

# Newsletter n°1

August 2003

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

Coordinator: Dr. Jürgen Kompenhans  
Deutsches Zentrum für Luft- und Raumfahrt e.V.  
Bunsenstraße 10  
37073 Göttingen - Germany

Tel: +49 551 709 2460  
Fax: +49 551 709 2830  
e-mail: [juergen.kompenhans@dlr.de](mailto:juergen.kompenhans@dlr.de)  
<http://pivnet.dlr.de/Partners>  
[pivnet@dlr.de](mailto:pivnet@dlr.de)

### **Objectives**

Particle Image Velocimetry (PIV) is a unique optical non intrusive experimental method to capture whole velocity fields in flows, in a very short time. PIV is especially suited to help the design of modern aircraft by improving consequently the performance of industrial wind tunnels. PIV provides much more quantitative information in much less time than any other experimental technique, giving a deeper insight in the flow physics and saving large amounts of wind tunnel costs. The knowledge about the state-of-the art of the PIV technique in aeronautics has been widely disseminated by the previous Thematic Network, PivNet 1 (1997 - 2001). The main activities of PivNet have been: establishing an information base on PIV, organization of workshops and presentations of the PIV technique for industrial end-users, training and exchange of personnel, and formation and organization of an ERCOFTAC Special Interest Group on PIV (SIG32).

The main benefit of the PivNet 2 network will be at an industrial level. Now, not just the general features of PIV shall be demonstrated like in PivNet 1, but - looking from the point of view of a specific problem of great industrial and economical interest, which must be solved, the state-of-the art of the application of PIV in complex flow fields shall be presented. Then, having the knowledge about specific tools which allow a better insight in the flow characteristics of critical regions, the designers will be in a better position to plan investigations of complex flow fields, the results of which will allow to develop aircraft and engines with enhanced performances and in a shorter time. This is the reason why the leading European teams in the field of PIV together with end users representative for different industrial applications as well as for geographical distribution in Europe have formed the PivNet 2 membership to combine their efforts and knowledge to strengthen a very successful networking activity.

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.

## Participating Partners

The membership of PivNet 2 consists of 38 partners of 14 European countries: Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Poland, Portugal, Spain, Sweden, Switzerland and United Kingdom. Among these partners are 13 industrial partners including 6 SMEs, who mainly manufacture PIV systems. The industrials come from aeronautic industry, car industry and turbomachinery industry. Five EREA partners, who perform most of the PIV measurements in GROWTH projects together with those European wind tunnels, offering PIV measurements, are part of the PivNet 2 network. The PivNet 2 membership is composed of:

**Deutsches Zentrum für Luft- und Raumfahrt e.V.**, Germany \* **Laboratoire de Mécanique de Lille (CNRS)**, France \* **Airbus Deutschland GmbH**, Germany \* **Von Karman Institute for Fluid Dynamics**, Belgium \* **Technische Universiteit Delft**, Netherlands \* **Industrie Pininfarina s.p.a.**, Italy \* **Office National d'Études et de Recherches Aérospatiales**, France \* **Istituto Nazionale per Studi ed Esperienze di Architettura Navale**, Italy \* **German-Dutch Wind Tunnels**, Netherlands \* **Centro Italiano Ricerche Aerospaziali ScpA**, Italy \* **Volkswagen AG**, Germany \* **Nationaal Lucht- en Ruimtevaartlaboratorium**, Netherlands \* **LaVision GmbH**, Germany \* **Intelligent Laser Applications GmbH**, Germany \* **Università degli Studi di Ancona**, Italy \* **Finmeccanica S.p.A. - Alenia Aeronautica**, Italy \* **Dassault Aviation SA**, France \* **Eurocopter Deutschland GmbH**, Germany \* **Rolls-Royce Deutschland Ltd & Co KG**, Germany \* **Dantec Dynamics A/S**, Denmark \* **Polish Academy of Sciences**, Poland \* **Swedish Defence Research Agency**, Sweden \* **Technische Universität Graz**, Austria \* **Università di Roma 'La Sapienza'**, Italy \* **Politecnico di Torino**, Italy \* **Rheinisch Westfälische Technische Hochschule Aachen**, Germany \* **Universidad de Zaragoza**, Spain \* **Universität Stuttgart**, Germany \* **Carl-von-Ossietzky Universität Oldenburg**, Germany \* **The University of Edinburgh**, United Kingdom \* **National University of Ireland, Galway**, Ireland \* **Lund University / Lund Institute of Technology**, Sweden \* **Instituto Superior Tecnico**, Portugal \* **Université de Rouen**, France \* **Technische Universität Berlin**, Germany \* **Universidad Carlos III de Madrid**, Spain \* **HARDsoft Microprocessor Systems**, Poland \* **RUAG Aerospace**, Switzerland

Network activities are jointly managed by the steering committee which is composed of: **Deutsches Zentrum für Luft- und Raumfahrt e.V.**, Germany \* **Laboratoire de Mécanique de Lille (CNRS)**, France \* **Airbus Deutschland GmbH**, Germany \* **Von Karman Institute for Fluid Dynamics**, Belgium \* **Technische Universiteit Delft**, Netherlands.

## Work Programme

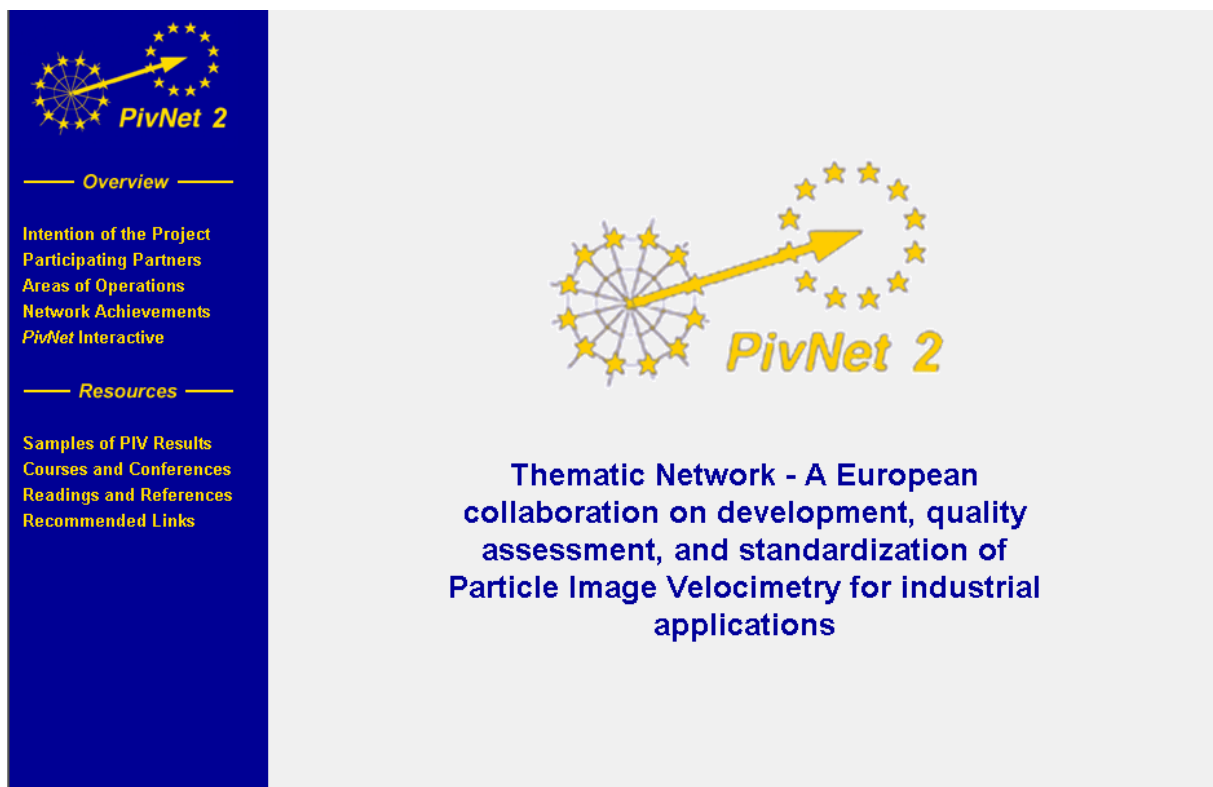
Activities within the network are organized in 6 workpackages. Workpackage 1 serves the needs of all coordination activities and general networking. Based on the knowledge of the partners, a knowledge base will be established and made available via internet. Each partner will act as gateway into and out of PivNet with his special main area of interest (PIV development, application, end-user interest, link to other GROWTH projects and networks, link to areas of industrial research, link to national or international organizations) in order to disseminate and collect information as quickly as possible. Workshops and presentations of the PIV technique in special test facilities and for complex applications are performed in workpackages 2 and 3. Working groups on PIV evaluation for industrial needs including recommendations for best practice or best solution, standardization of PIV equipment and quality assessment is organized within workpackage 4. Workpackage 5 deals with new applications of the PIV technique either in specialized fields of aeronautics or outside

aeronautics, and interaction with SME's by offering training and consulting by PIV experts. In workpackage 6 the networking activities mainly with university partners and industrials outside aeronautics in Europe, not being member of PivNet 2, are organized as ERCOFTAC Special Interest Group, but also international contacts will be followed with researchers from the US and Japan.

PivNet's main outputs comprise the operation of a European wide knowledge base on PIV development and application in different areas of industrial interest accessible by internet, the organization of presentations and workshops for industrial end users, the formation of working groups on standards and quality assessment of the PIV technique for use in industry and the stimulation of the interest in PIV for SMEs and to applications outside aeronautics.

## **PivNet 2 Website – Partners Web & Public Web**

New web-sites for PivNet 2 have been established. The public website <http://pivnet.dlr.de> comprises general information about PivNet 2, its intentions, participating partners, areas of operation, network achievements, links to the task managers as main representatives of PivNet 2 work etc. In addition, samples of PIV results, information about courses and conferences, suggested readings and references to PIV development and application, and a collection of recommended links (EC, Thematic Networks and projects, PIV related web sites, technical information) have been added.



The image shows a screenshot of the PivNet 2 website. On the left is a dark blue sidebar with the PivNet 2 logo at the top, which consists of a yellow arrow pointing right through a circle of yellow stars. Below the logo, the text "PivNet 2" is written in yellow. The sidebar contains two sections: "Overview" and "Resources", each with a list of links in yellow text. The main content area is light gray and features a larger version of the PivNet 2 logo. Below the logo, the text "Thematic Network - A European collaboration on development, quality assessment, and standardization of Particle Image Velocimetry for industrial applications" is displayed in blue.

**Overview**

- Intention of the Project
- Participating Partners
- Areas of Operations
- Network Achievements
- PivNet Interactive

**Resources**

- Samples of PIV Results
- Courses and Conferences
- Readings and References
- Recommended Links

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

Entry page of the Public Web which gives general insight and points of contact for PivNet 2 activities

While the Public Web gives a general overview on PivNet 2 activities and mainly is a pure information server, the password protected Partners Web <http://pivnet.dlr.de/Partners> has been designed for an interactive platform to substantially support network activities amongst partners. It is expected that this web site will be a focal point for information exchange and administrative work during the next years. This web contains all deliverables in electronic format, minutes, information contributed by the partners, information about their gateway

**Welcome & News**

---

**Mr. Holger Frahnert** last on **2003-08-26 11:59:50** from host **129.247.90.196**

---

The retrieval of submitted and approved deliverables is now possible for all partners by means of the **PivNet2 Knowledge Base**. Information can be accessed either by a keyword search or by selection of a specific task from the work program. Also free contributions, which are not an official deliverable but which might be of interest to the community are part of the knowledge base and can be found with a keyword search.

Free contributions can be submitted through the **PivNet2 Contributions** interface. It is possible to supply any pdf-document, an interesting web-link or simply a message to the news board. Free contributions can be revised or deleted at any time by the originator and the Local Executive Officer. However, please do not submit official deliverables from the project plan through this interface. They must be uploaded by means of the "Upload of Deliverables" - section only. The Local Executive Officer has access to this functionality.

For announcement to the community, the "Top 5" of latest contributions are always listed below. The attached document is linked with the headline of each dataset. Contact information for quick response is behind the originators name.

**Check it out!**

Try to make free contributions, your latest papers or presentations for example, by means of the **PivNet2 Contributions** interface. If you don't like the result, it is possible to delete the upload immediately. So it is worth a trial. If you like the result, it will be of value to all other partners.  
DLR - Mr. Holger Frahnert / 2003-08-11

---

**New contributions to the PivNet2 Knowledge Base**

---

**EC web site on aviation and space research**  
This website provides news and information on Aeronautics activities within the 'Aeronautics and space'

Personalized welcome page of the PivNet 2 Partners Web with new contributions from partners

activities and other relevant information. All documents are made available in the common framework of the PivNet 2 Knowledge Base which is accessible by a keyword search and systematic browsing by means of the specific project tasks. Documents collected within the Partners Web shall be made available on the public site six months after submission. The Partners Web is jointly updated and administrated the technical responsible at each partners sites. As the PivNet 2 Partners Web contains some new features to facilitate the administration of the network, its functionalities shall be briefly described here:

**PivNet 2**

---

**Partners Web**

Welcome & News **1**

PivNet2 Knowledge Base **2**

PivNet2 Contributions **3**

Contributors Guide **4**

List of Members **5**

---

**LEO's only**

Upload of Deliverables **6**

Registration of Members **7**

Letter of 18.07.2003

---

**Your Login**

Security & Password  
Logout

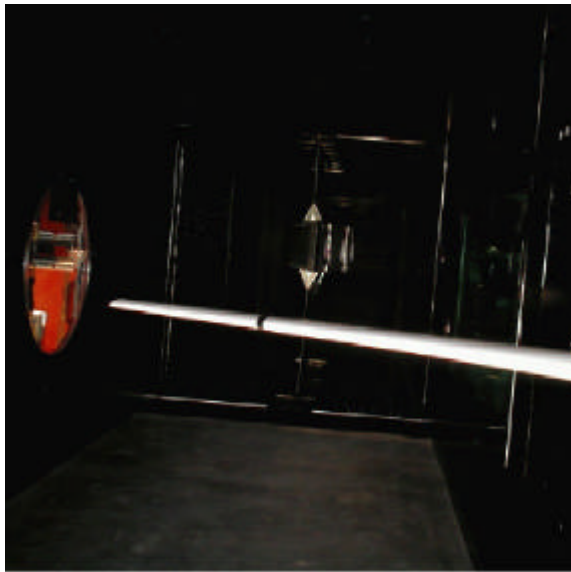
- 1) A personalized welcome page displays news from the coordinator, announcements of forthcoming workshops and administrative details. Also, new entries to the Knowledge Base are listed here.
- 2) The PivNet 2 Knowledge Base contains all contributions by Partners and allows for a systematic retrieval of deliverables. It is the actual backbone of this Partners Web.
- 3) Free contributions can be made by all registered members. This can be a document in pdf-format, a http-link or simply a message to the news-board. All registered members are encouraged to contribute information that is potentially to the benefit of all partners within PivNet.
- 4) The Contributors guide gives some guidelines for usage of the Partners Web and contains templates for official deliverables.
- 5) Contact details of all registered members are made available within the Partners Web. The section "Leo's only" is available to the technical responsible at each partners site only. It supplies functionality to
- 6) upload official deliverables to the PivNet 2 server. Behind this link is a schedule that is specific for each partner and allows for easy recognition of deadlines.
- 7) Registration of new members to the Partners Web as well as update of contact details can be accomplished by each technical responsible in the scope of its own institution.

## Presentation and Workshop: Application of Particle Image Velocimetry in large transonic wind tunnels

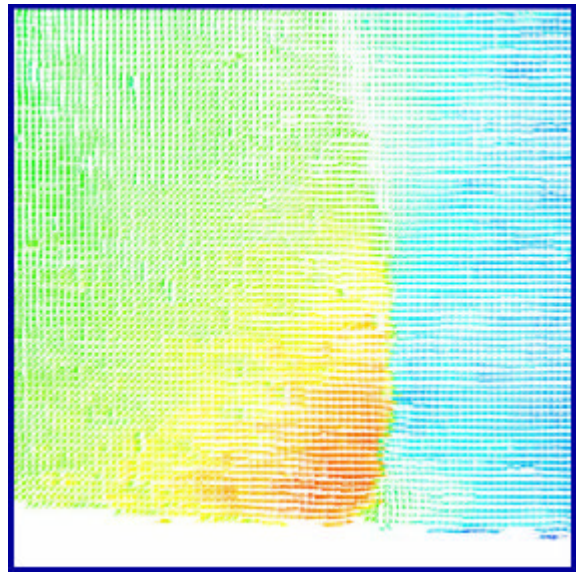
Location: Göttingen, 13.06.02

Organizing Committee: K. Pengel, DNW; M. Jacobs, DNW, G. Dietz, DLR

Connected to the kick-off meeting of the thematic network PivNet 2 a presentation and workshop on the utilization of Particle Image Velocimetry (PIV) for the investigation of transonic flows has been held at the Transonic Wind Tunnel (TWG), Göttingen. To carry forward the intention of the former network PivNet, the European collaboration on the development, quality assessment and standardization of Particle Image Velocimetry for industrial applications is vitalized by a series of thematic workshops and presentations.



Set-up for flow investigation in cross-section of an airfoil in the Transonic Wind Tunnel (TWG)



Instantaneous velocity vector field at Mach 0.86 with supersonic flow region and shock-front

During the last years, substantial progress has been made in the development and implementation of reliable, modular PIV systems for use in low speed wind tunnels. However, the successful application of PIV to transonic flows still demands both a sound standing expert knowledge and experience. With high flow velocities for example, seeding particles need to be of small and predictable size to ensure an acceptable velocity lag across shock-fronts. Additional requisites on image recording and evaluation techniques are then posed by the decreased scatter intensity of small tracers. A further challenge is the limited optical access to the test section of a transonic wind tunnel and the exclusion from direct manual interference to the experimental set-up during a measurement. This calls for compact, reliable and remotely controlled equipment and expertise in its assembly.

As this presentation was the first within PivNet 2 a wider prospect to the interconnection of Particle Image Velocimetry with other techniques has been given: pressure measurements by means of Pressure Sensitive Paint (PSP) and field measurements of density gradients by means of Background Oriented Schlieren (BOS). This holds the potential of data acquisition in a resolution and accuracy as required for quantitative comparison with numerical calculations and for the demanding problems of high-speed flow about complex geometries. The detection of model deformations under aerodynamic force load in transonic flows was discussed in a talk on the Moiré-Technique.

41 participants from 11 different European countries attended workshop and presentation. Participants came from industry (6), research organizations (24), and universities (11).

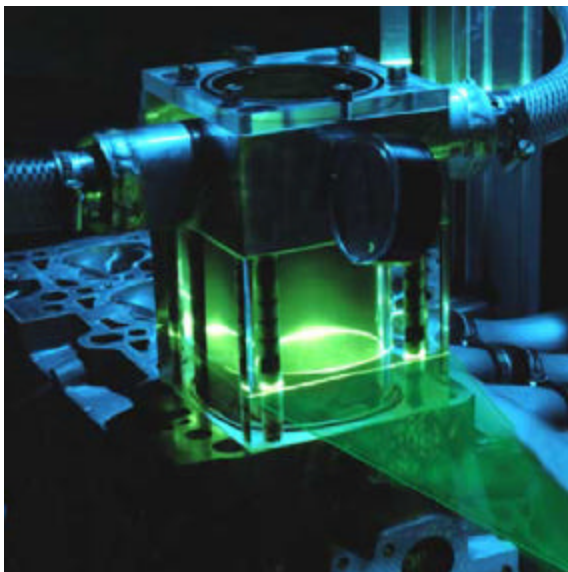


## Presentation and Workshop: Status, current developments and future trends for PIV applications in internal combustion engines

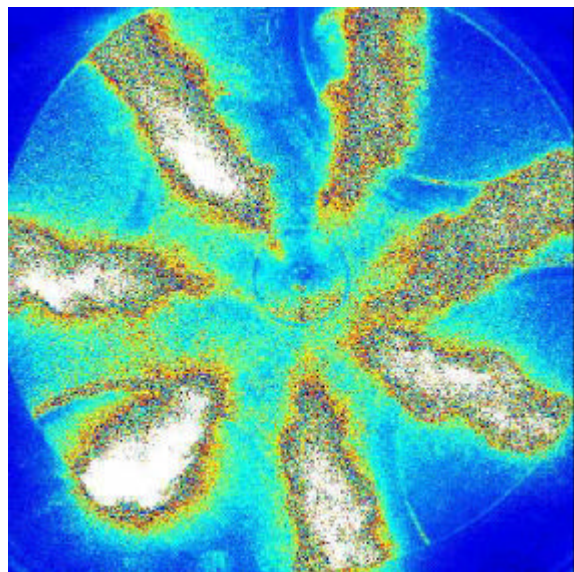
Location: Göttingen, 07.11.02; Wolfsburg 08.11.02

Organizing Committee: V. Beushausen, LLG; J. Scholz, LLG; W. Hentschel, VW

The objective of this presentation and workshop was the exchange of know-how between researchers and industrial partners on PIV and other optical techniques for the analysis of in-cylinder flows and fuel sprays in internal combustion engines. Since more and more attention is paid to the development of car engines with low pollutant emissions and low fuel consumption car manufacturers need to attend to the difficult topic of the flow field inside the cylinder of car engines in order to better understand the in-cylinder processes. Especially the temporal development of the flow during the engine cycle and the interaction of the in-cylinder air flow with the fast penetrating fuel spray are of major concern for development engineers and process simulation.



Analysis of in-cylinder intake flows in a steady-state water analogue test rig



PIV image of dense fuel spray pattern during fuel injection

The presentation of PIV and other optical diagnostic techniques in fuel sprays and internal combustion engines were performed at the Laser-Laboratorium Goettingen e.V. (LLG) as well as with Volkswagen AG Wolfsburg. While in the LLG mainly latest developments concerning new optical measurement techniques for fuel-sprays and mixture formation processes were demonstrated, the presentation with Volkswagen AG dealt with R&D-applications of PIV in combination with other optical diagnostic techniques to research engines.

37 people from 8 different European countries attended the workshop. All in all, 10 high quality talks were presented at the first workshop day concerning "status, current developments and future trends for PIV applications in internal combustion engines". The main topic at the second day was the presentation of optical diagnostic techniques at research engines with the Volkswagen R&D Centre at Wolfsburg.

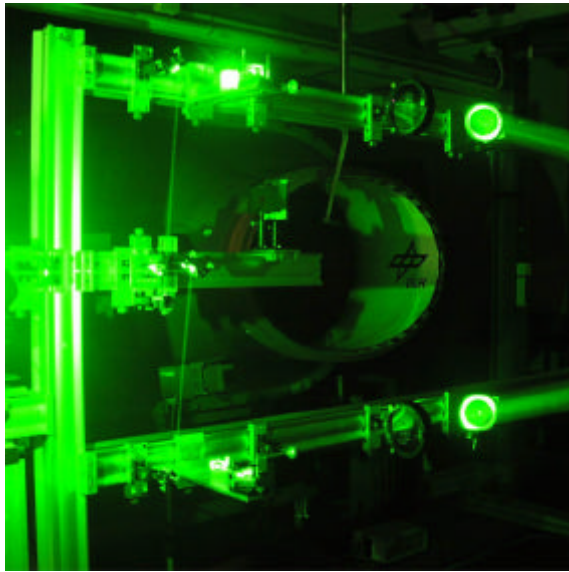
This workshop and presentation provided a unique opportunity to gain insight into current engine research activities of a leading German car manufacturer in collaboration with a research lab. Participants obtained a first hand impression of state of the art applications of PIV and its combination with other optical diagnostic techniques for in-cylinder analysis.

## International Workshop on Holographic Metrology in Fluid Mechanics

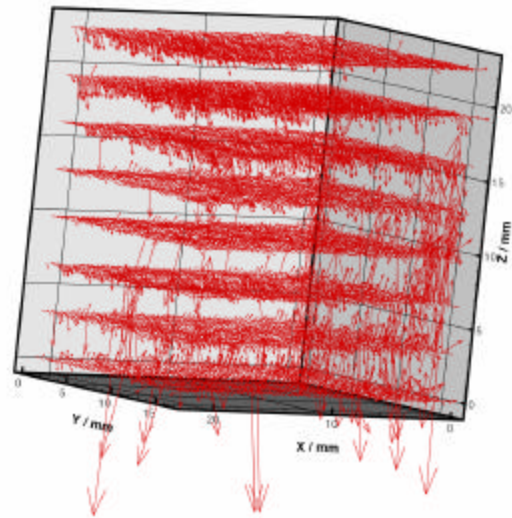
Location: Loughborough, UK, 28-30.05.03

Organizing Committee: S. Herrmann, Uni Oldenburg; N. Halliwell, Loughborough University

Holography is the only technique which can provide an instantaneous image of objects in an extended volume. Consequently, it was proposed and demonstrated to use holography for the extension of planar flow measurement techniques - like particle image velocimetry (PIV) - to measure in three dimensions simultaneously. Nowadays progress in the development of computers and imaging sensors, as well as development of alternative recording media encourage the vision that three-dimensional flow mapping may provide an advance similar to PIV. Clearly, this potential can be revealed only if holographic measurement systems are available as a fully digital and considerably fast technique.



Beam delivery for holographic recording of the wake vortices on an airfoil in a 1-m wind tunnel



16.640 vectors have been obtained by three-dimensional grey value correlation

Today's research on Holographic Particle Image Velocimetry (HPIV) is focused on two main approaches: Firstly resolution and accuracy are still increasing and some very impressive results have been obtained still using conventional holography. Secondly the digital version of holography is realized with more and more advanced algorithms and velocity measurements become feasible. Yet, both approaches still have many drawbacks. Conventional holography suffers from complexity of the setups and cumbersome chemical development. Digital solutions are mainly restricted by the resolution of the sensors.

The aim of this workshop was to bring together those researchers active in this field to provide a detailed overview of existent techniques, to discuss common problems, stimulate exchange of knowledge and to formulate a roadmap for future activities.

With substantial funding from a UK platform grant the participation at the three-day workshop was essentially free of charge. The financial contribution from the PivNet2 program did allow to invite three well known researchers (Prof. Joseph Katz / Baltimore, US, Prof. Hui Meng / Buffalo, US and Prof. Hans Bjelkhagen / Leicester, UK) to participate at the workshop, each presenting a keynote lecture. Furthermore, two researchers (Dr. Donald Barnhart / Urbana, US and Prof. I. Shimizu / Ibaraki, Japan) have been invited directly, each by a research group expressing their specific interest in holographic measurement techniques (TU Delft, Prof. Jerry Westerweel and Tokyo University, Prof. Koji Okamoto). In total 30 participants (see attached list) have contributed to the success of the workshop.