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Enhancing Automated Trade Studies using MBSE, SysML and PLM

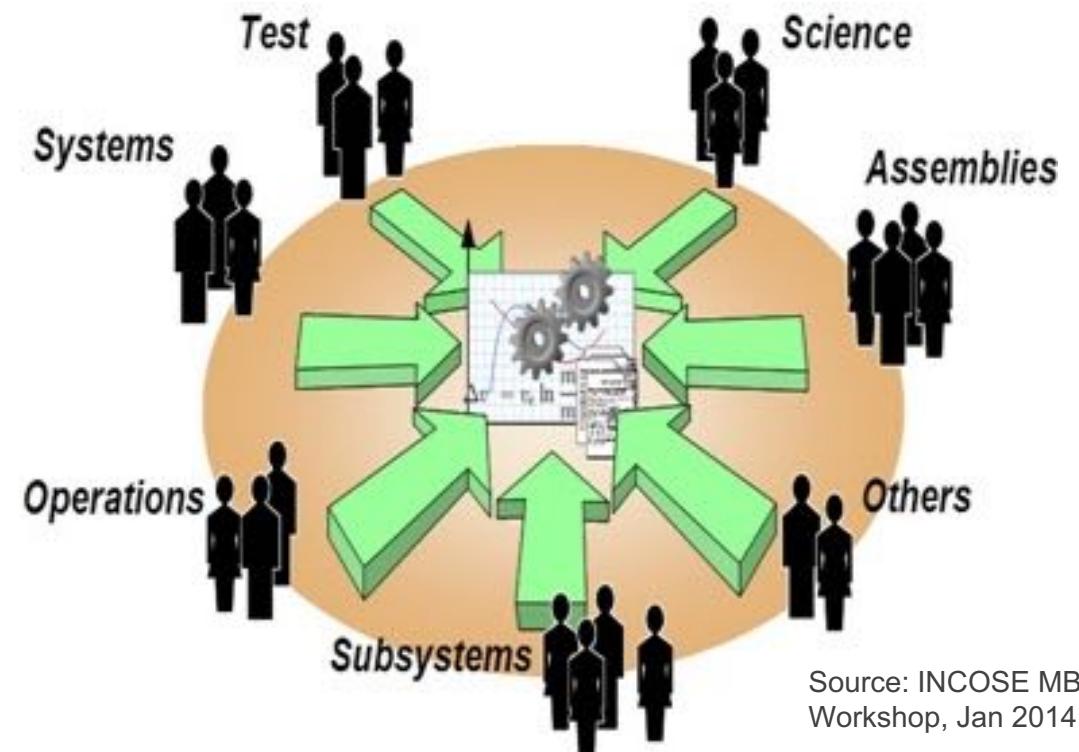


PLM and Systems Engineering

So what?
Who cares?



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



Study your use cases!!!

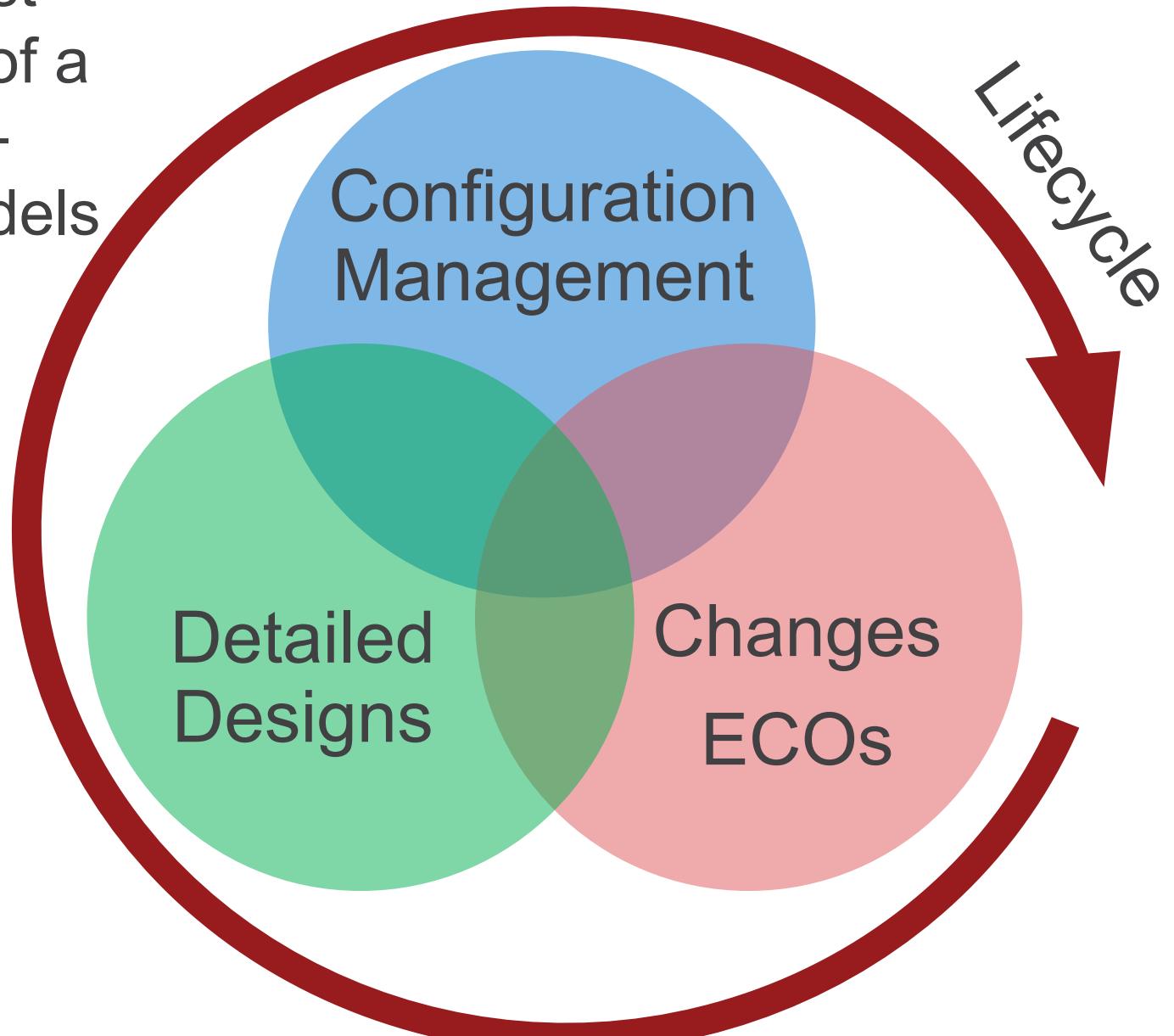
Source: INCOSE MBSE
Workshop, Jan 2014



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

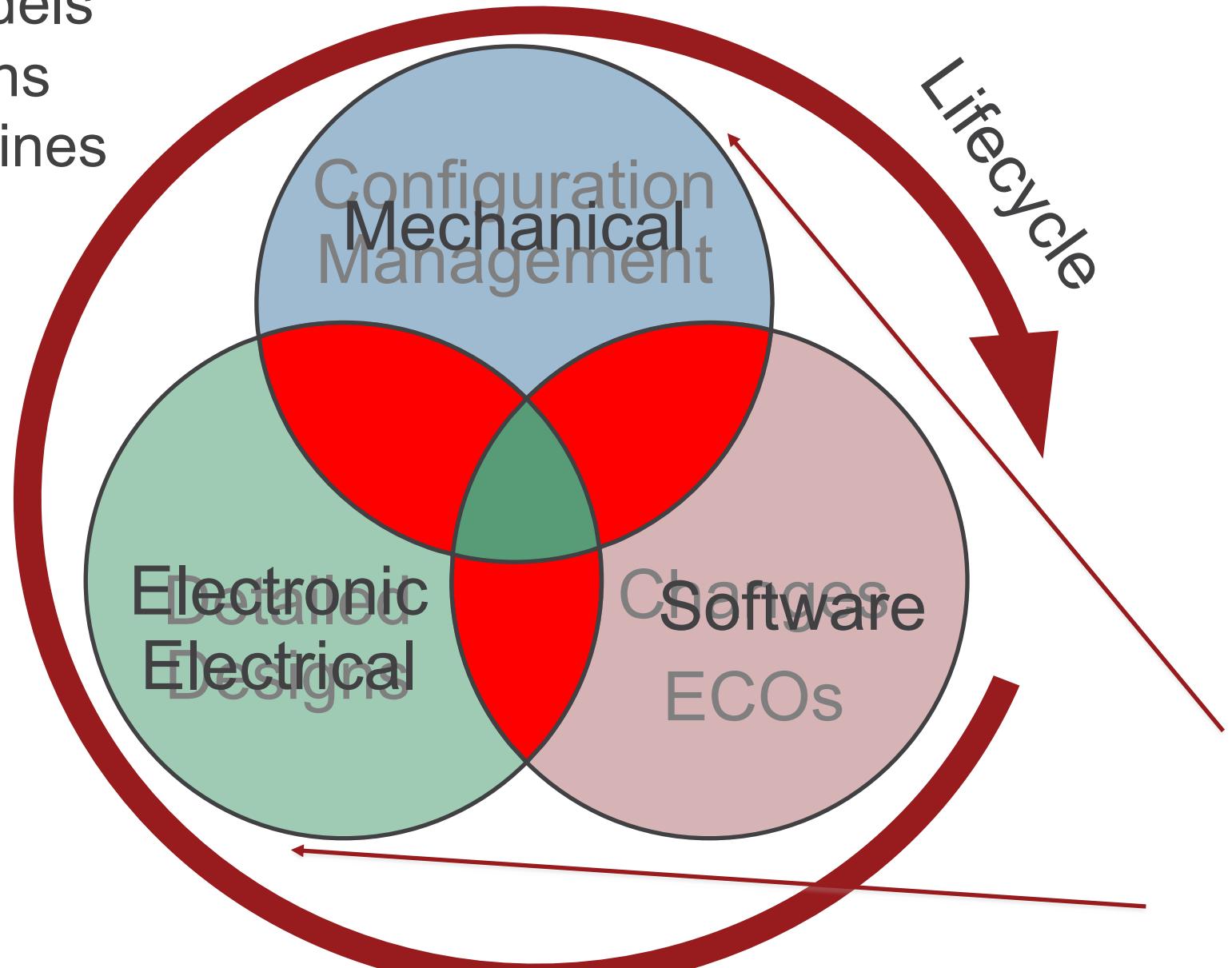
No - PLM is not “just” for managing mechanical assemblies

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





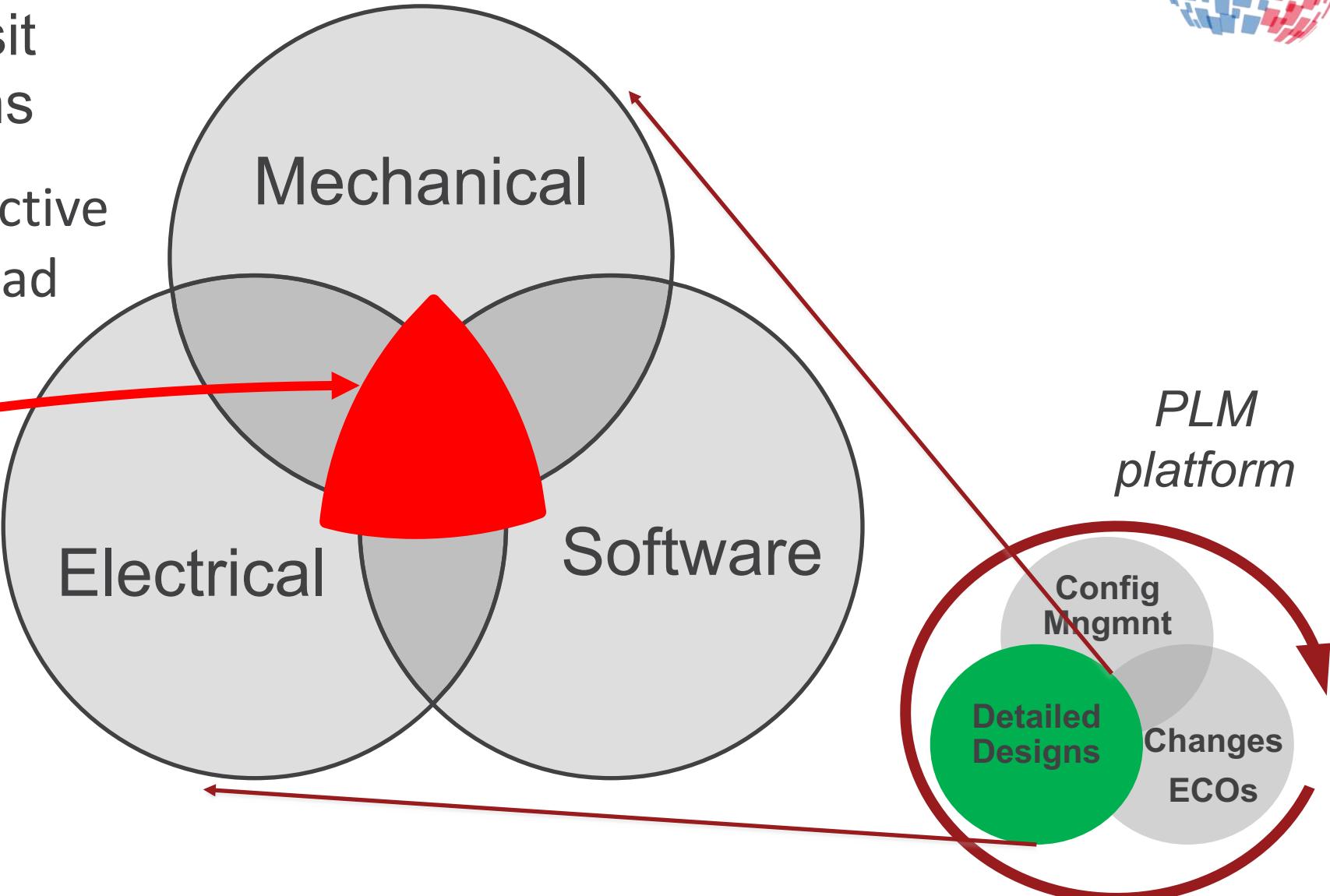
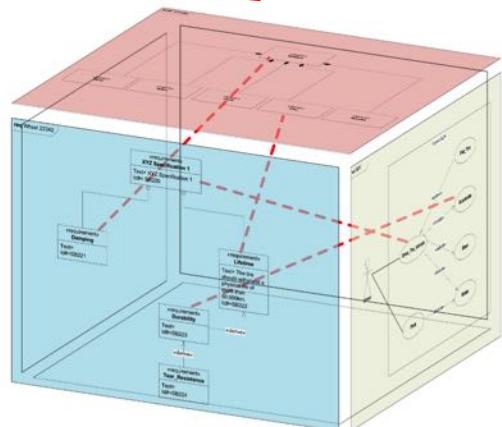
Without system models
Digital Thread runs
only between disciplines





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

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





PLM and Systems Engineering

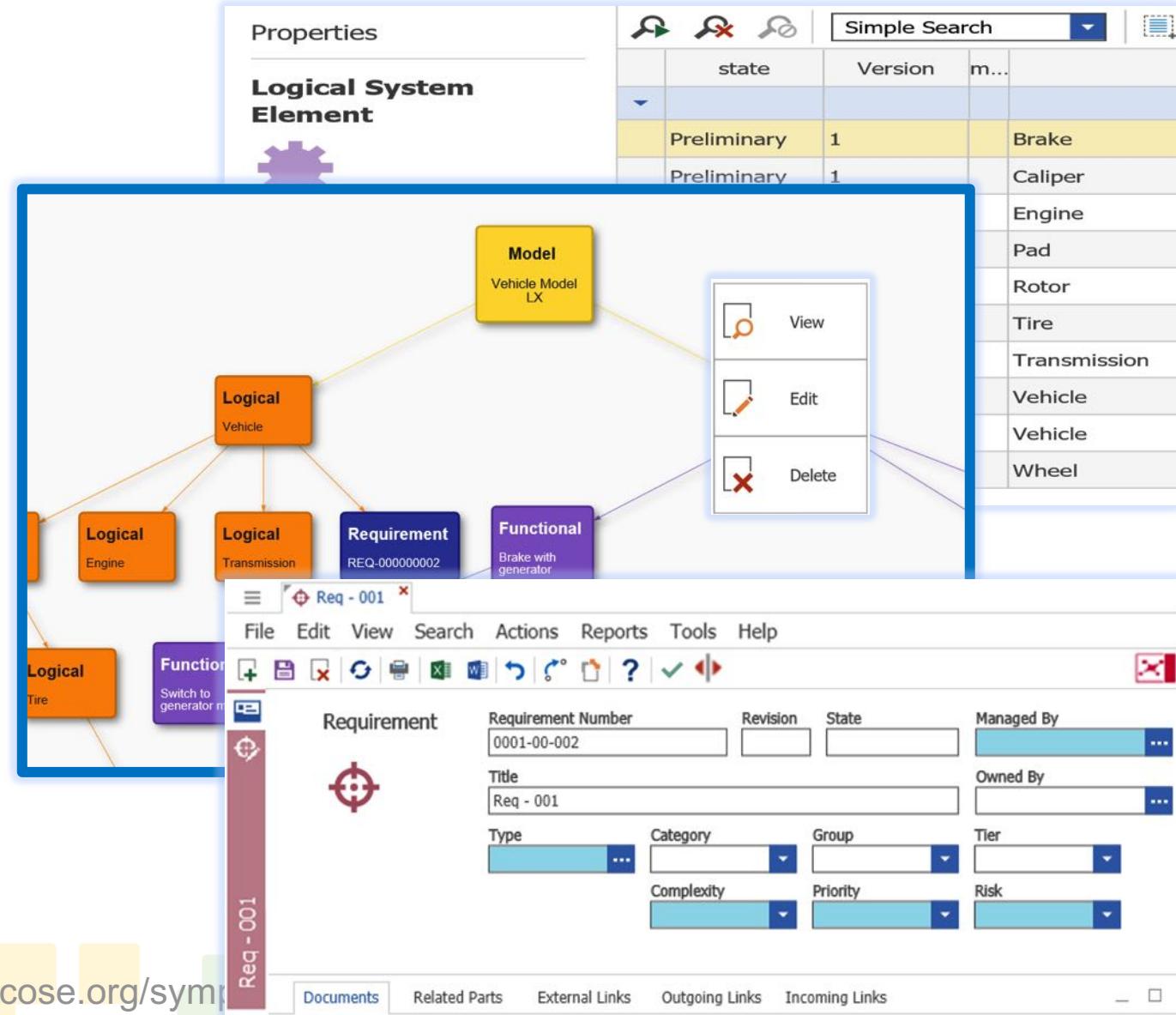
- Trade study and optimization of brake assembly
- Based on Aras Innovator PLM platform and No Magic MagicDraw SysML authoring tool
- Applicable to any SysML authoring tool like IBM Rhapsody or Vitech GENESYS





Early system definition in PLM

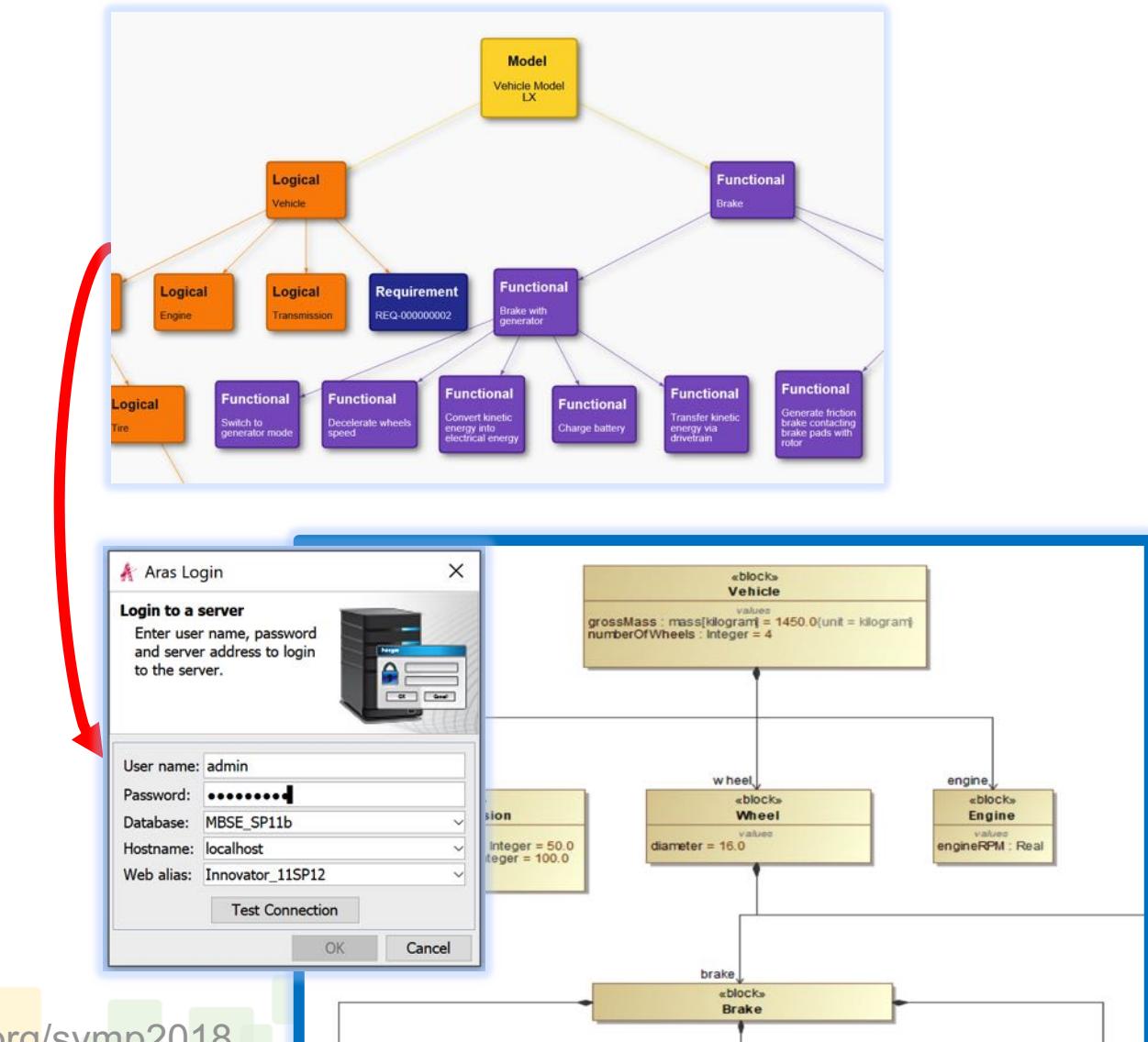
- Reuse of revision controlled system model elements
- Simple functional and logical break down
- Configuration and revision controlled data model
- Replaces simple documents like napkins, power point, and visio





Initiating detailed SysML model

- 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

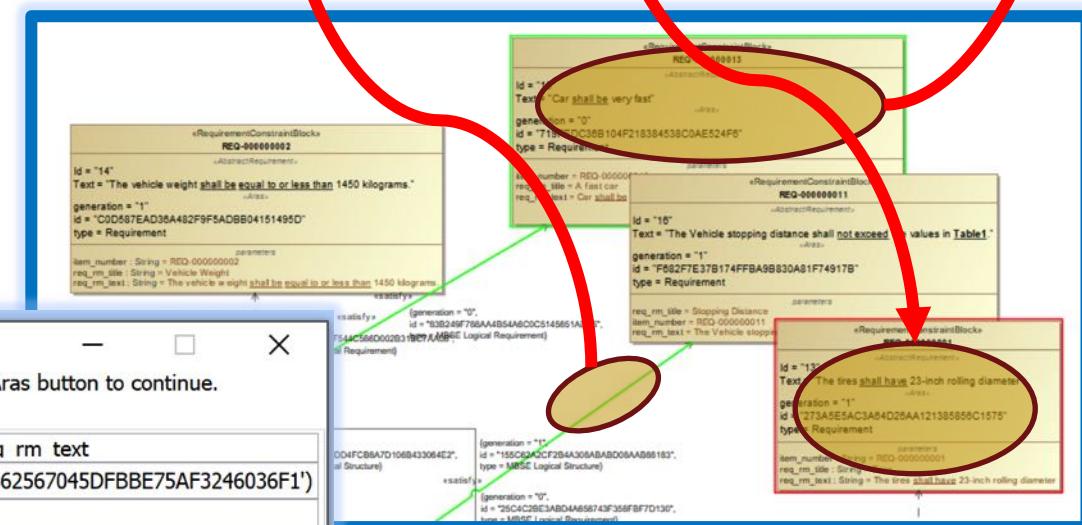


Synchronization of requirements



- 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)

Properties				
Requirement	Requirement Number	Title	State	Rev
REQ-000000001	Tires	Draft	A	1
REQ-000000002	Vehicle Weight	Draft	A	1
REQ-000000003	Pad Width	Draft	A	1
REQ-000000004	Stopping Distance	Draft	A	1
REQ-000000005	Table1	Draft	A	1
REQ-000000006	Pad Center Thickness	Draft	A	1
REQ-000000007	Brake Heating	Draft	A	1
REQ-000000008	Rotor Diameter	Draft	A	1
REQ-000000009	Brake Pad Life	Draft	A	1



Step not in the published paper

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='FB49D662567045DFBBE75AF3246036F1'

Classifier Name: Requirement

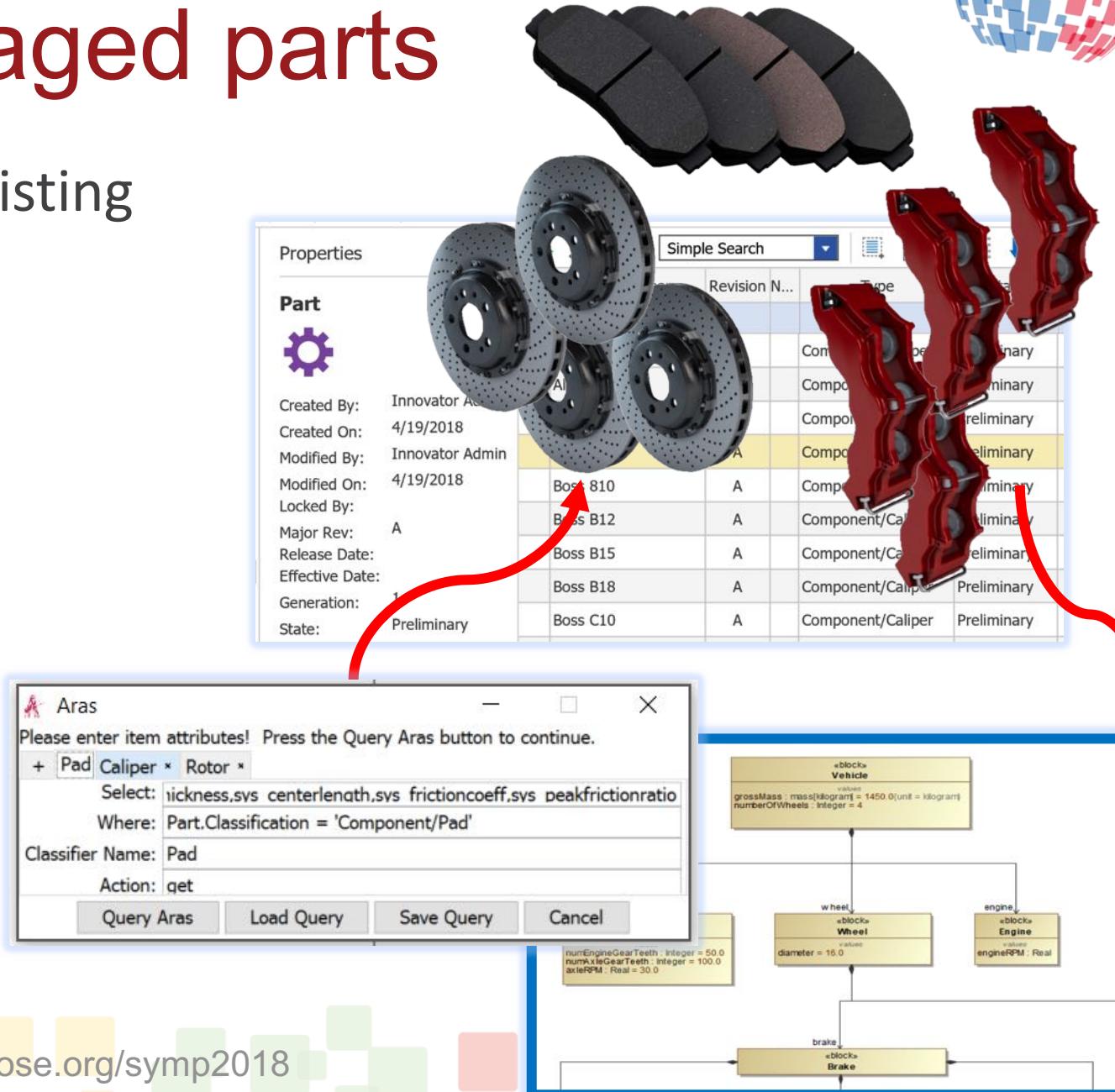
Action: get

Query Aras Load Query Save Query Cancel

Reuse of PLM managed parts



- 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

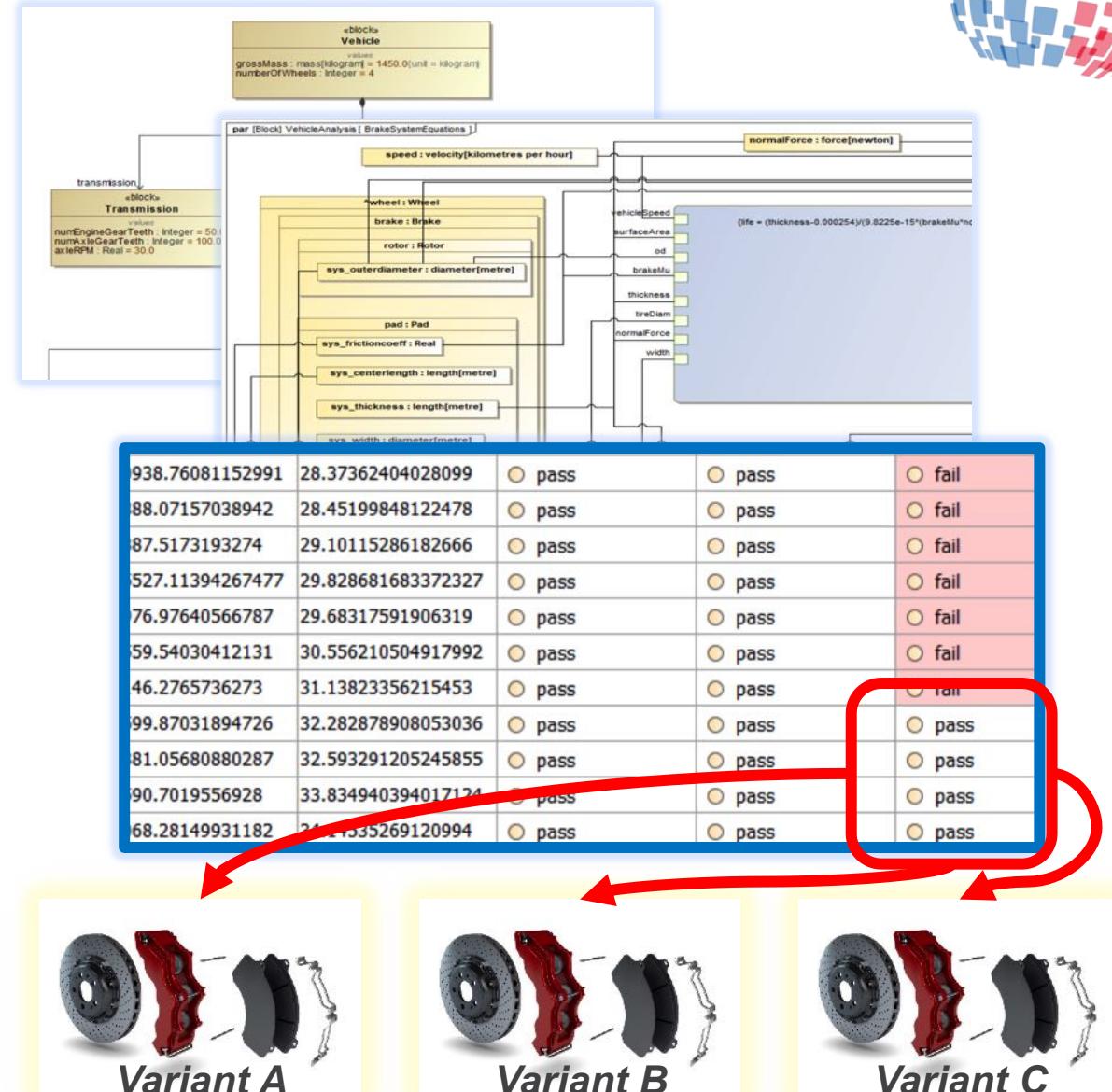


Trade Study



- 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

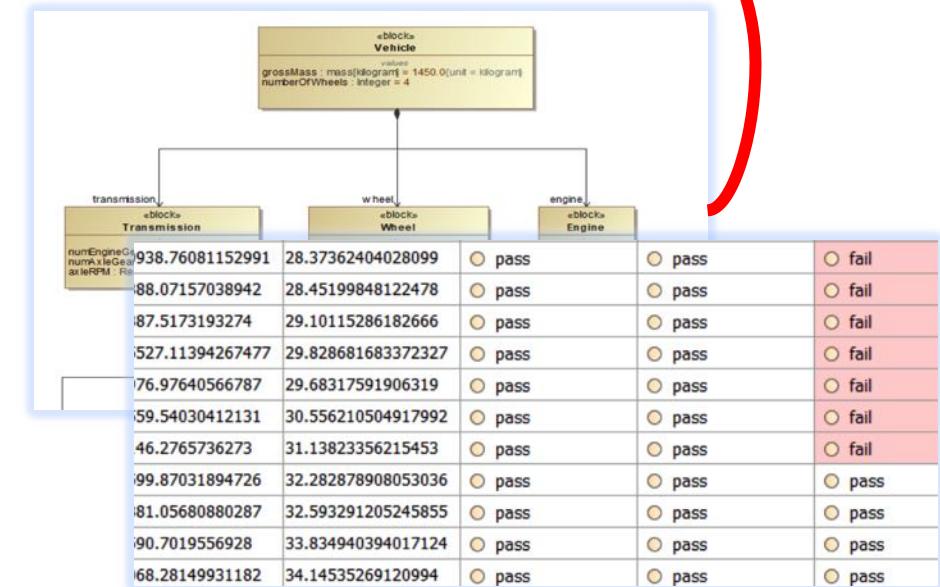
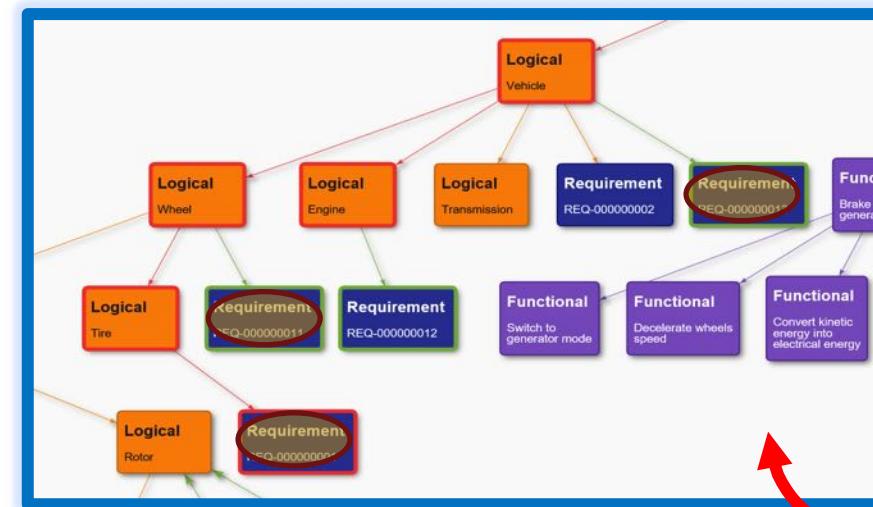
*) MagicDraw tool can stage auto execution of trade studies from SysML parametric diagrams



Updating PLM



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

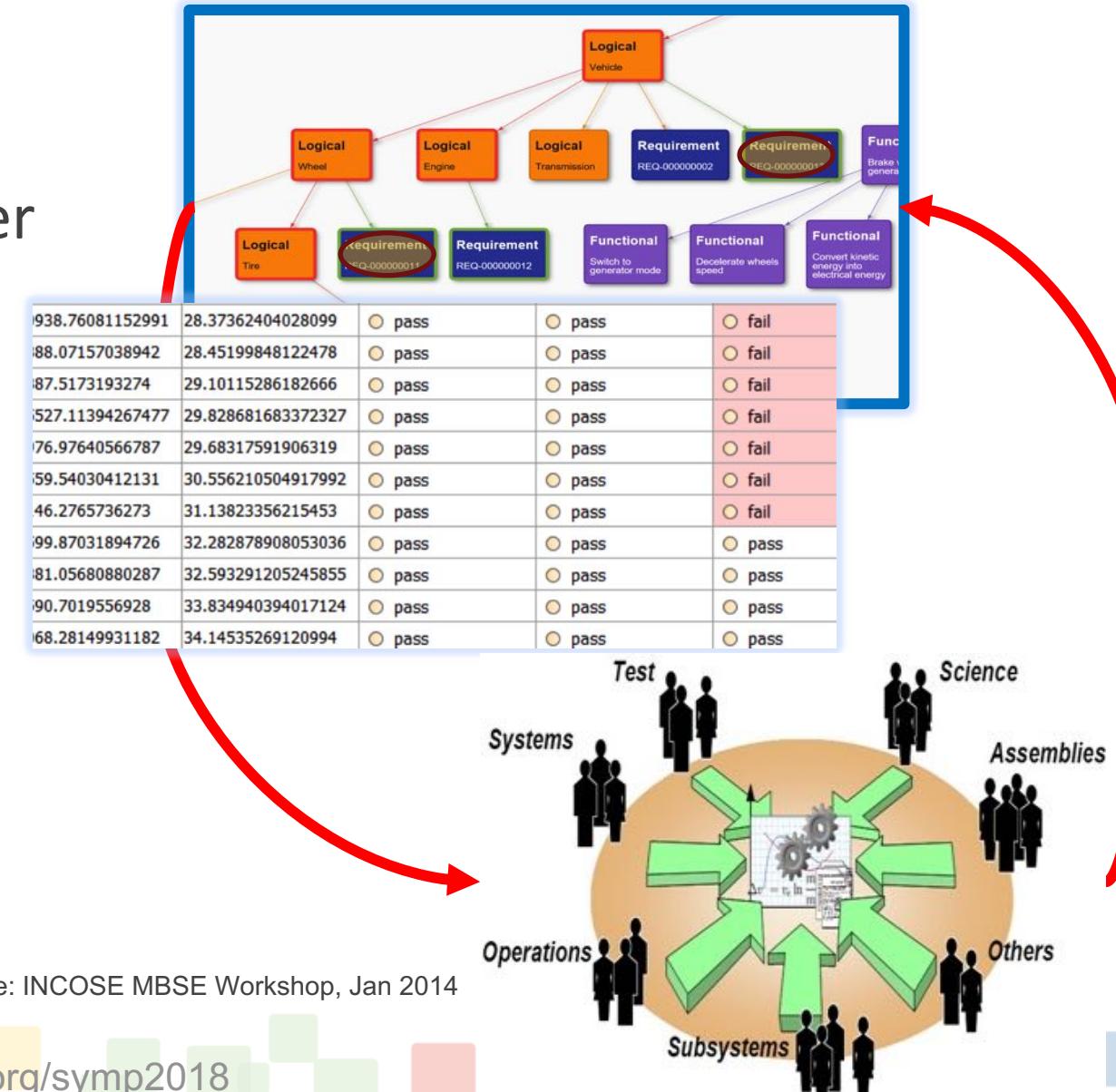


«block» Vehicle					
values					
grossMass : mass[diagram]	1450.0	unit : idagram	numberOfWorkers : Integer	4	
transmission : «block» Transmission		wheel : «block» Wheel	engine : «block» Engine		
numEngines : Integer	1	numWheels : Integer	4	fail	fail
numAxles : Integer	1	maxGearRatio : Real	1.0	pass	fail
maxRPM : Real	88.07157038942	maxGearRatio : Real	28.45199848122478	pass	pass
maxGearRatio : Real	87.5173193274	maxRPM : Real	29.10115286182666	pass	pass
maxRPM : Real	8527.11394267477	maxGearRatio : Real	29.828681683372327	pass	fail
maxGearRatio : Real	876.97640566787	maxRPM : Real	29.68317591906319	pass	fail
maxRPM : Real	859.54030412131	maxGearRatio : Real	30.556210504917992	pass	fail
maxGearRatio : Real	846.2765736273	maxRPM : Real	31.13823356215453	pass	pass
maxRPM : Real	849.9987031894726	maxGearRatio : Real	32.282878908053036	pass	pass
maxGearRatio : Real	881.05680880287	maxRPM : Real	32.593291205245855	pass	pass
maxRPM : Real	890.7019556928	maxGearRatio : Real	33.834940394017124	pass	pass
maxGearRatio : Real	868.28149931182	maxRPM : Real	34.14535269120994	pass	pass

Collaborating in PLM



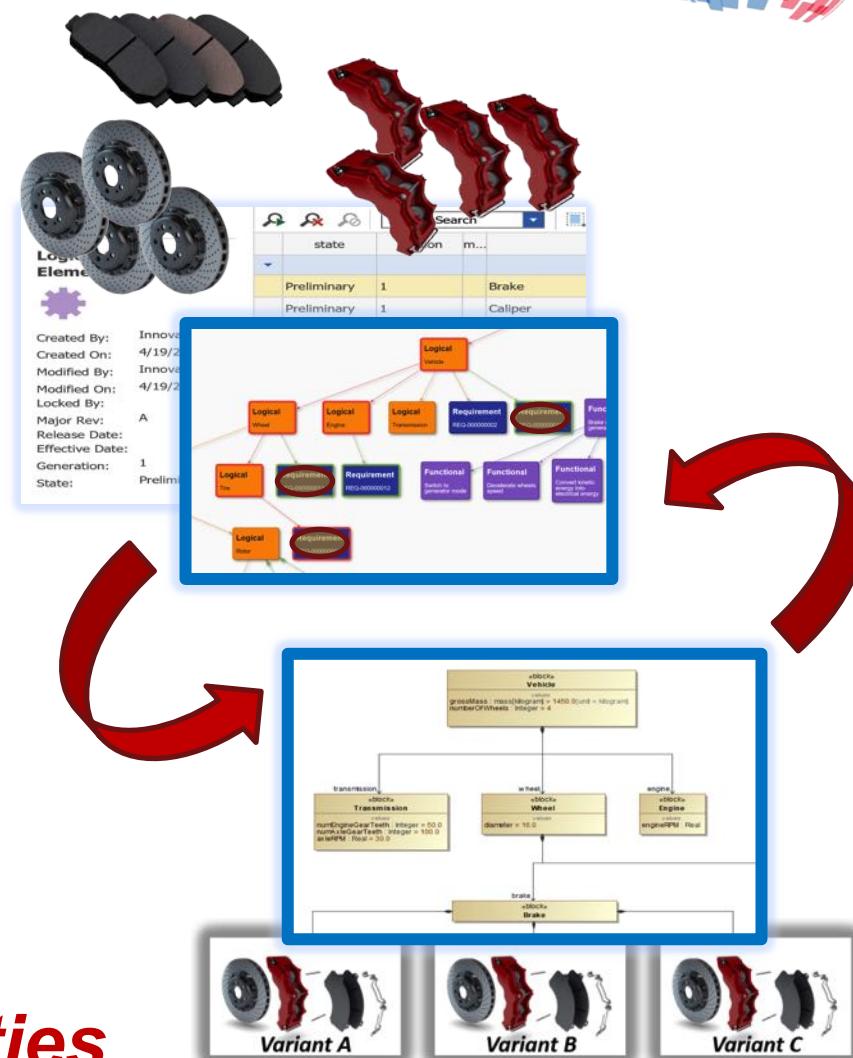
- PLM is a platform for exposing latest versions of the system model to a larger team of engineers
- Collaboration can involve discussion threads, visual annotations, and selection of implementation variants
- SysML trade study drives definition of PLE (Product Line Engineering) rules



Key Take-Aways



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



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www.incose.org/symp2018

Questions?

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Video: <https://youtu.be/HPIWyS0vgr0>