Multi-Domain-Matrices Industrial applications in Systems Engineering Validation

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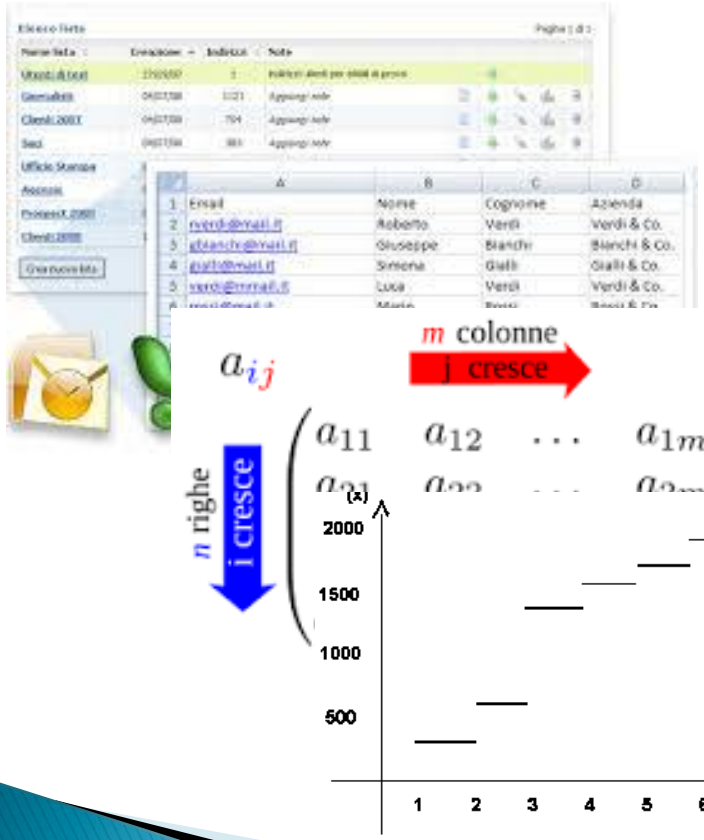
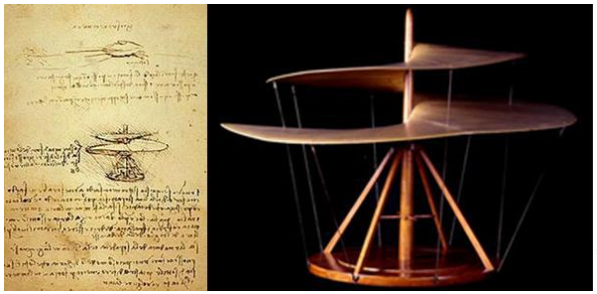
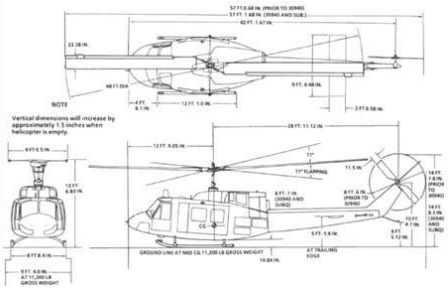
Lists-Matrices-Graphs vs. Model Based Systems Engineering

Lists, matrices and graphs



MBSE





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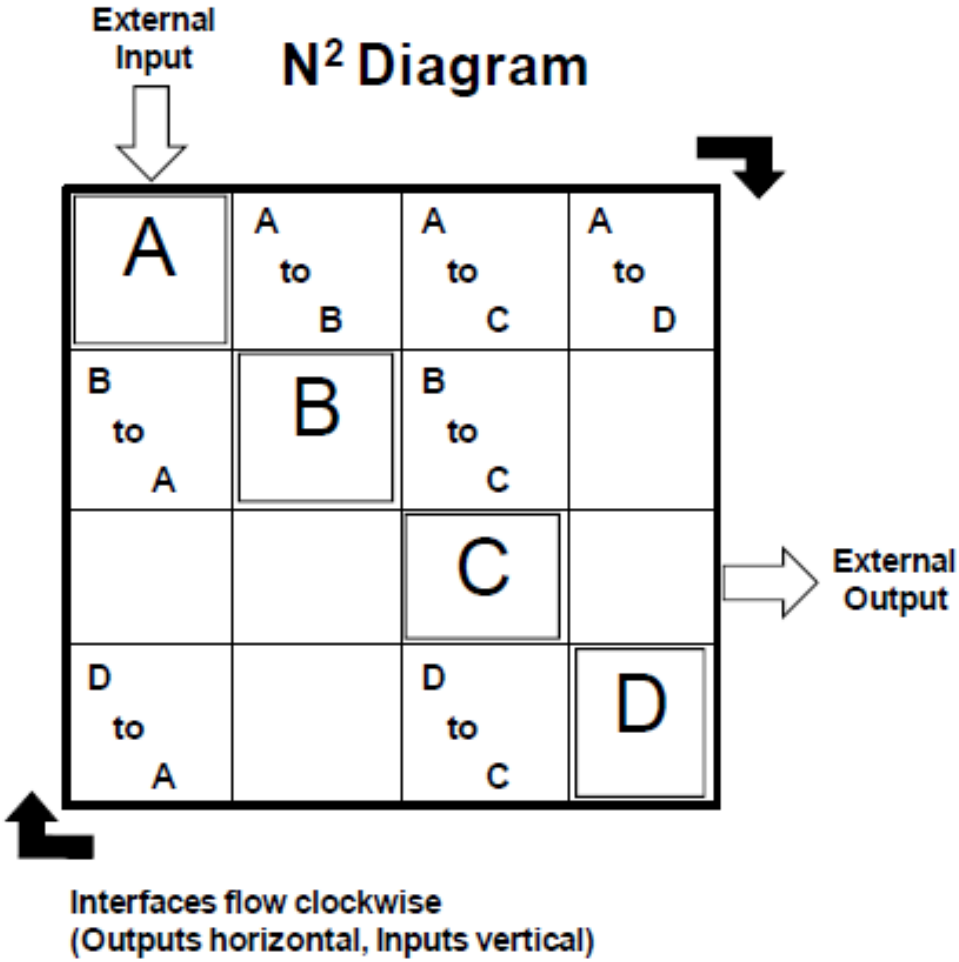
Robert J. Lano N^2 diagrams

Matrix of functional bidirectional interactions, or data flows, at a particular hierarchical level alias in a rigid bi-directional fixed framework.



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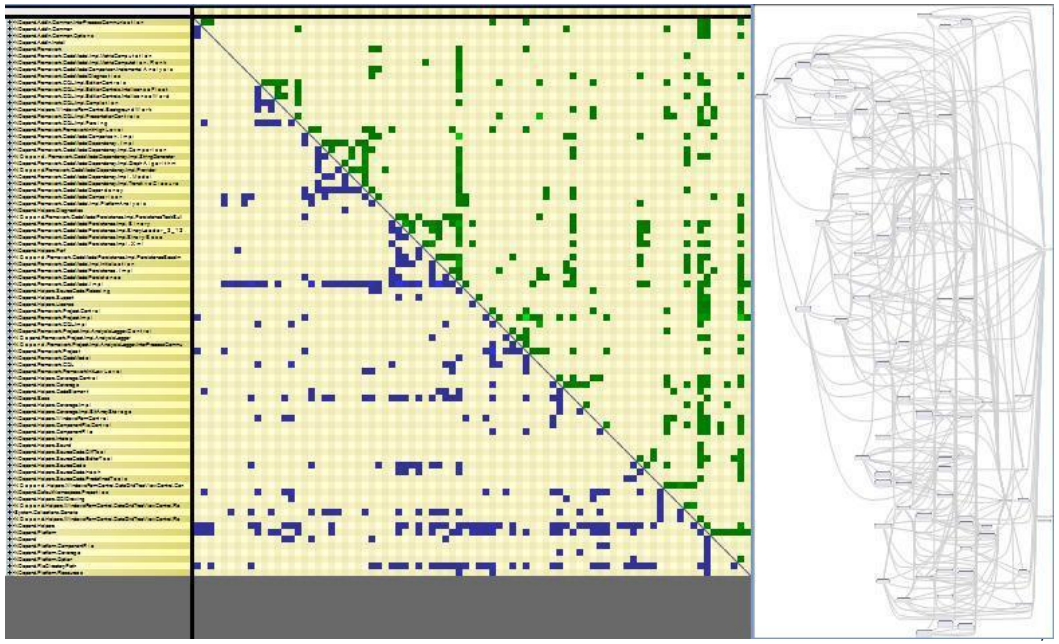
Design Structure Matrices

The Design Structure Matrix (DSM) is a simple tool to perform both the analysis and the management of complex systems.

It enables the user to model, visualize, and analyze the dependencies among the entities of any system and derive suggestions for the improvement or synthesis of a system.



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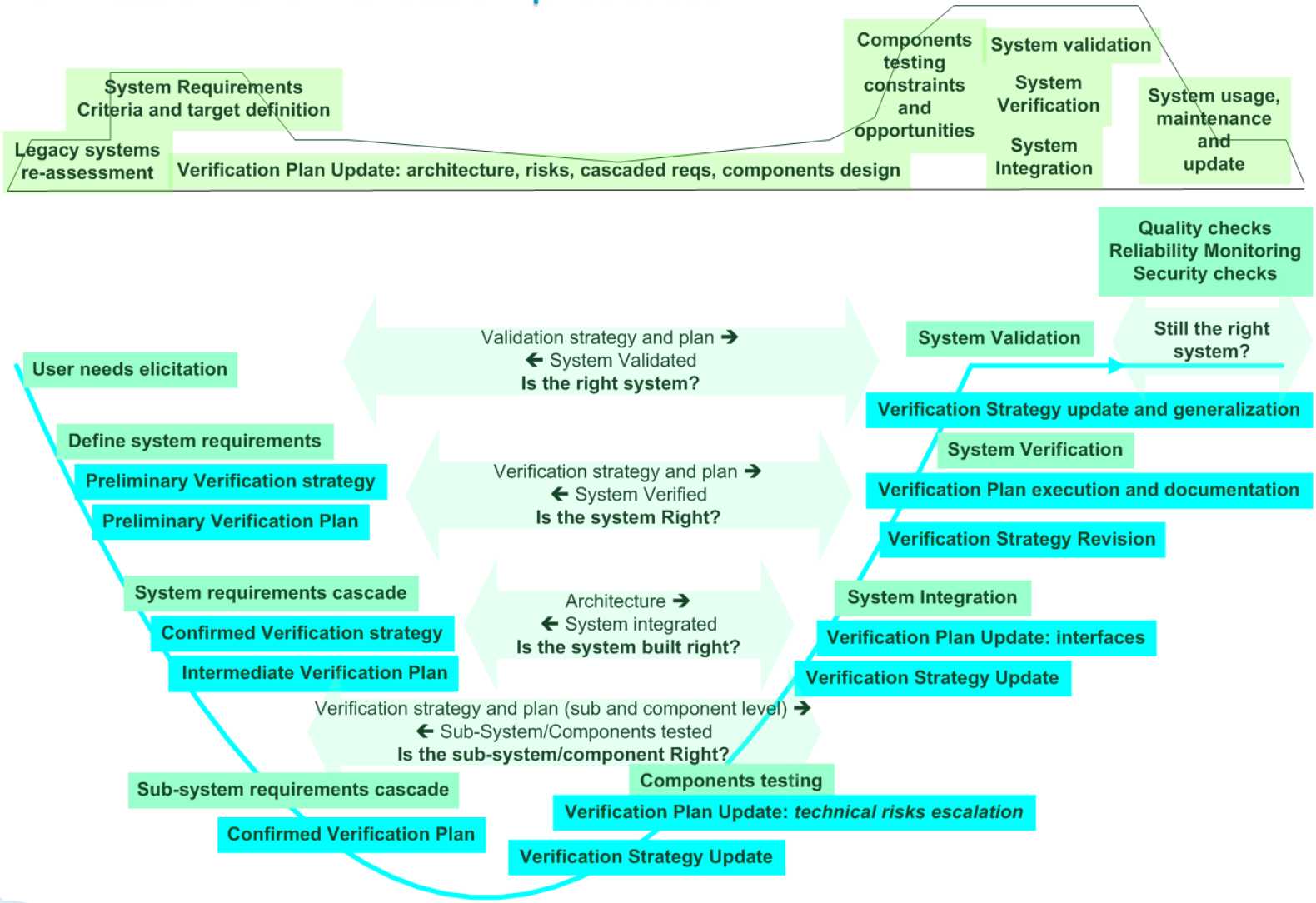
Verification and Validation processes



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Needs elicitation

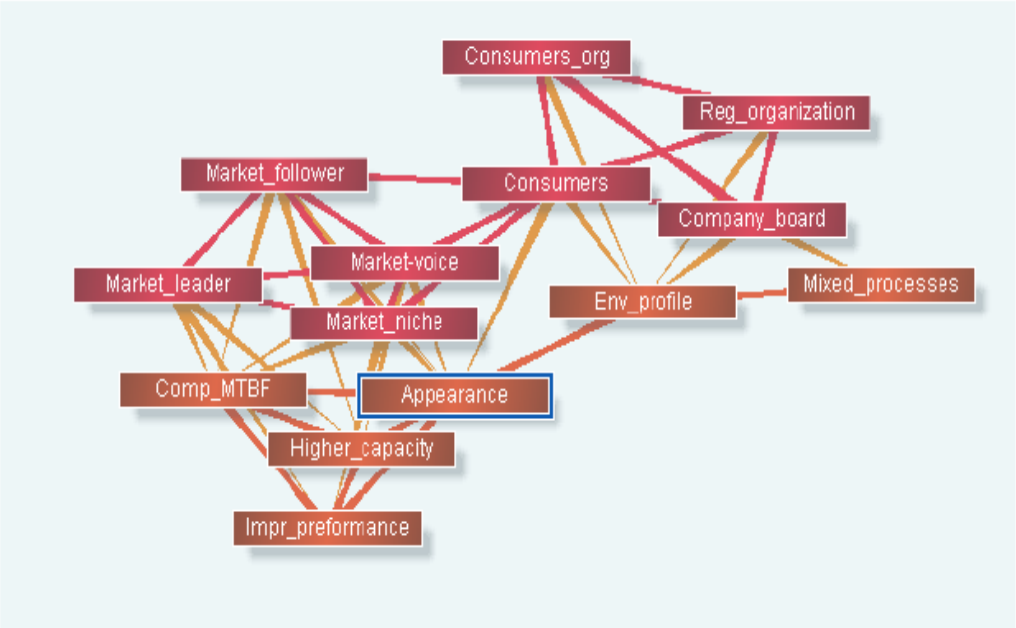
		Higher_capaci 1	Appearance 2	Mixed_proces 3	Comp_MTBF 4	Env_profile 5	Impr_preform 6
Market-voice	1	5	1		1		
Market_leader	2	7			3		3
Market_follow	3	3	1		1		
Market_niche	4		5		1		1
Company_boa	5			5		3	
Consumers	6		3			1	
Consumers_o	7					5	
Reg_organiza	8					1	

Highlight stakeholders dependencies

Target and evaluate validation efforts towards the right stakeholders

by

clustering, graphical representation, analytic



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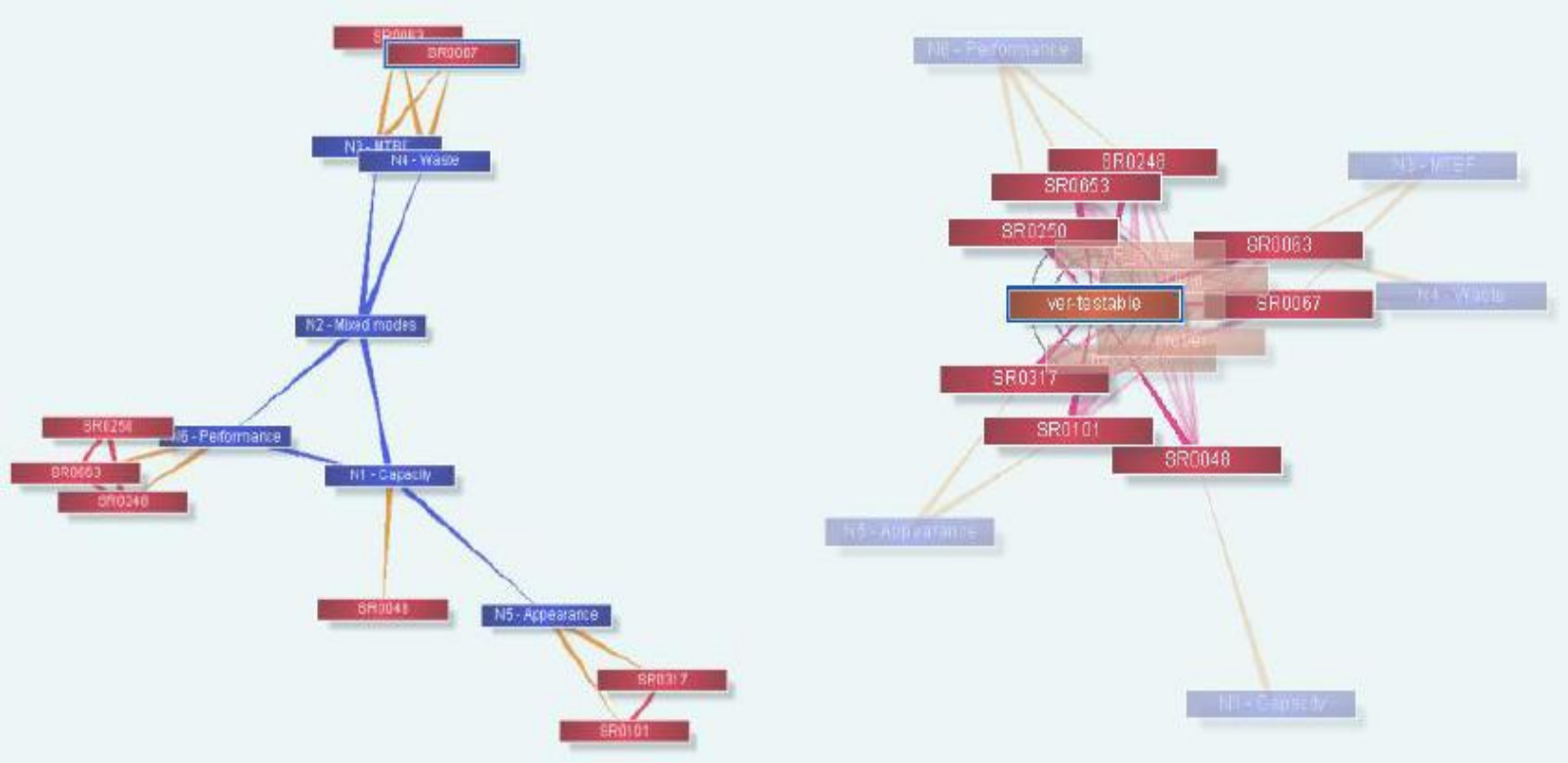
Requirements management

Evaluate needs translation into System Requirements

Highlight the “right system” uncertainties

by clustering, graphical representation, analytic



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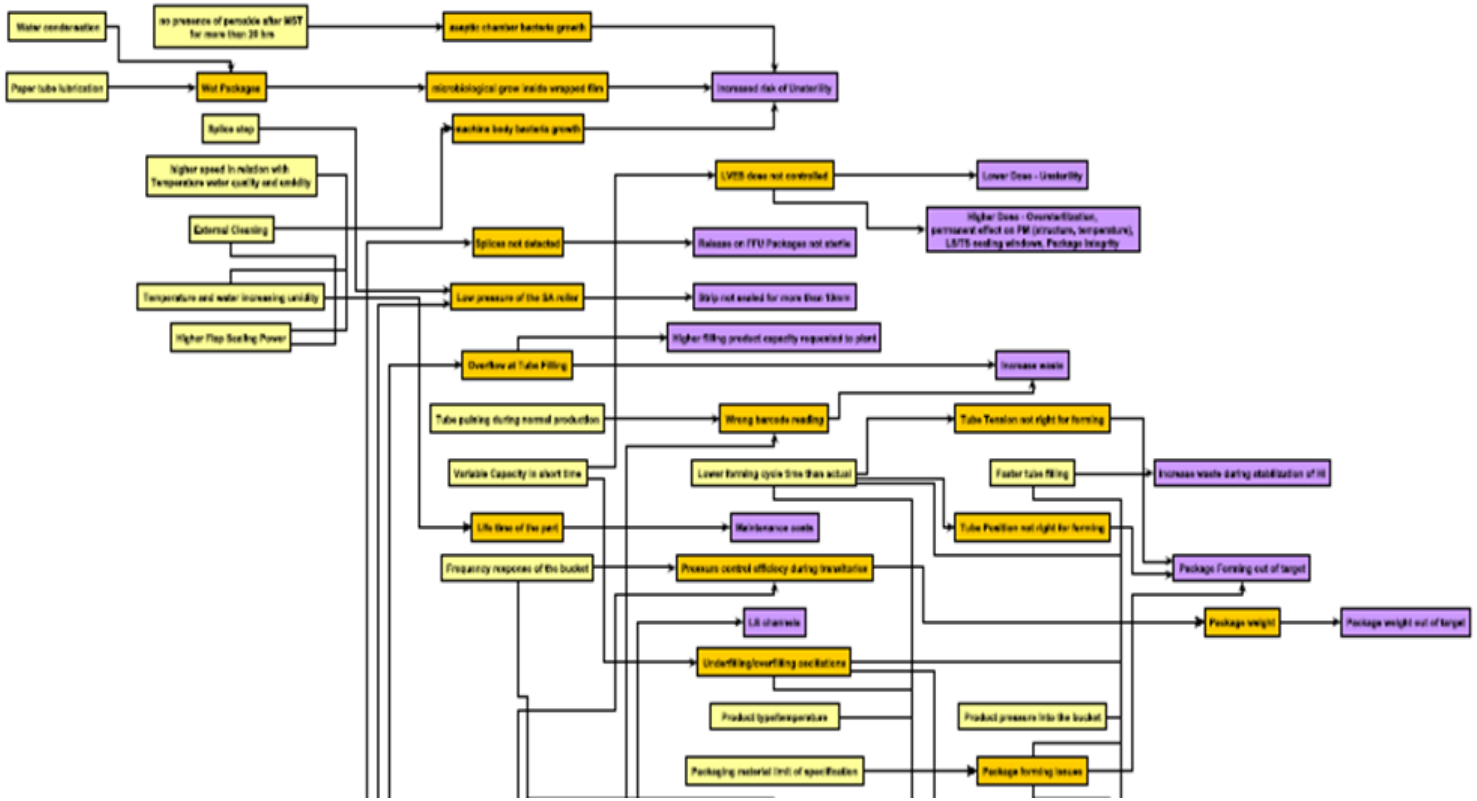
Technical Risk Assessment

Manage System FMEA complexity, identify red areas.
Foster the risk mitigation plan vs. root causes according to freq, impact and detectability.
Highlight downstream/upstreams flows
by sequencing, graphical representations, RPNs decomposition



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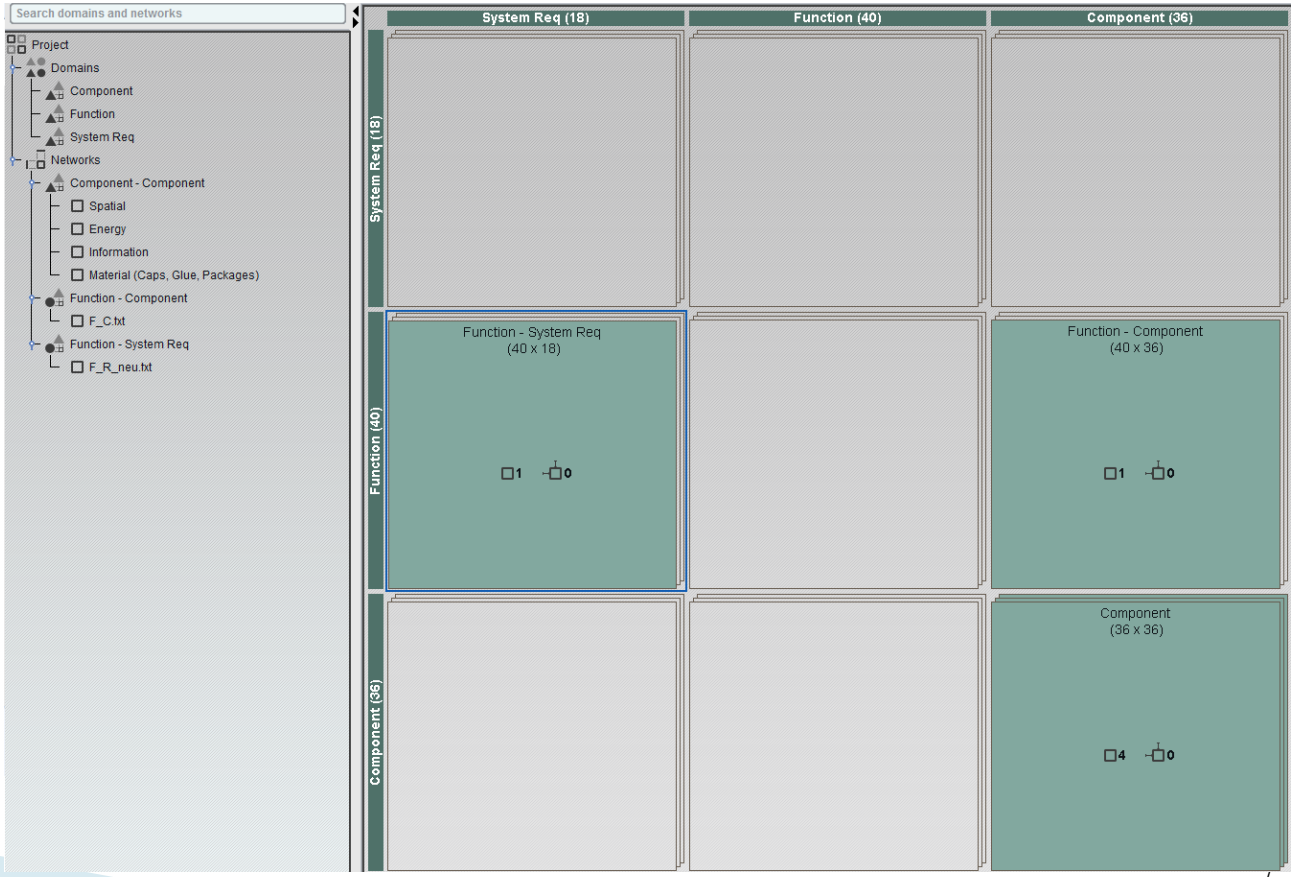
System Functional Models

System requirements, functions and components complexity managed in the same environment

Understand and share the requirements-solution space

by mapping ontology, vocabulary, clustering, graphical representations.



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V&V Strategies

Optimize Verification, Validation and Testing strategies by methodology and tool based on the DSMs was developed during the SysTest research project

SysTest products ...			... lead to improvements in ...	... lead to a reduction in ...	
VVT MG [1]	VVT PM [2]	VVT S&P [3]		VVT cost	rework cost
	++	+++	VVT process guidance	+	+
+++	+		rate of virtual versus physical testing	++	++
+++	+		VVT effectiveness	++	
+++	+		failure detection rate		++

[1] VVT MG = VVT Methodology Guidelines

[2] VVT PM = VVT Process Model

[3] VVT S&P = VVT Strategy & Planning Procedure

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Decision support

Model and share effects a repetitive decision affected by soft uncertainty sources by

graphical representations, clustering, re-use, Bayesian inference

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		MeasI.I(gramm	MeasI.II(ins-Al	MeasI.III(AluFo	MeasI.I(PLH_	MeasII.II(L1)	MeasII.III(A1)	MeasII.II(A2)	MeasIII.I(Pin-h	MeasIII.II(Pin-h	MeasIII.III(PHP	MeasIII.IV(Pin-	MeasIII.V(CoM	MeasIII.VI(FoP	MeasIII.VII(Tea	MeasIV.I(Adh-	MeasIV.II(Adh	MeasV.I(RCS)	MeasV.II(Ben
MeasI.I(gramm	1		19							7						7	1		
MeasI.II(ins-Al	2	19								4						4	1		
MeasI.III(AluFo	3				45					15	117	33		72	117	33	33		
MeasI.I(PLH_	4			45						6	45	12		27	45	12	12		
MeasII.II(L1)	5						3	6	3	3						1	1	9	4
MeasII.III(A1)	6					3		1	1	1									
MeasII.II(A2)	7					6	1		1	1						1	1	9	4
MeasIII.I(Pin-h	8					3	1	1		1									
MeasIII.II(Pin-h	9	7	4	15	6	3	1	1	1		15	4		9	15	6	6		
MeasIII.III(PHP	10			117	45					15		33		72	117	33	33		
MeasIII.IV(Pin-	11			33	12					4	33			21	33	10	10		
MeasIII.V(CoM	12																		
MeasIII.VI(FoP	13			72	27					9	72	21			72	21	21		
MeasIII.VII(Tea	14			117	45					15	117	33		72		33	33		
MeasIV.I(Adh-	15	7	4	33	12	1		1		6	33	10		21	33		12	6	3
MeasIV.II(Adh	16	1	1	33	12	1		1		5	33	10		21	33	12		6	3
MeasV.I(RCS)	17					9		9								6	6		21
MeasV.II(Ben	18					4		4								3	3	21	

		12	18	4	3	14	10	13	11	15	17	16	8	7	5	6	9	2	1
		MeasIII.V(CoM	MeasV.II(Ben	MeasI.I(PLH_	MeasI.III(AluFo	MeasIII.VII(Tea	MeasIII.III(PHP	MeasIII.VI(FoP	MeasIII.IV(Pin-	MeasIV.I(Adh-	MeasV.I(RCS)	MeasIV.II(Adh	MeasIII.I(Pin-h	MeasII.II(A2)	MeasII.I(L1)	MeasII.III(A1)	MeasIII.II(Pin-h	MeasI.II(ins-Al	MeasI.I(gramm
MeasIII.V(CoM	12																		
MeasV.II(Ben	18									3	21	3		4	4				
MeasI.I(PLH_	4				45	45	45	27	12	12		12					6		
MeasI.III(AluFo	3			45		117	117	72	33	33		33					15		
MeasIII.VII(Tea	14			45	117		117	72	33	33		33					15		
MeasIII.III(PHP	10			45	117	117		72	33	33		33					15		
MeasIII.VI(FoP	13			27	72	72	72		21	21		21					9		
MeasIII.IV(Pin-	11			12	33	33	33	21		10		10					4		
MeasIV.I(Adh-	15		3	12	33	33	33	21	10		6	12		1	1		6	4	7
MeasV.I(RCS)	17		21							6		6		9	9				
MeasIV.II(Adh	16		3	12	33	33	33	21	10	12	6			1	1		5	1	1
MeasIII.I(Pin-h	8													1	3	1	1		
MeasII.II(A2)	7		4							1	9	1	1		6	1	1		
MeasII.I(L1)	5		4							1	9	1	3	6		3	3		
MeasII.III(A1)	6												1	1	3		1		
MeasIII.I(Pin-h	9			6	15	15	15	9	4	6		5	1	1	3	1		4	7
MeasI.II(ins-Al	2									4		1					4		19
MeasI.I(gramm	1									7		1					7	19	

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Multi Domain Matrices Pro and cons

Multi domain matrices allow collecting and validating the relevant info into an essential ontology by using a unique vocabulary.

Design Structure Matrices and Multi Domain Matrices provide the modelling capabilities: representation, understanding, info preservation and transmission, analysis by: Graph Theory, Network and Motif Analyses.

The key advantage is surely managing a level of complexity not affordable with traditional static tools in an affordable and repeatable way.

The effort is efficiently moved from filling-in the data to designing the model, validating the inputs and analyzing the results. In this way the System Engineer is relieved from trivial or trivial activities and can focus on value-related items.

Data Validation as well as managing tools dependency absorb the majority of the effort.

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Further applications

The convenient **benefit/effort ratio** achieved in previous applications fosters future applications.

The available models shall be extended, re-used and enhanced in order to foster the system value through the **entire system life-time** and for the **overall stakeholders' chain**.

The scope of future applications is intended to further **integrate** the Systems Validation process within the overall system development and sharing key information among different team members.