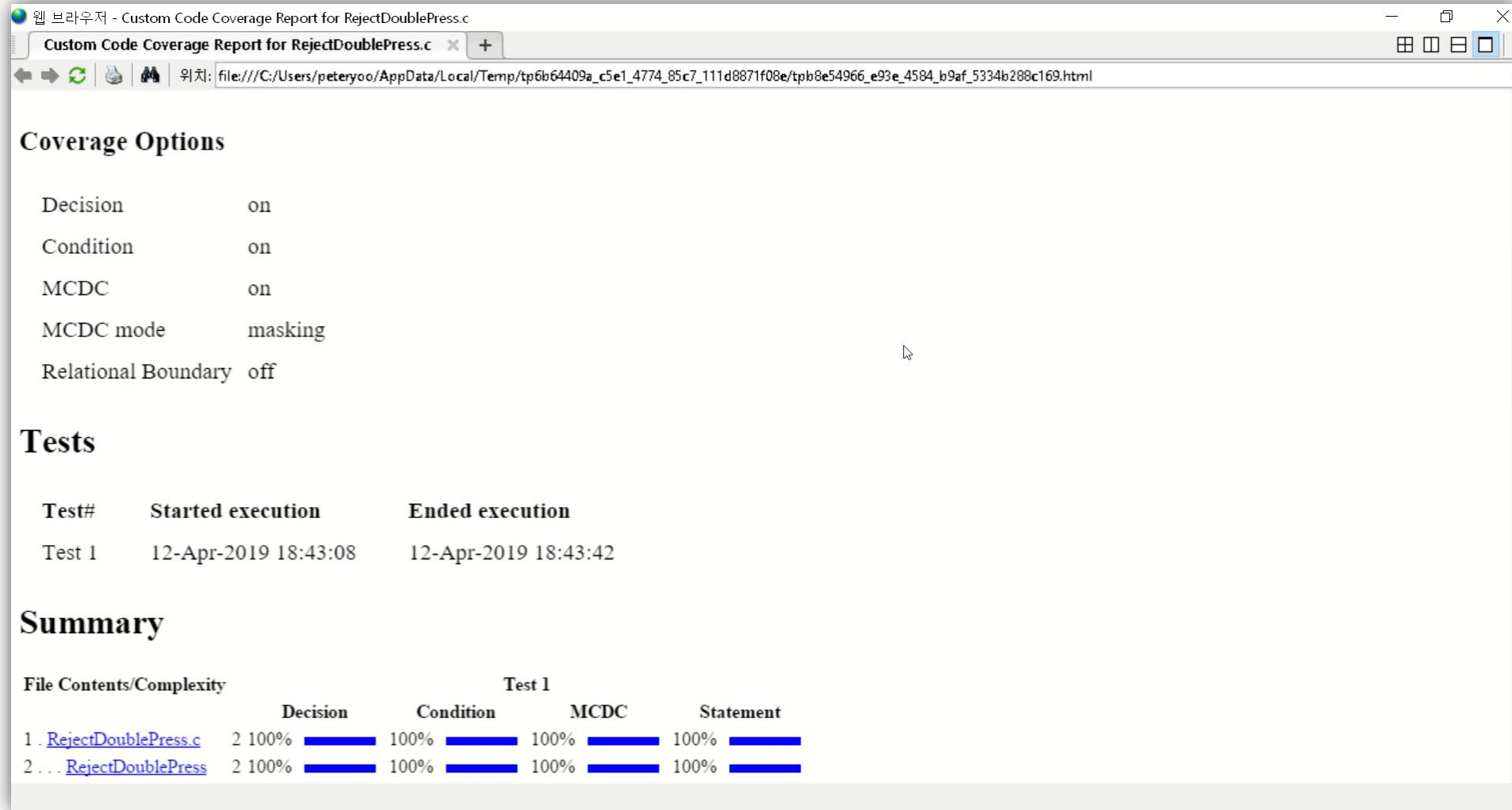
| Test# | Started execution | Ended execution |
|--------|----------------------|----------------------|
| Test 1 | 12-Apr-2019 18:18:42 | 12-Apr-2019 18:18:42 |

Summary

| File Contents/Complexity | Test 1 | | | |
|--|----------|-----------|------|-----------|
| | Decision | Condition | MCDC | Statement |
| 1. RejectDoublePress.c | 2 67% | 67% | 17% | 86% |
| 2. ... RejectDoublePress | 2 67% | 67% | 17% | 86% |

Details

DEMO : Test Case Generation









Coverage Options

- Decision on
- Condition on
- MCDC on
- MCDC mode masking
- Relational Boundary off

Tests

| Test# | Started execution | Ended execution |
|--------|----------------------|----------------------|
| Test 1 | 12-Apr-2019 18:43:08 | 12-Apr-2019 18:43:42 |

Summary

| File Contents/Complexity | Test 1 | | | |
|--|--|--|--|--|
| | Decision | Condition | MCDC | Statement |
| 1. RejectDoublePress.c | 2 100%  | 100%  | 100%  | 100%  |
| 2. ... RejectDoublePress | 2 100%  | 100%  | 100%  | 100%  |

Key takeaways

Bring C/C++ code into Simulink

- With full integration into Model-Based Design workflows
- To visualize simulation result
- Enable unified verification environment

MATLAB EXPO 2019

데모 부스와 상담부스로 질문 하시기 바랍니다.

감사합니다

