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Using Cognitive Computing to Elevate Requirements Quality and Test Case Accuracy

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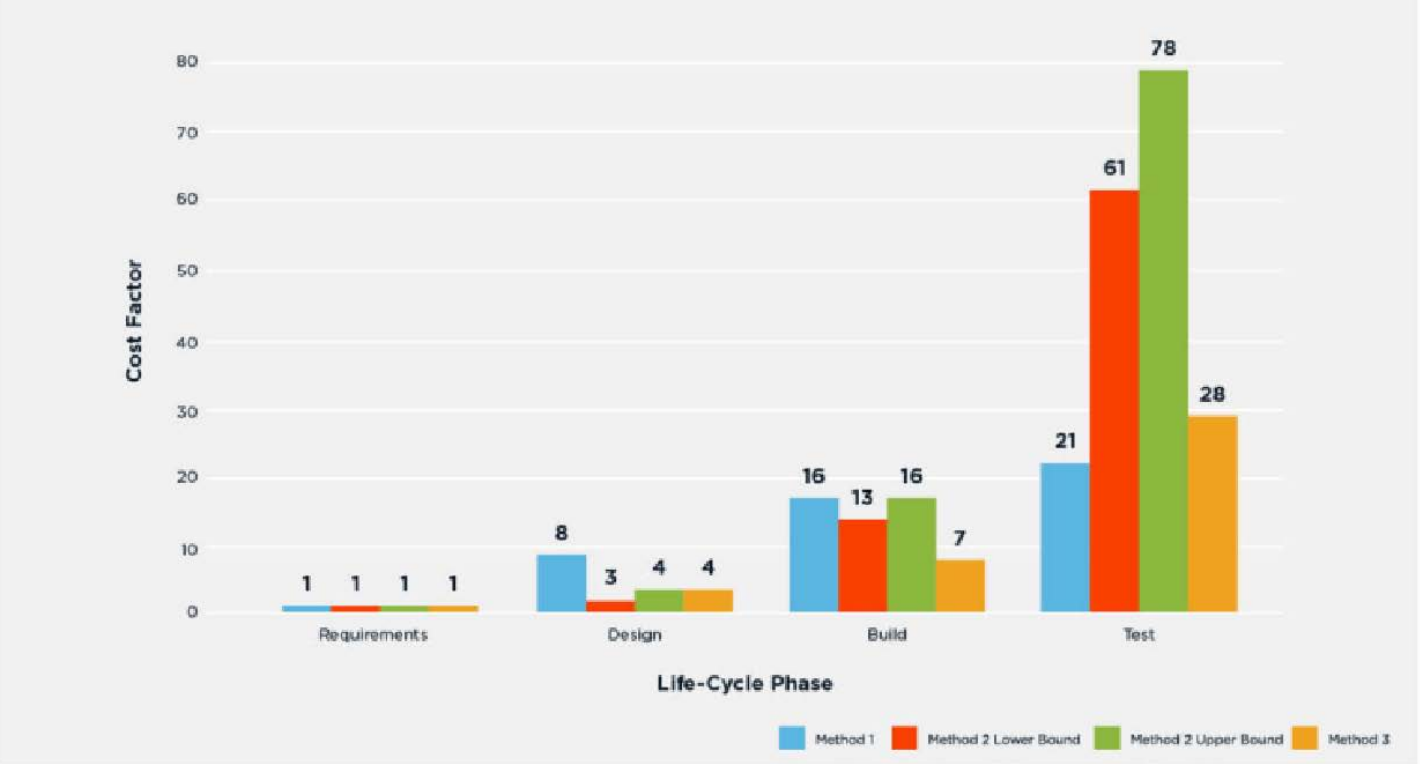
Agenda

- 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

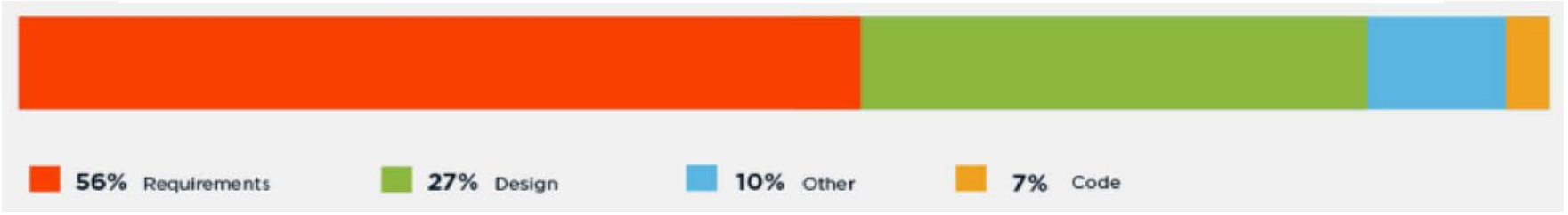
- Poor requirements are widely understood to be the cause of numerous project/product failures
  - Schedule delays, cost overruns, poor quality, going to market with reduced functionality compared to the original plan, going to market with the wrong product or solution
  - These impacts have been studied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

The problem



Comparison of System Cost Factors – Excluding Operations [Jonette]

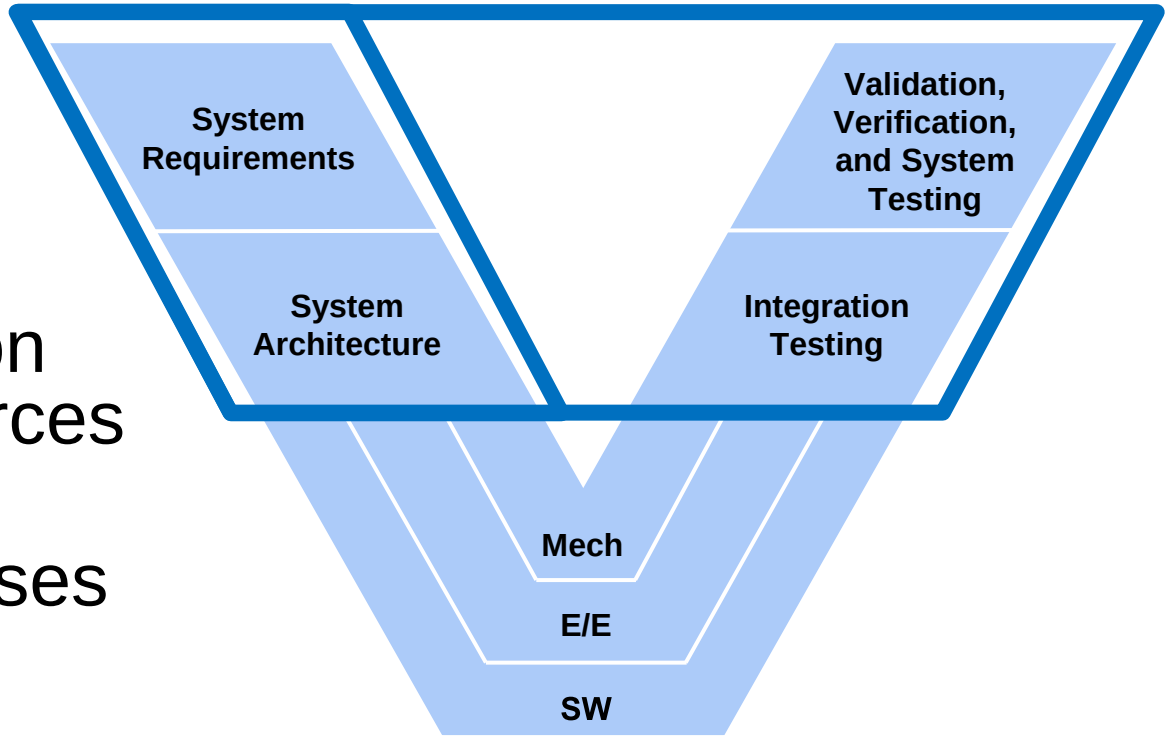
Cost to Fix Errors Increases Exponentially the Later They are Found in the Development Lifecycle



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

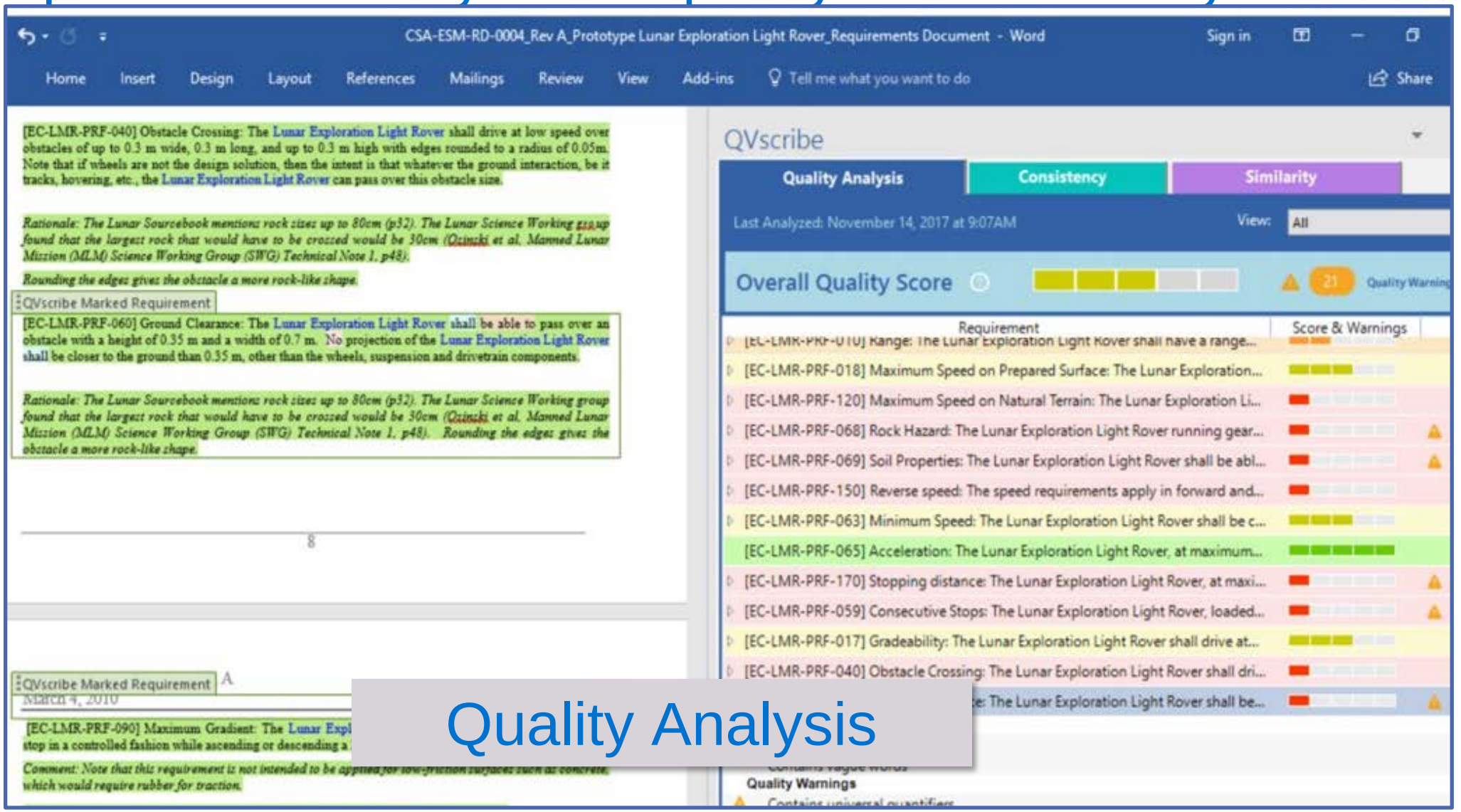
QVscribe from QRA Corp
Requirements analysis for quality & consistency

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

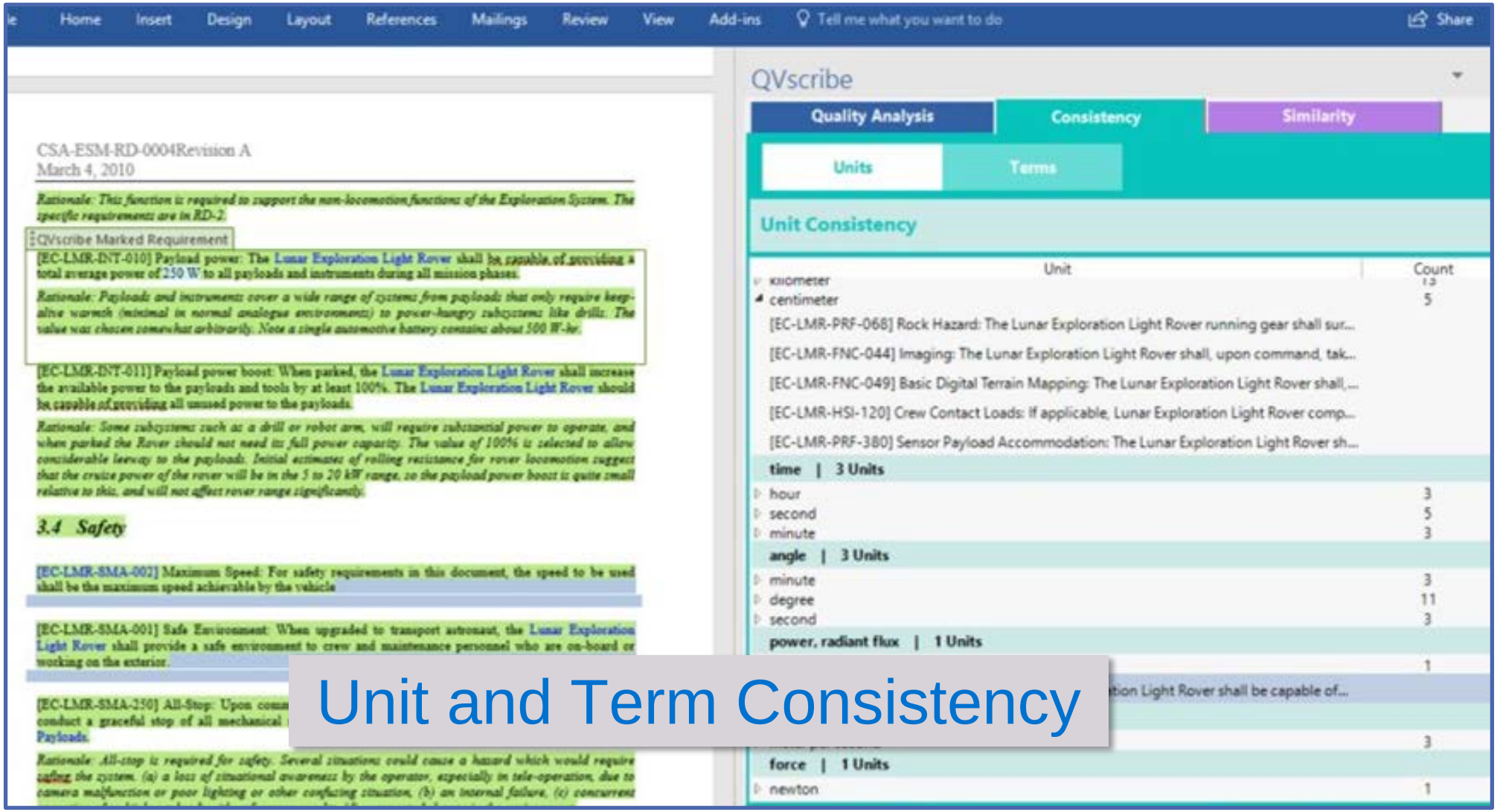
Requirements analysis for quality & consistency



Quality Analysis

QVscribe from QRA Corp

Requirements analysis for quality & consistency

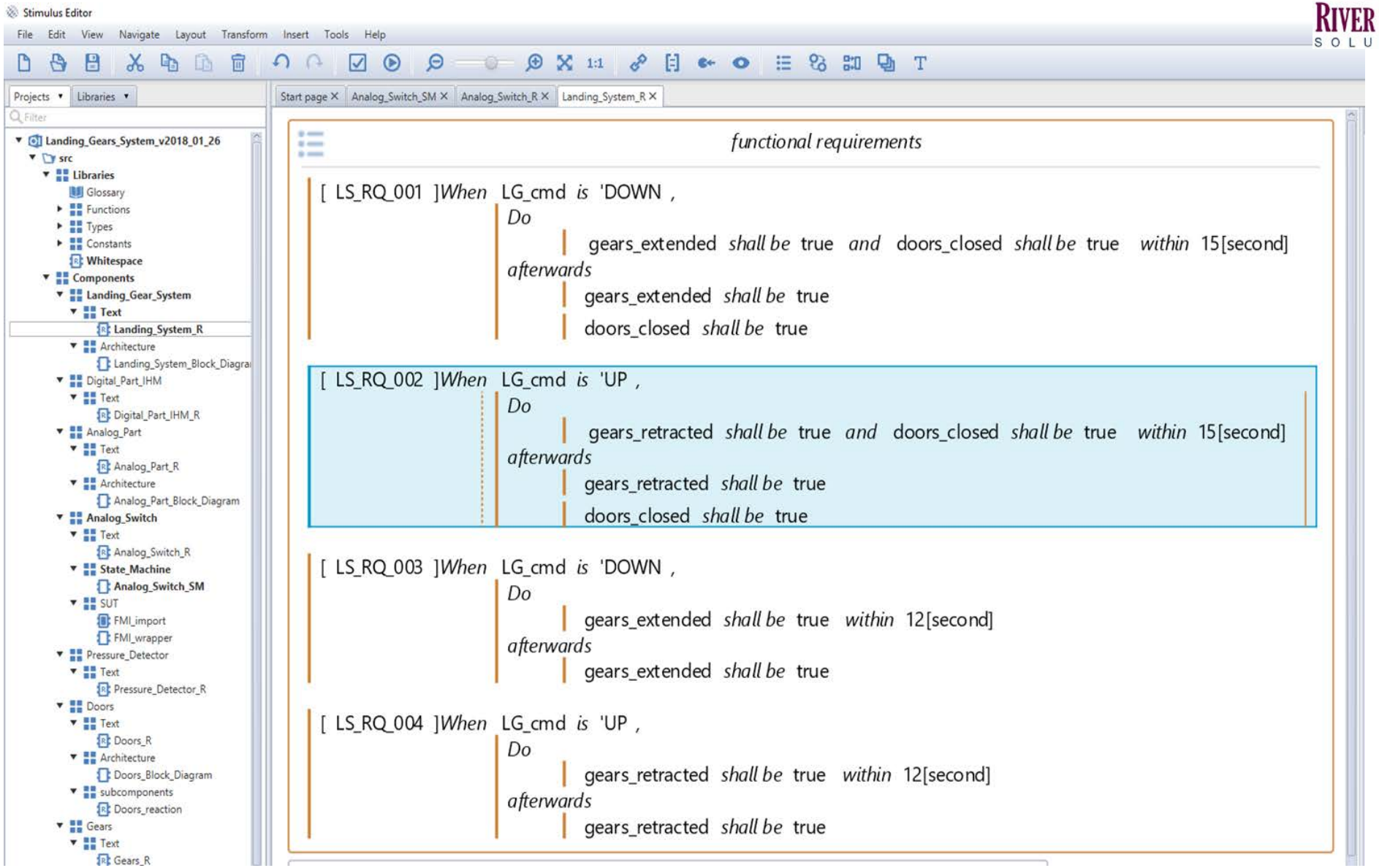


Unit and Term Consistency

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



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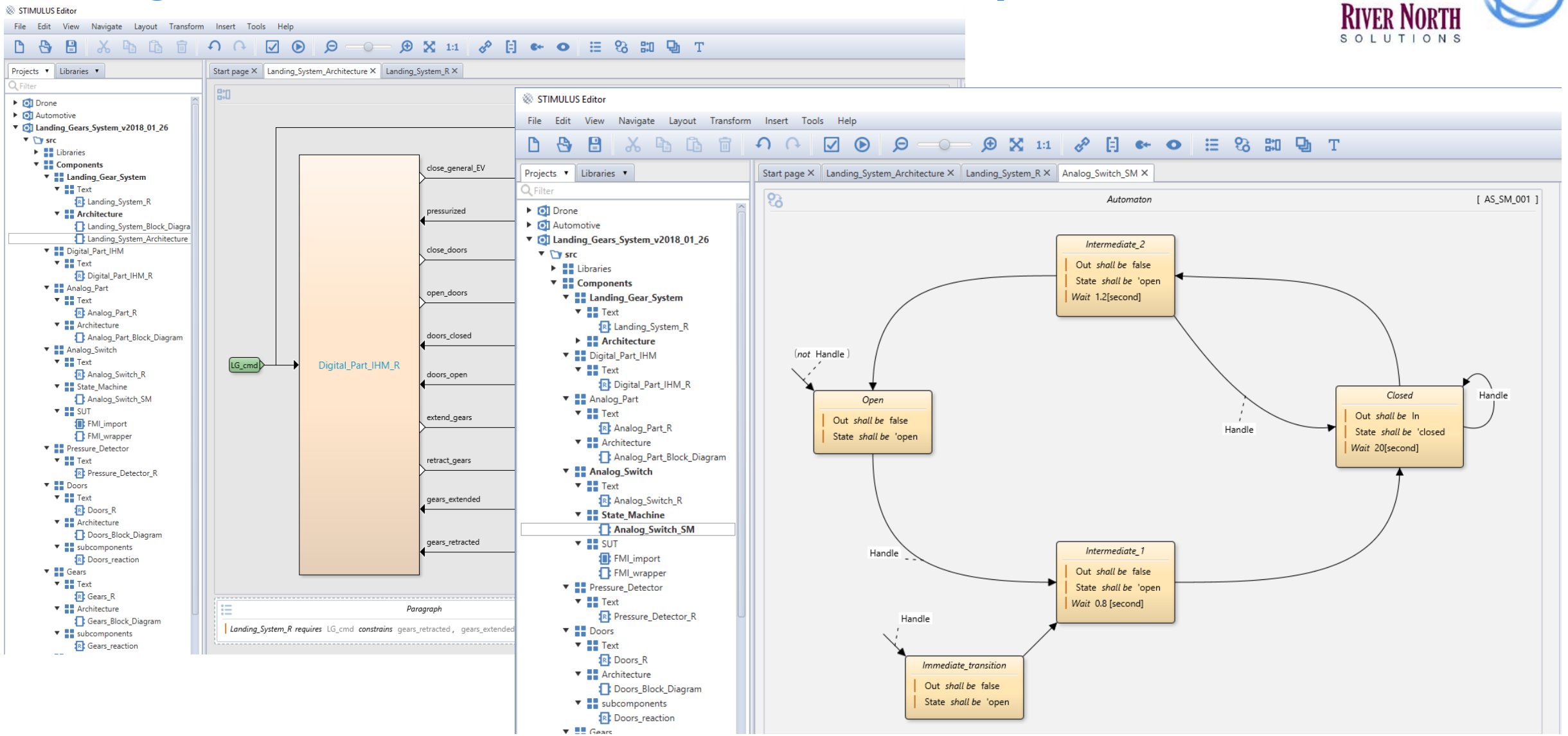
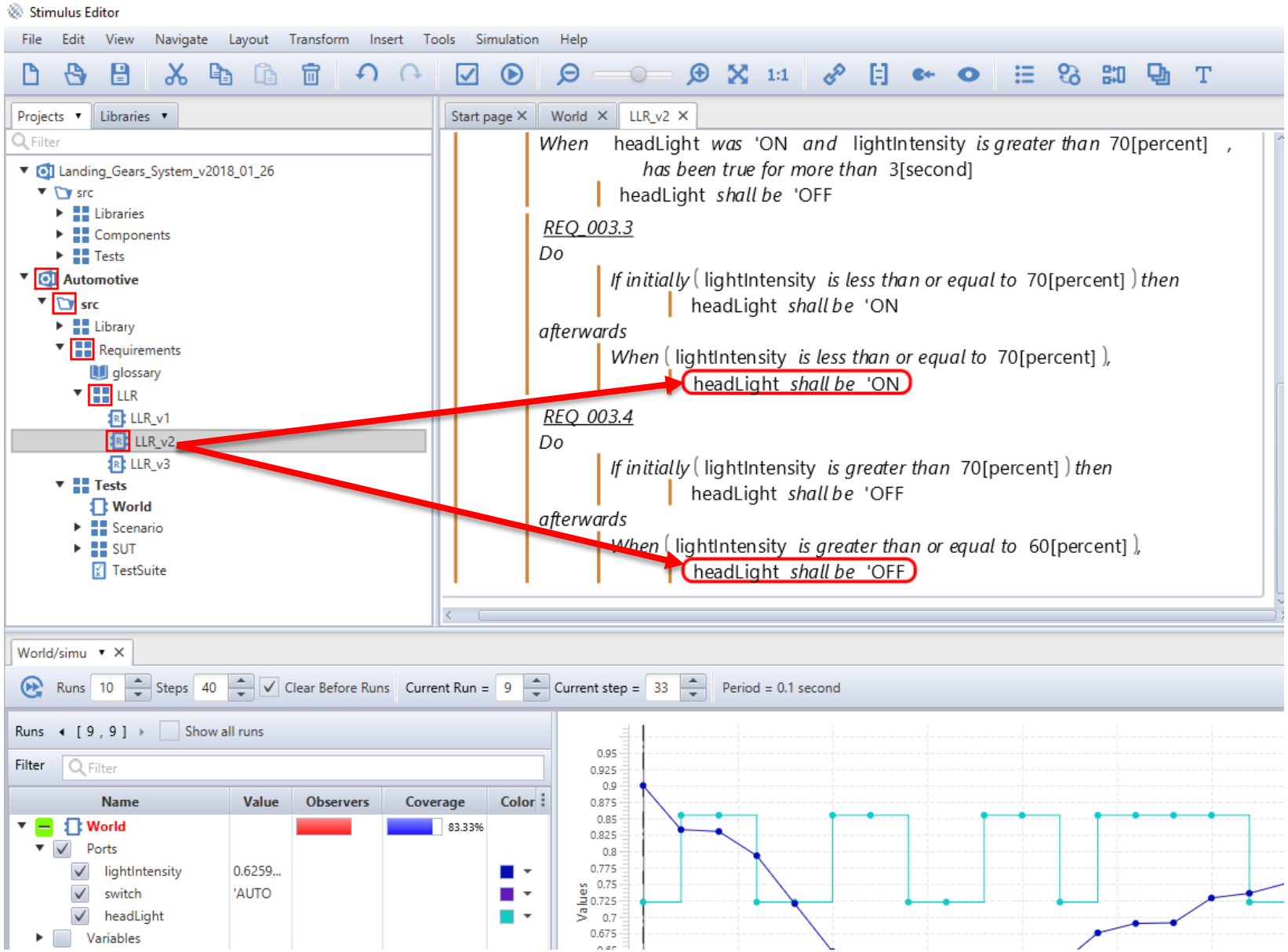
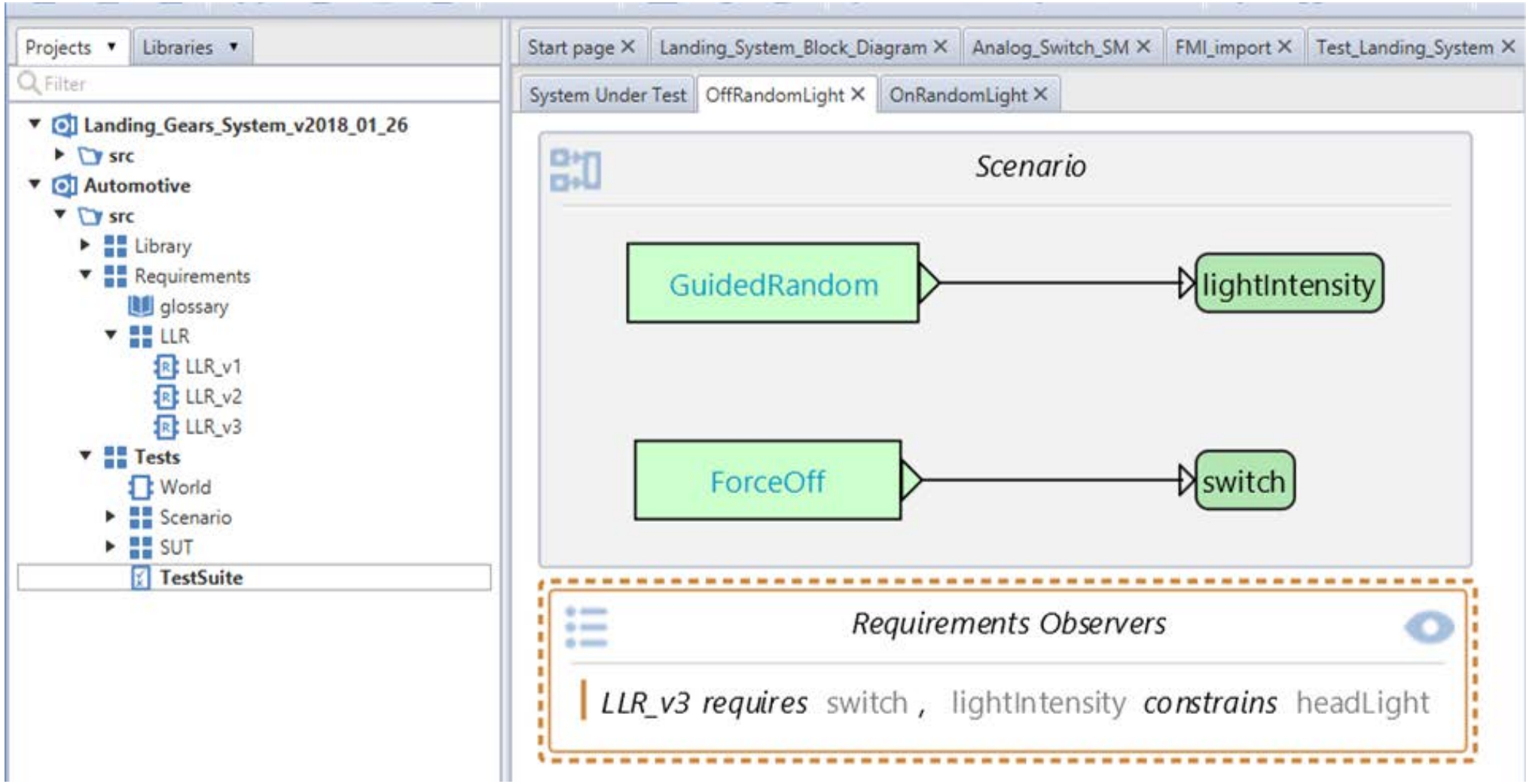


Argosim STIMULUS for Requirements



Argosim STIMULUS for Tests



Scout from Qualicen

Rapid user feedback provides strongest learning

Integrations

- Word, DOORS, PTC Integrity

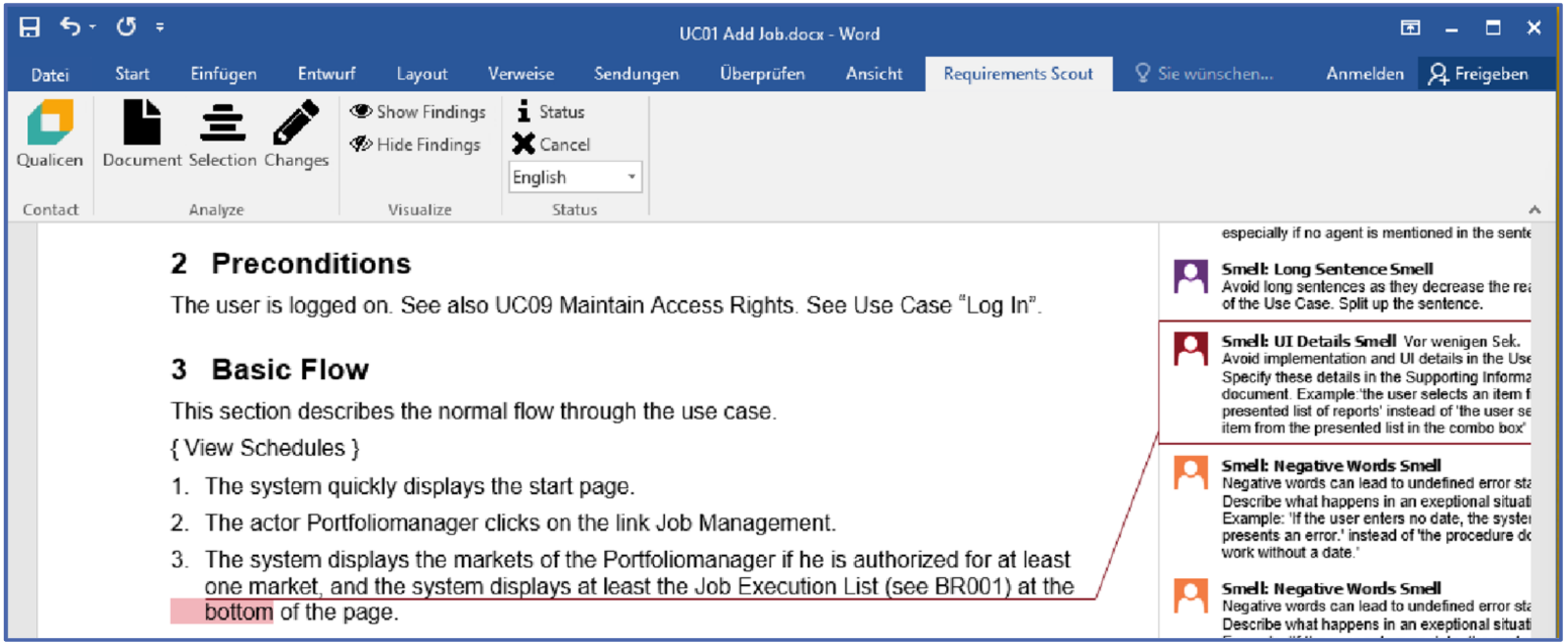
Trend analysis key capability

- 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



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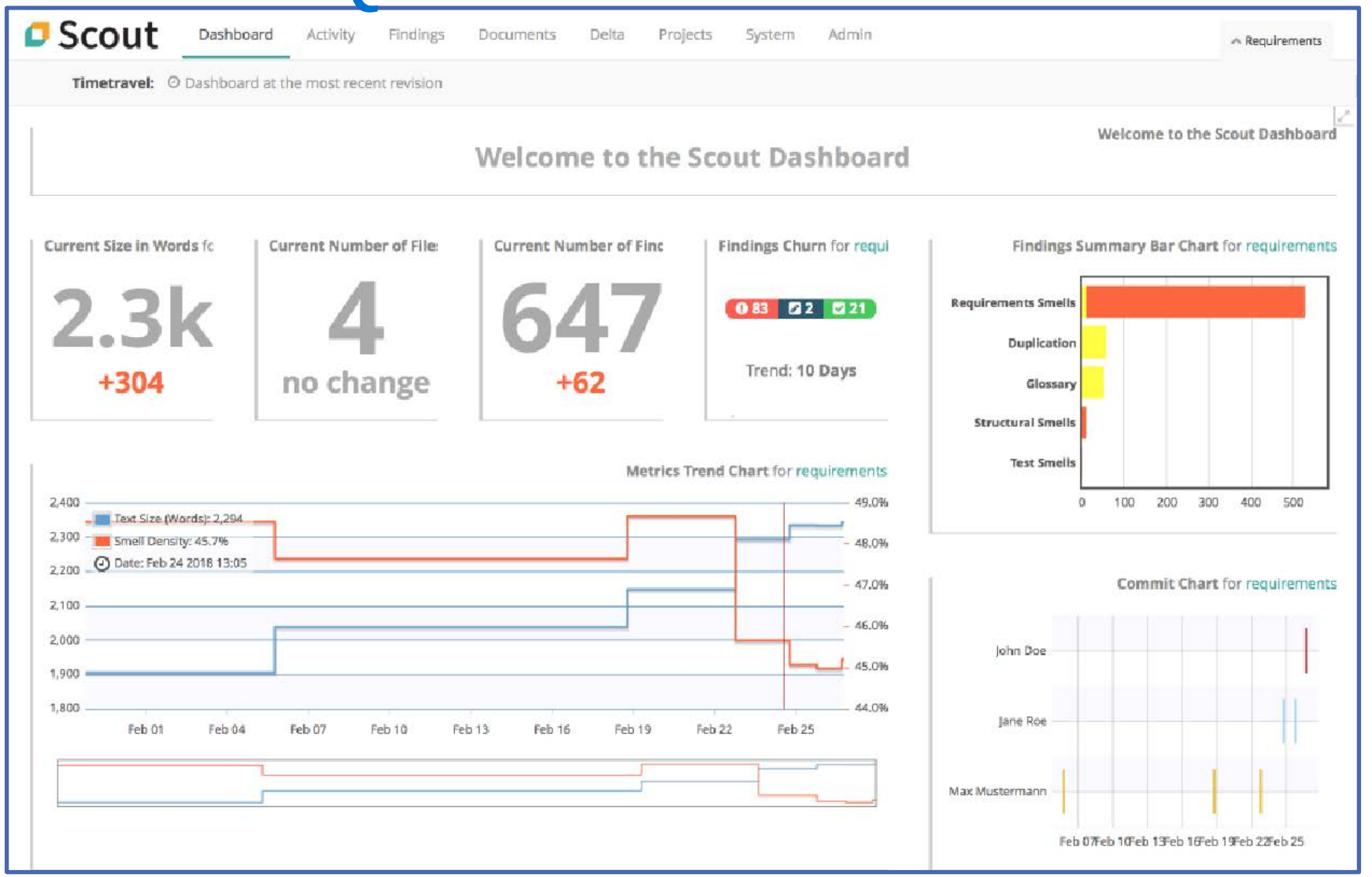


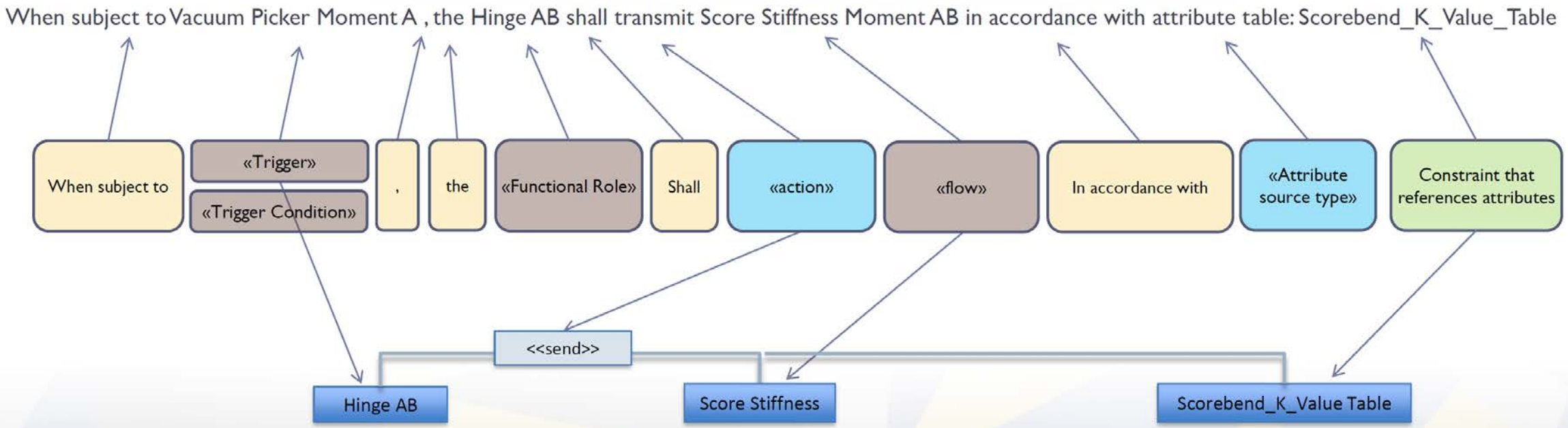
The REUSE Company

- 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

The REUSE Company

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.**



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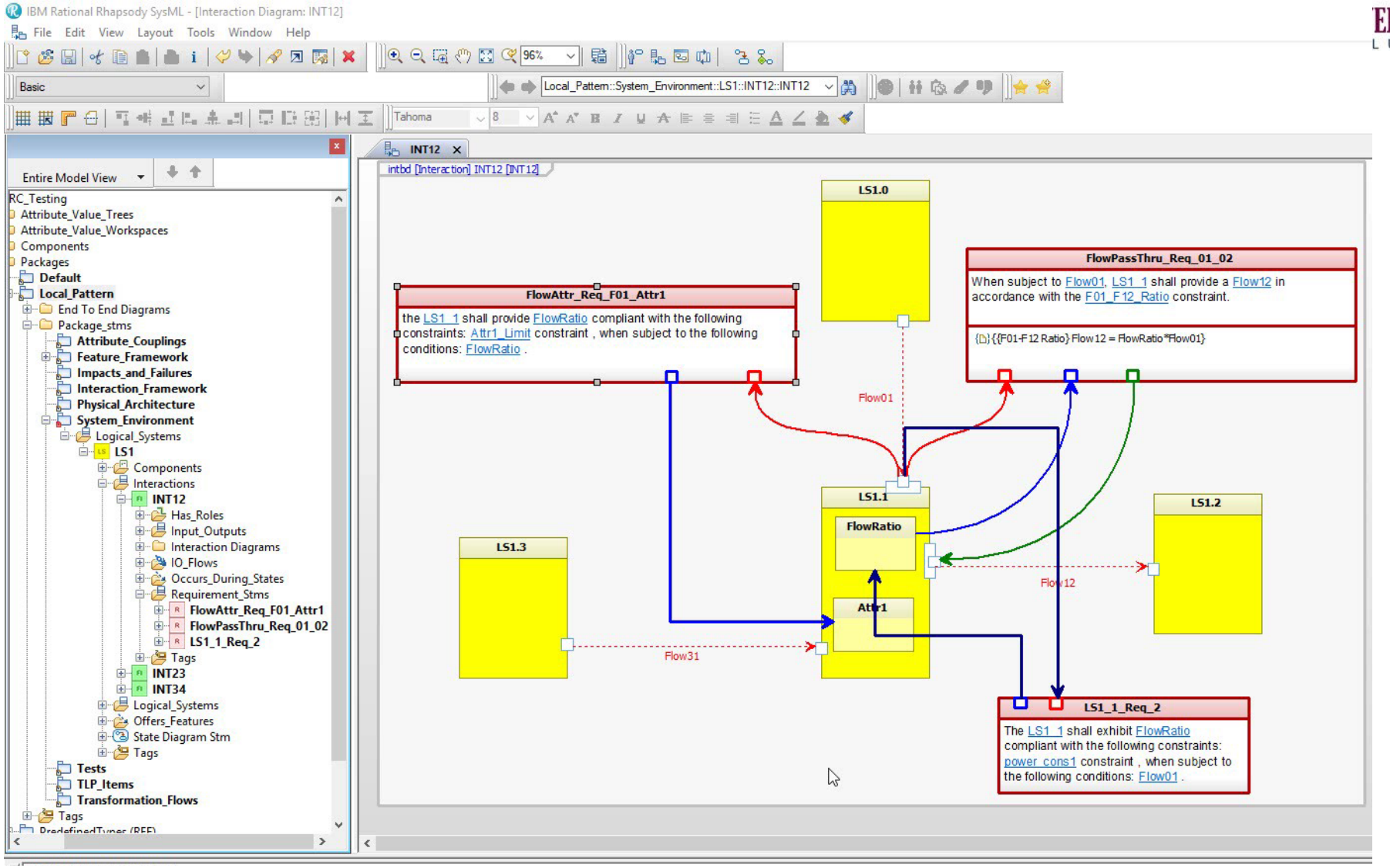

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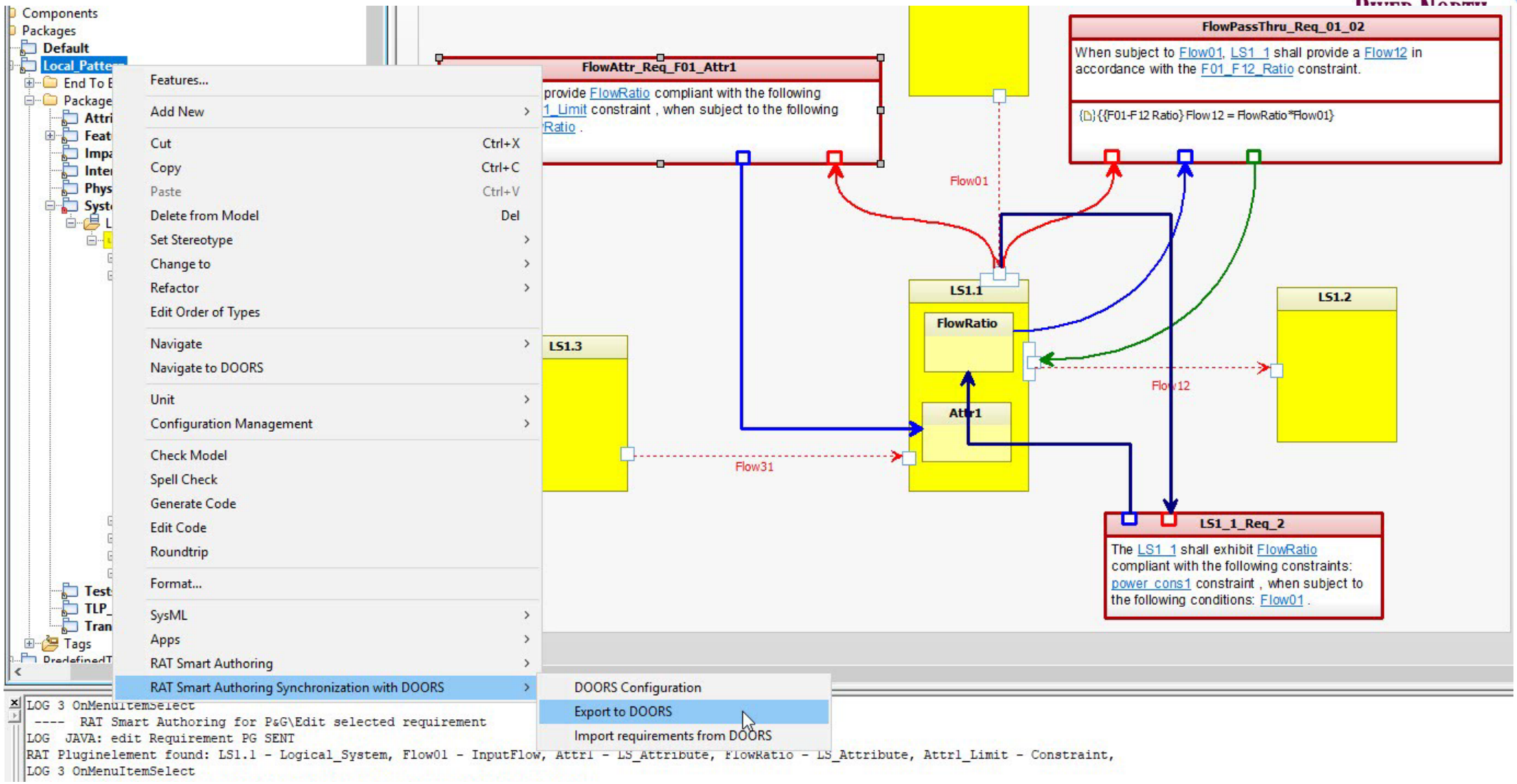

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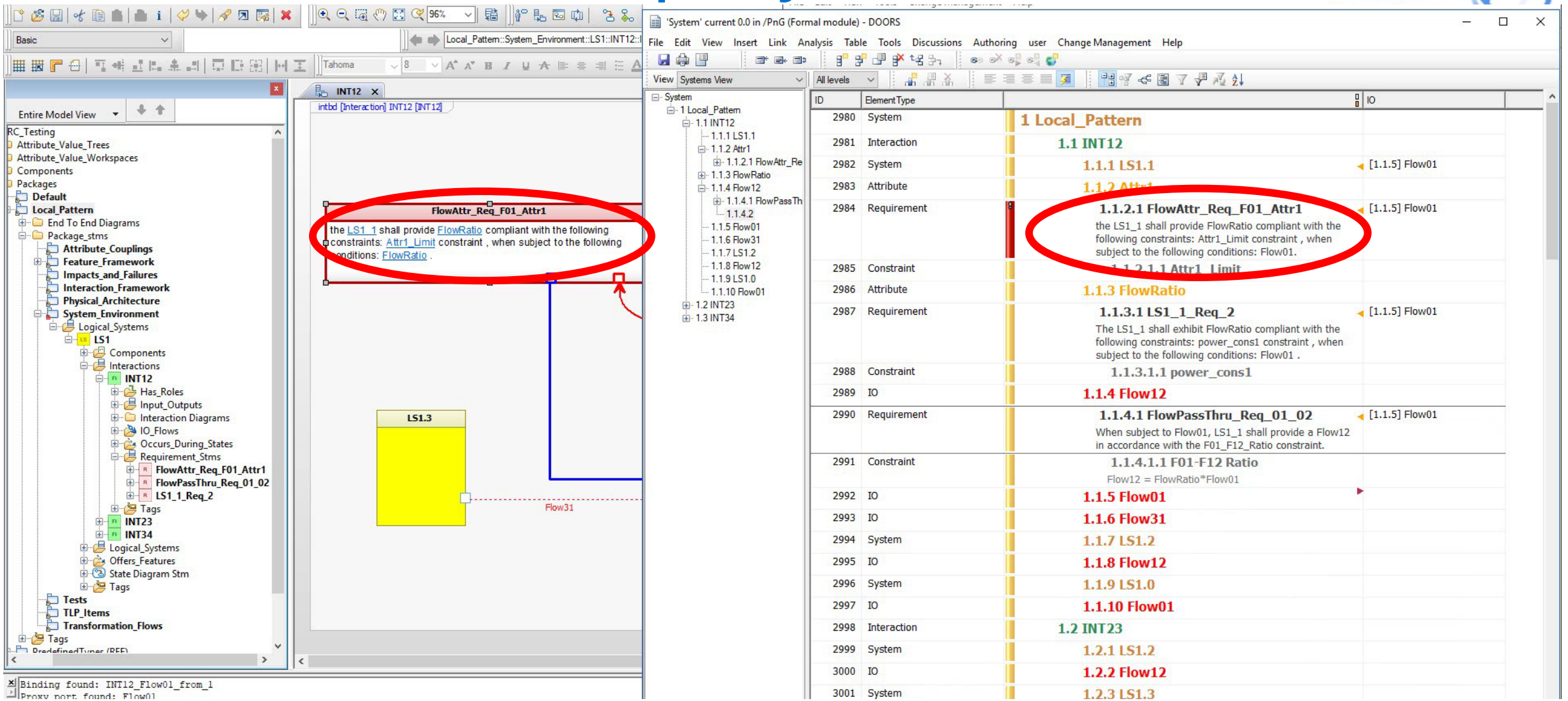

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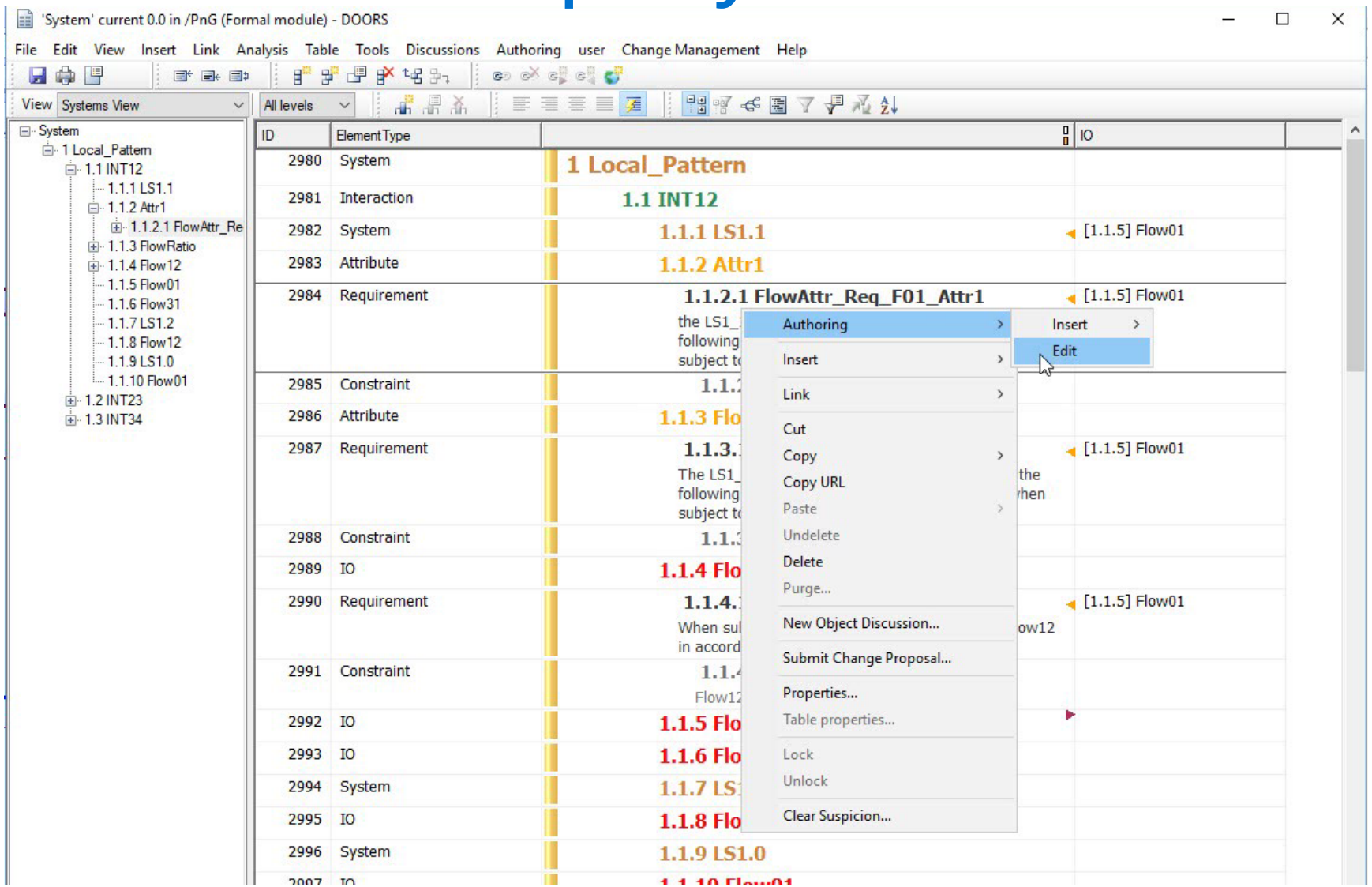

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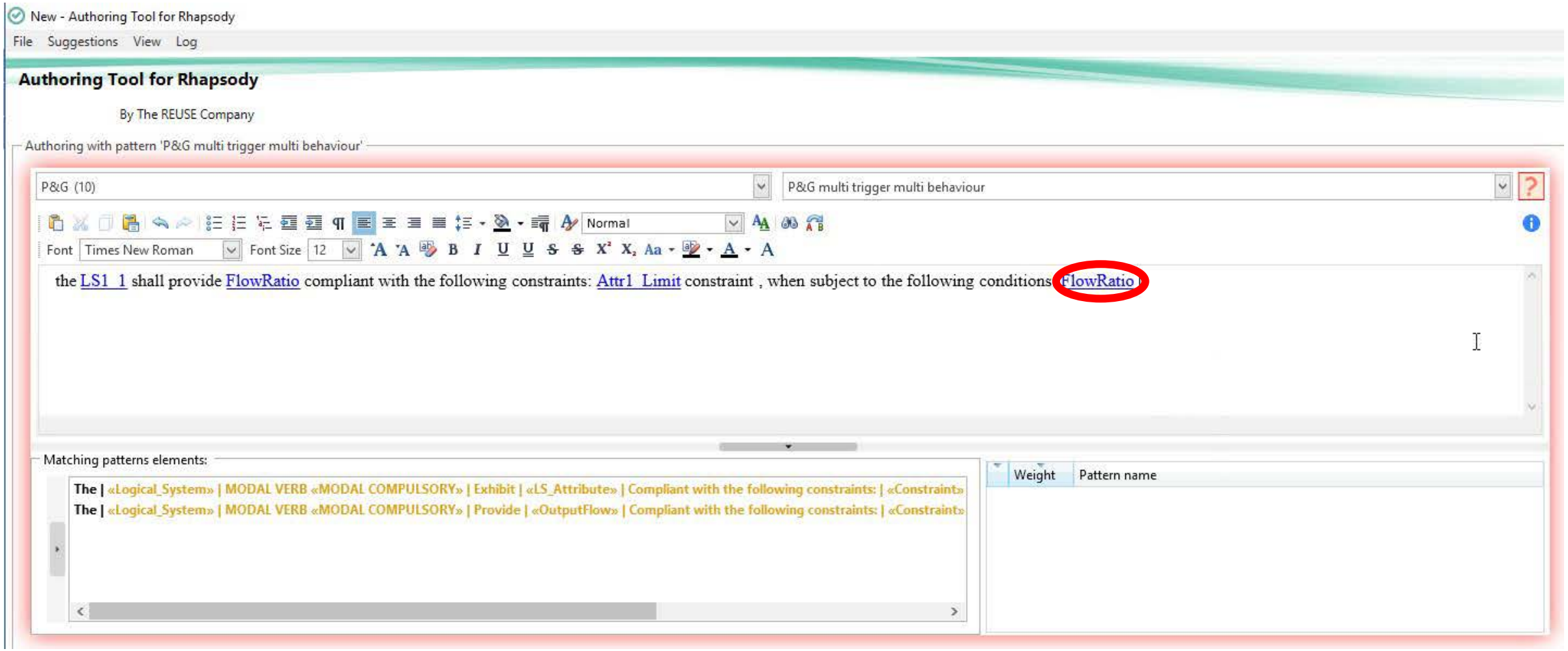

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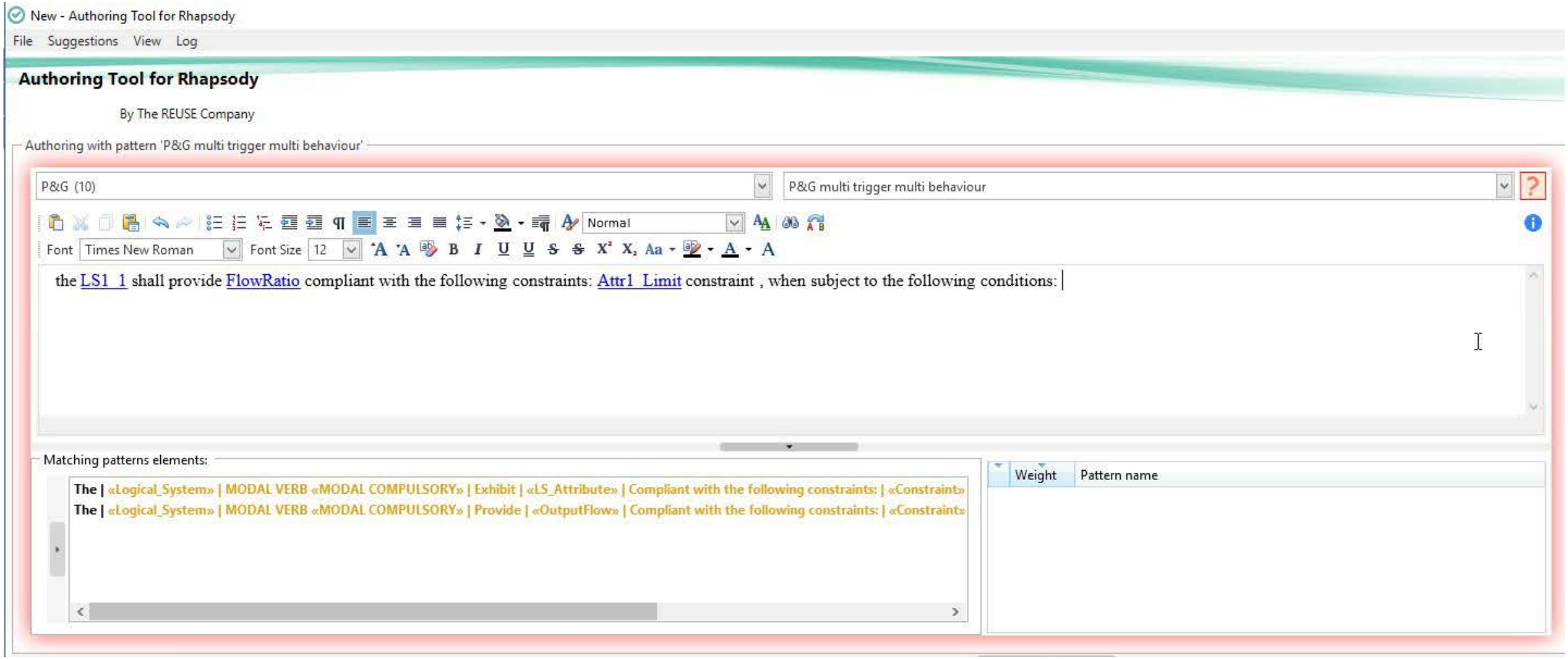

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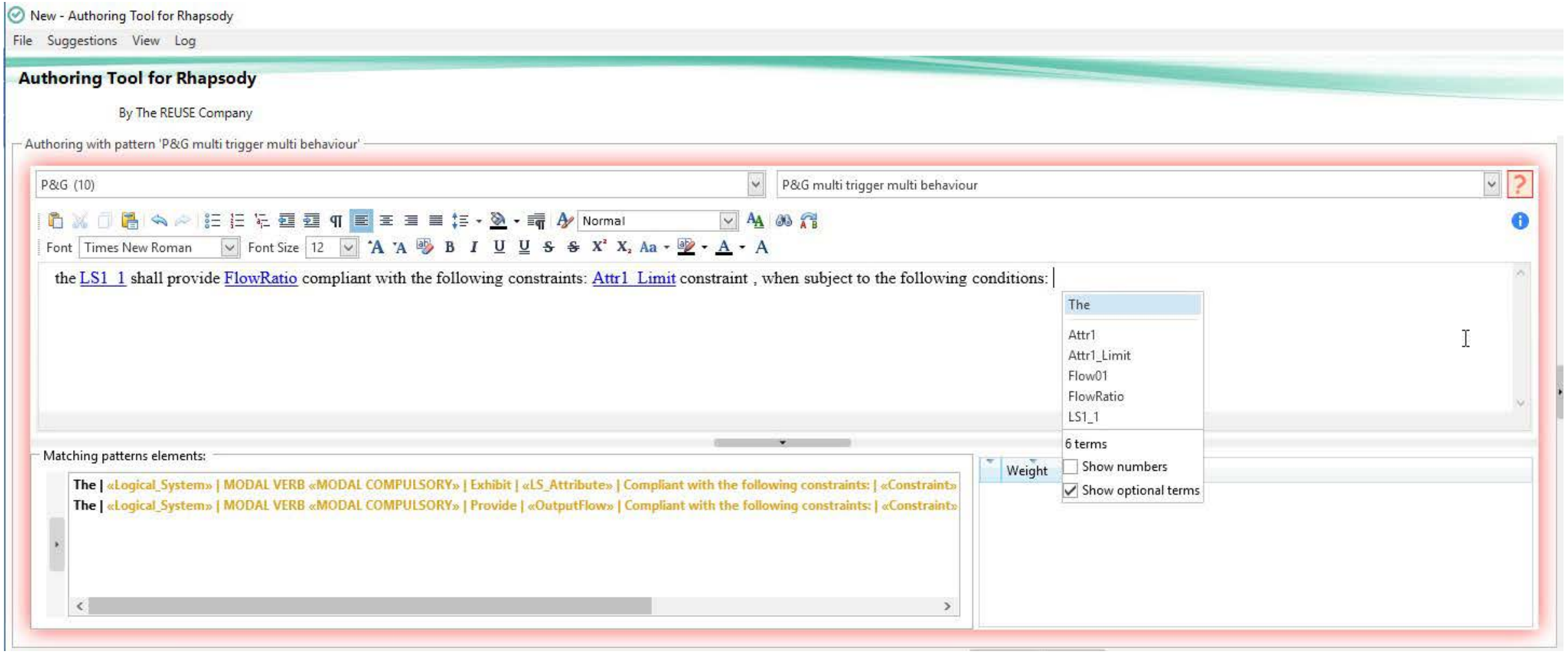

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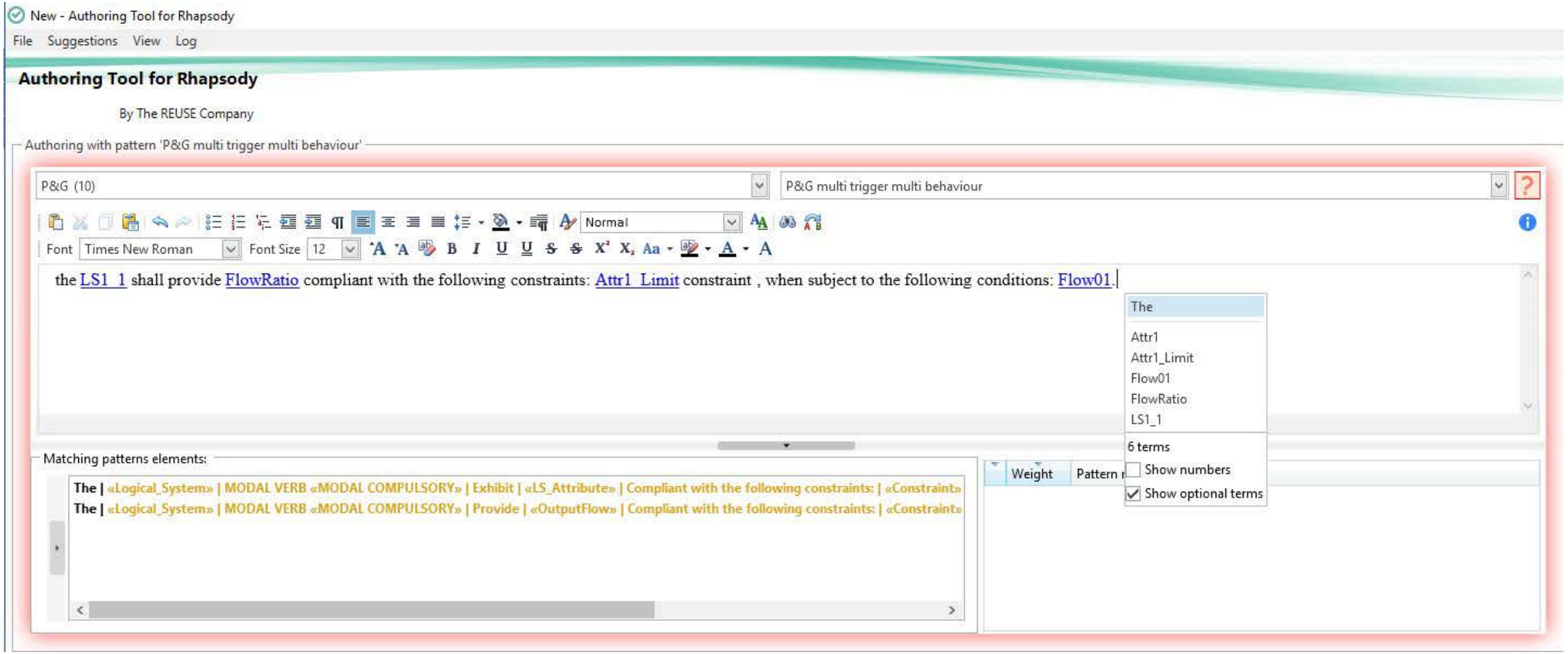

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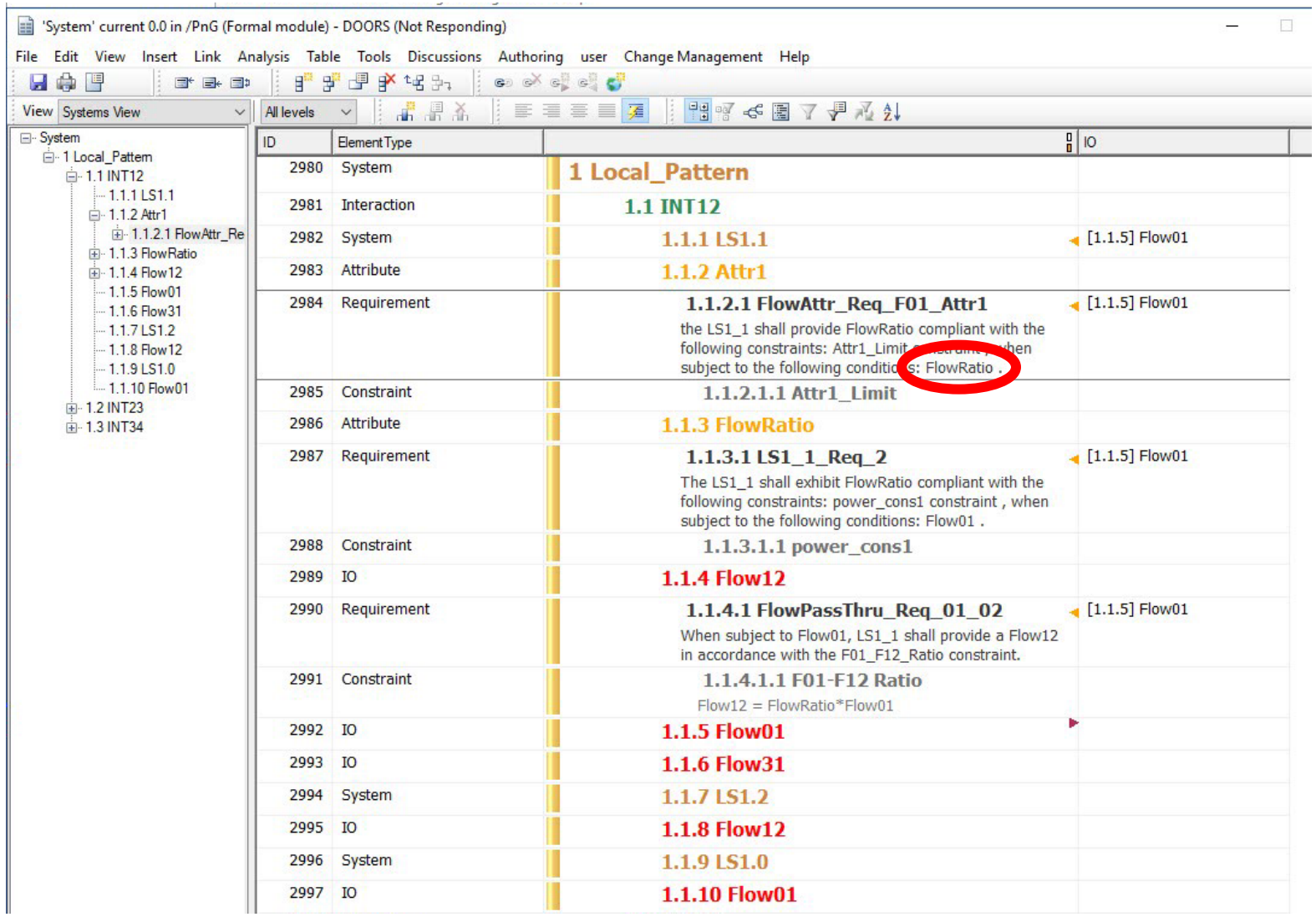

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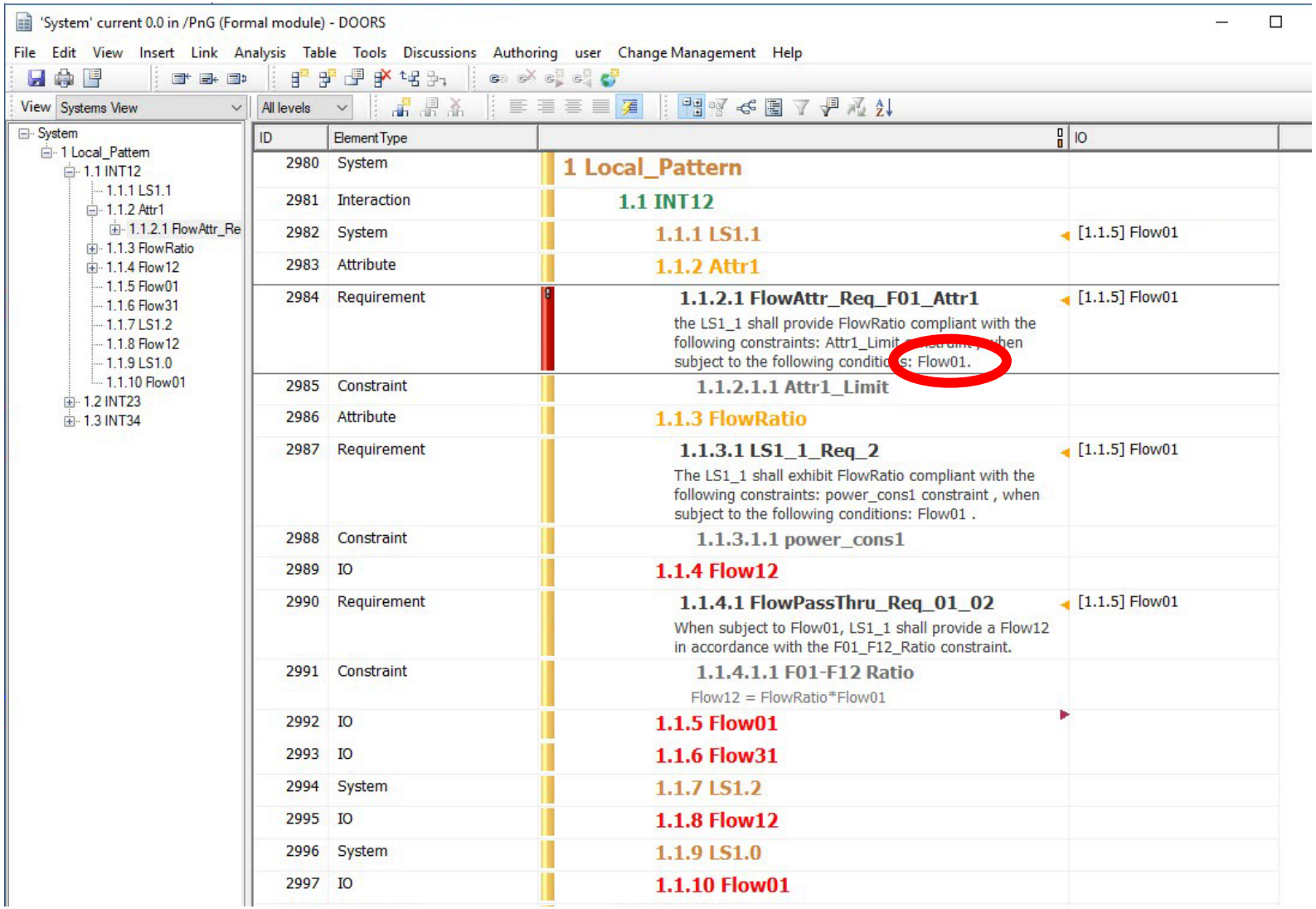

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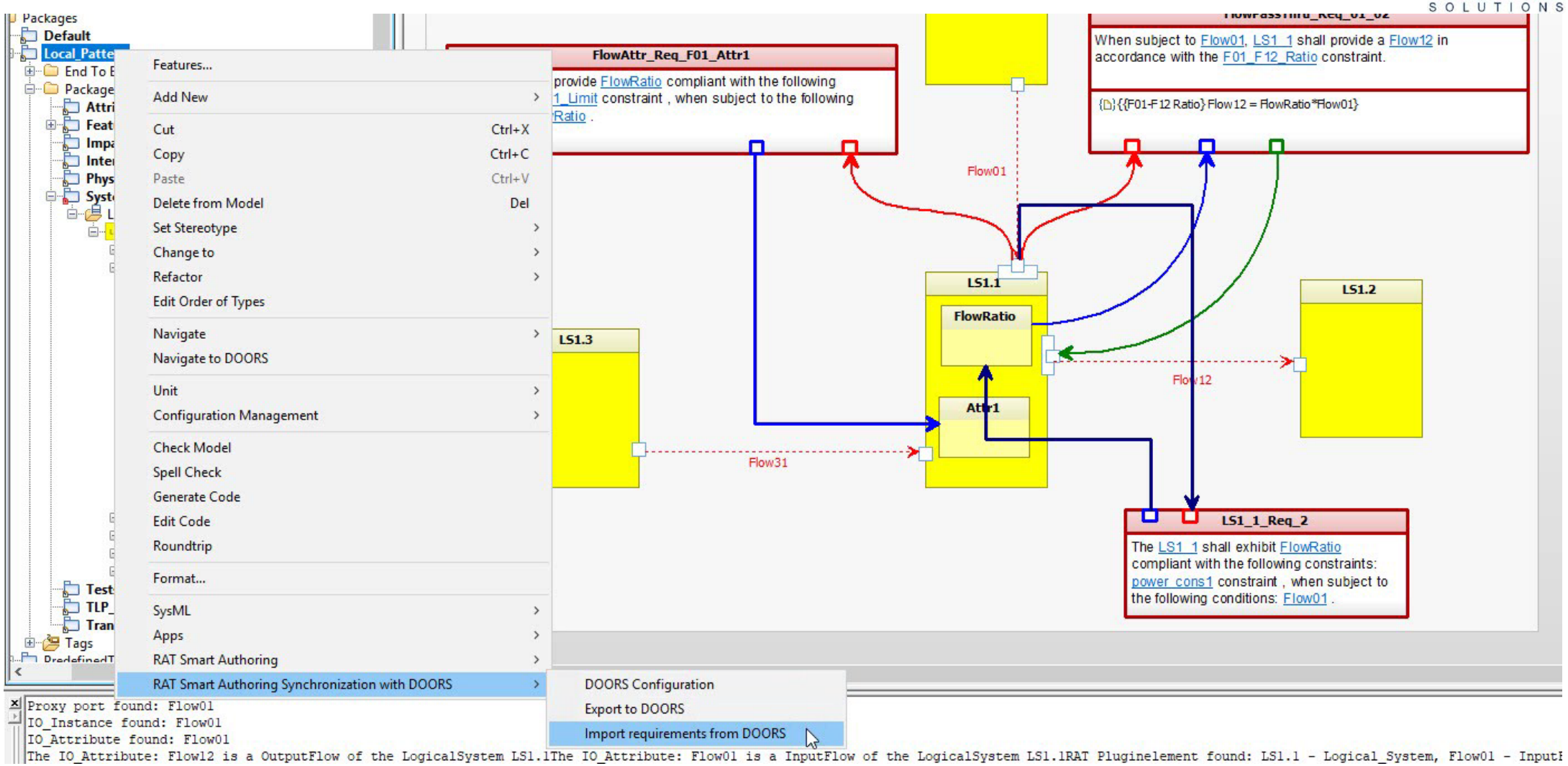

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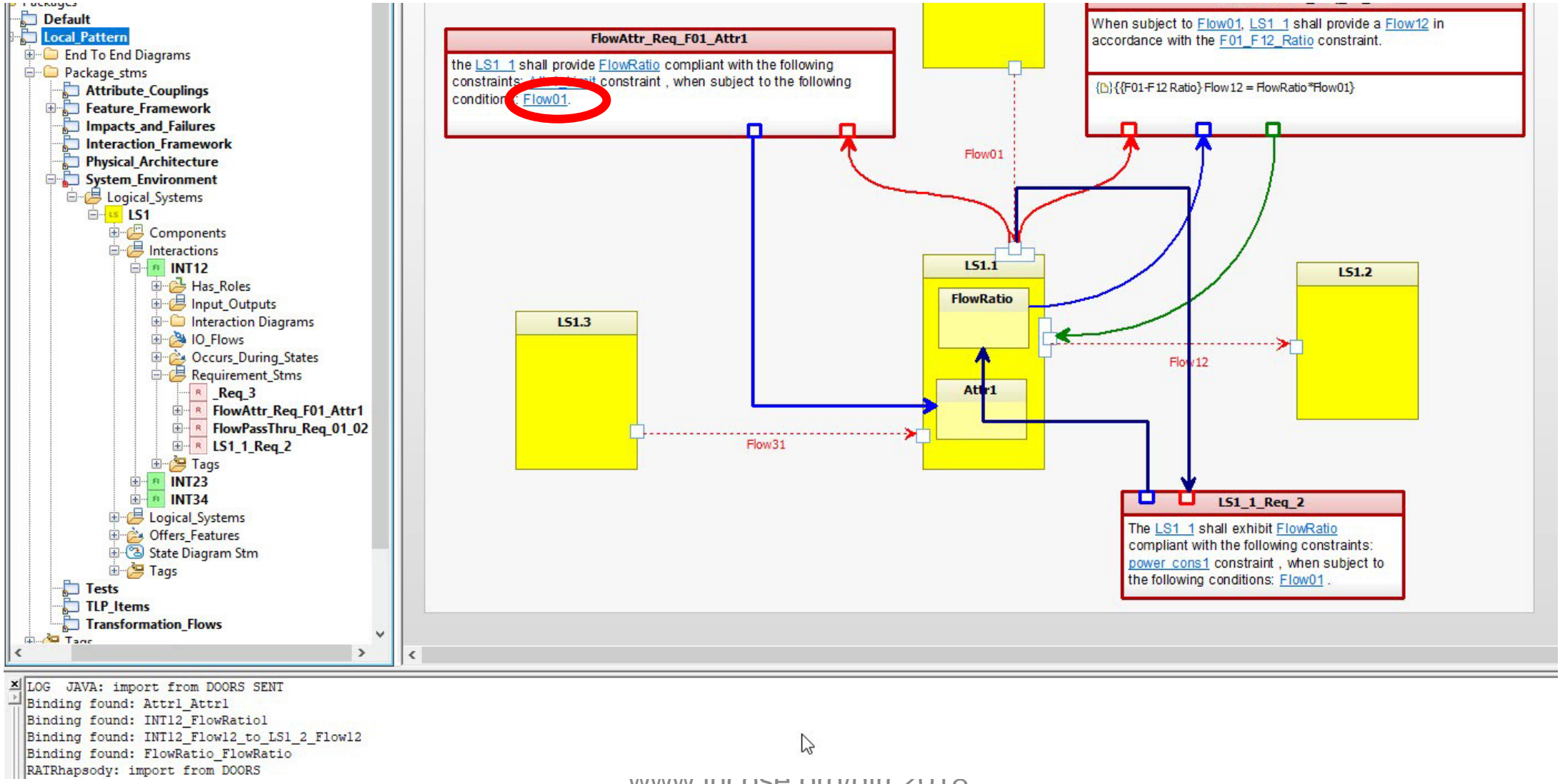
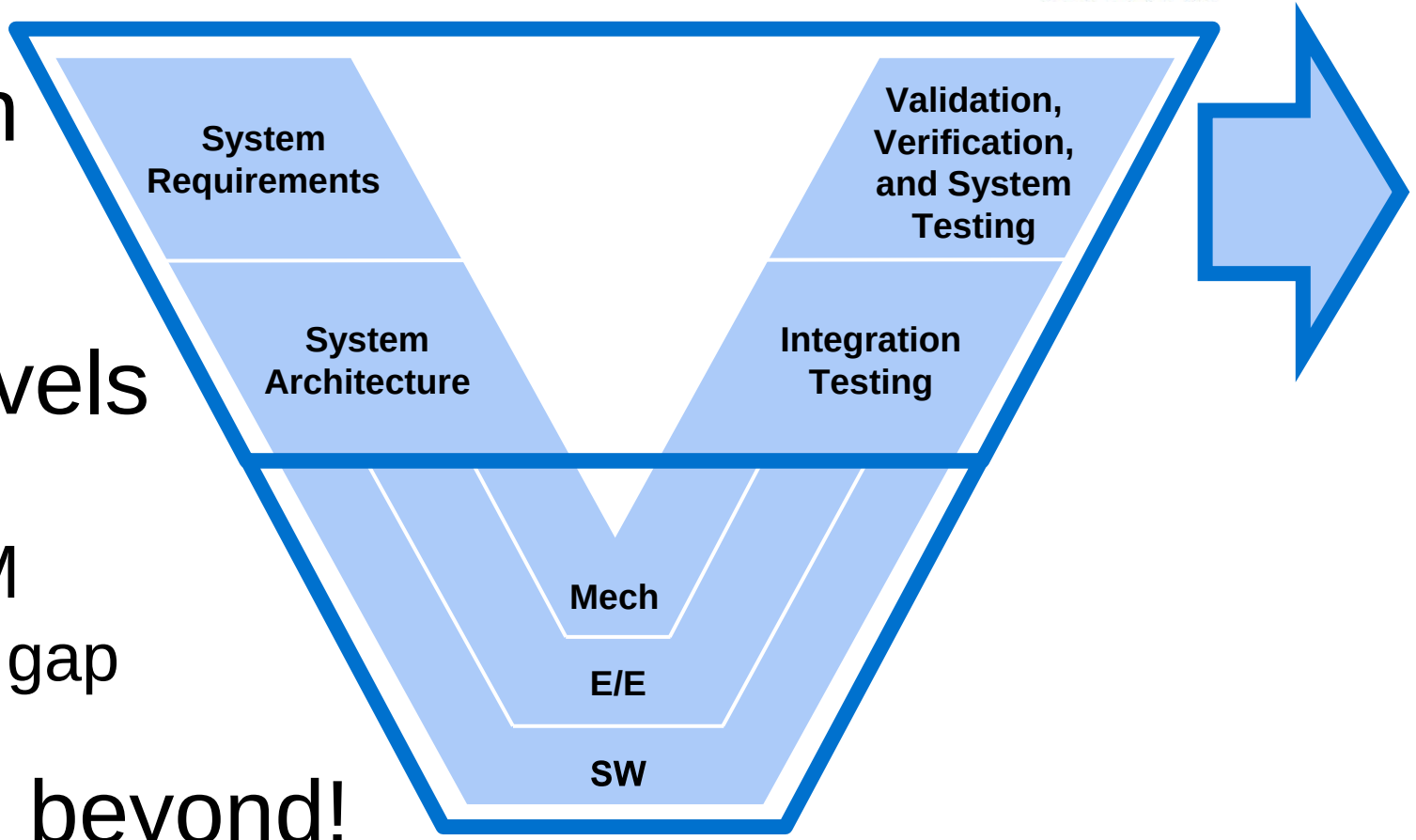


General benefits of cognitive requirements and test offerings

- 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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