



Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

AERO – AIRCRAFT DESIGN AND SYSTEMS GROUP

PreSTo - Aircraft Preliminary Sizing Tool

From Requirements to the Three-View-Drawing

Dieter Scholz Hamburg University of Applied Sciences

EWADE 2011 - 10th European Workshop on Aircraft Design Education

Naples, Italy, 24.-27.05.2011



PreSTo:

Aircraft
Preliminary
Sizing
Tool

PreSTo - Aircraft Preliminary Sizing Tool

Contents

- Goals
- *Aircraft Design* Lecture
- Screen Shots
 - PreSTo Control Center and Database
 - Preliminary Sizing
 - Cabin Design
 - Wing Design, High Lift Design
 - Tailplane Design
 - Landing Gear Design
- Data Export / Visualization
 - CEASIOM
 - Catia
 - PrADO
- PreSTo Homepage
- Conclusions and Outlook

PreSTo - Aircraft Preliminary Sizing Tool

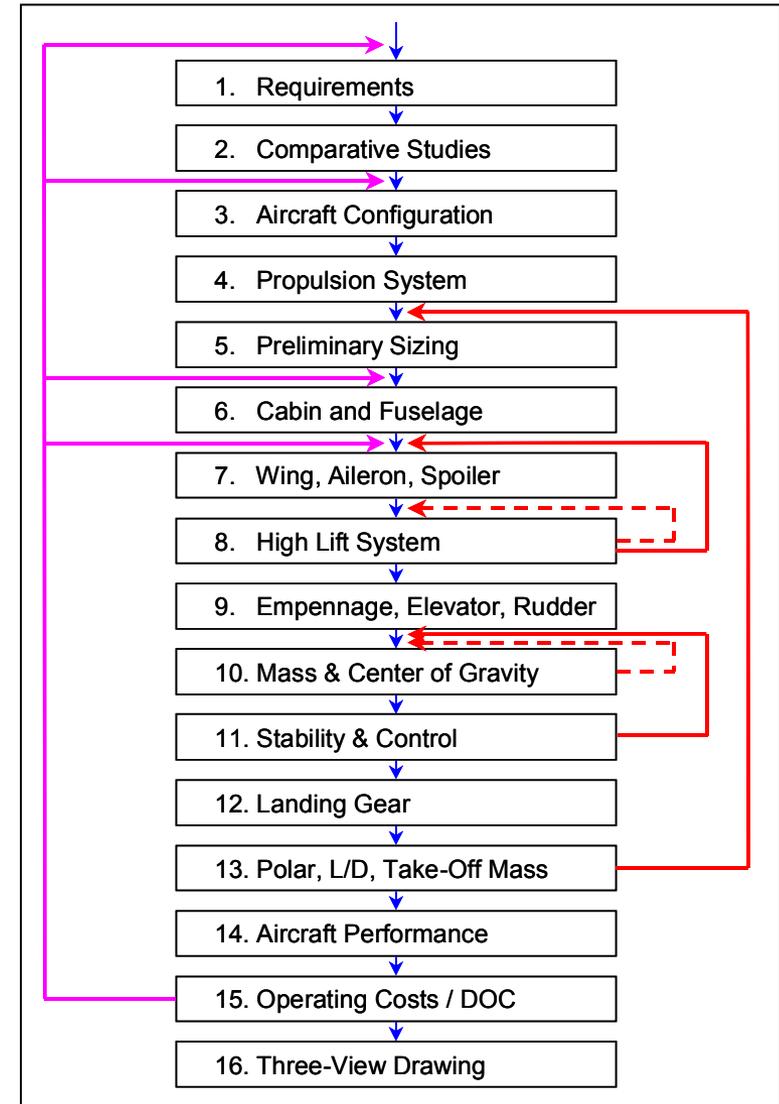
Goals

- Give full computer support for the *Aircraft Design* lecture by Prof. Scholz / Hamburg
- Start tool with nothing but **requirements**
- Never ask the user for data without giving proper support
- Provide straight forward and **fast solutions** (=> **PreSTo**)
- Give the best support (**didactics, methods, statistics database, ...**)
- Keep **user in the loop**
- Include **expert knowledge** in simple „if-then“ checks and provide answers with red / green buttons
- Provide aircraft data for **3D-plots** and **three-view-drawings**
- Couple to higher order tools for further investigation

PreSTo - Aircraft Preliminary Sizing Tool

Aircraft Design Lecture General remarks

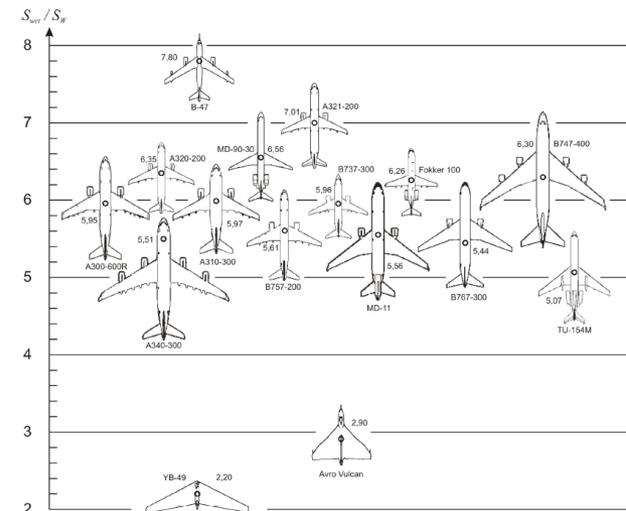
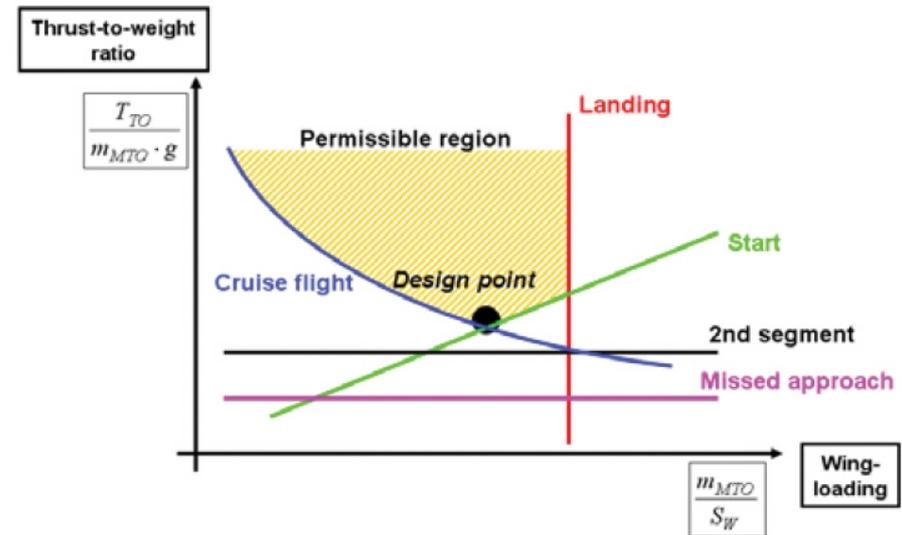
- Lecture is based on methods from:
 - Loftin, Torenbeek, Roskam, Raymer, ...
 - Datcom, ...
 - many own additions
- 16 design steps (see Fig.)
- Emphasis on *preliminary sizing* with *matching chart*:
 - Jet: $T/W = f(m/S)$
 - Prop: $P/W = f(m/S)$
- Lecture in this format since 1999:
 - about 1000 students taught
 - many student reports and theses produced
- Spreadsheet for preliminary sizing (only) is in service for many years: <http://FE.ProfScholz.de>
- Preliminary sizing spreadsheet has been used for:
 - tutorials, examinations
 - projects, theses



PreSTo - Aircraft Preliminary Sizing Tool

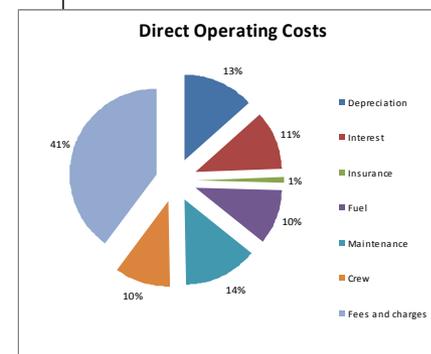
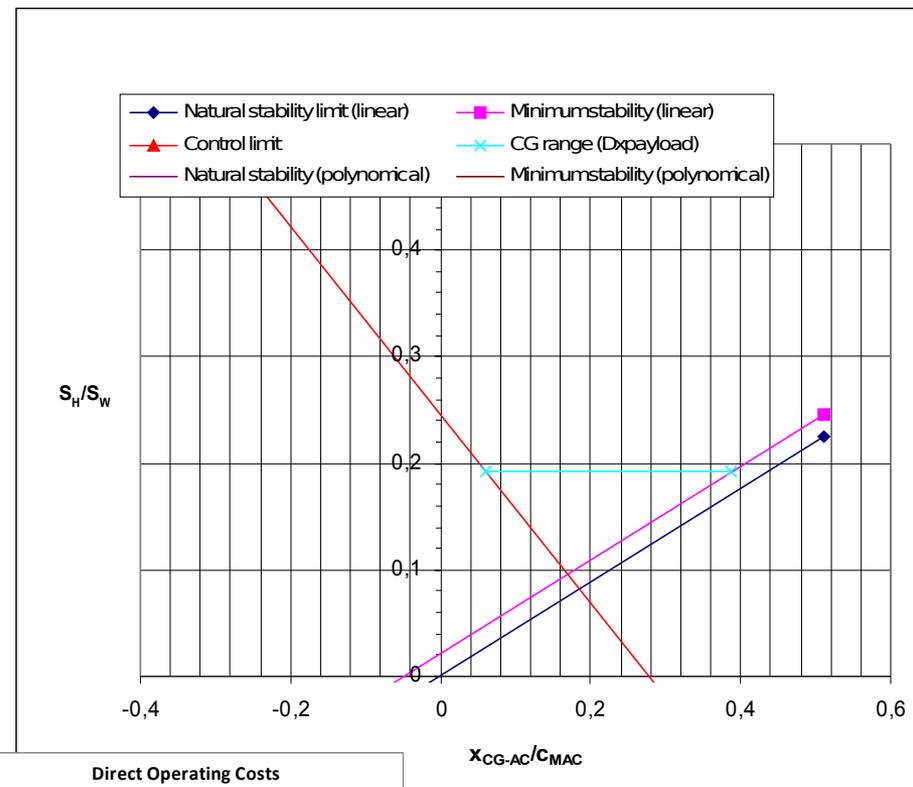
Aircraft Design Lecture Contents

- Preliminary sizing
 - Matching chart
 - $(L/D)_{max}$ estimation with „wetted aspect ratio“
 - Fuel calculation with fuel fractions
- Cabin & fuselage
 - Seats abreast optimum
 - Baggage and cargo volume check
 - Cross section optimization
 - Cabin surface estimation
 - Ditching check: waterline & door sill
 - Exit type and location: check
- Wing
 - Wing parameters found for best operational characteristics
- High Lift
 - High lift geometry found from trial & error procedure
 - $C_{L_{max}}$ found from Datcom
- Empennage I
 - Sizing from tail volume



Aircraft Design Lecture - Contents

- Mass and CG
 - Mass from three methods
 - Roskam (OEW distributed about A/C main components)
 - „Modified Raymer“ (mass from one key parameter)
 - Torenbeek (well proven)
 - CG determination and wing position correction
 - Loading diagramm (mass versus CG position) for all sensible load cases established
- Empennage II (stability & control power)
 - Horizontal tail
 - Vertical tail
- Landing gear (parameters selected)
 - tip over stability
 - clearance (engine, tail, L/G retraction)
 - Flotation with COMFAA.exe
- Drag
 - Drag from two methods:
 - wetted area
 - skin friction drag, pressure drag wave drag, interference drag
- Design evaluation:
 - Direct Operating Coast, DOC
 - Method: Association of European Airline



PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots

PreSTo Control Center and Database

 **PreSTo - Aircraft Preliminary Sizing Tool** 

Version 1.0 <http://PreSTo.ProfScholz.de>

Aircraft Name:
FD 728

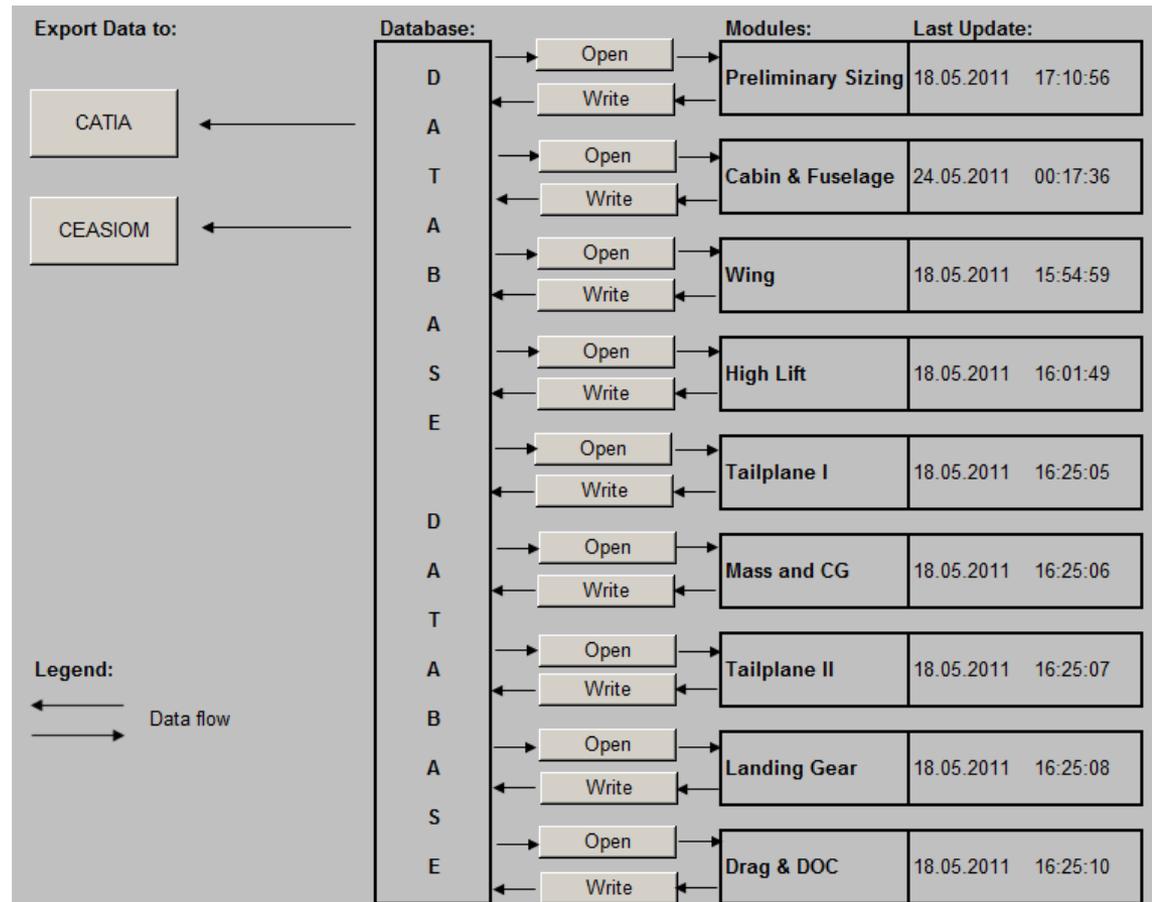
Description:
Redesign

PreSTo Control Center – **Start page**

PreSto - Aircraft Preliminary Sizing Tool

Screen Shots

PreSto Control Center and Database

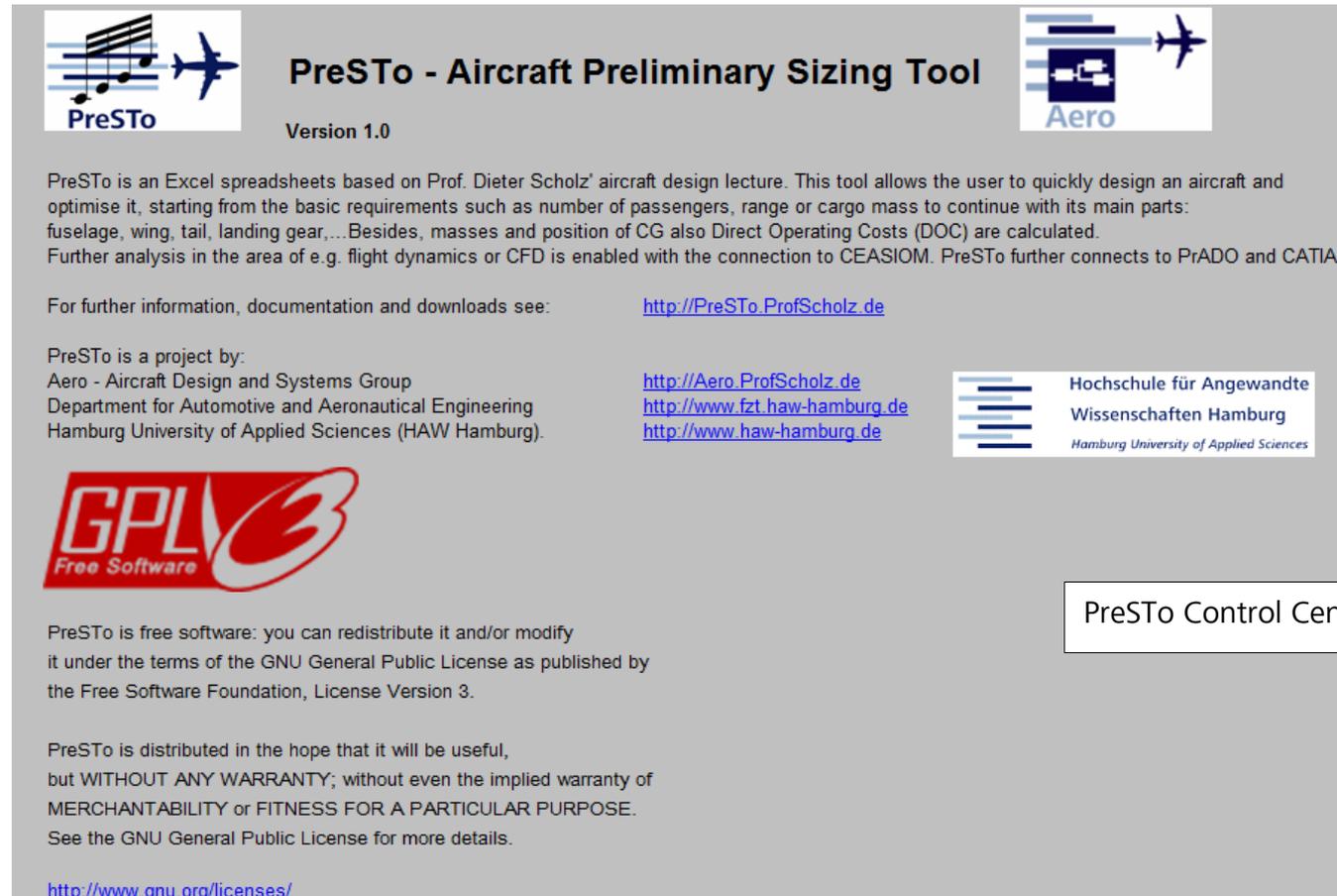


PreSto Control Center – **Module page**

PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots

PreSTo Control Center and Database



PreSTo - Aircraft Preliminary Sizing Tool
Version 1.0

PreSTo is an Excel spreadsheets based on Prof. Dieter Scholz' aircraft design lecture. This tool allows the user to quickly design an aircraft and optimise it, starting from the basic requirements such as number of passengers, range or cargo mass to continue with its main parts: fuselage, wing, tail, landing gear,... Besides, masses and position of CG also Direct Operating Costs (DOC) are calculated. Further analysis in the area of e.g. flight dynamics or CFD is enabled with the connection to CEASIOM. PreSTo further connects to PrADO and CATIA.

For further information, documentation and downloads see: <http://PreSTo.ProfScholz.de>

PreSTo is a project by:
Aero - Aircraft Design and Systems Group
Department for Automotive and Aeronautical Engineering
Hamburg University of Applied Sciences (HAW Hamburg).

<http://Aero.ProfScholz.de>
<http://www.fzt.haw-hamburg.de>
<http://www.haw-hamburg.de>



GPLv3
Free Software

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PreSTo is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU General Public License for more details.

<http://www.gnu.org/licenses/>

PreSTo Control Center – **License page**

PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots

PreSTo Control Center and Database

	A	B	C
1	R	2550	[km]
2	n_pax	99	[-]
3	m_cargo	0	[kg]
4	M_CR	0,81	[-]
5	S_LFL	1420	[m]
6	V_APP	135	[km/h]
7	S_TOFL	1463	[m]
8	n_E	2	[-]

PreSTo Control Center – **Database**

PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots Preliminary Sizing

User open und close
Chapters with + / - sign

Preliminary Sizing – Start page

Preliminary sizing of jet & large propeller driven aircraft

Please choose a design mode or press the 'COMPARE' button to compare both versions:

JET PROP COMPARE

1. General preliminary sizing data - JET
2. Landing - JET
3. Take-off - JET
4. 2nd Segment - JET
5. Missed approach - JET
6. Max. Glide Ratio in Cruise - JET
7. Cruise - JET
8. Matching Chart - JET
9. Preliminary Sizing - JET
10. Preliminary sizing results - JET

Results / selection

Select: Aircraft type for use in following sheets

Jet

Results used in following sheets

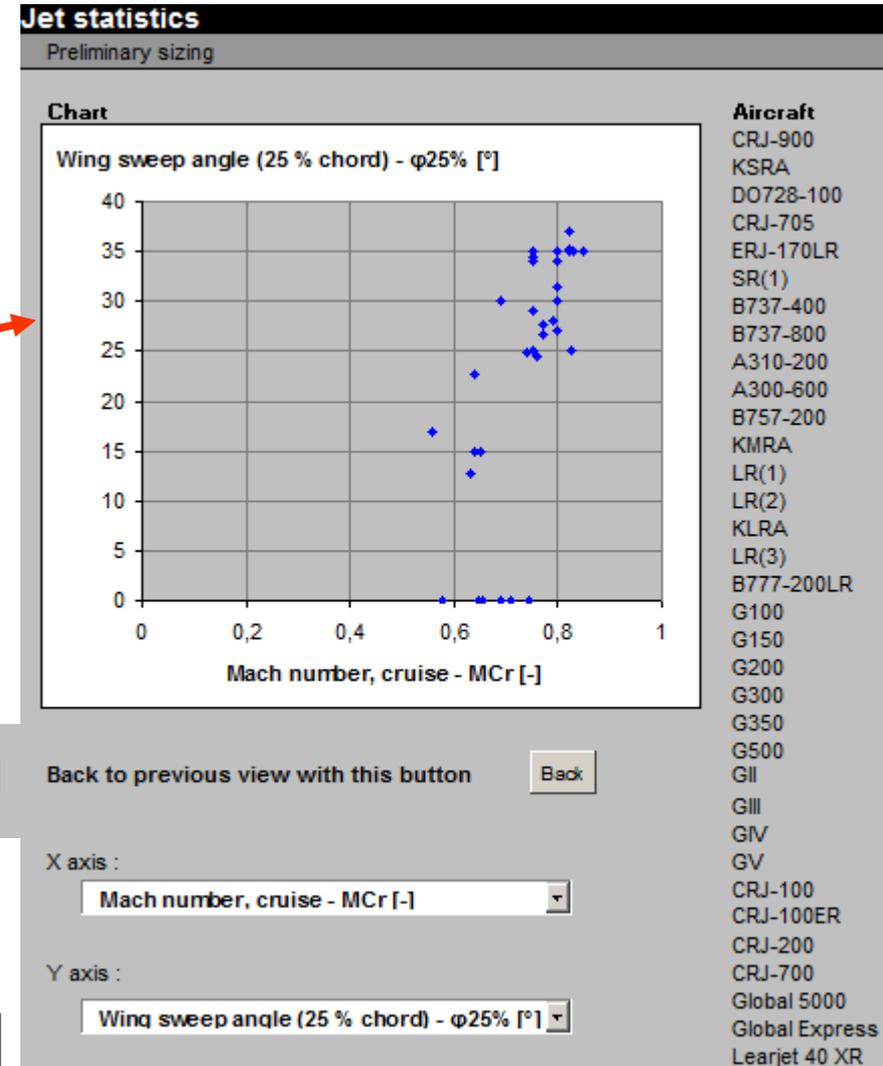
Wing loading	m_{MTO}/S_w	469 [kg/m ²]
Thrust-to-weight ratio	TTO/mMTO*g	0,324 [-]

PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots Preliminary Sizing

User may select data based on **statistics**

User may select data based on **pop up hints**



S_{wet} / S_w

6,2 [-]

Swet / Sw = 6,0 ... 6,2 for commercial aircraft

Preliminary Sizing – General statistic

PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots Preliminary Sizing

$$E_{max} = k_E \sqrt{\frac{A}{S_{wet} / S_W}}$$

Buttons starts statistics database

Estimation of max. glide ratio, E_{max}

Choose: factor k_E

15.8

Stat J

Relative wetted area

S_{wet} / S_w 6,2 [-]

Stat J

Aspect ratio

A 9,806592 [-]

Max. glide ratio

E_{max}

19,87 [-]

Max. glide ratio

E_{max} chosen 19,75 [-]

Suggestion

White: User input data
Gray: System calculated data

PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots Cabin & Fuselage

User **input and results are checked.**
Green means „ok“

Exit distribution analysis Start analysis

Total of allowed passengers through exits [-] > Number of passengers [-]

Overall number and size of exits is correct According to CS 25.807 (d)

Distance between exits **The distance is greater than the fuselage length factor** According to AC 25.807-1 (6) (b) (2) (v)

Distance between exits **The distance is smaller than 60 ft** According to CS 25.807 (d)(7)

Check of exit zones according to AC 25.807-1 (6)(b)(1)

Zone	Allowed PAX	Effective number of PAX
A	125	66
B	125	84

Check of exits positions according to AC 25.807-1 (6)(b)(2)(vi)

Exit	Position		Type	Offset		Allowed PAX
	Nominal	Actual		[m]	[% cab. length]	
1	1,48	1,48	Type C	0,00	0,00	55
2	12,61	12,48	Double Type III	0,13	0,57	70
3	23,73	23,73	Type C	0,00	0,00	55

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Screen Shots Cabin & Fuselage

Cross section dimensions (from Economy Class)

Automatic calculation

Automatic optimization

... to minimize this:

$d_{f,o}$ [m]

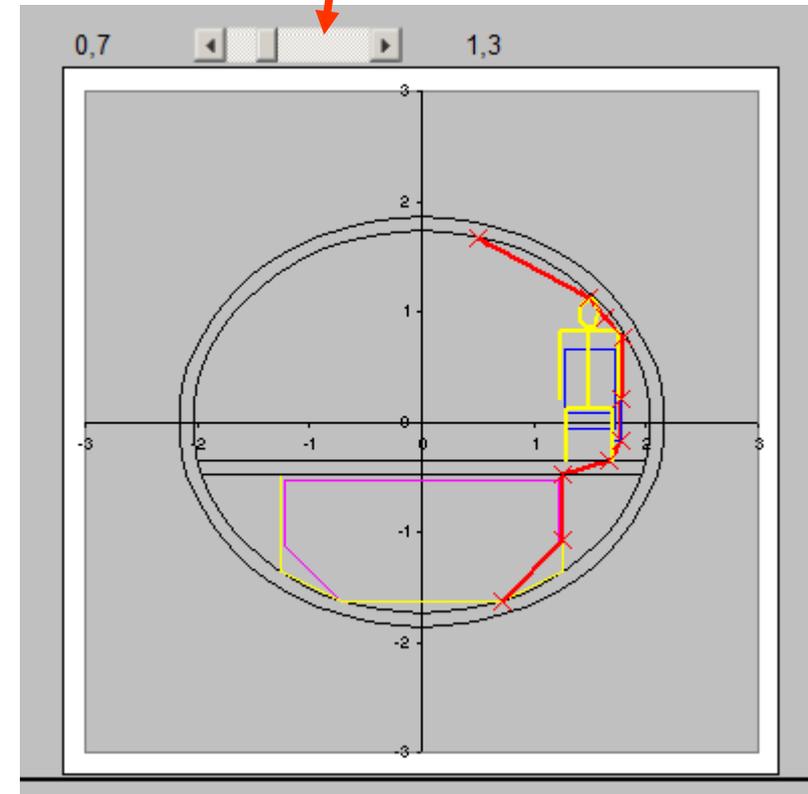
t_{floor} [m]

$h_{f,o}$ [m]

$w_{f,o}$ [m]

Optimize cross section parameters such that the equivalent outer diameter is a minimum. This will lead to a minimum wetted area of the fuselage and hence a minimum skin friction drag.

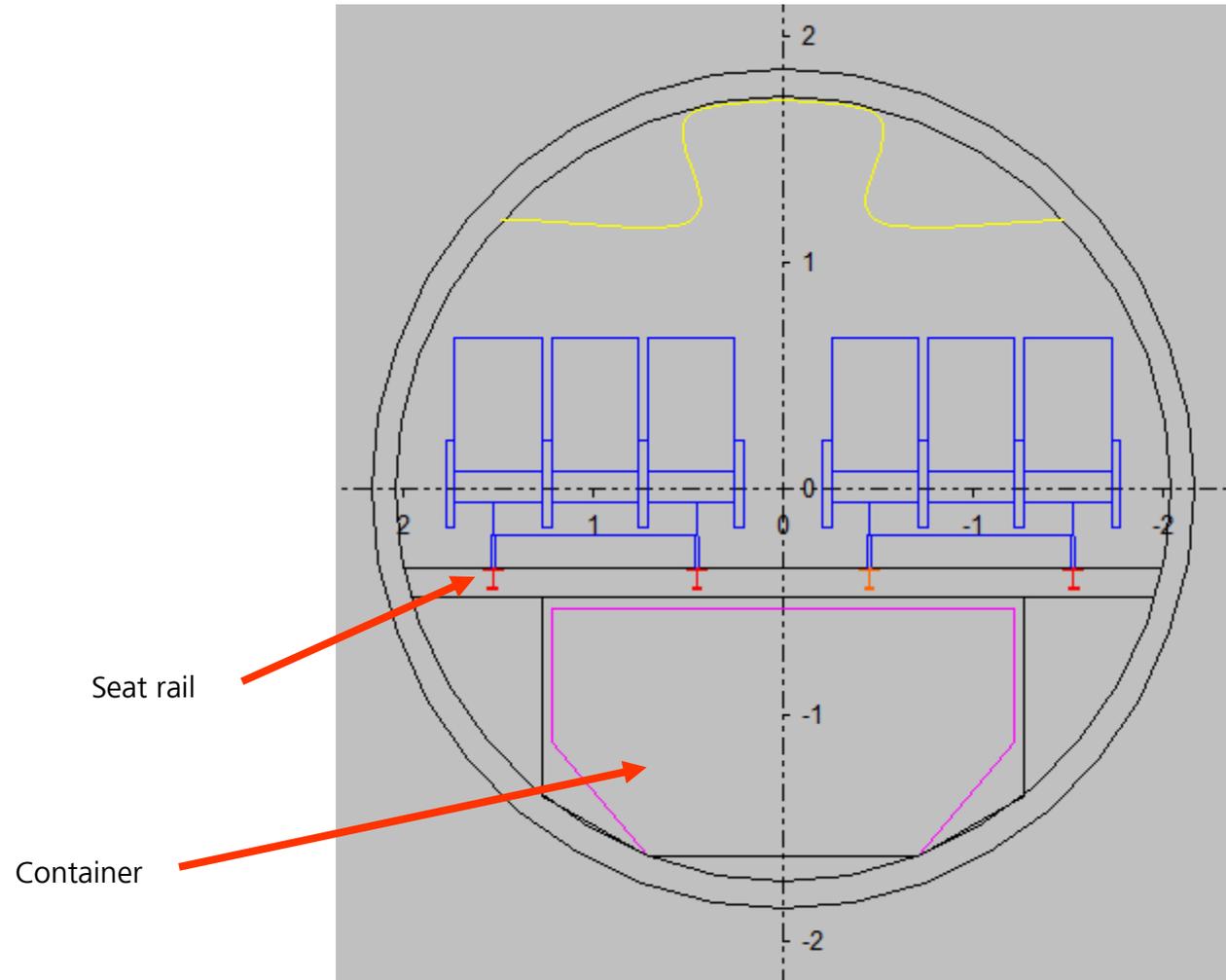
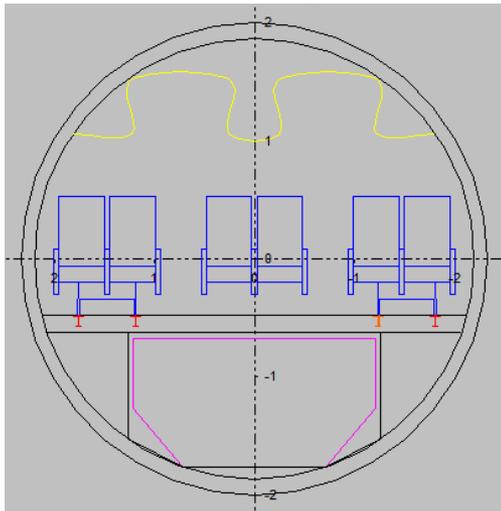
Change this ...



PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots Cabin & Fuselage

Alternative seat arrangement:



PreSTo - Aircraft Preliminary Sizing Tool

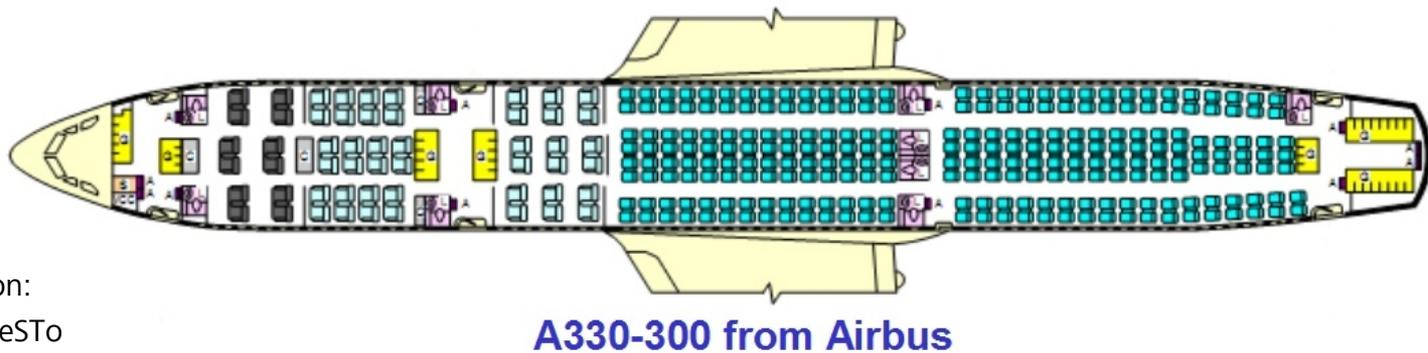
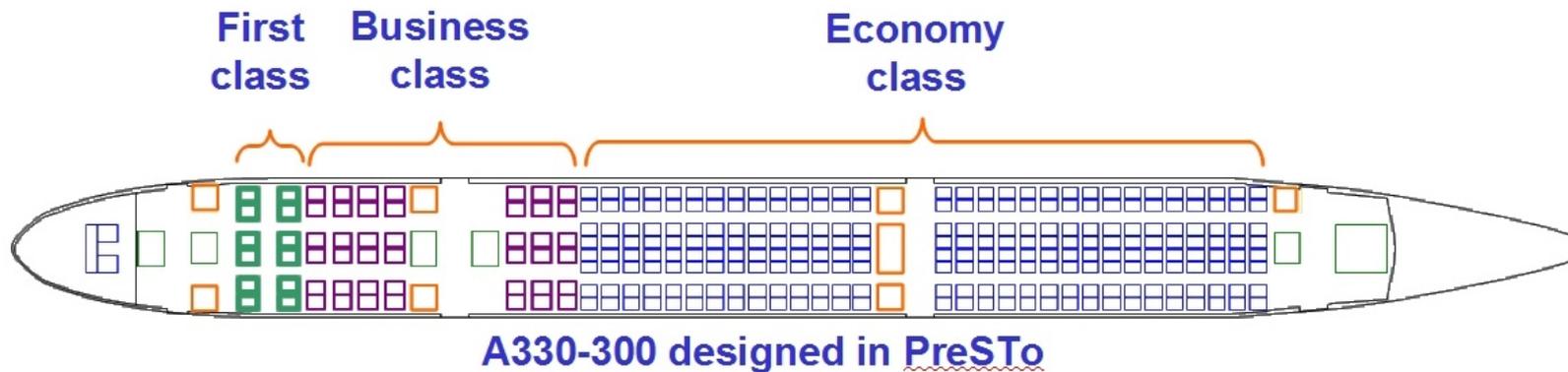
Screen Shots Cabin & Fuselage



Seat layout

PreSto - Aircraft Preliminary Sizing Tool

Screen Shots Cabin & Fuselage



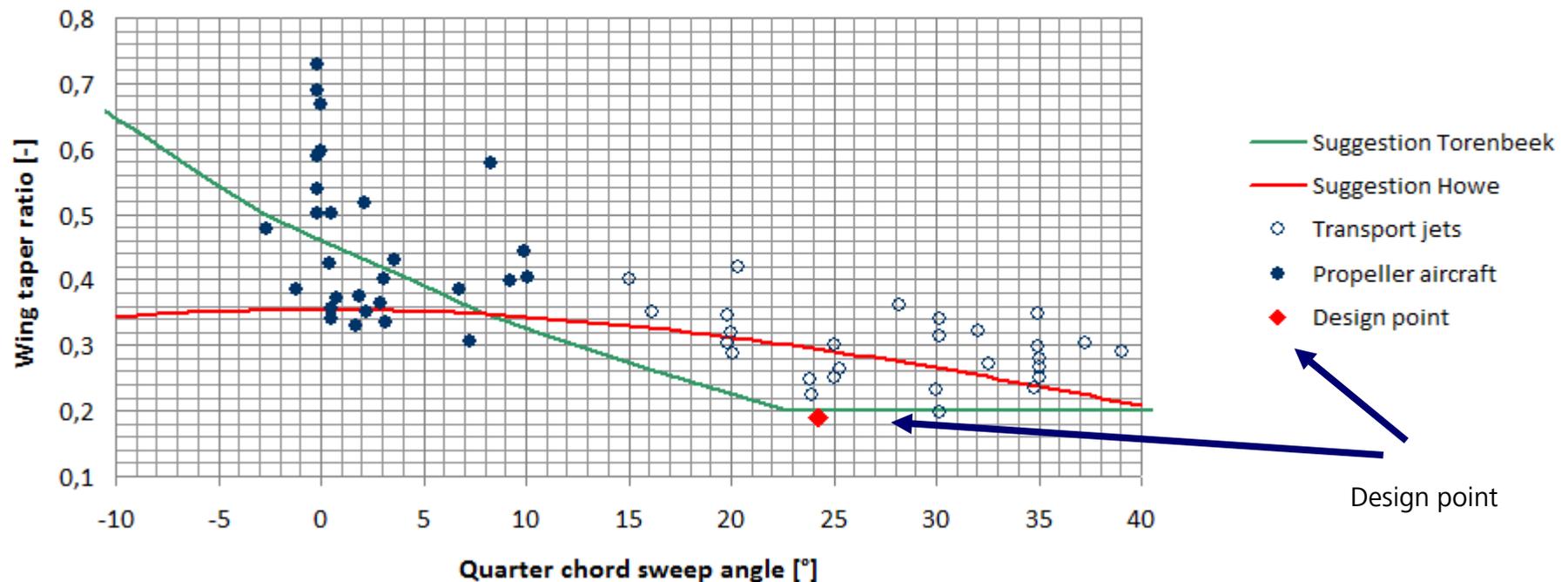
Seat layout comparison:
Airbus original and PreSto

PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots

Wing

Taper ratio suggestion

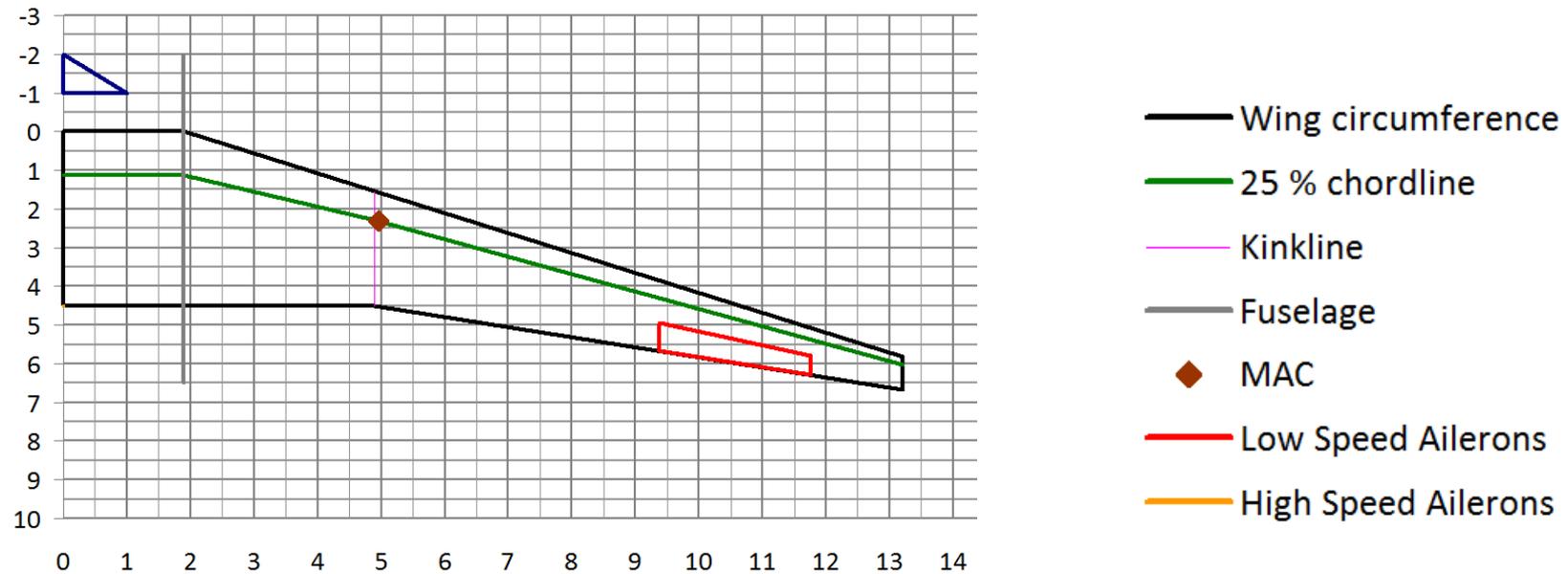


User support with **experience** from industry and academia **presented with respect to current design**

PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots

Wing

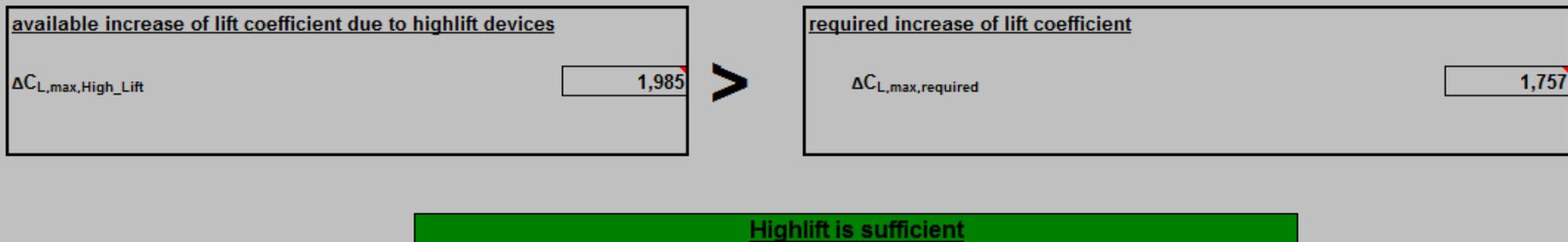


Preview of wing parameters

PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots High Lift

Final statement in
high lift preliminary design

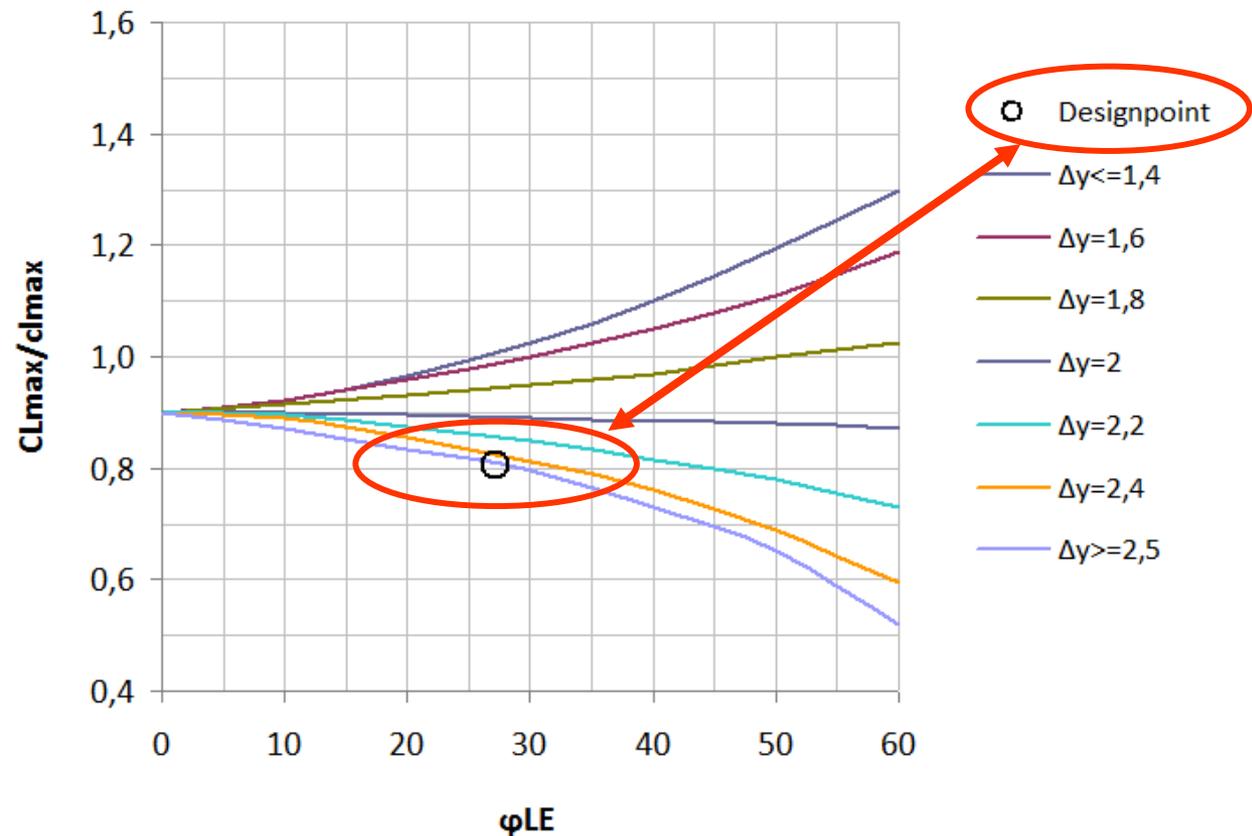


**Preview of high lift
parameters**

PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots
High Lift

SUBSONIC MAXIMUM LIFT OF HIGH-ASPECTED-RATIO WINGS
ACCORDING TO DATCOM FIGURE 4.1.3.4-21a



Display of calculated Datcom data
and

Automatic readout of parameters
with respect of actual design point

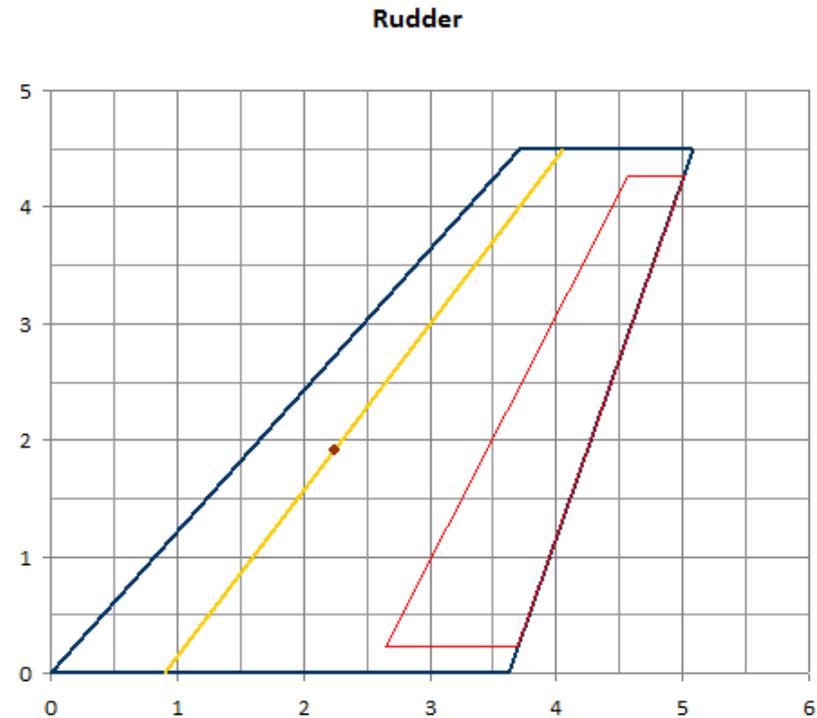
PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots Tailplane I

Preview of tail parameters



Horizontal stabilizer

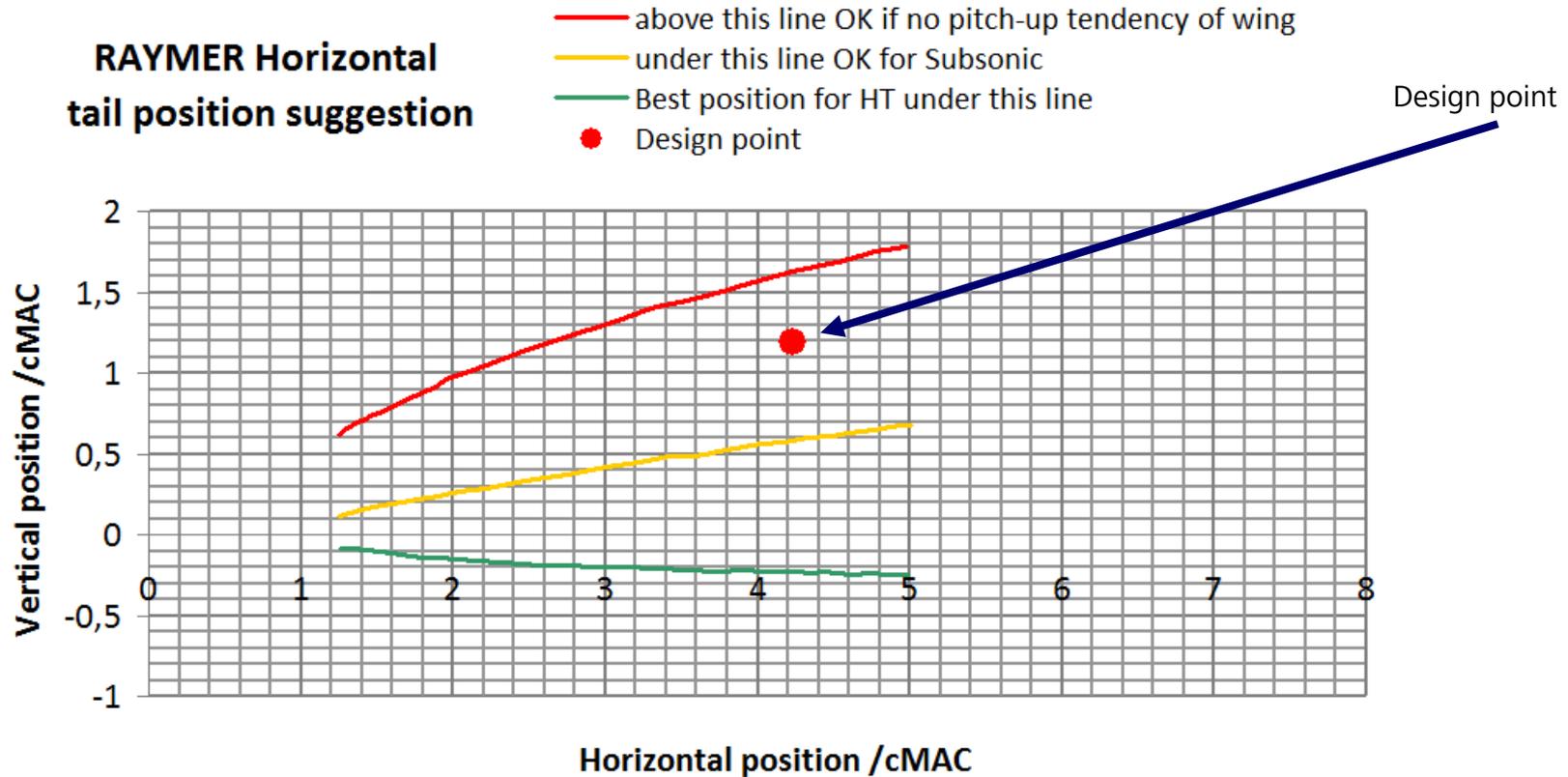


Fin

PreSTo - Aircraft Preliminary Sizing Tool

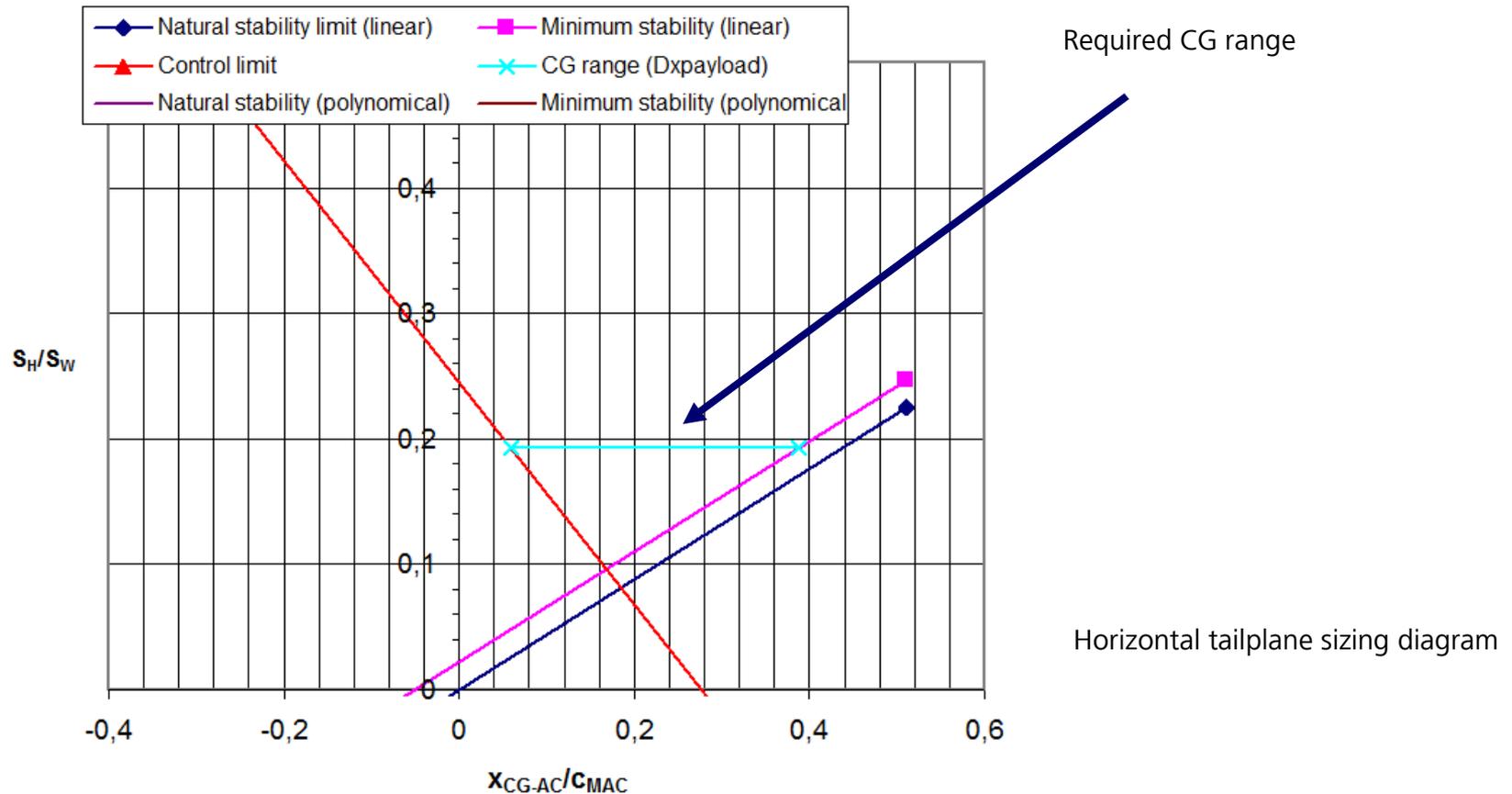
Screen Shots
Tailplane I

Showing design parameters with respect to established practise



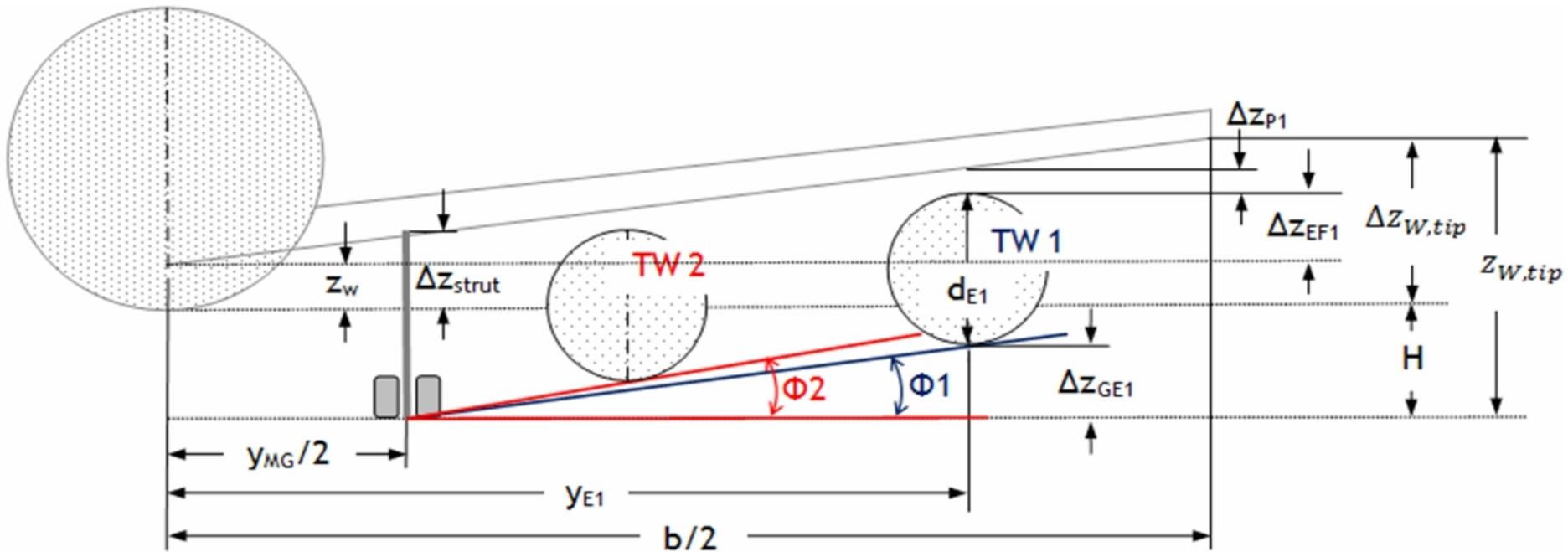
PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots Tailplane II



PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots Landing Gear

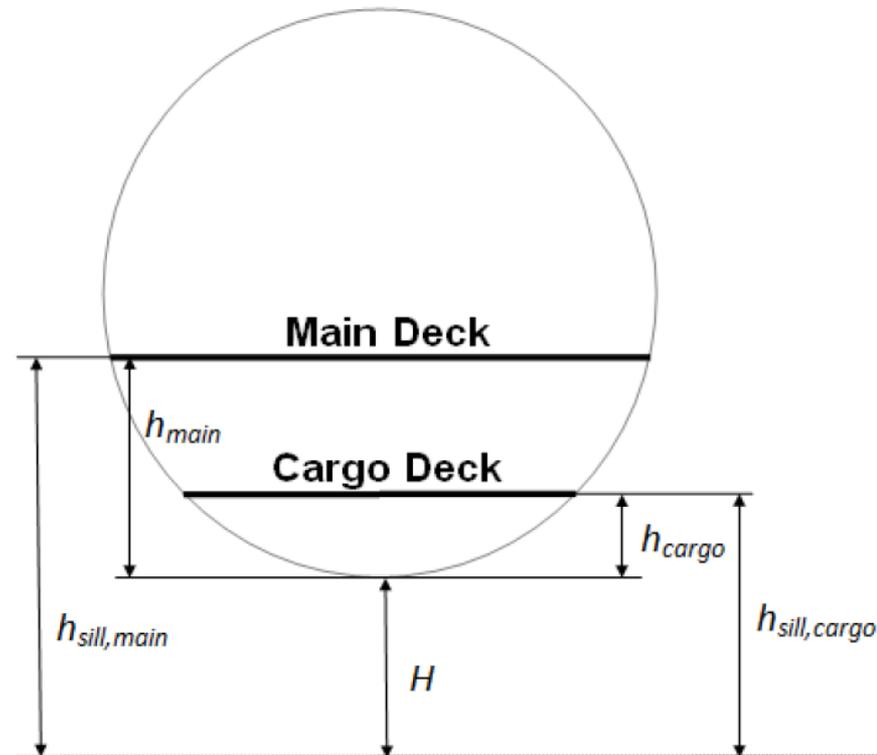


Engine ground clearance due to landing gear length

Engine 1 bank angle is OK

PreSTo - Aircraft Preliminary Sizing Tool

Screen Shots Landing Gear



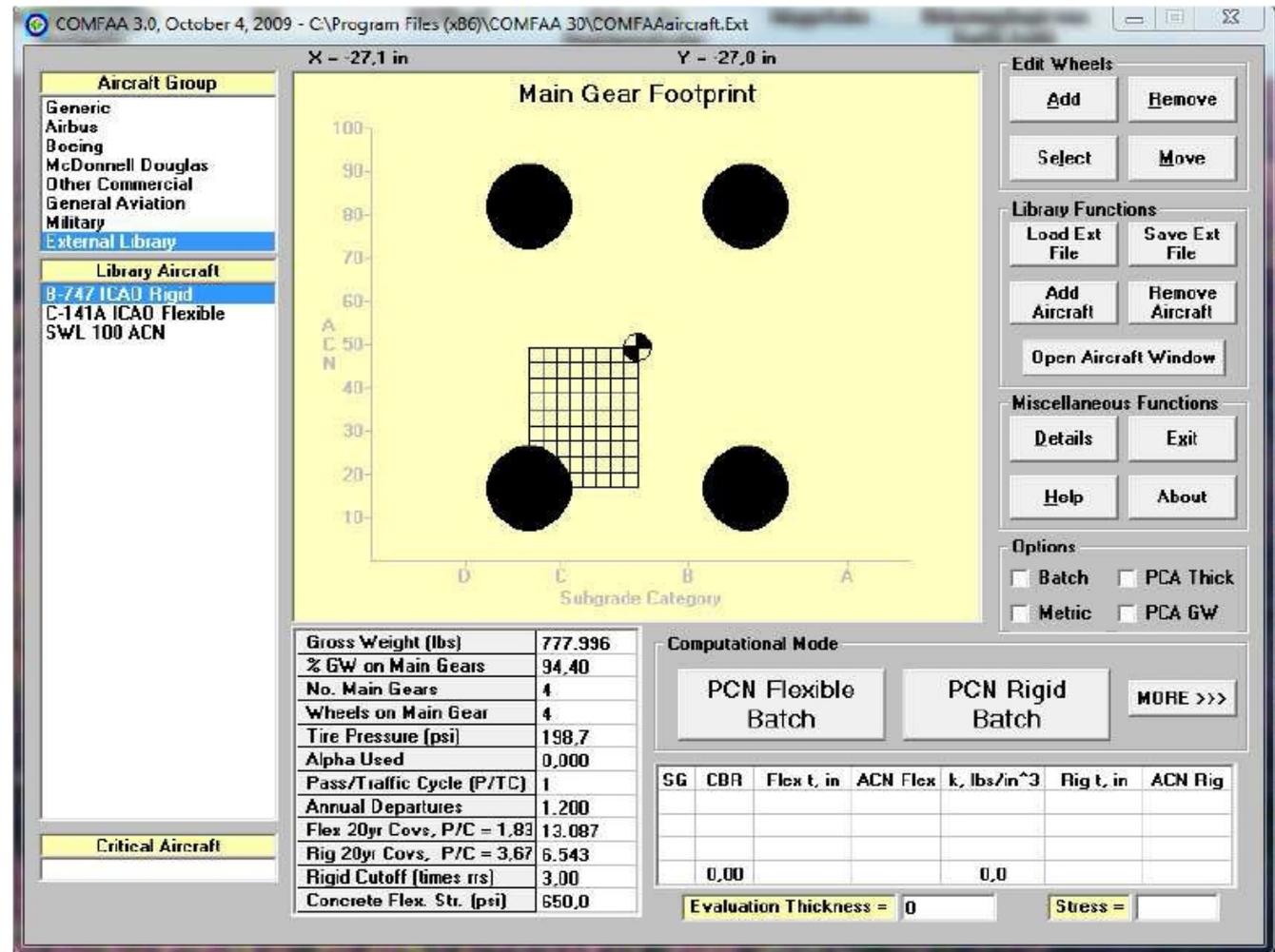
Calculating **sill height** – an important parameter for airport compatibility

PreSto - Aircraft Preliminary Sizing Tool

Screen Shots Landing Gear

Calculation of **ACN** values
Aircraft
Classification
Number

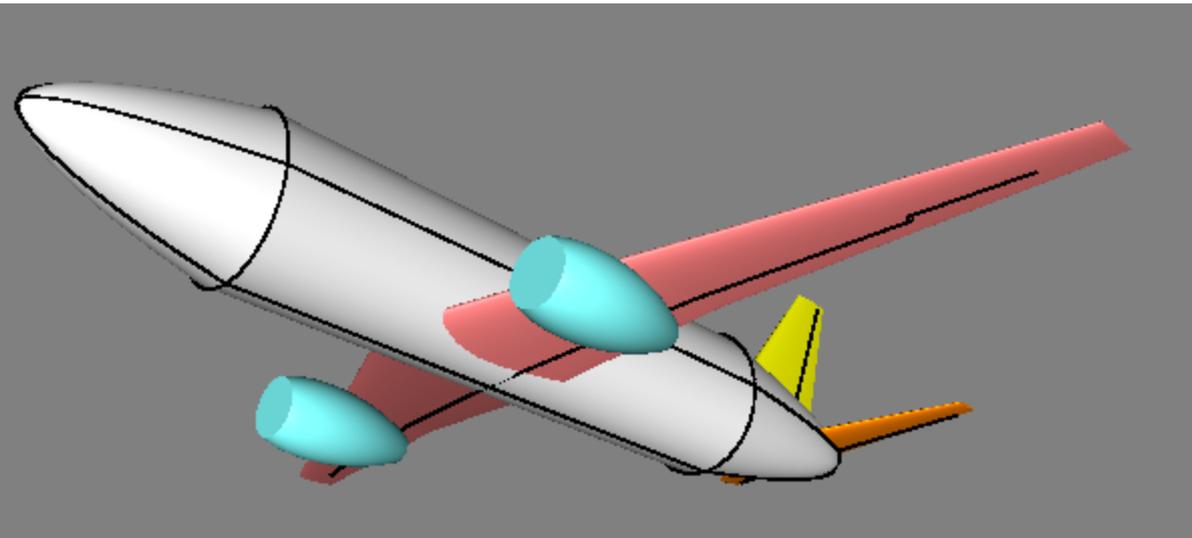
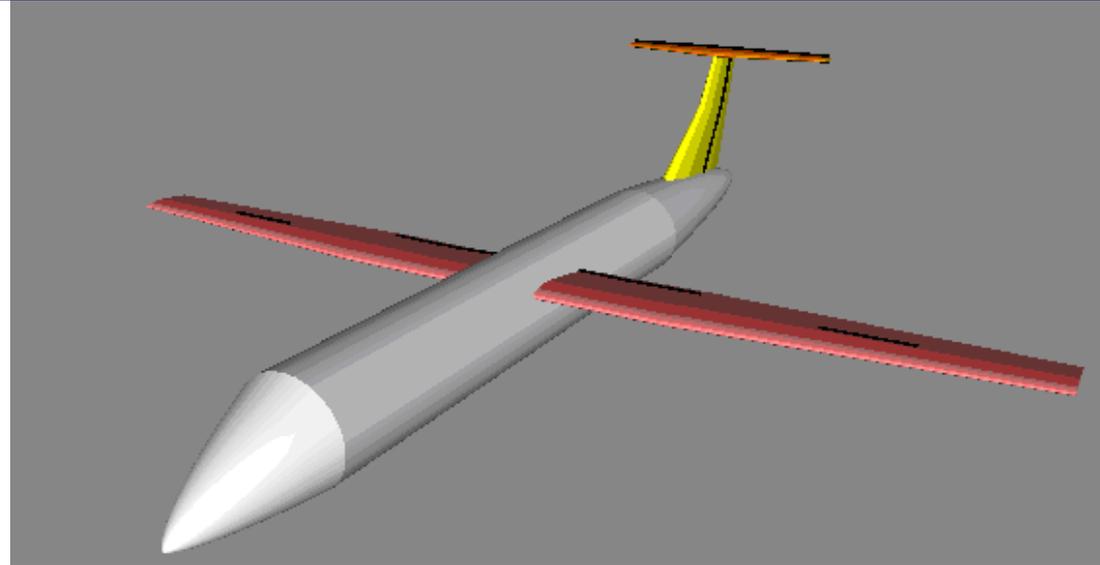
COMFAA is integrated into
PreSto:
o automatic input of data
o COMFAA results stored in
PreSto



PreSTo - Aircraft Preliminary Sizing Tool

Data Export / Visualization CEASIOM

FD 728 from PreSTo in
ACBuilder from CEASIOM

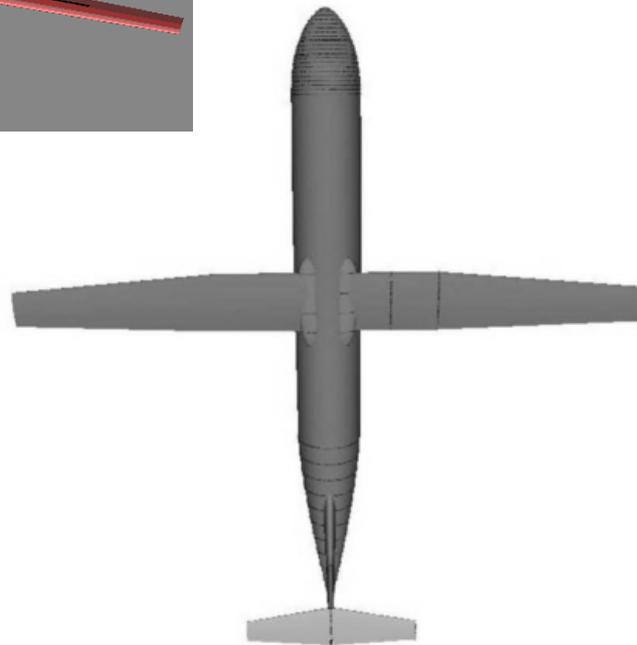
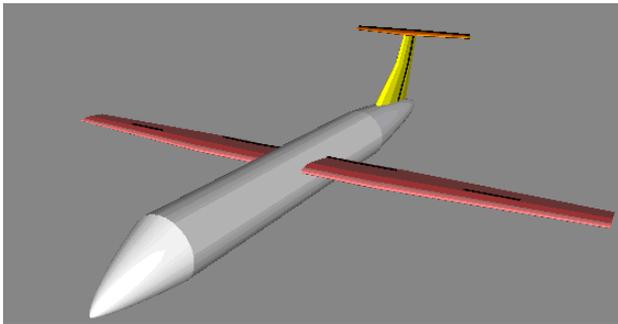


ATR 72 from PreSTo in
ACBuilder from CEASIOM

PreSTo - Aircraft Preliminary Sizing Tool

Data Export / Visualization CEASIOM

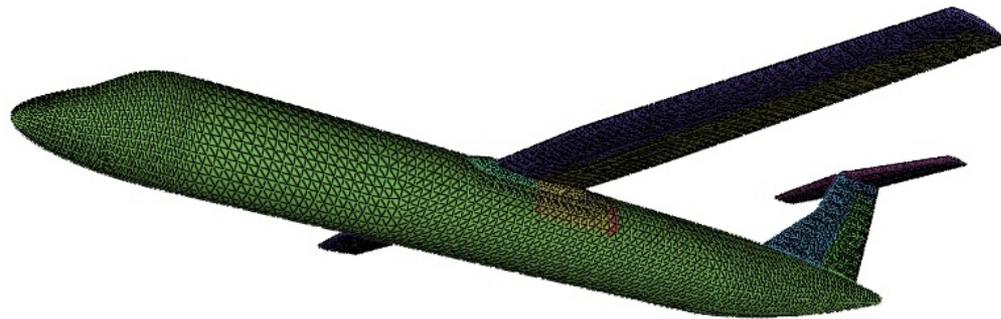
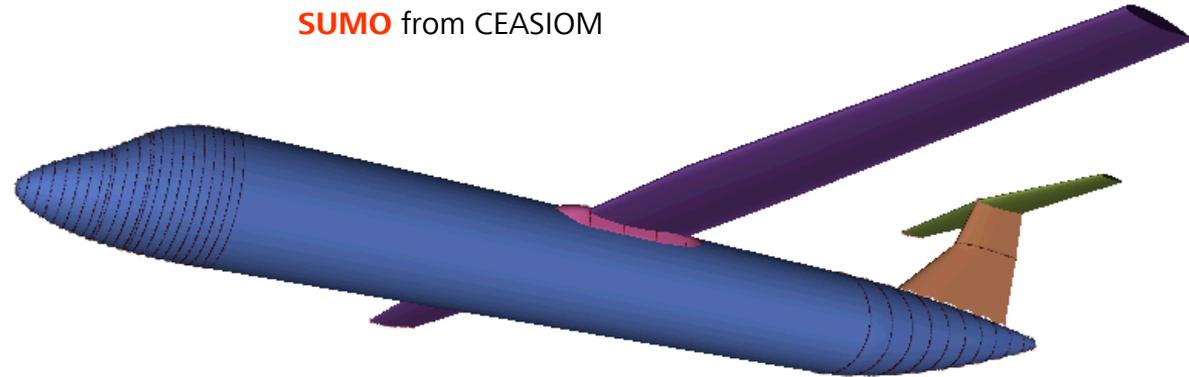
FD 728 from PreSTo in
ACBuilder from CEASIOM
shown in the style of a
three-view drawing



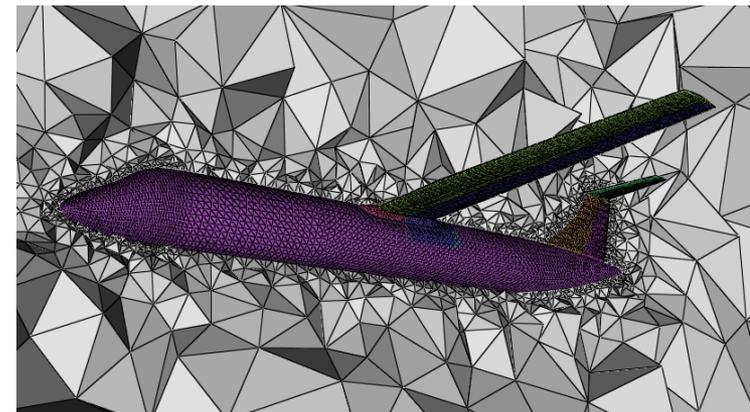
PreSTo - Aircraft Preliminary Sizing Tool

Data Export / Visualization CEASIOM

ATR 72 from PreSTo in
SUMO from CEASIOM

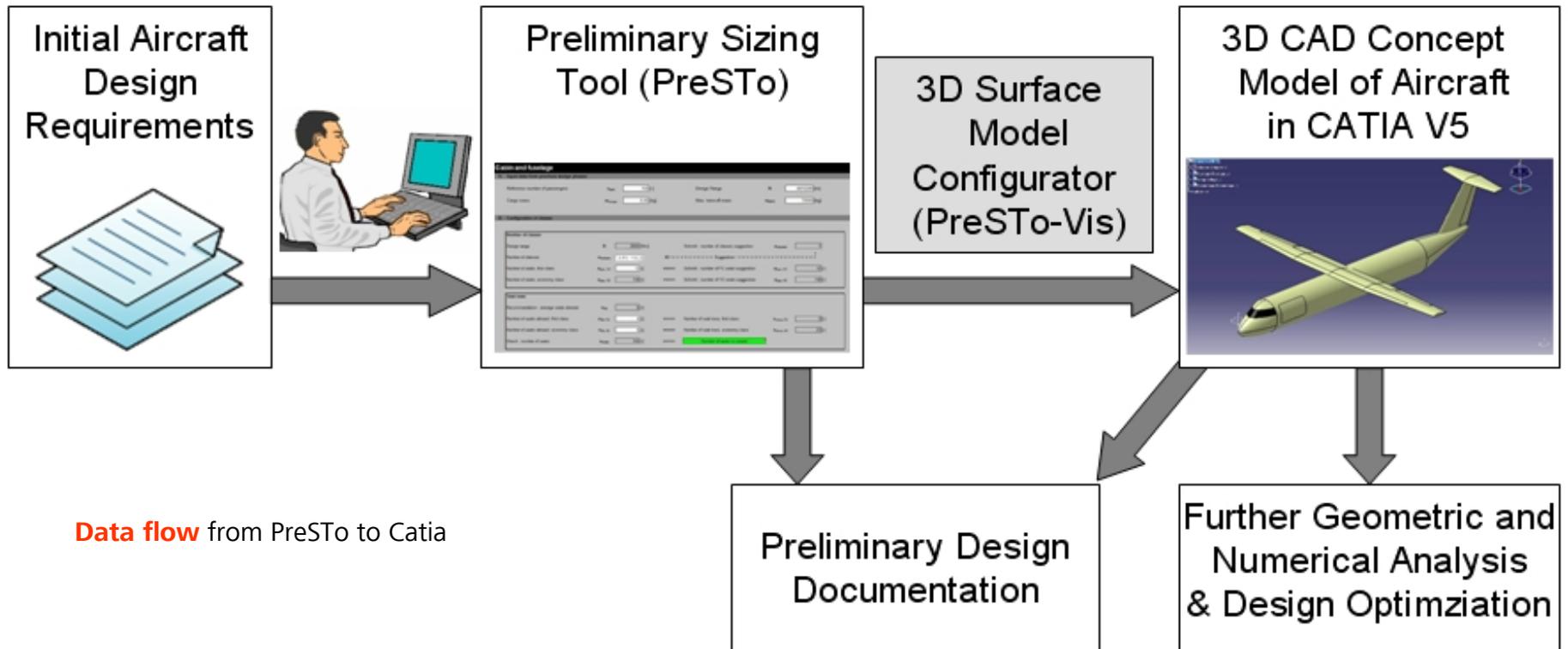


ATR 72 from PreSTo
with surface and volume mesh generated by
SUMO from CEASIOM



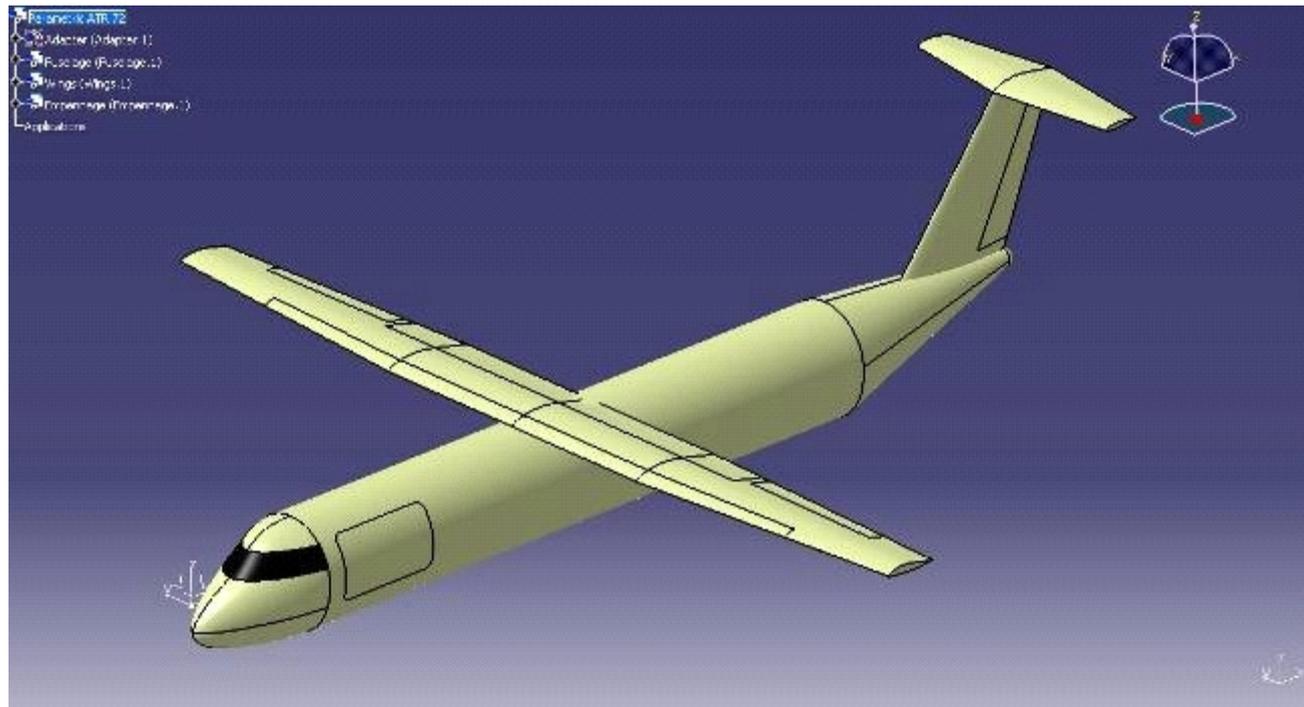
PreSTo - Aircraft Preliminary Sizing Tool

Data Export / Visualization Catia



PreSTo - Aircraft Preliminary Sizing Tool

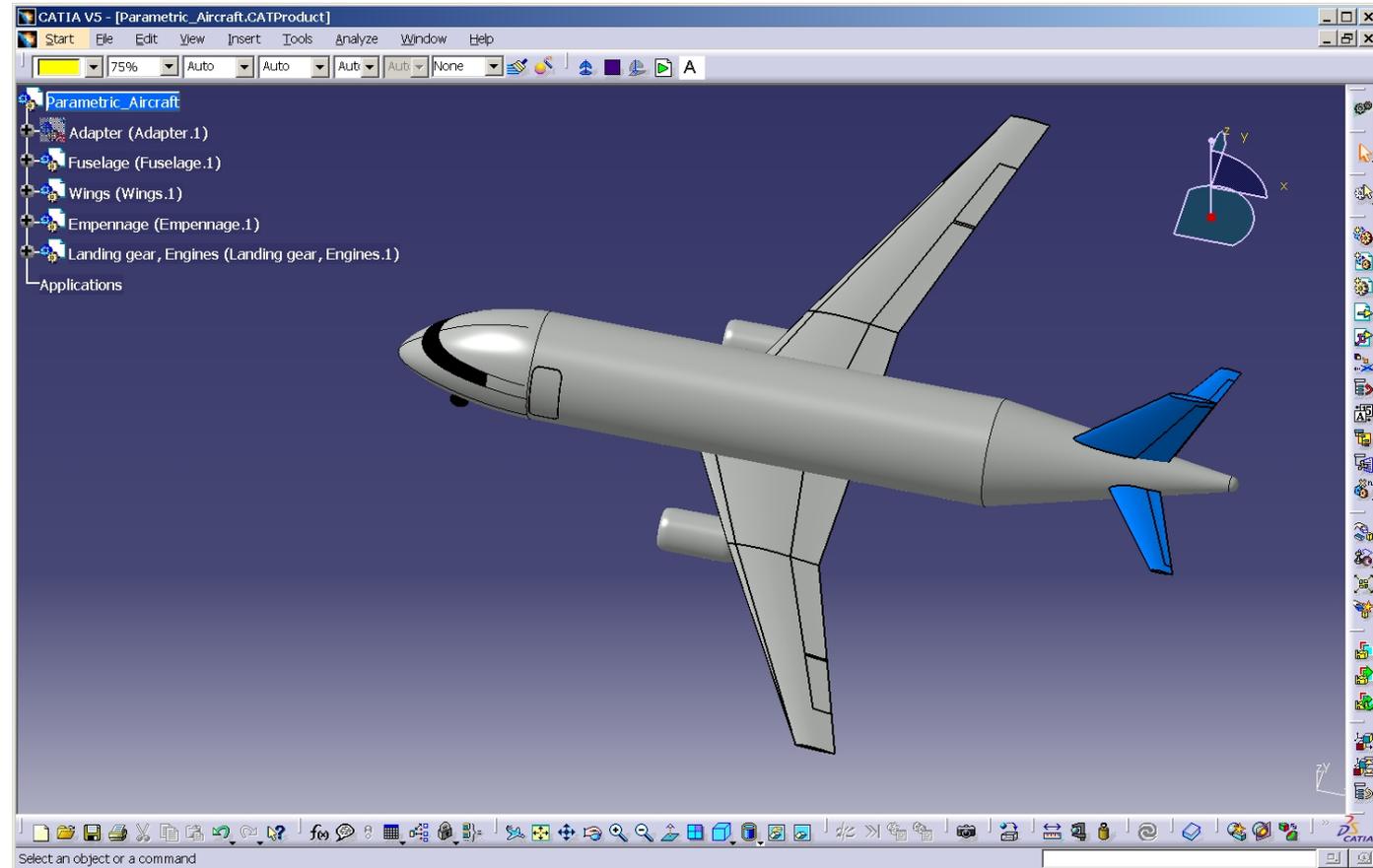
Data Export / Visualization Catia



ATR 72 from PreSTo in **Catia**
built with parametric model

PreSTo - Aircraft Preliminary Sizing Tool

Data Export / Visualization Catia

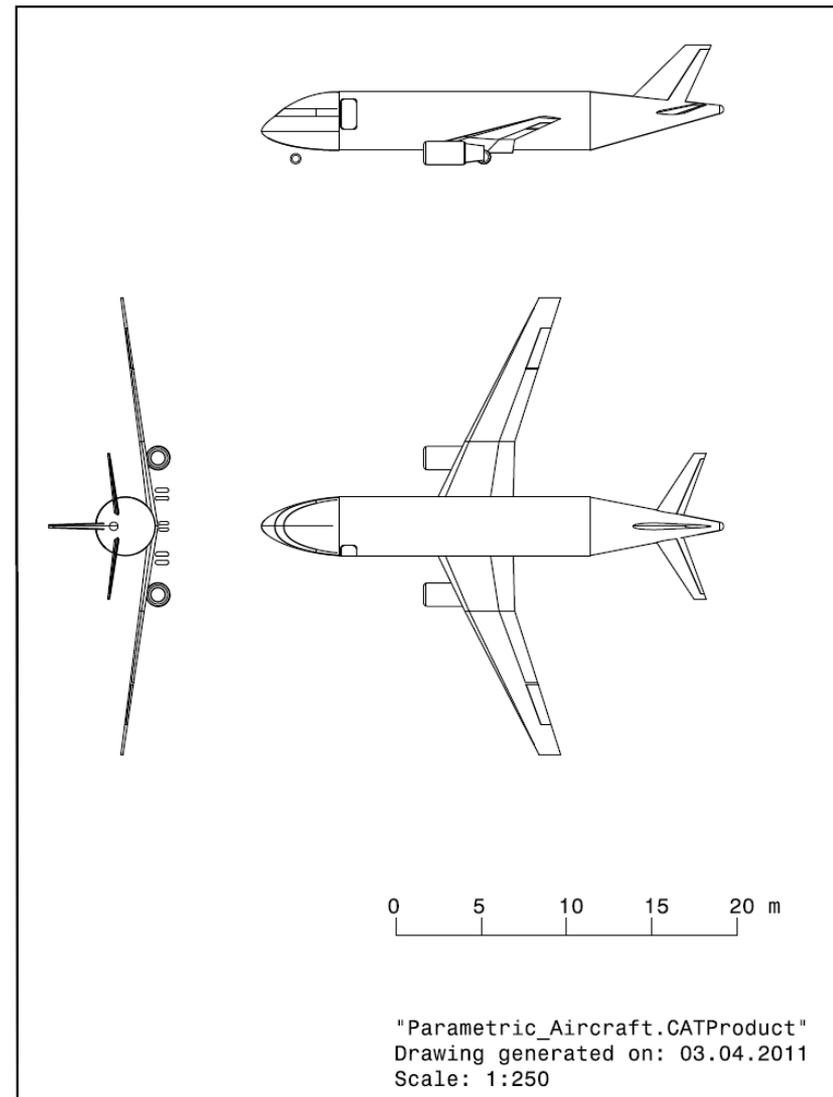


FD 728 from PreSTo in **Catia**
built with parametric model

PreSTo - Aircraft Preliminary Sizing Tool

Data Export / Visualization Catia

FD 728 from PreSTo in **Catia**
automatically generated three-view drawing
derived from parametric model



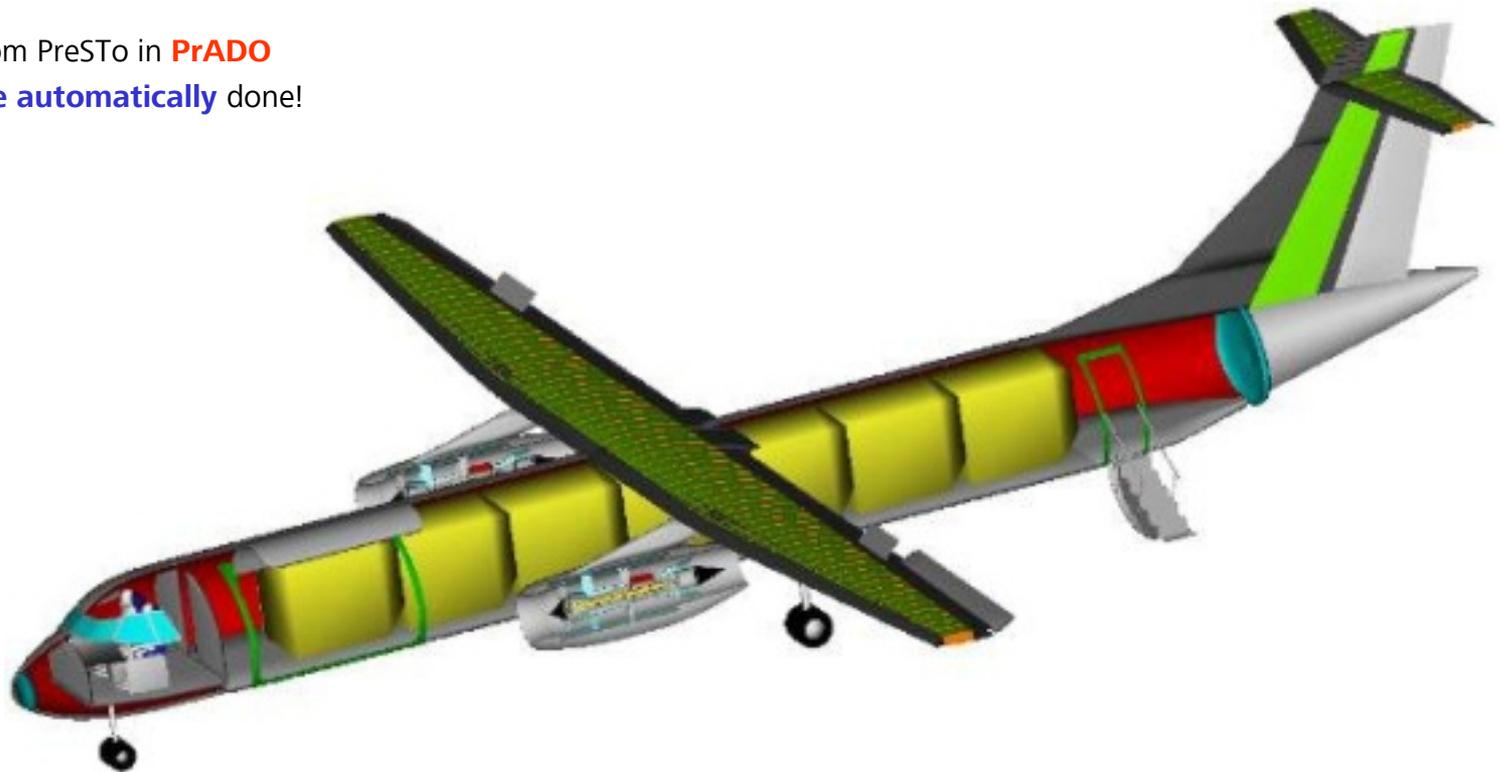
PreSTo - Aircraft Preliminary Sizing Tool

Data Export / Visualization

PrADO (Preliminary Aircraft Design and Optimization)

ATR 72 - Jet from PreSTo in **PrADO**

This is **not done automatically** done!



PreSto - Aircraft Preliminary Sizing Tool

PreSto Homepage

PreSto, University of Applied Sciences, Hamburg - Windows Internet Explorer

http://presto.profscholz.de/

Hochschule für Angewandte
Wissenschaften Hamburg
Hamburg University of Applied Sciences

PreSto - Aircraft Preliminary Sizing Tool

Introduction to PreSto

Aircraft Design Spreadsheet Calculation

Aim of PreSto is to convert the aircraft design calculation scheme from the [lecture](#) and [short course](#) of Prof. Scholz into a spread sheet. The spread sheet will ultimately include these modules:

1. Sizing (*PreSto-Sizing*)
2. Cabin and Fuselage Layout (*PreSto-Cabin*)
3. Wing Layout
4. Design for High Lift
5. Empenage Layout I and II
6. Mass and CG Estimation
7. Landing Gear Layout
8. Drag Estimation
9. DOC Calculation
10. Results, Interfaces to other Tools, 3D Visualization (*PreSto-Vis*)

Excel was selected as spread sheet. Experience has shown that the tool will get too big (and will not run on computers with limited computing power) if all modules are put together in one file. In addition this file will be rather big (some 10 MB). So the intention is to work with separate modules that are connected via a small Excel file that provides the link between all separate modules - each in one file - and contains a database which stores user input data. In this way the modules described above are Excel files that take input data, run the design/analysis and output data to a small and separated database.

Philosophy

Internet | Protected Mode: Off

Start

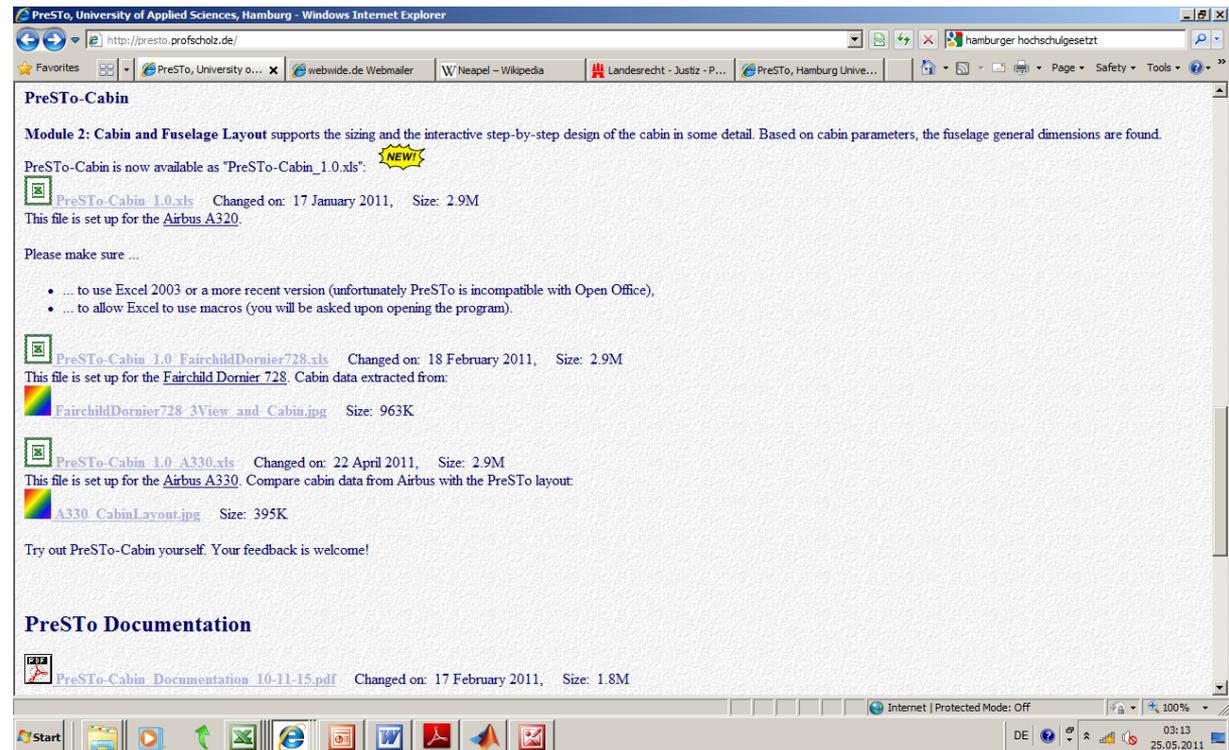
DE 03:11 25.05.2011

<http://PreSto.ProfScholz.de>

PreSto - Aircraft Preliminary Sizing Tool

PreSto Homepage

Download PreSto:



<http://PreSto.ProfScholz.de>

PreSTo - Aircraft Preliminary Sizing Tool

Conclusions and Outlook

- **PreSTo** supports a very **basic / standard** way of **aircraft design**

- **Interfaces** are provided to **higher order tools**
 - CEASIOM
 - PrADO

- **Visualization** of the aircraft is done with outside tools:
 - CEASIOM
 - **ACBuilder**
 - **SUMO**
 - Catia

- Next steps:
 - Finish PreSTo
 - Offer for download: <http://PreSTo.ProfScholz.de>

PreSTo - Aircraft Preliminary Sizing Tool

Contact

info@ProfScholz.de

<http://PreSTo.ProfScholz.de>

