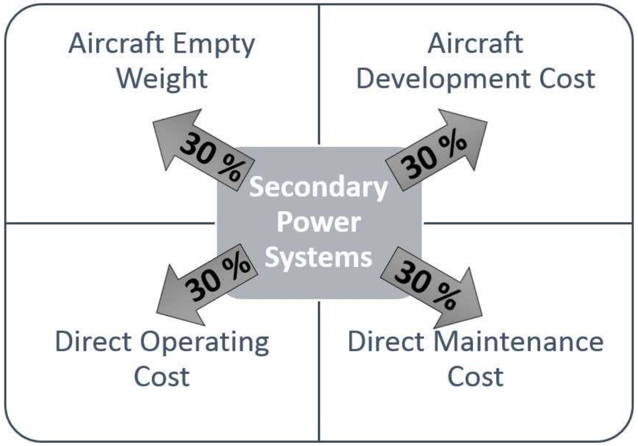
Aircraft Systems Engineering

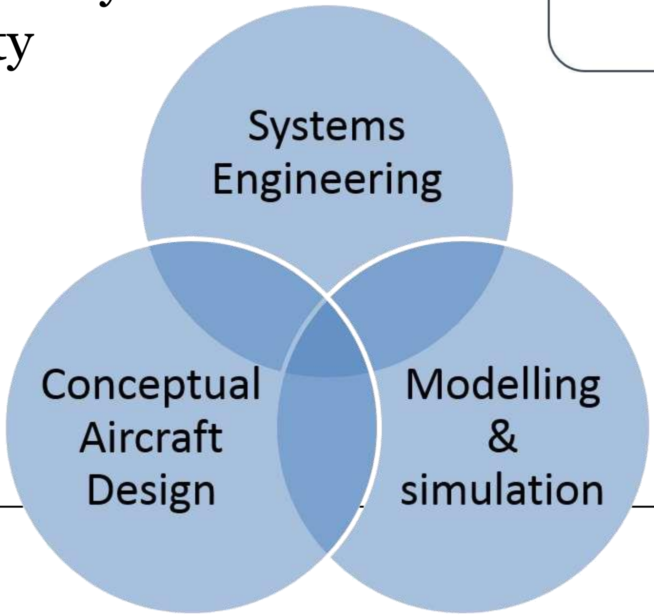
Ingo Staack
11th MODPROD Workshop
7-8 February, 2017

LINKÖPING UNIVERSITY

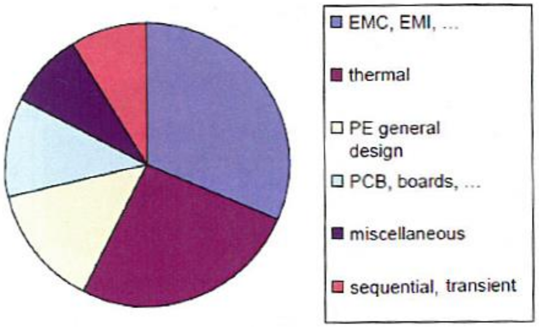
Why (Conceptual) Aircraft **Systems** Engineering?

- multi-aspect, multi-domain
- project specific
- low efforts, short period, small team
- enhanced complexity fidelity





More Electrical Airplane: Power Electronics



PE technical issues dispatched by discipline

"....the most significant common lessons learned are within the EMI/EMC discipline and could become showstoppersif not identified or applied."

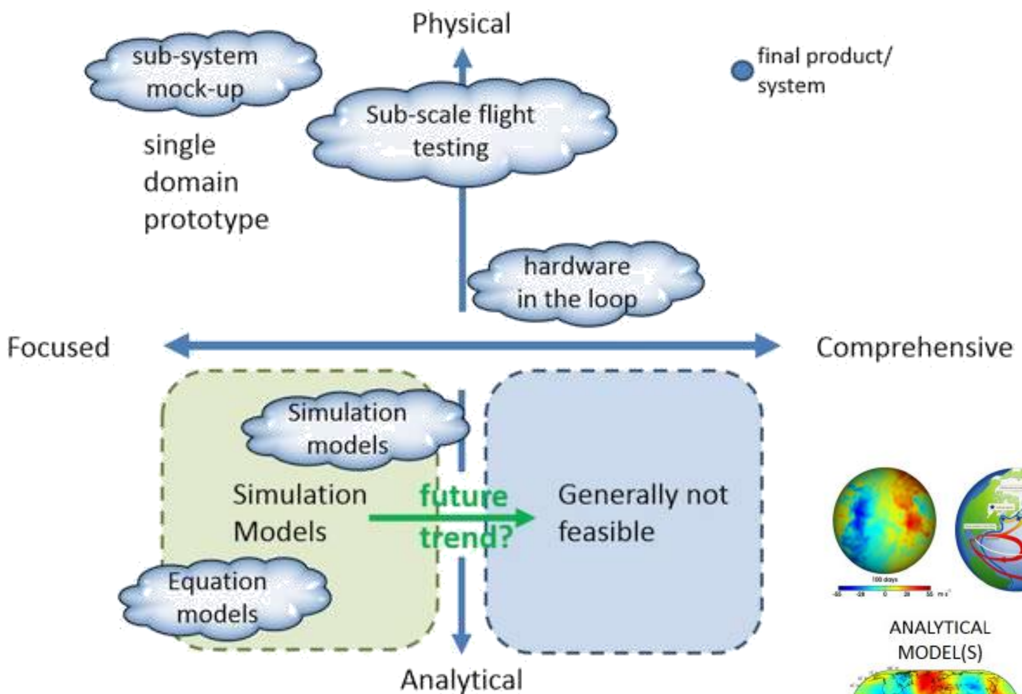
source: Michel Todeschi and Frédéric Salas, Airbus, 2016

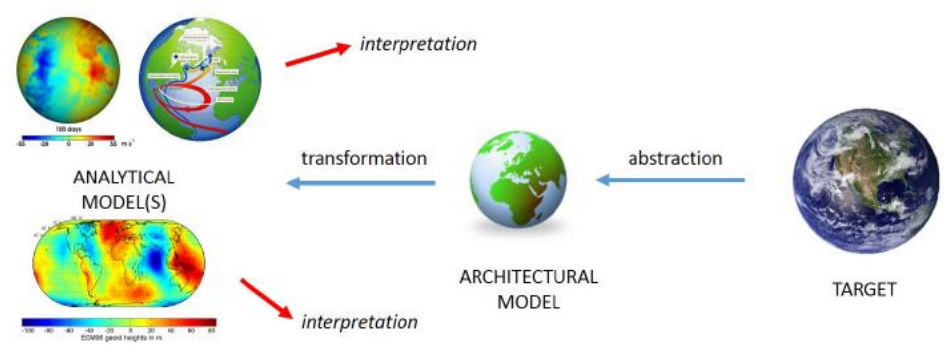
- a possible showstopper?
- workarounds?
- can this be addressed during the conceptual aircraft design process? if yes, how?

source: http://www.jobyaviation.com/LEAPTech/ (accessed 2016-09-07)

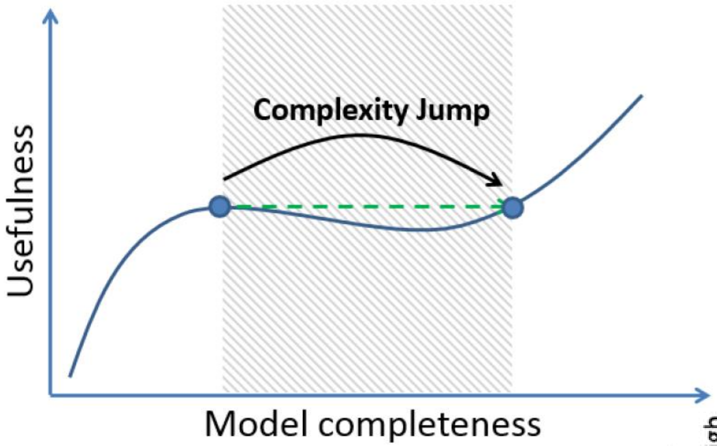
Nine-Passenger Hybrid Turboprop May Be On The Way source: Aviation Week, 2017-02-02

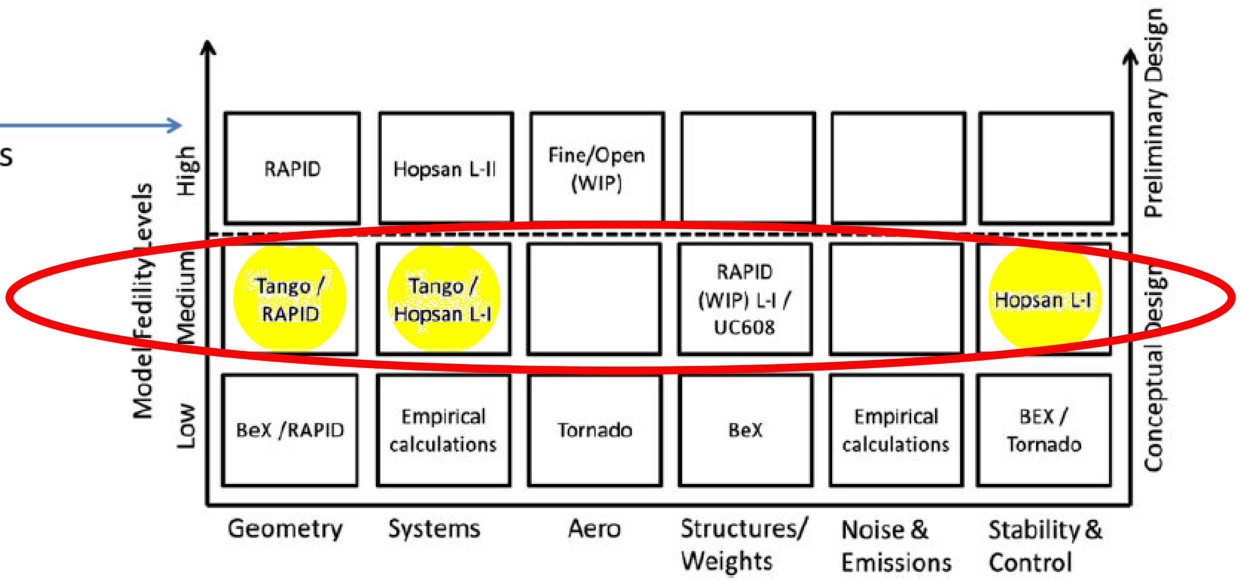
Model Types, Model Transformations and Model Implementations



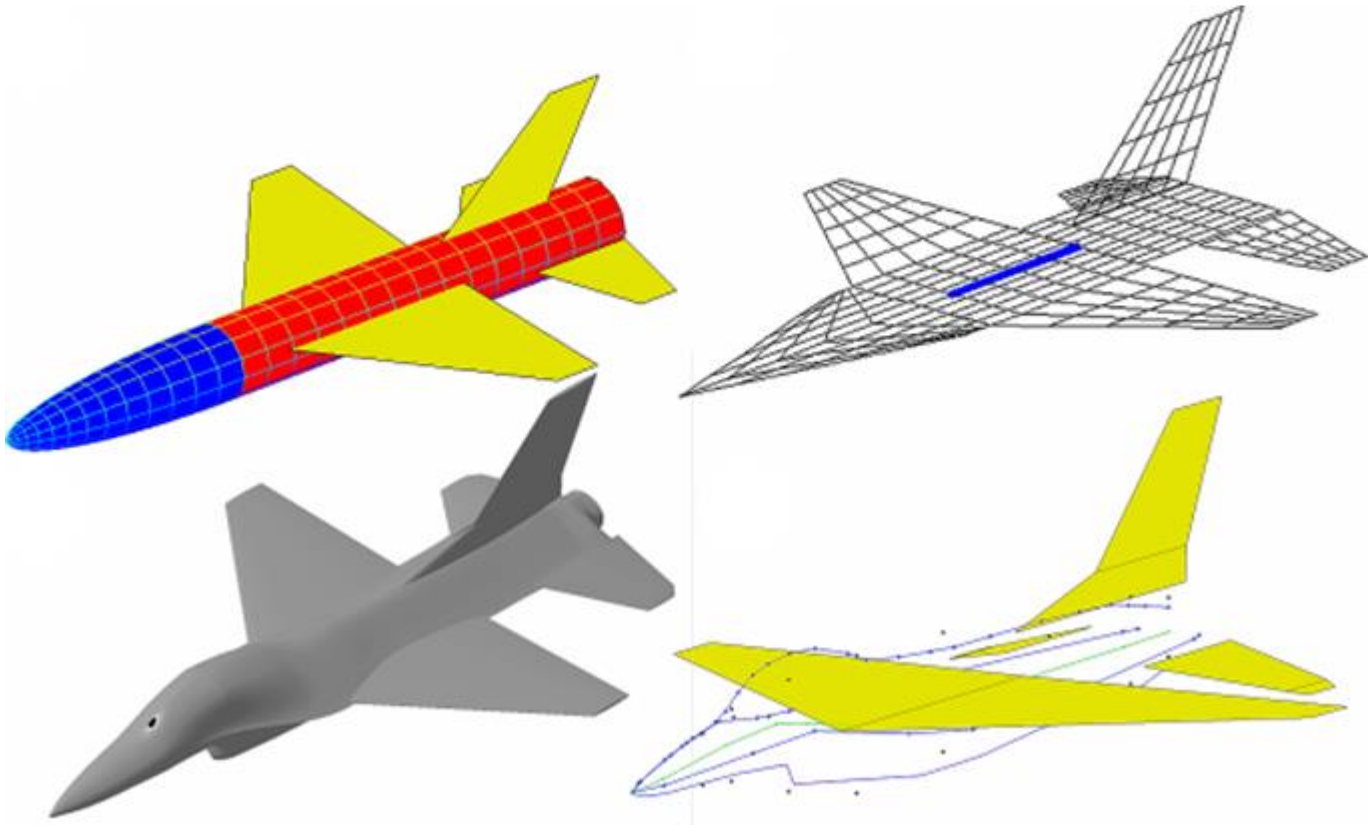


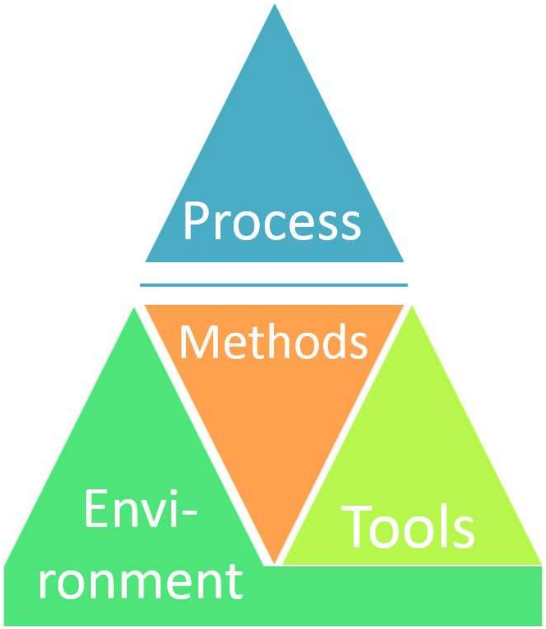
Model Fidelity and Integration





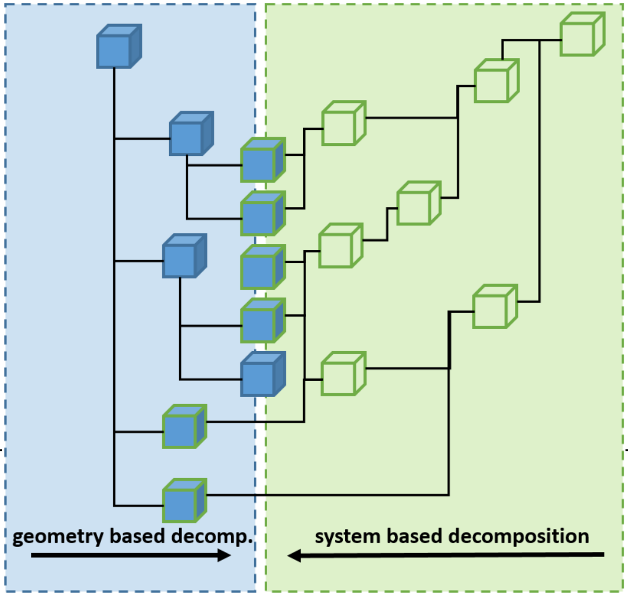
One Dataset – Different Tool-Fidelity Geometry Representation



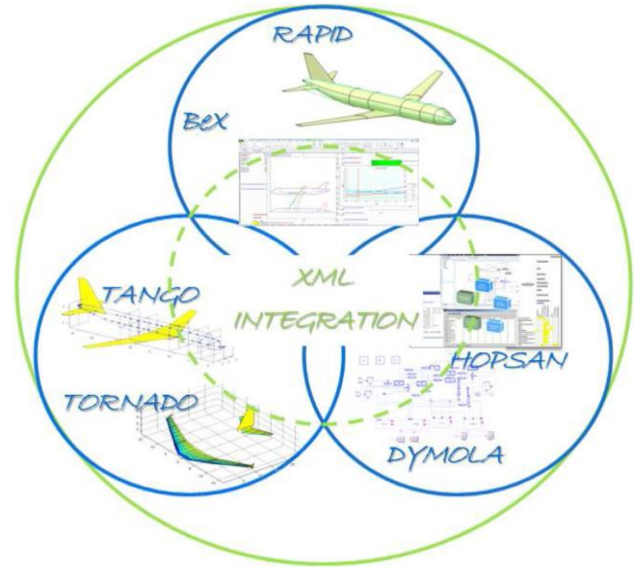


Implementation

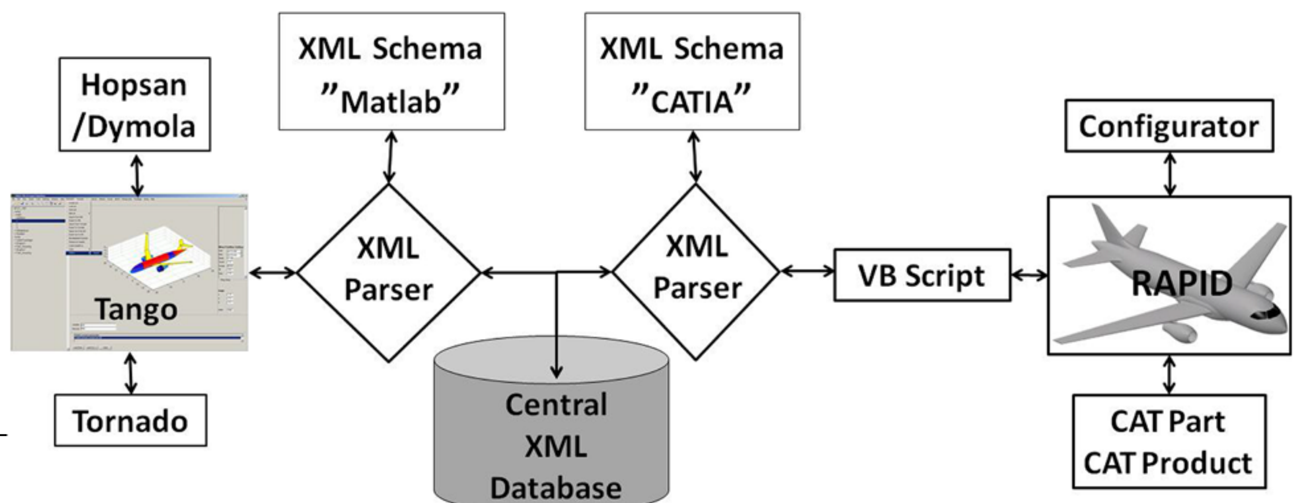
- change from risk management
  to management of complexity & details?
- from pure mechanical engineering towards **software** (data) engineering, **systems engineering** and **project management**
- conventional (eventual OOP), graph based, causal/acausal….



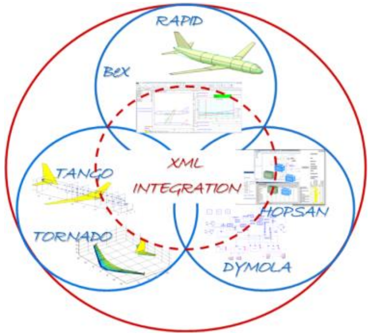
Framework Design: Information Model



- XML based a good (low-level) solution
- parametric design
- several standards:
  CPACS, TEI (literature) , Ecl@ss (acquisition, components), ISO/EC 81346 (construction building), etc.

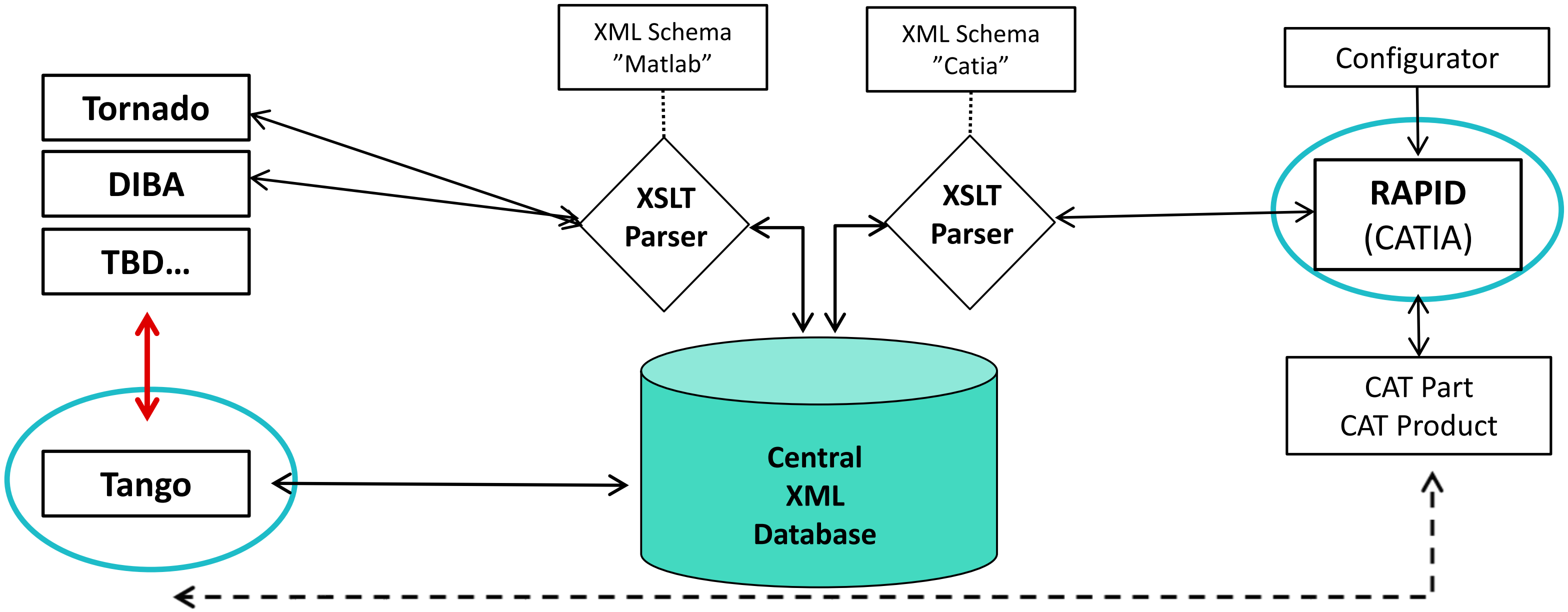


XML Based Tool Integration

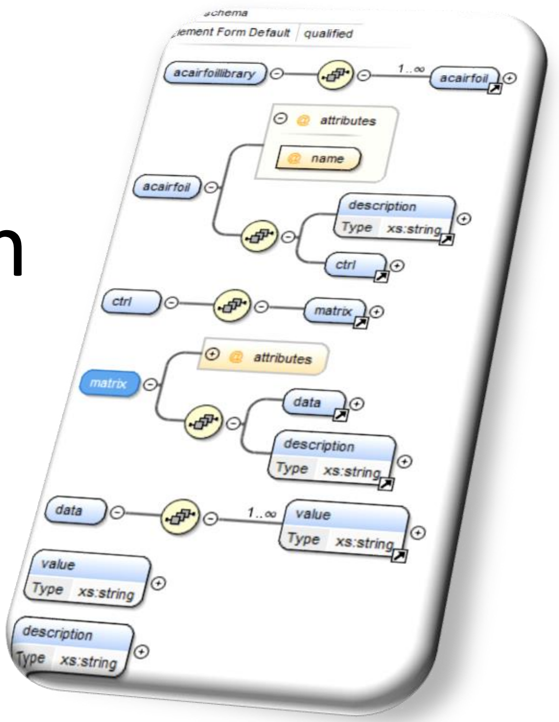


- Strict design space limitation (robustness counts!)
- CATIA model topology different from the XML data setup

  → complex data translations required



Example: Airfoil Representation



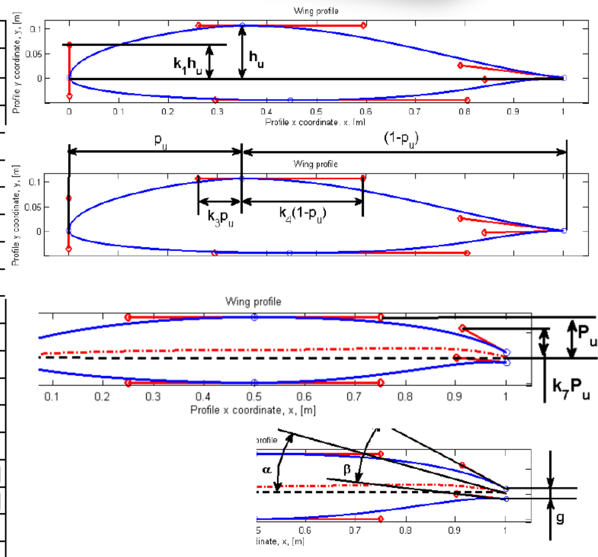
- unified parametric airfoil description (T. Melin, 2011):
- airfoil representation by four 2nd-order Beziér curves:

$$\bar{x}(t) = (1-t)^3\,\bar{p}_0 + 3(1-t)^2 t\bar{p}_1 + 3(1-t)t^2\,\bar{p}_2 + t^3\,\bar{p}_3$$

  - very robust format
  - name describing the geometry → perfect condition for (binary) optimization algorithms
  - only drawback: S-shaped trailing edge airfoils are are not representable

Parameters

Name	Var	Range
Leading edge		
Upper Nose fraction	k_1	[0..1]
Lower Nose fraction	k_2	[0..1]
Upper side		
Upper thickness	H_U	[0..1]
Upper thickness position	P_U	[0..1]
Upper forward fraction	k_3	[0..1]
Upper rearward fraction	K_4	[0..1]
Lower side		
Lower thickness	H_L	[0..1]
Lower thickness position	P_L	[0..1]
Lower forward fraction	k_5	[0..1]
Upper rearward fraction	K_6	[0..1]
Trailing edge		
Trailing edge gap	g	[0..1]
Boat tail angle	β	$[-\pi..\pi]$
Release angle	α	$[-\pi..\pi]$
Upper trailing edge fraction	k_7	[0..1]
Lower trailing edge fraction	k_8	[0..1]



LINKÖPING UNIVERSITY

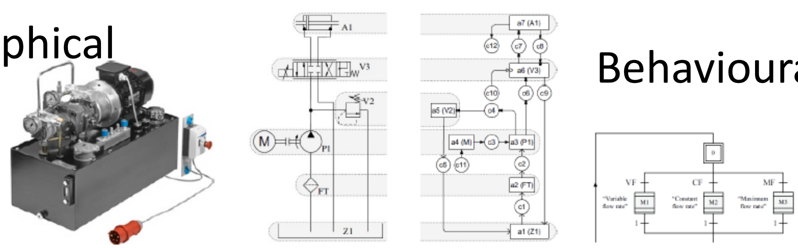
System Architecture Automation

System Architecture Automation

Modelling Trends: Unified Modelling or/and Semantic Handling Capabilities?

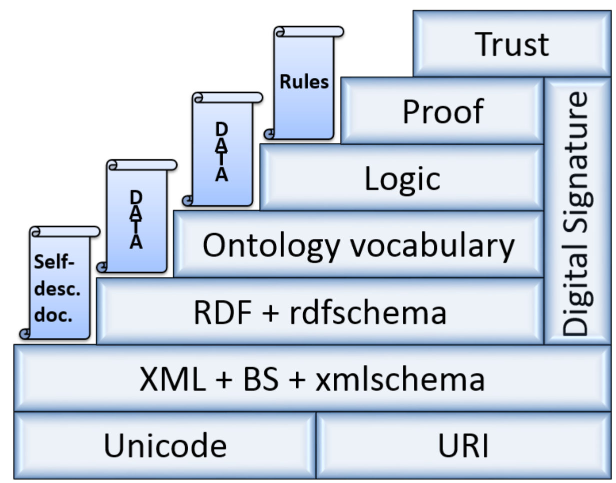
- Cyber-Physical Systems
- unified modelling or enabled model interpretation?
- *"the right tool/method for the right topic"* (efficiency, transparency, effort)

Graphical Structural Functional Behavioural

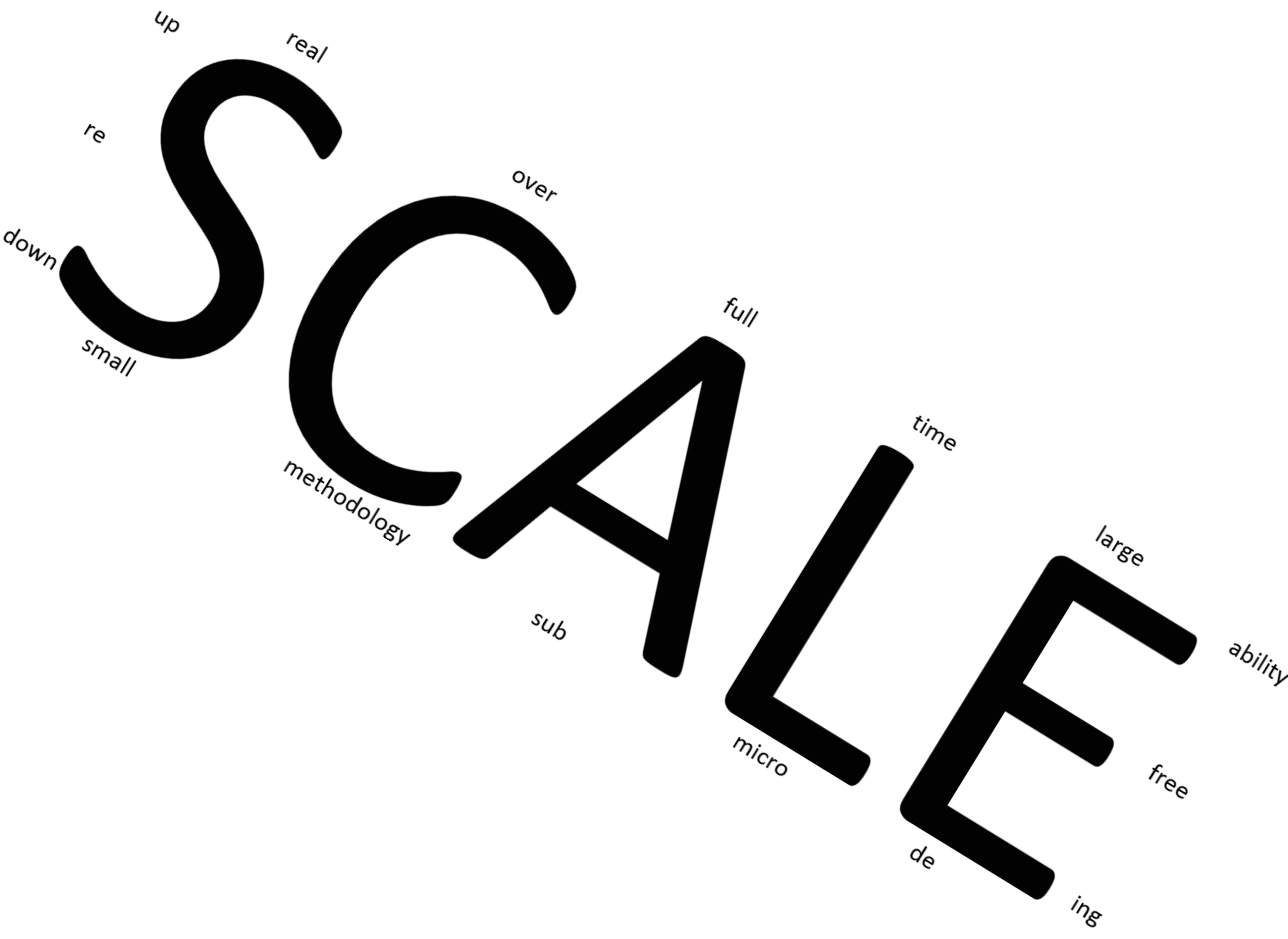


(a) *Hydr. power pack* (b) *Hydr. circuit* (c) *C-A net* (d) *Grafcet*

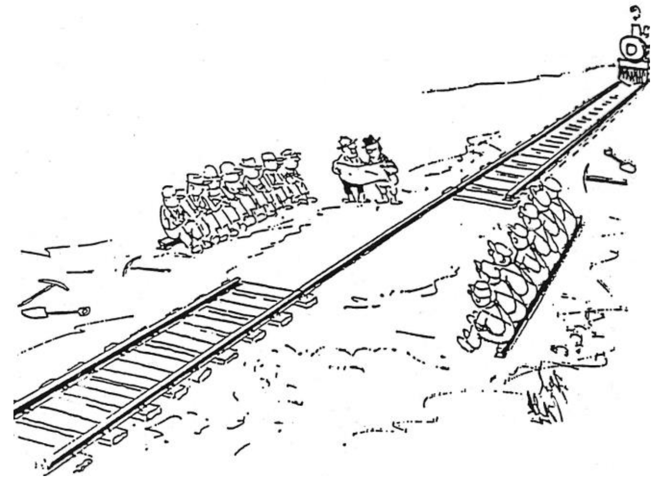
Different (analytical) models of a hydraulic power supply

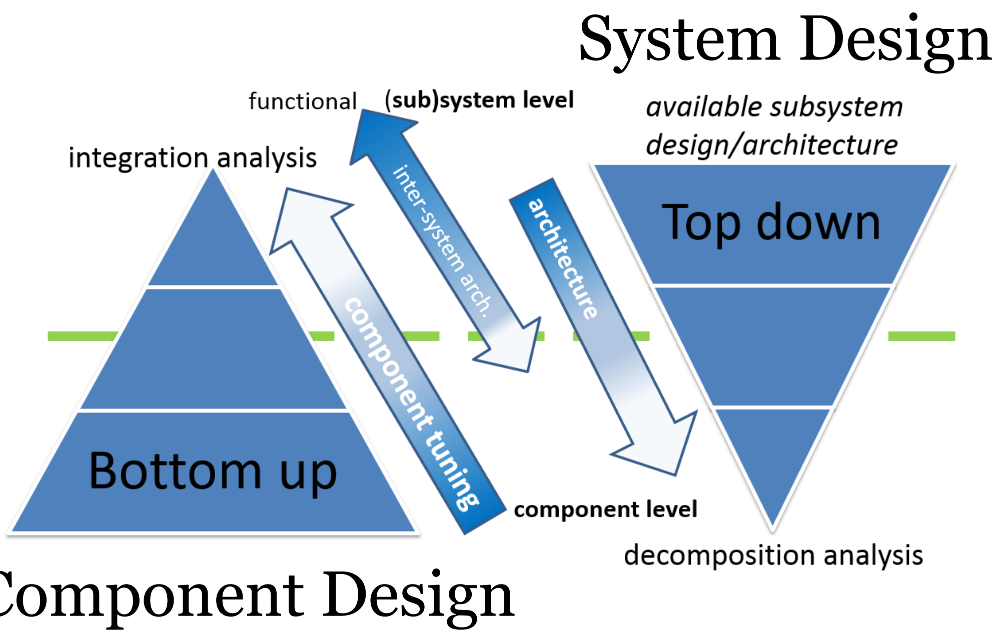


The semantic web approach (source: Bernes Lee)

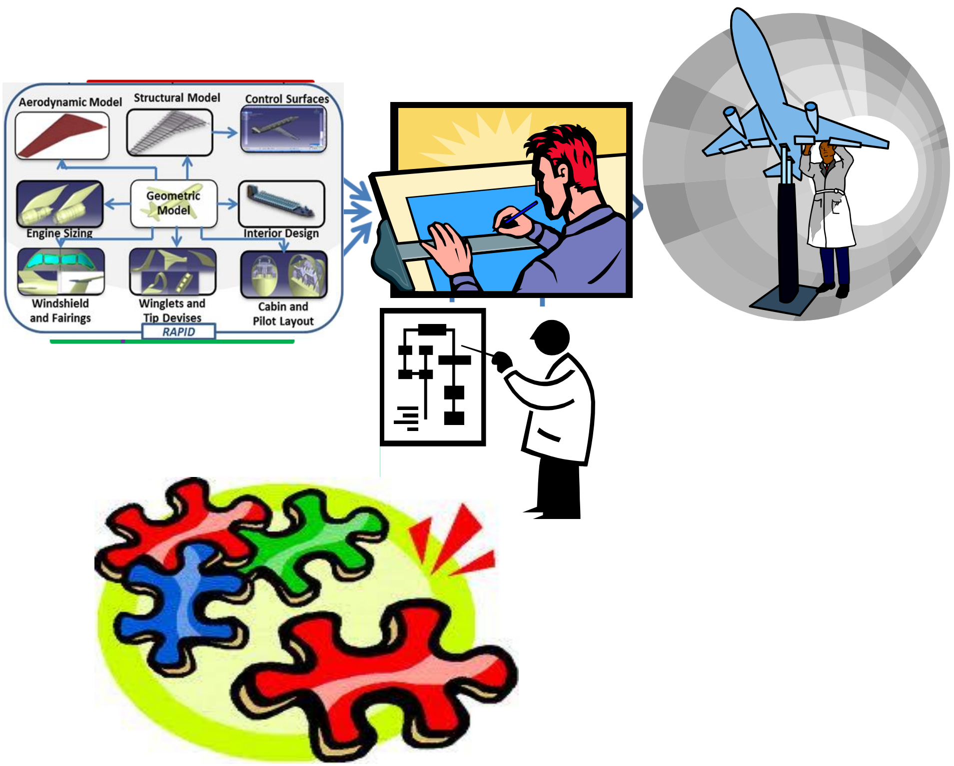

SCALE
up
real
re
over
down
small
full
methodology
time
sub
large
ability
micro
free
de
ing

Closing the Gap by KBE





KBE: System Architecture and Integration of Simulation Models

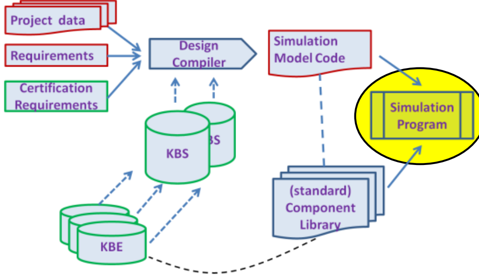


<u>KBS</u>: System Knowledge Base

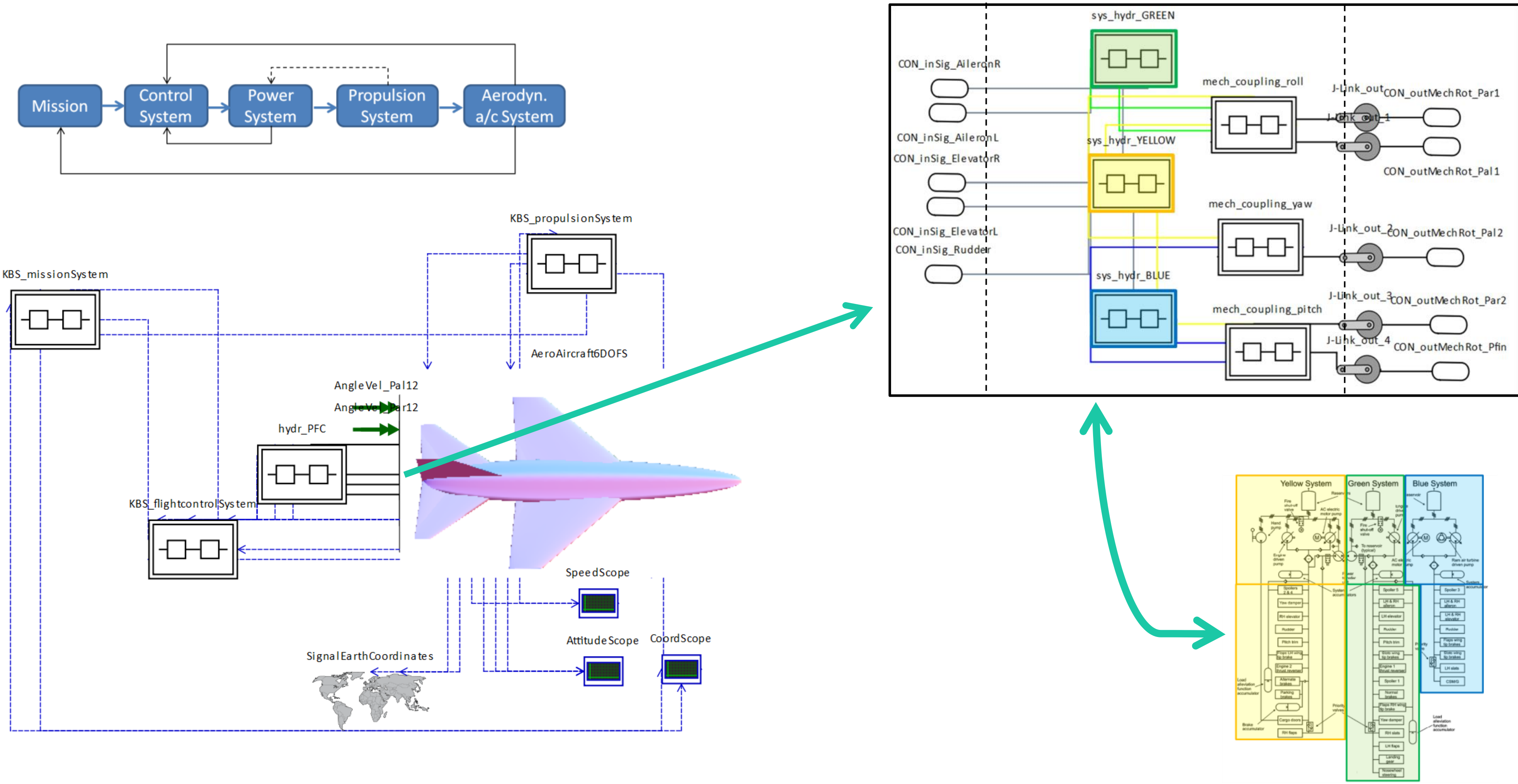
<u>KBE</u>: Element Knowledge Base

- serve for the translation from meta-components towards the simulation components in the library

Req. & project related data → (total) system simulation

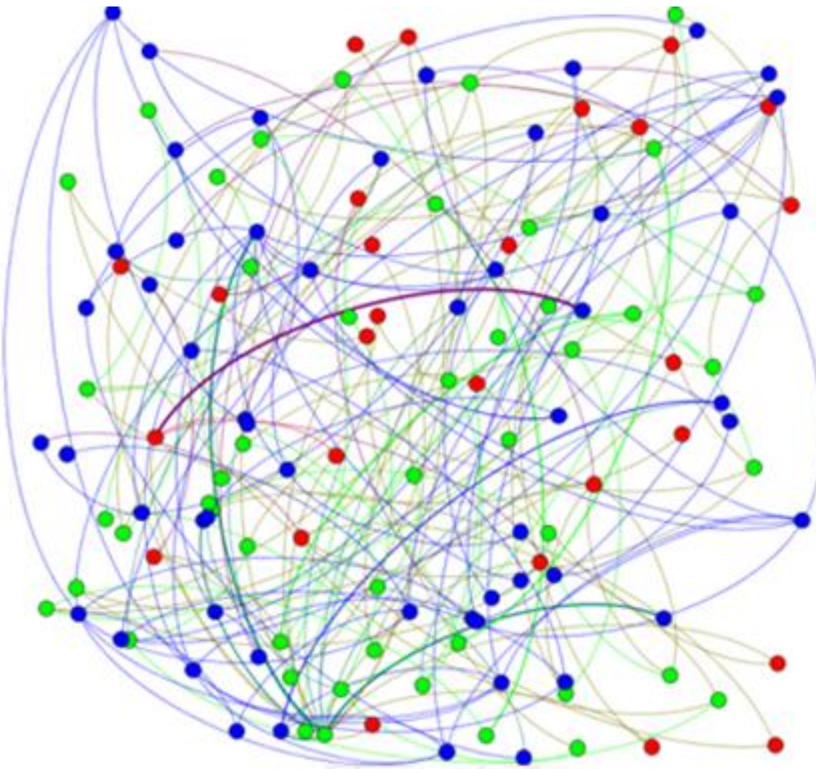


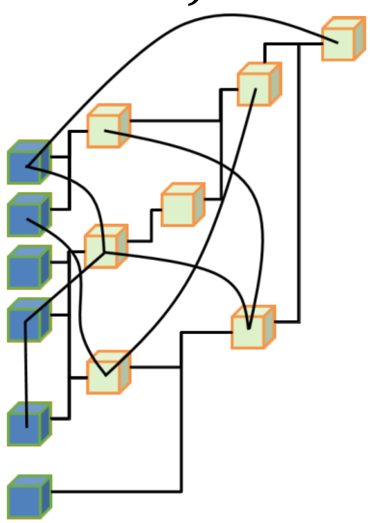
Example Result: Simulation Model



Complexity – How to maintain a **TRANSPARENT** process?

- how to maintain the overview?
- how to maintain flexibility?
- how to **present/visualize** huge data and **complex dependencies** (network/graph) structure
- tool efficiency (e.g. build-up and maintenance of KBE tools)

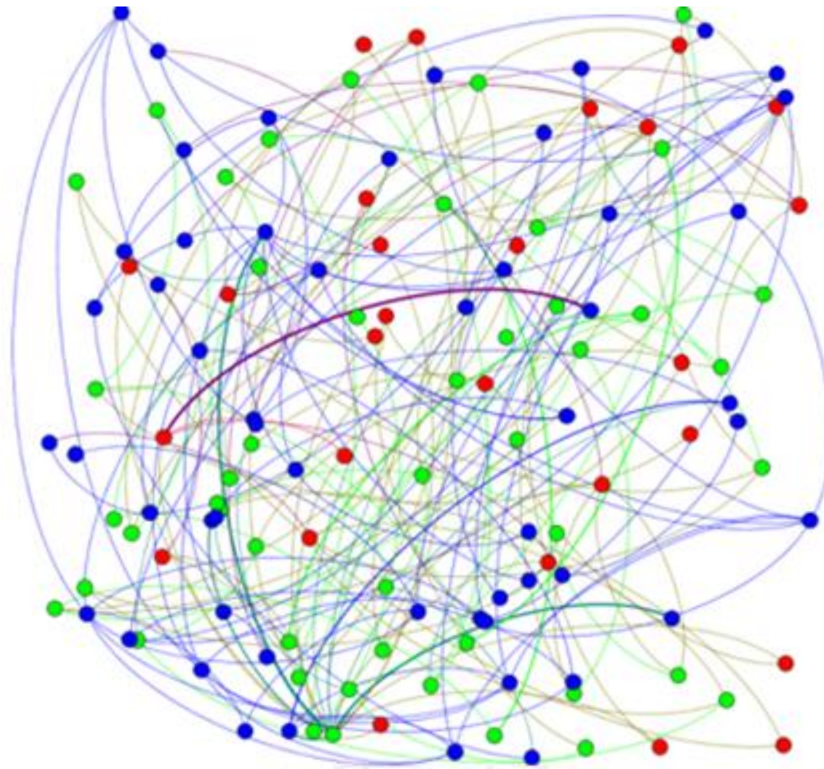


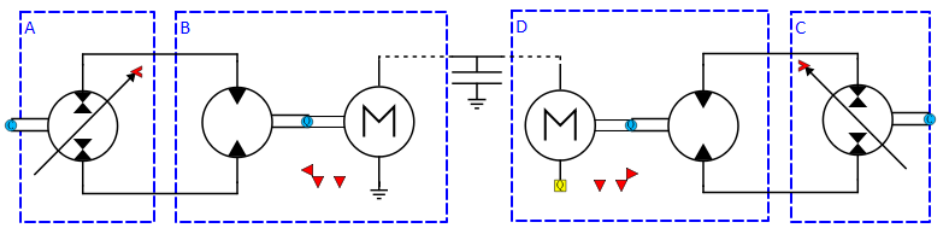


LINKÖPING UNIVERSITY

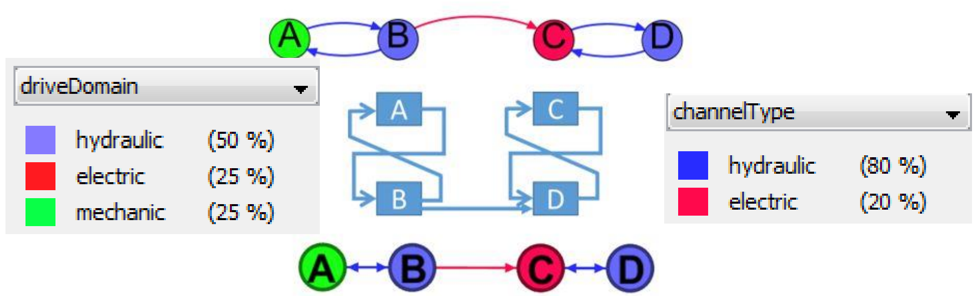
Complexity – How to maintain a **TRANSPARENT** process?

- how to maintain the overview?
- how to maintain flexibility?
- how to **present/visualize** huge data and **complex dependencies** (network/graph) structure
- tool efficiency (e.g. build-up and maintenance of KBE tools)

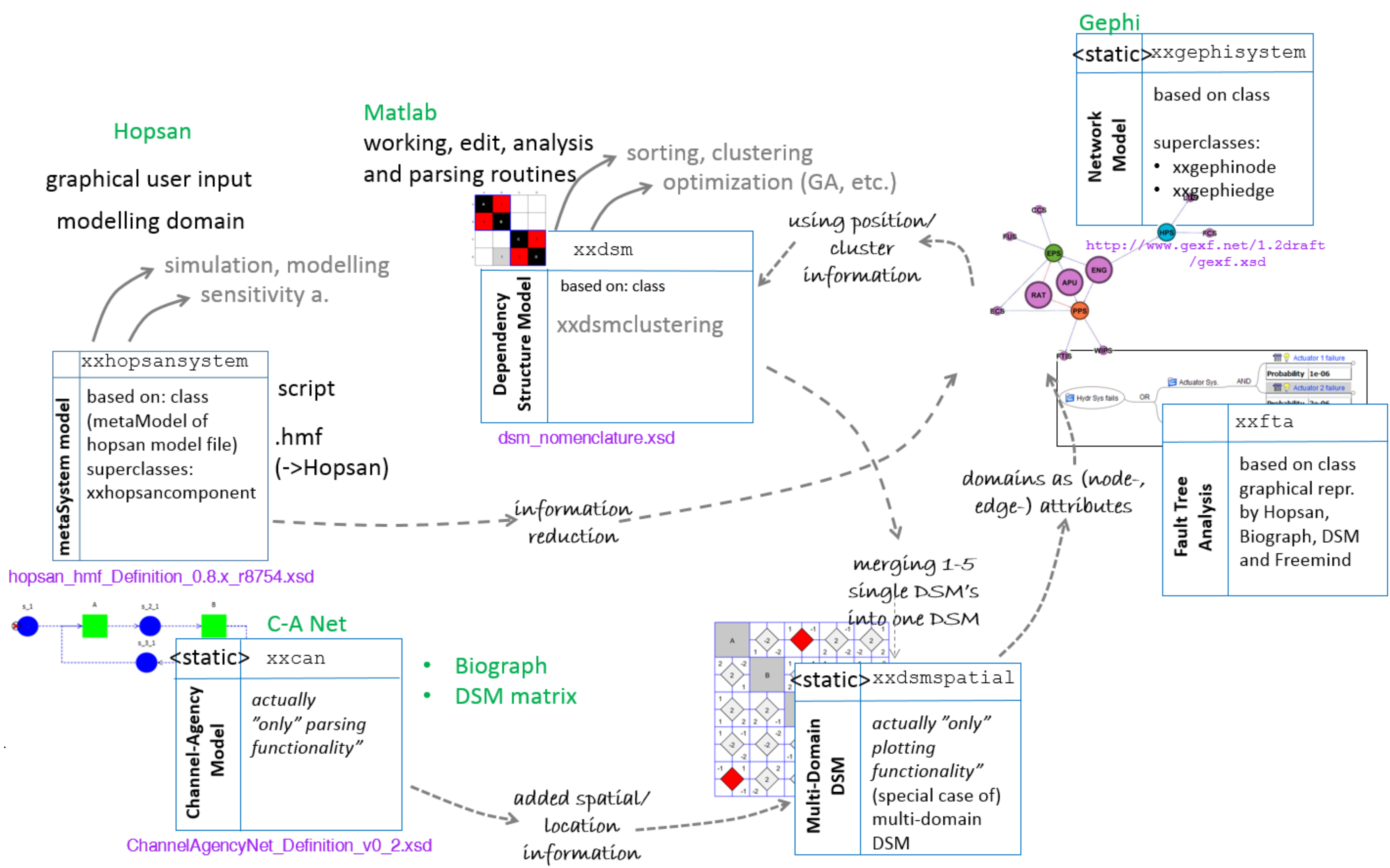




	D	A	C	B
D	D		1	1
A		A		1
C	1		C	
B		1		B



Unified OOP Modelling Approach



Project Outcomes

- Object-oriented implementation and a parametric, central dataspace with a matching fidelity; preferably in XML format is a good, easy (streamlined) solution
- KBE (excluding AI) is a way to enhance (generate) simulation model based on incomplete project-related information with limited increase of spend effort.
- By interpreting a system as a multi-domain graph network and appropriate modelling techniques, different system design aspects can be addressed. In combination with OOP and XML/XSD/XSLT model transformation forth an back are supported.

Thank you!

ingo.staack@liu.se

www.liu.se

LINKÖPING UNIVERSITY