



EWAD 2011
10th European Workshop on Aircraft
Design Education 24-27 May, 2011

Development of a Software for Aircraft Preliminary
Design and Analysis (ADAS)

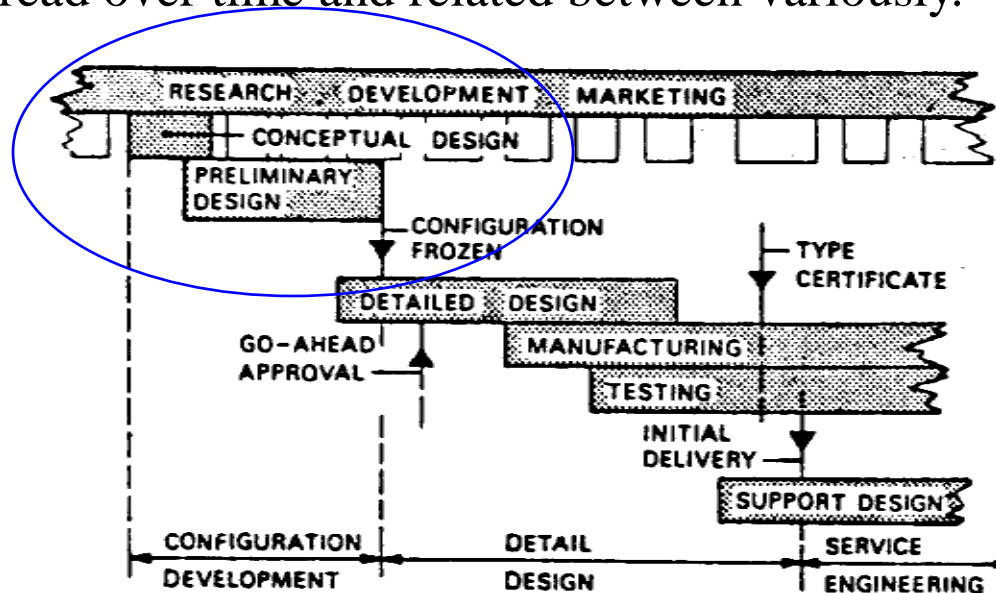
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Department of Aerospace Engineering (DIAS)
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Aircraft Design

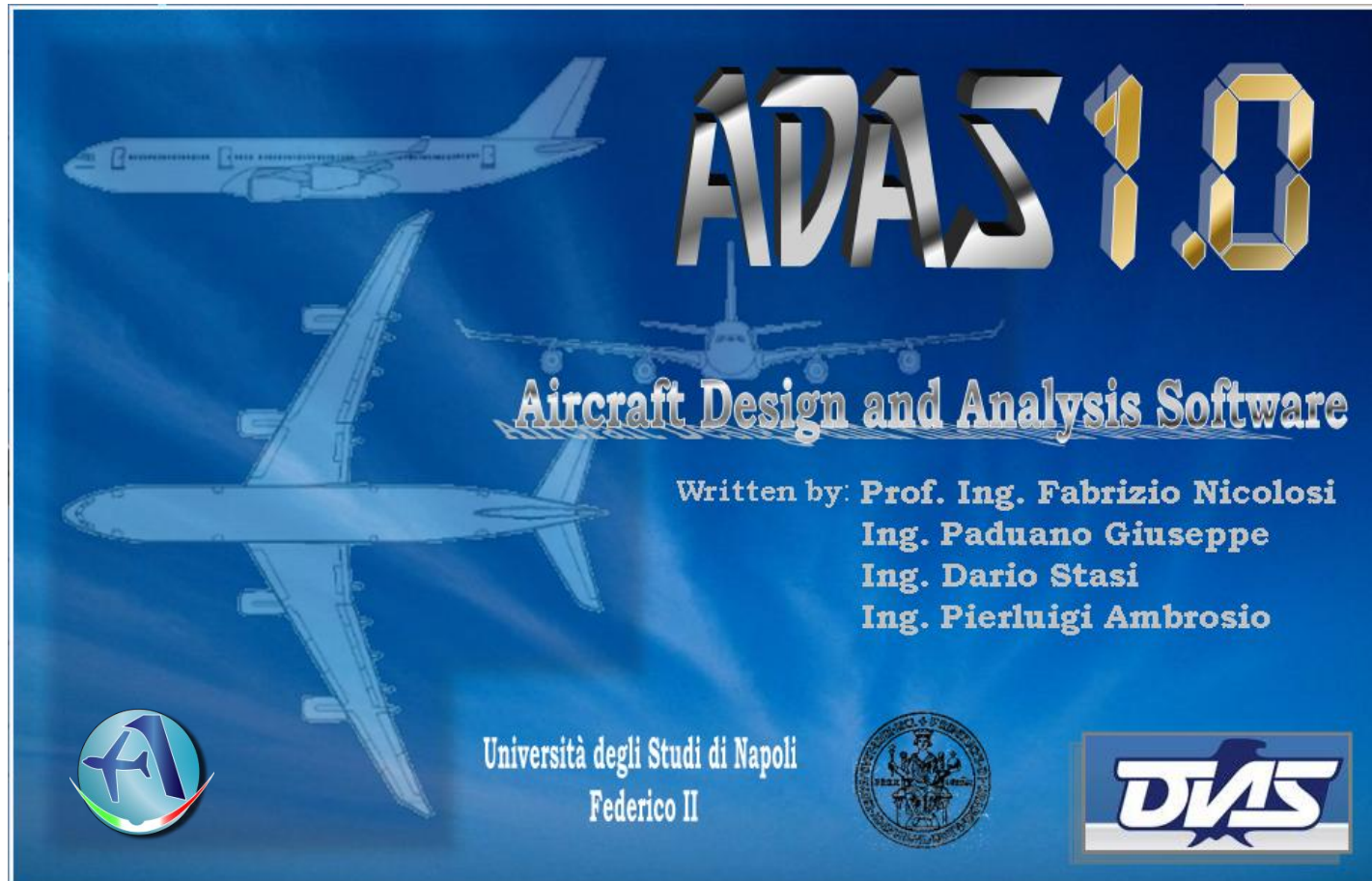
Aircraft Design is a complex process, articulated in many different stages spread over time and related between variously.



The preliminary/conceptual design is intended as an objective determination of the main geometric parameters, aerodynamic, structural, propulsion, stability and control characteristics useful to the initial definition of the new project, starting from the knowledge of the mission specifics.

AD AS 1.0

Aircraft Design and Analysis Software

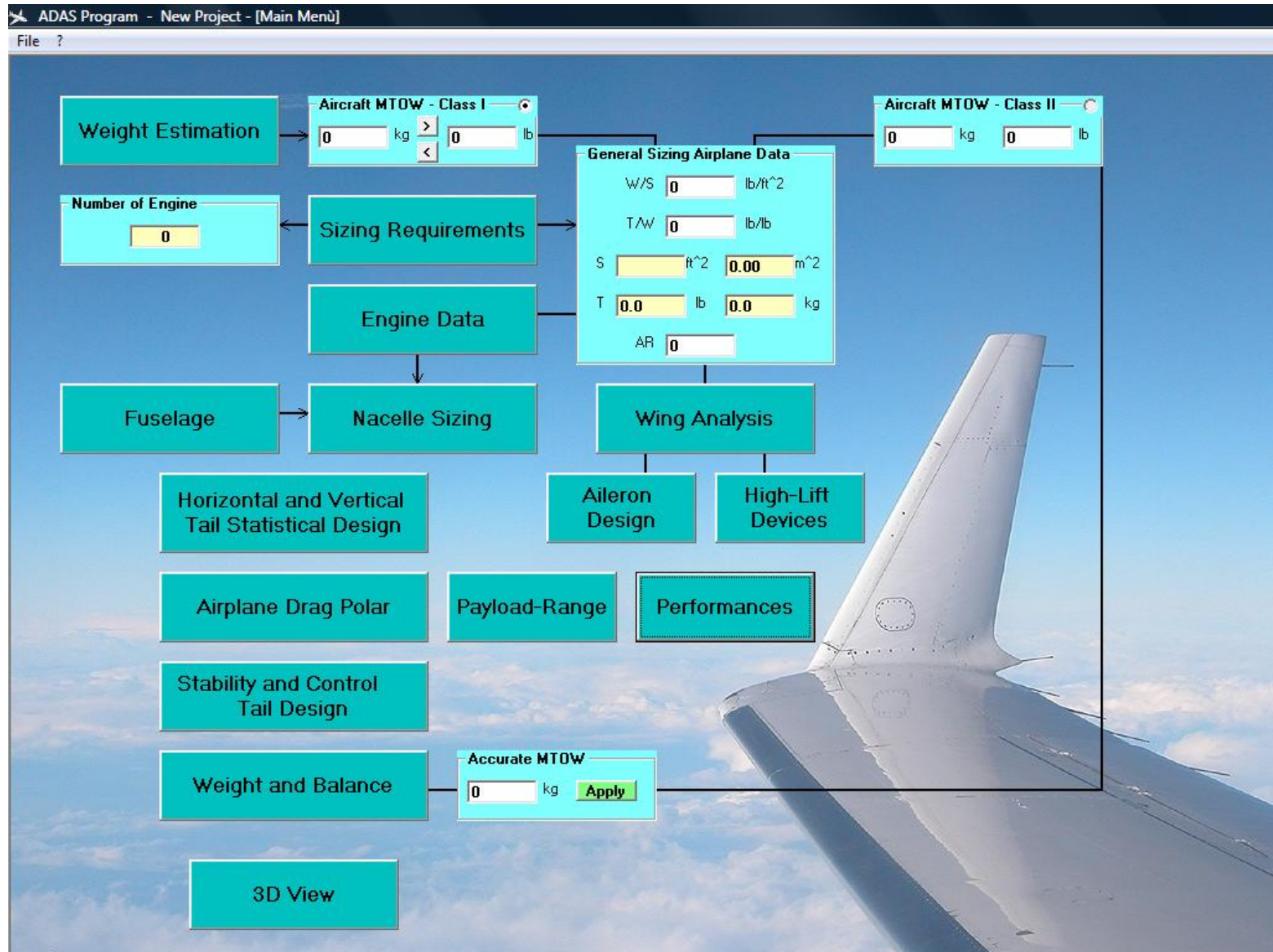


AD AS 1.0

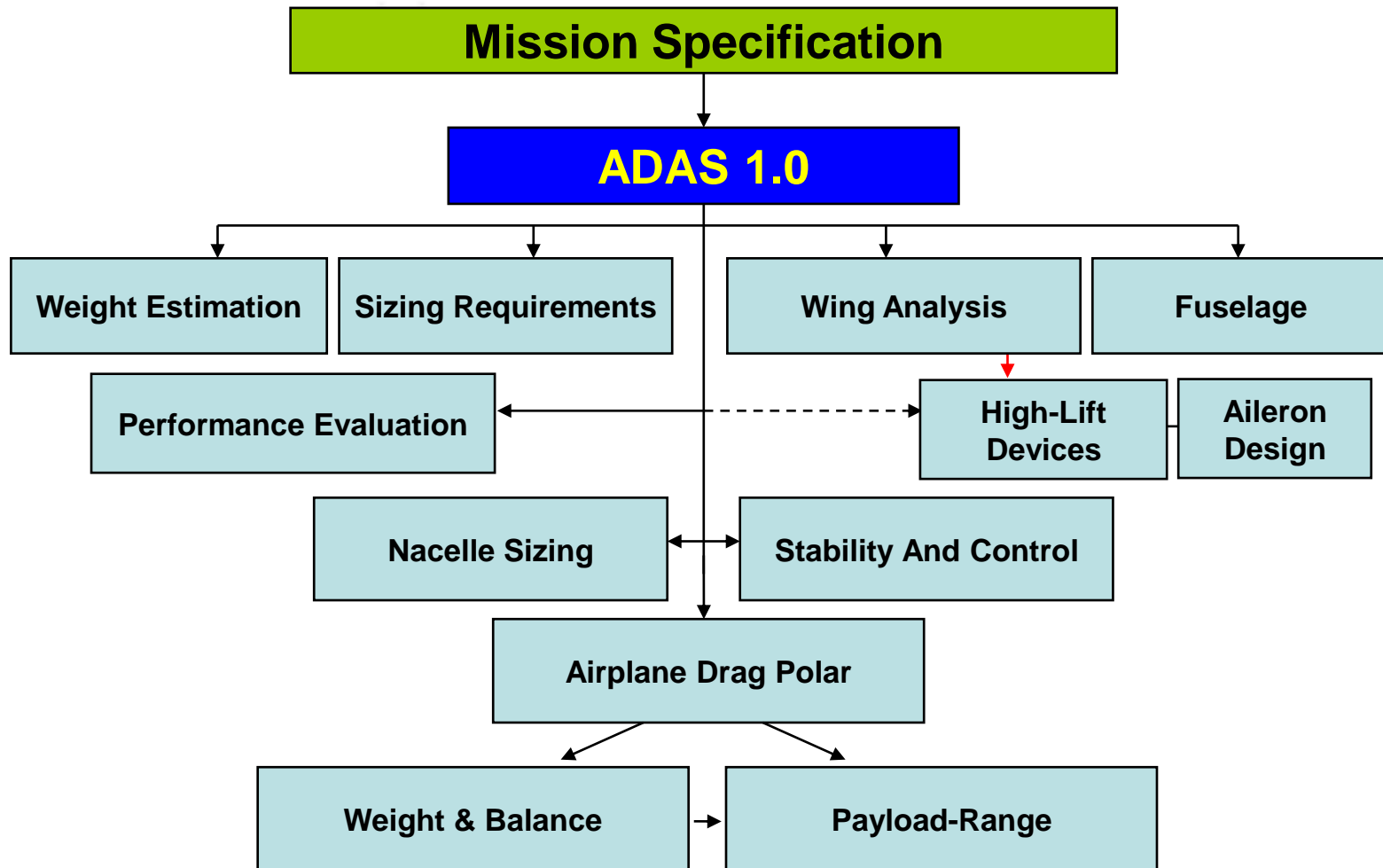
Aircraft Design and Analysis Software

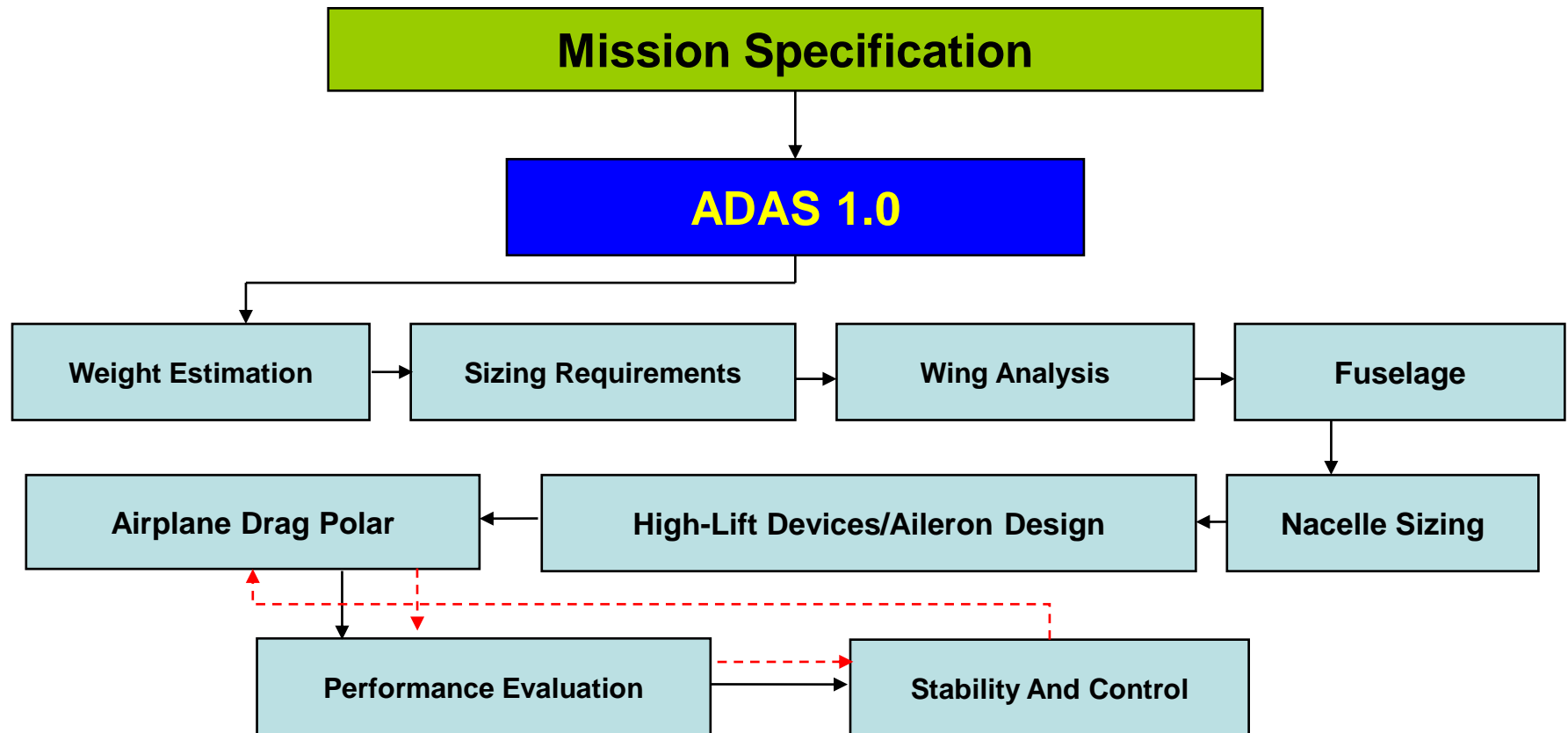
A Software for the conceptual/preliminary design of transport aircraft (Transport Jet, regional TBP, business jet) and light aircraft

- Written in *VISUAL BASIC (80 form x 1000 Average code lines)*
- *User Friendly GUI* and useble on any *Microsoft Windows Platform*
- Independent calculation modules
- .txt Output Files
- Valid for Teaching and Professional applications
- Development started 2005



ADAS Flow Chart



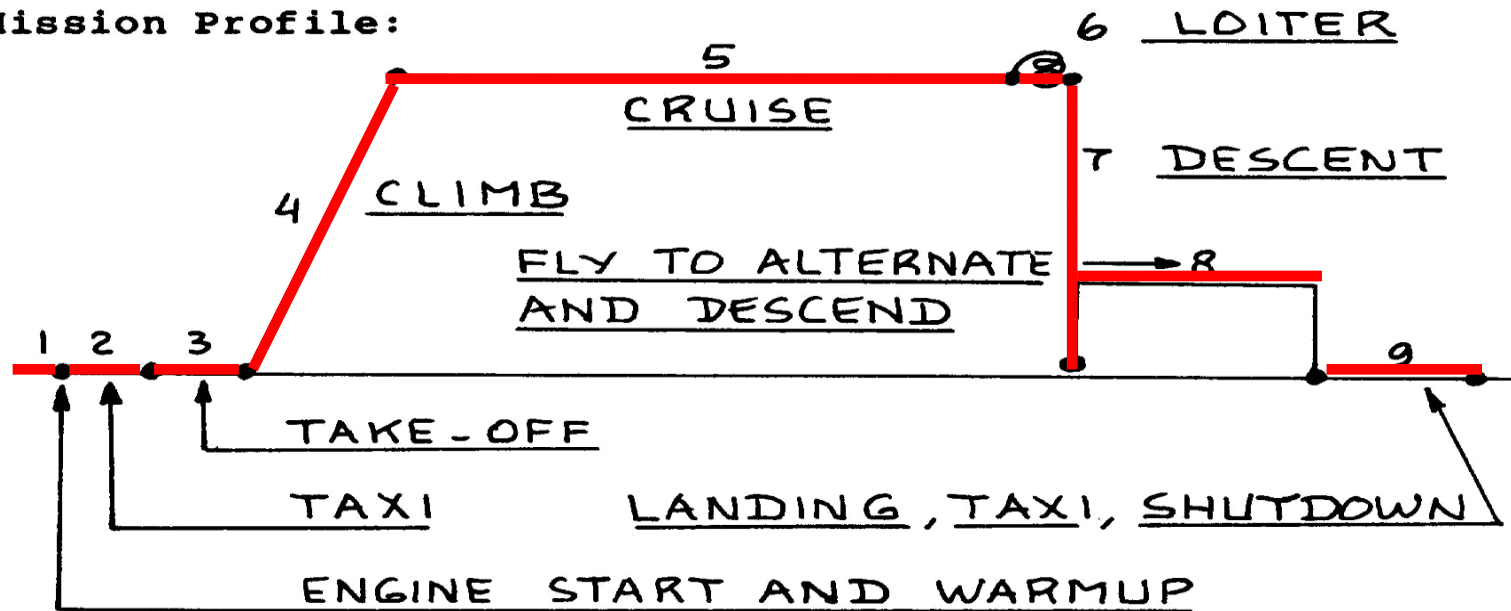


ADAS Modules

- *Weight Estimation:*

FUEL FRACTION METHOD

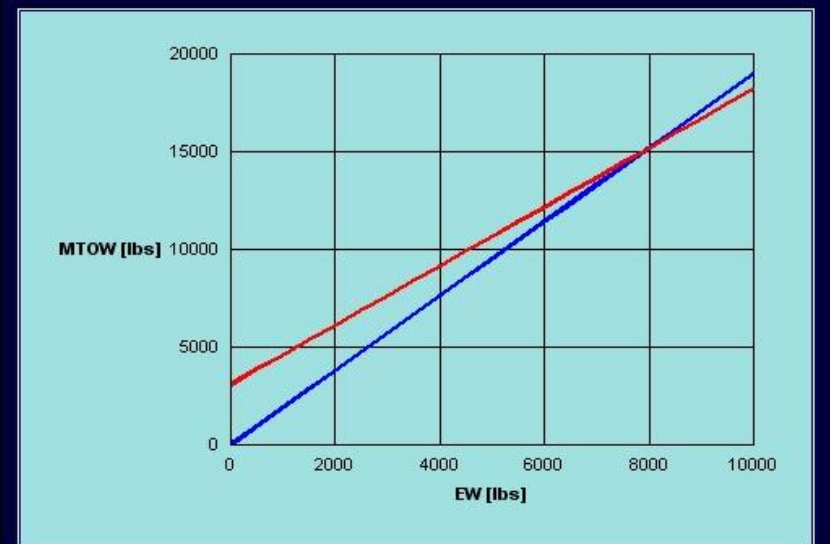
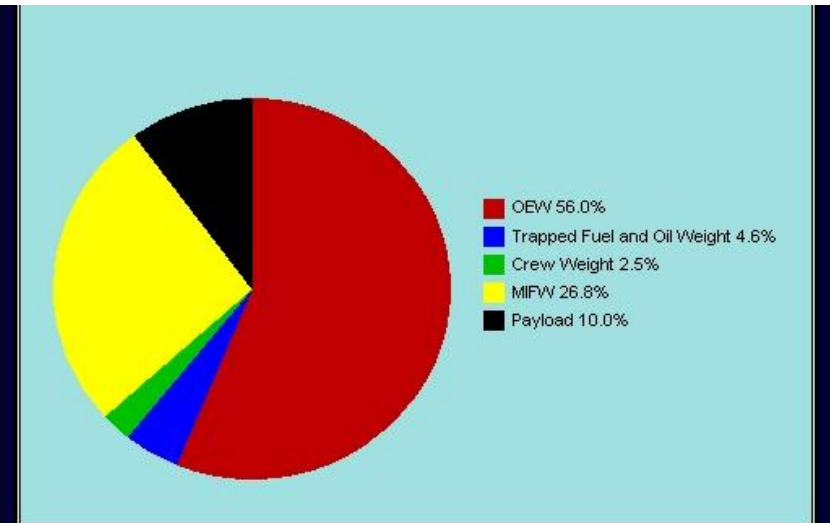
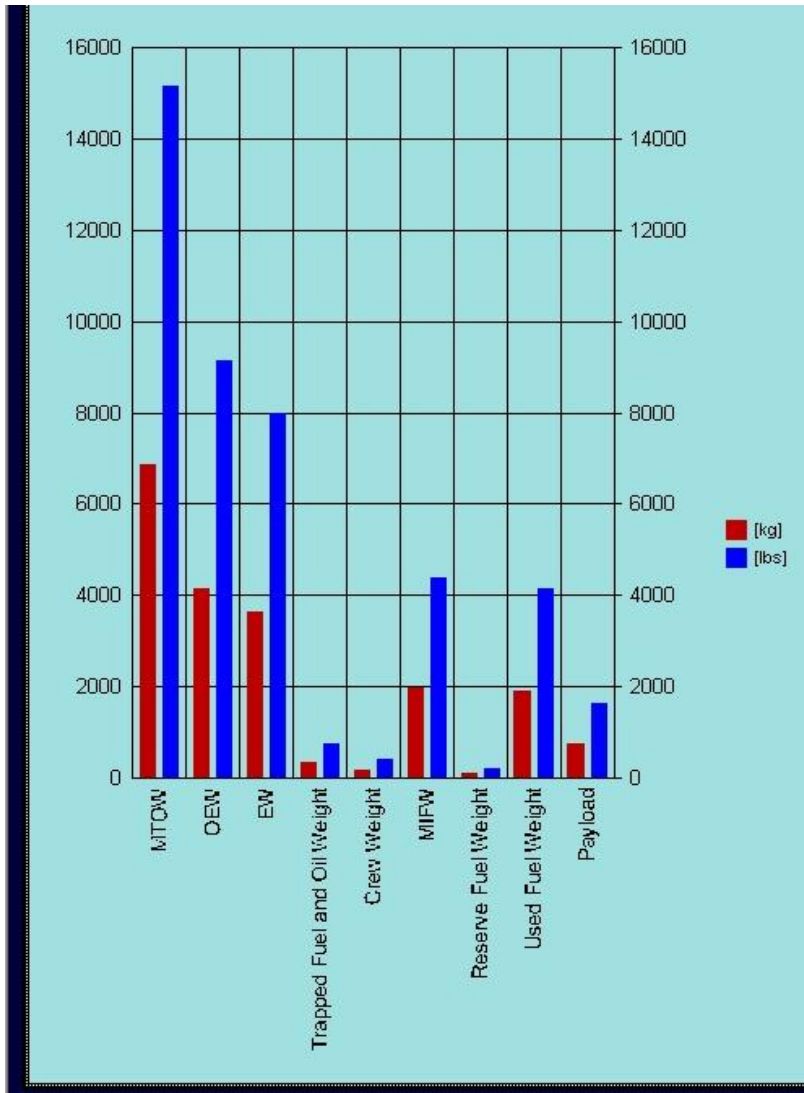
Mission Profile:



For any phase is possible to evaluate the fuel fraction: $\frac{W_{end}}{W_{start}}$

ADAS Modules

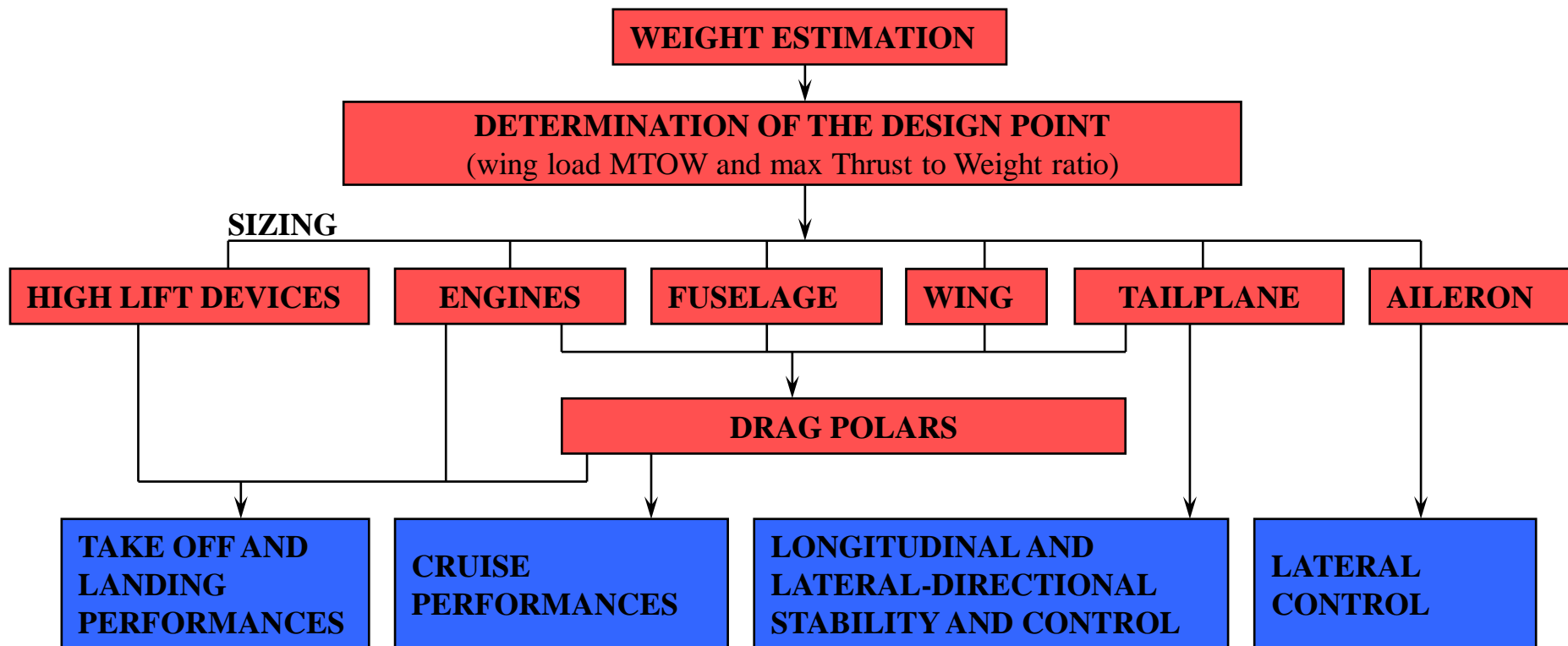
Example of results:



ADAS Modules

- Sizing Requirements:

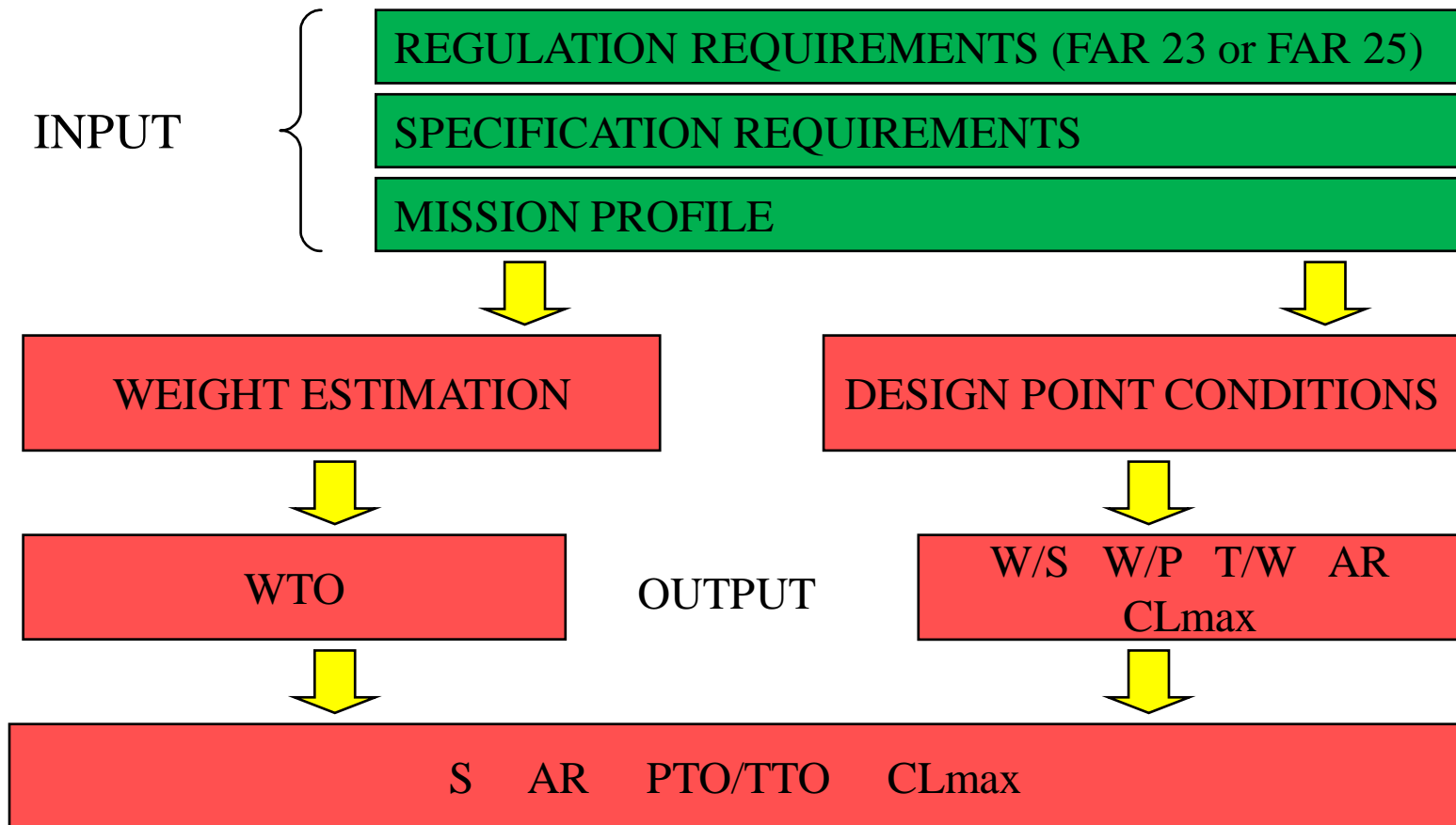
In this module will be established the Design Point. That is very Important for the next Modules as here shown:



ADAS Modules

- Sizing Requirements:

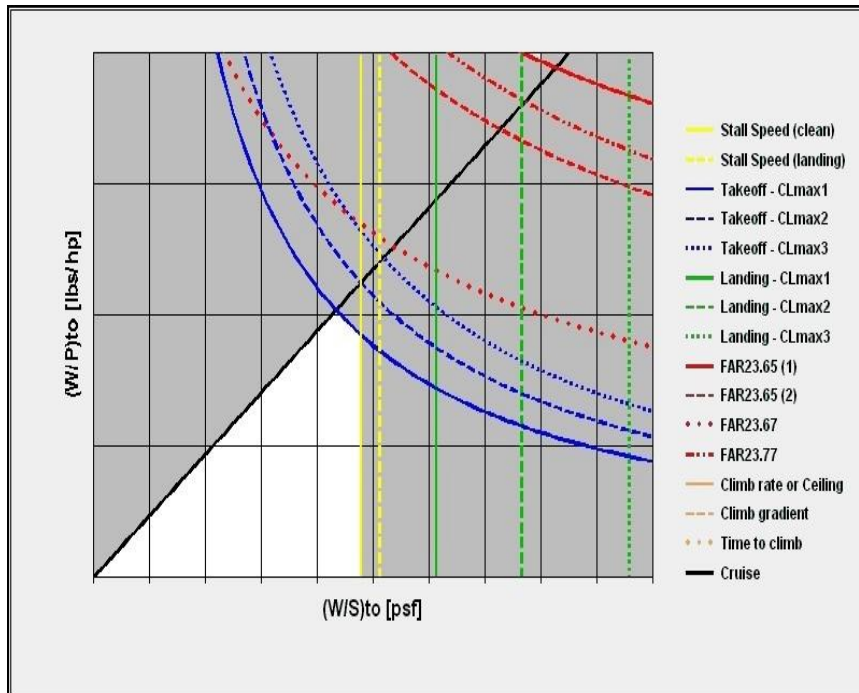
The method choosed for this module is the classical use of the FAR 23 and FAR 25, as shown by Roskam:



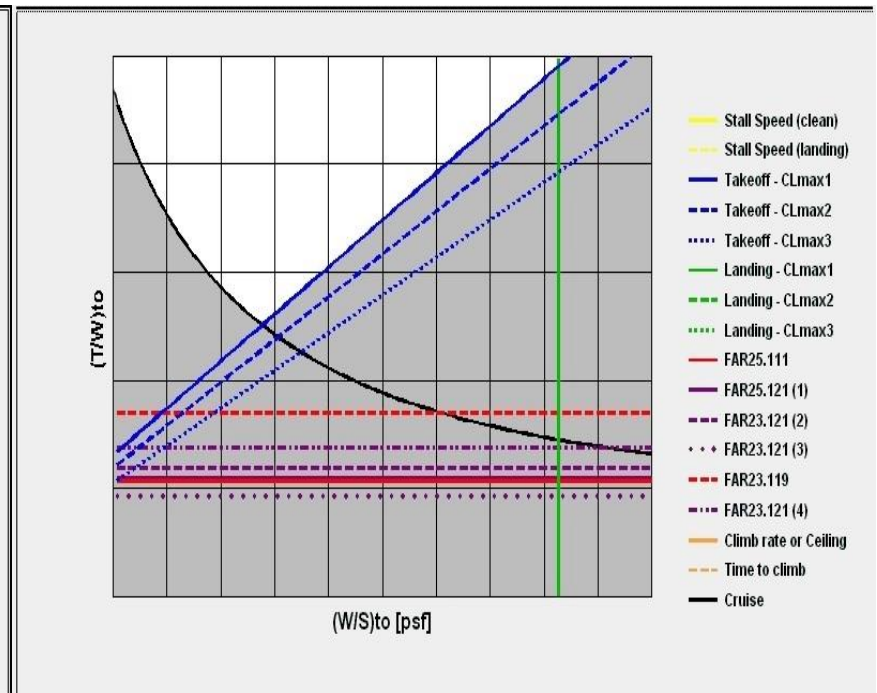
ADAS Modules

- Sizing Requirements:

The Restrictions for the two type of FAR are summarized below:



Propeller
Aircraft



Jet Aircraft

ADAS Modules

- Sizing Requirements:

In ADAS all Data must be insert in Tabs. First choice is the FAR then there is one Tab for each Flight Condition, here FAR 25 JET is shown:

ADAS Program - A320 - [Preliminary Sizing]

File ?

FAR 23 - Propeller Aircraft FAR 23 - Jet Aircraft FAR 25 - Propeller Aircraft **FAR 25 - Jet Aircraft**

Stall Speed **Take-Off Distance** Landing Distance Climb Performance Cruise Performance Results Comparison Chart

	Altitude [ft]	Distance type	Distance [ft]	(CL _{max}) _{to}
<input checked="" type="checkbox"/> Take-Off distance requirement 1	0	Stoll	6450	2.8
<input checked="" type="checkbox"/> Take-Off distance requirement 2	0	Stoll	6450	2.5
<input checked="" type="checkbox"/> Take-Off distance requirement 3	0	Stoll	6450	2.3

The diagram illustrates the layout of a runway and stopway. It shows a horizontal line representing the runway and stopway. Key points and distances are labeled: 'LIFT-OFF DISTANCE' (from start to lift-off), 'ENGINE FAILURE' (point of failure), 'STOP DISTANCE' (from failure point to stop), 'TAKE-OFF FIELD LENGTH' (total length), and 'STOPWAY' (beyond the runway). A vertical dimension of '35 FT' is shown at the end of the stopway. The total length is also labeled as 'STOFL'.

Main Menu Calculator Unit Converter ISA

ADAS Modules

- Sizing Requirements:

In ADAS all Data must be insert in Tabs. First choice is the FAR then there is one Tab for each Flight Condition, here FAR 25 JET is shown:

ADAS Program - A320 - [Preliminary Sizing]

File ?

FAR 23 - Propeller Aircraft		FAR 23 - Jet Aircraft		FAR 25 - Propeller Aircraft		FAR 25 - Jet Aircraft	
Stall Speed	Take-Off Distance	Landing Distance	Climb Performance	Cruise Performance	Results Comparison	Chart	

Aircraft Category: Transport jet

MTOW [lb]	160223	160223	CDO clean configuration	>	0.0183	0.0183	CLmax clean configuration	1.7
Swet [ft ²]	>	8648	8648	Oswald Factor - e	0.81	?	CLmax TO configuration	2.3
Eq. Friction Coefficient	?	?	0.0032	DCDO TO flap config.	0.013		CLmax L configuration	2.8
Eq. Parasite Area [ft ²]	>	28	27.50	Oswald Factor - e	0.80			
(W/S) [lb/ft ²]		105	?	DCDO L flap config.	0.061		Wland/Wto	1
Wing Area S [ft ²]	>	1525.93		Oswald Factor - e	0.73		Tmax continuous/Tto (sugg. 0.94)	0.94
Wing Aspect Ratio AR		9.5		DCDO gear down	0.020		Tto(50°F)/Tto (sugg. 0.80)	0.8
Wing Span [ft]	>	120.4		DCDO OEI	0.0060		Number of Engines	2
Wing ALE [deg] (Ex. 30)		25						

☒ FAR 25.111 - (OEI - Gear up - Takeoff flap - Takeoff Thrust or Power - Ground effect - Altitude=SL)
☒ FAR 25.121 - (OEI - Gear down - Takeoff flap - Takeoff Thrust or Power - Ground Effect - Altitude=SL)
☒ FAR 25.121 - (OEI - Gear up - Takeoff flap - Takeoff Thrust or Power - Altitude=SL)
☒ FAR 25.121 - (OEI - Gear up - no flap - Max continuous thrust or power - Altitude=SL)
☒ FAR 25.119 - (AEO - Gear down - Landing flap - Max landing weight - Altitude=SL)
☒ FAR 25.121 - (OEI - Gear down - Approach flap - Takeoff thrust or power - Max landing weight - Altitude=SL)

	Engines	Flap	Gear	T/Tto	W/Wto	Alt [ft]	RC [ft/min]	Time [min]	Ceiling [ft]
Requirement - Climb Rate or Ceiling	AEO	No flap	Up	1	1				
Requirement - Time to climb	AEO	No flap	Down	1	1				

Main Menü Calculator Unit Converter ISA

ADAS Modules

- Sizing Requirements:

In ADAS all Data must be insert in Tabs. First choice is the FAR then there is one Tab for each Flight Condition, here FAR 25 JET is shown:

ADAS Program - A320 - [Preliminary Sizing]

File ?

FAR 23 - Propeller Aircraft FAR 23 - Jet Aircraft FAR 25 - Propeller Aircraft **FAR 25 - Jet Aircraft**

Stall Speed Take-Off Distance Landing Distance Climb Performance **Cruise Performance** Results Comparison Chart

☒ Cruise speed requirement Refresh

Altitude [ft] 33000

Cruise Speed Type Mach

Cruise Speed 0.81

Wing Aspect Ratio AR 9.5

Oswald factor - e 0.81

CDo clean configuration 0.0183

Wcruise [lb] 145223 MTOW=160223
Wcr=126954

Wing Area S [ft²] 1525.93

CL 0.379

Airfoil mean thickness ratio t/c 10

Wing angle of sweep [deg] Λ 25

Mcc 0.775

DCCDo compressibility 0.0025 0.0025

Engine Type Turbofan High E

Throttle Setting [%] ϕ 100

Tcond/Tto 0.242 0.242

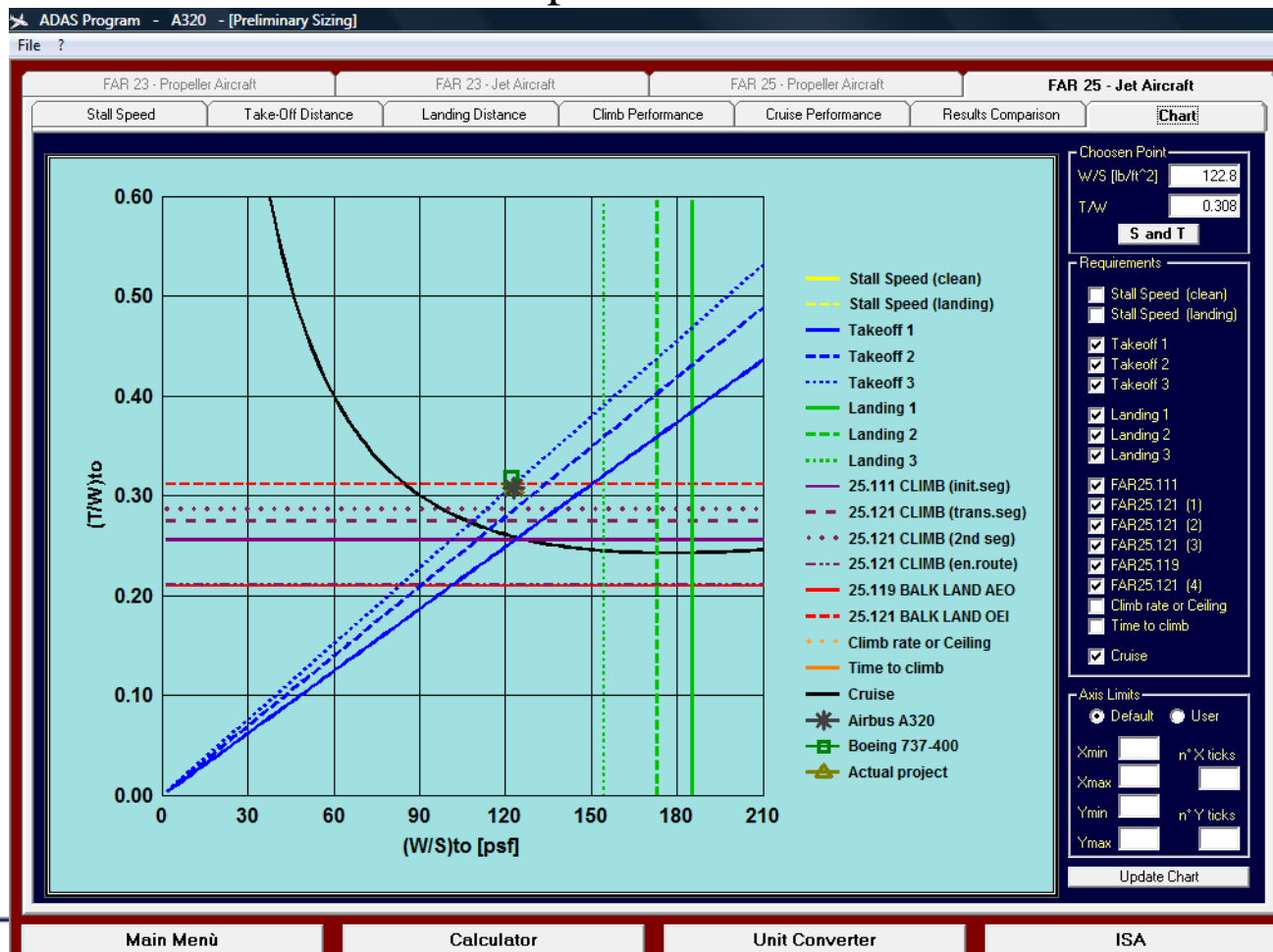
Wcond/Wto 1

Main Menu Calculator Unit Converter ISA

ADAS Modules

- Sizing Requirements:

When updating a chart all the requirements involved are displayed: some similar aircraft from a Database to compare:

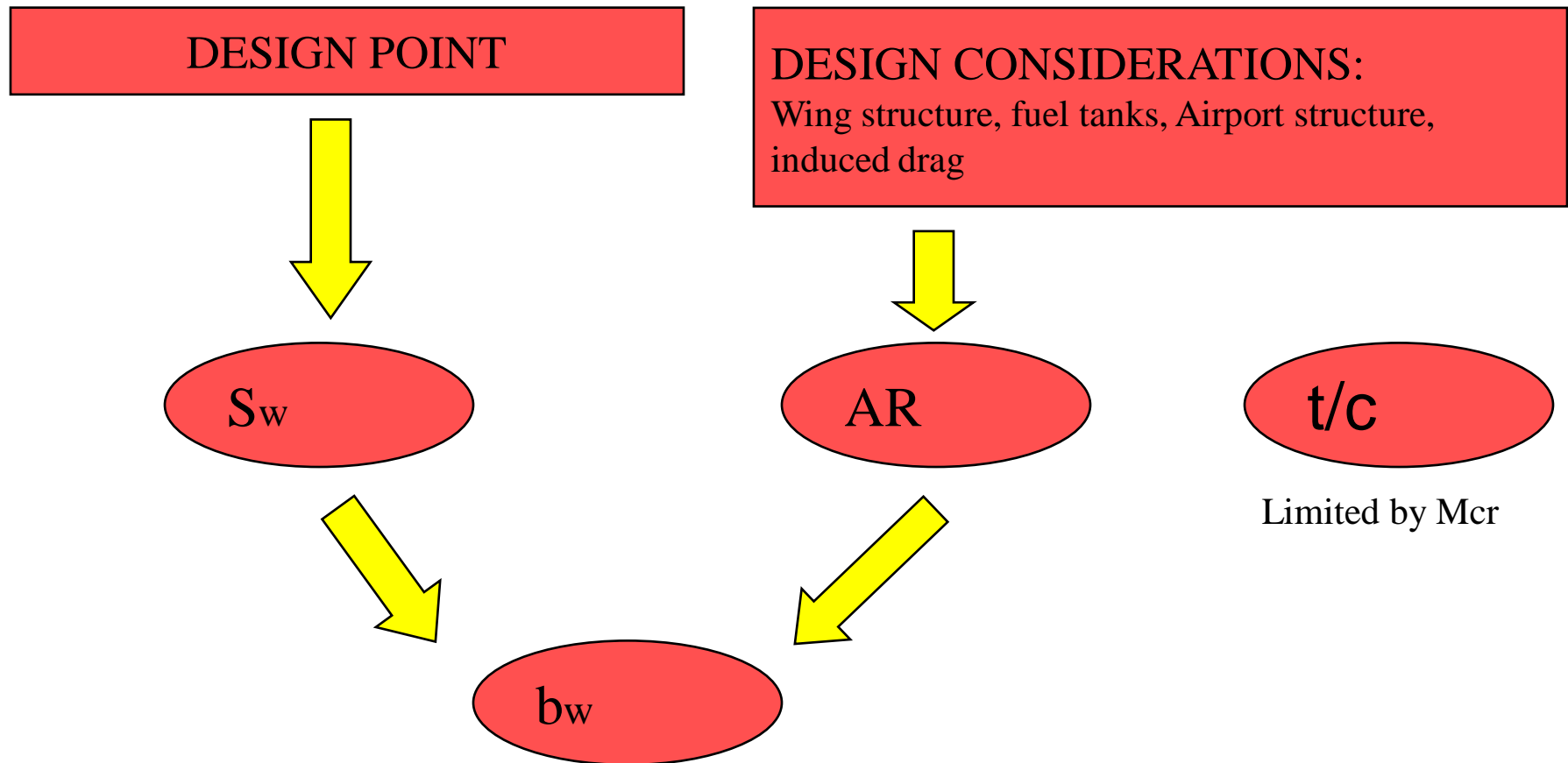


ADAS Modules

- Wing Analysis:

This module allow to design and analyze any type of wings.

The first step is to decide the **Wing Planform**:



ADAS Modules

- Wing Analysis:

Next step is to decide the aerodynamic and geometrical characteristics for the representative sections of the wing :

Section	y/(b/2)	Chord [m]	X l.e. [m]	Epsilon [°]	Alpha zl [°]	Xac/c	Cm ac	Clalpha[1/°]	Clmax	t/c	dy/c [%]	Cl*
1	0	2.7	0	0	-2	0.25	-0.02	0.11	1.5	0.12	2.6	1.1
2	0.3	2.7	0	-1	-2	0.25	-0.04	0.11	1.5	0.09	2.6	1.1
3	1	1.59	0.7	-2	-3	0.25	-0.06	0.11	1.5	0.09	2.6	1.1

Reynolds	Cd min. turb.	Cl0	Lam. Bucket	Cd0 Bucket	k factor	Cm 0.25c(Cl=0)	dCm 0.25c/dCl	Cl(Cm 0.25c n.l.)	Cm 0.25c(Clmax)
2,000,000	0.006	0.5	0.2	0.006	0.01	-0.02	0	1	-0.04E

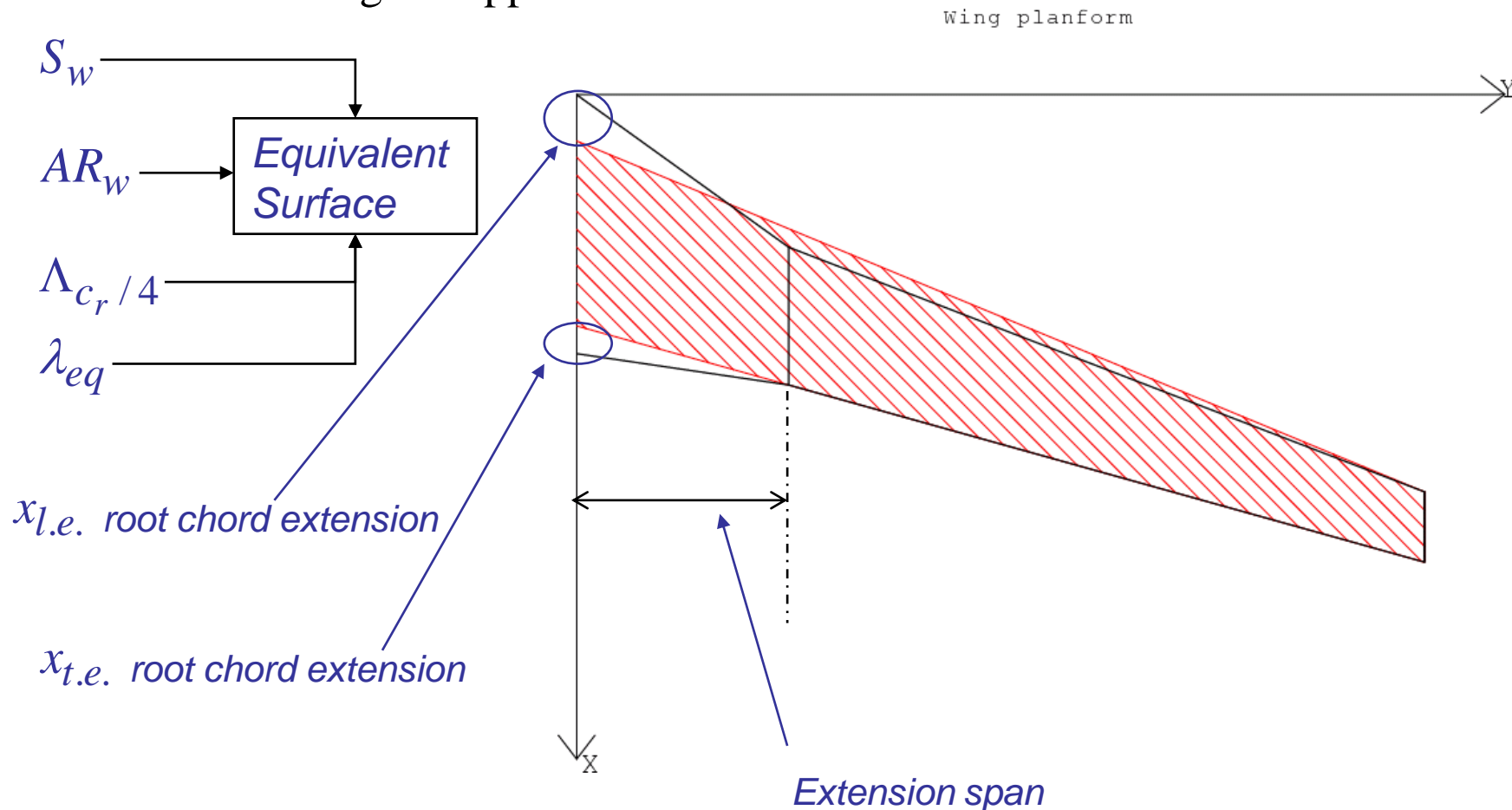
This step can be done also automatically, by the command “Wing Planform Easy Creator” that help the user to create:

- STRAIGHT TAPERED WING
- CRANKED WING

ADAS Modules

-Wing Analysis:

For Cranked wing the approach is sketched below:



ADAS Modules

-Wing Analysis:

ADAS Program - 8737P - [Wing Planform]

File ?

Geometric Input Data

MTOW [kg] 65746 **57000**

Wing Area [m²] 112.22 **105**

Wing Span [m] 34.29 **30.91**

Wing-Fuselage d/b **0.1**

Number of sections

Section	y/[b/2]	Chord [m]	X l.e. [m]	Epsilon [°]	Alpha z [°]	Xac/c	Cm ac	Clalpha [1/°]	Clmax	t/c	dy/c [%]	Cl*
1	0	6.23	0	0	-2	0.25	-0.04	0.11	1.5	0.1	2.2	1
2	0.3	3.8	2.465	0	-2	0.25	-0.04	0.11	1.5	0.1	2.2	1
3	1	1.36	8.218	0	-2	0.25	-0.04	0.11	1.5	0.1	2.2	1

Other Data

Output Data

Wing Area [m²]

Aspect Ratio

Taper Ratio = ct/cr

Mean t/c wing [%]

Chord [m]

chord [m]

7.00

6.00

5.00

4.00

3.00

2.00

1.00

0.00

Cranked Wing

Area [m²]

Aspect Ratio - AR

Taper Ratio eq.

Sweep Angle c/4 eq. [deg]

Cr eq.

y/b/2 Crank

EXT LE % Cr

EXT TE % Cr

Tip Twist Angle [deg]

Airfoil Thickness t/c

Root t/c

Outer Wing t/c (const)

Profile Data *

Alpha z.l.

Xac/c

Cmac

Clalpha [1/deg]

Cl max

dy/c [%]

Cl*

Reynolds number

Cd min turbulent

Cl0

Laminar Bucket

Cd0 Bucket

k Factor

Cm (Cl=0)

dCm/dCl

Cl (Cm non linear)

Cm (Clmax)

Cancel

Ok

* 2-D Aerodynamic data are assumed constant along wingspan

Wing Planform Easy Creator

Wing Data

Wing Length [m] 0 Mach 0

Wing Compressible

Lift ☒ Fuselage Effect on Drag

Drag Divergence Mach Estimation

Calculate Geometry (fixed sections)

Chord distribution

Equivalent Wing

Aerodynamic Results

Final Aerod. Results

Wing Analysis

Calculator

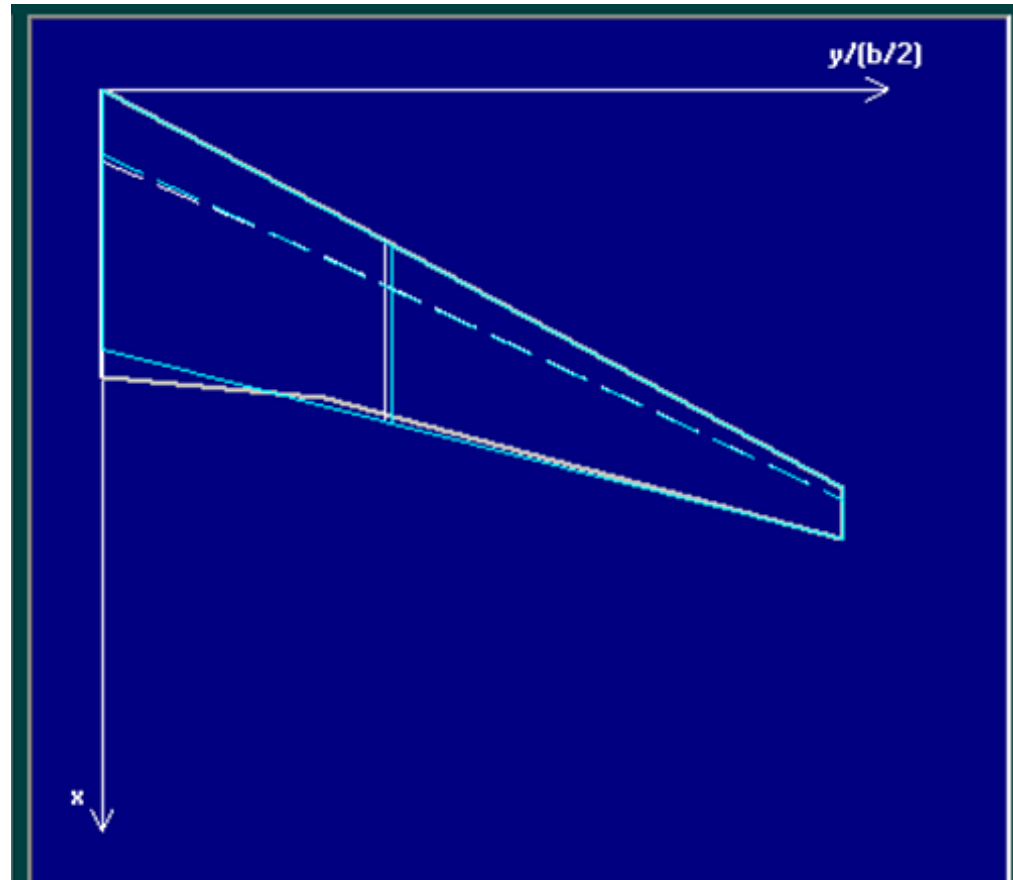
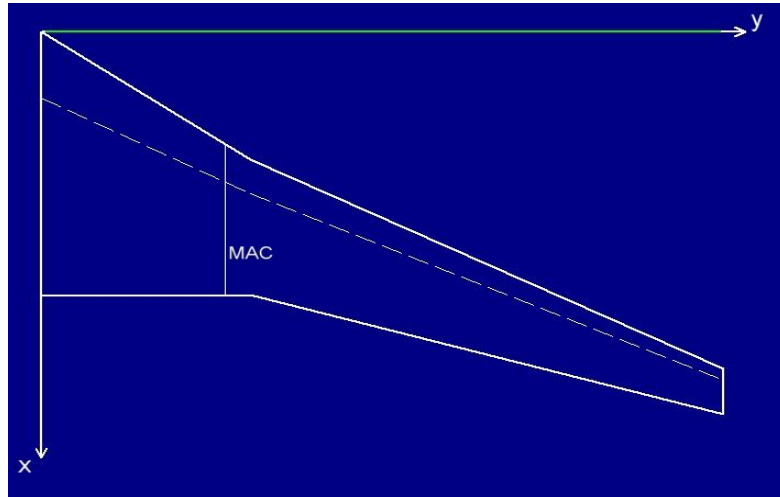
Unit Converter

ISA

Main Menu

ADAS Modules

- Wing Analysis:

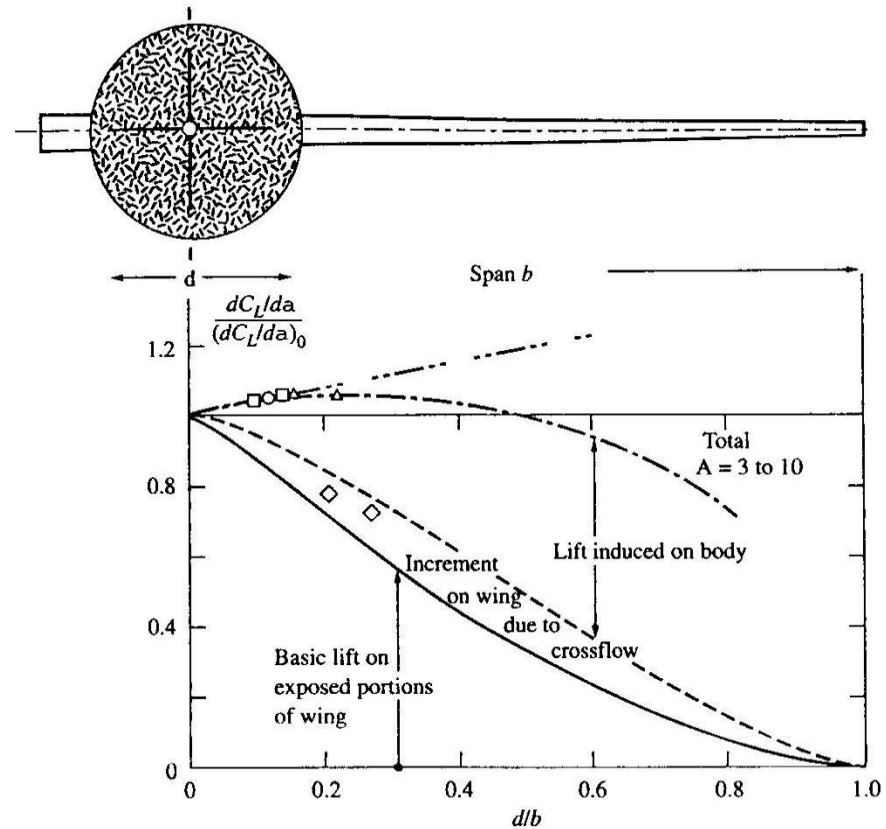


ADAS Modules

- Wing Analysis:

If required the correction for the presence of the fuselage is estimated

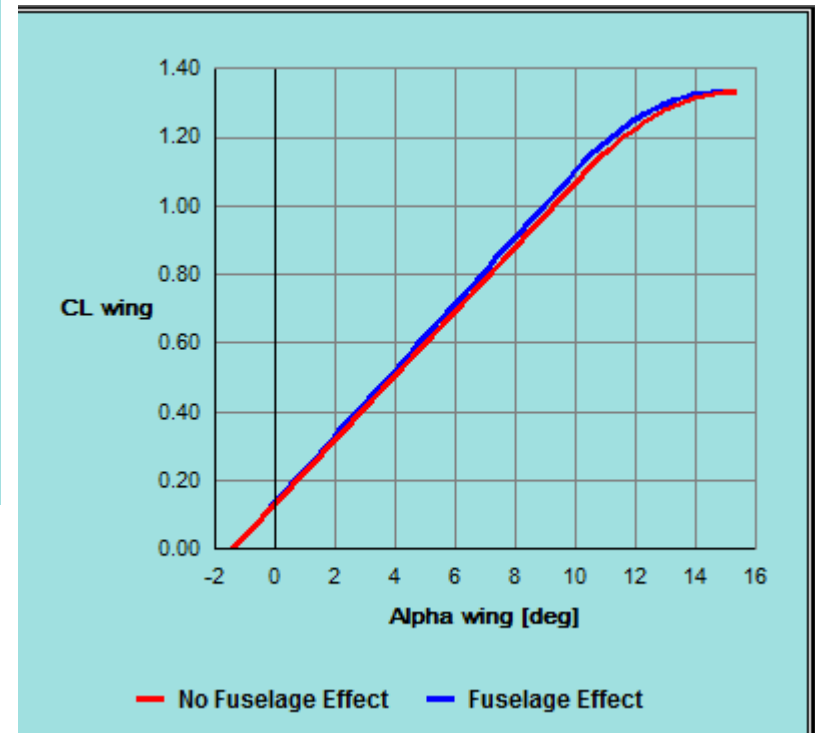
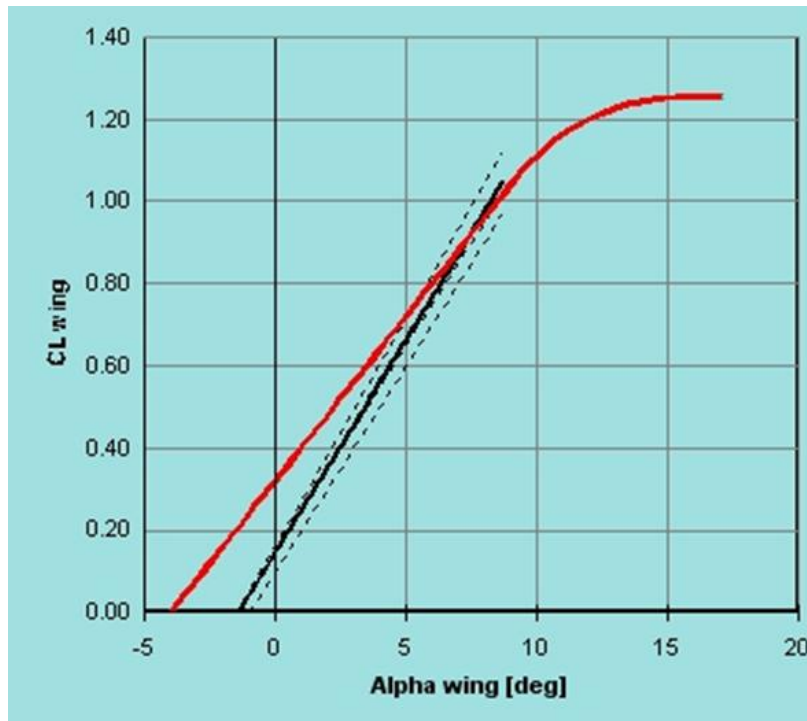
$$C_{L\alpha} = \frac{2 \cdot \pi \cdot AR}{2 + \sqrt{\frac{4 \cdot \pi^2 \cdot AR^2 \cdot (1 - M^2)^2}{\bar{C}_{l\alpha}^2 \cdot (1 - M^2)^2} \cdot \left(1 + \frac{\tan^2 \Lambda_{\frac{c}{2}}}{(1 - M^2)^2}\right) + 4}}$$



ADAS Modules

- Wing Analysis:

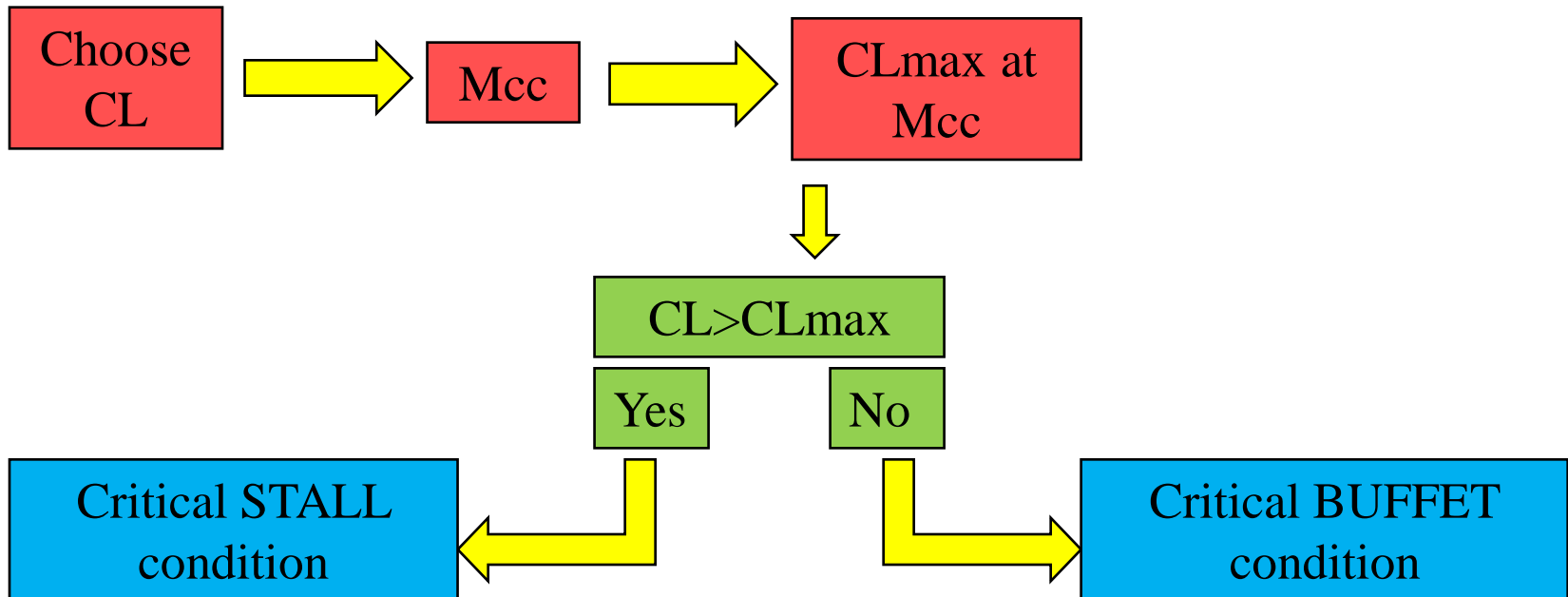
Here some sketch of results:



ADAS Modules

- Wing Analysis:

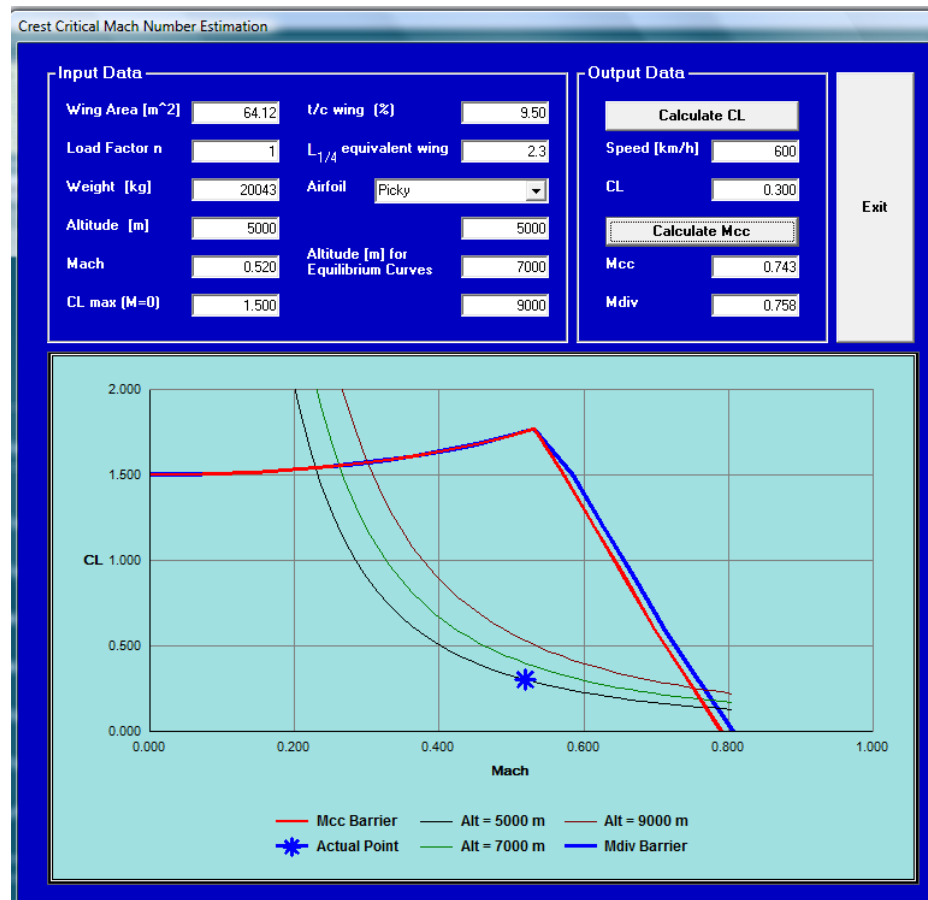
A great help for the choice of CL_{max} is given by the secondary module called *Crest Critical and Drag Divergence Mach Estimation*:



ADAS Modules

- Wing Analysis:

A great help for the choice of CL_{max} is given by the secondary module called *Crest Critical and Drag Divergence Mach Estimation*:



ADAS Modules - *Wing Analysis:*

ADAS Program - A320 - [Wing Planform]

File ?

Geometric Input Data

MTOW [kg]	72676	Section	y/[b/2]	Chord [m]	X l.e. [m]	Epsilon [°]	Alpha zl [°]	Xac/c	Cmac	Clalpha[1/°]	Clmax	t/c	dy/c [%]	Cl*	Airfoils
Wing Area [m²]	121.22	1	0	6.552	0	0	-2	0.25	-0.004	0.11	1.7	0.12	2.4	1	Other Data
Wing Span [m]	33.94	2	0.3	4.345	2.731	-1.5	-2	0.25	-0.004	0.11	1.7	0.12	2.4	1	
Wing-Fuselage d/b	0.1	3	1	1.191	9.103	-5	-2	0.25	-0.004	0.11	1.7	0.09	2.4	1	
Number of sections	3	Copy Data Section		Insert Section		Delete Section		Wing Planform Easy Creator							

Output Data

Wing Area [m²]	121.24	Wing Panel number	1	M.G.C. [m]	3.57
Aspect Ratio	9.501	Panel Area [m²]	27.74	M.A.C. [m]	4.19
Taper Ratio = ct/cr	0.182	Taper Ratio	0.663	X l.e. mac [m]	3.46
Mean t/c wing [%]	11.6	Sweep Angle L.E. [°]	28.2	Ymac [m]	6.46
Chord [m]		Sweep Angle 0.25c [°]	23.2	y/[b/2] mac	0.380

Aerodynamic Input Data

CL_α formula Altitude [m] 11260 Mach 0.78

Anderson: Subsonic Swept Wing Compressible

☒ Fuselage Effect on Lift ☒ Fuselage Effect on Drag

Crest Critical and Drag Divergence Mach Estimation

Aerodynamic Results

No Fuselage Effect	Fuselage Effect
CL* wing	1.00
s Factor	0.978 ?
CL max wing	1.39
CLα wing [1/°]	0.112
CLα wing [1/°]	0.117
αz.l. [°]	0.0
αCLmax [°]	15.9
αCLmax [°]	15.4
α* wing [°]	8.9
α* wing [°]	8.6
CM_1 (int. Cmac)	-0.0040
u factor (Λ=0)	0.970
CM_2 (Aer. twist)	0.0367 ?
u factor (Λ)	0.979 ?
CMac wing	0.0327

Alpha wing [deg]

— No Fuselage Effect — Fuselage Effect

Calculate Geometry (fixed sections)

Chord distribution

Equivalent Wing

Aerodynamic Results

Final Aerod. Results

Wing Analysis

Calculator

Unit Converter

ISA

Main Menu

ADAS Modules

- *Wing Analysis:*

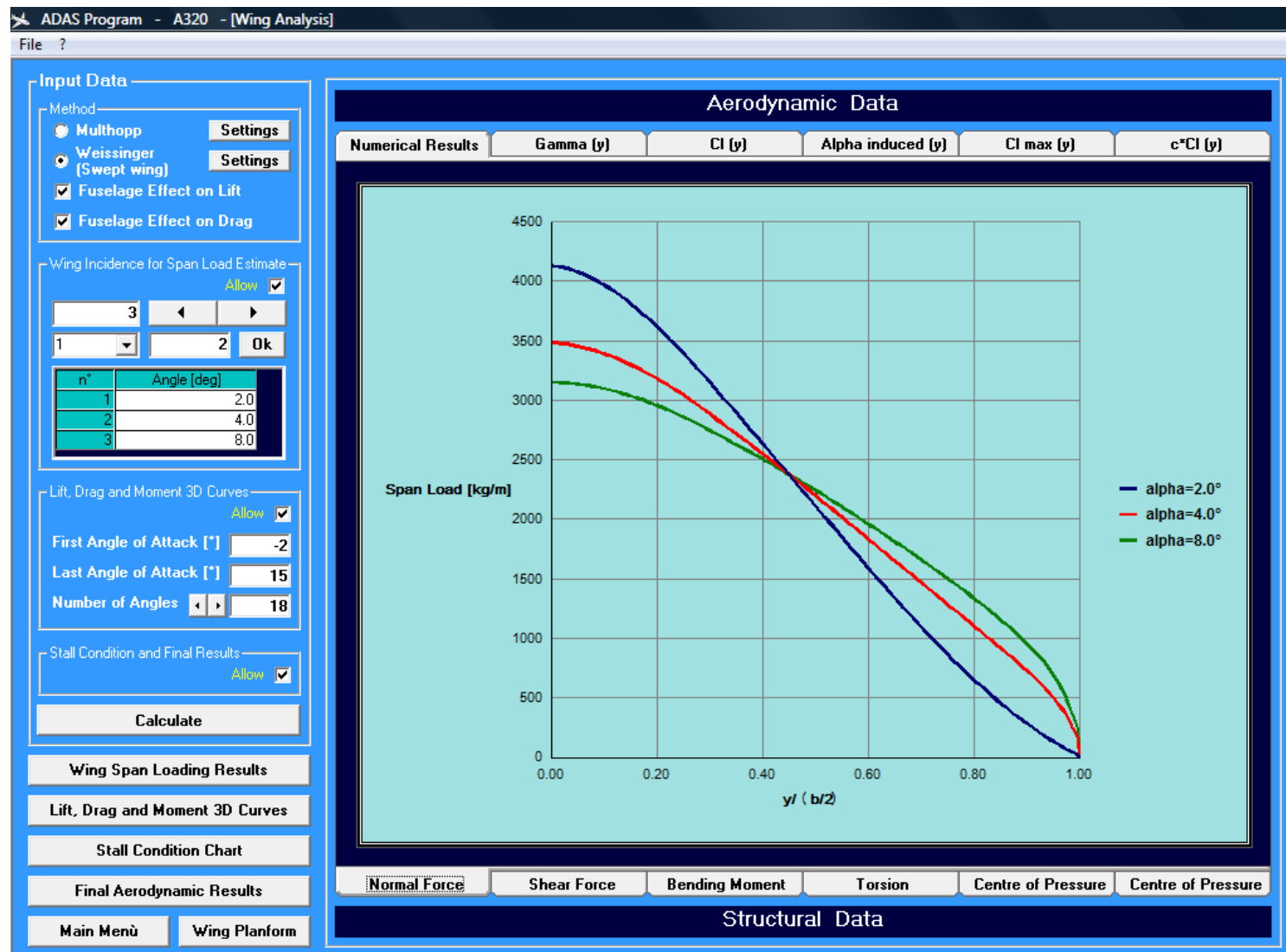
A more detailed analysis is possible after the Semiempirical calculation with panels methods:

- Multhopp (for straight wing)
- Vortex Lattice (useful for Swept wing)

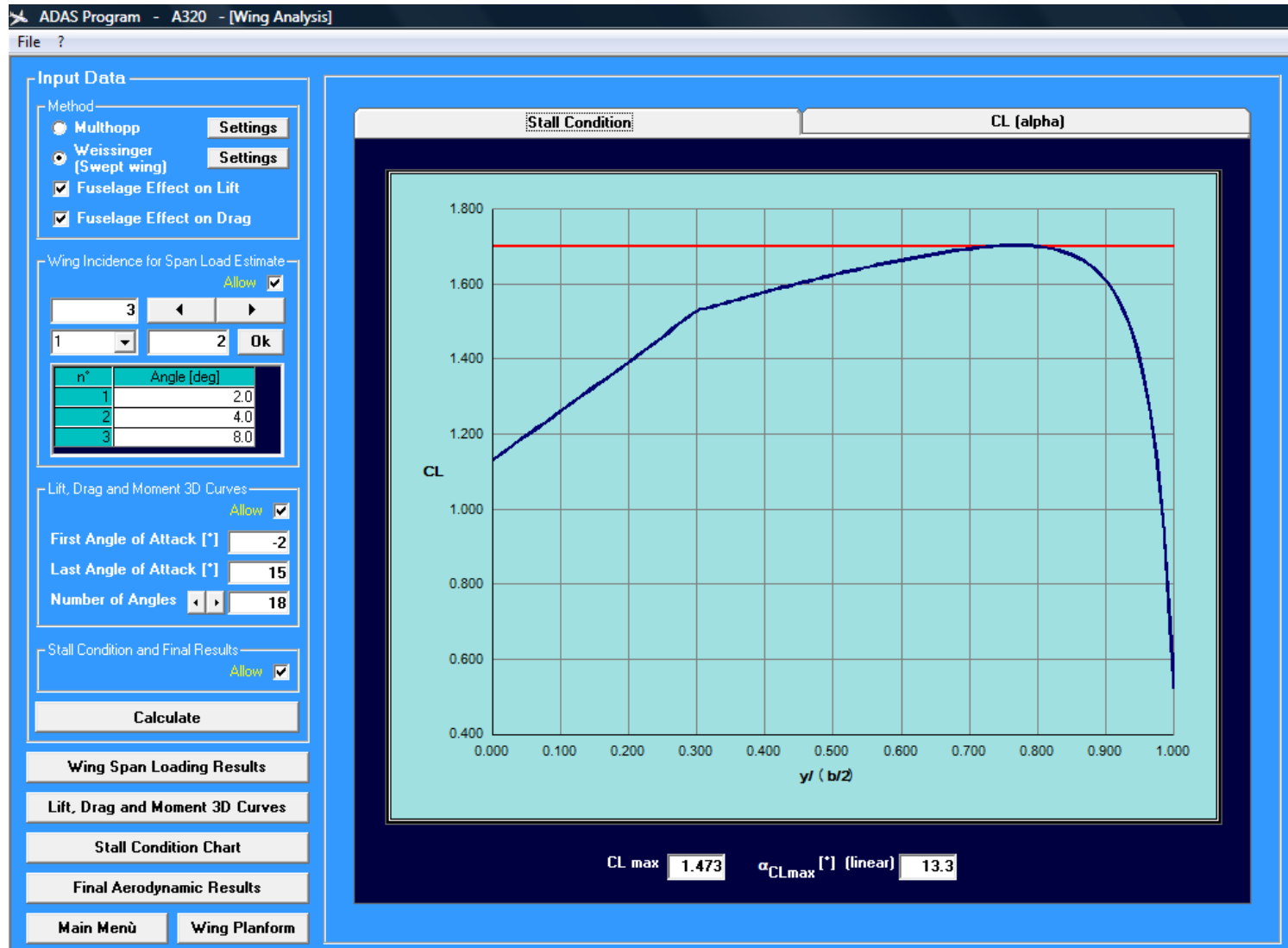
This methods allow us to calculate with a good approximation:

- Position of the Aerodynamic Centre
- CLmax with Stall Condition
- Structural Effect as Normal Force, Shear, Bending Moment and Torsion

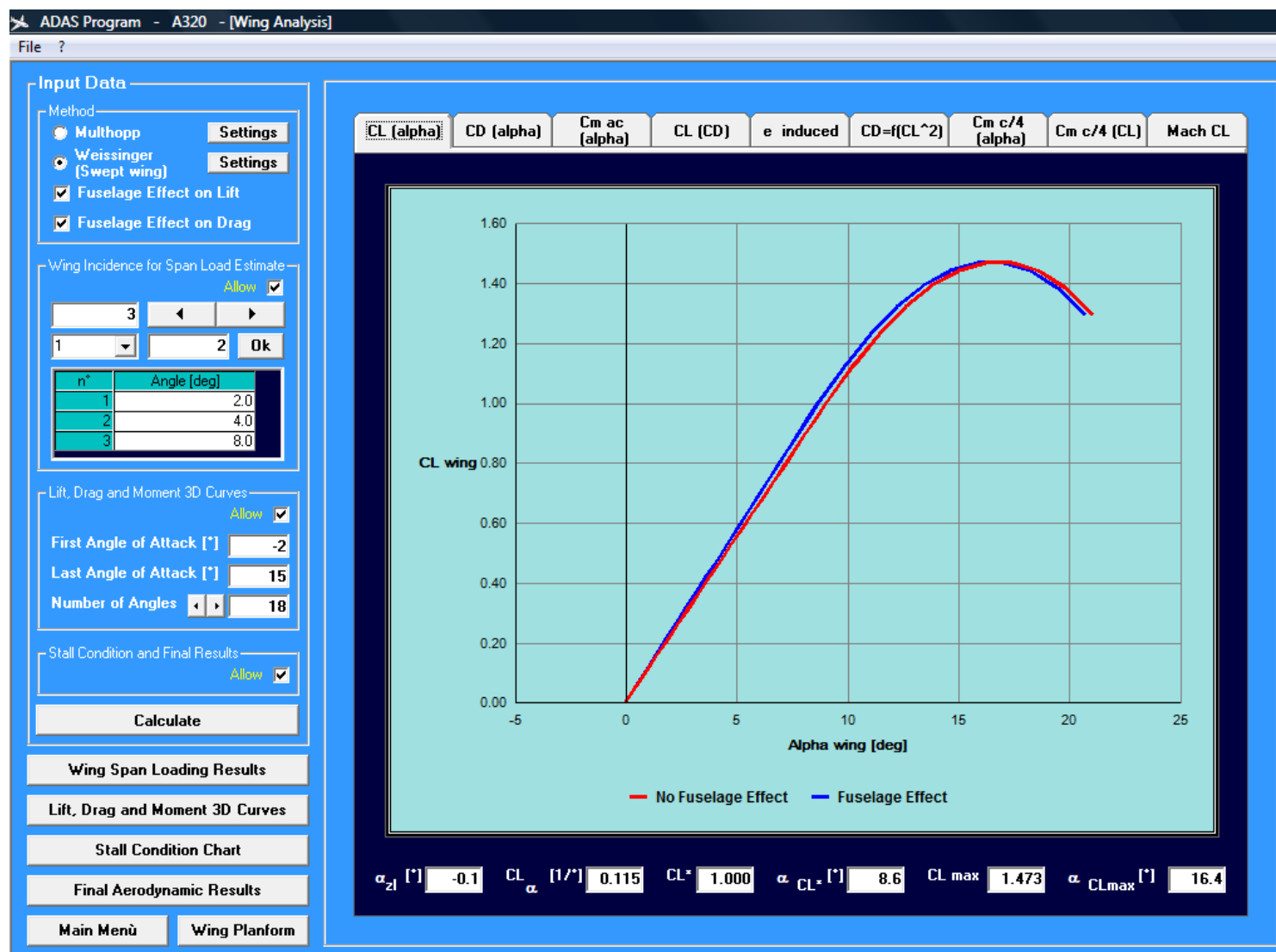
ADAS Modules - Wing Analysis:



ADAS Modules - Wing Analysis:



ADAS Modules - Wing Analysis:

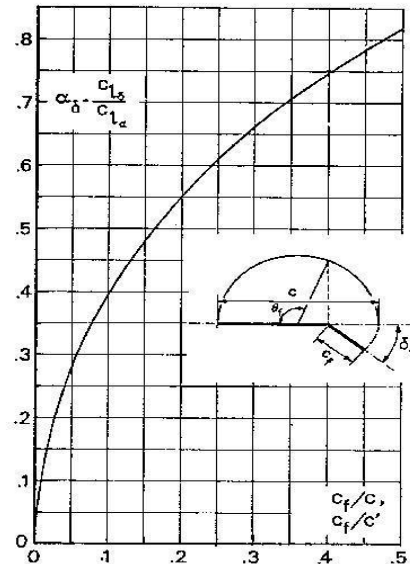


ADAS Modules

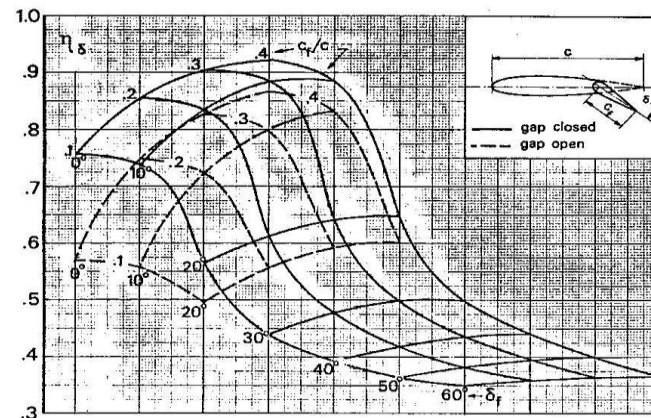
- High Lift Devices:

For this module it's used Semi-empirical approach combined by Torenbeek and Roskam methods.

$$\Delta Cl_0:$$



$$\Delta Cl_0 = \alpha_\delta \eta_\delta Cl_\alpha \delta_f$$



$$Cl_{\max}:$$

$$Cl_{\max} = (Cl_{\max})_{\delta=0} + \frac{2}{3} \Delta_f Cl_0$$

$$c_{l_{\max}}' = .533 \Delta y \left(\frac{R_c}{3 \times 10^6} \right)^{.08} + \frac{1}{2} (c_{l_0} + \Delta_f c_{l_0}')$$

ADAS Modules

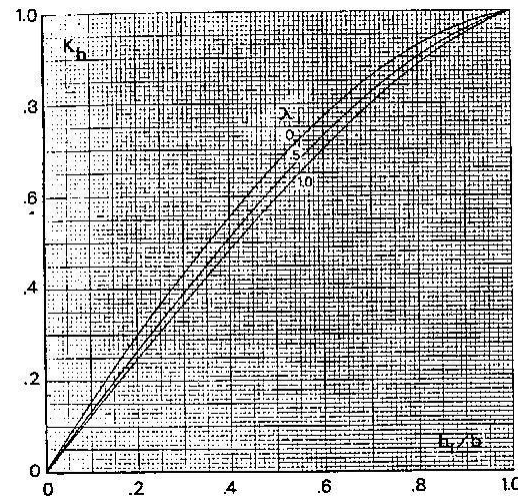
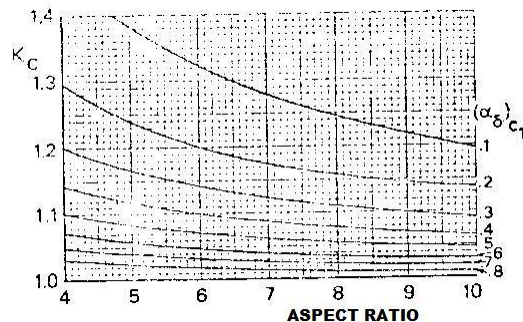
- High Lift Devices:

For this module it's used Semi-empirical approach combined by Torenbeek and Roskam methods.

- From 2D calculation to 3D

ΔCL_0 :

$$\Delta_f C_{L_0} = \Delta_f C_{l_0} \left(\frac{C_{L\alpha}}{C_{l\alpha}} \right) \left[\frac{(\alpha_\delta) C_L}{(\alpha_\delta) C_l} \right] K_b$$



ΔCL_{max} :

$$\Delta_f C_{L_{max}} = 0.92 \Delta_f C_{l_{max}} \frac{S_{wf}}{S} \cos \Lambda_{c/4}$$

ADAS Modules

- *High Lift Devices:*

For this module it's used Semi-empirical approach combined by Torenbeek and Roskam methods.

- From 2D calculation to 3D
- Flap Type used:
 - Plain
 - Single Slot
 - Fowler
 - Double Slot
- Slat Type:
 - Leading-Edge Plain Flap
 - Slat
 - Krouger Flap
- Take Off and Landing are individually saved

ADAS Modules - High Lift Devices:

ADAS Program - A320 - [High - Lift Devices]

File ?

Wing Data

Wing Area [m²] 121.24

Wing Span [m] 33.94

MAC [m] 4.19

Aspect Ratio 9.501

Taper Ratio λ 0.182

Sweep Angle $\Delta c/4$ [Deg] 23.2

Root Chord [m] 6.5

Wing-Fuselage d/b 0.100

Cranked ☒

Crank Station (y/b/2) 0.3

y/b/2

x

Fuselage

Aerodynamic Results

CL

Alpha [deg]

Flap+Slat Deflected All Retracted

All Retracted Data

Trailing Edge Flap

Flaps Number 2

☒ Torenbeek G-15a
☐ $\Delta C_{lmax} = 2/3 \Delta C_{l0}$

Flap 1 Flap 2

C_{flap}/C 0.3

Flap Type: Slotted

Inner Position (y/b/2) 0.11

Outer Position (y/b/2) 0.3

δ_f (°) 15

Use Flaps

Leading Edge Slat

Slats Number 2

Slat 1 Slat 2

C_{slat}/C 0.15

Flap Type: Slat

Inner Position (y/b/2) 0.3

Outer Position (y/b/2) 0.95

Use Slats

Numerical Results

ΔC_{l0} 0.562

$\Delta \alpha_0$ -6.36

CL_α 0.088

Torenbeek G-15a

ΔC_{lmax} 0.85

CL_{max} 2.37

$\Delta C_{lmax} = 2/3 \Delta C_{l0}$

ΔC_{lmax} 0.96

CL_{max} 2.47

CL_{max} Complete Airplane (Hor. Tail corr)

Total	Flap 1	Flap 2	Slat 1	Slat 2
ΔC_{D0}		0.012		
ΔC_m				-0.312

Load Take Off Data Calculator Unit Converter Calculate →

Load Landing Data Main Menu ISA

Save As.. Take Off Save As.. Landing

ADAS Modules - High Lift Devices:

ADAS Program - A320 - [High - Lift Devices]

File ?

Wing Data

Wing Area [m²]

Wing Span [m]

MAC [m]

Aspect Ratio

Taper Ratio λ

Sweep Angle $\Delta c/4$ [Deg]

Root Chord [m]

Wing-Fuselage d/b

Cranked ☒

Crank Station [y/b/2]

y/(b/2)

x

Fuselage

Aerodynamic Results

All Retracted Data

CL

Alpha [deg]

— Flap+Slat Deflected — All Retracted

Trailing Edge Flap

Flaps Number ? ☐ Torenbeek G-15a ☐ $\Delta C_{lmax}=2/3 \Delta C_{l0}$

Flap 1 Flap 2

C_{flap}/C

Flap Type:

Inner Position [y/b/2]

Outer Position [y/b/2]

δ_f (°)

Use Flaps

Leading Edge Slat

Slats Number

Slat 1 Slat 2

C_{slat}/C

Flap Type:

Inner Position [y/b/2]

Outer Position [y/b/2]

Use Slats

Numerical Results

CL_{max} Complete Airplane (Hor. Tail corr)

Horizontal Tail AC-CG Dist - d m ?

MAC/d Wing CL_{max}

ΔC_m Complete CL_{max}

MTOW kg V_{stall} m/s

km/h

kts

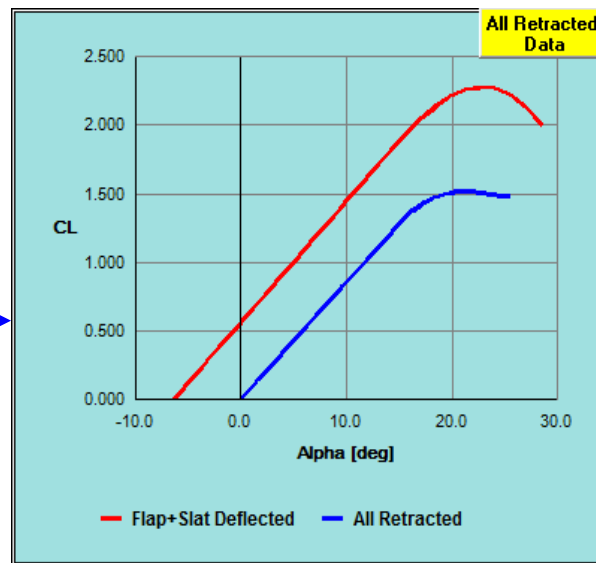
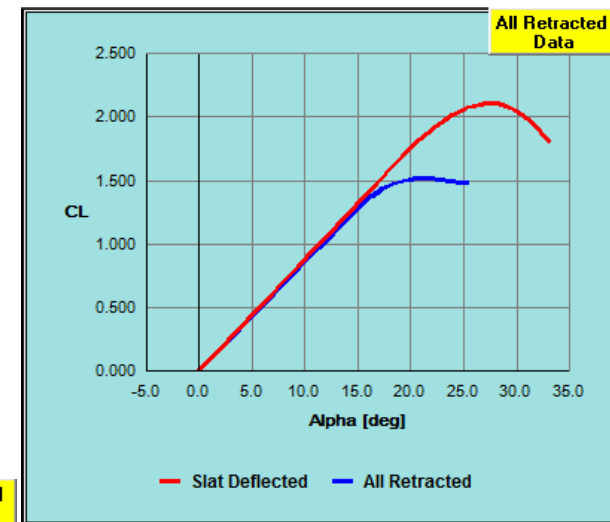
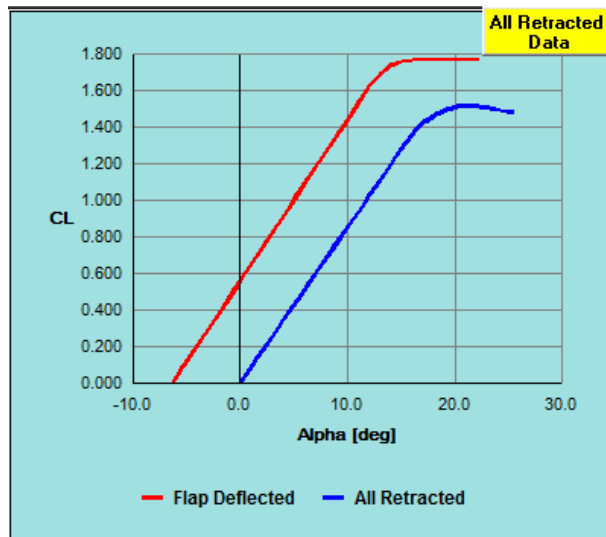
Load Take Off Data Calculator Unit Converter Calculate ->

Load Landing Data Main Menu ISA

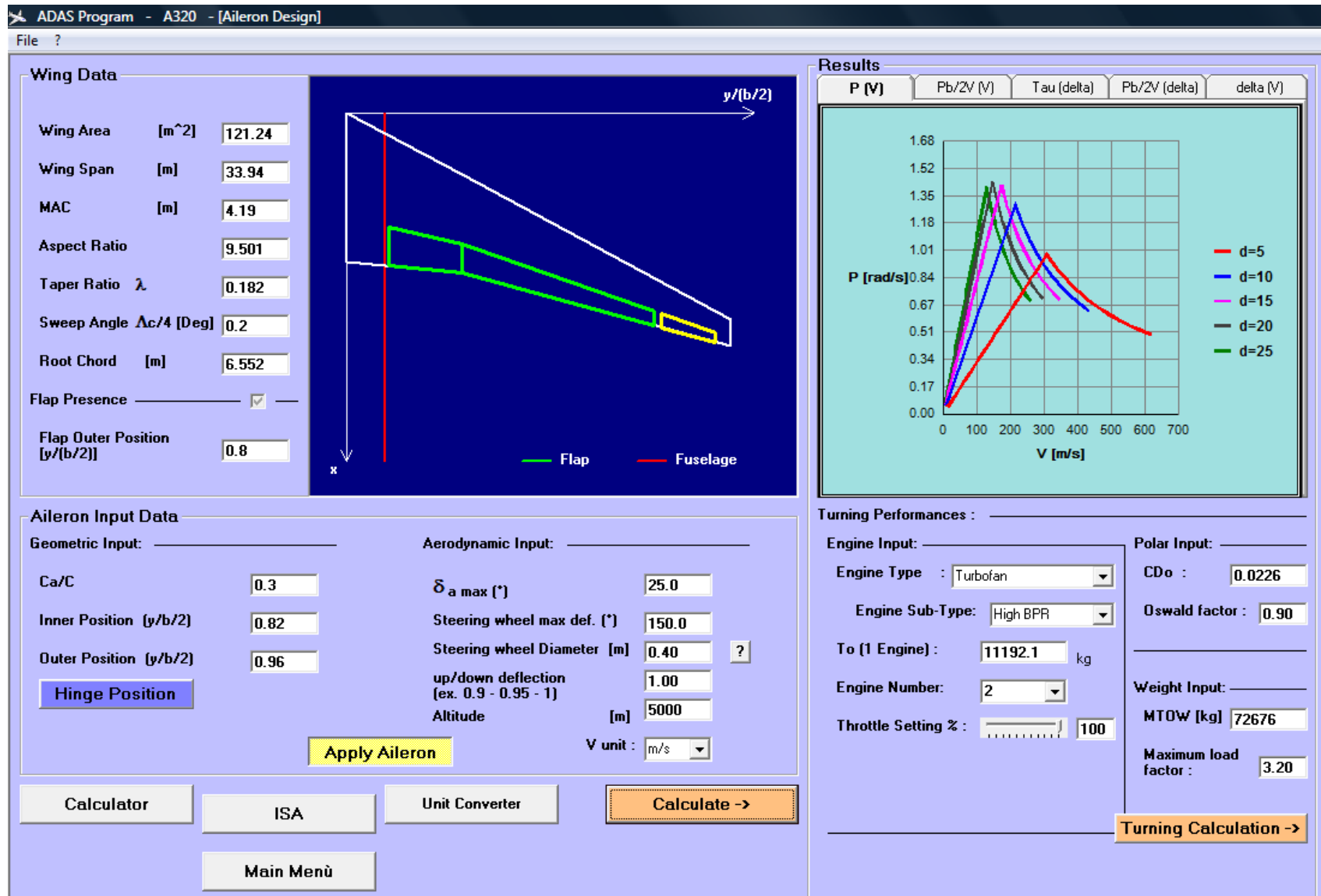
Save As.. Take Off Save As.. Landing

ADAS Modules

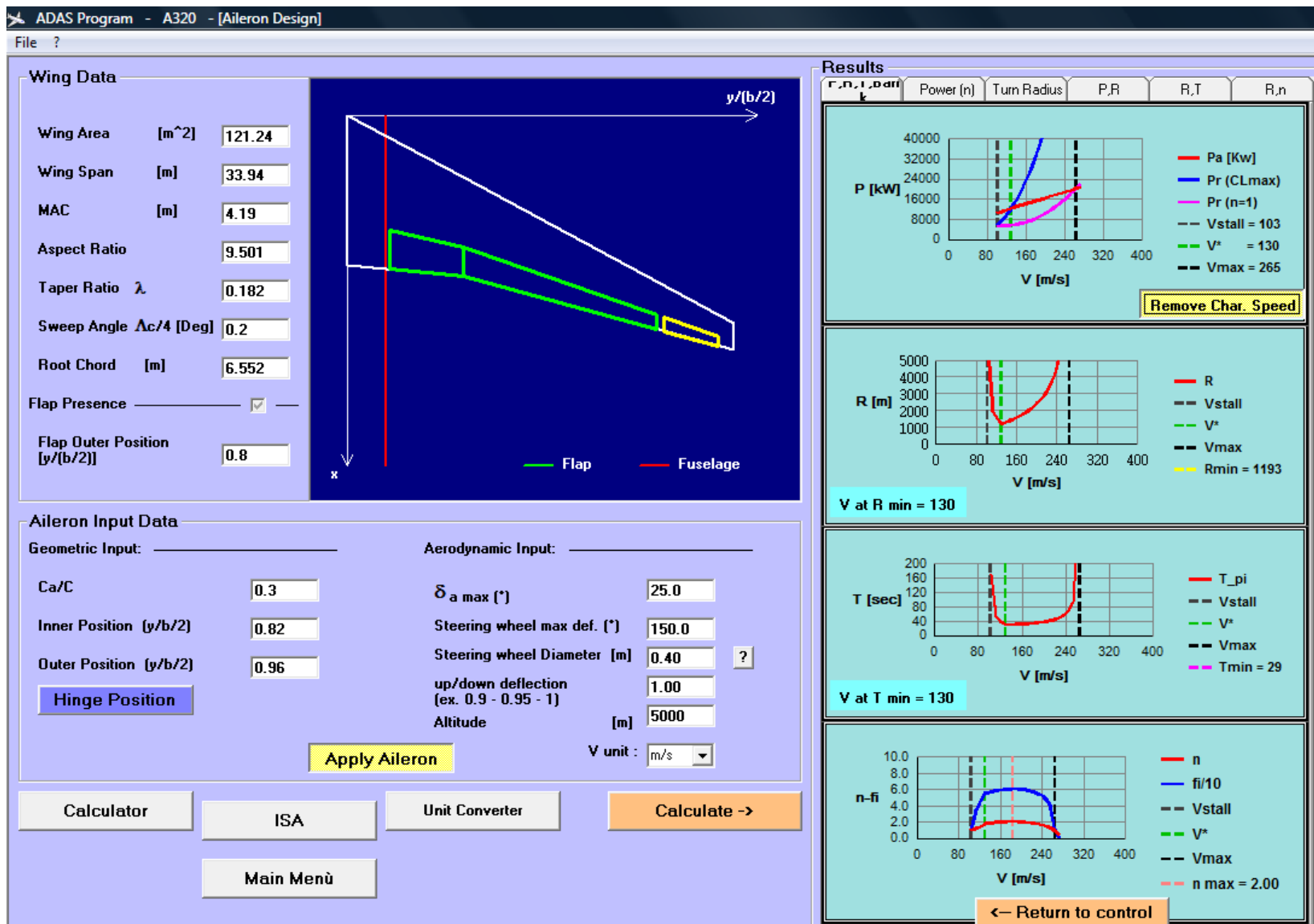
- High Lift Devices:



ADAS Modules - *Ailerons*:



ADAS Modules - Ailerons:



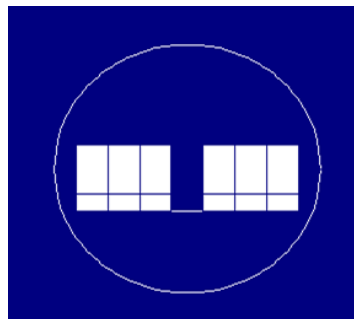
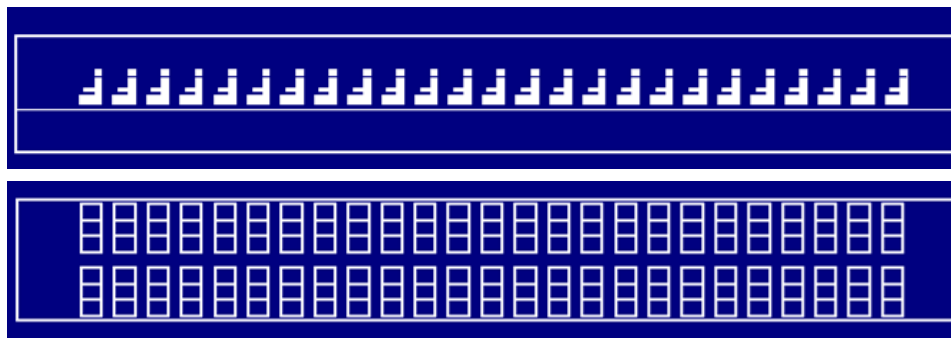
ADAS Modules

- *Fuselage:*

This module help the user to design a Fuselage for transport aircraft, contains also a sub-module that allow to approximate very well any type of fuselage shape.

- *Basic Passengers Cabin Layout*

The first step of Fuselage Design is to choose the Deck Layout:



Input Data	
Number of Seats	150
Deck Layout (ex. 23, 343)	33
Seat Width [cm]	Sugg 48
Seat Height [cm]	100
Seat Depth [cm]	60
Seat Pitch [cm]	98
Aisle Width [cm]	Sugg 48
Aisle Height [cm]	216
Aft Space [cm]	150
Fwd Space [cm]	150
Cargo Cabin Height [cm]	124

ADAS Modules - *Fuselage:*

- Standard Fuselage Layout for Transport Aircraft

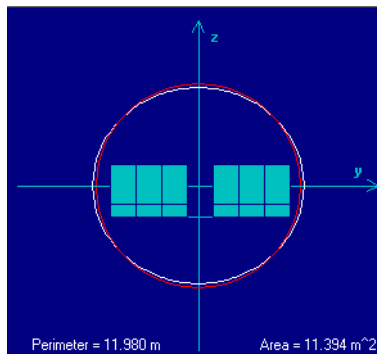
The second step is to design the fuselage Shape. It can be done with Standard approach, typical for Transport Aircraft, or Advanced.

For Standard Approach the program need:

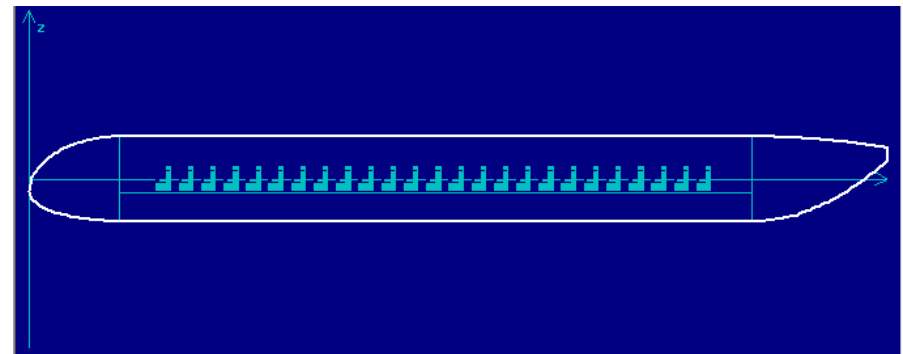
Input Data		
Nose Fineness Ratio	<input type="text" value="1.000"/>	Number of Sections
Cone Fineness Ratio	<input type="text" value="1.500"/>	
Znose/0.5*CabinHeight	<input type="text" value="-0.300"/>	Confirm Data
Zcone/0.5*CabinHeight	<input type="text" value="0.600"/>	
Base Diameter [m]	<input type="text" value="0.500"/>	

Section Number		
Nose Sections	<input type="text" value="30"/>	Confirm Section Number
Central Sections	<input type="text" value="20"/>	
Cone Sections	<input type="text" value="30"/>	

With the use of 4 classical polinomial is described the fuselage shape



Only elliptical section shape.



ADAS Modules

- **Fuselage:** - *Draw Advanced Fuselage Layout*

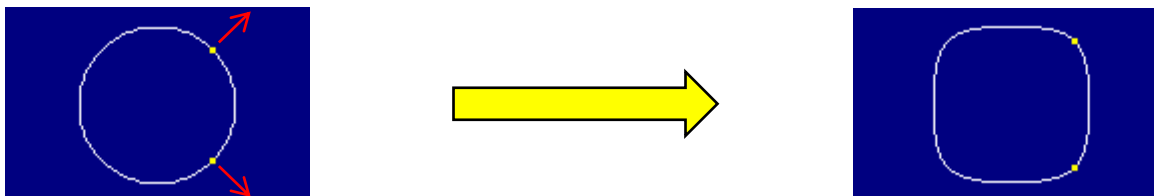
The alternative method to design a more detailed fuselage layout is to use the Advanced Fuselage Layout toolbox included in ADAS.

This sub-module allow to:

- Modify standard fuselage as desired.
- Custom a new fuselage by clicking each point on the picture.

Lateral and plant view are constucted by a Spline through all choosed point.

The sections shapes are default elliptical in all part. But they can be changed by modification of two **control point**, and placed in any part of the fuselage.



Zone with different type of section may be linked by a *transition zone*.

ADAS Modules

- *Fuselage:* - *Draw Advanced Fuselage Layout*

☒ Standard Fuselage
☒ Custom Fuselage

Data Lateral View
 N° of Points:
 Fuselage Length: m
 N° of Sections:

Upper

	X	Z
1	0.00	-0.48
2	0.30	-0.25
3	0.70	-0.05
4	1.40	0.35
5	2.20	0.65
6	3.25	0.80
7	5.50	0.80

Lower

	X	Z
1	11.67	0.03
2	11.30	-0.09
3	10.60	-0.30
4	9.70	-0.50
5	8.20	-0.66
6	6.67	-0.80
7	5.50	-0.80

Data Plant View
 N° of Point:

 This time the surfaces are symmetrical so draw only one side.

Plant

	X	Y
1	0.00	0.00
2	0.42	0.34
3	0.70	0.47
4	1.40	0.66
5	2.20	0.76
6	3.25	0.80
7	5.50	0.80
8	6.67	0.80

Section Shape

1	1	20
2	21	40 T
3	41	60
4	61	80 T

Zone Type

Sections Shape
 N° of Zone:
 Zone: From: To:
 Upper:
☐ Transition ☐ Elliptic ☐ Rect.

ADAS Modules

- *Fuselage:* - *Draw Advanced Fuselage Layout*

☒ Standard Fuselage
☒ Custom Fuselage

Data Lateral View
 N° of Points: 26
 Fuselage Length: 11.67 m
 N° of Sections: 100
 Draw Points -->
 26

Upper

	X	Z
1	0.00	-0.48
2	0.30	-0.25
3	0.70	-0.05
4	1.40	0.35
5	2.20	0.65
6	3.25	0.80
7	5.50	0.80

Lower

	X	Z
1	11.67	0.03
2	11.30	-0.09
3	10.60	-0.30
4	9.70	-0.50
5	8.20	-0.66
6	6.67	-0.80
7	5.50	-0.80

Modify
 Add Point
 Remove Point

Data Plant View
 N° of Point: 13
 Do Side Surface -->
 13
 This time the surfaces are symmetrical so draw only one side.

	X	Y
1	0.00	0.00
2	0.42	0.34
3	0.70	0.47
4	1.40	0.66
5	2.20	0.76
6	3.25	0.80
7	5.50	0.80
8	6.67	0.80

Modify
 Add Point
 Remove Point

Section View/Modify
 Section Number: 15 x 0.56
 Modify Point: Upper dm
 OK < V > Canc
 y: 0.32 -0.19 z

Section Shape **Zone Type**

1	1	20
2	21	40 T
3	41	60
4	61	80 T

Sections Shape
 N° of Zone: 5 Confirm Reset
 Zone: From: To: ρ
 Upper
☐ Transition ☐ Elliptic ☐ Rect.

Confirm Data Zoom Forward + - Zoom Backward + -
 Reload View Points View Line
 Back

ADAS Modules

- *Fuselage:* - *Draw Advanced Fuselage Layout*

☐ Standard Fuselage
☒ Custom Fuselage

Data Lateral View

N° of Points:
Fuselage Length: m
N° of Sections:
Draw Points -->

Upper

	X
1	0.00
2	0.30
3	0.70
4	1.40
5	2.20
6	3.25
7	5.50

Data Plant View

N° of Point:
Do Side Surface -->

This time the surfaces are symmetrical so draw only one side.

Confirm Data Zoom Forward
Reload Zoom Backward
Back View Points View Line

Lateral

3D View

Navigation controls: << > >>, Rotate (circular arrows), Rotate Z, Rotate Y, +, -

	X	Y	Z
5	2.20	0.76	
6	3.25	0.80	
7	5.50	0.80	
8	6.67	0.80	

Remove Point

Upper

☐ Transition ☐ Elliptic ☐ Rect.

ADAS Modules - *Fuselage*: - Advanced Fuselage Layout

Another way to particularize the fuselage shape is to modify section per section all part, it's also possible here to choose the X position of the passenger's cabin.

☒ Standard
 ☒ Advanced

Number of sections: 100

Insert Section Geometry Help
 Delete Section Back
 Copy Section Confirm Data

Section	X [m]	Height [m]	Z center [m]	L(B1) [m]	Teta(B1) [°]	L(B2) [m]	Teta(B2) [°]	r(S1) [m]	Teta(S1) [°]	r(S2) [m]	Teta(S2) [°]
1	0.001	0.010	-0.488	0.010	178.855	0.010	178.855	0.008	62.767	0.008	117.233
2	0.006	0.047	-0.477	0.034	175.908	0.034	175.908	0.032	55.309	0.032	124.692
3	0.026	0.101	-0.476	0.073	171.314	0.073	171.314	0.068	55.321	0.068	124.679
4	0.056	0.150	-0.471	0.113	166.544	0.113	166.544	0.104	56.281	0.104	123.719
5	0.095	0.199	-0.466	0.145	162.692	0.145	162.692	0.135	55.567	0.135	124.433
6	0.139	0.246	-0.459	0.181	158.475	0.181	158.475	0.169	55.856	0.169	124.144

Cabin Layout

Load Unload Confirm

☒ Standard

X Start Cabin [m]: 2.3 Z Deck Level [m]: -0.5

☒ Advanced

Seat Line	X [m]	Z [m]
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00
5	0.00	0.00

Multiple Section View

Section n° 1

Area = 0.015 m²
 Perimeter = 0.898 m

ADAS Modules - *Fuselage:* - *Wing-Fuselage Layout*

The Third Step is to choose the position of Wing.

Fuselage

☐ Standard Fuselage

Z level for fuselage nose [m]

☒ Advanced Fuselage

Lateral View

Wing

X wing root leading edge/ Fuselage Length [%]

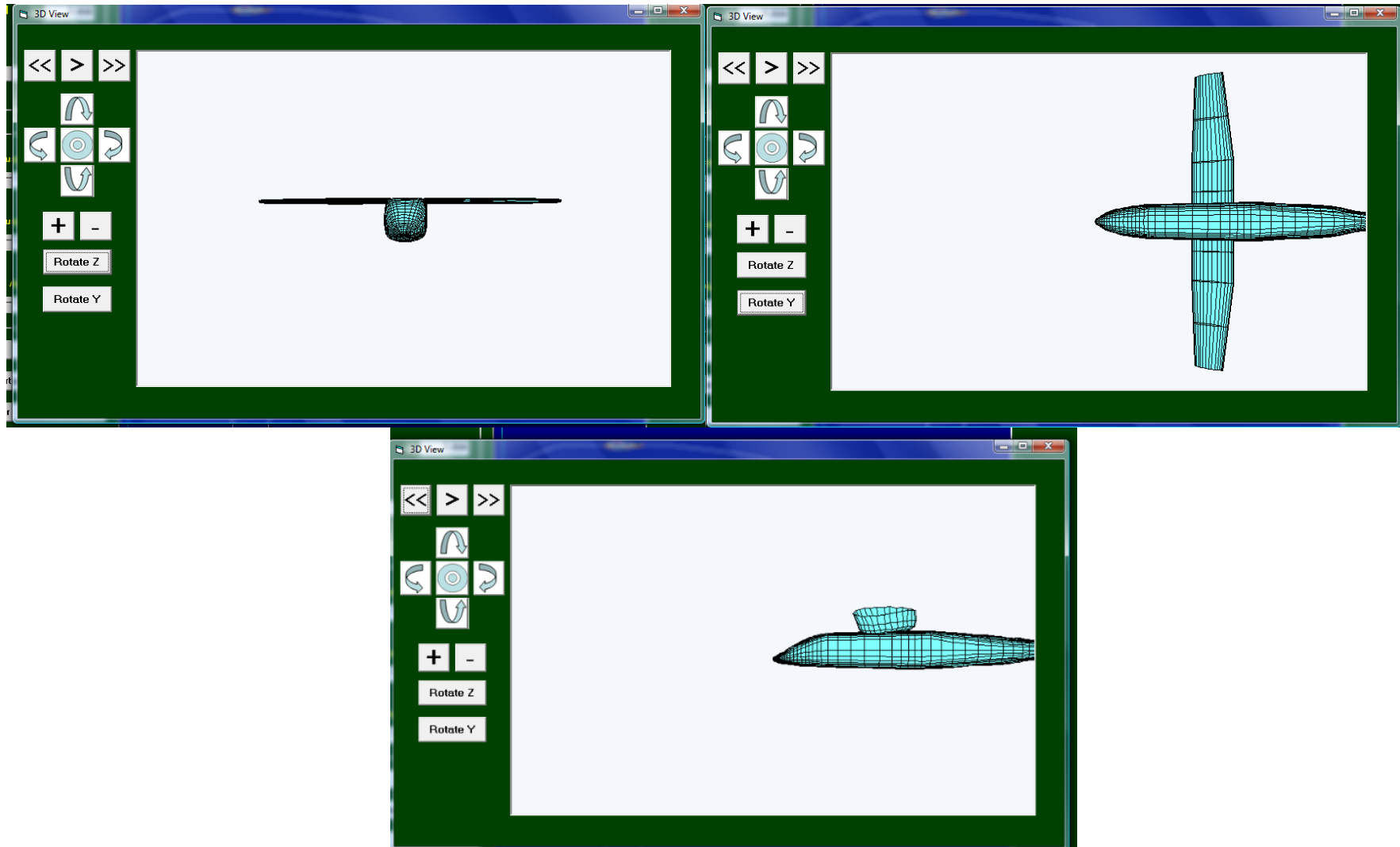
Z wing root leading edge/ Fuselage Max Height

Wing Root Chord - Fuselage Axis Angle [deg] ?

Plant View

ADAS Modules - *Fuselage:* - *Wing-Fuselage Layout*

The Third Step is to choose the position of Wing.



ADAS Modules - *Fuselage: - Analysis*

Reference Length [m]
37.380
37.565

Altitude [m]
11260

☒ Speed [km/h]
☐ Mach
0.8

X transition / Fuselage Length
0.000

Reynolds Number
219867643

Friction Coefficient Cf
0.00183

CL_{α} wing M=0
0.0840
0.0840

Calculate Downwash at Rear Fuselage Tip

$d\epsilon / d\alpha$
0.370

Choose Which Wf to Use
☒ Effective Wf
☐ Equivalent Wf
?

Fuselage Analysis

Alpha w	i wing	Alpha b	CD0 fus	CD base	CD upsw	CD(Lift)	CDtot fus	CM fus
-1.0	2.0	-3.0	0.0064	0.00004	0.0001	0.0001	0.0067	-0.1092
-0.4	2.0	-2.4	0.0064	0.00004	0.0001	0.0001	0.0067	-0.0980
0.1	2.0	-1.9	0.0064	0.00004	0.0001	0.0000	0.0066	-0.0869
0.7	2.0	-1.3	0.0064	0.00004	0.0001	0.0000	0.0066	-0.0757
1.3	2.0	-0.7	0.0064	0.00004	0.0001	0.0000	0.0066	-0.0646
1.8	2.0	-0.2	0.0064	0.00004	0.0001	0.0000	0.0066	-0.0534

Fuselage Top View
Fuselage Lateral View
Numerical Data

Parts forward wing
8
K2 - K1
?
0.932

Parts within wing
5

Parts behind wing
10

CM0 table
CMalpha

n	X start [m]	Xi center [m]
1	0.000	12.616
2	1.682	10.934
3	3.364	9.252
4	5.046	7.570
5	6.729	5.887
6	8.411	4.205
7	10.093	2.523
8	11.775	0.841
9	13.457	0.000
10	14.767	0.000
11	16.078	0.000
12	17.388	0.000
13	18.699	0.000

Drag
Moment

Fuselage Top View
Fuselage Lateral View
Numerical Data

Unit Converter
Calculator
ISA

ADAS Modules - *Nacelle*:

Another possibility of ADAS is to design the Nacelles:

Nacelle Integration

Wing

X wing root leading edge / Fuselage Length [%]

Z wing root leading edge / Fuselage Max Height [%]

Wing root chord - Fuselage axis Angle [deg]

Nacelle

☒ Nacelle 1

X / Fuselage Length [%]

Y / Wing Span [%]

Z / Fuselage Height

☒ Nacelle 2

X / Fuselage Length [%]

Y / Wing Span [%]

Z / Fuselage Height

☐ Nacelle 3

☐ Nacelle 4

☐ Nacelle 5

☐ Nacelle 6

Fuselage

☒ Standard Fuselage ☐ Advanced Fuselage

Z level for Fuselage Nose [m]

Lateral View

Nacelle 2 Orientation
LN [°]

Plant View

ADAS Modules

Parasite Drag

FLIGHT CONDITION

Altitude (Service Ceiling) [m]
11270

Speed [km/h]
Mach
0.78

WING

FUSELAGE

NACELLE

HORIZONTAL TAIL

VERTICAL TAIL

MISCELLANEOUS

WING

Reference Length (Mean Aerodynamic Chord) [m]
4.19
4.190

X transition / Reference Length [%]
0

☒ Laminar Bucket

Roughness Skin Value "k"
0.00000052 - Smooth molded composite

Wing Planform Area [m²]
121.240
121.24

Wing Wetted Area [m²]
217.917
217.26

Maximum Airfoil Thickness "t/c" [%]
11.6
11.6

Sweep Angle [deg]
25.0
25.0

CALCULATE WING PARASITE DRAG

Cut - Off Reynolds Number "Re_{cut-off}"
626035737

Reynolds Number "Re"
23882605

Skin Friction Coefficient "C_f"
0.00251

Form Factor "K_{ff}"
1.56

Wing Parasite Drag Coefficient "C_{Dw}"
0.0070

BACK

AIRPLANE TOTAL PARASITE DRAG COEFFICIENT

CDp
0.0226

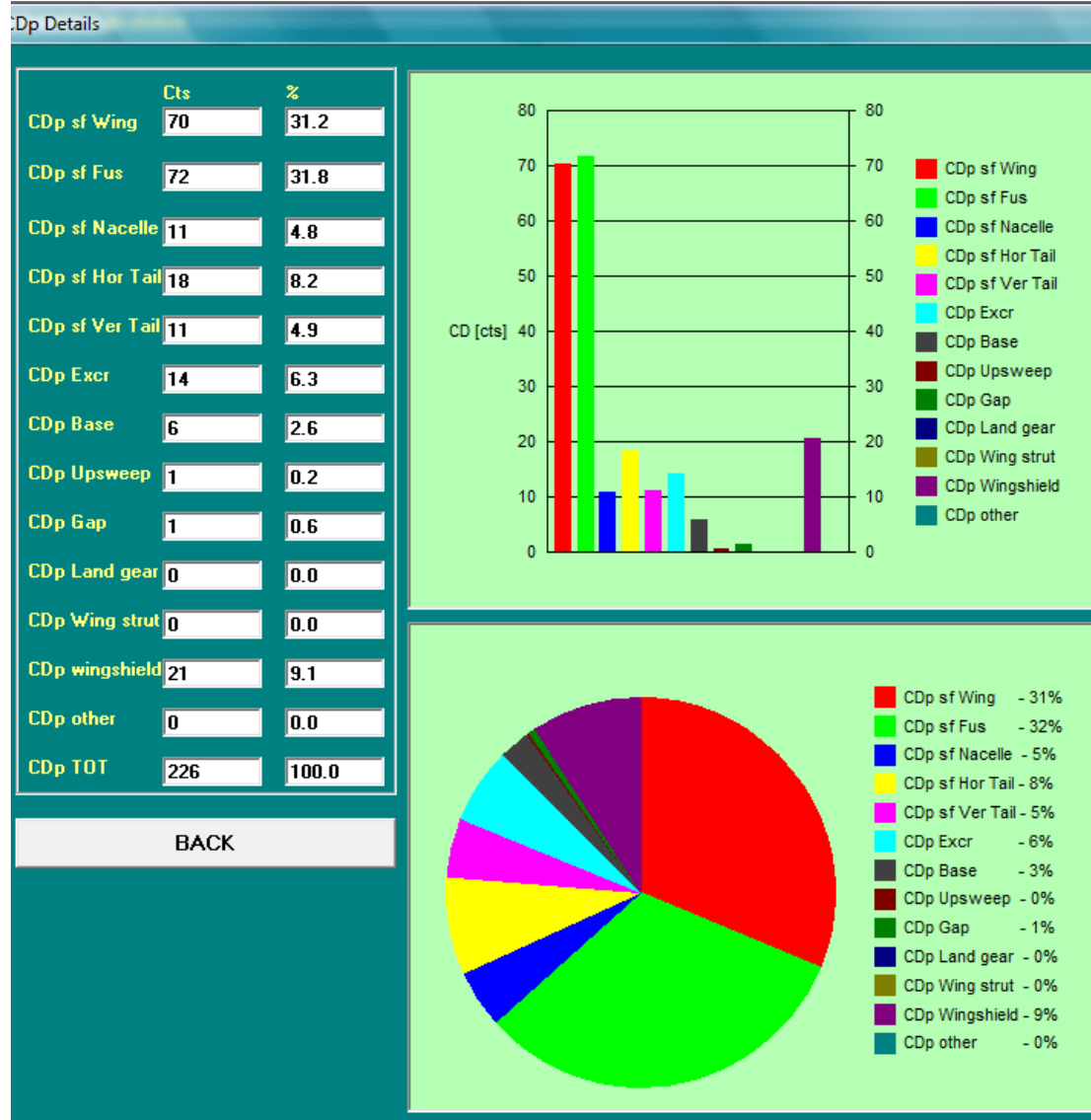
BACK

Calculator

Unit Converter

ISA

ADAS Modules



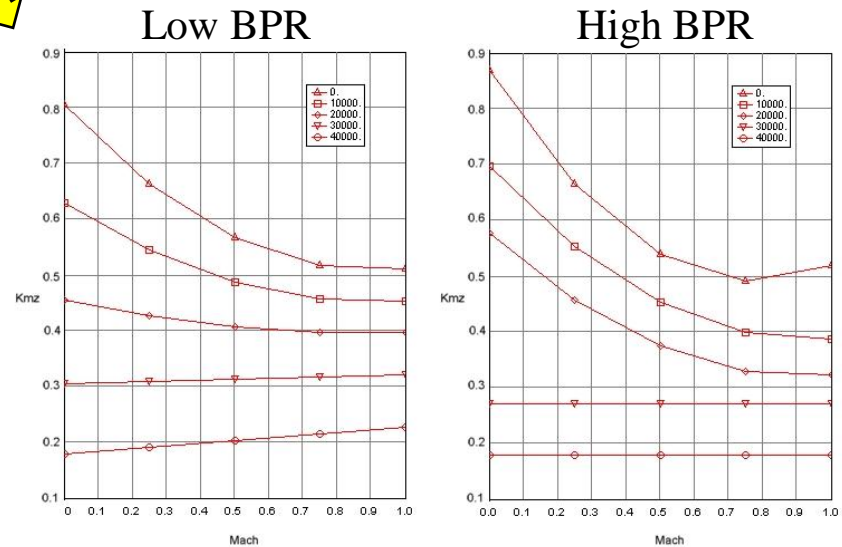
ADAS Modules - Performances:

➤ Turbofan model:

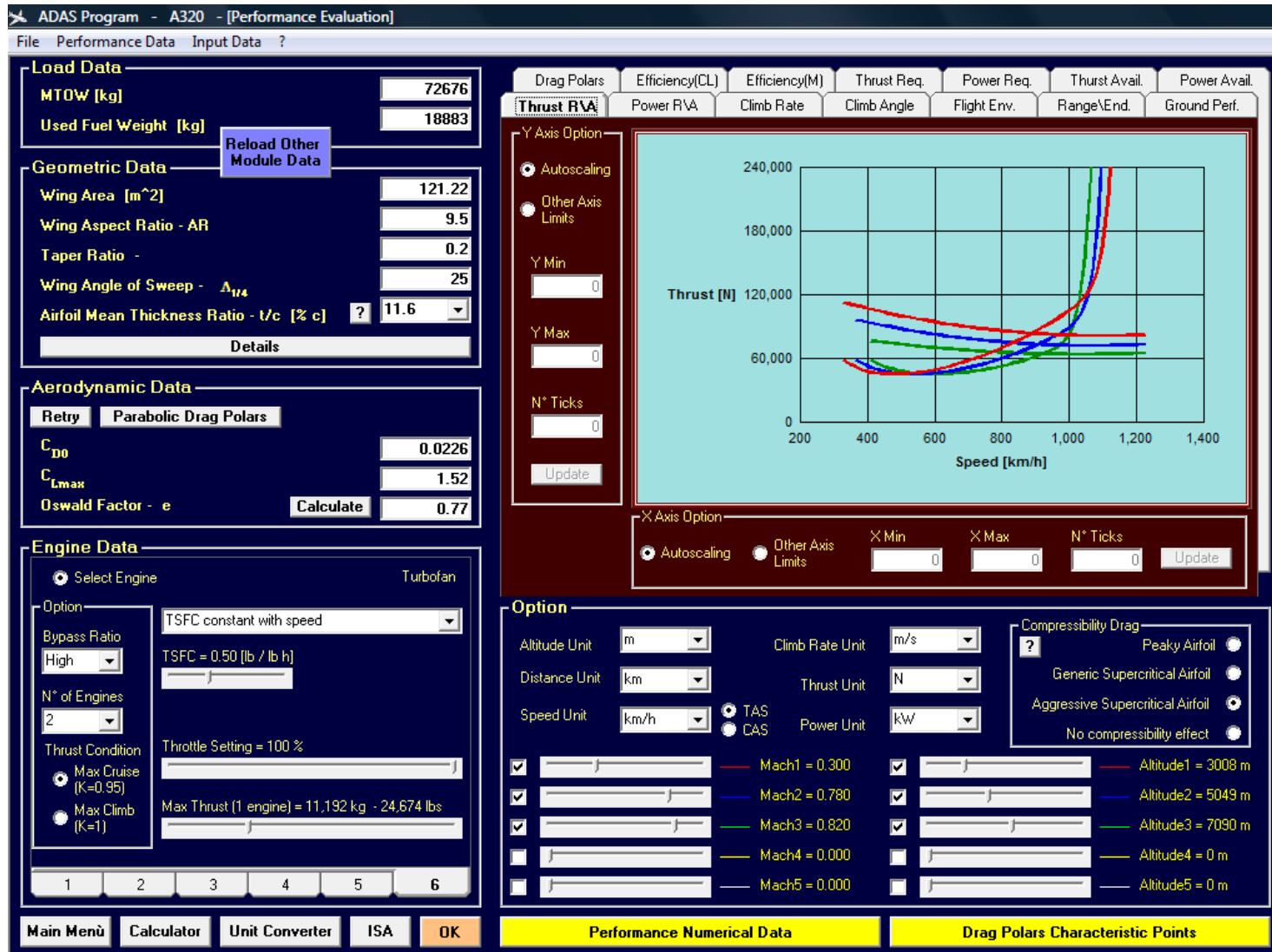
The model used for Low Bypass ratio is the *Pratt & Whitney JT8-D*
 For High Bypass ratio is the *Pratt & Whitney PW-2037*

$$k_{mz} = \frac{T}{T_{\max \text{cruise}}} = f(z, M) \quad \longrightarrow \quad f(z, M) = a_1(z) + a_2(z) \cdot M + a_3(z) \cdot M^2$$

$$\begin{cases} T = T_0 \cdot N_{\text{engines}} \cdot \varphi \cdot k_{mz} \\ P = T \cdot V \end{cases}$$



ADAS Modules - *Performance:*

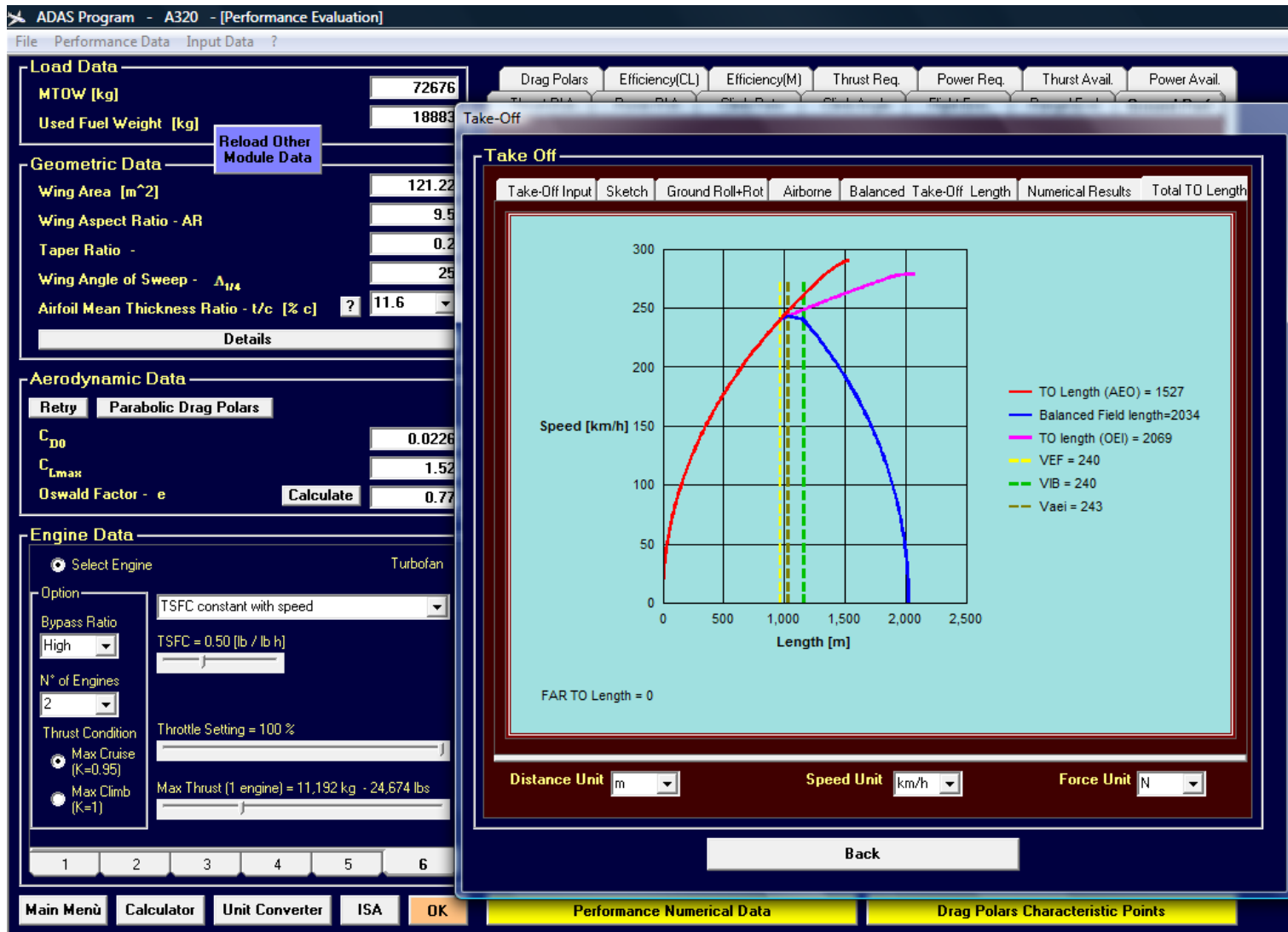


ADAS Modules - Performance:



ADAS Modules - Performance:

➤ Take Off:



ADAS Modules

- *Stability and Control:*

The analysis of stability and control is divided in two part:

- Horizontal Tail Design – Longitudinal Stability and Control
- Vertical Tail Design – Directional Stability



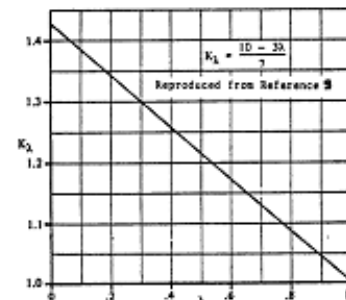
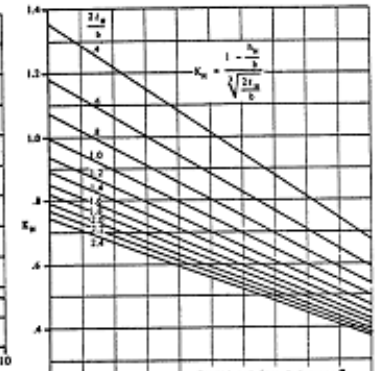
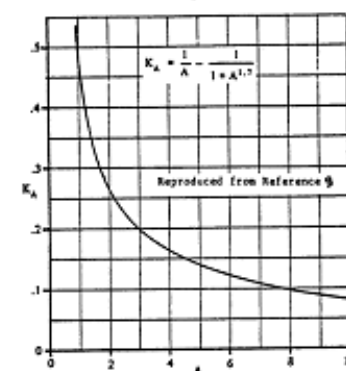
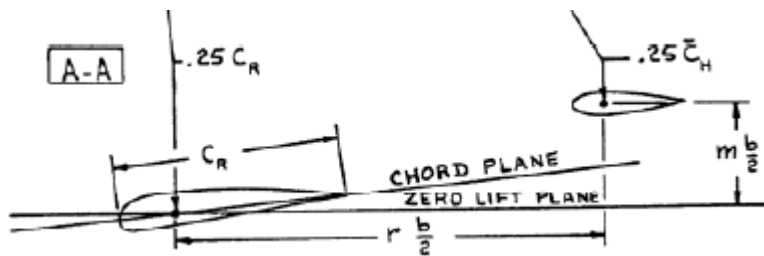
ADAS Modules

- *Stability and Control:*

The methodologies used for this module:

- Wing Downwash:
Roskam approach

$$\frac{\partial \varepsilon}{\partial \alpha} = 4.44 \left[\left(K_A K_\lambda K_h (\cos \Lambda_{c/4})^{1/2} \right)^{1.19} \right] \frac{CL_\alpha}{CL_{\alpha M=0}}$$



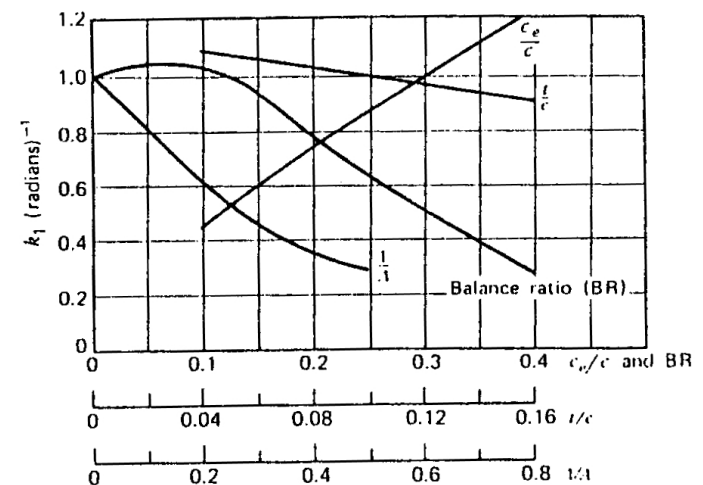
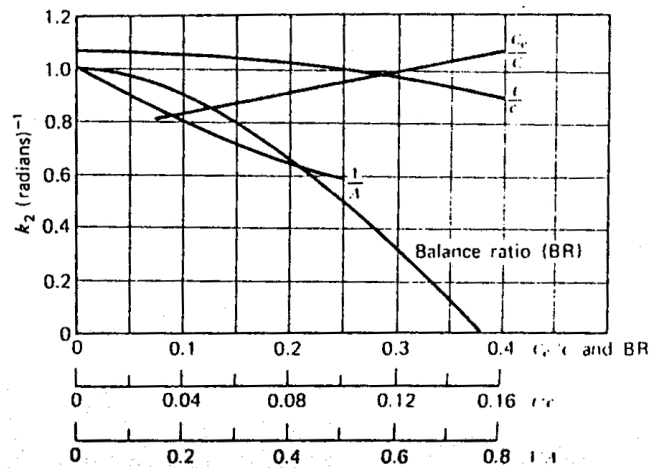
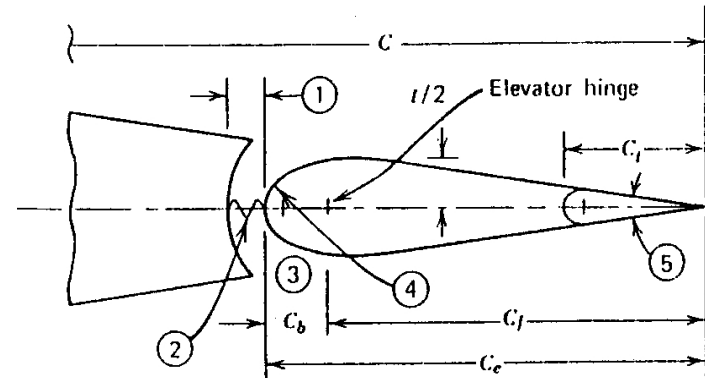
c)

ADAS Modules

- Stability and Control:

The methodologies used for this module:

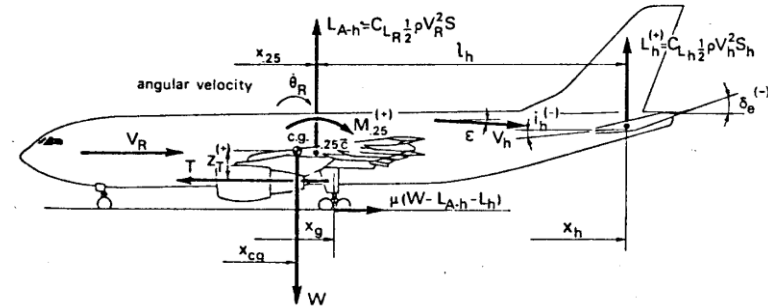
- $C_{h\alpha}$ and $C_{h\delta}$:
McCormick approach



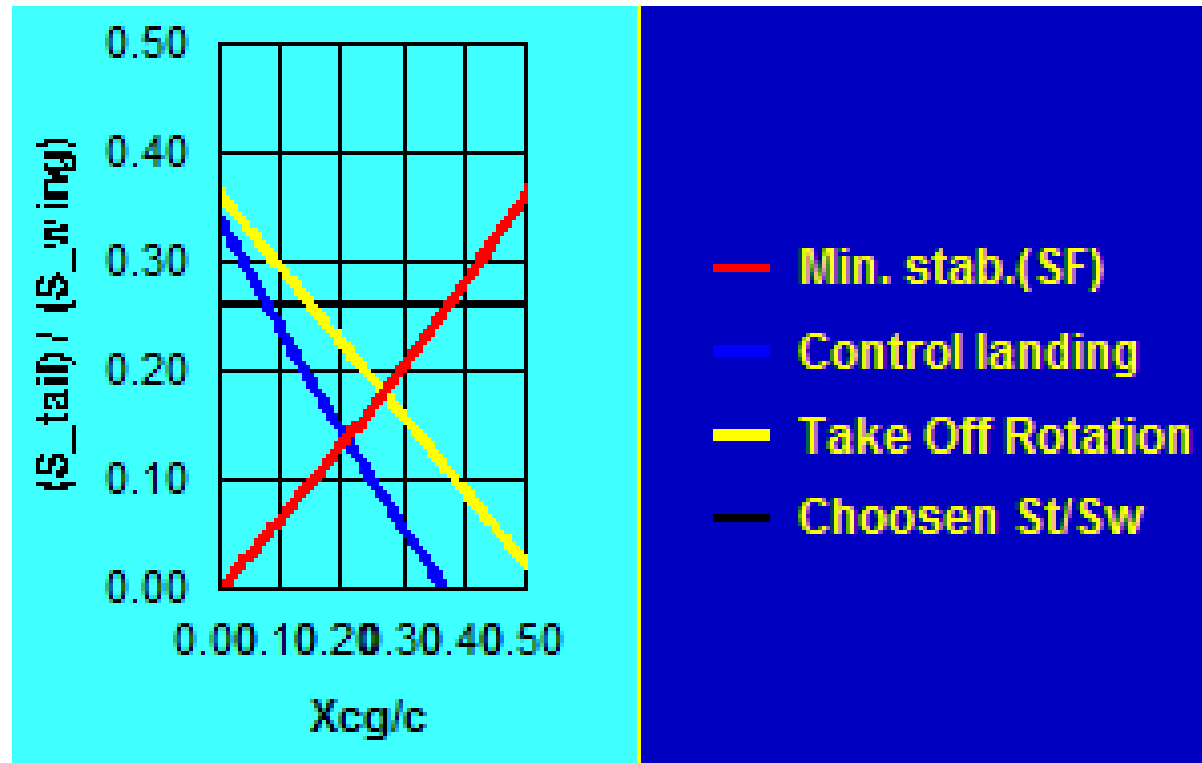
ADAS Modules

- *Stability and Control:*

For Horizontal Tail Design CG constraints due to minimum stability (stick free), Control deflection in landing and take off rotation have been considered



Take off Rotation forces



ADAS Modules - Stability and Control:

ADAS Program - A320 - [Horizontal Tail Design]

File ?

Preliminary data

Xacwb/c	0.055	α_{0L} [°]	-0.1
Cmacwb	-0.1004	$Cl_{max\ idg}$	2.616
$Cl_{aw\ M=0}$ [1/°]	0.084	$\Delta C_{m\ idg}$	-0.58
$Cl_{awb\ M=0}$	0.088	$\Delta \alpha_{idg}$ [°]	-13.027
		M cruise	0.78
Sw [m ²]	121.24	M idg	0.3
MAC [m]	4.19		
$\Lambda_{c/4w}$ [deg]	25	X le Cr [m]:	
λ_w	0.182		13.52
i_w [deg]	2	Xacwb [m]:	
AR	9.501		> 13.75
bw [m]	33.94		
Altitude [m]	10000		

Lateral View

Tail

☐ Fin Mounted: Fin dependant data blocked

Xac tail root / Fuselage Length [%]

Zac tail root / Fuselage Max Height

Confirm Data --->

Preliminary Calculation

Tail position angle [deg]	9.41	?	Cha	-0.228	1/rad
de/dalpha	0.409		Ch _δ	-0.440	
de/da LDG	0.380		$\tau_{\delta e\ max}$	0.31	
Lt [m]	20.79		τ	0.50	
at [1/deg]	0.077		i_0 [deg]	0.90	0.90 ?

Choose your "S tail"

St/Sw:

0.26

St [m²]

31.52

Calculate and Plot

Input data - Min Static Stab. - Control in land.

$\Lambda_{c/4t}$ [deg]	32.0	λ_t	0.26
Ce/Ct	0.30	η_t	1
% ext. elevator	90.00	$\delta_{e\ max}$ [°]	25
t/c tail	0.11	Veq/VsL	1.1
a_{0t} [1/deg]	0.11	Elevator Type :	
Xcg/c Max fwd	0.15	Gap	Closed
Xcg/c Max aft	0.30	Gap	Open
min SSM sfree	0.05		
ARt	4.60		

Other Optional Data

Take Off Rotation

Calculator

Load statistical data

ISA

Unit Converter

Main Menu

Back

St and bt Cond.

St-Xcg Plot

HT Quick sketch

Sexp = 17.95 Swet = 36.89

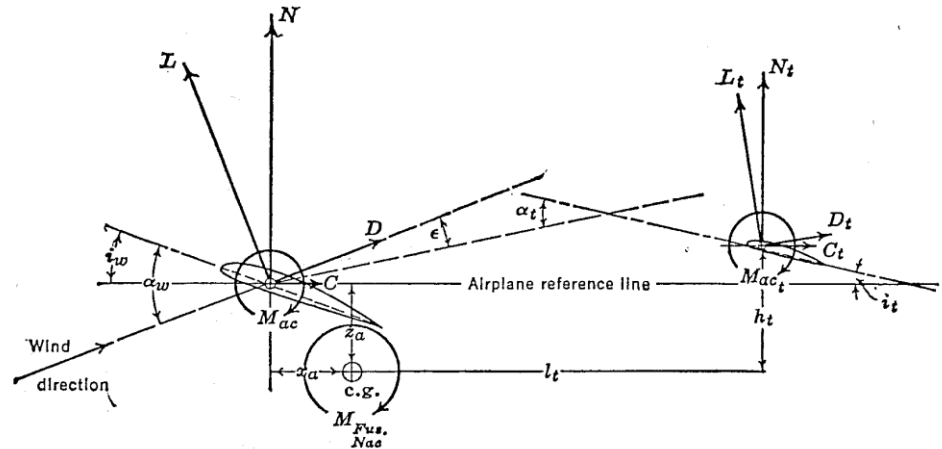
ADAS Modules

- Stability and Control:

➤ Longitudinal Stability and Control:

The equations used for the study of longitudinal stability are taken by classic methodology:

$$C_{m_{cg}} = C_N \frac{x_a}{c} + C_c \frac{z_a}{c} + C_{mac} + C_{m_{Fus_{Nac}}} + C_{m_{act}} \frac{S_t}{S_w} \frac{c_t}{c} \eta_t + C_{ct} \frac{S_t}{S_w} \frac{h_t}{c} \eta_t - C_{N_t} \frac{S_t}{S_w} \frac{l_t}{c} \eta_t$$



The slope of pitching moment with CL is given by:

$$\frac{dC_m}{dC_L} = \underbrace{\frac{dC_N}{dC_L} \frac{x_a}{c} + \frac{dC_c}{dC_L} \frac{z_a}{c} + \frac{dC_{mac}}{dC_L}}_{\text{Contr. of wing}} + \underbrace{\left(\frac{dC_m}{dC_L} \right)_{Fus_{Nac}}}_{\text{Contr. of fuselage and nacelles}} - \underbrace{\frac{dC_{N_t}}{dC_L} \frac{S_t}{S_w} \frac{l_t}{c} \eta_t}_{\text{Contr. of horizontal tail}}$$

PENDULAR Stability

ADAS Modules

- Stability and Control:

➤ Longitudinal Stability and Control:

The equation used for the calculation of neutral point is:

$$N_0 = x_{cg}(dC_m/dC_L=0) = x_{ac} - \left(\frac{dC_m}{dC_L} \right)_{Fus, Nac} + \frac{a_t}{a_w} \bar{V} \eta_t \left(1 - \frac{d\epsilon}{d\alpha} \right)$$

So the Stability Static Margin can be calculated:

$$\frac{dC_m}{dC_L} = x_{cg} - N_0$$

The effect of Thrust on these equations is an additive term calculated by:

• For Propeller: $\left(\frac{dC_m}{dC_L} \right)_{N_{PT=0}} = \frac{(dC_N/d\alpha)_{PT=0} (1 + d\epsilon/d\alpha) l_p S_p N}{S_w c a_w}$

$$(dC_N/d\alpha)_{PT=0}^*$$

• For Jet:

$$\frac{dC_M}{dC_L} = 0.035 \frac{\dot{m}}{\rho \sqrt{2q/\rho}} \frac{l_T N}{S_w c a_w}$$

$$\dot{m} = 0.032 \cdot T/N$$

.0024	Two-bladed propellers
.0032	Three-bladed propellers
.004	Four-bladed propellers
.0065	Six-bladed counter-rotating propellers

ADAS Modules - *Stability and Control*:

ADAS Program - A320 - [Longitudinal Stability and Control]

File ?

Wing

Geometry Input :

MAC [m] 4.19

Sw [m²] 121.22

bw [m] 33.94

AR 9.5

$\Lambda_{c/4}$ [deg] 25

λ 0.2

iw [deg] 2

Xacw/c 0.325

Xle Cr [m] 13.15

Xle \bar{C} > 17.645

Zxacw [m] 0.59

Aerodynamic Input :

Load Wing Data α_{OL} [°]

Insert Data => CLmax

Cm (post stall) Cmac

Fuselage

CMo_F -0.0963

CM_{aF} 0.0211

Refresh Chart

CL(alpha) CD(alpha) Cm(alpha)

Horizontal Tail

Position Input :

Xac [m] 34.54

Zac [m] 1.68

Geometry Input :

St [m²] 31.52

ARt 4.6

$\Lambda_{c/4}$ [deg] 32

λ 0.26

it0 [deg] 0.89

γ/c (ex 0.1) 0.11

Aerodynamic Input :

CL(alpha) CD(alpha) HT Sketch

CG Position and Options

Xcg/MAC 0.35 ?

Zcg/MAC -0.1 Positive if CG below the wing

☒ Non Linear effect wing lift curve slope

☒ Non Linear effect wing moment coefficient curve

☒ Non Linear effect Horizontal tail lift curve slope

☒ Effect of wing lift curve slope on downwash

☒ Effect of Hor. Tail distance of horizontal tail from wing vortex plane on downwash

☒ Effect of tail position on dynamic pressure ratio

☒ Effect of CG vertical position (Pendular Stability)

☒ Pitching Moment contribution due to Thrust ?

☒ Pitching Moment contribution due to Propulsive system working in non axial flow ?

α_b Max -8 (> -8.5)

α_b Min 22 (< 24.0)

N α_b 27

Close

Elevator Input :

Ce/Ct 0.3 η_{inner} [y/b/2] 0.1 Confirm Data

☒ Gap Closed η_{outer} [y/b/2] 0.9

☐ Gap Open Elevator Deflections

Airplane Drag polar for Thrust Calculation:

CD0 0.0226

Oswald factor 0.75

Altitude [m] 10000

Unit Converter

ISA

Calculator

Main Menù

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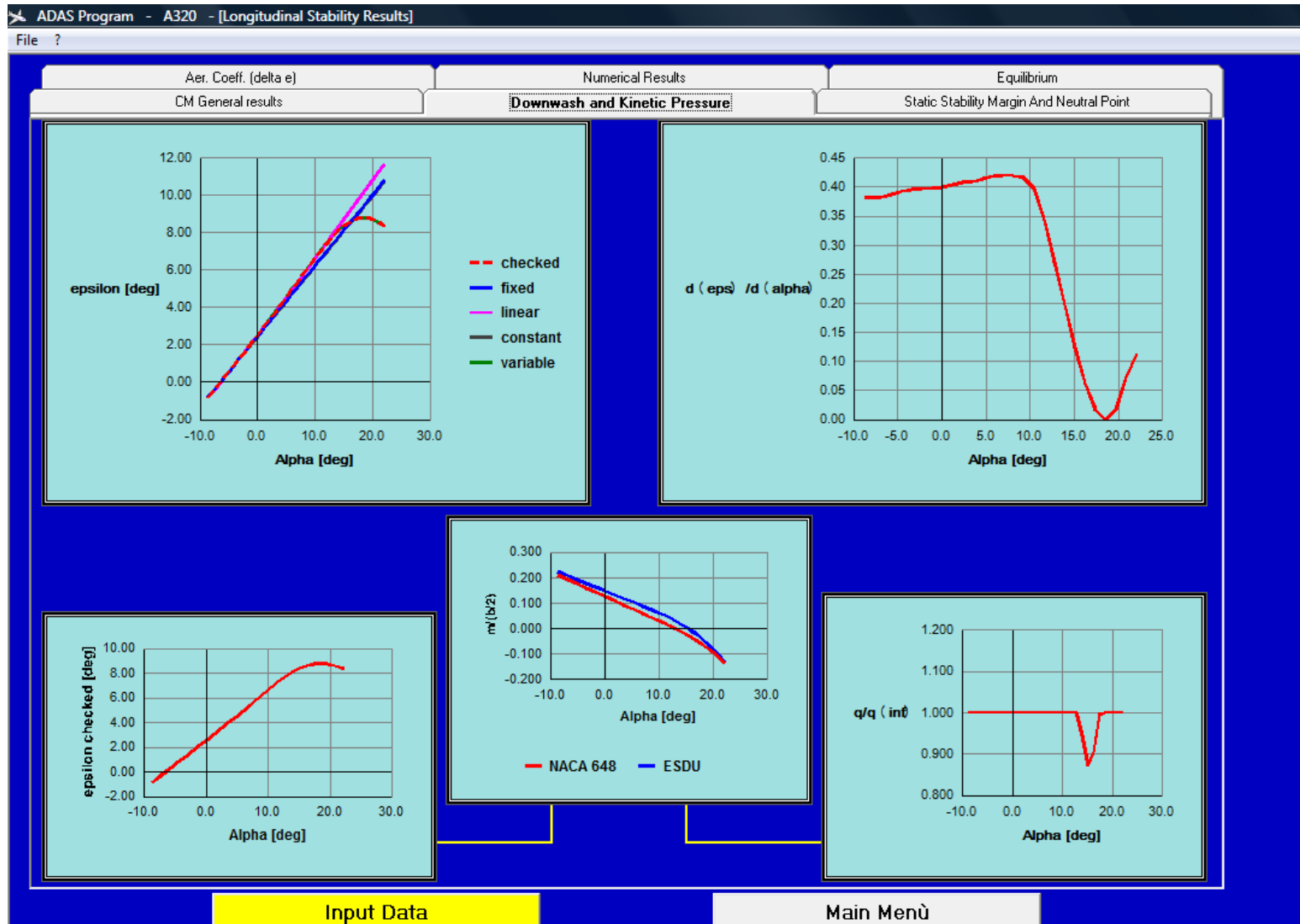
CG Pos. and Options

Calculate

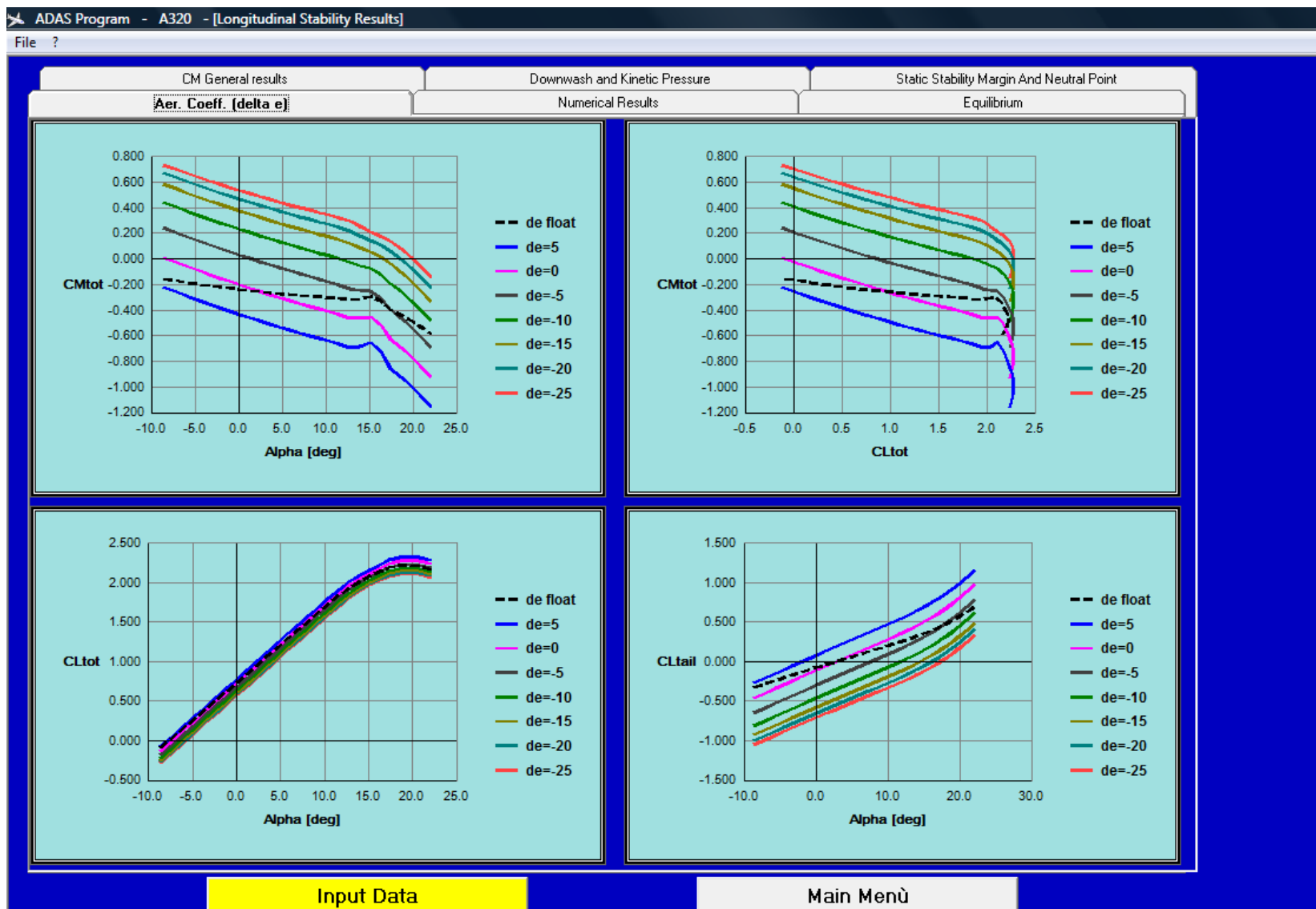
Open Results Page

Reload Other Module Data

ADAS Modules - *Stability and Control:*



ADAS Modules - *Stability and Control:*



ADAS Modules

- *Stability and Control:*

CG Position and Options

Xcg/MAC ?

Zcg/MAC Positive if CG below the wing

☐ Non Linear effect wing lift curve slope

☐ Non Linear effect wing moment coefficient curve

☐ Non Linear effect Horizontal tail lift curve slope

☐ Effect of wing lift curve slope on downwash

☐ Effect of Hor. Tail distance of horizontal tail from wing vortex plane on downwash

☐ Effect of tail position on dynamic pressure ratio

☐ Effect of CG vertical position (Pendular Stability)

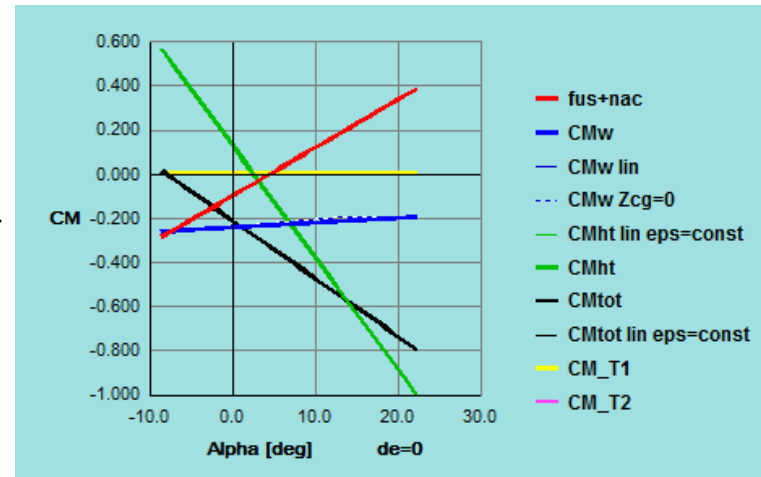
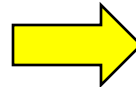
☐ Pitching Moment contribution due to Thrust ?

☐ Pitching Moment contribution due to Propulsive system working in non axial flow ?

α_b Max (> -8.5)

α_b Min (< 24.0)

N α_b



CG Position and Options

Xcg/MAC ?

Zcg/MAC Positive if CG below the wing

☒ Non Linear effect wing lift curve slope

☒ Non Linear effect wing moment coefficient curve

☒ Non Linear effect Horizontal tail lift curve slope

☐ Effect of wing lift curve slope on downwash

☐ Effect of Hor. Tail distance of horizontal tail from wing vortex plane on downwash

☐ Effect of tail position on dynamic pressure ratio

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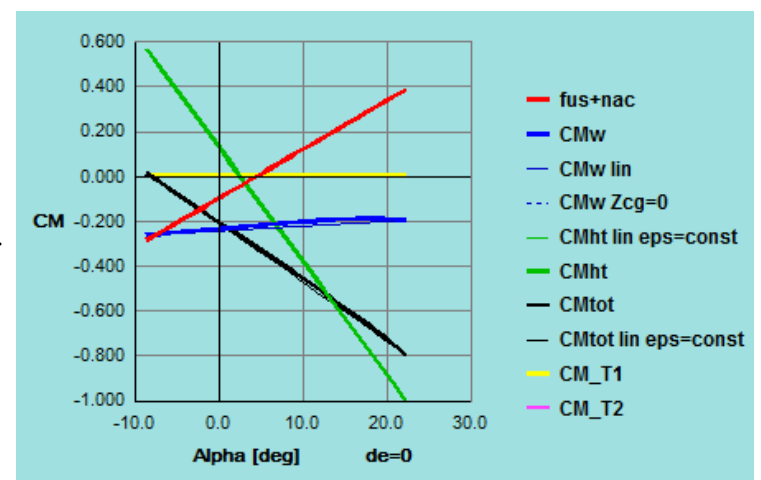
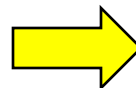
☐ Pitching Moment contribution due to Thrust ?

☐ Pitching Moment contribution due to Propulsive system working in non axial flow ?

α_b Max (> -8.5)

α_b Min (< 24.0)

N α_b



ADAS Modules

- Stability and Control:

-CG Position and Options

Xcg/MAC ?

Zcg/MAC Positive if CG below the wing

☒ Non Linear effect wing lift curve slope

☒ Non Linear effect wing moment coefficient curve

☒ Non Linear effect Horizontal tail lift curve slope

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☐ Effect of tail position on dynamic pressure ratio

☐ Effect of CG vertical position (Pendular Stability)

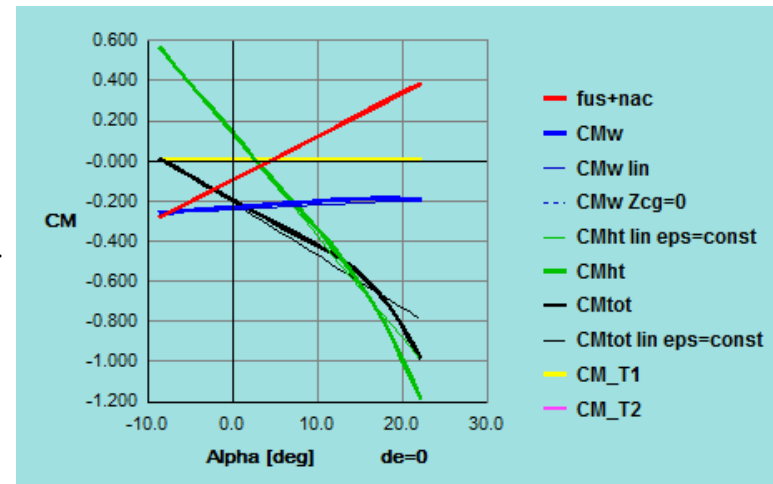
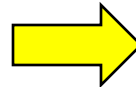
☐ Pitching Moment contribution due to Thrust ?

☐ Pitching Moment contribution due to Propulsive system working in non axial flow ?

α_b Max (≥ -8.5)

α_b Min (≤ 24.0)

N α_b



-CG Position and Options

Xcg/MAC ?

Zcg/MAC Positive if CG below the wing

☒ Non Linear effect wing lift curve slope

☒ Non Linear effect wing moment coefficient curve

☒ Non Linear effect Horizontal tail lift curve slope

☒ Effect of wing lift curve slope on downwash

☒ Effect of Hor. Tail distance of horizontal tail from wing vortex plane on downwash

☒ Effect of tail position on dynamic pressure ratio

☐ Effect of CG vertical position (Pendular Stability)

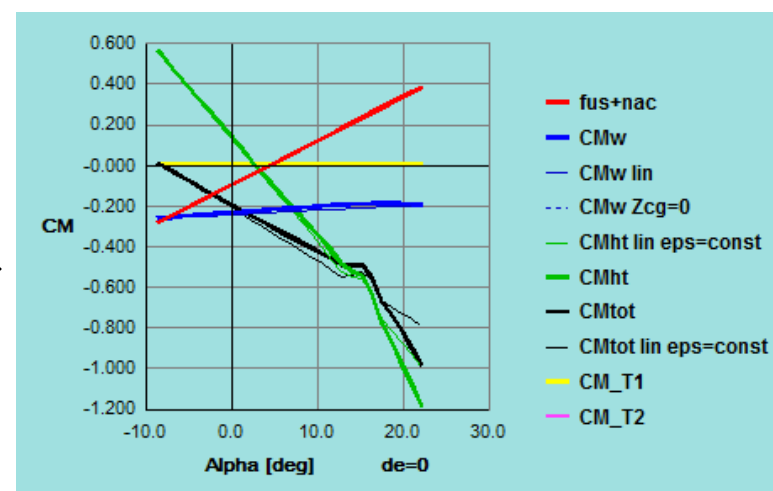
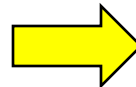
☐ Pitching Moment contribution due to Thrust ?

☐ Pitching Moment contribution due to Propulsive system working in non axial flow ?

α_b Max (≥ -8.5)

α_b Min (≤ 24.0)

N α_b



ADAS Modules

- Stability and Control:

CG Position and Options

Xcg/MAC ?

Zcg/MAC Positive if CG below the wing

☒ Non Linear effect wing lift curve slope

☒ Non Linear effect wing moment coefficient curve

☒ Non Linear effect Horizontal tail lift curve slope

☒ Effect of wing lift curve slope on downwash

☒ Effect of Hor. Tail distance of horizontal tail from wing vortex plane on downwash

☒ Effect of tail position on dynamic pressure ratio

☒ Effect of CG vertical position (Pendular Stability)

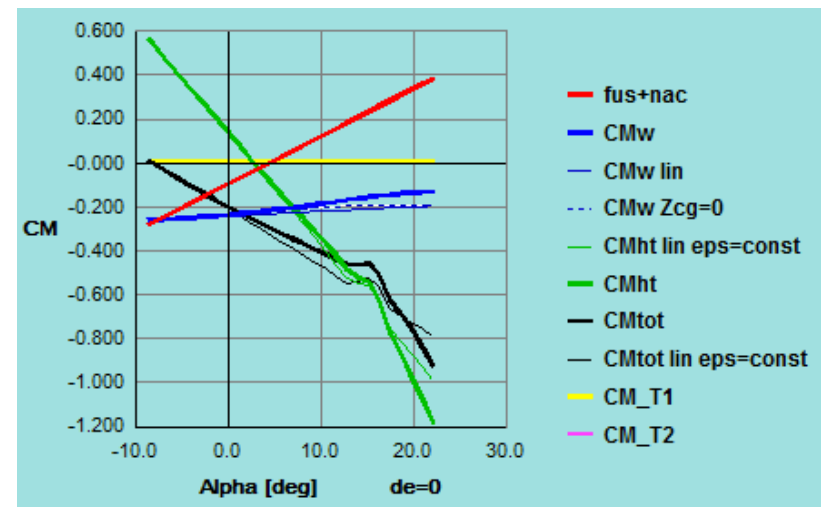
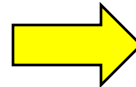
☐ Pitching Moment contribution due to Thrust ?

☐ Pitching Moment contribution due to Propulsive system working in non axial flow ?

α_b Max (> -8.5)

α_b Min (< 24.0)

N α_b



CG Position and Options

Xcg/MAC ?

Zcg/MAC Positive if CG below the wing

☒ Non Linear effect wing lift curve slope

☒ Non Linear effect wing moment coefficient curve

☒ Non Linear effect Horizontal tail lift curve slope

☒ Effect of wing lift curve slope on downwash

☒ Effect of Hor. Tail distance of horizontal tail from wing vortex plane on downwash

☒ Effect of tail position on dynamic pressure ratio

☒ Effect of CG vertical position (Pendular Stability)

☐ Pitching Moment contribution due to Thrust ?

☐ Pitching Moment contribution due to Propulsive system working in non axial flow ?

α_b Max (> -8.5)

α_b Min (< 24.0)

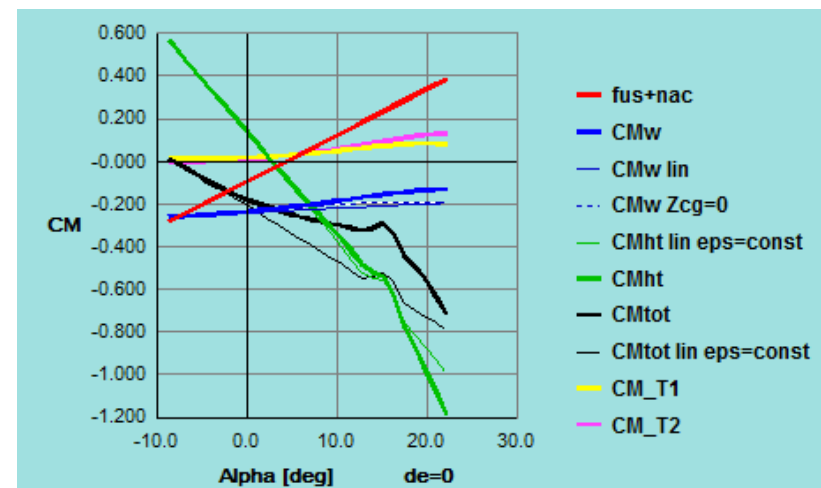
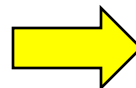
N α_b

Airplane Drag polar for Thrust Calculation:

CDo

Oswald factor

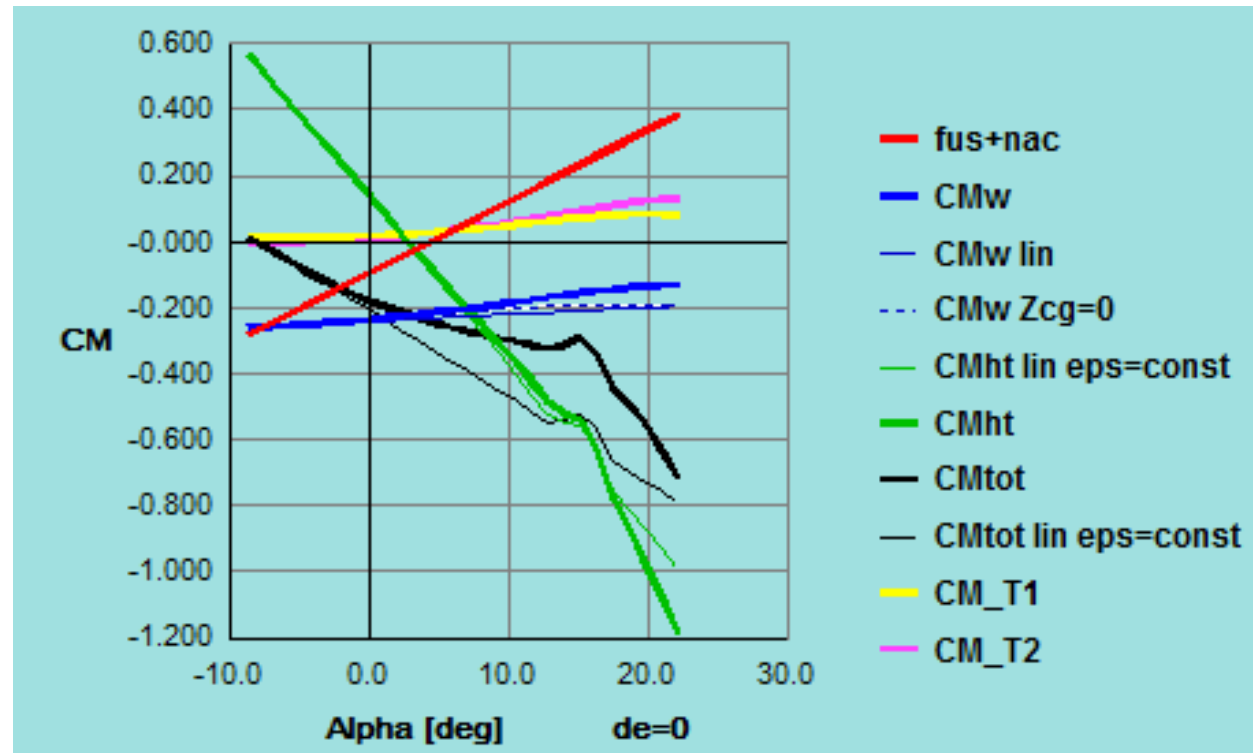
Altitude [m]



ADAS Modules

- *Stability and Control:*

- + *Non linear effects*
- + *Downwash on wing and Tail effects*
- + *Effect of Tail position on pressure ratio*
- + *Pendular Stability*
- + *Effect of Thrust*

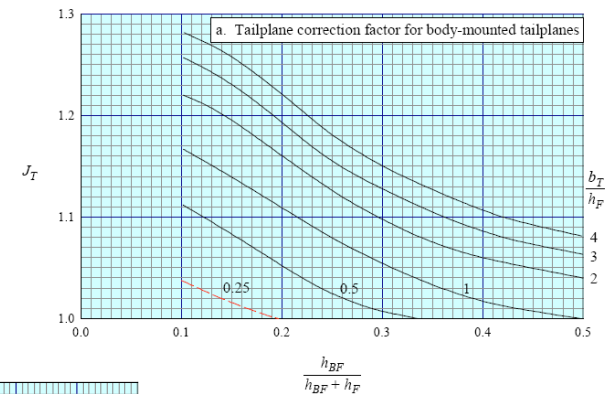
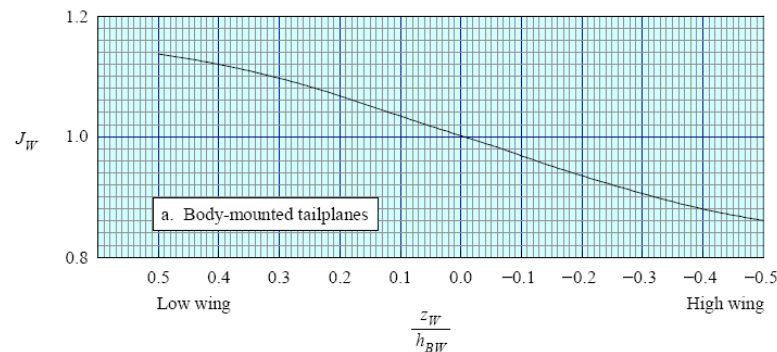
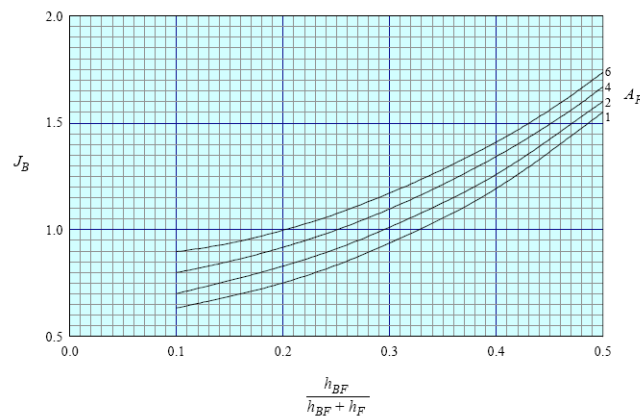


ADAS Modules - *Directional Stability and Control:*

The methodologies used for the Vertical Tail contribution on the Yaw Derivative coefficient due to β are from ESDU and Roskam:

- ESDU Approach:

$$C_{y_v} = J_B \cdot J_W \cdot J_T \cdot (C_{L\alpha})_V \cdot \frac{S_V}{S_W}$$

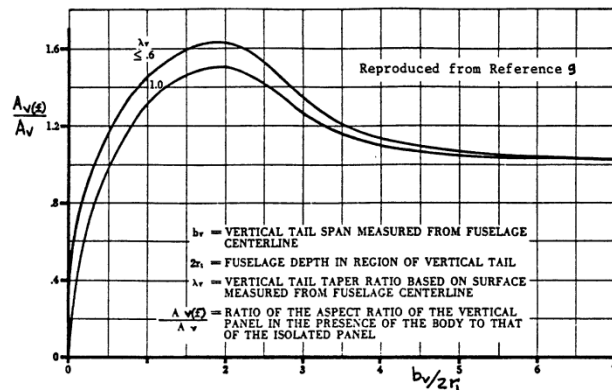


ADAS Modules

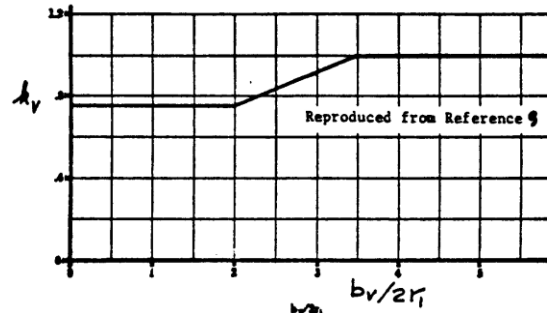
- Stability and Control:

- Roskam Approach need the estimation of the follow contributions:

J_B - Vertical Tail/Fuselage

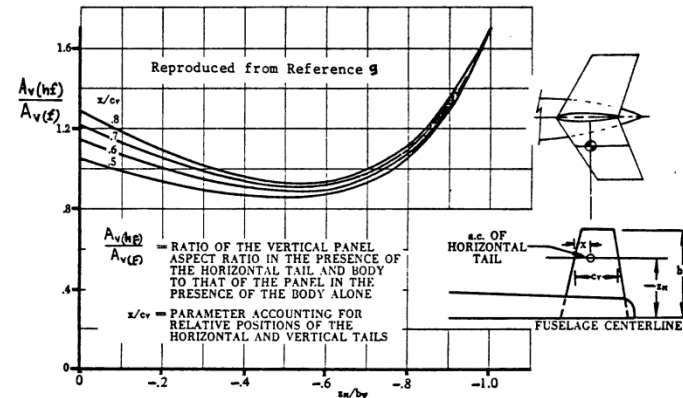
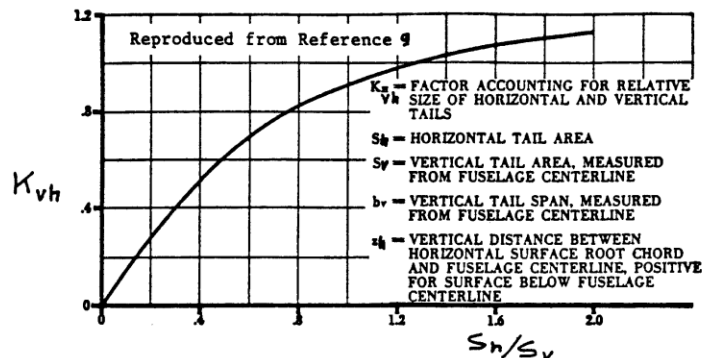


k_v - Isolated Vertical Tail



J_T - Horizontal and Vertical Tail Layout

k_{vh} - Vertical Tail/Horizontal Tail



ADAS Modules

- *Stability and Control:*

So the the Yaw Derivative coefficient due to β of vertical tail:

$$Cn_{\beta_V} = -k_V CL_{\alpha_V} \left(1 + \frac{\partial \sigma}{\partial \beta} \right) \eta_V \frac{S_V l_V}{S b}$$

Where CL_{α_V} is calculated with effective AR_V :

$$AR_{V_{eff}} = J_B [1 + K_{VH} (J_T - 1)]$$

For free stick condition, the hinge moments are estimated with the same methodology used in the Horizontal Tail design (McCormick approach).

$$Cn_{\beta_{V_{free}}} = -k_V CL_{\alpha_V} \left(1 + \frac{\partial \sigma}{\partial \beta} \right) \left(1 - \frac{C_{h\beta}}{C_{h\delta}} \tau \right) \eta_V \frac{S_V l_V}{S b}$$

ADAS Modules - *Stability and Control:*

Vertical Tail Design

Preliminary Data

MTOW [Kg]	72676
CLmax TO	2.085
lp [m]	6.11
MAC [m]	4.19
Sw [m ²]	121.24
Vmc/Vsto	1.1

Engine Type : Turbofan

Engine Features

Vmc [kts]	144.8
-----------	-------

Input Data

Xcg/MAC	0.300
η_v	1.0
ARv	1.68
$\Delta c/4$ [deg]	25.00
$a_{lv}(\Lambda=0)$ [deg]	0.11
$\delta_{r \max}$ (°)	25.00
Crudder/C Tail	0.30
% ext. rudder	90.00
λ_v	0.34
t/c	0.11

Rudder Type :
☒ Gap Closed
☐ Gap Open

Other "Optional" Data

Reload Other Module Data

Load statistical data

Calculator

Unit Converter

ISA

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Main Menü

Lateral View

Plant View PV

Vertical Tail Position

Xac V.tail root / Fuselage Length [%]	83.000
Zac V.tail root / Fuselage Max Height	0.95

Confirm Data

Horizontal Tail Influence:

☒ Fin Mounted $z_{HT/bv}$ 0.00 ?
☐ Body Mounted HT Data

☐ ESDU ☒ Roskam/USAF Datcom

Preliminary Calculation

lv [m]	17.57
ARv eff	3.07
τ at $\delta_r \max$	0.36
a_v [1/deg]	0.059
Cn β wing	-0.0003
Cn β fus	0.0029
Cn β nac	0.00002
Cn β eng	0.00016

Final Calculation

Sv [m ²]	19.75
Cn ξ_r	-0.0028
Cn β_v fix	-0.0050
Cn β Tot fix	-0.0022
Cn β_v free	-0.0038
Cn β Tot free	-0.0010
(δ_r/β)	0.79

Directional Deriv.

Choose your "Sv"

Sv [m ²]	21.50
----------------------	-------

Calculate

VT Quick Sketch

Ztip/fusH = 2.61
Bv = 6.01
Cr = 5.34
Ct = 1.82
Sexp = 20.51
Swet = 42.15
Vv = 0.092

VMC

Lateral Gust Yawing Mom. Coeff.

EWADE 2011 – 10° European Workshop on Aircraft Design education, Naples, Italy 24-27 May, 2011

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ADAS Modules

- Stability and Control:

➤ Lateral Stability (Dihedral effect) :

For the analysis of lateral stability it required after the design of all tailplane also the wing and horizontal tail dihedral angle.

The lateral derivative coefficient due to β is founded by:

$$C_{\ell\beta} = (C_{\ell\beta})_w + (C_{\ell\beta})_{\Gamma w} + (C_{\ell\beta})_{\varepsilon w} + (C_{\ell\beta})_{HT} + (C_{\ell\beta})_{\Gamma HT} + (C_{\ell\beta})_{\varepsilon HT} + (C_{\ell\beta})_{v.tail} \\ + \Delta C_{\ell\beta posw} + \Delta C_{\ell\beta posHT} + \Delta C_{\ell\beta tipW} + \Delta C_{\ell\beta tipHT}$$

Where:

$$\begin{aligned} \bullet (C_{\ell\beta})_w &= -\frac{1+2\lambda}{3(1+\lambda)} \cdot C_L \cdot \tan \Lambda_{c/4} & \bullet (C_{\ell\beta})_{posw} &= -1.2\sqrt{AR} \frac{z_w}{b} 2 \frac{df_{us}}{b} \\ \bullet (C_{\ell\beta})_{v.tail} &= -a_v \cdot \eta_v \cdot \frac{S_v}{S_w} \cdot \frac{z_v}{b_w} & \bullet (C_{\ell\beta})_{\varepsilon W} &= -\varepsilon \cdot \tan(\Lambda_{c/4}) K_{\lambda AR} \end{aligned}$$

- (a) Max. Ord. on Upper Surface in Plane $\Delta C_{l\psi} = .0002$
- (b) Max. Ord. on Mean Lines in Plane $\Delta C_{l\psi} = 0$
- (c) Max. Ord. on Lower Surface in Plane $\Delta C_{l\psi} = -.0002$

ADAS Modules

- Stability and Control:

ADAS Program - A320 - [Lateral Stability - Dihedral Effect]

File ?

Wing Data

Wing Area [m²] 121.24

Wing Span [m] 33.94

MAC [m] 4.19

Aspect Ratio 9.501

Sweep Angle ALE [Deg] 25

Root Chord [m] 6.552

Wing-Fuselage d/b 0.1

Cranked ☒

Crank Station (y/b/2) 0.3

Lateral View

Results

Horizontal Tail Data

HT Area [m²] 31.52

HT Span [m] 12.04

Aspect Ratio 4.6

Taper Ratio λ 0.26

Sweep Angle ALE [Deg] 37.56

Root Chord [m] 4.16

Vertical Tail Data

VT Area [m²] 21.5

VT Span [m] 6.01

Aspect Ratio 1.68

Taper Ratio λ 0.34

Sweep Angle ALE [Deg] 40.18

Root Chord [m] 5.34

Wing Dihedral Effect

Number of Dihedral Angle : 1

η (y/b/2) Γ [deg]

Ok

Wing Tip Type : ☐ UpTurned ☒ Symmetrical ☐ DownTurned

Numerical Results:

CL : 0.00

Cl $\beta \Gamma_w$ -0.00124

Cl $\beta_{pos.w}$ 0.00049

Cl $\beta_{\Delta.w}$ 0.00000

Cl $\beta_{\epsilon.w}$ -0.00418

Cl $\beta_{w tip}$ 0.00000

Cl β_H -0.00022

Cl $\beta_{H tip}$ 0.00000

Cl β_V -0.00255

Cl β_{TOT} -0.00771

☐ Cruise Configuration ☒ Full Flap Configuration

Gravity Centre Position

Xcg/C 0.2 0.35 Zcg/C 0.2 -0.1

Calculator Unit Converter

ISA Back

Main Menu

Horiz. Tail --> Calculate -->

ADAS Modules - Weight and Balance:

ADAS Program - A320 - [Weight & Balance]

File ?

Estimated MTOW

MTOW kg

Structural Mass

Max load Factor

Wing kg

Surface Control kg

Fuselage kg

Nacelles kg

Landing Gear kg

Horizontal Tail kg

Vertical Tail kg

Details Composite Confirm

Total struct mass kg

Operational Item Mass

Aircraft Flight Type

N* Cockpit Crew

Residual Fuel and Oil kg

Confirm

Total Oper. Item Mass kg

Weight

N* Passengers > N* Crew Member

Propulsion Group Mass

Engine Type

Engine Sub-Type

Engine Dry kg

Total Prop Group Mass kg

Payload Mass

Average Weight of Baggage kg

Confirm

Total Payload Mass kg

Fixed Equipment Mass

Aircraft Range Type

Confirm

Total Fixed Equip Mass kg

Fuel Mass

Estimate Max Tank Volume

Max Fuel Capacity lt

Max Fuel Mass kg

Used Fuel (Sugg.23604) lt

Confirm

Total Fuel Mass kg

FINAL MTOW

Calculate M_{OE} M_{ZF} MTOW kg **Reload Data**

Calculator **ISA** **Unit Converter** **Go To Balance ->**

Main Menù

ADAS Modules - *Weight and Balance:*

ADAS Program - A320 - [Weight & Balance]

File ?

Final MTOW

MTOW kg

Balance

N° Passengers Seat Layout

Xcg Components Positions

Wing Position % Fus Length

CG Wing % from MAC LE

CG Fuselage % Fus Length

Aircraft Loading Loops

Passengers take place FRONT - REAR —

Passengers take place REAR - FRONT —

Numerical Results on X

Xcg/c TOW

Xcg/c Max Forward

Xcg/c Max Backward

Xcg/c ZFW

Xcg/c OEW

Numerical Results on Z

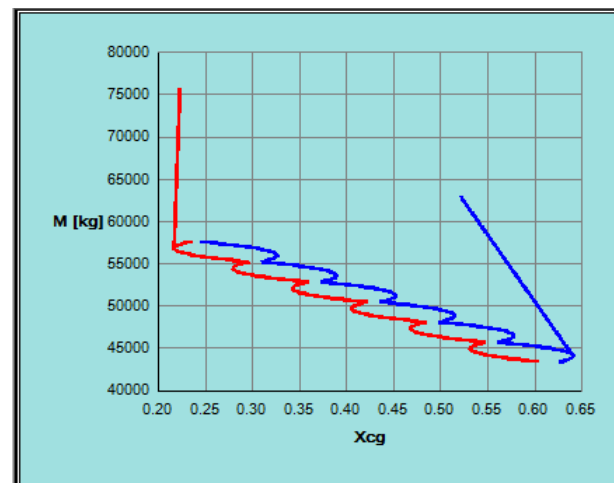
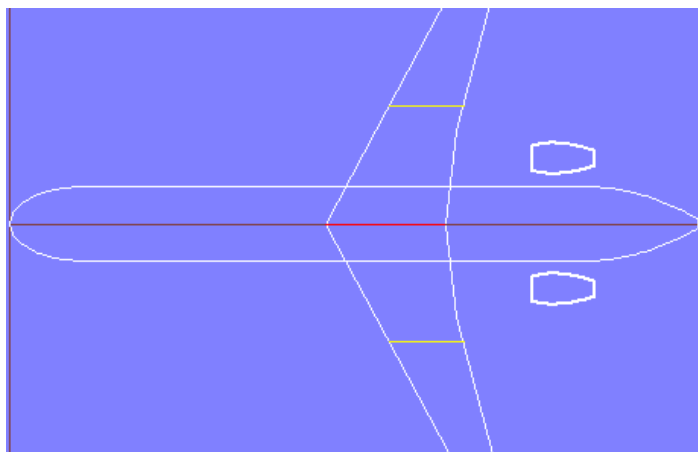
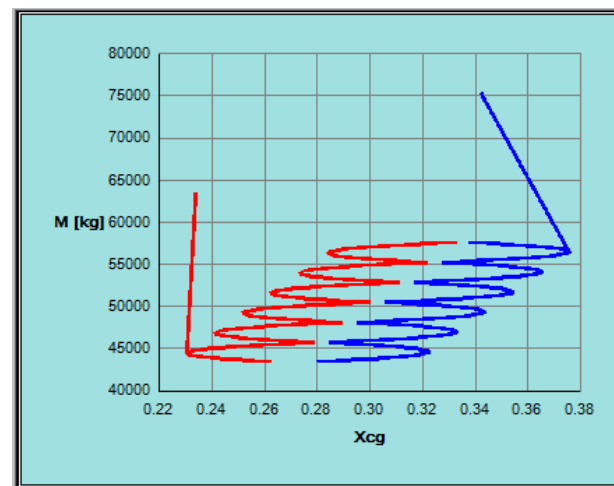
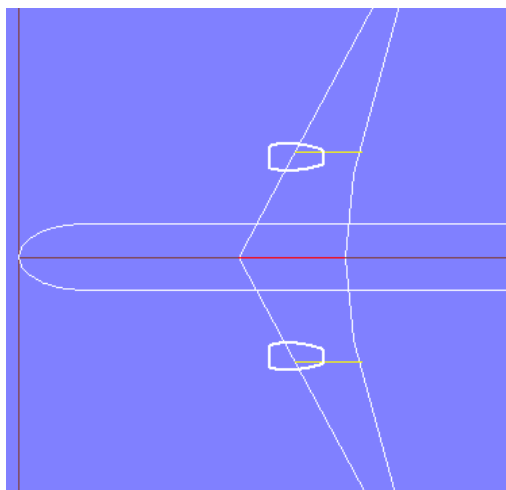
Zcg/c TOW

Zcg/c ZFW

Zcg/c OEW

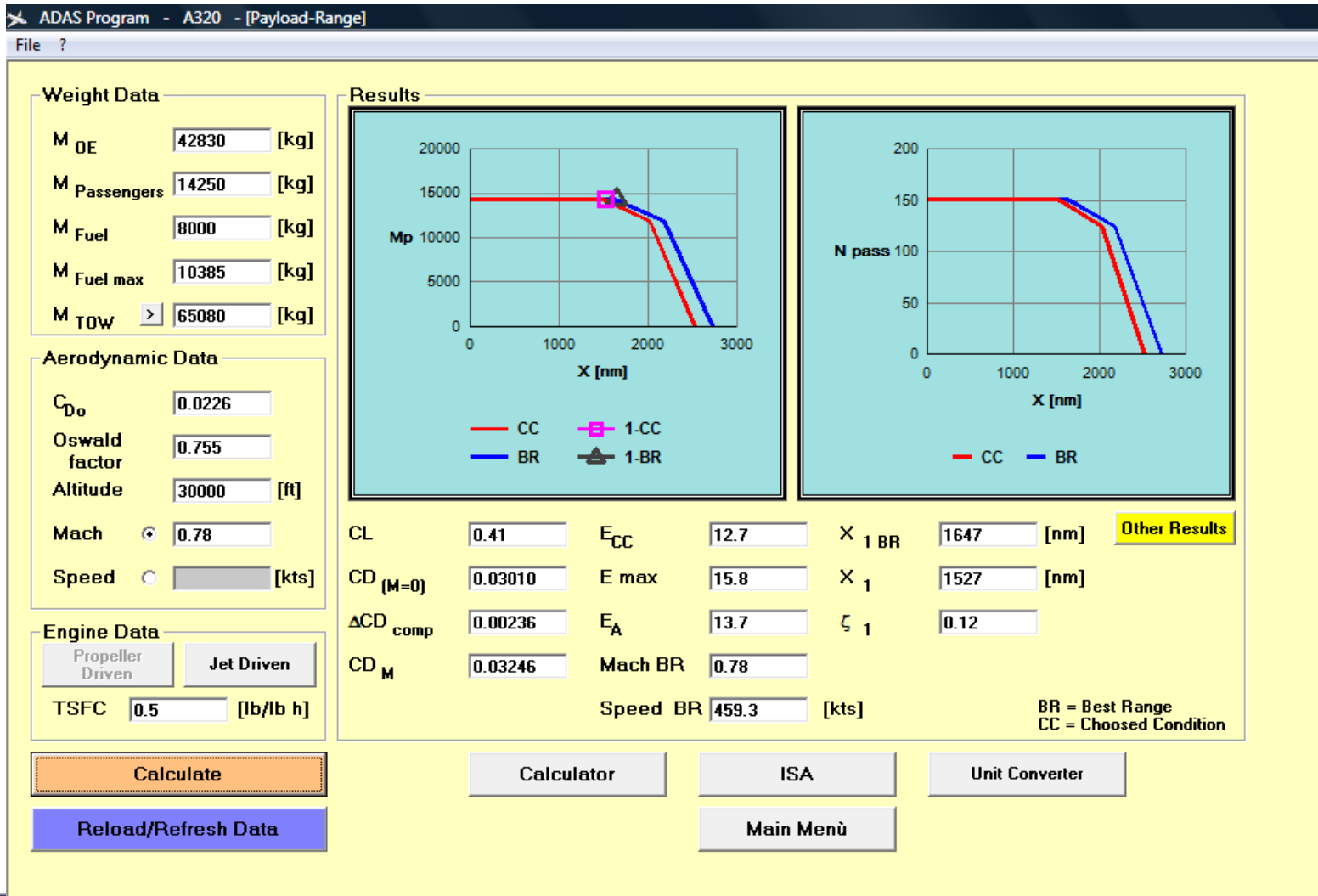
ADAS Modules

- *Weight and Balance:*



ADAS Modules

- *Payload Range:*



ADAS Modules

- Payload Range:

✈ ADAS Program - A320 - [Payload-Range]

File ?

Weight Data

M_{OE} [kg]

M_{Passengers} [kg]

M_{Fuel} [kg]

M_{Fuel max} [kg]

M_{TOW} > [kg]

Aerodynamic Data

C_{Do}

Oswald factor

Altitude [ft]

Mach ☒

Speed ☐ [kts]

Engine Data

TSFC [lb/lb h]

Results

Other Results

The Cruise Range is been calculated with constant CL and constant V, so the Altitude will be different.

Chooosed Condition

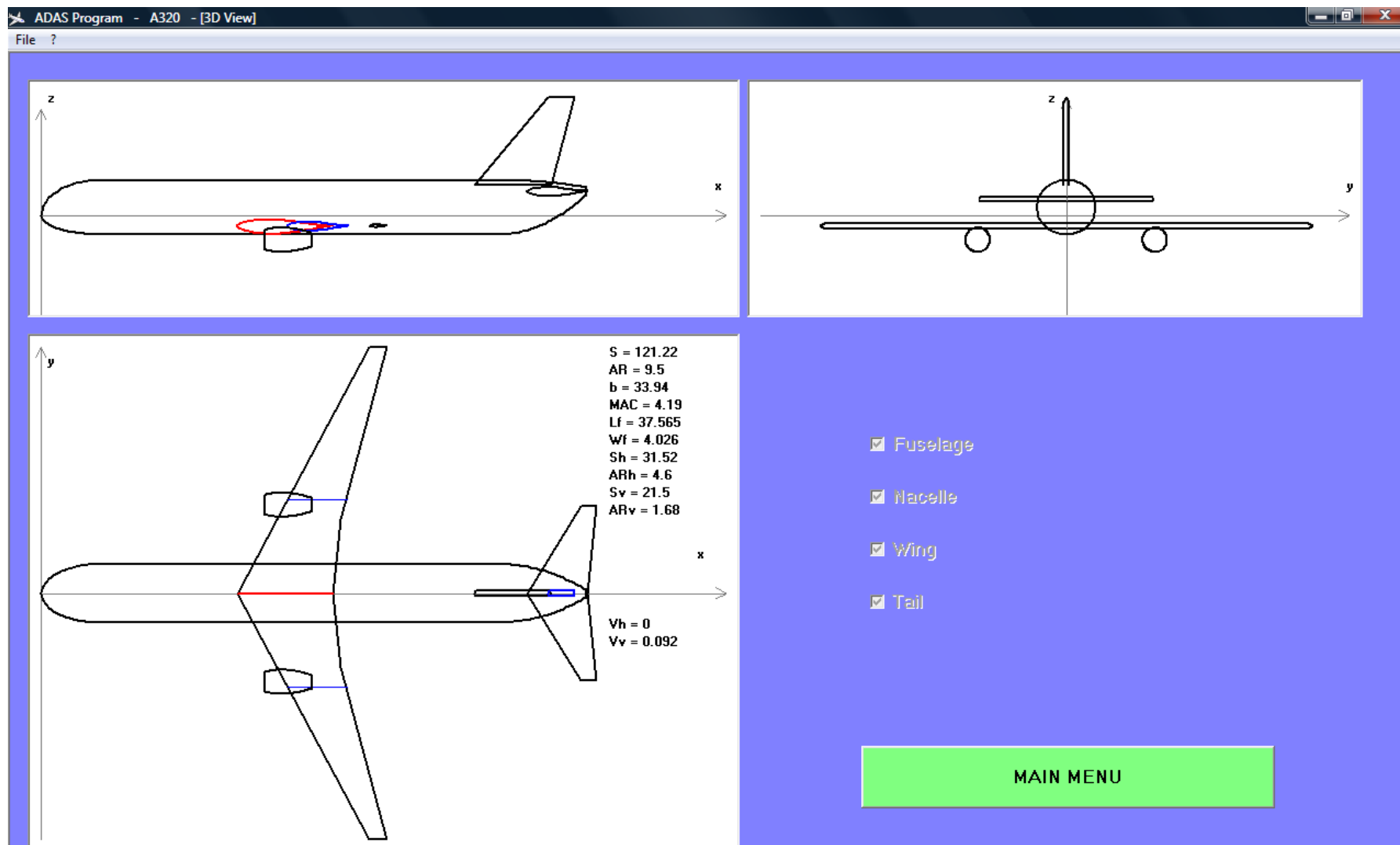
Best Range

CL	<input type="text" value="0.41"/>	E _{CC}	<input type="text" value="12.7"/>	X _{1 BR}	<input type="text" value="1647"/> [nm]	<input type="button" value="Close"/>
CD _(M=0)	<input type="text" value="0.03010"/>	E _{max}	<input type="text" value="15.8"/>	X ₁	<input type="text" value="1527"/> [nm]	
ΔCD _{comp}	<input type="text" value="0.00236"/>	E _A	<input type="text" value="13.7"/>	ξ ₁	<input type="text" value="0.12"/>	
CD _M	<input type="text" value="0.03246"/>	Mach BR	<input type="text" value="0.78"/>			
		Speed BR	<input type="text" value="459.3"/> [kts]			

BR = Best Range
CC = Chooosed Condition

ADAS Modules

- 3D view:



CONCLUSIONS:

- **The software allows the conceptual design and a preliminary analysis of the aircraft in less than 1 hour**
- **The software is USER FRIENDLY with many helps (but also to be improved)**
- **Many graphs helps user (students) with the comprehension of theory which is behind and to get the feeling of the obtained results**
- **Some non-linear effects are included (pendular stability, downwash, etc.)**
- **Students can “play” with the software learning all the links between separate performances and characteristics of the airplane**
- **The software can be also useful for researchers and people from industry**

FUTURE DEVELOPMENTS:

- **The software will be commercialized next year (hopefully)**
- **Optimization should be included**
- **Obtaining new semi-empirical laws to be implemented to enhance the software accuracy
(both through wind-tunnel tests or through 3D and 2D aerodynamic analysis (panel methods) or CFD (NS) calculations.**

THANKS for the ATTENTION