



## Newsletter n°3

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### **Thematic Network – A European collaboration on development, quality assessment, and standardization of Particle Image Velocimetry for industrial applications**

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#### **Introduction**

The main objective of PivNet 2 is the establishment of direct information exchange between end users in industry and PIV developers in universities and research institutes in order that the end users will obtain a clear picture of the state-of-the-art of the PIV technique and the developer will receive knowledge about problems in industry to be solved with PIV. Therefore, recent activities of PivNet 2 were addressed to the dissemination of know-how on the recording of high quality PIV images, PIV evaluation algorithms and data validation procedures. The exchange of knowledge and the discussion of the demands of potential end users have been undertaken in a variety of hands-on workshops and presentations in different fields of application.

Especially for the past 6 month a lot of activities can be listed. Workshop 2.2.2 and Presentation 3.2 *PIV technique for the investigation of wake vortices* was held on February 23-24, 2005 at B20 of ONERA, Lille, France and Presentation 3.3 *PIV technique for complex applications in aerodynamics* has been performed on January 27 at LSWT, Airbus, Bremen, Germany. A workshop on  $\mu$ PIV (5.8-2) on April 7-8, 2005 has been hold and organized at TU Delft.

A Joint EWA and PivNet 2 Workshop on 'CFD, PIV and Experiments in Aerodynamics' has been hold at DLR Göttingen on May 10-11, 2005, which was organized as the PivNet 2 WS 2.2.7, formerly 'Comparison between PIV experimental results and numerical results'. On a following workshop in June 2006 within the frame of EWA this work and cooperation shall be continued.

## Workshop on Applications of Particle Image Velocimetry to Naval and Industrial Hydrodynamics

Location: Rome, Italy, 05.-06.05.2004

Organizing partner: INSEAN

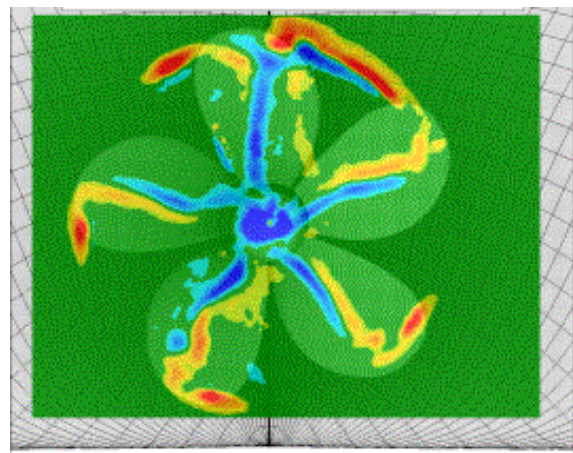
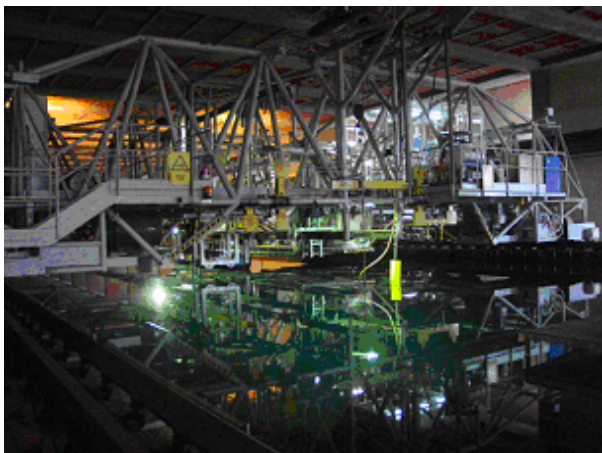
The growth of the PIV technique due to the improvement of its hardware components is clear: nanosecond pulse duration and high-energy lasers, high-resolution and low-noise CCD cameras, fast frame grabbers, as well as faster computers are among the major factors that have raised the capabilities of the measurement techniques.

Concurrently, naval and industrial applications present ever more challenging technical difficulties. The objective of the workshop was to focus the attention on the application of PIV on naval and industrial problems and to stimulate the transfer of technological know-how through presentations to industrial end-users.

The presentation of PIV in a large Circulating Water Channel/Towing Tank has been performed at INSEAN on a typical ship model. This demonstration has provided a unique opportunity for leading scientists and managers from the industry to evaluate the potential offered by the technique in large facility applications.

In order to allow all the participants to attend actively the presentations of the PIV experiments, and also for safety reasons due to the limited space on the basin carriage, 4 groups of 15 persons have been organised. For this purpose 4 stations have been settled. Each group had 15' minutes at each station for presentation and questions. Three stations consisted of PIV demonstration:

- in the n.1 INSEAN towing tank stereo PIV measurements behind a ship model with underwater probe
- in the CEIMM Cavitation tunnel stereo PIV measurements in the near wake of an isolated propeller
- in a little circulating channel, PIV measurements with high-speed camera and multi-frame adaptive correlation method



The n.1 INSEAN towing tank is a 6.5m deep, 13.5m wide and 470m long facility. The left image shows the basin carriage. An example of the vorticity field of a propeller wake is shown to the right.

## **7<sup>th</sup> Workshop on PIV 'Further assessment of PIV technique', T5/ERCOFTAC SIG32**

Location: Lisbon, Portugal, 09.-10-06.2004

Organizing partner: Laboratoire de Mécanique de Lille

The Seventh Workshop of PivNet 2 task 6/ERCOFTAC Sig 32 took place in Instituto Superior Technico in Lisbon on Friday the 9th and Saturday the 10th of July 2004. This Workshop was linked to the 12th International Symposium on Laser Techniques Applied to Fluid Mechanics which took place from the 12th to the 15th of July in Lisbon.

The aim of this series of Workshop is to enhance cooperative activity and exchange of information between the participating teams around the validation and the improvement of PIV.

For that purpose, a list of topics of interest has been identified by the organizing Committee. The preceding workshop was joint to the second International PIV challenge, which took place in Busan (Korea) on September 19th and 20th 2003. The present workshop has gathered 18 contributions and 50 participants. Attention was focused on PIV software, post processing, time resolved PIV and two phase flow. It comes out from this workshop and from the following Symposium that PIV is now widely applied in different fields linked to fluid dynamics. The workshop did show that some significant improvements can be gained on the software side, with the introduction, for example, of image deformation. The extension of the PIV methodology to other fields like BOS or two phase flow is also of interest. The first applications of time resolved PIV look promising. During the workshop, the organization of the third PIV challenge, which will take place in Caltech (USA) in September 2005, was also discussed. It was proposed to have fewer test cases which allow to assess the PIV spatial resolution and to test both stereo and time resolved PIV.

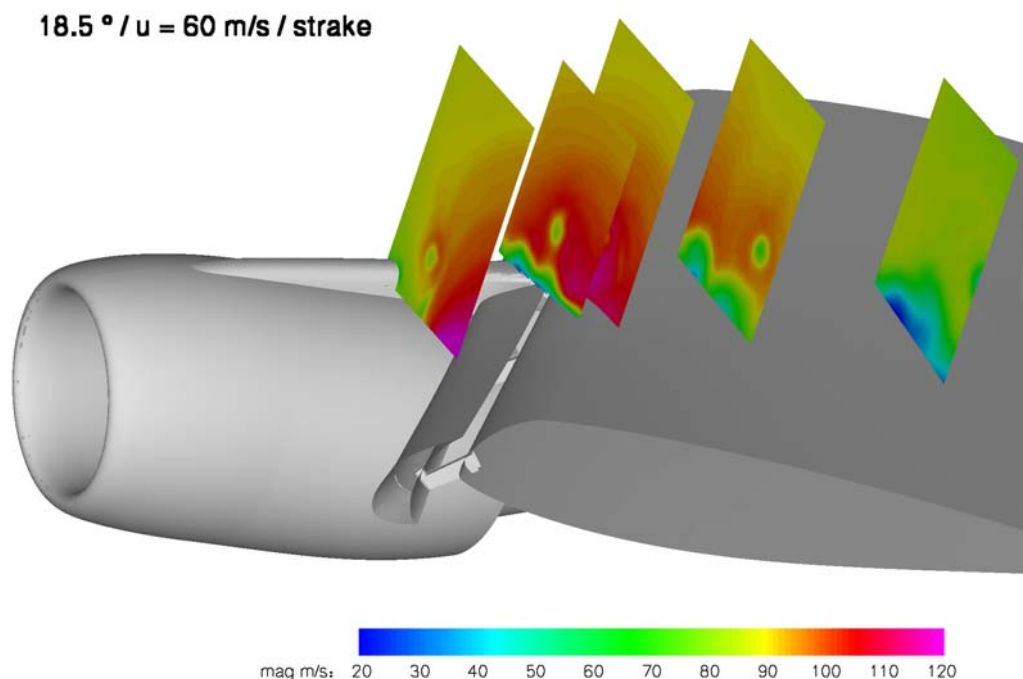
The CD-ROM containing the full minutes of the workshop is available to ERCOFTAC members by Pr Stanislas at [pivnet-sig32@univ-lille1.fr](mailto:pivnet-sig32@univ-lille1.fr)

## PIV Technique for Complex Applications in Aerodynamics

Location: Bremen, Germany, 27.01.2005  
Organizing partner: AIRBUS

The Bremen department of experimental aerodynamics engaged in the development of advanced high performance commercial transport aircraft and is recognized for its technological expertise in nearly all fields of aeronautical engineering. R&T capabilities of Airbus Deutschland GmbH cover all aspects of aircraft design and optimisation (aerodynamics, aero elastics, structures, weights, performances, operating costs, environmental aspects etc.), airframe and systems development and engine integration.

The AIRBUS wind tunnel testing department hosted a Particle Image Velocimetry (PIV) demonstration in conjunction with the thematic network PivNet 2 and the European project EUROLIFT2. A visit to the Low Speed Wind Tunnel (LSWT) was part of the demonstration. PIV measurements for the European research programme EUROLIFT 2 was performed at this time. The 3-dimensional, high-lift, half model has a half wing span of 1.4 metres. Normal 2- and stereoscopic 3-component PIV were applied to a modern tapered, swept wing in landing configuration. Complex measurements near to the nacelle were performed to investigate the interactions between the high lift system and the engine. During the measurements new PIV equipment was used. A traverse was mounted outside the wind tunnel. This traverse was able to move and rotate the PIV system. The light was coupled in to the wind tunnel from the lower side. The stereo cameras had optical access via the wind tunnel walls. The traverse and the model in the wind tunnel were moved simultaneously. So it was possible to measure several angles of attack with one calibration.



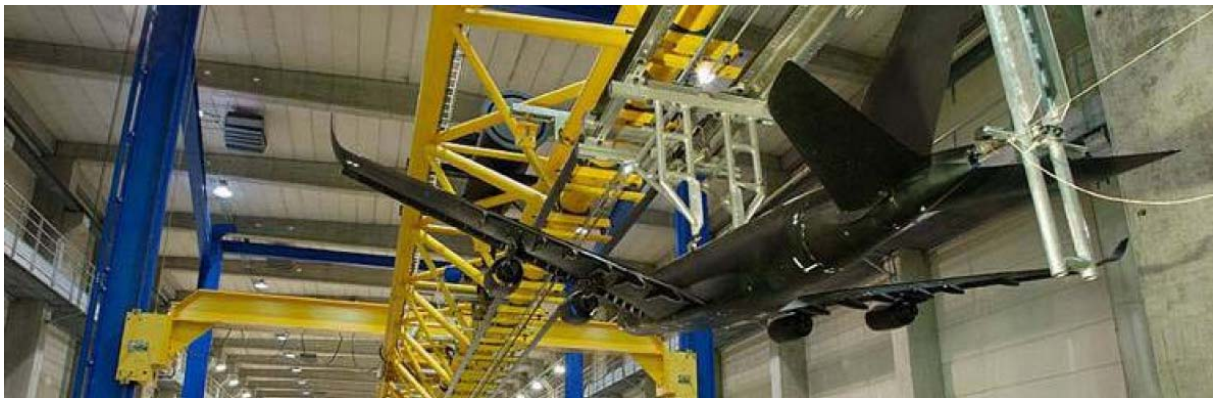
Velocity fields at 5 different cross-flow planes over the high-lift wing with strake deployed

## PIV Technique for the Investigation of Wake Vortices

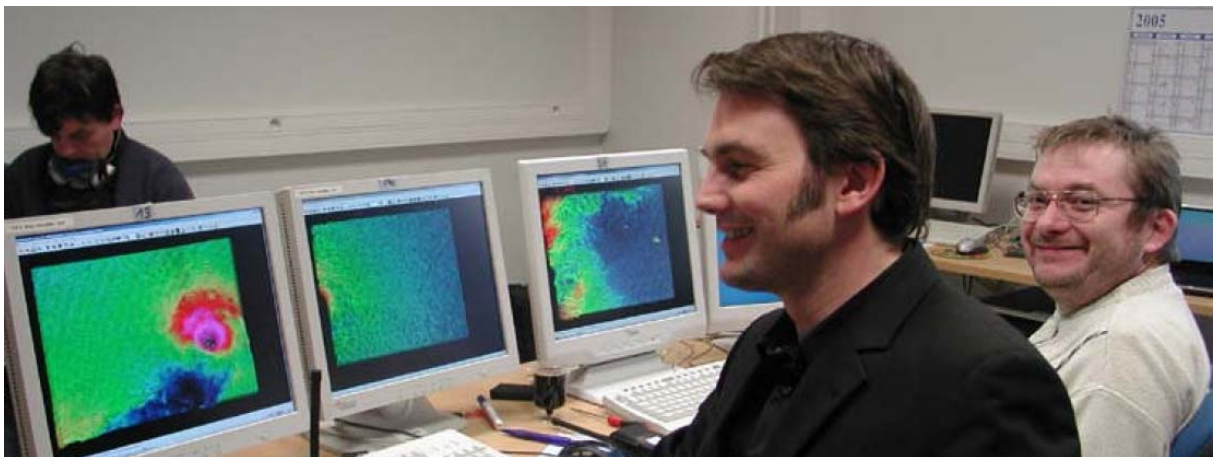
Location: Lille, France, 23.-24.02.2005  
Organizing partner: ONERA

During this workshop, the presentation of PIV in the ONERA B20 new catapult facility has been performed in Lille. This PIV presentation has taken place during an AWIATOR test campaign. AWIATOR is a European project which was launched to improve the understanding of characterization and control of wake vortices behind large aircraft in landing configuration. ONERA and DLR perform the PIV measurements.

Catapult tunnels or water towing tank, which are used for wake vortex investigations for large aircraft, impose special technical problems on the application of PIV, due to the "single-shot" character of the measurement. Solutions for these problems have been shown during a presentation of the PIV technique. Such a facility allows studying the trajectory, interaction and decay of the vortices originated by the plane. The objective is to disseminate condensed information to industrial end users on such topics. The industrial partners will comment on this and discuss their needs. Contacts have been established between developers of the new technique and the co-coordinators of GROWTH projects in order to be able to prepare new proposals for the next framework program.



Aircraft model ready for deployment in the ONERA free flight test laboratory B20 in Lille.



Specialists of DLR, demonstrating results of a dedicated PIV measurement to capture the wake vortex structure behind the model aircraft.

## **Joint PivNet 2 / ERCOFTAC International Workshop on $\mu$ PIV and Applications in Microsystems**

Location: Delft, The Netherlands, 07.-08.04.2005

Organizing partner: TU Delft

In April 2005 we organized for the first time a workshop on  $\mu$ PIV and applications in Microsystems at the Delft University of Technology. The event was organized as a joint PivNet 2 and ERCOFTAC workshop. PivNet 2 is an EC thematic network - A European collaboration on development, quality assessment, and standardization of Particle Image Velocimetry for industrial applications. The workshop was financially and logistically supported by the Dutch Pilot Centre - J.M. Burgers Centre, the Delft University of Technology and Springer Publishing.

The workshop addressed researchers and developers from industry, research organizations and universities. With 90 participants, 5 keynote lecturers and 25 oral presentations the meeting was one of the most successful PivNet 2 workshops. Most of the participants (35) came from the Netherlands and 23 participants came from Germany. Other participants came from the USA (8), France (6), Denmark (5), United Kingdom (3), Belgium (2) and Japan (2). There was one participant each from Ireland, Israel, Italy, Norway, Poland and Spain.

4 companies from Germany (2) and Denmark (2) manufacturing  $\mu$ PIV systems showed and demonstrated their equipment in live microfluidics experiments.

Microfluidics is a rather young field in fluid mechanics, but it is one of the fastest growing areas. The large number of participants shows that microfluidics is a "hot topic". This workshop concentrated on the measurement technique micro Particle Image Velocimetry ( $\mu$ PIV) as well as microfluidics applications involving optical flow measurement or visualisation techniques.

Five world-class keynote lecturers made this workshop attractive. The keynote lectures and the title of their talks are as follows:

S. Wereley, Purdue University, USA

M. Yoda, G. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, USA

Y. Garini, Imaging Science and Technology, Delft Univ. of Technology, Netherlands

K.D. Kihm, University of Tennessee, USA

Prof. C. Meinhart, University of California, UCSB, USA

Optimum particle size and correlation strategy for sub-micron spatial resolution  
Twenty-five oral presentations were given by researchers all over Europe. Some of the presentations dealt with the development of  $\mu$ PIV techniques, e.g. holographic  $\mu$ PIV, stereoscopic  $\mu$ PIV and single-pixel resolution PIV, other talks addressed electroosmosis, mixing, separation, filtration, two-phase flow, and heat transfer at micro scale. The speakers presented applications in the area of life science, pharmaceutical, biological and medical research, DNA analysis, chemical engineering, oil industry and thermodynamics.

Short summaries of the presentations are published in a book of abstracts. The book of abstracts is available in pdf format.

More detailed information about the workshop can be requested from Dr. Ralph Lindken, Laboratory for Aero- and Hydrodynamics, Delft University of Technology, Leeghwaterstraat 21, The Netherlands, Tel +31-15-278 29 91, Fax +31-15-278 29 47 r.lindken@wbmt.tudelft.nl Information about the workshop may also be found in the World Wide Web at <http://www.ahd.tudelft.nl/~mpiv/>

## Joint EWA / PivNet 2 Workshop on CFD, PIV and Experiments in Aerodynamics

Location: Göttingen, Germany, 10.-11.05.2005  
Organizing partner: DLR

The aim of this workshop was to support the exchange of knowledge between those scientists and end-users utilizing experimental data for validation or calibration of their numerical methods and those experimentalists who perform or have performed experiments in aerodynamics. This workshop primarily addressed the Particle Image Velocimetry technique, where the cooperation between CFD- and PIV-specialists is most advanced. The workshop provided an excellent opportunity for scientists and managers from European industry to participate in the discussion between experts in the fields of both numerical methods and experimental measurement techniques on problems encountered in the interaction of these fields. The workshop should help to stimulate advanced ways of approaching future aerodynamic studies.

Investigations in the field of aerodynamics often require huge data sets with high spatial and temporal resolution. Optical field measurement methods like PIV, DGV or PSP reach a relatively high spatial resolution in one plane of the flow or on the model surface, respectively. Today new camera and laser techniques are capable to enhance also the temporal resolution significantly. On the other hand CFD developers push the borders of their computers when they adapt the spatial and temporal grid resolution to a given flow in order to capture all important flow characteristics. For high Reynolds number flows CFD is often sensitive to the in-flow and boundary conditions and needs to be validated with regard to e.g. turbulence models of the flow. Experiments, especially non-intrusive field measurement techniques can give parts of the desired information about the flow conditions.

To continue this process future workshops are planned in the framework of EWA in order to provide a forum for discussions on the analysis and interpretation of results in aerodynamic studies using either each or combined CFD and PIV or other experimental methods. As none of the techniques can compete or displace the other honestly due to the different modeling processes a closer cooperation is demanded as a better physical insight into complex flow phenomena would positively influence the design capabilities of modern aircrafts at the European aviation industry.



Participants of the workshop during stimulating discussions in the DLR\_Schol\_Lab.