

Radi- Controlled Soaring Digest

February 2008

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Front cover: A Pike Perfect comes in with flaps down during the 2007 Tangerine soaring contest sponsored by the Orlando Buzzards. Photo by Peter Jensen. Canon EOS 20D, ISO 200, 1/2000 sec., f4.5, 170 mm.

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XFLR5, a "virtual wind tunnel" allows a detailed investigation of the aerodynamics of a specific airframe. Francesco Meschia demonstrates all of the procedures necessary to evaluate the X-Models 1.9 m Blade V-tail sloper.

Back cover: Piet Rheeders' photo of the incoming thunderstorm which brought an end to their flying at "Tamatie-Berg" Volksrust, South Africa, back in December. (See Piet's article on this adventure starting on page 4.) Panasonic DMC-LZ5, ISO 100, 1/250 sec, f5.6, 37mm

R/C Soaring Digest

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In the Air

This issue of R/CS Soaring Digest has some truly spectacular photography. Although photos make the resulting PDF substantially larger, reader feedback is very positive. We plan to continue incorporating a large number of photos in each issue, and presenting them at a resolution which displays them to best advantage.

For those desiring articles of a more technical nature, we're sure Francesco Meschia's detailed description of his use of XFLR5 <<http://sourceforge.net/projects/xflr5/>> to evaluate the X-Model 1.9 m Blade will be a most welcome addition to your library.

During our recent windy and rainy weather here in the Northwest, we've been able to devote some time to our Redwing XC project. All that's left to do is get some lead in the nose to bring the CG forward to the appropriate location. Unfortunately, it looks like this may take the overall weight to more than 11 pounds and over the FAI weight limit.

On a similar front, our granddaughter Alyssa is building a composite sailplane for summer flying. This is to be an entirely scratch-built enterprise, so there's been a lot of construction hardware to set up. She started by laminating tows of carbon fiber for the outer wing panel spar caps, and is excited to move on to building the fuselage and tail structures. Alyssa's planning a multi-part article which will document the entire construction process. Watch for that in future issues of *R/CS*.

Time to build another sailplane!

A Mid-summer trip to **Volksrust**

Piet Rheeders, d.rheeders@telkomsa.net
BERG club, South Africa

Mike May lets loose his Jart with a mighty heave. Note the whiplash on TX aerial.

The long awaited summer holidays normally starts in the beginning of December in South Africa. Most companies and businesses here come to girding halt for three to four weeks over Christmas, and only come to life again in the first or second week in January.

Although this might not be the best time of the year to go slope soaring at "Tamatie-Berg" Volksrust, the temptation to just go there and fly, even if the wind is going to be variable and light, is far too strong. At this time of the year

everything is green, and sitting on top of the mountain breathing in some fresh mountain air, admiring the stunning views that surround you, and in company of some fellow modelers, is alone worthy of the effort and expense to go there.

The BERG club had two groups visiting "Tamatie-Berg" recently, the first group drawing more members than the second, but opting to stay over for only two days. Myself and six other fellow R/C modelers stayed for four days, knowing that the wind condition would not be ideal, but

hoping that we would somehow get our fair share of good winds.

This turned out to be exactly the case, but most of us took a selection of models that could cope with just about any wind condition. This included electric park flyers, HLG gliders, Gentle Ladys, F3B glass slippers, Zagis, Weasels, Hill Billys, Jarts, scale gliders, IC-power gliders, and last but not least, some serious "Go Big Or Go Home" stand-off scale giant gliders.





A selection of models that we took along.

Opposite: The stunning views as seen from the top of “Tamatie-Berg” Volksrust, South Africa.





Mike, Glen and myself (from Durban) set out in the early morning on Wednesday the 2nd of January 2008, and arrived at Volksrust at around 10 AM. We had to wait, however until 1 PM before we could get to the top of “Tamatie-Berg” due to a locked farm gate. This was no problem as there was no wind from any direction. This gave us the time to go to our overnight guest farm, situated directly under the northwesterly slope, to unpack our baggage and personal belongings.



Our overnight accommodation situated directly under the northwest slope.



The 7.5 meter span, 15 Kg, stand-off scale DG500 Elan of Mike May.



Glen about to launch his weasel as high as possible in the week lift we had on Day 1.

Once we got to the top, a quick glance of the northwest slope showed no promise of any flying there, and we proceed to the SE slope and waited for the light wind to pick up somewhat.

Glen with his light weight Weasel was the first to test the air and sometimes managed to maintain height for a reasonable time before he was forced to turn and land. Other than that there was not anything else that could stay up in the light to no wind conditions.

By the end of the day we had very little flying time, and Izak Theron from the ETB club also now joined us.

At round about 4PM we packed up as the little wind we had died away completely. As the sun set we left the mountain with a hope that Thursday (Day 2) would yield better conditions, and we returned to our overnight quarters.

As per normal, and after we refresh ourselves, the braai (barbeque) fire was started, followed by the by many R/C flying stories until we could not keep our eyes open any more. Once you hit the sack you drift of into dreamland just about instantaneously.



No wind on Wednesday, Day 1.

On Day 2 the morning broke with a partly cloudy sky and the SMS I received from my friend Evan Shaw predicted SE wind later on in the day.

After breakfast, and just in case the wind did not work, I had two flights with my IC-power glider before we departed for the south slope.

This time round we had no problem with the locked farm gates. Once on top we quickly assembled our gliders and then waited as the early morning mist disappeared and as the sun got higher in the sky.

As we arrived at the SW slope we found some more glider pilots joining us — Herman and Izak from the ETB club, and Charl and Peter from the club BERG.



Piet launching his IC-power glider at our home base before departing for the day's flying on the slope.

Most of us, when we come to “Tamatie-Berg,” have at least one glider that needs to be maiden, as we only come here three to four times a year.

Mike May had a new Jart and also his big 7.5 meter span DG500 to fly their first flights, and likewise my Hill Billy.

Mike had his DG500 inspected by some other big scale R/C glider pilots to make sure that it would fly first time.

At around 2 PM the wind pickup nicely and I did one short maiden flight with my Hill Billy. Then as the wind go stronger Mike let lose his Jart on its maiden flight. The sky was now getting busier as the conditions improved as Zagi’s and other smaller slope ships took to the sky. At last this was the wind we waited for and now were enjoying every moment of it. I got my second flight in on my Hill Billy and this time around got it on the step as she cut through the sky.

Although the air was now good to launch Mike’s DG500 but he opted not to fly it because of the limited landing space on the south slope.

Needless to say we returned to our accommodation at the end of the day, well satisfied and happy as can be. For us a half a day of good slope flying is worth many a day’s waiting for the right conditions.



From left to right: Herman, Izak and his son Shane trimming his HLG. An HGL is ideal for no wind and low visibility/misty conditions in the early morning on top of the mountain.



Glen's pink Jart in a blue sky makes for a pretty sight.



Izak waiting for the breeze to pick up before he launches his F3B ship on NW slope.



Pre-flight check on Mike May's new monster 7.5 meter DG500 Elan.



Day 3 (Friday) we had similar conditions as Day 1 (Wednesday) and we ended up with light winds turning the full 360 degrees before ending the day on the northwest slope flying our light thermal

ships and managing some reasonable flights. The indications, however, were that the next day (Saturday) was going to be the best day of our visit.

This happened to be so on Day 4 (Saturday), with the wind direction from the northwest and picking up ever so gradually until it got strong enough for Mike to maiden his big DG500.



Charl launch Mikes' 3M Swift.
After this flight, Mike was confident
that the air was now good enough to
fly his 15 Kg monster DG 500 Elan.

Mike had one flight with his 3M Swift and was confident that the air was now good enough to fly the 15 Kg monster DG 500.

The launch went well with Glen on the left tip, Charl in the middle and Peter on the right tip. Mike was quick to pick up the left wing that dropped a bit because of a late release by Glen.

The DG500 then climbed high above the slope and soared for eight minutes before Mike became aware of a threatening thunderstorm on the lee-side of the hill and decided to land before the wind changed direction.

The landing was also good as the powerful flaps slowed the DG500 down and Mike had to tuck them away for a moment to retain some speed before touchdown.

The thunderstorm came closer and we had to dismantle and pack up our models in a hurry. [A photo of the approaching thunderstorm serves as the back cover for this issue.]

I don't think that any one of us would regret this outing, and as for myself I have flown six of seven models that I took with me, and so as we drove down this magic mountain we are already planning the next trip to Volksrust and "Tamatie-Berg." ■



The Berg team just before we departed for home on Sunday morning. From left to right: Piet, Glen, Jenny, Charl, Peter, Mike. Middle center: Blake

Launching Mike's 7.5 meter DG500 Elan.





David Copple captured this photo of two Tangent ASH-26 models against a sun ring at Cuesta Ridge in San Luis Obispo, California.
FujiFilm FinePix S5000, ISO 200, 1/2000 sec., f8.0

HAVE SAILPLANE - WILL TRAVEL

Tom Nagel, tomnagel@iwaynet.net

Sloping at Armadillo World Headquarters HSWT in Texas



My brother Terry has a daughter working on her graduate degree at the University of Texas in Austin. He talked me and the wife into joining with him and his wife for a trip down to Austin for Christmas. We'd get a chance to play a little music together, sample the local margaritas and meet up with his daughter's fiancé and family.

I didn't count on doing any sloping, so I didn't take a plane. Accordingly, you might notice a total absence of anything resembling an RC slope plane in the accompanying photos.

At first, Austin did not look too slope friendly. The locals kept telling me that Austin was at the south end of Texas Hill Country. I thought they meant Hank Hill, because as far as I could see Travis

County looked pretty darn flat.

Then, just before we left town, Terry took us up to Mt. Bonnell Park, on the northwest side of town. Mt. Bonnell turned out to be a limestone cliff rising almost vertically some 350 feet above the body of water variously known as Lake Austin, or Town Lake, or the Colorado River.

Mt. Bonnell isn't much of a mountain, but it looks like a pretty nice place to slope. The escarpment faces almost due west, with maybe a little West-South-West curve to it at the northern end. You can access the cliff top by walking up a fairly gentle slope from the north end of the park, or up 150 or so stone steps from the south end of the park.

The best launch sites appear to be

just to the north (to your right facing the slope) of the actual "peak" of Mt. Bonnell. "Peak" seems a little pretentious in this setting. What I really mean is, try launching 50 yards or so to the right of the highest point of the escarpment.

Mt. Bonnell Park is a relatively small Austin City Park. There are no facilities, and no rangers. The barriers at the edges of the cliffs are sketchy and trails (and a little trash here and there) indicate the barriers are not frequently observed.

There is no direct route down to the base of the cliff, and if you ootch out to the edge and look down, you will see upscale, you might even say Austintaceous, houses along



the waterfront, built on a series of man-made lake front parapets. You do not want to send a plane down there.

This would be a good place to slope something with an electric motor.

The landing zone comes in two varieties: full of tourists and full of trees. Luckily, the trees are of the Texas scrub vegetation variety, and not particularly thorny. Landing will require either dumping it in the trees on the downwind side of the access trail, or enlisting a spotter to keep the tourists at bay while you slide in on the gravel and stone access path.

This would be a good place to slope something foamiferous with an electric motor.

The very south end of the park affords a great view of downtown Austin and the Gozer Building. Austin has only one really tall building downtown, the proper name of which

is the Frost Bank Tower, but it looks a lot like the Gozer Building from Ghost Busters. You can see the Gozer Building from almost anywhere in Austin, so it is easy to get oriented again if you get lost driving around town.

Here are some other things to do and see in the Austin Area:

Armadillo World Headquarters, a restaurant and bar now known as Threadgill's, which in the years 1970 to 1980 was home to more bands and more live music than can be easily contemplated. Everybody from AC/DC to Frank Zappa played there, with groups like Asleep at the Wheel, Jimmy Buffet, Dire Straits, Genesis, Charlie Mingus, Willie Nelson, Linda Ronstadt, Earl Scruggs and Ravi Shankar filling in the middle. It is still a great live music venue.

The Broken Spoke: the same, for country music.

The Congress Street Bridge Mexican Free-tailed Bat flock: bug eating ornithopters by the millions.

The Texas State Capitol Building, which, because it is in Texas, is actually bigger than the US Capitol Building.

The Barton Springs swimming hole, a series of warm springs re-engineered into a year-round naturalistic two hundred yard long outdoor pool.

South Congress Street: the hip part of town to eat, drink, shop or be seen. No RC stores, though.

Austin Segway Tours, a gyro-stabilized livery that for \$59 will liberate your inner geek and give you a two-wheeled tour of Austin.

A QuickTime VR 360 degree view from the top of Mt. Bonnell is available at <<http://www.edb.utexas.edu/teachnet/QTVR/MtBonnell.htm>>. ■



At last... *the TROODONS are finished!*

Simon Nelson, shuttlewash@mweb.co.za

The Troodon (TROE-odon) is a 3.65 meter span F3J sailplane which can also be configured as an F5J machine.

The sailplane version weighs 2.2 Kg (77.6 ounces) ready to fly.

The wing chord is 300 mm, with the area about 35 % more than the Inkwazi, similar to the Eish, the local F3J plane, described in a previous issue of RC Soaring Digest.

The laser-cut ribs were done by Paul at Lasercore in Pinetown. The wing structure is composed of carbon tube spars with I beams. The fuselage is of balsa and full carbon.

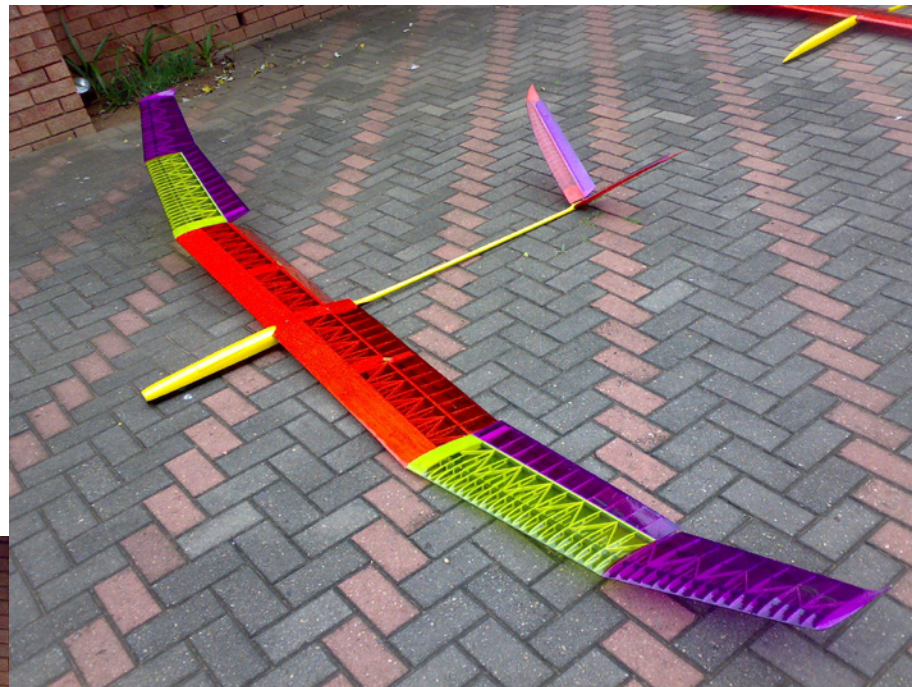
The stabilizer is from AMT.

The wing center section includes a D-tube leading edge, with the whole wing having a geodesic structure.

Transparent covering allows that interior structure to be featured.



Sorry, will wear a t-shirt next time.



The V-tail model is the electric F5J version. It has a 480-33 motor, a 15 x10 prop, and a 3-cell double stack 2200 LiPoly battery.

The name comes from a genus of relatively small, bird-like dinosaur from the Late Cretaceous Period.

It's from a long line of similar constructed planes. I will be doing plans, as with all the others.



In a future issue...



Morelli M-200 walk-around

Manufactured by CVT in Italy, this is an 18.15 meter span two-place staggered side-by-side sailplane which is stressed for aerobatics and has a 32:1 glide ratio. Wood construction and a large cockpit make it a good candidate for RC aerotowing with vario or GPS installed.



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Model analysis with **XFLR5**

Francesco Meschia, francesco.meschia@gmail.com

Virtual wind tunnels and simulators

Many aeromodelers are already familiar with XFoil, the famous virtual wind tunnel developed by Mark Drela and Harold Youngren at MIT. XFoil, like many of its siblings, simulates with good accuracy the airflow around a “two dimensional” airfoil, i.e. the purely ideal case, not likely to be attained in practice, of an airfoil section traveling through the air by itself, without an associated wing, therefore neglecting induced drag and any other planform induced effect.

This kind of analysis lends itself well to the comparison of different airfoils but, on the other hand, requires additional work if one wishes to analyze the performance of a wing or a complete aircraft, full-size or model, a task that involves many other variables and requires careful modeling of many other factors.

Because of its extreme importance for the whole aviation industry, the latter problem was investigated for a

long time, and a numerical method for aircraft performance analysis, known as vortex lattice method, or VLM, was developed since the 1930's. I am not an aerodynamicist and so I cannot describe the VLM in great detail, but from the Internet I learned that VLM involves dividing the lifting surfaces into a fine mesh of panels. Each panel is surrounded by a horseshoe vortex, that extends chord wise to infinity; with a few boundary conditions one can calculate the lift and drag contribution of each vortex and so, by summing the individual contributions, one eventually evaluates the performance of the whole surface.

Because of its numerical nature, the VLM didn't really “take off” until enough number crunching power became available, with the advent of computers in the 1960's; it proved since then to be a very powerful tool and it was used to study and develop a large number of different aerodynamic configurations.

In the last few years VLM has landed in

the aeromodeling realm, thanks to the increase in processing power of modern PCs and to a few suitable software packages which are now available. Again Mark Drela and its research group have released AVL, a powerful and complete program with a “family feeling” with XFoil in its command-line user interface. Much like what happened to XFoil with Stefano Duranti's “Profili 2,” VLM has become more accessible to the non-specialists thanks to XFLR5, a program developed by André Deperrois. Mr. Deperrois's work includes an interesting contribution: whereas the “classical” VLM analysis assumes a purely inviscid flow around the lifting bodies and is therefore a bit unrealistic for the Reynolds numbers used by model aircraft, XFLR5 postulates that the viscous and inviscid contributions to aerodynamic forces are linearly independent, so that an inviscid VLM output may be complemented by a viscous XFoil analysis to get a more realistic mathematical model. Deperrois warns the users, though, that



X-Models 1.9m Blade

Photo by Stefano Bisio

the “independence hypothesis” is not supported by a theoretical model, and so XFLR5 results need to be considered preliminary and experimental work and model validation still needs to be done.

XFLR5 users need to keep this philosophy in mind when approaching the program. XFLR5 must be “fed” with both a geometrical model of the lifting surfaces to be analyzed and a set of polars derived from viscous analysis of the adopted airfoils, for a range of Reynolds number and lift coefficient broad enough to cover all flying conditions. In other words, before even starting XFLR5 the user must find the coordinate files for all the airfoils which will be used, and a 3-view of the aircraft. Also we must remember that XFLR5 is merely a simulator for a set of physical behaviors, and can’t tell us anything about an aircraft but what we are prepared to ask; it’s a handy tool, but teaching us how to design a successful model is entirely out of its scope.

Much better, in my opinion, is to approach XFLR5 with a practical touch, to show what the program is capable of and also what to ask the program for. I have therefore chosen a well known model, the 1.9m Blade from X-Models, and I will use it as a test case to look for answers to some common questions such as lift distribution, stability analysis, and speed polar determination.

Modeling the Blade

The airfoil used in the Blade wing is a modified RG-15, which was thinned from the original 8.9% thickness to a sleek 7.8%. According to many modelers, it is likely that the airfoil evolves into some other variation near the wing tips, but I could get no final word about this and so I will neglect it in my analysis. With some juggling with cardboard templates I have determined that the V-tail relies upon a 7% thick symmetrical airfoil, a NACA 0007.

The coordinates for the 4-digit NACA foil may be calculated with a well-known algorithm, but the RG-15 coordinates must be found somewhere in literature. I would suggest using the airfoil database by M.Selig and the University of Illinois at Urbana-Champaign <http://www.ae.uiuc.edu/m-selig/ads/coord_database.html#R> for that.

Once the coordinate file has been downloaded, we can start XFLR5 and begin our journey by importing the foil data. From the “File” menu we choose “Load File” and we select the DAT file; XFLR5 will show an outline of the airfoil in the lower pane of the window (Figure 1). As we can see the thickness is 8.9% by the book, so it must be thinned to 7.8% if we want to model the actual Blade foil. This is done via the “Scale Camber and Thickness”

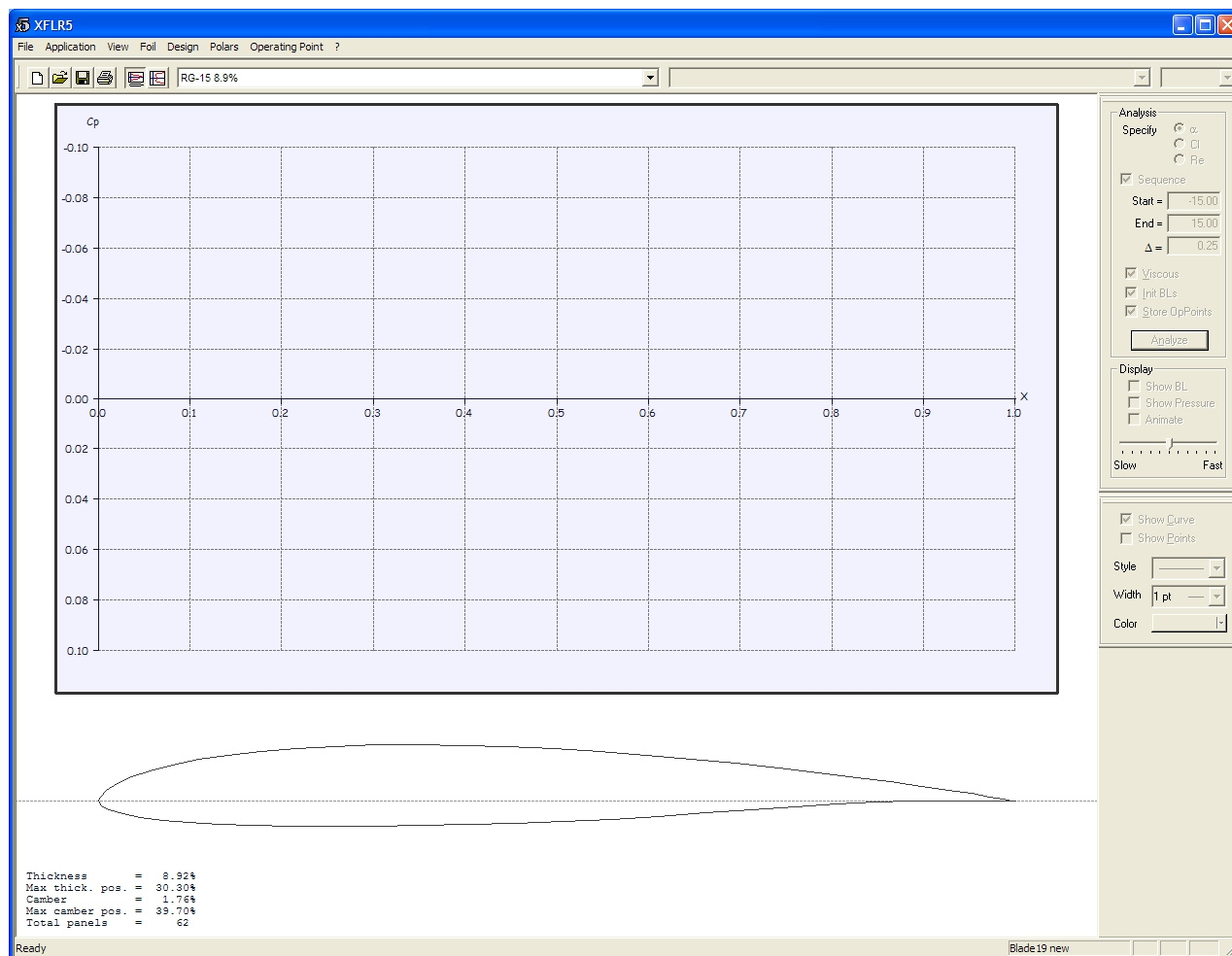


Figure 1

command in the “Design” menu, as shown in Figure 2.

The airfoil for the tail is calculated by a routine that may be invoked with the “Naca Foils” command under the “Design” menu. We need to tell XFLR5 the NACA number of our choice (0007)

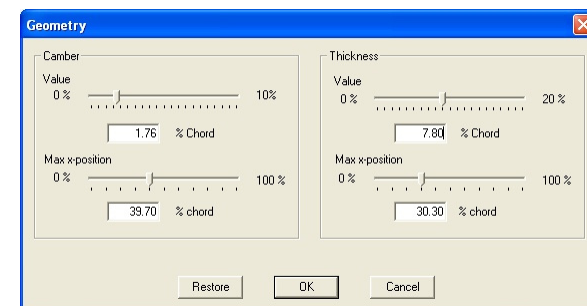


Figure 2

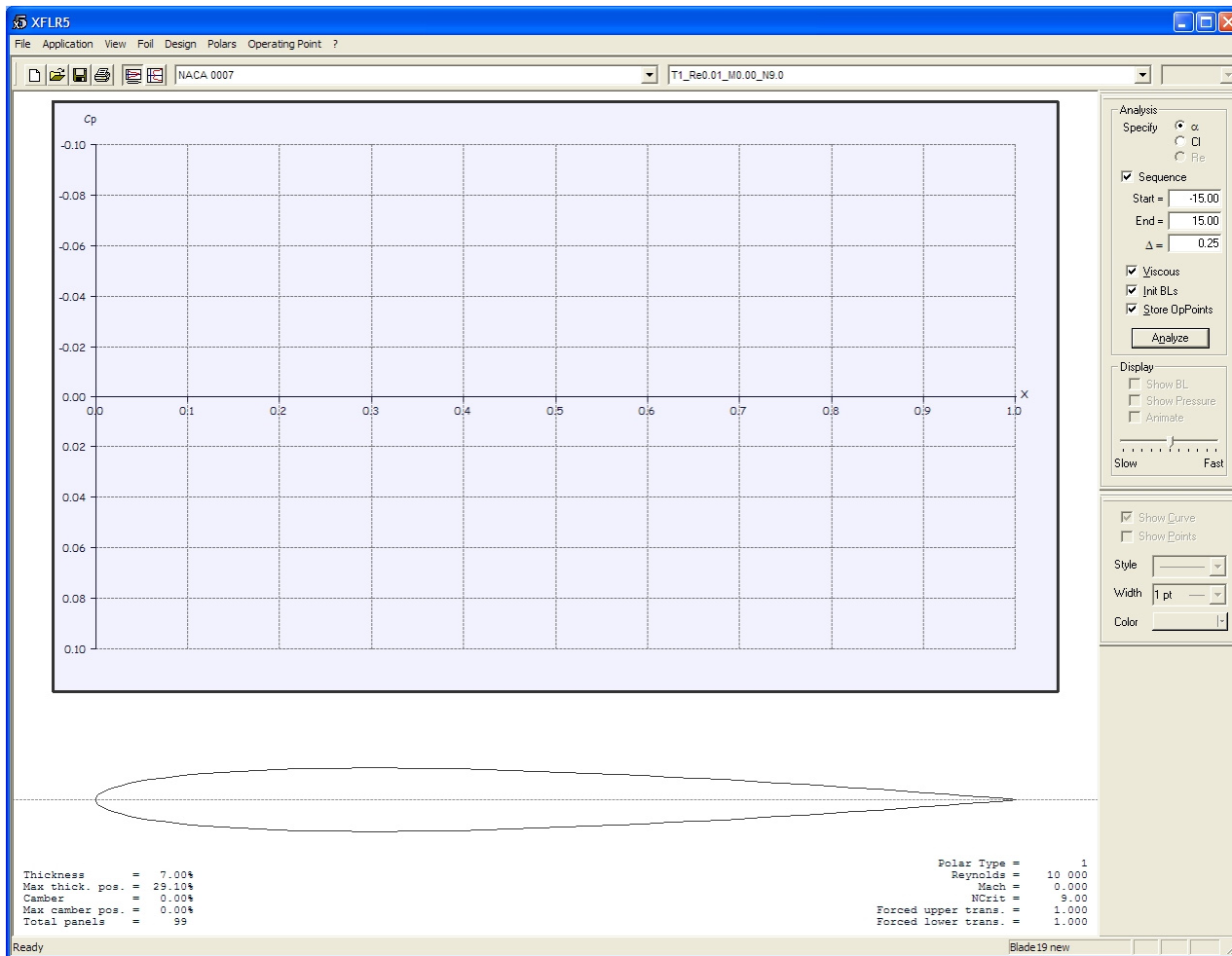


Figure 3

and the number of points (100 points will do). The program will calculate the coordinates and will draw the airfoil profile (Figure 3).

Now that we have the wing and tail airfoils it's time to use the embedded XFOIL module and compute their polars.

For each airfoil we must compute a set of polars that covers a range of Reynolds number representative of the "flying" conditions. XFLR5 will take those polars and will add the viscous contribution to the VLM analysis by interpolating between computations at

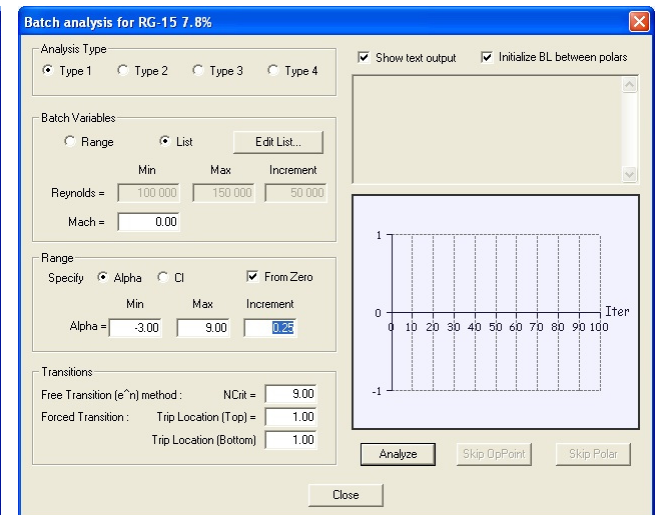


Figure 4

different Reynolds if needed. Care must be taken so that the Reynolds mesh coverage is tight enough and XFLR5 can use it. (We'll see later how to tell if this is correct and how to extend coverage if necessary.)

Polar computation might be carried out manually, Reynolds number by Reynolds number, but there's a handy utility that lets us process a whole polar family at once. We will begin by selecting from the airfoil drop-down list one of the foils (e.g. RG-15 7.8%) and then choose "Run Batch Analysis" from the "Polars" menu. A new window will pop up (Figure 4) where we shall enter the parameters for the batch run. First we select the desired analysis type (e.g. Type 1, that stands for fixed airspeed

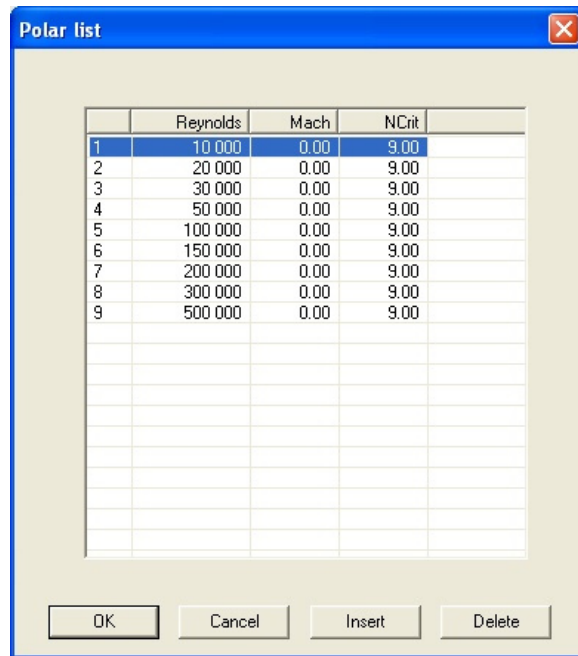


Figure 5

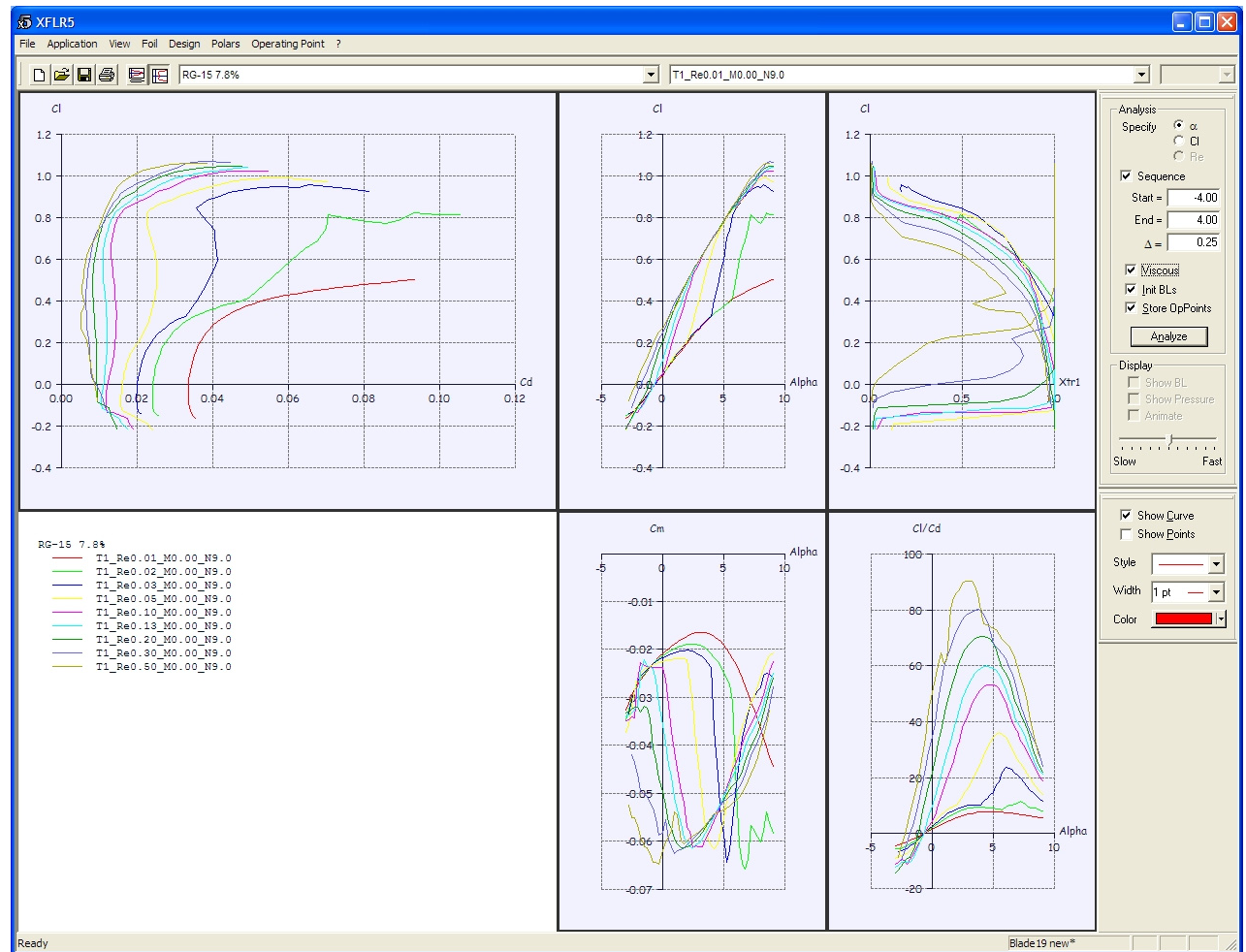


Figure 6

and chord, and variable lift coefficient); then we enter the desired Reynolds range (I'd suggest to use a list of Re's, like the one shown in Figure 5) and the angle of attack range (e.g. AoA ranging from -3° to $+9^\circ$, in 0.25° steps). When we click the "Analyze" button the XFOil

routine will start working and in a little while will crank out the polars. When the computation is over we may close the window, then we open the "View" menu and choose "Polars." The newly-computed polar family will be shown (Figure 6), and we'll be able to choose

any plot we're interested in (C_l vs. C_d , C_l vs. α , C_m vs. α , and so on) by choosing the appropriate item in "Polars > View."

The same procedure must be re-iterated for the NACA 0007 tail section (Figure 7), at first for the same range of Reynolds

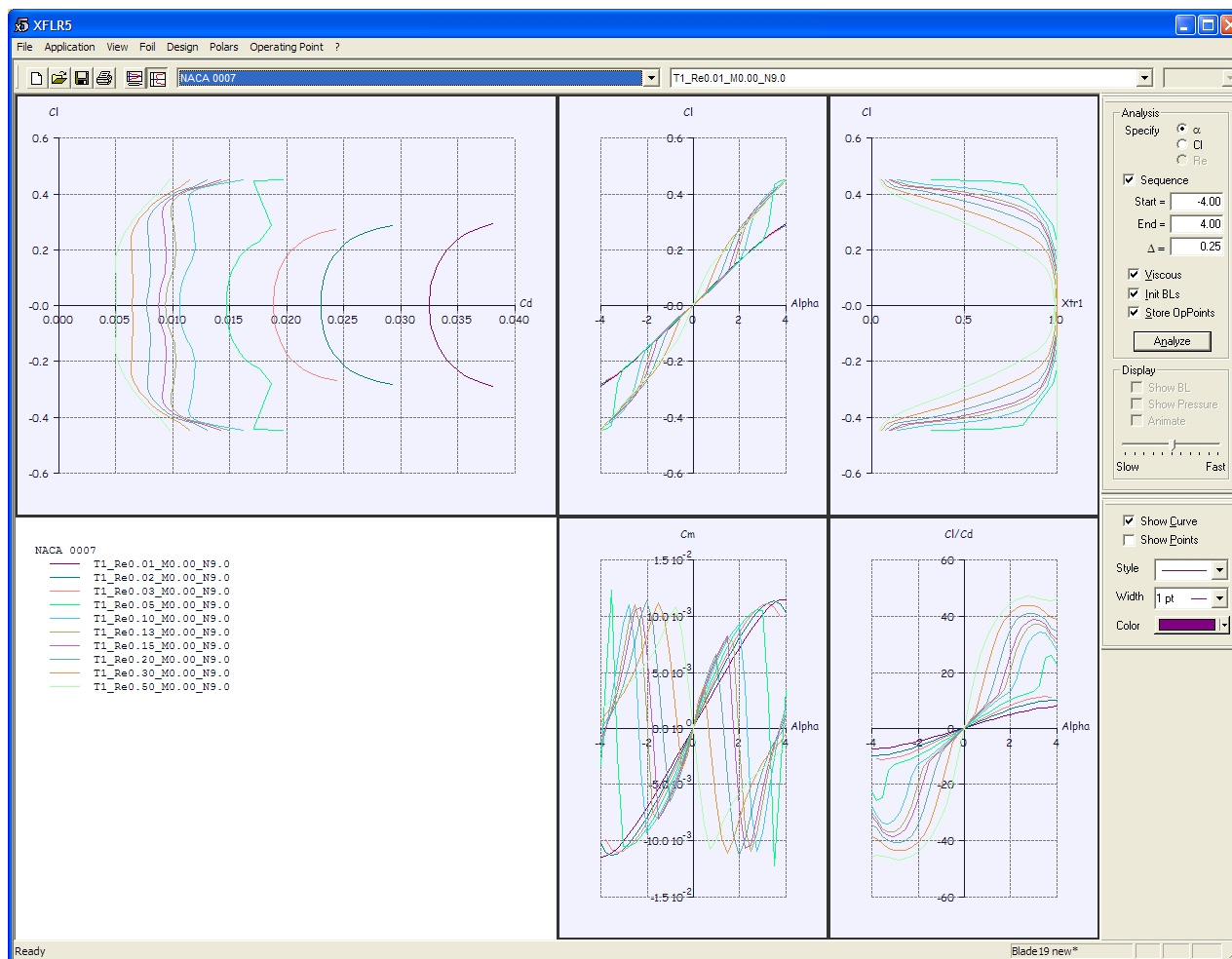


Figure 7

numbers used for the main wing section and for AoA between -4 and $+4$ degrees; theory suggests that we should shift the Reynolds range towards lower Re 's, because the tail chord is shorter than the wing chord, but we'll see later if this will actually be necessary.

Now we have the 2D polar families for both wing and tail sections, it's time to enter the realm of 3D simulation with the vortex lattice method. First we must set up in XFLR5 a simple three-dimensional model of the Blade, re-creating the wing planform, the wing dihedral, the tail with

its planform and decalage. For this I will use actual geometric data I measured on my own Blade.

We can enter the XFLR5 plane geometry routine first by selecting the "Wing Design" option from the "Application" menu, then by choosing "Define a Plane"

Plane Geometry

Name: Blade 1.9 DL 1 FL 0 EL 0

Main Wing

Define Import Export Tilt Angle: 1.0 °

Biplane

☐ Biplane Define Import Export x: 0.00 mm z: 0.00 mm Tilt Angle: 0.00 °

Elevator

☒ Elevator Define LE Position x: 685.00 mm z: 0.00 mm Tilt Angle: 0.0 °

Fin

☐ Fin Define LE Position x: 650.00 mm y: 0.00 mm z: 0.00 mm Tilt Angle: 0.0 °

☐ Symetric Fin ☐ Double Fin ☒ Identical ☐ Left and Right

Wing Area = 32.14 dm² Wing Span = 1900.00 mm
 Elevator Area = 4.47 dm² Elev. Lever Arm = 662.00 mm
 Fin Area = dm² Tail Volume = 0.42
 Plane Volume = 1.88e+007 mm³ Total Panels = 858

☒ Check Panels on Exit

OK Cancel

Figure 8

from the “Wing/Plane” menu which will appear. A window similar to the one shown in Figure 8 will pop up. In this window we can assign a name to the model, we can set the wing and tail rigging angles (via the “tilt” parameter) and, most important, we can enter the

geometry definition sub-windows. In these sub-windows (see Figure 9 for wing geometry and 10 for the tail) we will model the lifting surface planform by dividing it up in a series of trapezoidal panel, and we’ll also need to define a suitable mesh for each panel for VLM

purposes. A finer mesh means more accuracy, but we don’t want to take this too far because we could run into XFLR5 internal memory limitations. I suggest using the “Reset VLM Mesh” button after defining all the panels so that the program defines a mesh it sees

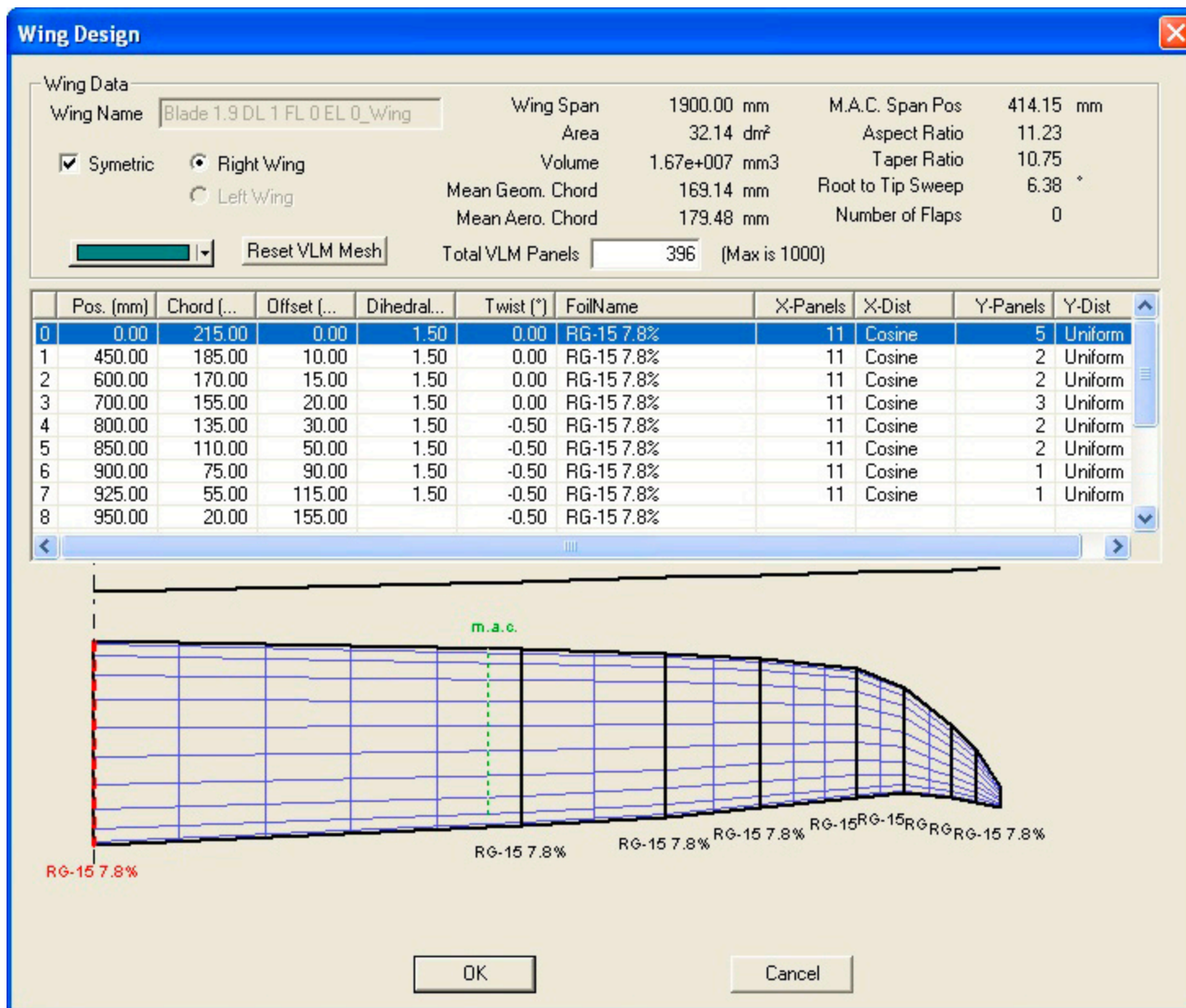


Figure 9

fit. Each panel is defined by its airfoil, its root and tip chords, its span, its offset, its dihedral relative to the horizontal plane, and its twist; XFLR5 uses metric units by default, but it may be set to use the U.S. system via the “Units” option in the “View” menu. (I am from Europe so I will use the metric international system in data and calculations.) As the data are entered, the program immediately calculates the wing surface, the mean aerodynamic chord, and the wing aspect ratio.

The wing of the Blade has three degrees central dihedral, that is 1.5 degrees per each half-wing relative to the horizontal plane. The V-tail is modeled in XFLR5 as an elevator without fin: each half-elevator has 35 degrees dihedral to the horizontal plane. I measured a longitudinal dihedral (decalage) of one

degree, which I modeled by setting the tail at zero degrees and rigging the wing at 1 degree, and the wing has a negative 0.5 degrees twist at the outer aileron edge relative to the root section.

When we have defined wing and tail geometry, I suggest we make sure that the “Check Panels on Exit” option is NOT checked (this option may sometimes cause a program crash in XFLR5 v3.21) and we can dismiss the window with the OK button. If we select the “3D” option in the “View” menu, a three-dimensional view of the model will be shown, like in Figure 11. We can also request any of the three orthogonal views with the X, Y and Z buttons in the window pane at the right.

The 3D polar of the model

We now are just one step from obtaining the 3D polar, that is the polar

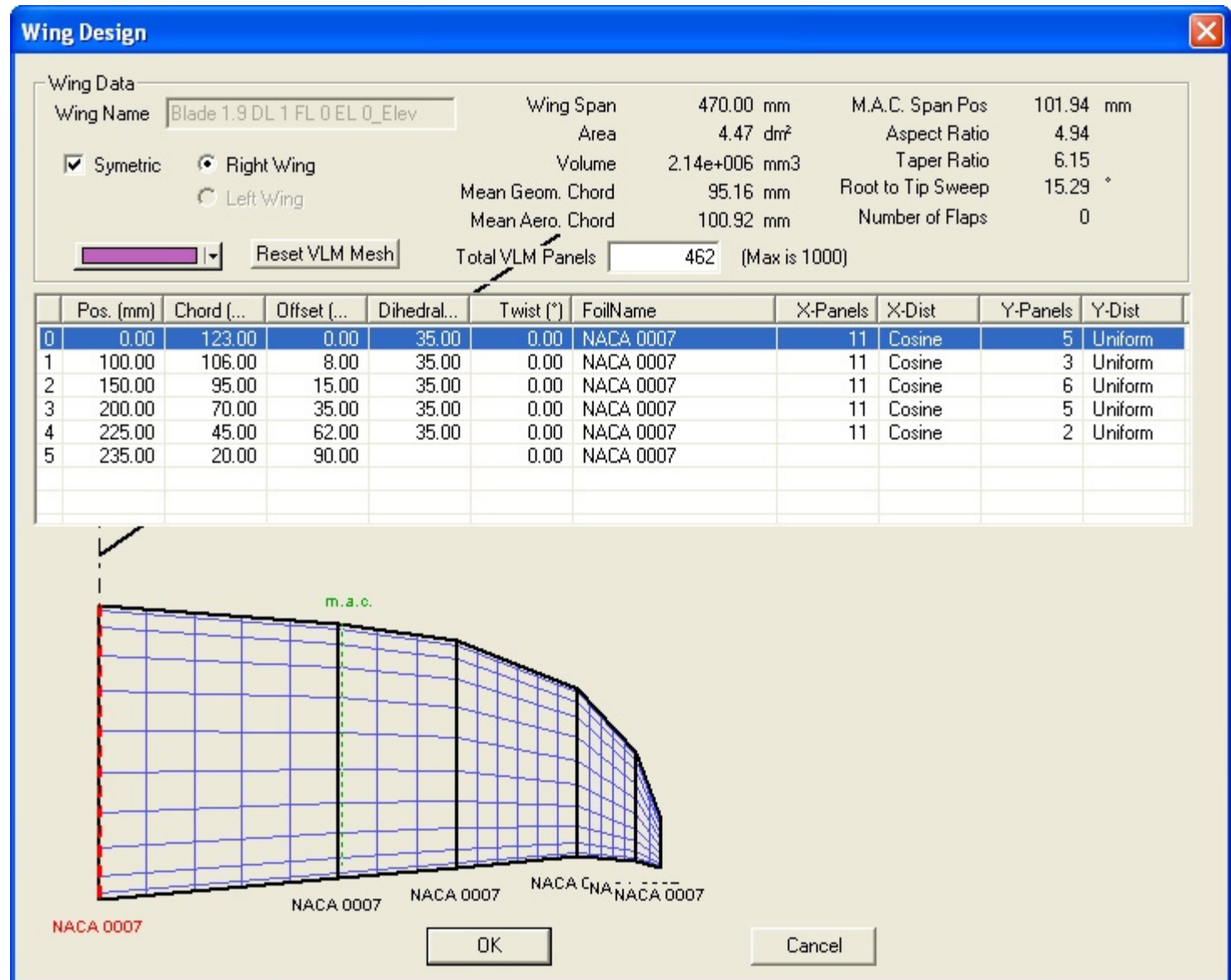


Figure 10

Figure 11

of the whole model. The polar computation requires a set of boundary conditions, and so we must decide whether we want to either have constant airspeed, or constant lift, or constant angle of attack. In the gliding task the wing must generate, at any given moment, just enough lift to balance the weight of the model, therefore we are mostly interested in the second type of boundary condition. We can tell XFLR5 about our choice by choosing “Define a Polar Analysis” from the “Polars” menu, and by choosing a “Type 2” analysis from the window that will pop up (Figure 11). We must also tell XFLR5 the weight of our model (my Blade weighs 1450 grams) and the position of the center of gravity (“moment reference location” in XFLR5 jargon) relative to the leading edge of the wing root that is taken as the coordinates’ origin (79 mm for my Blade). From the same window we notice that VLM is the only applicable analysis method (the other one, the lifting line theory method or LLT, can only be used for an isolated wing, i.e. without tail) and we need to make sure that the “Viscous” option is checked. That said, we can dismiss the window with the OK button and we are ready to run the computation task. In the rightmost window pane we set up a sequence of angles of attack, for instance from -2° to 7° in steps of 0.25° , we check the “Store OpPoints” and “Store points outside the polar mesh” boxes (see Figure 12) and we can start the job by clicking the “Analyze” button. A window will pop up with a processing log and maybe some final messages warning us that some operating point fell outside the polar mesh. We’ll see later what those log messages mean, for now we want to jump directly to the results. We choose (if not already done) the “3D” option in the “View” menu and we are presented with a beautiful color rendering of the distribution of the pressure coefficient over the lifting surfaces (Figure 13). By altering the angle of attack via the drop-down menu in the upper right part of the window we can see how the pressure distribution

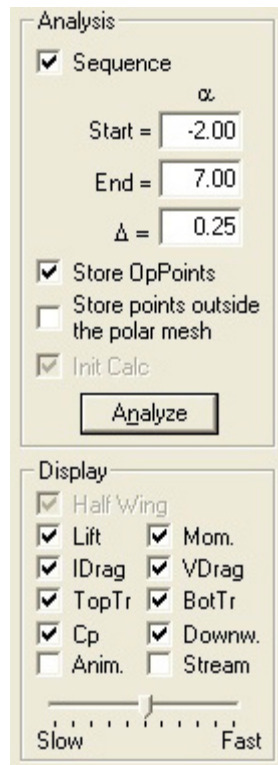


Figure 12

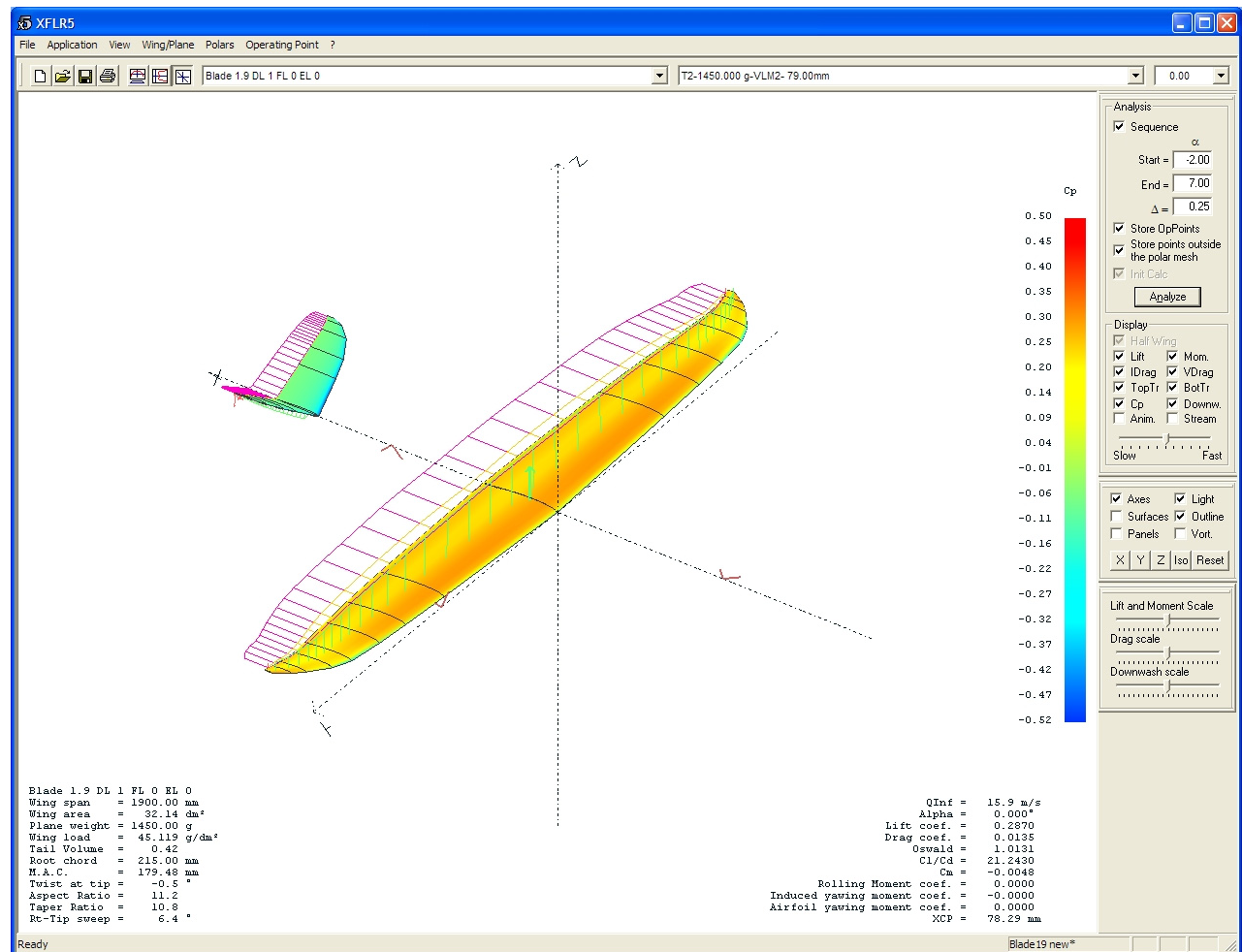


Figure 13

changes its shape accordingly. Undoubtedly impressive, but somewhat hard to decipher because on the same plot we can find lift vectors, drag vectors and also downwash vectors. A number of different output modes for the same data are available, equally interesting

and maybe easier to understand if a little less appealing. For instance, we may choose “Polars” from the “View” menu, then we right-click on the graph that will appear and last we choose “Graph” and then “Variables” from the pop-up menu. We’ll be presented with a

list of variables we can assign to X and Y axes. If we assign vertical velocity (V_z) to Y axis and airspeed (V_{inf}) to X axis we’ll get the speed polar for our 1.9m Blade (Figure 14). This graph pictures the relationship between airspeed and sinking speed, which is a true snapshot

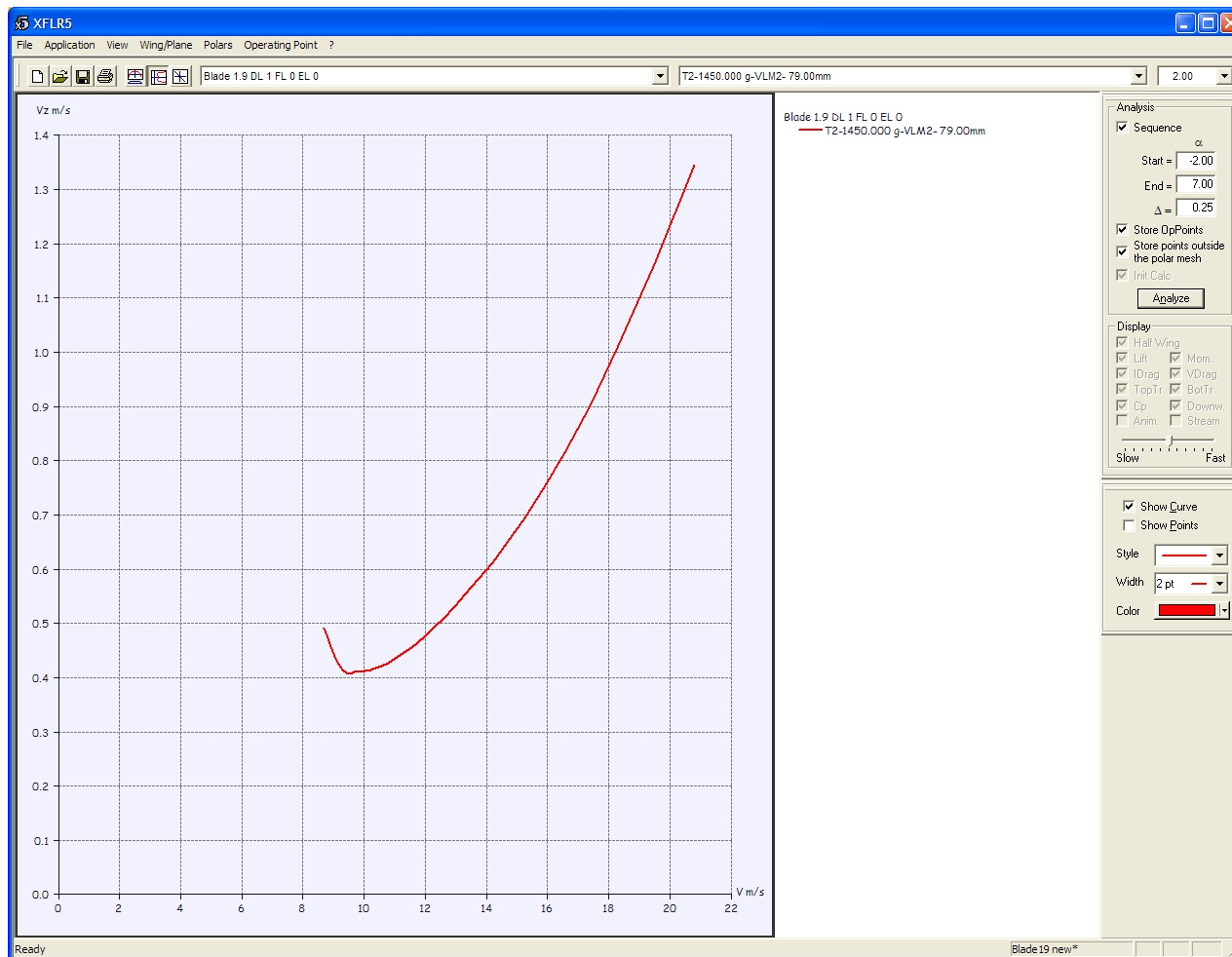


Figure 14

of the performance of a glider, be it full-size or a model. It is worth noticing that the plot has a minimum sink point which corresponds to an airspeed value slightly above stall speed (theoretically speaking, the 1.9m Blade could attain a sinking speed as low as 40 cm/s at an

airspeed of about 10 m/s), and another point, different from the former, for which the horizontal-speed-to-vertical-speed ratio (also known as efficiency and glide ratio) has a maximum (at 11 m/s airspeed for our Blade). These two points picture two very important attitudes of a glider:

the pilot who wants to stay aloft in dead calm air for as long as possible must trim the sailplane to keep the minimum sink airspeed, whereas the pilot who wants to travel as far as possible must trim for maximum glide ratio.

Another, clearer, way to study the glide

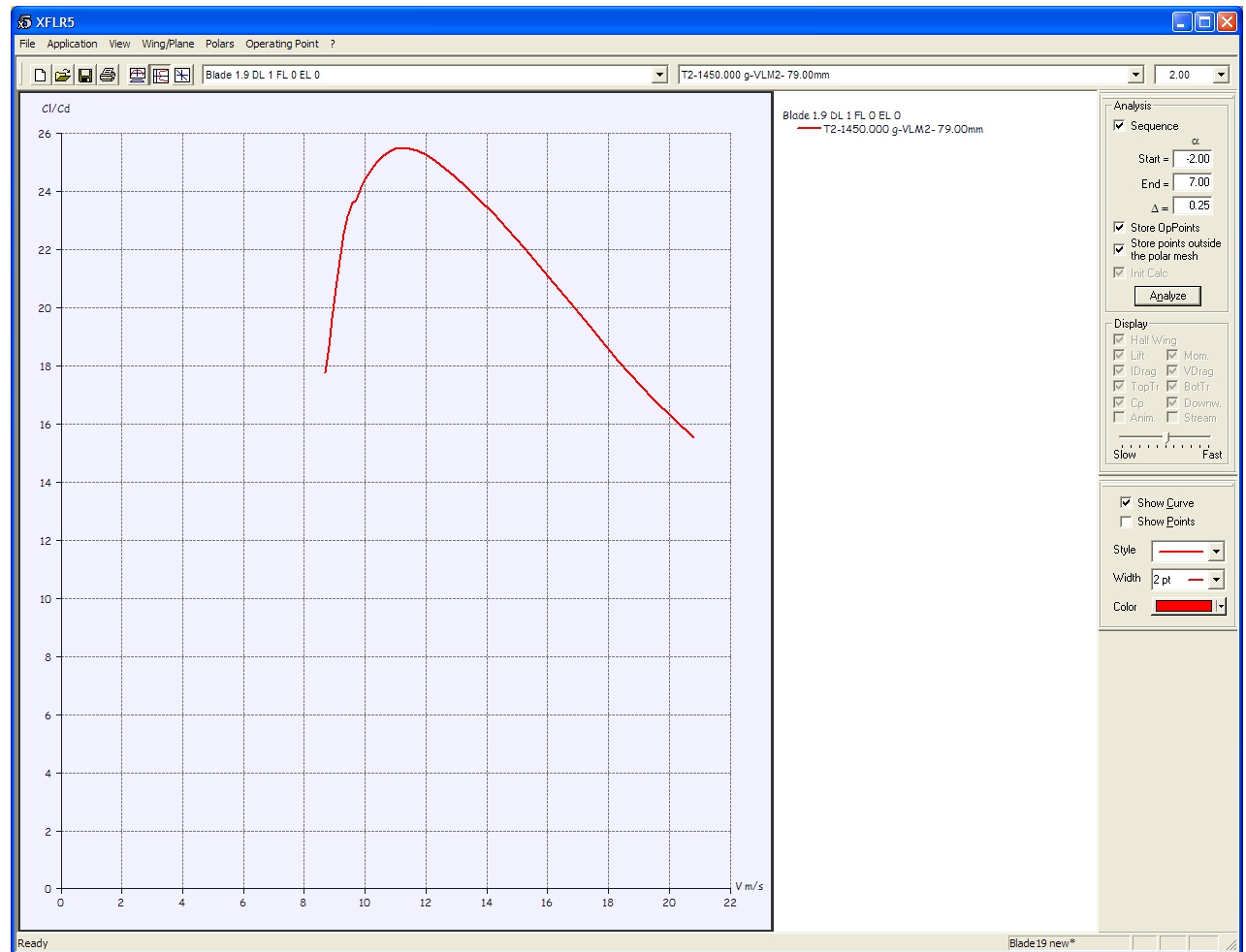


Figure 15

ratio versus airspeed relationship is to ask XFLR5 to assign the “Glide Ratio C_l/C_d ” to the Y axis while keeping airspeed (V_{∞}) on the X axis. The resulting chart (Figure 15) immediately displays not only the maximum glide ration point, but also the numerical value of the ratio,

which is theoretically above 25 at 11 m/s airspeed. The peak is well defined, that means that any drift from optimum airspeed translates into a marked loss of efficiency.

We should now ask ourselves how fast the Blade wants to fly, that is what its

trim speed is in normal conditions. The answer is readily found by asking XFLR5 to plot a pitching moment coefficient versus airspeed chart (Figure 16). We see that the curve crosses the horizontal axis at an airspeed of about 18 m/s. This point is the only balance point for the

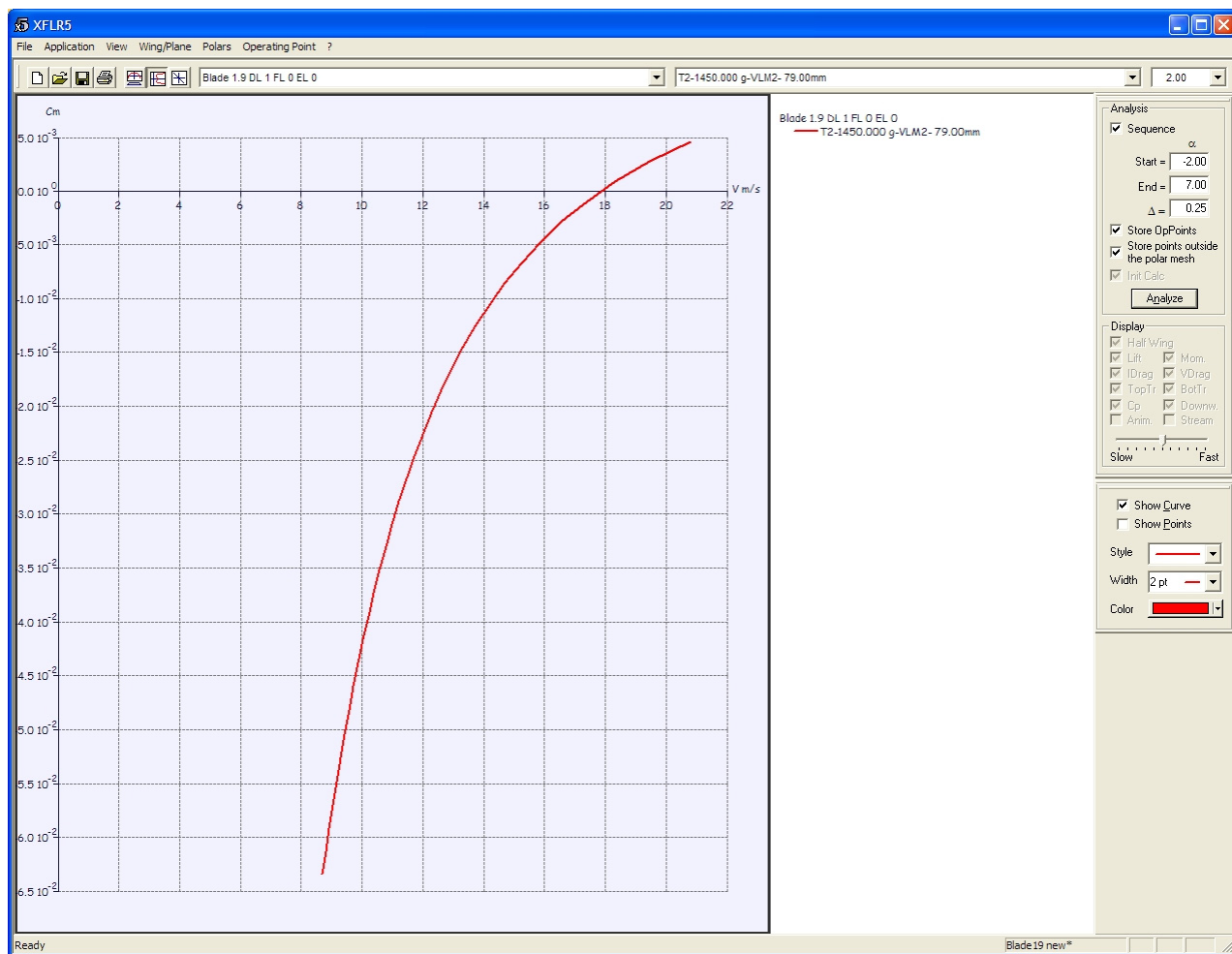


Figure 16

whole flight envelope of our glider, since here the model does not experience any pitching moment, neither upward nor downward. The model simply flies undisturbed at 18 m/s: this is its trim speed with neutral elevator trim and 1 degree of decalage. The curve

also suggests that any higher speed would cause the Blade to pitch up and decelerate, and any lower speed would make it pitch down and accelerate. That means that we have chosen a center of gravity location that allows for a stable equilibrium (but we'll see more about

stability later).

It is rather conspicuous that 18 m/s is significantly faster than both 10 m/s (minimum sink speed) and 11 m/s (maximum glide ratio speed). This is consistent with the kind of flight the Blade is made for. It's a fast glider and not a thermal duration model, a runner and not a floater. It wants to "sting like a bee" rather than "float like a butterfly." It does not make much sense to force it to fly at the minimum sink airspeed, and its pilot is probably willing to trade some efficiency for more thrill. At 18 m/s (40 mph) the Blade sinks in the air at a rate of a 1.1 meter per second. That means that a slope updraft with a vertical velocity component of just above 1 m/s (fairly common for most slopes) will be enough to keep it flying.

The lift distribution

We will now talk about another way to look at the results of XFLR5 computations. So far we have

looked at charts that are a picture of the behavior of the whole model as a function of one of the flight variables. Each point in the curve is an "operating point" of the model, that is a collection of data for lift, speed, efficiency, moment, etc., computed for one particular value of the independent variable we have chosen for our analysis (i.e., in our examples, the angle of attack). But

the vortex lattice analysis does not merely yield a “point,” a scalar value representing the entire model, but rather it produces a far richer collection of data, spread across the many panels that make up the lifting surfaces. XFLR5 lets us “drill down” in every operating point by looking at the aerodynamic parameters in their distribution over the lifting surfaces.

This kind of study is very interesting, a true fundamental exercise in computational aerodynamics. If we look at the lift coefficient at which every wing “station” is working, from the root all the way to the tip, we can easily see what parts of the wing are working “harder” (higher lift coefficient) to produce lift and, therefore, will be the first to come to a stall according to the viscous analysis we performed with the XFOil module at the very beginning of the journey. Let’s pull down the “View” menu and choose “Operating Point.” We should get a plot like the one shown in Figure 17, that is a set of curves that picture local lift coefficient versus position along the half-wing span, for a range of angles of attack. If we prefer, we can also examine just one curve, at a defined AoA, by right-clicking the chart area and choosing “Show Only Current Opp” and then choosing the desired AoA from the drop-down list in the far left end of the toolbar.

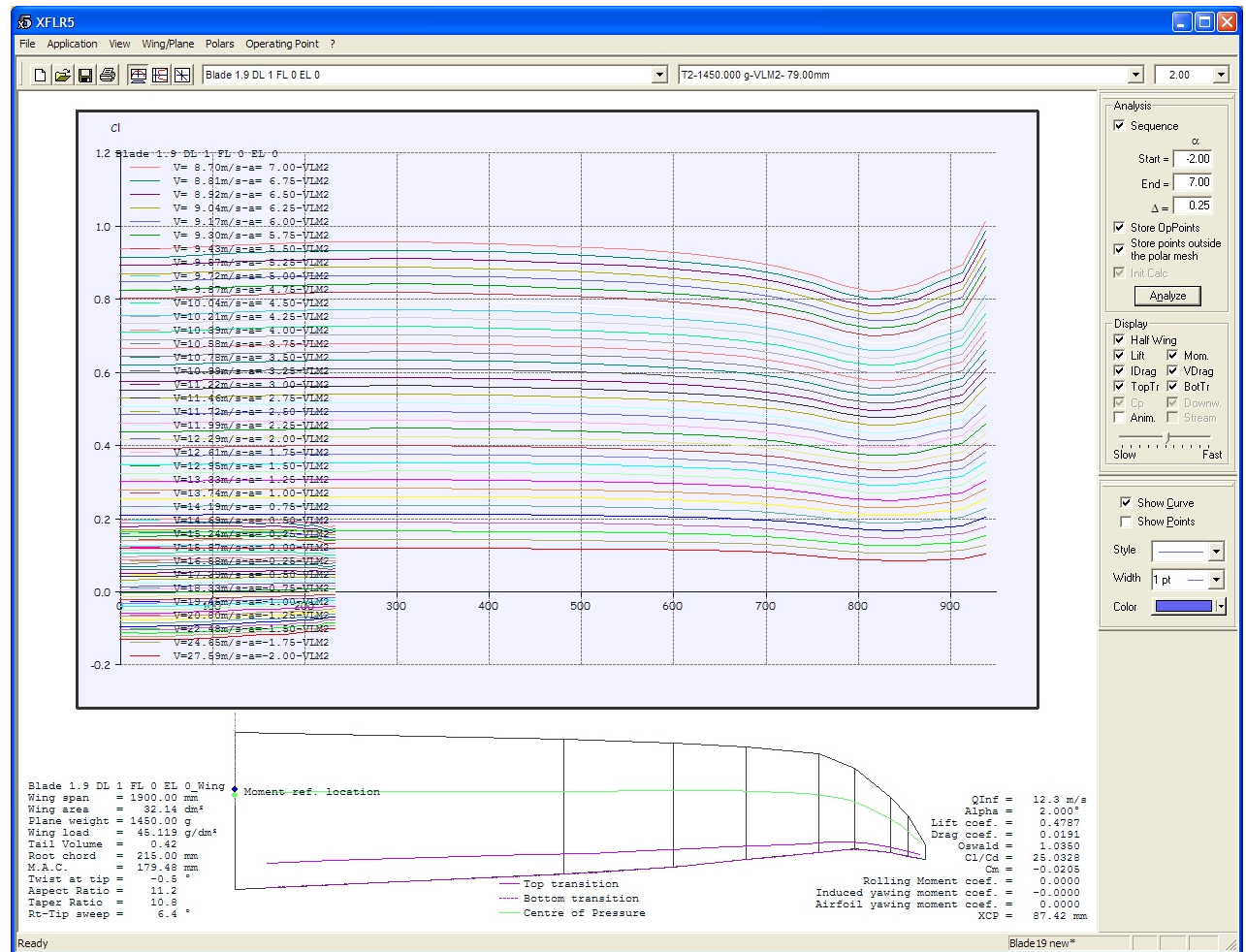


Figure 17

When we inspect the family of lift distribution curves we see that for small AoA's (up to 2 to 3 degrees) the portion of the wing that generates the highest lift is located at about one foot (300 mm) from the wing root; but if we further increase the AoA the tips are forced to work at a

higher and higher lift coefficient, so that eventually we shall have the dreaded tip stall.

To see this in greater detail, we need to take one step back and take a look at the error messages in the polar computation log file (“Operating Point” menu, then

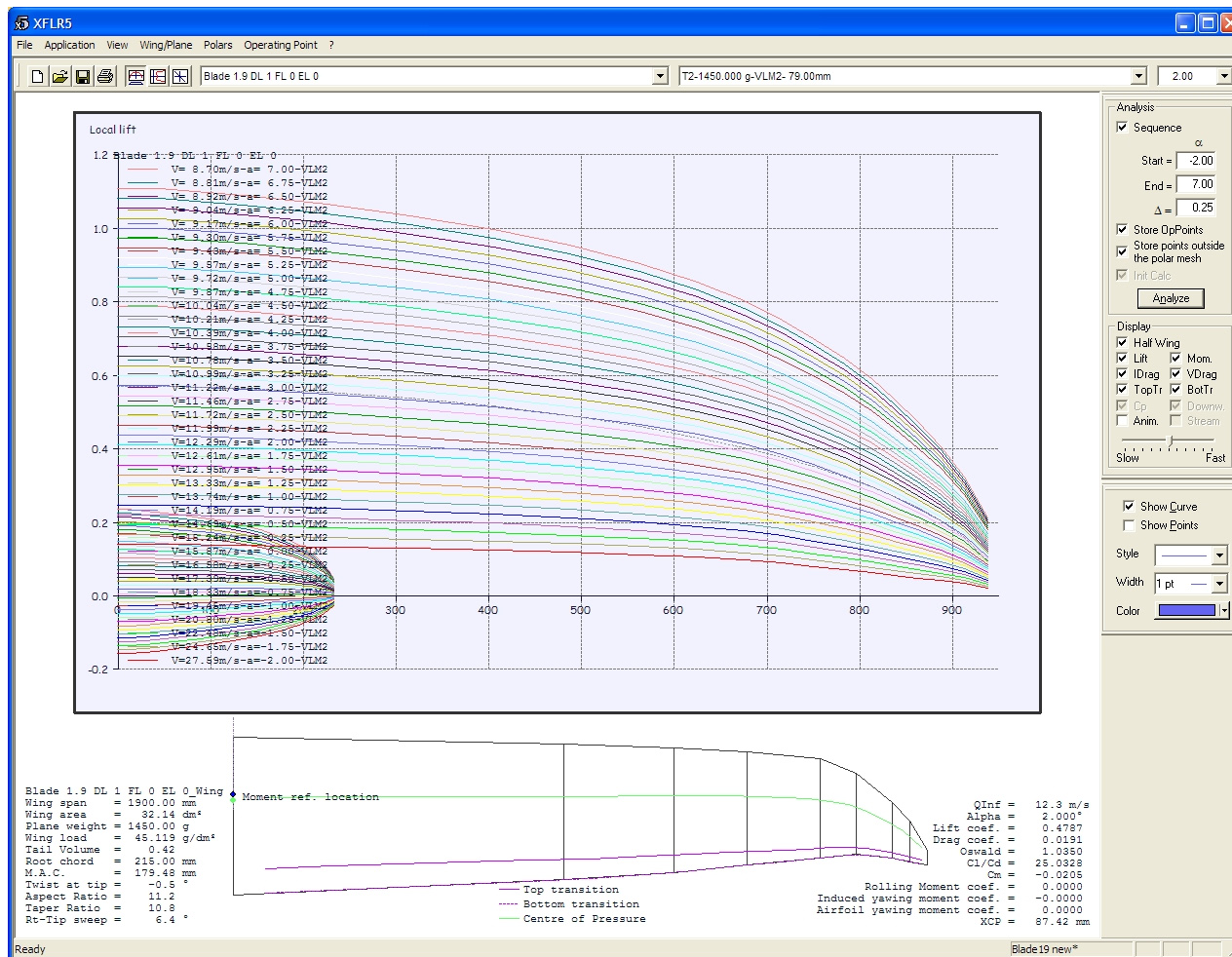


Figure 18

“View Log File”); at the end of the file we should see a similar message:

...Alpha=5.75

Calculating induced angles...

Calculating aerodynamic coefficients...

Calculating wing...

Span pos = -937.49 mm, Re = 23 308,

Cl = 0.86 could not be interpolated
Span pos = 937.49 mm, Re = 23 308,
Cl = 0.86 could not be interpolated
Calculating elevator...

What this message is telling us is that, at an AoA of 5.75°, the wing tip station (937 mm, or about three feet, away from

the wing root) ought to generate a lifting coefficient of 0.86 at Reynolds 23308. According to the Xfoil polars in its memory, XFLR5 doesn't think that our modified RG 15 airfoil can accommodate such requirements. In other words, XFLR5 foresees the beginning of a tip stall at this angle of attack. XFLR5 may not always be right (in this particular case, if we examine the family of airfoil polars we can see there's such a wide a gap between the Re=20000 and Re=30000 polars that XFLR5 interpolation might not be able to bridge reliably), but it is an interesting clue nevertheless. It is also worth mentioning that, despite XFLR5's opinion, the “real” Blade is not particularly prone to tip stall problems (or, at least, it hasn't yet played such bad tricks to me). This might support our initial suggestion that, at the wing tips, the RG 15 foil evolves into a different section, one that can generate more lift at low Reynolds numbers.

Another variable we might want to examine the distribution of is local lift (not lift coefficient). This is the force that is generated by every wing portion; it is important because, according to Prandtl's theory, the induced drag contribution for a given wing area is minimized whenever the lift distribution shape is elliptical. We can ask XFLR5 for this distribution by right-clicking on the

graph area, then choosing “Variables” and finally “Local Lift C. Cl/M.A.C.” The resulting curves (Figure 18) closely follow an elliptical arc (a true elliptical arc may be superimposed to the plot via a specific option from the right-button menu), and prove that the Blade wing planform is backed by a good amount of careful design and study.

Analysis of pitch stability

We now want to use XFLR5 to approach another classical problem in aircraft performance, that is the study of pitch behavior and static stability conditions. Stability, in this context, is the tendency of the aircraft to keep its pitch attitude against any disturbances that may arise (wind gusts, for instance).

We start this chapter by returning to the polar plotting mode (View > Polars) and by instructing XFLR5 (right-click > Graph > Variables) to plot the pitching moment coefficient versus AoA. We will get a chart like the one shown in Figure 19 - a simple monotonically decreasing curve.

The slope of the curve is “negative” (i.e. the curve is decreasing) for every point we have considered. This is of extreme importance because it means that the configuration we have chosen for the model is stable for all the AoA's of our interest. This is easily understood if we review the physical meaning of

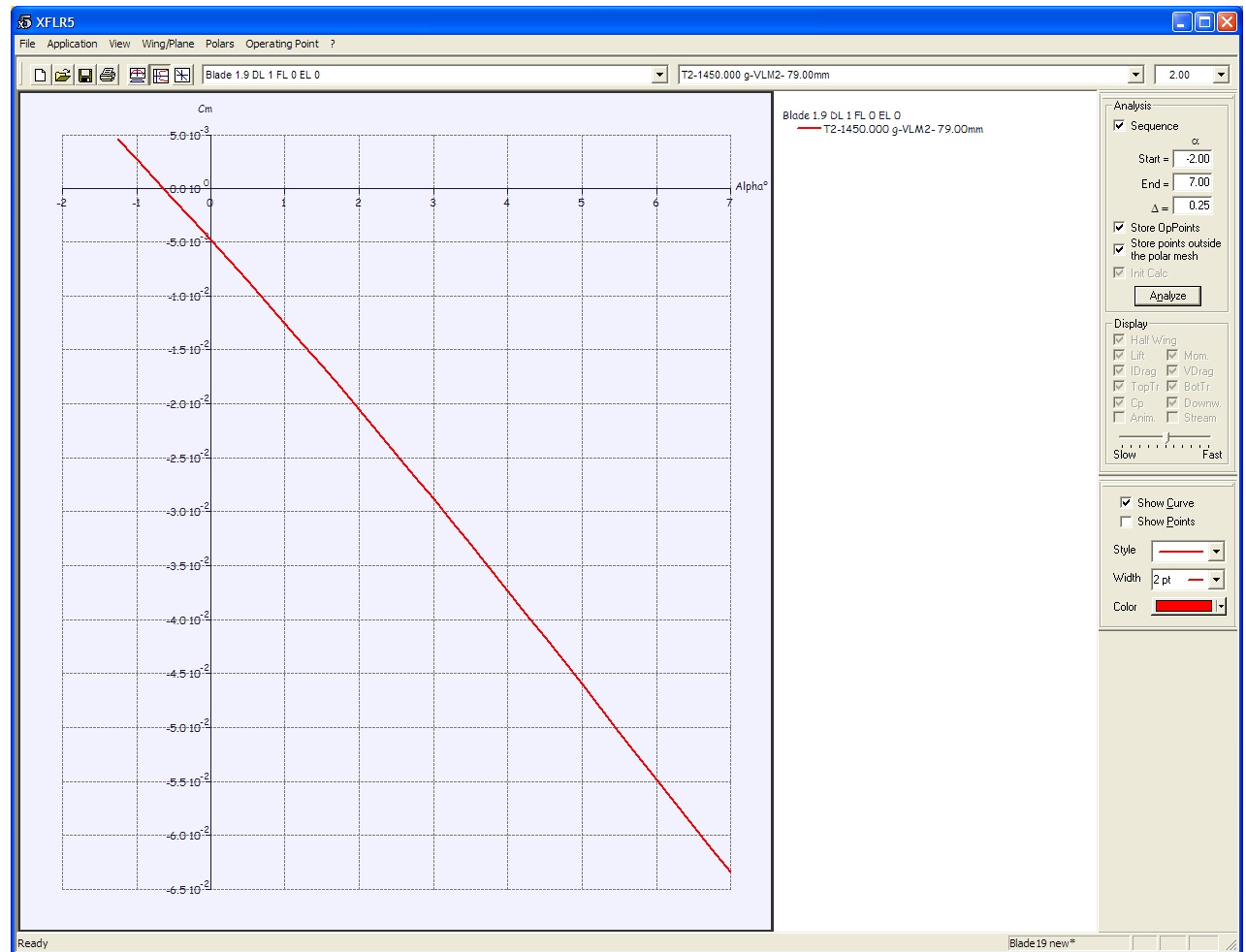


Figure 19

the chart. First of all, the chart is telling us that the model glides in balance (i.e. C_m is null) at an angle of attack of approximately -0.5 degrees. Let's now suppose that the flight is disturbed by a gust that forces the model to take a greater angle of attack, for instance zero

degrees. The chart shows that at zero angle of attack the model develops a negative pitching moment coefficient, i.e. it “feels” a nose-down moment that tries to push the wing to its original AoA, and therefore the model is longitudinally stable. Every configuration for which the

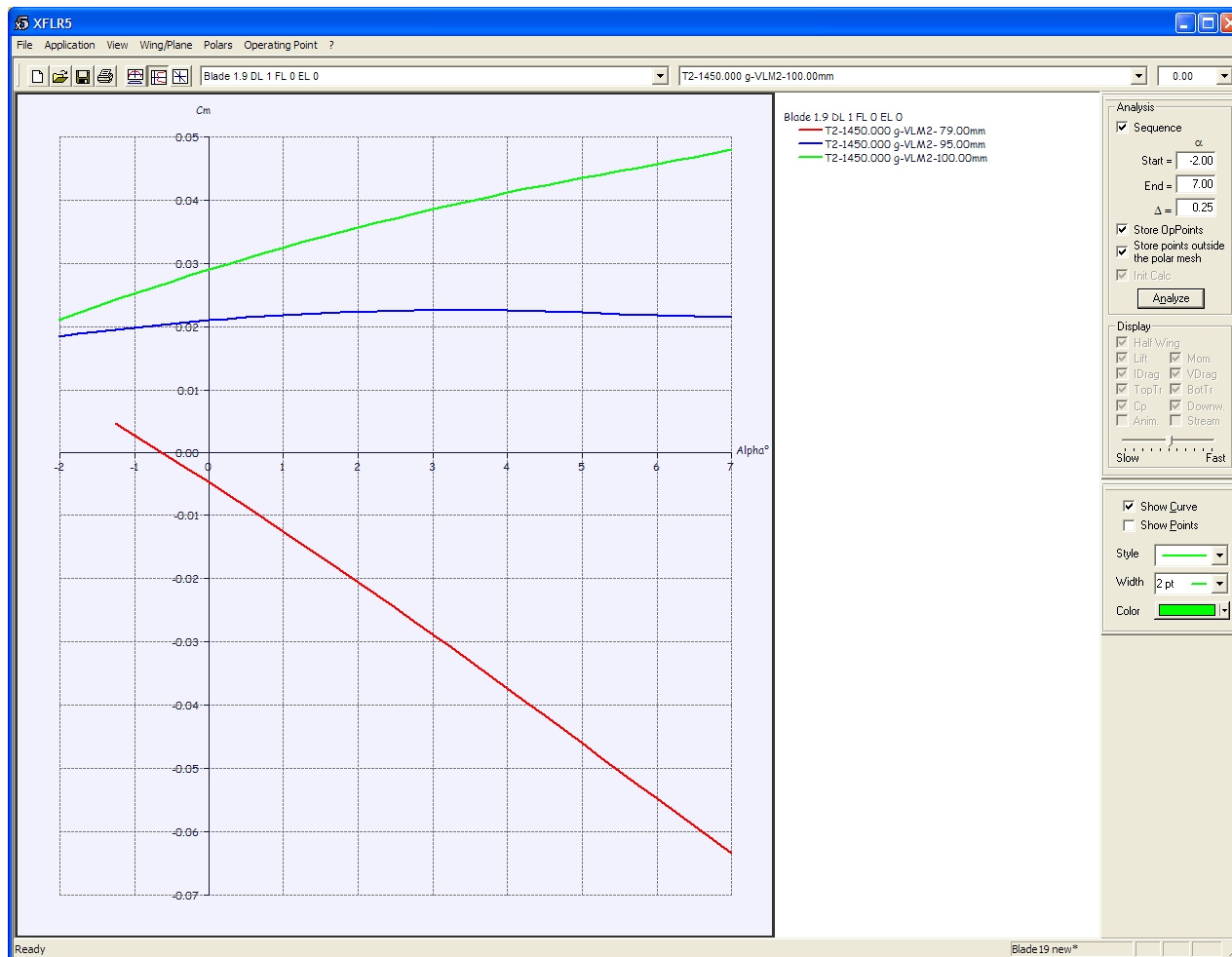


Figure 20

moment coefficient versus AoA curve is decreasing from left to right is stable; on the other hand all configurations with an increasing CM vs. AoA curve are unstable, because every disturbance results in a pitch unbalance that tries to further increase the disturbance effect.

The steeper the slope of the CM vs. AoA curve, the greater the stabilizing or de-stabilizing action will be.

If we want to decrease a model stability, or even make it unstable, we just need to move the CG aft; we can test that by computing a new polar and placing

the CG at 100 mm from the leading edge. The resulting CM vs. AoA curve will be like the green curve in Figure 20: it is a monotonically increasing curve, and therefore the model will be unstable for any AoA in the flight envelope.

We can take this even further by tracing other Cm vs. AoA curves for other CG locations. For instance, in Figure 20 I have also plotted (in blue) the curve that corresponds to a Blade balanced at 95 mm from the leading edge. This one is no longer monotonic but has a maximum at about two degrees. Balanced in this way, the model is neutrally stable. Strictly speaking, it will be neutral only at the angle of attack for which the $dCM/dAoA$ derivative is null, but in practice the CM shows such a slight variation, and for such a broad range of AoA's, that the stabilizing or de-stabilizing effect may be negligible. The model is not willing to react to any disturbance, but will fly at and maintain any angle of attack we can trim it to. As a consequence, it will require a pilot's constant attention and input, and personally I would not enjoy flying it at a slope with a brisk breeze.

The use of camber flaps and variable camber

The Blade, like many other gliders, has control surfaces (inboard flaps and

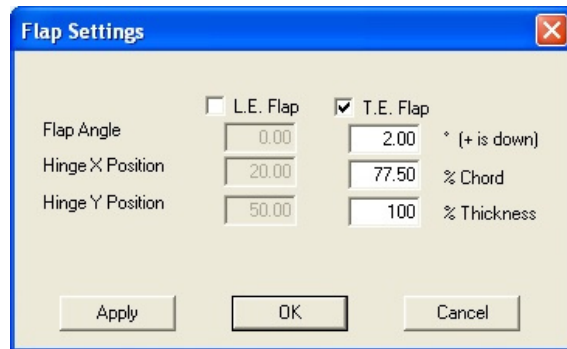


Figure 21

outboard ailerons) along the whole wingspan. This configuration allows for changing the wing camber in flight by taking advantage of the transmitter mixing capabilities.

What's the use of this feature?

Generally speaking, any variation in wing camber results in a modification in the polar curve, and in particular results in an upward or downward shift of the C_l vs. AoA curve while keeping the difference in drag at a minimum. Some airfoils are more suitable for this task than others, but the idea is that variable camber lets the pilot optimize the model for different flight conditions, thus extending its envelope.

It goes without saying that we are extremely interested in investigating this kind of optimization. We will therefore use XFLR5 to analyze different camber configurations, and then we will compare them against each other to find what is

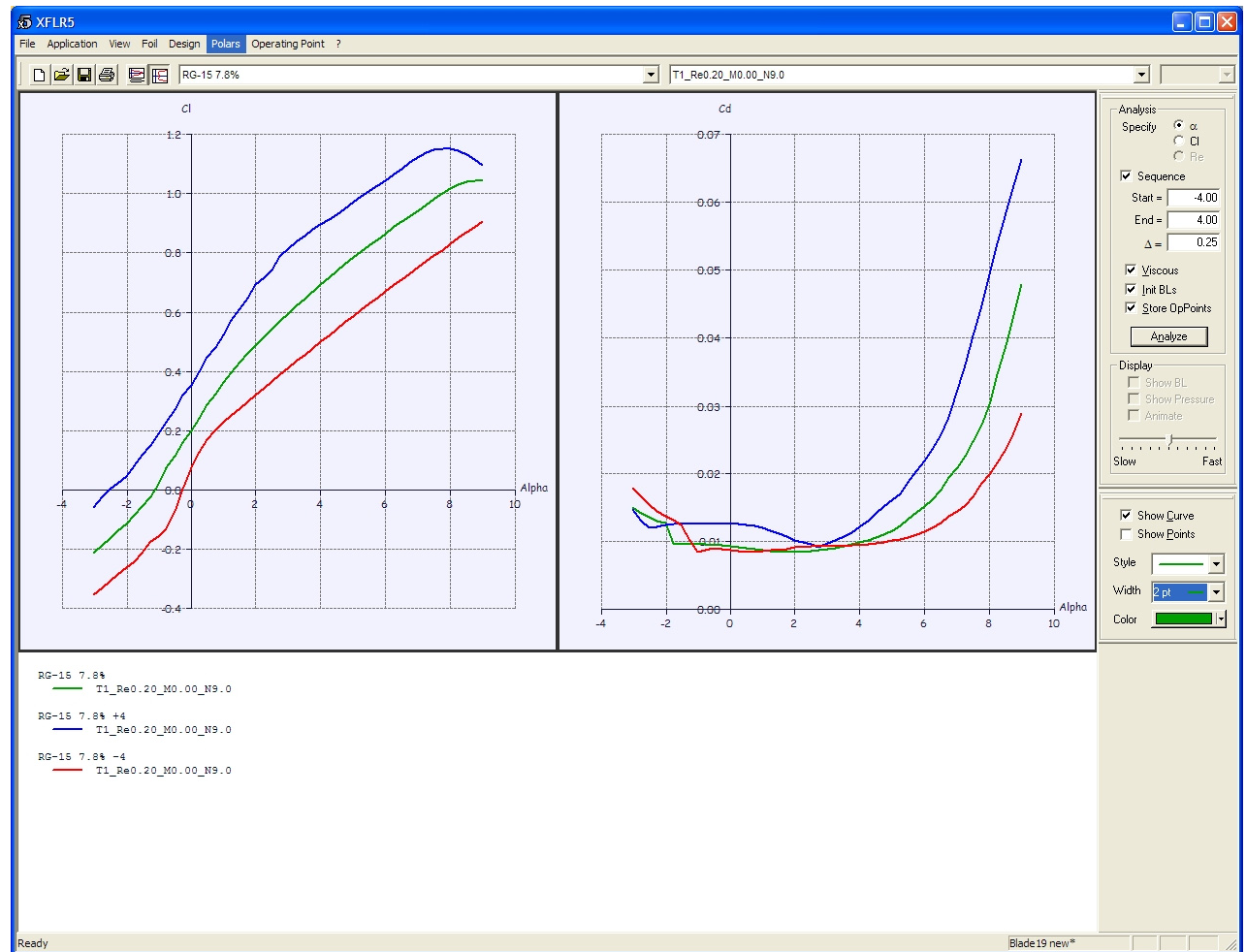


Figure 22

the best setup for different conditions. Our first step will be to go back to the Xfoil routine (Application > Xfoil Direct Analysis), then choose the RG-15 7.8% airfoil from the airfoil drop-down list and invoke the "Set Flap" command from the "Design" menu. From the window

that will pop up (Figure 21) we check the "T.E. Flap" box, then we input the desired deflection angle (we can start with +2 degrees, i.e. 2 degrees of downward deflection of the trailing edge flap) and the hinge position as a function of the chord (approximately 77.5% for the Blade

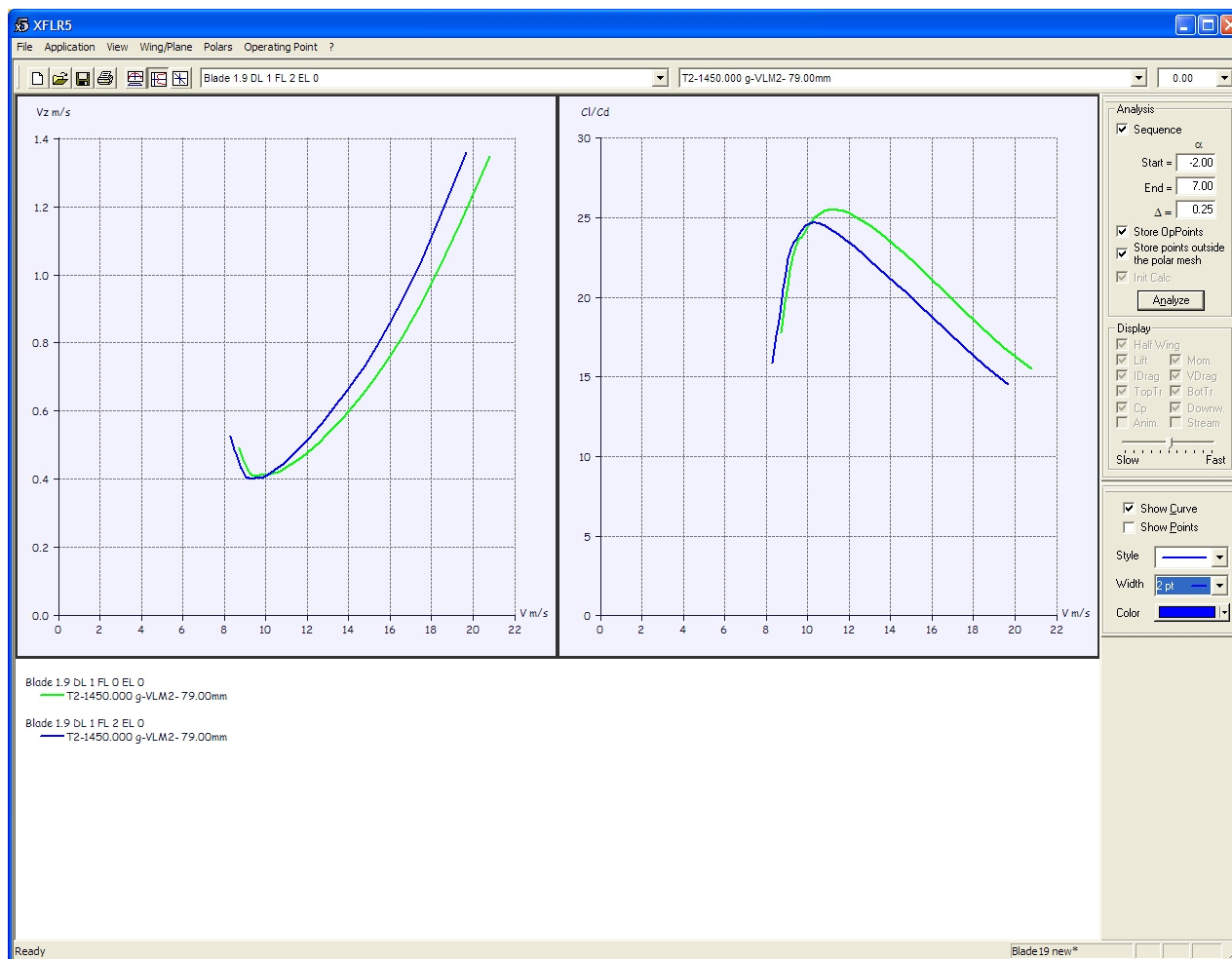


Figure 23

wing flaps) and of the airfoil thickness (100% in our case, because all wing control surfaces in the Blade are top hinged); then we click the “OK” button and we store the modified profile under a suitable name (for instance, “RG-15 7.8% +2”). Now we must pre-process

the polar family exactly like we did for the unmodified airfoil, and we might also want to repeat the whole process for a broader range of flap deflection angles (in addition to 0 and +2 degrees, I suggest +4, -2 and -4 degrees). Now, if we look at the Cl versus AoA and Cd

versus AoA plots (View > Polars, then right-click > Graph > Variables) we will probably see a tangled mess of curves, but if we clean up things a bit (Polars > Hide all polars) and then we plot only a single Reynolds number for each airfoil modification (by choosing the airfoil and the desired Re from the drop-down lists in the toolbar, then checking the “Show Curve” box) we should see a graph like the one shown in Figure 22. This graph shows that, in a limited AoA range, different flap settings result in a conspicuous variation in Cl , with a limited influence on Cd .

We might now feel the temptation to see what flap setting allows for maximum Cl/Cd ratio, but we must always keep in mind that these are the 2D polars, and the results may not be immediately translated into performance prediction for the complete model. My suggestion is to spend some more time and “persuade” XFLR5 to simulate the complete model with differently cambered airfoil sections, so that our investigations will be based upon a 3D model of the plane behavior.

To set up a 3D model of the Blade with flapped airfoil, first we shall enter the 3D module of the program (via the “Application > Wing Design” menu). Then we recall the already-processed Blade model via the drop-down list

in the toolbar, and we duplicate it (“Wing/Plane > Current Wing/Plane > Duplicate”), we assign a new name to the new copy and, via the geometry definition routine, we modify the wing by choosing one of the flapped airfoils (for instance, “RG-15 7.8% +2”) for all the wing stations from the root through the 850 mm station (which corresponds to the aileron outer tip). After we’ve finished, we dismiss the window, we process the 3D polar with the same procedure we’ve already been through, and we jump to the polar graphs. The speed polar (Figure 23) is now telling us that two degrees of flap deflection result in a small improvement in sink rate for airspeeds below 10 m/s, but things get rapidly worse for higher airspeed values. Glide ratio is also worse in all the speed envelope but in a small arc between stall speed and 10 m/s. This means that dialing in two degrees of flap deflection to increase the wing camber of the Blade is a good idea only if we plan to slow the model down to about 10 m/s. Should we want to do so? The answer is not so easy... it is common knowledge that the Blade doesn’t like to be slowed down, and undoubtedly it is no F3J model, and flying at the minimum sink rate is not its intended best. But in some cases, sinking at 50 cm/s instead of 70 cm/s may make the difference between returning safely to the landing zone and

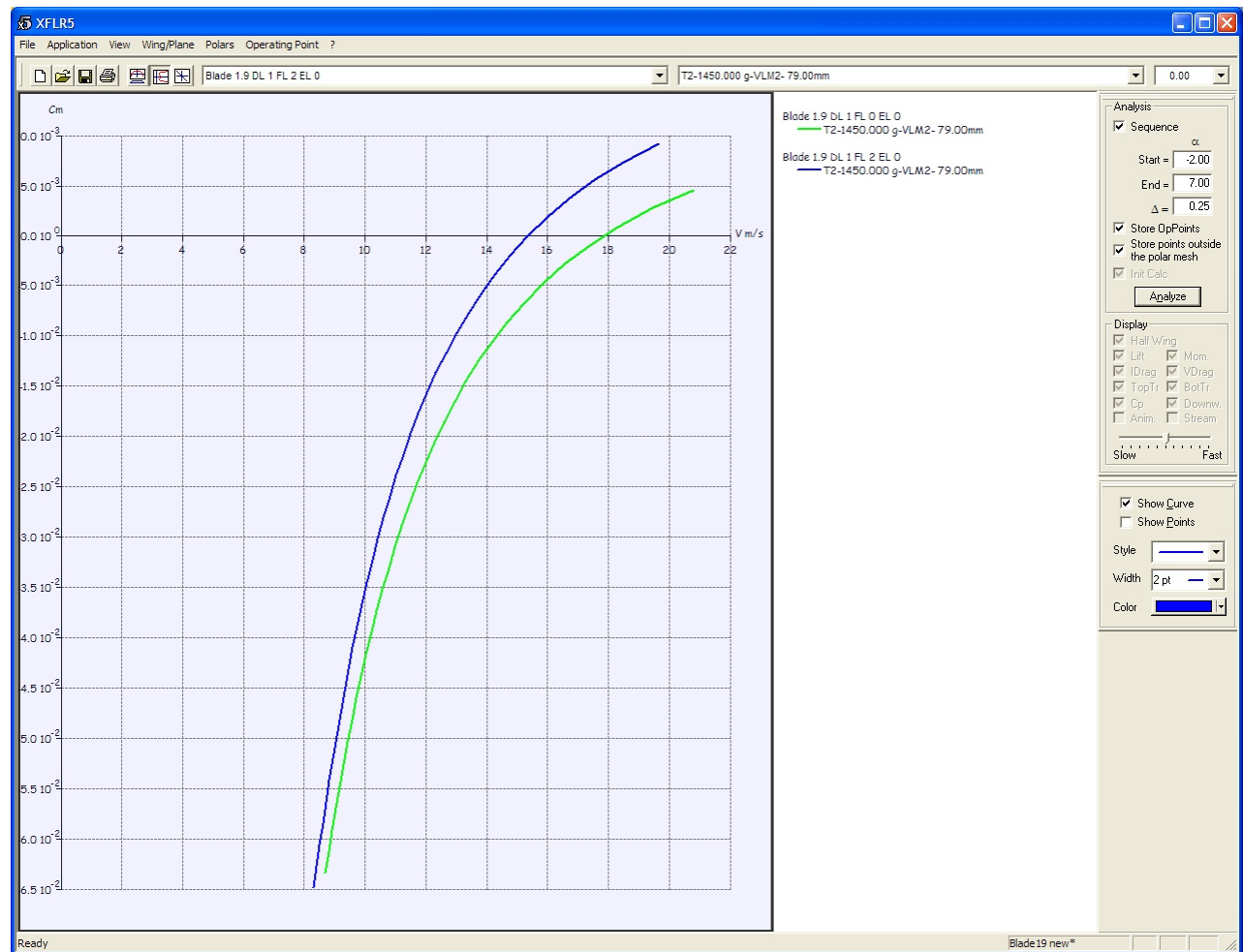


Figure 24

sticking the model up in some tree top; in these cases we may want to slow the model down and dial some flaps, even if flying at the minimum sink airspeed is not a funny exercise. Why? Just look at how close to stalling is the minimum sink airspeed. If we slow below 9 m/s

the model will stall; if we fly faster than 10 m/s we will not be attaining minimum sink. Increasing camber makes this more and more critical, because it makes the polar curve “narrower” and “sharper.”

There is also another effect to be considered. If we look at the CM vs. Vinf

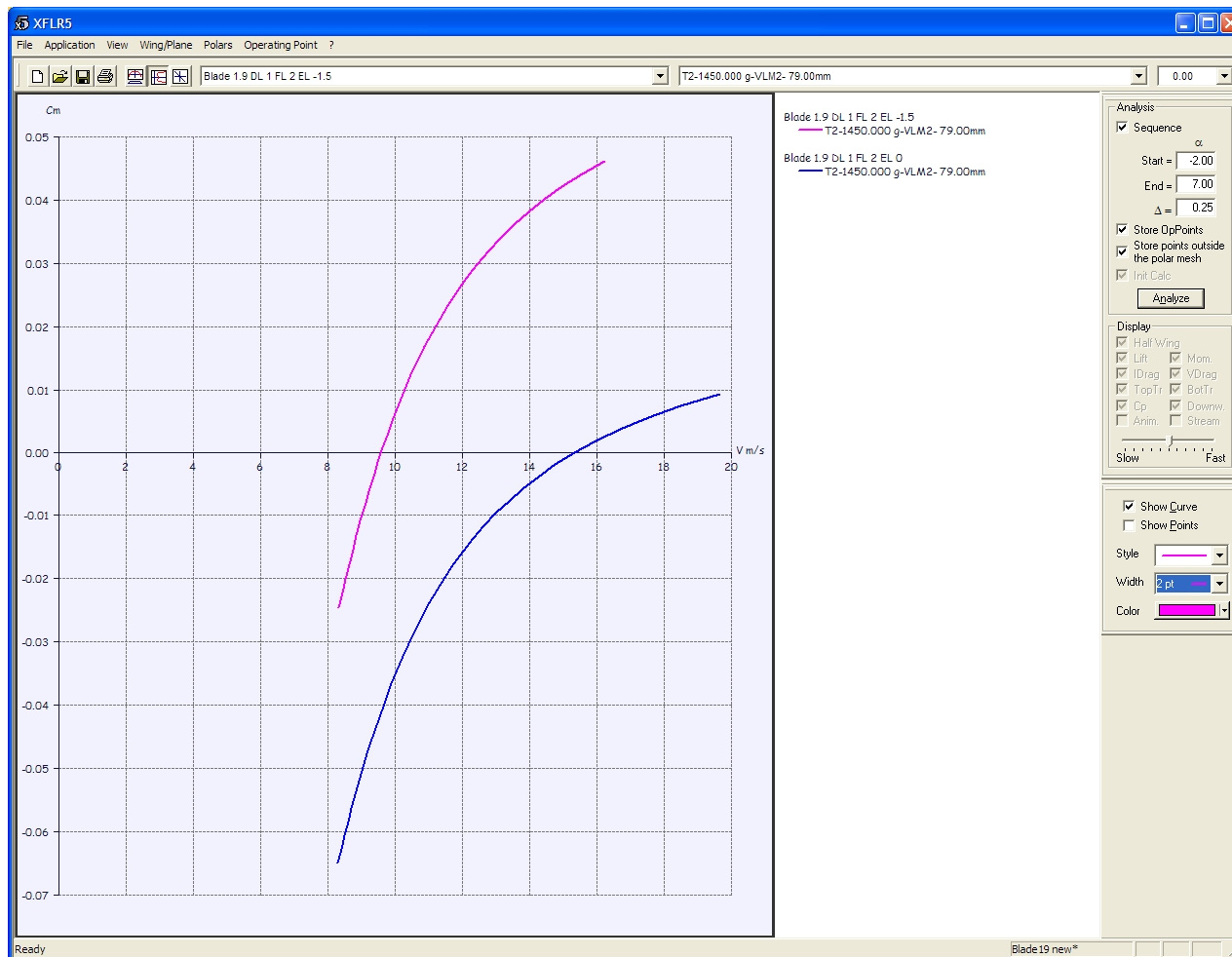


Figure 25

graph, Figure 24, the curve shows that the zero trim airspeed is about 15 m/s, slower than the trim speed for when no flaps were used, but faster than our target speed for which more camber is useful. This means that we should also dial some up trim to make the Blade fly

as slow as required. But there's a catch: as we trim the model in this way, the pitching moment to airspeed relation will change, and in particular when we trim for "nose up" the model will become more pitch-sensitive to airspeed changes. This will result in a stronger

tendency to oscillate around the desired airspeed rather than keep it throughout the flight.

This behavior can be investigated via XFLR5 by creating a modified NACA 0007 airfoil with a leading edge flap at 75% chord, deflected by -1.5 degrees (upward deflection, that is), and instructing the program to simulate a Blade endorsing this airfoil section in its V-tail. We will get a CM vs. Vinf graph like the one shown in Figure 25. The model with "up trim" (magenta curve) is now balanced at an airspeed of less than 10 m/s, but the slope of the curve near the balance point is much steeper than the slope of the curve that describes the "zero trim" Blade (blue curve) at the 15 m/s balance point. This means that, for instance, any drift from the trim airspeed for the "trimmed up" Blade will result in a pitch response three times stronger than we would have with the neutrally trimmed model; therefore, we may expect a stronger tendency to pitch oscillations.

Obviously there is a way to get the model to balance at 10 m/s without requiring so much up trim; we just need to move the CG aft. If we re-compute the model polar by setting the CG at 88 mm from the leading edge, we see that CM goes to zero at the desired airspeed of 10 m/s (Figure 26), and that the slope of the curve is not too steep, as predicted.

Flying with a such a rearward CG, though, may be challenging and may even hide any improvement (the model can really fly “by the polar” only if it’s not disturbed by pilot input, and this is not compatible with too aft a CG). This means that the “best” combination of CG position and pitch trim (or decalage) results from a trade-off between aerodynamic behavior and pilot skills. A model set up with a rearward CG is more pitch-sensitive and may be trimmed for a broad range of airspeeds, but it demands the hands of a keen pilot; a more forward CG likes to fly at an airspeed only, is less versatile but is easier to fly. When one is involved in competition flying, the temptation of moving the CG more and more aft is always strong. At first the model will become more versatile and suitable for different tasks, but at the same time it will be less easy to fly, and sooner or later the pilot will that he is losing performance instead of improving.

The very same method we have just applied may be reiterated for more flap settings, yielding a broad family of model polars. If we complement the two polars we already have with others, calculated for flap deflections of +6°, +2°, -2°, -4°, and then we ask XFLR5 to plot all the speed polar and glide ratio curves in a single chart, we will get something similar to Figure 27. If we look closely,

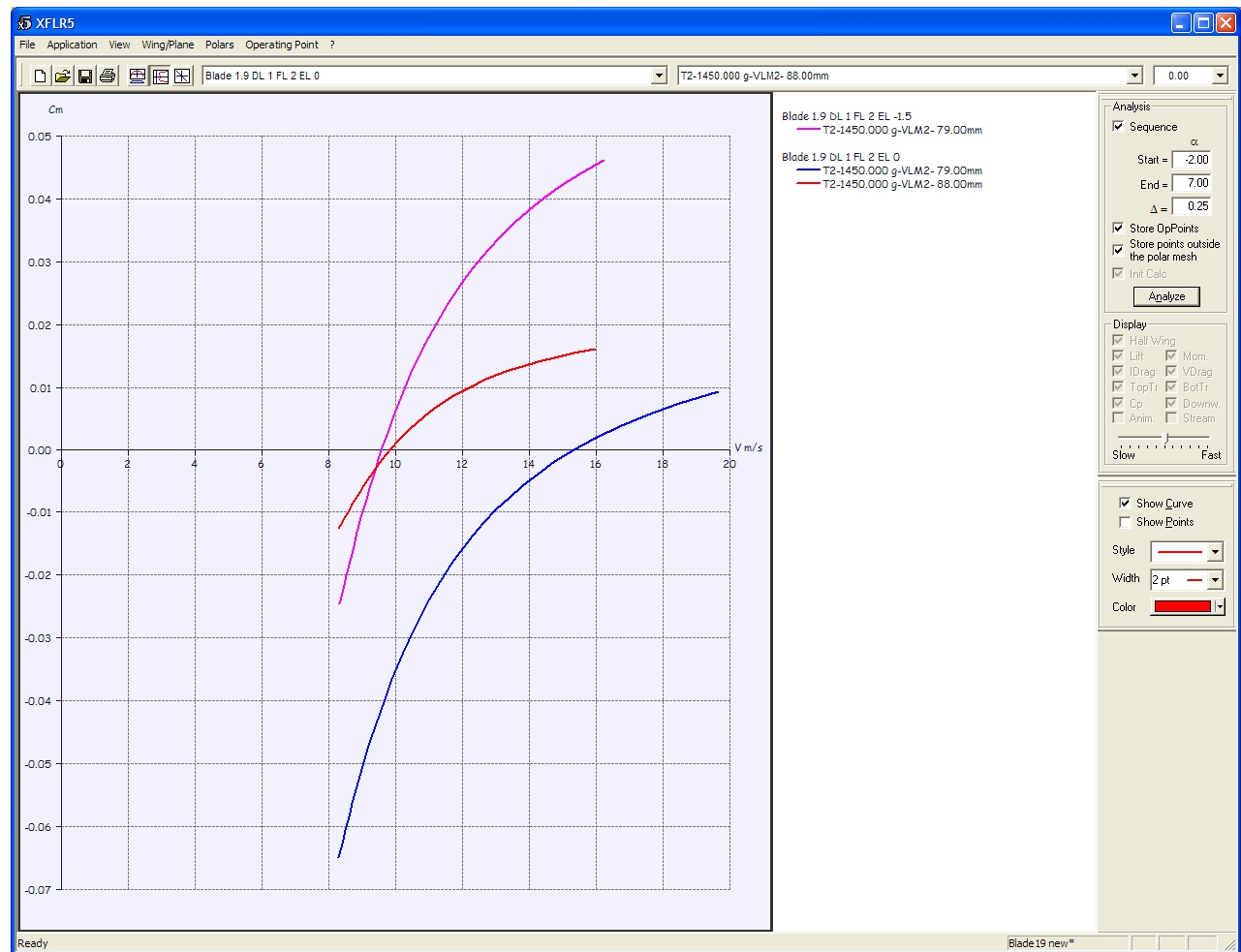


Figure 26

these graphs are very interesting. For instance, we can see that there is no single flap setting which is consistently better than others in the entire speed envelope. And, perhaps less obvious, we also see how difficult it is to design and fly a true “multi-task” model. Flying

at the minimum sink rate (or, in other words, flying as long as possible) is not the same as flying at the best glide ratio (or flying as far as possible), even in still air. It is part of a pilot’s skills to tailor his flying style to the particular task and to the particular weather conditions.

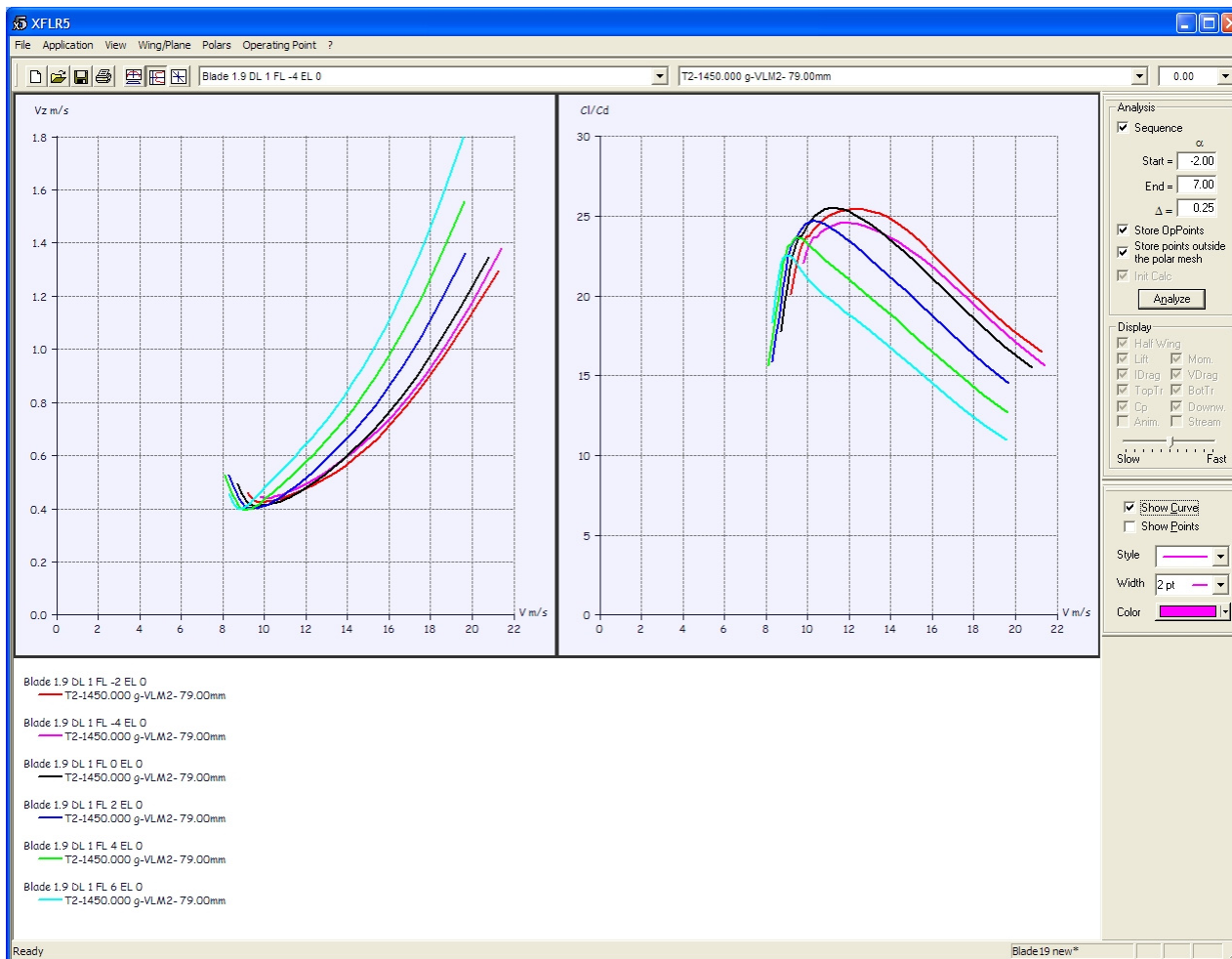


Figure 27

Trade-offs and conclusions

By looking at Figure 26 we see that the 1.9-m Blade has its peak efficiency (best glide ratio) when flying at about 11 m/s (25 mph) with “flat” wing (no flaps deflected), and that when we want to descend as slowly as possible we

need to deflect the leading edge flaps by 4 degrees downwards and keep an airspeed of 9 m/s (20 mph). We already mentioned that the Blade is a slope model, designed to fly fast and that probably nobody would want to fly it at the minimum sink or at the best glide

airspeed, especially at a turbulent slope where it would be virtually impossible to tell the former from the latter. But, just for fiction, let’s suppose we want to bring our Blade to a thermal duration contest on a flat field. In this case it’s easier to distinguish the two flight conditions, each in its own particular “task.” We will seek the best glide ratio when we want to explore as much air mass as possible while hunting for a thermal, and we will struggle to fly at the minimum sink rate in dead air, where there are no thermals to be found, or while we are trying to gain as much altitude as possible in a weak thermal. In addition, if we need to penetrate headwind or to escape from a sinking air zone, it is also important to fly faster than the best glide ratio airspeed. In other words, it becomes important for a pilot to exploit the “extended polar” of its model, that is the curve arising from the envelope of the many different polar curves associated with variable camber. To be successful in this, we need to study the curves and match the theoretical capabilities of the model with our piloting skills. For example, from the charts we see there is hardly any gain, either in sink rate or in glide ratio, when we deflect the leading edge upwards by more than two degrees; this may be translated in a radio setup that will allow for a “speed” flight

phase with no more than two degrees of up deflection for both flaps and ailerons. Conversely, the charts suggest that we may improve the sink rate by deflecting the leading edge downwards by 2, 4 or even more than 6 degrees, but... the more deflection we use, the narrower the polar curve will become, and the closer to stall the operating point will be. The pilot must find out how close to the limit he is still comfortable, and able, to fly; in any case we have seen that slowing down the model either requires a good amount of up trim (or, equivalently, a rather large decalage), or requires moving the CG aft. In the former case we'll have a more marked tendency to oscillation, in the latter we will have a more pitch-sensitive model. Only the pilot, with his own judgment, can tell the difference between "sensitive," "responsive," "critical" and "dangerous." In my Blade I have decided I see very little improvement in more than two degrees of downward flap deflection, and so I have setup a "thermal" flight phase accordingly.

There is an additional possibility which is worth mentioning, that is using the so-called "snap-flap" mix. This mix, available in most modern radios, causes a variation in the "camber" signal (which is then mixed and sent to flap and aileron servos) whenever the pilot acts on the pitch stick. In my opinion it is a good idea, and not only for fast F3F models in which it is typically used. When we

pull on the yoke of a glider, in fact, we are shifting the operating point towards lower airspeeds, and we have seen that increasing wing camber at the same time may be a good idea. The snap-flap mixer may be seen as a semi-automatic way to choose the most suitable polar for the conditions we are "requesting" with the pitch control. Setting up the snap-flap mixer is not trivial, but again a good simulation of the plane behavior, paired with a good understanding of what we are asking the model for in terms of airspeed and load factor, may be helpful.

The last thing I'd like to discuss is how XFLR5 simulation compares with reality. I've had the opportunity to test a flight data recording system by Eagle Tree Systems. Unfortunately I could not install it in my Blade (too narrow and crowded fuselage) but I used it in my F3J Stork 2 Pro model. With its static and dynamic pressure ports (the latter connected to a dynamic probe outside the boundary layer), the data recorder samples airspeed and barometric altitude ten times a second, so that the collected information may be analyzed offline on the PC. I've been glad to discover that the minimum sink setup (very important in an F3J model), that I had honed in several test flights, is consistent with the Stork behavior simulated with XFLR5. Camber settings for thermal flight, fast flight and towing were also comparable to those suggested by XFLR5. I was less satisfied with the predictions of the

elevator deflections required for minimum sink and best glide airspeeds, but I later found that these are consistent with the not-so-good accuracy (half degree) of the homebuilt incidence meter I used to measure the rigging angles of the main wing and the V-tail group.

My conclusion is that a simulator such as XFLR5 may be a valuable and useful tool, provided that the user knows what to look and ask for, and that he always keeps in mind the limitations of the underlying mathematical model and the finite precision both of our tools and of our beloved planes. ■

XFLR5

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Link: <http://xflr5.sourceforge.net>

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Current version as of print date: 3.21e

Blade 1.9

Maker: X-Models

Wingspan: 190 cm (75 in)

Length: 107 cm (42 in)

Airfoil: modified RG-15 (thickness 7.8%)

Wing surface: 32 dm² (3.44 sq ft)

Typical ready-to-fly mass: 1400-1500 g (49-53 oz)

