What is XFOIL?

- XFOIL is an interactive program for the design and analysis of subsonic isolated airfoils.

- It can be used for viscous/inviscid analysis, airfoil design, and inverse design of airfoils.

- The inviscid formulation is based on an inviscid linear-vorticity panel method with Karman-Tsien compressibility correction.

- Source distributions superimposed on the airfoil and wake permit modeling of viscous layer on the potential flow.

- A two-equation lagged dissipation integral method is used to represent the viscous layer.

- Laminar and turbulent flows are treated with the e^n - type amplification formulation to determine the transition point.

- The boundary layer and transition equations are solved simultaneously with the inviscid flow field by a global Newton method.

- It can be used from low to high Reynolds number.

- It is opensource and distributed under the GNU General Public License.

- More information at the following link:

 - http://web.mit.edu/drela/Public/web/xfoil/

What is XFOIL?

- The viscous/inviscid formulation implemented in XFOIL, allows you to conduct the following analysis,

  - Forced or free transition.

  - Laminar separation bubbles.

  - Limited trailing edge separation.

  - Lift and drag predictions just beyond maximum lift coefficient.

  - Karman-Tsien compressibility correction.

  - Fixed or varying Reynolds and/or Mach numbers.

- Airfoil design and redesign by interactive modification of surface speed distributions, in two methods:

  - Full-Inverse method, based on a complex-mapping formulation.

  - Mixed-Inverse method, an extension of XFOIL's basic panel method.

What is XFOIL?

- Airfoil redesign by interactive modification of geometric parameters such as,

    - Maximum thickness and camber, highpoint position.

    - Leading edge radius, trailing edge thickness.

    - Camber line via geometry specification.

    - camber line via loading change specification.

    - Flap/slat deflection.

    - Explicit contour geometry (via screen cursor).

- Blending of airfoils.

- Drag polar calculation with fixed or varying Reynolds and/or Mach numbers.

- Writing and reading of airfoil coordinates and polar save files.

- Plotting of geometry, pressure distributions, and multiple polars.

What is XFOIL?
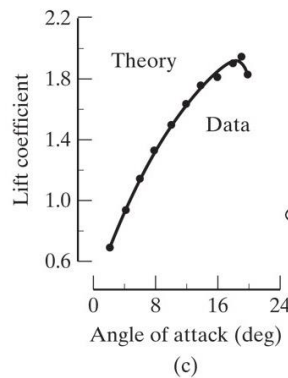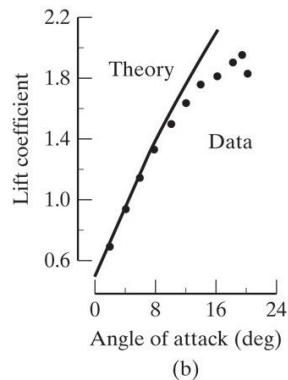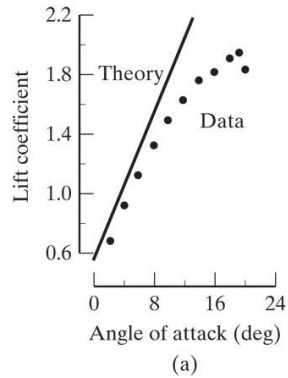
- The most important features of XFOIL compared to traditional panel methods, is that it can predict transition to turbulence, laminar separation bubbles, and lift and drag just beyond maximum lift coefficient.

- In the figure, you can see the relative importance of predicting viscous and separation effects:

  - (a) Neither viscous nor separation effects modeled.

  - (b) Analysis with boundary layer modeled but no separation effects.

  - (c) Analysis with boundary layer and separated wake modeled.

What is XFOIL?

- XFOIL is not the only alternative, but in our opinion, it is the most robust option, and is widely used in academia and industry.

- A few free or open-source alternatives:

  - XFLR5 – http://www.xflr5.com/xflr5.htm

  - Javafoil – https://www.mh-aerotools.de/airfoils/javafoil.htm

  - Eppler code – http://www.airfoils.com/

  - Aerofoil – http://aerofoilengineering.com/

  - PABLO- http://www.pdas.com/pablo.html

Additional comments about XFOIL

- XFOIL uses the e^n transition criterion where n is the critical amplification factor.

Less turbulence intensity

More turbulence intensity

| Situation	Ncrit (n)
Sailplane	12 – 14
Motorglider	11 – 13
Clean wind tunnel	10 – 12
Average wind tunnel	9 → standard method (default/recommended value)
Dirty wind tunnel	4 – 8

- The values of the variable n are always positive and can range from 0 to infinity.
- However, suggested values are within 1 and 15.

Additional comments about XFOIL

- In XFOIL, you can also change the transition point. This is equivalent to adding a boundary layer trip strip.

- To change the transition point you will need to modify the XTR parameter (0 < XTR < 1 or min and max values of airfoil chord).

- A value of 1 means natural transition (default value).

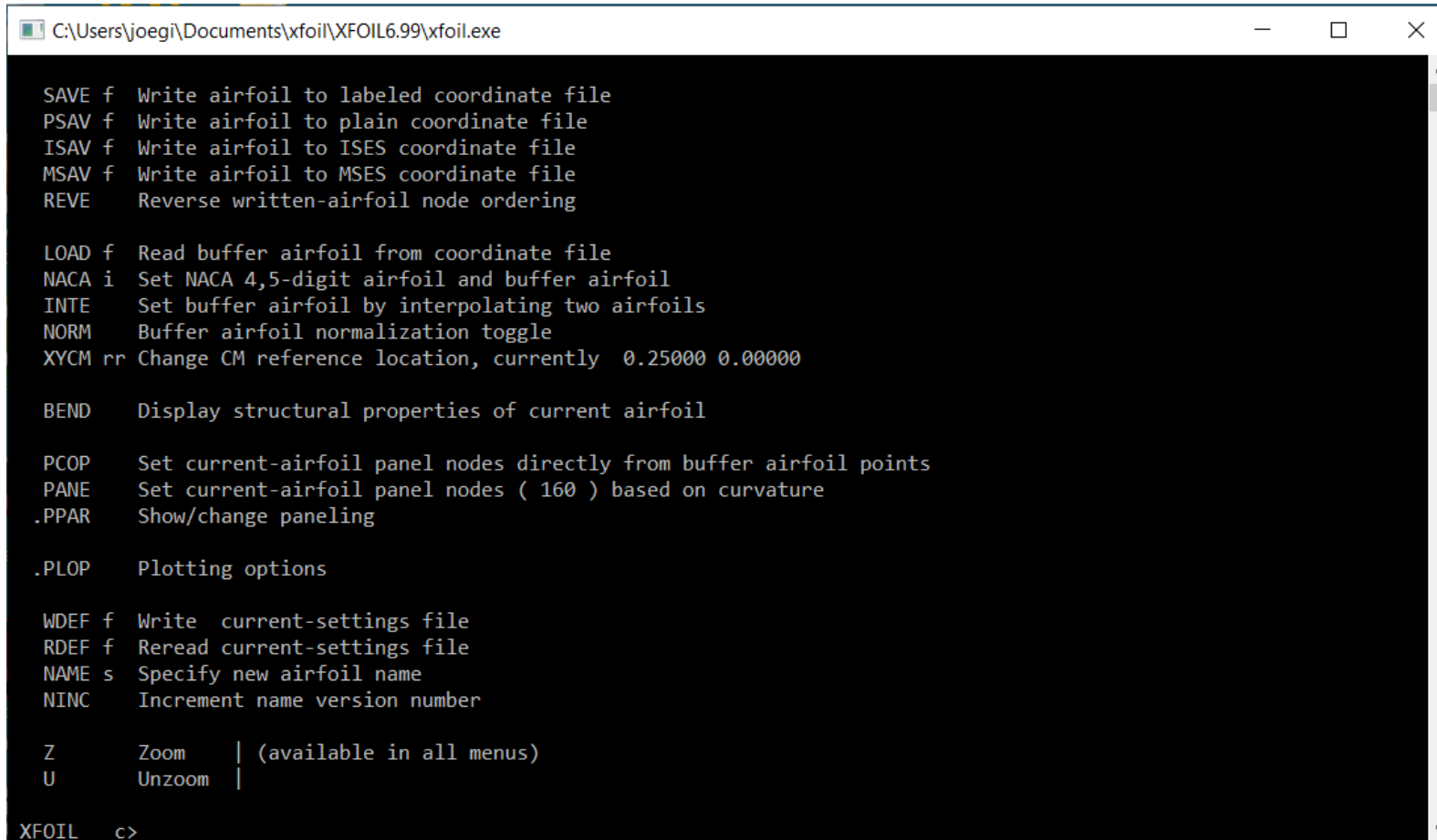- A value of 0.25 means transition will be forced at 25% of the airfoil's chord.
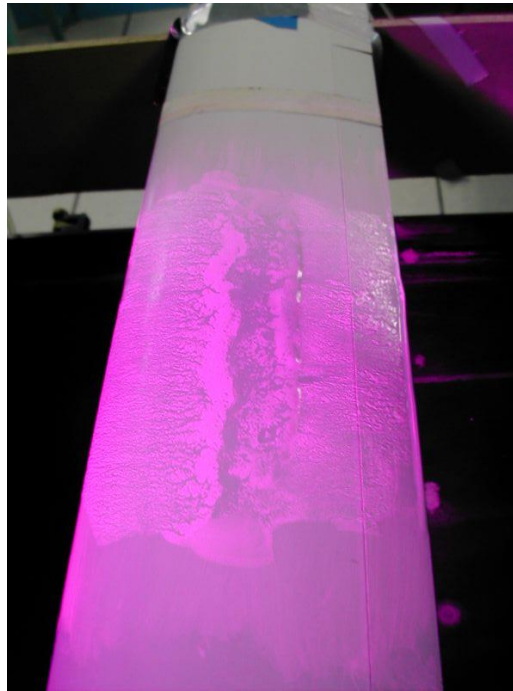
No trip strip
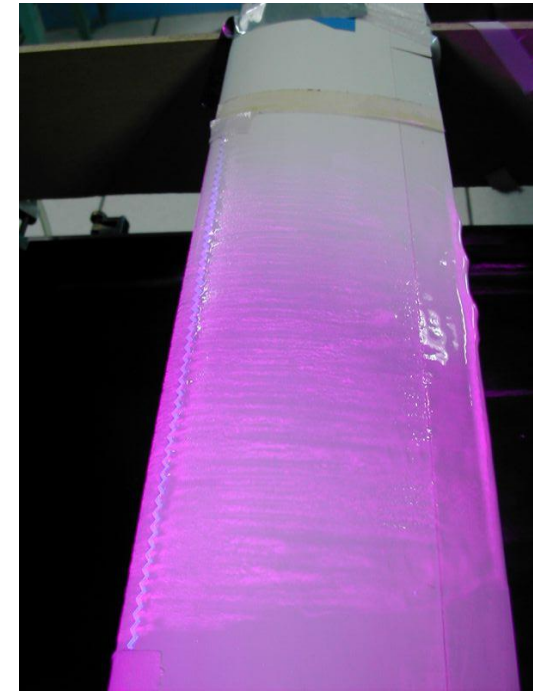
Zigzag trip strip

XFOIL terminal window – Command line interface (CLI)

- After launching XFOIL, you will see the following terminal window (with an 80ish style).

- XFOIL is waiting for your input, do not worry, we are going to address how to move in this terminal window.

- We will interact with XFOIL via a command line interface or CLI.

XFOIL terminal window – Command line interface (CLI)

- In XFOIL, you can conduct computations for a single operation point (a given angle of attack or a target lift coefficient value).

- All the data can be saved in ascii files and plotted using external applications.

XFOIL terminal window – Command line interface (CLI)

- You can also run a sequence of operating points and plot/save the data.

- Workflows can also be parametrized for design space exploration or optimization studies
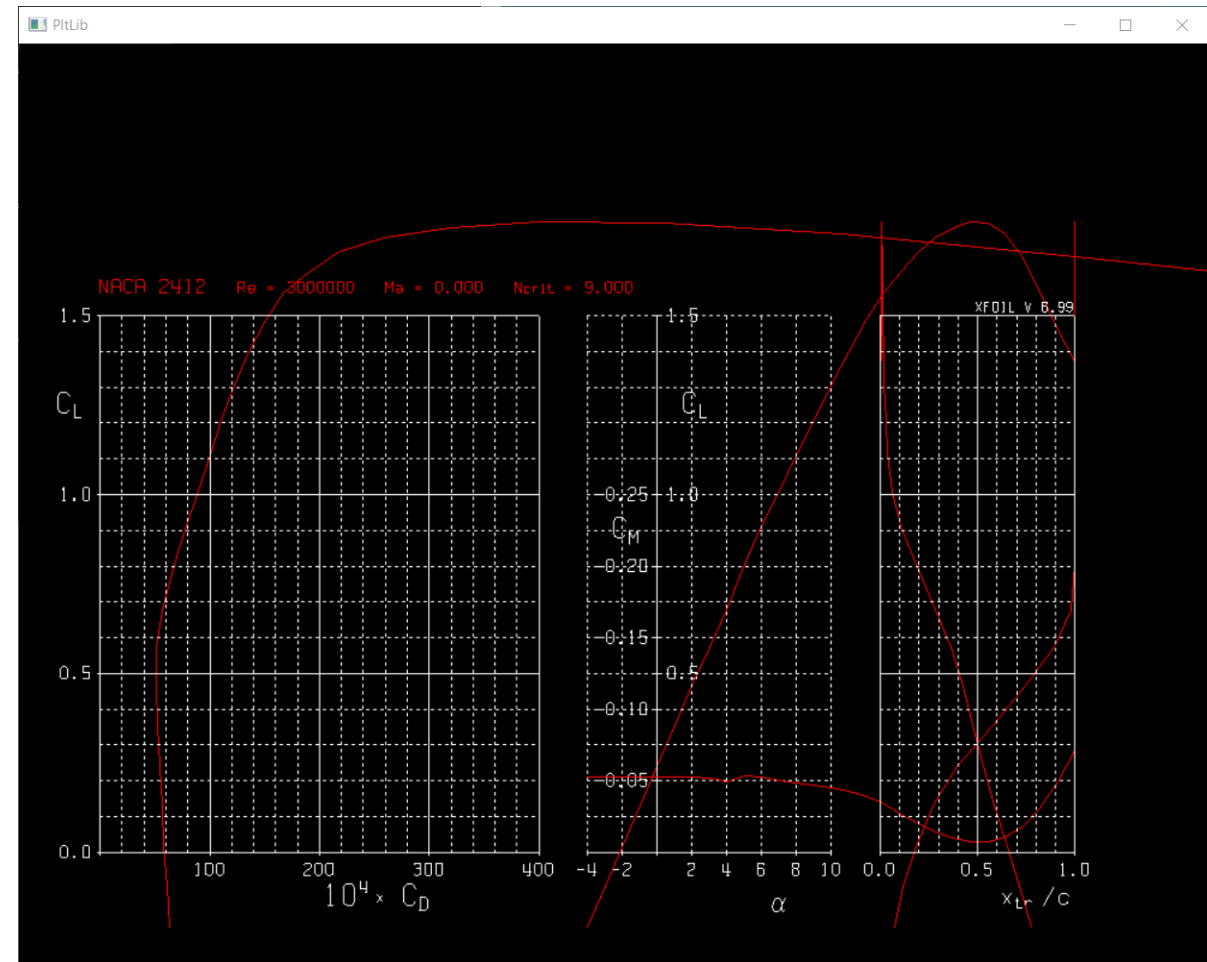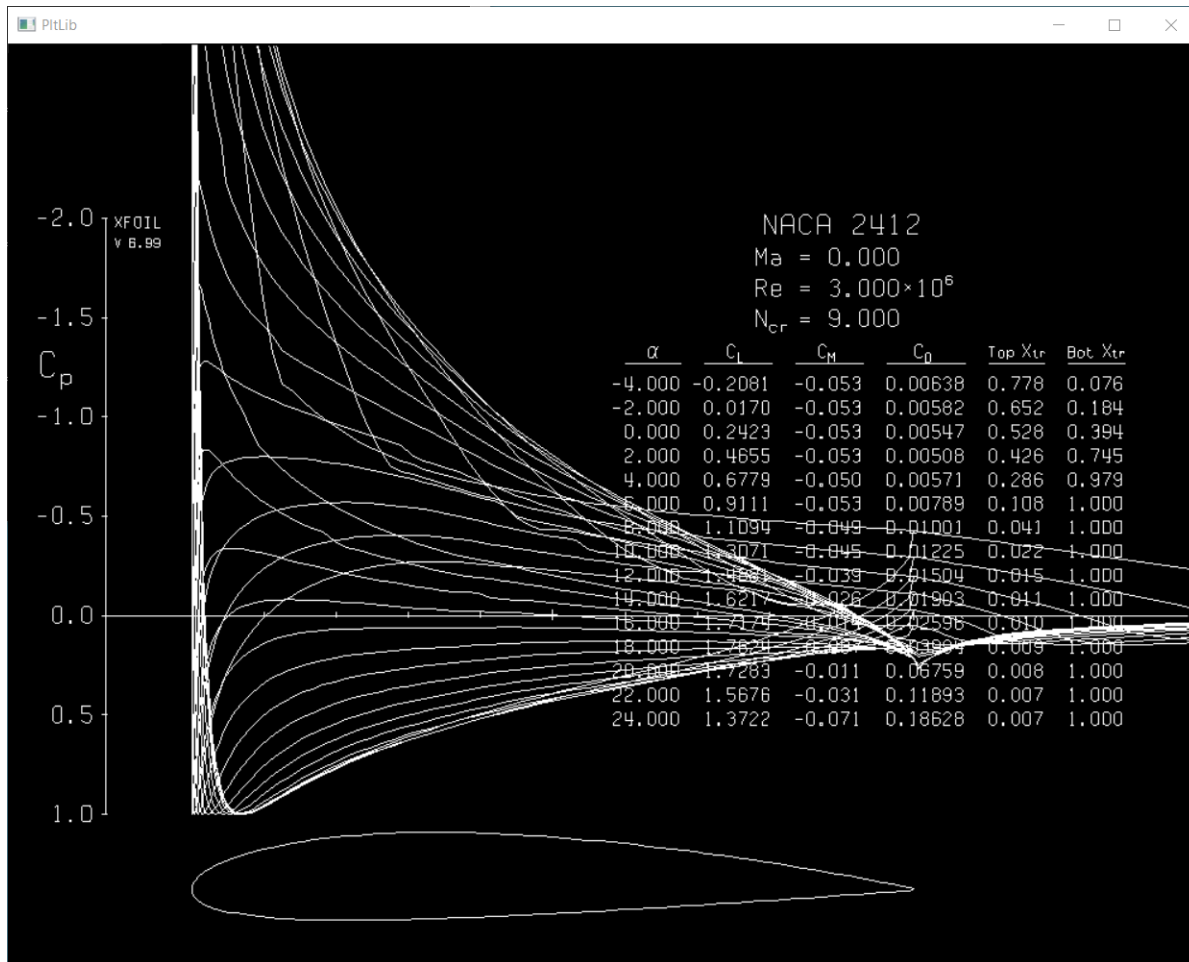
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