5. Design

5.1 Introduction

Which propulsion to use? Which engine? Which propeller? What must the surface of the wings, tails and fuselage be to ensure at the same time a sufficient lift and a good stability? What will the empty weight of the aircraft be? What will its aerodynamic quality be? What will its performances be during the various phases of the flight? Is it possible to respect the requirements of the specifications? How to fulfill the constraints linked to the airworthiness requirements? Is it necessary to consider a configuration with one or two engines…? There are many questions to be answered.

The « Design » module will be used to answer all those questions efficiently and quickly.

PCA2000 deals with the design in three phases:

1. Phase 1 or level 1 design: On the basis of a limited number of input data, the design determines the aircraft geometry and the necessary power to reach the desired performances at the adaptation point (or main phase of the flight).
2. Phase 2 or level 2 design: The input data is more precise and more numerous than the one necessary to carry out the previous phase. The user selects various components in products databases (engine, airfoil profiles, tires…). The geometry of the aircraft as well as its weight are updated on the basis of those new input data. The performances are calculated for various flight phases: the take-off, the climb and the cruise. The results are displayed in tables and graphs which are very easy to analyze.
3. Phase 3 or level 3 design: In opposition with the two previous levels, the level 3 design determines the aircraft performances for a given weight and geometry. The aim of this design is threefold:
    a. To analyze the performances (take-off, climb and cruise) of a given aircraft for various flight weight.
    b. To visualize the effects of some modifications on a given aircraft (replacement of the fixed landing gear by a retractable landing gear, modification of the surface of the wing, re-engining, modification of the aerodynamic qualities, ...) in order to visualize the effects of the modification on the whole system.
    c. To define boundaries or limits beyond which the (new) development would not be justified anymore. To be able, for example, to quantify the effects of a change in the maximum take-off weight on the general performances of the aircraft.

5.2 Table of contents

5.3 Level 1 design

5.3.1 Description

To access the « Design » module, **click** on [**Design**], [**Airplanes**] then [**Level 1**] of the menu bar in the main window. You can also access it directly by clicking on  of the vertical tool-bar.

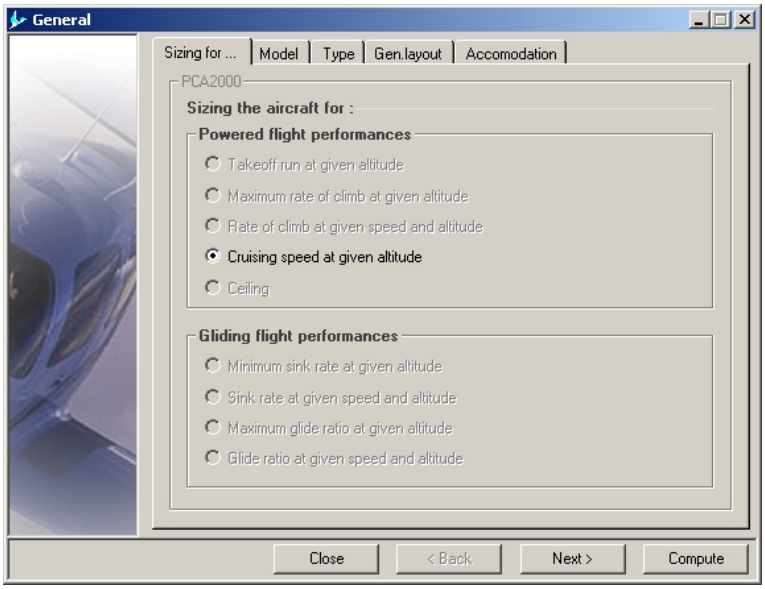


Figure 5.1 : Level 1 design (General)

If you have chosen to access the « Design » module via the control button  , you might have to specify the desired design level. This can be done via the status bar in the main window. **Click** on the indicated spot until the displayed number becomes 1.

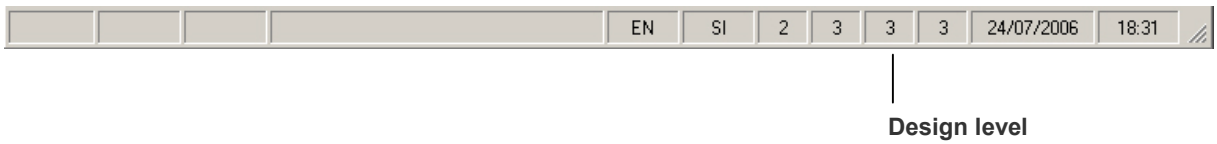


Figure 5.2 : Status bar of the main window

The acquisition of the input data is done via 10 specific windows:

1. Generalities
2. Wing
3. Tails
4. Fuselage
5. Engine
6. Propeller
7. Performances
8. Weights
9. Aerodynamic
10. Options

Each window contains a certain number of fields that the user has to fill in in order to be able to carry out the design. The **gray fields** are inaccessible and reserved for a different level design than the one in progress.

You can press on the **F1** key at any time to reach the contextual help.

To navigate within the controls of a window, use the **tab key**.

To navigate within the windows, use the keys Next > or < Back or the menu of the vertical toolbar.

5.3.2 Input data

5.3.2.1 Generalities

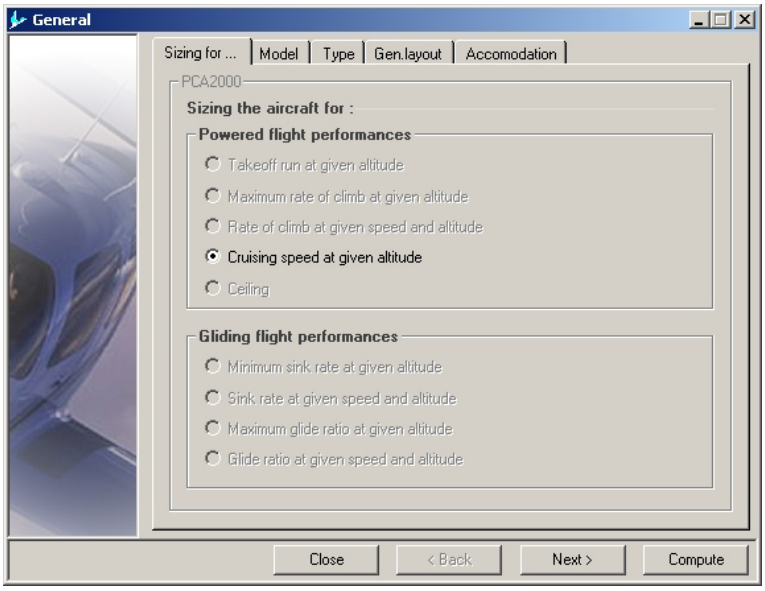


Figure 5.3 : Level 1 design (General)

5.3.2.2 Wing

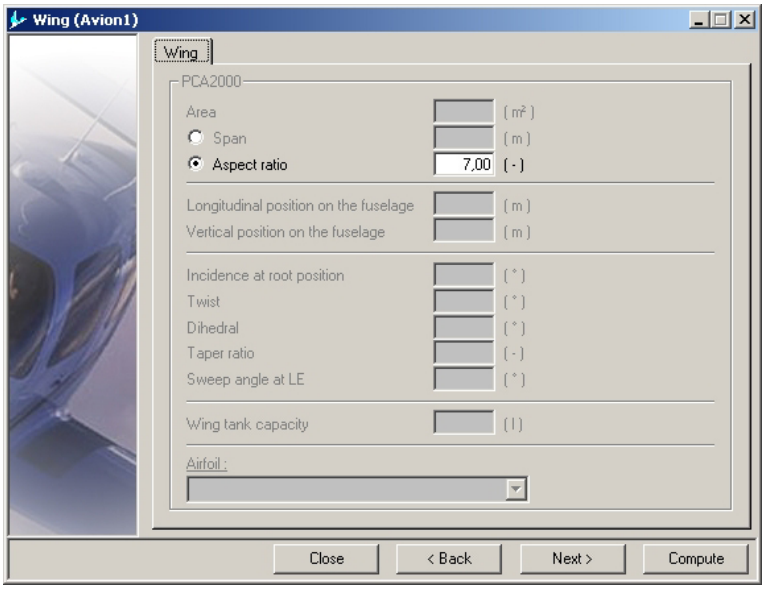


Figure 5.4 : Level 1 design (Wing)

5.3.2.3 Tail units

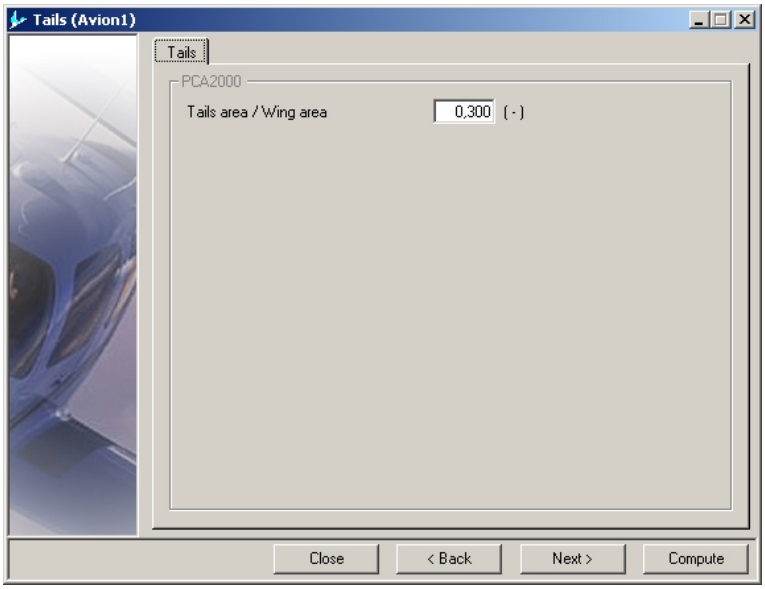


Figure 5.5 : Level 1 design (Tail units)

During a level 1 design, according to the general configuration of the aircraft, the relative surface of the tails includes the horizontal tail, the vertical one and the canard surface.

5.3.2.4 Fuselage

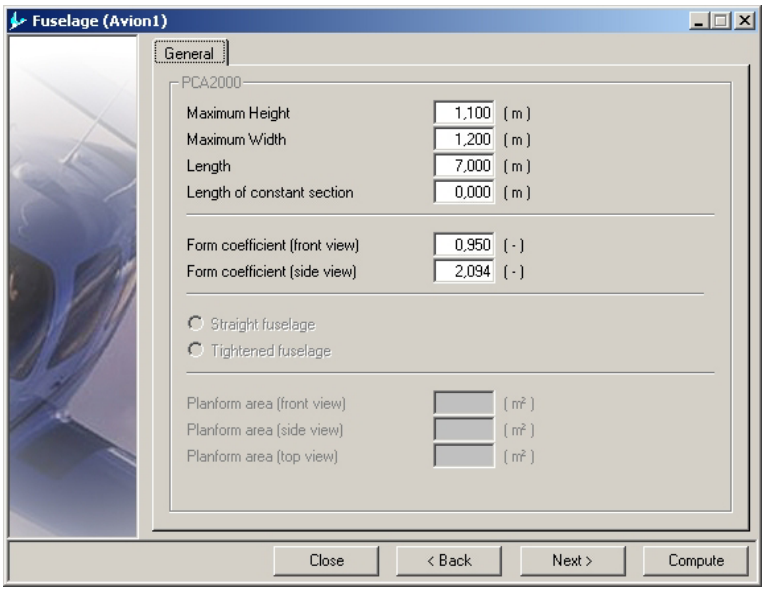


Figure 5.6 : Level 1 design (Fuselage)

5.3.2.5 Engine

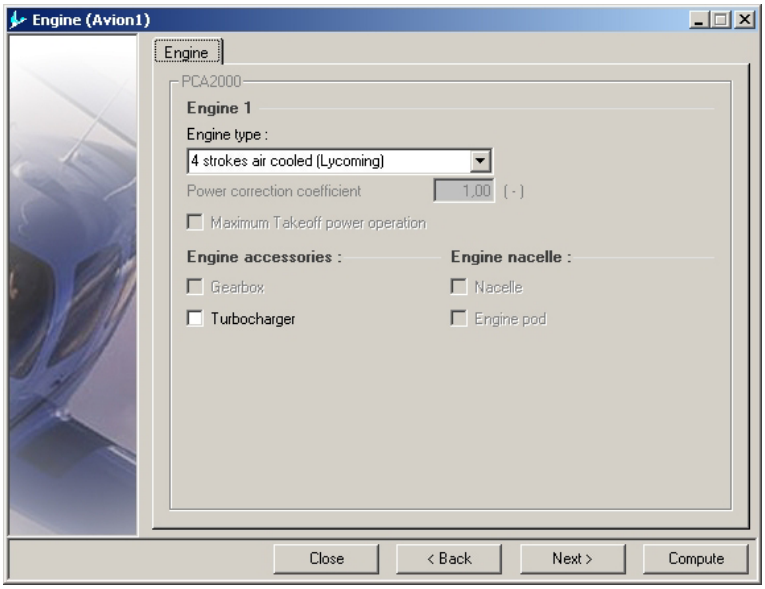


Figure 5.7 : Level 1 design (Engine)

The objective of the level 1 design is to determine, amongst other things, the theoretic power of the engine to reach the desired performances. At that design level, in order to be as exhaustive as possible, one does not choose a precise engine but an engine from a specific technology from which the specific weight and consumption characteristics will be taken out.

21 different engine categories have been determined:

1. 2T air cooled
2. 2T air cooled (Rotax)
3. 2T liquid cooled
4. 2T liquid cooled (Rotax)
5. 2T liquid cooled (2SI)
6. 4T air cooled
7. 4T air cooled (Jabiru)
8. 4T air cooled (Lycoming)
9. 4T air cooled (Limbach/Sauer)
10. 4T air & injection cooled
11. 4T air & injection cooled (Lycoming)
12. 4T air & turbo-injection cooled (Lycoming)
13. 4T liquid cooled
14. 4T liquid cooled (Rotax)

15. Diesel 2T air cooled
16. Diesel 2T liquid cooled
17. Diesel 4T air cooled
18. Diesel 4T liquid cooled
19. Rotational liquid cooled
20. Turbo-propeller
21. Jet engine

A statistical analysis has been carried out on all the engines belonging to a given category in order to determine the evolution laws of the weight and specific consumption in accordance with the rated power of the engine.

For a level 1 design, the propulsion weight as well as the quantity of fuel needed to fulfill the given task are determined according to those rules.

5.3.2.6 Propeller

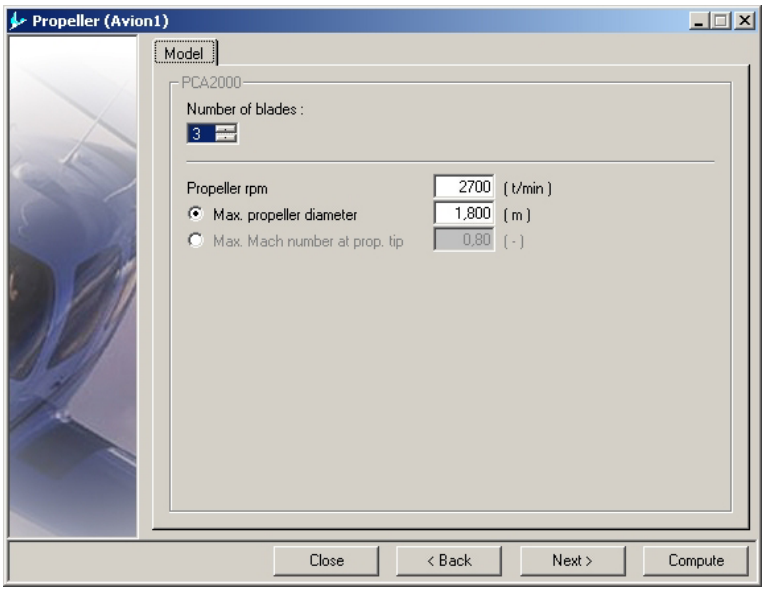


Figure 5.8 : Level 1 design (Propeller)

5.3.2.7 Performances

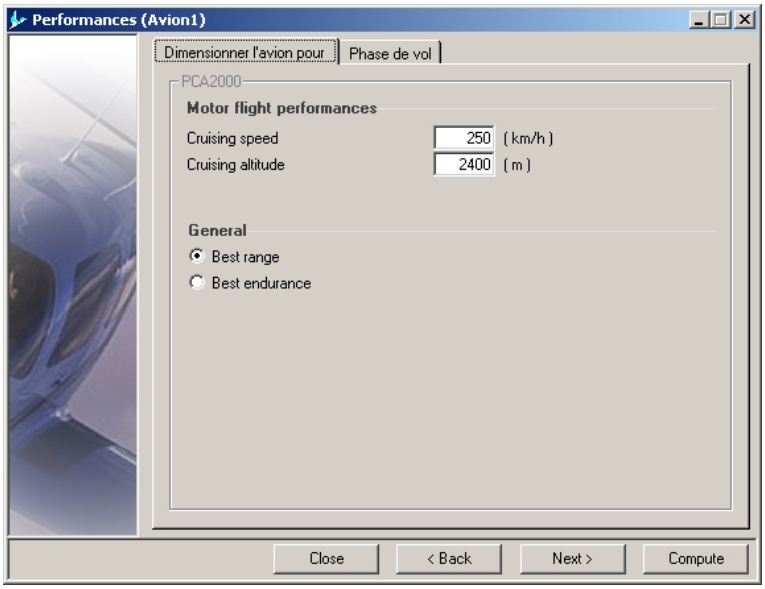


Figure 5.9 : Level 1 design (Performances)

5.3.2.8 Weights

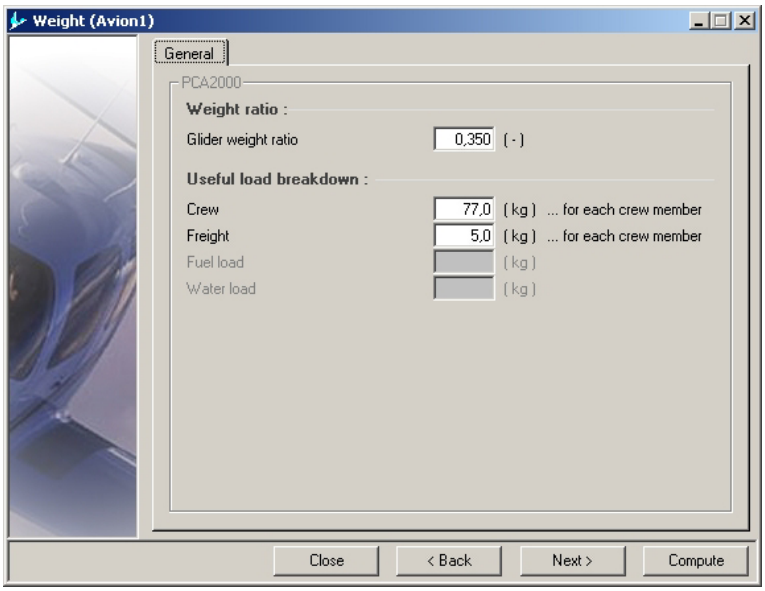


Figure 5.10 : Level 1 design (Weights)

5.3.2.9 Aerodynamics

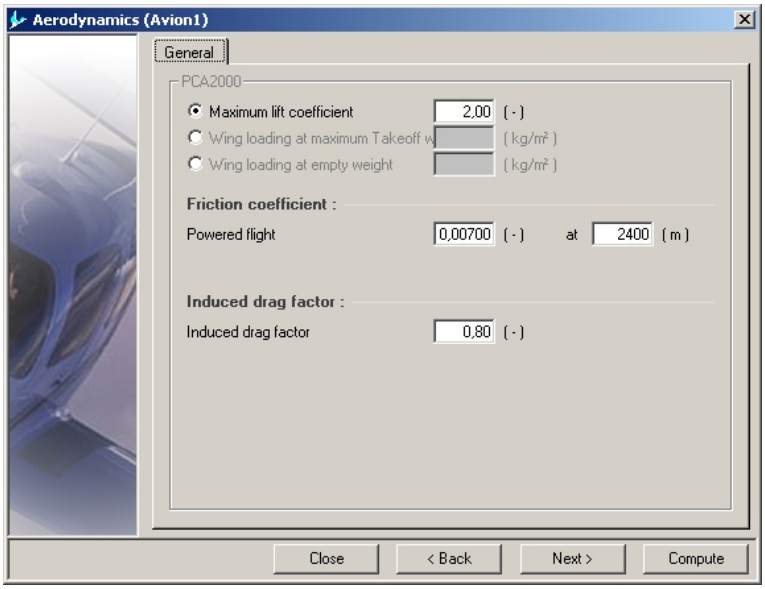


Figure 5.11 : Level 1 design (Aerodynamics)

5.3.2.10 Options

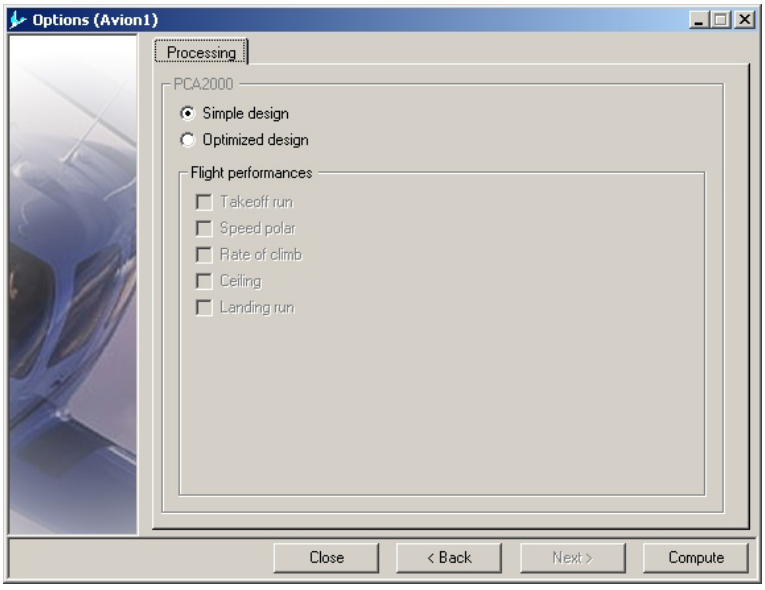


Figure 5.12 : Level 1 design (Options)

If your license allows it, you have the possibility to carry out an optimized design. In order to do that, we invite you to refer to the chapter called « Optimized design » in the user's manual.

As far as possible, the data is controlled during the introduction.

If, for example, the user introduces a negative value whereas the value can only be positive, a warning message appears on the screen, the cell is reset and the cursor comes back to it.

5.3.3 Calculations

In order to make the calculations, click on 

that appears on each data acquisition window.

If some data is missing, a warning message appears on the screen, then, the acquisition window that contains the blank cell appears on the screen as well and the cursor is positioned on the blank cell.

In order to obtain detailed information related to the algorithms used during the design process, we invite you to consult the technical notes available on the PCA2000 website.

5.3.4 Results

5.3.4.1 Introduction

Once the calculations are made, the results window is displayed automatically.

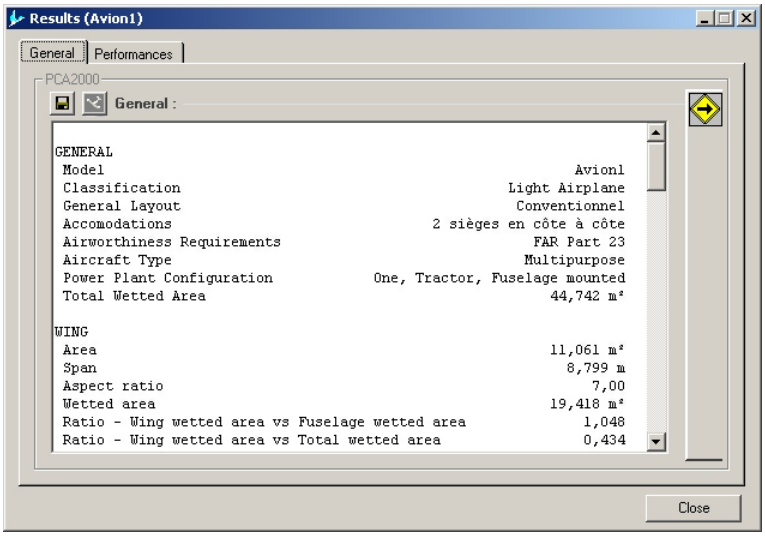


Figure 5.13 : Level 1 design (Results)

The first part contains all the information except that related to the performances. The second part contains only the information related to the performances.

To display all the results:

1. **Open** the box by moving the mouse pointer on it,
2. **Click** on the option button called Generalities.

All the results are now displayed on the same sheet.

To display the results belonging to only one particular item:

1. **Open** the box
2. **Click** on the corresponding option button.

5.3.4.2 Generalities

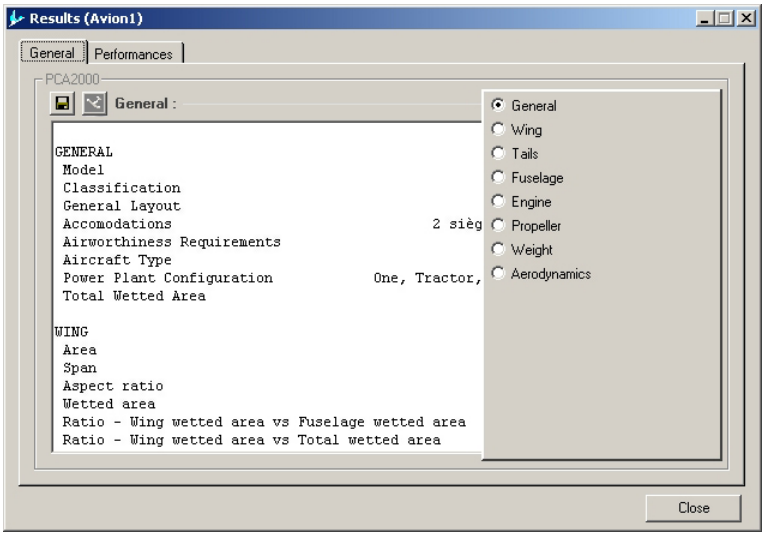


Figure 5.14 : Level 1 design (Generalities)

5.3.4.3 Performances

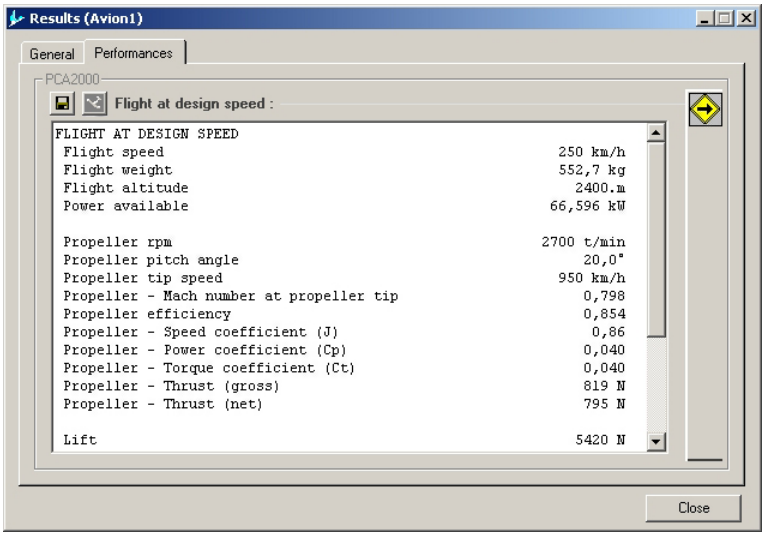


Figure 5.15 : Level 1 design (Performances)

5.3.4.4 Print the results

To print the results, **click** on the control button  in the toolbar in the main window.

5.3.4.5 Save the results

To save the results, **click** on the control button  in the toolbar in the main window.

A message appears in the comments display area to inform you about the saving status.

5.3.4.6 Save the content of the display area

To save the content of the display area:

1. **Click** on one of the option button available in the box
2. **Click** on the control button  located on top of the results display area.

A message appears in the comments display area to inform you about the saving status.

Two results files have been created :

1. The first one is a text file (format .rtf) that you can open with any word processing software.
2. The second is a text file (format .csv) that you can open with any spreadsheet program such as Excel for example.

5.4 Level 2 design

5.4.1 Description

To reach the «Design» module, **click** on [**Design**], [**Airplanes**] then [**Level 2**] in the menu bar in the main window. You can also reach it directly by clicking on  in the vertical toolbar.

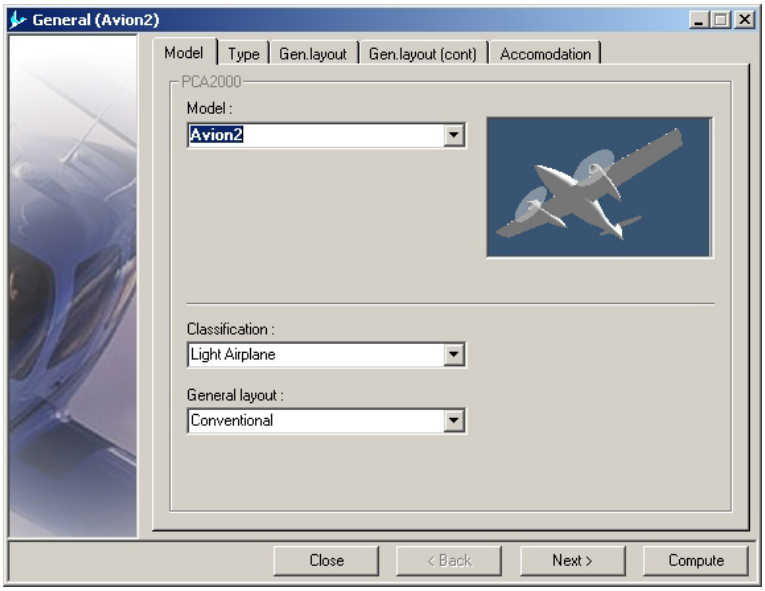


Figure 5.16 : Level 2 design (General)

If you have chosen to reach the « Design » module via the control button  , you might have to specify the desired design level. This can be done via the status bar in the main window. **Click** on the indicated place until the number displayed is 2.

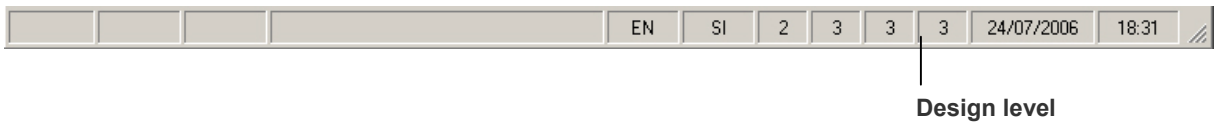


Figure 5.17: Status bar of the main window

The acquisition of the input data is done via 13 specific windows:

1. Generalities
2. Wing
3. Horizontal tail
4. Vertical tail
5. Fuselage
6. Landing gear
7. Engine
8. Propeller
9. Systems
10. Performances
11. Weights
12. Aerodynamic
13. Options

Each window contains a set of fields that the user must fill in in order to be able to proceed with the design. The **gray fields** are not accessible and reserved for a different level design than the one currently in use.

Press the **F1** key at any time to reach the contextual help.

To navigate within the controls of a window, use the **tab key**.

To navigate within the windows, use the Next > or < Back keys or the menu of the vertical toolbar.

5.4.2 Remarks

5.4.2.1 Determination of the maximum lift coefficient of a lifting surface

The determination of the magnitude of the maximum lift coefficient of a lifting surface is done according to the methodology described by Dr. Jan Roskam in his book Airplane Design Part VI, for simple flap, split flap, simple-slotted flap, double-slotted flap and Fowler flap.

5.4.2.2 The zero-lift drag coefficient (Cd0)

The zero-lift drag coefficient is calculated in relation with the wing area.

5.4.2.3 Propeller type

During a level 2 design, the propeller characteristics are determined only for fixed-pitch propellers or constant speed propellers but not for variable-pitch propellers. There is a simple reason for this. It is impossible to know the extreme values of the propeller pitch before the design is carried out. If the user wishes to consider the installation of a variable-pitch propeller, he has to proceed in the following way:

1. **Run** a design using a constant speed propeller
2. **Note** the extreme values of the propeller pitch
3. **Run** a design using a fixed-pitch propeller and choosing a propeller pitch near the small pitch to probe the performances of the aircraft at take-off and then, another pitch value for the climb and the cruise.

5.4.3 Input data

5.4.3.1 Generalities

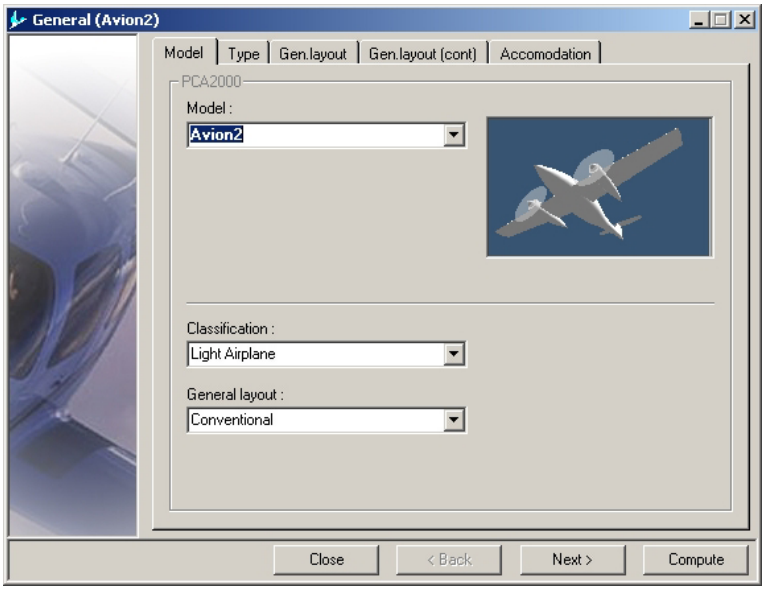


Figure 5.18 : Level 2 design (General)

5.4.3.2 Wing

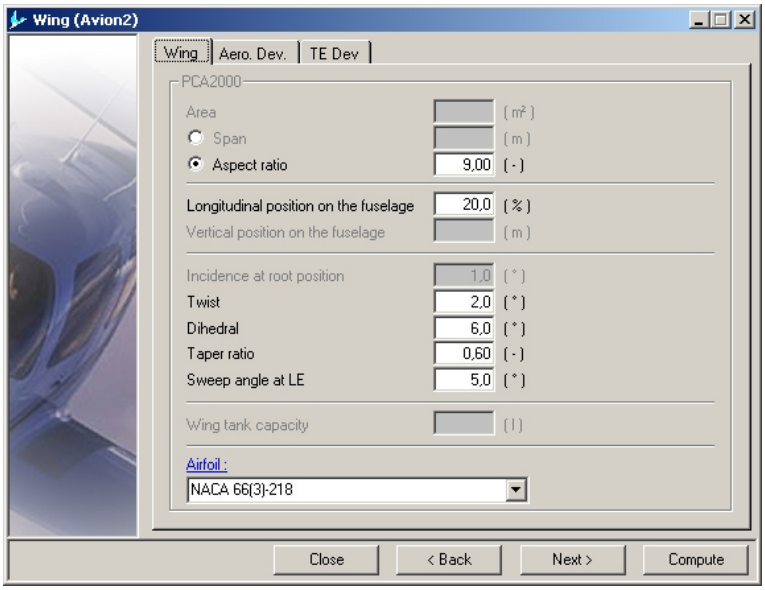


Figure 5.19 : Level 2 design (Wing)

5.4.3.3 Horizontal tail

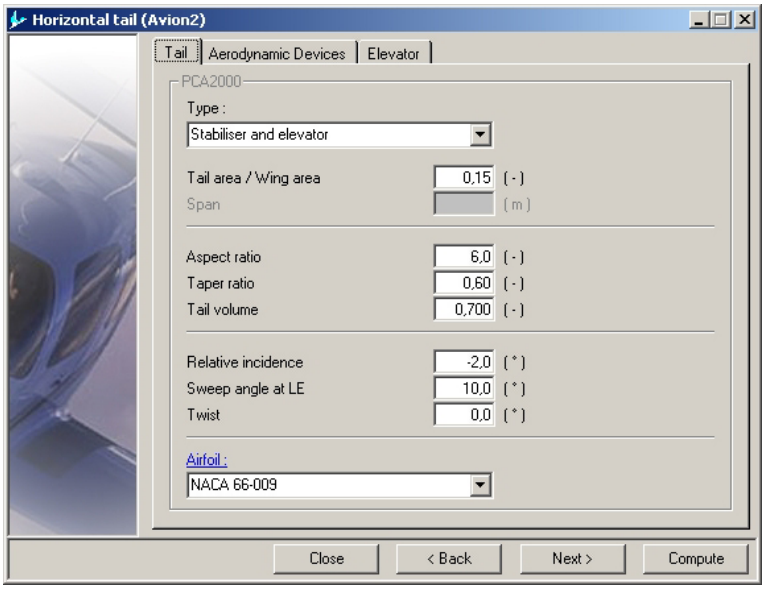


Figure 5.20 : Level 2 design (Horizontal tail)

5.4.3.4 Vertical tail

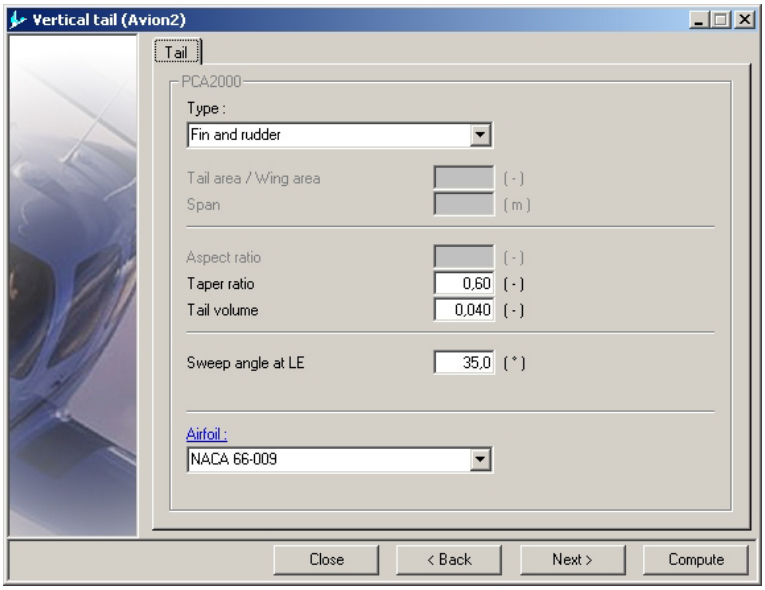


Figure 5.21 : Level 2 design (Vertical tail)

5.4.3.5 Fuselage

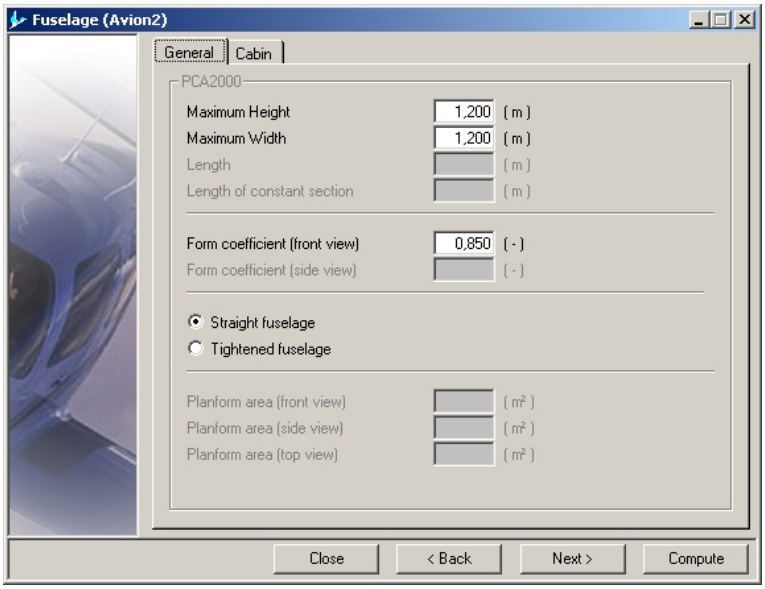


Figure 5.22 : Level 2 design (Fuselage)

The **length** of the fuselage is calculated according to:

- The positions of the tail units and therefore the stability criteria
- The dimension of the fuselage at the main bulkhead position in order to minimize the drag of the fuselage

The **wetted area** of the fuselage is calculated on the basis of the generated geometry.

The **longitudinal form factor** is deducted from the calculated wetted area and the total length of the fuselage.

5.4.3.6 Landing gear

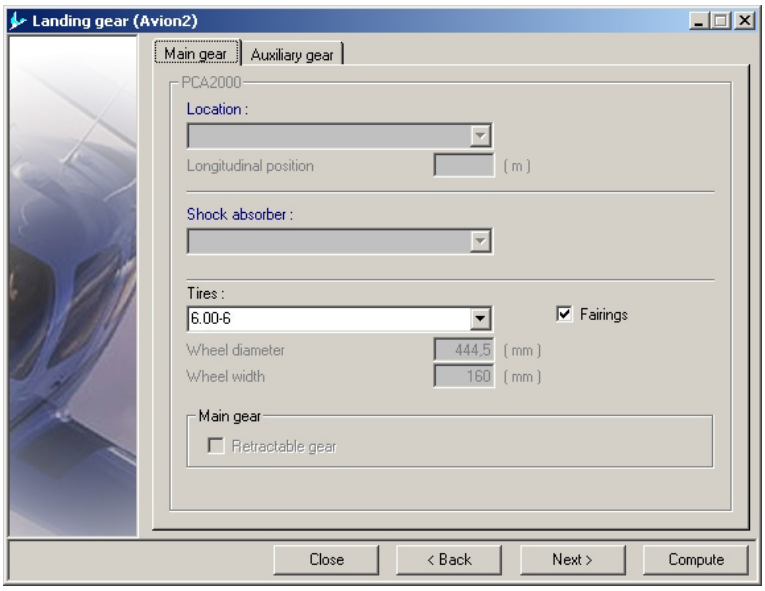


Figure 5.23 : Level 2 design (Landing gear)

The customer chooses the tires in a catalogue. This simple choice entails the immediate knowledge of the wheels dimensions. Important criteria to determine the drag caused by the various components of the landing gear. If the tire is not included in the proposed list, the user chooses NA (non available) and inserts himself the dimensions of the wheel in the appropriate spaces.

5.4.3.7 Engine

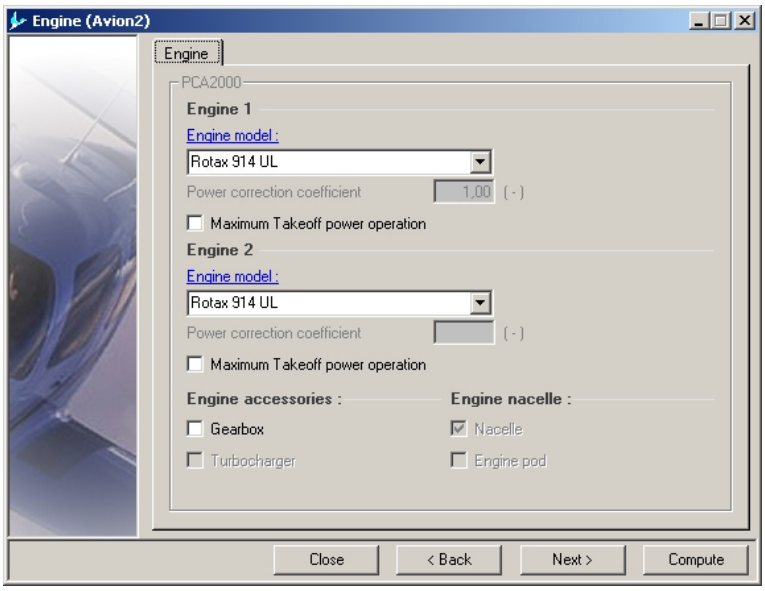


Figure 5.24 : Level 2 design (Engine)

The user chooses the engine he plans to use in a list of engines. This simple choice entails the immediate knowledge of all the characteristics of the engine including its power curves and its specific consumption curves.

BEWARE

If the engine is equipped with a reduction gear as it is the case with the **Rotax 912** for example, the characteristics of the reduction gear will have been specified in the engine data file (cf. chapter 8 of the user's manual).

At the level 2 design, the user has the possibility to give the characteristics of a reduction gear that would be added to an engine which is not equipped with it. We could, for a specific application for example, consider equipping an aircraft with an engine **Lycoming O-320-B1B** and adding a reduction gear at the 1/1.245 ratio. The characteristics of this « external » reduction gear will have to be specified once we reach the **Engine** sheet of the level 2 design.

5.4.3.8 The propeller

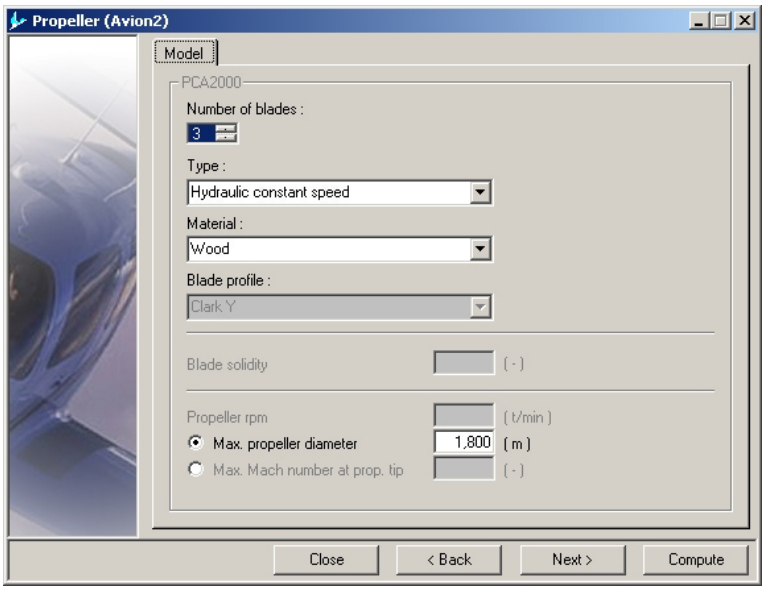


Figure 5.25 : Level 2 design (Propeller)

The user chooses the type of propeller he plans to use,

- either a constant speed propeller,
- either a fixed-pitch propeller.

The choice of the propeller type will influence considerably the performances during the take-off and the climb as well as the weight breakdown of the aircraft.

A constant speed propeller makes it possible to make the most of the engine power but is heavier than a simple fixed-pitch propeller.

5.4.3.9 Systems

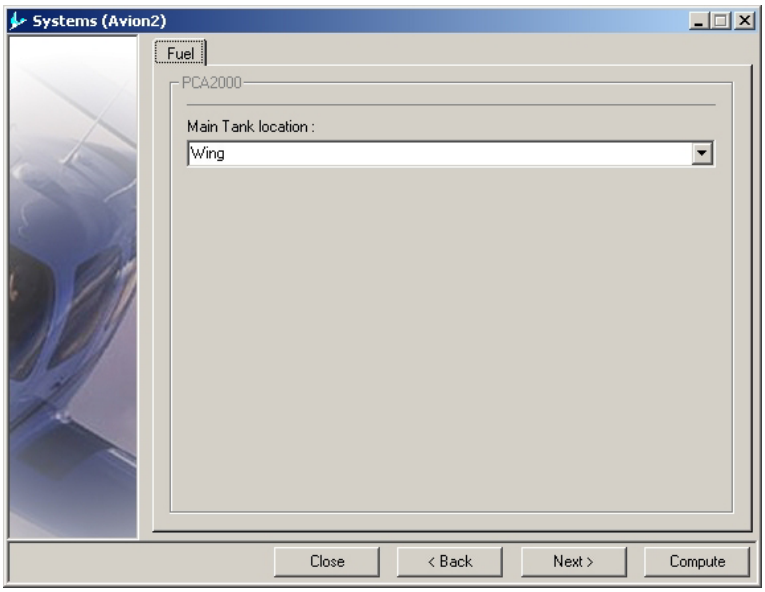


Figure 5.26 : Level 2 design (Systems)

5.4.3.10 Performances

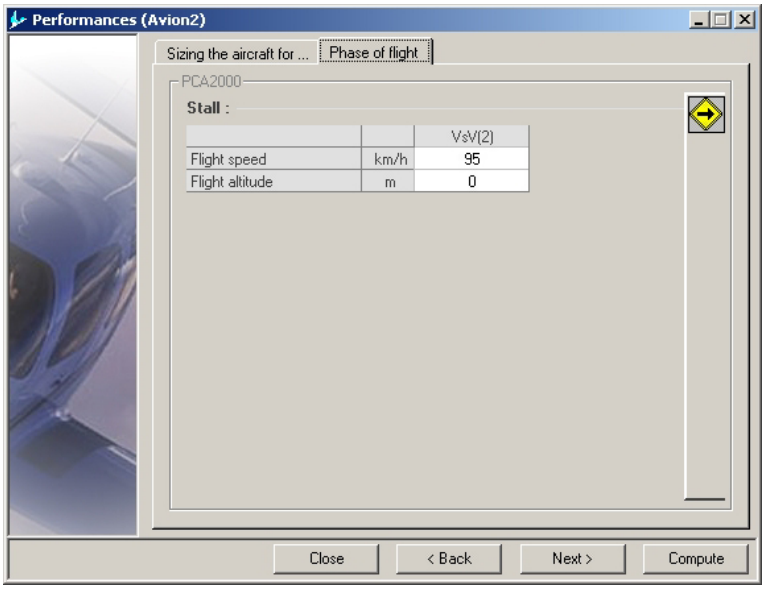


Figure 5.27 : Level 2 design (Performances)

5.4.3.11 Weights

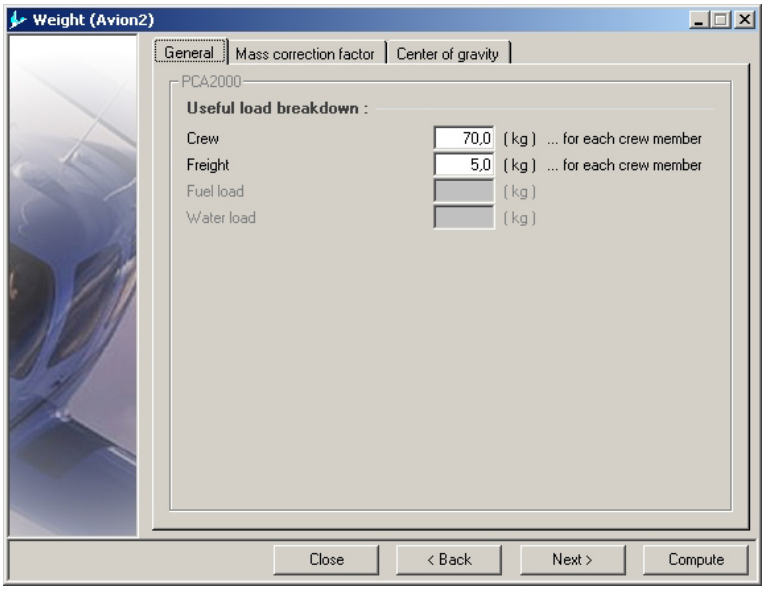


Figure 5.28 : Level 2 design (Weights)

The aircraft empty weight is calculated by adding the specific weights of the various components of the aircraft. The weight of a component is calculated on the basis of its geometric dimensions as well as on the maximum take-off weight of the aircraft.

In order to obtain detailed information about the algorithms used during the design, we invite you to look at the various technical data sheets available on the PCA2000 website.

5.4.3.12 Aerodynamics

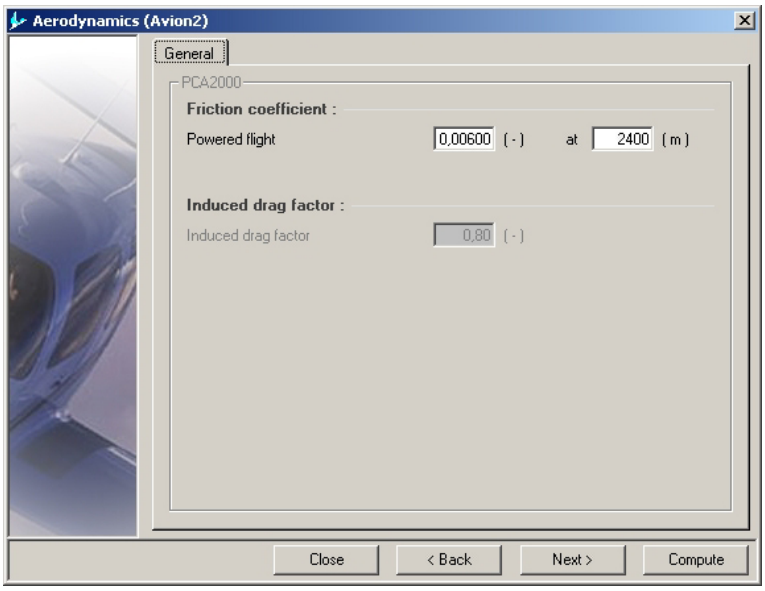


Figure 5.29 : Level 2 design (Aerodynamics)

5.4.3.13 Options

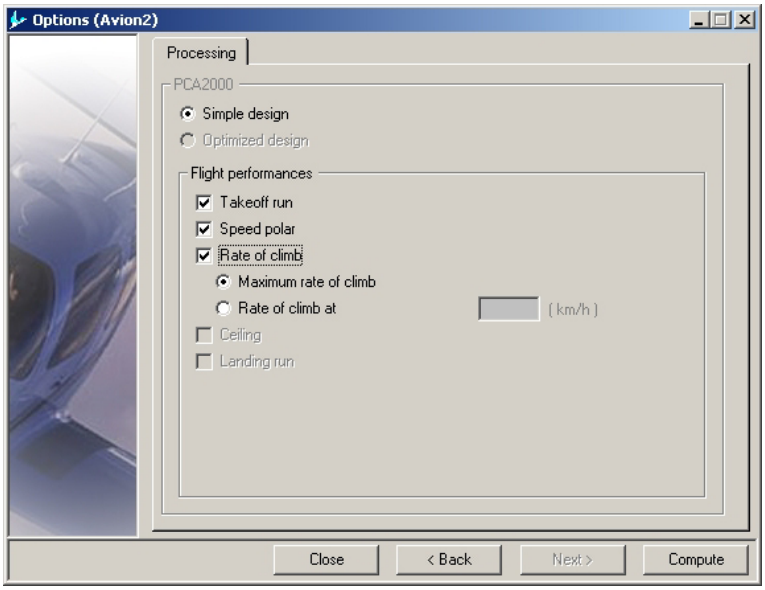


Figure 5.30 : Level 2 design (Options)

As far as possible, the data is controlled during the introduction stage.

If, for example, the customer inserts a negative value while the value can only be positive, a warning message appears on the screen, the cell is reset and the cursor is positioned on the blank cell.

5.4.4 Calculations

In order to make the calculations, click on Compute that is displayed on each data acquisition window.

If data is missing, a warning message appears on the screen, then, the acquisition window that contains the blank cell is also displayed on the screen and the cursor is positioned on the blank cell.

In order to obtain detailed information about the algorithms used during the design, we invite you to consult the technical notes available on the PCA2000 website.

5.4.5 Results

5.4.5.1 Introduction

Once the calculations are made, the results window is automatically displayed.

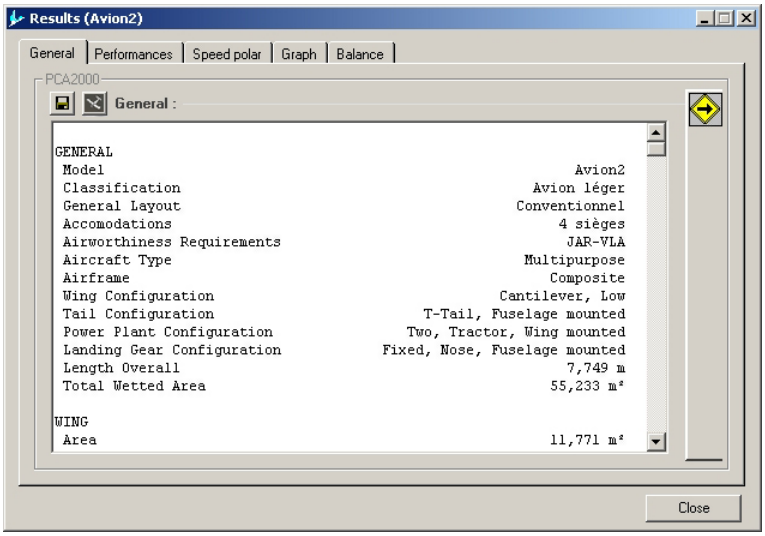


Figure 5.31 : Level 2 design (Generalities)

The first part contains all the information except the one related to the performances. The second part contains only the information related to the performances.

To display all the results:

1. **Open** the box by moving the mouse pointer on it,
2. **Click** on the option button called Generalities.

All the results are now displayed on the same sheet.

To display the results belonging to only one particular item:

1. **Open** the box
2. **Click** on the corresponding option button.

5.4.5.2 Generalities

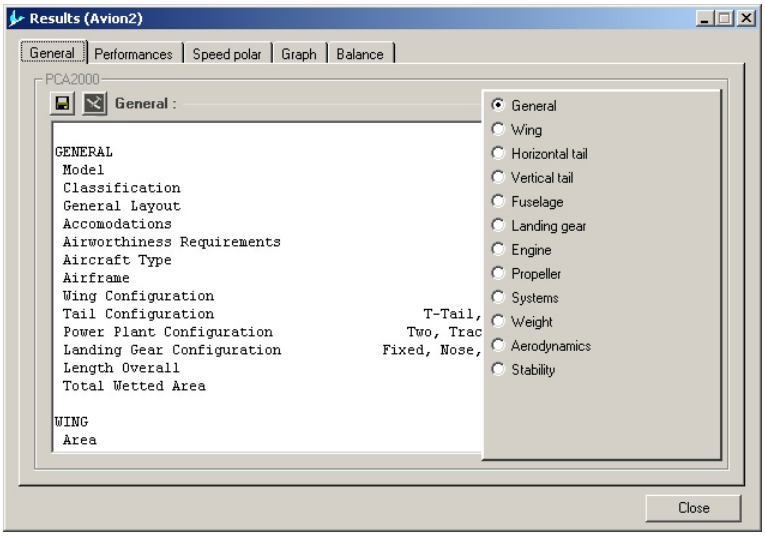


Figure 5.32 : Level 2 design (Selective display)

5.4.5.3 Performances

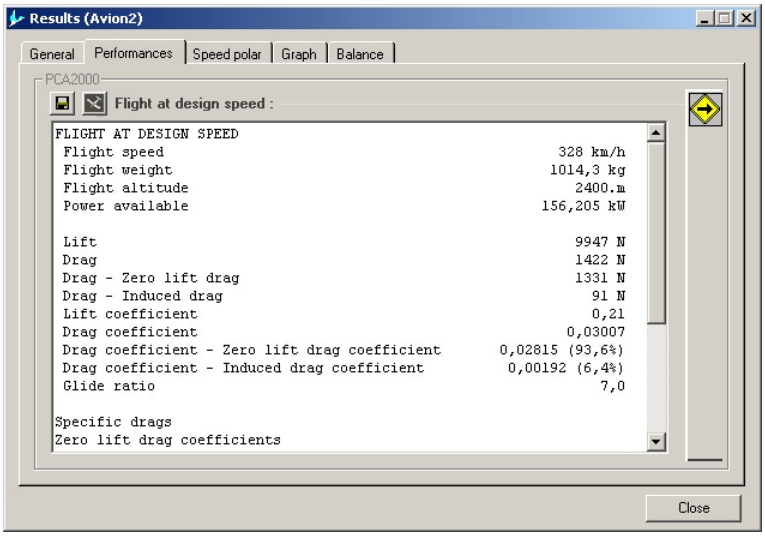


Figure 5.33 : Level 2 design (Performances)

To save the content of the display area (tabs **Generalities** and **Performances**):

1. **Click** on one of the available option buttons on the box
2. **Click** on the control button located on top of the results display area.

A message appears in the comments display area to inform you about the recording status.

Two results files have been created :

1. The first one is a text file (format .rtf) that you can open with any word processing software.
2. The second is a text file (format .csv) that you can open with any spreadsheet program such as Excel for example.

5.4.5.4 3D Design

If your license allows it, you can access directly the **3D Module** and look at a digital 3D model consistent in every way with the results of the design.

The access to the 3D module is done by clicking on located in the upper left part of the results window.

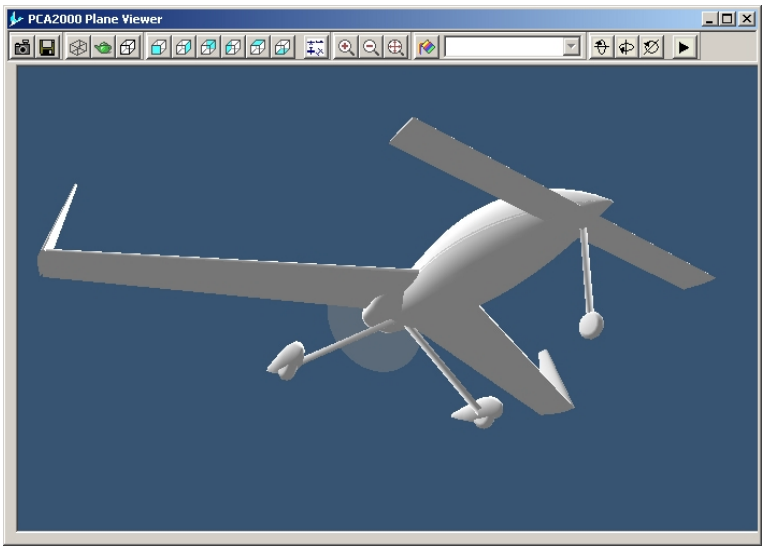
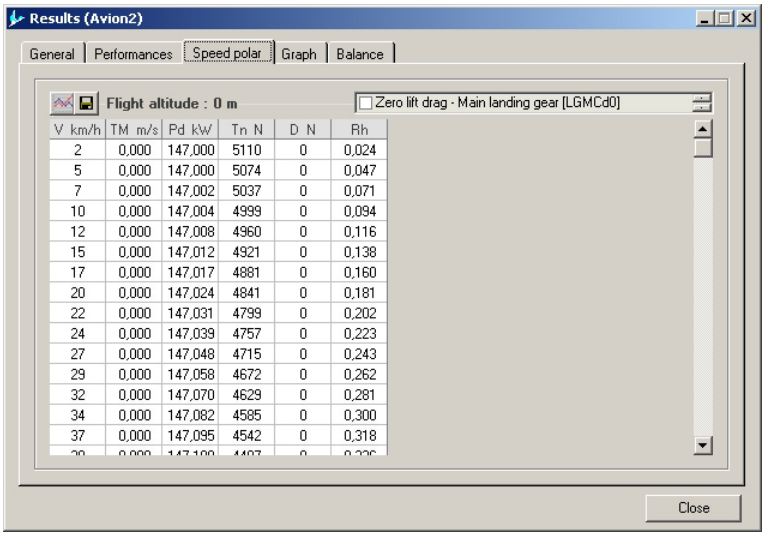


Figure 5.34 : Level 2 design (3D digital design)

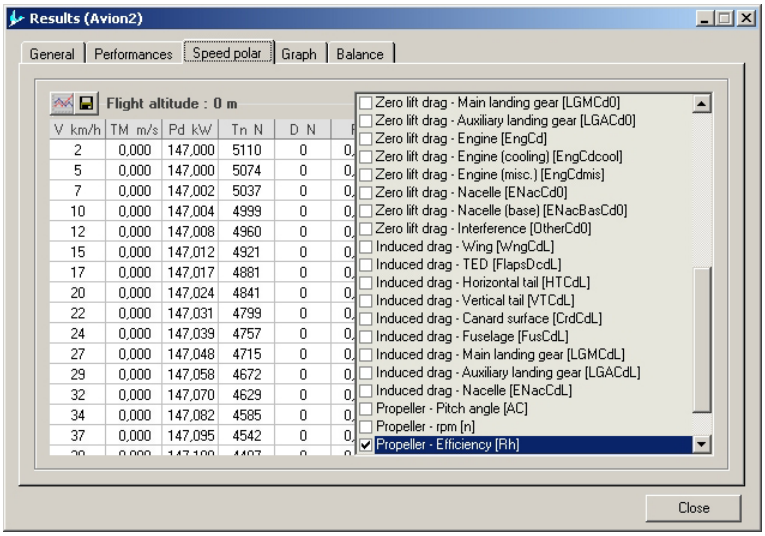
To obtain all the useful information related to the 3D design, we invite you to look at the chapter called 3D Module of the user's manual.

5.4.5.5 Speed polar



V km/h	TM m/s	Pd kW	Tn N	D N	Rh
2	0,000	147,000	5110	0	0,024
5	0,000	147,000	5074	0	0,047
7	0,000	147,002	5037	0	0,071
10	0,000	147,004	4999	0	0,094
12	0,000	147,008	4960	0	0,116
15	0,000	147,012	4921	0	0,138
17	0,000	147,017	4881	0	0,160
20	0,000	147,024	4841	0	0,181
22	0,000	147,031	4799	0	0,202
24	0,000	147,039	4757	0	0,223
27	0,000	147,048	4715	0	0,243
29	0,000	147,058	4672	0	0,262
32	0,000	147,070	4629	0	0,281
34	0,000	147,082	4585	0	0,300
37	0,000	147,095	4542	0	0,318

Figure 5.35 : Level 2 design (Speed polar)



V km/h	TM m/s	Pd kW	Tn N	D N
2	0,000	147,000	5110	0
5	0,000	147,000	5074	0
7	0,000	147,002	5037	0
10	0,000	147,004	4999	0
12	0,000	147,008	4960	0
15	0,000	147,012	4921	0
17	0,000	147,017	4881	0
20	0,000	147,024	4841	0
22	0,000	147,031	4799	0
24	0,000	147,039	4757	0
27	0,000	147,048	4715	0
29	0,000	147,058	4672	0
32	0,000	147,070	4629	0
34	0,000	147,082	4585	0
37	0,000	147,095	4542	0

Figure 5.36 : Level 2 design (Selective display)

The speed polar is determined at the sea level at standard atmosphere (0m, 15°C).

For each speed starting from 0 km/h to the maximum flight speed, the following data is given:

- Performances (rate of climb, climb slope and climb angle)
- Available power
- Traction of the propeller
- Drag (induced and specific)
- Drag coefficients (total, zero-lift, induced and specific)
- Propeller efficiency
- Propeller pitch angle
- Propeller coefficients (speed, power and torque)

Click on  to save the content of the spreadsheet in a file in the format .csv that you can open with any spreadsheet program such as Excel for example.

A message appears in the comments display area to inform you about the recording status.

The file .csv is saved in the data directory

The name of the file .csv is defined SP- + number that corresponds to the date and hour of the recording (for example SP-2005220933.csv).

To look at the information gathered in the table under the form of a graphic, **click** directly on the tab [**Graphic**] or **click** on the button  positioned in the upper left corner of the table.

5.4.5.6 Graphical display of the results

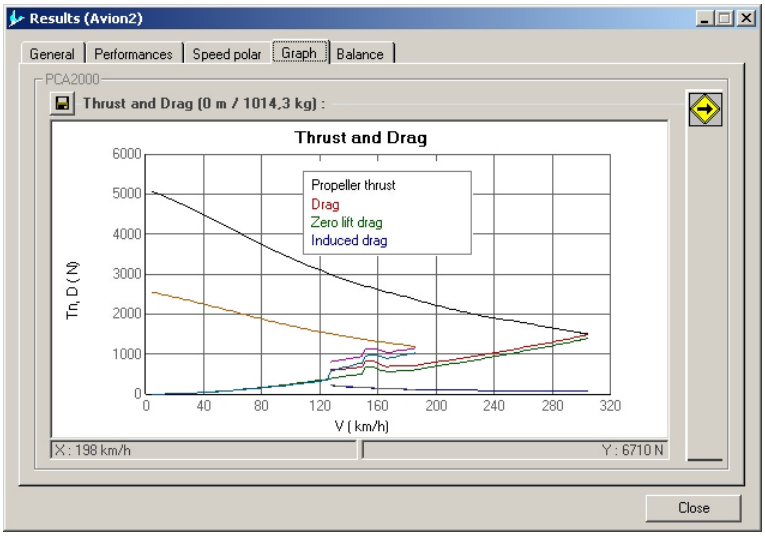


Figure 5.37 : Level 2 design (Performances curves)

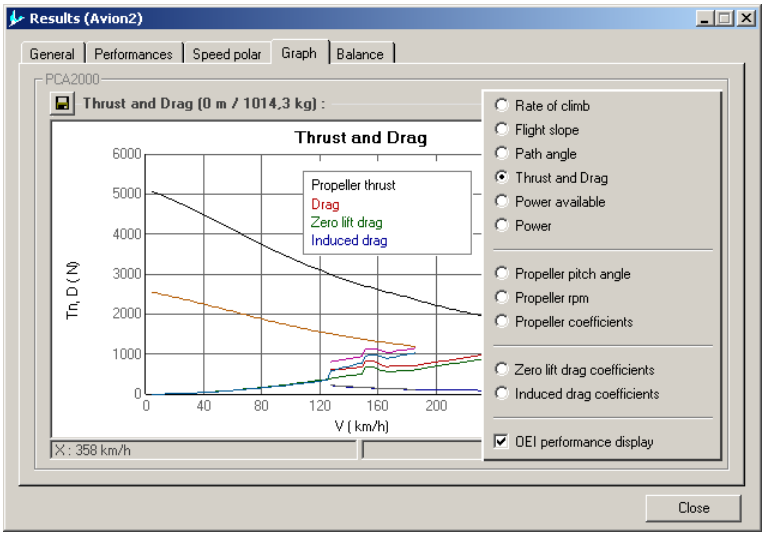


Figure 5.38 : Level 2 design (Selective display)

5.4.5.7 Balance

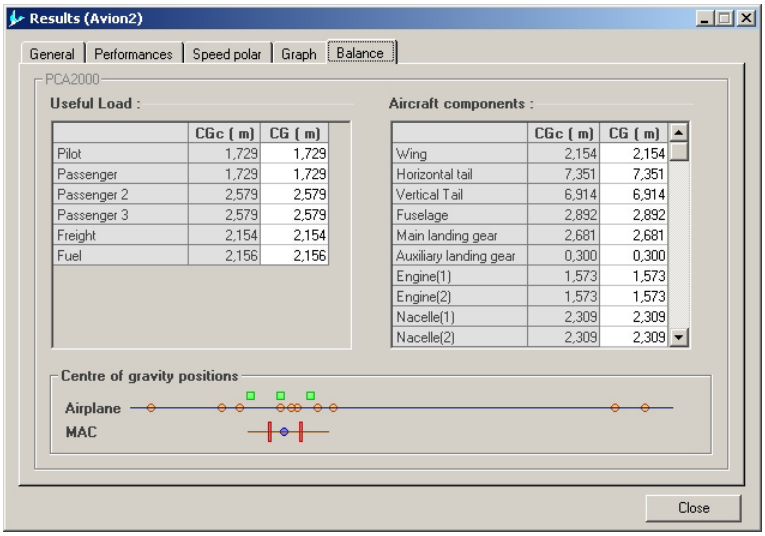


Figure 5.39 : Level 2 design (Balance)

The location of the CG of the individual subassemblies as well as the aircraft CG are automatically computed. The datum line is at the most forward point of the aircraft.

The table on the left hand side shows a breakdown for the payload. The table on the right hand side shows a breakdown for the subassemblies of the aircraft (wing, empennage,…).

In each table, the second column from the right (grey background) contains values which have been automatically calculated by PCA2000. Nevertheless, the values in the right hand column (white background) can be specified by the user and are used for further analysis. By default, the values are set equal to those calculated.

The lower part of the window shows a graphical presentation. The CG of the individual subassemblies are plotted as an amber circle along a line which corresponds to the length of the aircraft. Payload items are plotted as green squares.

The aircraft CG is shown by blue circles along a line of which the length corresponds to the Mean Aerodynamic Chord (MAC) of the wing. The aircraft CG is calculated and shown for 2 critical loading cases, i.e. one at the maximum weight and the other at the minimum weight.

Two vertical marks indicate the forward and aft CG position which are determined by manoeuvrability and stability criterions respectively. The loaded aircraft CG must fall within this CG range for all loading conditions.

Moving the mouse pointer over the plot will pop up the local coordinates as well as a reference to the selected subassembly.

To save an image from the graphic **click** on the control button  located on top of the graphic.

A message appears in the comments display area to inform you about the recording status.

Two image files have been created:

1. The first one in .bmp format
2. The second one in .jpg format

The different results that can be displayed under a graphic format are:

- The performances
- Rate of climb
- Climb slope
- Climb angle
- Thrust and drag
- Available power
- Powers
- The propeller coefficients
- Propeller pitch angle
- Propeller rpm
- Specific drag coefficients
- Zero-lift drag coefficients
- Induced drag coefficients

5.4.5.8 Print the results

To print the results, **click** on the control button  in the toolbar in the main window.

5.4.5.9 Save the results

To save the results, **click** on the control button  in the toolbar in the main window.

A message appears on the screen in the comments display area to inform you about the recording status.

5.5 Level 3 design

5.5.1 Description

To reach the «Design» module, **click** on [**Design**], [**Airplanes**] then [**Level 3**] in the menu bar in the main window. You can also reach it directly by clicking on  in the vertical toolbar.

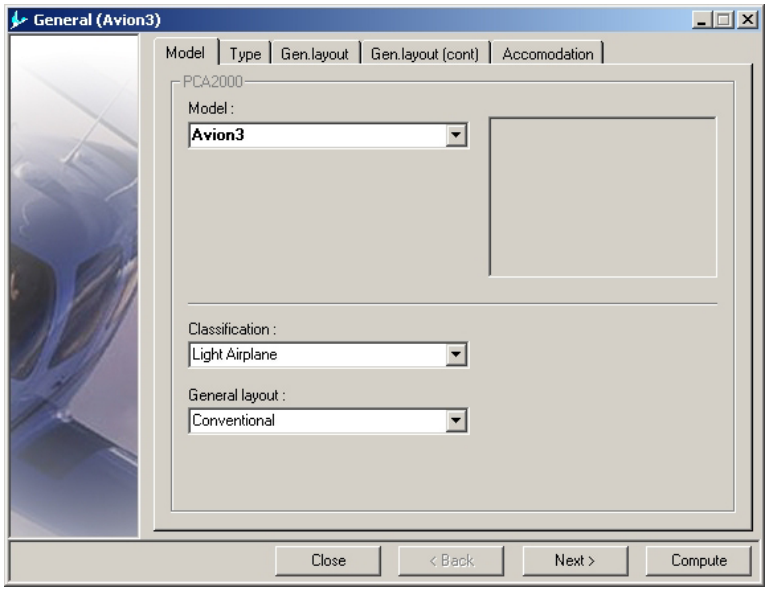


Figure 5.40 : Level 3 design (General)

If you have chosen to reach the « Design » module via the control button  , you might have to specify the desired design level. This can be done via the status bar in the main window. **Click** on the indicated place until the number displayed is 2.

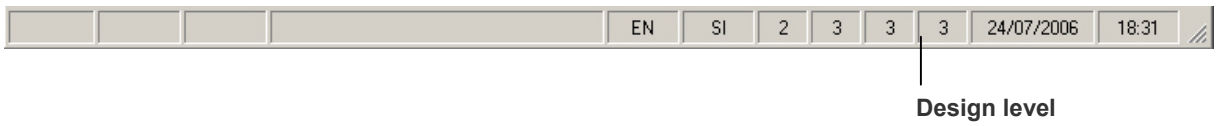


Figure 5.41: Status bar of the main window

The acquisition of the input data is done via 13 specific windows:

1. Generalities
2. Wing
3. Horizontal tail
4. Vertical tail
5. Fuselage
6. Landing gear
7. Engine
8. Propeller
9. Systems
10. Performances
11. Weights
12. Aerodynamic
13. Options

Each window contains a set of fields that the user must fill in in order to be able to proceed with the design. The **gray fields** are not accessible and reserved for a different level design than the one currently in use.

Press the **F1** key at any time to reach the contextual help.

To navigate within the controls of a window, use the **tab key**.

To navigate within the windows, use the Next > or < Back keys or the menu of the vertical toolbar.

5.5.2 Remarks

5.5.2.1 Determination of the maximum lift coefficient of a lifting surface

The determination of the magnitude of the maximum lift coefficient of a lifting surface is done according to the methodology described by Dr. Jan Roskam in his book Airplane Design Part VI, for simple flap, split flap, simple-slotted flap, double-slotted flap and Fowler flap.

5.5.2.2 The zero-lift drag coefficient (Cd0)

The zero-lift drag coefficient is calculated in relation with the wing area.

5.5.2.3 Propeller type

During a level 3 design, the propeller characteristics are determined for fixed-pitch propellers, variable pitch propeller and constant speed propellers.

5.5.3 Input data

5.5.3.1 Generalities

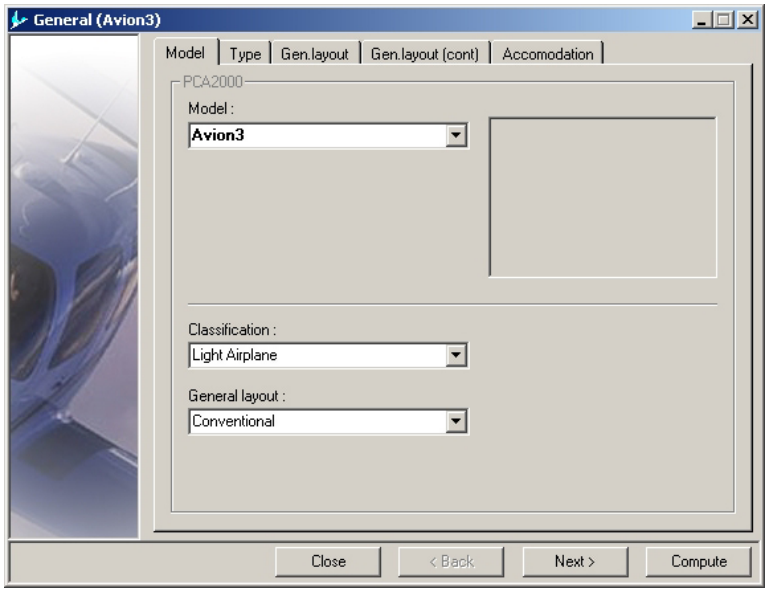


Figure 5.42 : Level 3 design (General)

5.5.3.2 Wing

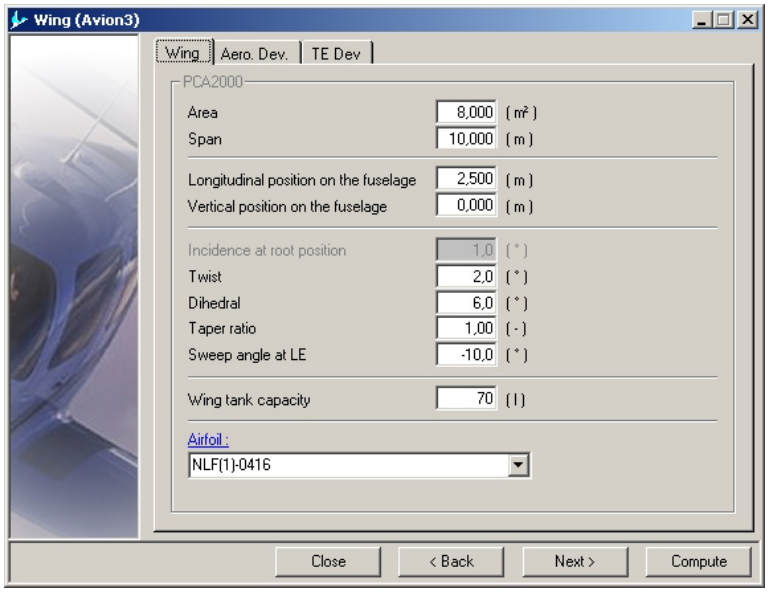


Figure 5.43 : Level 3 design (Wing)

5.5.3.3 Horizontal tail

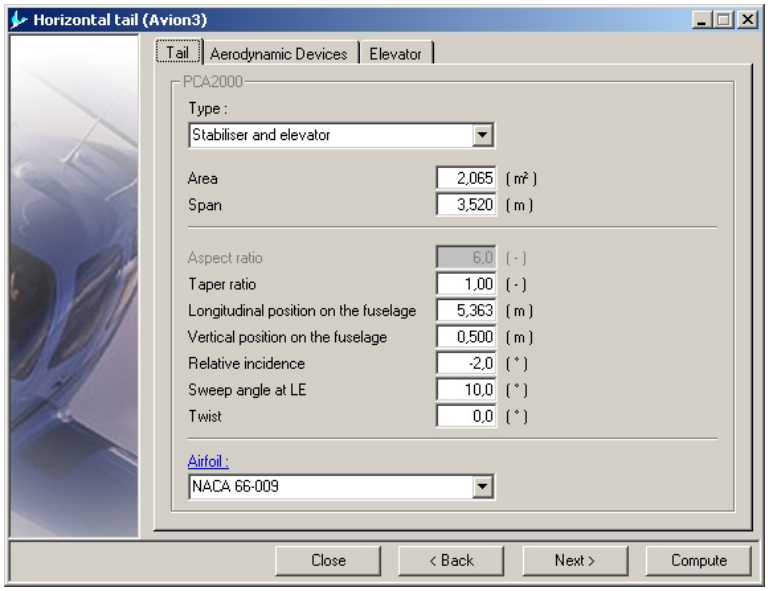


Figure 5.44 : Level 3 design (Horizontal tail)

5.5.3.4 Vertical tail

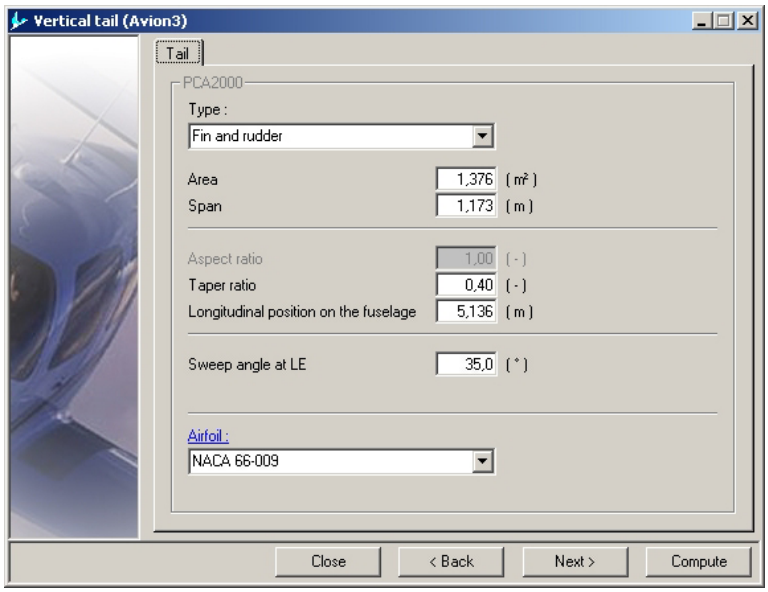


Figure 5.45 : Level 3 design (Vertical tail)

5.5.3.5 Fuselage

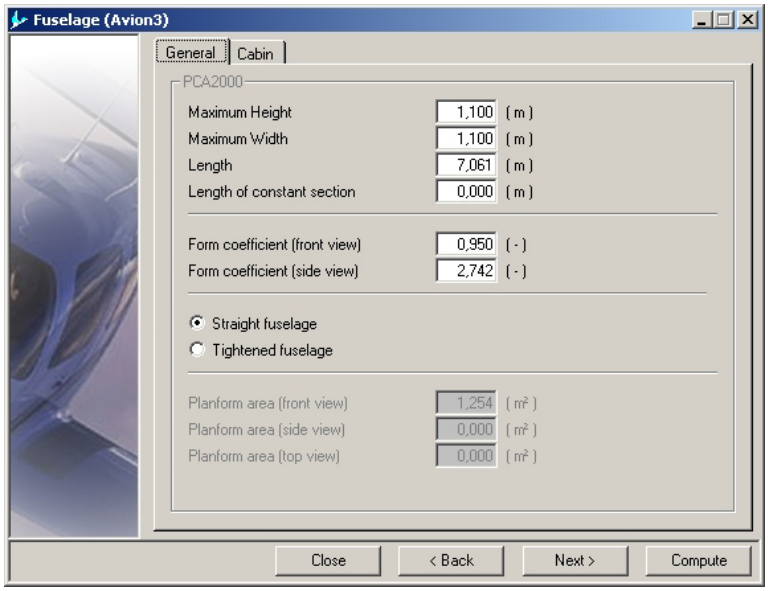


Figure 5.46 : Level 3 design (Fuselage)

5.5.3.6 Landing gear

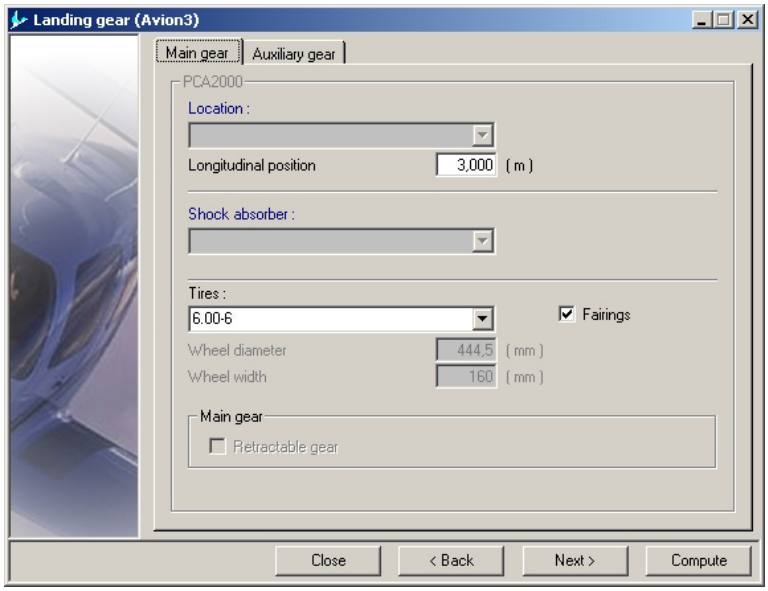


Figure 5.47 : Level 3 design (Landing gear)

The customer chooses the tires in a catalogue. This simple choice entails the immediate knowledge of the wheels dimensions. Important criteria to determine the drag caused by the various components of the landing gear. If the tire is not included in the proposed list, the user chooses NA (non available) and inserts himself the dimensions of the wheel in the appropriate spaces.

5.5.3.7 Engine

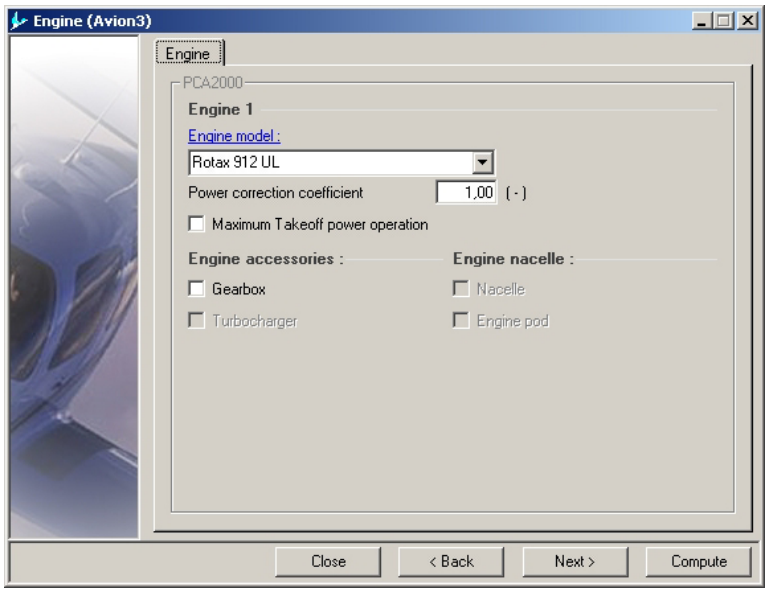


Figure 5.48 : Level 3 design (Engine)

The user chooses the engine he plans to use in a list of engines. This simple choice entails the immediate knowledge of all the characteristics of the engine including its power curves and its specific consumption curves.

BEWARE

If the engine is equipped with a reduction gear as it is the case with the **Rotax 912** for example, the characteristics of the reduction gear will have been specified in the engine data file (cf. chapter 8 of the user's manual).

At the level 3 design, the user has the possibility to give the characteristics of a reduction gear that would be added to an engine which is not equipped with it. We could, for a specific application for example, consider equipping an aircraft with an engine **Lycoming O-320-B1B** and adding a reduction gear at the 1/1.245 ratio. The characteristics of this « external » reduction gear will have to be specified once we reach the **Engine** sheet of the level 3 design.

5.5.3.8 The propeller

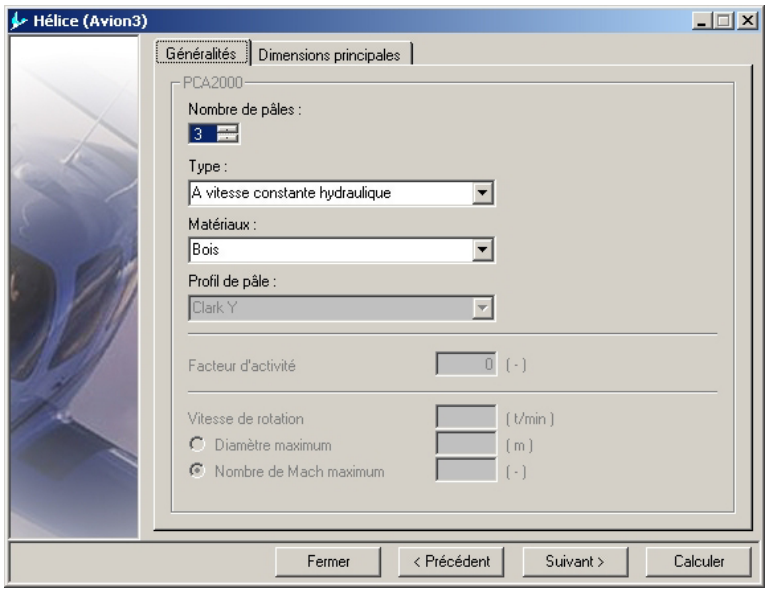


Figure 5.49 : Level 3 design (Propeller)

The user chooses the type of propeller he plans to use,

- either a constant speed propeller,
- either a fixed-pitch propeller.

The choice of the propeller type will influence considerably the performances during the take-off and the climb as well as the weight breakdown of the aircraft.

A constant speed propeller makes it possible to make the most of the engine power but is heavier than a simple fixed-pitch propeller.

5.5.3.9 Systems

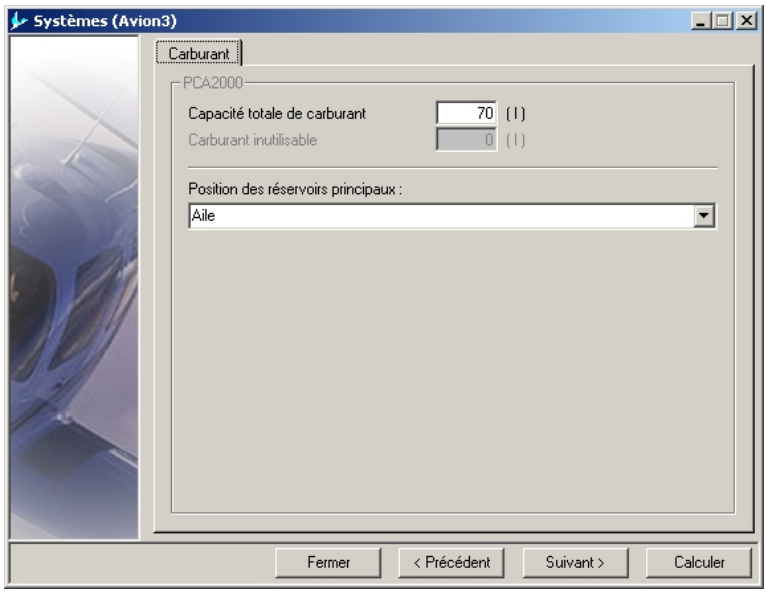


Figure 5.50 : Level 3 design (Systems)

5.5.3.10 Performances

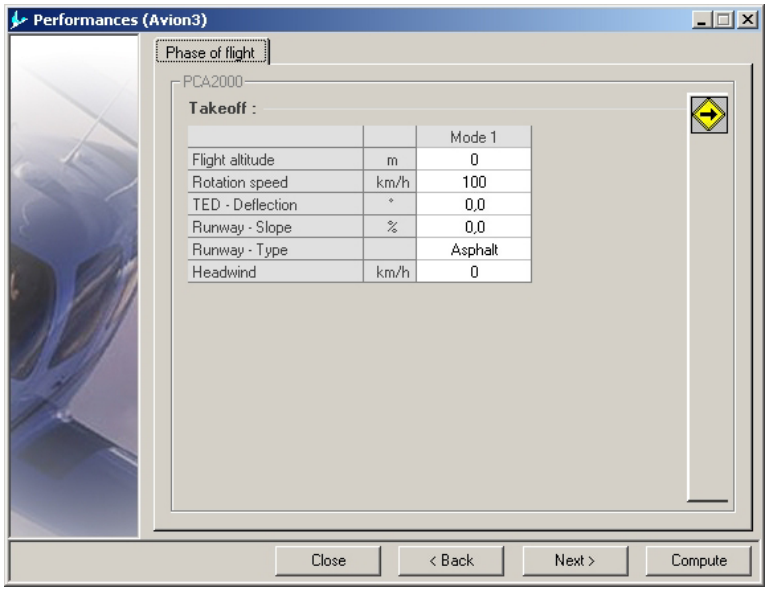


Figure 5.51 : Level 3 design (Performances)

5.5.3.11 Weights

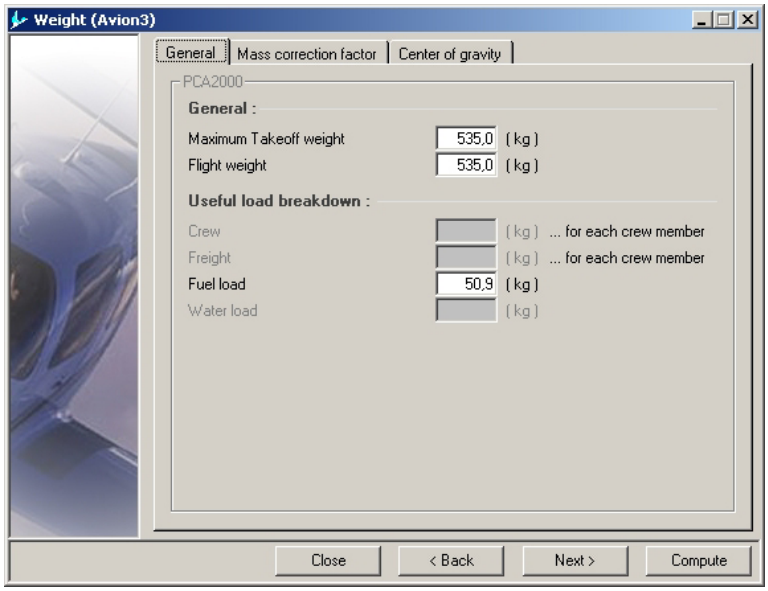


Figure 5.52 : Level 3 design (Weights)

Unlike the 2 preceding levels of design, the design of level 3 determines the performances of the airplane for a given flight mass.

The aircraft empty weight is calculated by adding the specific weights of the various components of the aircraft. The weight of a component is calculated on the basis of its geometric dimensions as well as on the maximum take-off weight of the aircraft.

In order to obtain detailed information about the algorithms used during the design, we invite you to look at the various technical data sheets available on the PCA2000 website.

5.5.3.12 Aerodynamics

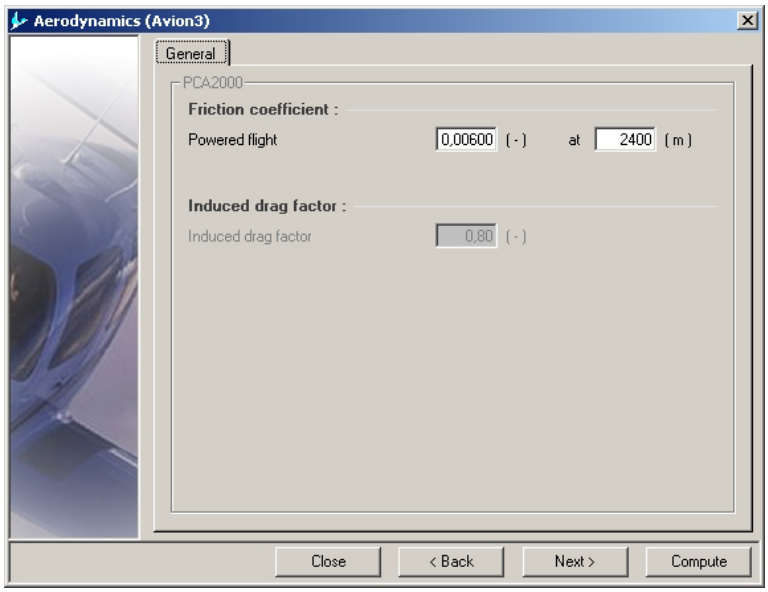


Figure 5.53 : Level 3 design (Aerodynamics)

5.5.3.13 Options

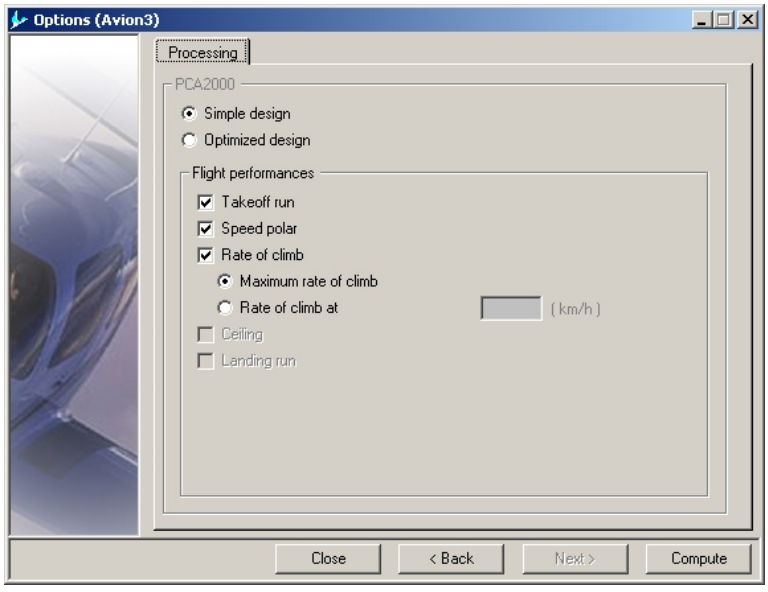


Figure 5.54 : Level 3 design (Options)

If your license allows it, you have the possibility to carry out an optimized design. In order to do that, we invite you to refer to the chapter called « Optimized design » in the user's manual.

5.5.4 Calculations

In order to make the calculations, click on Compute that is displayed on each data acquisition window.

If data is missing, a warning message appears on the screen, then, the acquisition window that contains the blank cell is also displayed on the screen and the cursor is positioned on the blank cell.

In order to obtain detailed information about the algorithms used during the design, we invite you to consult the technical notes available on the PCA2000 website.

5.5.5 Results

5.5.5.1 Introduction

Once the calculations are made, the results window is automatically displayed.

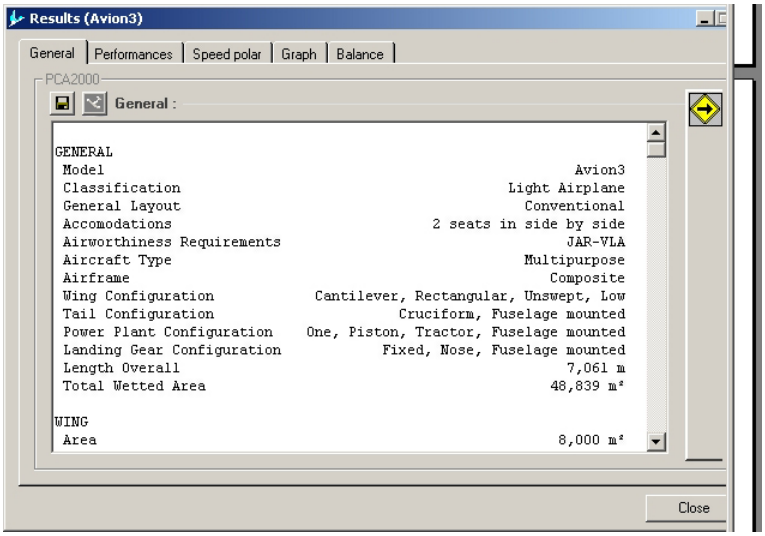


Figure 5.55 : Level 3 design (Generalities)

The first part contains all the information except the one related to the performances. The second part contains only the information related to the performances.

To display all the results:

1. **Open** the box by moving the mouse pointer on it,
2. **Click** on the option button called Generalities.

All the results are now displayed on the same sheet.

To display the results belonging to only one particular item:

1. **Open** the box
2. **Click** on the corresponding option button.

5.5.5.2 Generalities

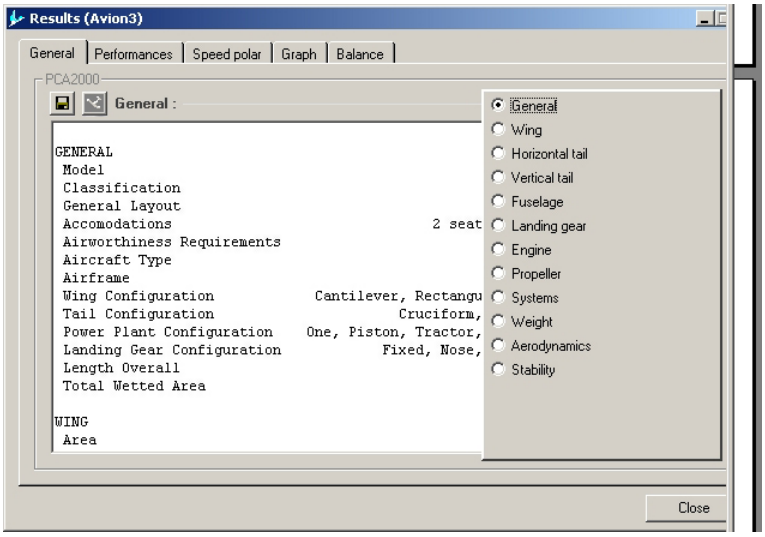


Figure 5.56 : Level 3 design (Selective display)

5.5.5.3 Performances

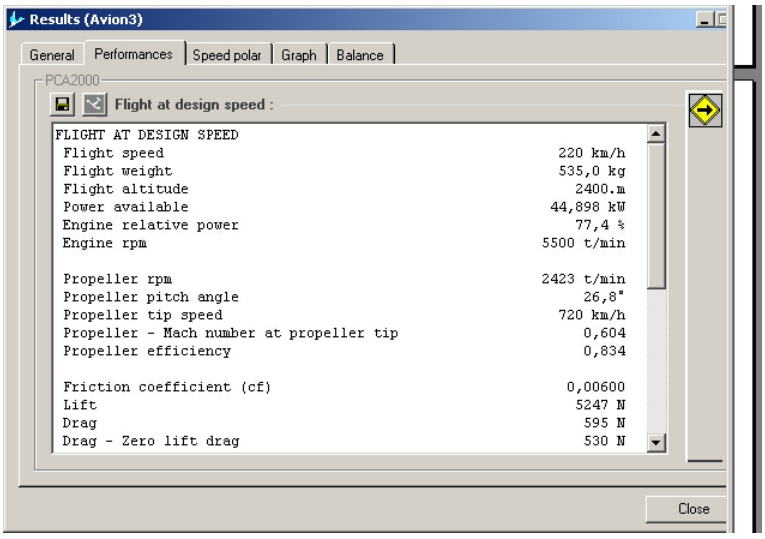


Figure 5.57 : Level 3 design (Performances)

To save the content of the display area (tabs **Generalities** and **Performances**):

1. **Click** on one of the available option buttons on the box
2. **Click** on the control button  located on top of the results display area.

A message appears in the comments display area to inform you about the recording status.

Two results files have been created :

1. The first one is a text file (format .rtf) that you can open with any word processing software.
2. The second is a text file (format .csv) that you can open with any spreadsheet program such as Excel for example.

5.5.5.4 Speed polar

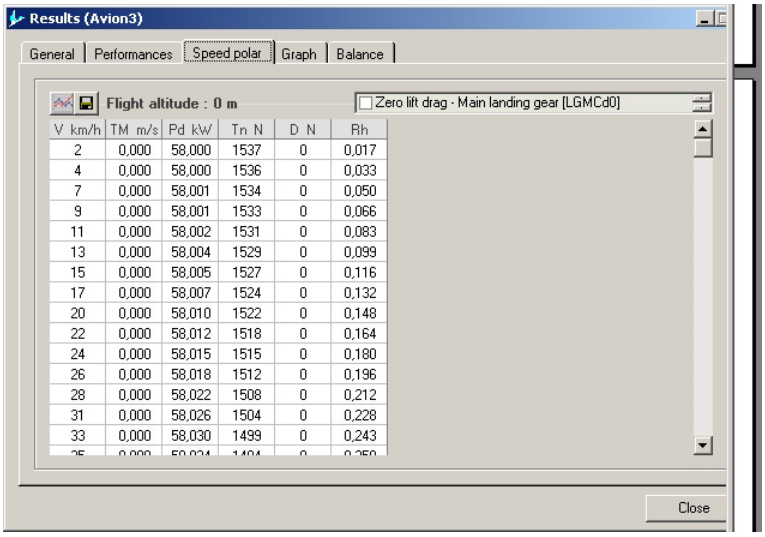


Figure 5.58 : Level 3 design (Speed polar)

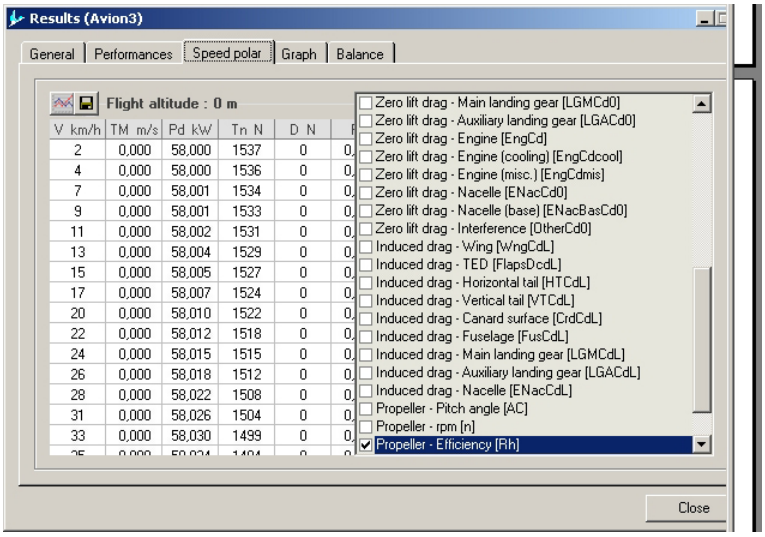


Figure 5.59 : Level 3 design (Selective display)

The speed polar is determined at the altitude given for the climb performance.

For each speed starting from 0 km/h to the maximum flight speed, the following data is given:

- Performances (rate of climb, climb slope and climb angle)
- Available power
- Traction of the propeller
- Drag (induced and specific)
- Drag coefficients (total, zero-lift, induced and specific)
- Propeller efficiency
- Propeller pitch angle
- Propeller coefficients (speed, power and torque)

Click on  to save the content of the spreadsheet in a file in the format .csv that you can open with any spreadsheet program such as Excel for example.

A message appears in the comments display area to inform you about the recording status.

The file .csv is saved in the data directory

The name of the file .csv is defined SP- + number that corresponds to the date and hour of the recording (for example SP-2005220933.csv).

To look at the information gathered in the table under the form of a graphic, **click** directly on the tab [**Graphic**] or **click** on the button  positioned in the upper left corner of the table.

5.5.5.5 Graphical display of the results

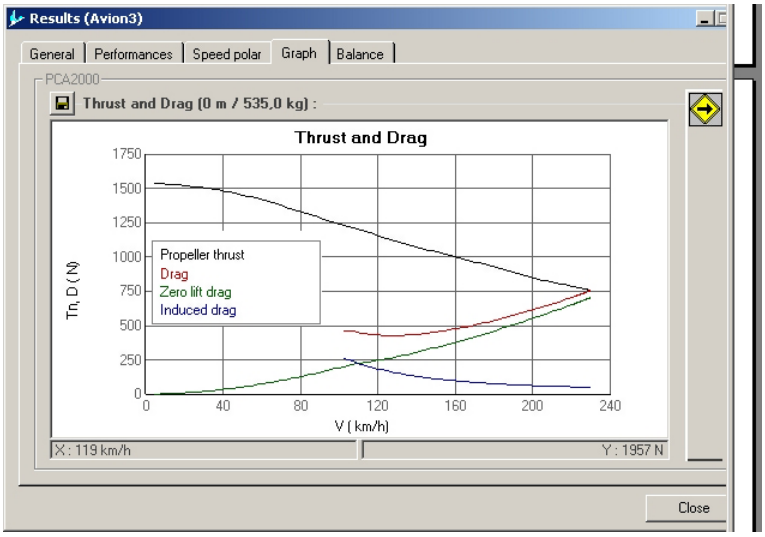


Figure 5.60 : Level 3 design (Performances curves)

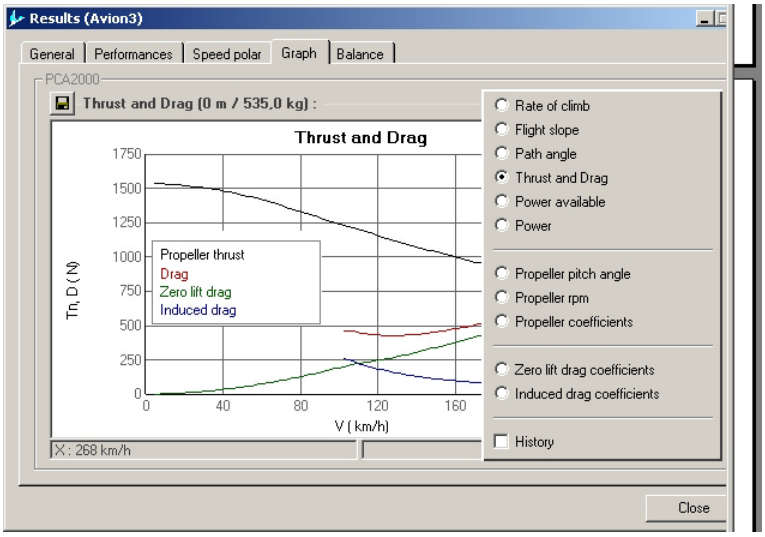


Figure 5.61 : Level 3 design (Selective display)

5.5.5.6 Balance

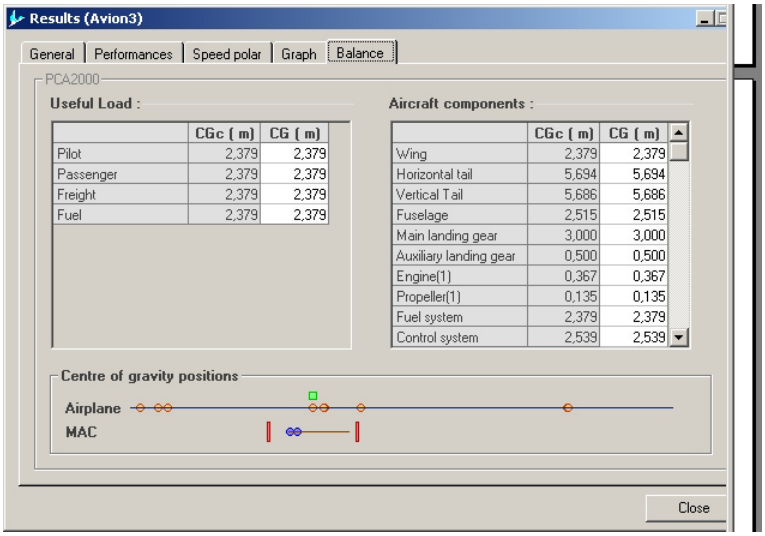


Figure 5.62 : Level 3 design (Balance)

The location of the CG of the individual subassemblies as well as the aircraft CG are automatically computed. The datum line is at the most forward point of the aircraft.

The table on the left hand side shows a breakdown for the payload. The table on the right hand side shows a breakdown for the subassemblies of the aircraft (wing, empennage,…).

In each table, the second column from the right (grey background) contains values which have been automatically calculated by PCA2000. Nevertheless, the values in the right hand column (white background) can be specified by the user and are used for further analysis. By default, the values are set equal to those calculated.

The lower part of the window shows a graphical presentation. The CG of the individual subassemblies are plotted as an amber circle along a line which corresponds to the length of the aircraft. Payload items are plotted as green squares.

The aircraft CG is shown by blue circles along a line of which the length corresponds to the Mean Aerodynamic Chord (MAC) of the wing. The aircraft CG is calculated and shown for 2 critical loading cases, i.e. one at the maximum weight and the other at the minimum weight.

Two vertical marks indicate the forward and aft CG position which are determined by manoeuvrability and stability criterions respectively. The loaded aircraft CG must fall within this CG range for all loading conditions.

Moving the mouse pointer over the plot will pop up the local coordinates as well as a reference to the selected subassembly.

To save an image from the graphic **click** on the control button  located on top of the graphic.

A message appears in the comments display area to inform you about the recording status.

Two image files have been created:

1. The first one in .bmp format
2. The second one in .jpg format

The different results that can be displayed under a graphic format are:

- The performances
- Rate of climb
- Climb slope
- Climb angle
- Thrust and drag
- Available power
- Powers
- The propeller coefficients
- Propeller pitch angle
- Propeller rpm
- Specific drag coefficients
- Zero-lift drag coefficients
- Induced drag coefficients

5.5.5.7 Print the results

To print the results, **click** on the control button  in the toolbar in the main window.

5.5.5.8 Save the results

To save the results, **click** on the control button  in the toolbar in the main window.

A message appears on the screen in the comments display area to inform you about the recording status.