Requirements-Driven Workflows in Implementation and Test

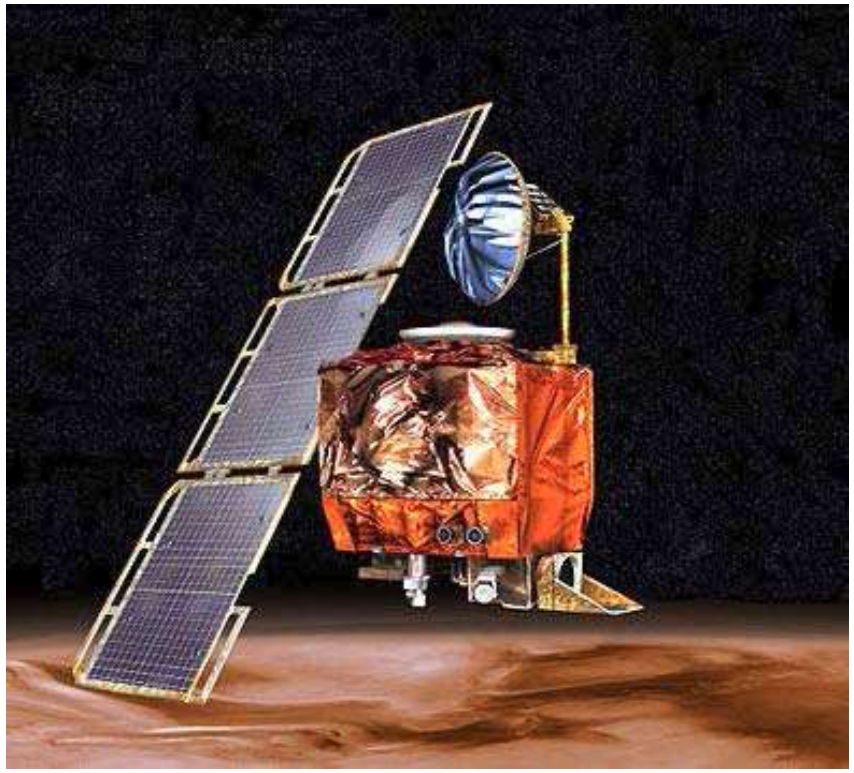
MATLAB EXPO 2018

Requirements – why we care

1. Because it is in our interests to care

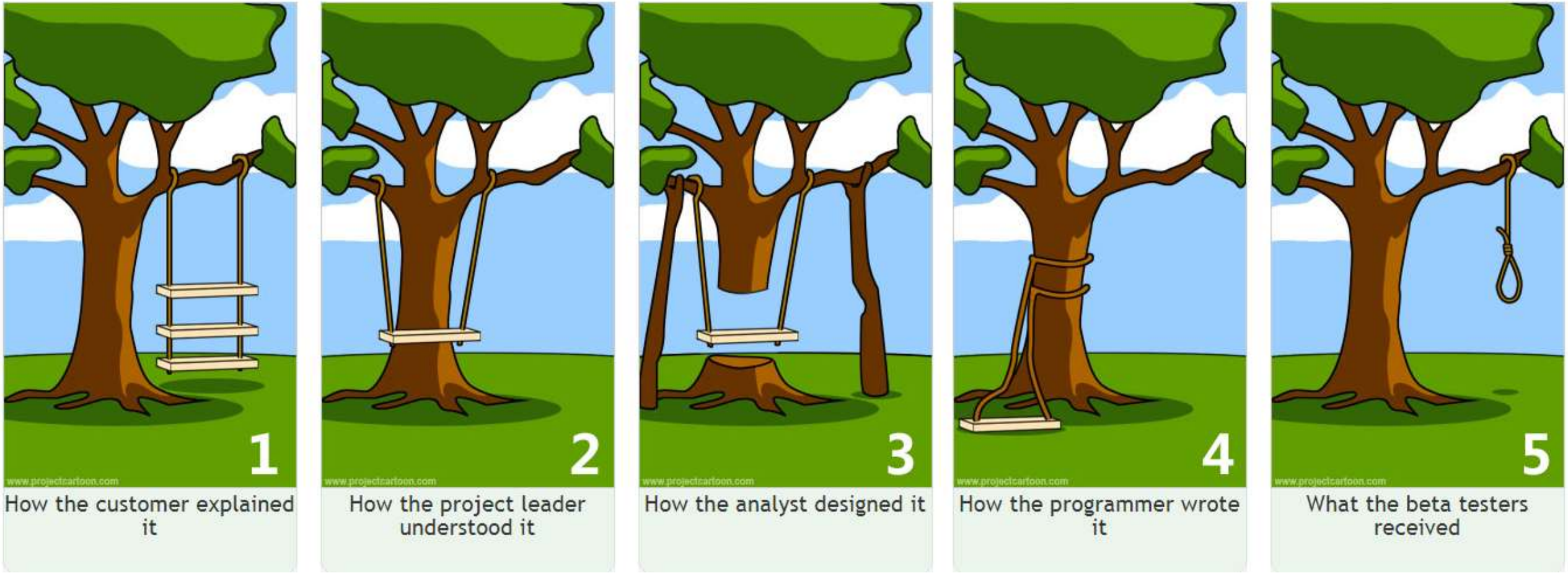
2. Because we have to care

Requirements – why we care

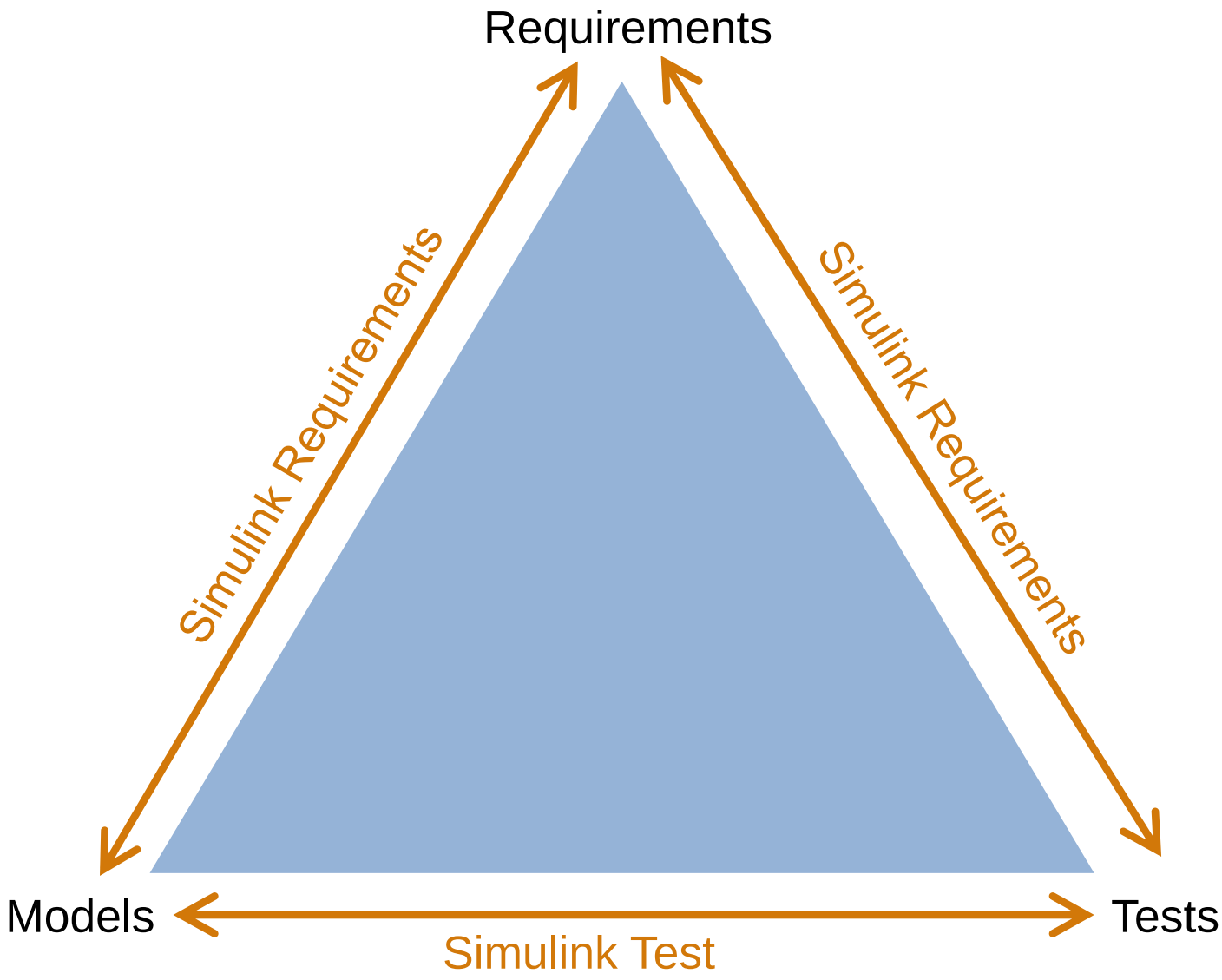


The cost of the mission was $327.6 million

Requirements – why we care

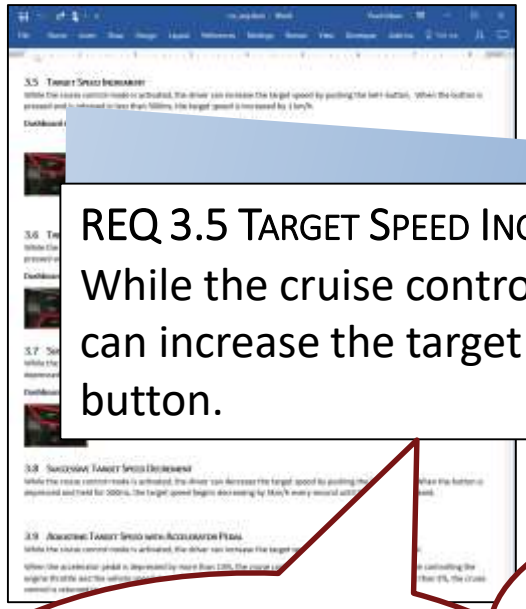


Requirements & Model-Based Design



Requirements & Model-Based Design

Because we have questions to manage such as:



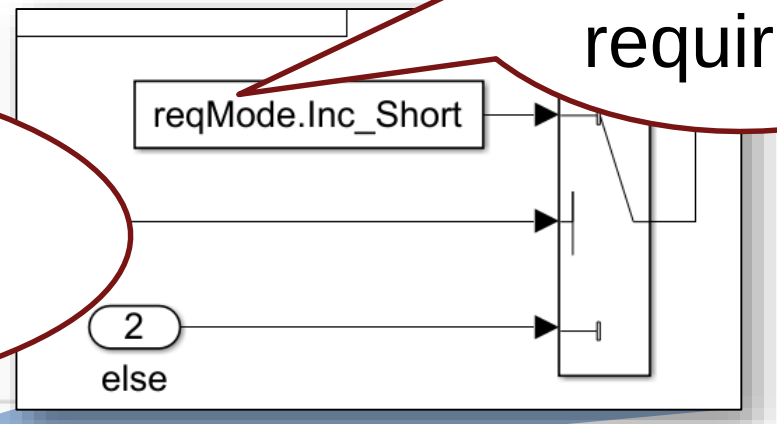
REQ 3.5 TARGET SPEED INCREMENT

While the cruise control mode is activated, the driver can increase the target speed by pushing the Set+ button.

What is the test result?

How is it being tested?

Why is this block required?



What is the impact of this requirement changing?

Is this implemented?

What verification coverage of my requirements do I have?

New Verification and Validation Products

R2017a and earlier

Simulink Verification and Validation

R2017b

Simulink Requirements

Simulink Coverage

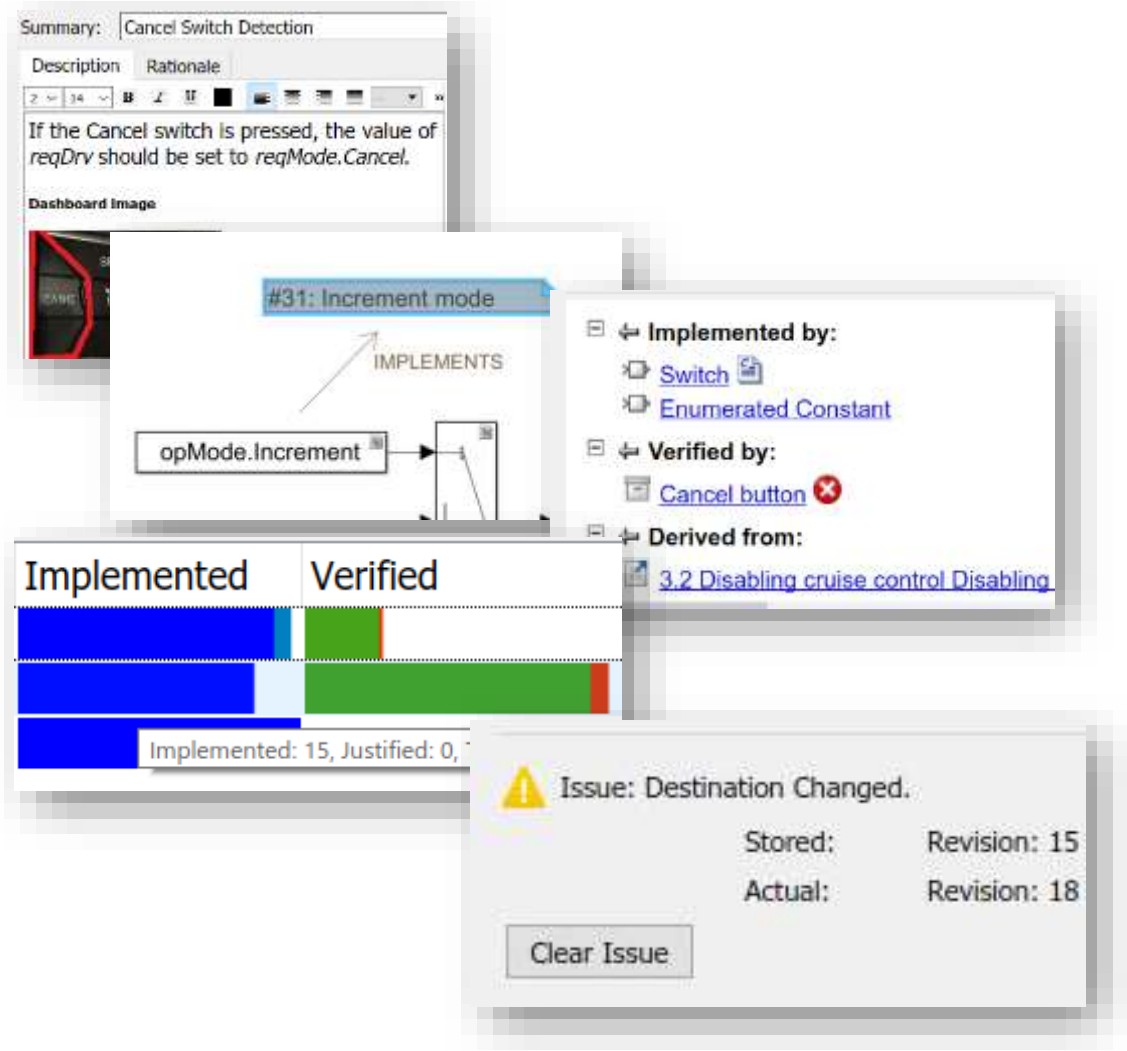
Simulink Check

- Simulink Requirements – requirements authoring, editing, trace, management

Simulink Requirements

Work with requirements without leaving Simulink

- Author or import requirements
- Trace to design, code and test
- Identify gaps in design or test
- Respond to requirement changes

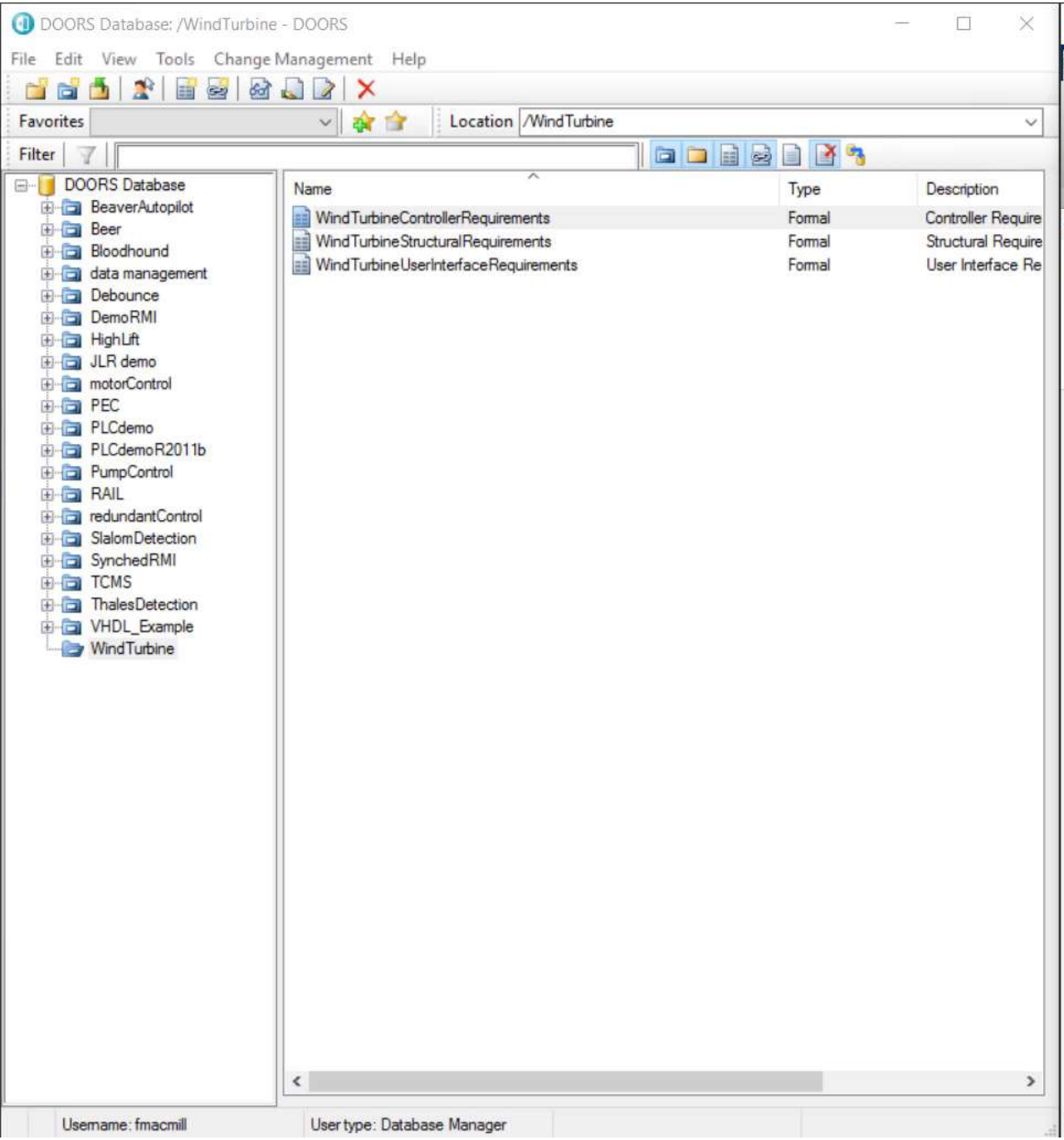


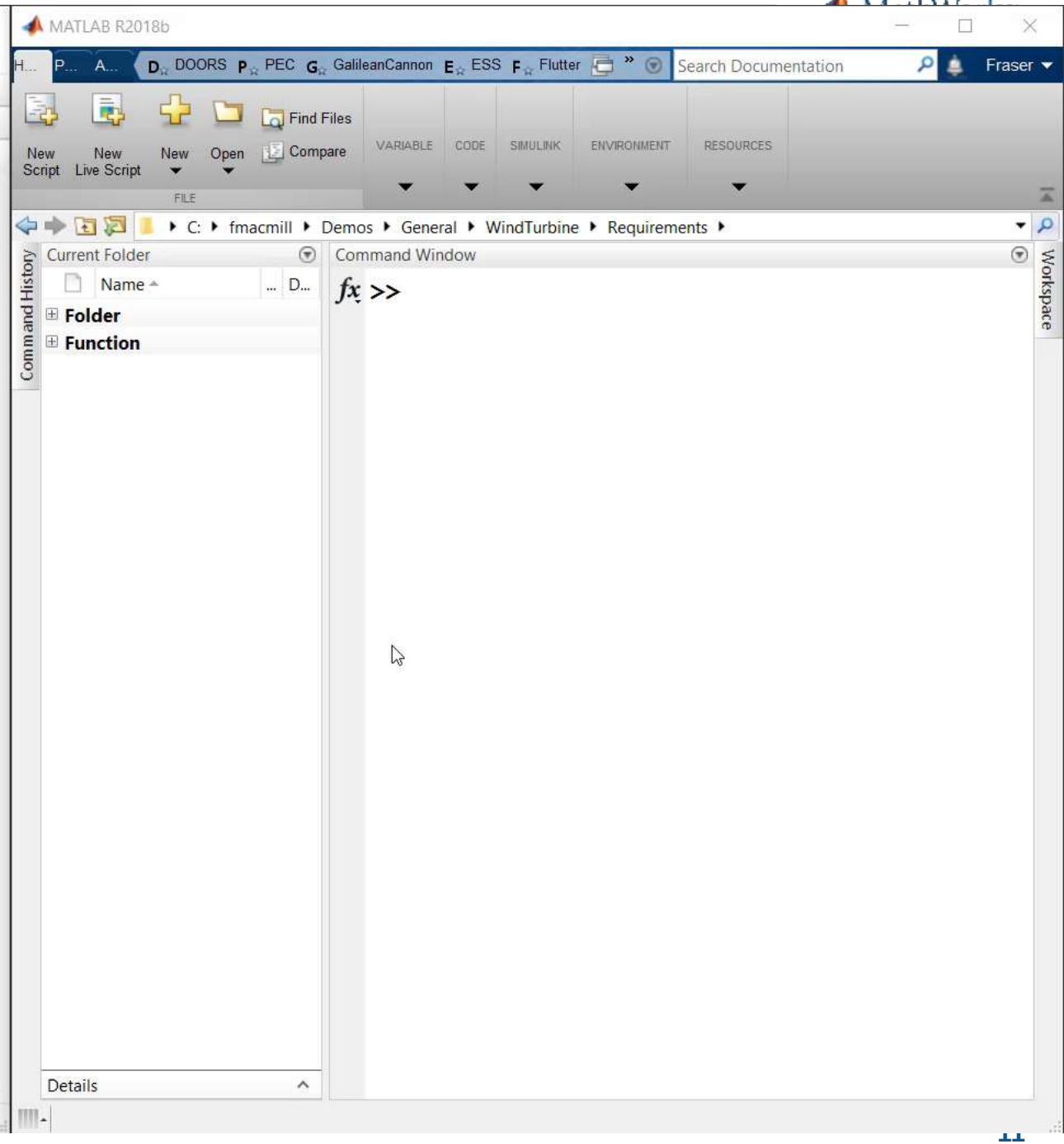
Agenda

- Importing requirements
- Tracing requirements to implementation
- Tracing requirements to tests
- Requirement change
- Reporting
- Programmatic interface

Agenda

- Importing requirements
- Tracing requirements to implementation
- Tracing requirements to tests
- Requirement change
- Reporting
- API


DOORS Database: /WindTurbine - DOORS
File Edit View Tools Change Management Help
Favorites
Location /WindTurbine
Filter
DOORS Database
BeaverAutopilot
Beer
Bloodhound
data management
Debounce
DemoRMI
HighLift
JLR demo
motorControl
PEC
PLCdemo
PLCdemoR2011b
PumpControl
RAIL
redundantControl
SlalomDetection
SynchedRMI
TCMS
ThalesDetection
VHDL_Example
WindTurbine
Name
Type
Description
WindTurbineControllerRequirements
Formal
Controller Require
WindTurbineStructuralRequirements
Formal
Structural Require
WindTurbineUserInterfaceRequirements
Formal
User Interface Re
Username: fmacmill
User type: Database Manager

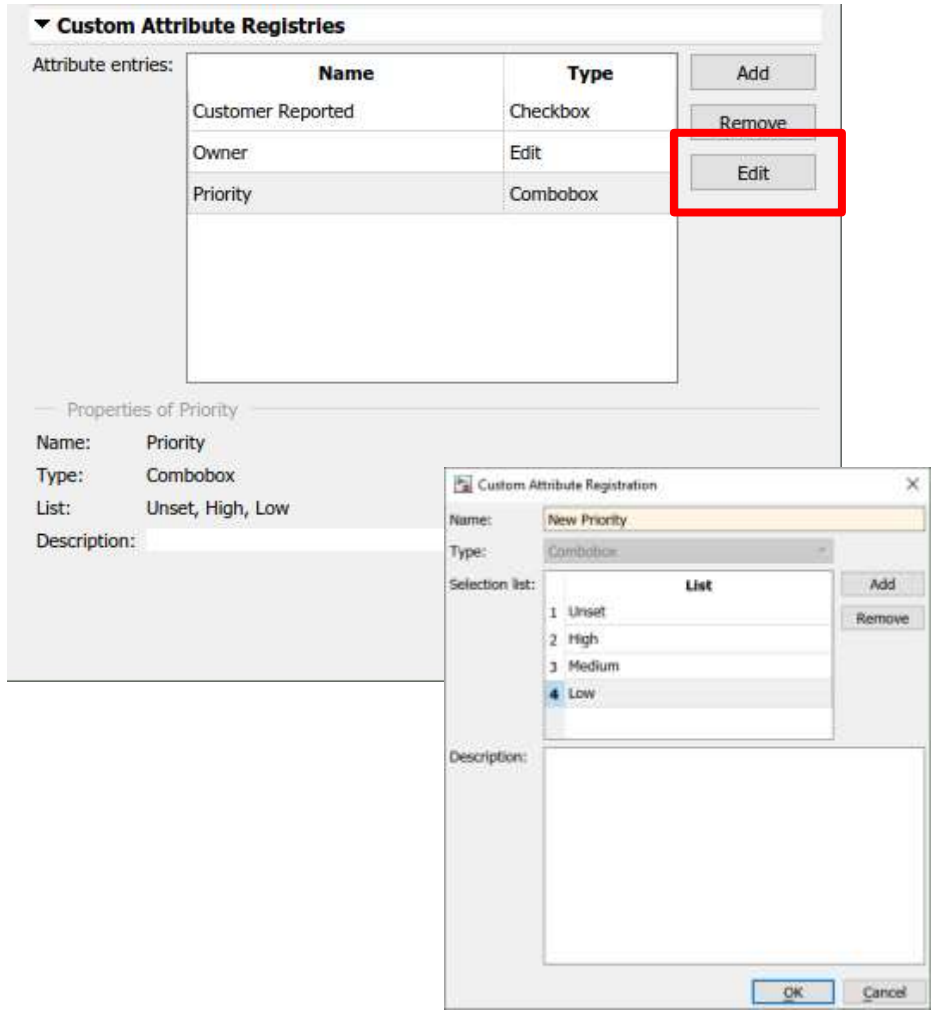

MATLAB R2018b
DOORS
PEC
GalileanCannon
ESS
Flutter
Search Documentation
Fraser
New Script
New Live Script
New
Open
Find Files
Compare
VARIABLE
CODE
SIMULINK
ENVIRONMENT
RESOURCES
FILE
C: fmacmill Demos General WindTurbine Requirements
Current Folder
Name
Folder
Function
Command Window
fx >>
Command History
Workspace
Details

Ability to Modify Custom Attributes

R2018a

Existing custom attributes can be modified.

- Custom attribute name and description is editable.
- New entries for Combobox can be added.
- Attributes value will be kept.



» Documentation: Custom Attributes of Requirement Sets

Requirements Import with ReqIF Standard

Allows you to work with requirements from third party tools in Simulink

DOORS
DOORS Next Generation

Siemens Polarion

PTC Integrity

Siemens Teamcenter

- Import requirements from third party tools using ReqIF standard (Requirements Interexchange Format)
- Import wizard supports mapping custom attributes
- Tools that support ReqIF standard:
  - IBM DOORS / DOORS Next Generation
  - Siemens Polarion
  - PTC Integrity

» Documentation: Import Requirements from ReqIF Files

Agenda

- Importing requirements
- Tracing requirements to implementation
- Tracing requirements to tests
- Requirement change
- Reporting
- Programmatic interface

Link requirements to model (implementation)

Requirements Editor

File Edit Display Analysis Report Help

View: Requirements

Search

Index	ID	Summary	Implemented
WindTurbineCont...			
Import1	00000320	References to WindTurbineC...	
1	SRD-CONTROL-1	Front Matter	
2	SRD-CONTROL-5	Controllers	
2.1	SRD-CONTROL-6	Signal Conditioning	
2.2	SRD-CONTROL-26	Supervisory Control	
2.3	SRD-CONTROL-9	Pitch Control System	
2.3.1	SRD-CONTROL-10	when in power generation m...	
2.3.2	SRD-CONTROL-11	Under inertial load only (zer...	
2.3.3	SRD-CONTROL-12	Under inertial load only (zer...	
2.4	SRD-CONTROL-18	Yaw Control System	
3	SRD-CONTROL-94	User Interface	

Properties

Type: Functional

Index: 2.3.1

Custom ID: SRD-CONTROL-10

Summary: when in power generation mode the

Description | Rationale

when in power generation mode the rotor s
% of the [RotorNominalSpeed]

Keywords: No

Revision information:

Custom Attributes

Definitions: [RotorNominalSpeed] shall be

Last Modified By: fmacmill

Last Modified On: 05 September 2018

Verification: by system level simulation

Links

No links

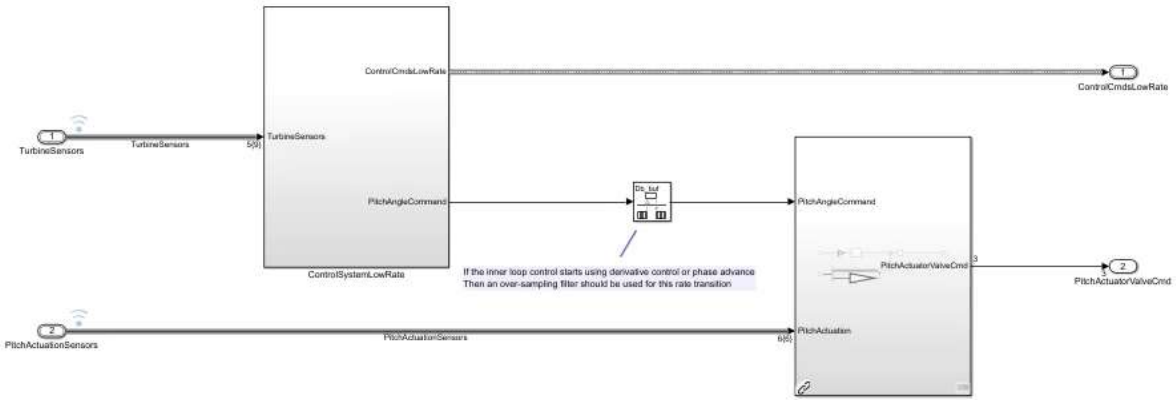
Comments

WindTurbineControlSystem - Simulink

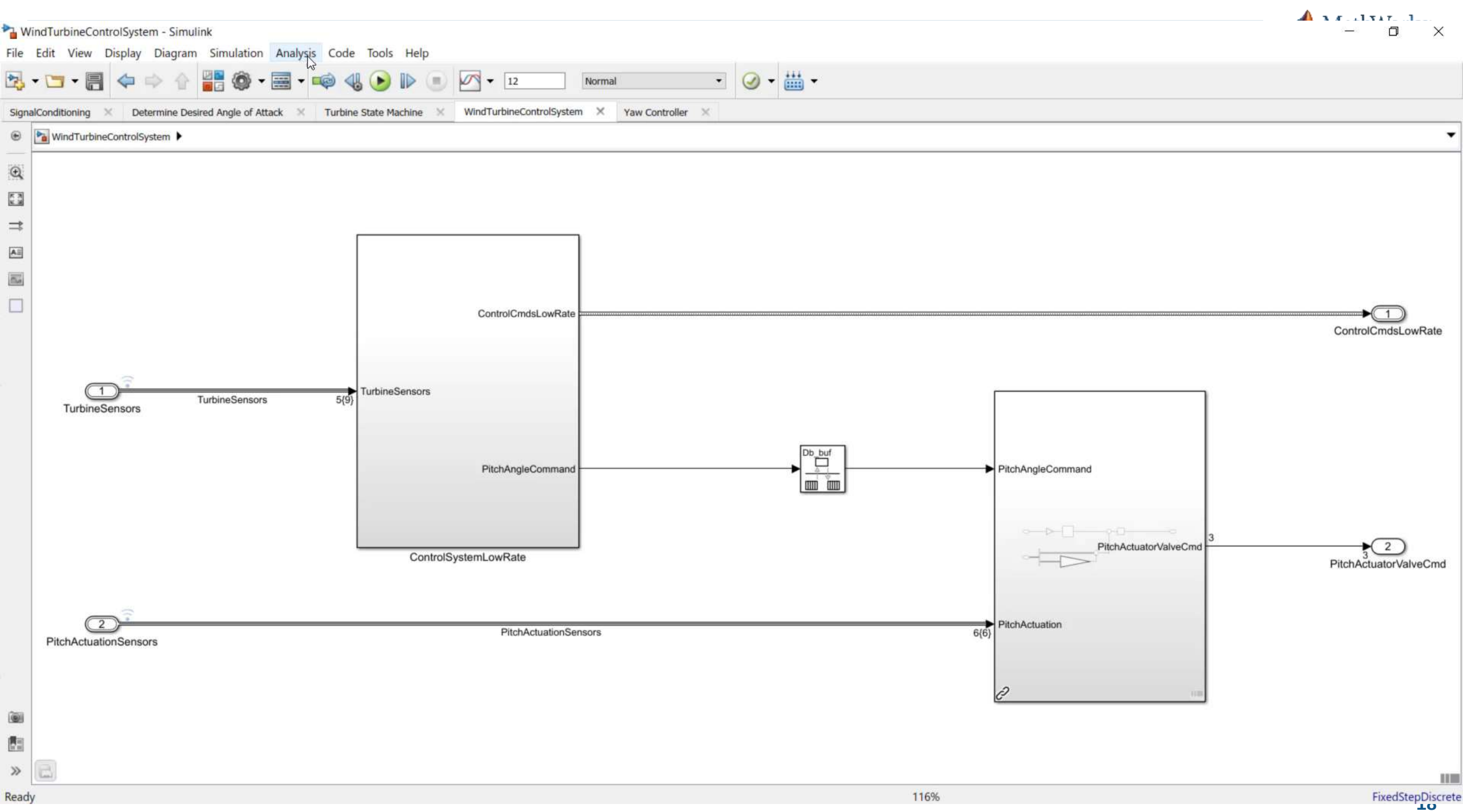
File Edit View Display Diagram Simulation Analysis Code Tools Help

SignalConditioning | Determine Desired Angle of Attack | Turbine State Machine | WindTurbineControlSystem

WindTurbineControlSystem



Ready 56% FixedStepDiscrete


WindTurbineControlSystem - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
12
Normal
SignalConditioning
Determine Desired Angle of Attack
Turbine State Machine
WindTurbineControlSystem
Yaw Controller
WindTurbineControlSystem
ControlCmdsLowRate
1
ControlCmdsLowRate
1
TurbineSensors
TurbineSensors
5{9}
TurbineSensors
PitchAngleCommand
Db_buf
ControlSystemLowRate
PitchAngleCommand
PitchActuatorValveCmd
3
2
3
PitchActuatorValveCmd
2
PitchActuationSensors
PitchActuationSensors
6{6}
PitchActuation
Ready
116%
FixedStepDiscrete

Link requirements to data (implementation)

Requirements Editor

File Edit Display Analysis Report Help

View: Requirements Search

Update completed. There are no changes.

Index	ID	Summary
WindTurbineControl...		
Import1	00000320	References to WindTurbineControllerR
1	SRD-CONTROL-1	Front Matter
2	SRD-CONTROL-5	Controllers
2.1	SRD-CONTROL-6	Signal Conditioning
2.2	SRD-CONTROL-26	Supervisory Control
2.3	SRD-CONTROL-9	Pitch Control System
2.4	SRD-CONTROL-18	Yaw Control System
2.4.1	SRD-CONTROL-19	The yaw rate magnitude shall be less t
2.4.2	SRD-CONTROL-101	The commanded yaw torque per actua
2.4.3	SRD-CONTROL-102	Place-holder
3	SRD-CONTROL-94	User Interface
Import2	00000321	References to WindTurbineStructuralR
3	#26	Justifications
WindTurbineSystem...		

Properties

Type: Functional

Index: 2.4.1

Custom ID: SRD-CONTROL-19

Summary: The yaw rate magnitude shall be less than 0.5 deg/s

Description | Rationale

The yaw rate magnitude shall be less than 0.5 deg/s

Keywords: No

Revision information:

SID: 21

Revision: 4

Updated on: 13-Sep-2018 07:56:47

Modified on: 13-Sep-2018 07:56:47

Show in document

Custom Attributes

Links

Implemented by:

Discrete PID Controller

Comments

Add Comment

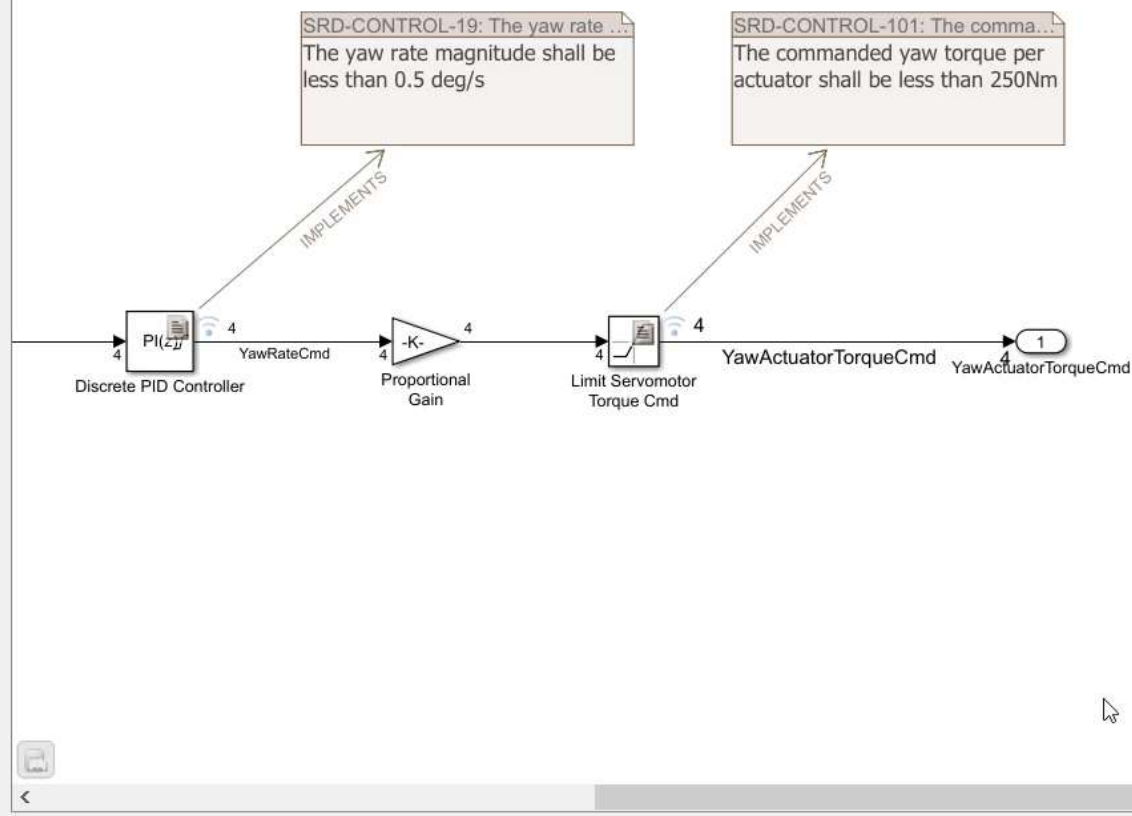
No comments

WindTurbineControlSystem/ControlSystemLowRate/Yaw Controller * - Simulink

File Edit View Display Diagram Simulation Analysis Code Tools Help

SignalConditioning | Determine Desired Angle of Attack | Turbine State Machine | ControlSystemLowRate | Yaw Controller

WindTurbineControlSystem ▸ ControlSystemLowRate ▸ Yaw Controller



Ready 100% FixedStepDiscrete

Simulink Requirements

New File Extensions

1) **.slreqx**

   File containing imported or authored requirements

2) **.slmx**

   Where links are stored

Managing Large Sets of Requirements

- Project may have thousands of requirements
- Simulink Requirements provides features to make it easier to find and navigate the requirements
- Customize browser view to only see relevant data
  - Sort by column
  - Select columns to display
- Keywords – add tags to requirements to categorize and search
- Search – filter and locate requirements by search term

Agenda

- Importing requirements
- Tracing requirements to implementation
- Tracing requirements to tests
- Requirement change
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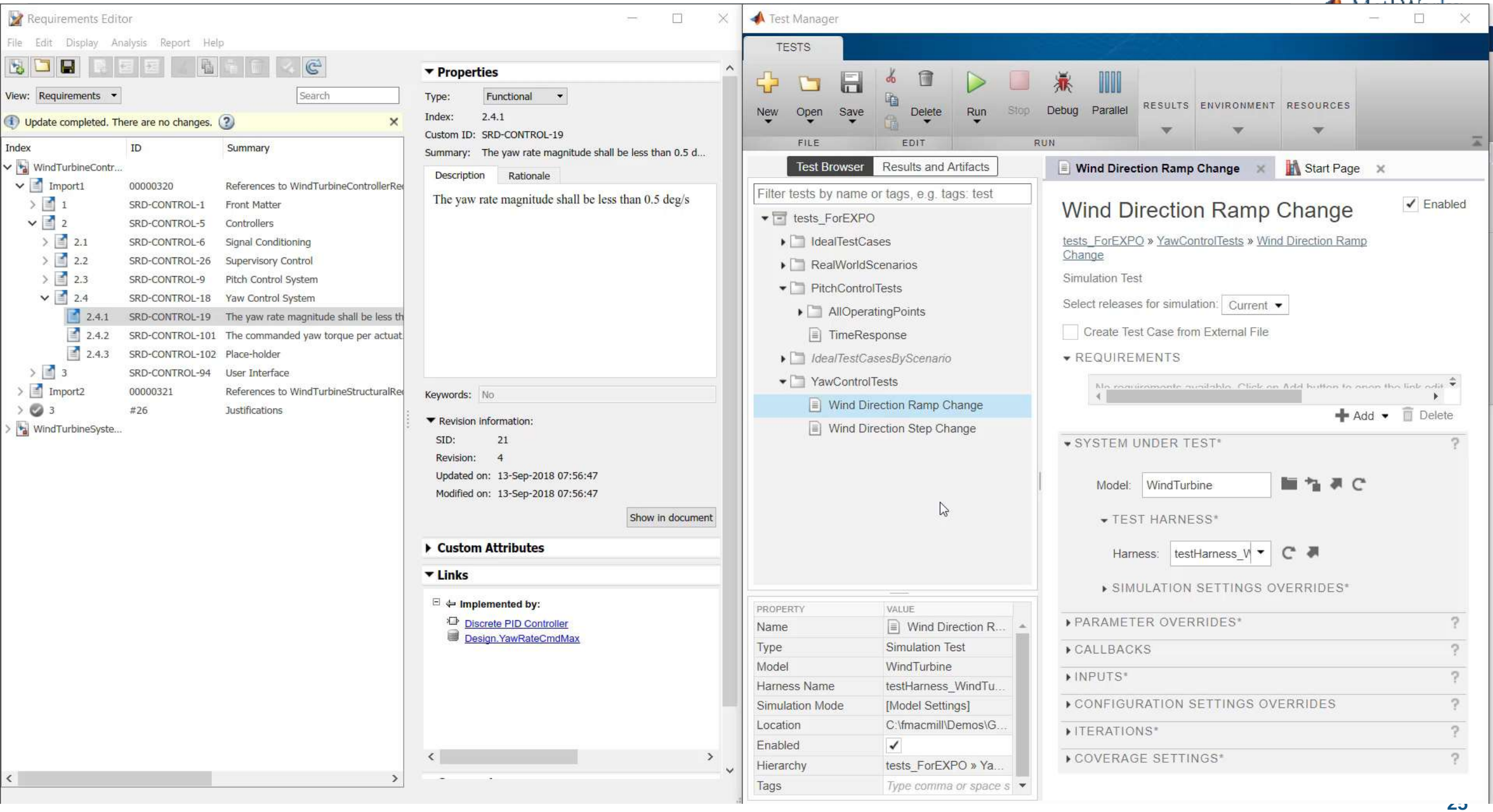
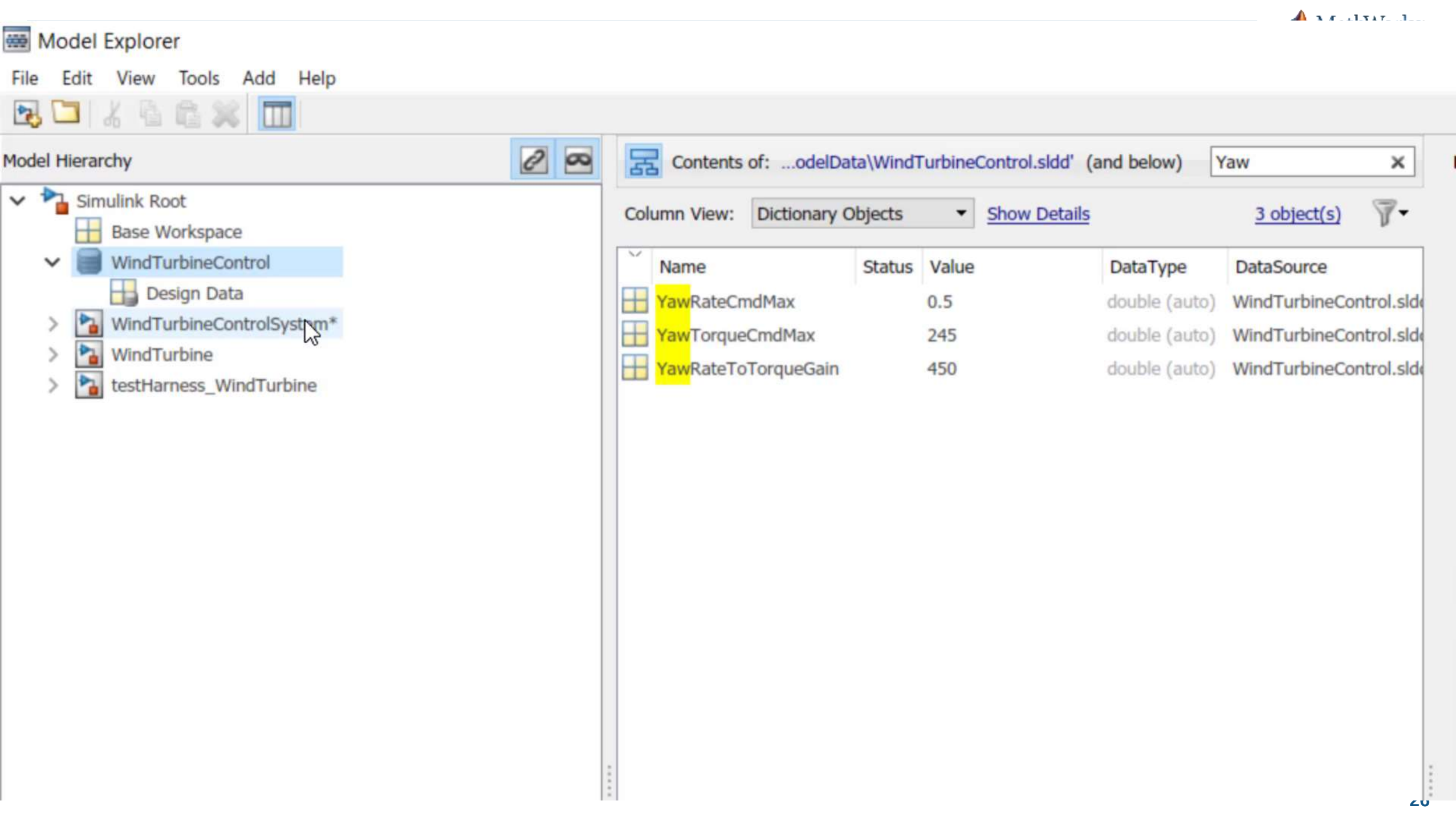
- Programmatic interface

Link requirements to test (verification)


Requirements Editor
File Edit Display Analysis Report Help
View: Requirements
Search
Update completed. There are no changes.
Index ID Summary
WindTurbineContr...
Import1 00000320 References to WindTurbineControllerRe
1 SRD-CONTROL-1 Front Matter
2 SRD-CONTROL-5 Controllers
2.1 SRD-CONTROL-6 Signal Conditioning
2.2 SRD-CONTROL-26 Supervisory Control
2.3 SRD-CONTROL-9 Pitch Control System
2.4 SRD-CONTROL-18 Yaw Control System
2.4.1 SRD-CONTROL-19 The yaw rate magnitude shall be less th
2.4.2 SRD-CONTROL-101 The commanded yaw torque per actuat
2.4.3 SRD-CONTROL-102 Place-holder
3 SRD-CONTROL-94 User Interface
Import2 00000321 References to WindTurbineStructuralRe
3 #26 Justifications
WindTurbineSyste...
Properties
Type: Functional
Index: 2.4.1
Custom ID: SRD-CONTROL-19
Summary: The yaw rate magnitude shall be less than 0.5 d...
Description Rationale
The yaw rate magnitude shall be less than 0.5 deg/s
Keywords: No
Revision information:
SID: 21
Revision: 4
Updated on: 13-Sep-2018 07:56:47
Modified on: 13-Sep-2018 07:56:47
Show in document
Custom Attributes
Links
Implemented by:
Discrete PID Controller
Design.YawRateCmdMax
Test Manager
TESTS
New Open Save Delete Run Stop Debug Parallel
RESULTS ENVIRONMENT RESOURCES
FILE EDIT RUN
Test Browser Results and Artifacts
Filter tests by name or tags, e.g. tags: test
tests_ForEXPO
IdealTestCases
RealWorldScenarios
PitchControlTests
AllOperatingPoints
TimeResponse
IdealTestCasesByScenario
YawControlTests
Wind Direction Ramp Change
Wind Direction Step Change
PROPERTY VALUE
Name Wind Direction R...
Type Simulation Test
Model WindTurbine
Harness Name testHarness_WindTu...
Simulation Mode [Model Settings]
Location C:\fmacmill\Demos\G...
Enabled
Hierarchy tests_ForEXPO » Ya...
Tags Type comma or space s
Wind Direction Ramp Change
Start Page
Wind Direction Ramp Change
Enabled
tests_ForEXPO » YawControlTests » Wind Direction Ramp Change
Simulation Test
Select releases for simulation: Current
Create Test Case from External File
REQUIREMENTS
Add Delete
SYSTEM UNDER TEST*
Model: WindTurbine
TEST HARNESS*
Harness: testHarness_W
SIMULATION SETTINGS OVERRIDES*
PARAMETER OVERRIDES*
CALLBACKS
INPUTS*
CONFIGURATION SETTINGS OVERRIDES
ITERATIONS*
COVERAGE SETTINGS*

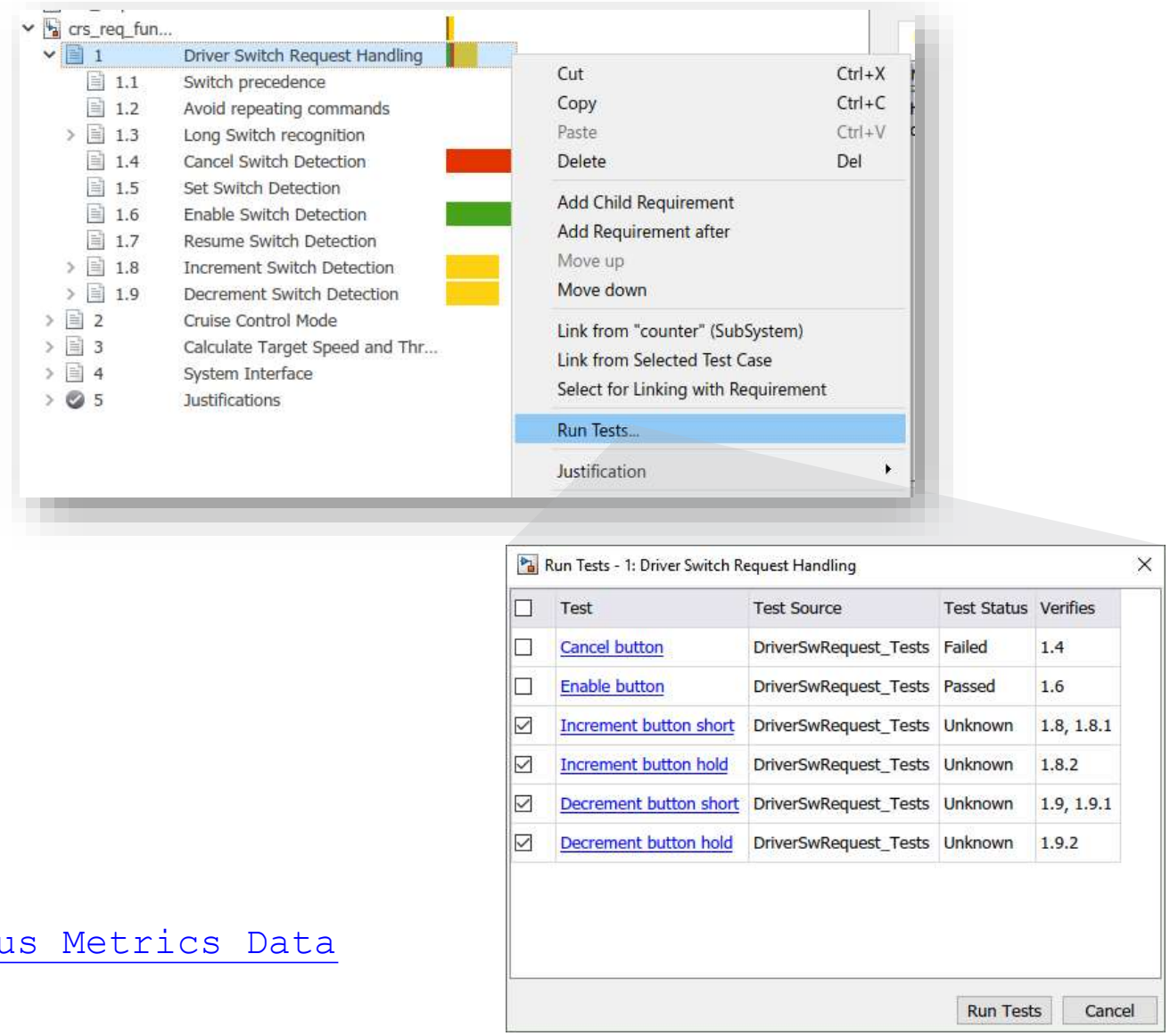

Model Explorer
File Edit View Tools Add Help
Model Hierarchy
Simulink Root
Base Workspace
WindTurbineControl
Design Data
WindTurbineControlSystem*
WindTurbine
testHarness_WindTurbine
Contents of: ...odelData\WindTurbineControl.sldd' (and below)
Yaw
Column View: Dictionary Objects
Show Details
3 object(s)
Name Status Value DataType DataSource
YawRateCmdMax 0.5 double (auto) WindTurbineControl.sld
YawTorqueCmdMax 245 double (auto) WindTurbineControl.sld
YawRateToTorqueGain 450 double (auto) WindTurbineControl.sld

Test Execution Support

R2018a

Invoke linked tests to verify requirements

- Run all tests which are linked to selected hierarchy of requirements
- Right-click on Requirement or Requirement Set for option to run tests



» See: Review Requirement Verification Status Metrics Data

Agenda

- Importing requirements
- Tracing requirements to implementation
- Tracing requirements to tests
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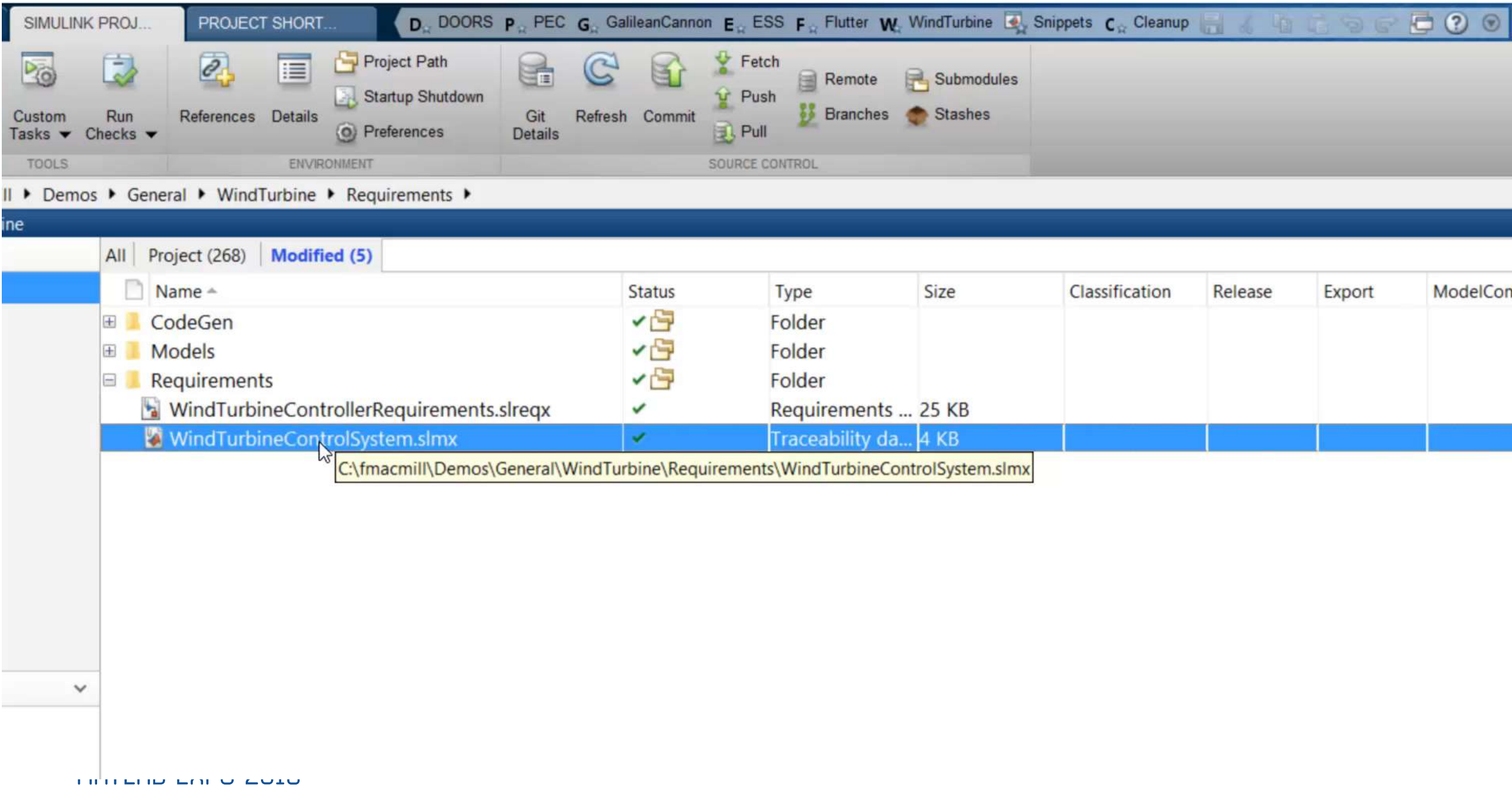
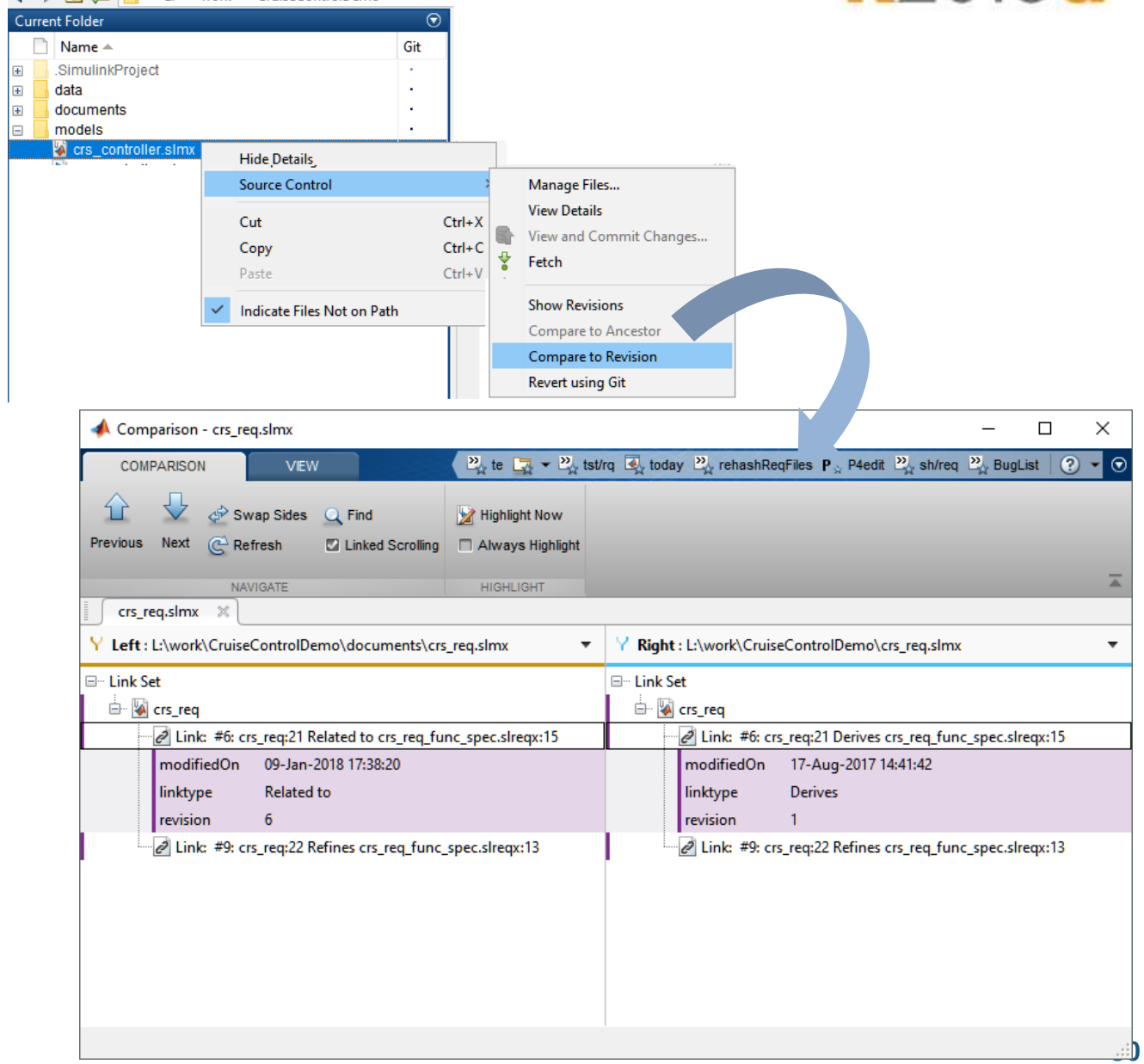

SIMULINK PROJ...
PROJECT SHORT...
D DOORS
P PEC
G GalileanCannon
E ESS
F Flutter
W WindTurbine
Snippets
C Cleanup
Custom Tasks
Run Checks
References
Details
Project Path
Startup Shutdown
Preferences
Git Details
Refresh
Commit
Fetch
Push
Pull
Remote
Branches
Submodules
Stashes
TOOLS
ENVIRONMENT
SOURCE CONTROL
Demos ▸ General ▸ WindTurbine ▸ Requirements ▸
All
Project (268)
Modified (5)
Name
Status
Type
Size
Classification
Release
Export
CodeGen
Folder
Models
Folder
Requirements
Folder
WindTurbineControllerRequirements.slreqx
Requirements ...
25 KB
WindTurbineControlSystem.slmx
Traceability da...
4 KB
C:\fmacmill\Demos\General\WindTurbine\Requirements\WindTurbineControlSystem.slmx

Link Set Comparison support

R2018a

Track changes to requirements links by comparing Link Set files

- View added / removed / modified links compared to previous revision.
- Improved change tracking by leveraging Simulink Project and SCM integration
- Use `visdiff` for invoking from command-line.



» Documentation: Compare Link Sets

Agenda

- Importing requirements
- Tracing requirements to implementation
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Requirements Editor

File Edit Display Analysis Report Help

View: Requirements

Search

Index	ID	Summary	Implemented	Verified	Definitions	La
WindTurbineControllerRequirements						
3	#26	Justifications				
Import1	00000320	References to WindTurbineControllerReq...				
1	SRD-CONTROL-1	Front Matter				fm
2	SRD-CONTROL-5	Controllers				fm
2.1	SRD-CONTROL-6	Signal Conditioning				fm
2.1.1	SRD-CONTROL-7	Wind speed filtering attenuation shall be...				fm
2.1.2	SRD-CONTROL-35	Wind speed filtering attenuation shall be...				fm
2.1.3	SRD-CONTROL-29	Wind direction filtering attenuation shall ...				fm
2.1.4	SRD-CONTROL-34	Wind direction filtering attenuation shall ...				fm
2.2	SRD-CONTROL-26	Supervisory Control				fm
2.2.1	SRD-CONTROL-36	Normal Operation				fm
2.2.2	SRD-CONTROL-32	The turbine shall start if all the following...			Yaw error = direction of nacelle - directi...	fm
2.2.3	SRD-CONTROL-84	Electrical power generation shall be ena...				fm
2.2.4	SRD-CONTROL-37	Abnormal Conditions				fm
2.2.5	SRD-CONTROL-33	The turbine shall stop if wind speed exc...				fm
2.3	SRD-CONTROL-9	Pitch Control System				fm
2.3.1	SRD-CONTROL-10	when in power generation mode the rot...			[RotorNominalSpeed] shall be calculated...	fm
2.3.2	SRD-CONTROL-11	Under inertial load only (zero aerodyna...			rise time shall be measured as the time ...	fm
2.3.3	SRD-CONTROL-12	Under inertial load only (zero aerodyna...			settling time shall be measured as the ti...	fm
2.4	SRD-CONTROL-18	Yaw Control System				fm
2.4.1	SRD-CONTROL-19	The yaw rate magnitude shall be less th...			Yaw rate as measured at tower hub	fm
2.4.2	SRD-CONTROL-101	The commanded yaw torque per actuat...				fm
3	SRD-CONTROL-94	User Interface				fm
Import2	00000321	References to WindTurbineStructuralReq...				
WindTurbineSystemRequirements						

Properties

Filepath: C:\fmacmill\Demos\General\WindTurbine\Requirements\WindTurbineControllerRequirements.slreqx
Revision: 7
Created by: fmacmill
Created on: 07-Sep-2018 15:14:35
Modified by: fmacmill
Modified on: 13-Sep-2018 13:50:04
Description:

Custom Attribute Registries

Agenda

- Importing requirements
- Tracing requirements to implementation
- Tracing requirements to tests
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- Reporting
- Programmatic interface

Programmatic interface

Requirements Definition

slreq.ReqSet	Work with Requirements sets
slreq.Reference	Work with external requirement proxy objects
slreq.Requirement	Work with Requirement objects
slreq.clear	Clear requirements and links from memory
slreq.convertAnnotation	Convert annotations to requirement objects
slreq.editor	Open Requirements Editor
slreq.find	Find requirement, reference, and link set artifacts
slreq.import	Import requirements from external documents
slreq.load	Load requirements/link set
slreq.new	Create requirements set
slreq.open	Open requirements set

Requirements Traceability and Consistency

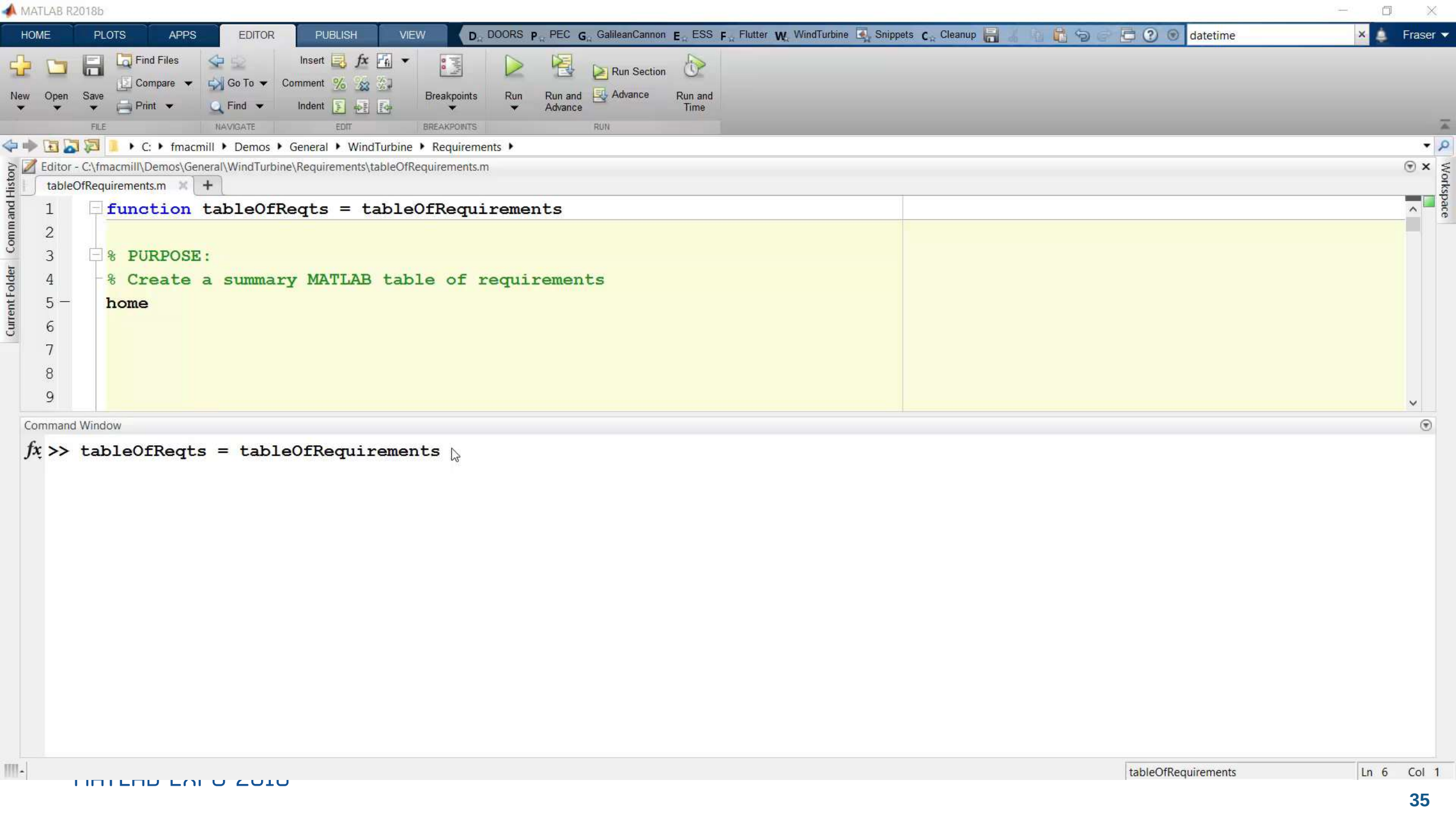
slreq.LinkSet	Work with link sets
slreq.Link	Work with link objects
slreq.clear	Clear requirements and links from memory
slreq.createLink	Create traceable links
slreq.find	Find requirement, reference, and link set artifacts
slreq.load	Load requirements/link set

Requirements Verification

slreq.Justification	Work with slreq.Justification objects

Requirements Comparison and Change Tracking

slreq.generateReport	Generate report for requirements set
slreq.getReportOptions	Get default report generation options
slreq.refreshLinkDependencies	Refresh requirement link dependencies

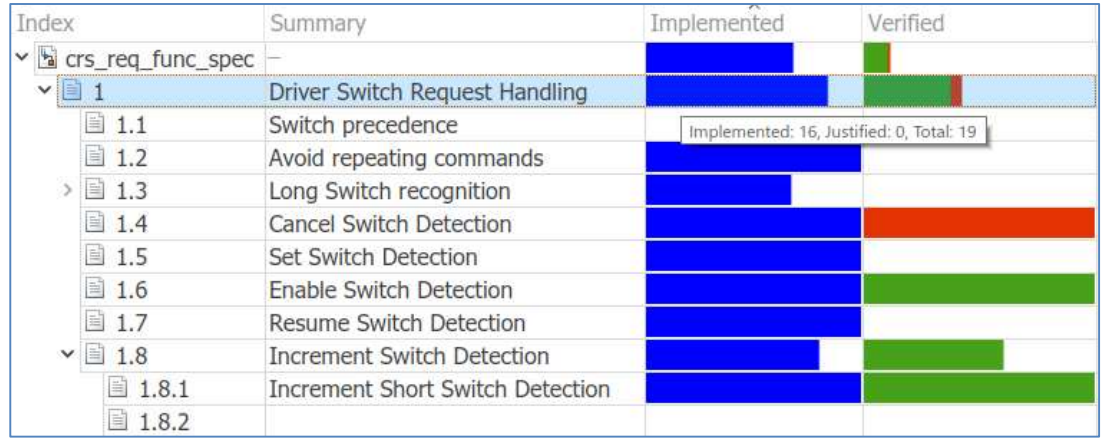

MATLAB R2018b
HOME
PLOTS
APPS
EDITOR
PUBLISH
VIEW
DOORS
PEC
GalileanCannon
ESS
Flutter
WindTurbine
Snippets
Cleanup
datetime
Fraser
New
Open
Save
Find Files
Compare
Print
Go To
Find
Insert
Comment
Indent
Breakpoints
Run
Run and Advance
Run Section
Advance
Run and Time
FILE
NAVIGATE
EDIT
BREAKPOINTS
RUN
C: ▸ fmacmill ▸ Demos ▸ General ▸ WindTurbine ▸ Requirements ▸
Editor - C:\fmacmill\Demos\General\WindTurbine\Requirements\tableOfRequirements.m
tableOfRequirements.m
1 function tableOfReqts = tableOfRequirements
2
3 % PURPOSE:
4 % Create a summary MATLAB table of requirements
5 home
6
7
8
9
Command Window
>> tableOfReqts = tableOfRequirements
tableOfRequirements
Ln 6 Col 1
Command History
Current Folder
Workspace

Conclusions

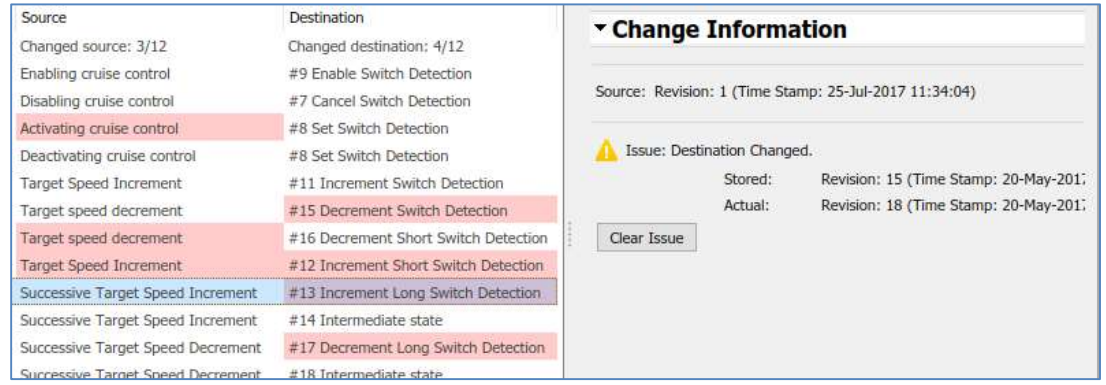
Simulink Requirements

Work with requirements and design together

- Author, edit and organize requirements
- View and link requirements within the Simulink graphical editor
- Track status and manage requirement changes



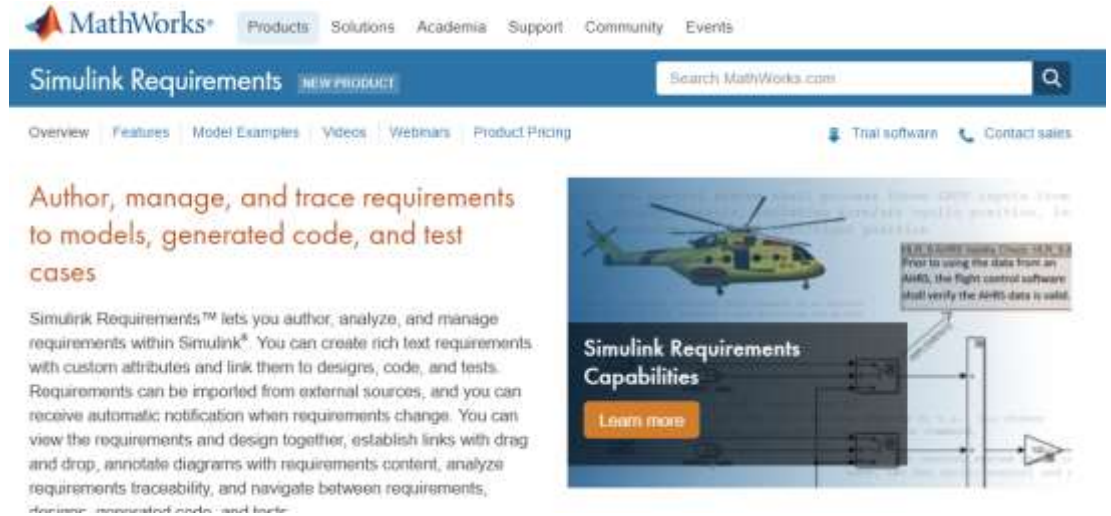
Implementation and Verification Status



Notification of Requirement Changes

What next…

More information: mathworks.com/products/simulink-requirements.html



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