Knowledge-based Aircraft Systems Integration

Raghu Chaitanya Munjulury, Ingo Staack, Petter Krus

Linköping University, SE-58183, Linköping, Sweden

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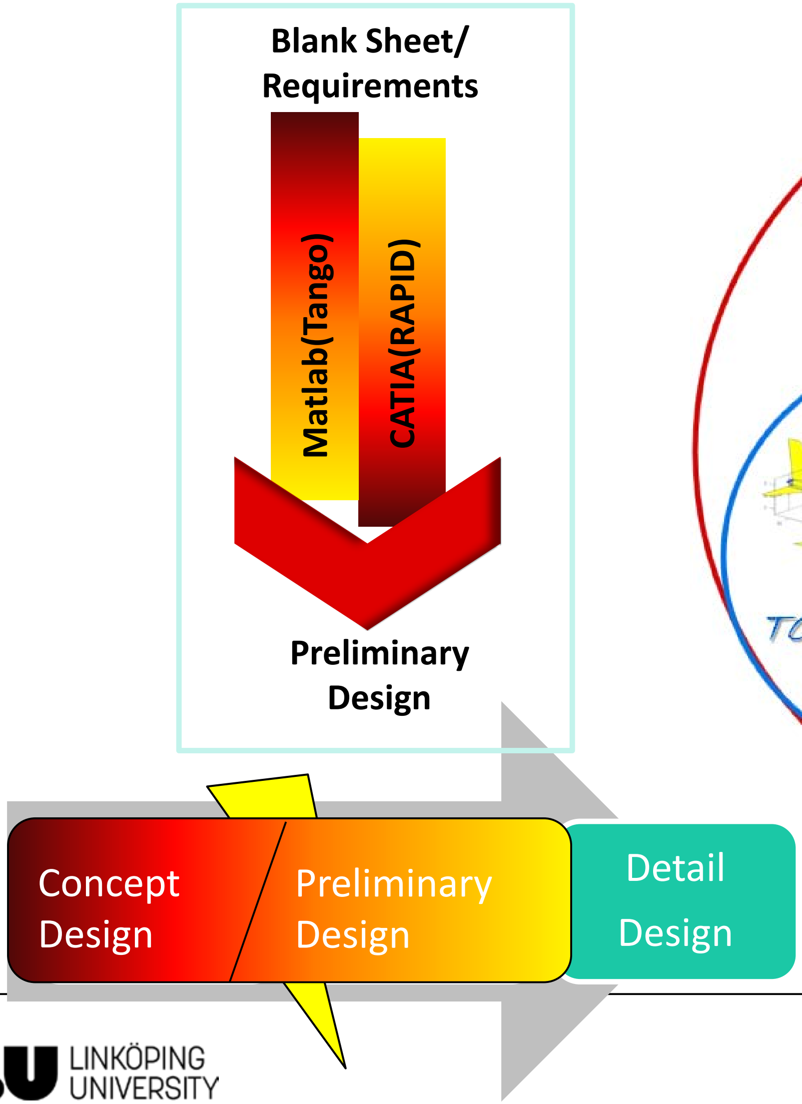
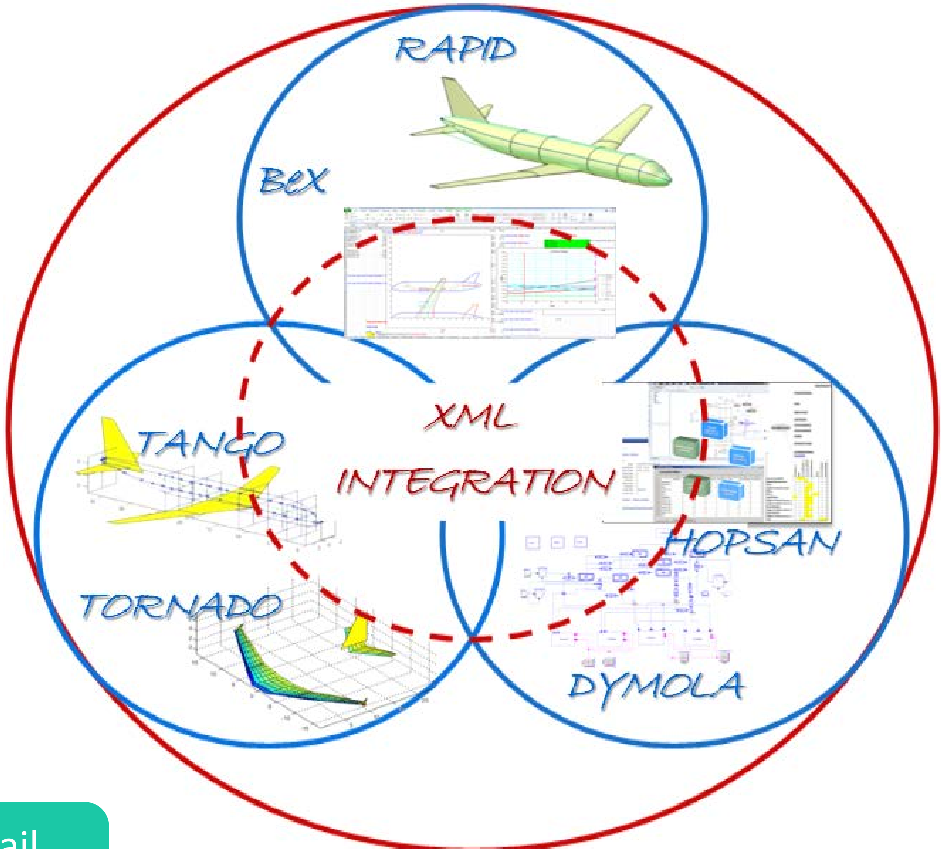
FluMeS
Fluid and Mechatronic Systems

Agenda

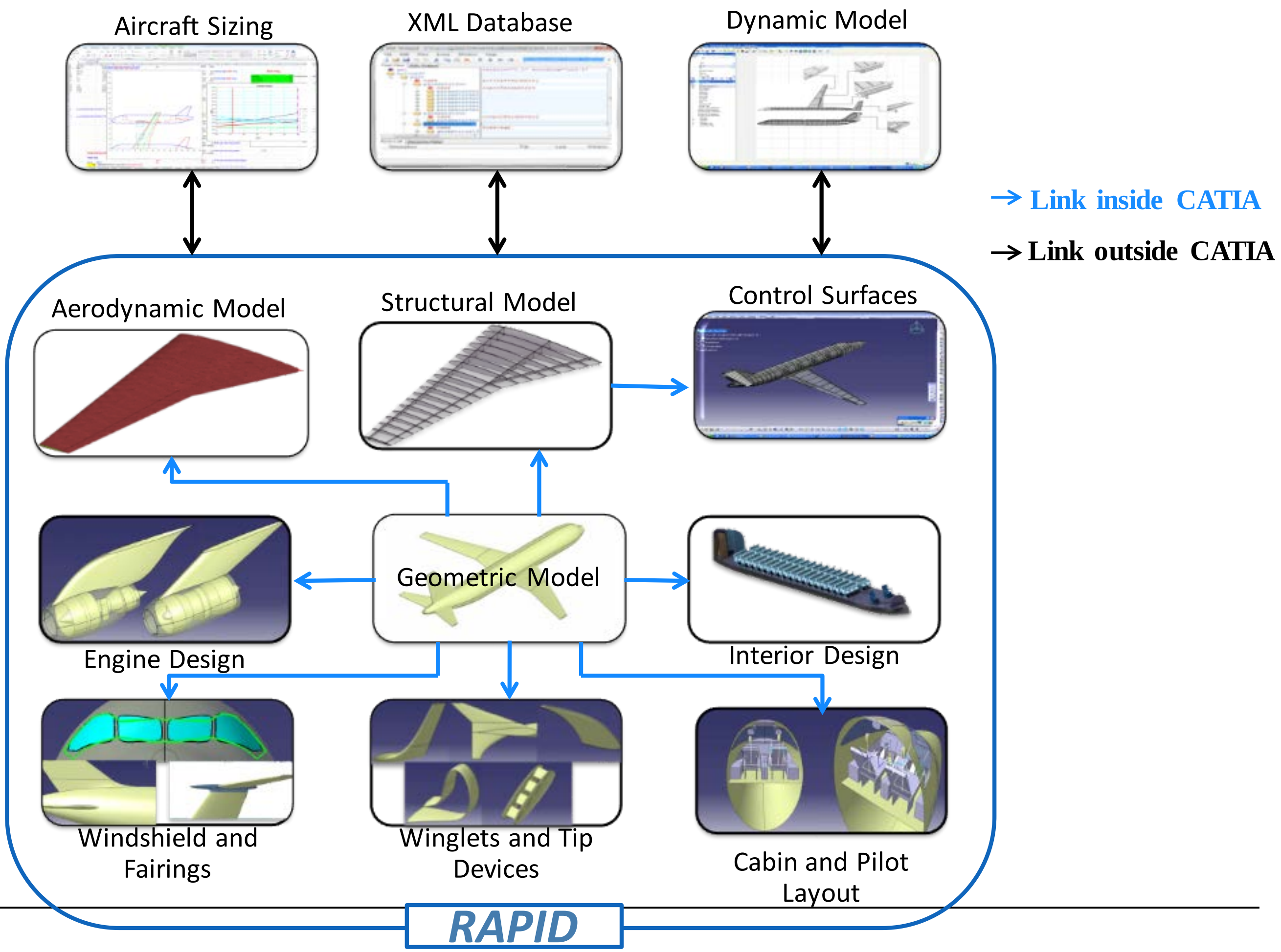
- Introduction
  - Framework
- Objective
- Systems Integration
  - Flight Control System Integration
    - Actuator Sizing
    - Control Surfaces Integration
  - Fuel systems
  - Landing gear integration
- Conclusions
- Future work

CADLab: Conceptual Aircraft Design Laboratory

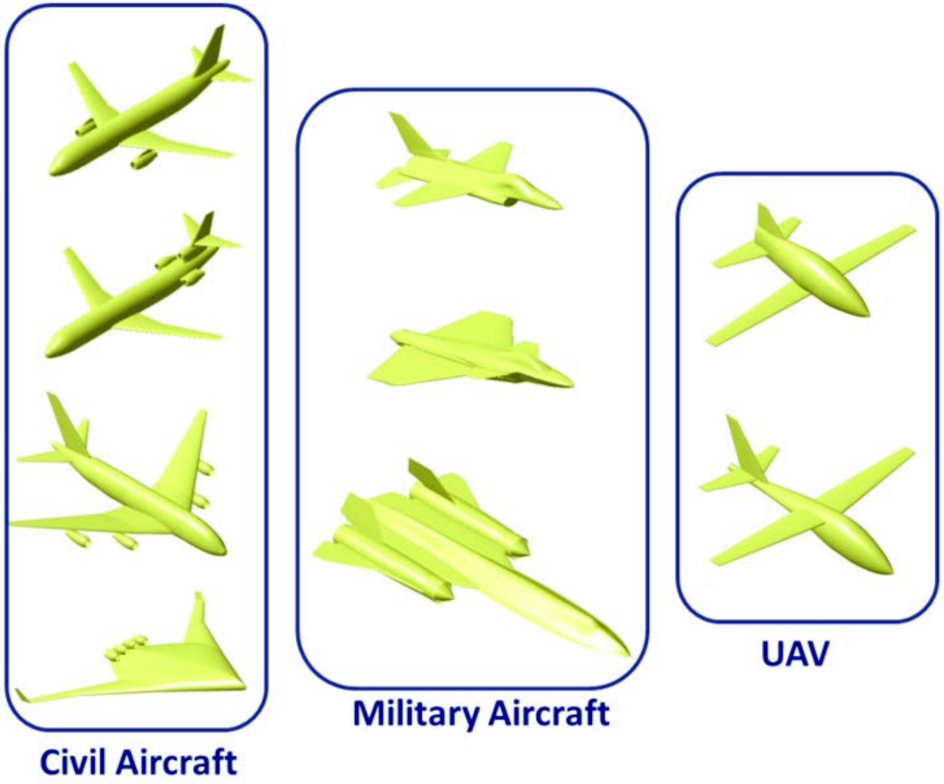




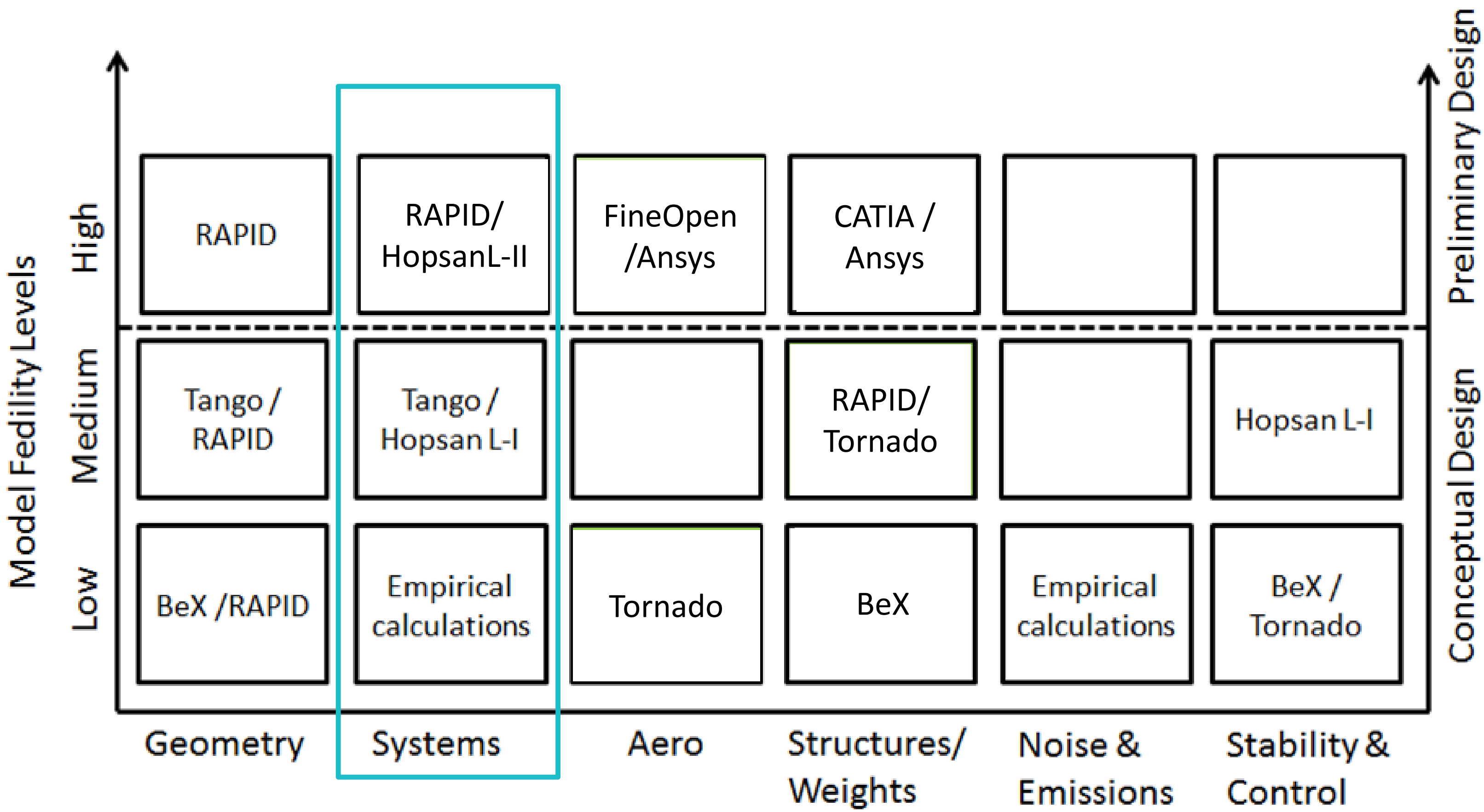
Knowledge-Based Geometry Design



Knowledge-Based Geometry Design



Framework Distribution



Objective

- To investigate the early design stages to define the aircraft systems integration.
- A knowledge-based parametric definition of different aircraft systems: FCS, Fuel system, Landging gear
- Use parameters to modify the general layout of the system.
- Measure variables used in conceptual design.

Flight Control System Integration

- Simplifications and Assumptions
  - Systems symmetry
  - Valves omission
  - Positioning of the flight control system
  - Flight control system
  - Routing
  - Hydraulic Power Assembly
  - Geometry simplicity

Flight Control System Integration

Hydraulic Circuit Basic Components		
NAME	QUANTITY	FUNCTION
Hydraulic Pump	2/system	It generates the hydraulic pressure which will power the actuators in the control surfaces.
Hydraulic Tank (Reservoir)	1/system	It storages the hydraulic fluid which transmits power within the circuit.
Regulating valve of the pump	2/system	It regulates the hydraulic fluid flow.
Hydraulic Accumulator	1/system	It storages hydraulic fluid which will be used in case of emergencies and peak performance.
Hydraulic conductors	N/A	They transfer the hydraulic fluid between the components of the circuit.
APU	1	It generates the hydraulic pressure which will power the actuators in the control surfaces.

Power and Control Units		
NAME	QUANTITY	FUNCTION
ARTCU	3	Deflection control unit.
Power Unit	1/actuators path	It powers a set of actuators.
Actuator Drive Assembly	1/actuator	It controls a specific actuator.
Electric Drive Unit	1	It powers slats rotary actuator.

Hydraulic Actuators		
NAME	QUANTITY	FUNCTION
Slats	1/surface	Rotary actuator which extends slats in the leading edge.
Ailerons	1/surface	It deflects ailerons' control surface.
Elevators	1/surface	It deflects elevators' control surface.
Rudder	1/surface	It deflects rudder's control surface.
Flaps	1/surface	It deflects flaps' control surface.
Spoilers	1/surface	It deflects spoilers' control surface.

Sizing - EHA

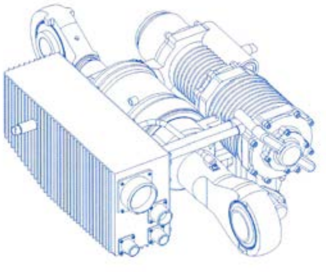


Figure 1. A330/340 Inboard Aileron EHA Solid Model

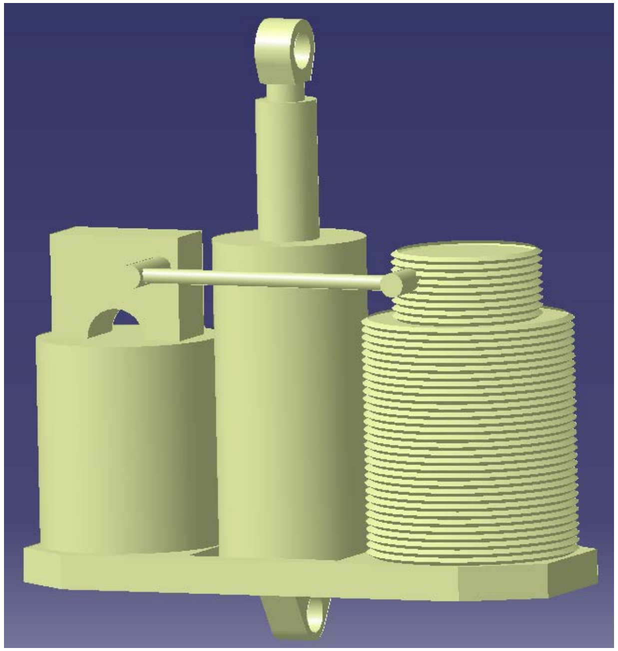
- Actuators based on an electric motor driven pump connected to a hydro-cylinder
- 5 main components: hydraulic cylinder, pump, motor, accumulator and power electronics
- Power electronics and accumulator size determined by their cooling surface, being considered as a cuboid
- It is assumed that motor and pump are on the same axis parallel to the cylinder

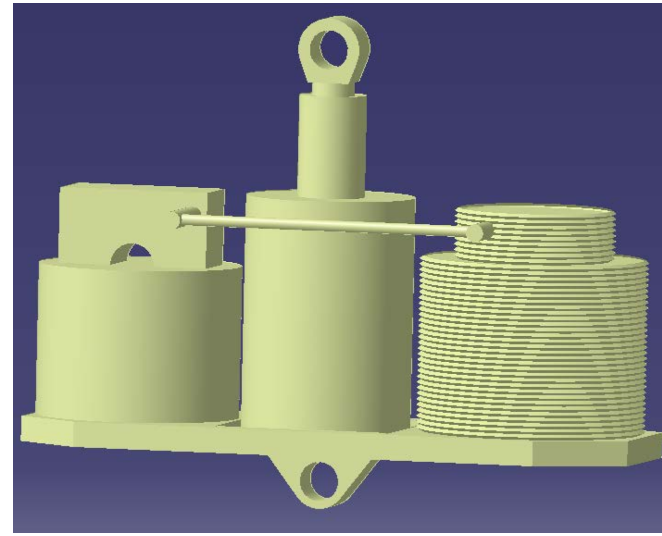
Sizing - EHA

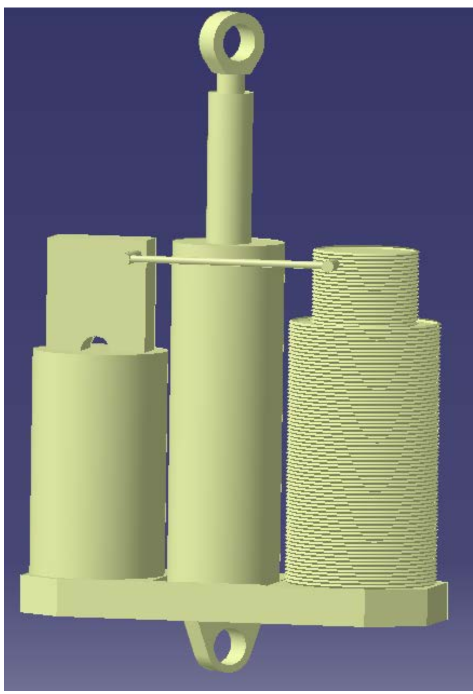
- The previous values and the table below (estimated statistically) allow to have a preliminary sizing of an EHA, depending on the value of the constants. With the dimensions of existing EHAs components it is possible to define those values.

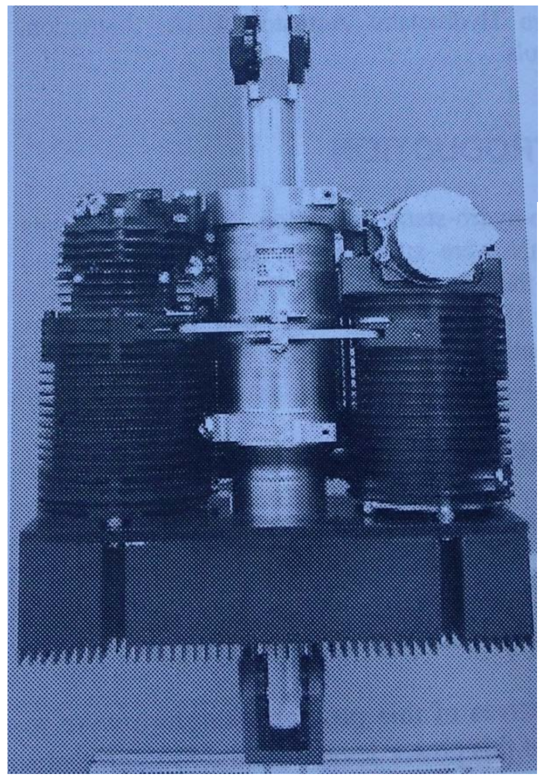
Component	**Parameters**	**Dimension Estimate**
Cylinder	piston diameter d_Z, stop-to-stop stroke $x_{\max} - x_{\min}$	$h_{Zyl} \approx k_0 + k_1\, d_Z$ $b_{Zyl} \approx k_2 + k_3\, \frac{d_Z^2}{h_{Zyl}}$ $l_{Zyl} \approx k_4 + k_5\, (x_{\max} - x_{\min})$
Axial piston pump	geometric displacement $V_{g\max}$, typical $\frac{l_P}{\sqrt{A_P}} =: \lambda_P,\ A_P = b_P \cdot h_P$	$l_P \approx k_0\, \lambda^{\frac{2}{3}}\, \sqrt[3]{1 + k_1\, V_g}$ $d_P \approx 2\sqrt{\frac{A_P}{\pi}} = \frac{2}{\sqrt{\pi}}\, \frac{l_P}{\lambda_P}$
AC induction / brushless DC motor	nominal torque $M_{mot,nom} := \frac{P_{mot,cont}}{n_{mot,\max}}$	$V_{mot} = \frac{\pi}{4} d_{mot}^2\, l_{mot}$ $V_{mot} \approx k_0\, M_{mot,nom}^{k_1}$

Frischemeier, S. (1997), 'Electrohydrostatic actuators for aircraft primary flight control-types, modelling and evaluation'.









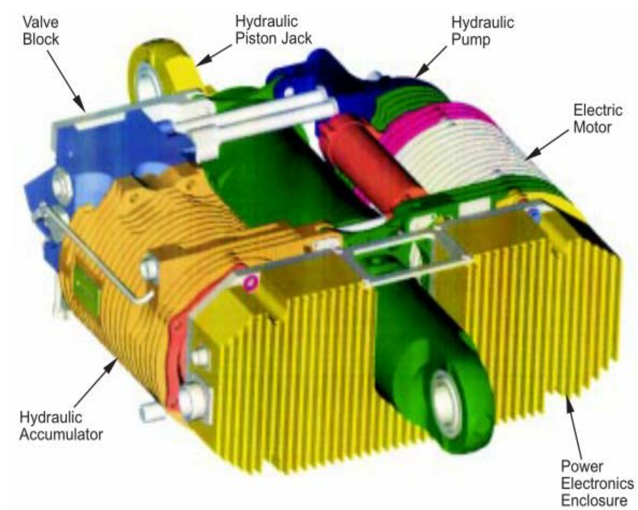


Figure 2. Large EHA

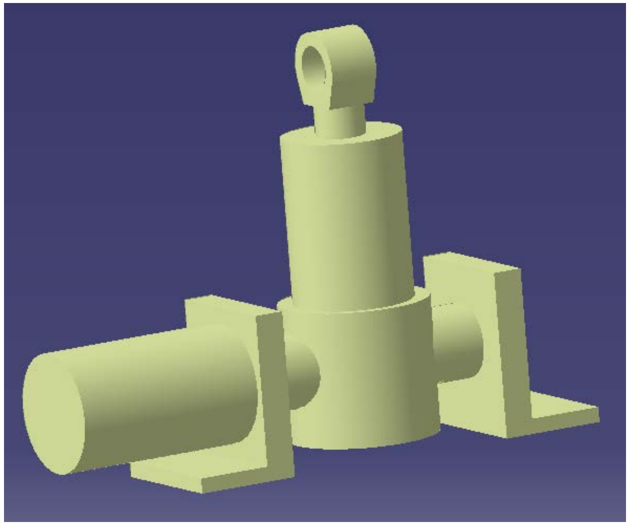
Sizing - EMA

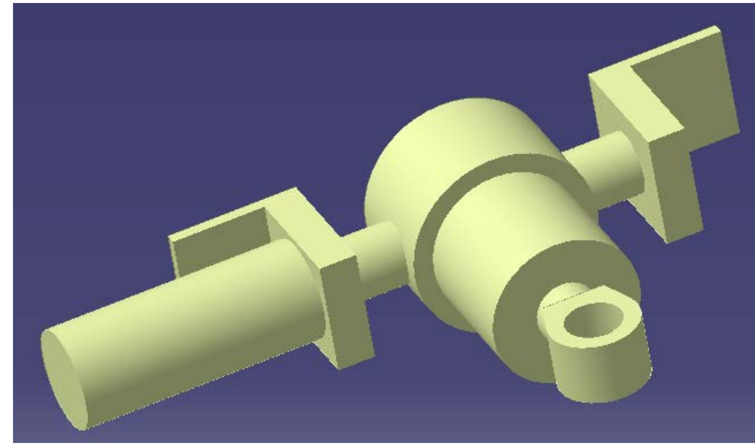
- Actuator where a mechanical gearing is used to couple an electric motor to a flight control surface.
- Aerospace EMA major components: Brushless motor (cylindrical or annular); Gearbox, Spur gear or Cycloidal reducer; ball or roller screw, Spherical, axial or radial load bearing
- Main design model: Scaling laws

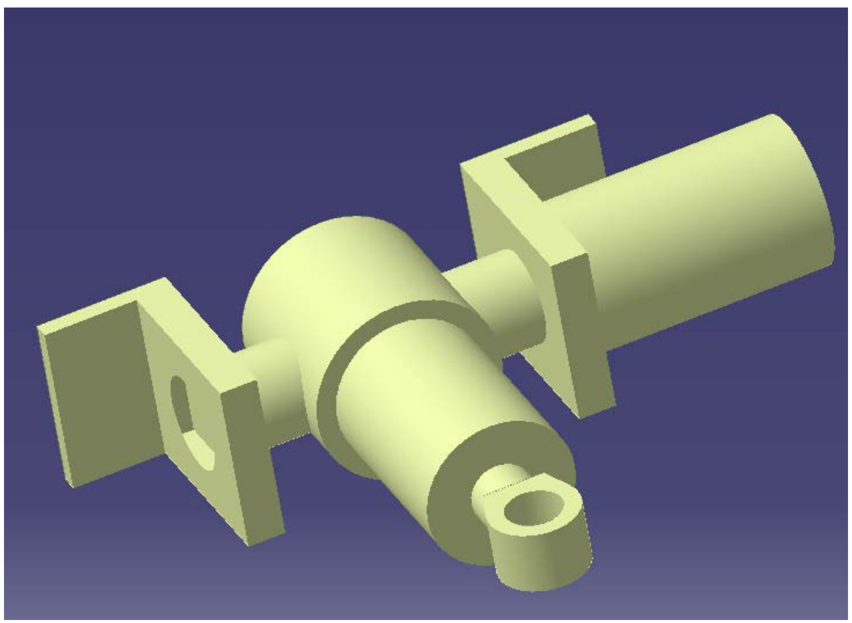
Scaling Laws

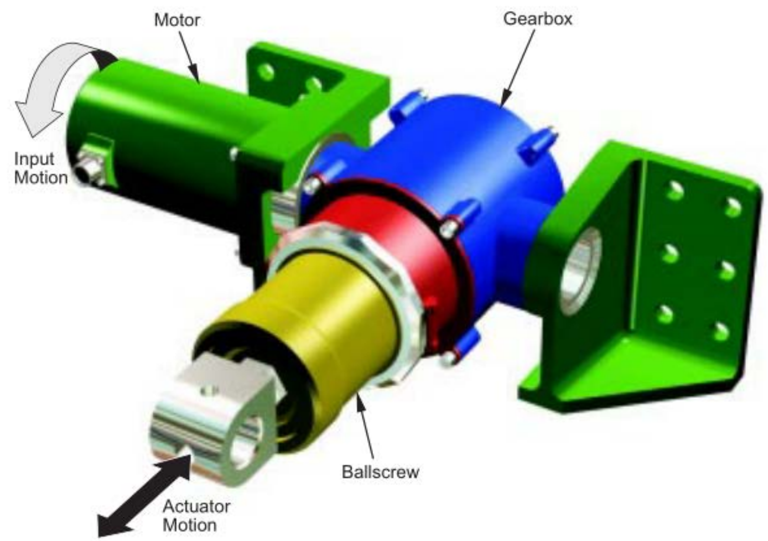
- Scaling laws evaluates the effect of varying parameters of a component compared to a known reference
- Scaling ratio of a paremeter: $x^* = x/x_{ref}$
- 2 main assumptions:
  - All material properties are identical to those of the reference
  - The ratio of all the lengths of the considered element to all the lengths of the reference component is constant
- Parameters representing geometric quantities can be directly obtained from the assumption of geometric similarity: $V^*=l^{*3}$, $M^*= l^{*3}$

Botten, S. L., Whitley, C. R. & King, A. D. (2000), 'Flight control actuation technology for next generation allelectric aircraft', Technol. Rev. J 23(6), 55–68.









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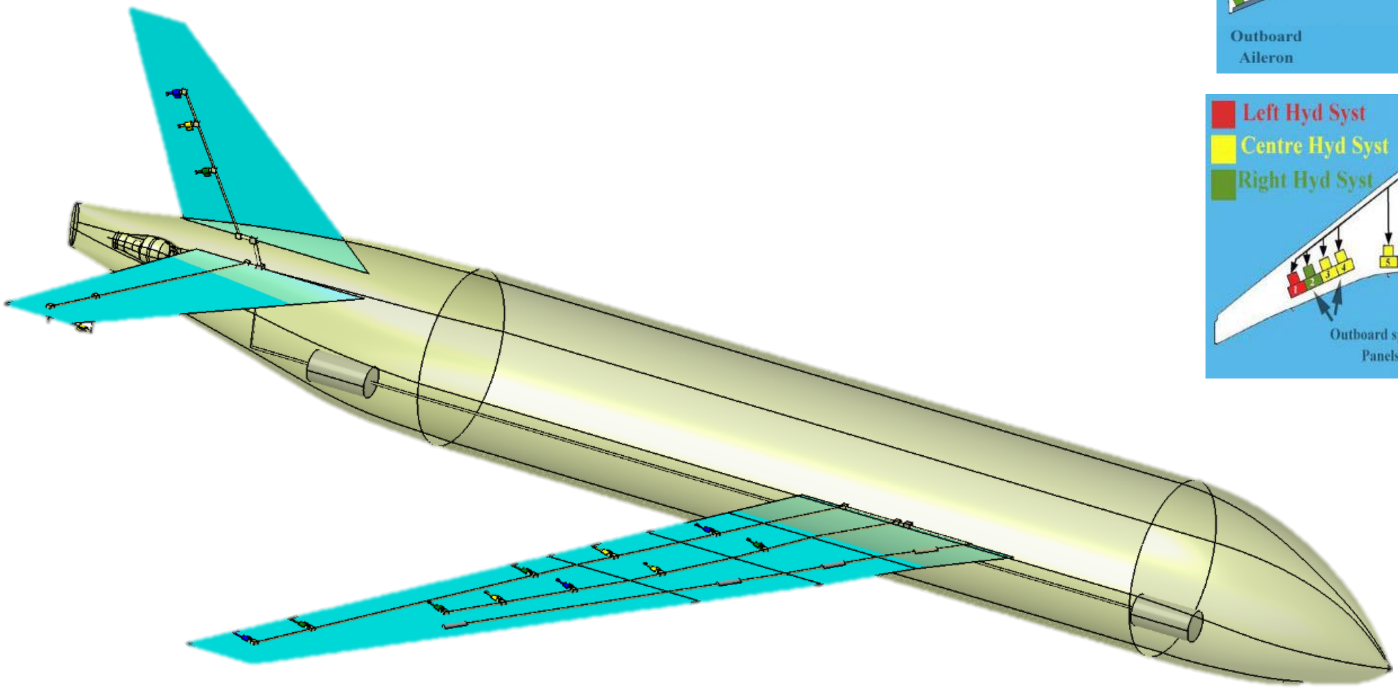
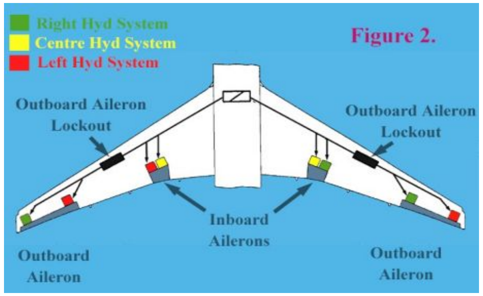
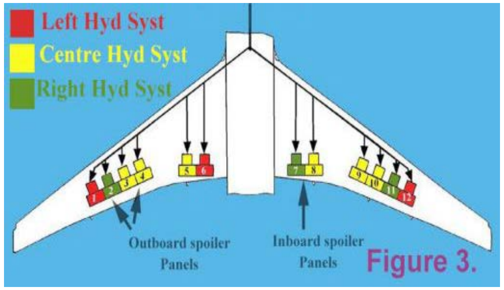
Botten, S. L., Whitley, C. R. & King, A. D. (2000), 'Flight control actuation technology for next generation allelectric aircraft', Technol. Rev. J 23(6), 55–68.

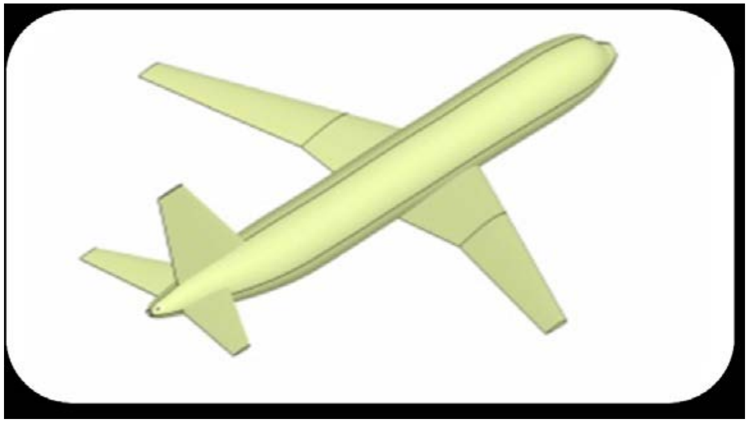
Flight Control Systems Integration

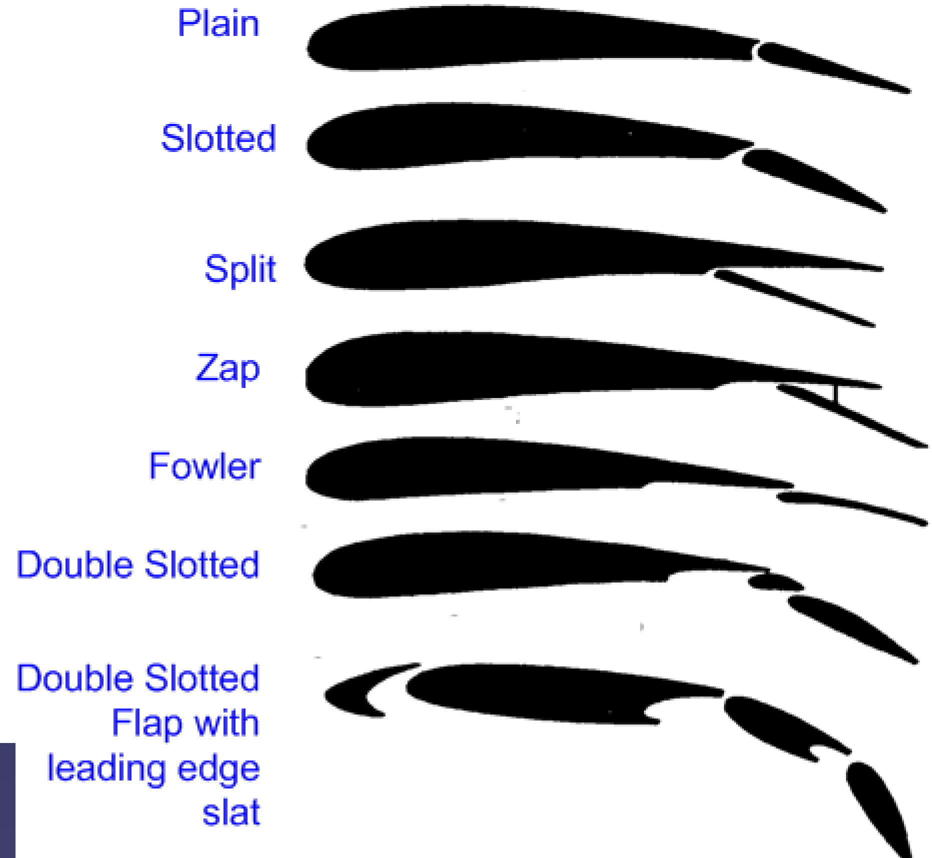


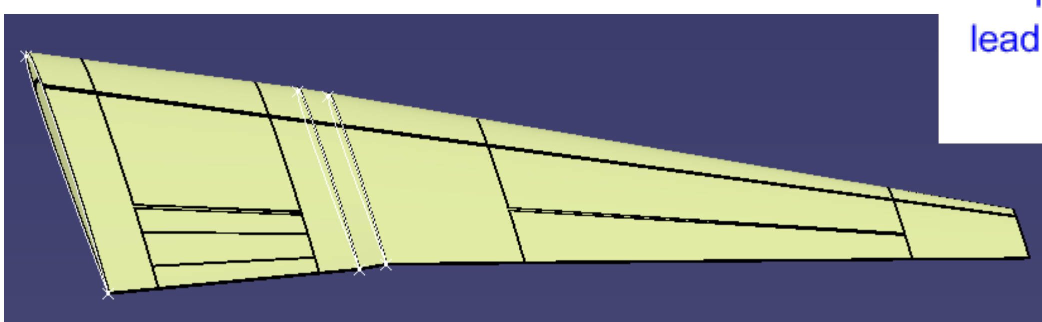




Control Surfacecs Integration

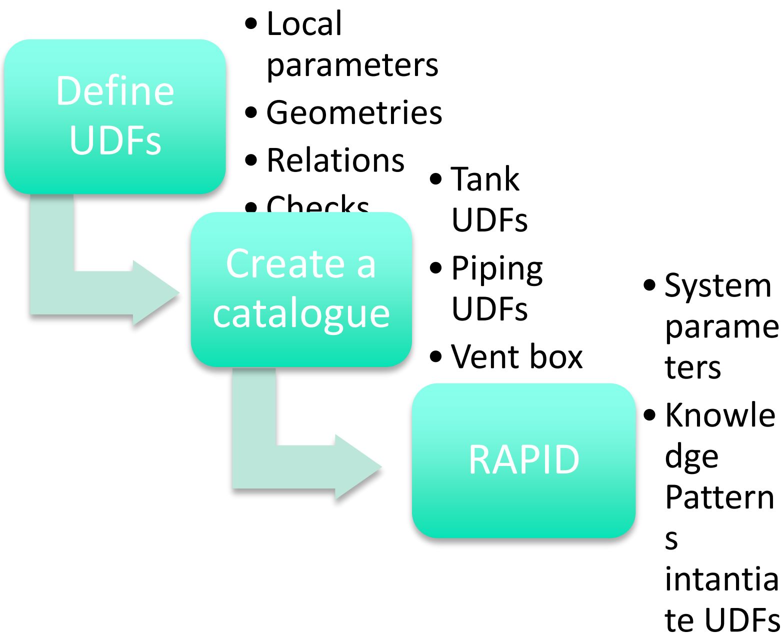






Aircraft fuel Systems - Method

- Description

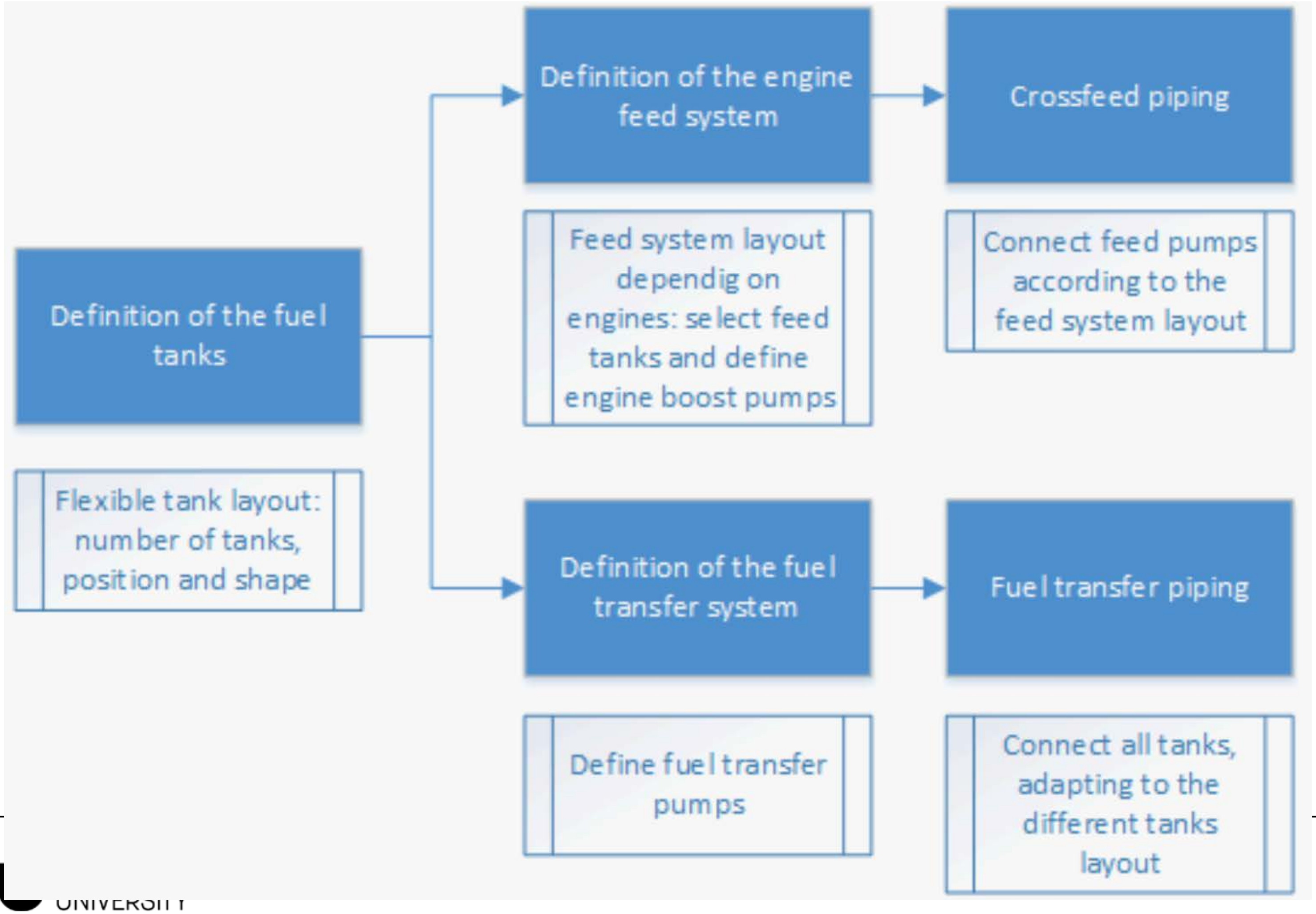


- A Knowledge Based Engineering (KBE) approach was used to define the system:
- Reusable information is previously defined and then automatically instantiated in a new environment with new inputs.
- User Defined Features contain flexible and parametric component models.

Method - Simplifications

- All geometries are symbolic, representing a space allocation inside the aircraft for the fuel system. A realistic representation of real components can be realized in detail design.
- Smaller geometries such as valves or fuel intakes inside the tanks are not represented/modeled.
- The fuel quantity measuring system is not included.
- Symmetry is applied in the whole system, but both sides are represented.
- Fuel tubing or piping is represented with direct lines between two pumps or tanks and represent the minimum length needed for this component. An exception for this is the pipe connecting fuel tanks from the tail to the fuselage, which is represented with more detail.
- Wing and horizontal stabilizer spars are represented as surfaces limiting the tanks.

Method - Work flow



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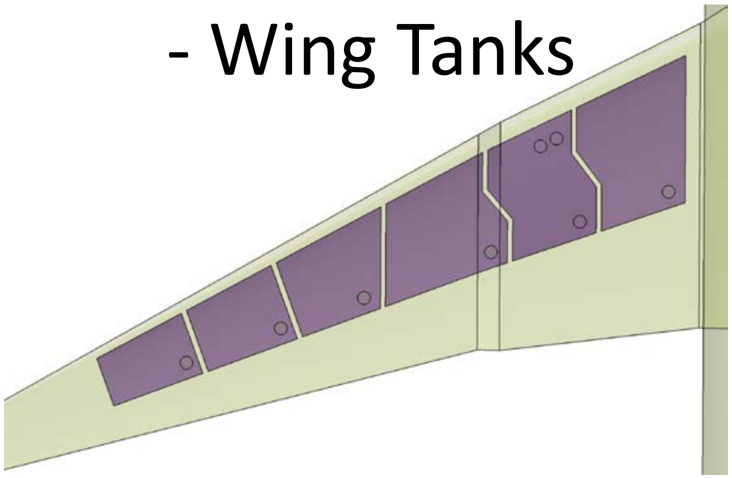
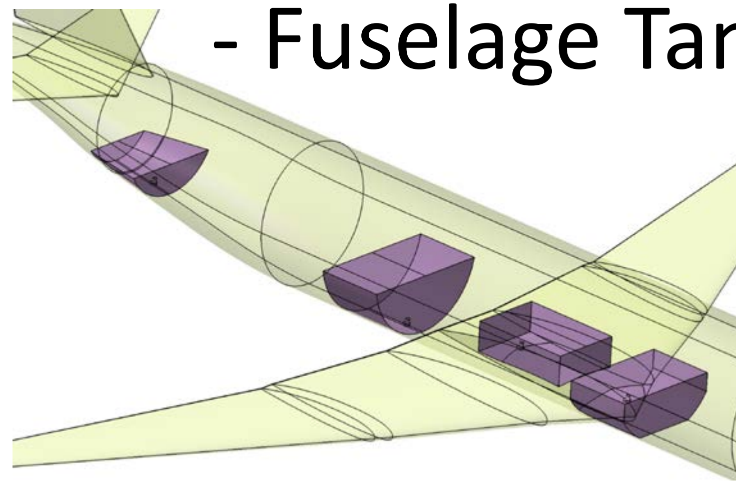
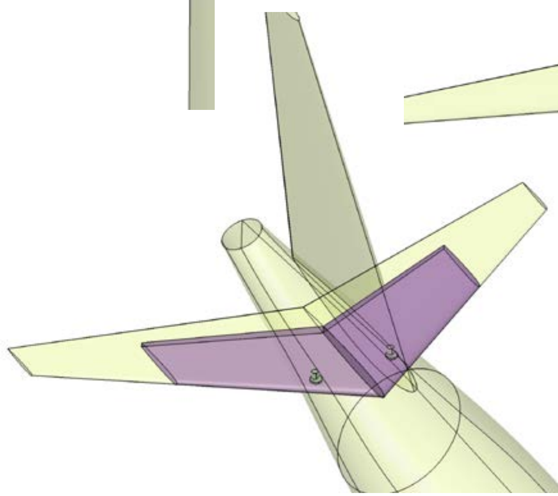
Functions implemented

- Wing Tanks



- Fuselage Tanks



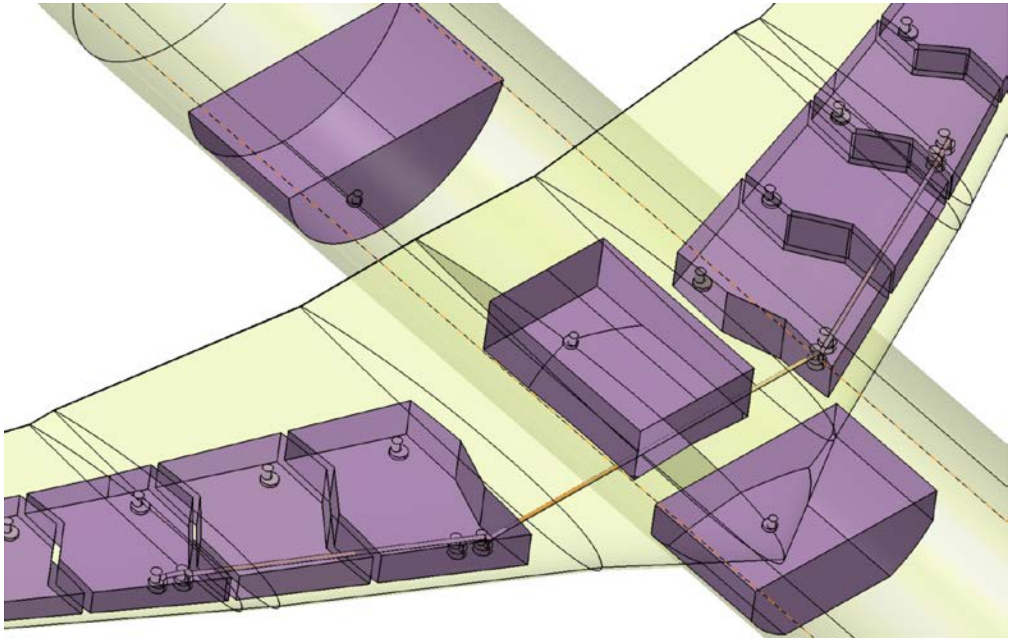


- HT Tanks

Functions implemented

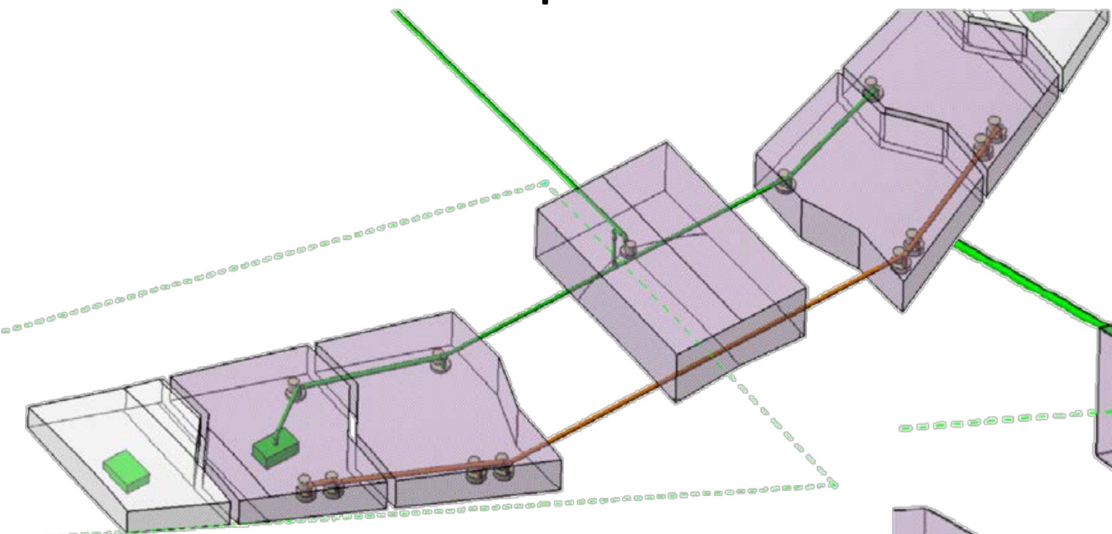
- Engine feed

- Feed pumps and tanks arrangement for 1 to 4 engines configuration.
- Centrifugal feed pumps (most common) of 3 types:
  - Skin mounted.
  - Cartridge-cannister.
  - Spar mounted.
- Redundancy selectable.
- Crossfeed piping selectable.

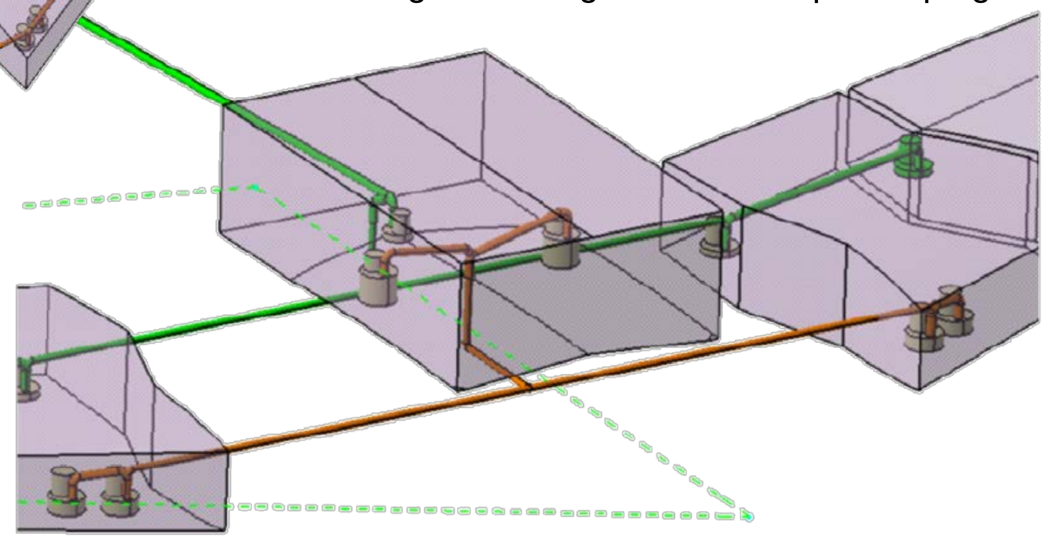


Functions implemented

- Fuel transfer

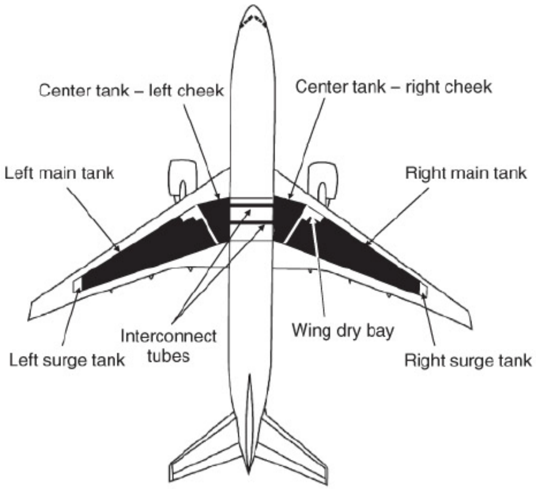


3-engines configuration with 3pointPiping

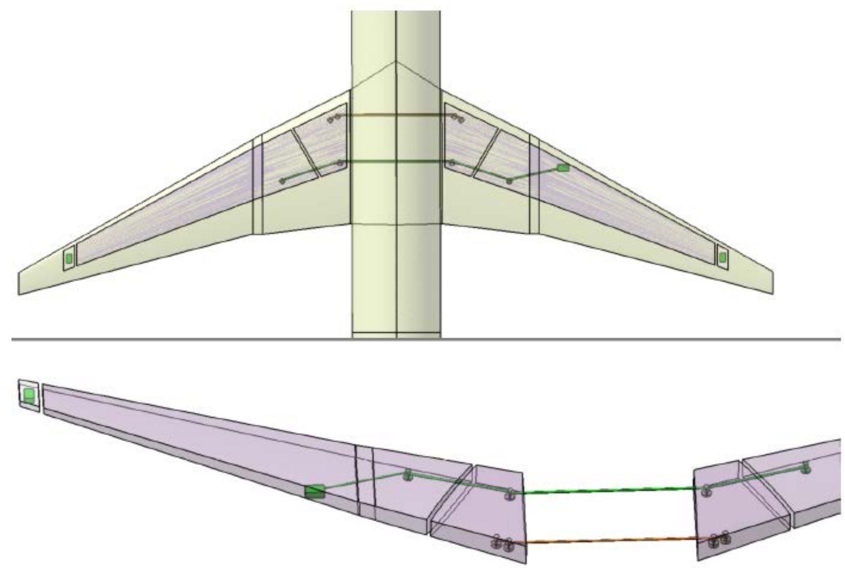


Crossfeed piping shown in orange; connecting four feed tanks with pump redundancy.
Transfer piping is shown in green, including the aircraft's refuel station.

Results

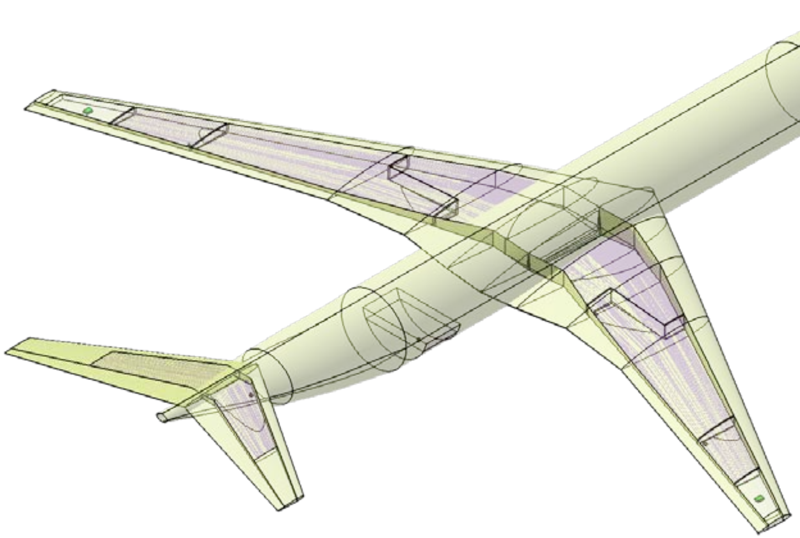


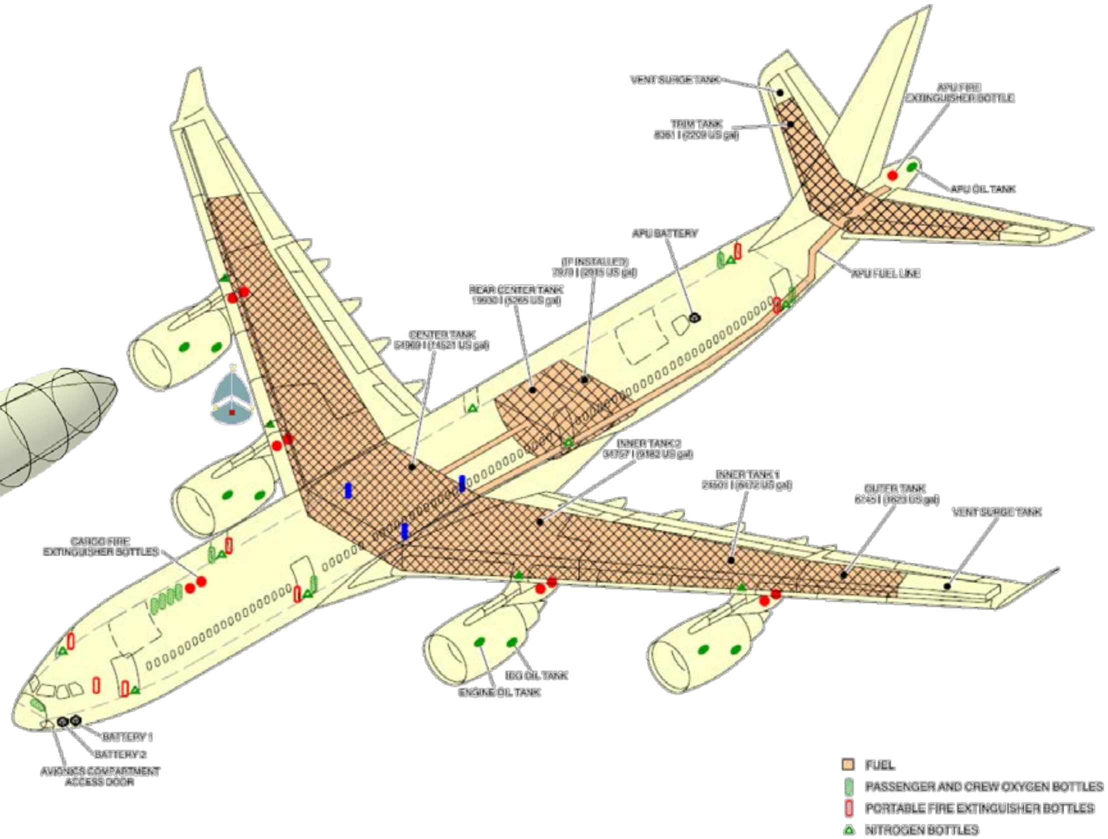
Boeing 777-200 fuel tank arrangement



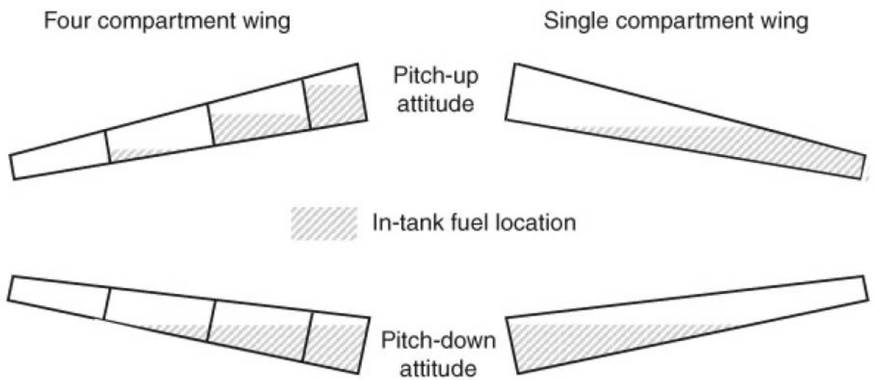
Representation of B777-like fuel systems in RAPID

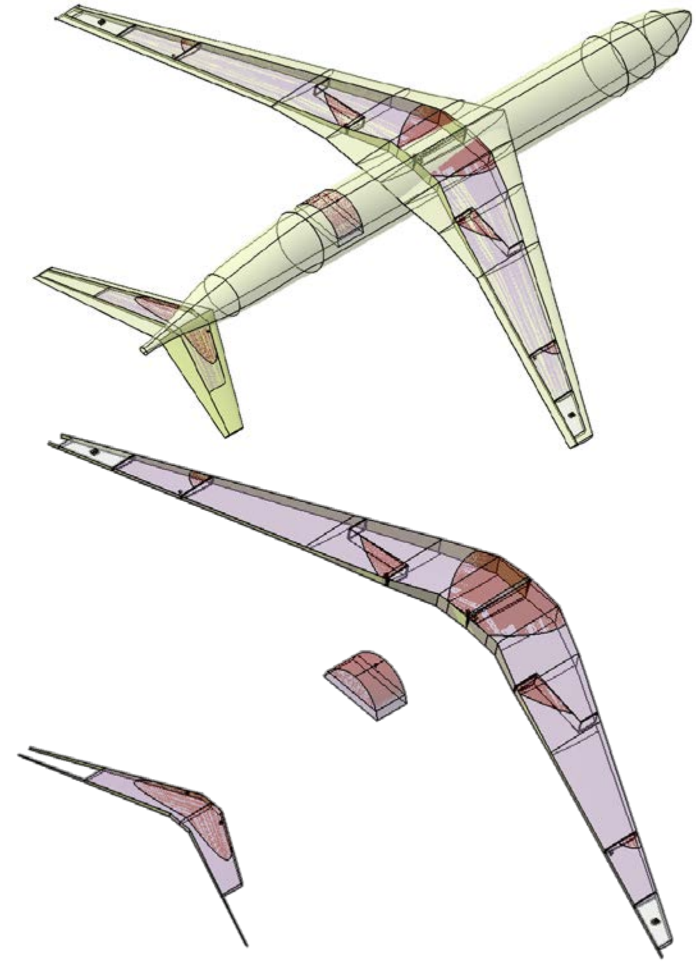
Results





A340- 500 like fuel representation


Four compartment wing
Single compartment wing
Pitch-up
attitude
In-tank fuel location
Pitch-down
attitude

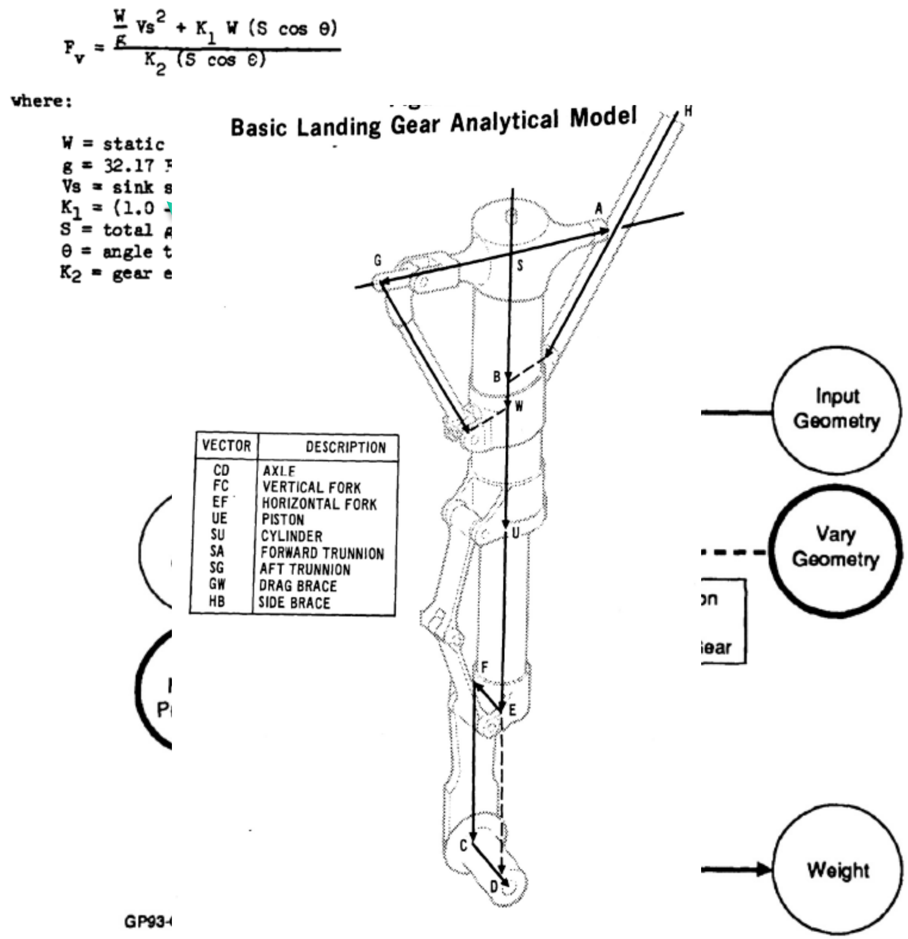


Fuel System Analysis

- The modeled fuel system can be used for enhanced center of gravity analysis. One important objective is the shift of the center of gravity due to the aircraft attitude (bank, roll, yaw) and accelerations in combination with the filling level of each tank.
- Surrogate models of the weight and center of gravity are created for every tank on the total system level.
  - These surrogate models may be used to study the center of gravity shift due to different filling-/emptying patterns, enabling the development (and inclusion) of a behavioral model for the fuel system.
  - A discrete mission point analysis on a enhanced conceptual aircraft design level, enabling a higher fidelity than normally applied in this stage of development which can be used to study the effects of a reduced stability or unstable configurations.
  - With the availability of the surrogate tank models and the behavioral concept, the fuel system can easily incorporated in other component based simulations (such as Modelica or Hopsan), enabling a very efficient way of detail investigations of the fuel system.

Introduction

- Paul R. Kraus shows a way to compute an analytical approach using bending moments in the LANGE program. His conclusion is that results obtained using an analytical method are more sensitive. Robert H. Wille describes how the LANGE program operates and modified it to extend its database to consider unconventional landing gears.



Kraus, P. R. (1970) An Analytical Approach to Landing Gear Weight Estimation. McDonnell Aircraft Corporation, St. Louis, Missouri.
Willie, R. H. (1989) Analytical weight estimation of unconventional landing gear designs. McDonnell Aircraft Corporation, Alexandria, Virginia.

Objectives for Case Study

- To study F-15 Eagle, F-16A, T-45A, and AV-8B (point-to-point analysis was performed to find the loads applied in the structure, Previous studies carried out by McDonnell Douglas [(Kraus, 1970), (Willie, 1989)]
- In the present study, a bending moment analysis is used to find out the loads affecting the structure and be able to compute the weight.
  - For bending moment analysis, landing gears have been simplified, the most important components such as pistons and main bars are considered.
  - The simplification also includes avoiding small bars and other components that do not take part in the load analysis.

Load Cases

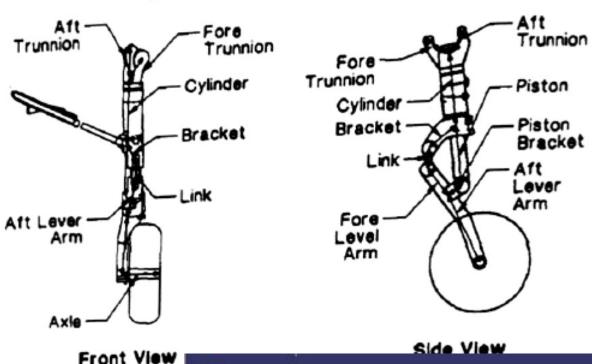
- Two/Three Point Landing (Case 1)
- Tail Down Landing (Case 2)
- Lateral Drift Landing (Case 3)
- Braked Roll (Case 4)
- Ground Turning (Case 5)
- Pivoting (Case 6)

Analytical Development

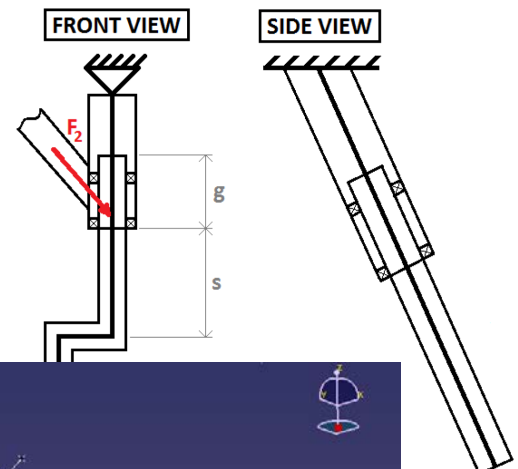
- The structural simplification of the models is made in order to ease the mathematical approach. (F-15 E, F-16A, T-45A, and AV-8B)
  - External reactions calculation
  - Bending moments calculation
  - Tubes sizing
  - Weight calculation

Analytical Development - *External reactions* - **T-45A**

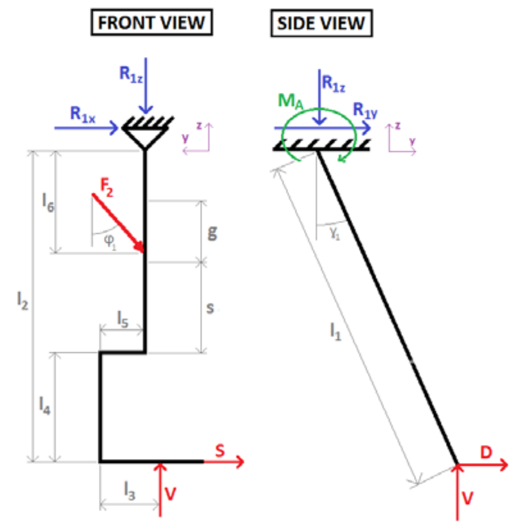
Original Structure

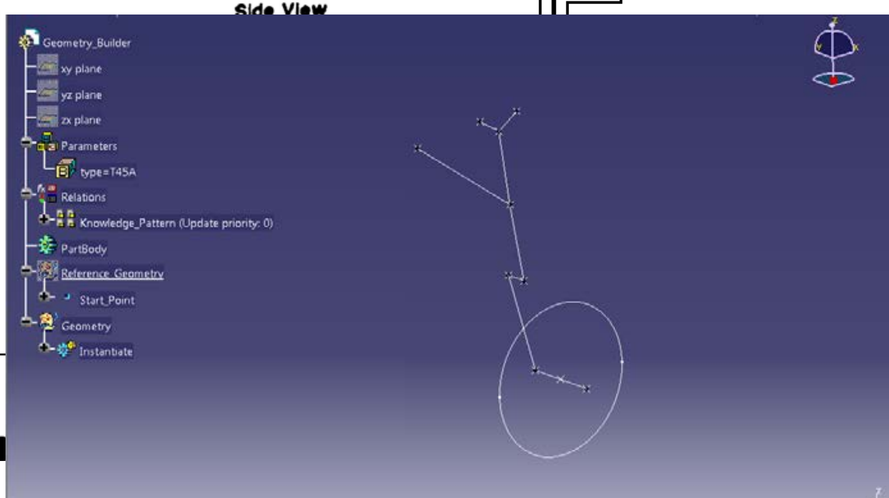


Simplified



External reactions





Analytical Development - *External reactions* - **T-45A**

- The structure is simplified in the front view by ignoring the existence of a drag brace and replacing it by an applied force directly into the main vertical bar.
- The bar that links the drag brace with the main bar that is used to guide the rotation of the landing gear is substituted by an all degree of freedom restriction. With respect to the side view, the model is considered as a cantilever.

- **Front View**

$$\Sigma F_x = 0 \rightarrow R_{1_x} + D = 0 \rightarrow R_{1_x} = -D$$
$$\Sigma F_z = 0 \rightarrow -R_{1_z} + V = 0 \rightarrow R_{1_z} = V$$
$$\Sigma M_A = 0 \rightarrow M_{A_1} = D \cdot \cos(\gamma_1) \cdot l_1 + V \cdot \sin(\gamma_1) \cdot l_1$$

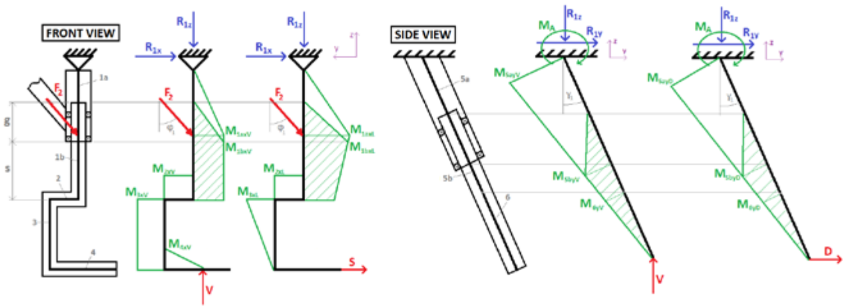
Note: For cases 4 to 6, l_1 refers to: $$l_1 = l_1 - \frac{s \cdot f}{\cos(\gamma_1)}$$

- **Side View**

$$\Sigma F_y = 0 \rightarrow R_{1_y} = -S - F_2 \cdot \sin(\phi_1)$$
$$\Sigma M_B = 0 \rightarrow F_2 = \frac{S \cdot l_2 + V \cdot (l_3 + l_5)}{l_6 \cdot \sin(\phi_1)}$$
$$R_{2_y} = F_2 \cdot \sin(\phi_1)$$
$$R_{2_z} = F_2 \cdot \cos(\phi_1)$$

Note: For cases 4 to 6, l_2 refers to: $$l_2 = l_2 - (s \cdot f)$$

Analytical Development – *Bending Moments* - **T-45A**



- the relation between the external cylinder and the piston need to be kept in mind, each element is sized, different bending moments are taken into consideration.

- **Front View. Vertical Loads**

$$M_{1a_{x_V}} = M_{1b_{x_V}} = M_{2_{x_V}} = M_{3_{x_V}} = M_{4_{x_V}} = V \cdot l_3$$

- **Front View. Side Loads**

$$M_{1a_{x_S}} = S \cdot (l_2 - l_6)$$
$$M_{1b_{x_S}} = S \cdot (l_4 + s)$$
$$M_{2_{x_S}} = M_{3_{x_S}} = S \cdot l_4$$
$$M_{4_{x_S}} = 0$$

Note: For cases 4 to 6, s and l_2 refer to:

$$s = s \cdot (1 - f)$$
$$l_2 = l_2 - (s \cdot f)$$

- **Side View. Vertical Loads**

$$M_{5a_{y_V}} = V \cdot \sin(\gamma_1) \cdot l_1$$
$$M_{5b_{y_V}} = V \cdot \tan(\gamma_1) \cdot (l_4 + s)$$
$$M_{6_{y_V}} = V \cdot \tan(\gamma_1) \cdot l_4$$

- **Front View. Drag Loads**

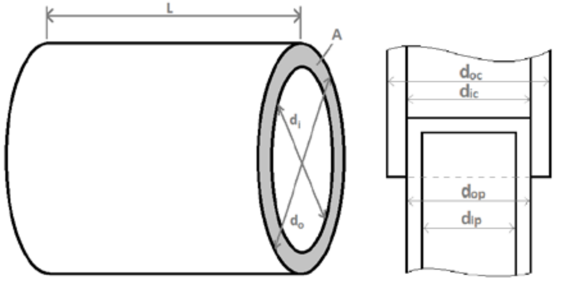
$$M_{5a_{y_D}} = D \cdot \cos(\gamma_1) \cdot l_1$$
$$M_{5b_{y_D}} = D \cdot (l_4 + s)$$
$$M_{6_{y_D}} = D \cdot l_4$$

Note: For cases 4 to 6, s and l_1 refer to:

$$s = s \cdot (1 - f)$$
$$l_1 = l_1 - \frac{s \cdot f}{\cos(\gamma_1)}$$

Analytical Development – *Tube Sizing*

- Based on the length and inner diameter information, the outer diameter is sized.
- It is clear that the inner diameter of the external cylinder needs to be equal to the outer diameter of the piston. Therefore, the piston has to be sized first by letting the user input the desired inner diameter.
- The external cylinder is sized after the outer piston diameter is obtained.
- If the length and the inner diameter of a tube are known, the elastic section modulus formulas of a hollow cylinder can be used so as to obtain the outer diameter.
- As the equations are of 4th order, there are four possible solutions. Two of them always have an imaginary part, therefore they can be discarded. The other two solutions may or may not have an imaginary component. The chosen solution is the minimum real value without the imaginary part.
- Once the outer diameter is obtained, the area of the tube can be calculated



$$W_c = \frac{M_{max}}{\sigma_t} \quad and \quad W_c = \frac{\pi \cdot (d_o^4 - d_i^4)}{32 \cdot d_o}$$

$$d_o^4 - \frac{M_{max} \cdot 32}{\sigma_t \cdot \pi} \cdot d_o - d_i^4 = 0$$

$$\sigma_t = \frac{\sigma_e}{n}$$

$$A = \pi \cdot ((\frac{d_o}{2})^2 - (\frac{d_i}{2})^2)$$

Analytical Development - Weight calculation

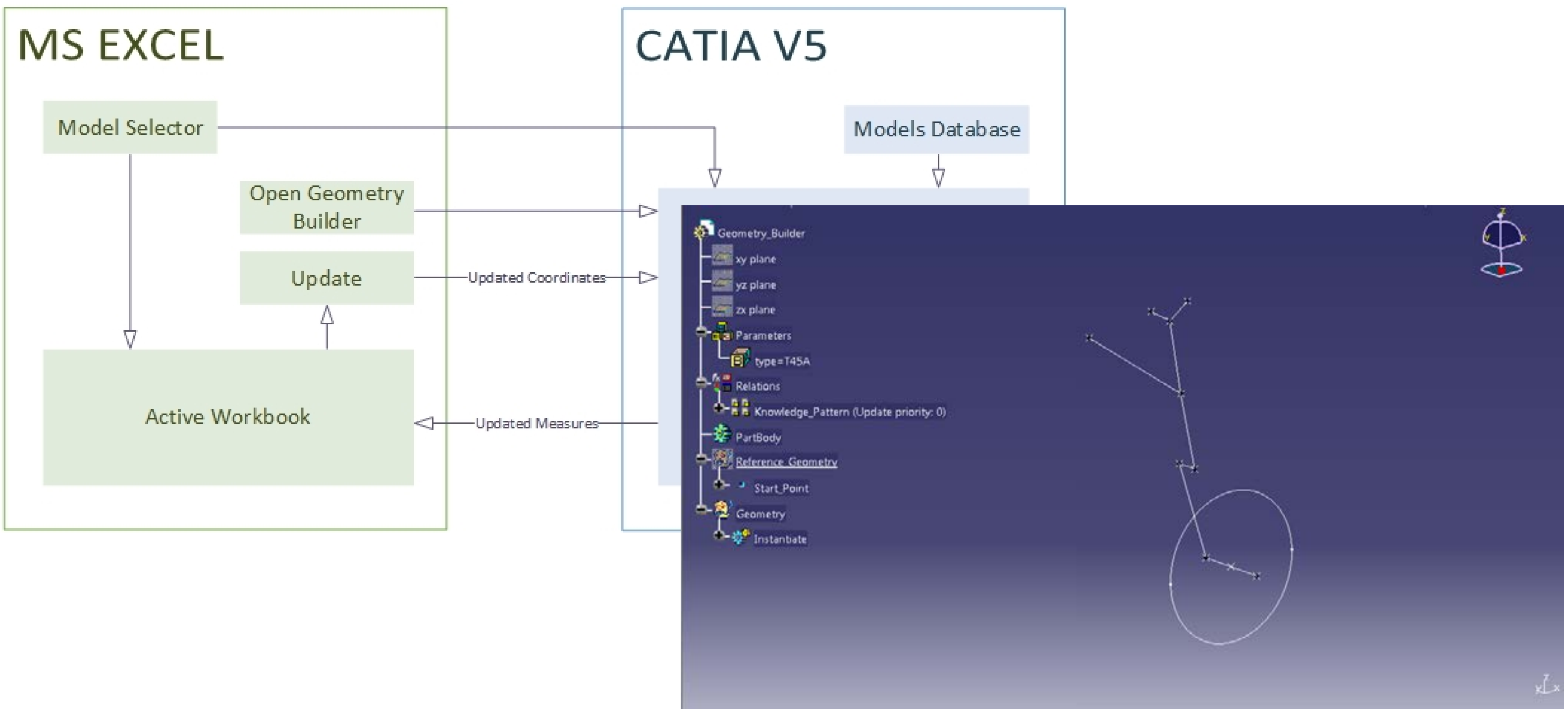
- The area and the length of the tube are known, the volume can be easily obtained

$$Volume = Area \cdot Length$$

- Finally, using the definition of density, the weight of the bar is

$$\rho = \frac{Mass}{Volume} \quad \rightarrow \quad Mass = \rho \cdot Volume$$

Overview of Implimentation



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Overview of Implimentation – Main Layout

Select the baseline model: F15E

Open Geometry Builder | Update

F15E

GEOMETRY BUILDER

Input data in Red

1a

Points	Coordinates X	Y	Z	Radius	Units	CATIA Reference names
1	0	0	0	-	mm	wheel
2	-	-	-	800	mm	Wheel/radiusWheel
3	0	200	3550	-	mm	Trunnion1
4	0	1500	3000	-	mm	Trunnion2
5	-1500	1000	3700	-	mm	Trunnion3
6	0	500	3400	-	mm	Vertical_upper_bar_P1
7	0	500	2000	-	mm	UpperP_Absorver
8	0	-500	0	-	mm	Start_Axis
9	0	500	0	-	mm	End_Axis

MEMBER CROSS-SECTION DATA

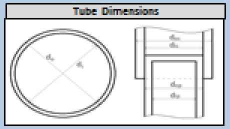
BAR 1a/3a	Selection/Value
Material	Ti-6Al-4V
σ_e [MPa]	950
ρ [kg/mm^3]	4,43E-06
Safety Factor	2
di [mm]	339,4581454

BAR 1b/3b	Selection/Value
Material	Ti-5Va-5Mo-5Al-3Cr
σ_e [MPa]	1236
ρ [kg/mm^3]	4,65E-06
Safety Factor	2
di [mm]	10

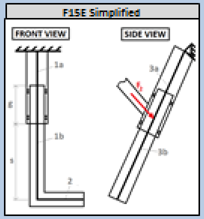
BAR 2	Selection/Value
Material	Ti-5Va-5Mo-5Al-3Cr
σ_e [MPa]	1236
ρ [kg/mm^3]	4,65E-06
Safety Factor	2
di [mm]	100

s [mm]	2900
g [mm]	500
f [%]	0,25

Tube Dimensions



F15E Simplified



1b

EXTERNAL FORCES

External Forces			
Case	Name	Value	Units
1. Two/Three Point Level L Tail Down Landing	V	1,00E+06	N
	S	0	N
	D	1,00E+04	N
3. Lateral Drift Landing	V	1,00E+06	N
	S	0,8*V / 0,6*V	N
	D	0	N
4. Braked Roll	V	3,60E+05	N
	S	0	N
	D	0,8*V	N
5. Ground Turning	V	3,60E+05	N
	S	0,5*V	N
	D	0	N
6. Pivoting	V	3,60E+05	N
	S	0	N
	D	0	N

2

BENDING MOMENTS

Sizing Bending Moments		
Bar	Mmax	Units
1a/3a	2,77E+09	N-mm
1b/3b	2,37E+09	N-mm
2	5,00E+08	N-mm

3

Overview of Implimentation - Main Layout Cont.

Select the desired graph: All Graphs

RESULTS

BAR 1a/3a	Parameter	Value	Units
	Inner Diameter	339,46	mm
	Outer Diameter	446,54	mm
	Section Area	66106,08	mm^2
	Longitude	500,00	mm
	Weight	146,42	kg

BAR 1b/3b	Parameter	Value	Units
	Inner Diameter	10,00	mm
	Outer Diameter	339,46	mm
	Section Area	90424,33	mm^2
	Longitude	3400,00	mm
	Weight	1429,61	kg

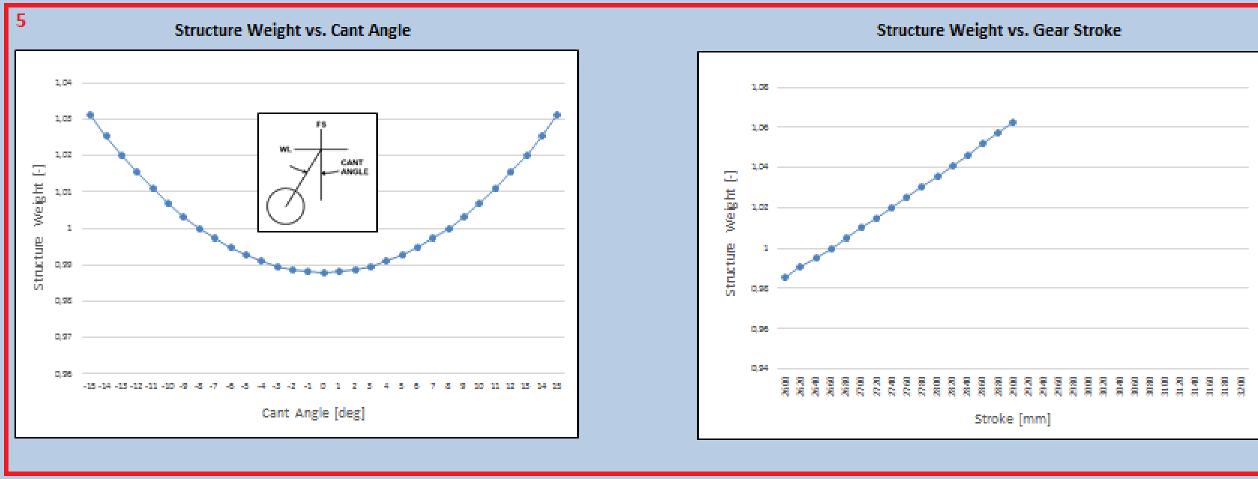
BAR 2	Parameter	Value	Units
	Inner Diameter	100,00	mm
	Outer Diameter	205,88	mm
	Section Area	25436,87	mm^2
	Longitude	500,00	mm
	Weight	59,14	kg

f0	1,30

Total Weight	Value	Units
Analytical	1635,17	kg
Approximated	2125,73	kg

4

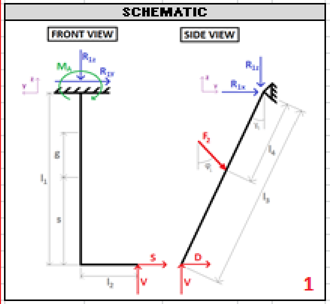
GRAPHS



Overview of Implimentation – Ereactions (left) and Bending Moments (Right)

F15E

SCHEMATIC

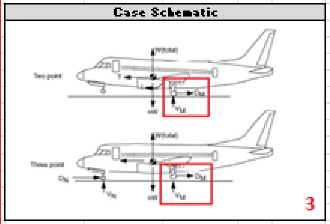


Longitudes and Angles		
Parameter	Value	Units
l1	3400	mm
l2	500	mm
l3	3400	mm
l4	1400	mm
s	2900	mm
g	500	mm
Y1_deg	0	degrees
Φ1_deg	41,423666	degrees
Y1_rad	0	radians
Φ1_rad	0,7229794	radians

2

CASE 1 & 2 Two/Three Point Level Landing (V ≠ 0 ; D ≠ 0 ; S = 0)
Tail Down Landing (V ≠ 0 ; D ≠ 0 ; S = 0)

Case Schematic



Front View 4a

eactions, Forces and Momentu		
Parameter	Value	Units
R1z	1000000	N
R1y	0	N
M_A	5,00E+08	N·mm

Side View 4b

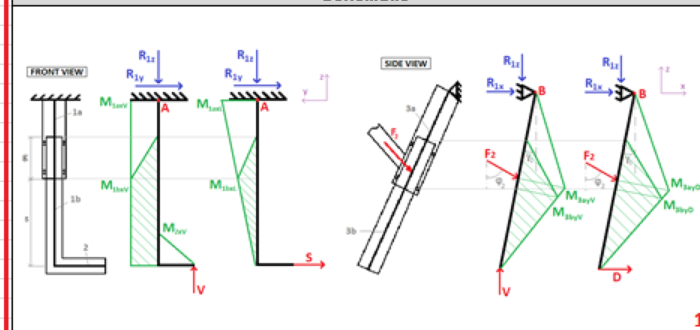
Reactions and Forces		
Parameter	Value	Units
F2	-36706,35	N
R1x	14285,714	N
R2x	-24285,71	N
R2z	-27523,81	N

F15E

Sizing Moments		
Bar	Mmax	Units
1a/3a	2,77E+09	N·mm
1b/3b	2,37E+09	N·mm
2	5,00E+08	N·mm

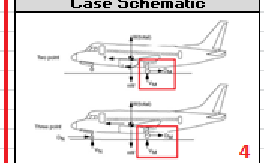
3

Schematic



CASE 1 & Two/Three Point Level Landing (V ≠ 0 ; D ≠ 0 ; S = 0)
Tail Down Landing (V ≠ 0 ; D ≠ 0 ; S = 0)

Case Schematic



2

Bar	My_V	My_D	My	Units
3a	0,00E+00	2,00E+07	2,00E+07	N·mm
3b	0,00E+00	2,90E+07	2,90E+07	N·mm

Bar	Mx_V	Mx_S	Mx	Units
1a	5,00E+08	0,00E+00	5,00E+08	N·mm
1b	5,00E+08	0,00E+00	5,00E+08	N·mm
2	5,00E+08	0,00E+00	5,00E+08	N·mm

Bar	Mx	My	M	Units
1a/3a	5,00E+08	2,00E+07	5,00E+08	N·mm
1b/3b	5,00E+08	2,90E+07	5,01E+08	N·mm
2	5,00E+08	0,00E+00	5,00E+08	N·mm

Overview of Implimentation – Cross-section Area and Weight

F15E

$$D^4 - \frac{M_{max} \cdot 32}{\sigma_t \cdot \pi} \cdot D - d^4 = 0$$

1

BAR 1a/3a

2

Parameter	Value
Mmax [N·mm]	2,77E+09
n	2
σ_e [MPa]	950
σ_t [MPa]	475
di [mm]	339,4581454

3

Coefficients

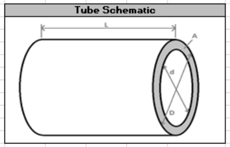
	Quartic
a	1
b	0
c	0
d	-59305065,84
e	-13278375217,53

4

Equation Solution	Specified Root	
D	Quartic	
1	-197,98914	0,00
2	446,54306	0,00
3	-124,27696	367,08
4	-124,27696	-367,08
Num Re/Im Roots	2	2

5

do [mm]	446,54306
A [mm ^2]	66106,07712

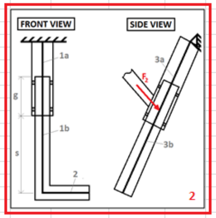


F15E

1

$$V = A \cdot L$$
$$m = \rho \cdot V$$

2



3

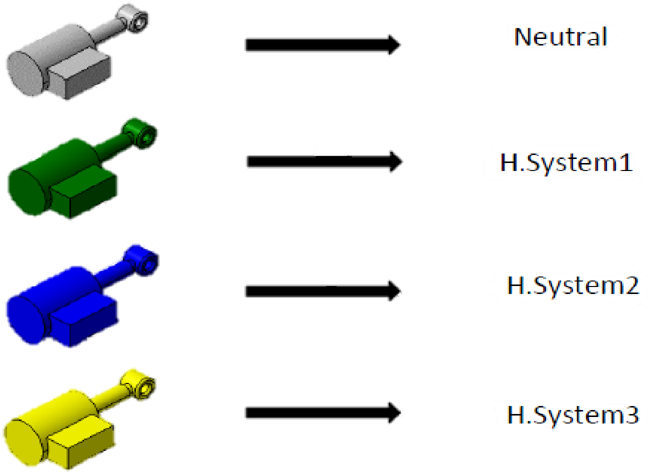
	Parameter	Value	Units
BAR 1a/3a	A	66106,077	mm^2
	l	500	mm
	V	33053039	mm^3
	m	146,42496	kg

	Parameter	Value	Units
BAR 2	A	25436,867	mm^2
	l	500	mm
	V	12718433	mm^3
	m	59,140715	kg

	Parameter	Value	Units
BAR 1b/3b	A	90424,33	mm^2
	l	3400	mm
	V	307442721	mm^3
	m	1429,6087	kg

Conclusion - FCS

- *Fast realisation of the concept*
- *To support* ***Conceptual*** *to* ***Preliminary*** *Aircraft Design*
- Specialized tool for specialized needs (full CAD env.)
- Coupling to for CFD analysis for all lifting surfaces
- Flexibility level
  - Characteristic parameter
  - It allows to tailor connections between hydraulics systems and flight control surfaces
  - Representation widely used in the industry
-



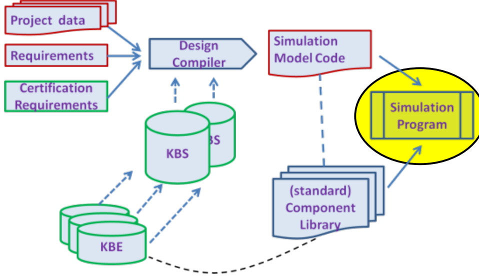
Conclusions – Fuel system

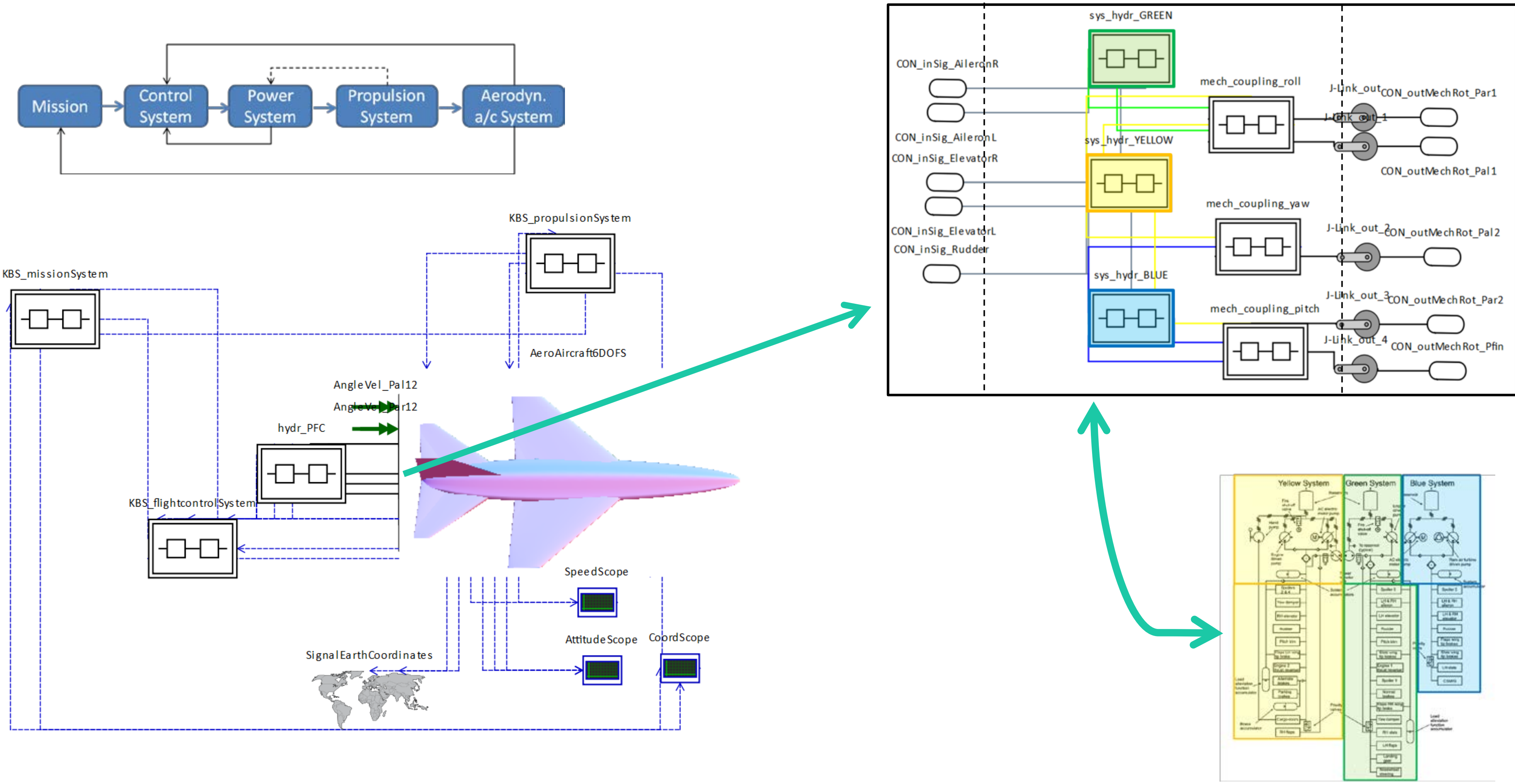
- Enabled fuel capacity estimation based on 3D geometries; an estimation that is specially complex when working with integral tanks.
- The possibility to accurately position tanks and pumps in a fast way, with the objective to be able to work with the tool in both, conceptual and preliminary design phases. A feature that can be used, for example, for space allocation or systems integration in early design stages.
- Measurement of piping or tubing length for a simple example of transfer system architecture; a first estimation that can be a relevant data for pump sizing.
- Attitude dependent fuel distribution (inuence of center of gravity) of partially filled tanks. This feature can help to position pump inlets and venting points and to analyze the fuel influence in aircraft's center of gravity and stability.
- Automation and parametric description of the system layout. Together with the former topic, this enables a export of the system to other (simulation) program for further, more detailed system analysis.

Conclusions – Landing Gear

- The procedure developed is able to compute the weight of the existing bars for a particular landing gear disposition.
- Support the designer both with a numeric and a graphical results. The computations keeps the user at all times in touch with a visual perspective on where the points are placed and the overall disposition of the bars.
- The results obtained by the bending moment process are satisfactory. The results are really close from the ones found in the studies done by (Kraus, 1970) and (Willie, 1989).
- Limitations when using the procedure are that, the bars that can be sized, are the ones that receive moments from the applied loads. The procedure is able to size the main bars of the gears for the simplifications done. For other bars that take just forces, the method from previous studies can be used and added as an extension to the work presented.

Future Work: Simulation Model





Thank You

raghu.chaitanya@liu.se

www.liu.se

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