

AERO – AIRCRAFT DESIGN AND SYSTEMS GROUP

Automatic Generation of 3D-CAD Models to Bridge the Gap between Aircraft Preliminary Sizing and Geometric Design

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PreSTo:

Aircraft
Preliminary
Sizing
Tool

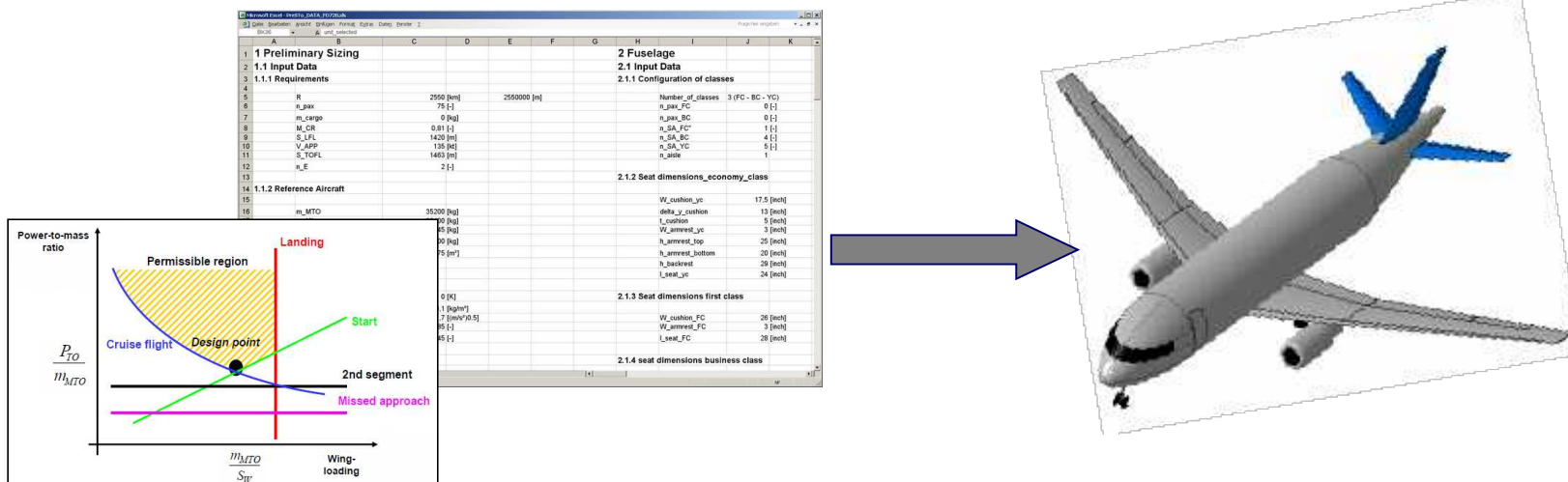
PreSTo-Vis:

Visualization
of PreSTo Aircraft
Configuration
in CATIA V5

Automatic Generation of 3D-CAD Aircraft Concept Models with PreSTo-Vis

Motivation

„Bridge the Gap between Aircraft Preliminary Sizing and Geometric Design “



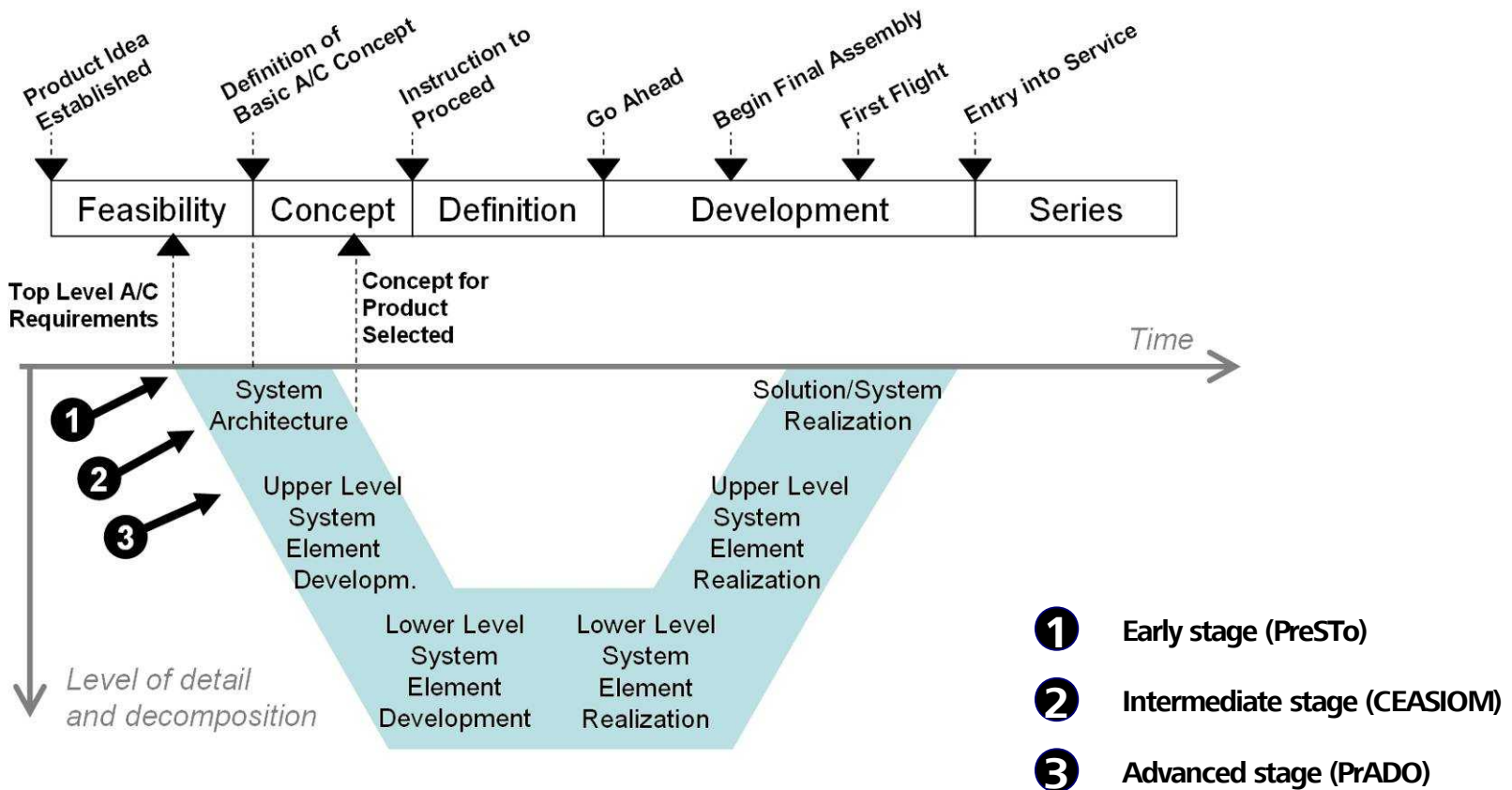
Automatic Generation of 3D-CAD Models to Bridge the Gap between Aircraft Preliminary Sizing and Geometric Design

Contents

- Introduction
- Preliminary Sizing and Aircraft Configuration with PreSTo
- PreSTo structure and user interface design
- PreSTo output
- PreSTo-Vis and the Parametric Aircraft Model in CATIA V5
- Realized Workflow
- Conclusions and Outlook

Introduction

Teaching Aircraft Design



Aircraft Design Process taught by Scholz at HAW Hamburg

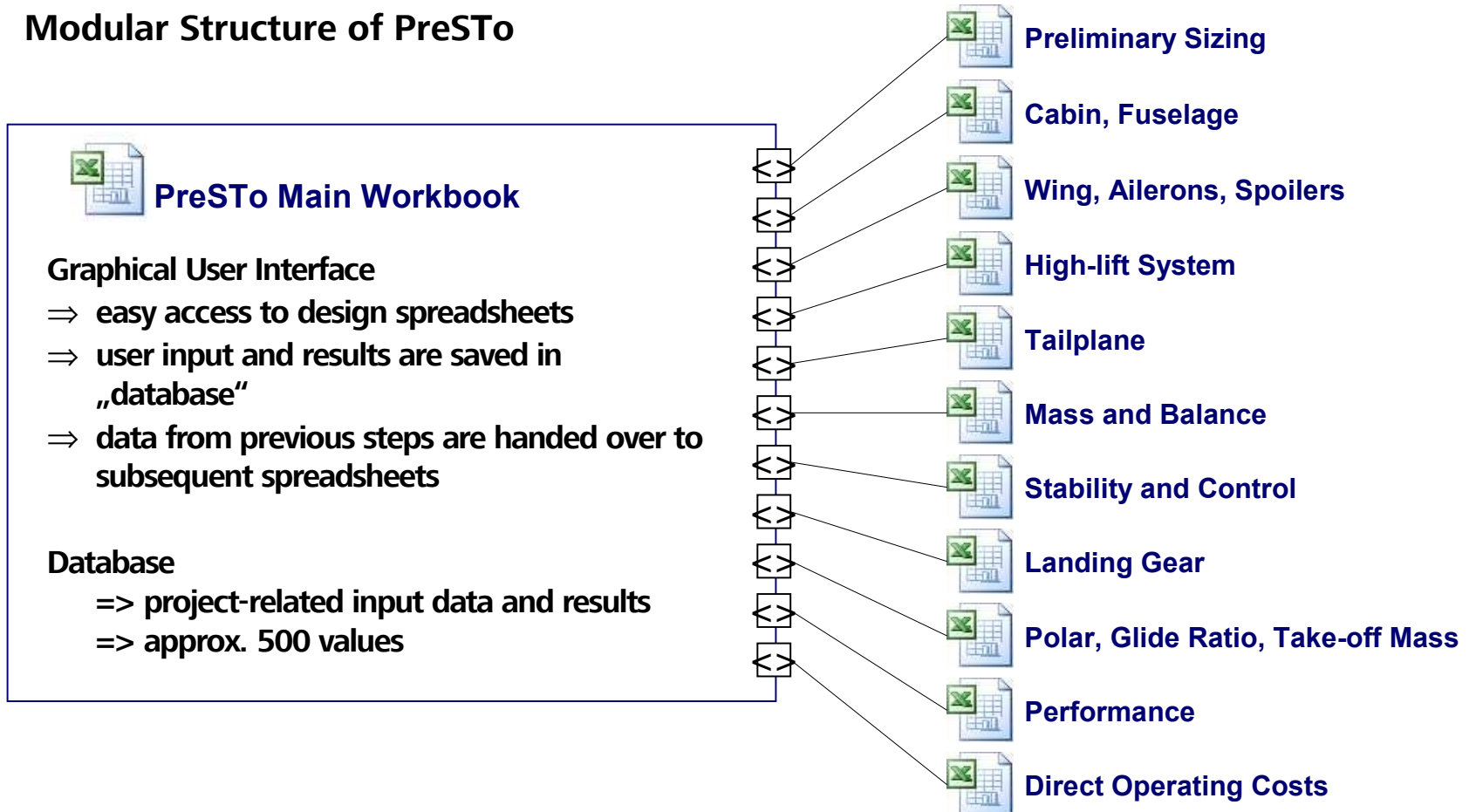
PreSTo = Aircraft Preliminary Sizing Tool

- For use in education and research
- Guides the user through initial steps of configuring a civil transport aircraft
- Easy to use expert knowledge and comparative data from reference aircraft
- 11 Spreadsheets, from Preliminary Sizing to Direct Operating Costs
- Starts off with top level a/c requirements to determine aircraft design point
- No initial geometric information necessary



PreSTo = Aircraft Preliminary Sizing Tool

Modular Structure of PreSTo



PreSto = Aircraft Preliminary Sizing Tool

PreSto Spreadsheets Example #1: Main Workbook

PreSto - Aircraft Preliminary Sizing Tool
Version 1.0 <http://PreSto.ProfScholz.de>

FD 728 Description Redesign

Export Data to:	Database:	Modules:	Last Update of Database:
CATIA	D	Preliminary sizing	18.08.2011 12:15:57
	A		
	T	Fuselage	13.08.2011 17:35:27
	A		
	B	Wing	29.07.2011 15:48:56
	A		
	S	High lift	29.07.2011 18:08:57
	E		
		Tailplane I	27.07.2011 18:29:27

GUI / Database / Path / Bereiten Berechnen

PreSTo = Aircraft Preliminary Sizing Tool

PreSTo Spreadsheets

Example #2: Preliminary Sizing

The screenshot shows the Microsoft Excel interface for the PreSTo spreadsheet. The spreadsheet is titled "Preliminary sizing of jet & large propeller driven aircraft". It contains several sections for user input and results.

User Input: The "General preliminary sizing data - JET" section includes input fields for ΔT_L (0 [K]), σ (1,000 [-]), k_L (0,100 [kg/m³]), k_{APP} (1,700 [(m/s²)/0.5]), S_{LFL} (1420 [m]), V_{APP} (64,1 [m/s]), k_L (0,107 [kg/m³]), $C_{L,max,L}$ (2,850 [-]), m_{HL}/m_{HTO} (0,920 [-]), and m_{HL}/m_{T0} (0,920 [-]).

Intermediate Results: The "Reference aircraft" section shows m_{HL}/S_W (432 [kg/m²]) and m_{HTO}/S_W (469 [kg/m²]).

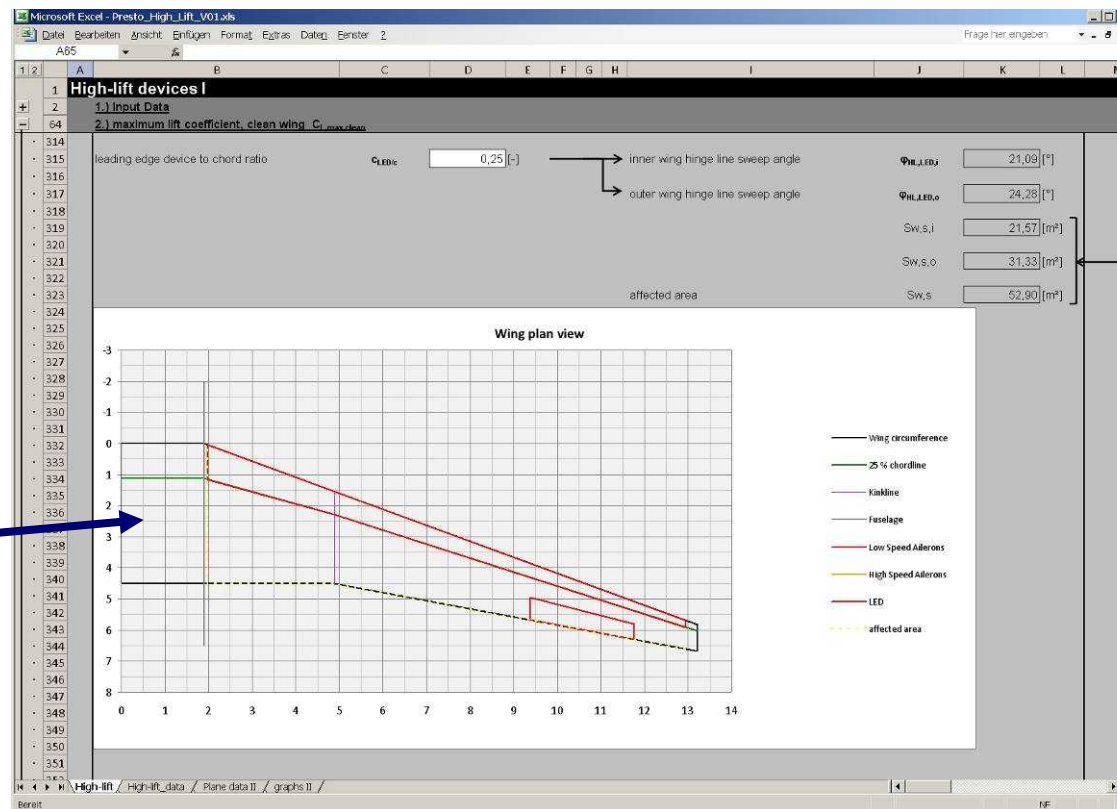
Comment: Suggestion or Explanation: A comment box contains the equation
$$m_{HTO}/S_W = \frac{m_{HL}/S_W}{m_{HL}/m_{HTO}}$$

Final Results Overview: The "Results / selection" section is visible at the bottom of the spreadsheet.

PreSTo = Aircraft Preliminary Sizing Tool

PreSTo Spreadsheets

Example #3: High-lift Devices



2D Graph to
visualize design
decision

PreSTo = Aircraft Preliminary Sizing Tool

PreSTo „Look and Feel“

Example #4: Fuselage Design and Cabin Configuration

The screenshot shows the Microsoft Excel interface for the PreSTo tool. The main window is titled "Microsoft Excel - Presto_Fuselage_V01.xls". The spreadsheet content is organized into sections:

- 1. Input data from previous design phases:**
 - Reference number of passengers: n_{pass} = 75 [-]
 - Cargo mass: m_{cargo} = 0.00 [kg]
 - Design Range: R = 2550000 [m]
 - Maximum take-off mass: m_{taro} = 33432 [kg]
- 2. Configuration of classes**
- 3. Cross section:**
 - Check: Business class seats abreast: $n_{BA,BC}$ = 4 [-] >>>> **Wrong number of seats abreast** (Red)
 - Economy class seats, right aisle: $n_{seats,right,YC}$ = 3 [-]
 - Economy class seats, middle aisle: $n_{seats,mid,YC}$ = 0 [-]
 - Economy class seats, left aisle: $n_{seats,leh,YC}$ = 2 [-]
 - Check: Economy class seats abreast: $n_{BA,YC}$ = 5 [-] >>>> **Number of seats abreast is correct** (Green)
 - Display: First class
- Seat rails:**
 - Use side seat rails:
 - Number of seat rails, right aisle: $n_{rails,right}$ = 2 [-]
 - Number of seat rails, middle aisle: $n_{rails,middle}$ = 0 [-]
 - Number of seat rails, left aisle: $n_{rails,left}$ = 2 [-]
 - Side seat rail height: $h_{side,seatrail}$ = [m]
 - Distance between seat extremity and first seat rail: $d_{seat,seat rail}$ = 0.20 [m]
 - Distance between two seat rails, right aisle: $d_{rails,right}$ = 1.09 [m]
 - Distance between two seat rails, middle aisle: $d_{rails,middle}$ = 0.49 [m]

At the bottom right, a 2D graph visualizes the fuselage cross-section with seat layouts and dimensions. The graph shows a semi-circular cross-section with a central aisle and two side aisles. The seat layouts are shown in blue and red. The graph is labeled "2D Graph to visualize design decision".

Plausibility checks

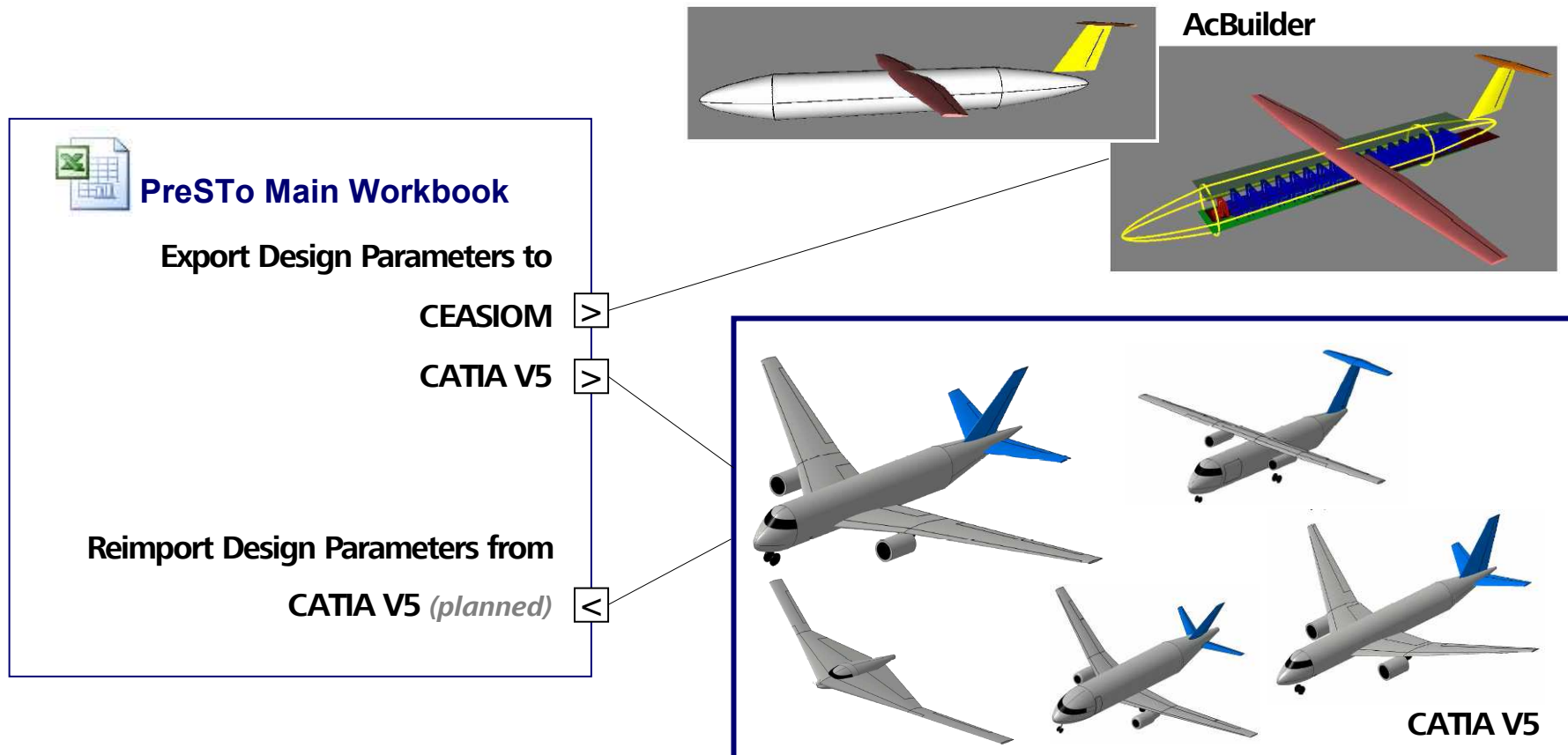
Red = failed

Green = o.k.

2D Graph to
visualize design
decision

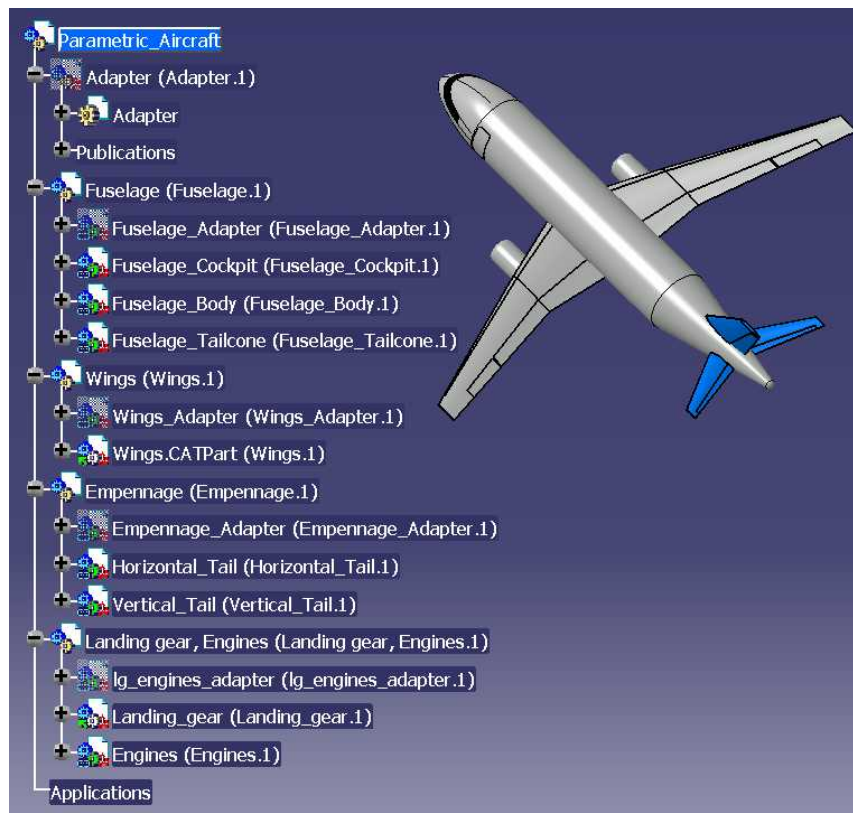
PreSTo = Aircraft Preliminary Sizing Tool

PreSTo Output Interfaces for 3D Geometry Generation



PreSto-Vis = Visual Basic Interface between PreSto and a 3D Parametric Aircraft Model in CATIA V5

Structure of Parametric Aircraft Model prepared in CATIA V5



- Hierarchical adapter models
- Main adapter contains design parameters to accept PreSto results
- Publication of parameters and geometry before creation of multi-model-links
- Clear internal structure:
Input -> Design -> Output
- Easy to modify & add more details
- Auxiliary geometry is hidden
- NACA profiles are recreated upon data import from PreSto-Vis and reconnected to derived geometry

Structure of Parametric Aircraft Model prepared in CATIA V5

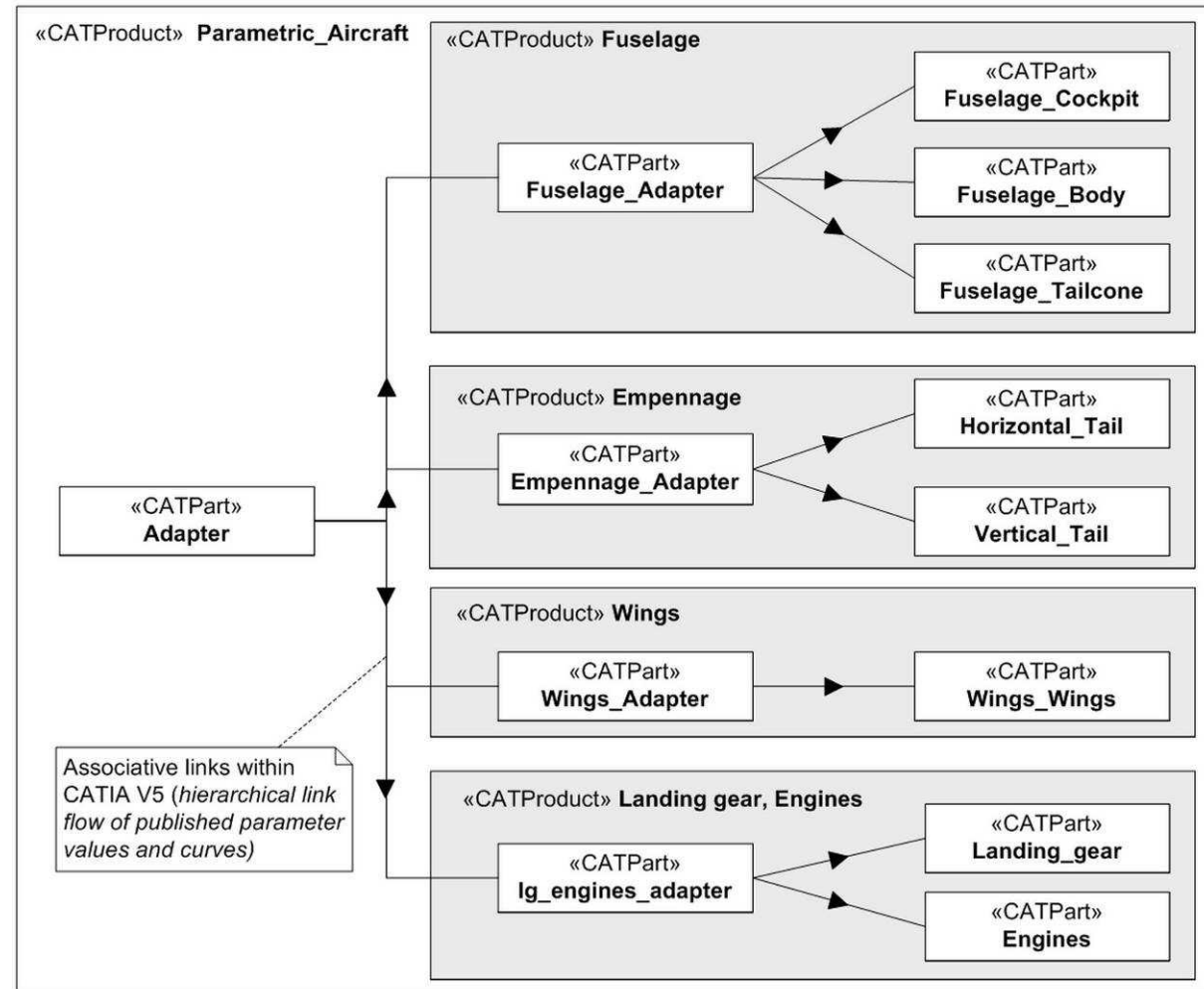
Cascading Adapters

Main Adapter:

- 76 design parameters
- Reference planes
- Airfoil curves

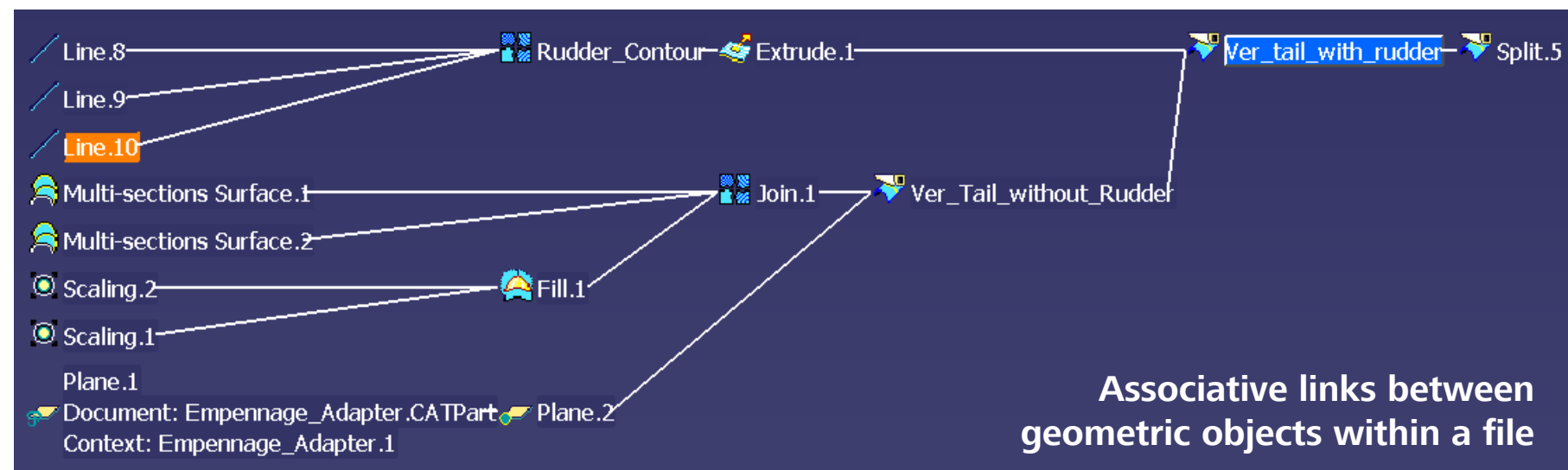
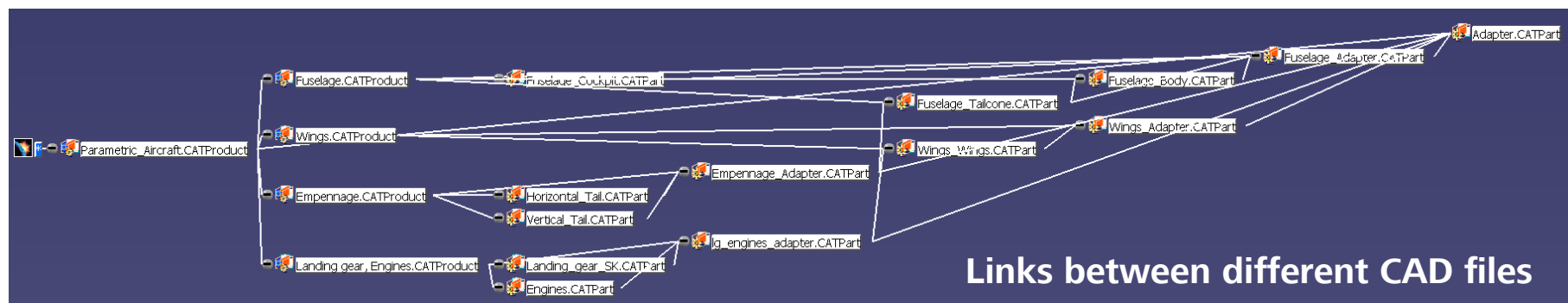
Subordinate Adapters:

- Receive required parameters from main adapter
- Receive geometry from main adapter/ neighboring adapters
- Publish output geometry



Structure of Parametric Aircraft Model prepared in CATIA V5

„A View Behind the Scenes“: The Network of Associative Links



Structure of Parametric Aircraft Model prepared in CATIA V5

Configuration Management in CATIA V5 Model

- Parametric-associative design for continuous geometric dependencies with 128 „Formulas“

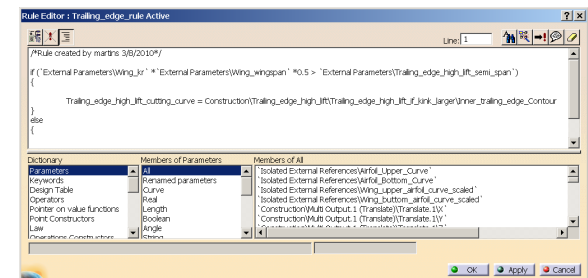
Formula.4: Construction\Fuselage\Planes\Plane_Fuselage_End\Offset=Fuselage_length

- Geometric parameters of type „Curve“ to enable automatic recreation of selected NACA profiles

Wing_upper_airfoil_curve Document: Adapter.CATPart Context: Adapter.1
 Airfoil_Upper_Curve Document: Wings_Adapter.CATPart Context: Wings_Adapter.1
 Airfoil_Upper_Curve Formula.41 Airfoil_Upper_Curve

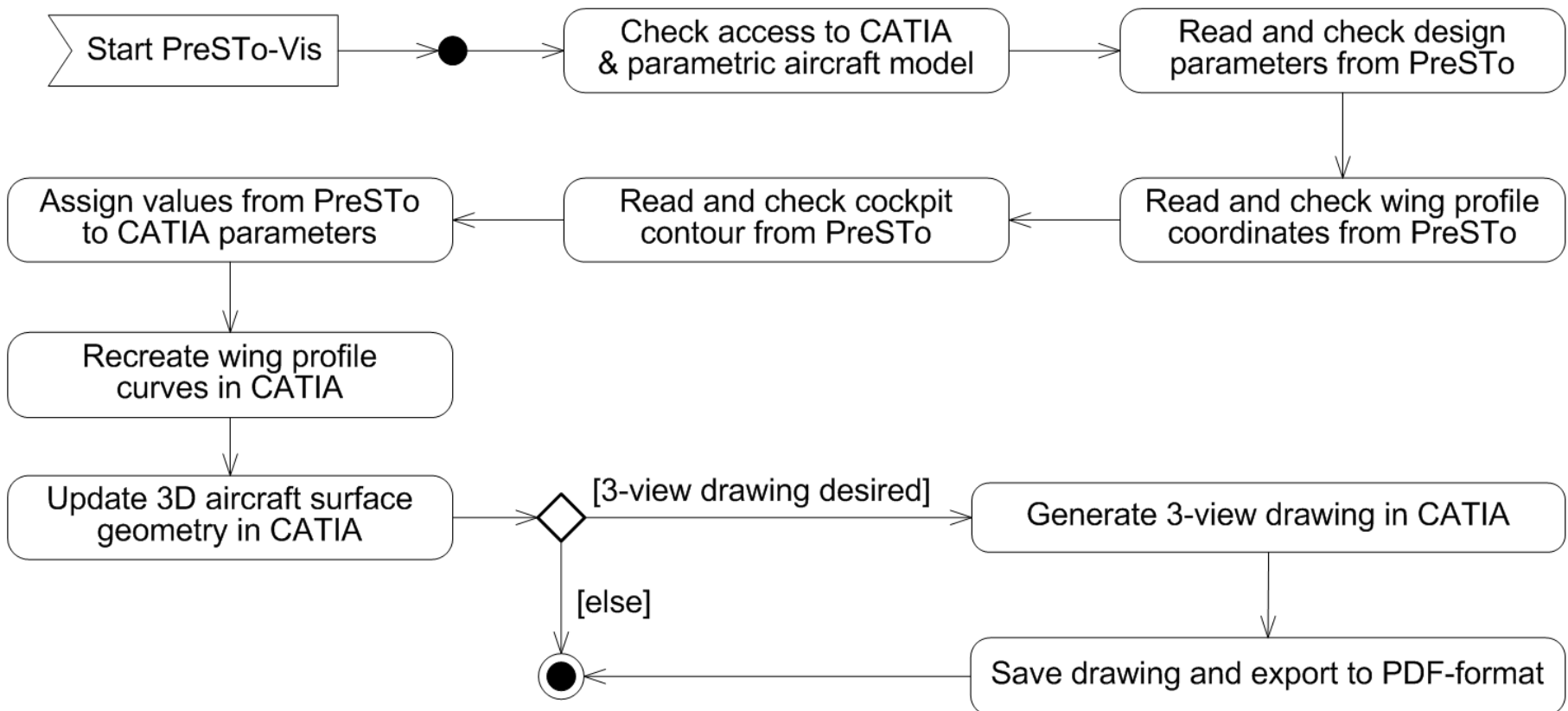
- 2 Knowledgeware „Rules“ for rule-based configuration:
if (condition) {parameter value} **else** {alternative value}
- 4 „Laws“ for design of cockpit profile

Law.1
 Law.2
 Law.3
 Law.4



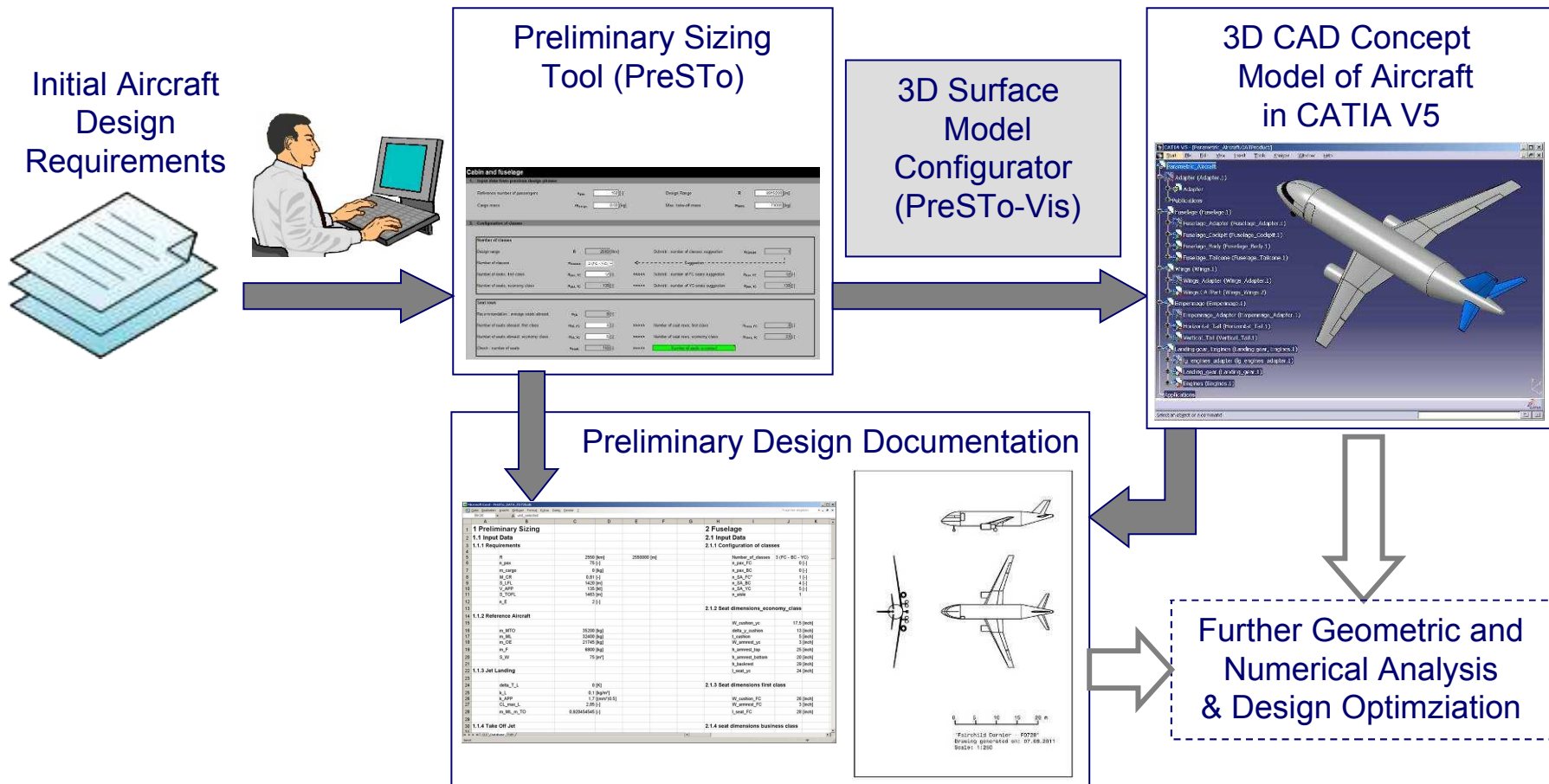
Visual Basic Interface between PreSTo and a 3D Parametric Aircraft Model in CATIA V5

PreSTo-Vis: Visual Basic Code (simplified activity diagram)



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Conclusion - Realized Workflow



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Conclusion - Organisational Aspects

- PreSTo coordinator with overall responsibility is essential
- Naming conventions must be accepted
- Rules for modeling and programming must be observed
- User-friendliness and robust design must be the ultimate goal
- Transparency of implemented calculations and design rules must be maintained
- No sophisticated programming knowledge required
- High discipline is a MUST for any person wishing to extend PreSTo or PreSTo-Vis



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Summary and Outlook

- PreSTo supports a very basic / standard way of aircraft design
- PreSTo offers interfaces to higher order aircraft design tools
- Aircraft concept geometry can be visualized and modified in CATIA V5
- Next steps:
 - Finish PreSTo
 - Enhance functionality of CATIA V5 model
 - Implement „roundtrip“ to feed back design parameter values from the CATIA model into PreSTo spreadsheets for analysis



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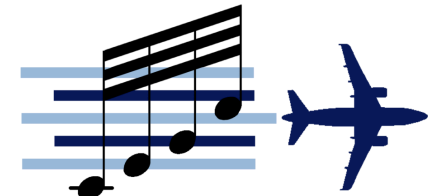
Contact

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info@ProfScholz.de

Further Information & Downloads

<http://PreSTo.ProfScholz.de>



PreSTo

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Preliminary
Sizing
Tool

PreSTo-Vis:

Visualization
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