NATIONAL TECHNICAL UNIVERSITY OF ATHENS
SCHOOL OF MECHANICAL ENGINEERING
LAB. OF THERMAL TURBOMACHINES
PARALLEL CFD & OPTIMIZATION UNIT (PCOpt/NTUA)
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RESEARCH ACTIVITIES

Computational Infrastructure

Clusters available for research and educational purposes:

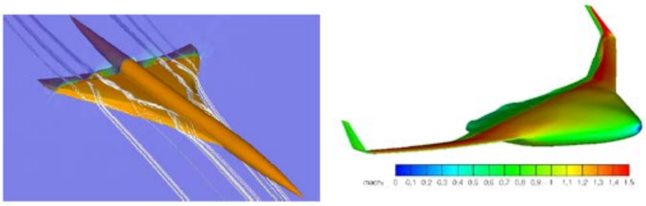
Cluster 1: 32 nodes Xeon, 64bit, 120 cores, 105GB RAM. Some nodes are equipped with NVIDIA GPU cards (GTX 280, 285 & 580) and are used for educational purposes.

Cluster 2: 70 DELL PowerEdge blade servers with 2 Quad, Six, Eight or Ten Core Xeon each, 64bit, 736 cores in total, 3TB RAM.

Cluster 3: 4 HP SL390s servers and 4 Dell PowerEdge C8220X nodes with 12 Nvidia Tesla M2050 (3 on each HP server), 4 K20 and 4 K40 Nvidia GPUs with 104 GPU memory in total.

Each analysis and design/optimization software developed by PCOpt/NTUA is **fully parallelized** using MPI. The in-house Navier-Stokes eqs. and adjoint solvers are all enabled to run on **NVIDIA GPUs using CUDA**, yielding a parallel speed-up of more than 50 with respect to a modern processor core.

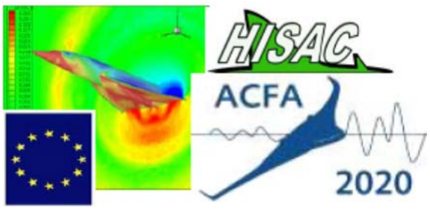
Research Activities (Basic & Applied Research)



External Aerodynamics Applications:
(a) Flow prediction around a supersonic business jet;
(b) Aerodynamic & aeroelastic simulations for a blended-wing body configuration, with moving flaps and ailerons.

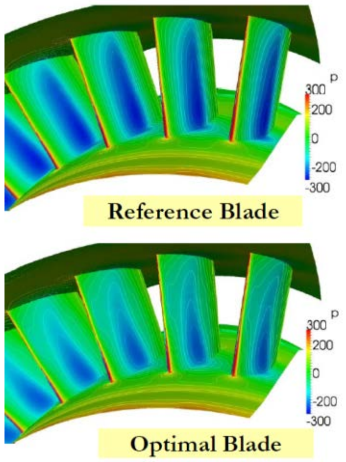
Development of In-house Flow Solvers:

- For internal & External Aerodynamics
- Steady & unsteady flows
- Compressible & incompressible fluids
- Parallel CPU & GPU enabled
- Hybrid unstructured meshes
- Grid adaptation



Development of Adjoint methods:

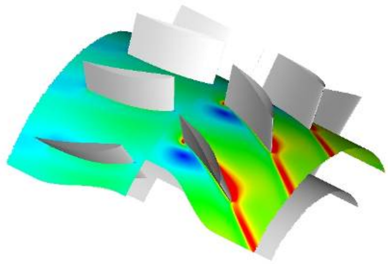
Development of continuous and discrete adjoint methods for the first- and higher-order derivatives, for use in conventional and robust design problems. The continuous adjoint method to well known turbulence model PDEs and some wall function based models have been developed, for the first time in the literature, so as to compute the exact gradient of the objective function.
The development is based on the in-house flow solver (continuous and discrete adjoint, compressible and incompressible fluids, GPU enabled) and OpenFOAM (continuous adjoint).

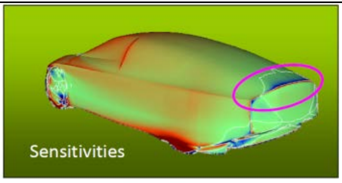


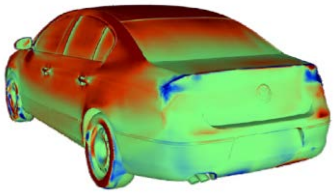
Turbomachinery Applications:

Design-optimization of compressor row for maximum rotor torque. Fully unsteady flow (using check-pointing for time histories of the primal flow solutions) with adjoint to the mixing plane. ➔

🡐 Design-optimization of a 3D peripheral compressor row, for minimum viscous losses, with geometric constraints using the continuous adjoint method.



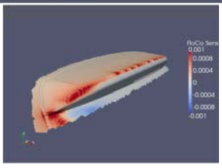


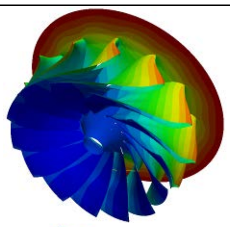


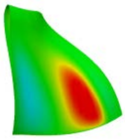
Automotive Industry Applications:

🡐 Use of the continuous adjoint approach to the DES turbulence model for the computation of sensitivity maps and shape optimization of low emission and conventional cars. Objective: Minimization of drag coefficient.

Use of the continuous adjoint approach in optimal active flow control. Computation of the optimal location and type of steady suction/blowing jets on the spoiler of a passenger car. ➔



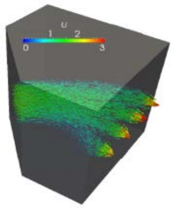


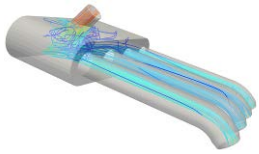


Other Applications:

🡐 Adjoint-based computation of the sensitivity maps over a Francis runner and its shape optimization. Objective: cavitation area minimization.

Topology optimization of ducts/manifolds using the adjoint methods. Objectives: minimization of viscous losses, maximization of heat transfer subject to flow constraints. ➔



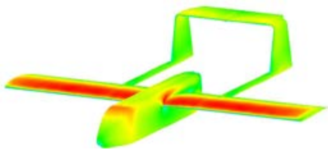


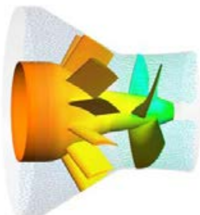
Development of Evolutionary Algorithms:

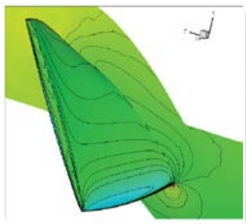
EASY is a generic, fully-parallelized optimization platform, developed & brought to market by PCOpt. It is based on metamodels-assisted evolutionary algorithms to speed-up the optimization process and supports multilevel/hierarchical and distributed optimization. Available in synchronous & a very efficient (on multiprocessor platforms) asynchronous mode.

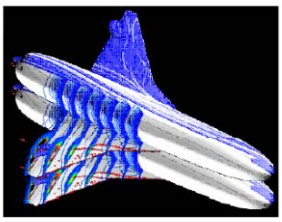
EASY v 2.0

Applications:
Design of thermal & hydraulic turbomachines, air-vehicles, etc









URL (Research Activities): http://velos0.ltt.mech.ntua.gr/research/
URL (Courses Taught, in Greek): http://velos0.ltt.mech.ntua.gr/kgianna/
URL (Software EASY): http://velos0.ltt.mech.ntua.gr/EASY/