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System Verification and Validation Approach Using the MagicGrid Framework

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Speakers

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- PhD, MS, and BS in Software Systems Engineering
- 17 years in Software and Systems Engineering
- UAF co-chairman in OMG, member of INCOSE and NATO ACaT
- Originator of the MagicGrid Framework
- ASEP, OCSMP, OCEB, OCUP certified professional

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- MS and BS in Electronics Engineering and Business
- ≈10 years in Software and Systems Engineering
- Focus on MBSE and executable system models
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Outline

- Motivation & Purpose
- MagicGrid and its Extensions for V&V
- Case Study
- Conclusions

Motivation

- The ongoing transformation in industry from a document-based systems engineering to a model-based systems engineering approach reveals a need for new methods of verifying and validating systems
- Traditional methods of testing the actual system are getting more and more expensive
- A model-based environment could significantly reduce testing and, most importantly, verification and validation processes costs
  - allows testing on the system model by applying various techniques, such as simulation, analysis, review, mock-ups, etc.

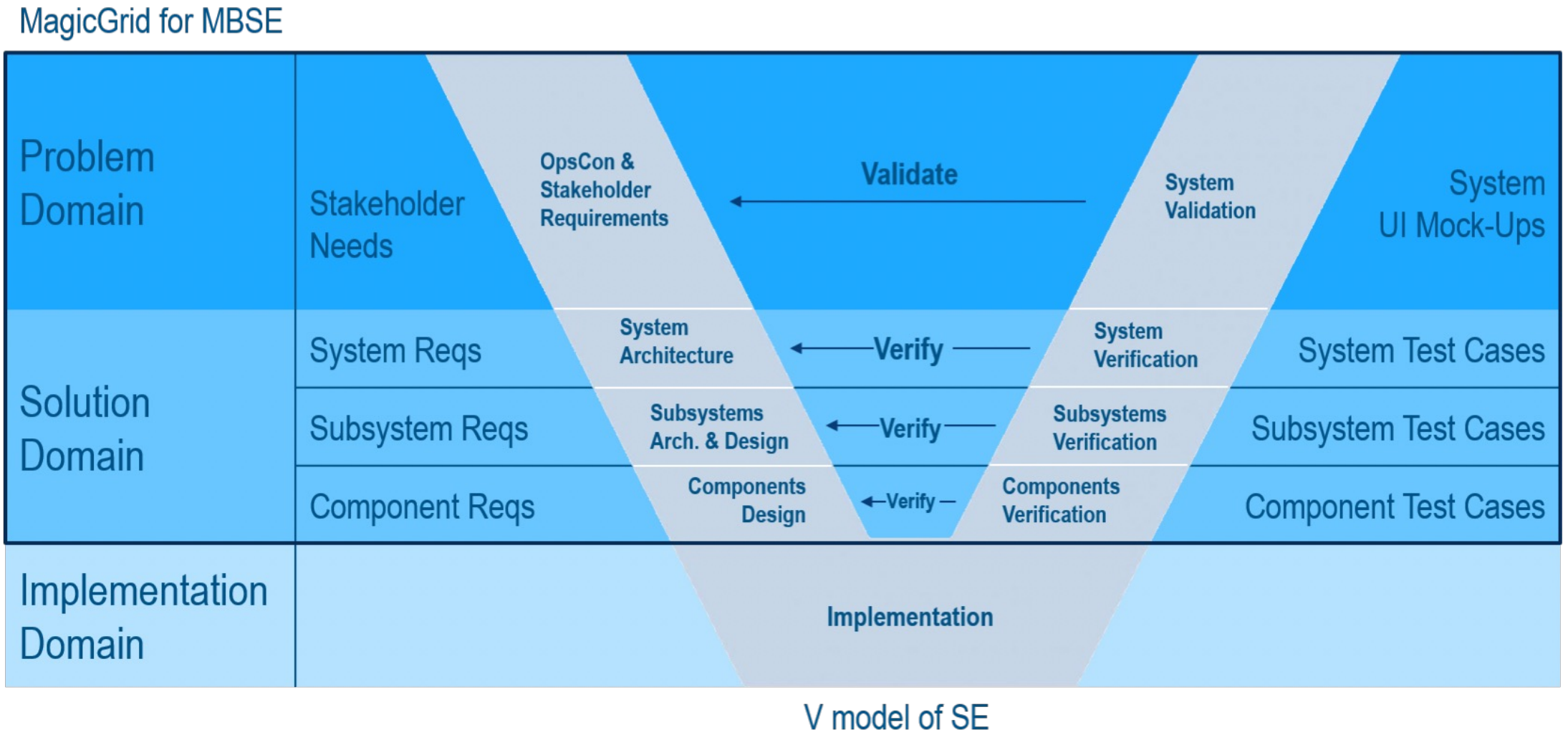
Purpose

- Our paper proposes an approach to perform verification and validation of a system using system models developed with Systems Modeling Language (SysML) and in accordance with the MagicGrid (formerly known as MBSE Grid) framework.
- The approach covers system testing activities beginning with verification of the lowest modeled system elements against system requirements and finishing with validation of the system as a whole, against stakeholder needs.
- A thorough case study on the vehicle model is presented to prove the usefulness of the proposed approach in the overall lifecycle of the system engineering.

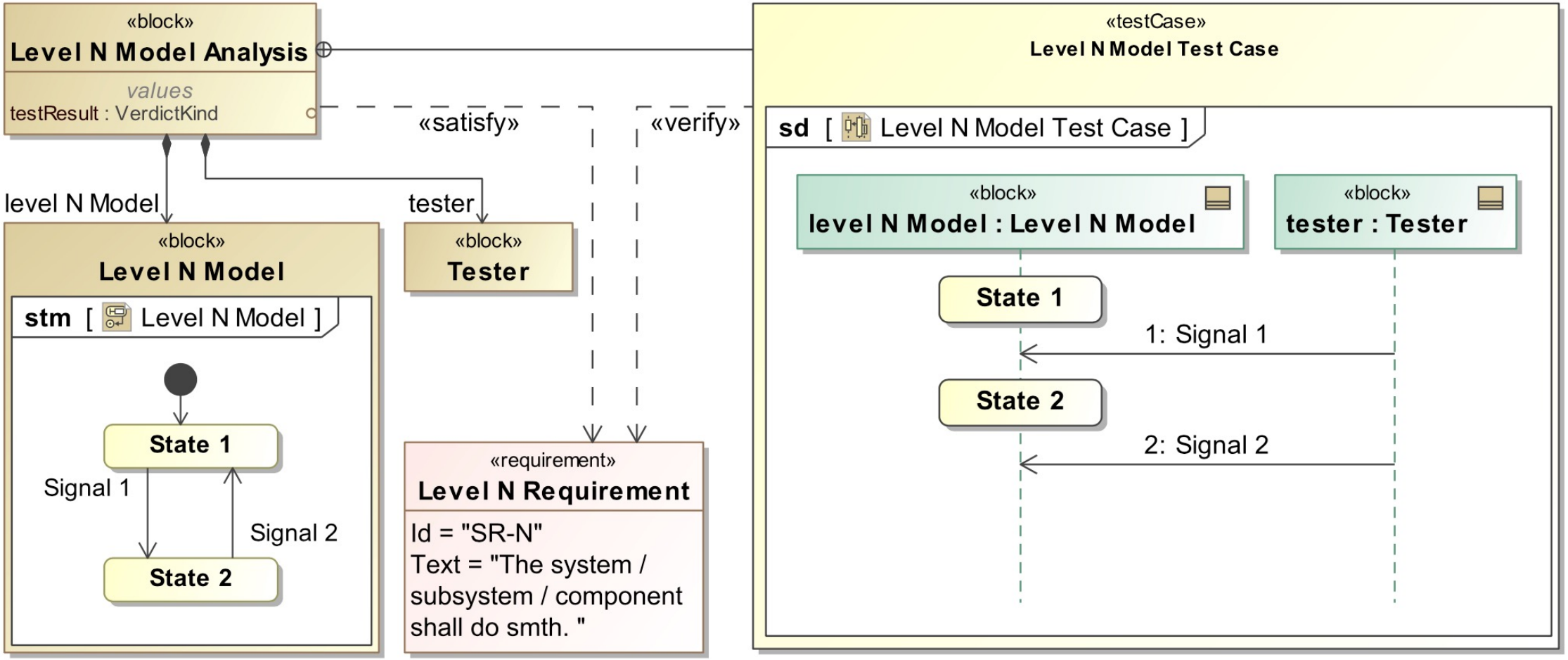
MagicGrid Framework

Domain			Pillar: Requirements	Pillar: Structure	Pillar: Behavior	Pillar: Parameters	Pillar: Safety & Reliability
Problem	Black Box		Stakeholder Needs	System Context	Use Cases	Measures of Effectiveness (MoEs)	Conceptual and Functional Failure Mode & Effects Analysis (FMEA)
Problem	White Box		Stakeholder Needs	Conceptual Subsystems	Functional Analysis	MoEs for Subsystems	Conceptual Subsystems FMEA
Solution			System Requirements	System Structure	System Behavior	System Parameters	System Safety & Reliability (S&R)
Solution			Subsystem Requirements	Subsystem Structure	Subsystem Behavior	Subsystem Parameters	Subsystem S&R
Solution			Component Requirements	Component Structure	Component Behavior	Component Parameters	Component S&R
Implementation			Implementation Requirements				

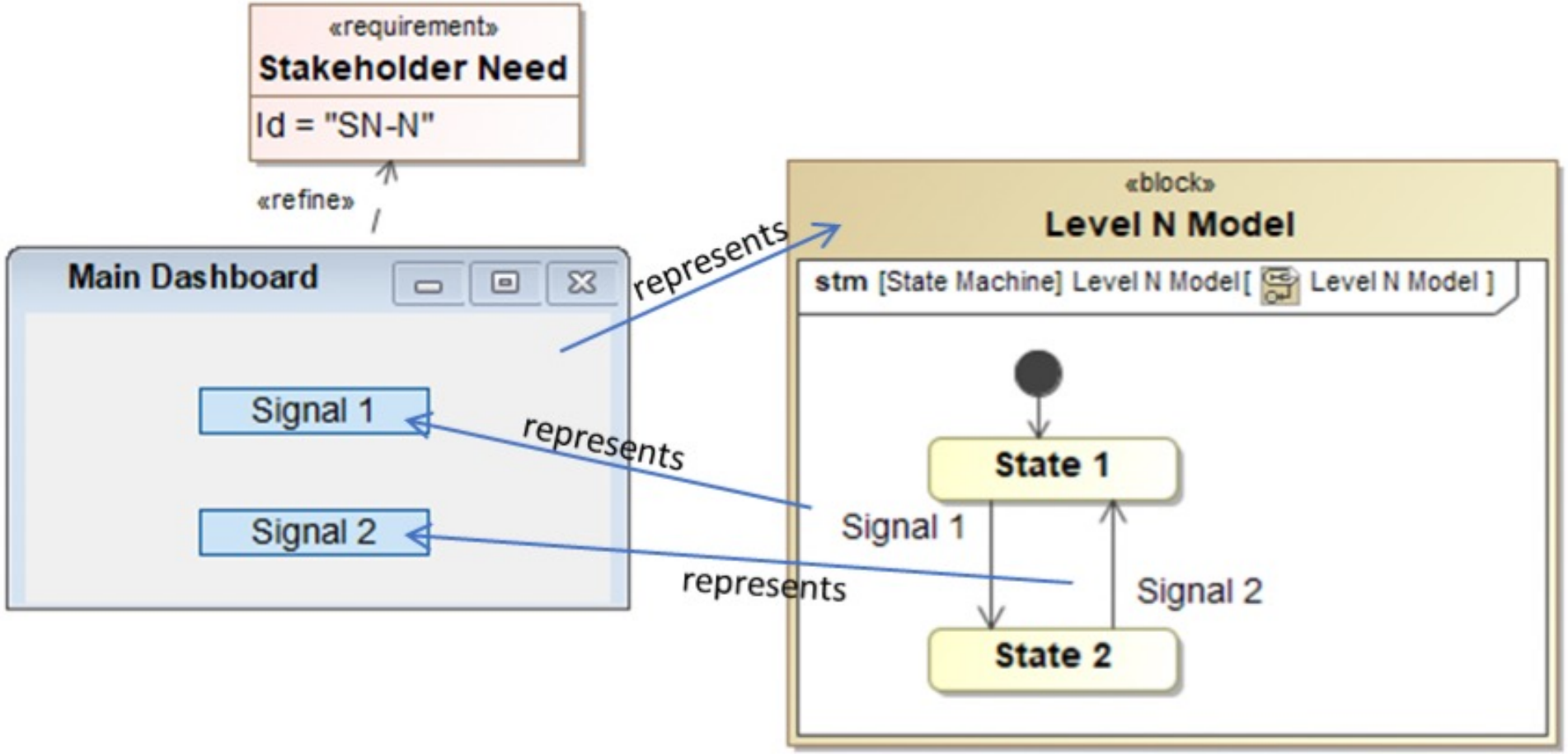
MagicGrid Extensions for V&V



Typical Model to Perform Verification



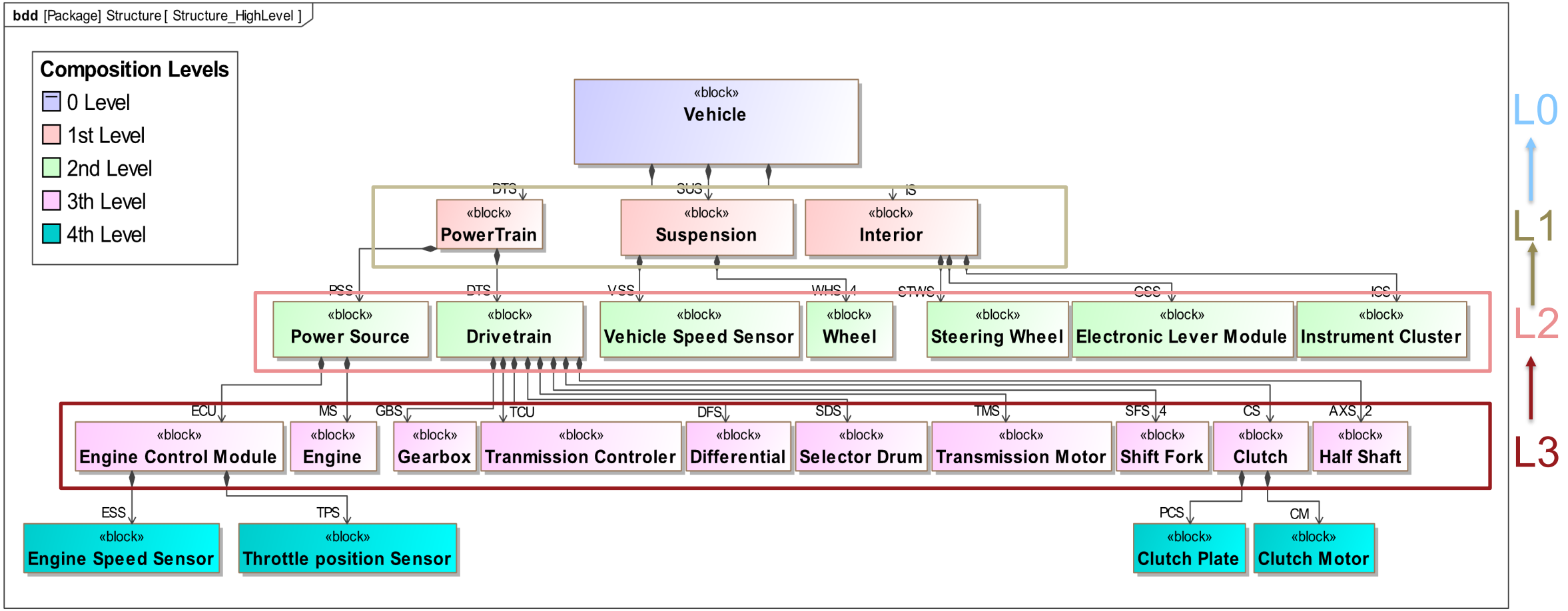
Typical Model for Validation



Case Study – System of Interest

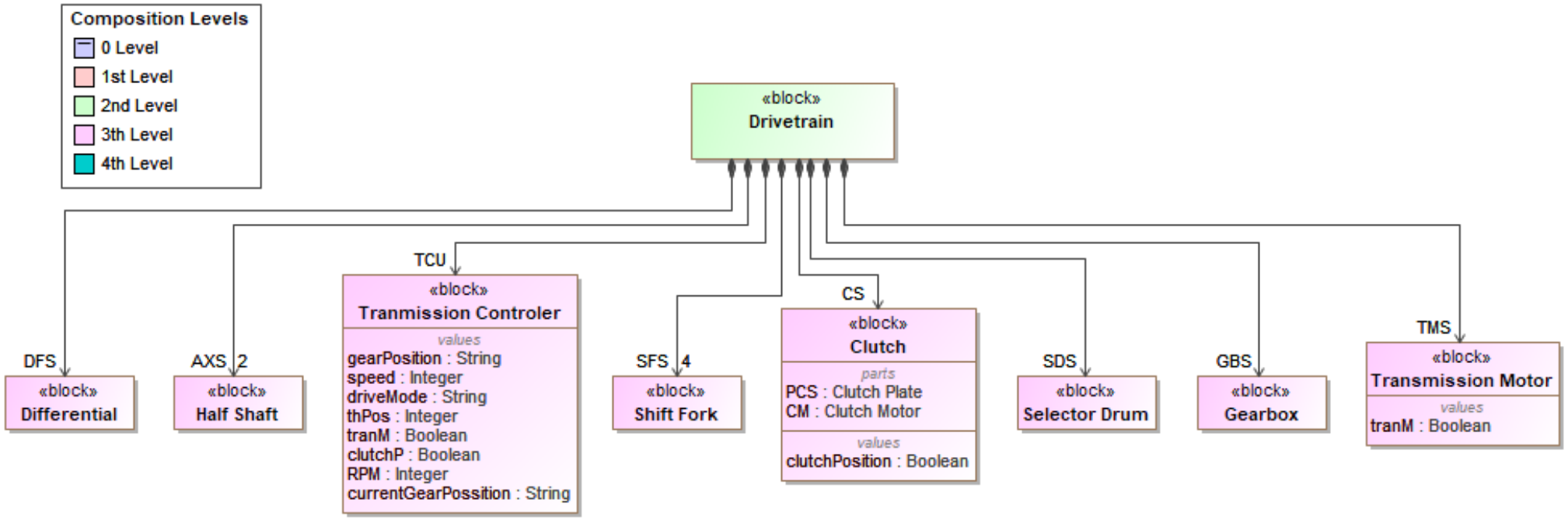
- For the case study example traditional ICE car was selected;
- In case study example it was decided to showcase the proposed approach by integrating system architecture elements from bottom to top;
- Due to scope assiociated with modern car systems only small subset of system in the case study example were used

System of Interest Architecture

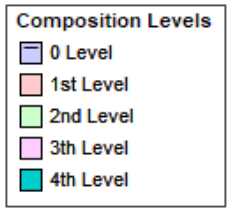


System to be integrated

- The selected transmission system is semi-automatic type (e.g. Tiptronic, Steptronic);
- Semi-automatic transmission is based on manual transmission while shifting of gears are done with electric motors



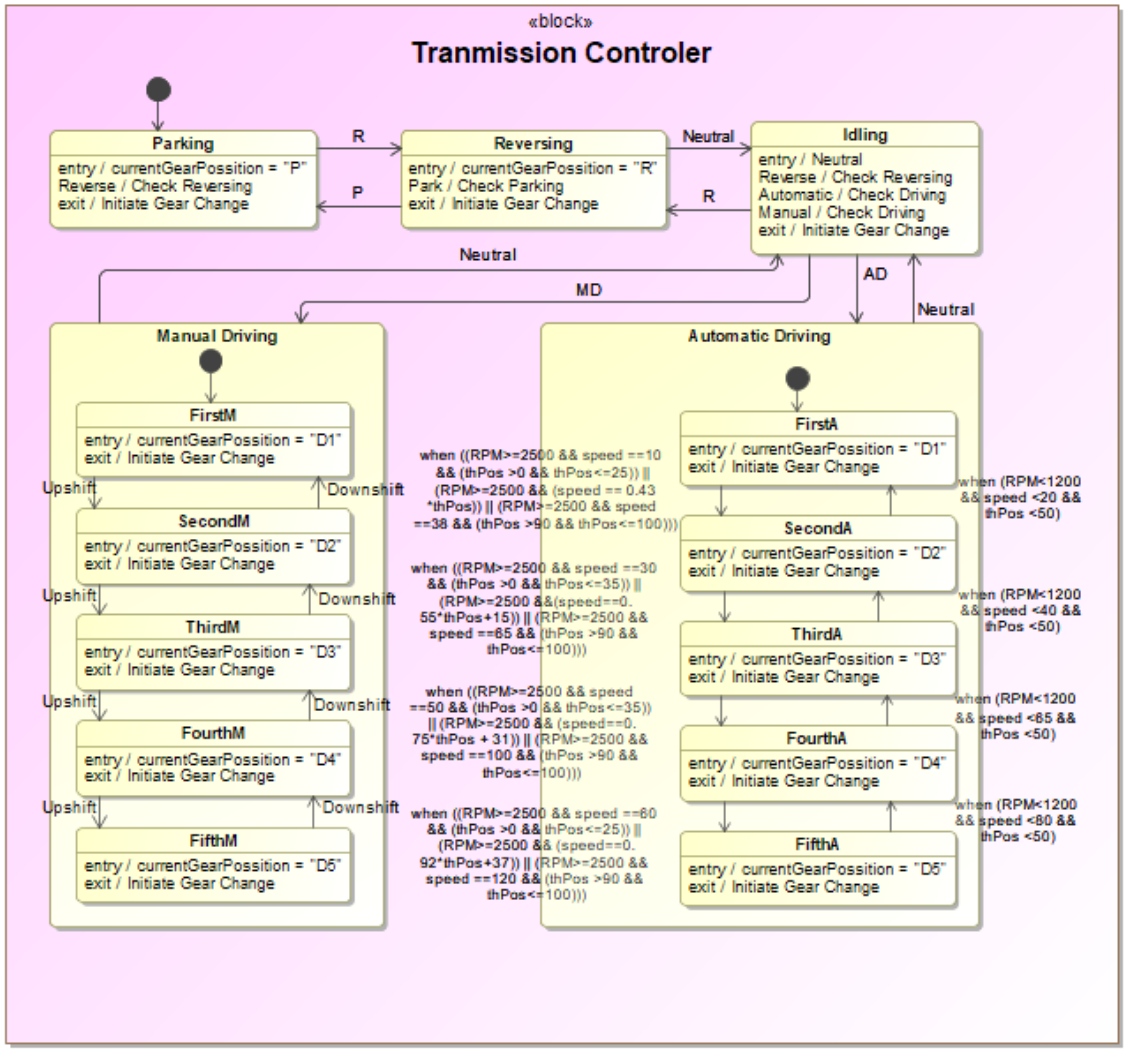
Behaviors and Requirements

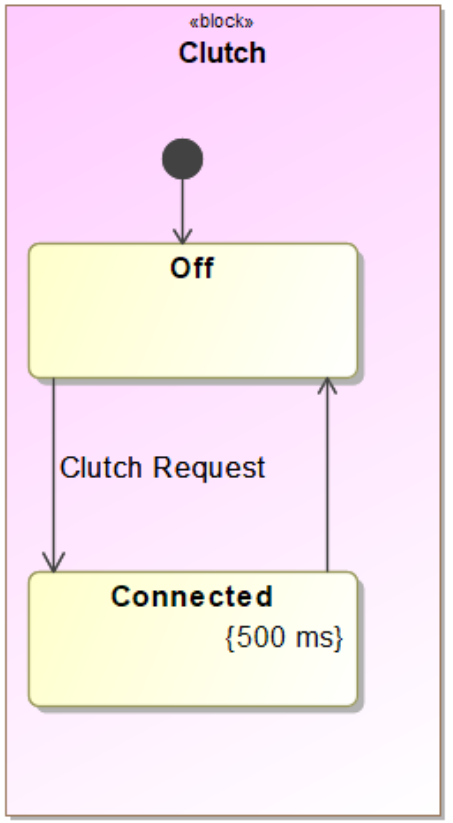


«requirement»
Driving Mode Changes for Clutch

Id = "1.2"
Text = "Clutch shall be connected when drive mode is changed "

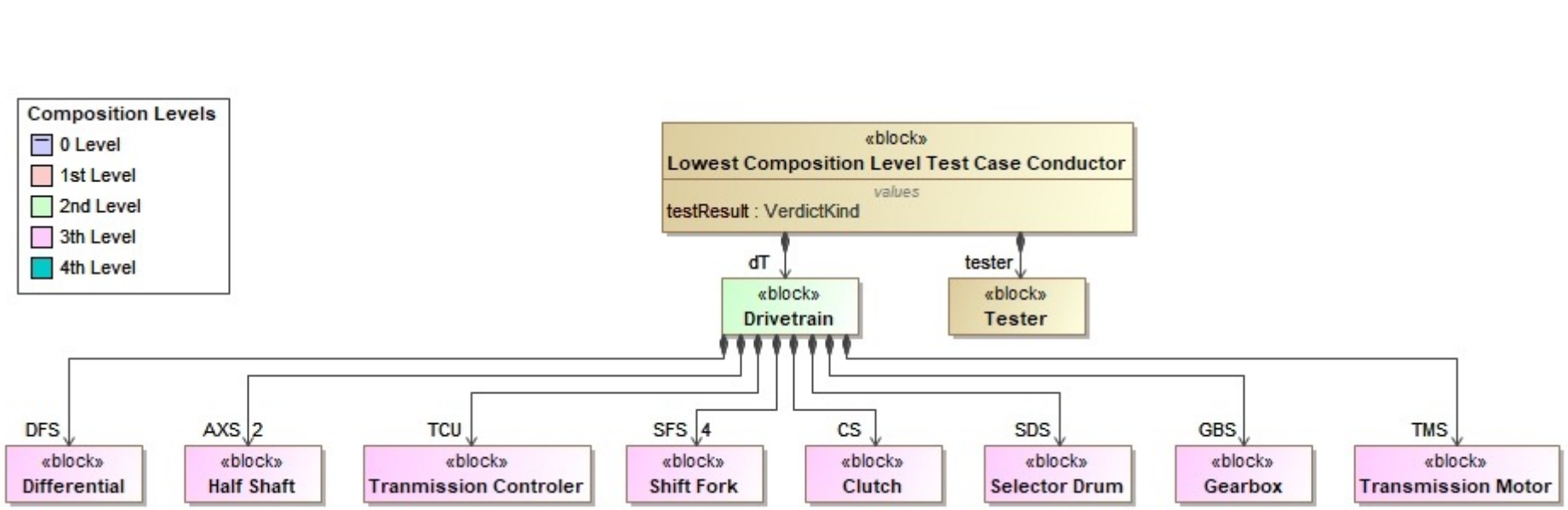
verify

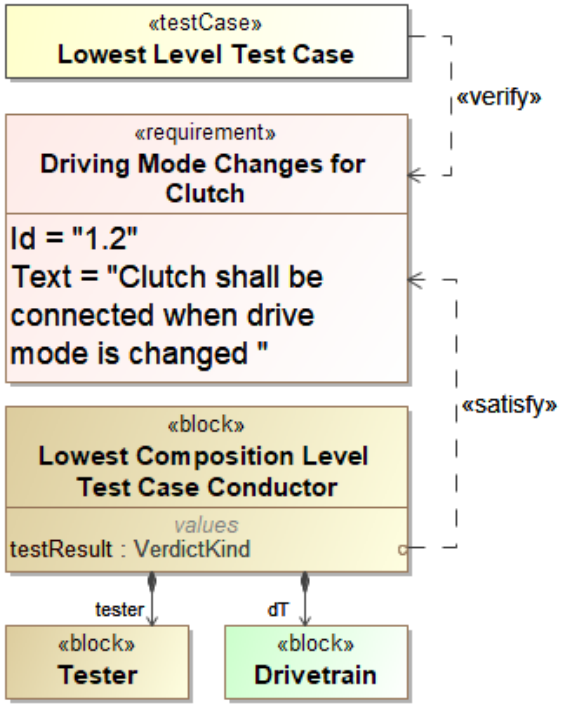




Verification Setup

- Model setup for verification



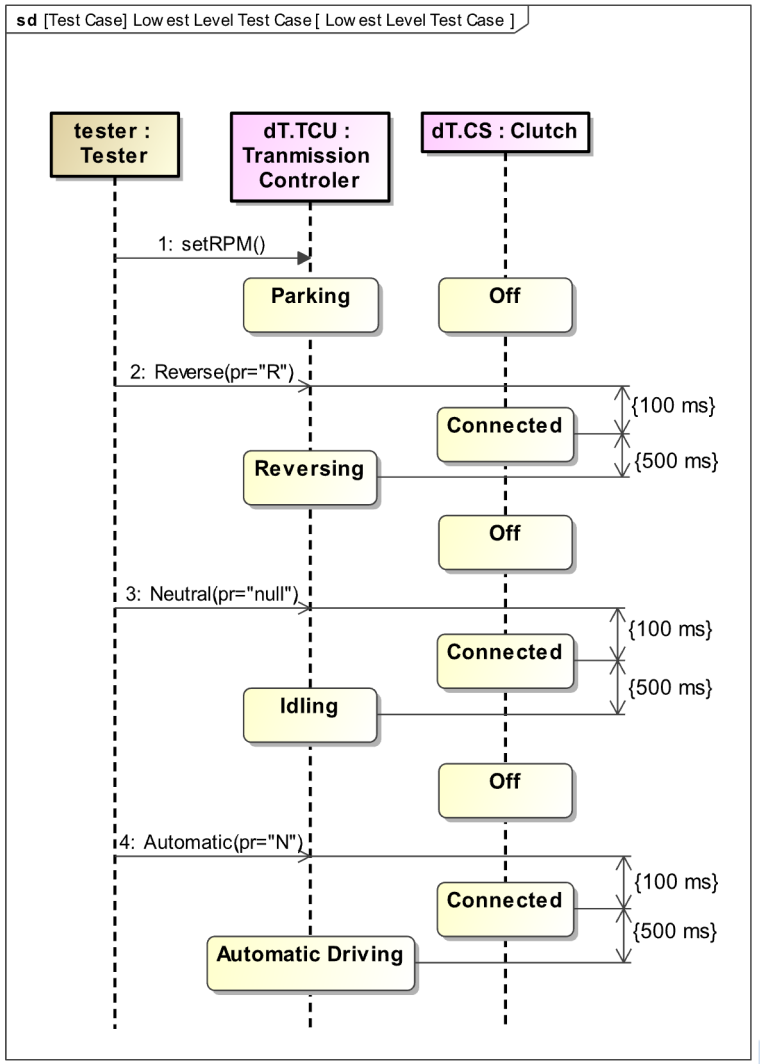


System L2 Test Case Description

- Model test case with Sequence diagram

Configurations as instance specification

#	Name	testResult
1	lowest Level Test Case at 2021.10.14 16.30	fail
2	lowest Level Test Case at 2021.10.15 11.19	fail
3	lowest Level Test Case at 2021.10.21 13.03	fail
4	lowest Level Test Cases at 2021.10.21 13.23	pass



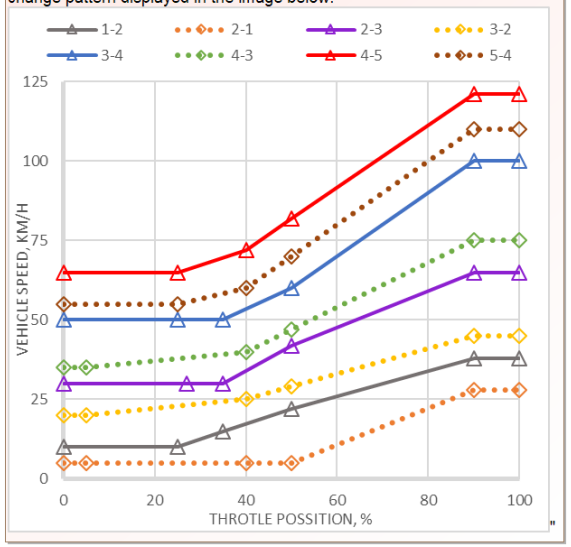
System L1+L0 Verified Requirements

System L1 verified requirements

bdd [Package] Intermediate Level Test Case [L1 Verified Requirements]

«requirement»
Automatic Gear Change

Id = "4.1.1.1"
Text = "Automatic gear change shall be completed according to the gear change pattern displayed in the image below:



«requirement»
Automatic Gear Upshift change depending on Engine Speed

Id = "4.1.1.2"
Text = "Automatic gear upshift shall be completed when engine speed is higher than 2500 revolutions per minute "

System L0 verified requirements

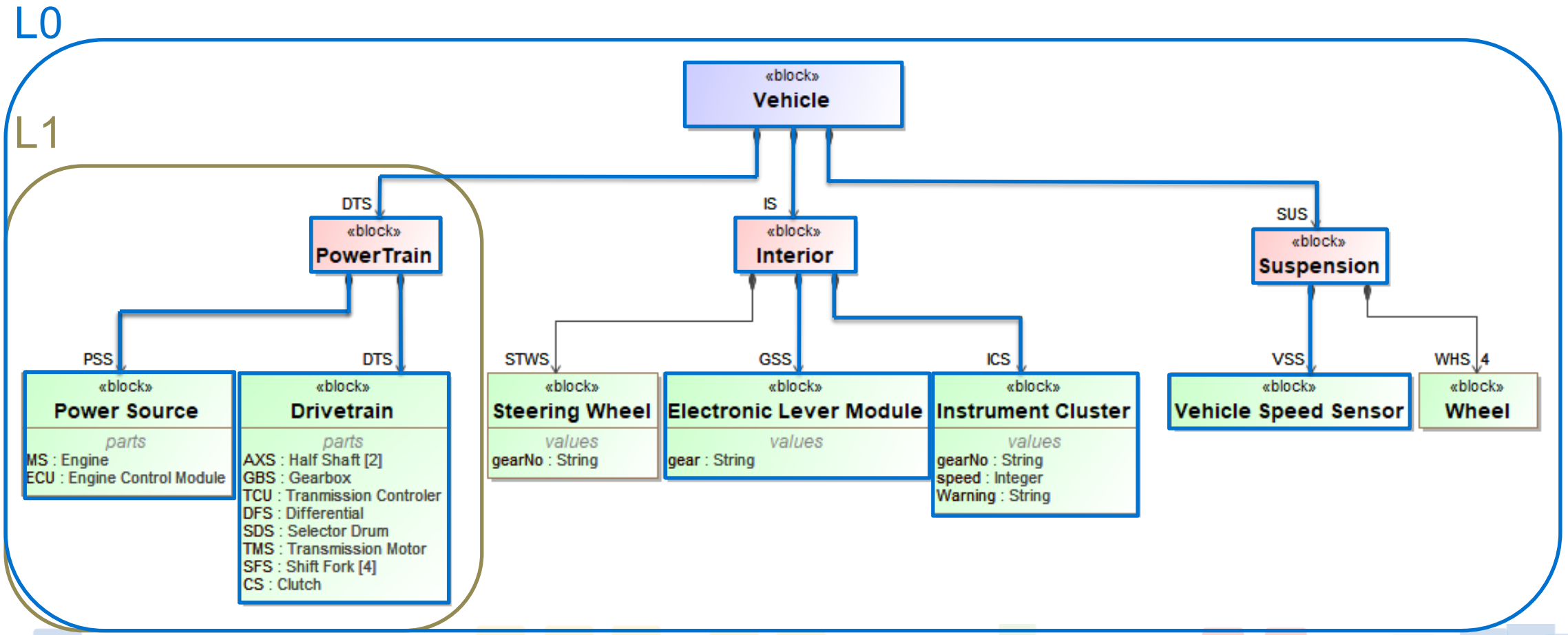
bdd [Package] Highest Level Test Case [L0 Verified Requirements]

«requirement»
Drive Mode Selection

Id = "6"
Text = "Driving mode change with the lever module shall result in the same change for the drivetrain system"

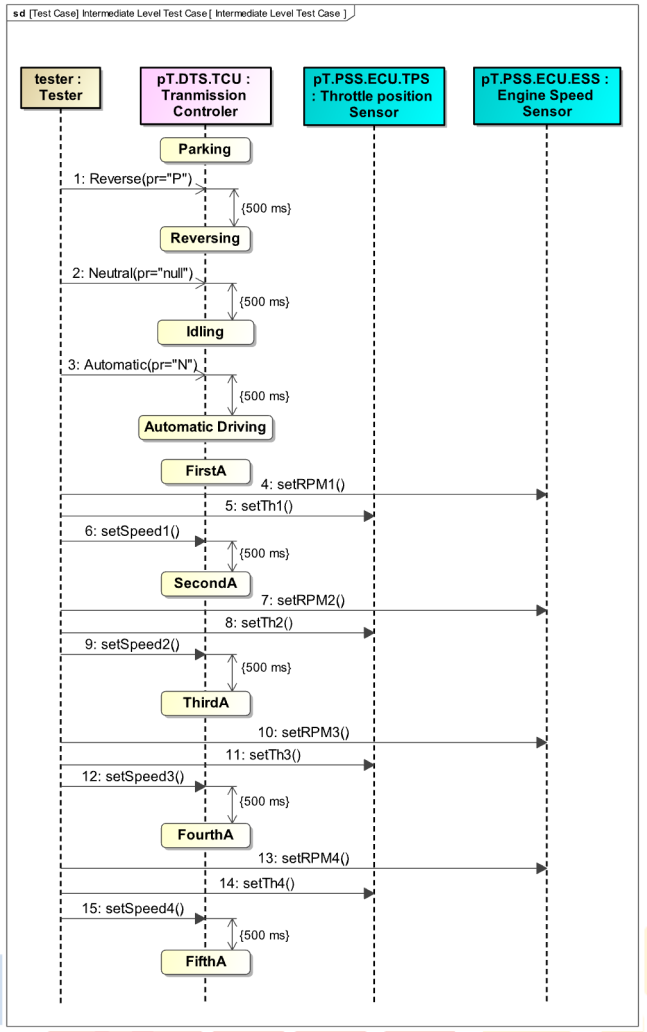
System L1 + L0 Architecture

- Systems that are used for L1, L0 integration

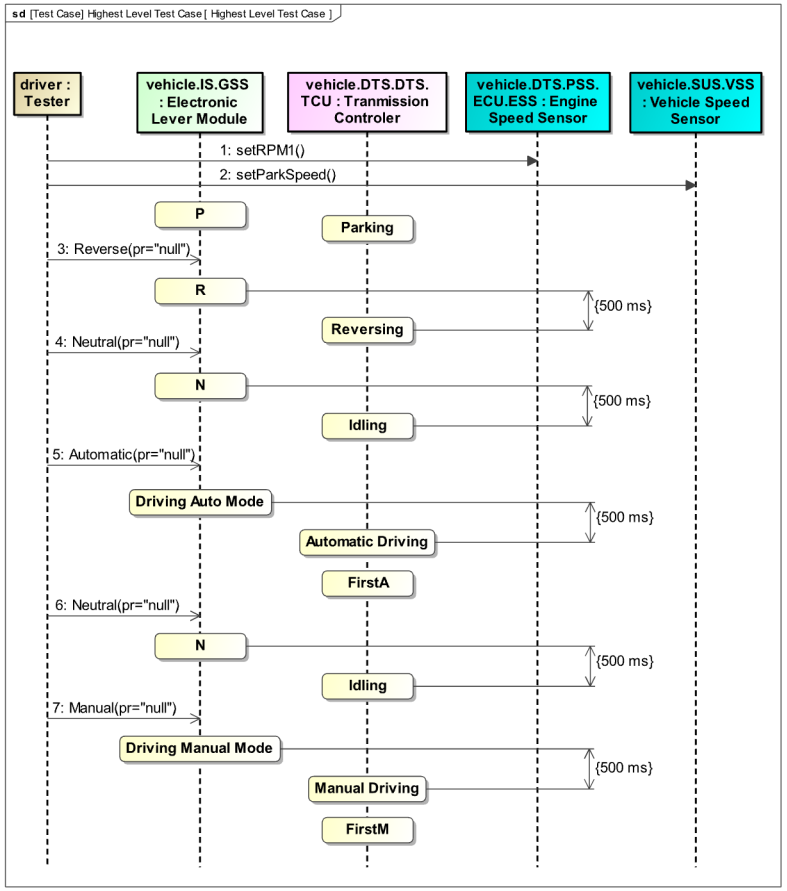


System L1+L0 Verification Setup

System L1 verification setup

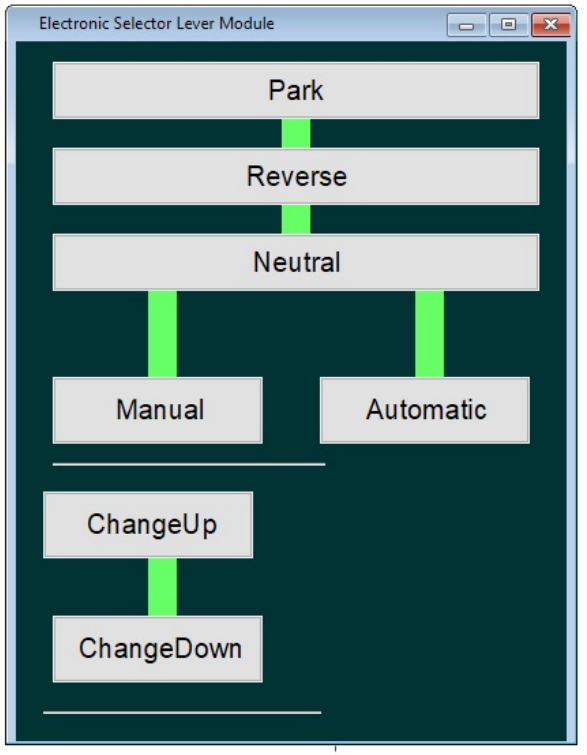


System L0 verification setup



GUI for System Model Validation

- For L0 we used GUI to validate instrument cluster



«requirement»
Gear Change with Level Module

Id = "7"
Text = "Gear change with the Electronic Lever Module shall result in the gear change visualization in instrument cluster"

«refine»

«refine»

Conclusions

- Proposed approach shows clearly defined steps how systems described with model based approaches can verified and validated;
- Proposed approach is alligned with MagicGrid method;
- Test case generation should be automatic as process of defining test cases manualy potentialy could be very tedious and laborous.

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