# Problem Workshop I: $SU^2$ as a High-fidelity Analysis Tool

***$SU^2$ Release Version 2.0 Workshop***

*Stanford University*

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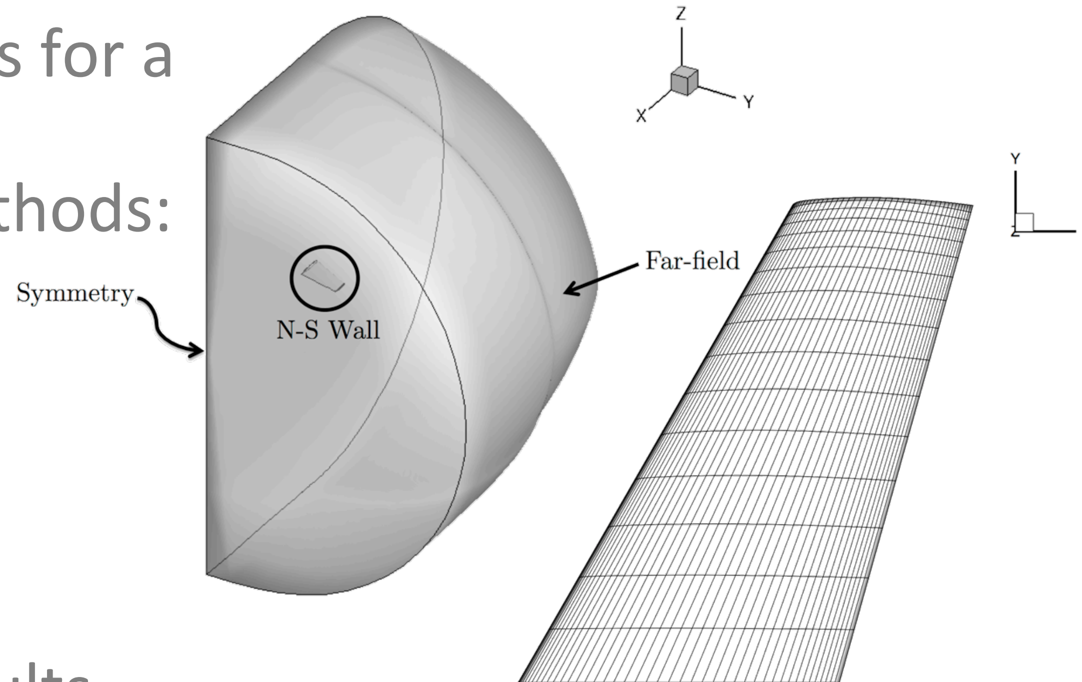
# ONERA M6 RANS Analysis

1. Prepare geometry & mesh beforehand.
2. Choose appropriate physics.
3. Set proper conditions for a viscous simulation.
4. Select numerical methods:
   - A. Convective terms
   - B. Viscous terms
   - C. Time Integration
   - D. Multi-grid
5. Run the analysis.
6. Post-process the results.

```
% Mesh input file
MESH_FILENAME= mesh_ONERAM6_turb_hexa.su2
```

```
---------------------- Read grid file information ----------------------
Three dimensional problem.
43008 interior elements. 46417 points, and 0 ghost points.
3 surface markers.
2560 boundary elements in index 0 (Marker = FARFIELD).
1408 boundary elements in index 1 (Marker = WING).
2688 boundary elements in index 2 (Marker = SYMMETRY).
```



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oneram6 — vim — 86×47

```
% ------------- DIRECT, ADJOINT, AND LINEARIZED PROBLEM DEFINITION ------------%
%
% Physical governing equations (EULER, NAVIER_STOKES,
%                               PLASMA_EULER, PLASMA_NAVIER_STOKES,
%                               FREE_SURFACE_EULER, FREE_SURFACE_NAVIER_STOKES,
%                               FLUID_STRUCTURE_EULER, FLUID_STRUCTURE_NAVIER_STOKES,
%                               AEROACOUSTIC_EULER, AEROACOUSTIC_NAVIER_STOKES,
%                               WAVE_EQUATION, HEAT_EQUATION, LINEAR_ELASTICITY)

PHYSICAL_PROBLEM= NAVIER_STOKES
%
% Specify turbulence model (NONE, SA, SST)
KIND_TURB_MODEL= SA
%
% Mathematical problem (DIRECT, ADJOINT, LINEARIZED)
MATH_PROBLEM= DIRECT
%
% Restart solution (NO, YES)
RESTART_SOL= NO
```

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a) Store the gas constants and freestream temperature, then calculate the speed of sound.
b) Calculate and store the freestream velocity from the Mach number & AoA/sideslip angles.
c) Compute the freestream viscosity from Sutherland's law and the supplied freestream temperature.
d) Use the definition of the Reynolds number to find the freestream density from the supplied Reynolds information, freestream velocity, and freestream viscosity from step 3.
e) Calculate the freestream pressure using the perfect gas law with the freestream temperature, specific gas constant, and freestream density from step 4.
f) Perform any required non-dim.

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```
%
% Conversion factor for converting the grid to meters
CONVERT_TO_METER= 1.0
%
% Write a new mesh converted to meters (NO, YES)
WRITE_CONVERTED_MESH = NO
```

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```
% -------------------- FLOW NUMERICAL METHOD DEFINITION -----------------------%
%
% Convective numerical method (JST, LAX-FRIEDRICH, ROE-1ST_ORDER,
%                              ROE-2ND_ORDER, AUSM-1ST_ORDER, AUSM-2ND_ORDER,
%                              HLLC-1ST_ORDER, HLLC-2ND_ORDER, ROE_TURKEL_1ST, ROE_TUR
KEL_2ND)
CONV_NUM_METHOD_FLOW= ROE-2ND_ORDER
%
% Slope limiter (NONE, VENKATAKRISHNAN, BARTH)
SLOPE_LIMITER_FLOW= VENKATAKRISHNAN
%
% Coefficient for the limiter (smooth regions)
LIMITER_COEFF= 0.3
%
% 1st, 2nd and 4th order artificial dissipation coefficients
AD_COEFF_FLOW= ( 0.15, 0.5, 0.02 )
%
% Viscous numerical method (AVG_GRAD, AVG_GRAD_CORRECTED, GALERKIN)
VISC_NUM_METHOD_FLOW= AVG_GRAD_CORRECTED
%
% Source term numerical method (PIECEWISE_CONSTANT)
SOUR_NUM_METHOD_FLOW= PIECEWISE_CONSTANT
%
% Time discretization (RUNGE-KUTTA_EXPLICIT, EULER_IMPLICIT, EULER_EXPLICIT)
TIME_DISCRE_FLOW= EULER_IMPLICIT

% -------------------- TURBULENT NUMERICAL METHOD DEFINITION ------------------%
%
% Convective numerical method (SCALAR_UPWIND-1ST_ORDER,
%                              SCALAR_UPWIND-2ND_ORDER)
CONV_NUM_METHOD_TURB= SCALAR_UPWIND-1ST_ORDER
%
% Slope limiter (NONE, VENKATAKRISHNAN, BARTH)
SLOPE_LIMITER_TURB= NONE
%
% Viscous numerical method (AVG_GRAD, AVG_GRAD_CORRECTED)
VISC_NUM_METHOD_TURB= AVG_GRAD_CORRECTED
%
% Source term numerical method (PIECEWISE_CONSTANT)
SOUR_NUM_METHOD_TURB= PIECEWISE_CONSTANT
%
% Time discretization (EULER_IMPLICIT)
TIME_DISCRE_TURB= EULER_IMPLICIT
```

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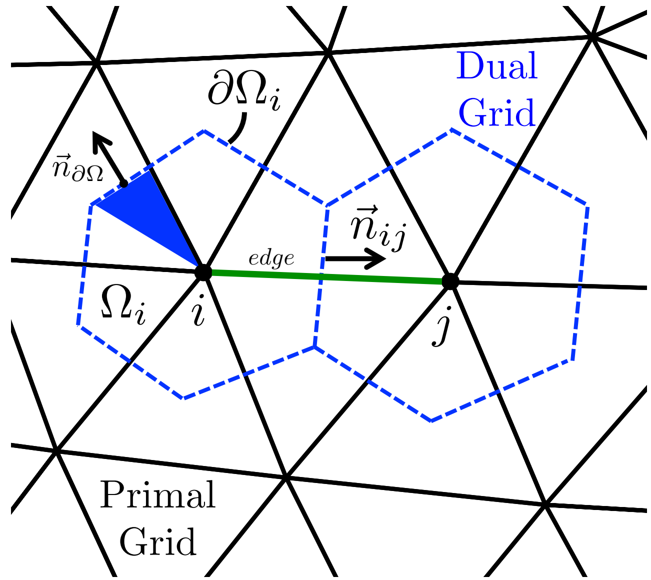


```
CONV_NUM_METHOD_FLOW= ROE-2ND_ORDER
%
% Slope limiter (NONE, VENKATAKRISHNAN, BARTH)
SLOPE_LIMITER_FLOW= VENKATAKRISHNAN
%
% Coefficient for the limiter (smooth regions)
LIMITER_COEFF= 0.3
%
% 1st, 2nd and 4th order artificial dissipation coefficients
AD_COEFF_FLOW= ( 0.15, 0.5, 0.02 )
% Convective numerical method (SCALAR_UPWIND-1ST_ORDER,
%                              SCALAR_UPWIND-2ND_ORDER)
CONV_NUM_METHOD_TURB= SCALAR_UPWIND-1ST_ORDER
%
% Slope limiter (NONE, VENKATAKRISHNAN, BARTH)
SLOPE_LIMITER_TURB= NONE
```

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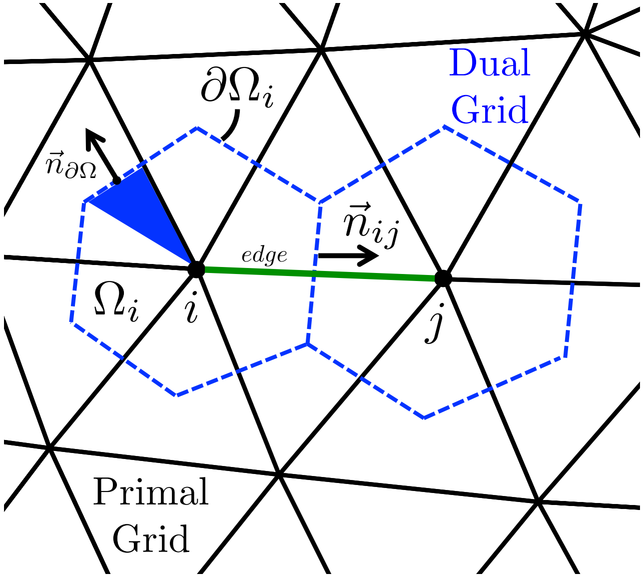


```
% Numerical method for spatial gradients (GREEN_GAUSS, WEIGHTED_LEAST_SQUARES)
NUM_METHOD_GRAD= GREEN_GAUSS

% Viscous numerical method (AVG_GRAD, AVG_GRAD_CORRECTED, GALERKIN)
VISC_NUM_METHOD_FLOW= AVG_GRAD_CORRECTED

% Viscous numerical method (AVG_GRAD, AVG_GRAD_CORRECTED)
VISC_NUM_METHOD_TURB= AVG_GRAD_CORRECTED
```

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```
% Time discretization (RUNGE-KUTTA_EXPLICIT,
                       EULER_IMPLICIT, EULER_EXPLICIT)
TIME_DISCRE_FLOW= EULER_IMPLICIT

% Time discretization (EULER_IMPLICIT)
TIME_DISCRE_TURB= EULER_IMPLICIT
```

oneram6 — vim — 86×47

```
% ----------------------- LINEAR SOLVER DEFINITION ---------------------------%
%
% Linear solver for the implicit (or discrete adjoint) formulation (LU_SGS,
%                                     SYM_GAUSS_SEIDEL, BCGSTAB, GMRES)
LINEAR_SOLVER= LU_SGS
%
% Preconditioner of the Krylov linear solver (NONE, JACOBI, LINELET)
LINEAR_SOLVER_PREC= JACOBI
%
% Min error of the linear solver for the implicit formulation
LINEAR_SOLVER_ERROR= 1E-6
%
% Max number of iterations of the linear solver for the implicit formulation
LINEAR_SOLVER_ITER= 5
```

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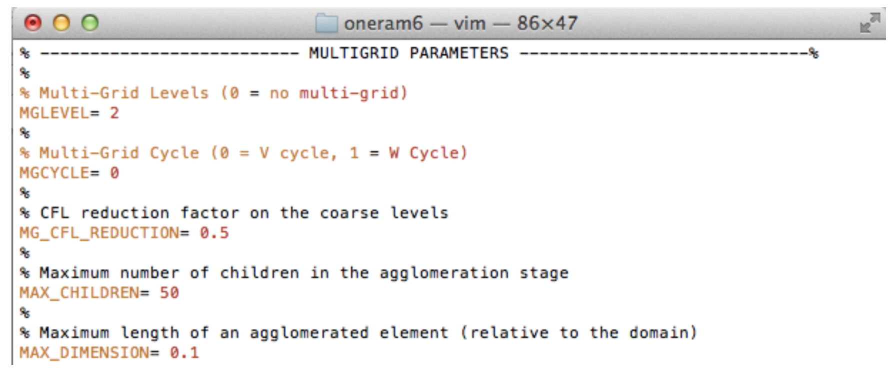
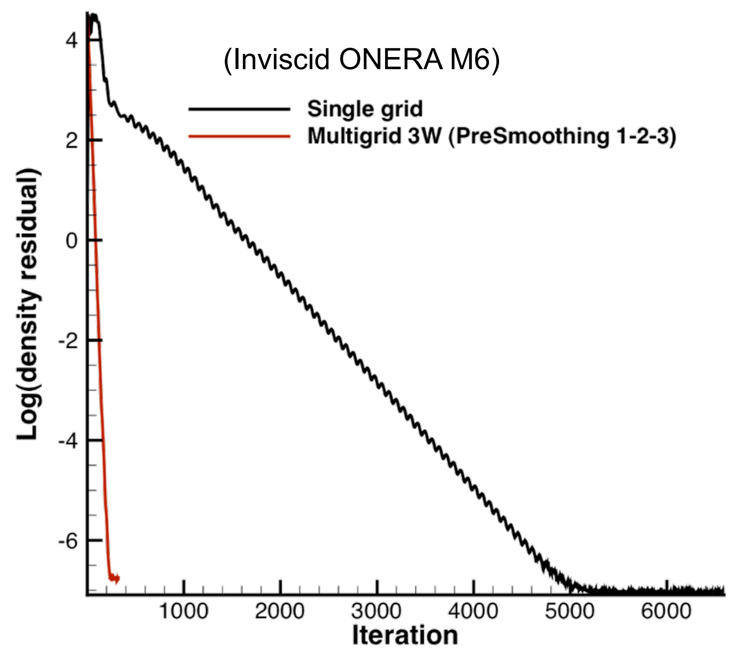


```
% ------------------------- MULTIGRID PARAMETERS ---------------------------%
%
% Multi-Grid Levels (0 = no multi-grid)
MGLEVEL= 2
%
% Multi-Grid Cycle (0 = V cycle, 1 = W Cycle)
MGCYCLE= 0
%
% CFL reduction factor on the coarse levels
MG_CFL_REDUCTION= 0.5
%
% Maximum number of children in the agglomeration stage
MAX_CHILDREN= 50
%
% Maximum length of an agglomerated element (relative to the domain)
MAX_DIMENSION= 0.1
```



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```
% Courant-Friedrichs-Lewy condition of the finest grid
CFL_NUMBER= 4.0

% Number of total iterations
EXT_ITER= 999999

% Convergence criteria (CAUCHY, RESIDUAL)
%
CONV_CRITERIA= RESIDUAL

% Writing solution file frequency
WRT_SOL_FREQ= 100
```

```
tde:~/SU2/trunk/TestCases/rans/oneram6 $ SU2_CFD turb_ONERAM6.cfg
----------------------------- Begin solver -----------------------------

Iter    Time(s)      Res[Rho]      Res[nu]     CLift(Total)   CDrag(Total)
   1   3.464825     -3.736620   -10.733734       0.235623       0.138384
   2   3.458526     -3.819456   -10.795100       0.257769       0.161235
   3   3.456265     -3.884336   -10.708376       0.251159       0.162511
   4   3.454473     -3.918854   -10.613289       0.248960       0.161138
   5   3.454418     -3.921856   -10.540246       0.245086       0.159738
   6   3.453593     -3.901621   -10.486060       0.243244       0.158791
   7   3.454111     -3.872761   -10.444949       0.242628       0.157833
   8   3.453991     -3.843843   -10.412412       0.242324       0.156698
   9   3.453802     -3.818142   -10.385427       0.241857       0.155291
  10   3.453641     -3.796223   -10.362069       0.241269       0.153543
```

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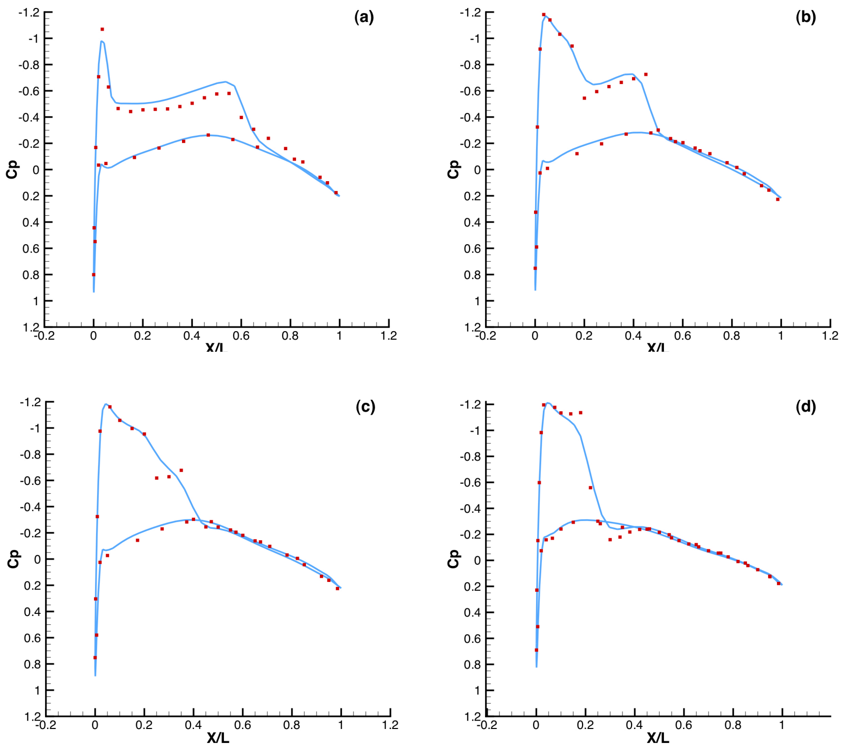


Comparison of Cp profiles of the experimental results of Schmitt and Carpin (red squares) against SU2 computational results (blue line) at different sections along the span of the wing. (a) y/b = 0.2, (b) y/b = 0.65, (c) y/b = 0.8, (d) y/b = 0.95

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DEMO