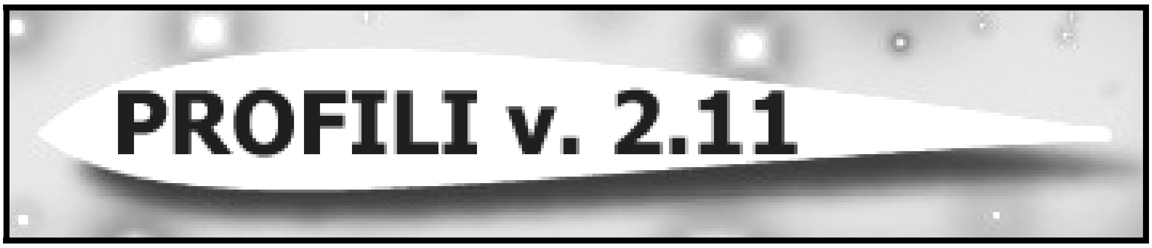


Sergio Montes and Chris Stoddart

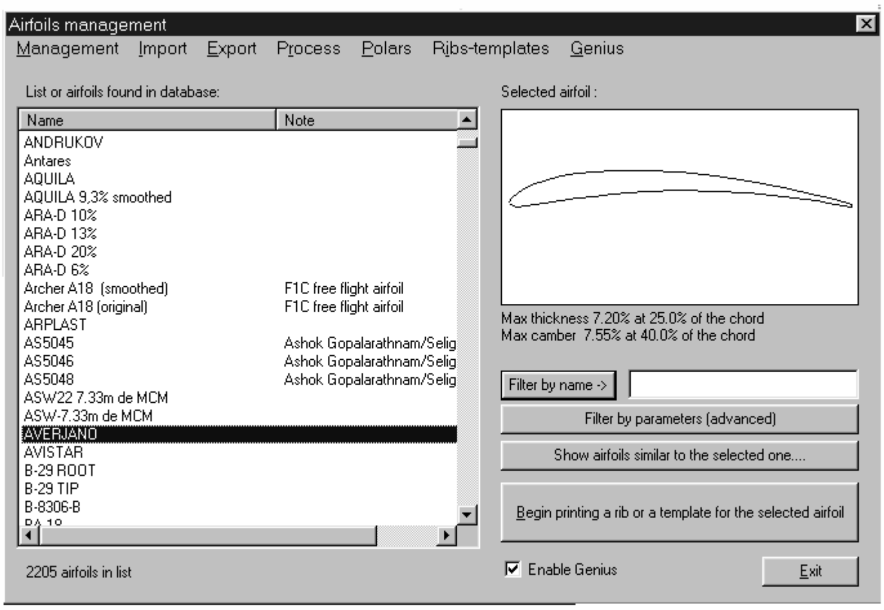
Profili is an amazing computer program created in 1998 in Italy by **Dr. Stefano Duranti**. (Stefano Duranti, via della Casazza 43/b 32032 - Foen di Feltre (BL), Italy, Tel. 0439310326, E-mail: st.duranti@tin.it)

This program has established itself as probably the best all-around computer database, tracing and printing utility and its capabilities are nothing short of sensational, especially considering its price. One can download for free from http://www.profili2.com a very good working version, or, for the relatively small sum of $10 US one can register the program with its creator. The registered version has many additional functions that make this modest outlay most productive.

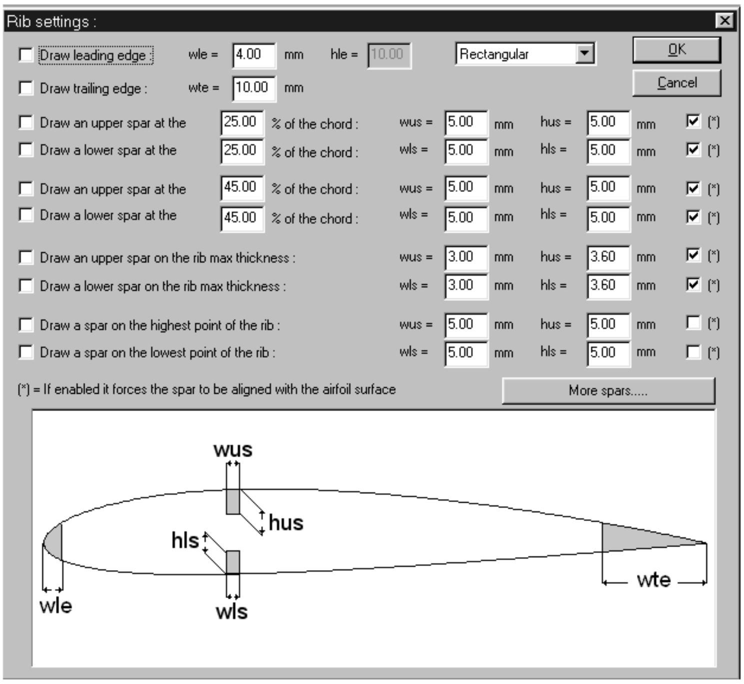
What can Profili do? We will divide this discussion in two parts that cover specific characteristics of Profili. In part 1 below we discuss the immediate and most salient database and graphical features of the program. Here is a list that we think is comprehensive, but probably does not exhaust the capabilities of this program

1) Database, airfoil tracing and printing.

- Profili contains a database of about 2200 different airfoils, many of them specialized airfoils whose coordinates are not easily obtainable elsewhere. A large percentage of the database is directed to the RC practitioners, but for the FF enthusiasts there is the entire Benedek family, dear to F1A and F1B designers, the entire Goettingen collection of airfoils, hundreds of them, F1E and full-size glider airfoils of the Wortmann and Eppler families, plus a separate facility for creating the 4-digit and 5-digit NACA families, etc. etc., in all an amazing selection and wealth of choices. This is the collection to end all collections, and it is being constantly improved by Dr Duranti! He has added about 400 airfoils to those in the first version of Profili. Bottom left is the window that is opened in the program to execute the program airfoil search and display. The search on this large database can be conducted by a series of filters based on full or partial names, and such characteristics as thickness or camber.
- Profili can modify an airfoil in many ways: it can change the thickness distribution, the mean (camber) line, can marry different airfoils in different proportions, say create a new foil that is 75% NACA 6409 and 25% Eiffel 400, can create an airfoil consisting of the extrados (upper contour) of one type with the intrados (lower contour) of another. The modified airfoils can be added to the database, allowing the enterprising designer to create entire new families of his/her own. Collections or "Libraries" of airfoils from other sources can be imported and managed with a special facility included in the program.
- Profili will print the selected airfoil in many ways. If the wing has tapered or elliptical tips, Profili will trace each individual rib simply by specifying the number of ribs in the tapered part. And, of course, it will also print individual ribs. One can select the thickness of the printed line as well as choose whether the printed foil will have a "skin" of a thickness which is adjustable, to represent the case of sheeted wings or cap-strips.
- The spar cut-outs and lightening holes can be also printed, and one can easily create a pattern for cutting the ribs with all the necessary details: LE, TE, spars, cap-strips, etc, as shown in the next window.



Profili will export the coordinates in a number of formats, from .dxf suitable for CAD drawings, to .pro. cor, .dat and .txt files. It will also import additional airfoil coordinates from other Airfoil Libraries in formats of same type. In fact one can also import a bitmap profile (a drawing of the profile) and Profili will digitize the coordinates, creating a series of numerical coordinates that can be subsequently saved as a file. This is most useful when dealing with vintage models, where there is rarely a name for the airfoil used, but many times a good drawing is available. This drawing can be scanned and the digitizing routine carried out, with the result that one can acquire the "genuine"



Lanzo, Korda, Warring, etc. airfoils.

As an example of the abilities of the program, we took the case of the modified **Benedek 8406** airfoil used in the FA13 glider, presented elsewhere in this issue. The designer, Frank Adametz, had thickened the airfoil to 9.5% and reduced the camber to 5.5%. These modifications are carried out using the "Process airfoil facilities" of Profili. Then the resulting airfoil is saved and exported in .txt format (the old NACA representation), as shown on the table below. Using the printing facility for multiple ribs, one can prepare a drawing of the profile for all the ribs of the trapezoidal tips of the FA13, as shown below. The drawn airfoils, whether standard or modified, can be stored for processing, by capturing the image using the Alt-PrintScreen keys. The image is sent to Clipboard, where it can be retrieved by graphics editors. Legends, colours, etc. can be added. The legend in the multiple-rib drawing was created by this routine, using the PSP image editor

We should also mention the **Profili Users Group** in the Internet, where users can comment and discuss features associated with the program. This Profili group can be contacted at:

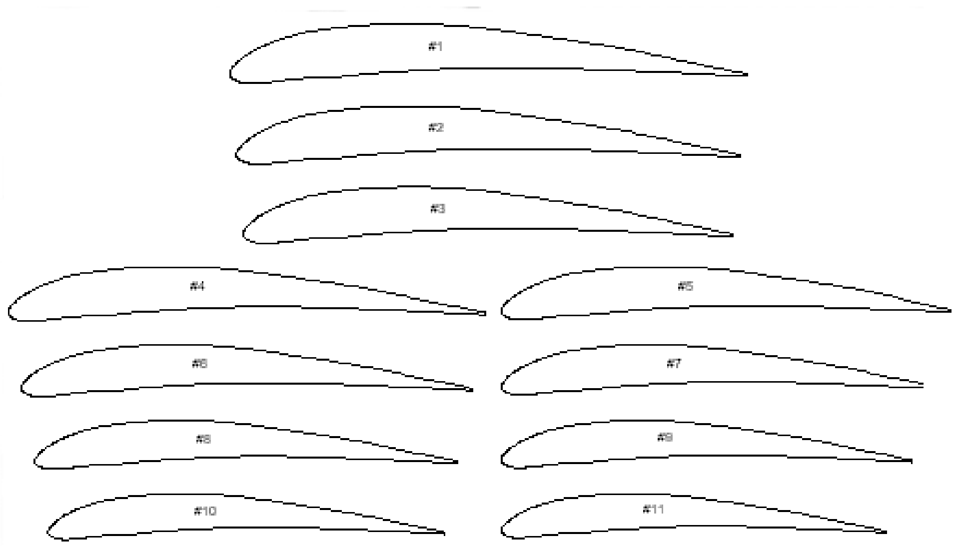
software_profili@yahoogroups.com

Dr Duranti, the creator of the program will answer queries and resolve problems related with the implementation of the program, database, etc. and also receive suggestions for additions and modifications to Profili. At present (March 2003) Duranti is embarked in a vigorous detail revision of Profili and the ideas suggested in the Profili discussion group have often been implemented in the numerous updates of the program. In each case there has been a useful enhancement of its capabilities.

2) Polar computation and verification

Several parameters, the lift, drag, and moment coefficients and their relationship to the angle of attack characterize the aerodynamic performance of an airfoil. These parameters are frequently referred to as the airfoil polars. In the past, modellers interested in studying the flight characteristics of their designs have had limited means to determine these parameters. Another impressive feature of Profili, which is of singular usefulness, is an integration of Profili with the airfoil performance predictor Xfoil of Prof. Mark Drela of MIT, so that the polars (curves of C_D vs C_L) for all the airfoils contained in the database are available. The program will allow the calculation of the polar diagram for a new airfoil, but because the calculations performed by Xfoil require significant computational resources, to analyze every airfoil included with Profili database would take many days. Hence, to cut down the time needed in such calculations, the polars for all the database airfoils are pre-computed.

Since the first version of XFoil in 1986, this program has steadily been enhanced and was released a few years ago for use by the general public. No significant additions to Xfoil are anticipated in the future. The



FA 13 Wingtip ribs as drawn by PROFILI 2.11

BE8406C		
X	Upper Y	Lower Y
0	0	0
1.25	2.0125	-0.7875
2.5	2.995	-1.075
5	4.45	-1.05
7.5	5.595	-0.725
10	6.5	-0.34
15	7.85	0.33
20	8.6	0.6
25	9.2	1.2
30	9.5	1.65
40	9.6	2.25
50	8.9	2.5
60	7.6	2.35
70	6.15	1.9
80	4.4	1.3
90	2.25	0.6
95	1.27	0.2
100	0.2	-0.2

program utilizes information from the airfoil geometry to determine the lift, drag, and moment coefficients. Of particular interest to modellers is that the effect of Reynolds number, general surface roughness and turbulators is included.

Several graphical formats of the polar information are provided. A separate color is used for each Reynolds number in Profili leading to ease of understanding. Other presentation formats include coefficients versus angle of attack, comparison of several airfoils at the same Reynolds number, coefficients versus Reynolds numbers for ranges of angles of attack, and the distribution of pressure coefficient over the airfoil surface. The user can tailor these plots to only display data in a particular range of interest.

Xfoil can readily determine the effect on airfoil of modifying an airfoil's geometry such as by changing the leading edge radius or by adding a turbulator with several minutes of computation. As with all analysis, some background knowledge is needed in order to obtain meaningful results. Fortunately there is an online forum of users of Xfoil. The Xfoil forum location is:

http://groups.yahoo.com/group/xfoil

A searchable archive of the prior messages and collection of files explaining the intricacies of using Xfoil makes this forum a must for new users of Xfoil.

Comparison between experiments and numerial computation:

Xfoil has been shown to predict airfoil polars that are consistent with wind tunnel test data. For Reynolds numbers below the turbulent/laminar transition region, and increasingly so below 100,000, the results from tunnel tests and analytical studies frequently differ from each other and from observations and correlations from flight tests.

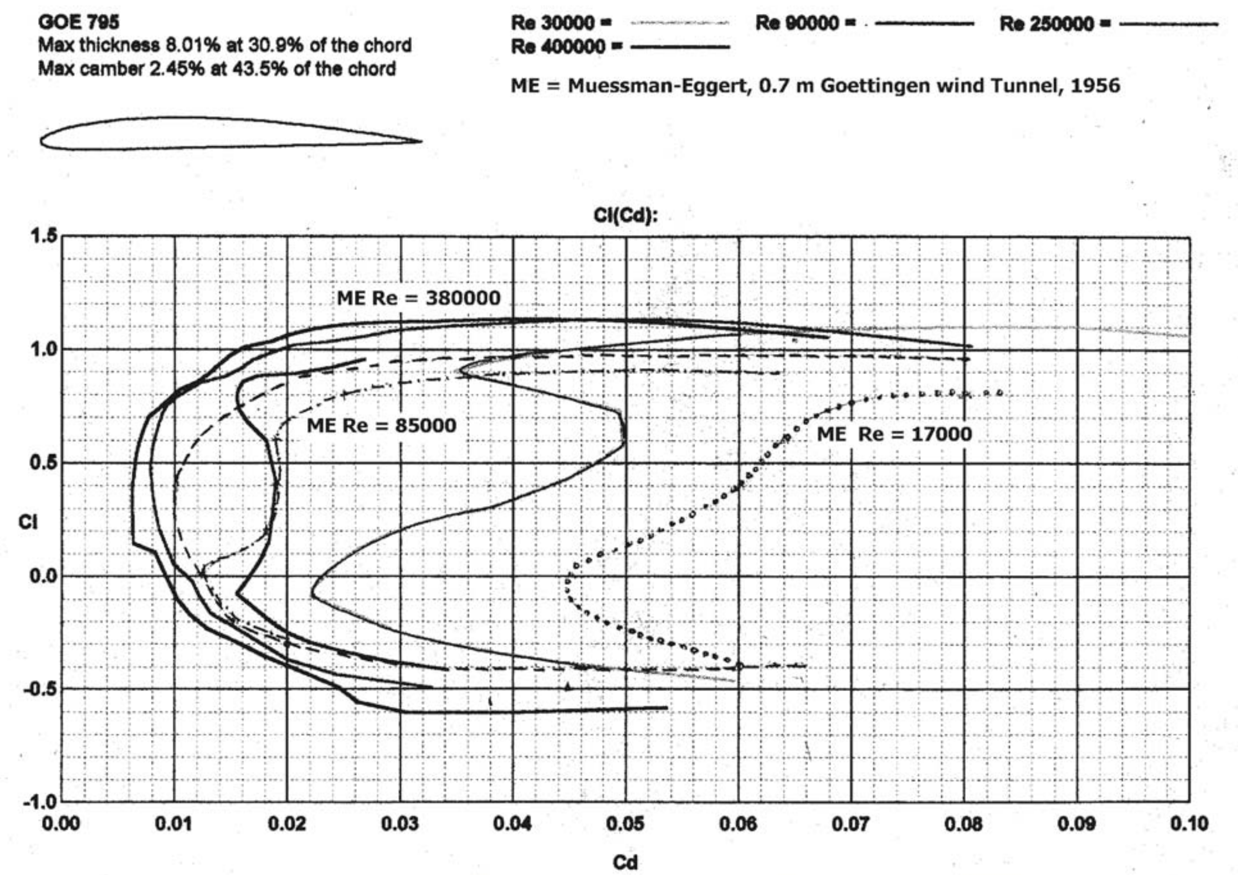
We present here a comparison, that of C_L vs C_D (polar curve) for the Goettingen 795 airfoil, at Reynolds numbers equal to 17000, 85000 and 380000, typical of a range between a Coupe d'Hiver to a fast climbing F1C. The previous figure shows that the XFoil calculation represents quite well the trend of the experiments by Muessman-Eggert in the Goettingen 0.7 m Wind Tunnel, as shown in Riegels, Pg. 244.

There are a number of reasons that may explain the differences between calculation and measurement, including details of airfoil geometry, surface roughness, data adjustments for wind tunnel turbulence, wall interference, aspect ratio and plan-form of test specimen.

Experienced Free Flight modellers have learned to accommodate these challenges. They consider all available sources of information and utilize these data to make their decisions. Regrettably, there has been a very slow progress in the experimentation and prediction of the airfoil characteristics below a Reynolds number of about 50,000, and it is not unusual to have widely diverging comparisons in this range. At larger values of the Reynolds numbers, typical of full-size aircraft, the agreement is much better and methods such as XFoil have shown in that range a great usefulness.♦.

Reference:

Riegels, FW, "Aerofoil Sections", Butterworths, London, 1961.



Comparison of calculated (XFoil) and measured polars (Muessman Eggert, 1956)