SIMPACK in Multidisciplinary Use: Aerodynamics/Flight-Mechanics Coupling

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SIMPACK
User Meeting
2001

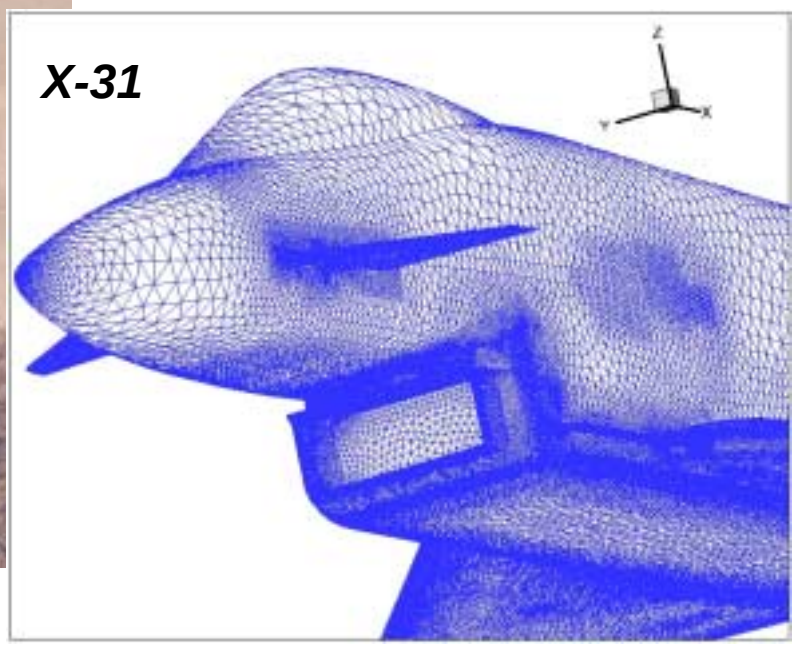
13. - 14 November, Bad Ischl, Austria

OUTLINE

- Objectives
- Simulation Modules
- Validation Experiments / Test-Cases
- Simulation Results
- Conclusions and Perspectives

Objectives

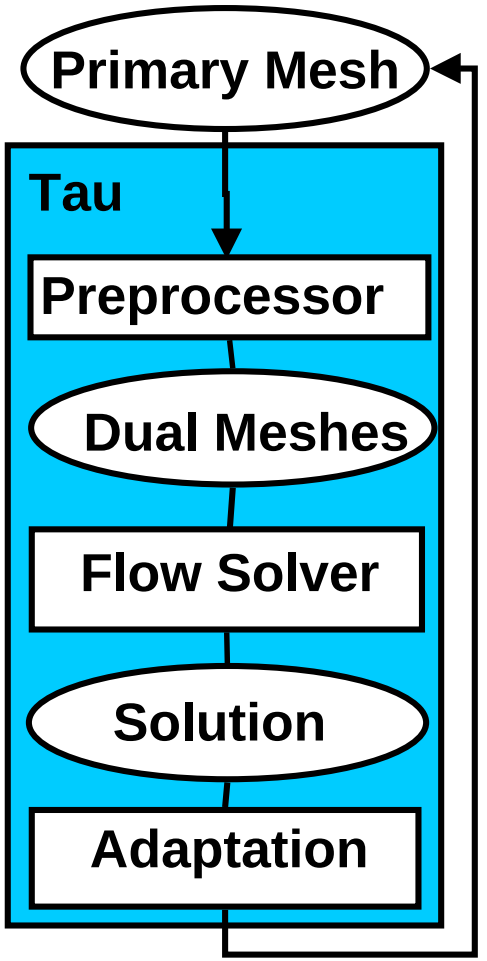
- **Tool for CFD / Flight-Mechanic Coupled Simulations**
- **Aim: Numerical Simulation of a Full Fighter Aircraft**



Simulation Modules: Aerodynamics (CFD)

DLR-Tau Code: Finite Volume Scheme for solving Euler/RANS Equations

- Unstructured Grid / Dual-Mesh Approach
- Multigrid Computation
- One- and Two-Equation Turbulence Models
- Dual Time-Stepping for Unsteady Cases
- Explicit Runge-Kutta Time-Integration Scheme
- Central and Upwind Flux-Calculation Schemes
- Guided and Free Rigid-Body Motion
- Parallelized using MPI
- Local Grid Refinement (steady computations)



Simulation Modules: Flight Mechanics

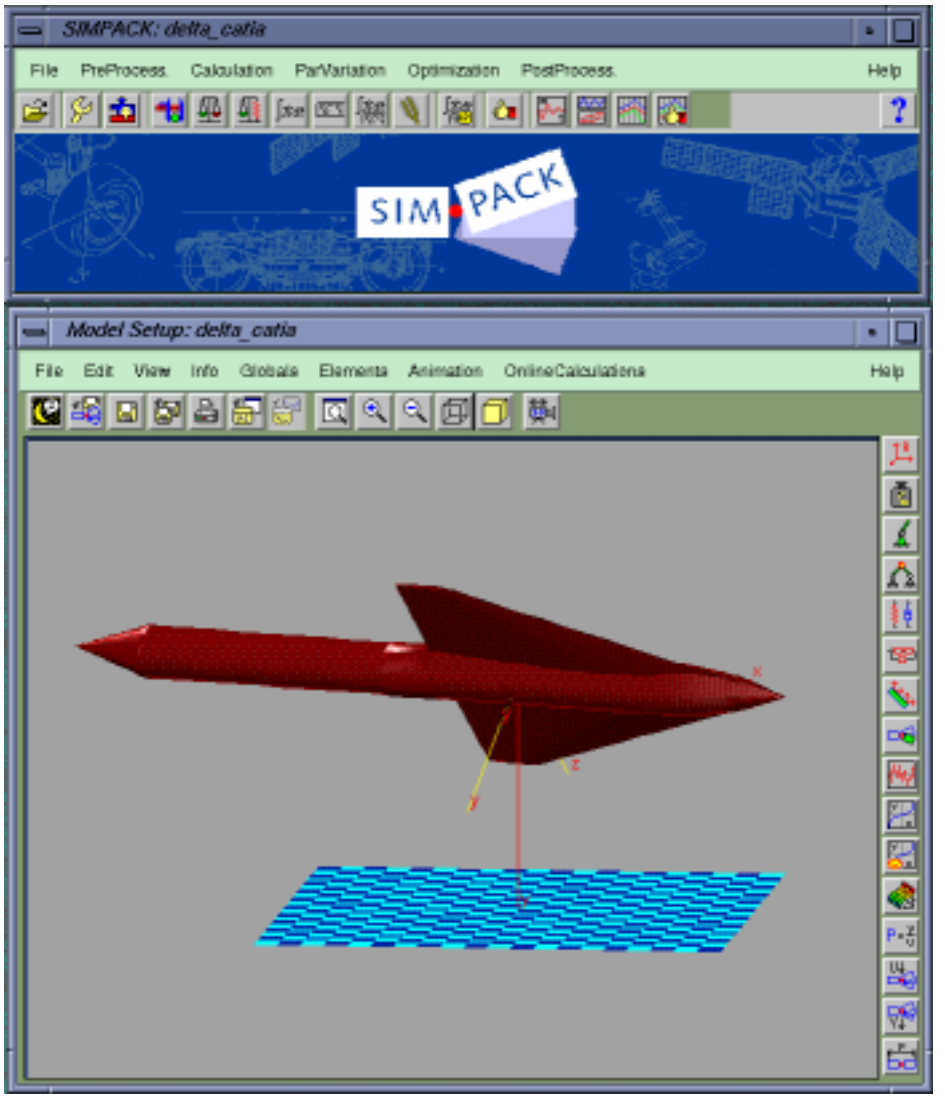
Implemented in the

Multi-Body Simulation Software

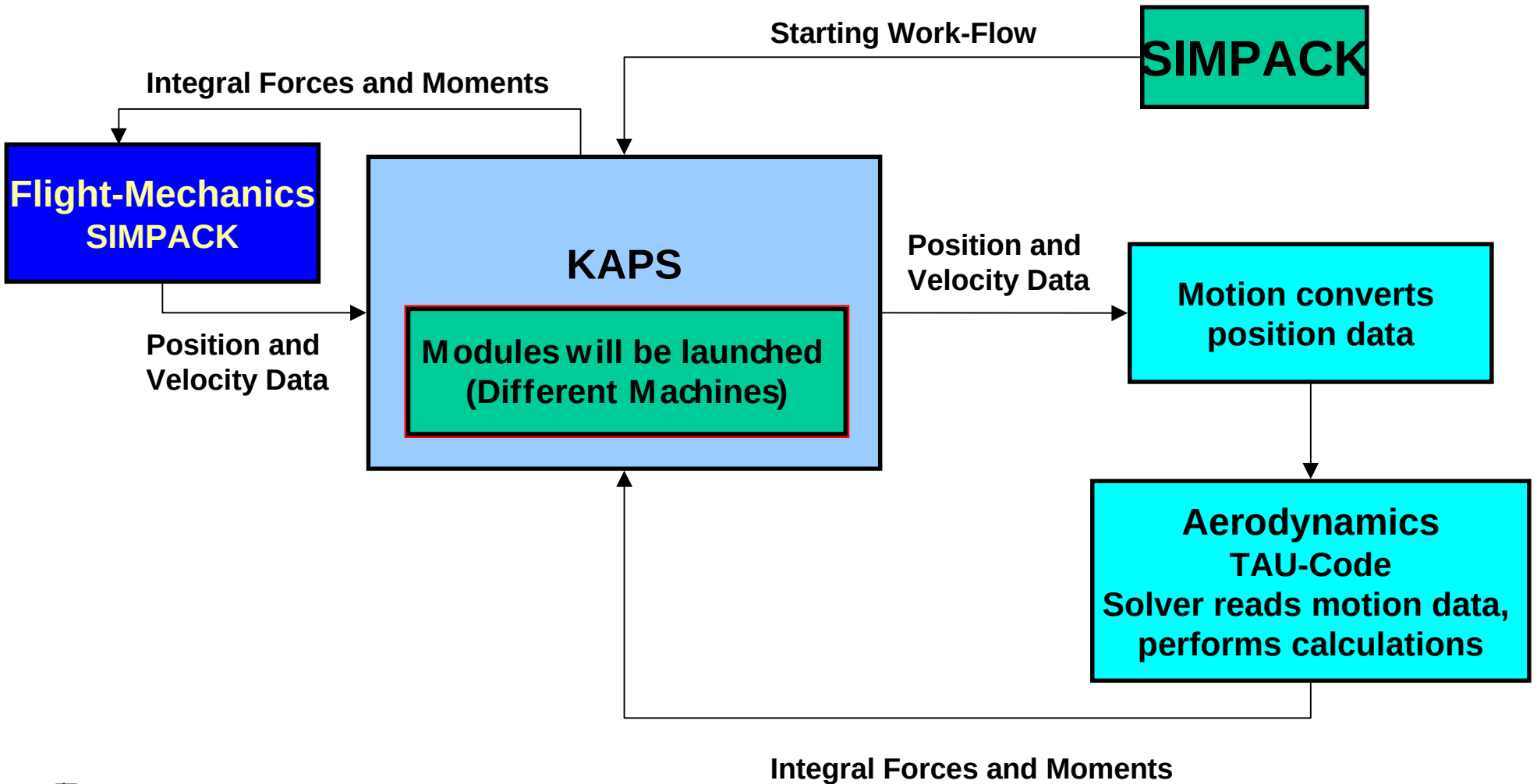
SIMPACK

User Defined Capabilities:

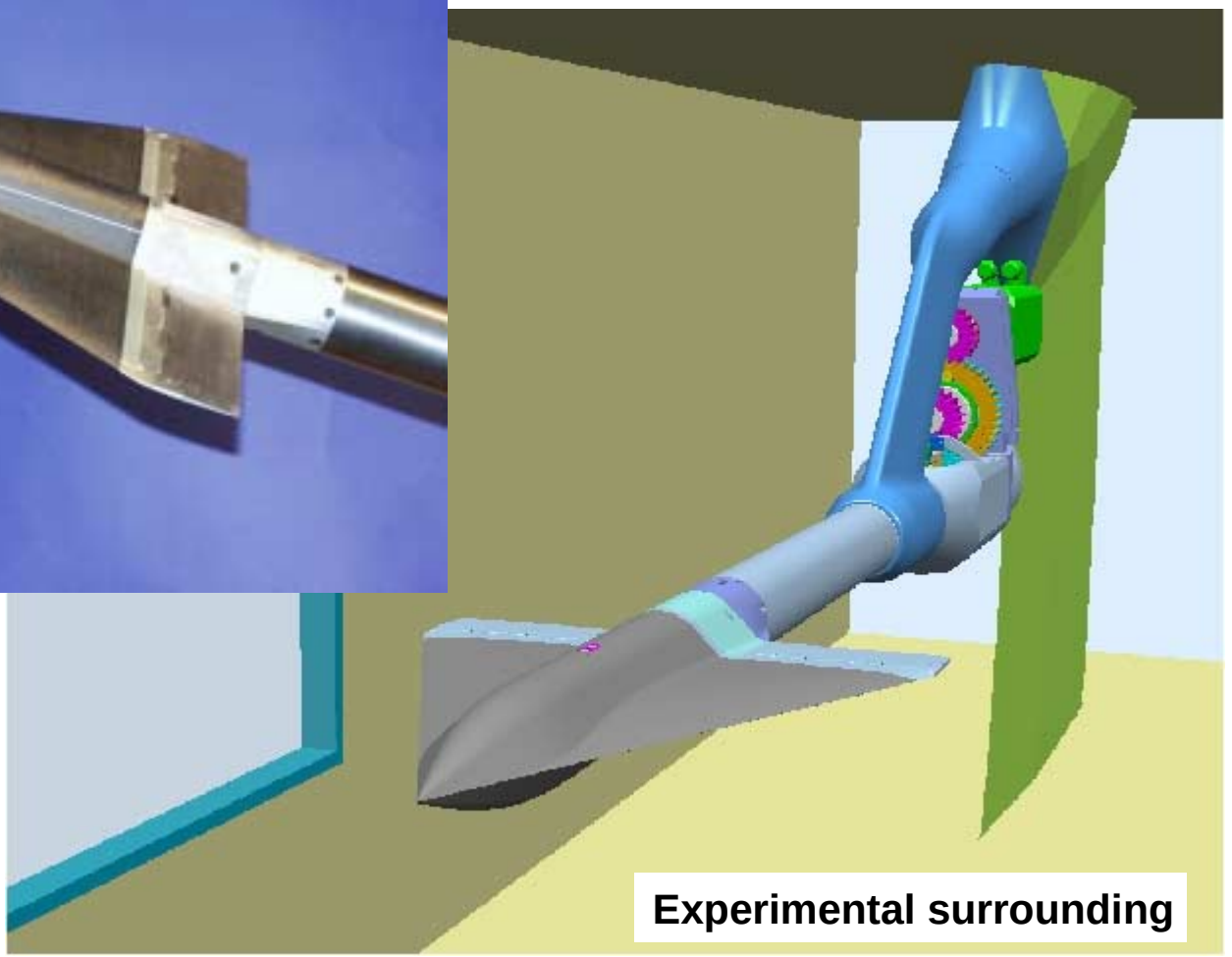
- **Flight-Mechanic Equations of Motion (1 to 6 DoF)**
- **2nd Order Runge-Kutta Time Integration**
- **Trim Function**
- **Communication Interface**



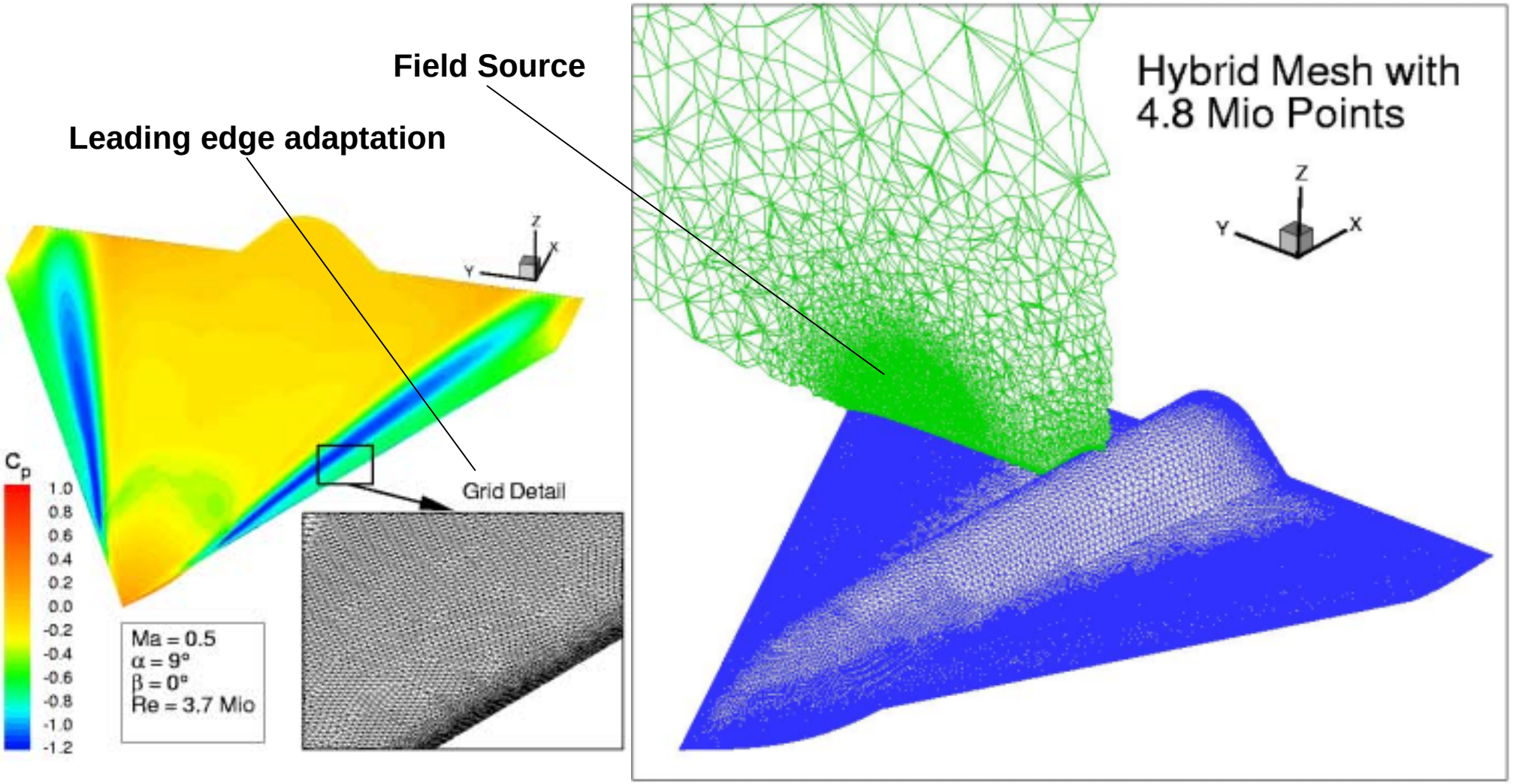
Simulation Modules:
Communication Interface (KAPS)



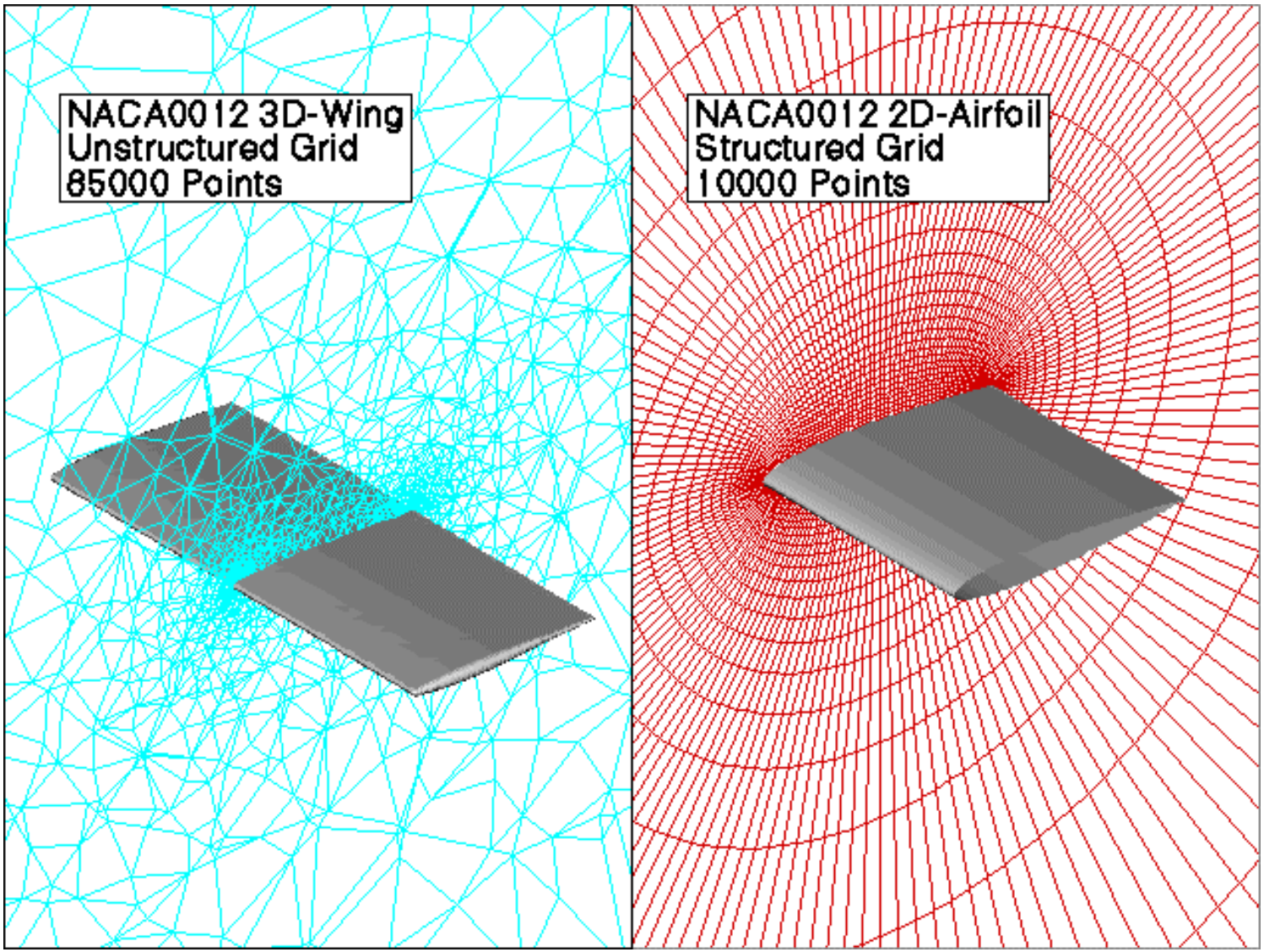
Validation Experiments



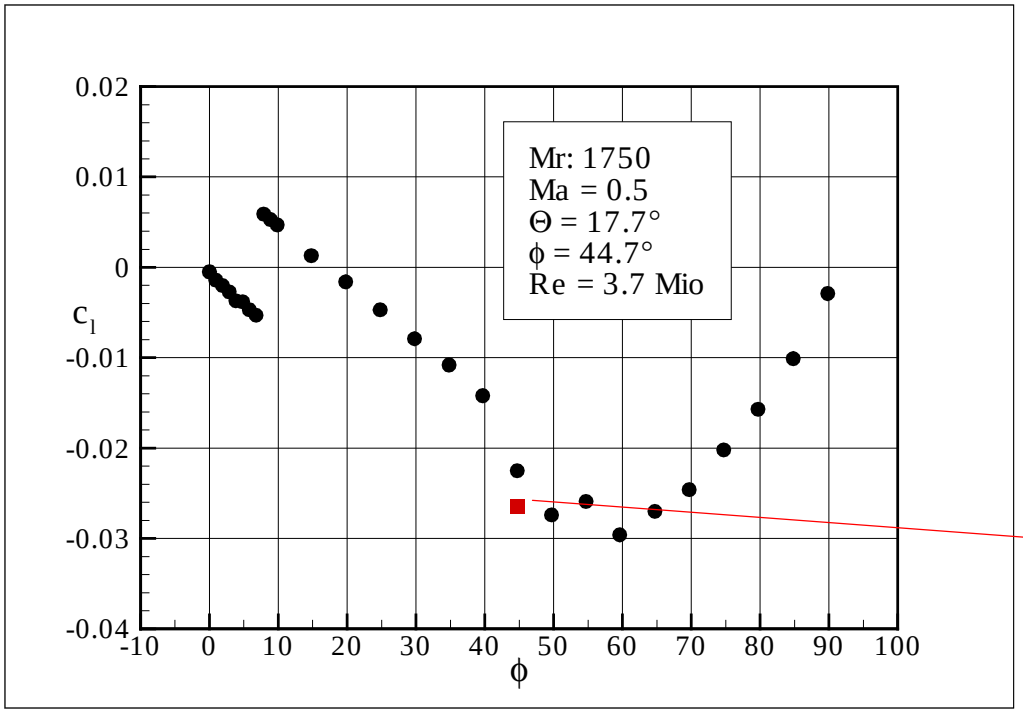
Test-Cases: AeroSUM Delta-Wing Model

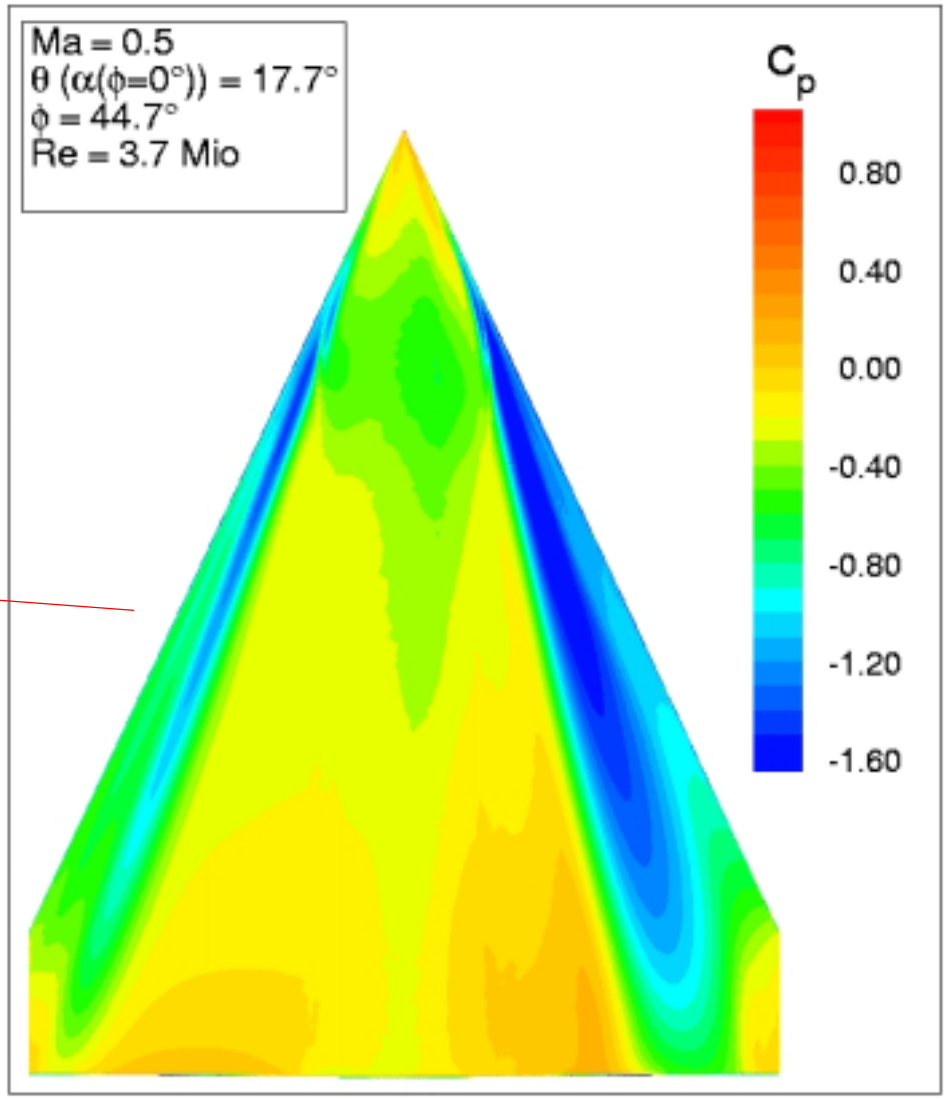


Test-Cases: NACA0012 3D-Wing / 2D-Airfoil



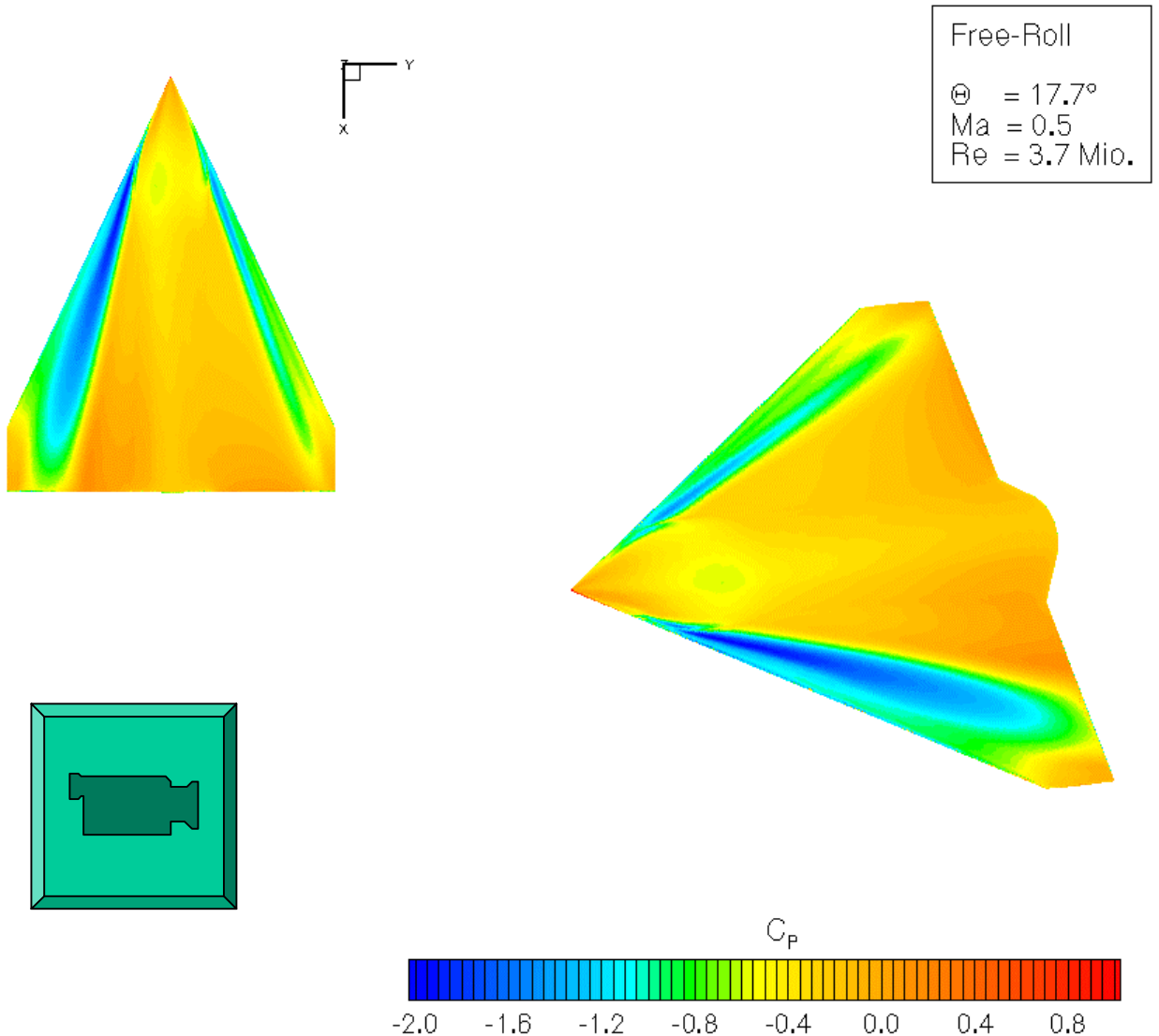
Simulation Results: Free Rolling Delta Wing



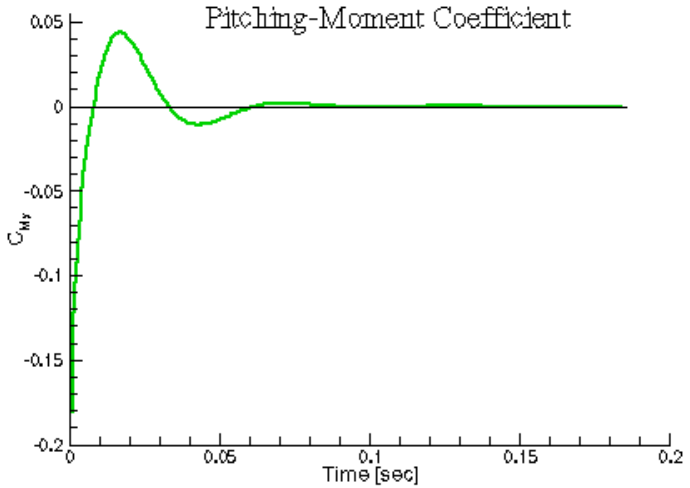


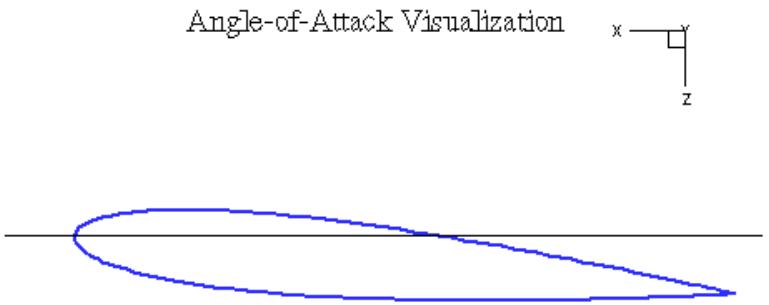
Static starting solution

Simulation Results: Free Rolling Delta Wing



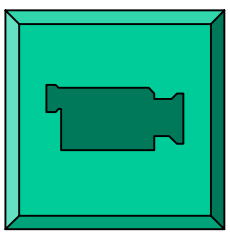
Simulation Results: NACA0012 2D-Airfoil

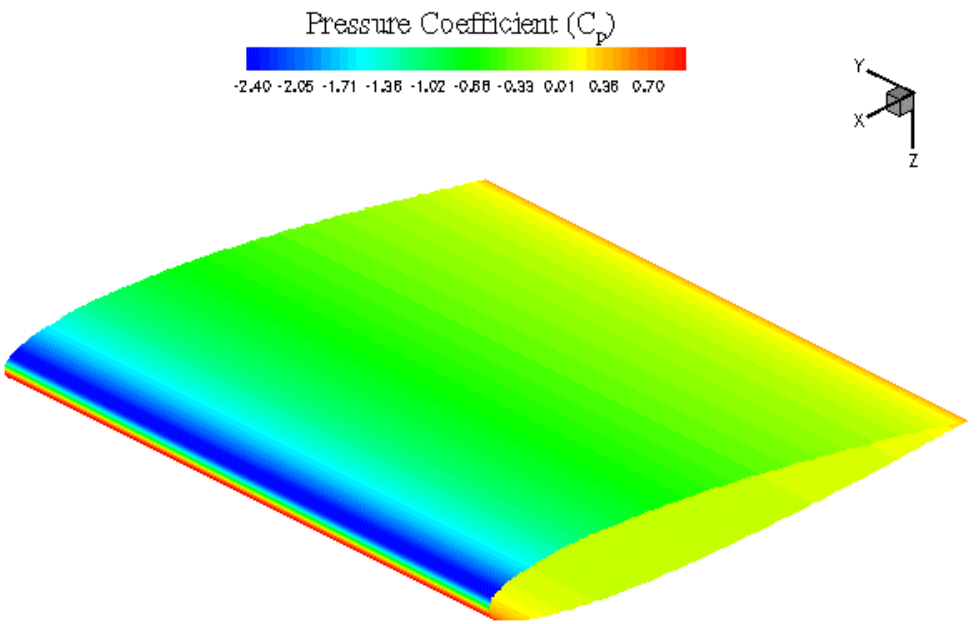




Free-Pitching NACA0012 2D-Airfoil

Simulation Parameters:
Euler Flow-Simulation
Rotation at 0% chord (Leading Edge)
Chord = 1.0 meters
Mach Number = 0.5
Initial Angle-of-Attack, $\alpha_0 = 5^\circ$





Conclusions

- Coupling of Aerodynamics and Flight-Mechanics is Successful
- Free-Pitching Symmetrical Wings Reach the Zero Trim-Condition

Perspectives

- Simulation of Delta-Wing with Movable Flaps (Chimera)
- Implementation of Adaptation for Unsteady Cases
- Investigations of Turbulence Models
- Parallel Processing of all Tau-Modules
- Increase the Complexity of the Aircraft Configuration
- Implementation of Aeroelasticity (Project SikMa, 2002)