3rd ESWIRP
Trans National Access Opportunity Workshop
11-12 October 2011

European Strategic Windtunnels Improved Research Potential

Abstracts (in alphabetical order)

Enhanced aerodynamic measurements on the Mexico rotor in the DNW, including methods for passive load control

Gerard Schepers

Energy Research Center of the Netherlands ECN, The Netherlands

Dr. Klaus Hufnagel

TU Darmstadt, Germany

The presentation will be largely similar to the presentation which has been given jointly by Mr. Schepers (ECN) and Mr. Hufnagel (University of Darmstadt) at the previous ESWIPR meeting. As such it will discuss wind tunnel measurements on a wind turbine to be placed in the DNW-LLF wind tunnel facility. The suggested project builds around the Mexico wind turbine experiment as carried out December 2006 in the DNW LLF. In this experiment pressure distributions were measured around the blades at different radial positions where furthermore the flow field was mapped with PIV. The analysis of these measurements is currently carried out in a large International Energy Agency (IEA) project (www.mexnext.org) and leads to several questions which can only be answered with additional measurements.

In yawed conditions the Mexico measurements show an azimuthal variation of the pressure distributions and resulting overall loads on the rotor blade. This azimuthal variation will even be enhanced on real turbines where atmospheric unsteady wind conditions increase the problem. TU Darmstadt has developed a concept with coupled leading and trailing edge flap to control these load variations. Up to now the investigation is limited to 2D experimental data. With the MEXICO rotor experiments in the DNW-LLF 3D data can be obtained to proof the rotor concept and to validate and improve numerical simulations on this concept.

Although the presentation will be largely similar to the presentation given at the previous meeting, some updated information will be added:

- Interest to the project has been shown by new participants
- Some developments have taken place, which may make it possible to find counterfinance for the suggested project within an FP7 Energy program.

Consortium

Germany

University of Darmstadt
Dr. Hufnagel

Mexnext partners:

Canada

École de technologie supérieur, Montreal, ETS, University of Victoria, Uvic

Denmark

RISØ-DTU/DTU-MEK

Germany

University of Stuttgart (IAG), University of Applied Sciences, Kiel and Forwind

Israel

Israel Institute of Technology (Technion)

Japan

Mie University, and National Institute of Advanced Industrial Science and Technology (Mie/AIST)

Korea

Korea Institute of Energy Research (KIER) and Korea Aerospace Research Institute (Kari)

Netherlands

The Energy Research Center of the Netherlands (ECN), University of Delft (TUDelft), Suzlon Blade Technology(SBT), University of Twente (TUTwente)

Norway

Institute for Energy Technology/Norwegian University of Science and Technology IFE/NTNU

Spain

Renewable Energy National Center of Spain (CENER) and National Institute for Aerospace Technology, INTA

Sweden

Royal Institute of Technology/University of Gotland (KTH/HGO)

USA

National Renewable Energy Laboratory (NREL)

Experimental Investigation of the Acoustic Field of a Realistic Wing Section with Slat and Flaps in High Lift Configuration

Dr. Ronald Abstiens

Institute of Aerodynamics RWTH Aachen University, Germany

Since air traffic has increased continuously over the last couple of decades, noise pollution by aircraft is a major problem of modern aviation. Especially during landing and take-off, i.e., in the vicinity of airports, the disturbance of airport residents is very high. Therefore, it is a must to decrease the noise level of future aircraft.

To gain a better understanding of the mechanisms that result in noise production, numerical studies of a wing-slat configuration have been performed. Noise, however, is not only produced by the high-lift devices of the wing, but also by any kind of additions to the wing such as tracks to move the flaps and the slats. Since the noise is strongly influenced by the geometry of the body exposed to the flow modeling the configuration in detail results in a very complex geometry the flow field of which is difficult to compute. To validate the computations performed at the Institute of Aerodynamics Aachen (AIA), high Reynolds-number measurements are necessary. Due to the limited size of the test-section area and the limited freestream velocity of the wind tunnel at the AIA and for example the AWB in Braunschweig, measurements in a wind tunnel of greater size and higher velocity are a great step forward. Due to this fact it would be necessary to use a large wind-tunnel like the DNW LLF in the Netherlands with the capability for acoustic measurements.

The PIV measurements at the DNW-LLF will be conducted by the Institute of Aerodynamics Aachen (AIA). Additionally acoustic measurements could be carried out by the Aeroacoustic Departement TsAGI in collaboration with INCAS Bucharest. The flow data from PIV measurements and the acoustic data could be used to validate numerical simulations done by all partners of the consortium.

Consortium

Dr.-Ing. R. Abstiens

Institute of Aerodynamics RWTH Aachen
Wüllnerstr. 5a
52062 Aachen
Germany

Prof. V.F. Kopiev

Head of Aeroacoustic
Departement, TsAGI,
105005 Moscow
Radio str.17
Russia

Stoica Corneliu

INCAS
B-dul Iuliu Maniu no. 220, sect 6
Bucharest 061126
Romania

Dr. Zdenek Patek

Chief Aerodynamicist
VZLU Aerodynamics
Beranovych 130
199 05 Praha - Letnany
Czech Republic

<u>Investigation of the small scales turbulence statistics in the MODANE S1 Wind tunnel: measurements of velocity, temperature and vorticity fluctuations in grid generated turbulence</u>

M. Bourgoin & N. Mordant

LEGI, France

In this third ESWIRP workshop, we will present an actualized view of our proposal of a detailed experimental investigation of the statistical properties aiming at a better understanding of turbulent flows at large Reynolds numbers. According to fruitful contacts established in the past months with the ONERA team in charge of the S1 wind tunnel facility, we are in position to propose a detailed program of investigations together with an updated list of the experimental teams which are planned to be involved in this initiative.

Our primary goal is to take advantage of the unequaled large scale dimensions of the ONERA S1 wind tunnel facility in Modane, to make available to the broad turbulence community experimental turbulence data with unpreceded resolution (both spatial and temporal) and accuracy (statistical convergency). We will focus our study on grid generated turbulence. This is an academic flow known to produce almost perfectly homogeneous and isotropic turbulence (HIT) which remains a unique playground to investigate fundamental properties of turbulent flows. We aim at producing a database as complete as possible, in terms of characterization of the turbulence, which will help the wide research community to get a better insight in longstanding mysteries which still limit our capacity to understand and accurately model turbulent flows. These include, among others, turbulence intermittency, mixing and dispersion properties, and the link between Eulerian and Lagrangian descriptions of turbulence. For this purpose, we plan to implement several measurements: (i) classical hot-wire anemometry, to access Eulerian statistics and correlations of the turbulent field, (ii) Lagrangian particle tracking, both acoustical and optical, to access Lagrangian statistics and dispersion properties, (iii) acoustical measurements of vorticity, (iv) temperature measurements (both acoustical and classical cold-wire thermometry) to investigate turbulent transport and mixing downstream a heating mandoline. (Note that, compared to our first proposal, the choice has been made to strongly consolidate the panel of measurements in the grid turbulence configuration and to drop the boundary layer investigation).

To achieve this ambitious project, we have federated a large international consortium with complementary expertise allowing to span a large spectrum in terms of measurement techniques, high resolution instrumentation and signal processing.

During the presentation, we will show the first design studies of the large-scale grid we plan to implement in the tunnel and we will detail the instrumentation and the planned measurements. We will emphasize the relevance of the S1 wind tunnel in Modane considering the challenges and expected outcomes of our proposal regarding both the small scale instrumentation devices and the access of a large turbulence signals database for sake of a wide dissemination of scientific results to the research community.

Consortium

France
LEGI laboratory (University Grenoble I-FR)
M. Bourgoin, C. Baudet,
S. Tardu & N. Mordant

France
CEA (Grenoble-FR)
J-P. Moro

Germany
TWIST laboratory
(University of Oldenburg - DE)
Pr J. Peinke

United Kingdom
Department of Aeronautics
(Imperial College - UK)
Pr C. Vassilicos

Australia
Priority Research Center for Energy
(University of Newcastle - AU)
Pr L. Djenidi, Pr B. Antonia

France
LP ENS-Lyon (ENS-Lyon-FR)
Pr J-F. Pinton, Dr. R. Volk

France
CORIA (University Rouen-FR)
Pr L. Danaila

France
Institut Néel (CNRS Grenoble-FR)
Dr. E. Roche

Czech Republic
Institute of Thermomechanics
Academy of Sciences of the Czech Republic
Pr V. Uruba

Canada
McGill University (Montreal, Canada)
Dr. L. Mydlarski

High Reynolds Wind Tunnel Tests for Active Flow Control with Plasma Actuators

Dr. Leo Veldhuis

Delft University of Technology, The Netherlands

As Dr. Veldhuis took over this presentation on very short notice, there is no abstract available.

For further information please have a look at the presentation, which is published on www.eswirp.eu.

Consortium

Italy
University of Milan-Bicocca

The Netherlands
University of Delft

United Kingdom
University of Manchester

Reynolds number influence on delta wing vortex flows

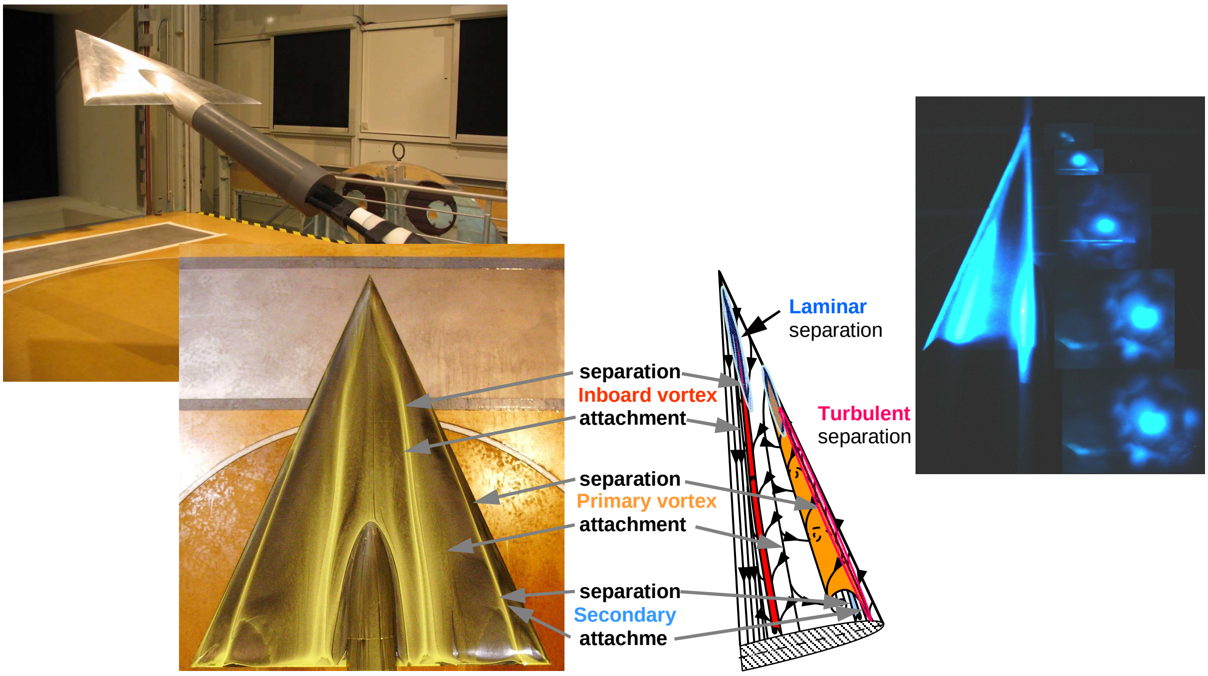
Dr. Christian Breitsamter, presented by **Jan Ulrich Klar**

Institute of Aerodynamics, Technical University Munich, Germany

Concerning large-scale vortices shed at wing leading edges, strakes and other geometries of high maneuverability aircraft, there is still some lack of knowledge on the Reynolds number influence. Within the Vortex Flow Experiment 2 (VFE-2; RTO AVT-113) the relevance of this influence on the vortex flow topology and aerodynamic quantities was clearly demonstrated studying a generic delta wing of 65 deg wing sweep providing sharp and rounded leading-edge geometries. The onset of separation and the associated Reynolds number influence is now further addressed in the frame of the RTO AVT-183 research team concentrating on a diamong wing geometry.

Here, a detailed Reynolds number investigation on the VFE-2 configuration is proposed. The model is prepared for cryogenic test facilities. A systematic variation of Reynolds number (Re) at low to moderate Mach number (Ma) and angle of attack (α) will result in a consistent and sounded data base obtained in a strategic wind tunnel facility. Force, pressure and flowfield measurements are planned to analyze the influence of separation onset, of partial and fully developed leading-edge vortices and of vortex bursting for rounded leading-edge geometries. The corresponding results will substantially extend the vortex flow data base related to Reynolds number influence. Such data are needed to serve as reference values for the validation of modern CFD tools employing e.g. hybrid RANS/LES methods. For the FP7 project ATAAC and GARTeur AG49, the VFE-2 configuration has been selected as a test case of particular relevance.

There is a strong interest in this activity both by academia and research institutes within Europe. In particular, consortium partners are: *Aeronautical Research and Test Institute Czech Republic* (VZLU), *City University of London*, *National Technical University of Athens* (NTUA), *Swedish Defence Research Agency* (FOI), and *Warsaw University of Technology.* In addition, the GARTeur Action Group 49 provide support via FOI.



Upper left: VFE-2 wind tunnel model; Upper right: laser light sheet flow visualization for $\alpha = 18°$; Lower middle: surface oilflow visualization and corresponding flow topology for rounded leading edge at $\alpha = 13°$, Re = 2×10^6, Ma = 0.14

Consortium

Czech Republic

Aeronautical Research and Test Institute Czech Republic (VZLU)

Greece

National Technical University of Athens (NTUA)

Sweden

Swedish Defence Research Agency (FOI)

Germany

Technical University Munich

Poland

Warsaw University of Technology

United Kingdom

City University of London

Time-resolved wake measurements of separated wing flow and wall interference investigations

Dr. Thorsten Lutz

Institute of Aerodynamics and Gas Dynamics (IAG), University of Stuttgart, Germany

Aircraft stall at the boundaries of the flight envelope is characterized by massive flow separation from the wing. The wake is highly unsteady due to global flow unsteadiness and large scale turbulent fluctuations. The unsteady wake can affect the empennage by exciting structural responses and by impacting the efficiency of the control surfaces. Both effects are safety critical and the understanding and prediction of these interference effects is therefore of high interest for the aircraft industry. As public available time-resolved measurements focus on 2D airfoil configurations at low speeds, time-resolved PIV wake measurements for complete aircraft configurations at realistic Reynolds numbers are proposed in the frame of ESWIRP. The measurements shall include time-resolved velocity measurements in several planes between the wing trailing-edge and the empennage. Beside flow field measurements with and without attached htp, unsteady Kulite c_p measurements at the wing trailing edge and at distinct locations on the htp are proposed.

These measurements can be combined with wall interference experimental investigations. Wall interference investigations will include simultaneous measurements of wall, wing and horizontal tail pressure distribution (steady and unsteady), aerodynamic forces and moments and wing deformation. Two (at least one) model configurations will be tested: wing/body with/without htp. Testing will be performed in slotted test section wall configuration. It is desirable to measure characteristics of incoming flow turbulence. The main goal of the second proposal is to gather experimental database for the future CFD activities on ETW wall interference investigations.

Both proposals were already presented separately at the first and the second ESWIRP workshop. Since then effort was spent to get access to an adequate wind tunnel model that is suited for the proposed cryogenic ETW tests. NASA confirmed via DLR that the NASA Common Research Model (CRM) can be provided for the ESWIRP investigations. The CRM is a generic, transport aircraft type full model in clean configuration. The span of the model relative to the ETW test section width is 0.66, while the blockage ratio is 5.83%. The CRM model is suitable for this joint proposal. NASA aerodynamic measurements of the CRM served as test case for the past AIAA drag prediction workshop and the geometric data is public available. Furthermore the feasibility of the proposed TR-PIV measurements was discussed with specialists from DLR Göttingen and a rough test programme that fits the frame of ESWIRP was defined. Finally the tasks and contributions of the consortia partners were elaborated.

Consortium

France

Gerald Carrier, Joel Renaux
ONERA DAAP, France

Gerald.Carrier@onera.fr,
Joel.Reneaux@onera.fr

Germany

Thorsten Lutz, Ewald Krämer

Institute of Aerodynamics and Gas Dynamics (IAG), Universität Stuttgart, Germany

lutz@iag.uni-stuttgart.de, kraemer@iag.uni-stuttgart.de

Russia

Anton Gorbushin
Aerodynamic Department, Central Aerohydrodynamic Institute, Russia

gorbushin@tsagi.ru

Germany

Ralf Rudnik
DLR AS, Germany

Ralf.Rudnik@dlr.de