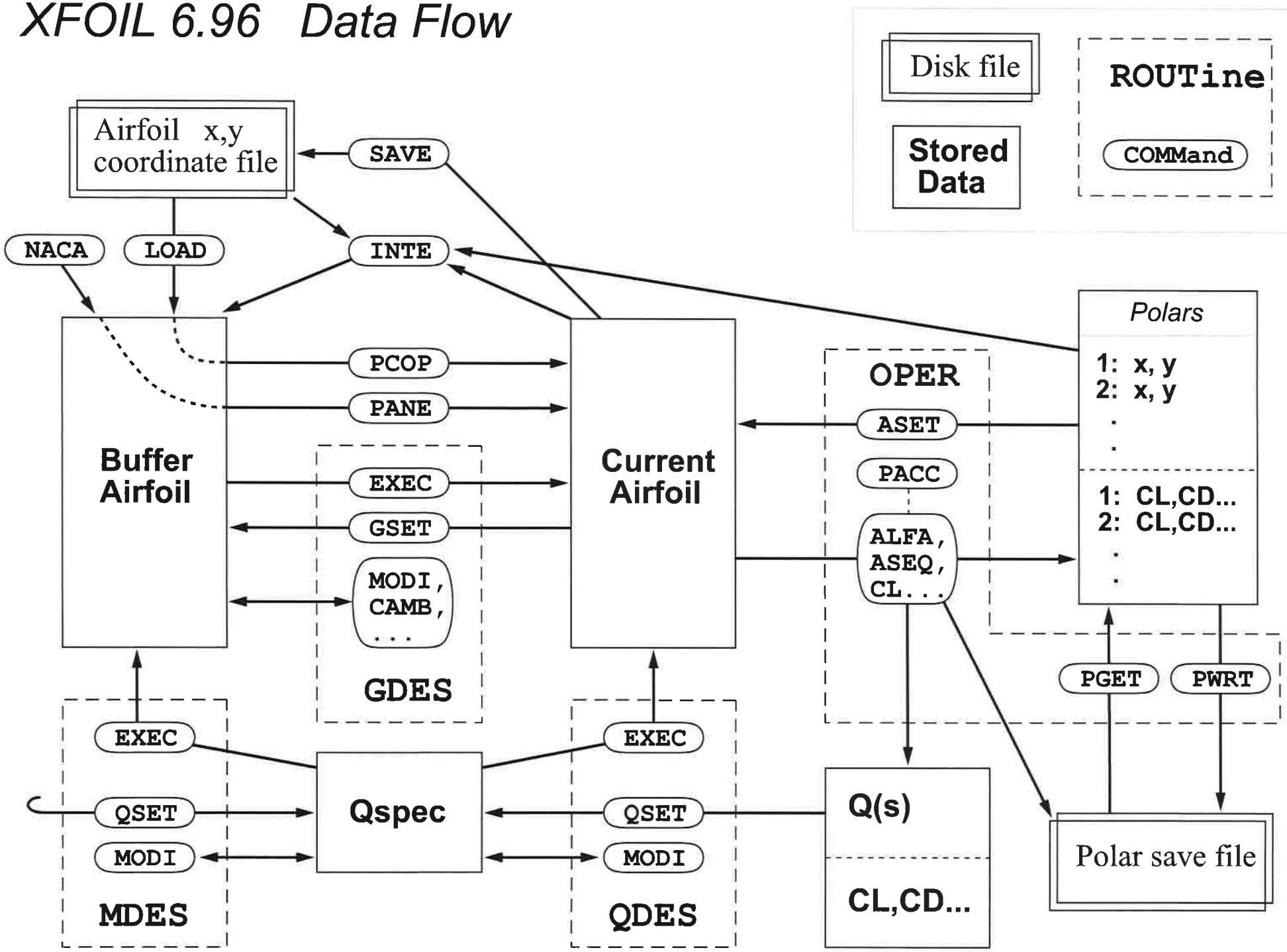
# Lesson 9

# XFOIL

# XFOIL 6.96 Data Flow



xfoilp4.exe

? help from any menu.

load clarcy.dat

ppar (show or change paneling)

N 280 } show ~~#~~ panels
N 50

$C_p = \frac{p - p_\infty}{q}$

<enter> returns to prev menu (up)

oper (direct mode ... given shape, find flow properties)

alfa 0 zero AOA

displays airfoil and pressure plot
Notice low resolution LE/TE (Need to fix)

<enter>

ppar

N 280

experiment with spacing values

<enter>

oper

alfa 0 ⇒ $C_L = .4163$ $C_m = -0.0879$ $C_{Dp} = -0.00053$

5 counts neg drag

alfa 5

alfa 10

Cpv (pressure vector)

Notice the variation in $C_p$ near LE. If for aircraft design, I would investigate this further.

Being inviscid (so far), the flow never separates.

alfa 20 , alfa 50 , alfa 90

$C_L = 6.9134$

Missing a fundamental part of aerodynamics, and the destroyer of performance.

Viscousity

visc , 500000

alfa 0 (needs extra iteration) "!"

dashed lines inviscid
solid visc solution

plateau + dip (bane of low Re flows)

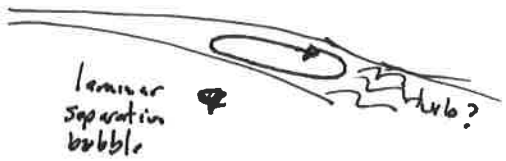
Airfoil properties

$\alpha = 0$

$C_L = 0.3760$ (vs 0.4163 invis)

$C_M = -0.0794$ (vs $-0.0879$)

$C_D = 0.00652$ (65 counts)
vs
$-5$ counts)




alfa 5 (notice needed more iterations)

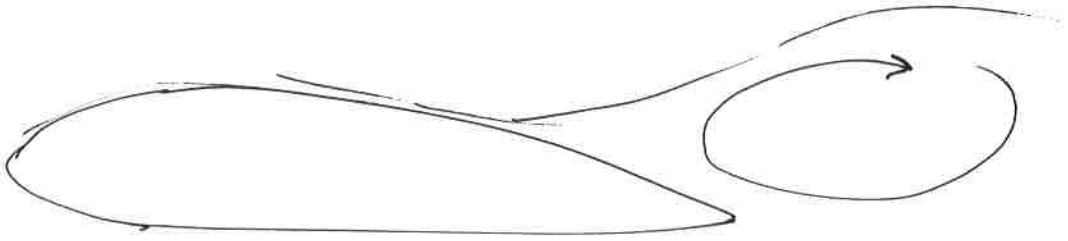
iter current is 10

500

alfa 5 look at command window (shows iteration)

transition at $x/c = 0.3739$ (exactly when LSB appears!)

alfa 10 → alfa 15 see TE separation



What about neg angles?

Sequence. (so you don't need to manually run sweep)

aseq
- 0 start AOA
- 16 stop AOA
- 1 increment

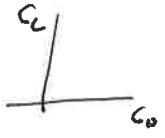
$\Rightarrow$ $C_{L_{max}} \approx 1.42 \Rightarrow \alpha \approx 14^\circ$

Store polar + visualize

pacc turns on the accumulator (starts storing data)
Send to file n not
CYpolar.txt CYpolar.dat

aseq
- 0
- 17
- 0.5

$\Rightarrow$ plot in excel.




or

pplo $\Rightarrow$ polar, $C_L, C_M$ vs $\alpha$, transition pt.

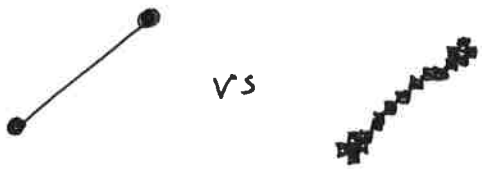
options to store, delete, etc.

Output to vector based Postscript file .eps or .ps

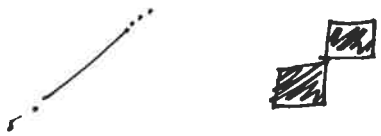
hard

open plot.ps in ghostscript or vector image program.

Aside: Why use vector graphics rather than raster graphics?




Zoom into each



What about negative angles of attack?

alfa -15 fails to converge.

alfa 0 fails to converge (but wait, it worked before!)
Updates/iteration, so can get stuck in terrible space.

fix this with initialization of BL

init

alfa 0 converges.

Let's find when XFOIL fails.

aseq 0 -10 -0.5 ⇒ fails around -9°

alfa -8

alfa -8.5 watch BL on lower surface.

alfa -9.0 " $C_{D_a}$ as a decreases.

At Re = 500$^K$, the Clark Y is effective (not stalled) between -9 and 15deg

NACA 4 digit and 5 digit airfoils are built in.

naca 4415

oper

alfa 0

re 200000

alfa 0

re 100000

alfa 0

Show Boundry layers

bl

z click on corners

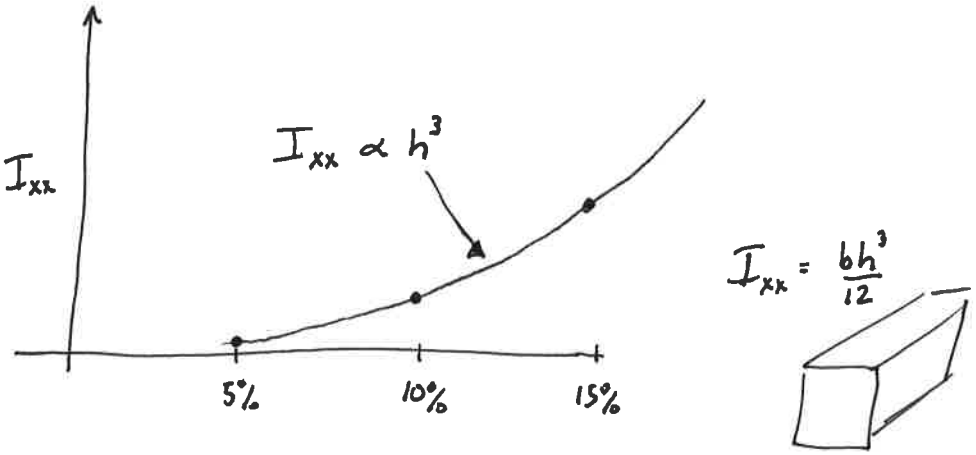
u unzoom

Step through alfa 12° rev flow

Material Properties

naca 0012

bend ⇒ centroid, moments of inertia / thickness, skin, polar moment of inertia



Remember the NACA 0070 ? $C_{L_\alpha}$ was/is negative (cf. lesson 7A)

Start from scratch

naca 0070

ppar , N 280

oper

visc 600000 (to match exp data)

alfa 0 , ! $C_L \approx 0$ $C_D$ 708 counts ✓ $C_{D_{\text{wind tunnel}}} \approx 700$ counts

alfa 5 , ! $C_L = -0.17$ $C_D = 731$ counts

alfa 10 , ! ! ! $C_L = -0.36$ $C_D = 804$ counts

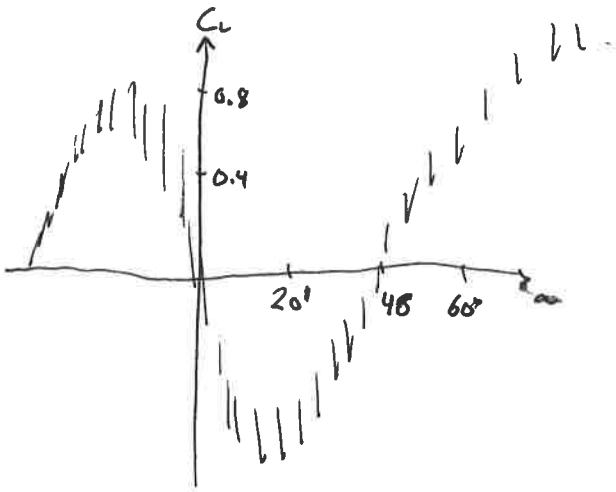
iter 1000

alfa 15 $C_L = -1.1$ $C_D = 1403$ counts ✗ $C_{L_{WT}} \approx -0.7$ $C_{D_{WT}} \approx 3200$ counts

For fully separated flows, XFOIL is not so good (model breaks down)

Yet, the trend is correct and clear

$\text{sign}(C_{L_\alpha}) = -$

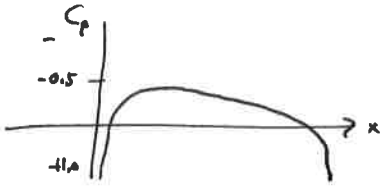


# Inverse problems

Given a velocity, calculate a shape. (ndes, qdes)

naca 0012 , oper , alfa 0

qdes shows $q/V_\infty$




Say we want to reduce the velocity on the underside. (between 20% and 80%)

mark click 20% , 80%

modi form line at -0.5 from points

d done

X , 100 execute

oper

alfa 0

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naca 0012

ndes

Similar

mark

modi

Geometry design

naca 0012

gdes

flap 0.7 999 1.0 30

x

oper, alfa 0

Move max thickness, camber

high 0.6 0.4

x

oper, alfa 0

Leading edge radius