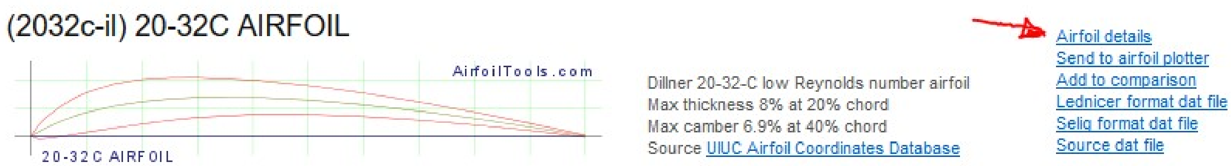
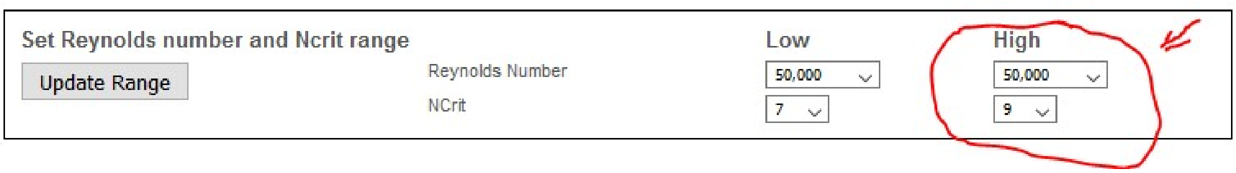
Choosing an Airfoil for Your Tethered Electric Airplane

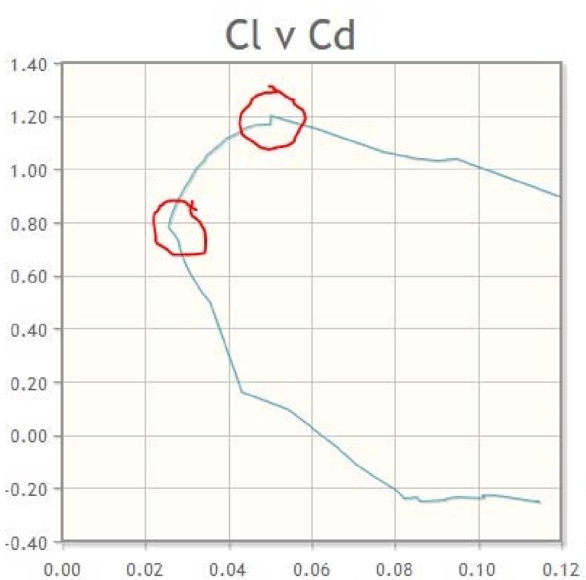
1) Go to http://airfoiltools.com/
2) Select "Airfoil Search" – click "Search"
    a. This should bring up a list of hundreds of airfoil designs.
    b. Note the first one, "20-32c Airfoil – Dillner 20-32-C Low Reynolds Number Airfoil"

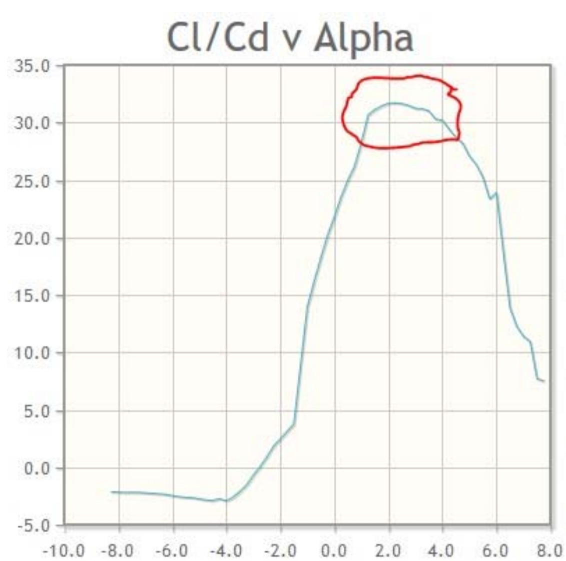


3) Click on "Airfoil Details"
4) Scroll Down to "Polars for 20-32C Airfoil" and set the High Reynolds Number to 50,000.
    a. This will simplify our charts to only look at airfoil performance at Re=50,000
        i. This is the closest approximation for most of our tethered electric airplanes b. Click "Update Range"

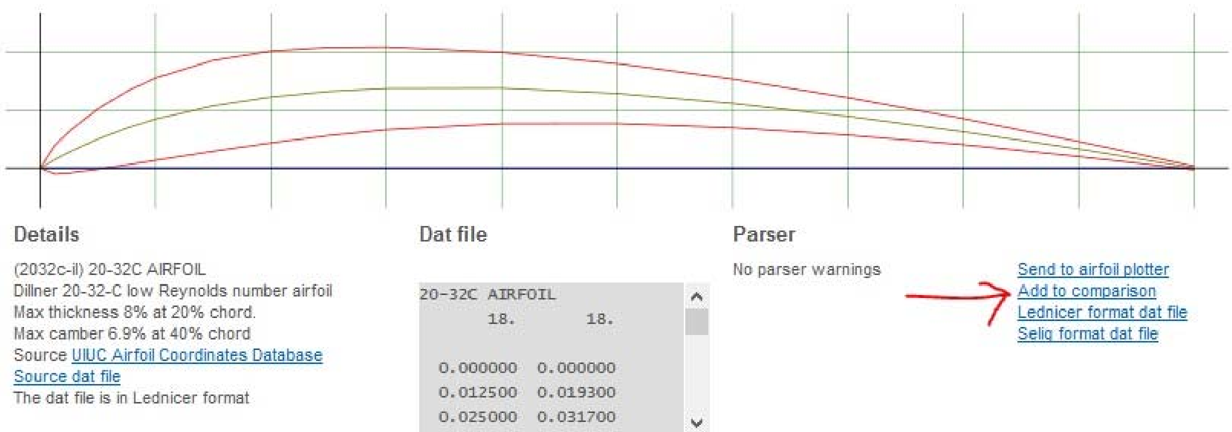


5) Observe the Chart "Cl vs Cd". Shows the lift and drag coefficients over a range of different angles of attack. Cd is the horizontal axis, while Cl is the vertical. Note the minimum Cd is 0.025, while the maximum Cl is 1.2. Low Cd is good for going fast, while high Cl is good for heavy lift. Note, however, that a high Cl requires a higher Cd due to induced drag.



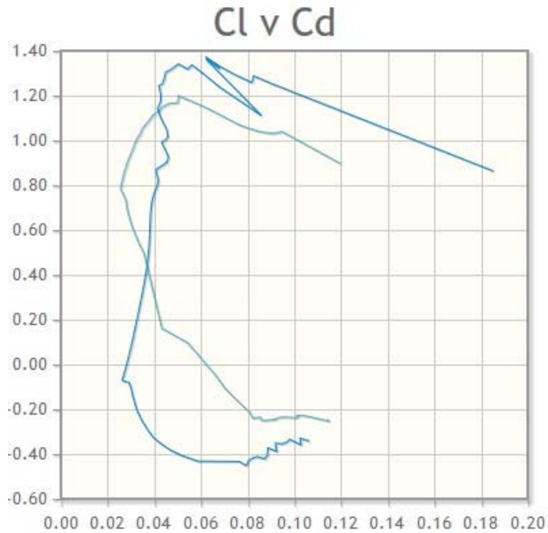


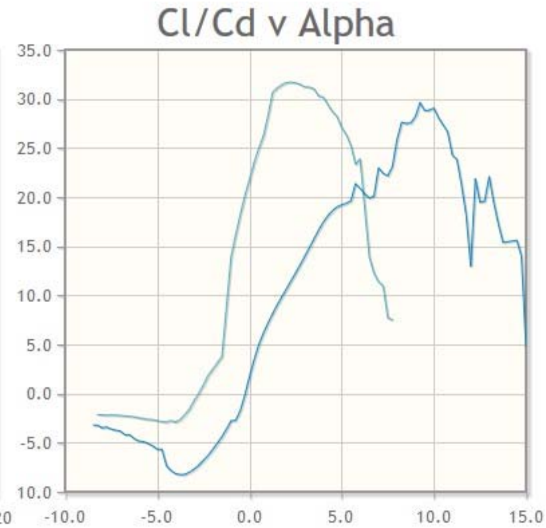
6) Note the chart “Cl/Cd vs Alpha”, immediately below the first chart. (shown here on the previous page). This helps identify the range of angles of attack over which the airfoil is efficiently producing lift. Peak performance occurs between 1° and 4° angle of attack.
    a. A high number for the Cl/Cd ratio is good
    b. Having a high number across a wide range of angles of attack is even better
        i. This means you don’t have to trim your airplane as perfectly to achieve performance
    c. Knowing a promising angle of attack can help you trim your plane. If you are flying this airfoil with an angle of attack greater than 4°, then you are likely approaching inefficiency.
    d. Note that the data stops at about 8°. This is because the wing has stalled and your airplane is crashing. Having a high stall angle can help keep your plane from stalling.
7) The “Cl vs Alpha” and “Cd vs Alpha” also let you analyze performance over various angles of attack. If you are designing purely for speed, then you want the lowest Cd over the greatest range of angle of attack.
8) Click on “Add to Comparison” (right underneath the drawing of the airfoil, see below)



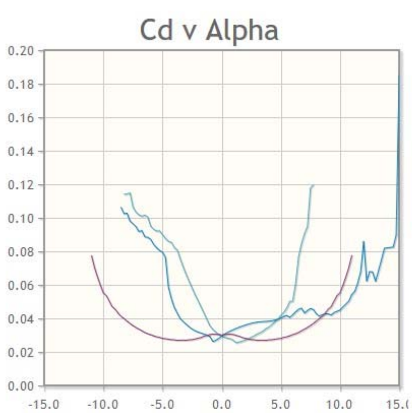
9) Click on “Airfoil Database Search” (under Applications… top right corner)
10) In the “Text Search” box, type “Clark Y” and press enter (or “Search”)
    a. The Clark Y is a very common airfoil for small airplanes and model aircraft 11) Select “Airfoil Details” for the (clarky-il) CLARK Y AIRFOIL.
12) Note that the drag polars are somewhat different for this airfoil, as would be expected given it has a different profile.
13) Click on the “add to comparison” option (as in step 8).
14) The drag polars will now show the comparison between the two airfoils. Unfortunately the colours for the two are very similar… the legend (above the plots) shows the Clark Y is the slightly darker blue line.

15) Observe Cl vs Cd and Cl/Cd vs Alpha (the Clark Y on these diagrams is the higher one with the zig zag in Cl vs Cd and the one “shifted to the right” on Cl/Cd vs Alpha)





16) Note that the Clark Y airfoil has:
    a. A higher maximum coefficient of lift – good for a heavy lift aircraft.
    b. Higher drag in the range midrange of lift… from about Cl=0.45 to Cl=1.15
    c. A positive Cl/Cd ratio from 0° to 15° while the 20-32 has a positive ratio from -2.5° to 7.5°. The Clark Y is able to generate lift over a wider range of angles of attack… it is a "more forgiving" airfoil… but it's peak lift/drag ratio is lower than for the 20-32.
        i. Will you trade off peak performance at a narrow range of operating conditions for "good" performance across a wide range of operating conditions?
17) So far we have looked at the 20-32 airfoil, a slightly "under cambered" airfoil (the bottom of the wing is concave) and the Clark Y, a roughly flat bottomed airfoil. Another common type of airfoil is the symmetric airfoil. Select "Airfoil Database Search" and try "NACA 0015". Add this airfoil to your comparison.
18) You'll notice that the NACA 0015 doesn't appear to be a strong contender in the Cl vs Cd or in the Cl/Cd vs Alpha charts, but note the Cd vs Alpha chart (at left, below).



This shows the NACA 0015 having lower drag across the range of 2° to 8° angle of attack. That means this airfoil may result in a plane that is capable of flying faster than the other two airfoils. Since total lift is a function of both Cl and airspeed, and airspeed is squared, while Cl is linear, the lower drag may offer lift advantages over the other two airfoils with higher drag, IF your fuselage and propeller are designed to allow the aircraft to travel at higher speeds.

In short, there is no "one best" airfoil for this project… you may want to build one airfoil, test it on your plane, then consider a different design and test it. Try out a few different airfoils to see how they compare and get your plane flying early for more testing time!