Linux-cluster in an Aerodynamic Design Environment

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Agenda

- Introduction
- CFD methods for Aerodynamic design
- Computer resources
- Performance comparison
- Applications
- Comments

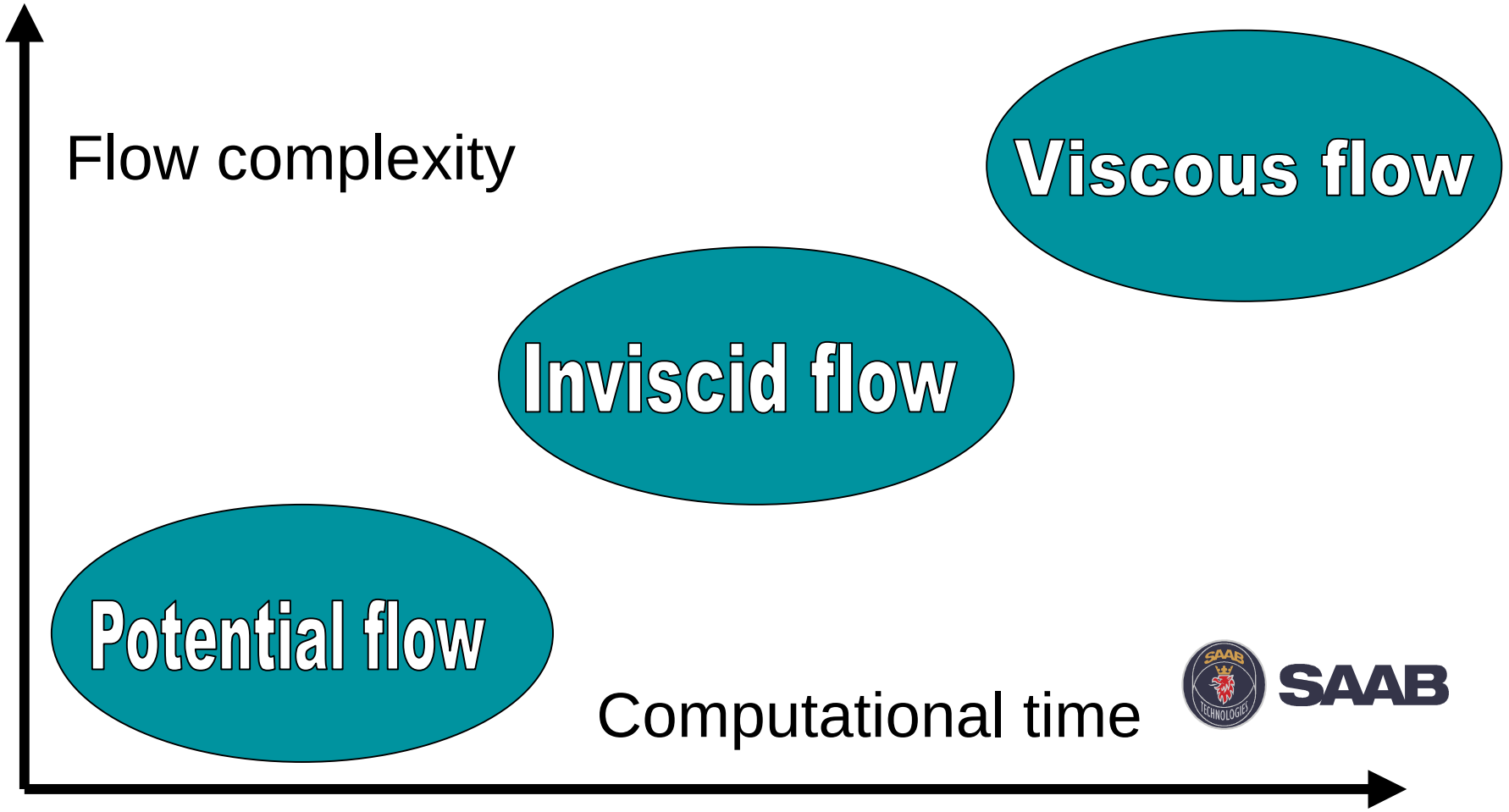
Introduction

- CFD – Computational Fluid Dynamics
- Simulation of air-flow around bodies
- Forces and moments
- Detailed information about the flow
  location of vortices, shocks, flow separation etc.
- Numerical wind-tunnel

Introduction

- Increased demand of flow simulations in the development process
- Increased usage of advanced methods in the early design-stages
- CFD-development driven by increase of CPU speed

CFD-methods in the Aerodynamic design process



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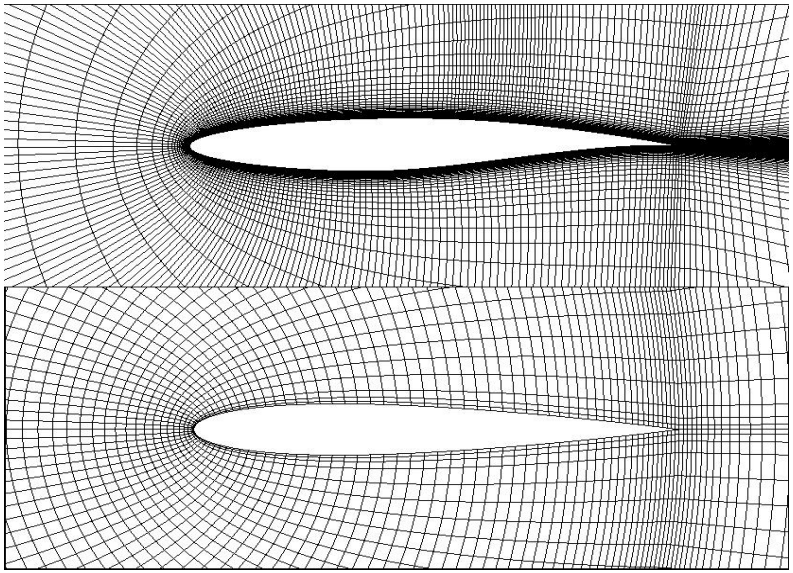
CFD-methods in the Aerodynamic design process

- Viscous flow – Navier-Stokes equations
- Inviscid flow – Euler equations



CFD methods cont’

- Flow equations – system of non-linear partial differential equations
- Finite volume formulation of equations
- Discretization on structured or unstructured meshes with central difference or upwind schemes
- Time integration – Runge-Kutta + convergence acceleration techniques
- Solvers developed in-house and in cooperation with research institutes

CFD methods cont’

Flow model	Inviscid	Viscous
Unknowns	5 per cell	5-12 per cell
Problem size	0.1-1.5 million cells	2-5 million cells
# iterations	100-1000	1000-10000
CPU time	1-24 h	24h-4 weeks

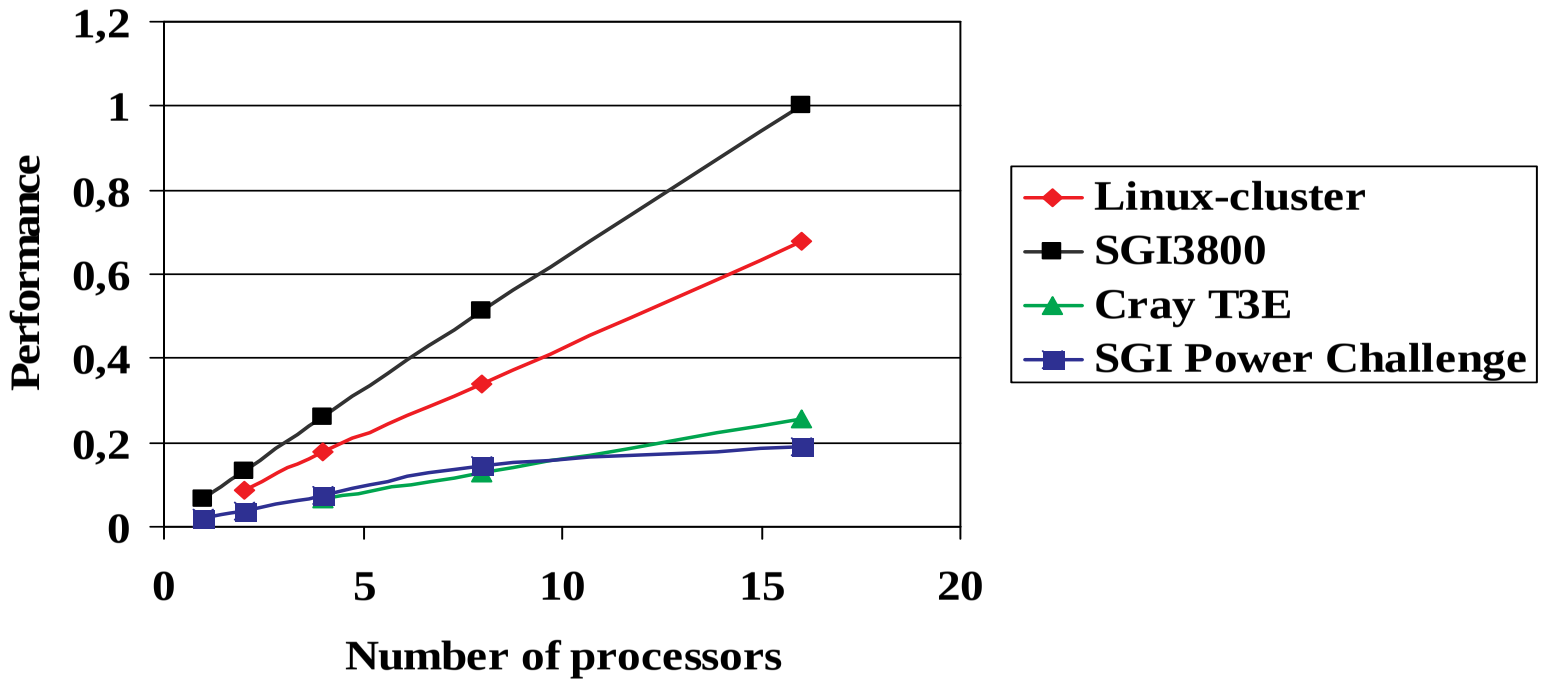
Computer resources

- 16 proc Linux-cluster
- 96 proc SGI3800 and 256 proc Cray T3E at NSC
- 20 proc SGI Power Challenge

Computer resources cont’

- Linux-cluster assembled by NSC
- 16 AMD Athlon Thunderbird 850 MHz
- Fast Ethernet
- 1 node with 1.5 Gbyte + 15x512 Mbyte memory
- PBS queuing system
- PVM and MPI

Performance comparison



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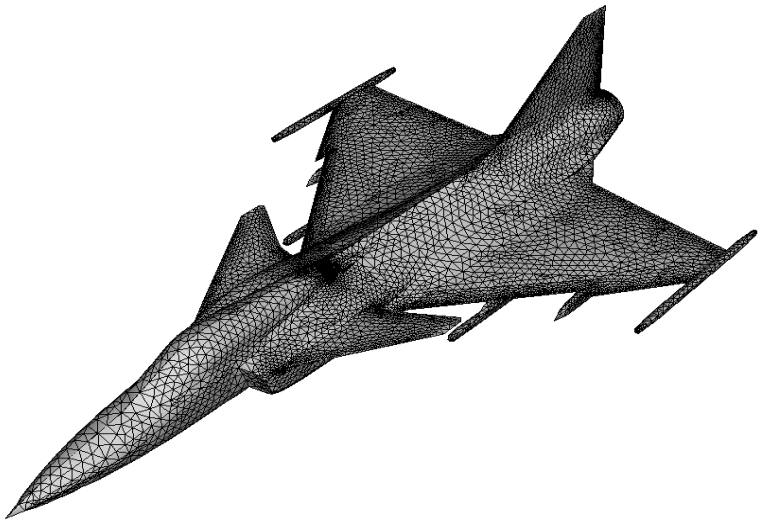
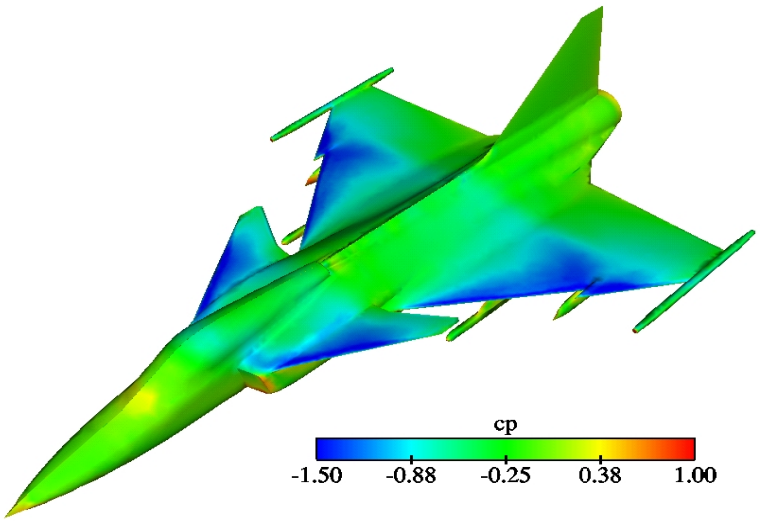
Application – JAS 39 Gripen

- Saab JAS 39 Gripen a/c in pitch manoeuvre
- Inviscid flow
- Unstructured mesh with 90 000 points



Application – JAS 39 Gripen

- Parallelized by domain decomposition for 8 processors – 7 hours on Linux-cluster
- Angle of attack sweep from 0 to 26 deg
- Pressure distribution at M=0.85 and 12 deg angle of attack



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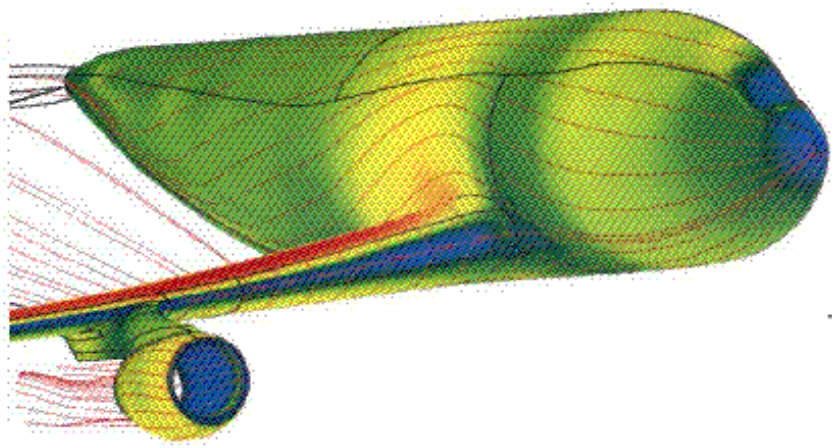
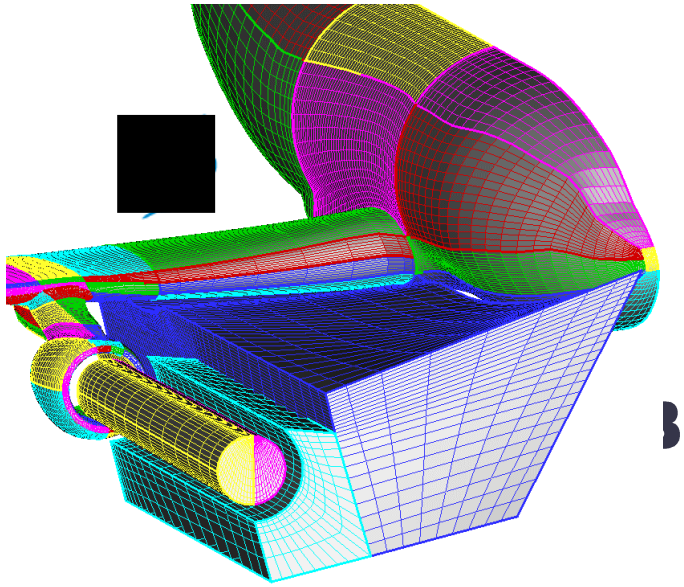
Application - Airbus

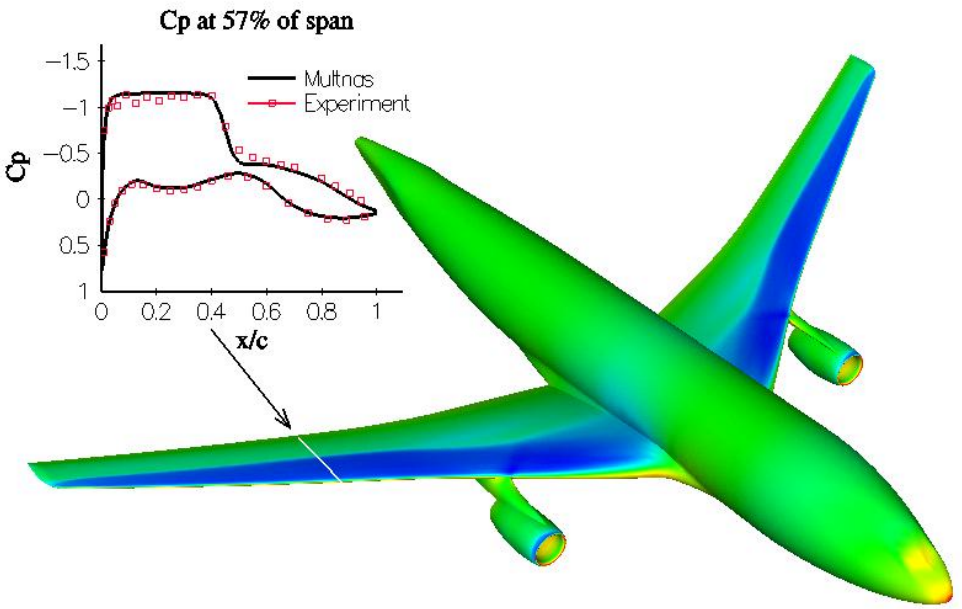
- Airbus configuration at cruise conditions
- Viscous flow
- Structured mesh with 5 million cells in 239 blocks
- Investigation of flow behaviour and drag





Application - Airbus

- Mach=0.80 2.2º angle of attack
- Non-linear 2 eq. turbulence model
- 30 hours on 16 processors
- Excellent agreement with wind tunnel results



Comments

- Flow simulation programs perform very well on Linux-clusters
- Excellent price/performance
- Reliable system
- Experience limited to few users and homogenous program mix