Knowledge Based Engineering for System Design: *Application on Aircraft On-Board Power System*

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CONCEPT REALISATION LABORATORY

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Agenda

- Need of System Design within Aircraft Conceptual Design
- Theory and Proposed Methodology:

  Knowledge Based Metamodel Approach
- System Metamodelling
- Implementation & Use Case
  1. Hydraulic PFCS and actuator design
  2. Whole aircraft system
- Conclusion

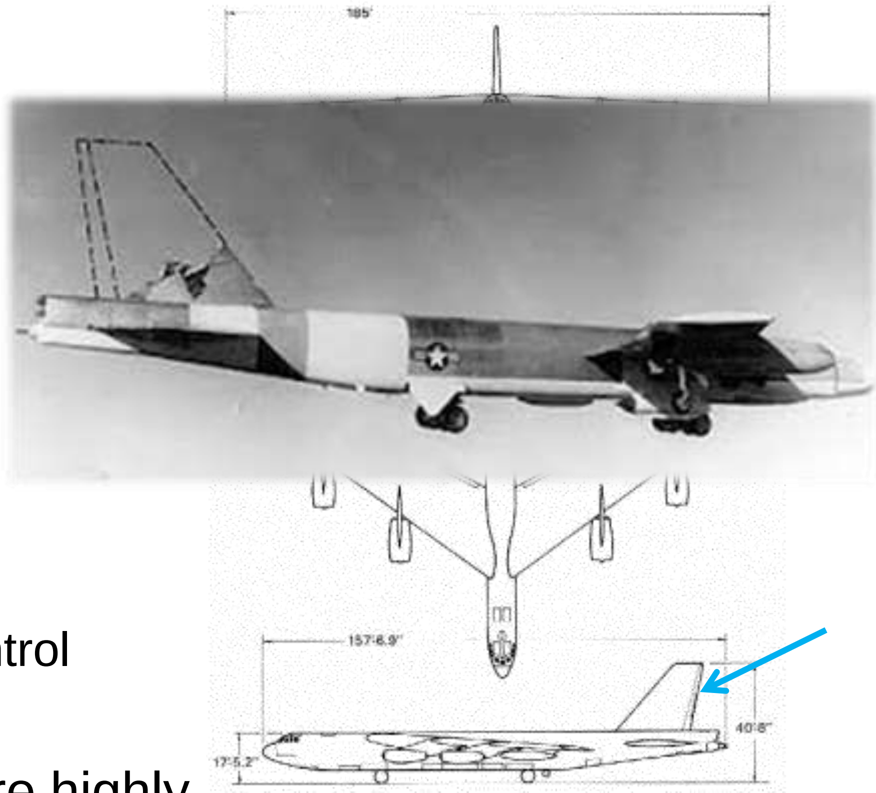
Future Aircraft Design: Configurations

- Future fighter study:
  - single engine, TVC
  - low radar signature
  - instable configuration (maneuverability)
  - vertical stabilizer / tail-less configuration
  - → realistic?
  - → control modes?
  - → needed systems?
  - → performance & benchmark?

→ Advanced/Modern designs: Configuration and Control System may not be separately developed

Historic Example: Concept ←→Systems Relation

Historical example of ”unusual” concept solution:
B-52 rudder:



- actuator reliability doubts:
  huge impact on whole concept
  - LDG integration(!)
  - structure, weight, size
  - operation
  - systems
  - aerodynamic/geometry was driven by (absence & unreliability of) power control system
- Nowadays: power control systems are highly driven by aerodynamic/layout configuration

Civil Example: Performance Influence of System Control & Operation

- Civil transportation: **Conventional** vs. **Canard** configuration
  - benchmark will be misleading without detailed system knowledge:
    - **Conventional**: aerodynamic penalty (hor. stabilizer down force)

But in reality:

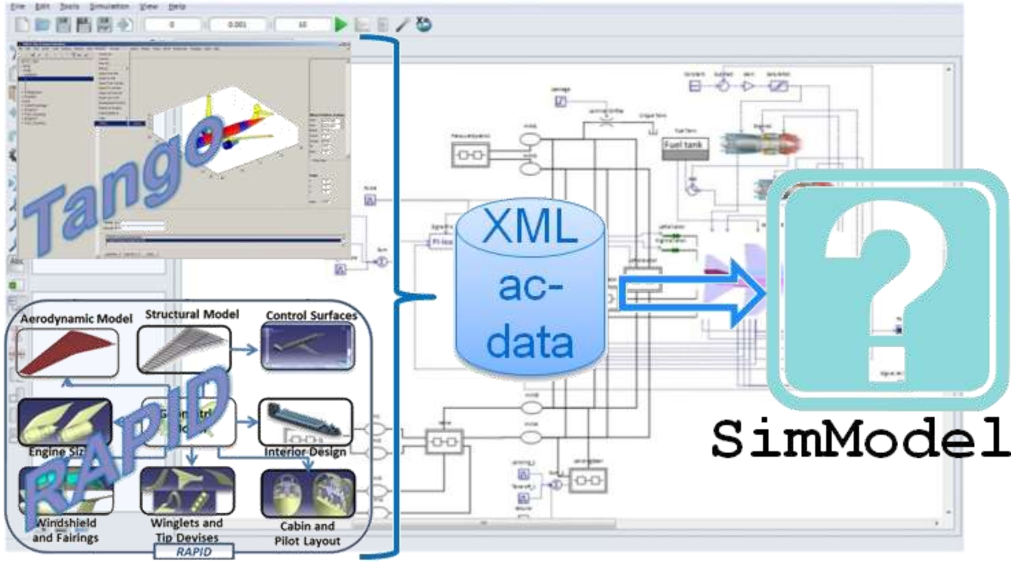
- existence of a rear trim fuel/ballast tank
- → during conceptual design already (parts of) subsystems are defined
- → impact on the benchmark
- Need to handle this systems (information) during conceptual design

Target: Automated System Simulation

Demand of multidisciplinary analysis:

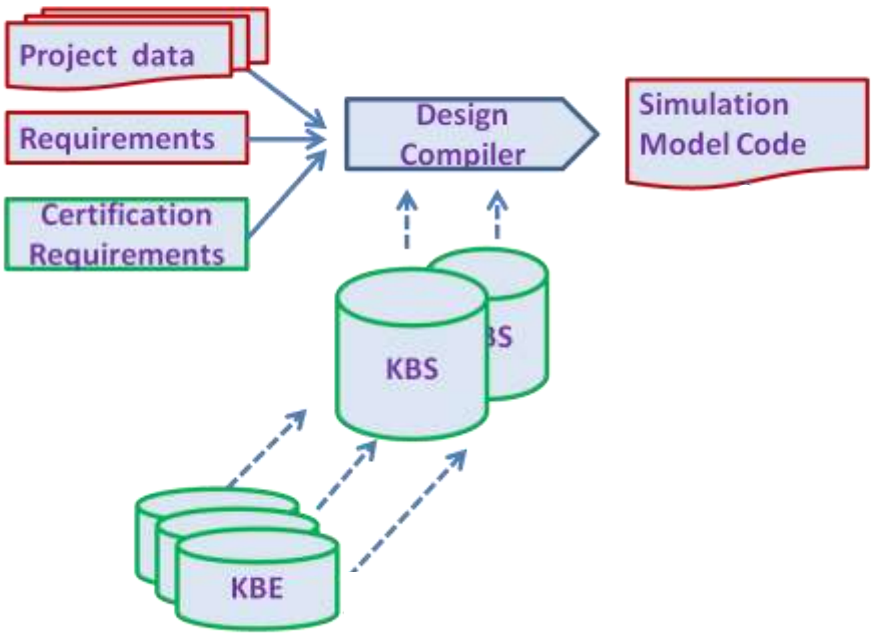
- *straight forward solution*: **simulation model**
  - design exploration and cross-coupling effect investigation
  - first instance of qualitative design "verification"
  - fault- and de-rated function analysis
  - way of communication

→ Generation of a simulation model out of the project data



Example: Manual built whole a/c SimModel

Suggested <Knowledge Based> Model Generation Methode

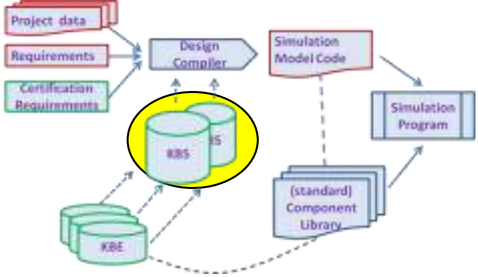


KBS: System Knowledge Base

KBE: Element Knowledge Base

- serve for the translation from meta-components towards the (real) components in library

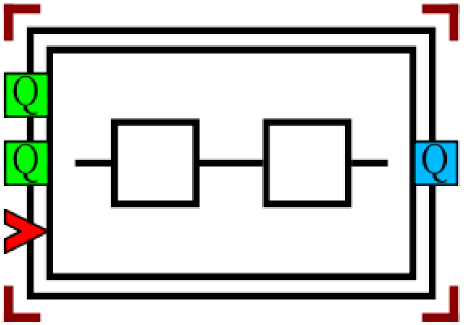
KBS Definition

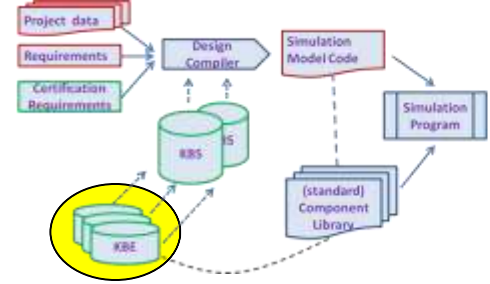


- meta-system model:
  - ”black box”
  - defines system ports (input/output)
  - contains
    - KBSs (subsystems)
    - KBEs (components)
    - layout/connection rules
    - parameter setup rules

- KBS Levels:

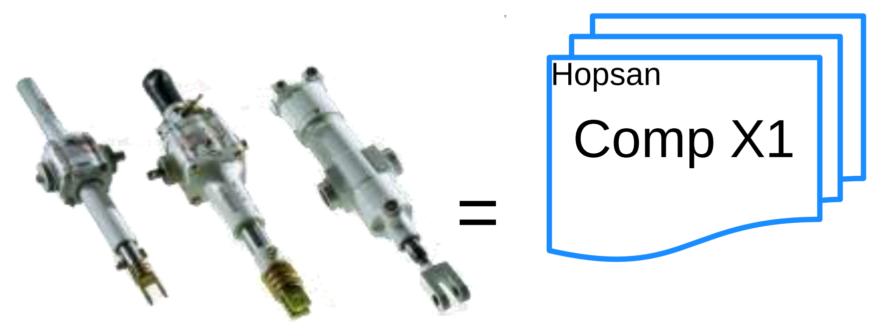
I. Fixed Ports, Static Layout
II. Fixed Ports, Repetitive Layout
III. Fixed Ports, Flexible Layout
IV. Flexible Ports, Flexible Layout



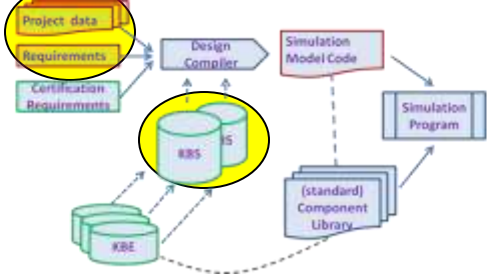


KBL Definition

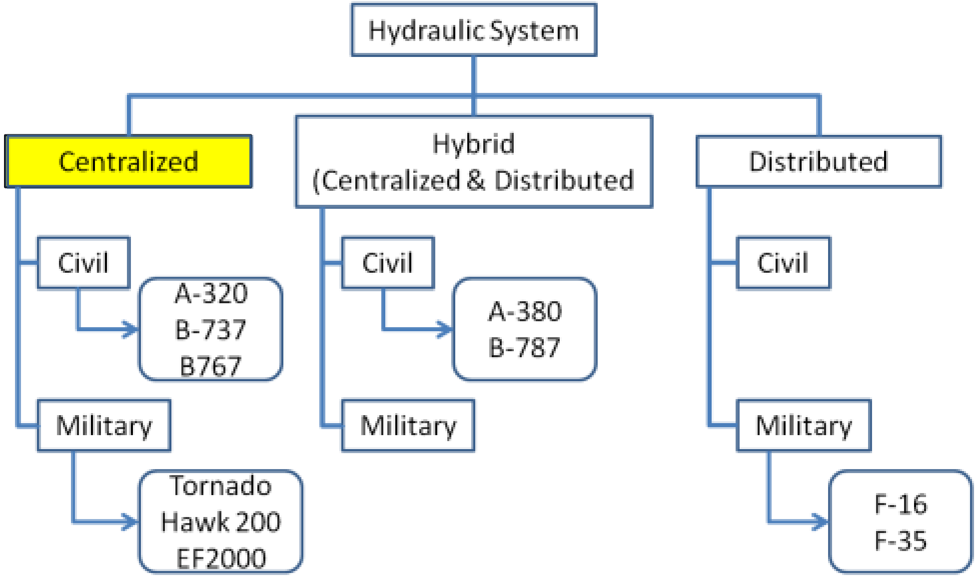
- component metadata
  - serve for the conncetion towards the used component library
  - contains:
    - component library link/information
    - port definitions
    - parameter (tuning) informations



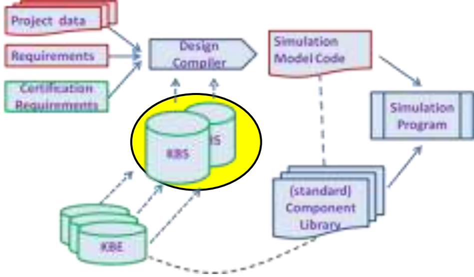
KBS Defintion: Actuation Power System



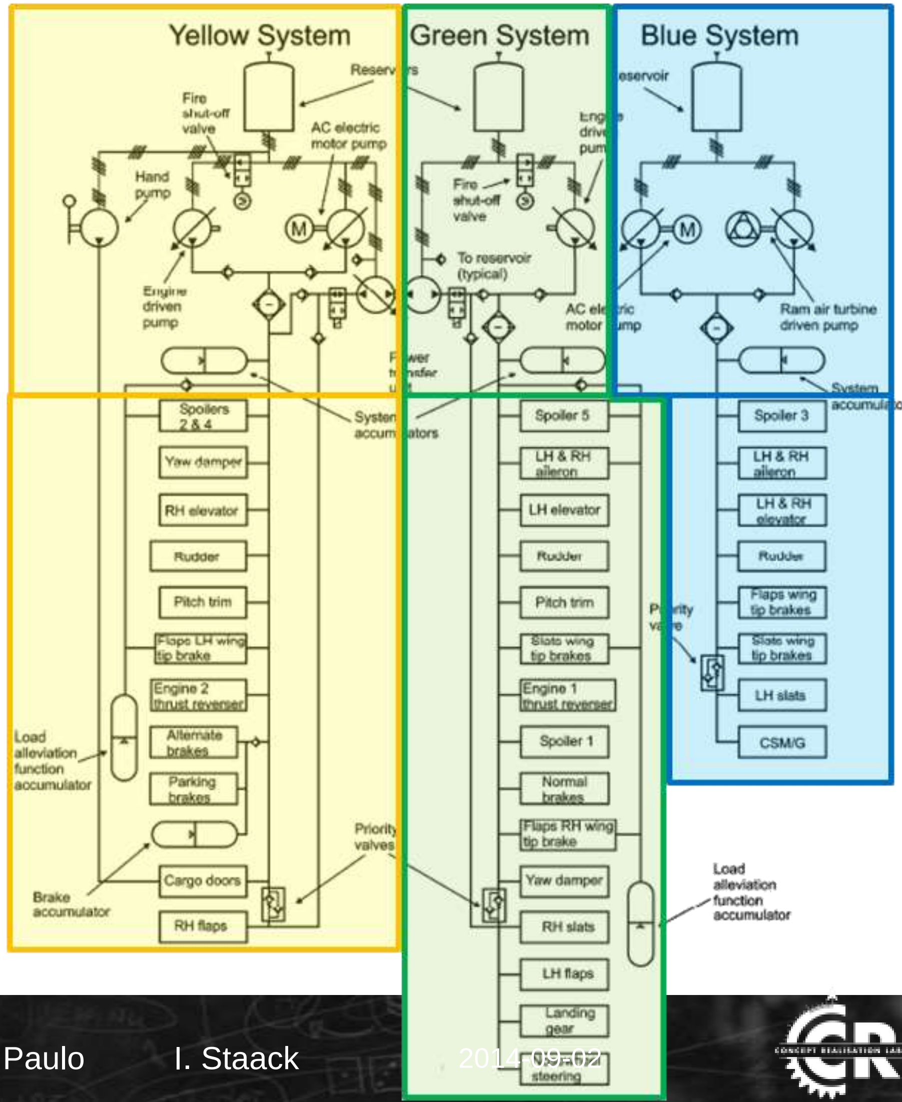
- (PFCS) hydraulic system layout development:
  - statistic data
  - expert knowledge
  - certification req.



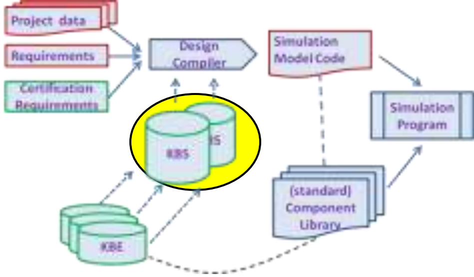
Hydraulic System Example: Civil FAR/JAR 25 Aircraft



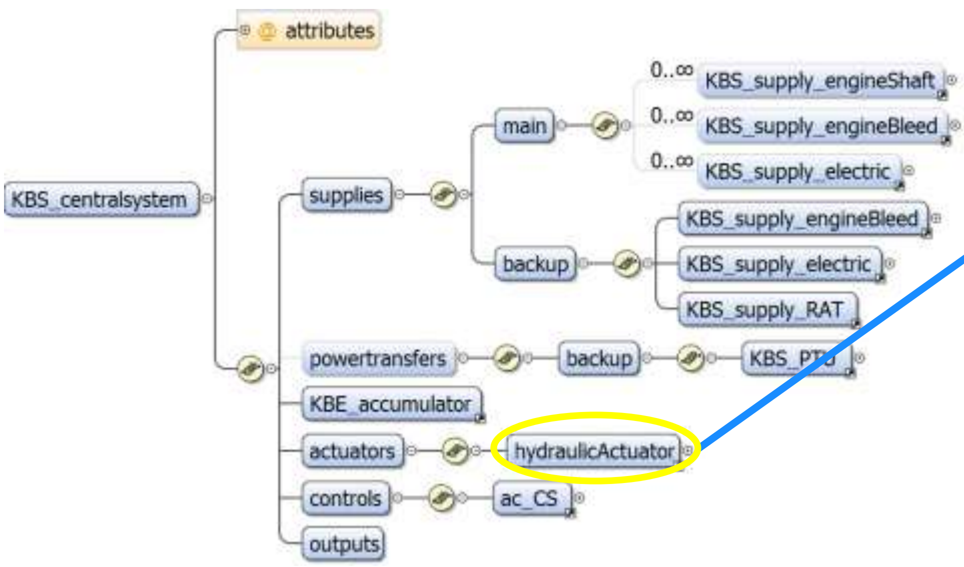
- usually 3 hydr. systems
  - 3 active
  - 2 + back-up
- split-up into:
  - I. supply system
    - a. primary
    - b. secondary (back-up)
  - II. power transfer
  - III. PFC actuators
  - IV. SFC actuators

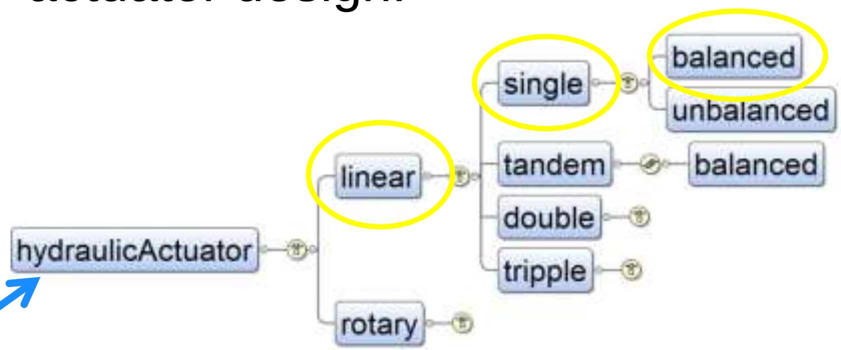


Metamodel / Layout Description of one Centralized Hydraulic System



- actuator design:

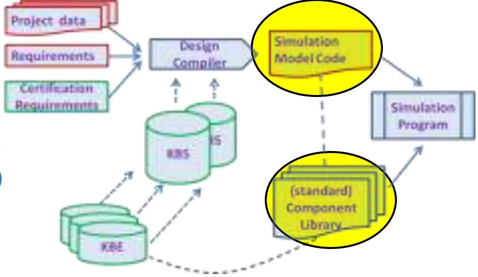




- with boundary conditions:
  - centralized
  - civil
  - PFC

→ Type selection: `single linear unbalanced actuator`

Sim. Model Instantiation of the KBS



KBS instantiation of:

```
hydraulicActuator(type= ”linear”
                  housing= ”single”
                  subtype= ”balanced”);
```

➢ Result: Hopsan model file (XML)

system		
	@name	KBS_LinkServo
	@typename	Subsystem
	objects	component (6 rows); systemport (4 rows)
	connections	

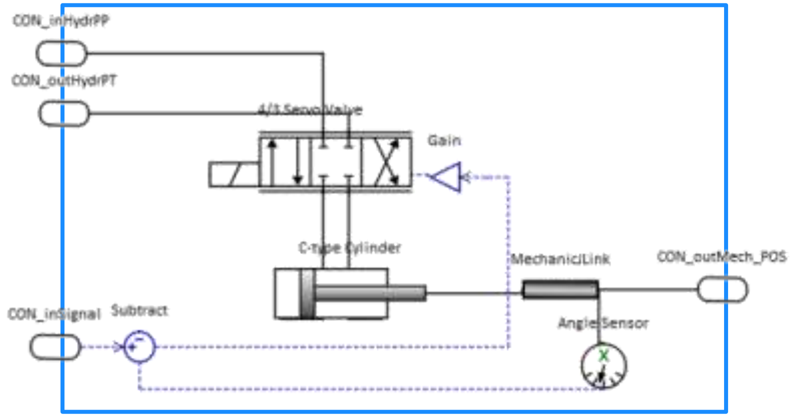
component (6 rows)

	@name	@typename	parameters
1	4/3 Servo Valve	Hydraulic43Valve	parameters
2	C-type Cylinder	HydraulicCylinderC	parameters
3	Gain	SignalGain	parameters
4	Subtract	SignalSubtract	parameters
5	MechanicJLink	MechanicTranslationalLosslessConnector	
6	Angle Sensor	MechanicPositionSensor	parameters

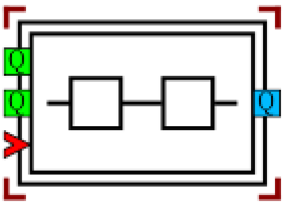
systemport (4 rows)

	@name	hopsangui
1	CON_inSignal	hopsangui
2	CON_inHydrPP	hopsangui
3	CON_outHydrPT	hopsangui
4	CON_outMech_POS	hopsangui

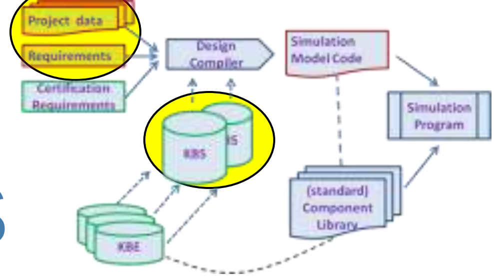
➢ System Level:



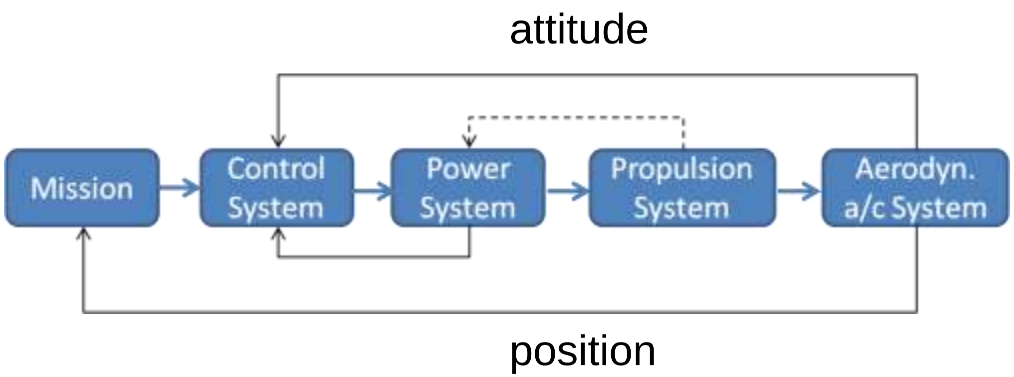
➢ Parentsystem level:



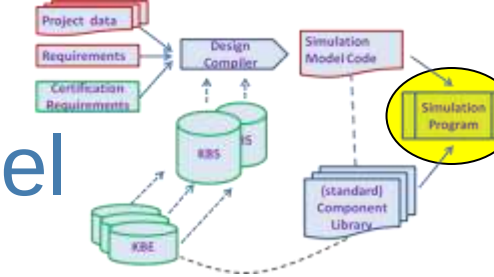
Methodology Application: Whole A/C Simulation incl. PFCS

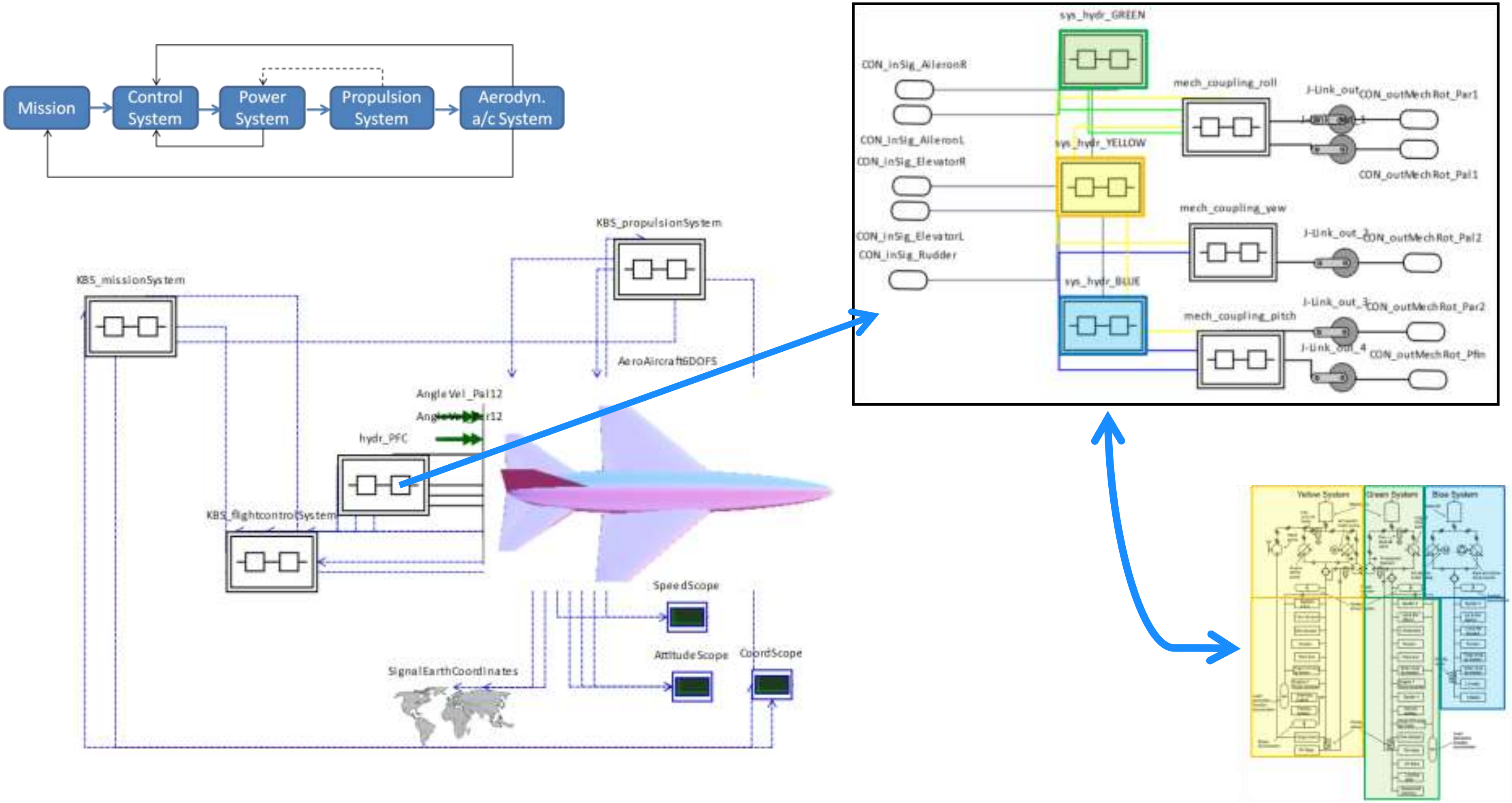


- Definition of the highest system level: KBS **”aircraft system”**
  - flat hierarchy of five **KBS**´s



Example Result: Simulation Model

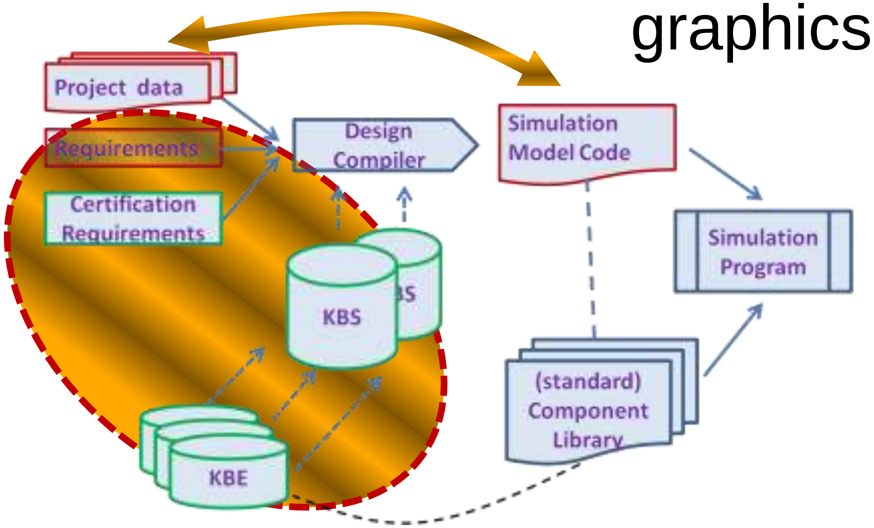




Conclusion & Future Work

- ✓ automated simulation integration process
- ✓ knowledge base approach
- ✓ backed by the XML language family
- ✓ Good adaptability

- ➢ design "compiler"
- ➢ requirement – KBS translation
- ➢ configurator integration
- ➢ simulation model graphics



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