



Automated Requirements Verification using SysML

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- **Chief MBSE Solutions Architect**, training and consulting companies as: Ford, Orbital ATK, Boeing, Google, Abbott, Raytheon, UTAS, NYTA, SMEE, NASA, BAH.
- **PLM Product Integrations Manager**, working with all major PLM vendors.
- Former **Analyst** on the MagicDraw R&D team for over 10 years.
- **Major expertise area** is MBSE, Requirements engineering, PLM, Traceability.
- **Ph.D.** from Kaunas University of Technology (KTU) in model traceability area. Former **researcher** at Kaunas University of Technology on multimillion projects.
- **Research and technical articles** in model-based solutions presented at INCOSE IS, NDIA. Check modeling community blog (blog.nomagic.com) for more.
- **Representative at INCOSE CAB.**



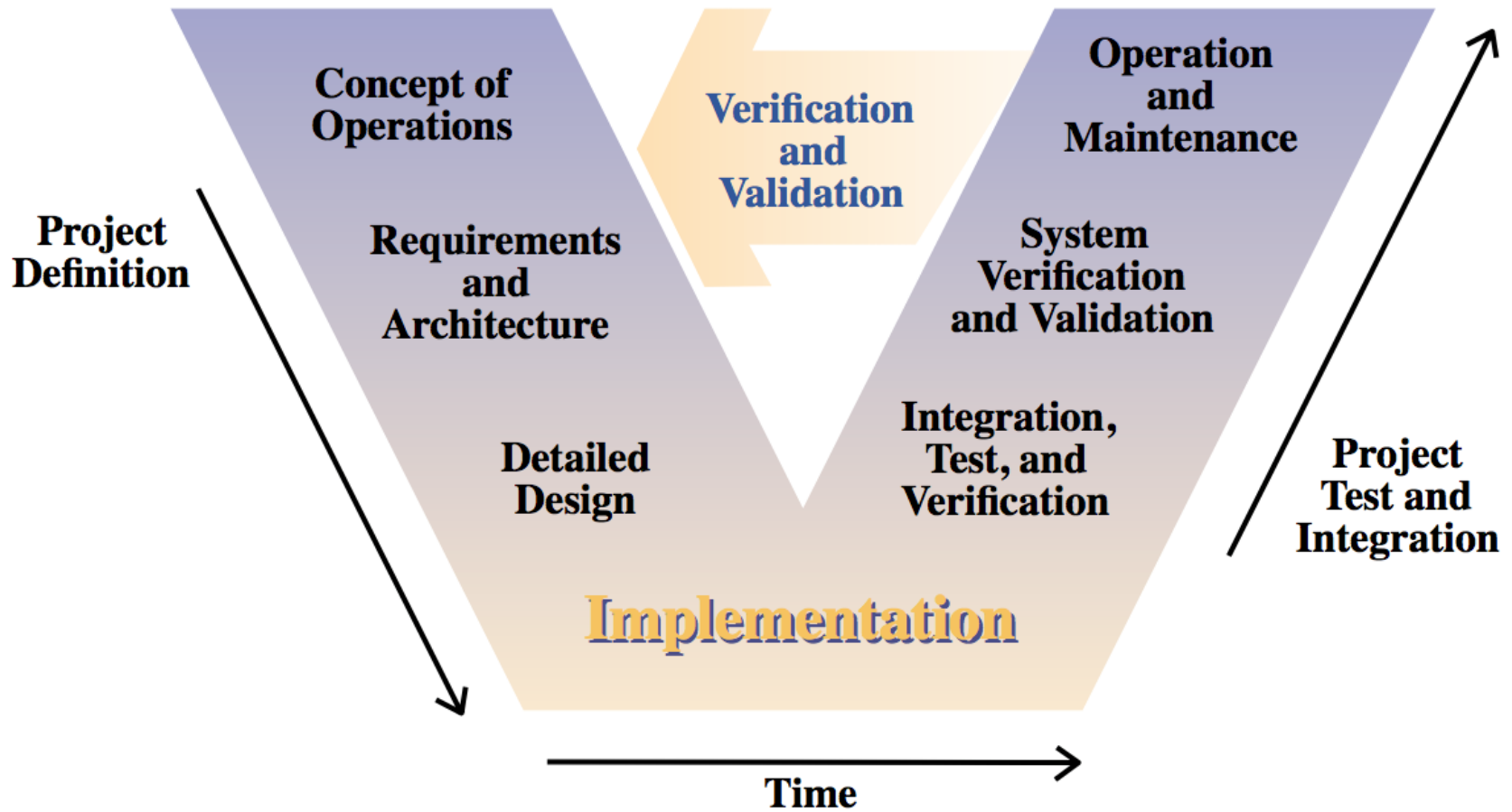
Agenda



- Introduction to V&V
- Requirements modeling concepts
- Cameo Systems Modeler demo
- Questions & Answers session



V-model



Verification and Validation



- **Validation**

- "Are you building the right thing?"
- Always against the real world or user needs

- **Verification**

- "Are you building it right?"
- Always against the requirements

Requirements in SysML



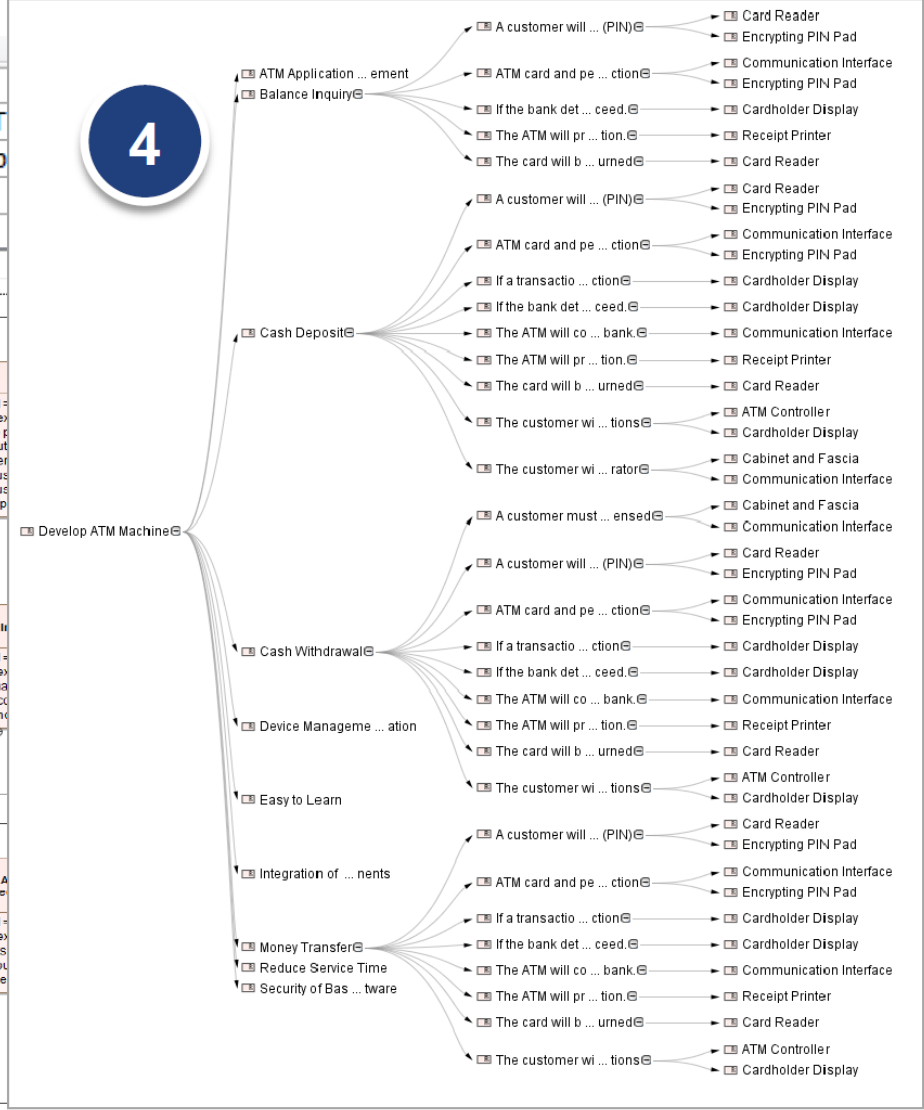
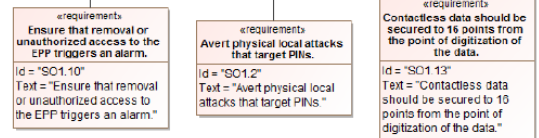
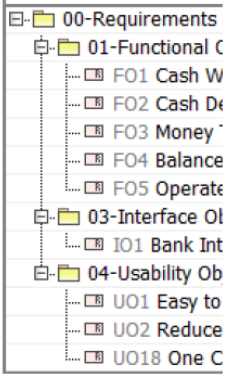
#	Id	Text
1	SO1	Avert magnetic-stripe skimming and PIN stealing
2	SO2	Prevent abuse of OS and reduce the attack surface of the ATM
3	SO3	Prevent exploitation of public domain vulnerabilities in the Operating System
4	SO4	Reduce attack surface from public and private networks.
5	SO2.4	Prevent abuse by software suppliers.
6	SO5	
7	SO6	
8	SO7	
9	SO8	
10	SO9	
11	SO10	

1

2

3

4



Requirements Verification in SysML



Requirements can be customized by adding properties such as verification method, verification status , criticality, risk, and requirements category.

The verifyMethod property includes :

- Inspection
- Analysis
- Demonstration
- Testing

Verification Methods



- The test case definition and execution depends on the method of verification
- For example, the method of verification for a system requirement that “The vehicle shall weigh between 98 and 100 pounds” may be performed by testing or analysis.
- To **verify the requirement by testing**, a test case is defined to weigh the system on a scale and compare the measured weight against the required weight.
- To **verify this requirement by analysis**, the estimated weight of each component is summed to estimate the system weight. In the latter case, a parametric diagram may be used to verify the requirement by analysis.

Steps to Automate Requirements Verification



Steps

- Refine, formalize requirement by the Constraint Block
- Define analysis context
- Use constraint block in analysis context
- Bind system parameters to constraint parameters
- Evaluate default or alternative system configurations
- Verify requirements
- Capture verification results

Text-based Requirements verification



bdd [Package] Analysis [bdd_RequirementsCheck]

«block»
Vehicle

constraints

: stopDistance
: SD Equation
: Bool2Verdict
: Distance

grossWeight : lbs

stoppingDistance : ft

speed : mph

wheel : Wheel [4]

brake : Brake

pad : Pad

heat : kW

life : mi

tire : Tire

diameter : in

«requirement»
Vehicle Weight

Id = "4"

Text = "The vehicle weight shall be equal to or less than 3200 pounds."

«requirement»
Brake Heating

Id = "2"

Text = "Braking at 60 miles per hour shall generate less than 54kW of heat at each wheel."

«requirement»
Tires

Id = "5"

Text = "The tires shall have 22-inch rolling diameter"

Simulation

Trigger: []

Variables x Console x Sessions x

Name	Value
Vehicle {grossWeight <= 32...	Vehicle@1c1200d7
grossWeight : lbs	3000.0000
numberOfWheels : Integer	4
Required Distance	
speed : mph	60.0000
StopDistance Requiremen...	inconclusive
stoppingDistance : ft	0.0000
stopTime : sec	0.0000
engine : Engine	Engine@29e01eed
transmission : Transmission	Transmission@302638e9
wheel : Wheel [4]	[Wheel@494d4f74, Wheel@11...
Wheel [1]	Wheel@494d4f74
diameter : in [1]	16.0000
speed : mph [1]	71.3598
brake : Brake	Brake@49145e88
torque : lbs-foot ...	506.1438
caliper : Caliper	Caliper@67e9540b
pad : Pad {life > ...	Pad@11b14343
brakeMU : Real	0.8000
centerLength : in	3.0000
cost : \$	0.0000
effectiveRadiu...	4.5000
heat : kW	54.0000
life : mi	3.7000E4
specificCost : \$	2.0000
surfaceArea : ...	0.0000
thickness : in	2.0000
width : in	2.0000
rotor : Rotor	Rotor@1dc674fe
tire : Tire {diameter...	Tire@18953806
diameter : in	22.0000
RPM : Real [1]	916.7325
tireMU : Real [1]	0.9000

Description

less than (Glossary):
heat < 54.0

9

Trade-off analysis



Trade Study Examples Assembly_Variants x

#	pad	caliper	rotor	vhc.stoppingDistance	vhc.brakeLifeExpectancy
1	Mk 84S : Pad	Alphine K2 : Caliper	Rotus 25 : Rotor	68.5723972066752	107379.42889659776
2	Mk 84S : Pad	Alphine K2 : Caliper	Rotus 26 : Rotor	65.36807958019504	102361.6985743268
3	Proto C10F : Pad	Alphine K2 : Caliper	Rotus 30 : Rotor	40.35221835623579	72306.36397703875
4	Proto C10F : Pad	Alphine K2 : Caliper	Rotus 275 : Rotor	44.64500754306939	79998.53035757477
5	Titan P50 : Pad	Alphine K2 : Caliper	Rotus 26 : Rotor	53.711143887139784	125110.30896456122
6	Titan P50 : Pad	Alphine K2 : Caliper	Rotus 30 : Rotor	44.759286572616496	104258.59080380102
7	Mk 86S : Pad	Alphine K3 : Caliper	Rotus 30 : Rotor	52.31220755621267	105967.00592221653
8	Mk 86S : Pad	Alphine K3 : Caliper	Rotus 275 : Rotor	58.256776596691374	118008.7111406502
9	Proto C7 : Pad	Alphine K3 : Caliper	Rotus 25 : Rotor	55.455970029542755	79164.71058002321
10	Proto C9 : Pad	Alphine K3 : Caliper	Rotus 275 : Rotor	49.50575865298238	79504.47328637523
11	Sapphire 66 : Pad	Alphine K3 : Caliper	Rotus 275 : Rotor	40.55851535212692	94884.02244816629
12	Titan P50S : Pad	Alphine K3 : Caliper	Rotus 275 : Rotor	44.70868901606547	104140.73302839688
13	Titan P20 : Pad	Alphine K3 : Caliper	Rotus 25 : Rotor	46.42459980578633	54432.75245364985
14	Proto C5F : Pad	Alphine K5 : Caliper	Rotus 26 : Rotor	41.630008678887265	61414.02233658255
15	Proto C9 : Pad	Alphine K5 : Caliper	Rotus 275 : Rotor	41.25122920077894	66247.9949658522
16	Proto C9F : Pad	Alphine K5 : Caliper	Rotus 25 : Rotor	37.78119655574486	62598.768022234166
17	Titan P40 : Pad	Alphine K5 : Caliper	Rotus 26 : Rotor	39.0522363228567	68026.233212698
18	Titan P40 : Pad	Alphine K5 : Caliper	Rotus 30 : Rotor	32.803878511199635	57142.035898666334
19	Proto C10F : Pad	Alphine K7 : Caliper	Rotus 275 : Rotor	32.77256002380488	58734.510000000000
20	Proto C5 : Pad	Alphine K7 : Caliper	Requirement 3 - "Brake pads shall have a projected life of driving conditions, as per industry standard assumptions."		
21	Proto C7F : Pad	Alphine K7 : Caliper	Rotus 25 : Rotor	40.00806028880076	
22	Proto C10 : Pad	Alphine K7 : Caliper	Rotus 25 : Rotor	44.43202849381238	
23	Mk 85S : Pad	Boss 810 : Caliper	Rotus 30 : Rotor	55.23246711545633	
24	Mk 85S : Pad	Boss 810 : Caliper	Rotus 275 : Rotor	61.36940790606257	
25	Proto C10F : Pad	Boss 810 : Caliper	Rotus 25 : Rotor	49.314702781657445	
26	Proto C7F : Pad	Boss 810 : Caliper	Rotus 26 : Rotor	51.35250041726311	
27	Sapphire 85 : Pad	Boss 810 : Caliper	Rotus 26 : Rotor	46.649043171838116	
28	Sapphire 85 : Pad	Boss 810 : Caliper	Rotus 30 : Rotor	39.52705184789337	
29	Titan P40 : Pad	Boss 810 : Caliper	Rotus 26 : Rotor	50.49286974231136	
30	Titan P40 : Pad	Boss 810 : Caliper	Rotus 30 : Rotor	42.41401058354156	
31	Mk 82S : Pad	Boss 812 : Caliper	Rotus 26 : Rotor	50.87011291111454	
32	Proto C7F : Pad	Boss 812 : Caliper	Rotus 25 : Rotor	46.509817518733286	
33	Sapphire 66 : Pad	Boss 812 : Caliper	Rotus 25 : Rotor	42.231701850736606	

- Parametric alternatives
- Topological alternatives
- Finding the best design
- Help decision making

Truck variants x

Criteria

Classifier: Forklift Truck Scope (optional): Instances Filter: Q

#	Name	Support	Steering	Stopping	Moving	Power	Transmission
1	var1	: Air Cushion	: Air thrust	: Blocks under wheels	: Air thrust	: Diesel	: Belts or chains
2	var2	: Slides	: Turning wh	: Brakes	: Power to w	: Petrol	: Flexible cable
3	var3	: Spheres	: Turning wh	: Brakes	: Air thrust	: Electric	: Hydraulic
4	var4	: Tracks	: Rails	: Reverse power	: Power to w	: Diesel	: Flexible cable
5	var5	: Wheels	: Turning wh				

1. Click +

2. Select subtype

Select Classifier:

Q-Search by Name

4 matches found

- Blocks under wheels
- Brakes
- Drag a weight on the floor
- Reverse power

No Magic

Automate Testing Execution



- Simulation can be executed through command line and show test results through Jenkins, as another alternative to run the project.
- You can create JUnit test cases and configuration files and set up Jenkins for automated testing.

The screenshot shows the Jenkins web interface for a test run. The top navigation bar includes the Jenkins logo, a search box, and user information (Administrator | log out). The breadcrumb trail is: Jenkins > Test Simulation Command Line > #28 [20180907_1649] > Test Results. A sidebar on the left contains navigation links: Back to Project, Status, Changes, Console Output, Edit Build Information, History, Environment Variables, Test Result (highlighted), Failure Cause Management, and Previous Build. The main content area is titled 'Test Result' and shows a progress bar with 1 failure (-1) in red and 1 success in blue. Summary statistics indicate 2 tests (±0) and a duration of 1 min 27 sec. Below this is a section for 'All Failed Tests' with a table containing one entry: 'com.nomagic.magicdraw.simulation.TestSimulationCommandLine.testGenerateFailResult' with a duration of 49 sec and 3 failures. At the bottom, the 'All Tests' section contains a table with columns for Package, Duration, Fail, (diff), Skip, (diff), Pass, (diff), Total, and (diff). The table shows one package, 'com.nomagic.magicdraw.simulation', with a duration of 1 min 27 sec, 1 failure, 0 skips, and 1 pass.

Package	Duration	Fail	(diff)	Skip	(diff)	Pass	(diff)	Total	(diff)
com.nomagic.magicdraw.simulation	1 min 27 sec	1	-1	0		1	+1	2	

Cameo Systems Modeler v19.0 (enterprise edition)



Questions





Thank You!

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