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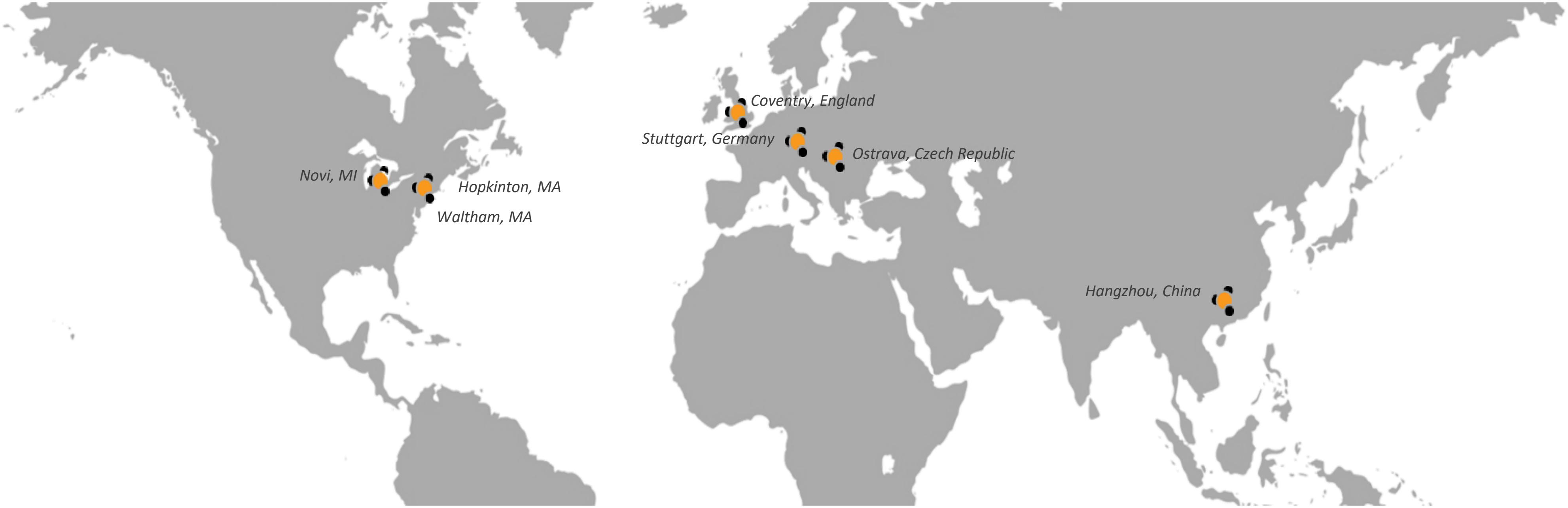

Continuous Integration within a Model Based Workflow

MathWorks Automotive Conference

Nick Mazzilli, P.E.

10/28/2020

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A123 Systems Corporate Profile

A123 Systems is a global leader in designing and manufacturing lithium-ion battery cells and systems. Built upon the pursuit of bringing innovation to the market, A123 offers an ever growing portfolio of world class lithium-ion batteries from a full line of high power mild-hybrid systems to energy dense solutions for the transportation and energy storage markets.

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Transportation Solutions

Low Voltage Hybrids

World-class technology delivers a light weight option that supports fuel economy improvements through high charge rate capability

Plug-In & Hybrid Electric Vehicles

With very long cell life, a modular component strategy, and strong cost focus, A123 quickly provides complete battery systems

Commercial Vehicles

Customizable solutions help A123 dominate the market for large commercial vehicles that demand high power

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Technology Drives the Energy Storage

Renewable Integration

Large form factor LFP and NMC cells, flexible module solutions and strong focus on cost provides unique technical and commercial solutions

Critical Power

Uninterruptable Power Systems powered by A123 long life and reliable cells offers competitive advantage for back-up power systems

Frequency Regulation

A123 expertise in high power LFP chemistry supports power demand of grid-tied frequency regulation systems

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Project Background

- A123 looking to develop new MBD core for Autosar production programs (from legacy C-code)
- Developed between small team (<2) but how to roll out to larger team (10+) and maintain consistency and quality?
- Partnered with MathWorks to help automate this through a Jenkins build server

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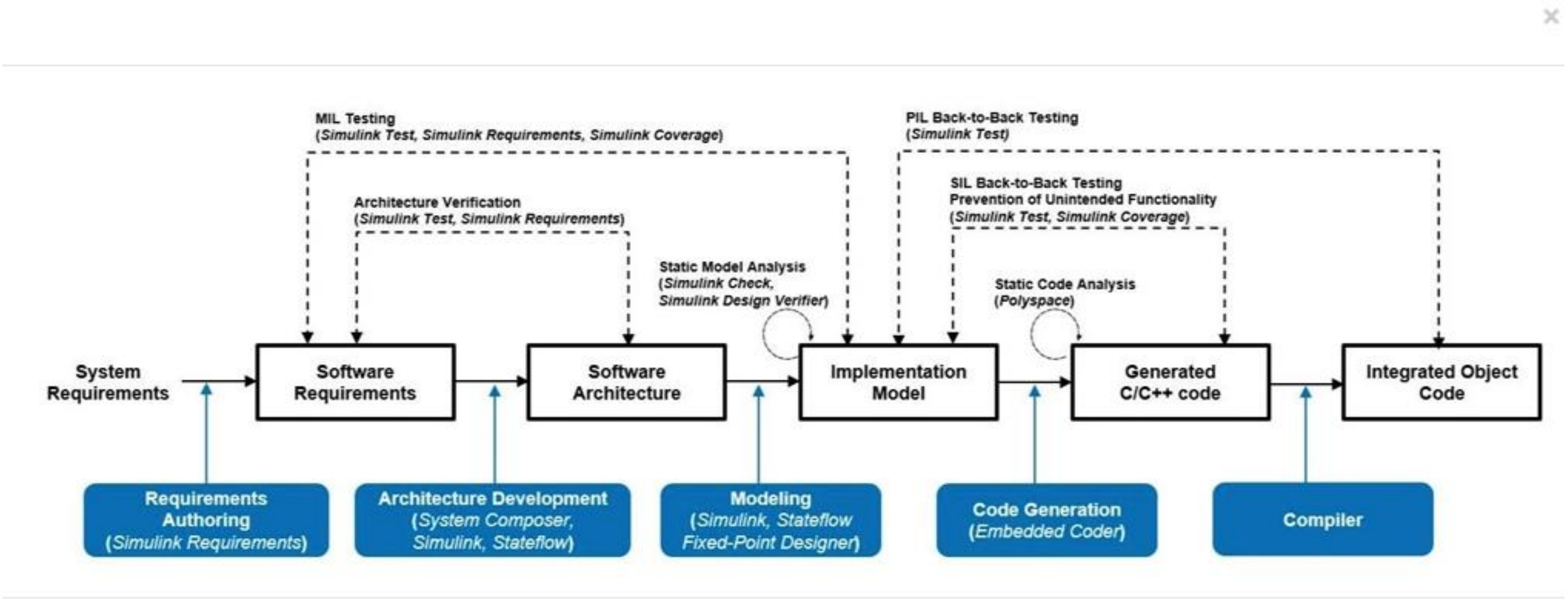
ISO 26262 Reference Workflow



MIL Testing
(*Simulink Test, Simulink Requirements, Simulink Coverage*)

Architecture Verification
(*Simulink Test, Simulink Requirements*)

Static Model Analysis
(*Simulink Check, Simulink Design Verifier*)

PIL Back-to-Back Testing
(*Simulink Test*)

SIL Back-to-Back Testing
Prevention of Unintended Functionality
(*Simulink Test, Simulink Coverage*)

Static Code Analysis
(*Polyspace*)

System Requirements → Software Requirements → Software Architecture → Implementation Model → Generated C/C++ code → Integrated Object Code

Requirements Authoring
(*Simulink Requirements*)

Architecture Development
(*System Composer, Simulink, Stateflow*)

Modeling
(*Simulink, Stateflow Fixed-Point Designer*)

Code Generation
(*Embedded Coder*)

Compiler

Figure 2. Verification and validation activities specified in IEC Certification Kit.

https://www.mathworks.com/company/newsletters/articles/an-iso-26262-workflow-for-automated-driving-applications-using-matlab-guidelines-and-best-practices.html

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CI Workflows

Individual SWCs

- Check model over standards compliance
- *Generate* Code
- Run test cases on model (MIL vs SIL)
- Polyspace reports
- Traceability reports
- HTML template of model with linked requirements and descriptions
- SVN commit

Integration of SWCs

- External links to all individual SWCs
- Combine shared utilities
- Get all necessary .c and .h files for each SWC
- Composition testing (Application Layer Testing)
- Binary creation, ready to test on hardware

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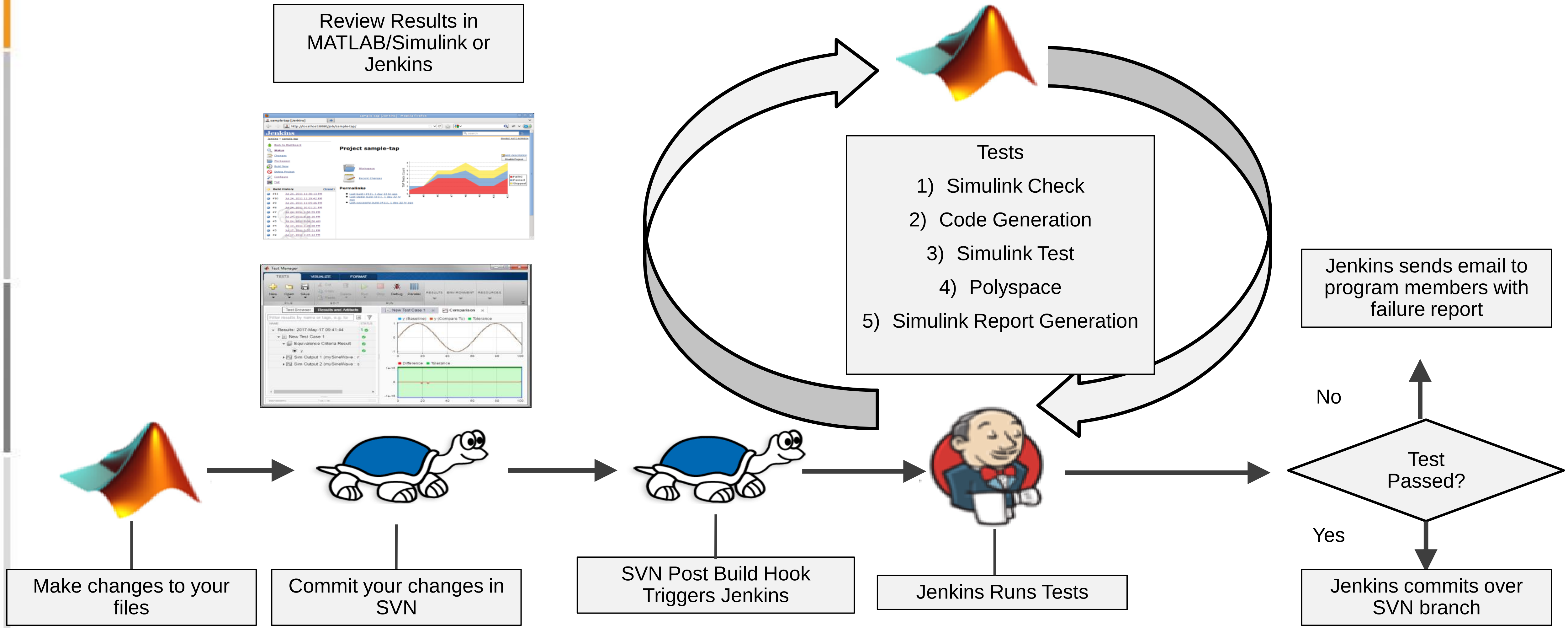
SWC Example



Review Results in MATLAB/Simulink or Jenkins

Tests

1) Simulink Check
2) Code Generation
3) Simulink Test
4) Polyspace
5) Simulink Report Generation

Jenkins sends email to program members with failure report

No

Test Passed?

Yes

Make changes to your files

Commit your changes in SVN

SVN Post Build Hook Triggers Jenkins

Jenkins Runs Tests

Jenkins commits over SVN branch

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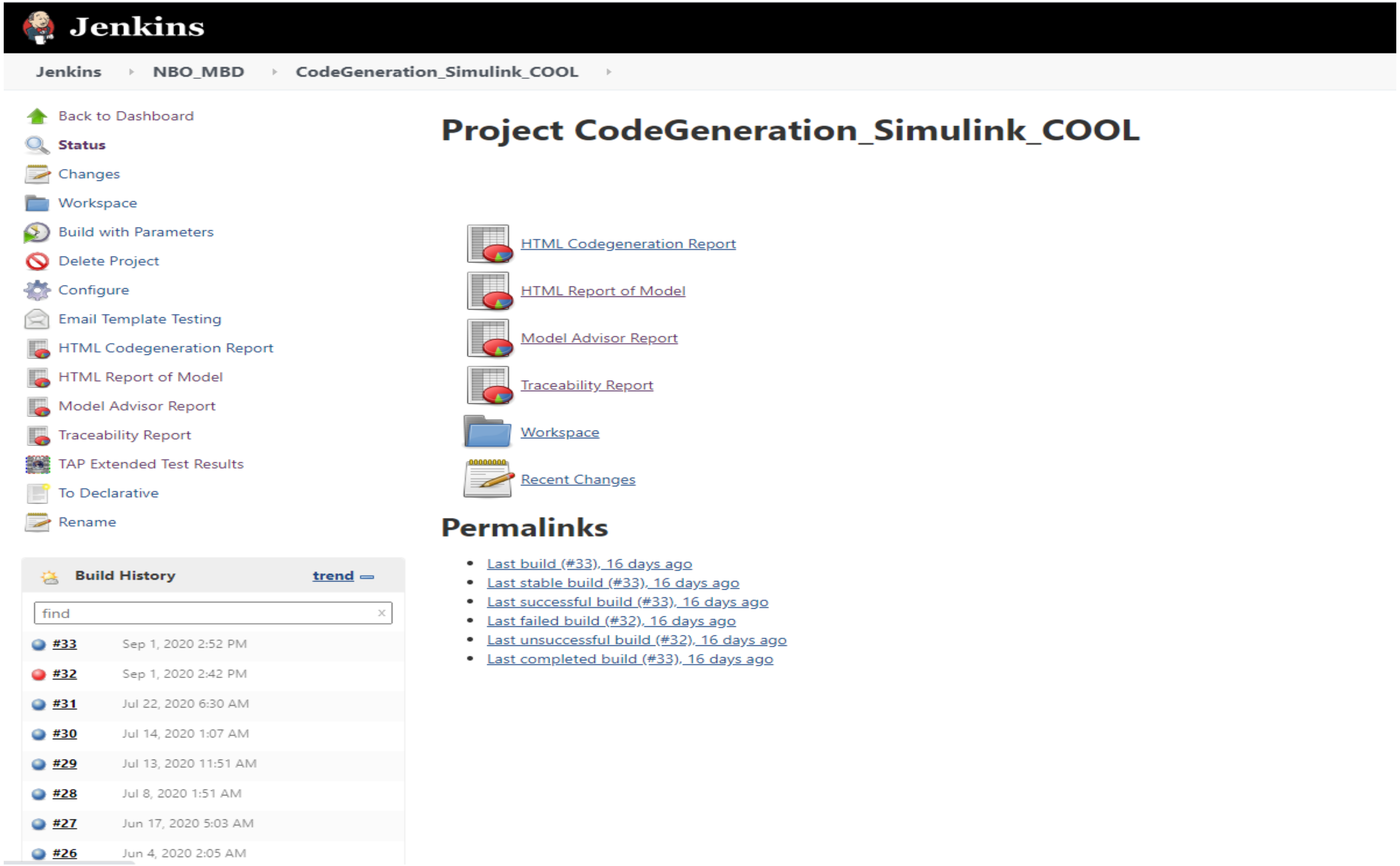
Jenkins Dashboard



#33	Sep 1, 2020 2:52 PM
#32	Sep 1, 2020 2:42 PM
#31	Jul 22, 2020 6:30 AM
#30	Jul 14, 2020 1:07 AM
#29	Jul 13, 2020 11:51 AM
#28	Jul 8, 2020 1:51 AM
#27	Jun 17, 2020 5:03 AM
#26	Jun 4, 2020 2:05 AM

Project CodeGeneration_Simulink_COOL

- HTML Codegeneration Report
- HTML Report of Model
- Model Advisor Report
- Traceability Report
- Workspace
- Recent Changes

Permalinks

- Last build (#33), 16 days ago
- Last stable build (#33), 16 days ago
- Last successful build (#33), 16 days ago
- Last failed build (#32), 16 days ago
- Last unsuccessful build (#32), 16 days ago
- Last completed build (#33), 16 days ago

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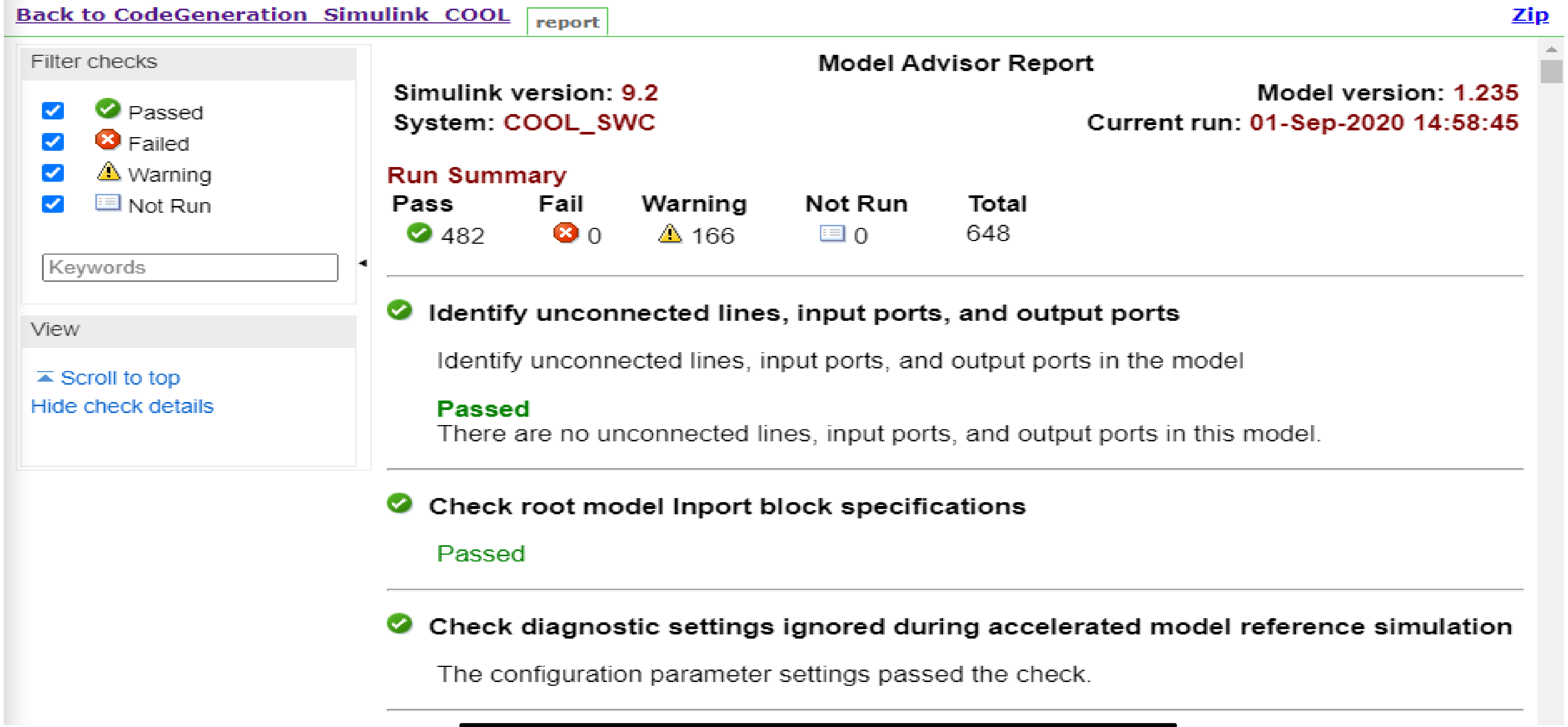
Model Advisor Report



Back to CodeGeneration_Simulink_COOL report

Zip

Filter checks

- ☑ ✓ Passed
- ☑ ☒ Failed
- ☑ ⚠ Warning
- ☑ ▤ Not Run

View

Model Advisor Report

Simulink version: 9.2
System: COOL_SWC

Model version: 1.235
Current run: 01-Sep-2020 14:58:45

Run Summary

Pass	Fail	Warning	Not Run	Total
✓ 482	☒ 0	⚠ 166	▤ 0	648

✓ **Identify unconnected lines, input ports, and output ports**

Identify unconnected lines, input ports, and output ports in the model

Passed
There are no unconnected lines, input ports, and output ports in this model.

✓ **Check root model Inport block specifications**

Passed

✓ **Check diagnostic settings ignored during accelerated model reference simulation**

The configuration parameter settings passed the check.

Static model analysis at each branch commit!

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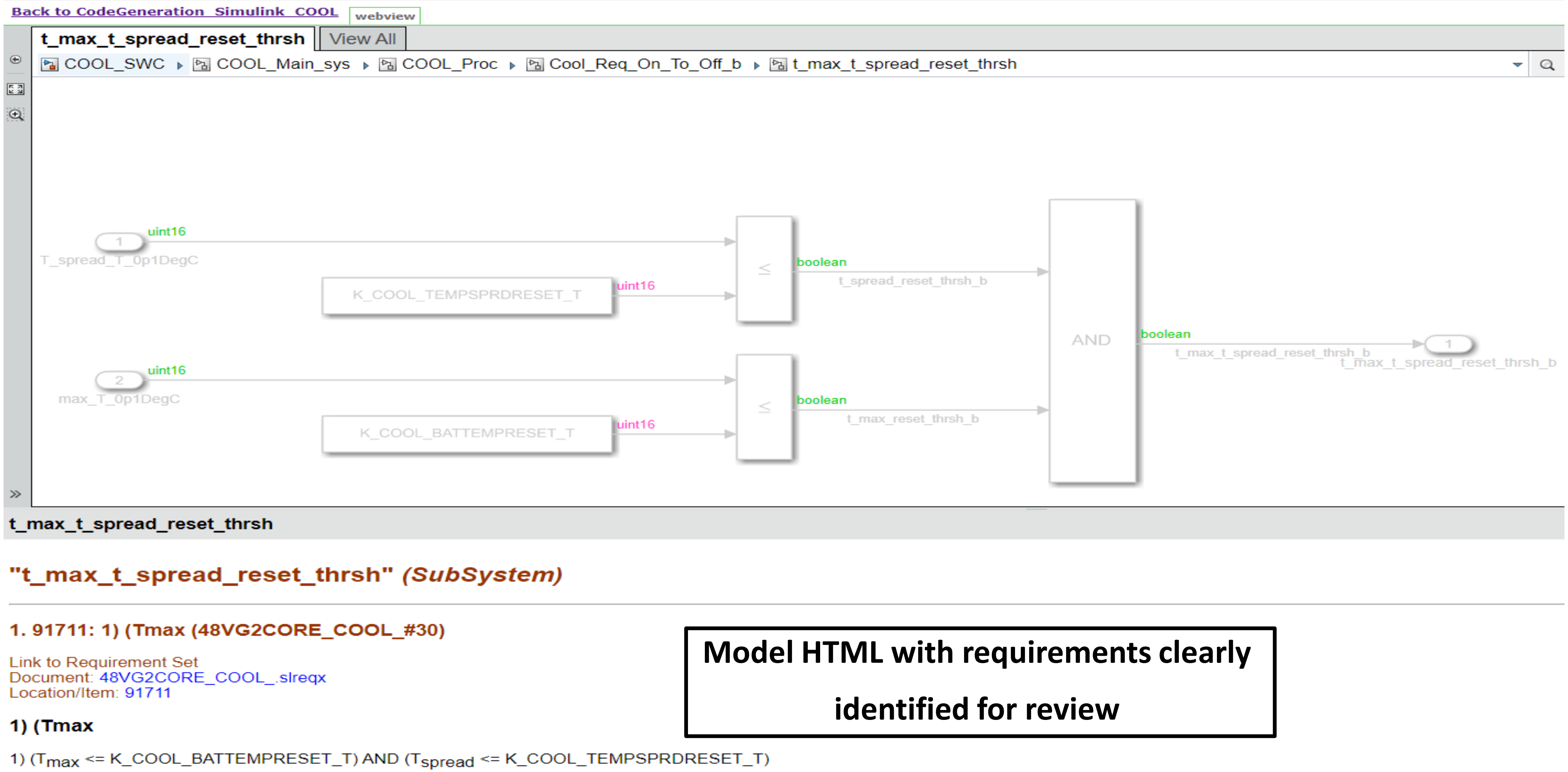
HTML of Model



"t_max_t_spread_reset_thrsh" *(SubSystem)*

1. 91711: 1) (Tmax (48VG2CORE_COOL_#30)

Link to Requirement Set
Document: 48VG2CORE_COOL_.slreqx
Location/Item: 91711

1) (Tmax

1) (T_{max} <= K_COOL_BATTEMPRESET_T) AND (T_{spread} <= K_COOL_TEMPSPRDRESET_T)

Model HTML with requirements clearly identified for review

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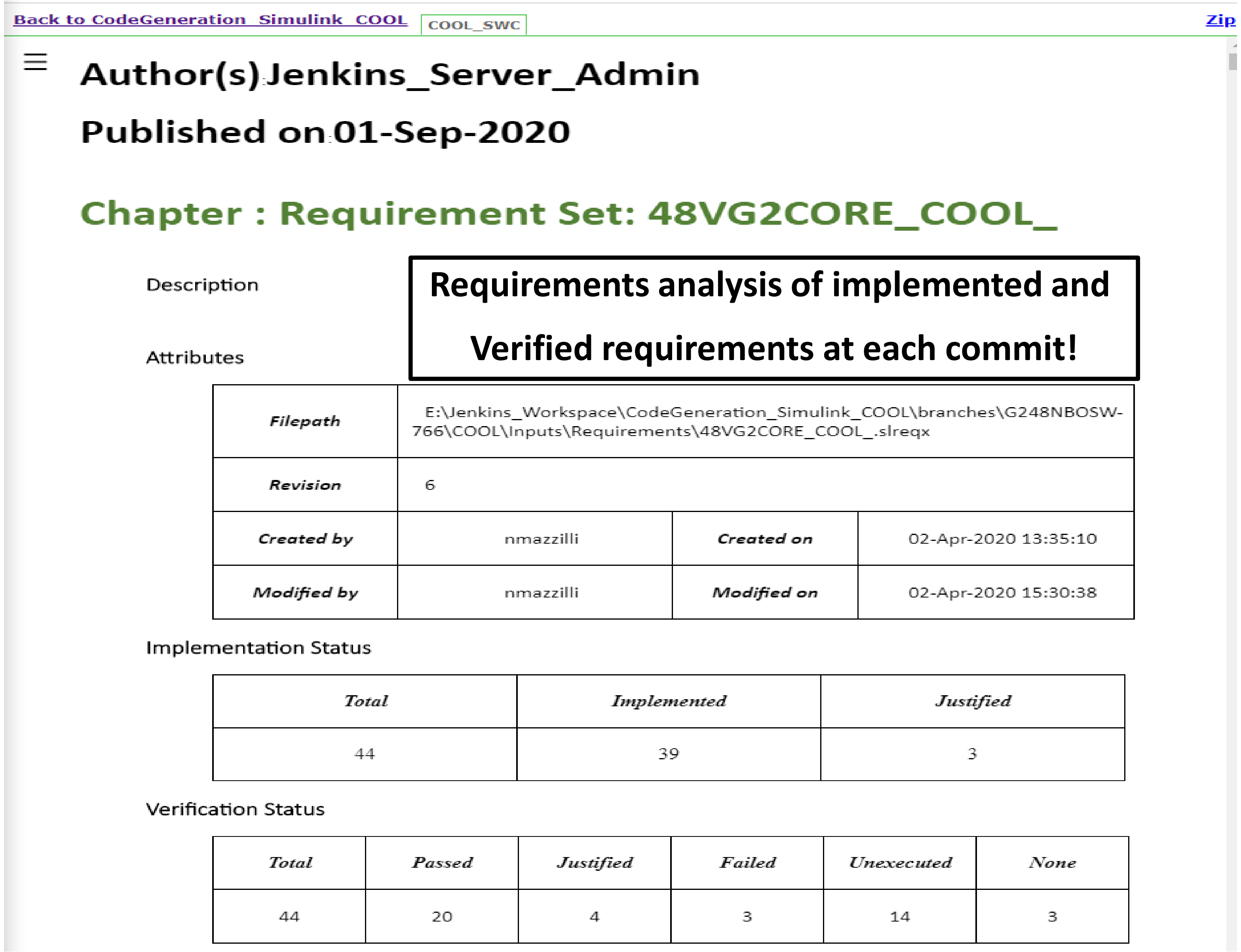
Traceability Report



Back to CodeGeneration_Simulink_COOL | COOL_SWC | Zip

Author(s):Jenkins_Server_Admin

Published on:01-Sep-2020

Chapter : Requirement Set: 48VG2CORE_COOL_

Requirements analysis of implemented and Verified requirements at each commit!

Description

Attributes

Filepath	E:\Jenkins_Workspace\CodeGeneration_Simulink_COOL\branches\G248NBOSW-766\COOL\Inputs\Requirements\48VG2CORE_COOL_.slreqx		
Revision	6		
Created by	nmazzilli	*Created on*	02-Apr-2020 13:35:10
Modified by	nmazzilli	*Modified on*	02-Apr-2020 15:30:38

Implementation Status

Total	*Implemented*	*Justified*
44	39	3

Verification Status

Total	*Passed*	*Justified*	*Failed*	*Unexecuted*	*None*
44	20	4	3	14	3

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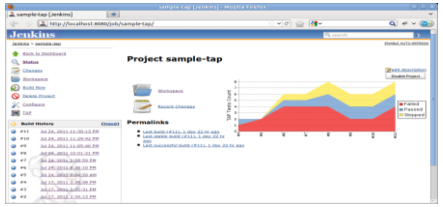
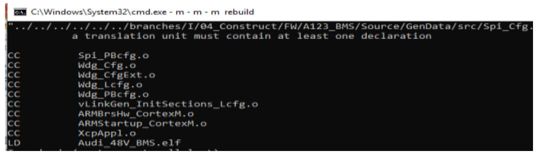
Integration Example

Review Results in MATLAB/Simulink or Jenkins

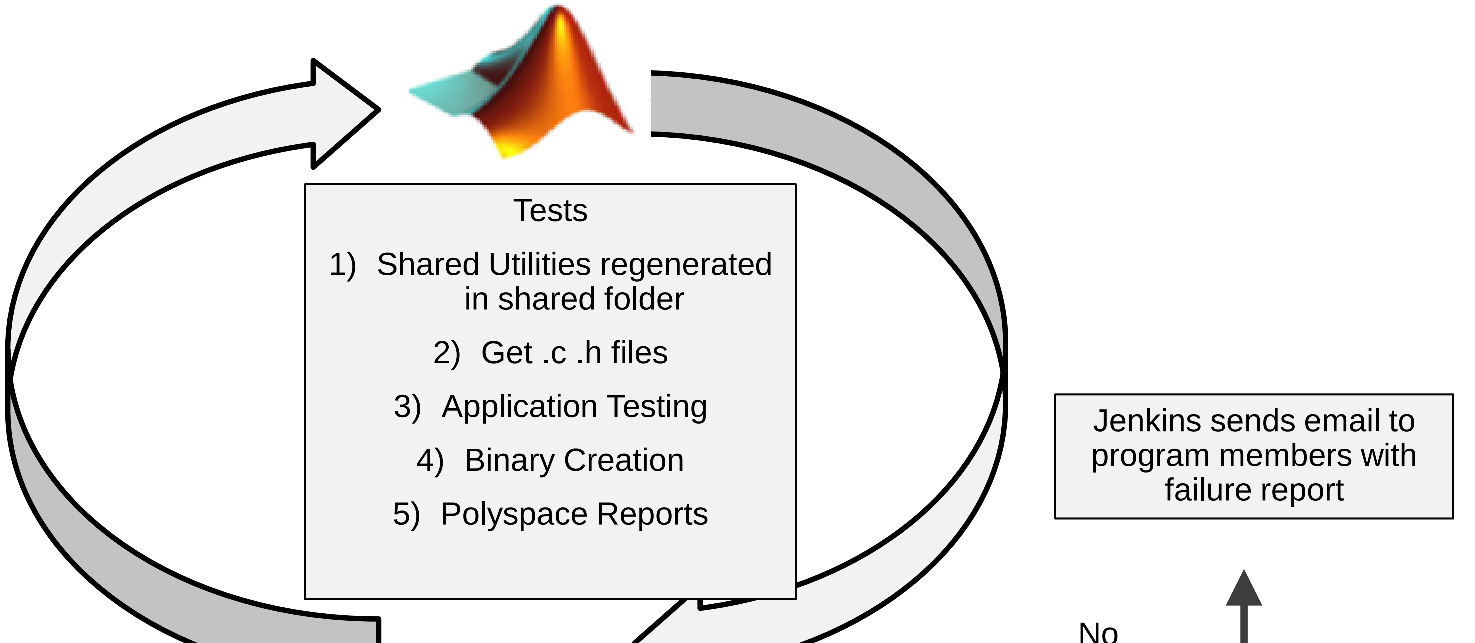




C:\Windows\System32\cmd.exe - m - m - m rebuild

```
"../../../../../../branches/I/04_Construct/FW/A123_BMS/Source/GenData/src/Spi_Cfg.
          a translation unit must contain at least one declaration

CC           Spi_PBcfg.o
CC           Wdg_Cfg.o
CC           Wdg_CfgExt.o
CC           Wdg_Lcfg.o
CC           Wdg_PBcfg.o
CC           vLinkGen_InitSections_Lcfg.o
CC           ARMBrsHw_CortexM.o
CC           ARMStartup_CortexM.o
CC           XcpAppl.o
LD           Audi_48V_BMS.elf
```

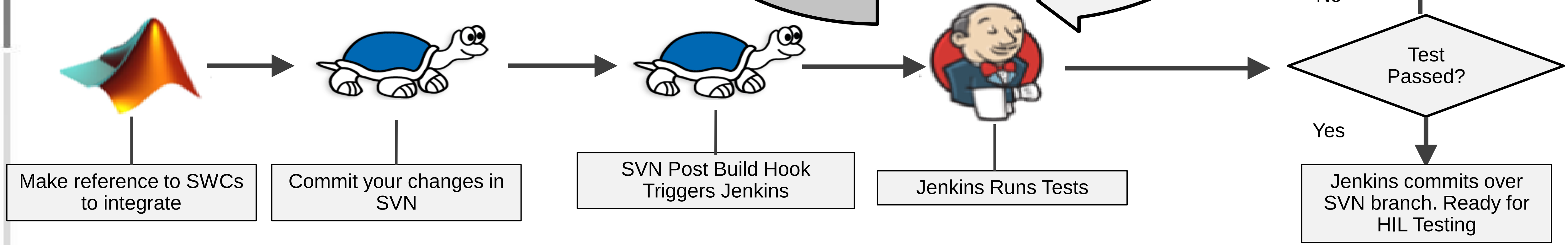


Tests

1) Shared Utilities regenerated in shared folder
2) Get .c .h files
3) Application Testing
4) Binary Creation
5) Polyspace Reports

Jenkins sends email to program members with failure report

No



Make reference to SWCs to integrate

Commit your changes in SVN

SVN Post Build Hook Triggers Jenkins

Jenkins Runs Tests

Test Passed?

Yes

Jenkins commits over SVN branch. Ready for HIL Testing

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Project Value

- Build server acts as sheriff
- Model reviews are based on generated report metrics not emotions
    - Model Advisor
    - Cyclomatic complexity
    - Polyspace
    - Simulink Test
    - Linked Requirements
- Bug tickets are created based on these reports in Jira
- Integration can still be automated

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Next Steps

- Integration testing / composition testing needs to be improved upon
- Add HIL testing to this automation process
- Add PIL testing to this automation process
- Continue to refactor models with best practices and refine library usage

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Conclusion

- One tool to develop software, link requirement, write test cases and create reports for ISO compliant workflow
- Built in reports necessary for reviews
- Reviews can be done by team members over Jenkins
- Write Jenkins test steps so that failures at any individual test can trigger a build failure
- 90% of steps that can be automated are
- Recommend top-down approach to control .arxml files for build process

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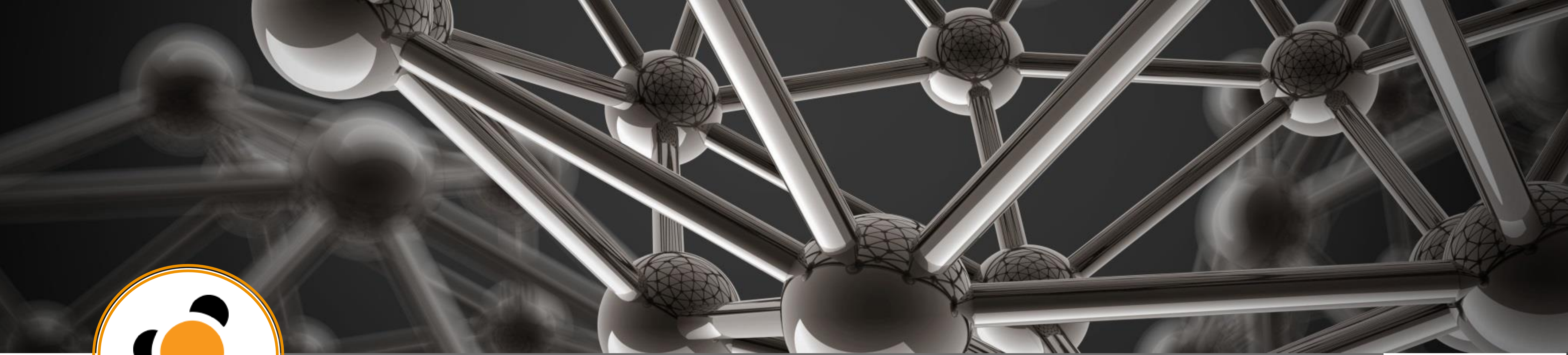

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