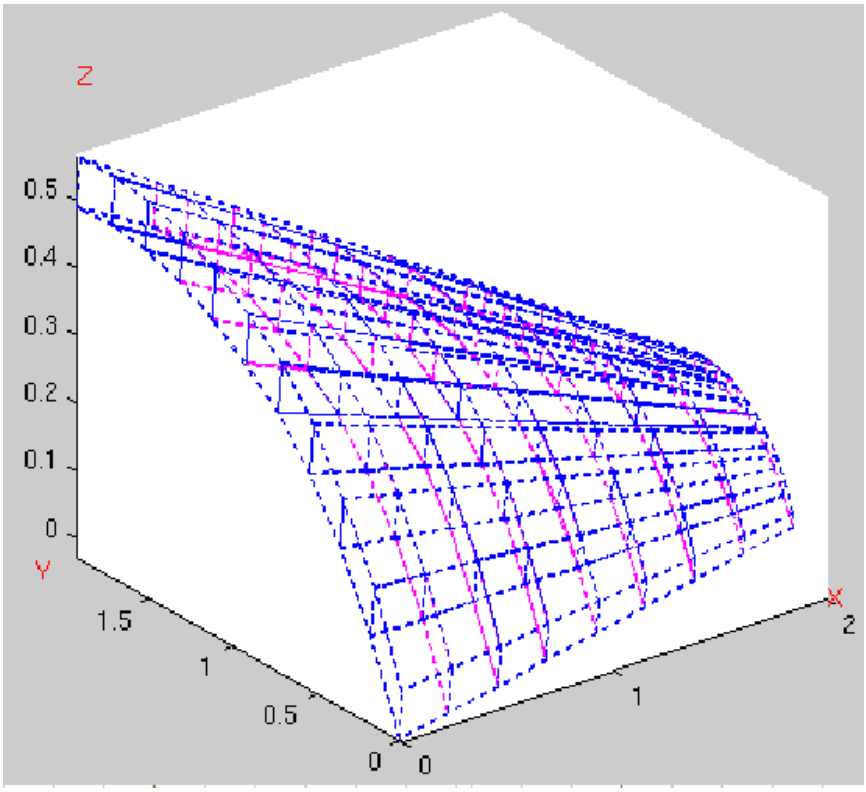
AerWing©

Version 1.10

The aeroelasticity program for 3-D finite wing in incompressible and steady potential air flow

By

Christophe Paget



Edition 1.1 August 1999

This is edition 1.1 of the AeroWing documentation, and it concerns the AeroWing program version 1.10. Both the program and the documentation were written by Christophe Paget. Acknowledgement is given to Jérôme Matrat who provided the finite element code in this program.

The original was distributed by Christophe Paget < ptc@ffa.se > June 15th 1999.

Edition 1.1 was made by Christophe Paget < aerowing@engineer.com > on August 27th 1999 by restricting capabilities of the program due to finite element code limitations.

This documentation can be found at the following World Wide Web addresses:
http://aerowing.go.to or http://aerowing.fly.to or
http://www.geocities.com/Tokyo/Club/7077/ or even
http://tv.acmecity.com/parody/99/

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INTRODUCTION

*A*ero*W*ing© is a program concerning 3-D finite wing in an incompressible, non-rotational and steady potential flow. This program contains the basis of aeroelasticity, meaning that it calculates the aerodynamic pressure distribution on the wing and computes the displacement field of the 3-D wing due to loading. The program was written from an educational point of view using fully graphic user interfaces. The authors of the program welcome any new routines that could improve the use of this free-based licensed program. The novelty of this program is that it handles finite wing made of two composite skins. The users can also set-up the composite lay-up sequences.

The *A*ero*W*ing© program is in fact a library of Matlab, therefore it needs the *MATLAB* program for running. In any case *A*ero*W*ing belongs to MATLAB© from MathWorks. *A*ero*W*ing© was written at the very beginning in PC platform and was extended to Unix and Unix-like platforms. Besides, the program is compliant with Matlab versions 4.xx and 5.xx. However, the program takes care of the platform type (PC, Unix or Unix-like platform) and Matlab version by itself.
The MAC version of the program will be available in the next version of *A*ero*W*ing.

Chapter 1 *GETTING STARTED*

1.1. How to download the program

The free program *A*ero*W*ing© can be downloaded from the following web sites:
http://go.to/aerowing or **http://fly.to/aerowing** or
http://aerowing.go.to or **http://aerowing.fly.to**
or **http://www.geocities.com/Tokyo/Club/7077/**
or even **http://tv.acmecity.com/parody/99/**

A copy can be sent for free on request at one of the following Emails:
aerowing@engineer.com or **ptc@ffa.se**

1.2. Set-up the program

Matlab 4 users

For users running the program on matlab version 4, the administrator needs to store the whole folder content "aerowf" at the location "~\matlab\toolbox\matlab\". It remains to the administrator to set the matlab path. For this, at the location "~\matlab\", the administrator has to write the path for the folder "*aerowf*" in the file named " *matlabrc.m*.
If the program is used by several users, make sure that all files can be accessed by all users by setting the full rights on all files (in writing, reading and executing modes), otherwise the program will not work.

To run the program, start the program Matlab first, then write the program name ***aerowing***. Then, follow the help menus provided in each window.

Matlab 5 users

For users running the program on matlab version 5, the administrator needs to store the whole folder content "aerowf" at the location of the administrator's choice (typically at "~\matlab\toolbox\matlab\". It remains to the administrator to set the matlab path. For this, the file named "aerowing.m" (located originally at "~\aerowf\aerowing.m") has to be moved to any location the administrator's wish.
If the program is used by several users, make sure that all files can be accessed by all users by setting the full rights on all files (in writing, reading and executing modes), otherwise the program will not work.

To run the program, start the program Matlab first, then go the directory where the file "aerowing.m" is and write the program name *aerowing*. Then follow the help menus provided in each window.

Chapter 2 *COMMAND DESCRIPTION*

2.1. Main window

The program will start with the main window as shown in Figure 1.

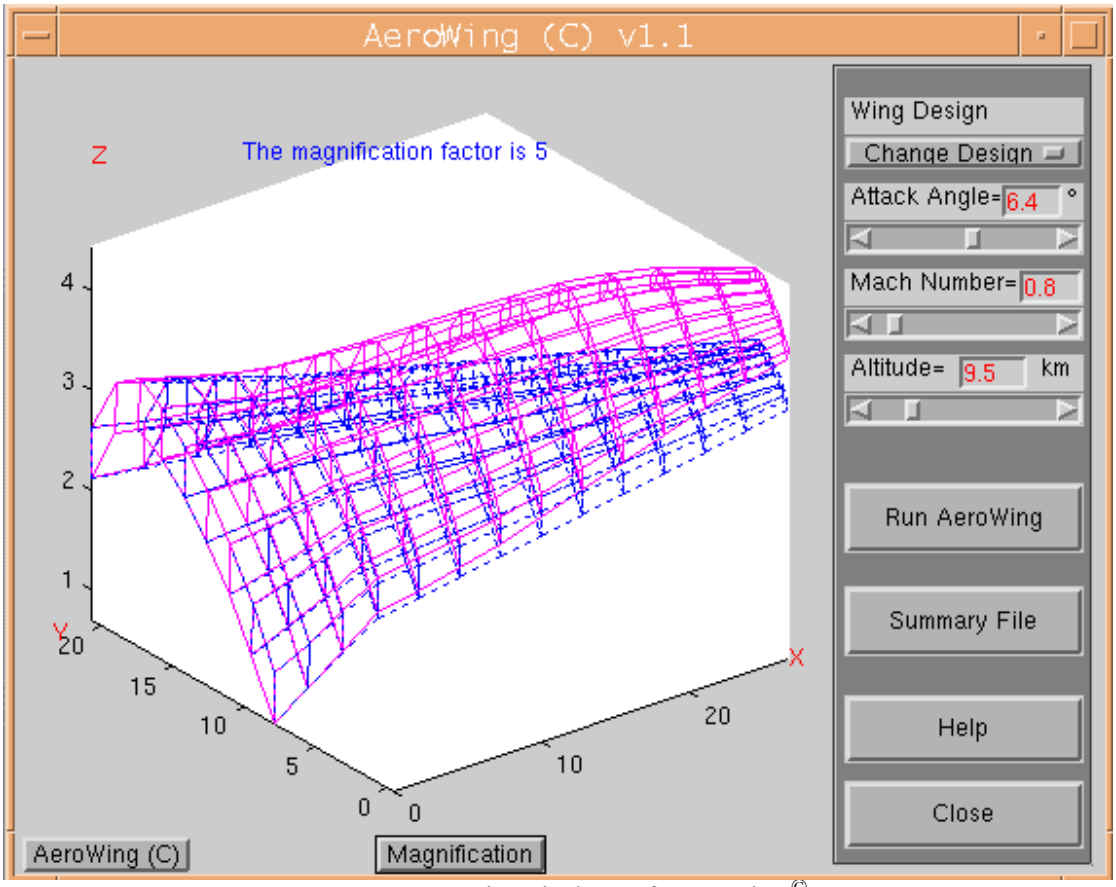

Figure 1: Main window of *A*ero*W*ing©

On the right hand side of this main window, one can see the main menu. It includes the "***Wing design***" popup menu, the "***Angle of attack***" slider, the "***Mach number***" slider, the "***Run***" button, the "***Summary file***" button, the "***Help***" button and the "***Close***" button.

The "***Wing design***" popup menu gives the user two choices:

1- "***Saved Design***": To retrieve the user file, containing all the information on the design of the wing that the user previously set and saved.
2- "***Change Design***": To start or change the design of a wing. It will open a new window called "***Wing Property***"

The "***Angle of attack***" slider allows the user to select an angle of attack using the mouse, dragging the slider. The user might also write the angle of attack by hand, using the *edit* window to the right of "***Attack Angle***", with a red number. Note that the angle of attack is here expected in degree. It is also important to write a numerical value and not any other letters (such as 0 instead of O).

The "***Mach number***" slider allows the user to select the velocity of the simulated aircraft wing by using the mouse, dragging the slider. The user might also write the Mach number by hand, using the *edit* window to the right of "***Mach number***", with a red number. Note that the Mach number is obviously expected in Mach, depending on the altitude. It is also important to write a numerical value and not any other letters (such as 0 instead of O).

The "***Altitude***" slider allows the user to select the altitude of the simulated aircraft wing by using the mouse, dragging the slider. The user might also write the altitude by hand, using the *edit* window to the right of "***Altitude***", with a red number. Note that the altitude is expected in kilometre. It is also important to write a numerical value and not any other letters (such as 0 instead of O).

Once the angle of attack, the velocity and the altitude are set, the user might start running the program by clicking on the "***Run AeroWing***" button with the mouse. A window will then appear (Figure 2) to ask the user to give the wished name for the result file. At the same time the user will give the path where the file will be stored.

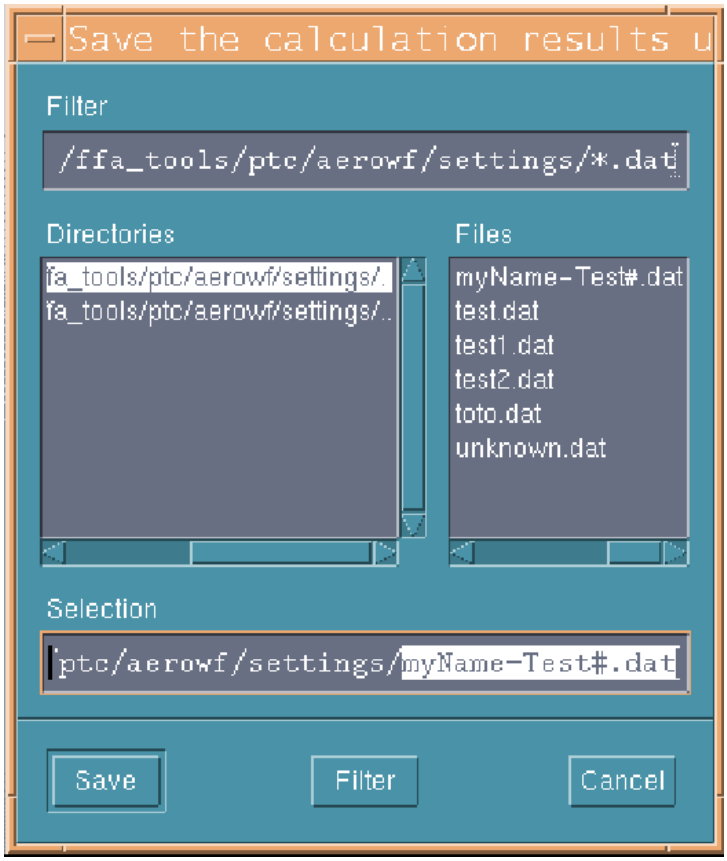

Figure 2: Save window for the calculation results

Once the file name and location has been defined, the program will start to calculate the aerodynamic pressure difference distribution using the "***Lifting-surface solution by vortex ring element***" method [1]. The pressure difference will then be applied on the wing top-element surfaces of the wing mesh, and the displacement and "loads" will be calculated using the finite element method [2].

During the calculation the entire menu panel will freeze until the calculations are completed.

The "***Summary file***" button will be valid when the calculation will be completed. Clicking it will display the file containing a summary of all needed information.

The "***Help***" button will open a window to give the user some help to use this main window.

The "***Close***" button will close the window and bring the user back to the user's original-directory.
The user must NOT close any window using the "close button" situated on the top right, but only using the "close button" situated on the bottom right.

"***Magnification***" button opens a window to give the user the choice of the magnification for the calculated displacement, because the displacement might often be a very small amplification.

"***AeroWing©***" button situated on the bottom left of the main window will give the user more information about the free license agreement that *AeroWing©* is subjected to.

2.2. "Wing Property" window

When the "***Change wing***" command is selected, a new window "***Wing Property***" window will open, as shown in Figure 3. This window allows the user to entirely define the wing to be studied.

The user has to go through all buttons and popup menus to fully define the wing to be studied: i.e. popup menus "***Wing Type***", "***Material Type***", "***Y-Splitting***", "***X-Splitting***", "***NACA Airfoil***" and the button "***Save Settings***", "***Refresh Window***" as often as possible, and finally change the coordinates of the main nodes of the wing if necessary.

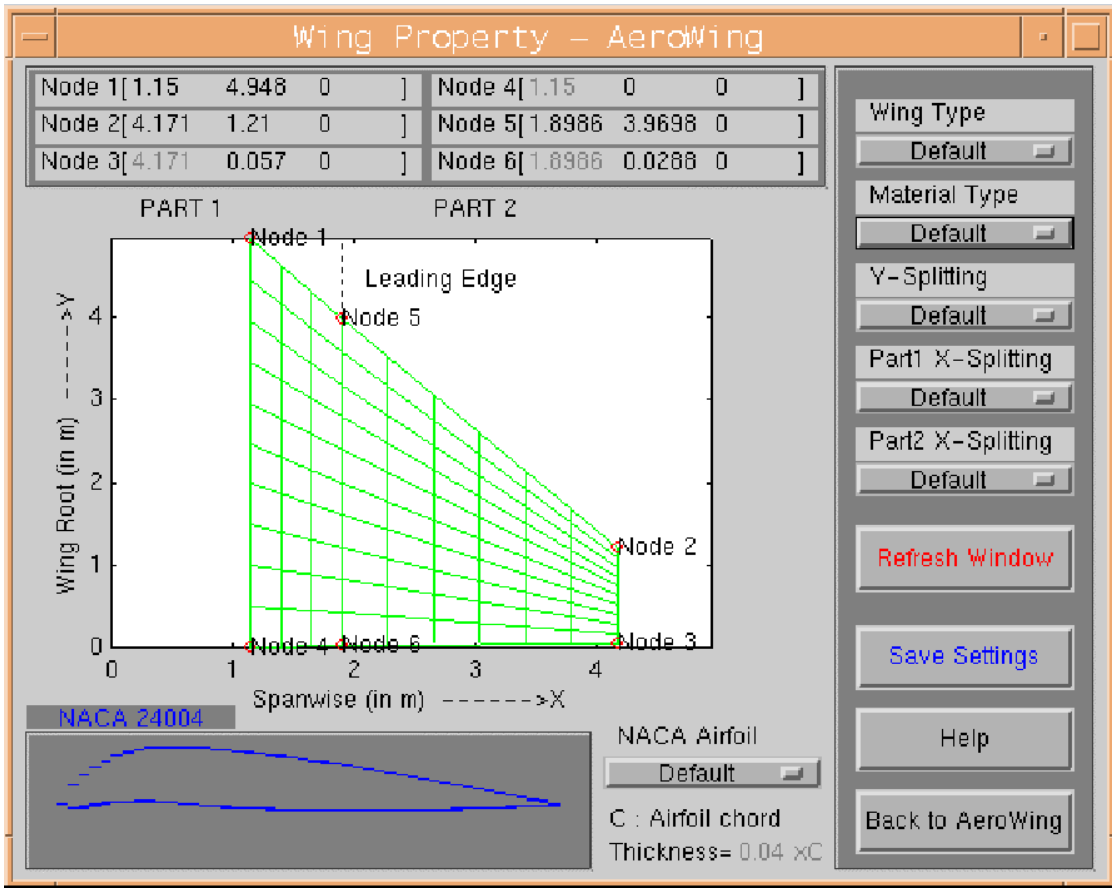

Figure 3: "Wing Property" window

The popup menu "***Wing Type***" gives the user the choice of the wing shape, as shown in Figure 4.

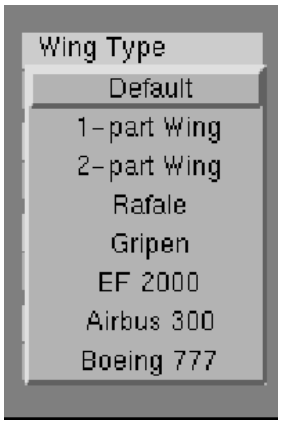

Figure 4: Wing type popup menu

"***1-part Wing***" will give the user the hand on the ***four*** main node coordinates, situated to the top left, defining a wing in only one part. Only the data in ***red*** can be changed by the user.

"***2-part Wing***" will give the user the hand on the ***six*** main node coordinates, situated to the top left, defining a wing in two parts (named Part 1 at the wing root and Part 2 at the wing tip). Only the data in ***red*** can be changed by the user.

The remaining alternatives are given libraries, meaning the user cannot change the node coordinates, but only the airfoil profile.

Note that all data are in **meters** unless clearly specified in any window.

If the user desires to add more libraries, changes need to be done on the Matlab files named "***uif.m***" and "***visu3d.m***" only.

The popup menu "***Material Type***" gives the user the choice of the material type, as shown in Figure 5.

Figure 5: Material type popup menu

"***Titanium***", "***Advanced Aluminium***", "***Carbon Steel***" and "***Monel***" are homogeneous material. These material data could be found in the file with the extension ".sum", by clicking on the "***Summary file***" button in the main window. Besides, the wing will be entirely made of the selected material, which is not the case of the "***Composite***" case.

"***Composite***" is a material made of several layers that can be orientated in several different directions. This material is considered as orthotropic. Besides, the composite will be considered as two skins, in the upper and lower side of the wing, while the inside of the wing will be filled of advanced aluminium material. The composite characteristics will be defined in other windows by selecting in "***Material Type***" the option "***Composite***".

The popup menu "***Y-Splitting***" gives the user the choice of the number of elements in the chordwise direction between 1 and 10, as shown in Figure 6.

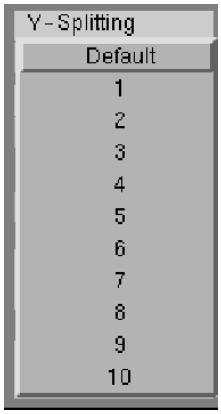

Figure 6: Y-Splitting popup menu

The popup menu "***X-Splitting***" gives the user the choice of the number of elements in the spanwise direction between 2 and 20. When the wing is defined in two parts, two popup menus will define the splitting such as "***Part 1 X-Splitting***" and "***Part 2 X-Splitting***".

Note that the more splitting the wing has, the longer the calculations will take.

As an example, the computing time* was evaluated for the following extreme cases:

X-splitting	Y-Splitting	Composite material	Time (in s)
2	1	No	**15**
20	10	No	**6200**
2	1	Yes	**40**
14	6	Yes	**8000**

* Defined with a Unix station HP-Apollo-series 700 for one aeroelasticity iteration.

"***NACA Airfoil***" popup menu will allow the user to define the airfoil section between 3 different families:

1. NACA 4 digits and modified 4-digits
2. NACA 5 digits and modified 5-digits
3. NACA ***n***-series.

For more information about NACA profile, refer to the "***Help***" button of respective windows. In any case, close the window using the button on the bottom right.

As an example, the NACA modified 5-digits is shown in Figure 7.

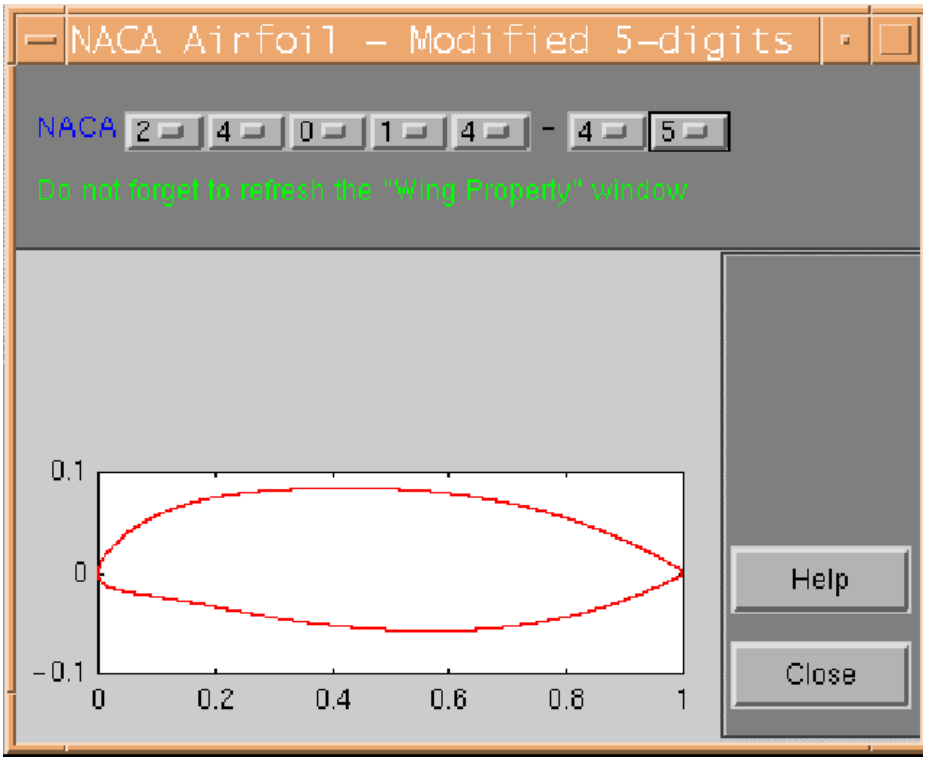

Figure 7: NACA modified 5-digits window

In the wing definition, only the camber line was modelled. The wing section was then modelled flat, with the airfoil maximum thickness for the wing thickness. Besides, the chord line was assumed to be the same as the zero-lift chord. *A*ero*W*ing version 1.2 is then expected to take into account the thickness distribution and to take into account the real chord line.

"***Refresh Window***" button will refresh the window, in case some changes were not displayed in the present window. It is advised to the user to refresh the window as often as possible.

"***Save Settings***" button will save all the settings of the wing that the user has just defined under the user's desired location, under the user's desired name, with the extension "***.mat***", as shown in Figure 8.

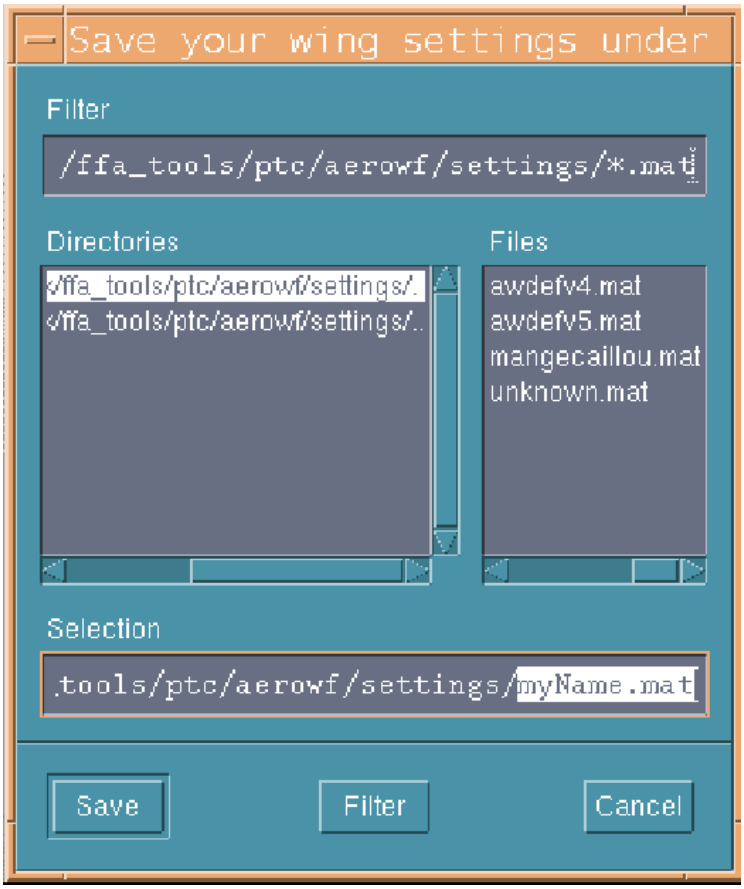

Figure 8: "Save settings" window

The "***Help***" button will open a window to give the user some help to use this "***Wing Property***" window.

The "***Back to AeroWing***" button will close the window and bring the user back to the main window.
The user must NOT close any window using the "close button" situated on the top right, but only using the "***Back to AeroWing***" button situated on the bottom right.

2.3. "Composite Stacking" window

When the "***Composite***" command is selected in the popup menu "***Material Type***", a new window "***Composite Stacking***" window will open, as show in Figure 9. This window allows the user to entirely define the composite skin of the wing.

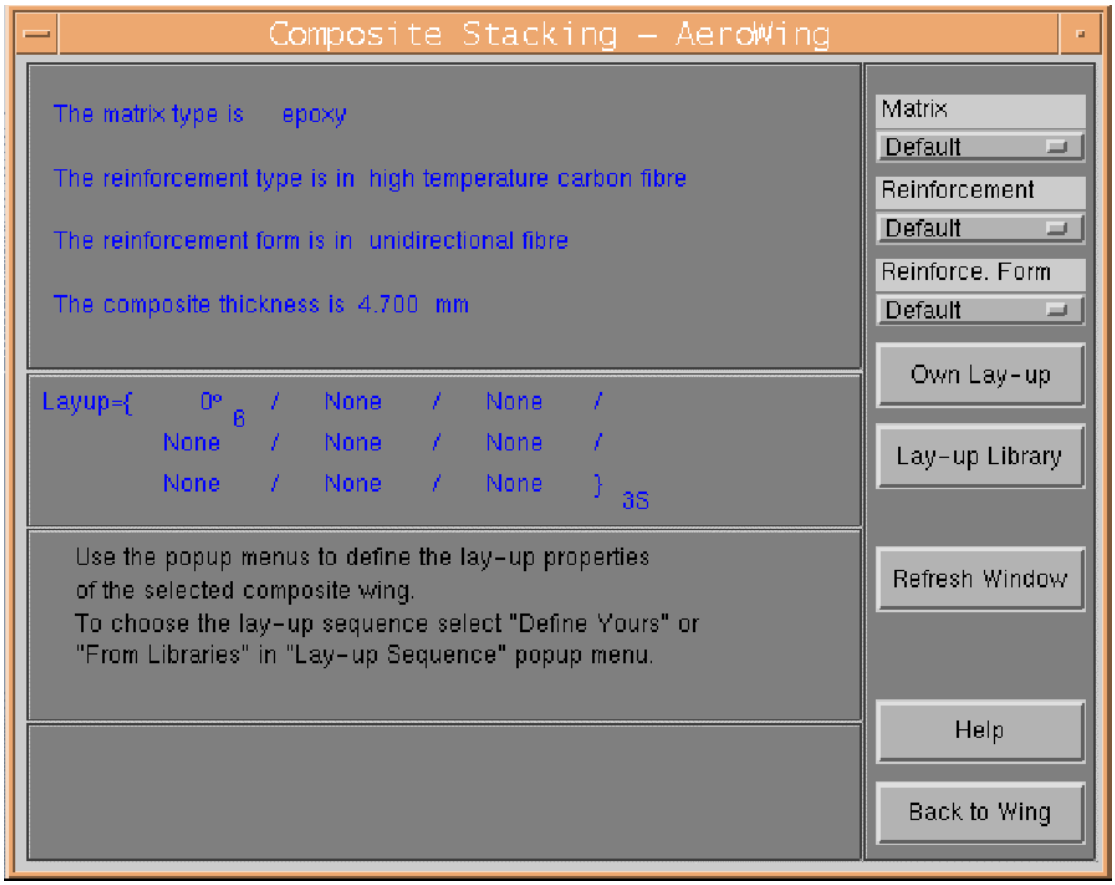

Figure 9: Composite stacking window

This window allows the user to select the matrix and reinforcement types, as well as the lay-up sequence. The reinforcement form includes only the "unidirectional" option. Later versions of AeroWing will include new reinforcement forms such as chopped fibre, weaving, non-crimp fabrics, knitting or mats.

For *aerodynamicians*, who do not know anything about composites, a brief summary follows.

Composite materials are one of the best innovations of recent decades. This material has a lot of advantages over other materials, such as 20% lower ratio weight/area than aluminium, stronger on privileged direction than advanced material used in aeronautics. The main disadvantages of the composites are time consumption, that is higher than for conventional alloy, the complexity of manufacturing, necessitating autoclave and skilled labour, and their weakness to low energy impacts.

However, the composites are made of several layers called ply stacked one on top of the others. Each ply is made of a matrix, often epoxy in aeronautics, which is reinforced by fibres, usually carbon or glass in aeronautics. The fibres can have several forms such as unidirectional, chopped fibres or fabrics. In aeronautics, the best quality and strength are expected, therefore only unidirectional fibre will be used, so far. Besides, each ply can be orientated differently to each other creating a lay-up (or stacking) sequence. The lay-up is the key of the whole composite structure, and will be the most difficult part of the composite wing to choose. Aircraft manufacturers usually hide the lay-up sequence they use in the composite structure, for reasons of competition.

After this small introduction on composites, only four parameters need to be defined by the user, the "***Matrix***", "***Reinforcement type***", "***Reinforcement form***" and "***Lay-up sequence***".

"***Matrix***" popup menu gives the user the libraries of available matrix type, as shown in Figure 10.

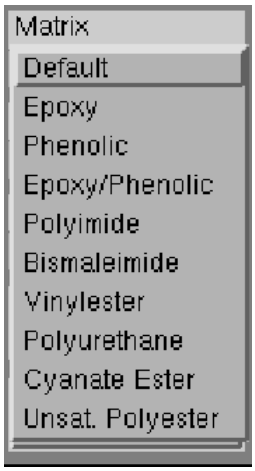

Figure 10: Matrix popup menu

"***Reinforcement***" popup menu gives the user the libraries of available reinforcement type, as shown in Figure 11.

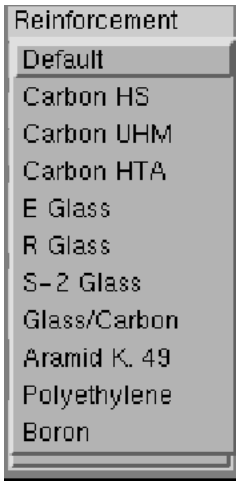

Figure 11: Reinforcement popup menu

"***Reinforcement form***" popup menu gives the user only the option of unidirectional reinforcement form. Other reinforcement forms are expected in the next version of AeroWing.

"***Own Lay-up***" button opens a new window called "***Free Hand Stacking Sequence***" which gives the user the opportunity to define freely the composite lay-up sequence of the wing to be studied.

"***Lay-up Library***" button opens a new window called "***Database Stacking Sequence***" which gives the user the opportunity to pick a composite lay-up sequence from a library.

The "***Help***" button will open a window to give the user some help to use this "***Composite Stacking***" window.

The "***Back to Wing***" button will close the window and bring the user back to the "***Wing Property***" window.
The user must NOT close any window using the "close button" situated on the top right, but only using the "***Back to Wing***" button situated on the bottom right.

Note: The composite plies are not individually modelled in the laminate, in order to save computing time, but are homogenised to a single layer, that is the skin.

2.4. "Free Hand Stacking Sequence" window

When the "***Own Lay-up***" button is pushed in the "***Composite Stacking***" window, a new window "***Free Hand Stacking Sequence***" window will open, as shown in Figure 12. This window allows the user to freely define the lay-up sequence of the composite skin.

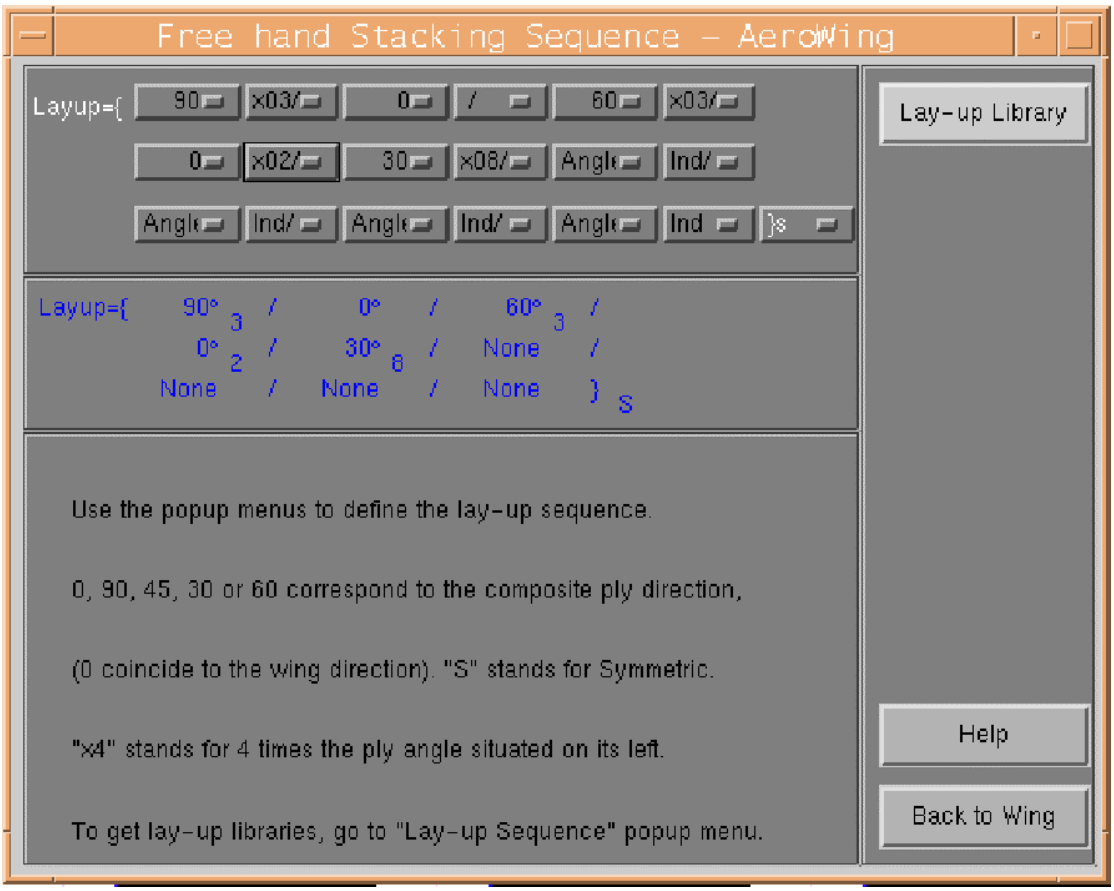

Figure 12: Free Hand Stacking Sequence window

The popup menus on the top left side of the present window define the lay-up sequence, as shown in the example of Figure 12. The selected lay-up sequence will be displayed in blue colour right below the popup menus.

For those again which are not familiar with the composites, brief summary is given on the lay-up code.

Let us study the following example:
$\{0_4/\pm45_4/\pm30_S/90_2\}=\{0/0/0/0/45/-45/45/-45/45/-45/45/-45/30/-30/-30/30/90/90\}$

Each *script* corresponds to an angle in degree only where 0° coincides with the spanwise direction (X-direction in the model), then 90° the chordwise direction (Y-direction in the model). Basically the subscript ***n*** defines the number of times of ply with the same orientation will be repeated (0_4 = 0°+0°+0°+0°). The subscript ***s*** stands for *symmetric*, meaning that for example:
$\pm 45°_S = (+45°)+(-45°)+(-45°)+(+45°)$.
Note that $\pm$ is different from $\mp$ in the plies order.
Besides, the subscript at the end of the lay-up (such as $\{\ \}_{4S}$) determines the number of times the part of the lay-up is repeated. This is for simplicity of the lay-up writing. When the subscript is just a number ***n***, the part of the lay-up is repeated ***n***-times. When the subscript is a number followed by ***s*** for symmetric, the symmetry is first applied and further the repeated number of times containing the symmetric part, such as:
$\{0_3/90\}_{3S}$ = {0/0/0/90/90/0/0/0}{0/0/0/90/90/0/0/0}{0/0/0/90/90/0/0/0}

"***Lay-up library***" button will close the present window to open the "***Database Stacking Sequence***" window to allow the user to select a lay-up from lay-up libraries.

The "***Help***" button will open a window to give the user some help to use this "***Free Hand Stacking Sequence***" window.

The "***Back to Wing***" button will close the window and bring the user back to the "***Wing Property***" window.
The user must NOT close any window using the "close button" situated on the top right, but only using the "***Back to Wing***" button situated on the bottom right.

2.5. "Database Stacking Sequence" window

When the "***Lay-up Library***" button is pushed in the "***Composite Stacking***" window, a new window "***Database Stacking Sequence***" window will open, as shown in Figure 13. This window allows the user to select a lay-up sequence of the composite skin from a lay-up library.

For more information on composite lay-up sequence, do refer to the previous section 2.4.
The libraries of lay-up are absolutely arbitrary. It is made to be customised by the user for simplicity reasons.

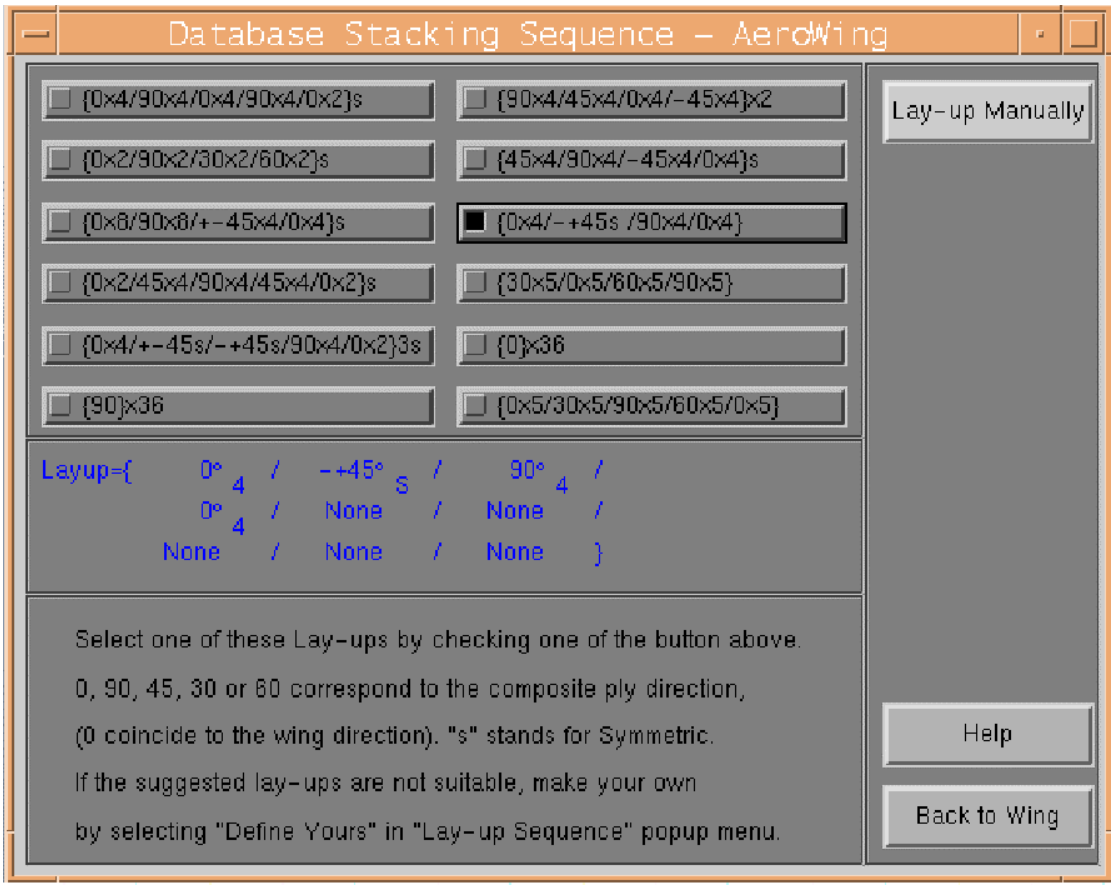

Figure 13: Database Stacking Sequence window

If the case where the user decides to go for the "***Free Hand Stacking Sequence***", just push the button "***Lay-up Manually***" on the top right of the window.

The "***Help***" button will open a window to give the user some help to use this "***Database Stacking Sequence***" window.

The "***Back to Wing***" button will close the window and bring the user back to the "***Wing Property***" window.
The user must NOT close any window using the "close button" situated on the top right, but only using the "***Back to Wing***" button situated on the bottom right.

Chapter 3 *ERROR AND WARNING MESSAGES*

Because nobody is perfect, the user might initiate some anomalies in the program, such as in the wing definition. Indeed, in the "***Wing Property***" window, the user is asked to define the wing geometry (in the free hand case only). In the case where the user defines somehow a zero chord, which does not exist in reality, the program will warn the user to resolve the mistake, as shown in Figure 14. Nevertheless, in the hypothesis the user would like to define a delta wing, where in the theory the tip chord is zero, the program will set by itself a chord of 1 millimetre (0.0394 inch). If this condition were not respected, the element defined at the tip would have an inhomogeneous shape, which will initiate error in the calculation by the finite element method.

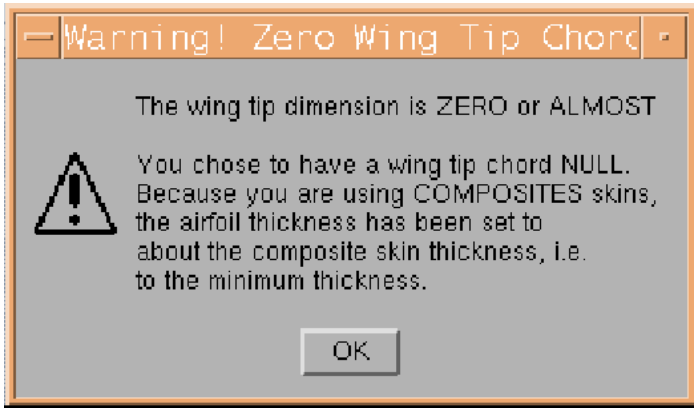

Figure 14: Warning message for zero chord at the wing tip

For the case where the user selects a composite wing (a wing made of two panels of composites), some constrains may appear, being warned by messages such as the one shown in Figure 15. Because the airfoil thickness is proportional to the airfoil chord, the airfoil thickness might be smaller than the two composite skin thicknesses, which is not physically possible. The program will thus make sure the distance between the two composite skins will remain positive.

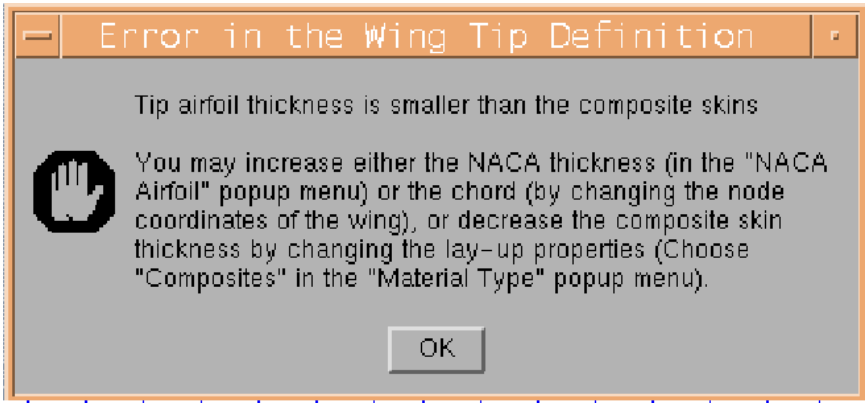

Figure 15: "Error in the wing definition" window

Besides, if changes in the Matlab license or in the computer platform occurred, the program AeroWing will warn the user to make sure the ***free license agreement*** has been read.

Chapter 4 *EXAMPLES*

The theory used in this program is reported in a report [3], and contains examples and checking of the results with experimental tests. The report can be sent on demand by Email at aerowing@engineer.com.

For the first example, the wing properties were:

Wing Type	Airbus 300-200
Material Type	Advanced Aluminium
Y-Splitting	2
X-Splitting	5
NACA Airfoil	5333
Angle of Attack (degree)	8
Velocity (Mach Number)	0.8
Altitude (km)	10
Magnification factor	5000

Table 1: Case of wing in AeroWing software

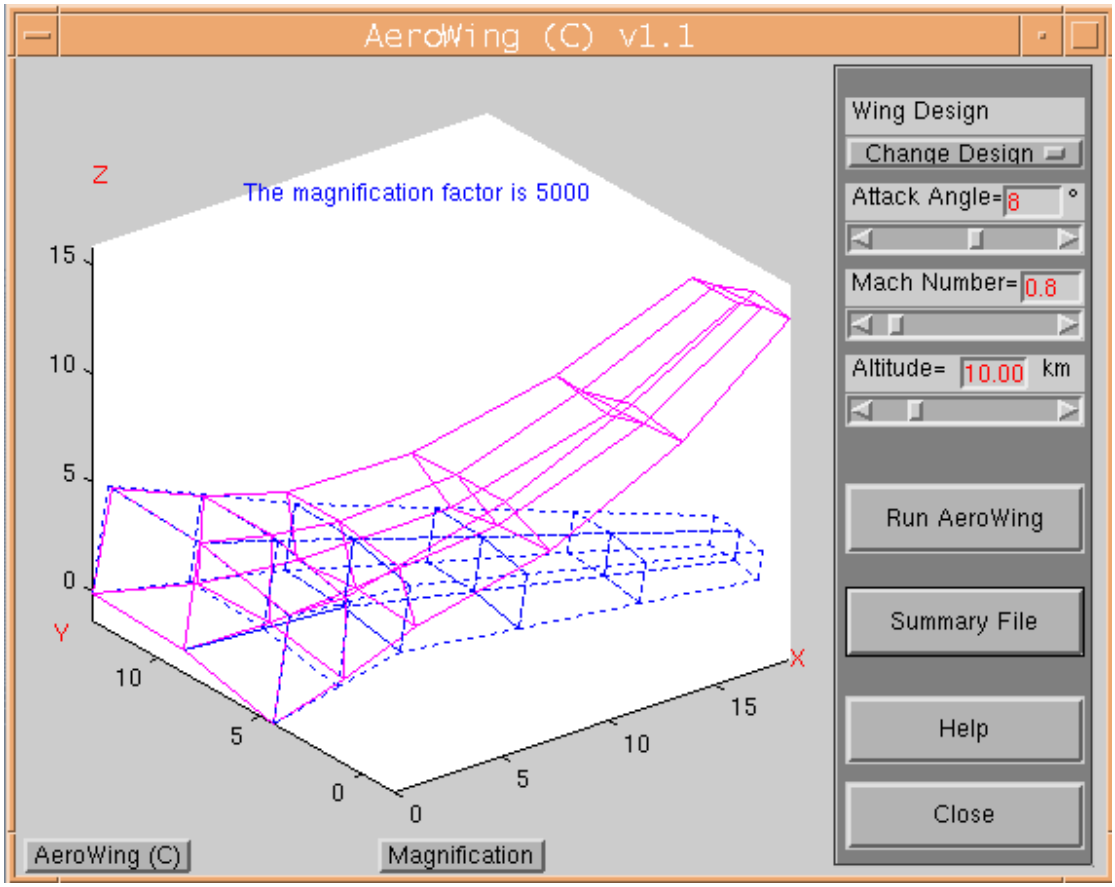

Figure 16: Example of 3D-displacement of a wing with data from Table 1.

For the second example, the wing properties were:

Wing Type	Dassault Rafale
Material Type	Composite
• **Matrix Type**	Epoxy
• **Reinforcement Type**	HTA
• **Reinforcement Form**	Continuous
• **Lay-up Sequence**	$(0_4/45_4/90_4/-45_4/0_2)_S$
• **Skin Thickness**	4.56 mm
• **Inner material type**	Advanced Aluminium
Y-Splitting	5
X-Splitting	6
NACA Airfoil	4508
Angle of Attack	4
Velocity (Mach Number)	2.2
Altitude (km)	12
Magnification factor	10000

Table 2: Case of wing in AeroWing software

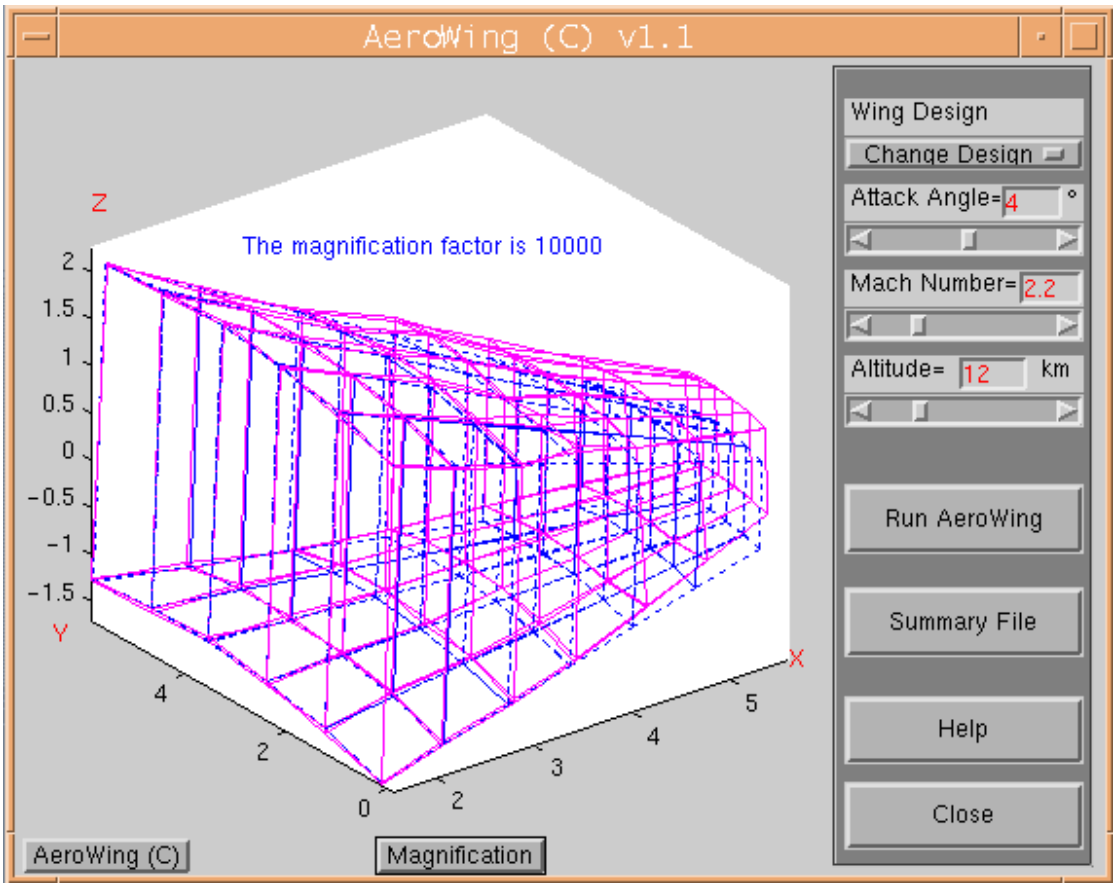

Figure 17: Example of 3D-displacement of a wing with data from Table 2.

Figure 16 shows the vortex ring elements, as well as the wake in solid lines, on the top of the finite wing. All panels are placed a quarter backward (towards the trailing edge) in order to fulfil the Kutta condition. The collocation points in dots, are placed in the centre of each vortex panel.

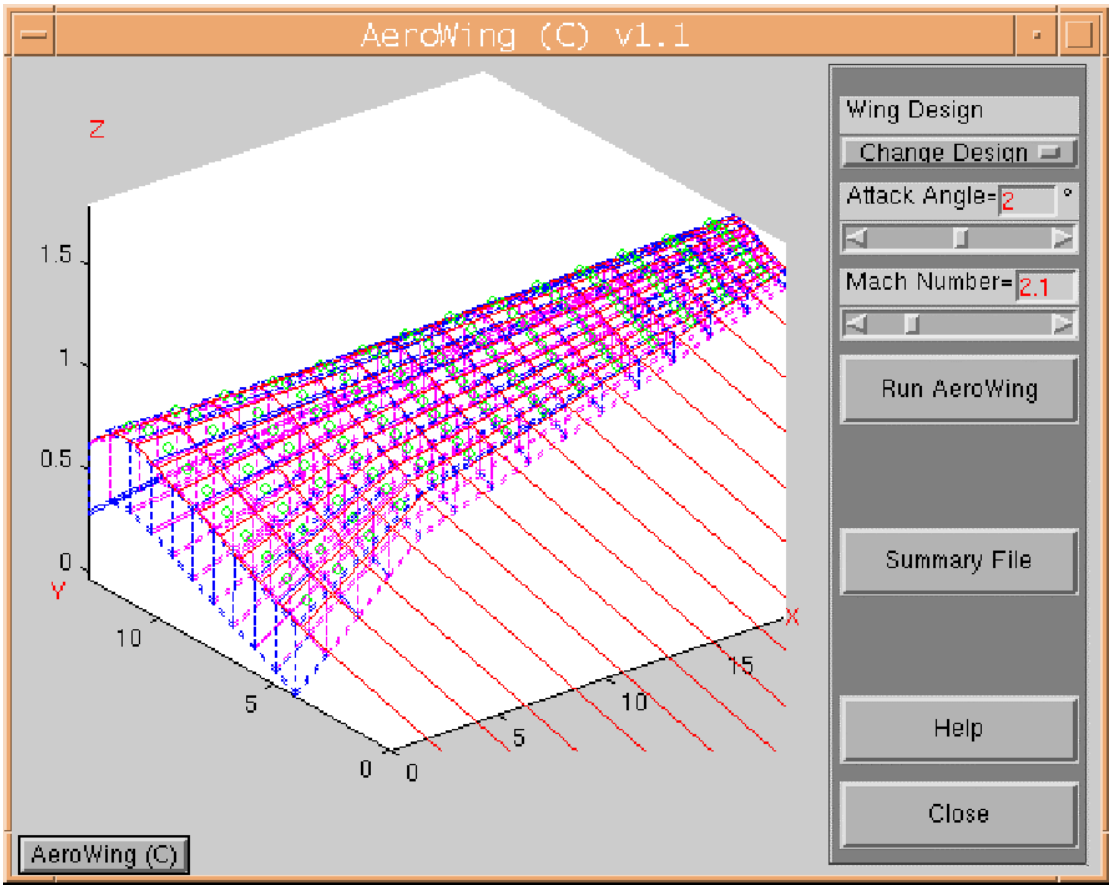

Figure 18: Vortex ring elements and wakes (in solid lines) and collocation points (in dots)

Appendix A: *WHAT IS WHAT IN THE PROGRAM?*

In order to make sure somebody succeeds in improving this program, this section is devoted to explaining what each file does and where to change different parameters. However, if the reader discovers bugs or has questions, do not hesitate to contact the authors at the following Email addresses:

aerowing@engineer.com or ptc@ffa.se

The main files:

Addaw.m : This M-file set the path of AeroWing folder in Matlab v5.

Aerow4.m : This M-file checks if the Matlab version 4 or platform changed, in order to display the license agreement.

Aerow5.m : This M-file checks if the Matlab version 5 or platform changed, in order to display the license agreement.

Aerowing.m : This M-file is the command to start Matlab from the directory it is placed and directs the user folder to the AeroWing folder "aerowf".

Aerowg.m : This M-file sets the Matlab path.

Airstd.m : This M-file defines the air properties at the selected altitude.

Awlicen.m : This M-file contains the free license agreement.

Awlicen.txt : This Text-file contains the free license agreement.

Awlicense.html : This HTML-file contains the free license agreement.

C.m : This M-file calculates the Theodorsen coefficient F and G of the Theodorsen function.

Css.m : This function is the User Interface for the Stacking Sequence of Composite materials. It works only with the file ***visu4d.m*** and with the program AeroWing.

Css2.m : This function is the User Interface for the Stacking Sequence of Composite materials. It works only with the file ***visu5d.m*** and with the program AeroWing.

Iae.m : This M-file is the file that concerns the main window so called "***AeroWing***".

Mae.m : This M-file defines the model nodes and elements.

Mae2.m : This M-file is the manager file of the program. It launches the program ***Vis2.m***, ***Vis3.m*** and ***Sif.m***.

Mag.m : This M-file launches the magnification window and displays the new wing without displacement and with magnified displacement.

Mal.m : This M-file checks if there are any elements with corners having angles greater than ***135°***, which cannot be handled by the finite element program.

Matdata.m : This M-file contains the material data of the matrix and the reinforcement. It also defines the 3-D material data for the composite skins.

Matlab.mat : This Mat-file is opened automatically by the Matlab program when the user starts to save data, and cancel the on-going process. Therefore, the data contained in this file are the saved data of the wing properties.

Nac16.m : This M-file is the graphic user interface for airfoil profile NACA series ***n***.

Nac4.m : This M-file is the graphic user interface for airfoil profile NACA 4 digits.

Nac4m.m : This M-file is the graphic user interface for airfoil profile NACA modified 4-digits.

Nac5.m : This M-file is the graphic user interface for airfoil profile NACA 5 digits.

Nac5m.m : This M-file is the graphic user interface for airfoil profile NACA modified 5-digits.

Naca.m : This M-file contains the thickness distribution and camber equations.

Pdis.m : This M-file calculates the pressure distribution of an arbitrary airfoil. This is the main file for defining the pressure distribution of an arbitrary airfoil section (Not completed).

Psifct.m : This M-file defines the function $\psi(\theta)$ used in ***Pdis.m*** (Not completed).

Rma.m : This M-file removes the angle of attack on the deformed wing for recalculation of the aerodynamic forces.

Rmaw.m : This M-file removes the AeroWing path from the Matlab v5 path.

Rmo : This Unix or Unix-like file removes the file "***_output.dat**" created by the finite element code which computed the displacement and the stresses.

Sif.m : This M-file defines the finite element input file (.dat) as well as the summary file (.sum).

Theo.m : This M-file calculates the moment and lift of an airfoil section for 2-D incompressible and steady flow, from the Theodorsen theory. This file is the main file for defining the lift and moment of thin plate by Theodorsen.

Uif.m : This M-file works together with ***iae.m***.

Vis2.m : This M-file displays the reference model in 3D.

Vis3.m : This M-file displays the loaded model in 3D.

Vis4.m : This M-file displays the magnified loaded model in 3D.

Visu3d.m : This M-file defines the graphic user interface of "***Wing Property***" window.

Visu4d.m : This M-file defines the graphic user interface of "***Composite Stacking***" window.

Visu5d.m : This M-file defines the graphic user interface of the "***Free Hand Stacking Sequence***".

Visu6d.m : This M-file defines the graphic user interface of the "***Database Stacking Sequence***".

Vorwing.m : This M-file is the main file that deals with the lift-surface solution by vortex ring element developed in reference 1.

Voring.m : This M-file calculates the induced velocity created by the four-segment strength that constitutes the vortex ring.

Voring2.m : This M-file calculates the induced velocity created by the two-segment strength that constitutes the trailing vortex segment.

Vortex.m : This M-file calculates the global velocity induced by the vortex ring and wake, taking into account the other half wing.

Vortxl.m : This M-file calculates the velocity induced by any segment.

Yoc16.m : This M-file is the function thickness distribution (in percent of chord), depending on the chord ordinate: y/c=f(x/c), for profile NACA series ***n***.

Yoc4.m : This M-file is the function thickness distribution (in percent of chord), depending on the chord ordinate: y/c=f(x/c), for profile NACA 4 digits.

Yoc4m.m : This M-file is the function thickness distribution (in percent of chord), depending on the chord ordinate: y/c=f(x/c), for profile NACA modified 4-digits.

Yoc5.m : This M-file is the function thickness distribution (in percent of chord), depending on the chord ordinate: y/c=f(x/c), for profile NACA 5 digits.

Yoc5m.m : This M-file is the function thickness distribution (in percent of chord), depending on the chord ordinate: y/c=f(x/c), for profile NACA modified 5-digits.

README.txt : This Text-file is the set-up explanation file. Do refer to this file for installation. Do not forget to change this file if any changes where performed by the reader.

20nodes.f : This source file is the finite element code file in FORTRAN 77.

20nodes.exe : This executable file is the finite element code file in FORTRAN 77.

inputname.inp : This file is the finite element result file containing the node displacement field.

20node : This Unix file only executes the program 20nodes.exe and transfers output file to the main directory for FEM calculations.

The data files for Matlab v5 (under Database folder):

s2sa.mat : *s1*=Part 1 x-splitting, *s2*=Part 2 x-splitting.

labsa.mat. : *labs, labl, labs5, labl5, nafore, naback, napm, btnPospop* are information for defining the colour and position and changes in popup menus.

choicesa.mat : *choice, choice5, col, col5, col5_text, col_text, switch1, switch2, colorStr2* are variables to define the colour and position and changes in popup menus.

visu3dsa.mat : *evalStr* is the string used in the ***visu3d.m*** file.

thicksa.mat : *thickness* is the thickness of the NACA profile.

nacasa.mat : *yocpup* and *yocpun* are the thickness distributions of the NACA profile and *yocpc* is the camber distribution. *Supemax* is the maximum thickness value.

nodesa.mat : *x1 y1 z1, x2 y2 z2, x3 y3 z3, x4 y4 z4, x5 y5 z5, x6 y6 z6* are the node coordinates of the six main nodes defining the complete wing. *1* corresponds to the top root and *6* to the bottom root. Note that *2* here is the top middle node, *3* is the top tip node, *4* is the bottom tip node and *5* is the bottom middle node.

nonewsa.mat : nodevis3a is the new node and displacement at the last iteration of the aeroelasticity feedback for the specific accuracy.

comppsa.mat : *matrixStr2 reinfStr2 reinffStr2 thickStr2* are some data displayed in ***visu4d.m***.

angixsa.mat : *angle_ind* contains all angles of all plies defined in the composite stacking sequence.

visu4dsa.mat : *wevalStr* is the command string data for the file ***visu4d.m***.

angdisa.mat : *angle_disp2* is the set of ply angles, *angle_disp3* is the set of corresponding subscripts of the ply angles and *angle_disp4* is the last subscript concerning the whole lay-up block.

lmplysa.mat : *nbrlaminae* is the number of composite layers and *lsss2* is a string describing the lay-up.

visu5dsa.mat : *levalStr* is the command string data for the file ***visu5d.m*** and ***visu6d.m***.

lyupsa.mat : *layup* is the string defining the lay-up.

dat2sa.mat : *angle_ind2 bomb16* are parameters used in the file ***visu6d.m***.

visu6dsa.mat : *levalStr* is the command string data for the file ***visu5d.m*** and ***visu6d.m***.

nacnasa.mat : *nacav1 nacav2 nacav3 nacav4 nacav5 nacava nacavb nacav16a nacav16b nacav16c nacav16d nacav16e mltam cliu mltan clil* are the parameters used to identify a NACA airfoil.

matersa.mat : *thickStr volumf e11l e22l e33l g12l g13l g23l nu12l nu13l nu23l* are the material data of composite laminate defined by the "Simplified Composite Micromechanics Equations for Hygral, Thermal and Mechanical Properties", Nasa Technical Memorandum 83320.

mahosa.mat : *rhoho eho nuho wingdefws wingdefwm* are the material data for homogeneous materials.

perset.mat : *newmatfile newpath* are the file name and file location given by the user for the results.

ataksa.mat : *attack* is the angle of attack in degree and *speed* is the velocity in Mach number.

commsa.mat : *wlibrary_comment* is the string comment in file ***visu3d.m***.

***elemsa*.mat** : *element* is the element code, *node* is the node coordinates of the referenced mesh, *elem* is a part of *element*, *nxestr* is the number of element in the x-direction, *nyestr* is the number of element in the y-direction, *nzestr* is the number of element in the z-direction.

invisa.mat : *initvis* is the index to check if this program was started for the first time of not.

layupsa.mat : Parameters for setting the lay-up display in ***visu4d.m***.

nbl5.mat : i*ndexation* and *licensmatlab* are parameters to check to state of change in terms of matlab version or computer platform.

awpfp.mat : This file contains the image of the first window for MATLAB v5.

The data files for Matlab v4 (under Database folder):

pcs2sa.mat : *s1*=Part 1 x-splitting, *s2*=Part 2 x-splitting.

pcbsa.mat. : *labs, labl, labs5, labl5, nafore, naback, napm, btnPospop* are information for defining the colour and position and changes in popup menus.

pcoicesa.mat : *choice, choice5, col, col5, col5_text, col_text, switch1, switch2, colorStr2* are variables to define the colour and position and changes in popup menus.

pcsu3dsa.mat : *evalStr* is the string used in the ***visu3d.m*** file.

pcicksa.mat : *thickness* is the thickness of the NACA profile.

pccasa.mat : *yocpup* and *yocpun* are the thickness distributions of the NACA profile and *yocpc* is the camber distribution. *Supemax* is the maximum thickness value.

pcdesa.mat : *x1 y1 z1, x2 y2 z2, x3 y3 z3, x4 y4 z4, x5 y5 z5, x6 y6 z6* are the node coordinates of the six main nodes defining the complete wing. *1* corresponds to the top root and *6* to the bottom root. Note that *2* here is the top middle node, *3* is the top tip node, *4* is the bottom tip node and *5* is the bottom middle node.

pcnewsa.mat : nodevis3a is the new node and displacement at the last iteration of the aeroelasticity feedback for the specific accuracy.

pcmppsa.mat : *matrixStr2 reinfStr2 reinffStr2 thickStr2* are some data displayed in ***visu4d.m***.

pcgixsa.mat : *angle_ind* contains all angles of all plies defined in the composite stacking sequence.

pcsu4dsa.mat : *wevalStr* is the command string data for the file ***visu4d.m***.

pcgdisa.mat : *angle_disp2* is the set of ply angles, *angle_disp3* is the set of corresponding subscripts of the ply angles and *angle_disp4* is the last subscript concerning the whole lay-up block.

pcplysa.mat : *nbrlaminae* is the number of composite layers and *lsss2* is a string describing the lay-up.

pcsu5dsa.mat : *levalStr* is the command string data for the file ***visu5d.m*** and ***visu6d.m***.

pcupsa.mat : *layup* is the string defining the lay-up.

pct2sa.mat : *angle_ind2 bomb16* are parameters used in the file ***visu6d.m***.

pcsu6dsa.mat : *levalStr* is the command string data for the file ***visu5d.m*** and ***visu6d.m***.

pccnasa.mat : *nacav1 nacav2 nacav3 nacav4 nacav5 nacava nacavb nacav16a nacav16b nacav16c nacav16d nacav16e mltam cliu mltan clil* are the parameters used to identify a NACA airfoil.

pctersa.mat : *thickStr volumf e11l e22l e33l g12l g13l g23l nu12l nu13l nu23l* are the material data of composite laminate defined by the "Simplified Composite Micromechanics Equations for Hygral, Thermal and Mechanical Properties", Nasa Technical Memorandum 83320.

pchosa.mat : *rhoho eho nuho wingdefws wingdefwm* are the material data for homogeneous materials.

pcrset.mat : *newmatfile newpath* are the file name and file location given by the user for the results.

pcaksa.mat : *attack* is the angle of attack in degree and *speed* is the velocity in Mach number.

pcmmsa.mat : *wlibrary_comment* is the string comment in file ***visu3d.m***.

***pcemsa*.mat** : *element* is the element code, *node* is the node coordinates of the referenced mesh, *elem* is a part of *element*, *nxestr* is the number of element in the x-direction, *nyestr* is the number of element in the y-direction, *nzestr* is the number of element in the z-direction.

pcvisa.mat : *initvis* is the index to check if this program was started for the first time of not.

pcyupsa.mat *:* Parameters for setting the lay-up display in ***visu4d.m***.

nbl4.mat : i*ndexation* and *licensmatlab* are parameters to check to state of change in terms of Matlab version or computer platform.

The setting files (under Settings folder):

Unknown.mat : This file is an example file for the first user. ***Warning!!***, this file should remain if the administrator or the user decides to delete useless files of this folder "*Settings*".

Note: It might be some more files, but it would have been files defined by the previous users or works.

All files with the extension ***.mat*** correspond to the files that contain *wing properties* data.
All files with the extension ***.dat*** are the *input file* of the finite element code.
All files with the extension ***_output.dat*** are the *output file* of the finite element code.
All files with the extension ***.sum*** are the corresponding *summary file* to help the user.

Appendix B: *REFERENCES*

[1] J. Katz and A. Plotkin, *Low-Speed Aerodynamics*: From Wing Theory to panel Methods, McGraw-Hill ed., 1991

[2] I. M. Smith and D. V. Griffiths, *Programming the finite element method*, Second edition, ed. John Wiley & Sons Ltd., 1988

[3] C. A. Paget and J. Matrat, *Advanced topic in Aeronautics: A 3-D Aeroelastic Program*, internal report, FFA-KTH, 1999