

# Enhancing Automated Trade Studies using MBSE, SysML and PLM

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## GLOBAL PRODUCT DATA INTEROPERABILITY **S U M M I T** 2018



# PLM and Systems Engineering

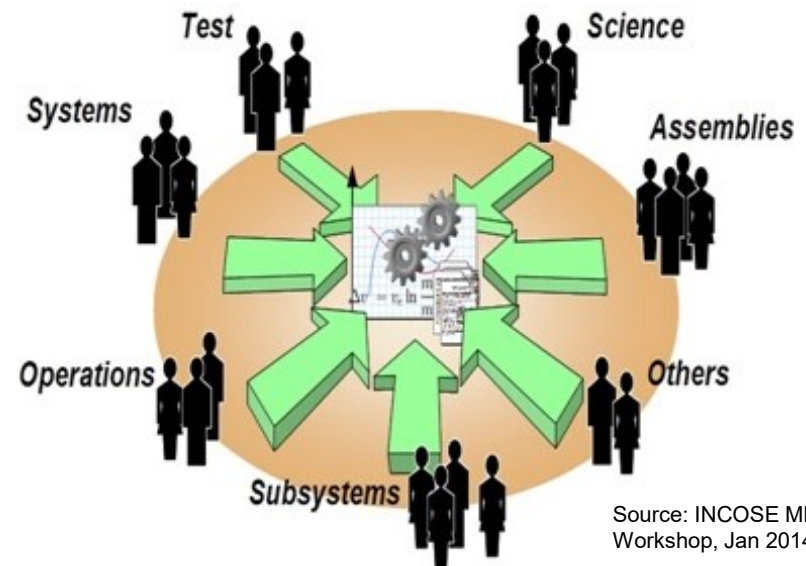
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So what?  
Who cares?



Quite many care – if it is  
enabling, practical, demonstrable

***Study your use cases!!!***



Source: INCOSE MBSE  
Workshop, Jan 2014

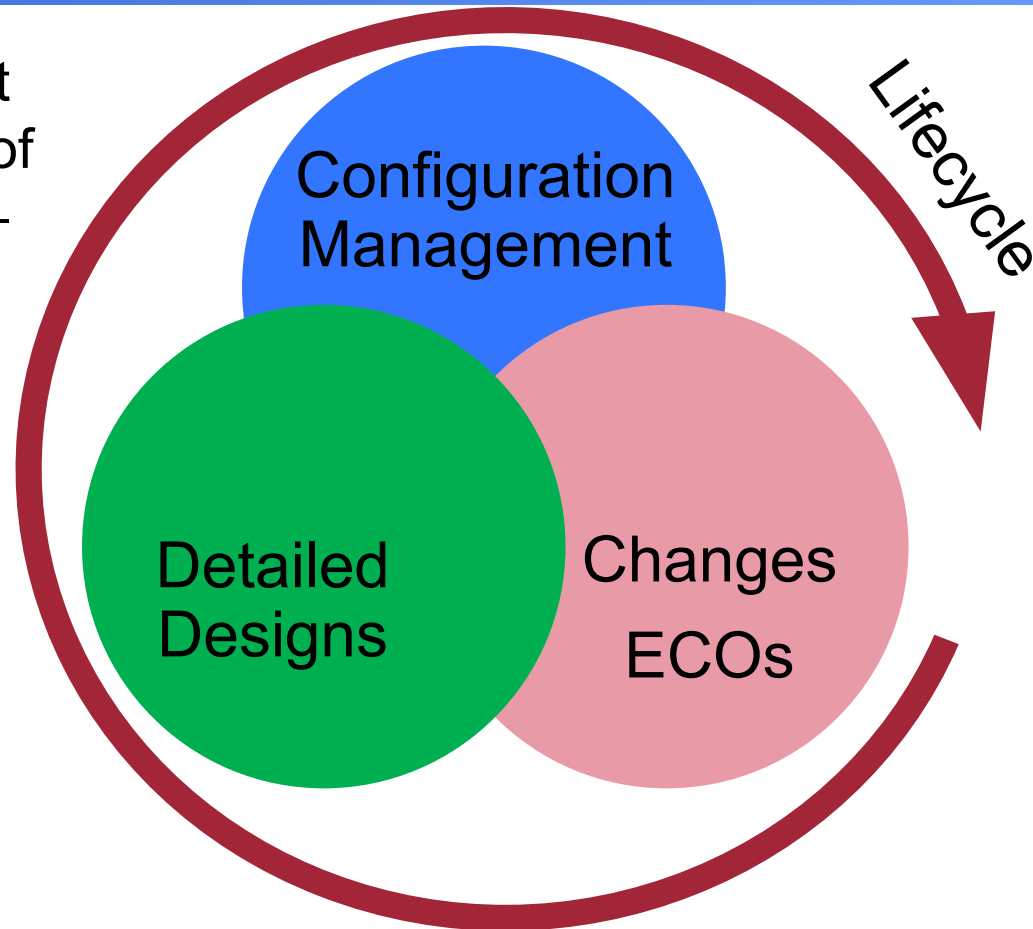
# Systems Engineering is central to PLM

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PLM platforms must manage all aspects of a product lifecycle – including system models

**No** – PLM is not “just” for managing mechanical assemblies

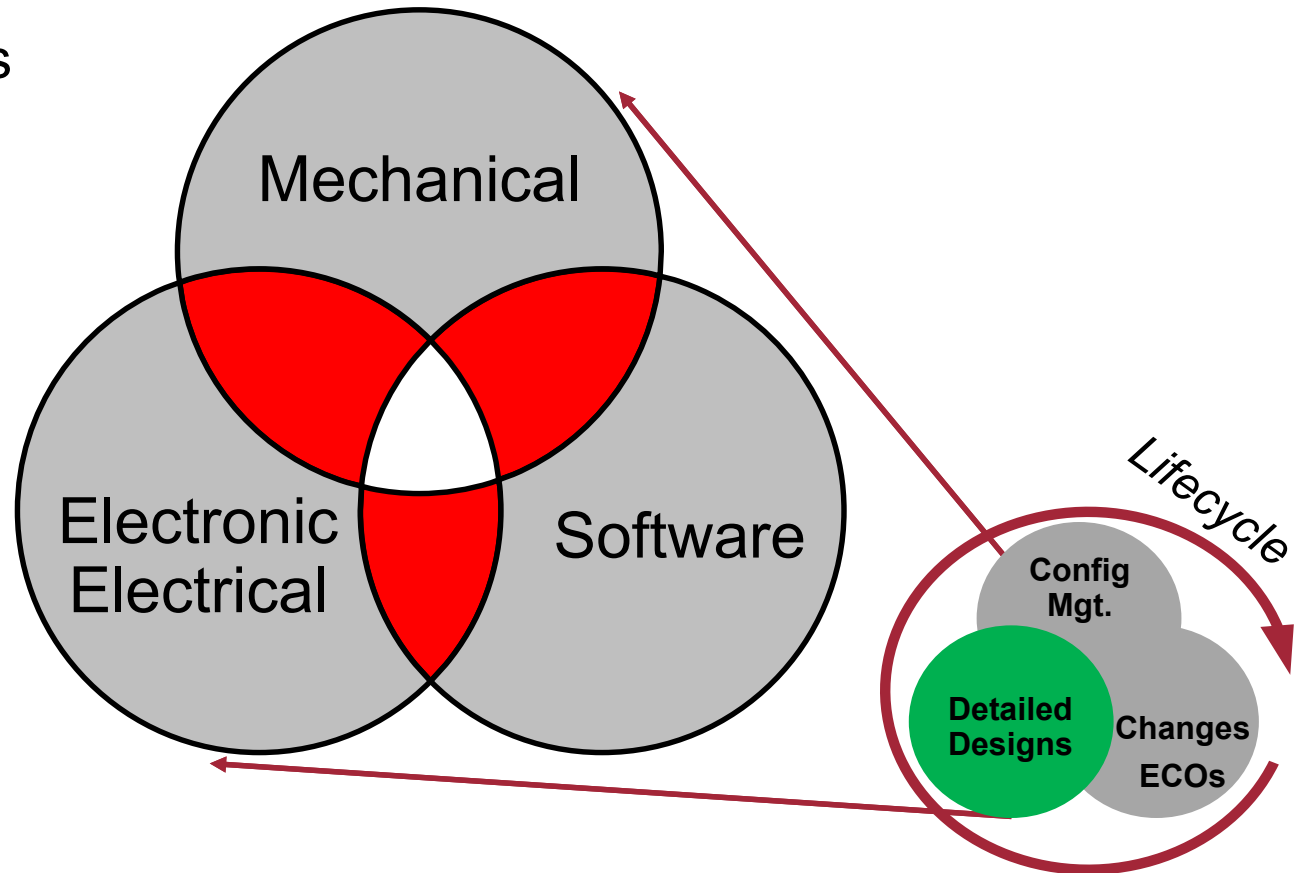
**No** – “manage” does not mean “contain everything”



# Systems Engineering is central to PLM

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Without system models  
***Digital Thread*** runs  
only between  
disciplines

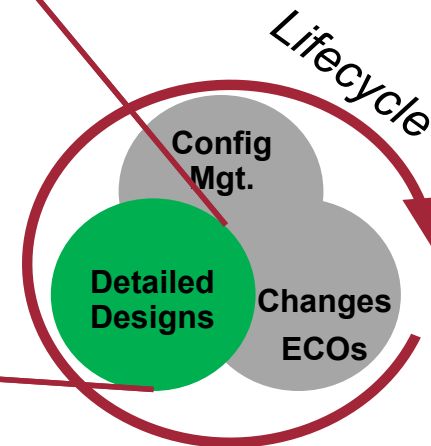
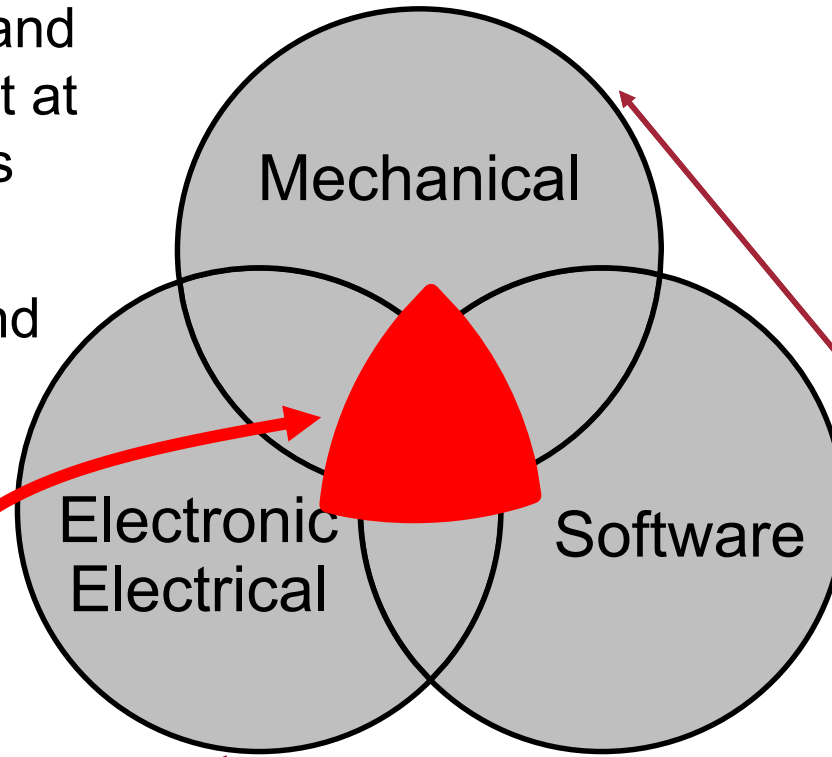
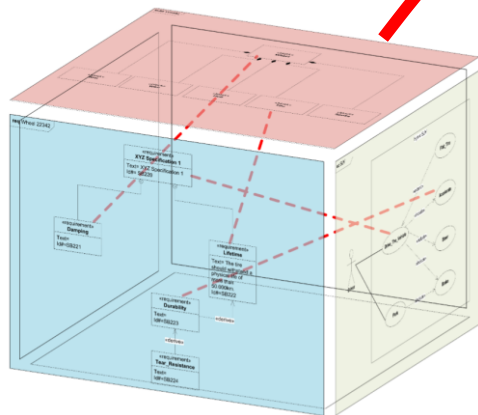


# Systems Engineering is central to PLM

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When system models and related requirements sit at the center of designs

... they become the connective tissue – and ***Digital Thread*** runs through them



# Example: PLM and Systems Engineering

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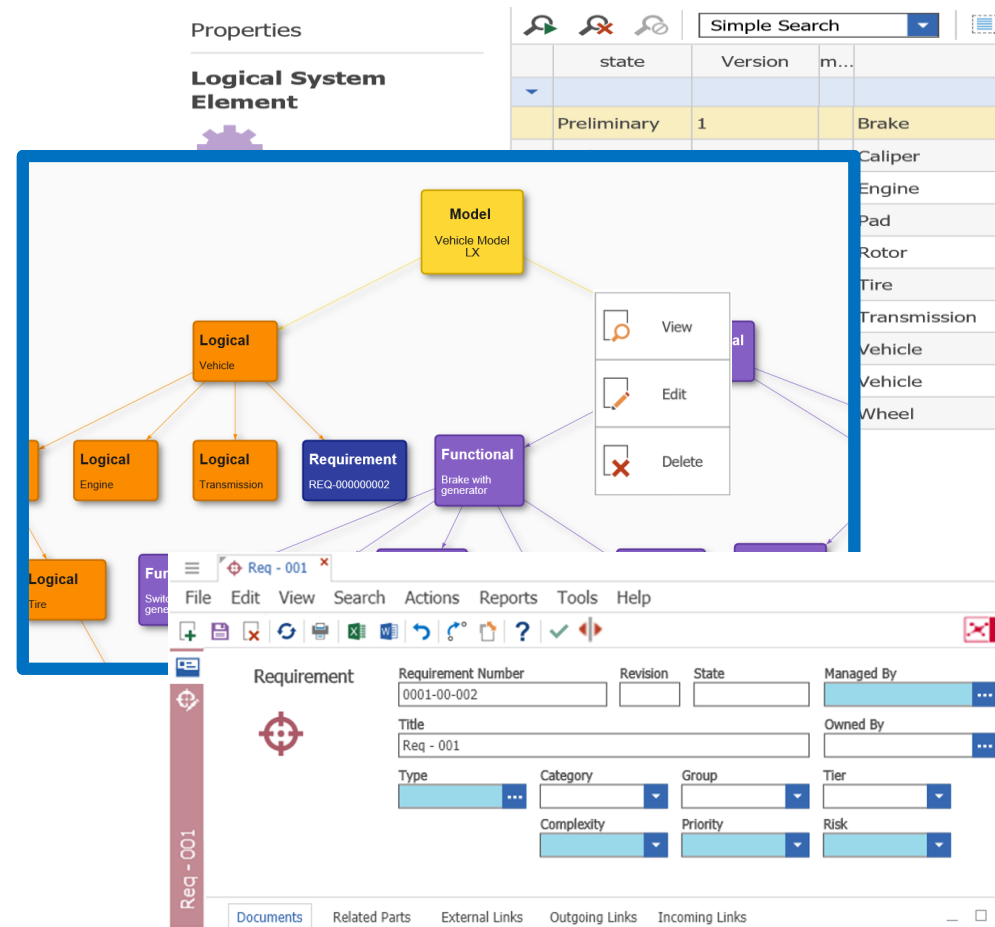
- Trade study and optimization of brake assembly
- Based on Aras Innovator PLM platform and No Magic MagicDraw SysML authoring tool
- Applicable to any SysML authoring tool like IBM Rhapsody or Vitech GENESYS



# Early system definition in PLM

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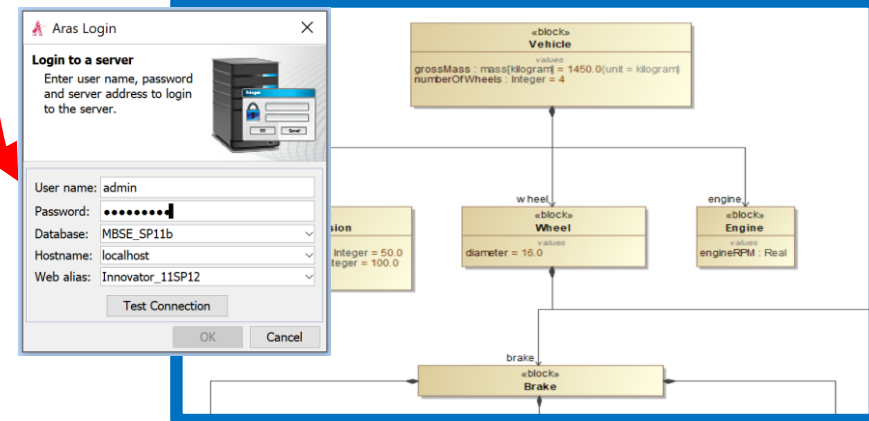
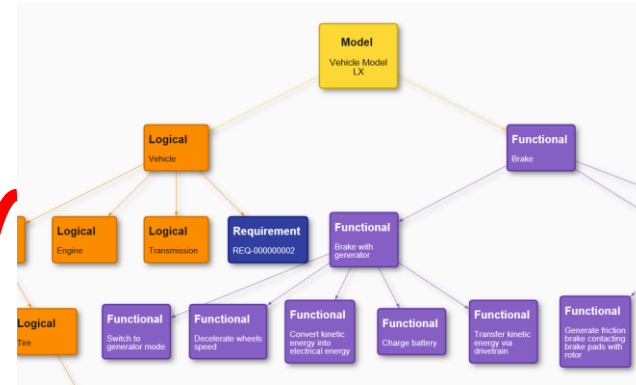
- Reuse of revision controlled system model elements
- Simple functional and logical break down
- Configuration and revision controlled data model
- Replaces simple documents like napkins, PowerPoint, and Visio



# Initiating detailed SysML model

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- SysML tool user authenticates in PLM
- SysML authoring tool reads system structures from PLM
- Unique global IDs are on all model elements managed by PLM
- Systems Engineer continues developing a detailed SysML model
- SysML tool remains connected to PLM





# Synchronization of requirements

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- SysML user manipulates parametrically-driven requirements at will
- Integration provides visual feedback regarding PLM status of SysML changes
  - Red -> modified from PLM (change)
  - Green -> not in PLM (create)
  - No color -> query from PLM (add)

Requirement Number	Title	State	Rev
REQ-000000001	Tires	Draft	A
REQ-000000002	Vehicle Weight	Draft	A
REQ-000000003	Pad Width	Draft	A
REQ-000000004	Stopping Distance	Draft	A
REQ-000000005	Table1	Draft	A
REQ-000000006	Pad Center Thickness	Draft	A
REQ-000000007	Brake Heating	Draft	A
REQ-000000008	Rotor Diameter	Draft	A
REQ-000000009	Brake Pad Life	Draft	A

Properties  
Requirement  
Created By: Innovator Admin  
Created On: 4/19/2018  
Modified By: Innovator Admin  
Modified On: 4/19/2018  
Locked By:  
Major Rev: A  
Release Date:  
Effective Date:  
Generation: Draft  
State:

Aras

Please enter item attributes! Press the Query Aras button to continue.

+ Requirement

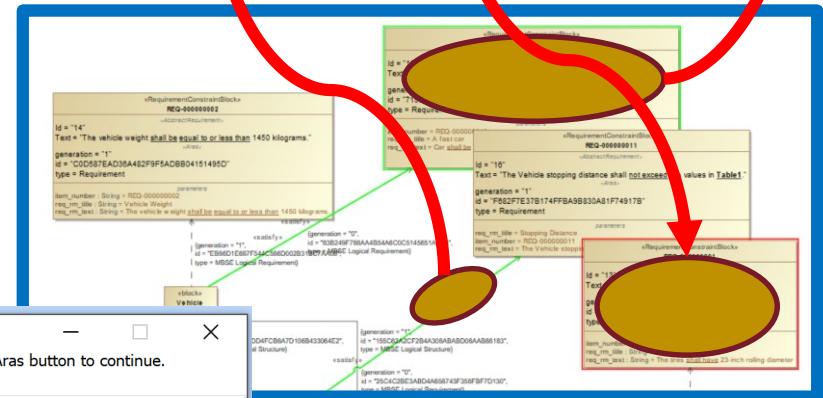
Select: item number, req rm title, req rm text

Where: NT where source\_id='FB49D662567045DFB8BE75AF3246036F1'

Classifier Name: Requirement

Action: get

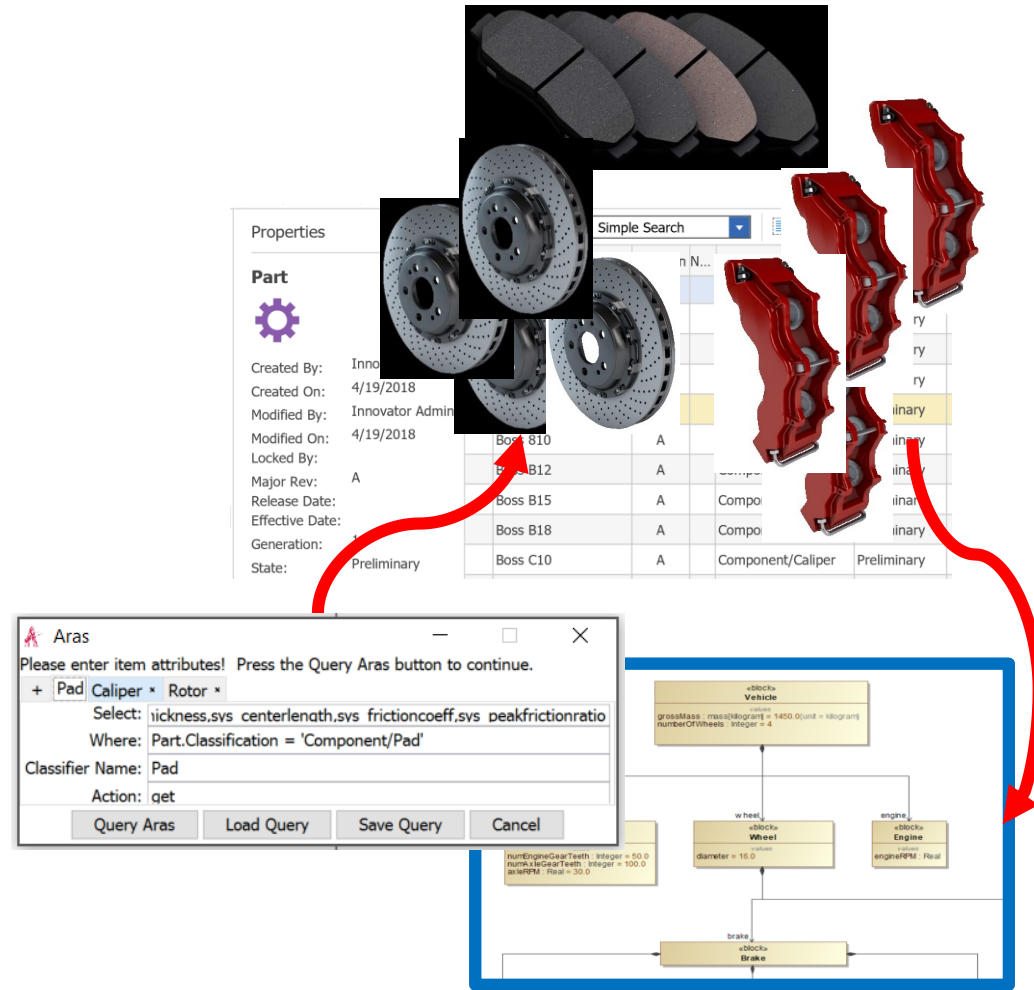
Query Aras Load Query Save Query Cancel



# Reuse of PLM managed parts

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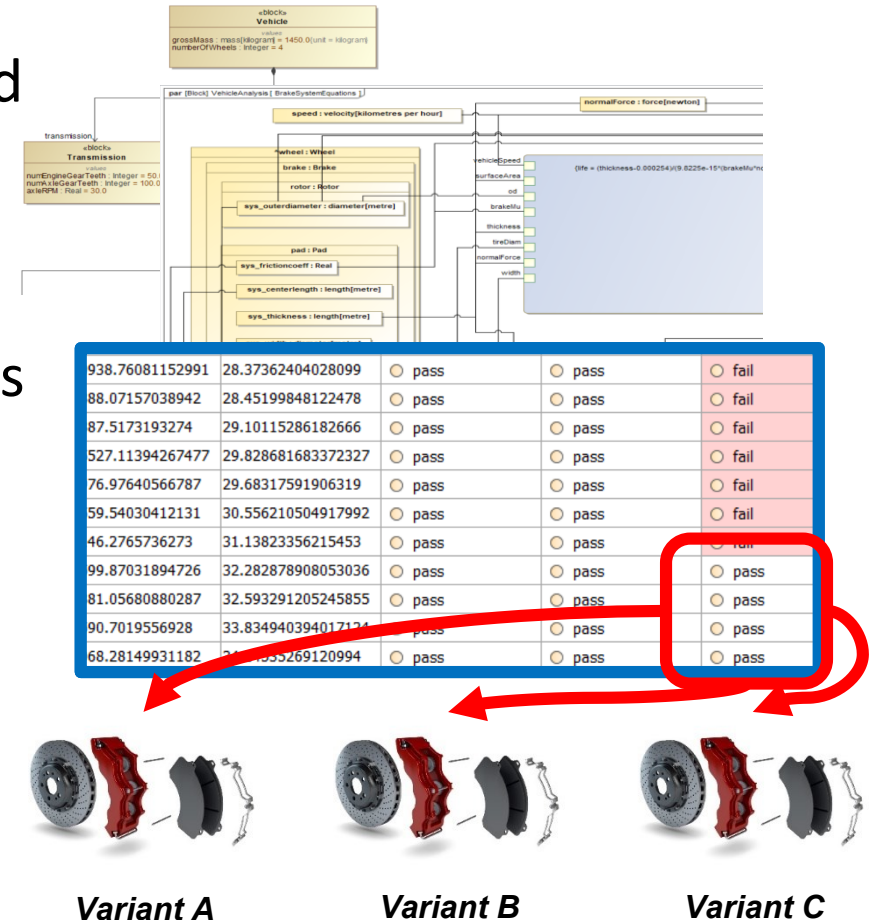
- SysML interacts with PLM to find existing physical implementations
- Query is based on SysML defined parameters
- PLM provides SysML with physical implementation choices for a 150% system model
- Parts are added but not connected



# Trade Study

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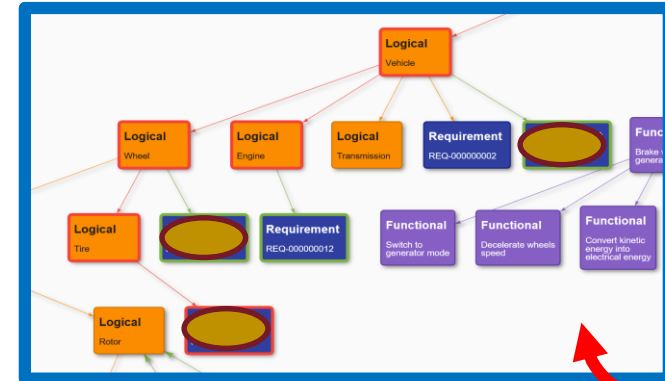
- Part variant table is auto-generated
- SysML runs various parametric studies on the model
- Results are based on reusable parts dynamically identified in PLM
- Studies identify valid implementation variants for the 150% SysML model
- MagicDraw tool can stage auto execution of trade studies from SysML parametric diagrams



# Updating PLM

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- Evolved SysML model updates system models managed by PLM
- Global IDs allow revision control of the model and model elements

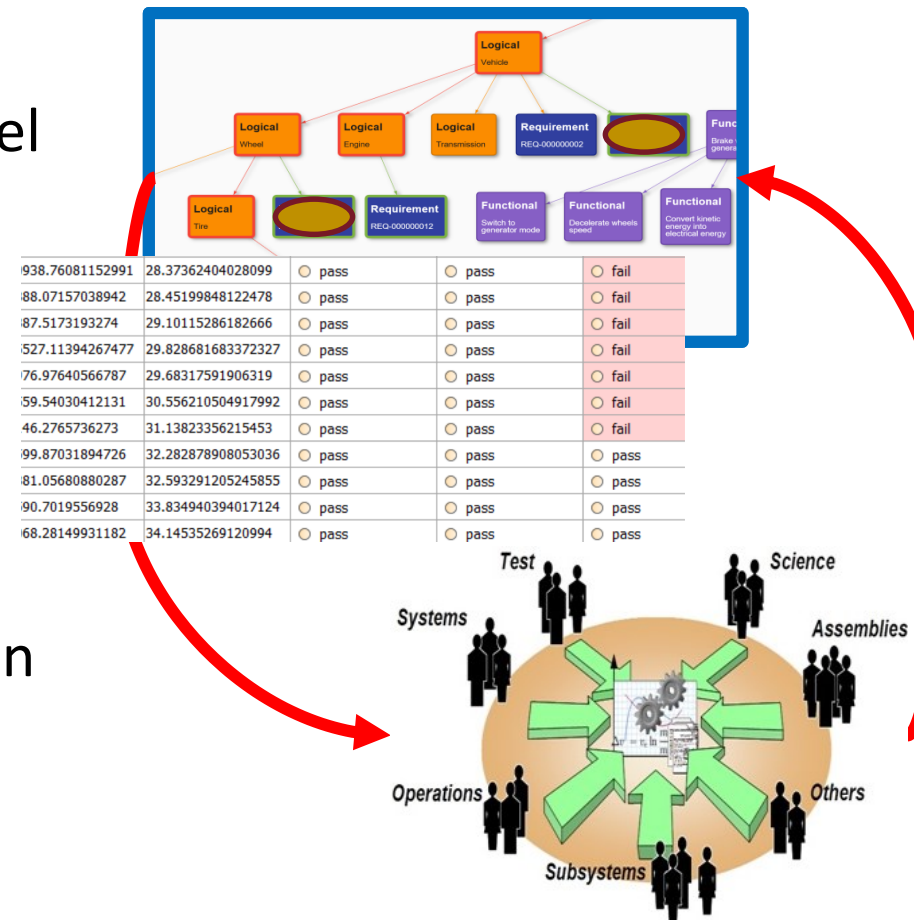


«block» Vehicle				
grossMass mass(kilogram) = 1450.0 unit = kilogram numberOfWheels integer = 4				
transmission	wheel	engine		
«block» Transmission	«block» Wheel	«block» Engine		
numEnginesGlobal numEnginesGlobal numEnginesGlobal numEnginesGlobal				
938.76081152991	28.37362404028099	pass	pass	fail
88.07157038942	28.45199848122478	pass	pass	fail
87.5173193274	29.10115286182666	pass	pass	fail
527.11394267477	29.828681683372327	pass	pass	fail
76.97640566787	29.68317591906319	pass	pass	fail
59.540304112131	30.556210504917992	pass	pass	fail
46.2765736273	31.13823356215453	pass	pass	fail
99.87031894726	32.282878908053036	pass	pass	pass
81.05680880287	32.593291205245855	pass	pass	pass
90.7019556928	33.834940394017124	pass	pass	pass
68.28149931182	34.14535269120994	pass	pass	pass

# Collaborating in PLM

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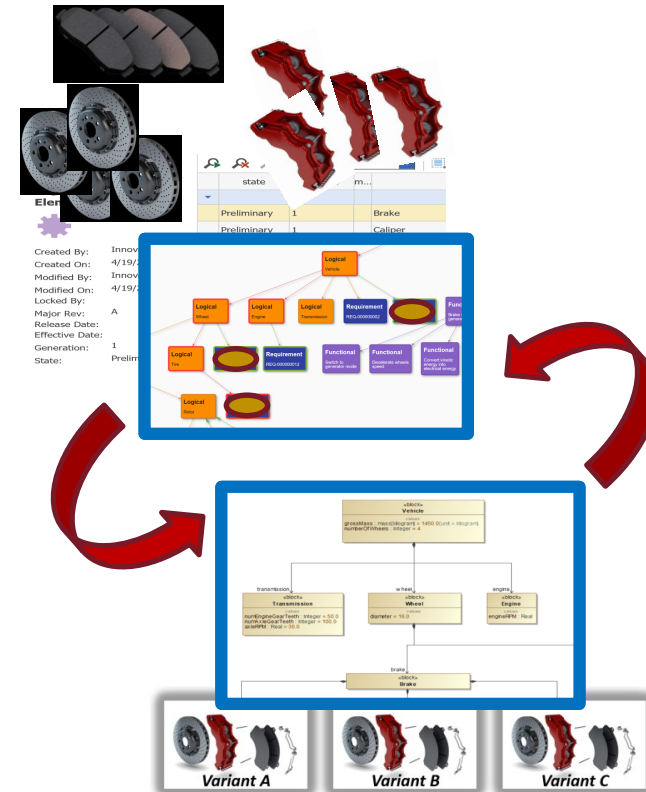
- PLM is a platform for exposing latest versions of the system model to a larger team of engineers
- Collaboration can involve discussion threads, visual annotations, and selection of implementation variants
- SysML trade study drives definition of PLE (Product Line Engineering) rules



# Key Take-Aways

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1. Making system model part of PLM traceability
2. Initiating SysML model from PLM managed system models
3. Sync of SysML parameter driven requirements with PLM
4. Dynamic reuse of PLM parts in SysML
5. Deriving physical PLM variants from a 150% SysML model
6. Revision control of selected SysML structures in PLM
7. Collaborating on model-driven PLE solutions (Product Line Engineering) in PLM



***Without constraining SysML authoring activities!***