



2018 Annual INCOSE
Great Lakes Regional Conference
SYSTEMS AT THE CROSSROADS
17 - 20 October 2018 | Indianapolis, Indiana

Using Cognitive Computing to Elevate Requirements Quality and Test Case Accuracy

Bob Parro, VP Business Development & Product Development, River North Solutions

Steve Denman, Principal Consultant, Stephen D. Denman Consulting, LLC

Kevin McHugh, Senior Managing Consultant, IBM Watson IoT Lab Services

Agenda



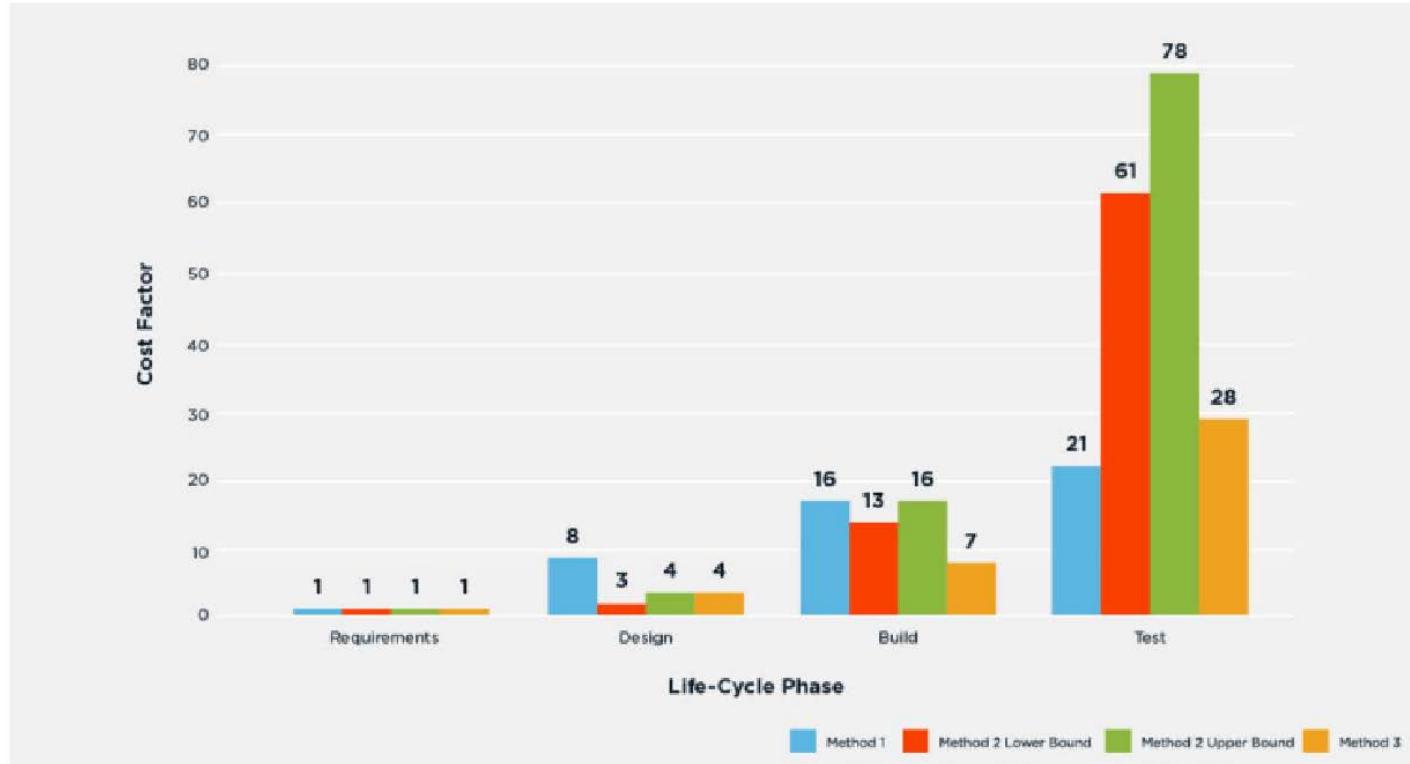
- The problem
- Cognitive approaches
- Cognitive engineering
- Cognitive requirements and test offerings
- Benefits of cognitive tools
- Future of cognitive engineering
- Summary & challenge
- Q&A

The problem

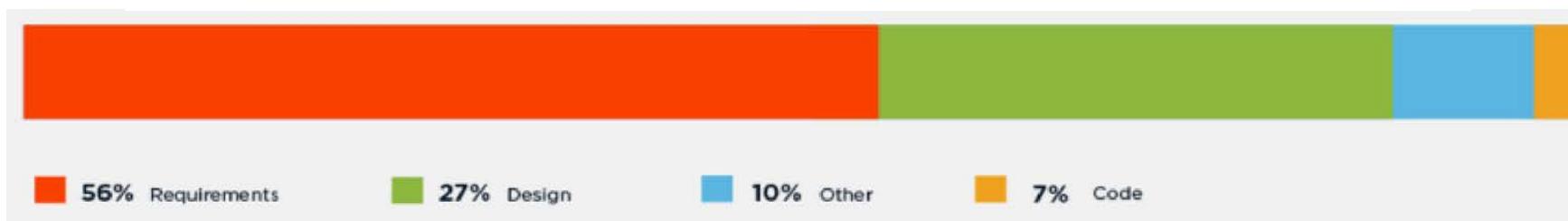


- Poor requirements are widely understood to be the cause of numerous project/product failures
 - Schedule delays, cost overruns, poor quality, going to market with reduced functionality compared to the original plan, going to market with the wrong product or solution
 - These impacts have been studied and long understood

The problem



Comparison of System Cost Factors – Excluding Operations [Jonette]

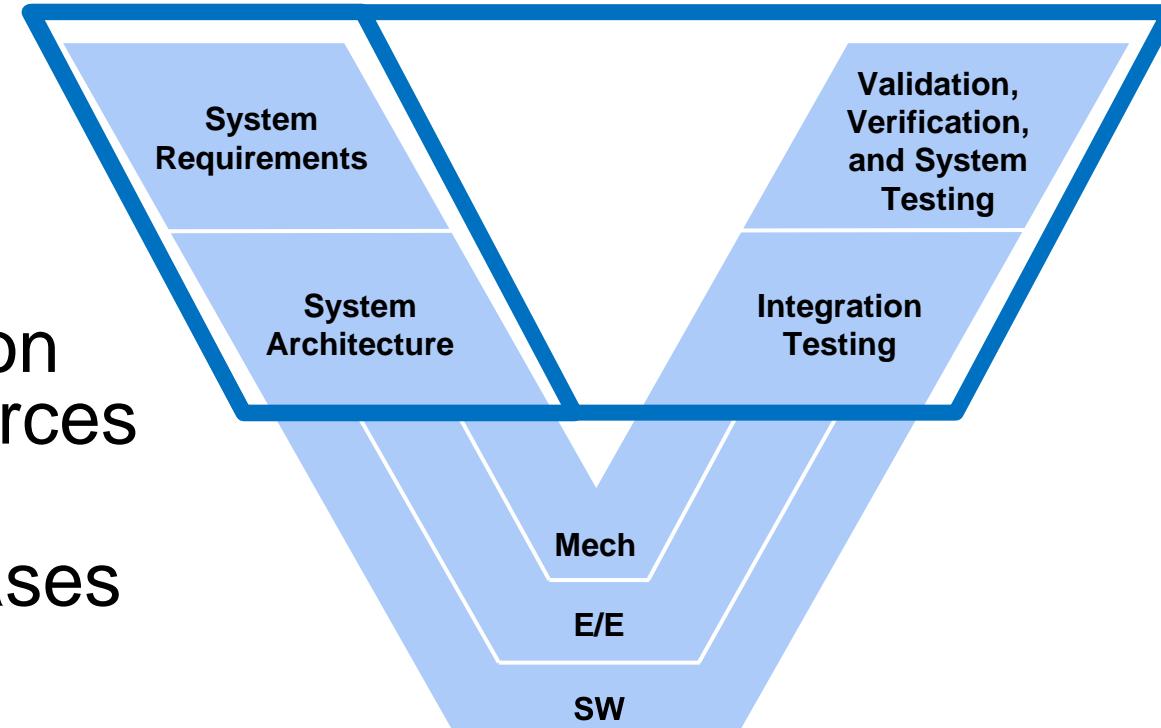


Cost to Fix Errors
Increases Exponentially
the Later They are
Found in the
Development Lifecycle

Distribution of defects
in software projects by
development phase
(Martin)

The problem

- But, there's more to this picture
 - Poor validation & verification practices also lead to failures
 - Test development and execution typically consume lots of resources and schedule
 - Only amplified when test cases are written poorly
 - Poor requirements result in poor test cases
 - Compounded by poor test case development practices



The problem underlying the problem



- Human language, aka natural language (NL), *still* the primary engineering specification language
 - Ambiguous by nature, even for humans
 - Computer comprehension still far behind human
- 60+ years developing computer comprehension of NL
 - Procedural
 - Formal specification
 - Cognitive computing
 - Combinations of above

Procedural approaches



- Conventional programming and information models to process natural language
 - Text parsed based on rules-based and/or pattern recognition techniques
 - Rules/patterns based on linguistics knowledge
 - Graph of text parts and relationships created and used to “understand” current and new text
 - Works better when requirements written within constraints
 - The <entity> shall <action verb> <object> <per some measure>

Formal specification



- Avoid issues with natural language by not using it
 - Formal languages
 - Structured, rigorous textual expressions
 - Range from sets of rules/constraints to highly formal expressions
 - Difficult to write - even more difficult to read
 - Modeling (graphical languages)
 - Graphical expression of structure, relationships, behavior, constraints, etc., e.g., SysML
 - Valuable but limited ability to express richness available in NL
 - Use of modeling + NL specifications expanding rapidly

Cognitive computing & deep learning



- Cognitive computing
 - Technology apps/services/platforms based on Artificial Intelligence (AI) techniques, including deep learning
- Deep learning
 - A non-procedural computing approach based on neural network model of human brain
 - Training needed to “teach” the network to recognize patterns
 - Supervised learning stage: Guided by SMEs
 - Requires input corpus of known “good” and “bad” patterns
 - Semi-supervised and unsupervised learning

Natural Language Understanding and Processing (NLU/NLP)

- NLU
 - Machine comprehension of parts of speech, interrelationships, and meaning in a body of text
 - Based on deep learning over a corpus of knowledge
- NLP: Apps and services that utilize NLU
 - Ex: Digital assistants: Apple Siri, Amazon Alexa
 - Ex: Sentiment analysis: IBM Watson, MS Azure
 - Language translation: Google Translate



Cognitive engineering



- Cognitive computing in engineering tool chains
- Tools can *finally* begin to *assist* engineers
 - Improving quality
 - Reducing errors, oversights, time, cost, ...
 - Requirements are getting most of focus currently
 - Testing is next logical choice
 - Also based heavily on NL
 - Derived directly from requirements
- Cross-domain, cross-lifecycle traceability next

Cognitive engineering

Improving quality of requirements & test



- Requirements
 - Numerically score quality – Rationale behind it
 - Recommendations – Rationale behind them
- Test
 - Numerically score quality – Rationale behind it
 - Recommendations – Rationale behind them

Cognitive engineering

Cognitive requirements and test offerings



A sample of the available offerings:

- QRA Corp QVscribe
- Argosim STIMULUS
- Qualicen Scout
- The Reuse Company offerings

QVscribe from QRA Corp

Requirements analysis for quality & consistency



Uses Natural Language Processing (NLP)

- Auto-detects requirements
- IDs and corrects ambiguities
- IDs duplicate or conflicting requirements
- Checks terminology and units consistency
- Quality Indicators
 - Imperatives (e.g. shall), Options (e.g. can, may), Vagueness (e.g. pronouns), Weaknesses (e.g. adequate), Subjectiveness (e.g. larger), Continuances (e.g. below), Universal quantifiers (all)
- Produces quality scorecard

QVscribe from QRA Corp

Requirements analysis for quality & consistency



CSA-ESM-RD-0004_Rev A_Prototype Lunar Exploration Light Rover_Requirements Document - Word

Sign in Share

Home Insert Design Layout References Mailings Review View Add-ins Tell me what you want to do

[EC-LMR-PRF-040] Obstacle Crossing: The Lunar Exploration Light Rover shall drive at low speed over obstacles of up to 0.3 m wide, 0.3 m long, and up to 0.3 m high with edges rounded to a radius of 0.05m. Note that if wheels are not the design solution, then the intent is that whatever the ground interaction, be it tracks, hovering, etc., the Lunar Exploration Light Rover can pass over this obstacle size.

Rationale: The Lunar Sourcebook mentions rock sizes up to 80cm (p32). The Lunar Science Working group found that the largest rock that would have to be crossed would be 30cm (Ozimski et al. Manned Lunar Mission (MLM) Science Working Group (SWG) Technical Note 1, p48).

Rounding the edges gives the obstacle a more rock-like shape.

QVscribe Marked Requirement

[EC-LMR-PRF-060] Ground Clearance: The Lunar Exploration Light Rover shall be able to pass over an obstacle with a height of 0.35 m and a width of 0.7 m. No projection of the Lunar Exploration Light Rover shall be closer to the ground than 0.35 m, other than the wheels, suspension and drivetrain components.

Rationale: The Lunar Sourcebook mentions rock sizes up to 80cm (p32). The Lunar Science Working group found that the largest rock that would have to be crossed would be 30cm (Ozimski et al. Manned Lunar Mission (MLM) Science Working Group (SWG) Technical Note 1, p48). Rounding the edges gives the obstacle a more rock-like shape.

§

QVscribe Marked Requirement A

[EC-LMR-PRF-090] Maximum Gradient: The Lunar Exploration Light Rover shall stop in a controlled fashion while ascending or descending a slope. The Lunar Exploration Light Rover shall be able to stop in a controlled fashion while ascending or descending a slope. Comment: Note that this requirement is not intended to be applicable for low-friction surfaces such as concrete, which would require rubber for traction.

QVscribe

Quality Analysis Consistency Similarity

Last Analyzed: November 14, 2017 at 9:07AM View: All

Overall Quality Score 21 Quality Warning

Requirement	Score & Warnings
[EC-LMR-PRF-010] Range: The Lunar exploration Light Rover shall have a range...	Score: 100 Warnings: 0
[EC-LMR-PRF-018] Maximum Speed on Prepared Surface: The Lunar Exploration...	Score: 100 Warnings: 0
[EC-LMR-PRF-120] Maximum Speed on Natural Terrain: The Lunar Exploration Li...	Score: 0 Warnings: 100
[EC-LMR-PRF-068] Rock Hazard: The Lunar Exploration Light Rover running gear...	Score: 0 Warnings: 100
[EC-LMR-PRF-069] Soil Properties: The Lunar Exploration Light Rover shall be ab...	Score: 0 Warnings: 100
[EC-LMR-PRF-150] Reverse speed: The speed requirements apply in forward and...	Score: 0 Warnings: 100
[EC-LMR-PRF-063] Minimum Speed: The Lunar Exploration Light Rover shall be c...	Score: 100 Warnings: 0
[EC-LMR-PRF-065] Acceleration: The Lunar Exploration Light Rover, at maximum...	Score: 100 Warnings: 0
[EC-LMR-PRF-170] Stopping distance: The Lunar Exploration Light Rover, at maxi...	Score: 0 Warnings: 100
[EC-LMR-PRF-059] Consecutive Stops: The Lunar Exploration Light Rover, loaded...	Score: 0 Warnings: 100
[EC-LMR-PRF-017] Gradeability: The Lunar Exploration Light Rover shall drive at...	Score: 100 Warnings: 0
[EC-LMR-PRF-040] Obstacle Crossing: The Lunar Exploration Light Rover shall dri...	Score: 0 Warnings: 100
[EC-LMR-PRF-090] Maximum Gradient: The Lunar Exploration Light Rover shall be...	Score: 0 Warnings: 100

Contains illegal words
Quality Warnings
Contains universal quantifiers

Quality Analysis

QVscribe from QRA Corp

Requirements analysis for quality & consistency



File Home Insert Design Layout References Mailings Review View Add-ins Tell me what you want to do Share

CSA-ESM-RD-0004 Revision A
March 4, 2010

Rationale: This function is required to support the non-locomotion functions of the Exploration System. The specific requirements are in RD-2.

QVscribe Marked Requirement:

[EC-LMR-INT-010] Payload power: The Lunar Exploration Light Rover shall be capable of providing a total average power of 250 W to all payloads and instruments during all mission phases.

Rationale: Payloads and instruments cover a wide range of systems from payloads that only require keep-alive warmth (minimal in normal analog environments) to power-hungry subsystems like drills. The value was chosen somewhat arbitrarily. Note a single automotive battery contains about 500 W-hr.

[EC-LMR-INT-011] Payload power boost: When parked, the Lunar Exploration Light Rover shall increase the available power to the payloads and tools by at least 100%. The Lunar Exploration Light Rover should be capable of providing all unused power to the payloads.

Rationale: Some subsystems such as a drill or robot arm, will require substantial power to operate, and when parked the Rover should not need its full power capacity. The value of 100% is selected to allow considerable leeway to the payloads. Initial estimates of rolling resistance for rover locomotion suggest that the cruise power of the rover will be in the 5 to 20 kW range, so the payload power boost is quite small relative to this, and will not affect rover range significantly.

3.4 Safety

[EC-LMR-SMA-002] Maximum Speed: For safety requirements in this document, the speed to be used shall be the maximum speed achievable by the vehicle

[EC-LMR-SMA-001] Safe Environment: When upgraded to transport astronaut, the Lunar Exploration Light Rover shall provide a safe environment to crew and maintenance personnel who are on-board or working on the exterior.

[EC-LMR-SMA-250] All-Stop: Upon command, the Lunar Exploration Light Rover shall conduct a graceful stop of all mechanical and electrical systems and payloads.

Rationale: All-stop is required for safety. Several situations could cause a hazard which would require safety of the system. (a) a loss of situational awareness by the operator, especially in tele-operation, due to camera malfunction or poor lighting or other conflicting situation, (b) an internal failure, (c) concurrent system failure, (d) a system that is not properly initialized, (e) a system that is not properly shutdown.

QVscribe

Quality Analysis Consistency Similarity

Units Terms

Unit Consistency

Unit	Count
kilometer	12
centimeter	5
Rock Hazard	1
Imaging	1
Basic Digital Terrain Mapping	1
Crew Contact Loads	1
Sensor Payload Accommodation	1
hour	3
second	5
minute	3
angle	3
minute	3
degree	11
second	3
power, radiant flux	1
Newton	1
force	1
newton	1

Unit and Term Consistency

Argosim STIMULUS



- *Requirements-in-the-loop*
 - Executable requirements and system specs
- Automated requirements validation and verification
 - Based on formal requirements specification language and system models
 - Conflicting/missing requirements and functional coverage
- Formal language and system models automatically converted to software-in-the-loop (SIL) validation tests
 - Based on conversion to executable SIL test code via the Functional Mockup Interface (FMI) standard

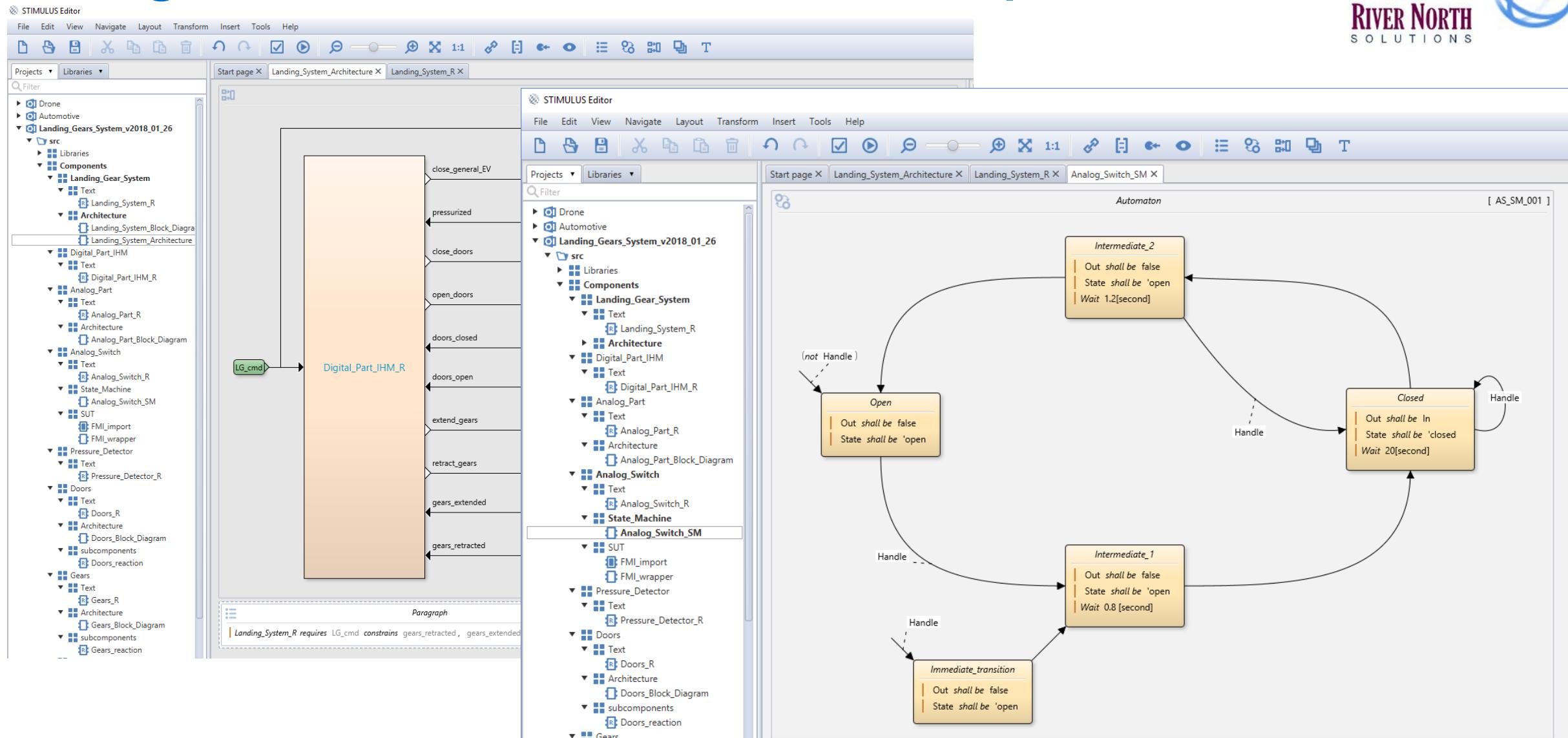
Argosim STIMULUS for Requirements



The screenshot shows the Stimulus Editor interface with the following details:

- Top Bar:** File, Edit, View, Navigate, Layout, Transform, Insert, Tools, Help.
- Toolbar:** Includes icons for file operations (New, Open, Save, Print, Find, Replace, etc.) and other tools.
- Project Explorer:** Shows the project structure under "Landing_Gears_System_v2018_01_26".
 - src:** Contains Libraries, Functions, Types, Constants, and Whitespace.
 - Components:** Contains Landing_Gear_System, which has Text and Landing_System_R (selected).
 - Landing_System_R:** Contains Architecture, Digital_Part_IHM, Text, Digital_Part_IHM_R, Analog_Part, Text, Analog_Part_R, Architecture, Analog_Part_Block_Diagram, Analog_Switch, Text, Analog_Switch_R, State_Machine, Analog_Switch_SM, SUT, FMI_import, FMI_wrapper, Pressure_Detector, Text, Pressure_Detector_R, Doors, Text, Doors_R, Architecture, Doors_Block_Diagram, subcomponents, Doors_reaction, Gears, Text, Gears_R.
- Functional Requirements:** The main content area displays functional requirements for the landing gear system.
 - [LS_RQ_001]** When `LG_cmd` is 'DOWN',
 - Do**
 - `gears_extended` shall be true and `doors_closed` shall be true within 15[second]
 - afterwards**
 - `gears_extended` shall be true
 - `doors_closed` shall be true
 - [LS_RQ_002]** When `LG_cmd` is 'UP',
 - Do**
 - `gears_retracted` shall be true and `doors_closed` shall be true within 15[second]
 - afterwards**
 - `gears_retracted` shall be true
 - `doors_closed` shall be true
 - [LS_RQ_003]** When `LG_cmd` is 'DOWN',
 - Do**
 - `gears_extended` shall be true within 12[second]
 - afterwards**
 - `gears_extended` shall be true
 - [LS_RQ_004]** When `LG_cmd` is 'UP',
 - Do**
 - `gears_retracted` shall be true within 12[second]
 - afterwards**
 - `gears_retracted` shall be true

Argosim STIMULUS for Requirements



Argosim STIMULUS for Requirements



Stimulus Editor

File Edit View Navigate Layout Transform Insert Tools Simulation Help

Projects Libraries Filter

Landing_Gears_System_v2018_01_26

- src
 - Libraries
 - Components
 - Tests
- Automotive
 - src
 - Library
 - Requirements
 - glossary
 - LLR
 - LLR_v1
 - LLR_v2
 - LLR_v3
 - Tests
 - World
 - Scenario
 - SUT
 - TestSuite

Start page X World X LLR_v2 X

When headLight was 'ON and lightIntensity is greater than 70[percent] ,
has been true for more than 3[second]
headLight shall be 'OFF

REQ_003.3

Do

If initially(lightIntensity is less than or equal to 70[percent]) then
headLight shall be 'ON

afterwards

When (lightIntensity is less than or equal to 70[percent]),
headLight shall be 'ON

REQ_003.4

Do

If initially(lightIntensity is greater than 70[percent]) then
headLight shall be 'OFF

afterwards

When (lightIntensity is greater than or equal to 60[percent]),
headLight shall be 'OFF

World/simu X

Runs 10 Steps 40 Clear Before Runs Current Run = 9 Current step = 33 Period = 0.1 second

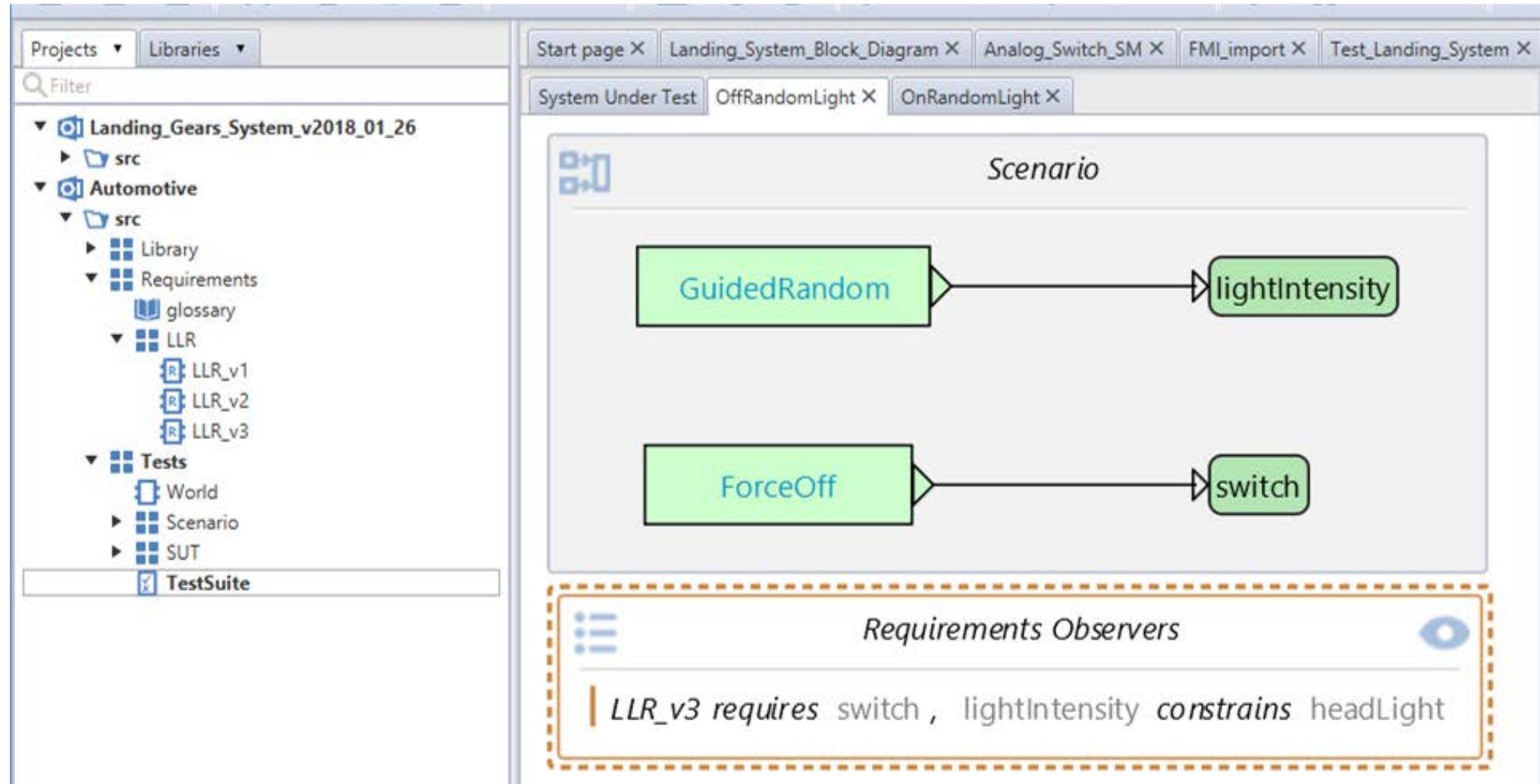
Runs [9 , 9] Show all runs

Filter

Name	Value	Observers	Coverage	Color
World			83.33%	
Ports				
lightIntensity	0.6259...			
switch	'AUTO			
headLight				
Variables				

Values

Argosim STIMULUS for Tests



Scout from Qualicen



Rapid user feedback provides strongest learning

Integrations

- Word, DOORS, PTC Integrity

Trend analysis key capability

- Users want quality improvement over time

Key quality indicators

- Long, complicated sentences
- Passive voice
- Multiple negations
- Vague phrases and pronouns
- Comparatives and superlatives
- Dangerous slash
- UI details
- Cloning (same data not in sync)
- ToDos

Scout from Qualicen



UC01 Add Job.docx - Word

Datei Start Einfügen Entwurf Layout Verweise Sendungen Überprüfen Ansicht Requirements Scout Sie wünschen... Anmelden Freigeben

Qualicen Document Selection Changes Contact Analyze Visualize Status

Show Findings Status Hide Findings Cancel English

2 Preconditions

The user is logged on. See also UC09 Maintain Access Rights. See Use Case "Log In".

3 Basic Flow

This section describes the normal flow through the use case.

{ View Schedules }

1. The system quickly displays the start page.
2. The actor Portfoliomanager clicks on the link Job Management.
3. The system displays the markets of the Portfoliomanager if he is authorized for at least one market, and the system displays at least the Job Execution List (see BR001) at the bottom of the page.

especially if no agent is mentioned in the sentence

Smell: Long Sentence Smell
Avoid long sentences as they decrease the readability of the Use Case. Split up the sentence.

Smell: UI Details Smell
Vor wenigen Sek. Avoid implementation and UI details in the Use Case. Specify these details in the Supporting Information document. Example: 'the user selects an item from the presented list of reports' instead of 'the user selects an item from the presented list in the combo box'

Smell: Negative Words Smell
Negative words can lead to undefined error states. Describe what happens in an exceptional situation. Example: 'If the user enters no date, the system presents an error.' instead of 'the procedure does not work without a date.'

Smell: Negative Words Smell
Negative words can lead to undefined error states. Describe what happens in an exceptional situation.

Scout from Qualicen

Scout Dashboard Activity Findings Documents Delta Projects System Admin Requirements

Timetravel: Dashboard at the most recent revision

Welcome to the Scout Dashboard

Welcome to the Scout Dashboard

Current Size in Words: 2.3k +304

Current Number of Files: 4 no change

Current Number of Findings: 647 +62

Findings Churn for requirements: 0 83 2 21 Trend: 10 Days

Findings Summary Bar Chart for requirements

Requirements Smells: 500

Duplication: 50

Glossary: 50

Structural Smells: 10

Test Smells: 0

Metrics Trend Chart for requirements

Text Size (Words): 2,294

Smell Density: 45.7%

Date: Feb 24 2018 13:05

Feb 01 Feb 04 Feb 07 Feb 10 Feb 13 Feb 16 Feb 19 Feb 22 Feb 25

49.0% 48.0% 47.0% 46.0% 45.0% 44.0%

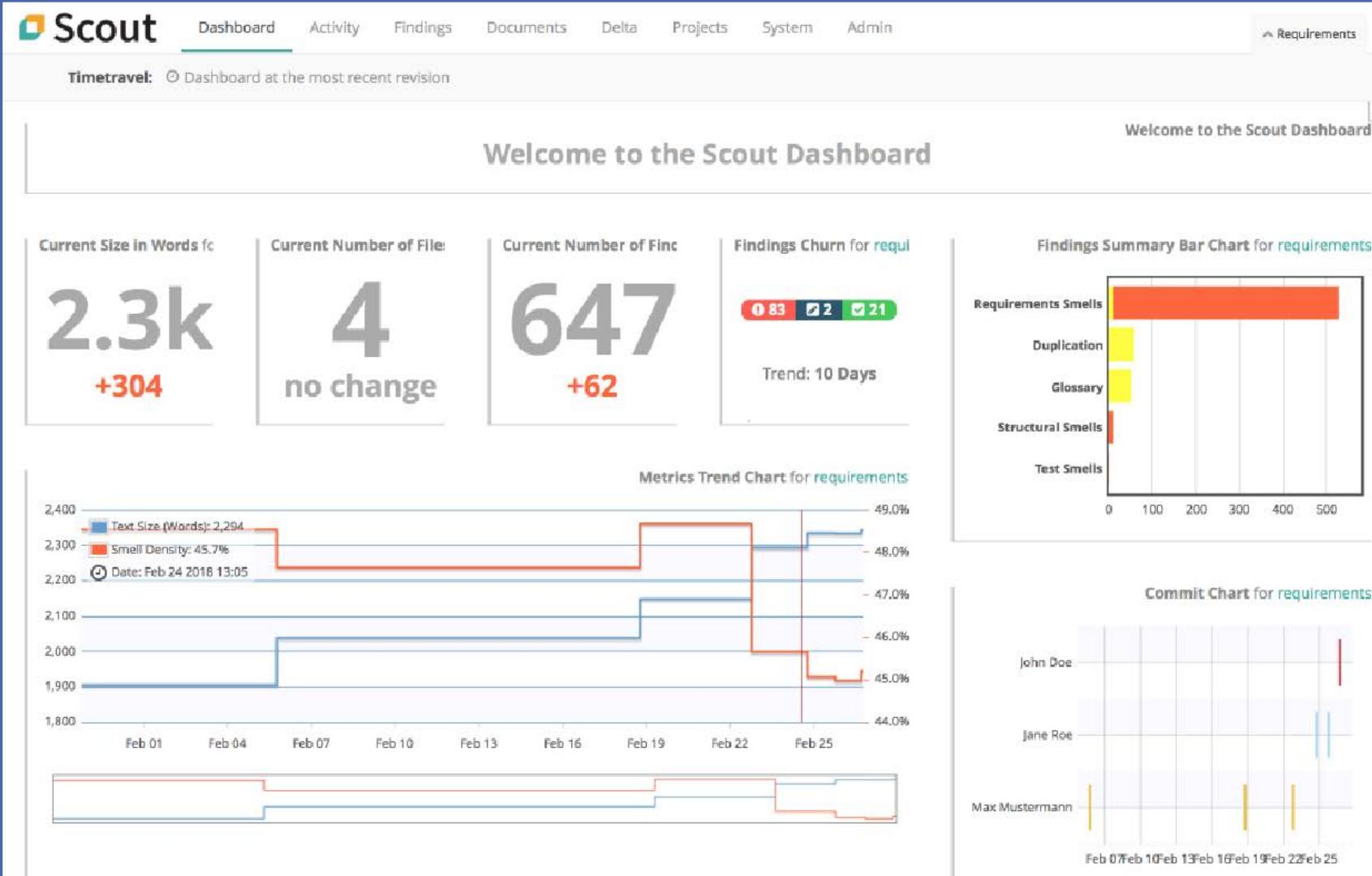
Commit Chart for requirements

John Doe

Jane Roe

Max Mustermann

Feb 07 Feb 10 Feb 13 Feb 16 Feb 19 Feb 22 Feb 25



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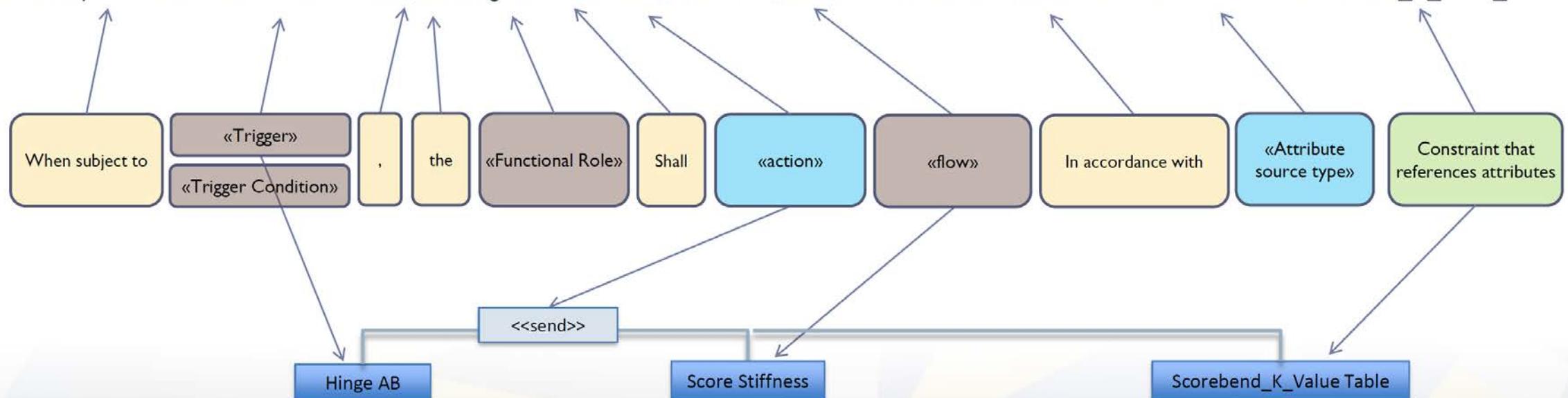


- Offerings
 - Requirements Authoring Tools (RAT)
 - V&V Studio
 - Traceability Studio
 - Knowledge Manager (KM)
- Unified model
 - Based on a single, integral, underlying graph
 - NLU is used to unify textual assets with modeling and simulation assets

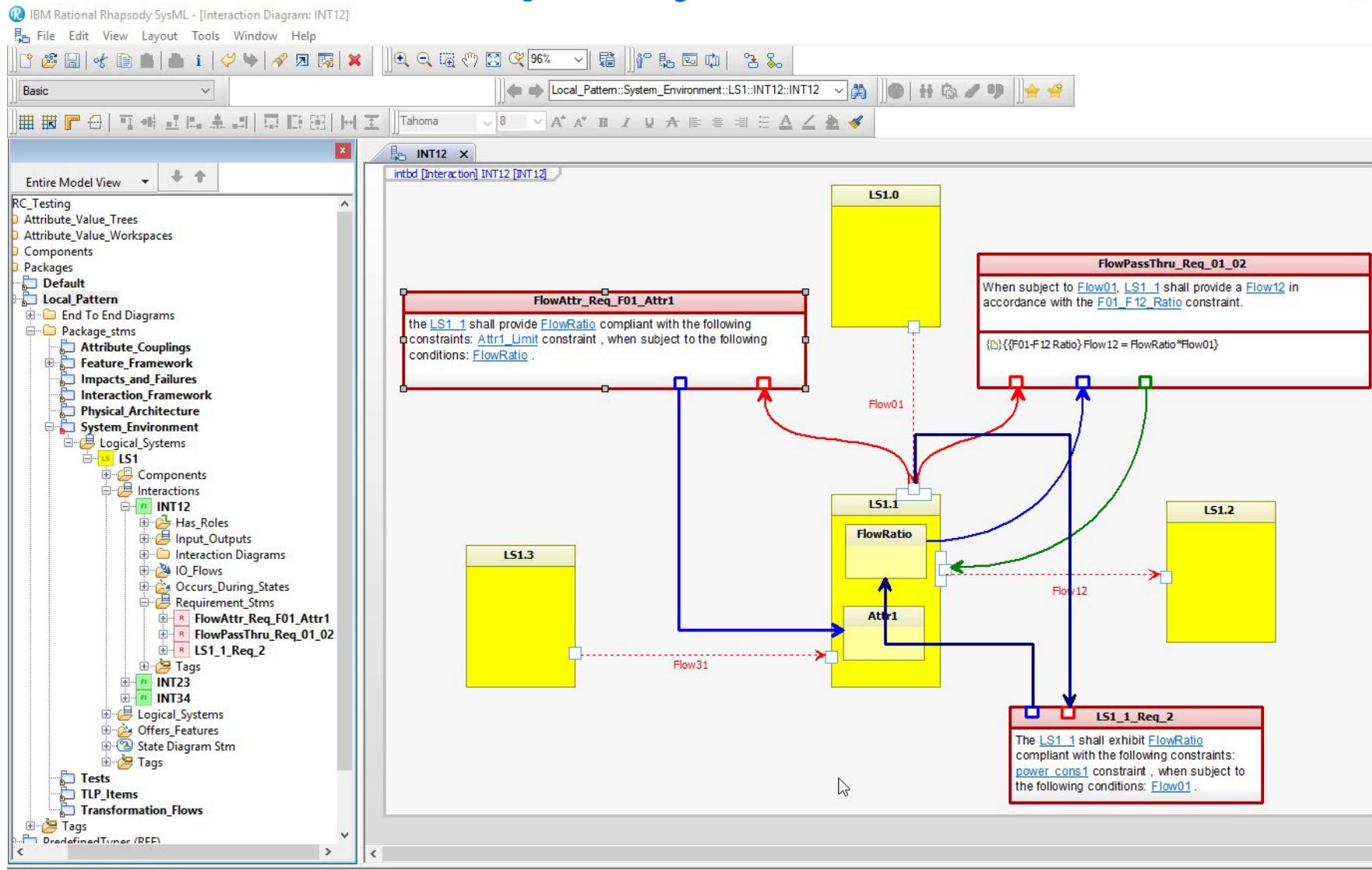
Structuring Requirements A formal representation

When subject to **Vacuum Picker Moment A**, **Hinge AB** shall transmit **Score Stiffness Moment AB** in accordance with attribute table: **Scorebend_K_Value_Table**.

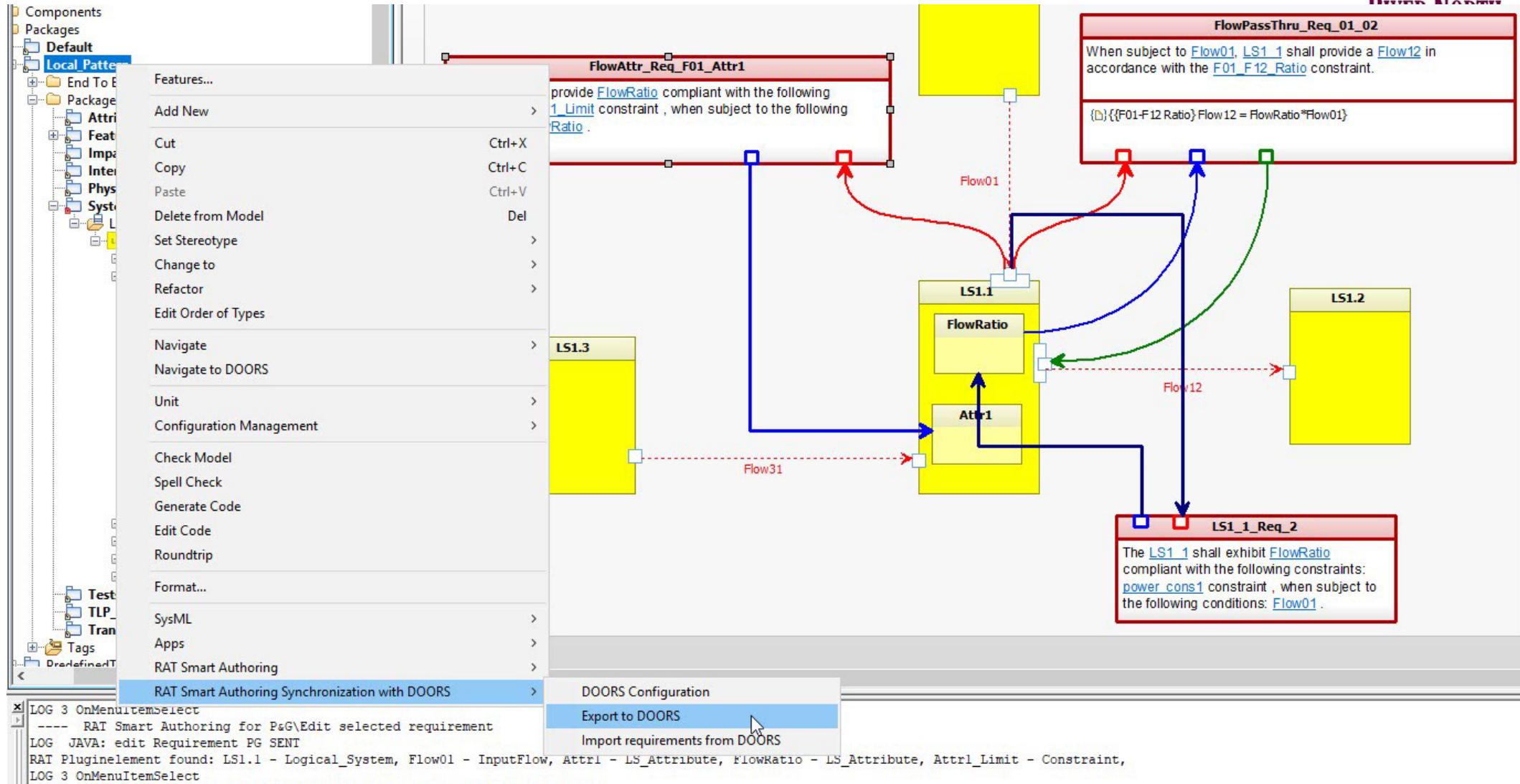
When subject to Vacuum Picker Moment A , the Hinge AB shall transmit Score Stiffness Moment AB in accordance with attribute table: Scorebend_K_Value_Table



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Diagram illustrating the reuse of a Local Pattern (INT12) within a System Environment (LS1). The Local Pattern (INT12) is defined with constraints and requirements, which are then applied to the System Environment (LS1).

Local Pattern (INT12) Definition:

- FlowAttr_Req_F01_Attr1:** The LS1_1 shall provide FlowRatio compliant with the following constraints: Attr1_Limit constraint, when subject to the following conditions: FlowRatio.

System Environment (LS1) Application:

- Requirement:** 1.1.2.1 FlowAttr_Req_F01_Attr1
 - the LS1_1 shall provide FlowRatio compliant with the following constraints: Attr1_Limit constraint, when subject to the following conditions: Flow01.
- Requirement:** 1.1.3.1 LS1_1_Req_2
 - The LS1_1 shall exhibit FlowRatio compliant with the following constraints: power_cons1 constraint, when subject to the following conditions: Flow01.
- Requirement:** 1.1.4.1 FlowPassThru_Req_01_02
 - When subject to Flow01, LS1_1 shall provide a Flow12 in accordance with the F01_F12_Ratio constraint.

Diagram Details:

- LS1.3:** A yellow rectangular component representing a logical system.
- Flows:** A blue line labeled "Flow31" connects the LS1.3 component to a white rectangular component.
- Requirement:** FlowAttr_Req_F01_Attr1 is highlighted with a red oval.
- Requirement:** 1.1.2.1 FlowAttr_Req_F01_Attr1 is highlighted with a red oval.

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'System' current 0.0 in /PnG (Formal module) - DOORS

File Edit View Insert Link Analysis Table Tools Discussions Authoring user Change Management Help

View Systems View All levels

ID	ElementType	Content	IO
2980	System	1 Local_Pattern	
2981	Interaction	1.1 INT12	
2982	System	1.1.1 LS1.1	
2983	Attribute	1.1.2 Attr1	
2984	Requirement	1.1.2.1 FlowAttr_Req_F01_Attr1	
2985	Constraint	1.1.2.2 FlowAttr_Req_F01_Constraint1	
2986	Attribute	1.1.3 Flow01	
2987	Requirement	1.1.3.1 Flow01	
2988	Constraint	1.1.3.2 Flow01	
2989	IO	1.1.4 Flow01	
2990	Requirement	1.1.4.1 Flow01	
2991	Constraint	1.1.4.2 Flow01	
2992	IO	1.1.5 Flow01	
2993	IO	1.1.6 Flow01	
2994	System	1.1.7 LS1.0	
2995	IO	1.1.8 Flow01	
2996	System	1.1.9 LS1.0	
2997	IO	1.1.10 Flow01	

A context menu is open over the requirement row with ID 2984, showing options like Authoring, Insert, Edit, Link, Cut, Copy, Copy URL, Paste, Undelete, Delete, Purge..., New Object Discussion..., Submit Change Proposal..., Properties..., Table properties..., Lock, Unlock, and Clear Suspicion... The "Edit" option is highlighted.

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New - Authoring Tool for Rhapsody

File Suggestions View Log

Authoring Tool for Rhapsody

By The REUSE Company

Authoring with pattern 'P&G multi trigger multi behaviour'

P&G (10) P&G multi trigger multi behaviour

Font Times New Roman Font Size 12 **A** *A* ^a _b **B** *I* U S S X X Aa ab A A

the LS1_1 shall provide FlowRatio compliant with the following constraints: Attr1_Limit constraint , when subject to the following conditions FlowRatio

Matching patterns elements:

The | «Logical_System» | MODAL VERB «MODAL COMPULSORY» | Exhibit | «LS_Attribute» | Compliant with the following constraints: | «Constraint»
The | «Logical_System» | MODAL VERB «MODAL COMPULSORY» | Provide | «OutputFlow» | Compliant with the following constraints: | «Constraint»

Weight	Pattern name

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New - Authoring Tool for Rhapsody

File Suggestions View Log

Authoring Tool for Rhapsody

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Authoring with pattern 'P&G multi trigger multi behaviour'

P&G (10) P&G multi trigger multi behaviour

Font Times New Roman Font Size 12 **A** *A* A ^A _A **A** *A* A ^A _A

the LS1_1 shall provide FlowRatio compliant with the following constraints: Attr1_Limit constraint , when subject to the following conditions:

Matching patterns elements:

The | «Logical_System» | MODAL VERB «MODAL COMPULSORY» | Exhibit | «LS_Attribute» | Compliant with the following constraints: | «Constraint»
The | «Logical_System» | MODAL VERB «MODAL COMPULSORY» | Provide | «OutputFlow» | Compliant with the following constraints: | «Constraint»

Weight	Pattern name

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New - Authoring Tool for Rhapsody

File Suggestions View Log

Authoring Tool for Rhapsody

By The REUSE Company

Authoring with pattern 'P&G multi trigger multi behaviour'

P&G (10) P&G multi trigger multi behaviour

Font Times New Roman Font Size 12 **I** U S S X² X₂ Aa ab A A

the LS1_1 shall provide FlowRatio compliant with the following constraints: Attr1_Limit constraint , when subject to the following conditions: |

Matching patterns elements: |

The | «Logical_System» | MODAL VERB «MODAL COMPULSORY» | Exhibit | «LS_Attribute» | Compliant with the following constraints: | «Constraints»
The | «Logical_System» | MODAL VERB «MODAL COMPULSORY» | Provide | «OutputFlow» | Compliant with the following constraints: | «Constraints»

The Attr1 Attr1_Limit Flow01 FlowRatio LS1_1

6 terms Show numbers Show optional terms

The REUSE Company



New - Authoring Tool for Rhapsody

File Suggestions View Log

Authoring Tool for Rhapsody

By The REUSE Company

Authoring with pattern 'P&G multi trigger multi behaviour'

P&G (10) P&G multi trigger multi behaviour ?

Font Times New Roman Font Size 12 A A B I U U S S X X Aa A A A A

the LS1_1 shall provide FlowRatio compliant with the following constraints: Attr1_Limit constraint , when subject to the following conditions: Flow01.

Matching patterns elements:

The | «Logical_System» | MODAL VERB «MODAL COMPULSORY» | Exhibit | «LS_Attribute» | Compliant with the following constraints: | «Constraint»
The | «Logical_System» | MODAL VERB «MODAL COMPULSORY» | Provide | «OutputFlow» | Compliant with the following constraints: | «Constraint»

Weight	Pattern
	The
	Attr1
	Attr1_Limit
	Flow01
	FlowRatio
	LS1_1

6 terms Show numbers Show optional terms

The REUSE Company



'System' current 0.0 in /PnG (Formal module) - DOORS (Not Responding)

File Edit View Insert Link Analysis Table Tools Discussions Authoring user Change Management Help

View Systems View All levels

ID	Element Type	IO
2980	System	1 Local_Pattern
2981	Interaction	1.1 INT12
2982	System	1.1.1 LS1.1
2983	Attribute	1.1.2 Attr1
2984	Requirement	1.1.2.1 FlowAttr_Req_F01_Attr1 the LS1_1 shall provide FlowRatio compliant with the following constraints: Attr1_Limit constraint , when subject to the following conditions: FlowRatio .
2985	Constraint	1.1.2.1.1 Attr1_Limit
2986	Attribute	1.1.3 FlowRatio
2987	Requirement	1.1.3.1 LS1_1_Req_2 The LS1_1 shall exhibit FlowRatio compliant with the following constraints: power_cons1 constraint , when subject to the following conditions: Flow01 .
2988	Constraint	1.1.3.1.1 power_cons1
2989	IO	1.1.4 Flow12
2990	Requirement	1.1.4.1 FlowPassThru_Req_01_02 When subject to Flow01, LS1_1 shall provide a Flow12 in accordance with the F01_F12_Ratio constraint.
2991	Constraint	1.1.4.1.1 F01-F12 Ratio Flow12 = FlowRatio*Flow01
2992	IO	1.1.5 Flow01
2993	IO	1.1.6 Flow31
2994	System	1.1.7 LS1.2
2995	IO	1.1.8 Flow12
2996	System	1.1.9 LS1.0
2997	IO	1.1.10 Flow01

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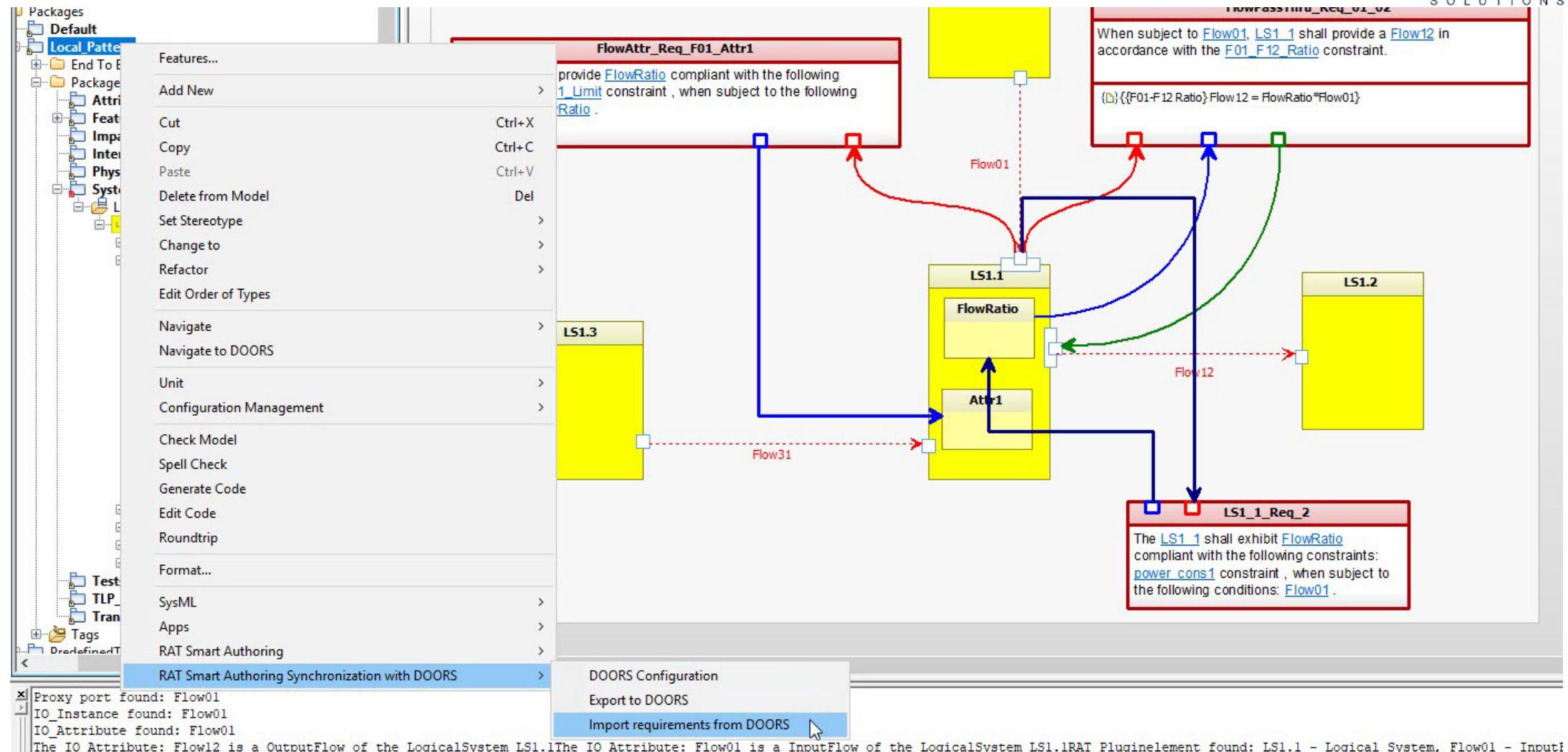
'System' current 0.0 in /PnG (Formal module) - DOORS

File Edit View Insert Link Analysis Table Tools Discussions Authoring user Change Management Help

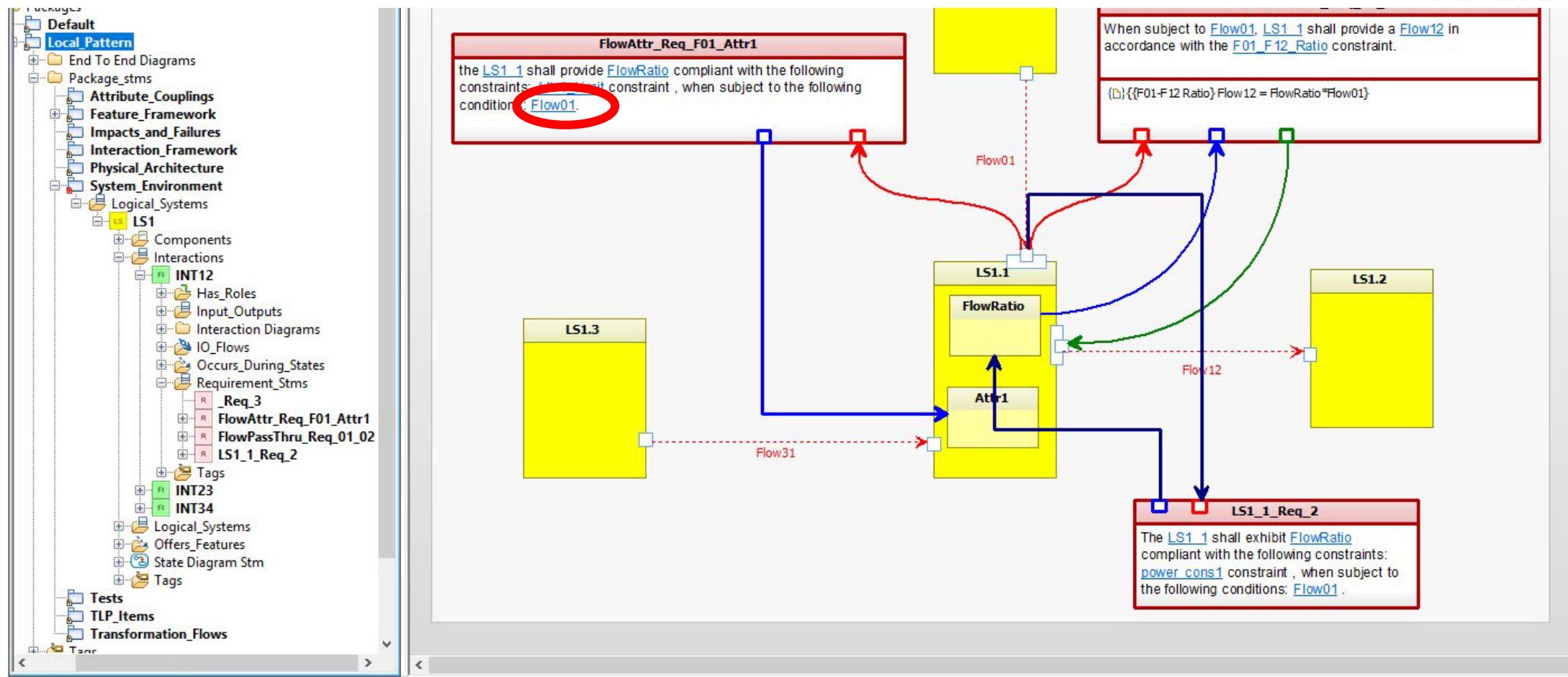
View Systems View All levels

ID	ElementType	IO
2980	System	1 Local_Pattern
2981	Interaction	1.1 INT12
2982	System	1.1.1 LS1.1
2983	Attribute	1.1.2 Attr1
2984	Requirement	1.1.2.1 FlowAttr_Req_F01_Attr1 the LS1_1 shall provide FlowRatio compliant with the following constraints: Attr1_Limit constraint , when subject to the following conditions: Flow01 .
2985	Constraint	1.1.2.1.1 Attr1_Limit
2986	Attribute	1.1.3 FlowRatio
2987	Requirement	1.1.3.1 LS1_1_Req_2 The LS1_1 shall exhibit FlowRatio compliant with the following constraints: power_cons1 constraint , when subject to the following conditions: Flow01 .
2988	Constraint	1.1.3.1.1 power_cons1
2989	IO	1.1.4 Flow12
2990	Requirement	1.1.4.1 FlowPassThru_Req_01_02 When subject to Flow01, LS1_1 shall provide a Flow12 in accordance with the F01_F12_Ratio constraint.
2991	Constraint	1.1.4.1.1 F01-F12 Ratio Flow12 = FlowRatio*Flow01
2992	IO	1.1.5 Flow01
2993	IO	1.1.6 Flow31
2994	System	1.1.7 LS1.2
2995	IO	1.1.8 Flow12
2996	System	1.1.9 LS1.0
2997	IO	1.1.10 Flow01

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```
LOG  JAVA: import from DOORS SENT
Binding found: Attr1_Attr1
Binding found: INT12_FlowRatio1
Binding found: INT12_Flow12_to_LS1_2_Flow12
Binding found: FlowRatio_FlowRatio
RATRhapsody: import from DOORS
```

General benefits of cognitive requirements and test offerings

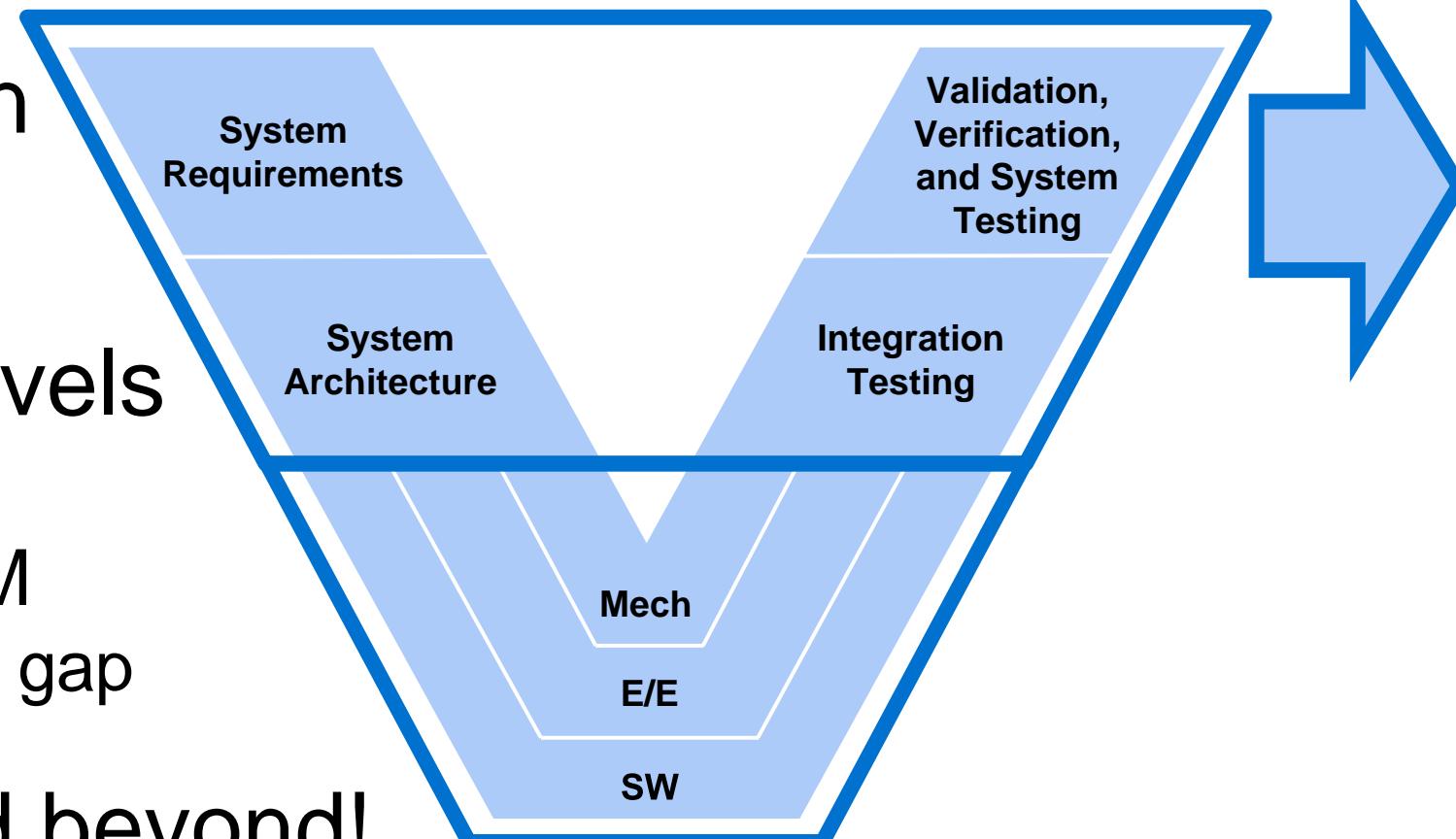


- Automation of time-intensive, error-prone tasks
- Pinpoints where focus needs to be delivered
- Prioritizes work
- Configurable for domain-specific applications
- Customizable to company policies and best practices
- Accelerates good requirements training for new users
- Accelerates high-quality requirements authoring even for experienced requirements engineers
- Accelerates review of customer requirements specs

Future of cognitive engineering



- Current focus is on top left/right of V
- Moving to lower levels
 - All product data
 - Cognitive ALM-PLM
 - To help bridge the gap
 - To the V and beyond!
 - Including manufacturing, service, and operations



Summary



- Cognitive engineering is maturing and growing rapidly
- Cognitive requirements and test tools can enable:
 - Higher productivity and efficiency
 - Immediate feedback to author for faster learning
 - Moving defect discovery to early development phases
 - Less downstream churn for requirements, design, test
 - Reducing product development cost and schedule
- Technology is moving fast in this space
- Expect rapid developments in the near term

Challenge



Pilot these capabilities

Report back next year

- at IW, IS, and/or GLRC

Questions?



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Bob Parro, River North Solutions - bparro@rivernorthsolutions.com

Steve Denman, Stephen D. Denman Consulting, LLC - stephen@sddenmanconsulting.com

Kevin McHugh, IBM Watson IoT Lab Services - mchughm@us.ibm.com