EUROMECH   Final Report

EUROPEAN MECHANICS SOCIETY

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EUROMECH Colloquium No:449

Title: **Computational AeroAcoustics: from acoustic sources modeling to farfield radiated noise prediction**

Dates and location: **9-12 December 2003, Majestic Congress Center in Chamonix, France**

Chairperson: **Eric MANOHA and Pierre SAGAUT**

Co-Chairperson: **Thiên-Hiêp LÊ**

Is there need of another Colloquium on the same or a related subject? Which year? **2006**

Full registration fee: **298 Euros**

What other funding was obtained? **ONERA and French Ministry of Defense**

What were the participants offered? **Book of 4-page papers, coffee breaks, lunches (4 days), welcome reception (Tuesday 9th), conference dinner (Wednesday 10th)**

Number of members of EUROMECH (reduced registration fee): 57

Number of non-members of EUROMECH (full registration fee): 20

Number of participants from each country:

Country		Country		Country	
Austria	4	Great Britain	6	Slovakia	-
Belgium	4	Greece	-	Slovenia	-
Byelorussia	-	Hungary	-	Spain	2
Bosnia	-	Ireland	1	Sweden	6
Bulgaria	-	Italy	1	Switzerland	-
Croatia	-	Latvia	-	Ukraine	-
Czech Republic	-	Lithuania	-	Yugoslavia	-
Denmark	1	Netherlands	-	Turkey	-
Estonia	-	Norway	3	USA	4
Finland	-	Poland	-	Korea	1
France	32	Portugal	-	Australia	2
Georgia	-	Romania	-		
Germany	12	Russia	-	Total	79

Please turn

Scientific Report

1. Topic

Computational AeroAcoustics (CAA) is known to be of exponentially growing interest, in both automotive and aeronautical industries. The numerical prediction of aerodynamic noise is of great interest for both academic and applied research. The noise generation mechanisms are not understood in many cases, and the diffraction/refraction of acoustic waves by turbulent flows is very difficult to predict. CAA is nowadays used as an investigation tool to understand aerodynamic noise, but also for noise reduction via active control and unsteady shape optimisation.

2. Attendance

The colloquium has gathered 79 participants, most of them coming from Europe (11 countries, 74 participants) but also beyond : USA (4 participants), Korea (1 participant) and Australia (2 participants). All major european research teams involved in CAA were present. Among them :

Universities (36 participants) :École Centrale de Lyon (France), University of Southampton (United-Kingdom), Universities of Uppsala and KTH (Sweden), Technical University of Delft and University of Aachen (Germany), Trinity College of Dublin (Ireland).

Research centers (18 participants) : NASA Langley (USA), ONERA (France), FOI (Sweden), DLR (Germany).

Industries (25 participants) : Boeing Commercial Airplanes (USA), EADS and Airbus-Germany (Germany), Airbus-France (France), Volvo Car Corporation (Sweden). It should be noticed that several CFD/CAA software editors, who are more and more present in scientific conferences, also attended the colloquium : CD Adapco Group (United-Kingdom), EXA Europe (France) and Fluent Inc. (USA).

3. Technical programme

The Colloquium programme was based upon 3 "Invited Lectures" (NASA Langley, University of Southampton, German Aerospace Center), and 37 oral presentations in 8 Technical Sessions.

Session 1 : Advanced hybrid methods development : Advanced hybrid methods typically associate (i) a local unsteady flow simulation using Navier-Stokes equations CFD computation and (ii) a simulation of acoustic propagation through a non-uniform mean flow using linearized (or not) Euler equations in perturbation.

Session 2 : Computation AeroAcoustic methods based on RANS : These methods include (i) stability analysis and (ii) turbulence reconstruction based on a stochastic model and a source term modelling for Euler equations in perturbation.

Session 3 : Numerical methods development : These methods aim at developing advanced spatial, low-dispersion, low dissipation, high order (4th or 6th) schemes for the simulation of sound wave propagation through non-uniform flows using Euler perturbation equations on structured and unstructured grids.

Session 4 : Jet noise : Several approaches for jet noise prediction were presented, including the influence of temperature and complex geometries (serrated nozzles). These simulations are based on DNS for moderate Reynolds numbers (~ 2500) or LES for realistic flow (Re $\sim 10^6$). These unsteady computations are coupled to an acoustic integral method for the farfield noise prediction (Ffowcs Williams-Hawkings or Kirchhoff).

Session 5 : Unstructured grids : Unstructured grids are of high interest when very complex geometries are considered. However, such grids are particularly adapted to 2nd order spatial schemes used for CFD. For CAA applications, the difficulty is to develop high order schemes with the same accurracy as provided by finite difference schemes on structured grids. Applications presented in this session address the use of Euler equations and Dicontinuous Galerkin equations to evaluate the accuracy of an acoustic pulse advection.

Session 6 : Airframe Noise : Airframe noise studies cover the numerical prediction of the aerodynamic noise radiated by a simple airfoil or a high lift wing with flap and slat. The methods are mostly zonal or hybrid : noise sources are simulated by use of unsteady Navier-Stokes equations, then acoustic propagation through non-uniform mean flow uses Euler equations, and finally integral equations are used for farfield noise predictions.

Session 7 : Cavity noise : Cavity noise mechanisms are known to involve very strong physical interactions between aerodynamics and acoustics. Consequently, it represents a large application field of for CAA. Again, most CAA methods used for cavity noise prediction are hybrid methods, generally coulpling LES or DNS for the near field and LEE (linearized Euler equations) for the mid- and far fields.

Session 8 : Internal noise : Typical internal noise problem is the fan noise propagating inside an engine nacelle and the radiating outside the duct.

4. **Main results**

This colloquium has offered the opportunity to share experiences dealing with the development and the use of numerical simulation for aeroacoustics studies. Emphasis has been put on modern developments relying on the coupling of CFD and CAA tools. The main addressed topics were the prediction of noise generation, including several approaches recently developed (stochastic reconstruction, direct simulation, large-eddy simulation, non-linear disturbance equation, linear stability analysis), and the simulation of acoustic wave propagation, including direct simulation, linearized Euler equations and wall acoustic treatment modelling. Acoustic far-field prediction using integral methods (Kirchhoff integration, Lighthill-like and Ffowcs Williams-Hawkings models) were also largely addressed.

All presented works were original. The most promising techniques are probably the hybrid methods in which sevral techniques are associated, each solving one particular mechanism in a specific region, by use of the most appropriate set of equations. With the rapid growth of the computing capacities (teraflop) and the development of coupling techniques between very different numerical methods, there is no doubt that CAA will soon become an industrial tool as widely used as CFD in the design of future vehicle projects.

5. **Conclusions**

The general quality of the audience and of the presented research suggest that a colloquium with similar topics should be organized again within 2 or 3 years, with the main challenge -acknowledged by all particpants- being the accurate prediction of turbulent flow noise sources. In the meanwhile, industrial partners will be more and more involved in the development and appplications of CAA tools, with the consequence that they probably will be better represented in future conferences devoted to CAA.

19/03/04

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