



28th Annual **INCOSE**
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Enhancing Automated Trade Studies using MBSE, SysML and PLM

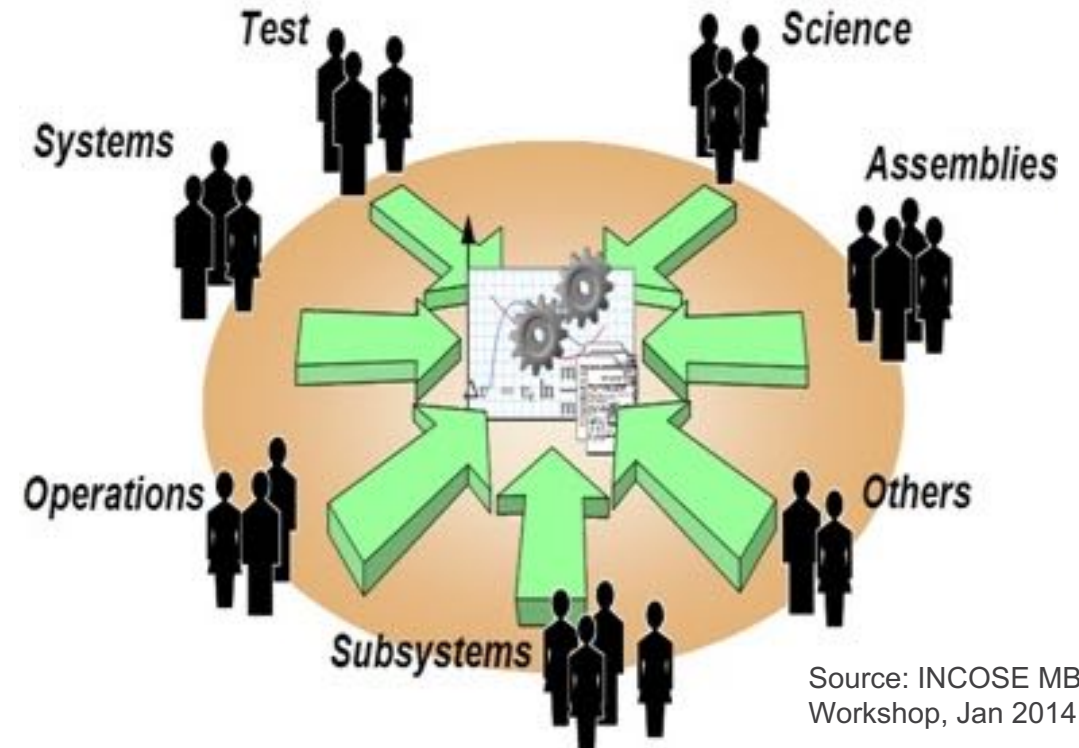


PLM and Systems Engineering

So what?
Who cares?



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



Source: INCOSE MBSE
Workshop, Jan 2014

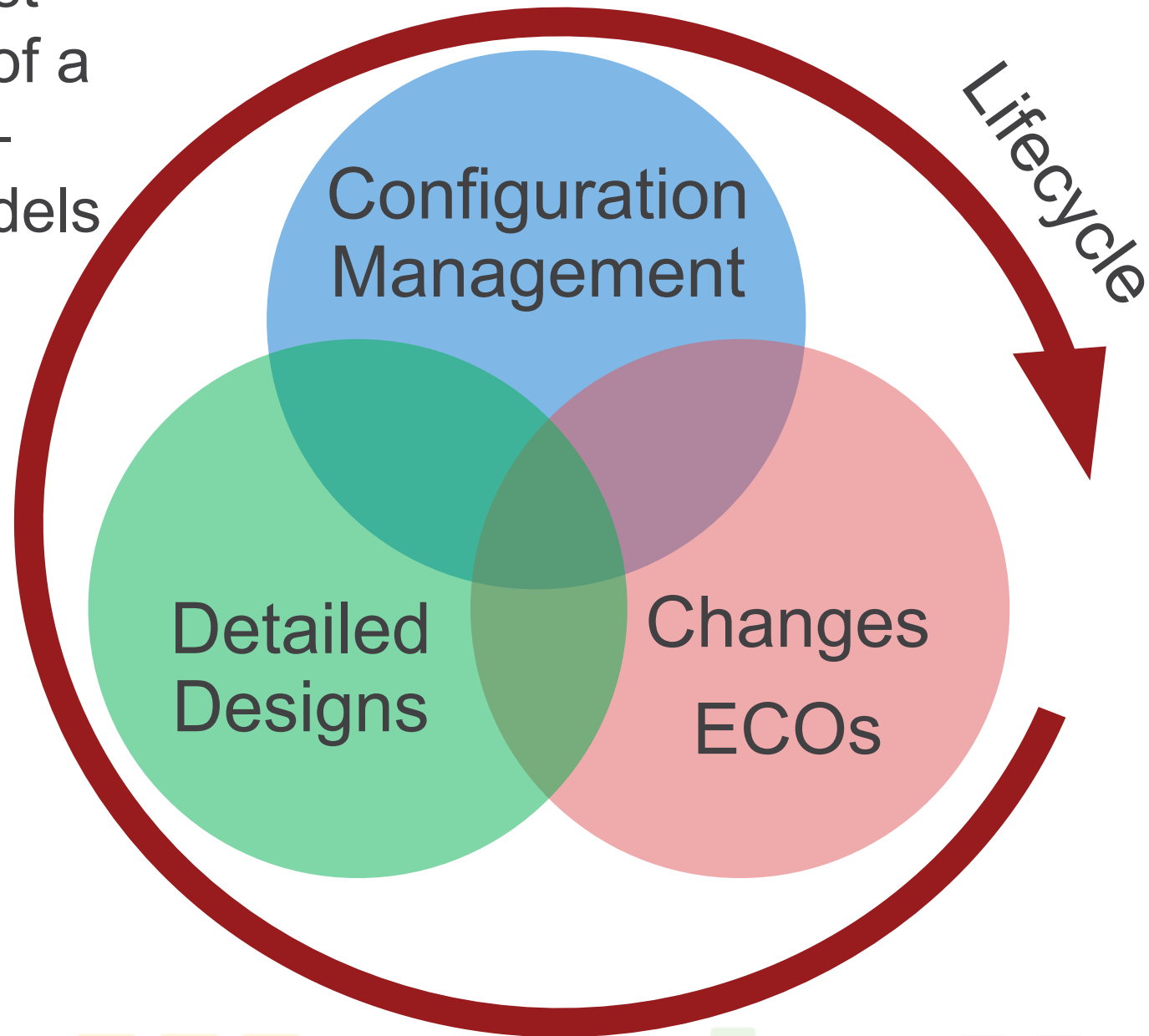
Study your use cases!!!



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

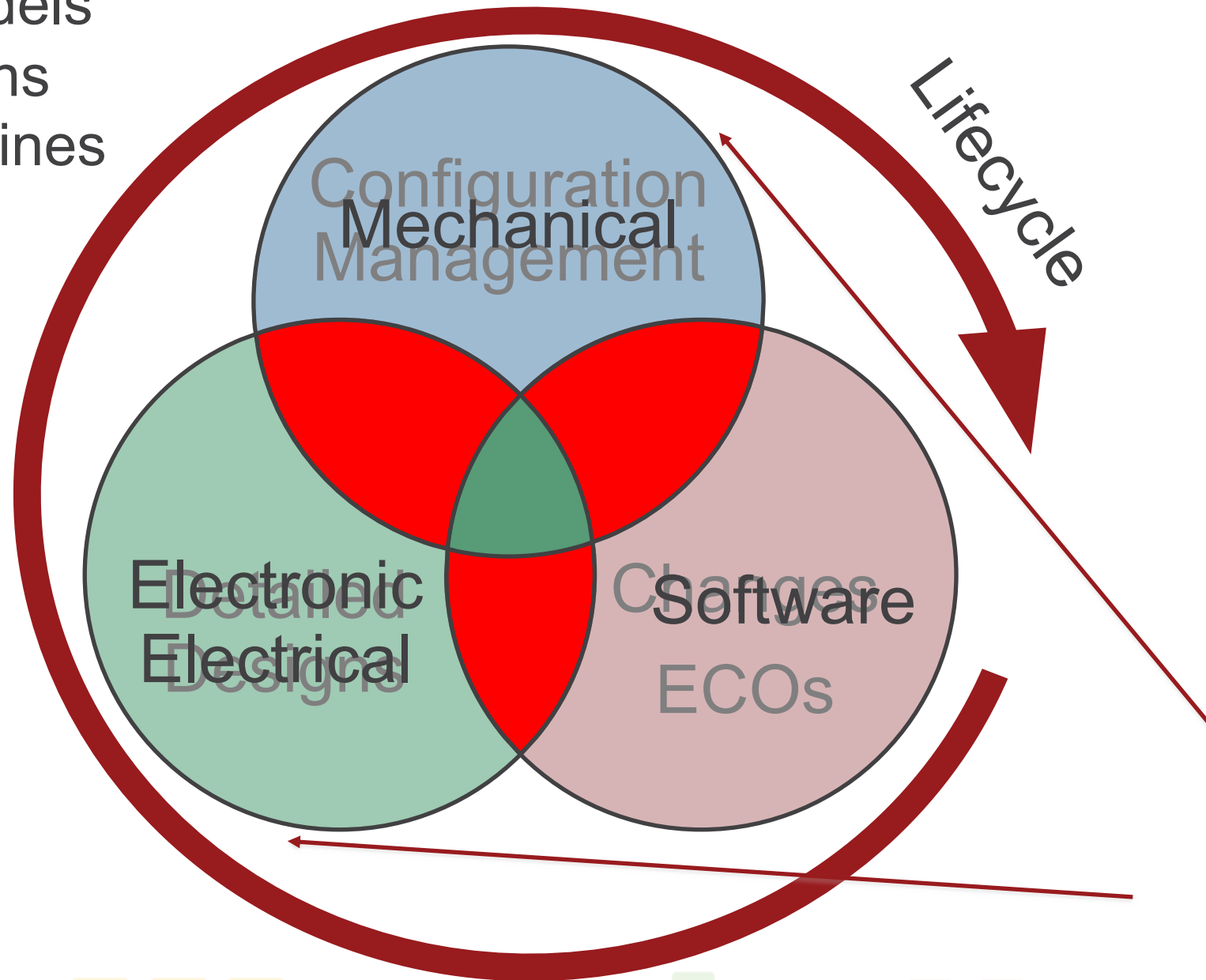
No - PLM is not “just” for managing mechanical assemblies

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





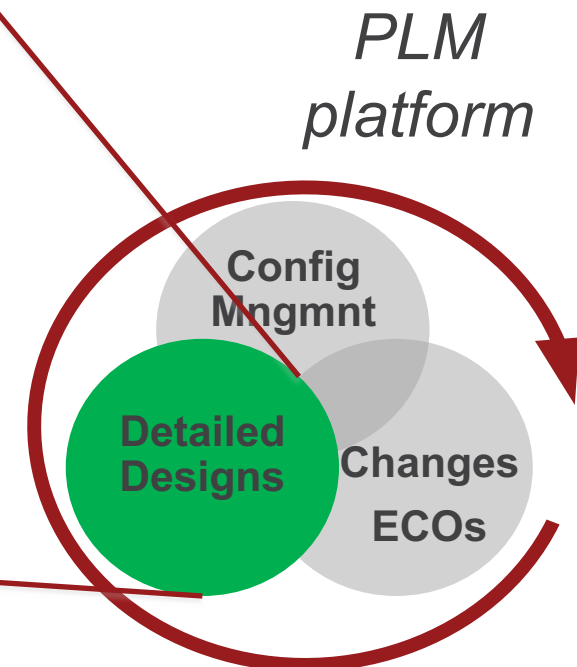
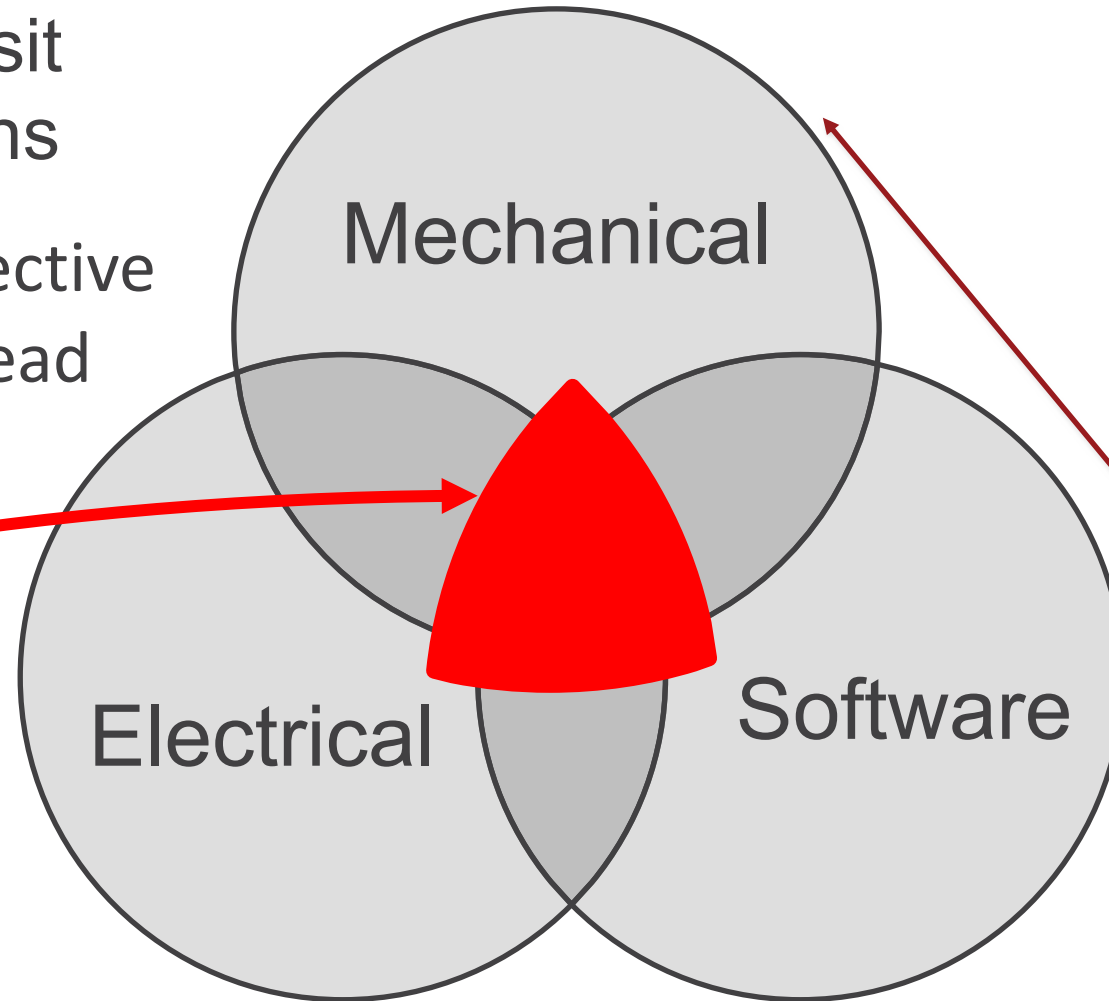
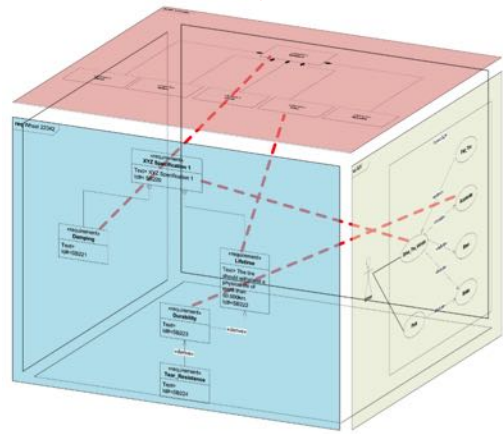
Without system models
Digital Thread runs
only between disciplines





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

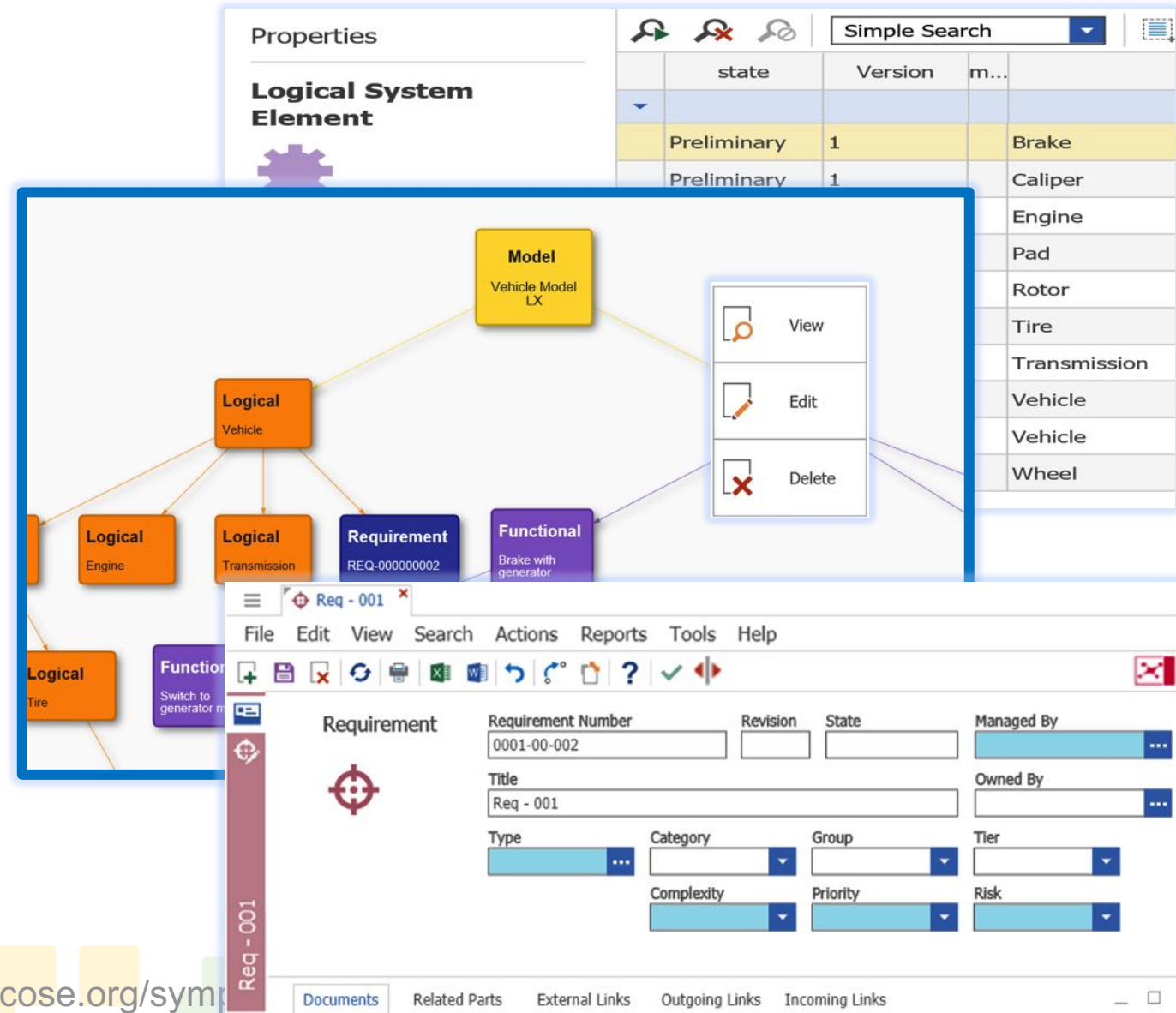
- Trade study and optimization of brake assembly
- Based on Aras Innovator PLM platform and No Magic MagicDraw SysML authoring tool
- Applicable to any SysML authoring tool like IBM Rhapsody or Vitech GENESYS





Early system definition in PLM

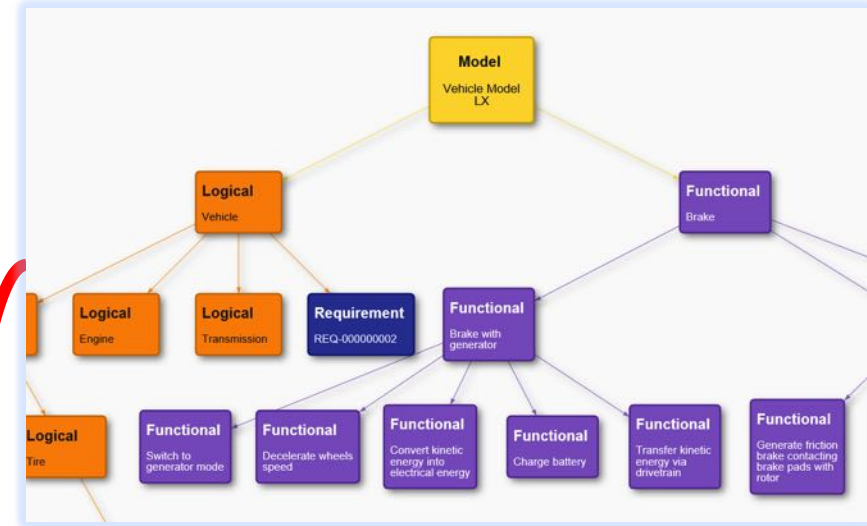
- Reuse of revision controlled system model elements
- Simple functional and logical break down
- Configuration and revision controlled data model
- Replaces simple documents like napkins, power point, and visio





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



Aras Login

Login to a server
Enter user name, password and server address to login to the server.

User name: admin

Password: ••••••••

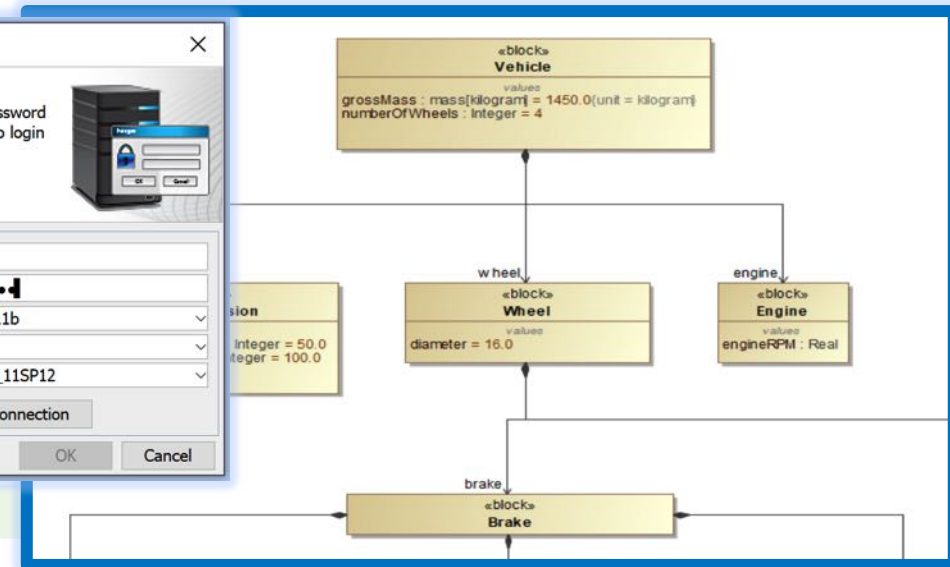
Database: MBSE_SP11b

Hostname: localhost

Web alias: Innovator_11SP12

Test Connection

OK Cancel

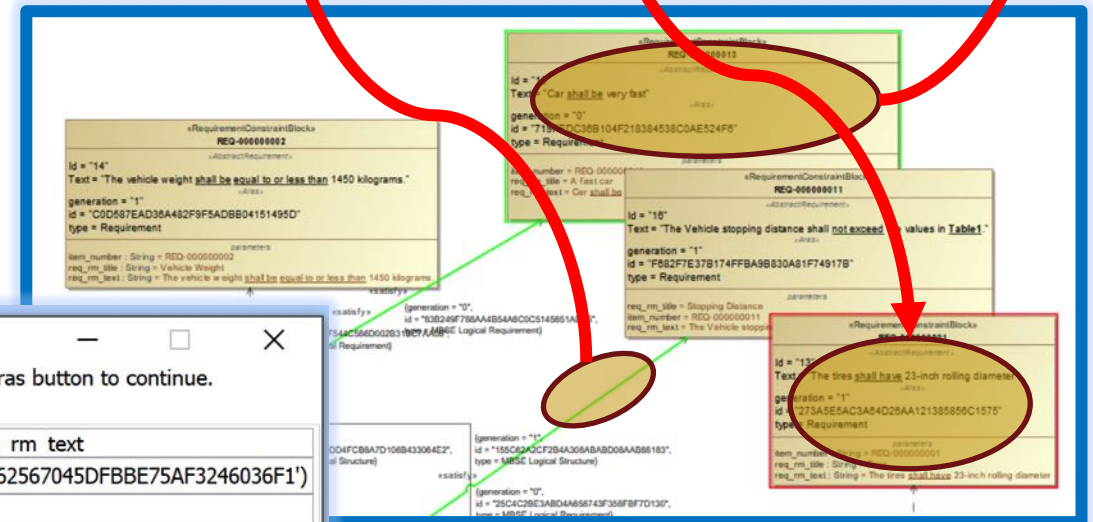




Synchronization of requirements

- 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)

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



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

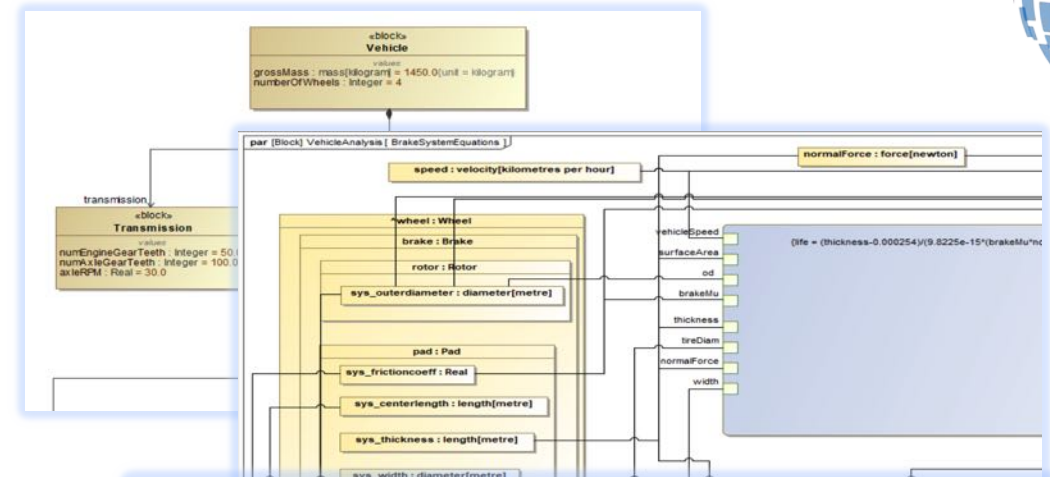
Action: get

Query Aras Load Query Save Query Cancel

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

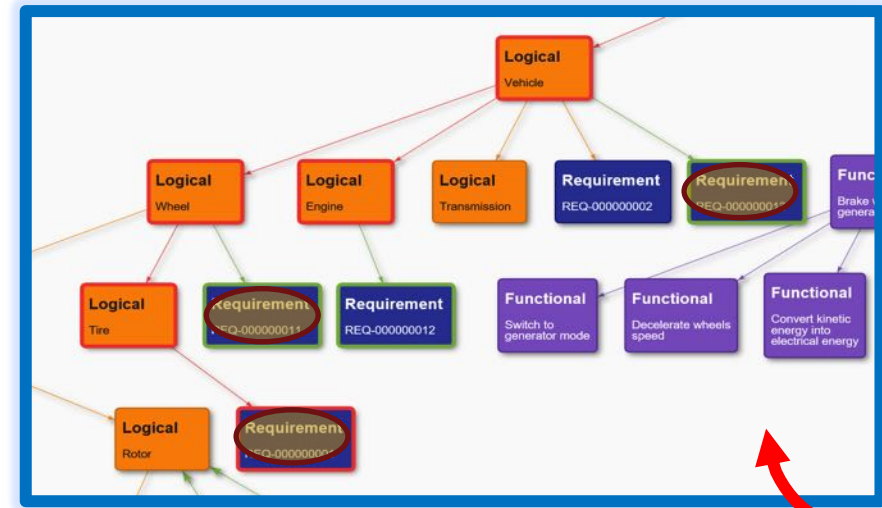


938.76081152991	28.37362404028099	pass	pass	fail
88.07157038942	28.45199848122478	pass	pass	fail
87.5173193274	29.10115286182666	pass	pass	fail
527.11394267477	29.828681683372327	pass	pass	fail
76.97640566787	29.68317591906319	pass	pass	fail
59.54030412131	30.556210504917992	pass	pass	fail
46.2765736273	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	34.14335269120994	pass	pass	pass



Updating PLM

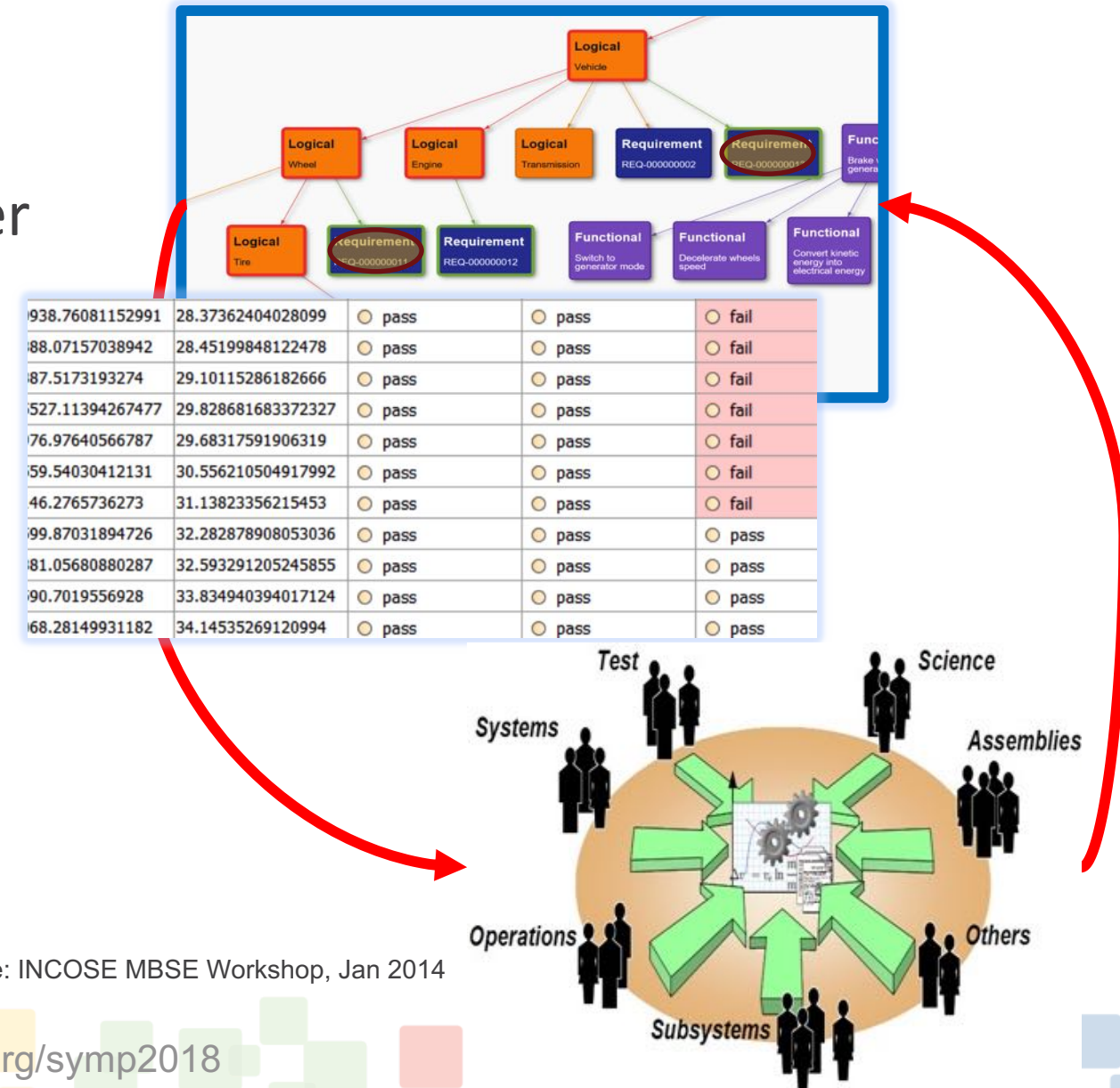
- Evolved SysML model updates system models managed by PLM
- Global IDs allow revision control of the model and model elements



«block» Vehicle				
grossMass : mass[kilogram] = 1450.0(unit = kilogram) numberOfWheels : integer = 4				
transmission	wheel	engine		
«block» Transmission	«block» Wheel	«block» Engine		
numEngineGrossPower	938.76081152991	28.37362404028099	pass	fail
numAxleGearRatio	88.07157038942	28.45199848122478	pass	fail
axleRPM	87.5173193274	29.10115286182666	pass	fail
	527.11394267477	29.828681683372327	pass	fail
	76.97640566787	29.68317591906319	pass	fail
	59.54030412131	30.556210504917992	pass	fail
	46.2765736273	31.13823356215453	pass	fail
	99.87031894726	32.282878908053036	pass	pass
	81.05680880287	32.593291205245855	pass	pass
	90.7019556928	33.834940394017124	pass	pass
	68.28149931182	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



Source: INCOSE MBSE Workshop, Jan 2014



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www.incose.org/symp2018

Questions?

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Video: <https://youtu.be/HPIWYS0vgr0>