Symmetric or Asymmetric?

A quick and dirty study on the issue of using symmetric or asymmetric sections for dagger boards

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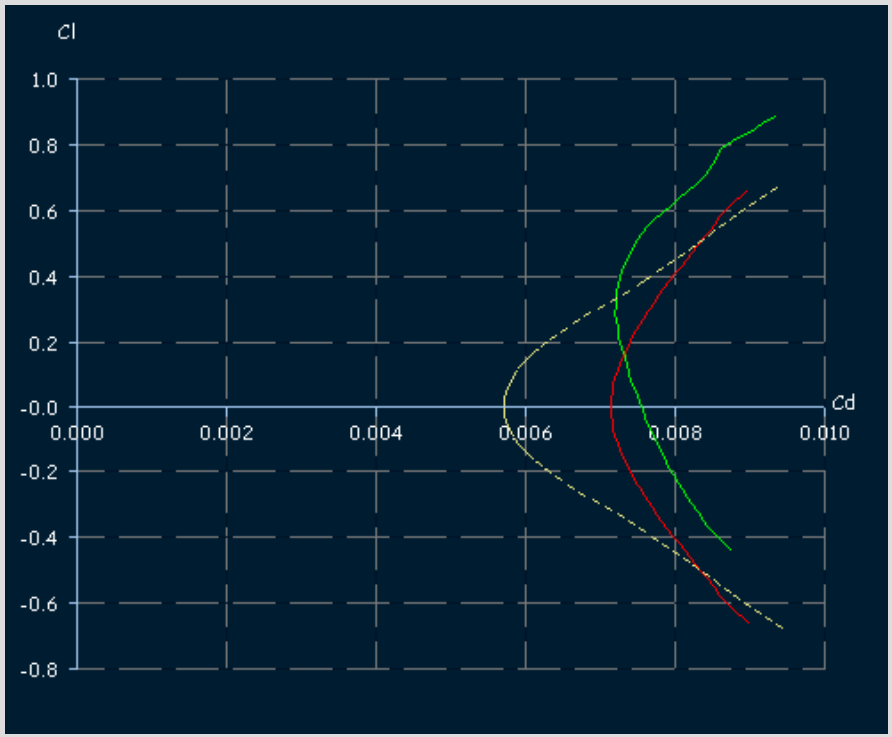
Overview

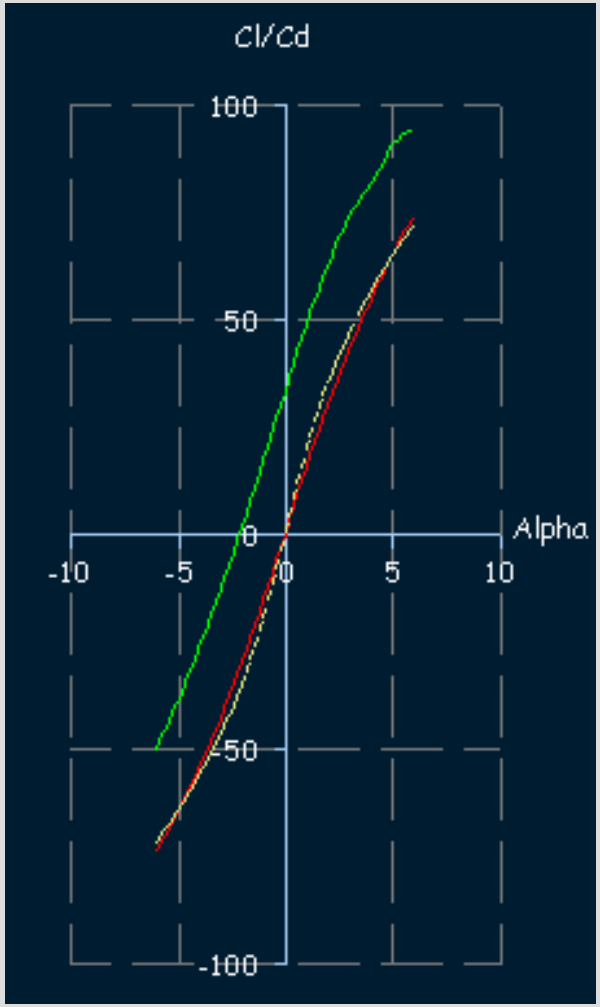
- I have tried to illustrate the particulars of symmetric and asymmetric foil sections.
- I also put the foil section differences into perspective by showing what their contribution is to a dagger board of realistic aspect ratio.
- I have used two old NACA sections for this study. The symmetric one is the venerable and popular 0012 and the asymmetric is its cousin 2412. I also throw in a modern, symmetric foil section for good measure.
- The program I used is called XFLR5 which is based on the famous xfoil code.
- All computations are made for a Reynolds number of $2*10^6$ and the ncrit parameter is set to 3 to simulate a more realistic, turbulent environment than the standard value of 9 approximates.

Foil Section Polars I



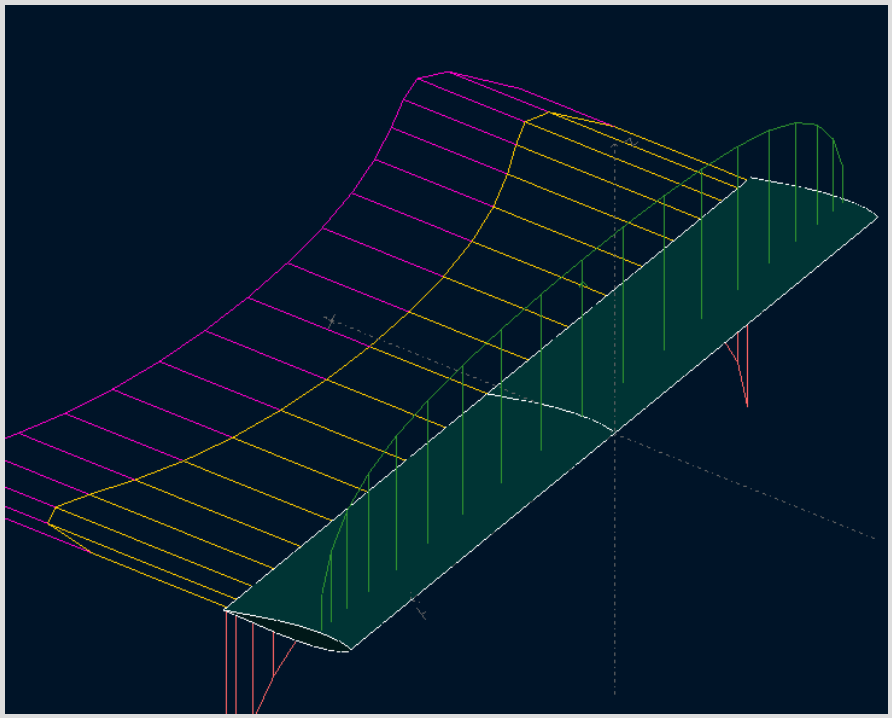
- 0012, 2412, prulsY
- Cd is the drag coefficient.
- Cl is the lift coefficient.
- The off-set of the asymmetric section is clearly seen.
- Also note that the minimum value of Cd is the same for 0012 and 2412.

Foil Section Polars II



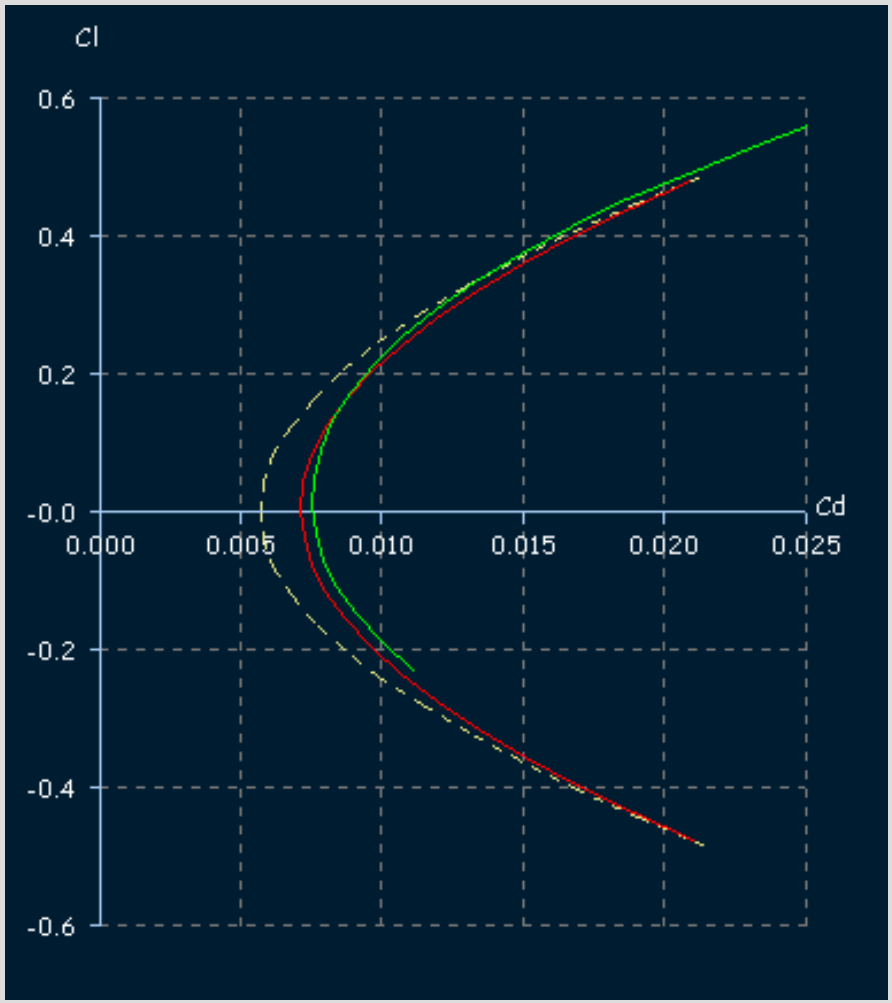
- This plot clearly shows how much better lift-to-drag ratio the asym-metric section offers.

Wing



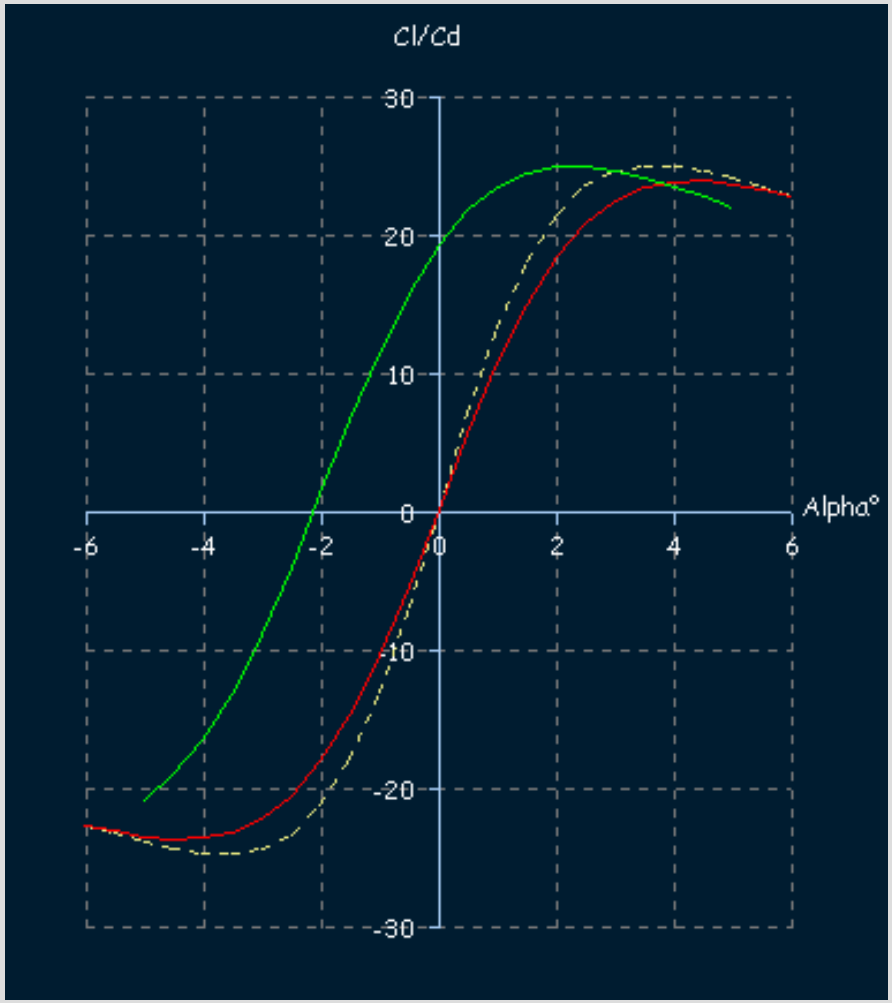
- Half of this wing has the same proportions as my dagger boards.
- The full span simulates the end-plate effect of a wide hull. For a fast cat this isn't true so the real aspect ratio is (much) worse.

Wing Polars I



- Note that there is little gain from using an asymmetric section now that the induced drag of the humble aspect ratio is factored in.
- Note also how much worse Cd vs. Cl is for a wing.

Wing Polars II

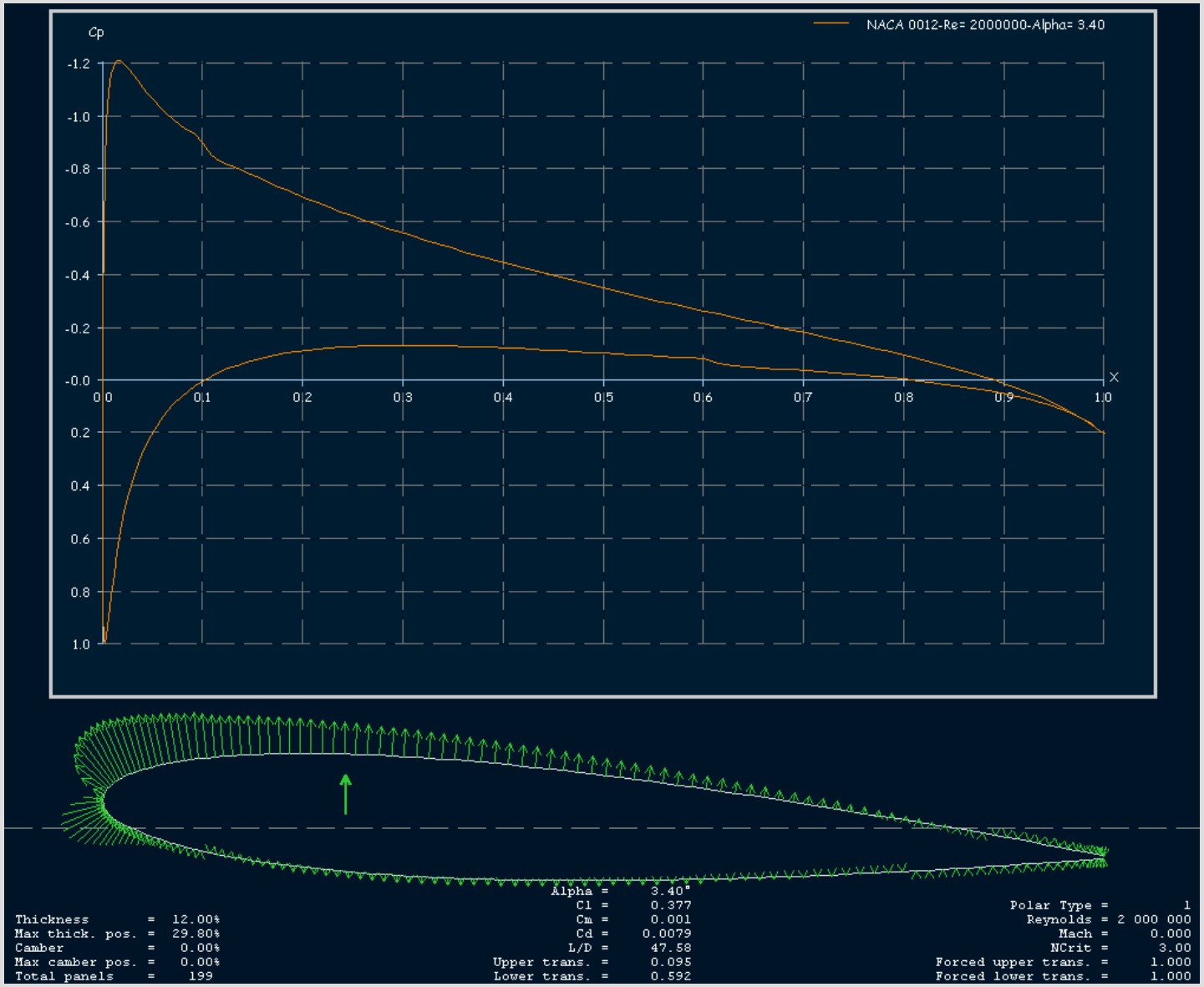


- Not much difference in lift-to-drag ratio now.
- There is an off-set in angle of attack of some 2 degrees, however.
- Note that peak lift-to-drag is down by a factor of four compared to the section performance.

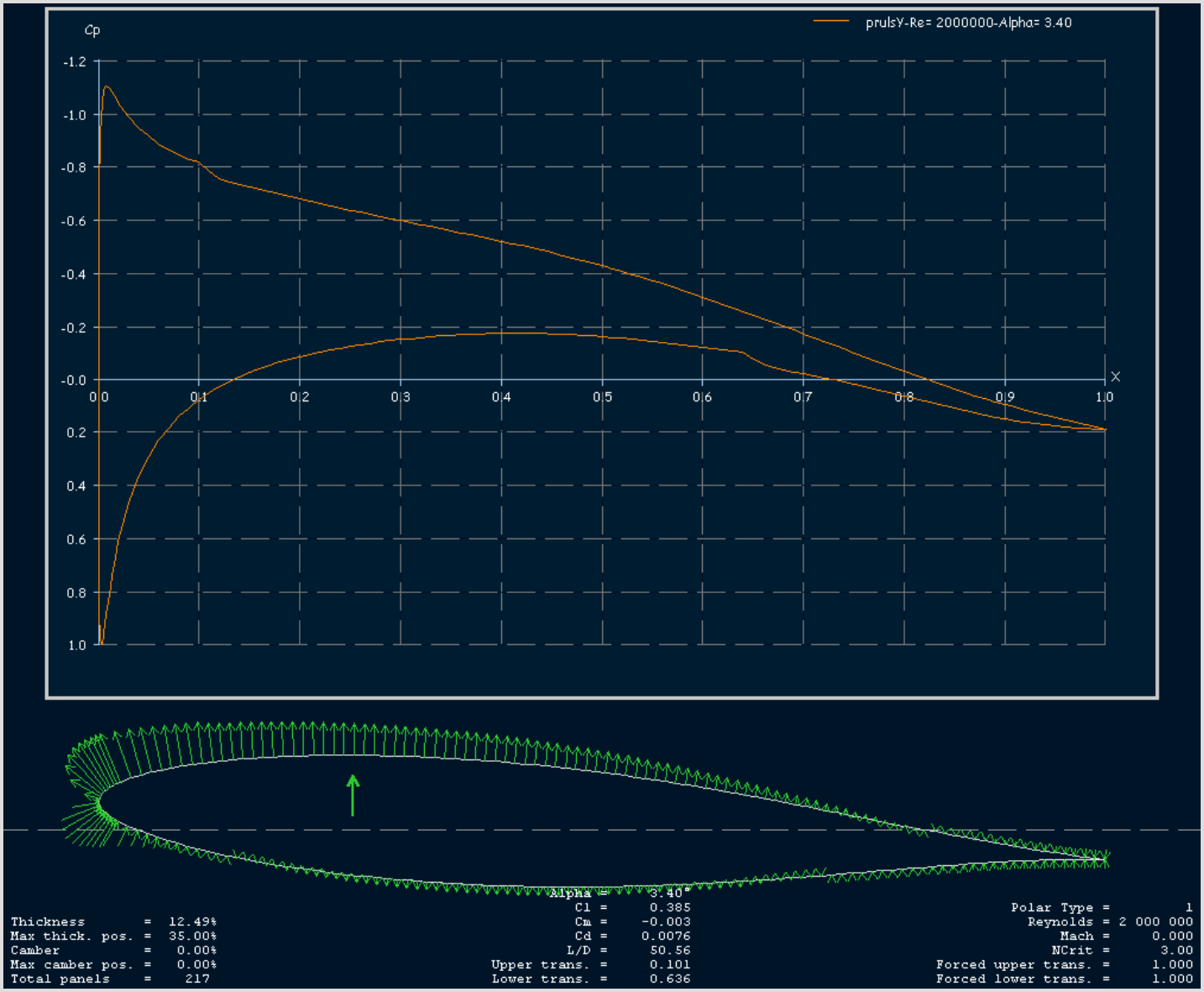
Groove width study

- There is more to this than lift-to-drag ratio and hull leeway though.
- In the following slides I show plots of the foil sections of interest at an angle of attack that results in a lift coefficient between 0.37 and 0.38.
- The important thing is the difference in pressure distribution of the suction side of the foil (top orange curve). The green arrows on the surface of the foils illustrates the same thing in a another way.

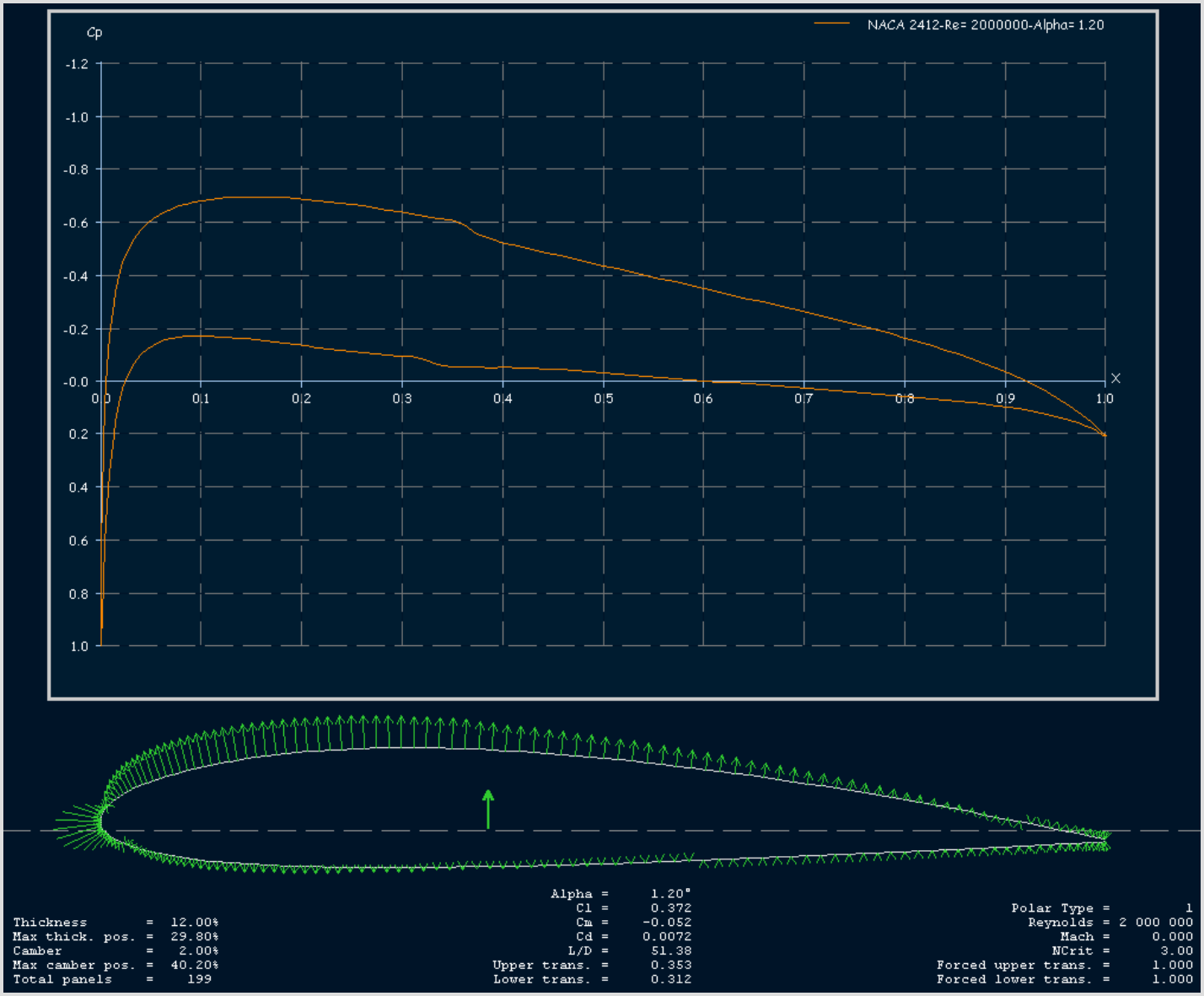
naca 0012


NACA 0012-Re= 2000000-Alpha= 3.40
Cp
-1.2
-1.0
-0.8
-0.6
-0.4
-0.2
-0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
X
Thickness = 12.00%
Max thick. pos. = 29.80%
Camber = 0.00%
Max camber pos. = 0.00%
Total panels = 199
Alpha = 3.40°
Cl = 0.377
Cm = 0.001
Cd = 0.0079
L/D = 47.58
Upper trans. = 0.095
Lower trans. = 0.592
Polar Type = 1
Reynolds = 2 000 000
Mach = 0.000
NCrit = 3.00
Forced upper trans. = 1.000
Forced lower trans. = 1.000

prulsY


Cp
prulsY-Re= 2000000-Alpha= 3.40
-1.2
-1.0
-0.8
-0.6
-0.4
-0.2
-0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
X
Alpha = 3.40°
Cl = 0.385
Cm = -0.003
Cd = 0.0076
L/D = 50.56
Upper trans. = 0.101
Lower trans. = 0.636
Thickness = 12.49%
Max thick. pos. = 35.00%
Camber = 0.00%
Max camber pos. = 0.00%
Total panels = 217
Polar Type = 1
Reynolds = 2 000 000
Mach = 0.000
NCrit = 3.00
Forced upper trans. = 1.000
Forced lower trans. = 1.000

naca 2412


Cp
NACA 2412-Re= 2000000-Alpha= 1.20
-1.2
-1.0
-0.8
-0.6
-0.4
-0.2
-0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
X
Thickness = 12.00%
Max thick. pos. = 29.80%
Camber = 2.00%
Max camber pos. = 40.20%
Total panels = 199
Alpha = 1.20°
Cl = 0.372
Cm = -0.052
Cd = 0.0072
L/D = 51.38
Upper trans. = 0.353
Lower trans. = 0.312
Polar Type = 1
Reynolds = 2 000 000
Mach = 0.000
NCrit = 3.00
Forced upper trans. = 1.000
Forced lower trans. = 1.000

Discussion

- You no doubt noticed the peak in the curves of the two symmetric foils and the more gentle shape of the asymmetric foil. This means the nose of the a symmetric foil is a much more critical area than for the asymmetric foil. Irregularities to the shape will have a greater impact on the performance of the foil.
- There is also a bigger risk of air being sucked down as the local pressure us much lower for the symmetric foils.

Summing up

- A clear cut case in favour of the asymmetric foil?
- Well, asymmetric foils must be lifted/lowered each time you tack and they must be bigger than the symmetric ones as only one carry the load at a time.
- If you do a lot of short-tacking like me the small performance gain of asymmetric foils simply isn't worth it.
- Asymmetric sections may be the way to go if you are looking for the ultimate in performance and if man-power is not a limiting factor.