

MSES



EU
Research
Program



VZLU
Aeronautical Research and Test Institute
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MSES

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MSES

MSES is a coupled viscous/inviscid Euler method for airfoil design and analysis featuring:

Subsonic, Transonic and Supersonic Single- and Multi-Element Airfoil Analysis

- Forced or free boundary layer transition
- Transitional separation bubble modeling
- Lift and drag predictions to just beyond $C_{L \max}$
- Blunt trailing-edge treatment

Polar and Mach Number Sweeps Mode

- Program steps through angles of attack
- Program steps through Mach numbers while holding lift or angle of attack constant



Input files

blade.xxx – airfoil geometry and grid domain

- Created by user
- Used in MSET and AIRSET programs
- „xxx“ – variable extension
- XINL – x-location of the left grid inlet plane
- XOUT – x-location of the right grid outlet plane
- YBOT – y-location of the lowest grid streamline
- YTOP – y-location of the topmost grid streamline

```
NAME
XINL XOUT YBOT YTOP
X(1,1) Y(1,1)
X(2,1) Y(2,1)
X(3,1) Y(3,1)
. .
. .
X(i,1) Y(i,1)
999.0 999.0
X(1,2) Y(1,2)
X(2,2) Y(2,2)
X(3,2) Y(3,2)
. .
. .
X(i,2) Y(i,2)
999.0 999.0
X(1,2) Y(1,2)
. .
. .
```



Input files

mSES.xxx – runtime parameters

- Used in solver programs MSES, MSIS, MPOLAR and MPOLIS
- GVAR(1) ... GVAR(N) – list of integers specifying the global variables to be used
- GCON(1) ... GCON(N) – list of integers specifying the global constraints to be used
- MACHIN – free stream Mach number
- CLIFIN – specified C_L (if C_L option invoked in GCON)
- ALFAIN – free stream angle of attack
- ISMOM – momentum/entropy conservation
- IFFBC – farfield boundary conditions
- XTRS_n, XTRP_n – top and bottom surface transition strip x/chord location on element n
- MCRIT – critical Mach number above which artificial dissipation is added
- MUCON – artificial dissipation coefficient

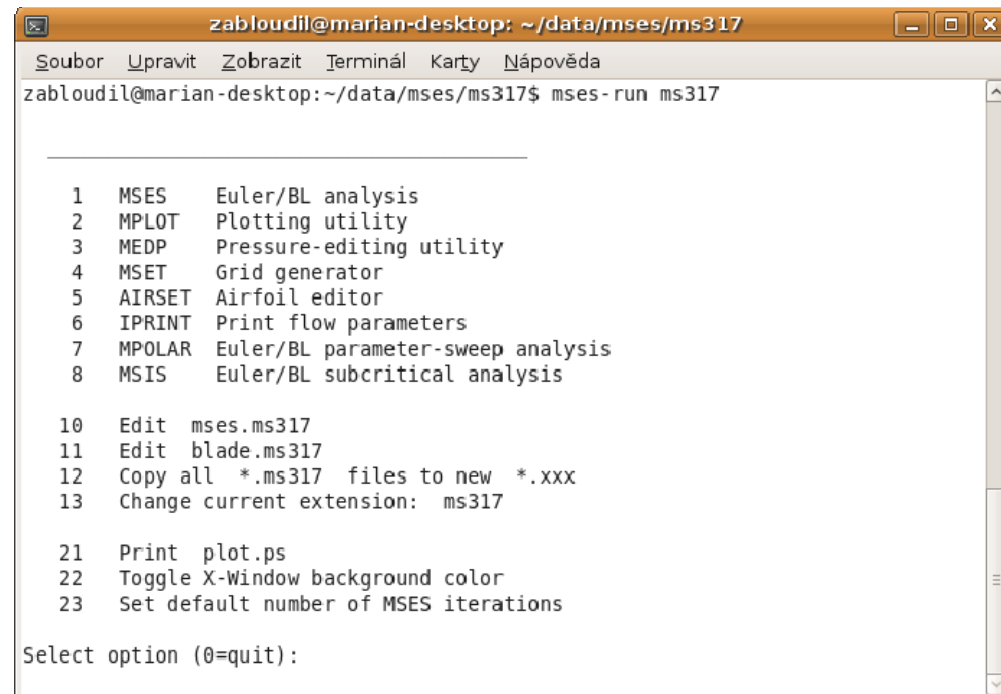
```
GVAR(1) GVAR(2) ... GVAR(N)
GCON(1) GCON(2) ... GCON(N)
MACHIN CLIFIN ALFAIN
ISMOM IFFBC
REYNIN ACRIT
XTRS1 XTRP1 XTRS2 XTRP2 ...
MCRIT MUCON
```



Executing MSES

mr_un xxx

- With “xxx” extension to distinguish case being run
- For repetitive program execution
- Menu for executing all programs



```
zabloudil@marian-desktop: ~/data/mSES/ms317
Soubor  Upravit  Zobrazit  Terminál  Karty  Nápověda
zabloudil@marian-desktop:~/data/mSES/ms317$ mSES-run ms317

-----
1  MSES   Euler/BL analysis
2  MPLOT  Plotting utility
3  MEDP   Pressure-editing utility
4  MSET   Grid generator
5  AIRSET Airfoil editor
6  IPRINT Print flow parameters
7  MPOLAR Euler/BL parameter-sweep analysis
8  MSIS   Euler/BL subcritical analysis

10 Edit  mSES.ms317
11 Edit  blade.ms317
12 Copy all *.ms317 files to new *.xxx
13 Change current extension:  ms317

21 Print plot.ps
22 Toggle X-Window background color
23 Set default number of MSES iterations

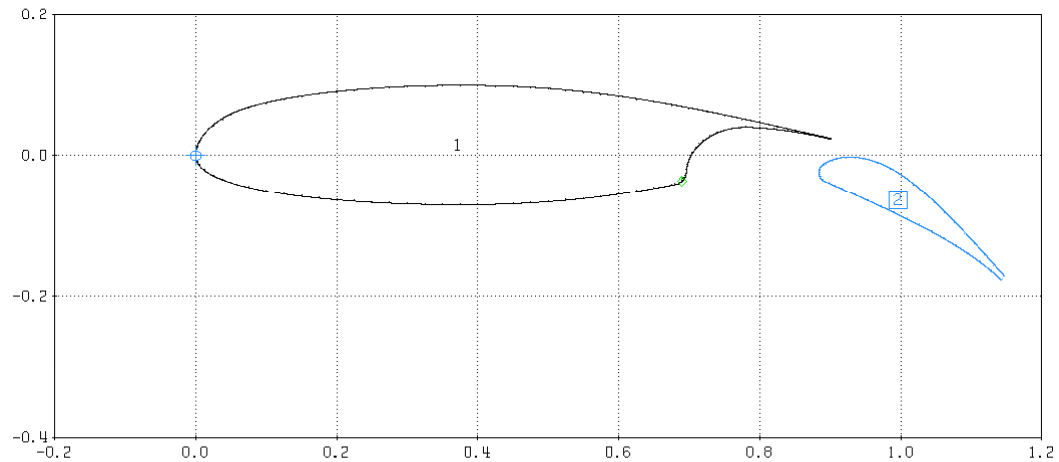
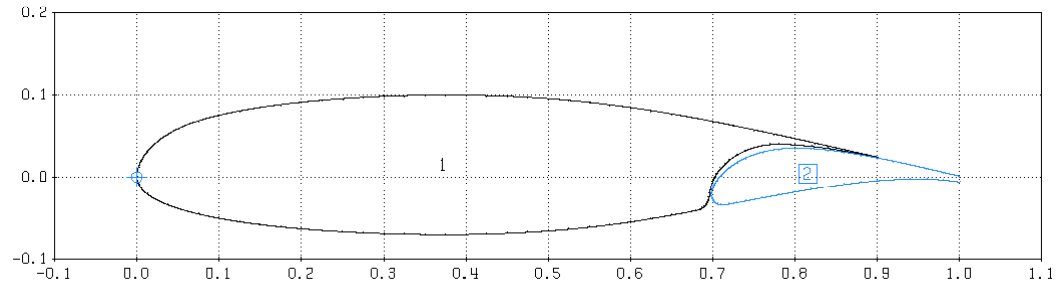
Select option (0=quit):
```



AIRSET

Airfoil geometry manipulator

- Translate elements
- Rotate elements
- Scale elements
- Split off flap
- Modify contour
- Add/delete corner points

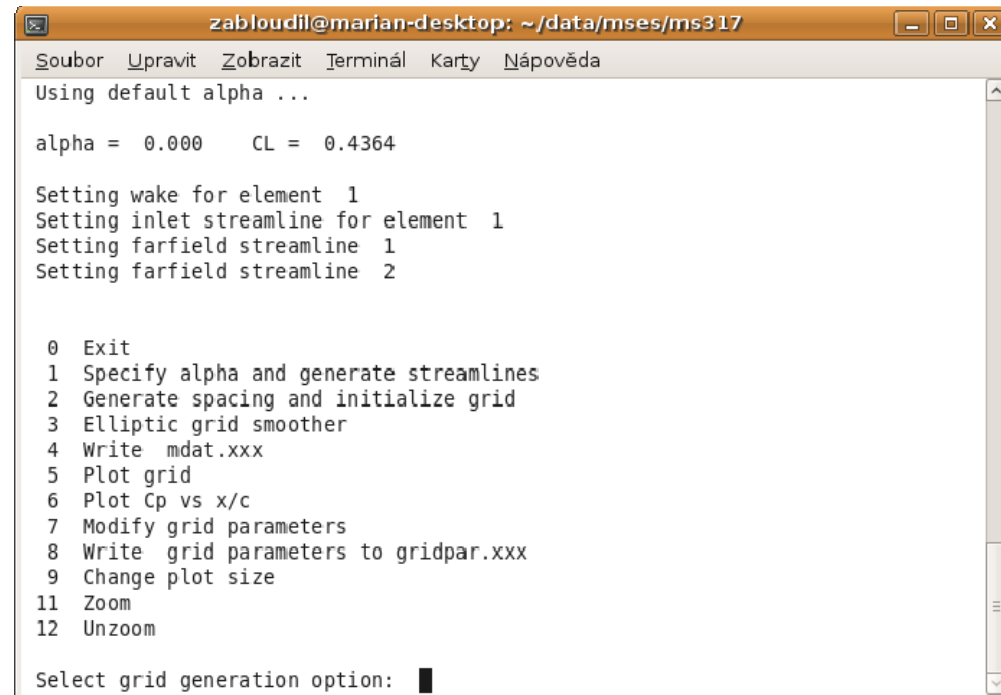


MSET

Grid and flow initializer

- Options 1, 2, 3, 4 must be issued as a minimum.
- 1 – specifies angle of attack to generate a panel solution to trace stagnation lines and the upper and lower farfield streamlines.
- 2 – initial surface gridding. Distributes grid nodes along the streamlines on the element surfaces. Intermediate streamline nodes are generated in the flowfield interior.

The resulting grid is not yet suitable for MSES calculation!



```
zabloudil@marian-desktop: ~/data/msex/ms317
Soubor  Upravit  Zobrazit  Terminál  Karty  Nápověda
Using default alpha ...
alpha = 0.000    CL = 0.4364
Setting wake for element 1
Setting inlet streamline for element 1
Setting farfield streamline 1
Setting farfield streamline 2

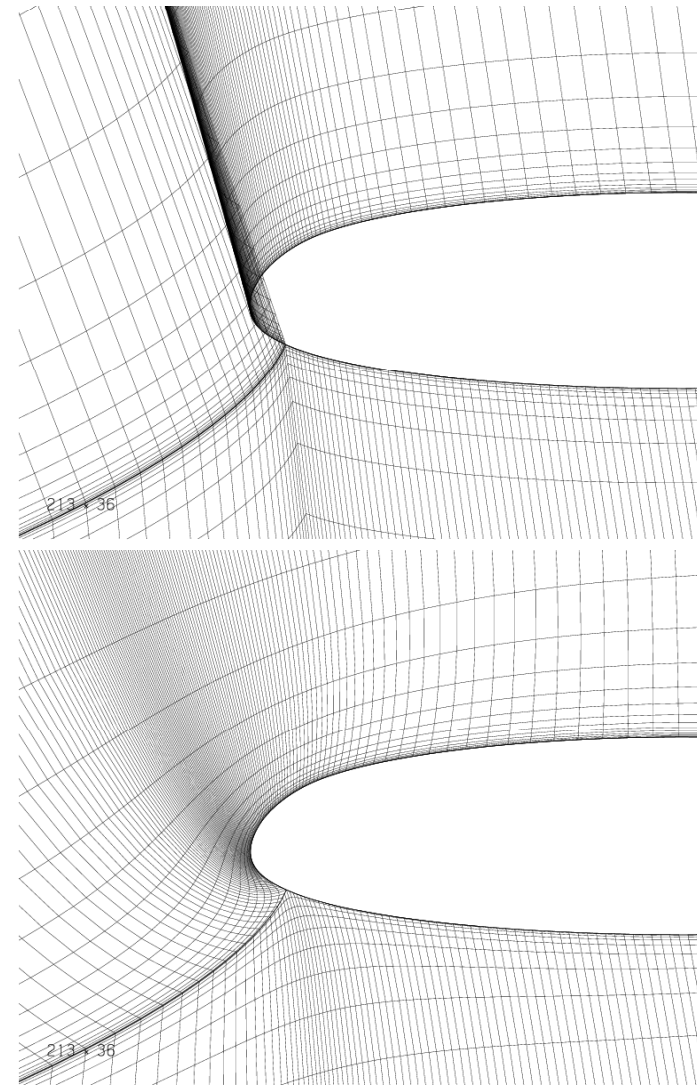
0 Exit
1 Specify alpha and generate streamlines
2 Generate spacing and initialize grid
3 Elliptic grid smoother
4 Write mdat.xxx
5 Plot grid
6 Plot Cp vs x/c
7 Modify grid parameters
8 Write grid parameters to gridpar.xxx
9 Change plot size
11 Zoom
12 Unzoom

Select grid generation option: █
```



Grid smoothing

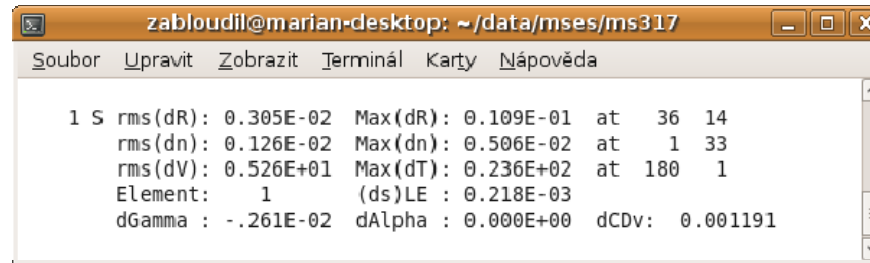
- 3 – elliptic grid smoothing of linearly interpolated grid. Eliminates all kinks, overlaps and makes all grid streamlines correspond to streamlines of inviscid incompressible flow.
- 4 – writes out the initial solution to file mdat.xxx, which is then ready for the MSES solver.
- The grid can be viewed with option 5. Options 2,3 or 1,2,3 can be repeated to obtain acceptable grid.



MSES

Flow solver

- Solves the Euler equations.
- Has two input files: mdat.xxx and mses.xxx.
- User specifies “n” – maximum number of iterations to be executed.
- Possibility to coarse/refine the grid to speed up the convergence by typing “-” or “+” at the iteration number prompt.
- After each iteration, MSES prints out a table of flow parameters change (r.m.s. and max)



```
zabloudil@marian-desktop: ~/data/mses/ms317
Soubor Upravit Zobrazit Terminál Karty Nápověda
1 S rms(dR): 0.305E-02 Max(dR): 0.109E-01 at 36 14
rms(dn): 0.126E-02 Max(dn): 0.506E-02 at 1 33
rms(dV): 0.526E+01 Max(dT): 0.236E+02 at 180 1
Element: 1 (ds)LE : 0.218E-03
dGamma : -.261E-02 dAlpha : 0.000E+00 dCDv: 0.001191
```

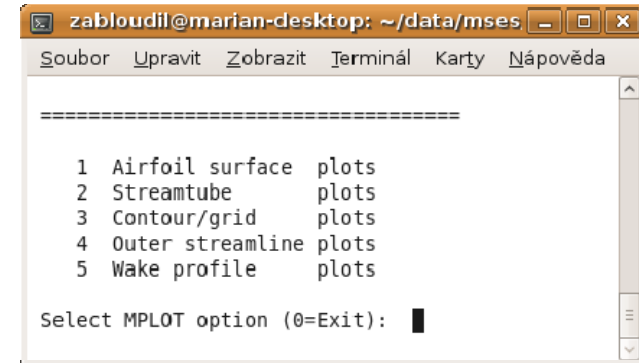
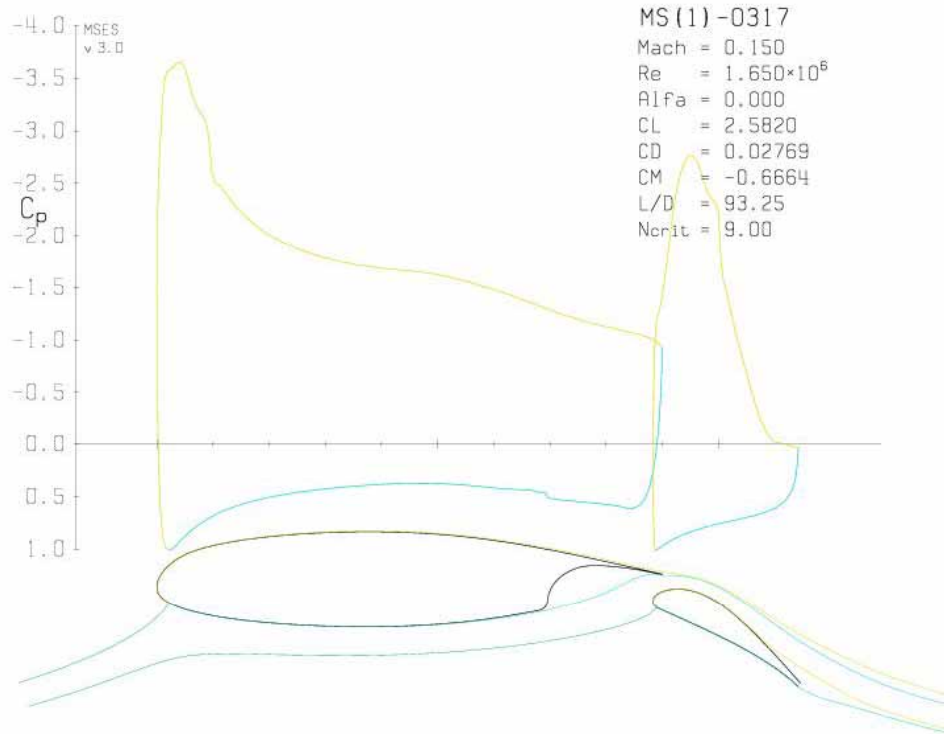
- The number of iterations specified before is only a limit.
- MSES will terminate early if the r.m.s. drop below the convergence tolerance limits and the maximum changes drop 10x these limits.
- Writes the solution back to mdat.xxx



M PLOT

Solution plotter

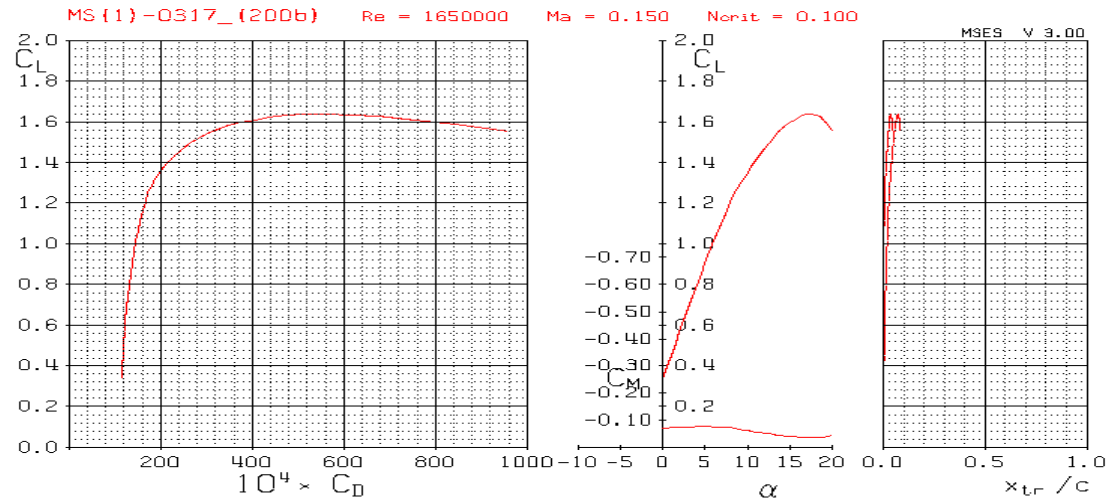
- Displays solution in mdat.xxx whether it is converged or not.



MPOLAR

α -sweep calculation driver

- Conveniently sweeps through a range of specified angles of attack.
- Takes advantage of the quadratic convergence of the Newton method.
- Much more efficient than running a sequence of independent cases with MSES.
- Requires an alfas.xxx file, which contains the sequence of angles of attack.
- Writes out the integrated parameters to polar.xxx and the surface pressure distribution and boundary layer variables to polarx.xxx
- Results from polar.xxx can be plotted using program PPLOTT.



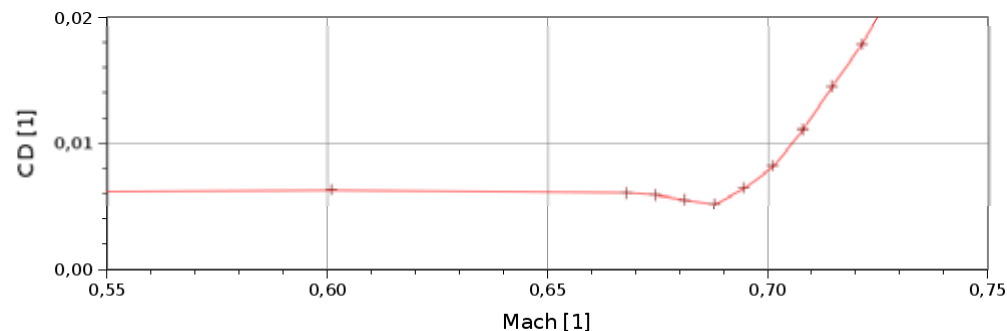
MPOLARC, MPOLARM

C_L -sweep calculation driver

- Essentially the same as MPOLAR.
- Converges on specified lift coefficients.
- Requires a cls.xxx file, which contains the sequence of lift coefficients.
- Output files polar.xxx and polarx.xxx have same format as for MPOLAR.

Mach-sweep calculation driver

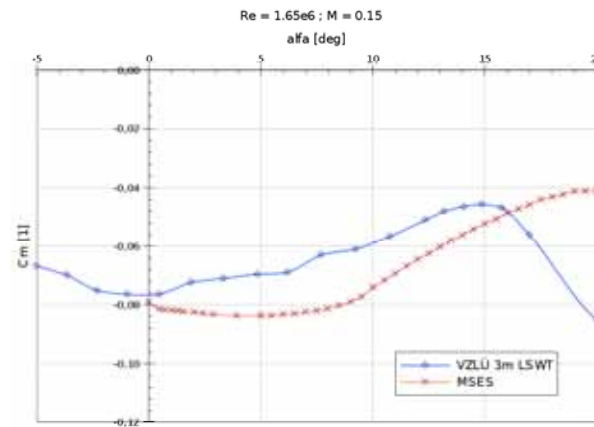
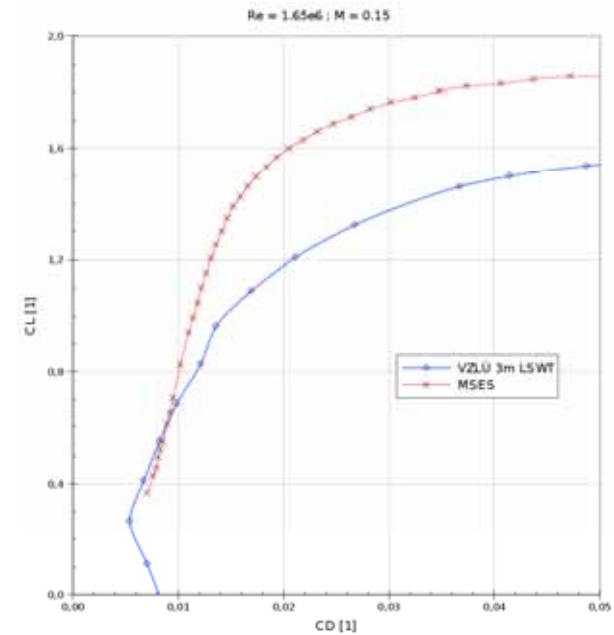
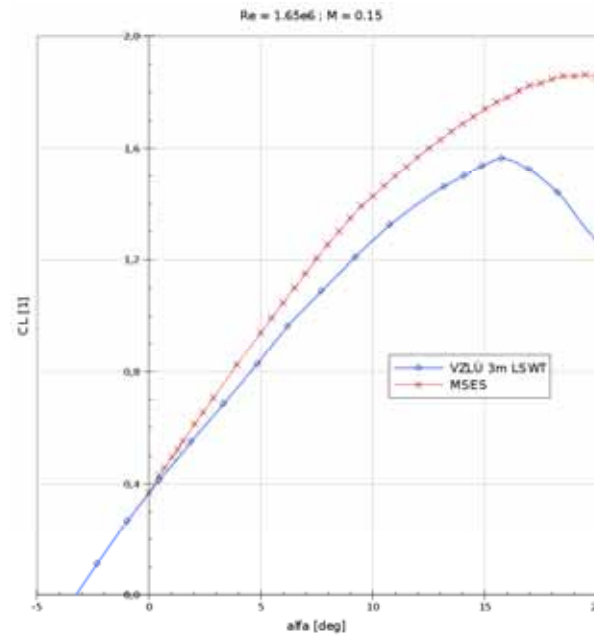
- Generates a Mach sweep in a manner similar to a polar.
- Requires a file machs.xxx containing the Mach numbers to be executed.
- Results are written to files msweep.xxx and msweepx.xxx



Results Comparison

Comparison with VZLÚ wind tunnel results:

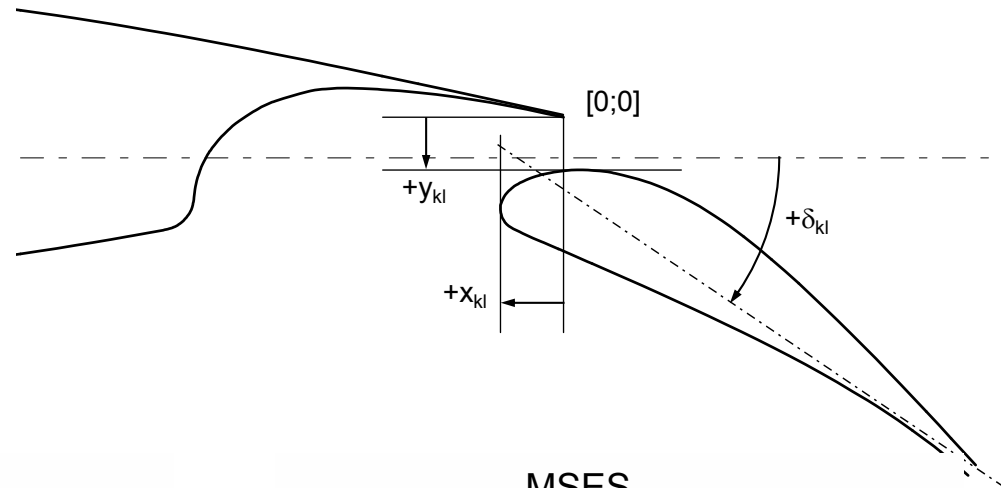
- Cruise configuration
- MSES overpredicts $C_{L\max}$ and α_{crit}
- Overpredicts $dC_L/d\alpha$
- Good drag agreement



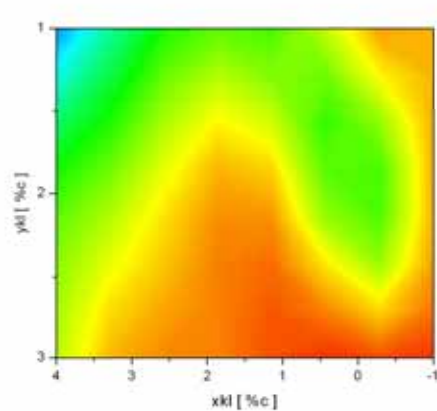
Results Comparison

Comparison with VZLÚ wind tunnel results:

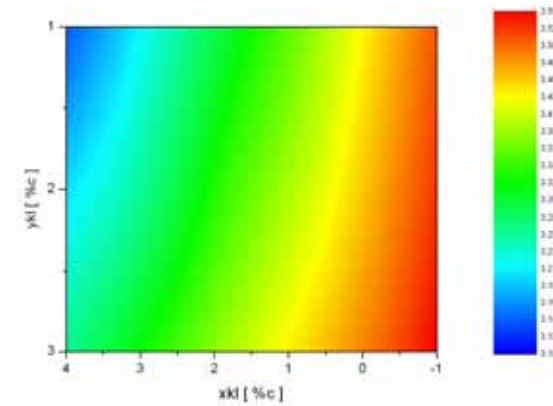
- Take-off configuration
- Flap deflection 20°
- $C_{L\max}$ comparison
- Disagreement caused by wrong α_{crit} prediction



Wind Tunnel



MSES



Other Features

Computational Design of Multi-Element Airfoil Systems

- Mixed inverse design mode
- Modal inverse design capability
- Modal geometry perturbations

Multi-Point Optimization of Single- and Multi-Element Airfoils With Geometric Thickness and Area Constraints



THANK YOU FOR YOUR ATTENTION!

