www.geminiaerotools.com

Gemini Aero Designer

A powerful, reliable and user-friendly planes analysis tool for RC, UAV and ultralight aircrafts

Made for hobbyists and engineers by hobbyists and engineers

User manual

v1.0.2.0
Update : 2025.07.01

TABLE OF CONTENTS

1 Introduction

Gemini Aero Designer (G.A.D.) is a software package for the analysis and design of airfoils, wings and aircraft running on Microsoft Windows and Linux, ranging from micro RC to ULM, including fixed-wing UAVs. It's aimed at curious modelers and model aircraft designers, as well as drone professionals, academics and aeronautical engineering schools, not forgetting amateur ultralight builders.

Thanks to the real-time refreshing of calculations, the vast majority of aircraft configurations (aircraft, gliders, jets, hang gliders, ducks, etc.) can be designed or simply verified with maximum efficiency and minimum time.

G.A.D.'s modular architecture makes it very easy to share different files (airfoils, polars, aircraft, wind tunnel results, etc.) with other users. This modular architecture also means that G.A.D. can be easily maintained and improved over time. A forum is also available for suggestions for new functions and bug reports.

A few highlights :

- Handle multi-panel and elliptic-like lifting surfaces, multifoil wings with dihedral and twist, normal or V-Tail, most of fuselage configurations
- Simultaneous analysis : 3D VLM dual-coupled (linear and non-linear) with xFoil + 1.5D extended Polhamus Wing(s) and plane analysis at user fixed or variable parameters (AOA, speed, lift, motor flight at level and climb)
- Instant refresh of drawings, results and analysis on plane modification
- Reliable neutral points estimation with fuse effect and A.C. extended Küchemann's correction
- CSV data export
- Advanced airfoil workshop : Bezier & Spline curves, NACA generator, point by point or global modification, graphic and text editor, etc.
- Airfoil polar generation, visualization and comparison , with 2D and 3D polar : Alpha, Cl, Cd, Cm, Cl/Cd and boundary layer at any Reynolds
- Automatic Reynolds non-linear interpolator with sensitivity analysis and critical Reynolds identification
- Advanced Aspect Ratio design and tuning module
- Advanced Motor and Propeller (static + in flight) simulation module
- Integrated notepad like editor to store comments associated to plane, wings, polar, etc.

Some possible results :

- Designing, modifying and blowing a airfoil
- Determining the settings (centering, incidences) of an aircraft
- Orientation of design choices (airfoils, aspect ratio, wing and tail geometry,tail volume, etc.)
- Glide performance curves, at constant speed and under power (level + climb)
- Determination of the optimum motorisation for a desired operating point
- Servo sizing (coming soon)

Gemini Aero Designer can be used in two different ways:

- Direct design, starting from a blank sheet of paper.
- Reverse engineering engineer of an existing aircraft, using measurements, a 3-view drawing or simply a top-view photo, for example to check the centring and trim settings

Gemini Aero Designer is supplied as is, and the author cannot be held liable in any way whatsoever in the event of an accident involving an aircraft designed or adjusted using this software.

2 General presentation

2.1 Compatibiliy

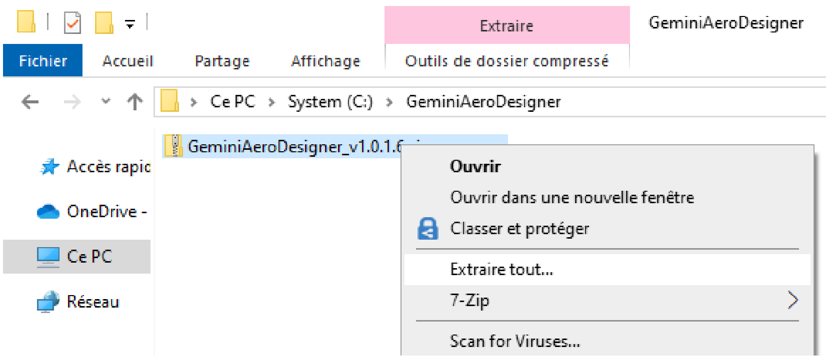
G.A.D. runs on Windows, from 7 to 11, in 32 and 64 bits.

It is also compatible with Linux (requires WinHQ and WineTricks) and potentially MacOS (untested, with the same tools as for Linux). In all cases, the .NET Framework 4.5 or higher must be installed (recommended: 4.8).

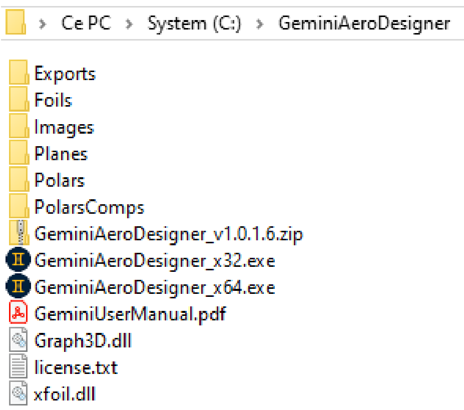
2.2 Installation and package contents

G.A.D. works in portable mode, i.e. without formal installation. All you need to do is :

- copy the zip file to the G.A.D. installation folder of your choice (on a hard disk or USB key), for example C:\GeminiAeroDesigner :



- extract the contents of the archive into this folder, using the Windows tool or a dedicated tool (7Zip, WinZip, WinRar, etc.) :



- Launch the application by double-clicking on ‘GemeniAeroDesigner.exe’ (32 or 64 bits)

NOTA : several instances of G.A.D. can be launched simultaneously, and each can open the same file as the others (for example to study the same pairfoil or aircraft simultaneously with different parameters).

2.3 Data handled and associated files

Several types of file are handled:

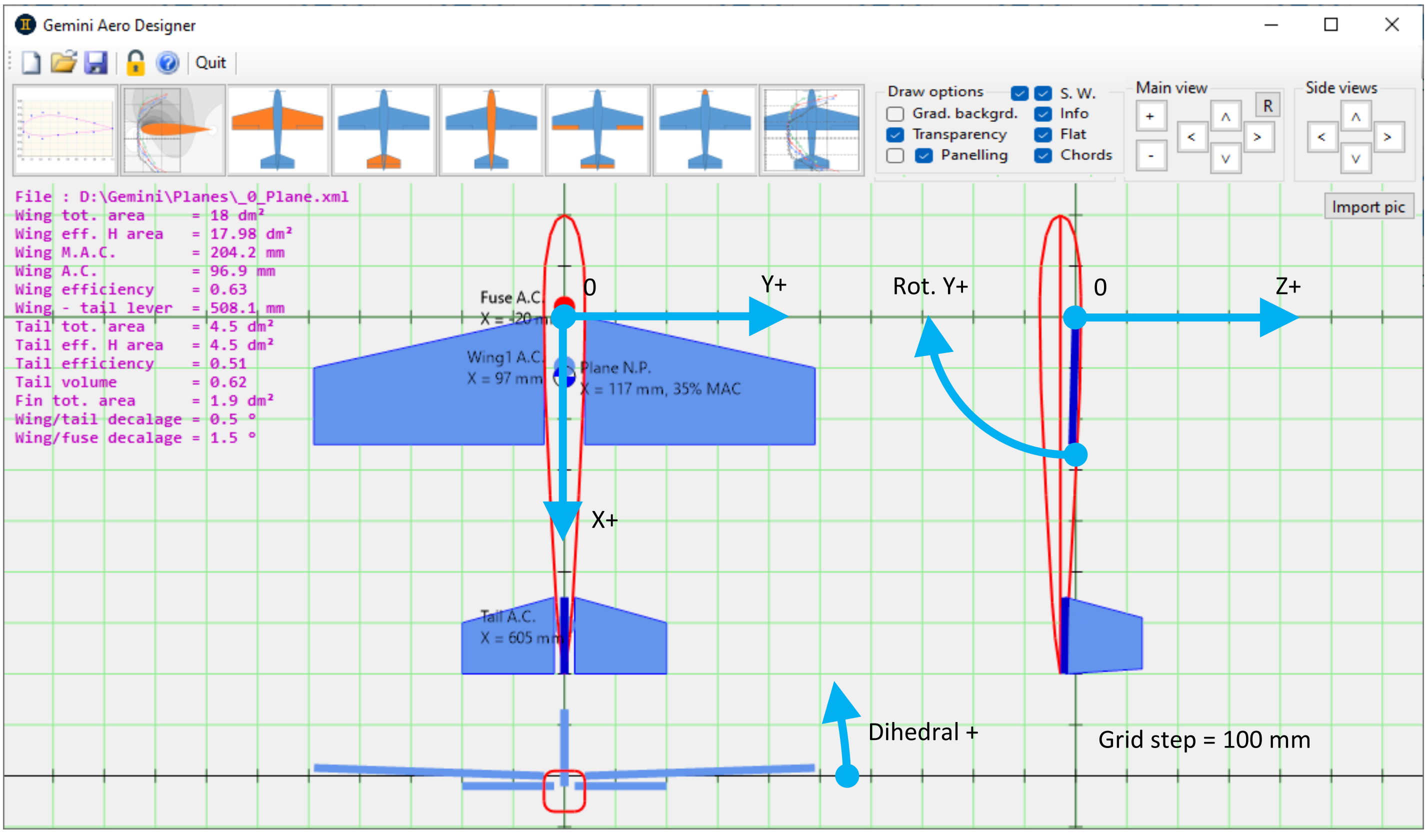
- aircrafts : .xml format, \Planes folder
- airfoils : Selig (text) .dat format and vectoriel files (.dxf, .plt, hpgl, .eps), \Foils folder
- airfoils profipolar: .xml format, \FoilsPolars folder
- polar comparisons : .xml format, \ FoilsPolars\Comparisons folder
- aircraft performance : .xml format, \PlanesPerfs folder
- aircraft performance comparisons : .xml format, \PlanesPerfsComparisons folder
- templates for aircraft perfs. : .xml format, \PlanesPerfs\ Comparisons\Templates folder
- export (aircraft or wing performance) : .csv format, \Exports folder
- images (background or screenshot) : .png or .jpg format, folder \Images

Certain types of complex file contain others:

- a polar file contains the polar points calculated by xFoil, as well as the .dat airfoil used to generate them and a note.
- a polar comparison file contains several polars (each of which contains the associated airfoil) and a note.
- an aircraft file contains, in addition to geometry data, polar files, a background image and a note.

All the files are independent of each other, because using one file (e.g. an airfoil polar) in another (e.g. in an aircraft) duplicates the first in the latter. Via the user interface, each included sub-file can later be extracted for reuse separately from its container file.
For example, it is possible to extract the .xml airfoil polars from an aircraft file and then the .dat airfoil files, e.g. if the source files are lost. This logic means that files can be reused in other projects without having to regenerate them within the new project.

2.4 Main interface

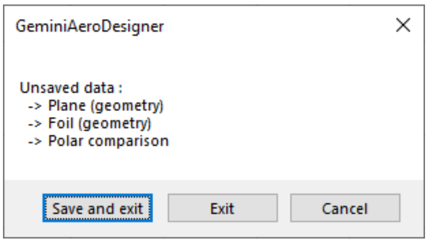


2.5 Main menu

The buttons relating to the files (new, open, save) only concern the aircraft being studied, and have no influence on the other data manipulated by G.A.D (airfoils and polars).

2.1 Closing the application

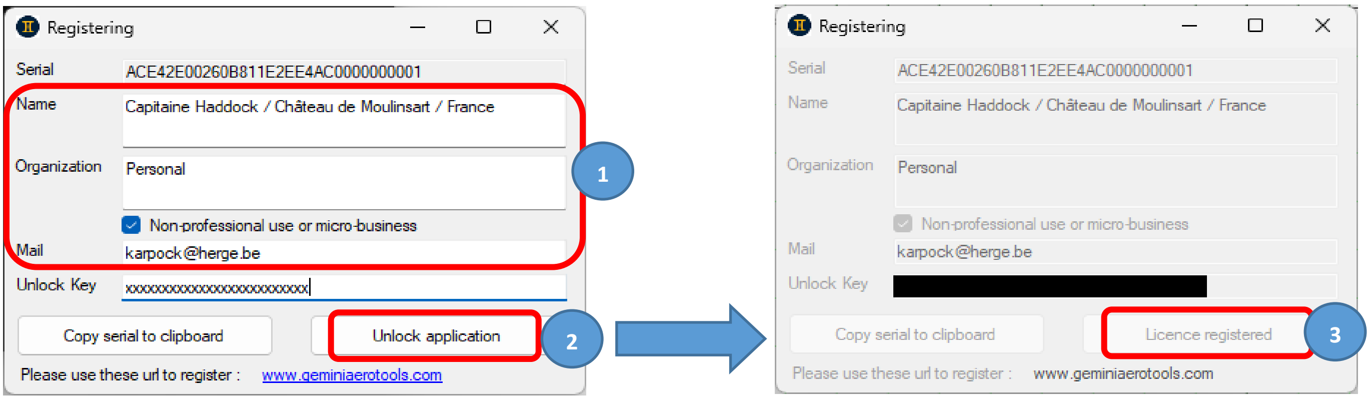
On closing, G.A.D. displays the unsaved data by type :



Warning: by default, ‘Save and exit’ only saves aircraft data; for airfoil and polar data, you must cancel the close and go to each workshop to save the data.

2.2 Registering

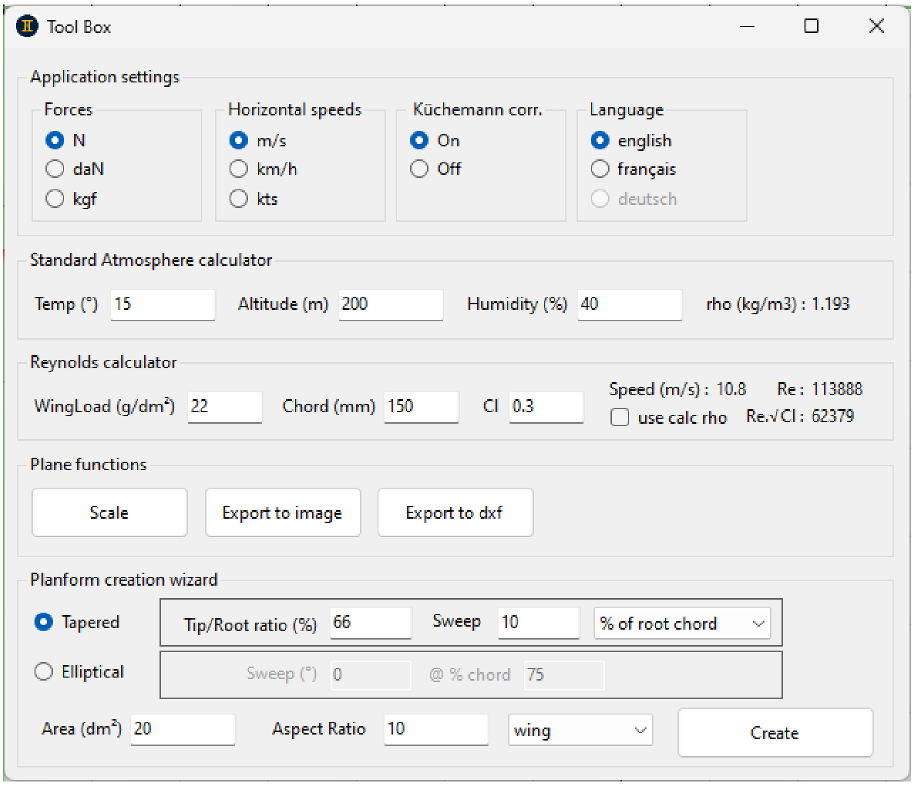
Use the copy/paste function to enter the licence data from the email. Please note that each character (lower case, upper case, etc.) counts for the unlock key to work.



2.3 Toolbox

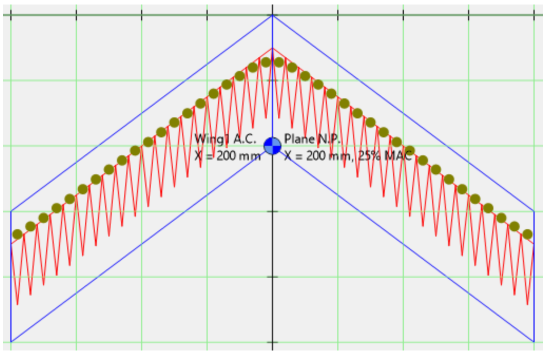
The toolbox is used to configure the application (units and language) and provides tools to help you use G.A.D.:

- automatic wing planform creation
- Reynolds and density calculator
- for the aircraft under study: scaling, export as an image or as a vector .dxf file.

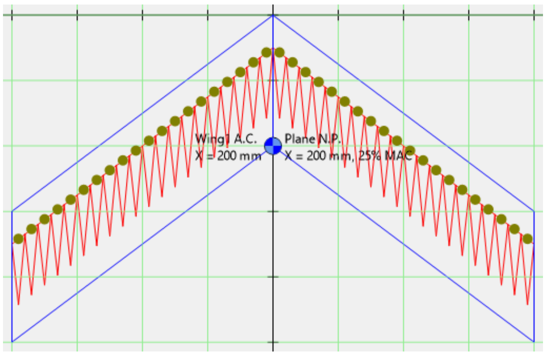


The Küchemann correction (active by default and can be deactivated if required) modifies the position of the local geometric foci used in the VLM calculation, as a function of the change in deflection at the interface between two panels. This correction anticipates airflow deviation at the leading edge, and in particular improves the accuracy of the flying wing moment calculation.

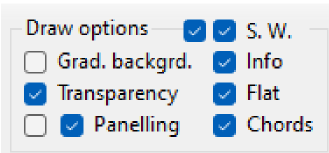
With correction :



Without correction :



2.4 Drawing options



The options define the graphical appearance of the aircraft drawings:

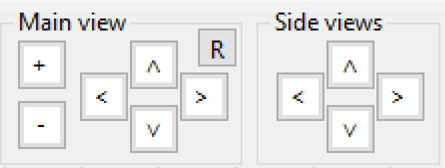
- plain or gradient background colour
- transparent or coloured wing surfaces
- display of VLM panels
- display of intermediate chords
- aircraft information in the background
- flattening (momentary removal of the dihedral) of the wings in plan view (very useful for

reverse engineering on a 3-view plan)

The S.W. ('Save Windows') buttons can be used to :

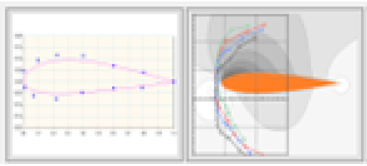
- save windows that are still open when the application is closed, so that they can be restored when it is restarted
- save the size and position of windows, so that they can be restored when the application is reopened.

2.5 Drawing scale and view positioning



The arrows position the views on the grid (at 100 mm intervals), while the '+' and '-' buttons adjust the drawing scale. The 'R' button restores the default value.

2.6 Airfoil editing and polar modules

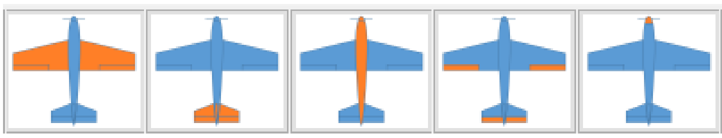


The airfoil design module lets you open an existing airfoil or create a new one from scratch or from an imported image, then modify it (point by point or globally), etc., and finally generate its polar curve. Note that polar generation automatically covers a flight envelope ranging from micro RC to ULM size, with automatic quality control of the result.

The polar comparison module allows you to view one or more polars, at blow-by Reynolds as well as at any Reynolds thanks to the Cm/Cl/Cd/Alpha non-linear interpolator. Among other things, you can also identify the critical Reynolds, carry out an elongation study for the airfoil under study, etc.

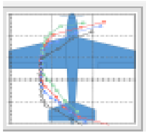
Note that these two modules are independent of the other modules in the application (which are linked to the aircraft), and have their own file opening and saving functions.

2.7 Aircraft editing modules



The icons speak for themselves... Each opens a screen dedicated to the object being manipulated (wings, empennage, fuselage, control surfaces, engine, see details below), bearing in mind that several screens open at the same time communicate with each other (e.g. the stabiliser volume is recalculated in the empennage screen when the wings are modified).

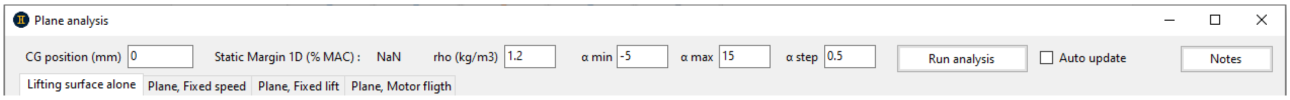
2.8 Performance and behaviour analysis module



This module is used to generate polar diagrams of the aircraft and its components :

- of the wings and tail, at constant speed
- the aircraft at imposed speed
- the aircraft at imposed lift (glide, level flight)
- powered flight (level flight, climb)

This is where the Centre of Gravity, flight speeds and weights are entered :



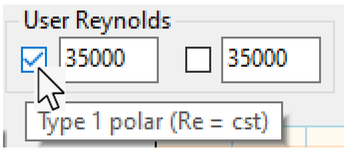
2.9 Methods for entering values

There are two methods:

- from the keyboard, with two ways of entering the cell:
    - with the tab key from the neighbouring cell, in which case the content is automatically preselected
    - by clicking directly with the mouse to select the value to be modified
- with the mouse wheel (press the ‘ctrl’ key to increase the step by a factor of 10), by positioning the mouse cursor on the cell to be modified (no need to select the contents).

2.10 Contextual help

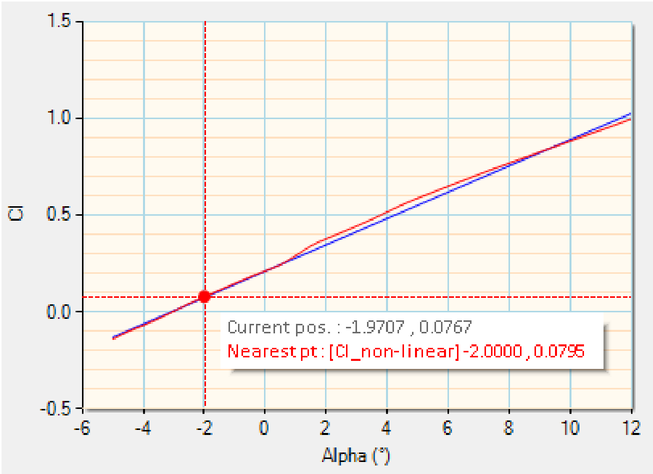
Many cells, checkboxes and texts are accompanied by a help comment, which is displayed when the mouse cursor is held over the area in question for approximately one second :



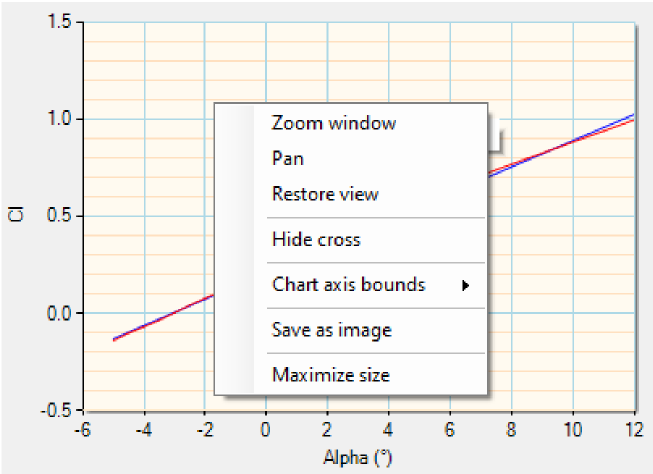
2.11 Chart options

By default, the cursor is a measurement cross, which indicates its current coordinates in text.

Moving the cursor over curves also displays the nearest point (highlighted on the curve) and the name of the associated curve :

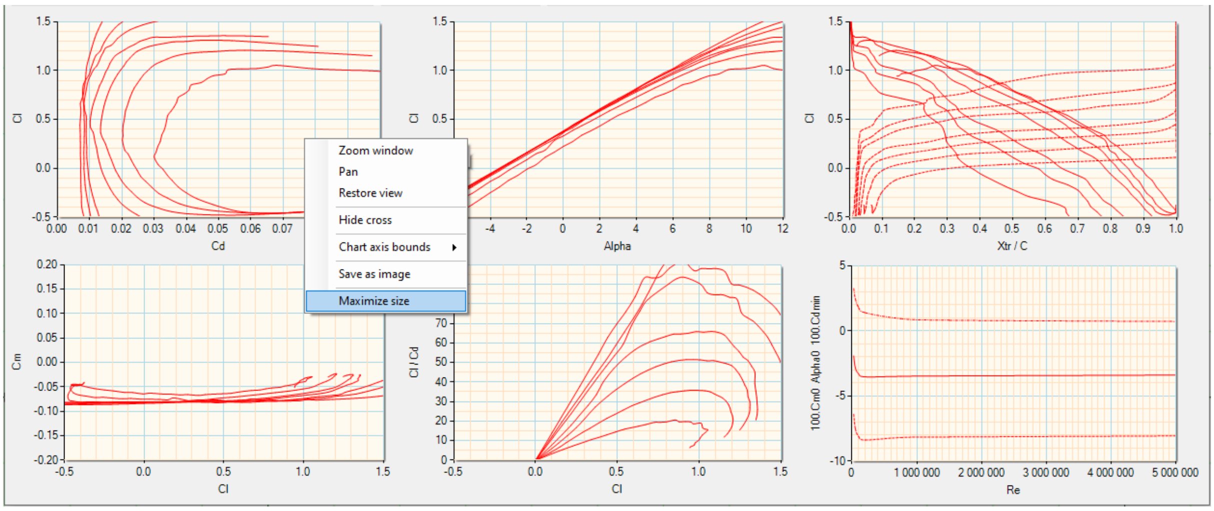


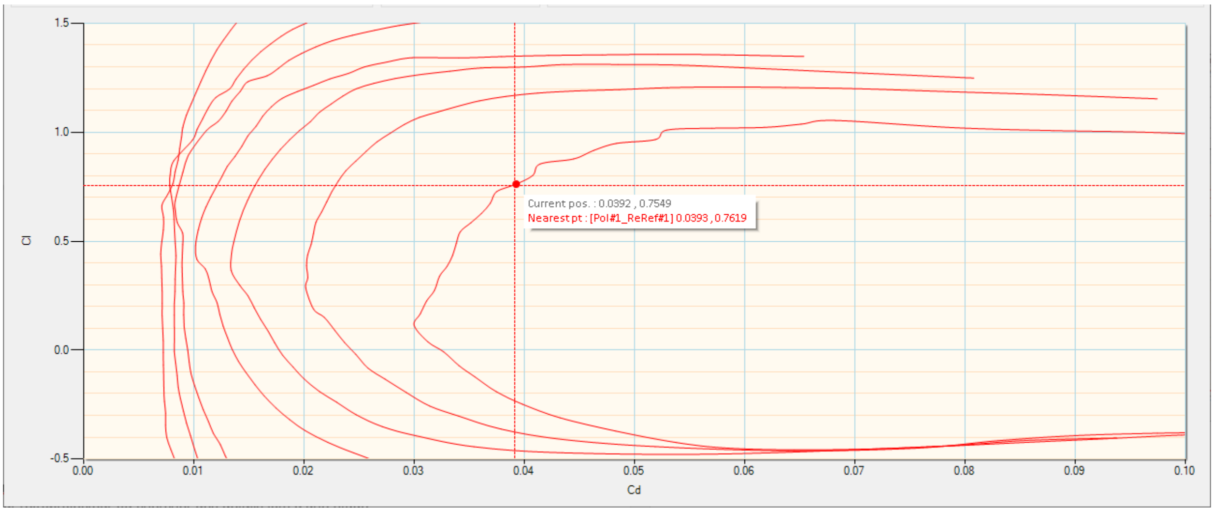
Right-clicking on a graph opens a popup menu :



The 'Chart axis bounds' function allows you to manually change the scale of the chart along each axis, with the min, max and step for each axis.

The 'Maximize size' function enlarges the chart to the size of the screen, which is very useful for an overhead projector presentation or for finding details during a study.





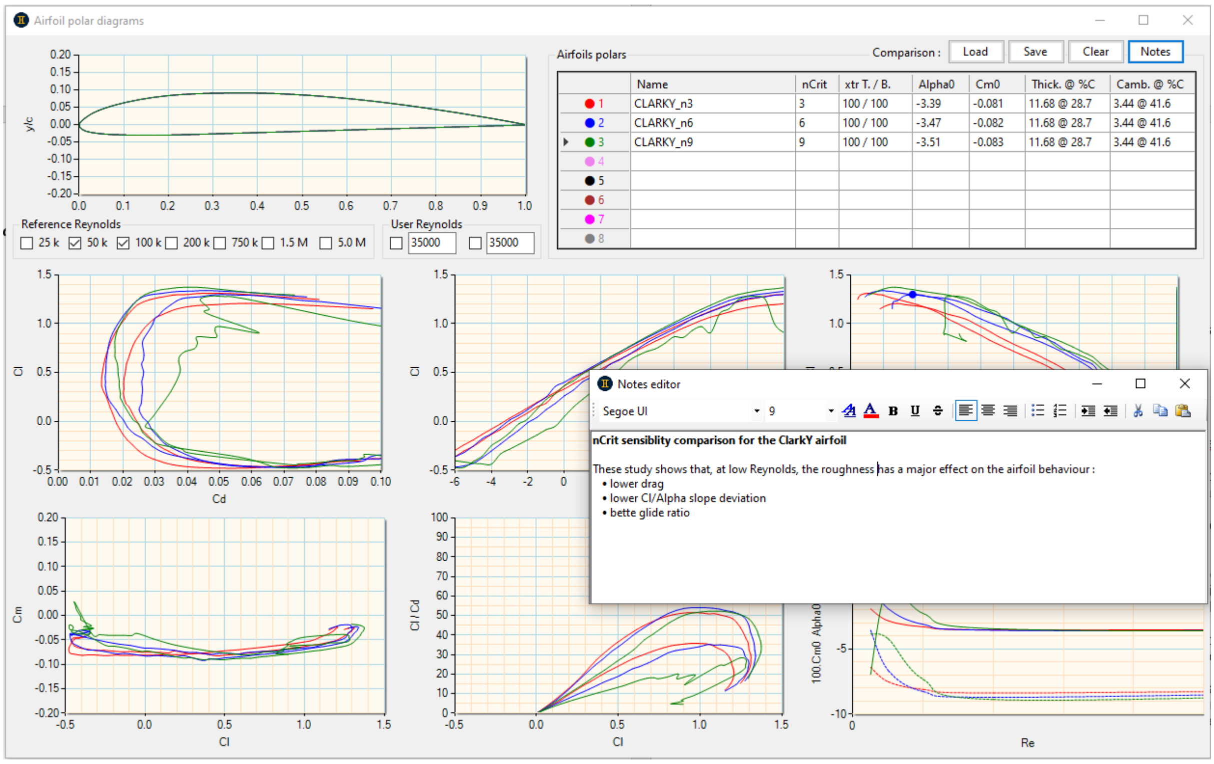
To return to normal display, reopen the popup menu and click on 'Return to normal size'.

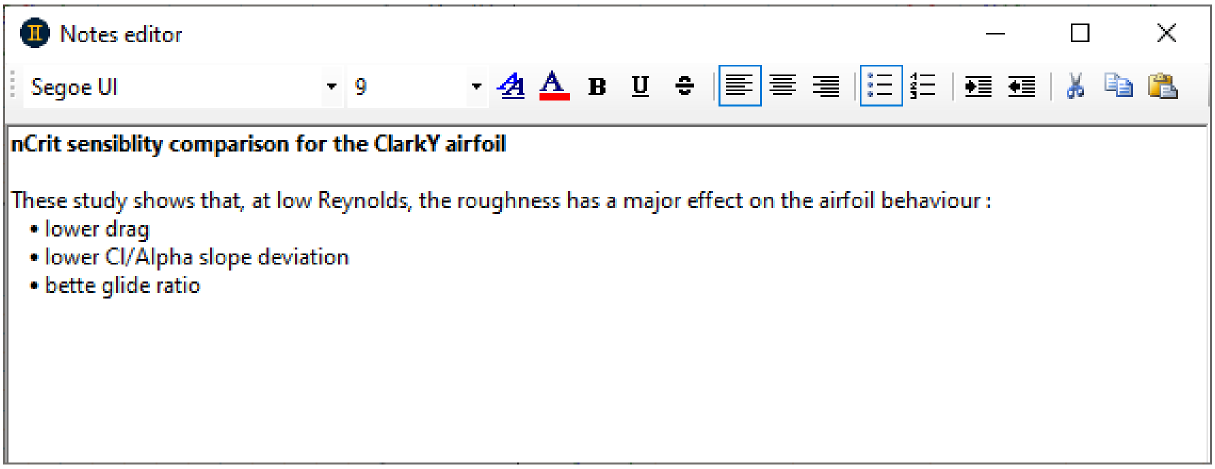
2.12 Notes editor

Each complex object manipulated by Gemini (polars, comparison of polars, aircraft) includes a 'note', which can be used to store text information: for example, explanations of work in progress, or a reminder.

The note, which opens a NotePad-style editor, is accessed from the window managing the objects being manipulated. In the case of the aircraft, which uses several windows, the note is accessed from the performance analysis.

Example of a note, here relating to a comparison of airfoil polars :




Notes editor
Segoe UI
9
nCrit sensiblity comparison for the ClarkY airfoil
These study shows that, at low Reynolds, the roughness has a major effect on the airfoil behaviour :
• lower drag
• lower Cl/Alpha slope deviation
• bette glide ratio

3 *A few définitions*

3.1 Geometric parameters

Neutral line : characteristic line of a fuselage, corresponding to its minimum drag angle of attack. It can be assimilated to its mean axis, like the chord for an airfoil.

Incidence : construction angle between the wing or stabiliser in relation to the fuselage's neutral line. Whether for the wing or the tail, this angle is positive when the leading edge is higher than the trailing edge, and vice versa. Not to be confused with Angle Of Attack (AOA).

Tail volume : dimensionless value that reflects the ability of the tail to balance the wing in different flight configurations. The greater the tail volume, the more likely the aircraft is to evolve at high angles, which often goes against the aim of minimum drag. This is also the case if the Cm0 of the wing airfoil is large.

Aspect Ratio (AR) : characterises the importance of the span in front of the chords (wing or tail) and, conversely, the influence of the marginal vortex on the rest of the wing.

Aerodynamic mean chord (AMC) : virtual chord, equal to the average of the chords weighted by the elementary surfaces, equivalent from an aerodynamic point of view to all the chords of a wing. It is the basis for calculating the centre of gravity and lever arms of an aircraft.

Focal point of an airfoil or wing : point where a variation in angle of attack does not lead to a variation in moment, located at 25% of the mean chord (in thin airfoil theory).

Aircraft focal point : point of neutral stability, where the variations in the moments (same definition as above) of the lift forces (wing, tail and fuselage) are balanced during a variation in angle of attack (desired, after an elevator action, or undergone due to turbulence). In linear flight, the focal point depends only on the geometry of the plane, not its airfoils.

Static margin : percentage which indicates the degree of stability of a plane, defined by the ratio of the CG/focal point distance to the mean chord. This value is valid whatever the configuration: flying wings, canard, etc. Key points to remember :

- negative static margin: the flight is divergent, the slightest disturbance to the trajectory (depth action or air movement) is amplified.
- zero static margin: the plane is neutral.
- positive static margin: the higher the static margin, the faster the plane returns to its natural trajectory.

The static margin can range from 0 for a speed or aerobatic aircraft to 10% for a calm aircraft where stability is the priority. Note that for a plane with a horizontal stabiliser, these values are only valid for an aft C of G limit which takes into account the contribution of the fuselage.

3.2 Aerodynamic parameters

Alpha (α) : angle of attack of the airfoil in relation to the air, varies according to the depth setting. Not to be confused with incidence.

Cd : drag coefficient, of an airfoil, wing or plane, characterising resistance to forward movement.

Cl : lift coefficient, of an airfoil or wing, proportional to the angle of angle of attack.

Cm : moment coefficient of an airfoil or wing. The Cm reflects the pivoting torque around the neutral point of the airfoil (25% of the chord) generated by the airflow. It is positive for a flying wing (naturally balanced), and negative for a standard airfoil (unbalanced). In the latter case, it is the stabiliser that has to counteract this torque, which is all the greater the higher the absolute value of Cm.

CmCG : moment coefficient of a wing and the aircraft relative to its centre of gravity.

α0 and Cm0 : angle of attack of the airfoil and moment coefficient at zero lift (Cl), used by trim and perfos calculations.

Lift and drag : forces respectively perpendicular and parallel to the direction of forward motion, expressed in N (newton, 10N ≈ 1kg).

Induced drag (Cdi) : drag linked to the aspect ratio of the wing or tail. It is zero for Cl = 0 and increases with Cz, but decreases as the aspect ratio increases. Physically, induced drag is generated at the tip by a flow of air from the lower surface (overpressure) to the upper surface (underpressure). The greater the aspect ratio, the less this circulation affects the rest of the wing.

Reynolds number (Re) : dimensionless coefficient which includes the speed of evolution and the dimension (chord) of an airfoil.
Postulate: a chord X airfoil evolving at speed Y behaves identically to the same chord X/2 airfoil evolving at speed Y*2, because they evolve at the same Reynolds number.

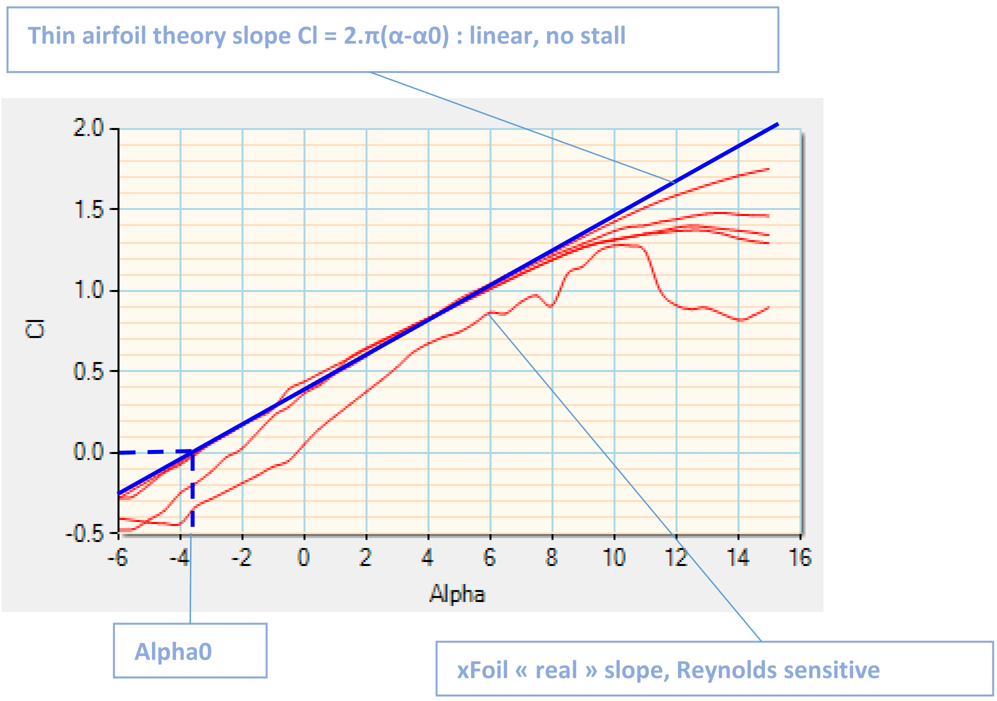
Polar(s) : characteristic curve(s) of the performance or behaviour of a airfoil, wing or plane. The most common polars are :

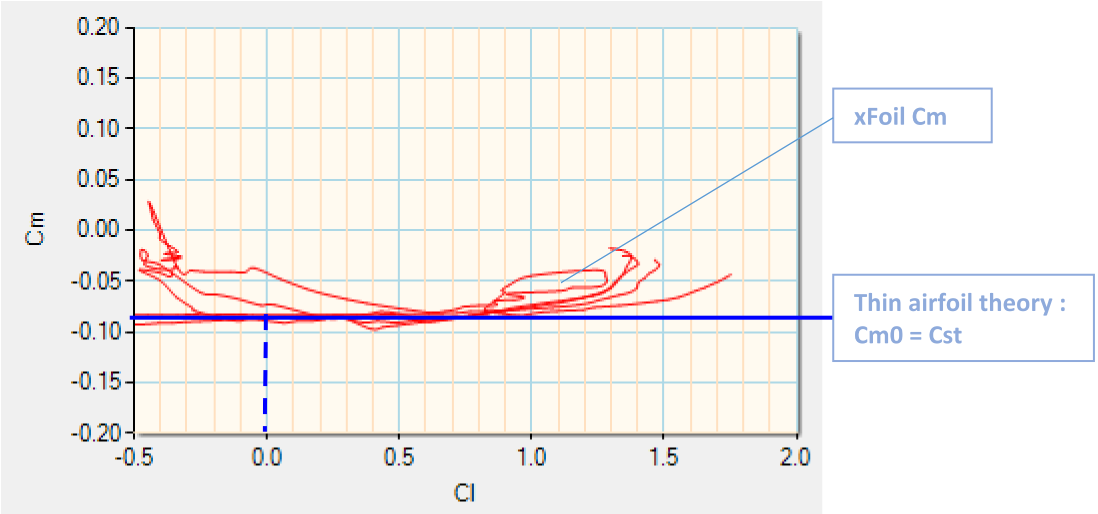
- airfoile polars: Cl as a function of Cd, Cl as a function of Alpha, Cm as a function of Cl. These polars are generally plotted for different Re.
- plane polars: sink rate as a function of flight speed, glide ratio as a function of flight speed. These polars are generally plotted for different masses.

Wing downwash : this is the downward airflow generated by a wing. Depending on its lever arm and height, a stabiliser is more or less affected by this flow, and its geometric setting must be corrected accordingly to position its aerodynamic angle of attack in relation to this flow.

Interaction : refers to the drag generated by the intersection of two surfaces. Typically, interaction drag is found at the junction of the fuselage with the wings or the tail.

3.3 Liner vs non-linear





The linear theory [of thin airfoils] is a simplification of reality, which considers that the relationship between lift and angle of attack is independent of the airfoil (apart from its Alpha0) and that the moment is constant. This theory is reliable and predictive in the majority of cases, except in the vicinity of the stall and when the airfoil is poorly adapted to the flight Reynolds (= used below its critical Re).

In contrast, the non-linear approach is more representative of reality, but is very sensitive to Reynolds effects, depending in particular on the modelling conditions (nCrit, turbulator). Care must therefore be taken when choosing these conditions, depending on the flight envelope and the design of the aircraft being studied.

G.A.D. uses these two approaches simultaneously, via the 1.5D + VLM 3D lifting surface solver coupled with the non-linear xFoil interpolator, whose data is partially reduced using thin airfoil theory for the linear case.

Concerning the nCrit, which is used to represent the average turbulence level of the boundary layer around the airfoil, a few classic values : 9 for a moulded wing, 6 for a formwork wing, 3 for a structural wing.

NOTE: in G.A.D., the curves are generally annotated with the suffix _D (1.5D), _L (linear) or _N (non-linear).

3.4 1.5D vs VLM lifting surface analysis

In scientific terminology, '1D' indicates that the result (here: drag, lift, etc.) is obtained by an analytical method via correlations using global quantities representing the system under study. In this case, an aerofoil (wing, tail, fin) is reduced to its surface area, its aspect ratio and its mean chord, and its performance is studied on the basis of these elements.

G.A.D. uses the term '1.5D' to indicate that it incorporates other dimensions, such as deflections, twists and dihedral, as well as Alpha0 and Cm0 airfoil, which are weighted by the surface area of each panel to be reduced to the complete wing. In addition, instead of using the classic Prandlt lift efficiency (A = AR/(AR+2), G.A.D. uses the Helmbold-Polhamus correlation, which is much closer to reality, particularly for wings with low aspect ratio. This approach gives very robust and instantaneous results, which are used as input to the VLM solver to enable it to converge much more quickly than with a conventional iterative numerical approach.

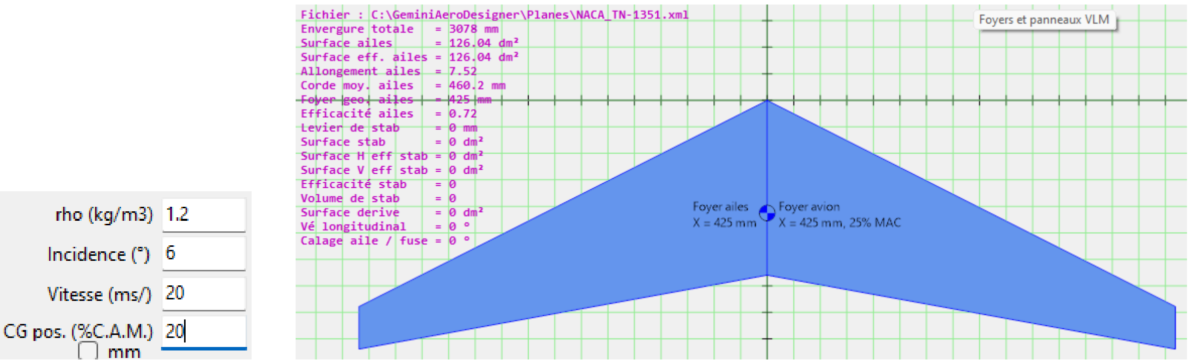
The VLM solver is of the full 3D type, i.e. it takes into account the angles induced by twists and dihedrals, including in the calculation of induced drag. This solver operates simultaneously in linear and non-linear mode (see above), with xFoil coupling via the non-linear interpolator, and offers rapid resolution over the entire flight envelope, enabling analyses to be refreshed in near-real time when the aircraft's geometry is modified.

It should also be noted that induced drag is calculated by integrating along the span the projection of the local lift by the local induced angle (instead of using the simple projection of the global lift), which means, for example, that this drag can be calculated correctly in the case of a heavily twisted wing with zero lift (where the local lift at the tip is not zero...).

The dual operation of the solver also offers unprecedented analysis possibilities, such as the identification of stall initiation zones and the study of non-linear moments for balance and longitudinal stability.

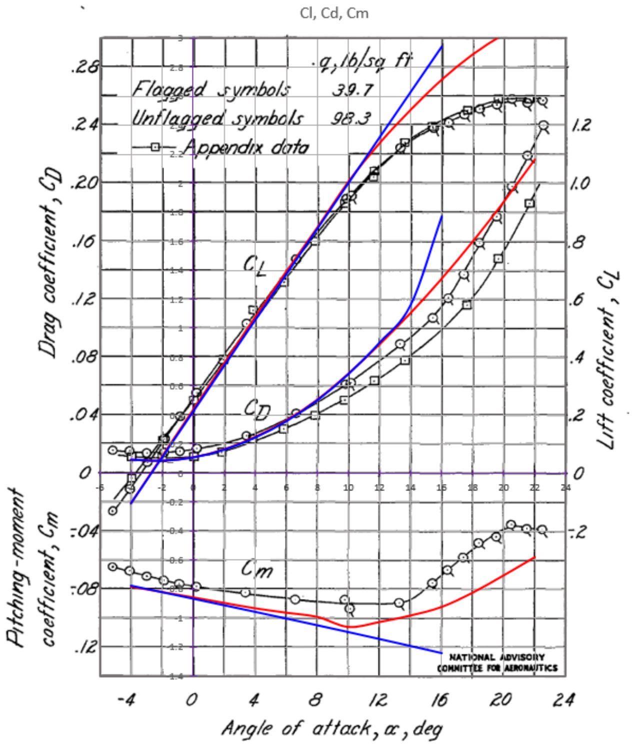
In the general case (= airfoil well suited to the flight envelope) and outside the stall, the 1.5D and 3D VLM results superimpose very well, demonstrating the robustness of these two completely different approaches.

Example of validation with the NACA TN1351 :



Analyse	Cl	Cd (profil)	Cdi (port.)	Cd (total)	Cl/Cd	Cm0.25	CmCG	e factor	dCl/dCl∞	Port. (N)	Traînée (N)
1.5D Polhamus	0.67	0.009	0.0224	0.0314	21.3	-0.101	-0.134	-	0.72	202.6	9.5
VLM Linear	0.67	0.009	0.027	0.0361	18.5	-0.101	-0.14	0.934	0.72	201.8	10.91
VLM NonLinear	0.66	0.0091	0.0267	0.0357	18.5	-0.096	-0.136	0.922	0.73	200	10.81

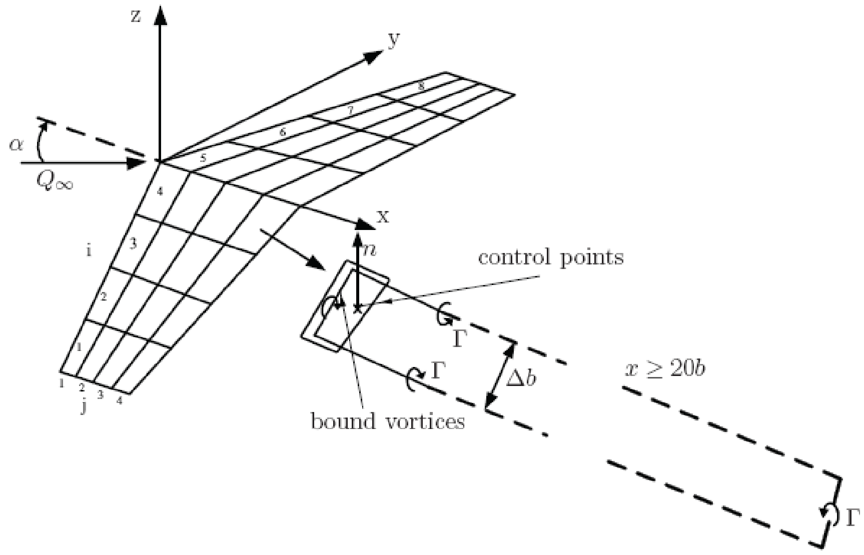
Fig. 13b NACA TN No. 1351



(b) Swept-back wing.

It should be noted that the differences of lift at high angle of attack is explained by the wall effect at the root, as the tests done by the NACA were carried out on a single wing attached to the root, and not on two wings.

NOTE : the principle of a VLM solver is to divide the wing into several small finite elements, each with a vortex and a control point :



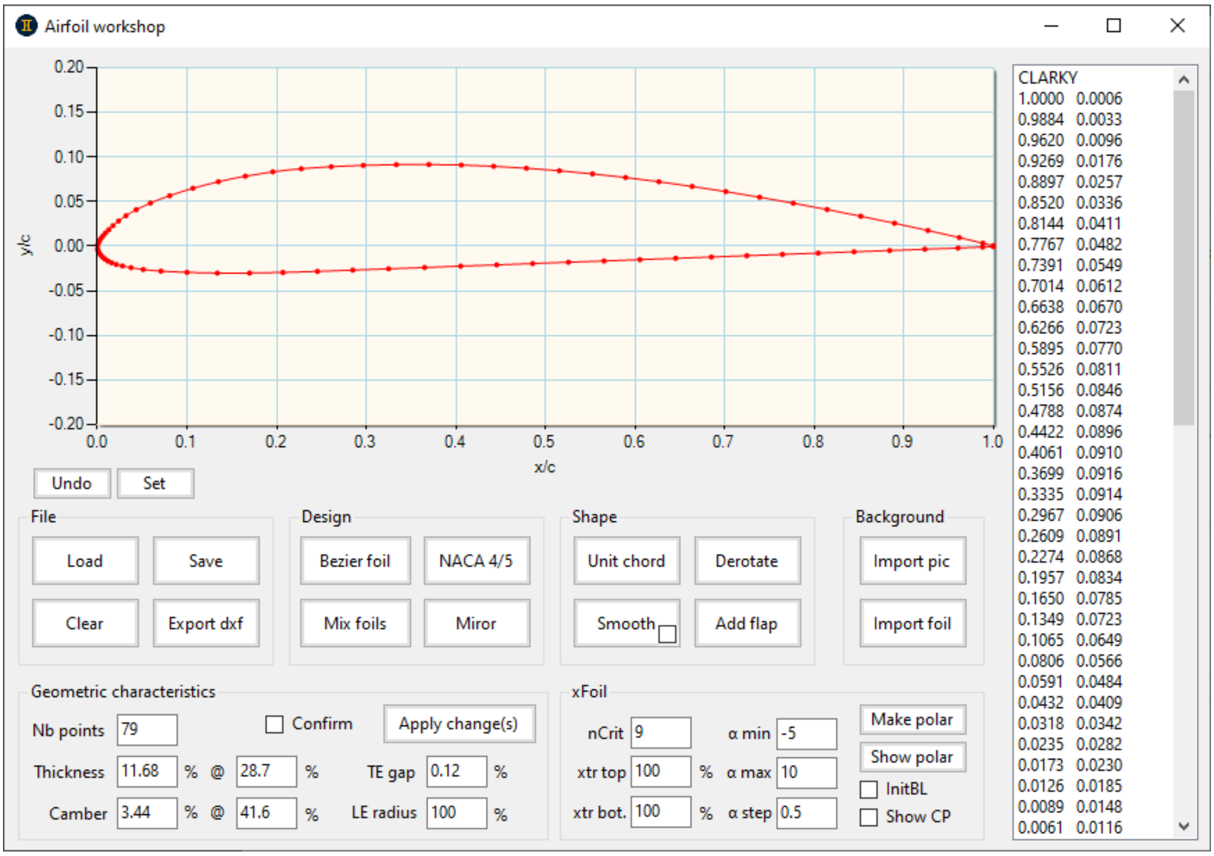
4 Using Gemini Aero Designer

4.1 Airfoil workshop

This module manipulates four types of object:

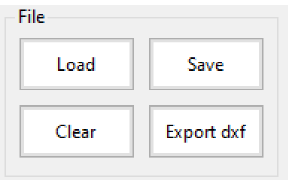
- the coordinates of the current .dat airfoil: these can be modified as required.
- the airfoil polar: a file containing the coordinates of the airfoil and its polars generated by xFoil.
- background airfoils (.dat or image): used for comparison with the current airfoil.
- a Bezier curve: to quickly create a airfoil from scratch or from a background image.

Both the coordinates of the current airfoil and the airfoil polar can be stored on hard disk, using the open/save buttons in this workshop. It is also possible to export the airfoil in dxf format.



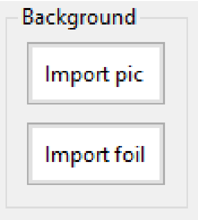
4.1.1 Managing airfoil files

The buttons for managing the current airfoil speak for themselves :

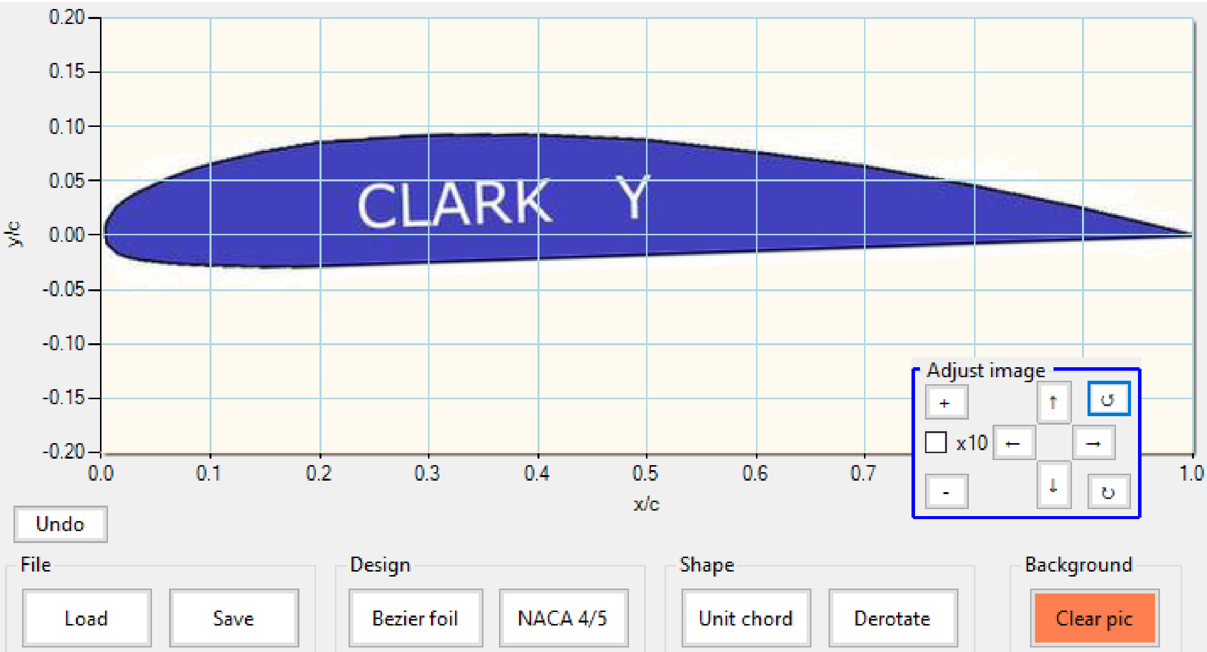


4.1.2 Importing an airfoil into the background

This function allows a second airfoil to be added in the background, either from a conventional .dat file or from an image, for comparison and/or redesign purposes (see below) :



Once you have imported an image file, a toolbox will help you position it correctly :



Caution : an image that is too small will be difficult to read and will in any case be cropped when it is enlarged too much.

4.1.3 Standard airfoil format and best practices

Airfoils must be in Selig format:

- file extension : .dat
- file format : text
- first line : airfoil name
- following lines : X Y coordinates
- numeric format :
    - decimal separator : dot
    - number separator : space(s)
    - scaled to chord = 1
    - coordinates order: 1.0 0.0 ➔ 0.0 0.0 ➔ 1.0 0.0

G.A.D. can also import vector files (.dxf ASCII, .plt, hpgl, .eps) and convert them to .dat.

Example of .dat file with the ClarkY, whose intermediate points have been replaced by "..." to fit in the screenshot :

```
CLARKY.dat

CLARKY
1.00000    0.00060
0.98842    0.00334
0.96196    0.00957
0.92693    0.01757
...
...
...
0.00098    0.00368
0.00023    0.00132
0.00000    0.00000
0.00012    -0.00318
0.00079    -0.00545
...
...
...
0.92364    -0.00341
0.96056    -0.00205
0.98809    -0.00104
1.00000    -0.00060
```

When loading a airfoil, it is useful to take a critical look at its conformation by checking :

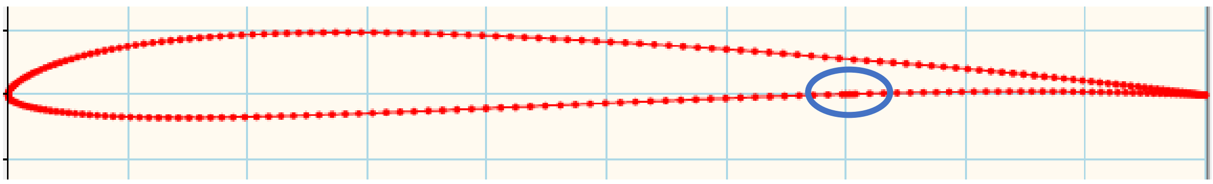
- there are no overlapping or duplicate points
- tangency continuity
- the distribution of points
- the number of points

A few points of reference and good practice:

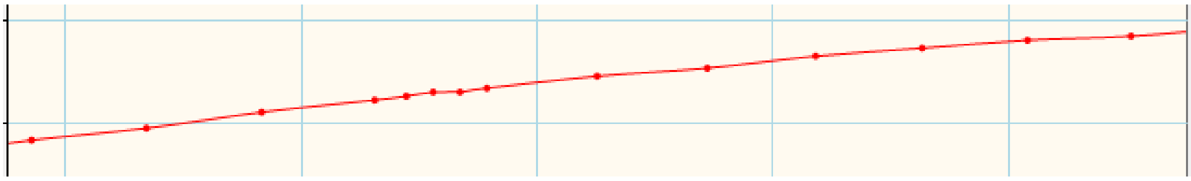
- distribution of points: the airfoil should have more points the more pronounced the local curvature (typically at the leading edge) and fewer the less pronounced the curvature (typically at the trailing edge).
- number of points: preferably odd, with 79 to 101 points for a good compromise between calculation time and representativeness of the results. Don't believe that ‘the more points, the more accurate the result’ - nothing could be further from the truth!
- the thickness of the LF must be non-zero and representative of reality.
- the chord must be standardised (length of 1 and rotated so that the centre of the leading edge and the trailing edge are aligned at Y = 0).
- the points must have good tangency continuity (see below with the vertical zoom function).

Example of anomalies on a thin airfoil for RC glider :

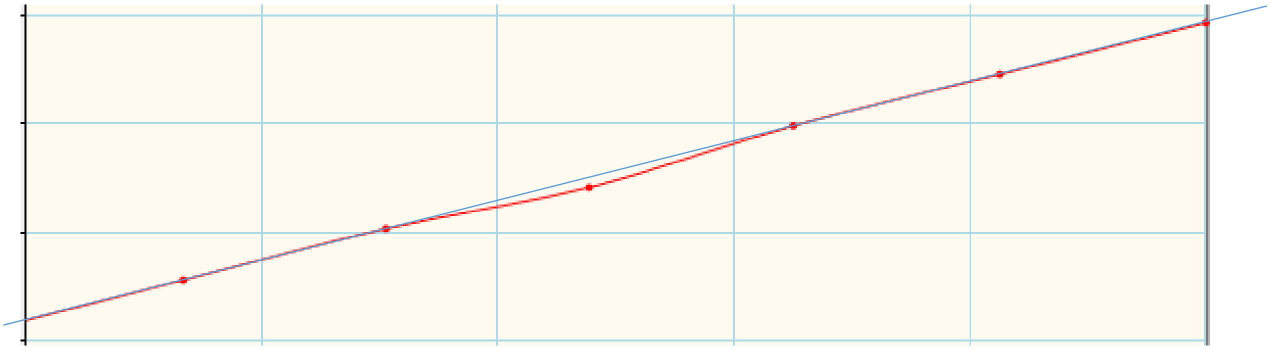
The number of points is exaggeratedly high (260), which greatly reduces calculation time without improving accuracy (it is even degraded, as too many points ‘noise’ the results). In addition, the density of points is too high at the trailing edge.

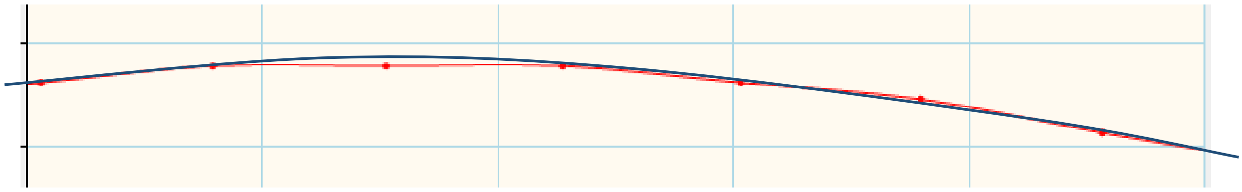


Local anomalies in the distribution of points :

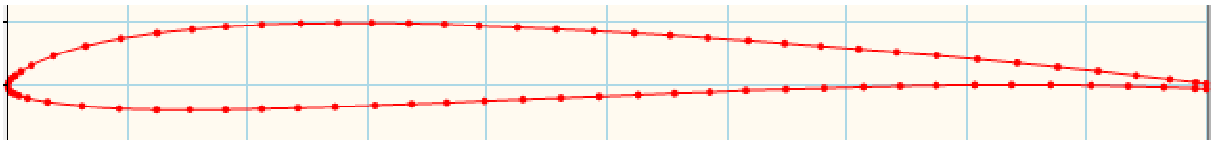


Tangency anomalies :



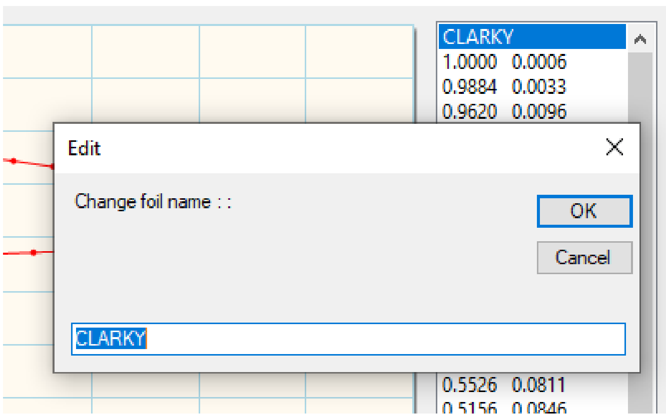


After smoothing, normalising, changing to 79 points and using a non-zero trailing edge thickness, the airfoil is now usable :



4.1.4 *Changing the airfoil name*

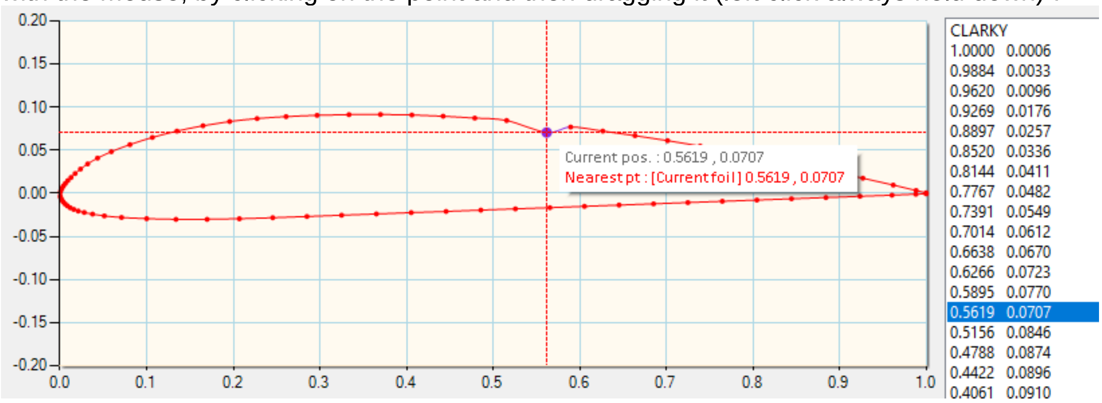
This is done by double-clicking or 'enter' on the airfoil name at the top of the points list.



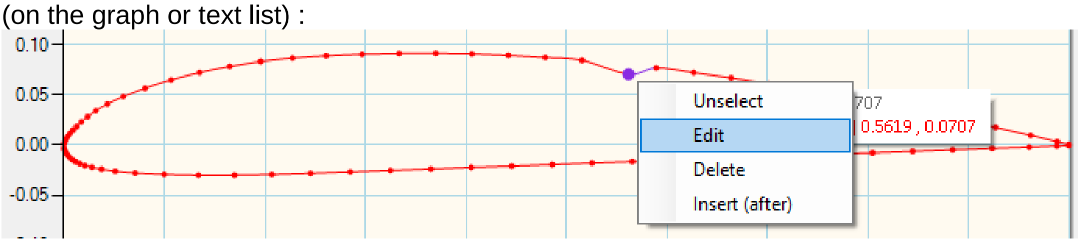
4.1.5 *Editing the airfoil point to point*

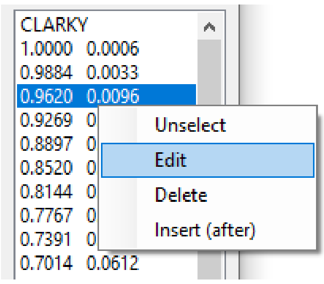
Airfoil points can be modified in several different ways :

- with the mouse, by clicking on the point and then dragging it (left click always held down) :



- via the context menu, by left-clicking to select the point and then right-clicking the point (on the graph or text list) :



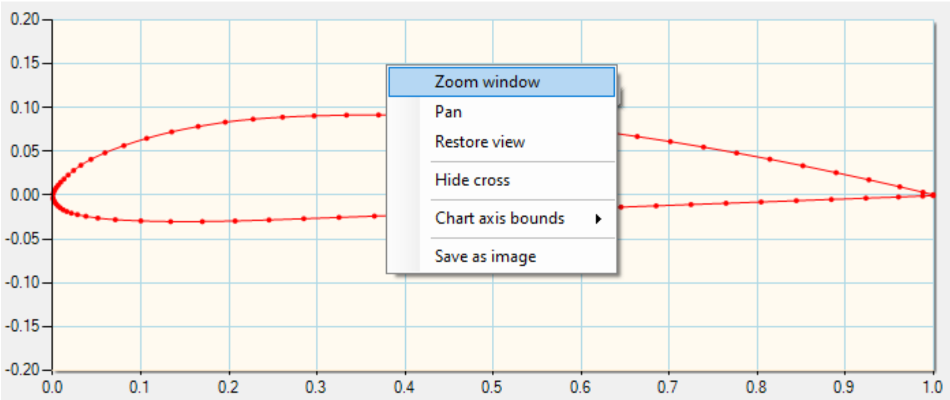


- via the keyboard shortcuts: ‘insert’ to insert a point, ‘del’ to delete, and ‘enter’ to edit.

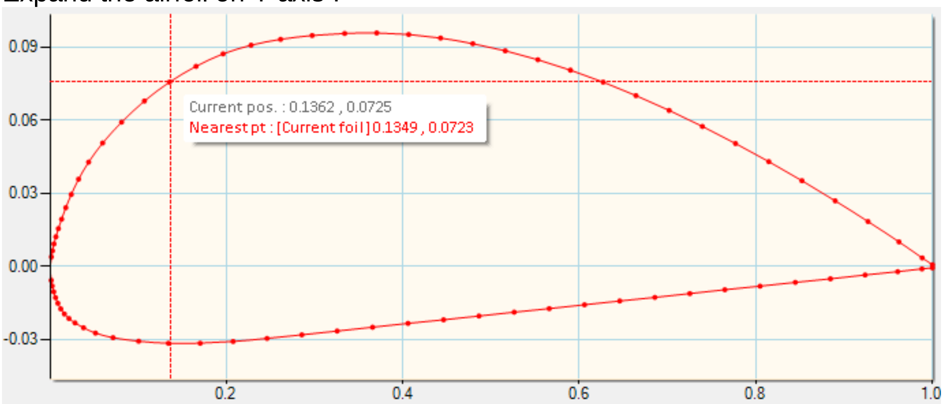
Once the change has been made, the modified point is identified on the graph by a different colour.

4.1.6 *Using the zoom function for graphical editing*

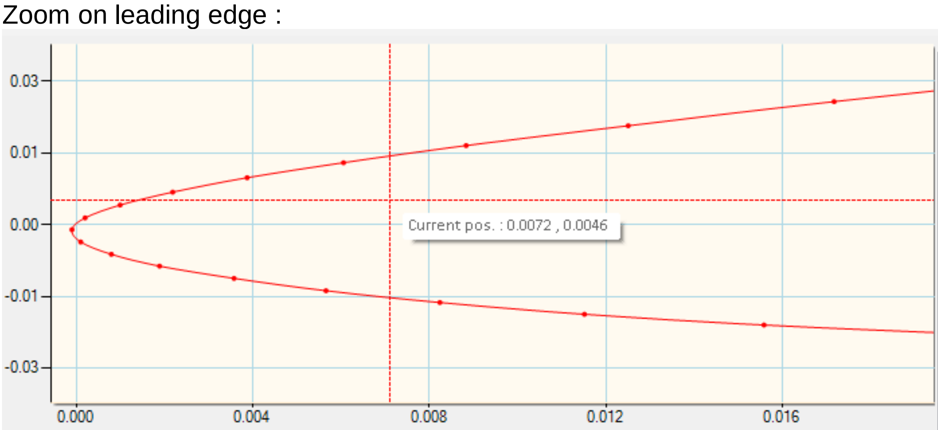
By default, the airfoil drawing is orthonormal, i.e. the X and Y axes have the same scale. However, it is also possible to use the zoom function (window or adjustment of the graph limits) to expand the scale to look for breaks in continuity or redundant points, for example, or simply to look for differences between two superimposed airfoils.



Expand the airfoil on Y axis :

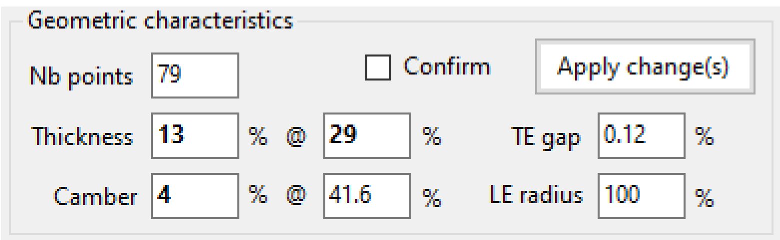


Zoom on leading edge :



4.1.7 Modifying the geometric characteristics of the airfoil

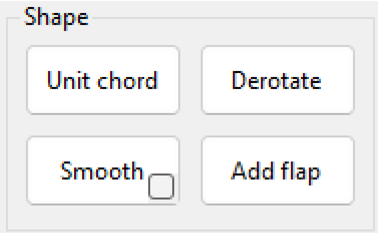
he global geometric characteristics can be modified value by value, by pressing ‘enter’ each time, or all at once by clicking on the ‘Apply change(s)’ button after modifying the desired values (the text of which is identified in bold) :



The values entered are targets and not exact values, except for the leading edge radius, which is a percentage applied to the existing radius. All other values are recalculated after modification, sometimes with a slight deviation, which is normal.

If the 'Confirm' checkbox is activated, a message indicates that the modification has been made.

4.1.8 Global modification of the airfoil shape



These tools can be used to :

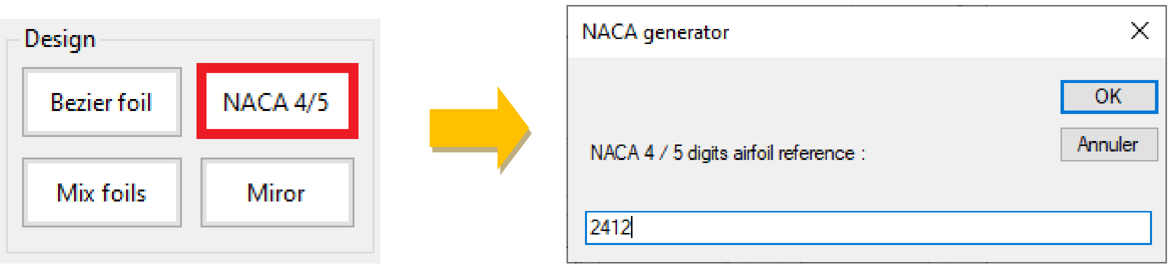
- set the string length to 1 (= 100%)
- rotate the airfoil to align the chord with the 0-X axis
- smooth the airfoil (with the option of redistributing the points, useful for Eppler and Selig airfoils, for example)
- deflect a flap

Warning : never rotate the airfoil after adding flap, as this will break the angle of attack reference and therefore the calculations. Similarly, any modification to the airfoil (slackening, etc.) must be made before adding flap.

4.1.9 Undoing modification(s)

When a airfoil is loaded, or each time the 'Set' button is clicked, the current airfoil is saved in memory and all the modification indicators are reset to zero. Clicking on the 'Undo' button restores the current airfoil as it was at that moment.

4.1.10 NACA airfoil generator



NACA airfoils are coded as follows:

- 4 digits :
  - the first digit defines the maximum camber as a percentage of the chord,
  - The second digit defines the point of maximum camber in relation to the leading edge, as a percentage of the chord.
  - the last two digits define the maximum airfoil thickness as a percentage of the string.

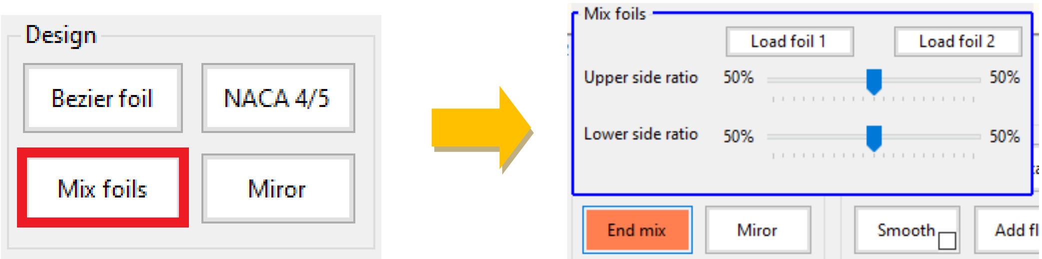
- 5 digits :
    - the first digit defines the optimum lift coefficient (giving the minimum drag), to be multiplied by 0.15
    - the second digit defines the point of maximum camber in relation to the leading edge, as a percentage of the chord
    - the third digit indicates whether the airfoil has single (0) or double (1) camber
- the last two digits give the maximum thickness of the airfoil as a percentage of the chord.

For example:

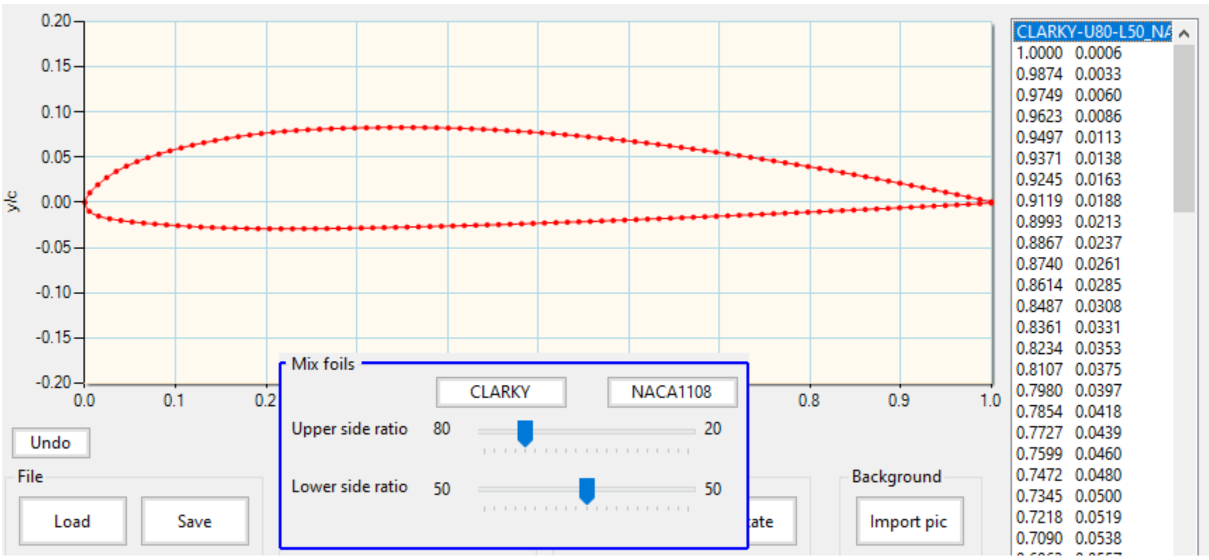
- the NACA2412 airfoil has a maximum camber of 2% at 40% from the leading edge, with a maximum relative thickness of 12%.
- NACA0009 has zero camber and a relative thickness of 9%.
- the NACA12018 has a relative thickness of 18%, a maximum camber located at 20% from the chord and a lift coefficient at minimum drag of 0.15.

In the event of an incorrect entry, no airfoil is generated and a warning message indicates the anomaly.

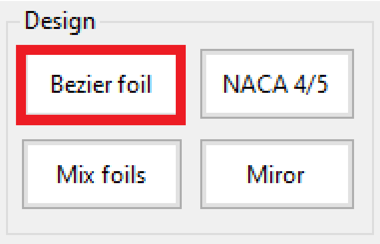
4.1.11 Mixing two airfoils



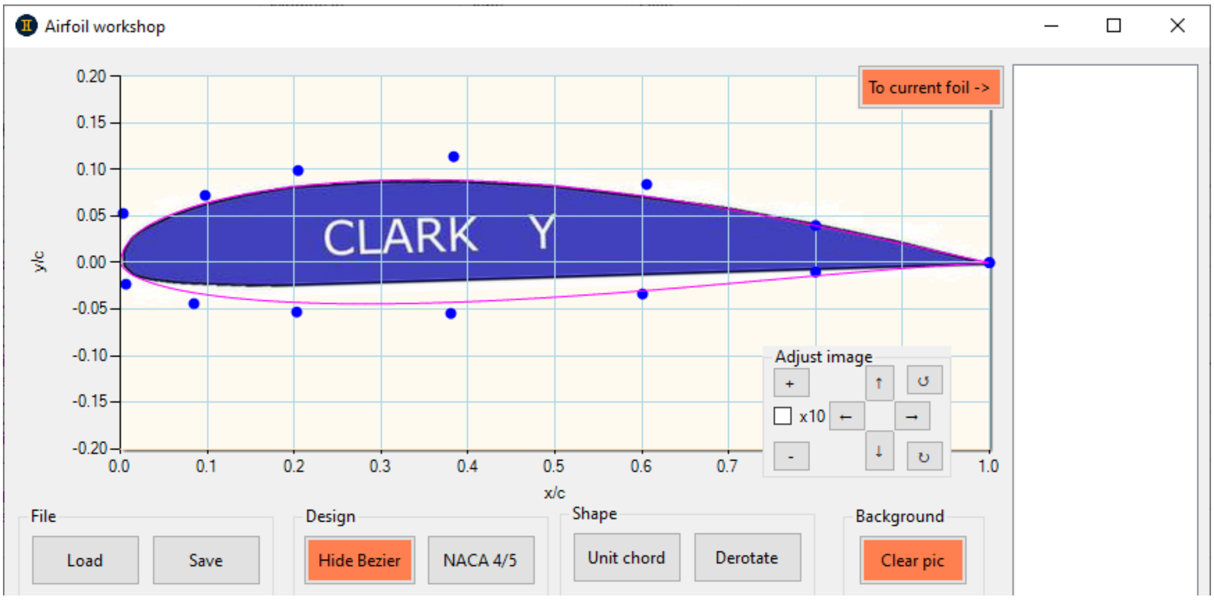
Select each airfoil (their name appears in the button), then set the mixing ratios for the upper and lower surface. The airfoil name and coordinates are adjusted at the same time as the graph. Click on 'End mix' to close this screen.



4.1.12 Creating a airfoil using a Bezier curve

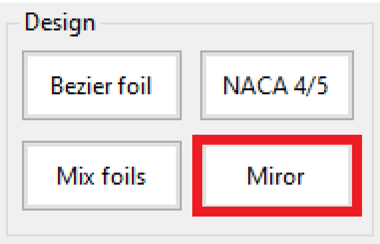


The airfoil can be manipulated graphically using the control points (in blue). One of the most common uses is to import an image (a photo or scan of a wing root airfoil, for example) as a background to redesign the airfoil.



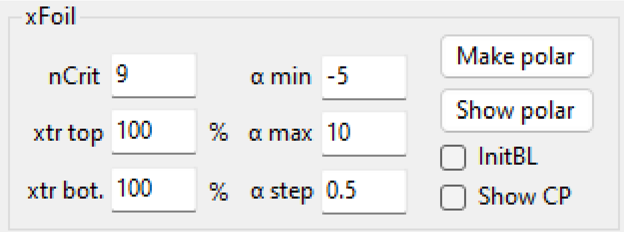
Once the airfoil has been adjusted, simply click on ‘To current foil’ to transform this airfoil into a usable airfoil and duplicate it in the current airfoil.

4.1.13 Horizontal mirror



This function can be used, for example, to study backwards flight in more detail, and then create a specific polar curve for this phase of flight. It can also be used to create a symmetrical airfoil from the lower or upper surface of a given airfoil, using the airfoil blending function (used with the normal airfoil and the inverted airfoil).

4.1.14 *Airfoil polar generation*



The nCrit is an indicator of the average turbulence level around the airfoil, and is used to represent its surface state. A few benchmark values: nCrit = 3 for an open structure wing, 6 for a fully boxed wing covered with plastic film, 9 for a composite moulded wing.

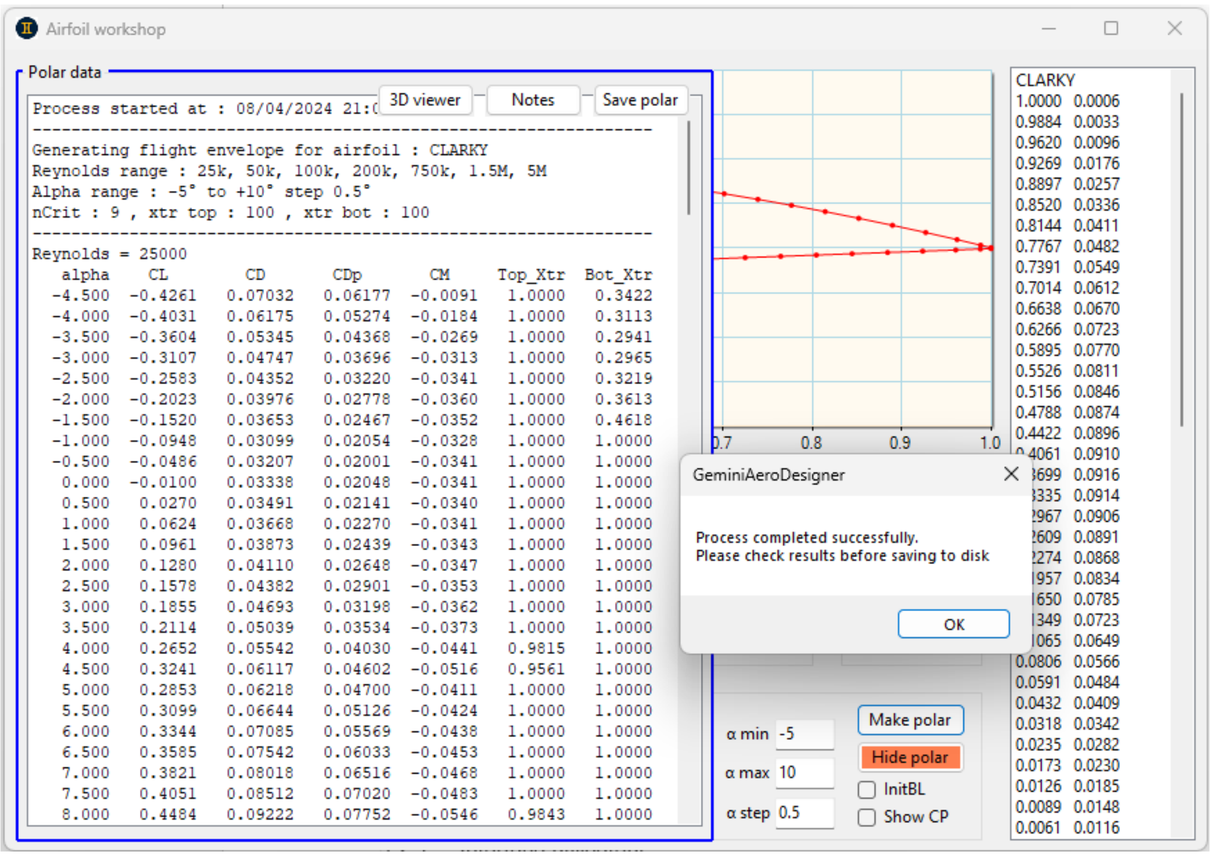
xtr top. / bot. indicate the position, in % of the chord, of a turbulator on the top surface and bottom surface respectively. A value of 100% indicates that there is no turbulator.

The 'InitBL' checkbox initializes the boundary layer at each blow point, which facilitates xFoil convergence (useful for certain airfoils) but slows down polar generation.

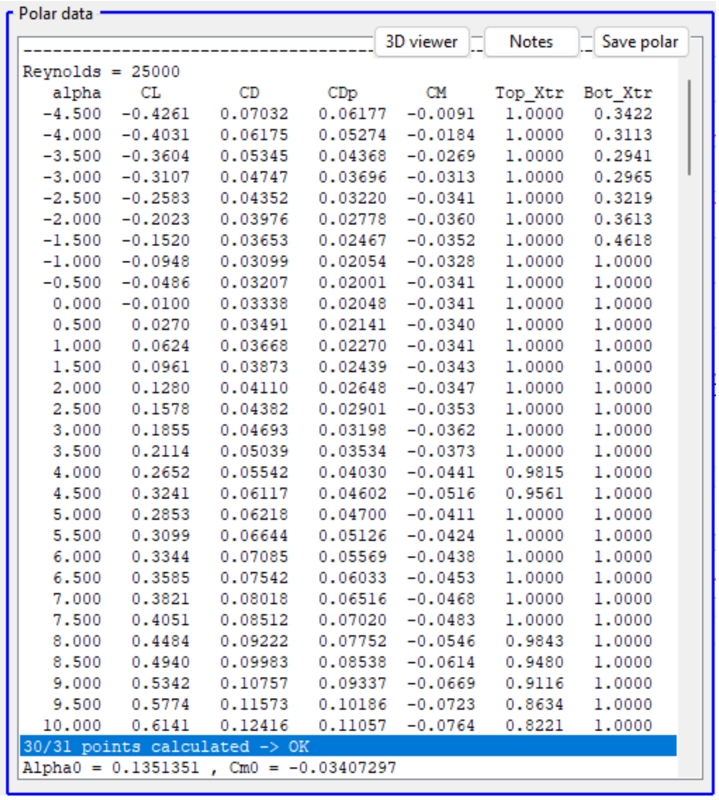
The 'Show CP' checkbox shows the CP distribution graphs in real time.

4.1.15 *Checking and saving the airfoil polar*

At the end of the polar generation process, a message is displayed indicating the overall quality of the result :



By scrolling through the list of calculated function points, you can check the completeness of the polar for each Reynolds, again with a quality indicator. If the quality is insufficient (too many points missing), it is strongly recommended that the polar be regenerated, either by using the 'InitBL' option, or (and this is strongly recommended) by first modifying the airfoil: increasing the number of points to 79 (a passe-partout value, with good generation speed and good quality), smoothing, modifying the distribution of points, etc.

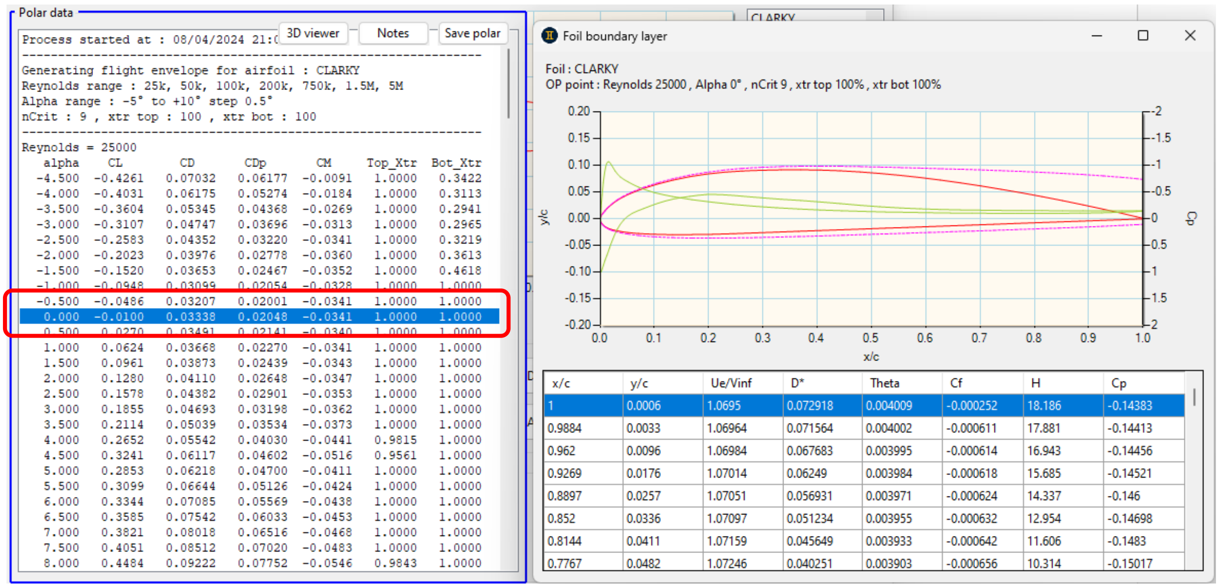


alpha	CL	CD	CDp	CM	Top_Xtr	Bot_Xtr
-4.500	-0.4261	0.07032	0.06177	-0.0091	1.0000	0.3422
-4.000	-0.4031	0.06175	0.05274	-0.0184	1.0000	0.3113
-3.500	-0.3604	0.05345	0.04368	-0.0269	1.0000	0.2941
-3.000	-0.3107	0.04747	0.03696	-0.0313	1.0000	0.2965
-2.500	-0.2583	0.04352	0.03220	-0.0341	1.0000	0.3219
-2.000	-0.2023	0.03976	0.02778	-0.0360	1.0000	0.3613
-1.500	-0.1520	0.03653	0.02467	-0.0352	1.0000	0.4618
-1.000	-0.0948	0.03099	0.02054	-0.0328	1.0000	1.0000
-0.500	-0.0486	0.03207	0.02001	-0.0341	1.0000	1.0000
0.000	-0.0100	0.03338	0.02048	-0.0341	1.0000	1.0000
0.500	0.0270	0.03491	0.02141	-0.0340	1.0000	1.0000
1.000	0.0624	0.03668	0.02270	-0.0341	1.0000	1.0000
1.500	0.0961	0.03873	0.02439	-0.0343	1.0000	1.0000
2.000	0.1280	0.04110	0.02648	-0.0347	1.0000	1.0000
2.500	0.1578	0.04382	0.02901	-0.0353	1.0000	1.0000
3.000	0.1855	0.04693	0.03198	-0.0362	1.0000	1.0000
3.500	0.2114	0.05039	0.03534	-0.0373	1.0000	1.0000
4.000	0.2652	0.05542	0.04030	-0.0441	0.9815	1.0000
4.500	0.3241	0.06117	0.04602	-0.0516	0.9561	1.0000
5.000	0.2853	0.06218	0.04700	-0.0411	1.0000	1.0000
5.500	0.3099	0.06644	0.05126	-0.0424	1.0000	1.0000
6.000	0.3344	0.07085	0.05569	-0.0438	1.0000	1.0000
6.500	0.3585	0.07542	0.06033	-0.0453	1.0000	1.0000
7.000	0.3821	0.08018	0.06516	-0.0468	1.0000	1.0000
7.500	0.4051	0.08512	0.07020	-0.0483	1.0000	1.0000
8.000	0.4484	0.09222	0.07752	-0.0546	0.9843	1.0000
8.500	0.4940	0.09983	0.08538	-0.0614	0.9480	1.0000
9.000	0.5342	0.10757	0.09337	-0.0669	0.9116	1.0000
9.500	0.5774	0.11573	0.10186	-0.0723	0.8634	1.0000
10.000	0.6141	0.12416	0.11057	-0.0764	0.8221	1.0000

30/31 points calculated -> OK
Alpha0 = 0.1351351 , Cm0 = -0.03407297

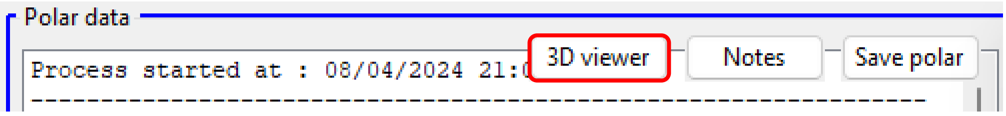
4.1.16 Boundary layer analysis

A simple click on an operating point automatically opens the boundary layer and pressure distribution analysis tool, which can be very useful for determining the position of a turbulator, for example :



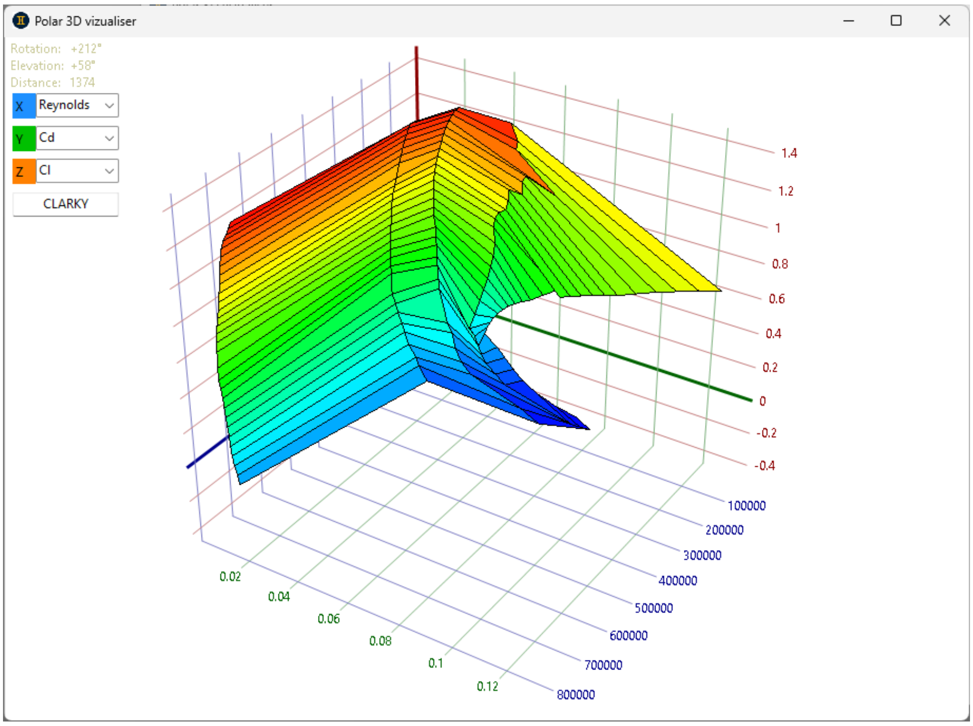
x/c	y/c	Ue/Vinf	D*	Theta	Cf	H	Cp
1	0.0006	1.0695	0.072918	0.004009	-0.000252	18.186	-0.14383
0.9884	0.0033	1.06964	0.071564	0.004002	-0.000611	17.881	-0.14413
0.962	0.0096	1.06984	0.067683	0.003995	-0.000614	16.943	-0.14456
0.9269	0.0176	1.07014	0.06249	0.003984	-0.000618	15.685	-0.14521
0.8897	0.0257	1.07051	0.056931	0.003971	-0.000624	14.337	-0.146
0.852	0.0336	1.07097	0.051234	0.003955	-0.000632	12.954	-0.14698
0.8144	0.0411	1.07159	0.045649	0.003933	-0.000642	11.606	-0.1483
0.7767	0.0482	1.07246	0.040251	0.003903	-0.000656	10.314	-0.15017

4.1.17 Displaying the polar in 3D



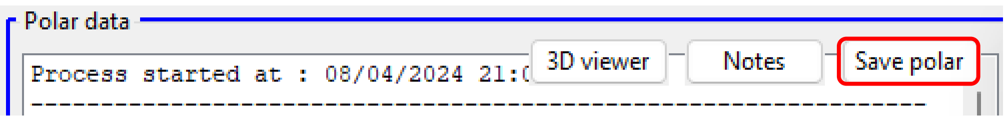
Clicking on the ‘3D viewer’ button opens a screen showing the polar in 3D, with the option of :

- select the data to be displayed for each axis
- rotate the 3D view: left-click + mouse movement for the horizontal plane, right-click + movement for the vertical plane, ctrl + vertical movement for zoom.

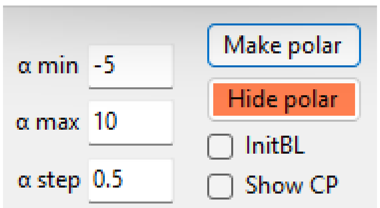


4.1.18 Saving the airfoil polar

When the polar is judged to be satisfactory, clicking on the ‘Save polar’ button saves it to disk.



The stored polar can be hidden / displayed at any time using the ‘Show’ / ‘Hide’ button :



This allows you to go back to modifying the airfoil, for example, and then re-launch a new polar after it has been modified.

In parallel with the polar creation process, you can also use the airfoil polar comparison screen to load each polar generated during a airfoil modification and check the progress of your airfoil design work step by step, so that you end up with the most interesting result.

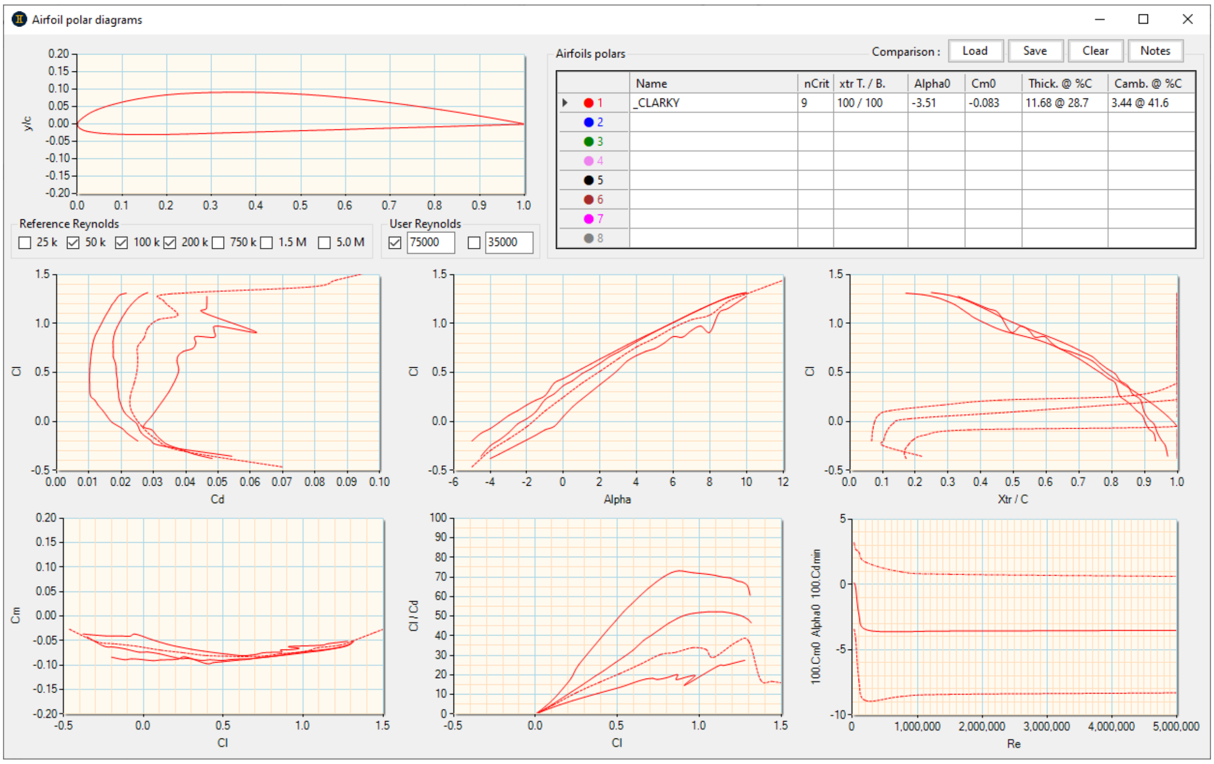
4.2 *Airfoil polar analysis and comparison*

4.2.1 User interface

This tool can be used to read airfoil polars, compare several polars with each other and store the comparison on disk. It is completely independent of the rest of the application.

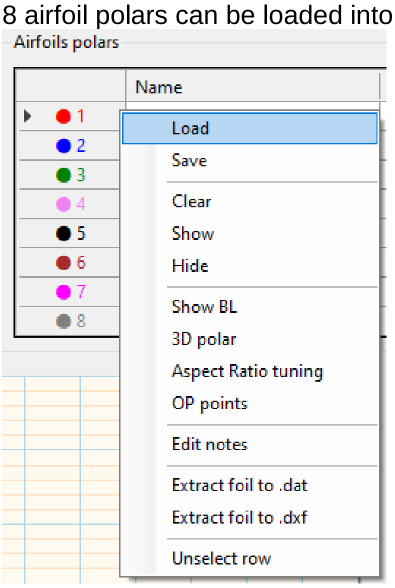
It contains four classic graphs (Cl / Cd, Cl / Alpha, Cm / Cl, Cl/Cd / Cl) as well as :

- the laminar/turbulence transition (xtr) for the lower surface (bot) and the upper surface (top)
- the Reynolds sensitivity of the airfoil, via three variables (Cd mini, Cm0, Alpha0) which can be assimilated to constants when the airfoil is used above its critical Reynolds.



4.2.2 Airfoil polar management

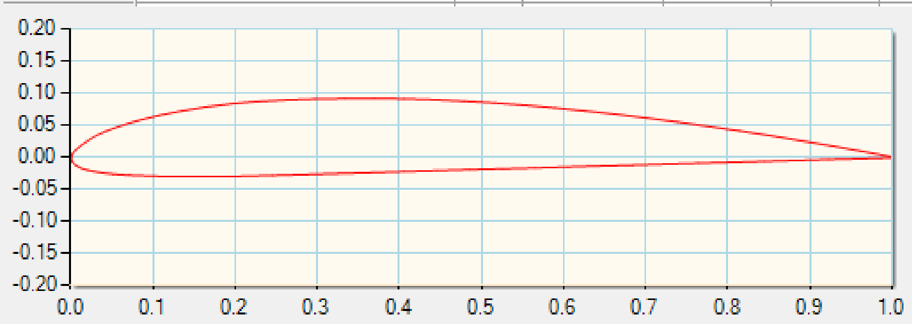
8 airfoil polars can be loaded into the comparison via the popup menu (right-click on the desired line) :



This menu offers additional functions, such as deleting or hiding the polar, displaying CP curves (‘Show BL’), choosing the elongation (associated with the airfoil), etc. The ‘OP points’ button gives access to the points calculated when the polar was blown. It is also possible to extract the airfoil and save it to disk.

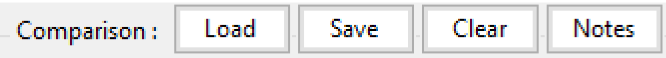
Once the polar curve has been loaded, the main information (blowing parameters and dimensions) is displayed in the table and the airfoil is drawn on the graph :

	Name	nCrit	xtr T. / B.	Alpha0	Cm0	Thick. @ %C	Camb. @ %C
1	CLARKY_n3	3	100 / 100	-3.39	-0.081	11.68 @ 28.7	3.44 @ 41.6



4.2.3 *Comparison management*

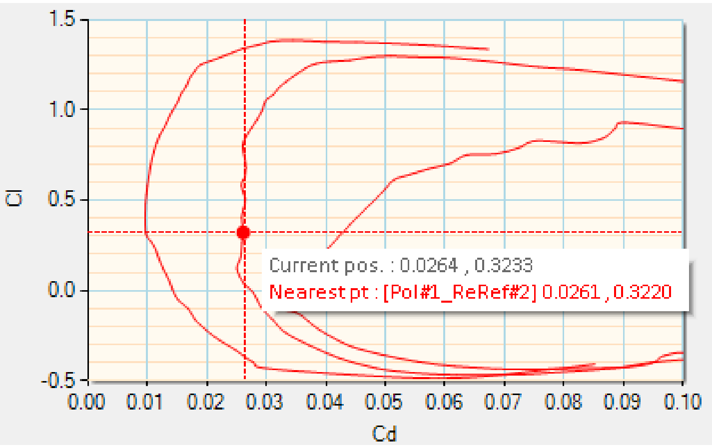
The polar comparison is the recording of the whole of this screen (polar airfoils + ticked box, plus the associated note) and can be saved to disk :



4.2.4 *Flight envelope and reference Reynolds*

he curves passing through the operational points calculated at reference Reynolds (and then used by the xFoil interpolator) can be hidden/displayed using the checkboxes :

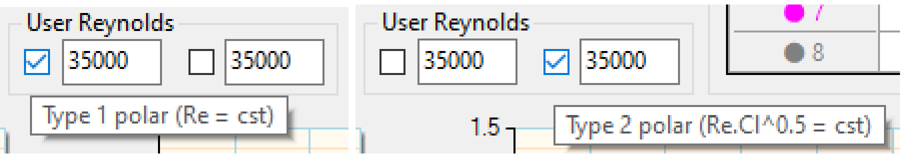
Given the large number of curves that can be displayed, the graphs are not captioned, so you have to move the cursor over the curves to find out what they represent. Here, it is polar no. 1 (ClarkY, see above) and reference Reynolds 2 (i.e. 50 k, i.e. Re = 50000).



4.2.5 Variable Reynolds polars

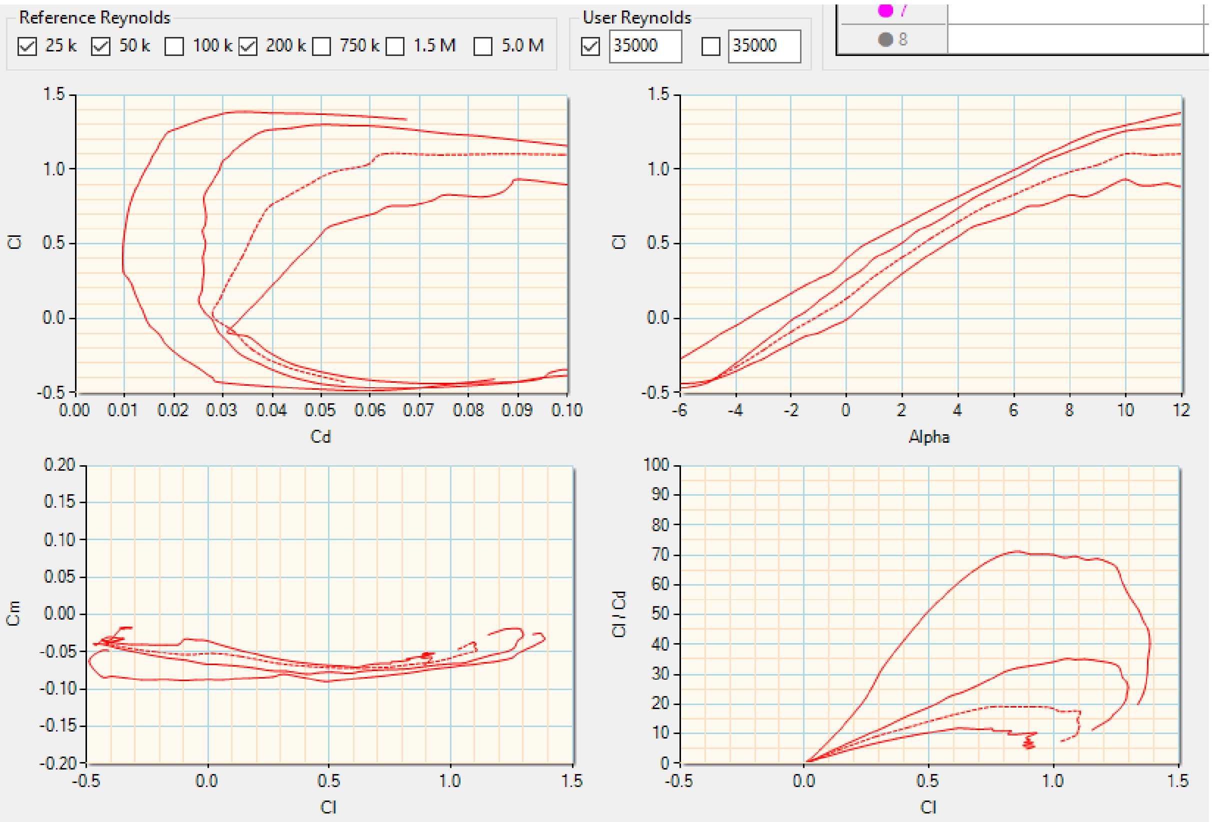
Two modifiable Reynolds polars (using the keyboard or mouse scroll) can be displayed:

- at constant Reynolds: type 1 polar (constant speed)
- at constant R.Cl^0.5: type 2 polar (constant lift)



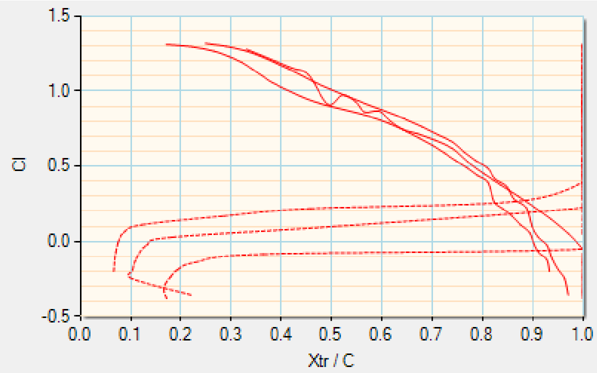
These two curves are drawn in dotted lines, to distinguish them clearly from the reference Reynolds (in solid lines).

Four graphs are concerned by these user Reynolds polars, with the interpolator working simultaneously in Alpha, Cl, Cd and Cm:



The type 1 polar is also very useful for dynamically visualising the operation of Gemini's non-linear interpolator using the mouse scroll. This shows its remarkable efficiency, which means that only 7 reference Reynolds (judiciously staggered) are needed to correctly describe flight domains ranging from micro RC to full-scale ULM.

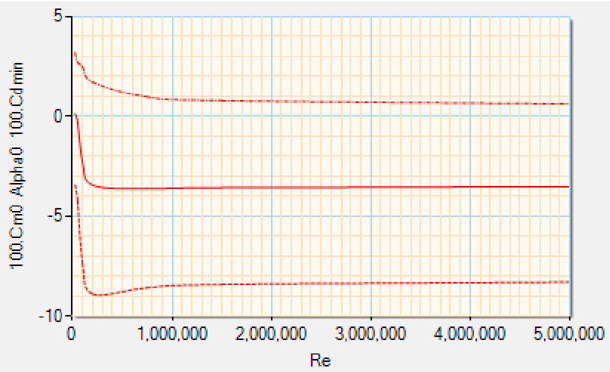
4.2.6 Laminar-turbulent transition



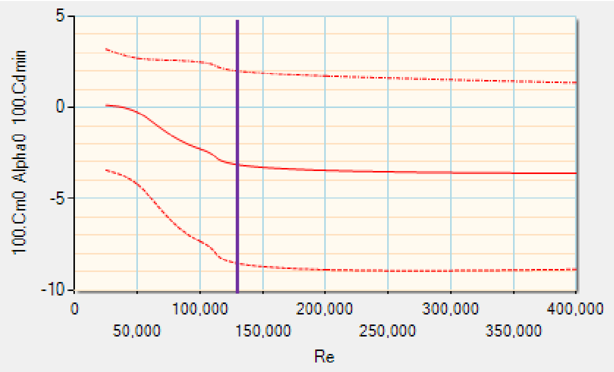
Ce graphique se lit de manière inversée, comme celui de Cl / Cd. Par exemple, pour Cl = 0.5, on a ici une transition qui se fait à l'extrados à 80% de la corde (Xtr/C = 0.6).

4.2.7 Identifying the critical Reynolds

A graph dedicated to this identification shows, as a function of Reynolds, the evolution of parameters that can be assimilated to constants when the airfoil is operating normally, i.e. when it is used above its critical Reynolds.



By zooming in, the critical Reynolds is very easy to identify (here : around 130,000) :

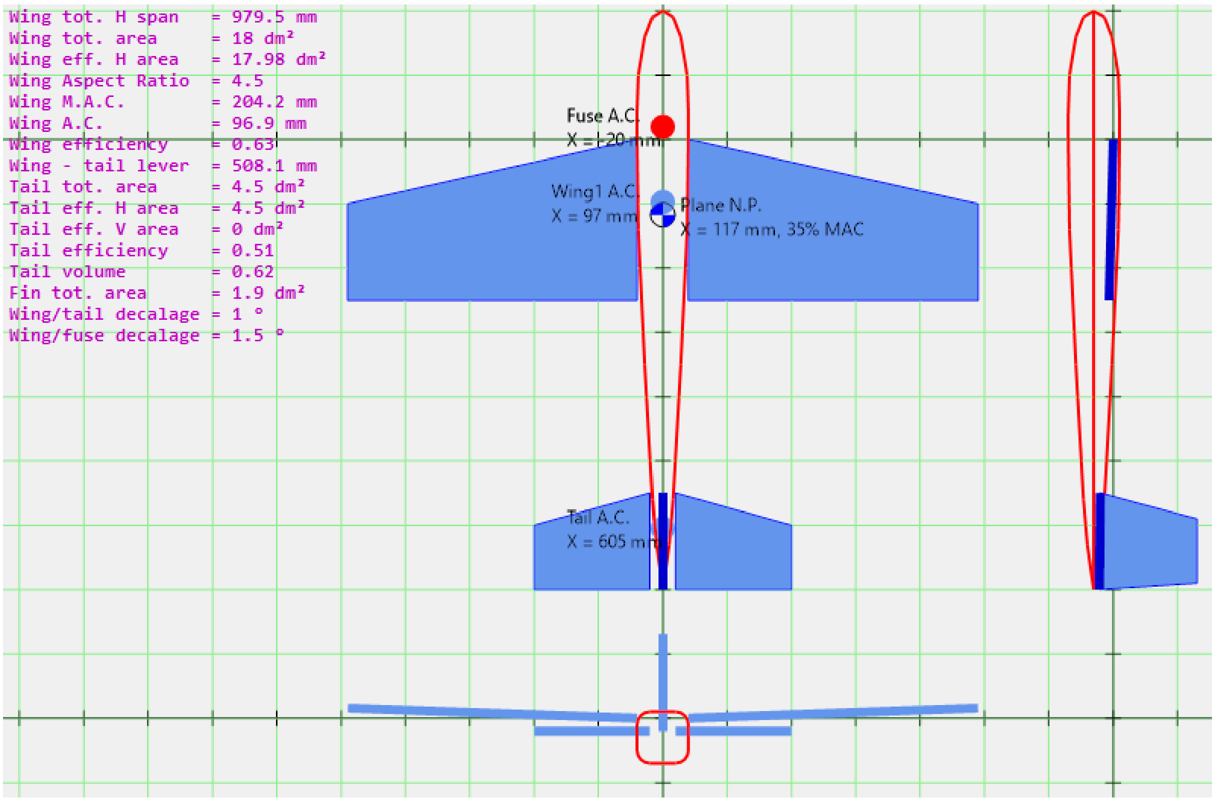


4.3 Editing the plane

4.3.1 Main interface

The drawing and text data displayed in the main interface are automatically recalculated each time the dimension is changed.

For reasons of clarity, only a few global results and simplified foci (calculated in linear 1.5D) are displayed. The CG, for example, will be defined in the performance analysis.

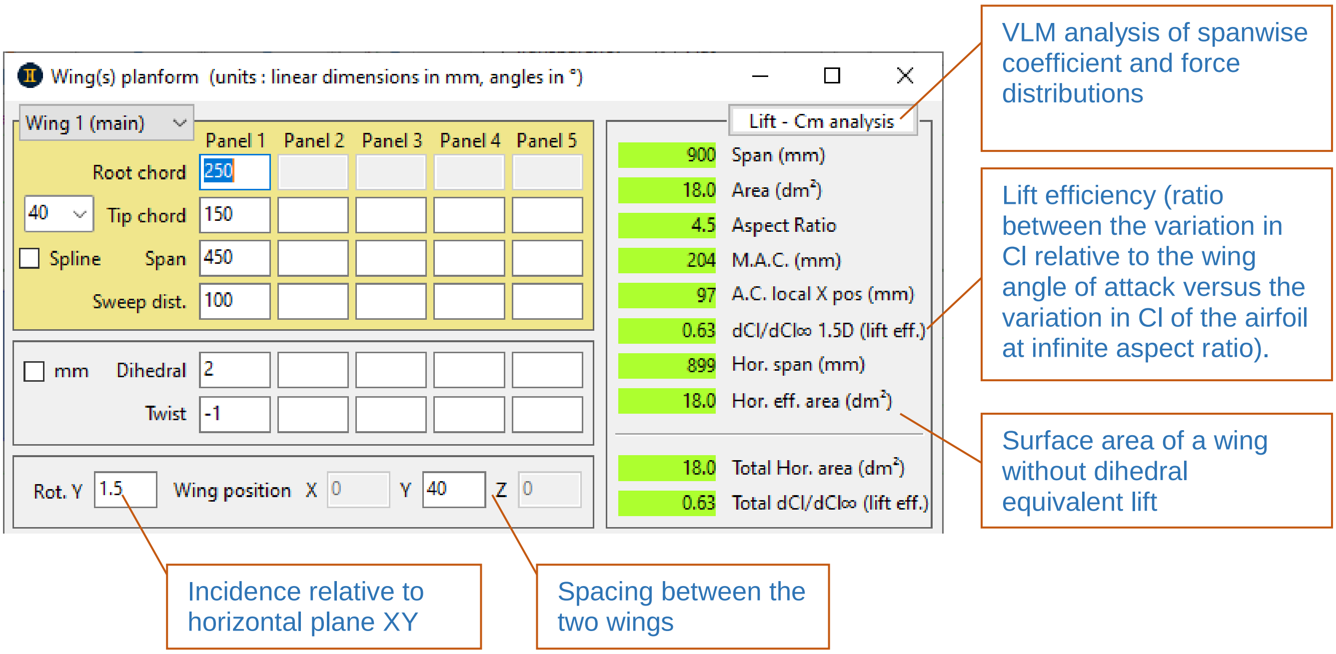


4.3.2 Definition of the wings

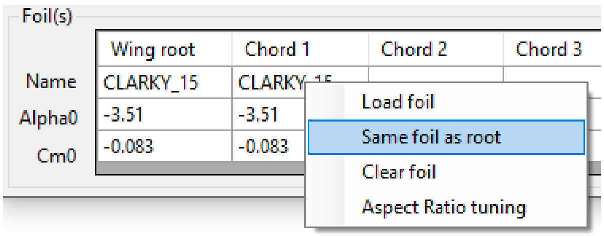
For the moment, only one pair of wings is planned ('Wing 1'), but eventually the biplane configuration will be taken into account.

You can navigate through the dimension cells using the 'tab' key, or by clicking directly on a cell with the mouse. Values can be entered using the keyboard or by scrolling the mouse (pressing the 'ctrl' key at the same time increases the step size by a factor of 10).

Some dimensions are relative to the panel in question (chord, length), while others are absolute in relation to the origin (wing root chord (sweep, dihedral, twist).
The position of the wing (angular, eq. trim, and linear) is considered in relation to the X, Y, Z axis system of the aircraft drawing.



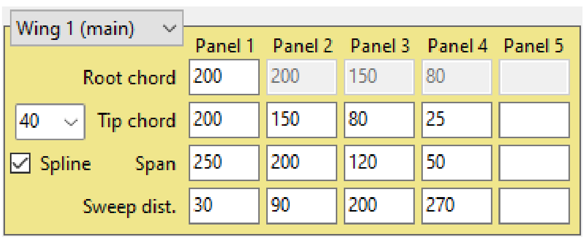
The airfoils, or more precisely: the airfoil polars, are relative to the chords entered (wing root = panel 1 root chord, chord 1 = panel 1 root chord, chord 2 = panel 2 root chord, etc.). Airfoils are loaded by clicking the mouse on the relevant column.

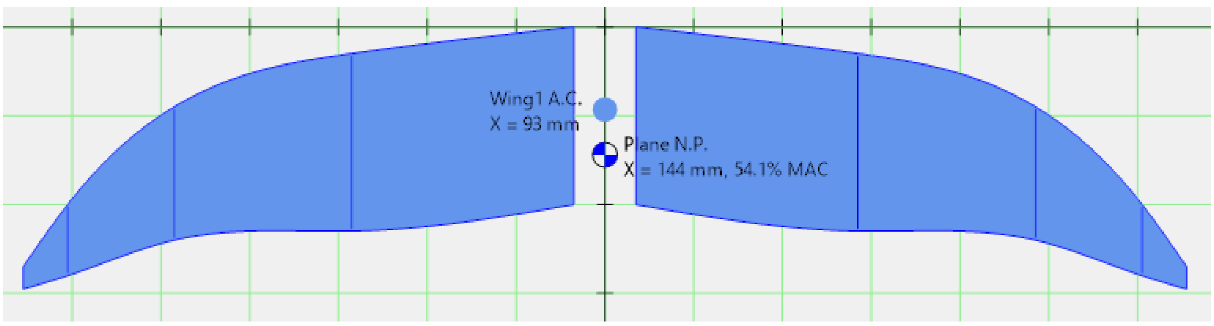


The absence of a airfoil for a chord does not prevent certain calculations from being made, such as those relating to geometry (surface, etc.), but all calculations using airfoils (Cl, Cm, etc.) will be erroneous.

4.3.3 *Elliptical wings*

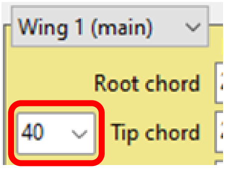
It is possible to draw elliptical wings or wings with an evolving shape by checking the 'Spline' option, which makes it possible to generate complex wings with very few panels :



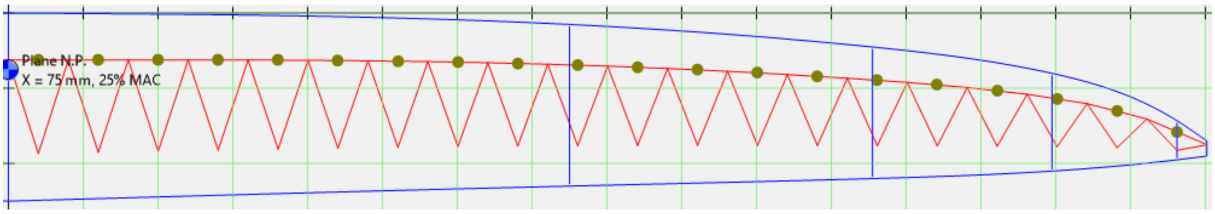


4.3.4 VLM mesh

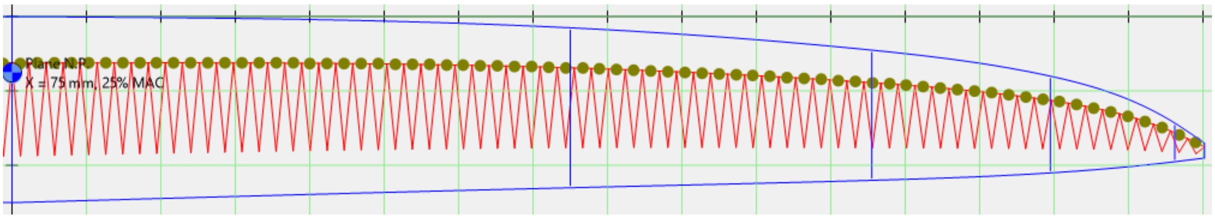
Multi-panel or elliptical wings typically have panels whose dimensions decrease towards the root chord. In some cases, these dimensions are smaller than the small element discretization of the VLM calculation, in which case it is desirable to increase the number of elements, so that each panel of the wing has at least two elements.



For example, with an F3F glider wing, the default mesh (made up of 40 elements, each represented by a point and a triangle) does not cover the last panel :



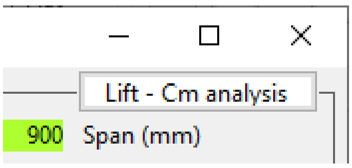
With a finer mesh, the last panel is discretised into 2 elements, which is sufficient to obtain representative results (especially as the surface area concerned is very small relative to that of the wing) :



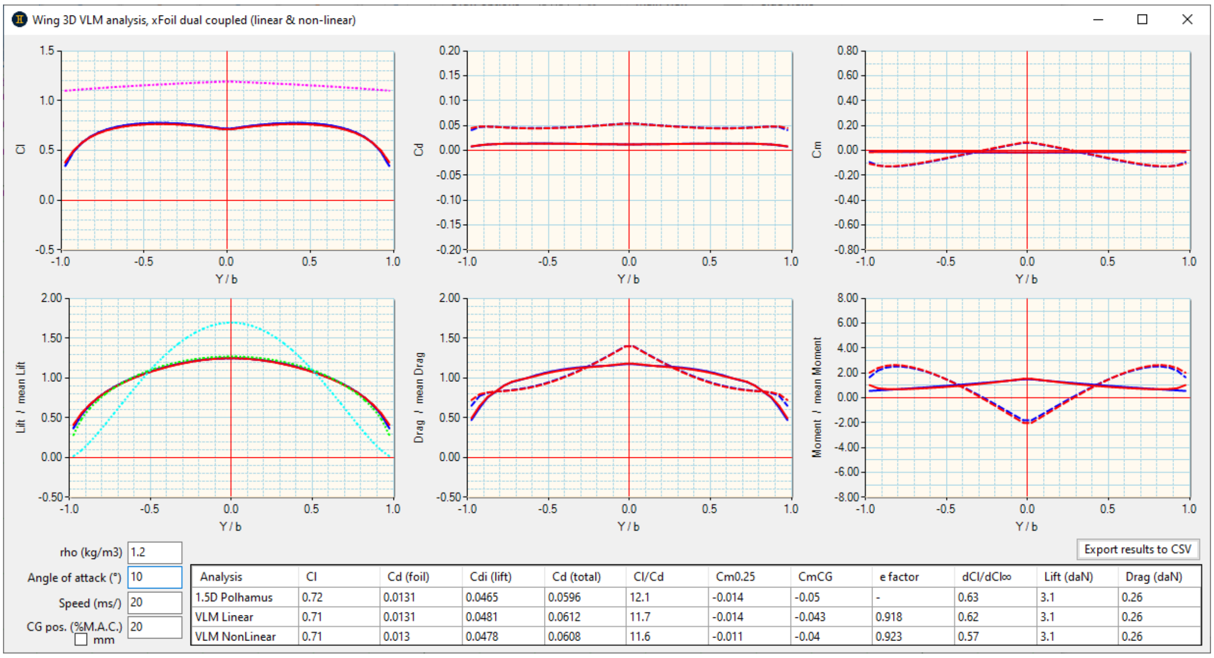
Caution: the finer the mesh, the longer the calculation time.

4.3.5 Distribution of forces and coefficients over the span

This function is activated from the wing dimensions input screen (same for stabiliser) :

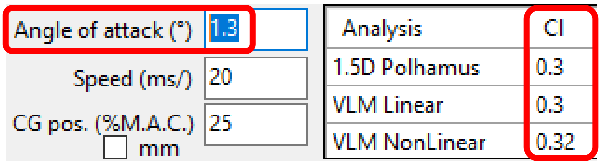


This analysis tool allows you to study the distribution of the main aerodynamic forces and coefficients of the wings along the span (b) as a function of angle of attack and flight speed.

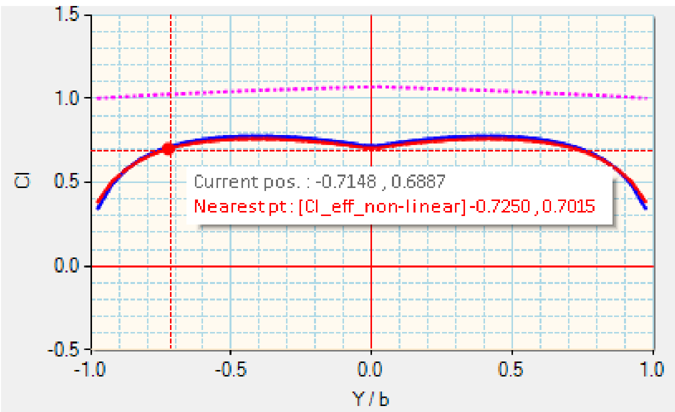


It also calculates the overall coefficients, which makes it particularly useful for the design of flying wings (seeking longitudinal balance at the design Cl, i.e. CmCG = 0), as well as glider and performance aircraft wings.

Another practical use is to determine the angle of attack for a given Cl, which can be used, for example, as a wing/fuselage setting for the design Cl :



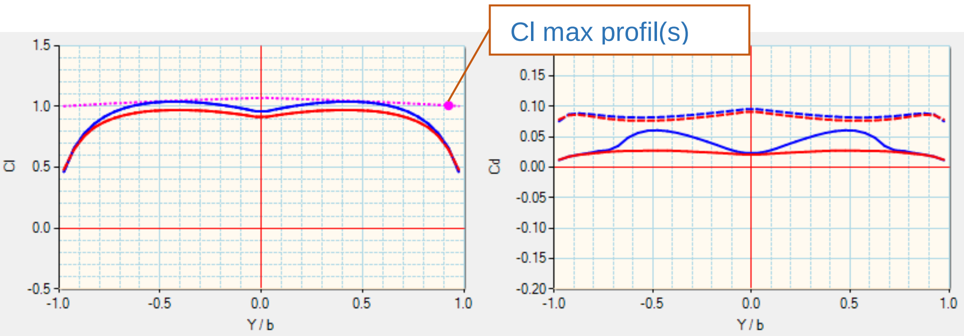
Given the large number of curves, no legend is given (this would overload the screen), so you have to move the mouse cursor over each one to find out what it means :



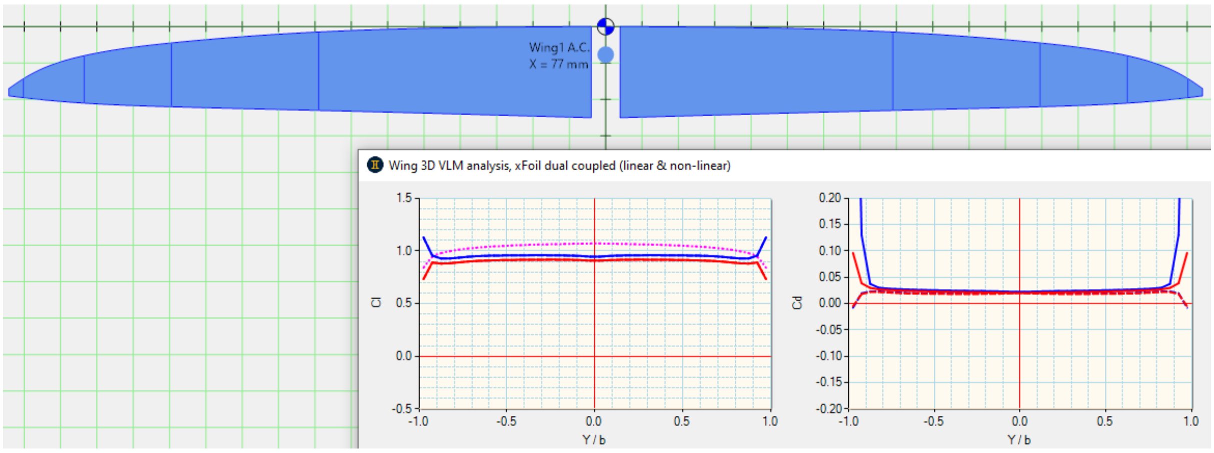
However, a colour code is used to make it easier to identify the curves: green = 1.5D, blue = linear, red = non-linear.

This tool can also be useful in the general case, for example to study the stall initiation zones and, if necessary, change the airfoil and/or add a twist adapted to the root chord. In fact, for healthy behaviour, it is preferable for the stall to initiate towards the root rather than the tip, so as to maintain roll control.

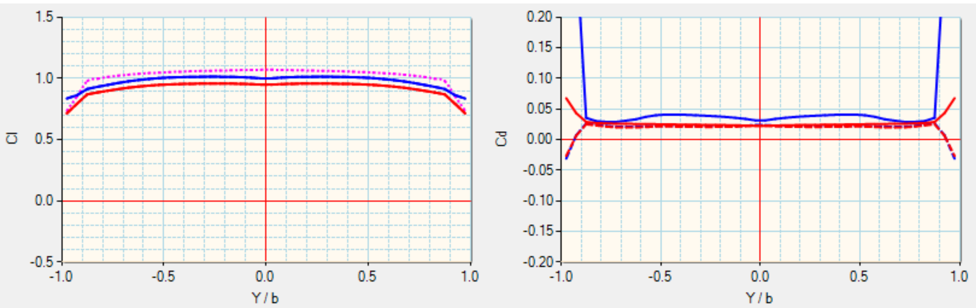
Healthy behaviour on a low aspect ratio trapezoidal wing :



Problematic behaviour on a 'raw' F3F glider wing :



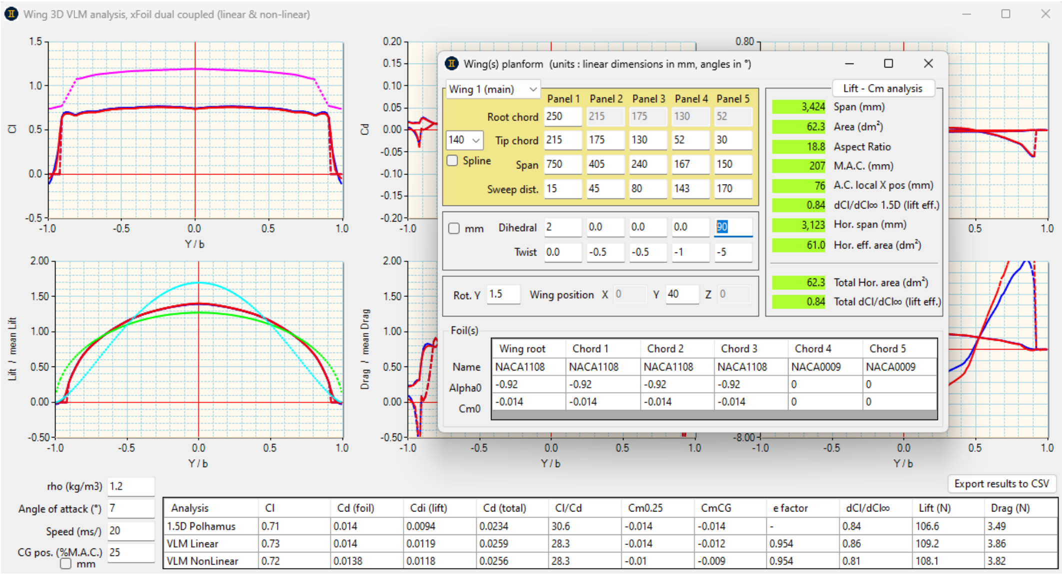
The same wing after adapting the airfoils and adding a slight twist to the last 3 chords :



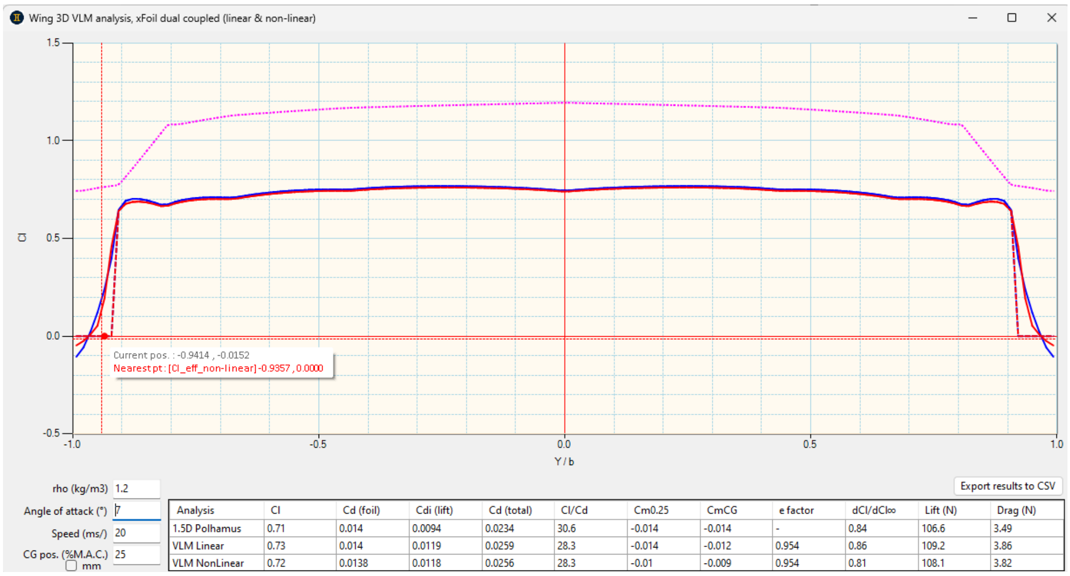
The graph on the right shows an increase in the drag coefficient at the last panel, which is normal (very low Reynolds), but not very significant for performance given the very small surface area involved.

4.3.6 *Winglets*

Since the G.A.D. VLM solver is of the full 3D type, it is perfectly possible to study wings with winglets :



Note that G.A.D. calculates two types of Cl curves: normal to the surface and effective in terms of lift (projection on the vertical axis) :



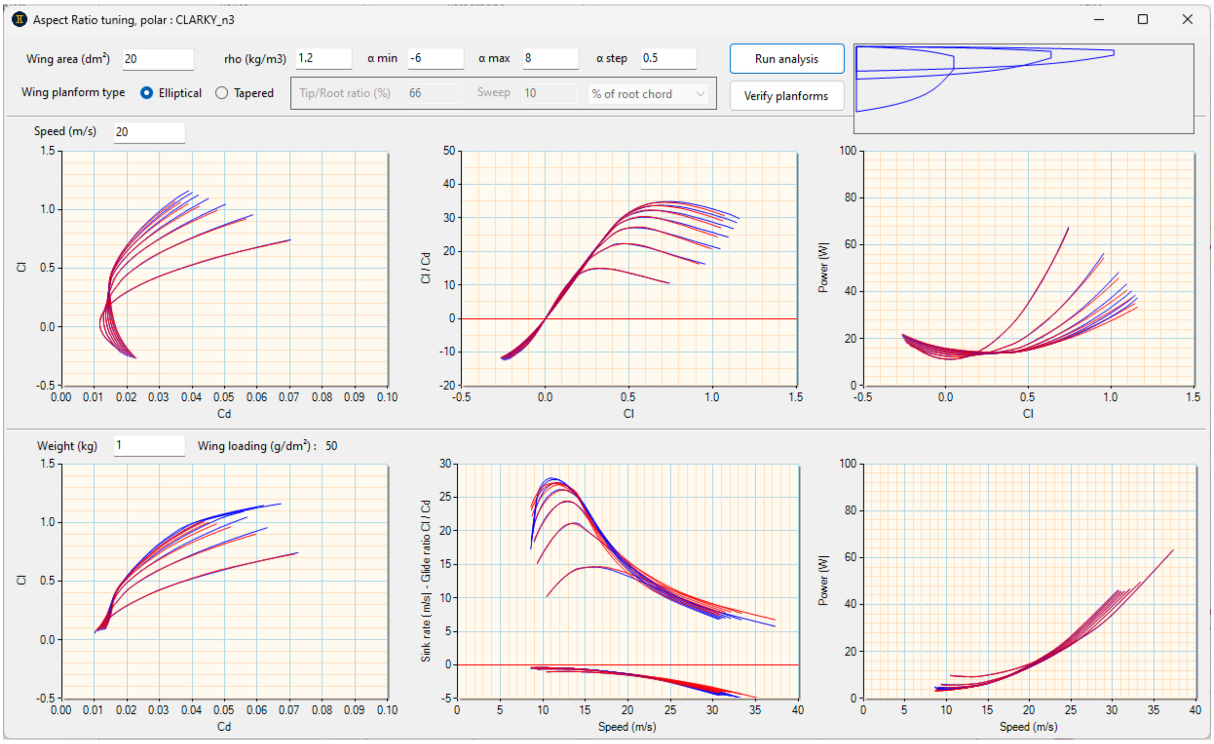
4.3.7 *Optimising aspect ratio*

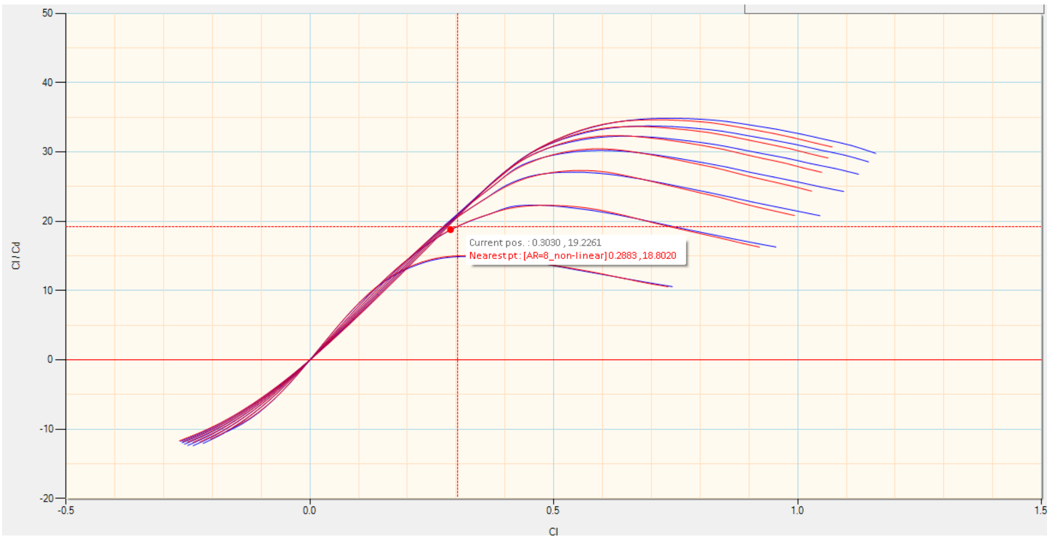
This wing design aid can be accessed from any of the D.A.M. areas that manipulate airfoil polars, such as polar comparison or loading a polar for a wing.

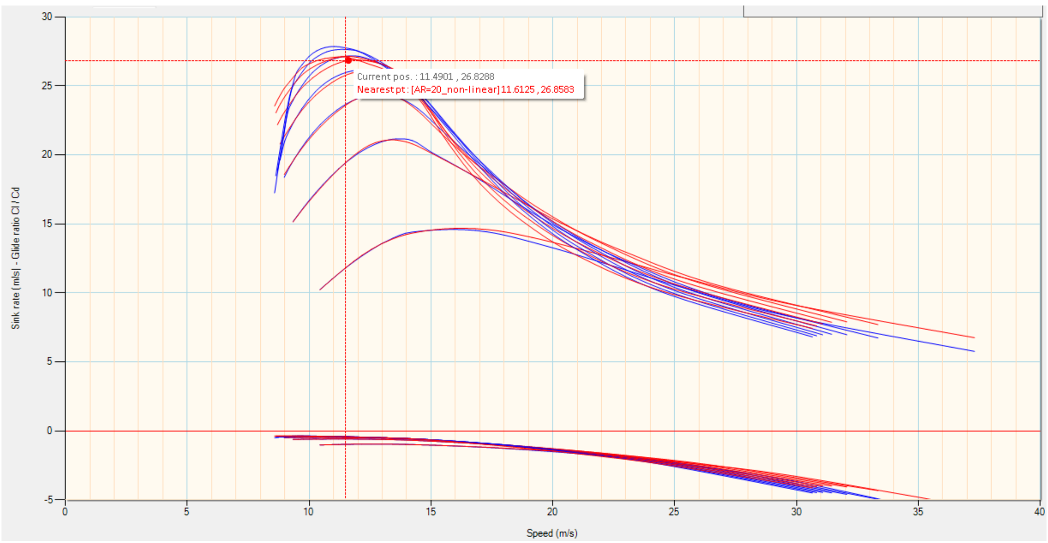
The principle is to scan a range of aspect ratios for a given airfoil associated with a given wing surface and shape. The various polars thus plotted can be used to analyse the effect of aspect ratio on performance and, on that basis, to choose the best compromise for the desired flight envelope.

Two typical flight conditions are studied simultaneously:

- at constant lift and variable speed: level, straight glide
- at constant speed and variable lift: turns, loops, etc.


Aspect Ratio tuning, polar : CLARKY_n3
Wing area (dm²) 20
rho (kg/m3) 1.2
α min -6
α max 8
α step 0.5
Run analysis
Wing planform type
Elliptical
Tapered
Tip/Root ratio (%) 66
Sweep 10
% of root chord
Verify planforms
Speed (m/s) 20
Weight (kg) 1
Wing loading (g/dm²) : 50
Cl
Cd
Cl / Cd
Power (W)
Sink rate (m/s) - Glide ratio Cl / Cd
Speed (m/s)


Cl / Cd
Cl
Current pos. : 0.3030 , 19.2261
Nearest pt : [AR=8_non-linear]0.2883 , 18.8020

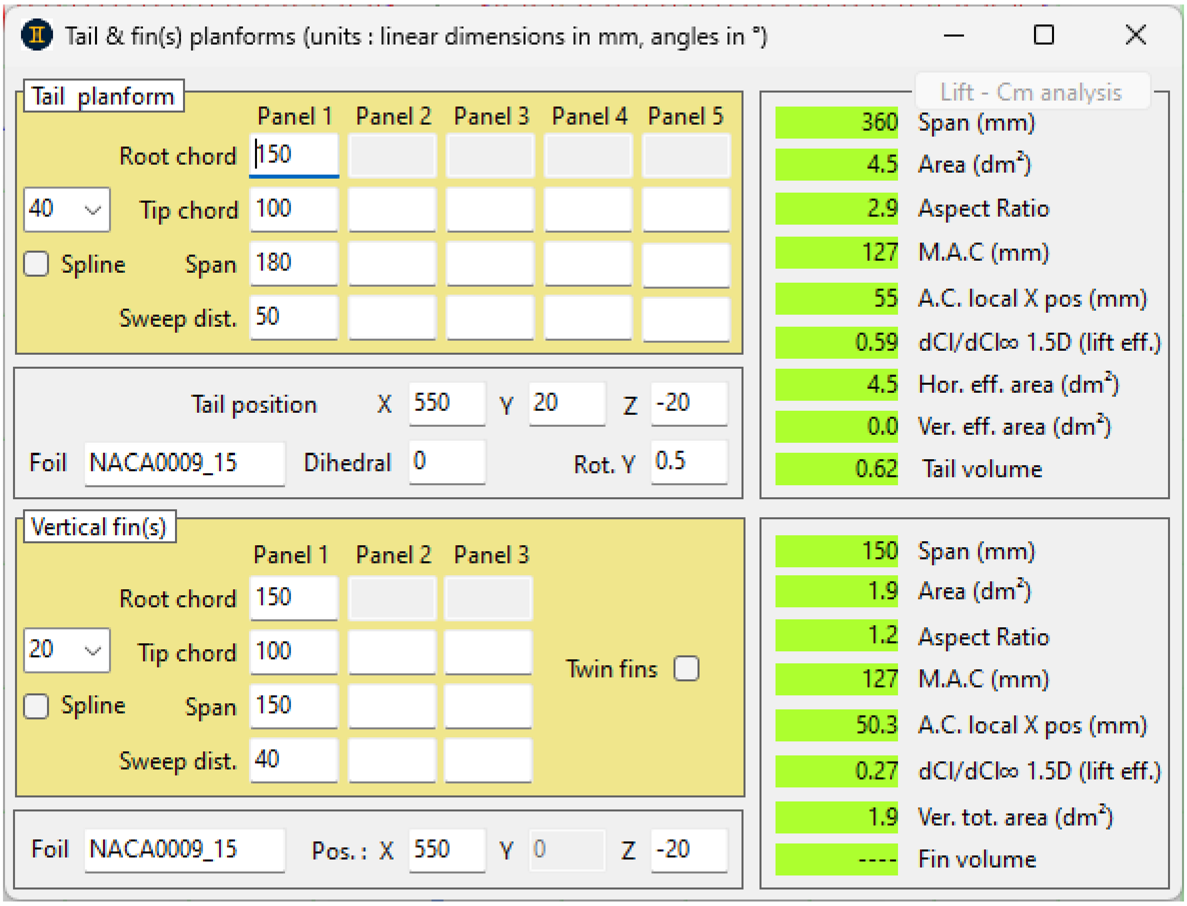

Sink rate (m/s) - Glide ratio Cl / Cd
Speed (m/s)
Current pos. : 11.4901 , 26.8288
Nearest pt : [AR=20_non-linear]11.6125 , 26.8583

The key to using this tool lies in defining the flight envelope, which can be synthesised into 3 variables (flight speed, weight and Cl), the challenge of which is to identify typical values. An example for the F3F: https://www.rc-network.de/threads/flugvermessung-bei-f3f.11812891/

4.3.8 *Tailplane and fin definition*

This screen is structured in exactly the same way as the wing screen, with a few minor differences:

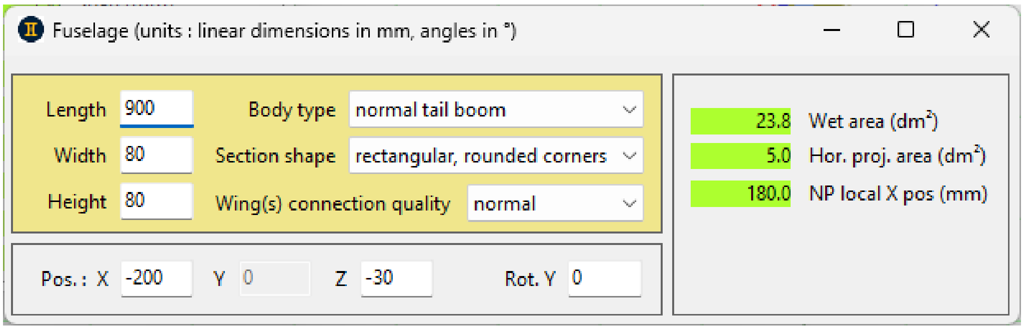
- the airfoil and dihedral are constant throughout the span
- no twisting
- certain global aircraft data (tail volume) are calculated here



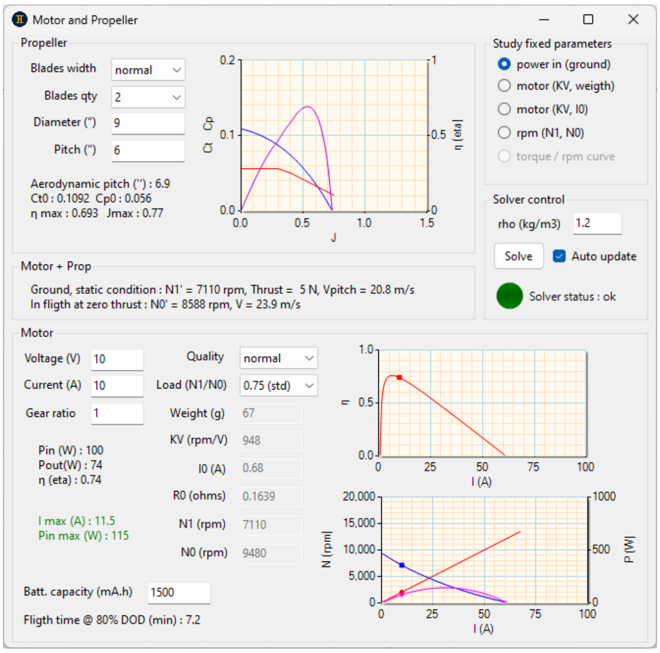
4.3.9 *Fuselage definition*

Fuselage modelling is deliberately very simple, using an approach similar to that developed by Gilruth (see NACA Report 711), with experimentally recalibrated coefficients for low Reynolds. The results are robust and very close to those obtained with a more complex discretisation method such as Multhopp's (see NACA TM1036).

The only precaution to take is to choose a shape that is visually representative of the fuselage being modelled (refer to the aircraft drawing in the main interface).

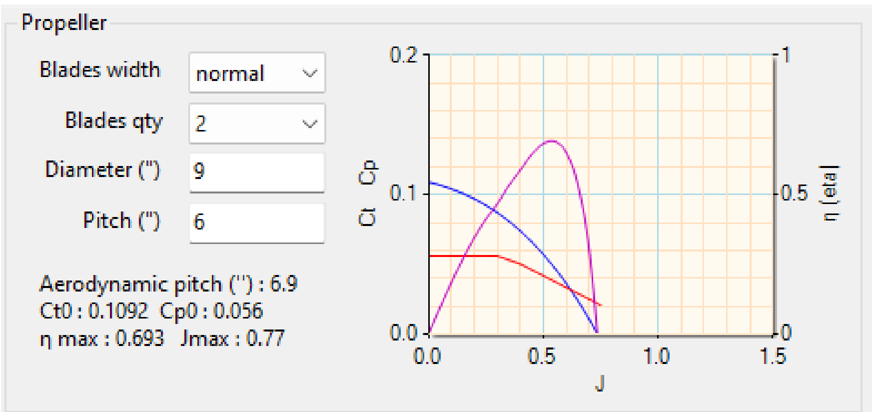


4.3.10 Powertrain definition



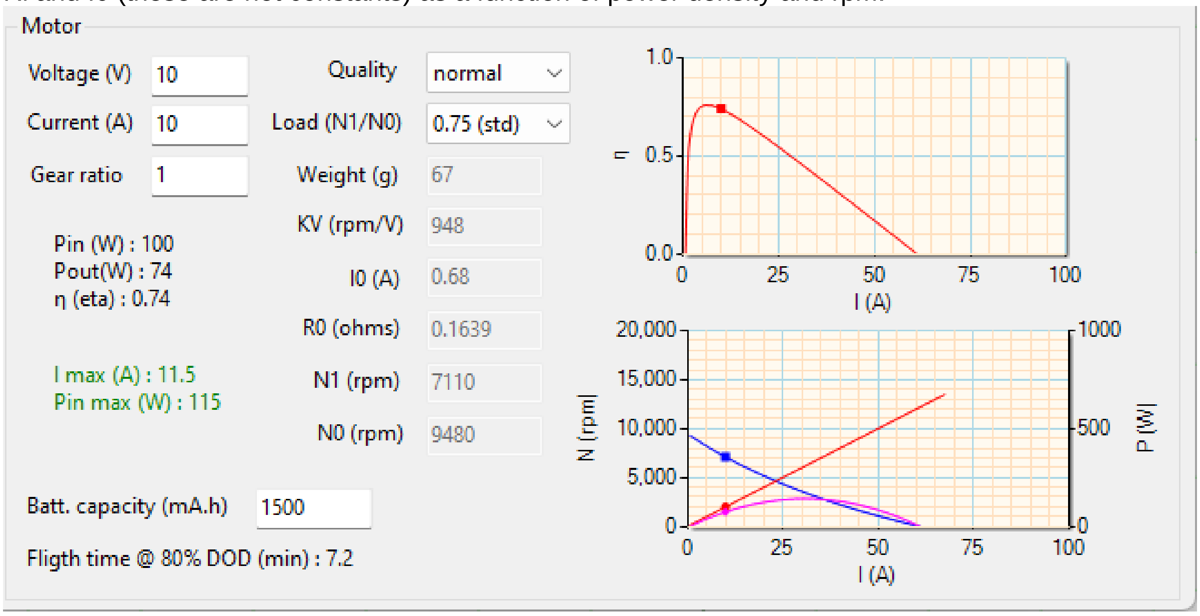
The results are given by the curves of the coefficients of traction (Ct), power (Cp) and efficiency (eta) versus the factor of advance (J = flight speed / (rpm * propeller diameter)).

Unlike conventional calculators based on very approximate methods (Boucher formula, etc.) covering only the static operating point, G.A.D. uses aerodynamic modelling of the propellers based on hundreds of wind tunnel measurements (e.g. . UIUC Propeller DataBase), from the static point (J = 0) up to the transparent speed (zero traction, J = Jmax).



Note that the pitch entered is the geometric pitch (= propeller airfoil set at 70% of the rayaon) given by the manufacturers. The aerodynamic pitch is then calculated, generally with a value significantly higher than the geometric pitch, which explains why many aircraft can fly at pitch speed (Vpitch), when we would expect a lower speed.

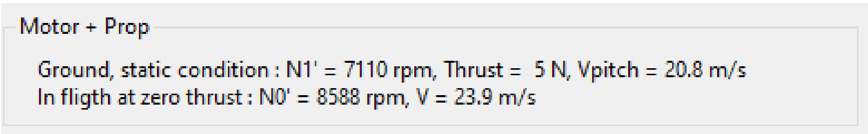
The engine calculation model is also based on physical data, incorporating automatic corrections for Ri and I0 (these are not constants) as a function of power density and rpm.



These advanced models offer two decisive advantages:

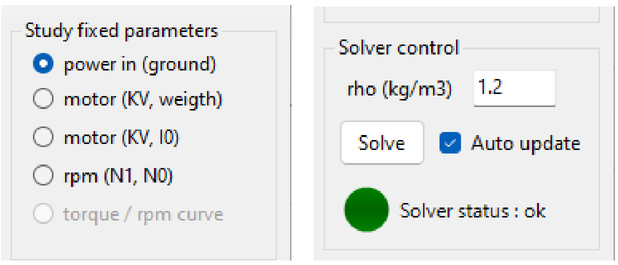
- they are generic, so you don't need to scroll down a list of equipment and/or manufacturers to identify the elements under study; all you need to do is enter their physical characteristics (which are easy to measure and/or find in the manufacturer's data).
- they enable the engine flight envelope to be calculated accurately (by cross-referencing with the aerodynamic performance of the aircraft).

Obviously, the ground operating point is calculated (the units can be changed via the ToolBox) :



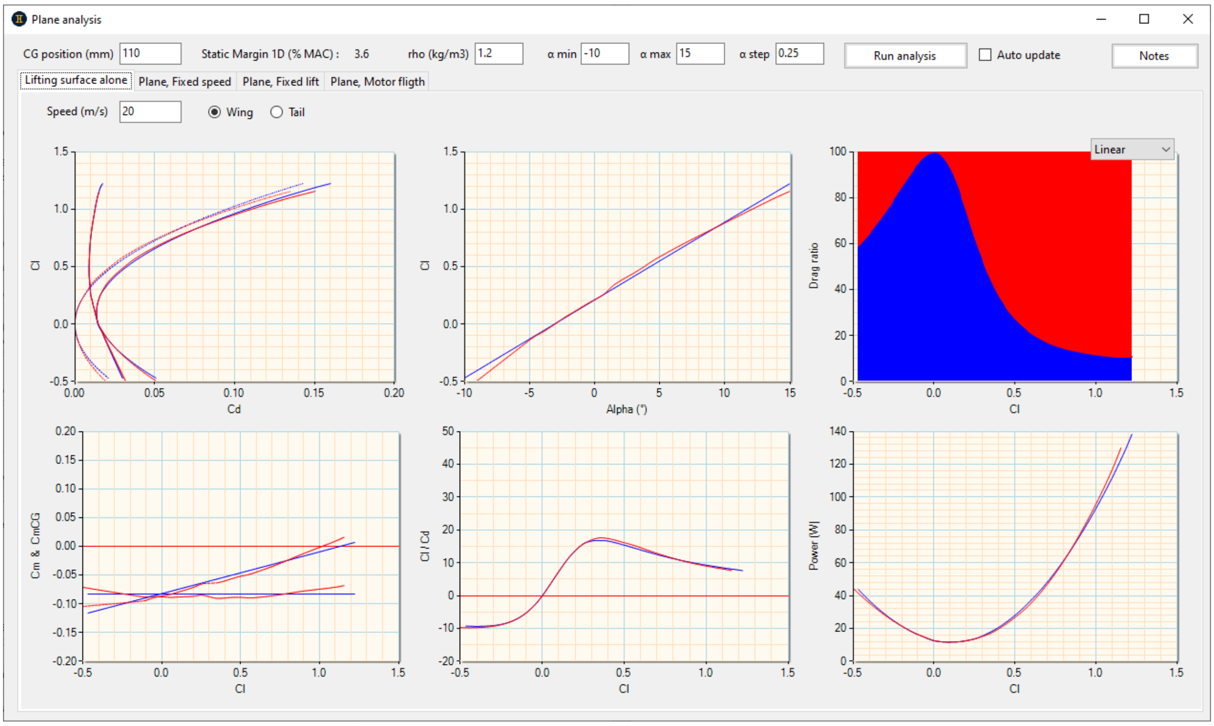
The density of the air (rho) is taken into account in the calculations. The solver can solve different scenarios, depending on the parameters known and/or set and the objectives of the study (a status indicates whether the solver finds a solution to the input data entered):

- imposed input power: the solver determines the motor that will drive the chosen propeller while consuming this power
- known motor (KV and weight or KV and I0): the solver calculates the speed and current with the chosen propeller
- known main speeds (with propeller and at no load): this makes it possible to simulate any type of engine, including thermal engines.



4.4 *Performance, balance and stability analyses*

This screen is used to simulate aircraft performance in different contexts.



The graphs used for the most common analyses are specific to each context. It is possible to go further in the analysis, by exporting the performances to be analysed in the comparison tool.

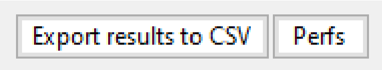
4.4.1 *Simulation parameters*

The parameters in the banner are applied to all simulations :

he analysis is launched for the current context (single wing, aircraft, etc.), and can be manual or automatic (each time a dimension of the aircraft is changed) :

The parameters on the tabs are specific to the context :

4.4.2 *Exporting performances*

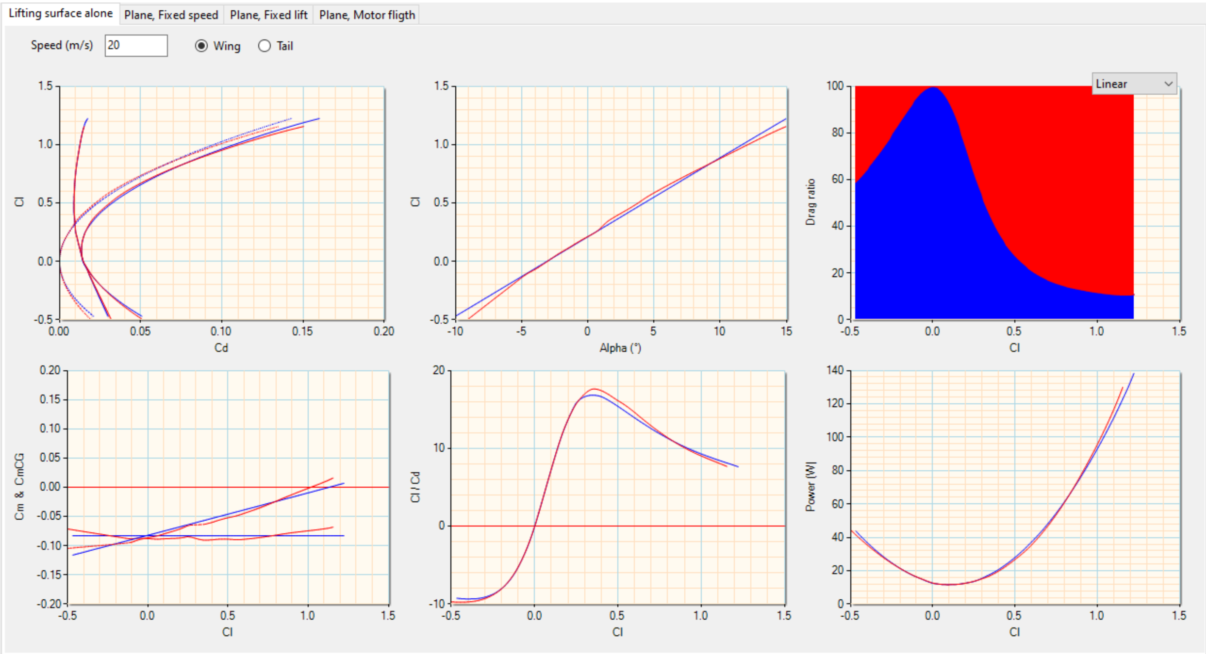


For each of the analysis contexts presented below, these two buttons can be used to export the results in two formats:

- CSV: for customised analysis in Excel spreadsheets
- Gemini: for analysis in the performance comparison tool.

4.4.3 *Isolated wing or tail analysis*

This section looks at the performance of the wings and empennage in isolation from the rest of the aircraft.



Note that backwards flight (negative Cl) can be studied at the same time as normal flight.

4.4.4 *Plane analysis at constant speed*

The aircraft is analyzed at a given speed and at variable angle of attack, i.e. during a maneuver such as a loop or a tight turn. This is where balance (CmCG = 0) and stability (dCmCG > 0) are studied.

Reminders:

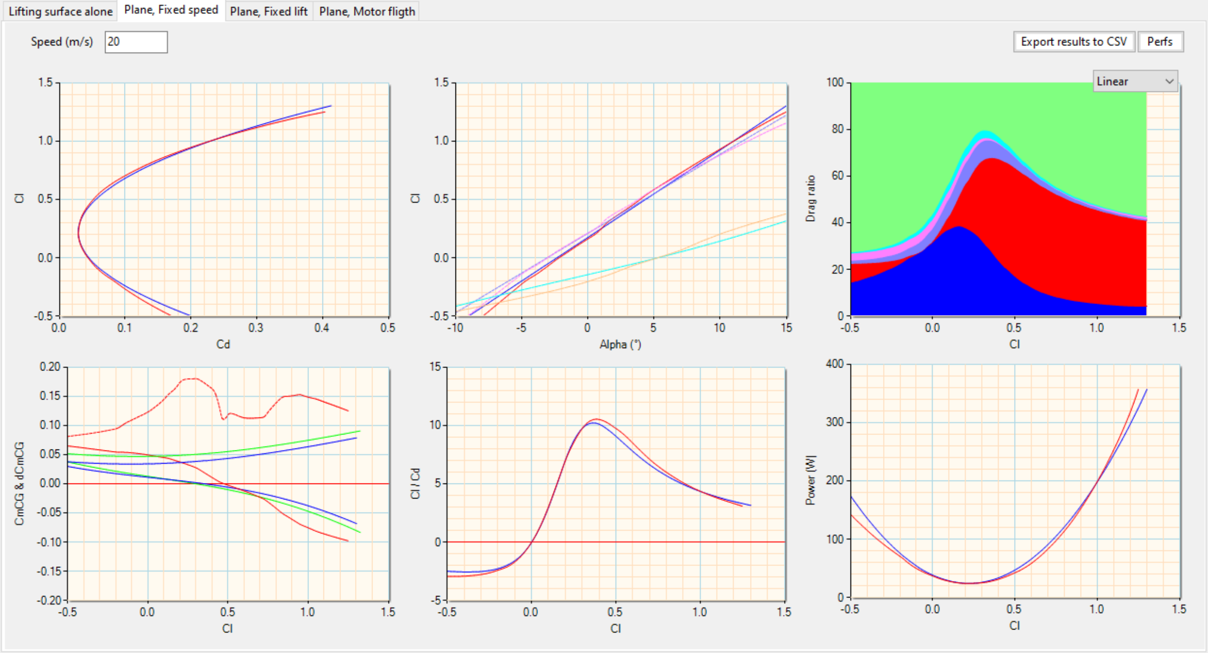
- Longitudinal equilibrium is achieved, for a given operating point (Cl, flight speed), when the CmCG curve is zero at this point.
- Stability, at which point of this equilibrium, is:
  - o positive when the slope of CmCG is decreasing.
  - o zero (neutral centering, i.e. at the general focus).
  - o negative (unstable) when the slope of CmCG is increasing.
- The stability rate is given by the dCmCG curve (derived from CmCG), and is homogeneous at the static margin.

To remain consistent with the notion of static margin, and therefore comparable with this value, the definition of dCmCG retained is as follows: dCmCG = - CmCG / 2π.A.dAlpha.
With : A the 1.5D lift efficiency, dAlpha the difference between the local AOA and the balance AOA.

Consequently, if the CmCG curve does not cross the zero ordinate, there is no balance and stability cannot be calculated.

To note that :

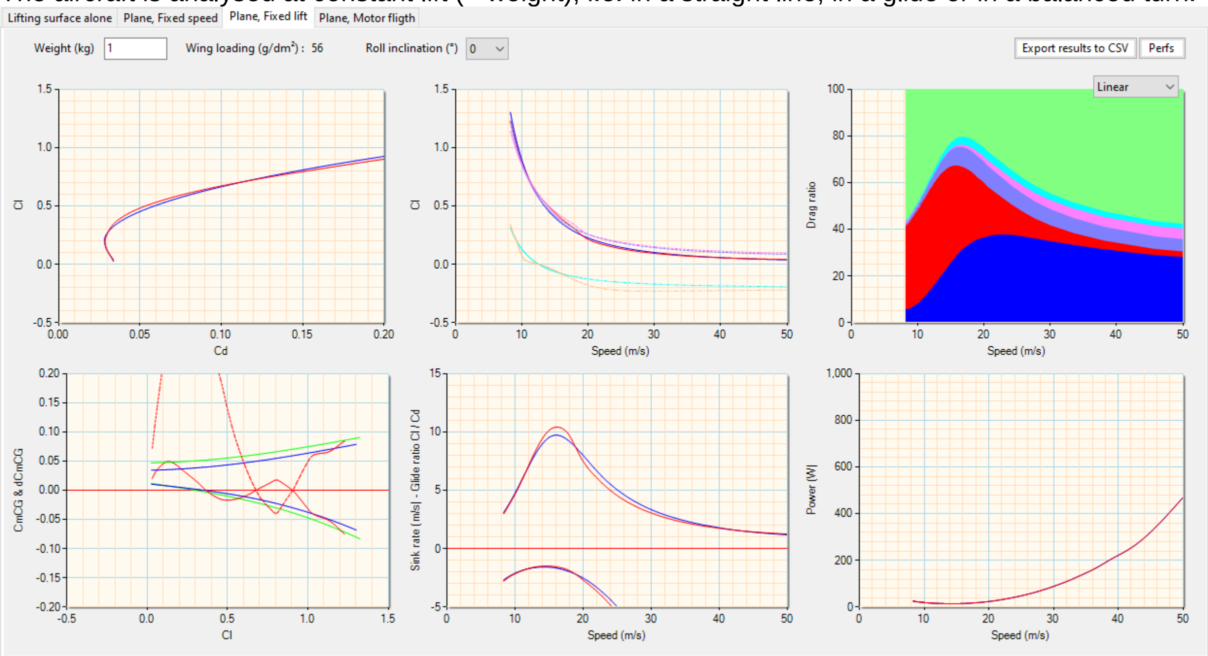
- this definition of dCmCG represents the pitch stiffness of the aircraft, which is the most relevant notion for studying stability on this axis.
- the 1.5D and linear VLM curves are calculated with variable downwash (the height and axial position of the tail are recalculated at each angle of attack), which gives curves which are not necessarily linear.



This approach makes it possible to predict (non-linearly) the aircraft's stall behaviour, depending on how the CmCG curve evolves in this flight regime. For example, we can clearly see the loss of efficiency of a V or T stabiliser at high angles.

4.4.5 Aircraft analysis at constant lift

The aircraft is analysed at constant lift (= weight), i.e. in a straight line, in a glide or in a balanced turn.



Here we find the same notions of equilibrium and stability as in the constant speed analysis, with the emphasis here on Reynolds effects as in the non-linear analysis.

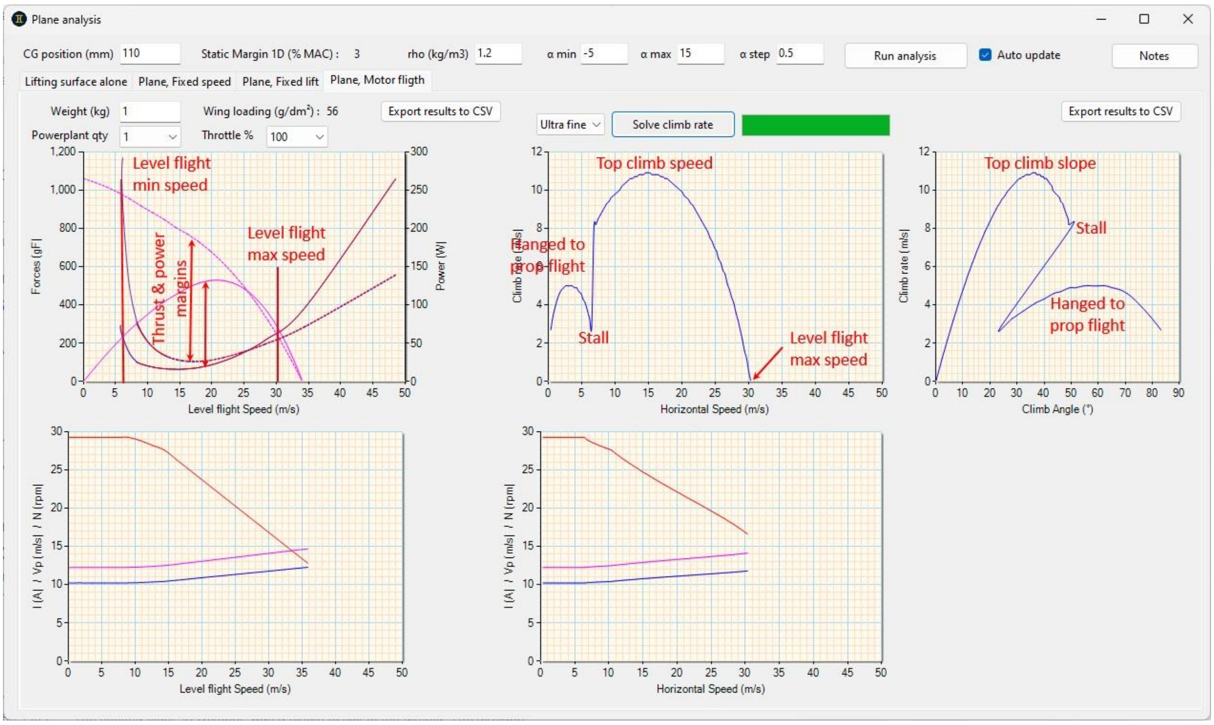
You can see from the non-linear dCmCG curve that the flight is very stable at low and high angle of attack, but has a slightly unstable zone at Cl = 0.8. This will require a small check of the nCrit used to blow the airfoils and, if it is representative, the use of a turbulator (or a change to the offending airfoil) to improve matters. At the very least, the centre of gravity could be brought forward so that stability is positive over the entire flight envelope.

4.4.6 *Aircraft analysis in engine flight*

The aircraft is analysed during engine flight in two typical flight phases:

- in level flight: analysis of the power reserve and/or traction and search for the maximum speed as well as the second gear speed
- in climb: analysis of rate and angle of climb as a function of horizontal speed.

In both cases, propeller speed, blade peripheral speed and engine current are calculated at each operating point studied.



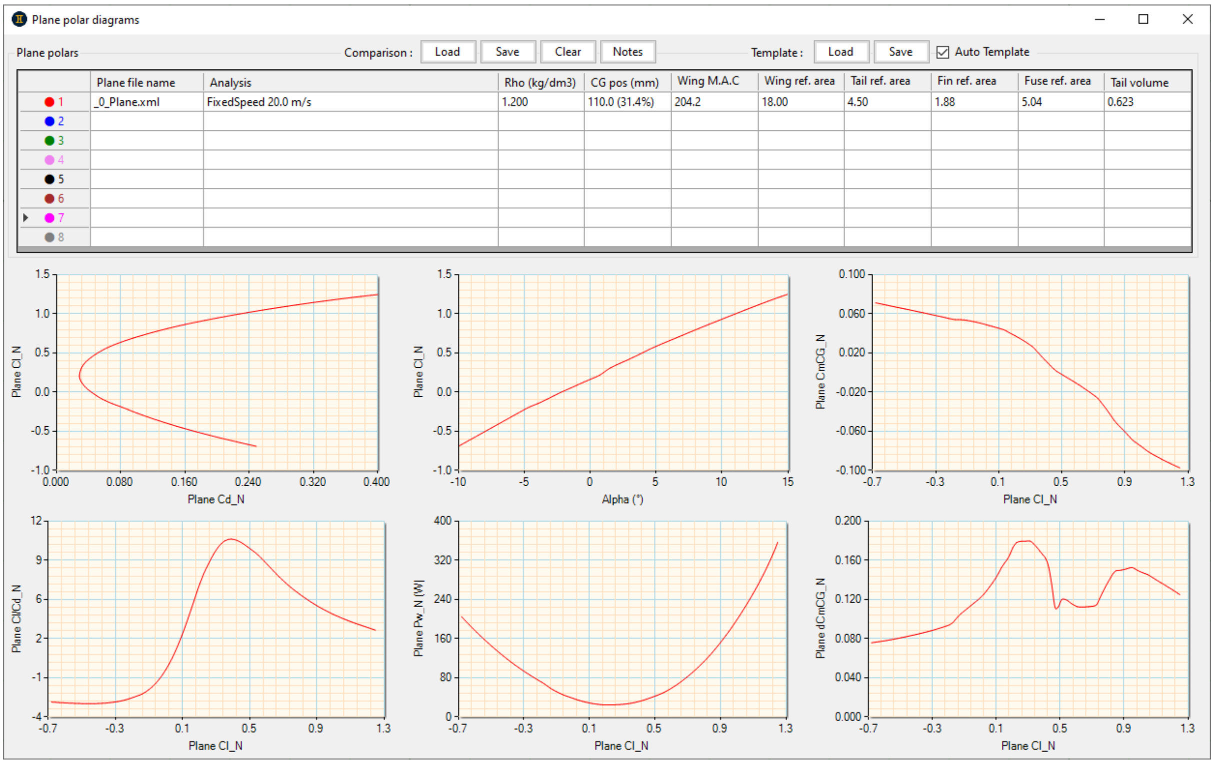
Note that the graph at the top left has two ordinate scales, so as to simulate level flight in terms of power (transmitted by the propeller versus dissipated by the aircraft) and forces (propeller pull versus aircraft drag).

Since the climb flight calculation is not instantaneous, it must be manually regenerated after a change of input data.

4.5 Aircraft performance comparison

4.5.1 User interface

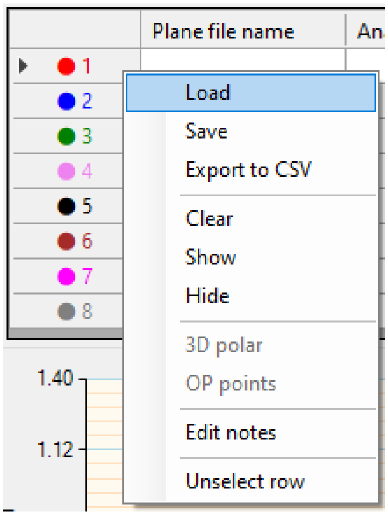
The aircraft performance [polar] comparison screen is presented in exactly the same way as the airfoil polar comparison screen.



It allows you to compare several different aircraft, or the same aircraft with different parameters (weight, aspect ratio, etc.).

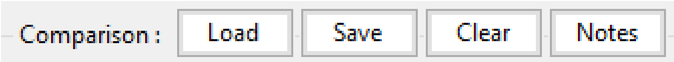
4.5.2 Performances management

In the same way as for the airfoil polar comparison screen, clicking on each line opens the menu for loading / hiding / deleting / etc. an aircraft performance polar.



4.5.3 Comparison management

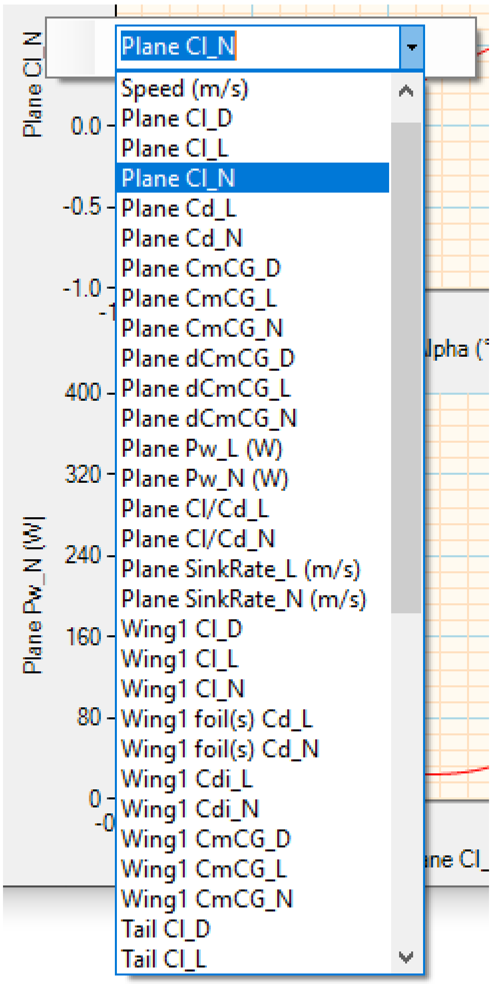
Here too, the principle is strictly identical to that of airfoil polar comparisons.



4.5.4 Axis configuration s

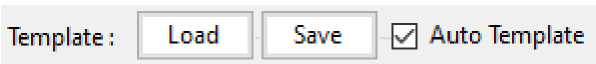
Unlike the rest of the application, the data displayed can be configured for each axis, so that the results can be analysed as closely as possible to your needs. These settings are saved in the comparison at the same time as the data.

To do this, simply click on the label for each axis, then choose the data to be displayed from the drop-down list :



4.5.5 Templates

Templates are configuration files for the axes of all the graphs.



By default, the application is delivered with four templates :

› PlanesPerfs › Comparisons › Templates

TemplateDefault.xml
TemplateFixedLift.xml
TemplateFixedSpeed.xml
TemplateMotorClimb.xml

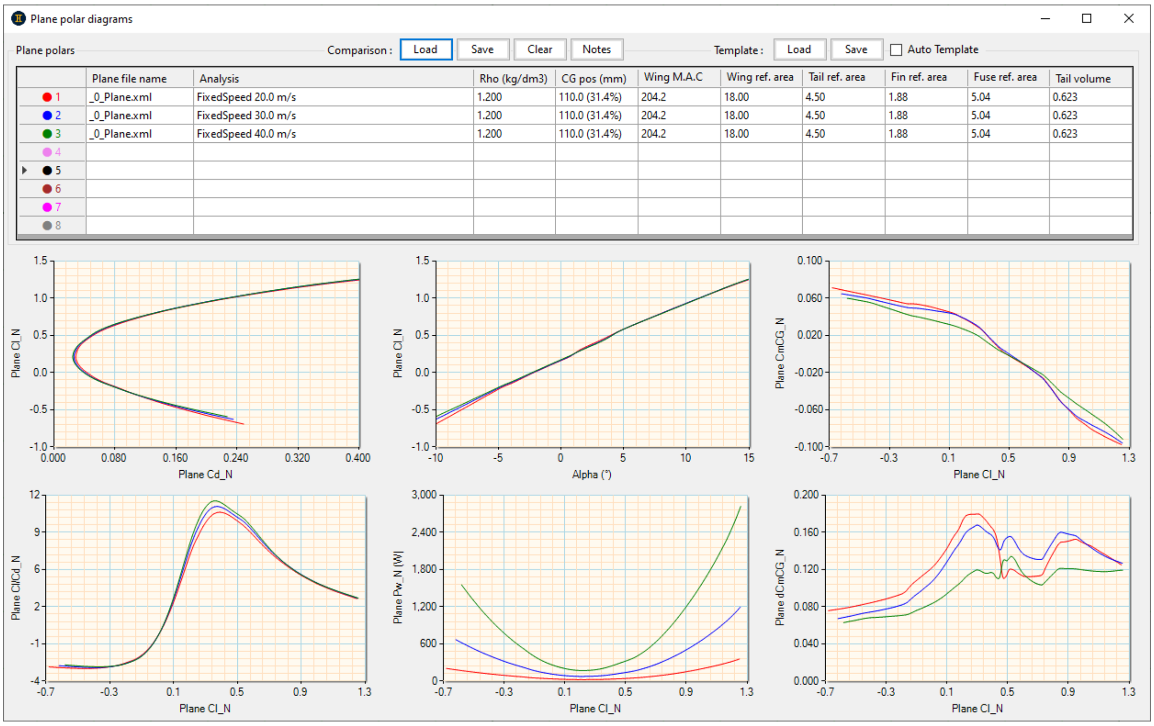
These standard files (do not rename or move them!) are used automatically when a performance polar is loaded (depending on its type) if the ‘Auto Template’ box is ticked. As its name suggests, the ‘Default’ template is used when this screen is opened and no polar is loaded.

These templates can be modified, and new ones created as required, by configuring the axes (regardless of whether or not data is displayed) and then saving the template.

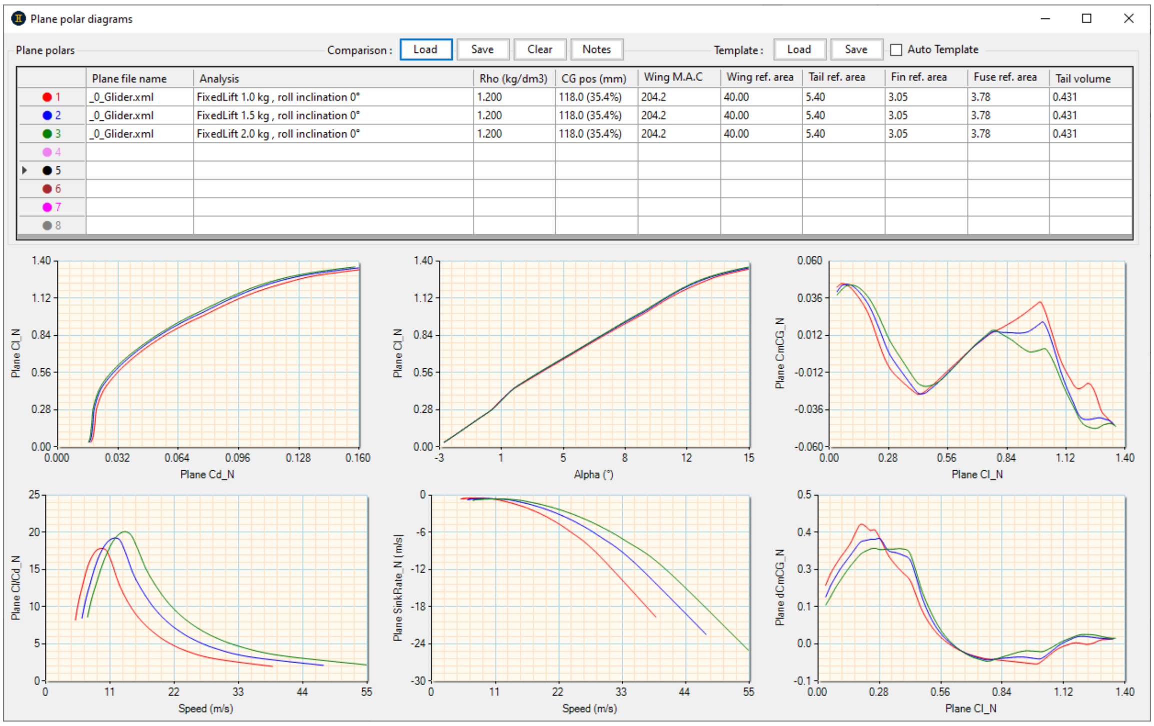
4.5.6 *Analysis examples*

Here are a few examples of analysis carried out using the default templates.

Study of the influence of flight speed during manoeuvres :



Study of the influence of ballast on a glider when gliding :



Study of the influence of engine power on engine climb performance (it also shows the top speed in level flight, when Vz = 0) :