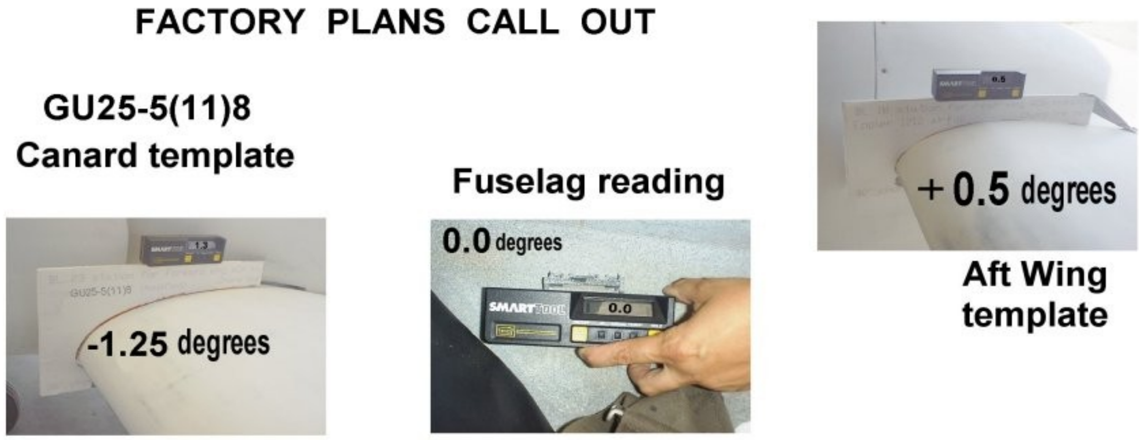
This page is an attempt to shed some light on a poorly understood topic: the angle of installation of the airfoils called for in the factory Dragonfly plans.



This section is about airfoils, chord lines and them imaginary things called "install lines". Know this, What you see (read, hear, smell touch....etc) ain't always what you think it is. Take a step back from what you think you know and consider the following information for what it is.....a really good guess at what is actually happening out there in the wind.

THE FORWARD CANARD

Note : The Dragonfly "factory" issued plans do not tell the builder what airfoil was used for the canard. My best guess (and that is exactly what it is....an educated guess based upon looking at a lot of airfoils) is that the dragonfly's canard airfoil is a variation of the GU25-5(11)8. Click ....here.... to take a look at some data on this airfoil.

his airfoil, originally developed in the late 60's for powered hang gliders at Glasgow University, UK, was chosen by B. Rutan for its " known " low Reynolds Number handling characteristics. The coordinates for the original version of this airfoil (GU255118.dat) are posted on the UIUC (public domain) website for your investigation.
http://amber.aae.uiuc.edu/~m-selig/ads/coord_database.html These original coordinates will create an airfoil that is "close" to the one used on the D-Fly, but not close enough to be of any value in a digital wind tunnel analysis. Note : Just to keep it clear: the (GU255118.dat) coordinates found on the UIUC were ***not*** the ones used by anyone in the Dragonfly design process (myself included). The (GU255118.dat) are from the original Glasgow report of a powered hang-glider (40 mph max speed, RN# =

700,000). Rutan, Walters and the Q-bird boys may have started with this airfoil in mind, but all changed it significantly for use on their designs.

During my study of the Dragonfly's (factory) canard, I also received a "scanned in" image (ACAD 14 format) and the location of a set of modified airfoil coordinates created from what I think was yet another set of digitized D-fly plans. The "modified " data points can be found at **drgnfly.dat** This set of data points will create a shape that is very close to the shape of the canard airfoil found in the printed factory plans. It is quite possible that reproduction errors or paper shrinkage could be the difference seen between these two sets of data. The "**drgnfly.dat** " data set was used for all the GU25 digital analysis shown on this website. Please see **Canard Lines** for a graphical explanation of the differences in the airfoil shape files and the different lines talked about in this discussion.

For digital windtunnel simulations (computer modeling) the **drgnfly.dat** version is close enough to the actual shape to produce accurate results. The computer generated aerodynamic curves seen below are derived from using the **drgnfly.dat** data. Note : computer wind tunnels tend to give results that are 0.1 to 0.3 coefficient of lift units higher than the real airfoils do. These are ideal curves that would best be compared to a real airfoil tested at Reynolds numbers near 9E6 or 12E6 (9 to 12 million). Also, the Cl vs AOA curve is for the airfoil with no elevator deflection or elevator gap losses. The shape of the lift curve changes radically if you deflect the elevator or have gap losses. See the AOA page or the math model page for that discussion.

GU25-5(11)8 " mod " [drgnfly.dat] Airfoil Profile

GU25-5(11)8 " mod " [drgnfly.dat] Aerodynamic Drag vs. Lift Coefficient

curve GU25-5(11)8 " mod " [drgnfly.dat] Lift coefficient vs. AOA curve

In any event, all the data you see above is based upon the airfoil's chord line. The " level line / water line " shown on the factory plots is " not " an airfoil chord line. The paper plot line shown is an " install line ". The difference is very important from a designers perspective. The line that is labeled " install line " is drawn on the plans' template in such a way that you would only know to install that shape so that the line is level to the fuselage water/level line. this is great if you are building and wish to know nothing about the airfoil or aircraft performance trouble shooting.

The chord line of any airfoil is defined as the straight line connecting the leading edge to the trailing edge. Any computer analysis of an airfoil will use this definition and will assume that the " theoretical " chord line is horizontal and level. The person who set up the data points (shape coordinates) will do so with this in mind. Any set of data points you see, will be referenced to he chord line of the airfoil. You, as the investigator must understand the rules of the game. Keeping in mind that all simulations are based upon a horizontal and level chord line will allow you to apply the results to the shapes you see on the plans.

The canard airfoil you see in the plans is drawn so that you would install the airfoil at negative (-)1.25 degrees Angle Of Attack to the fuselage level line. This is the true installed AOA based upon the true chord line. That is to say, when the fuselage " level line" is level to the earth and the canard " level / install line " is level to the fuselage, the canard will be actually installed at (-) 1.25 degrees. This is not bad, it is just what the original designer wished to have happen.

If you wander over to the math model pages of this website, keep this chord line vs. install line information in mind. In the math analysis, if the canard's airfoil is shown to need some negative install value, it is referencing the theoretical chord line of that airfoil, not the plans drawn "installation line" that is seen on the D-fly plans template. In the case of the D-fly plans that I bought, the difference between the theoretical canard chord line and the actual install line is about (-)1.1 degrees. (this is close enough to the high resolution scanned in version that showed 1.250 degrees)

An Example : A computer analysis determines that the "theoretical" optimum angle for a Gu25 canard is to be at negative two (- 2.250) degrees AOA to the virtual wind. Then in the real world, (the one we actually live and fly in), using the real set of D-fly templates, the real canard would be put on with the canard install / level line at (--) 1.00 degrees to the fuselage level line. It is ***implied*** that the builder will remember that there is another (-- 1.250) degrees built into the position of the "as seen" install line on the paper. The " chord line " (not seen on the paper templates unless you draw it in yourself) would be at a combined value of (--) 2.250 degrees to the fuselage. This -- 2.250 degrees is what the computer is telling you is the correct install angle. Simple, if you use chord lines as the install lines.

Designers note : You might consider drawing the " actual chord line" onto the canard template. To do this, use a pencil from the forward most curve tip of the leading edge to the aft most tip of the trailing edge of the elevator. Now you will have a true set of information lines on the template to use as a basis for comparison when looking at any of these computer simulations or digital wind tunnel outputs.

THE AFT WING :

Aft Wing Note : The Dragonfly "factory" plans call do not tell the builder what airfoil is used for the aft wing. My best guess is that the airfoil section is a variation of the EPPLER 1212 airfoil developed by Dr. Eppler. The coordinates for the original version of this airfoil are posted on the UIUC (public domain) website (see above) for your investigation. The file name is **e1212.dat** There is another file just below this one titled "e1212 mod" that is labeled for the quickie aircraft. This "mod" version is very similar to the "e1212" except for a shift in the chord line that causes a strange built in incidence. We did not use this file and do not recommend using this shape file for anything. We used the **e1212.dat** data file and clearly understand that the "chord line" is the only line that means anything when it comes to correctly installing a wing onto a fuselage.

The original data coordinates set **e1212.dat** will create an airfoil shape that looks a lot like the one on the D-Fly plans. An ACAD 14 drafting file of these data points may be seen by clicking **Eppler 1212 shape** . We also have a set of ACAD 14 format, digitized, aft wing coordinates (courtesy of One Sky Dog) These coordinates were overlaid onto the **e1212.dat** set for comparison. With the exception of some paper shrinkage errors and aileron alignment mistakes, there is no difference in the shape files. There is a 0.5288 degree difference between the true chord line of the Eppler 1212 airfoil and the "install line" as shown on the digital scan of the D-fly aft wing. That is to say, if you install the plans built wing with the install line at "level" you are actually installing the airfoil with a 0.5288 degree AOA to the relative wind.

A graphical comparison of these data files can be seen by clicking **comparisons** . Owen Strawn (DF builder and designer) picked up on this problem some time ago and has done his very best to get the D-fly community to pay some attention to this very serious consideration. His information may be found at **http://home.earthlink.net/~owenstrawn/images** and has contributed greatly to the information on this concern.

In any event, all computer math models (simulations) assume that the only line you care about is the "chord line". The imaginary things called "install lines" or "level lines" or "water lines" will never be mentioned, considered or even acknowledged in an aerodynamic analysis. For our digital windtunnel simulations (computer modeling) we used the original Eppler 1212 data set to create the output curves seen below. Note : computer wind tunnels tend to give results that are 0.1 to 0.2 units higher (near stall) than the real airfoils do. These are ideal curves that would best be compared to a real airfoil tested at Reynolds numbers near 9E6 or 12E6 (9 to 12 million). Also, the aileron is not deployed at all in these simulations. Deployment of the aileron will radically change the shape of the curves.

Eppler 1212 Airfoil Profile

Eppler 1212 Drag vs. Lift Coefficient curve

Eppler 1212 Lift Coefficient vs. AOA curve

To reconcile the analysis outputs to the real world application : you must know that the D-Fly's paper templates have the " install line " set at 0.50 degrees positive to the theoretical chord line of the airfoil. That is to say, when the airfoil is installed with its " water / install line " set at level (0.0 degrees to the fuselage level) the airfoil is actually sitting at an AOA equal to one half of a degree to the relative wind. If you think this is not worth concerning yourself about, you are thinking very, very wrong. 1/2 of a degree is very significant in the setting of a wing's pitch.

An Example : A computer analysis determines that the " theoretical " optimum angle for a Eppler 1212 airfoil wing is to be at zero (0) degrees AOA to the virtual wind. Then in the real world, (the one we actually live and fly in), using the real set of D-fly templates, the real wing would be put on with the "install line" at negative (-) 0.50 degrees to the " level line " of the real fuselage. It is implied that the builder will remember that there is another negative one half (- 1/2) degrees built into the airfoil's "as seen" install line on the paper. The "theoretical chord line" (not seen on the paper templates unless you draw it in) would then be set at a combined value of zero (0) degrees to the fuselage. This value of (0.0 degrees) is what the computer is telling you is correct for the chord line of the airfoil.

Designers note : You might consider drawing the " actual chord line" onto the wing template. To do this, use a pencil from the forward most curve tip of the leading edge to the aft most tip of the trailing edge of the aileron. Now you will have a true set of information lines on the template to use as a basis for comparison when looking at any of these computer simulations or digital wind tunnel output

We also looked at the NASA LS(1)-0417 and -0421 airfoils also. They are the " fixed and improved " versions of the GAW-1 (made to be less nasty in stall recovery). We believed that we could not build a 17% thick airfoil strong enough for our aircraft's loads, and the 21% didn't make enough lift to get the job done. Note : Nate Rambo (DF builder and designer) has done a lot of work on the -0417 canard and eventually got it flying. If you are interested in this airfoil, you should look up his work.

We chose to use the Roncz R1145MS airfoil for our canard. It has docile stall characteristics and generates a tremendous amount of lift at its max AOA of 15 degrees (with 20 degrees of elevator deployed). It does a better job of getting the nose up than the GU25 airfoil (max AOA of 11 degrees with 20 degrees of elevator deployed) as the fuselage can achieve 3 degrees greater AOA. That equates to a higher AOA for the aft wing, smaller platform area and a lesser (high speed) aft wing AOA. Not bad for an airfoil that has less parasite drag and better stall characteristics. No wonder everybody in the Velocity, Cozy, EZ and AeroCanard world use it (not to mention the Beechcraft Starship).