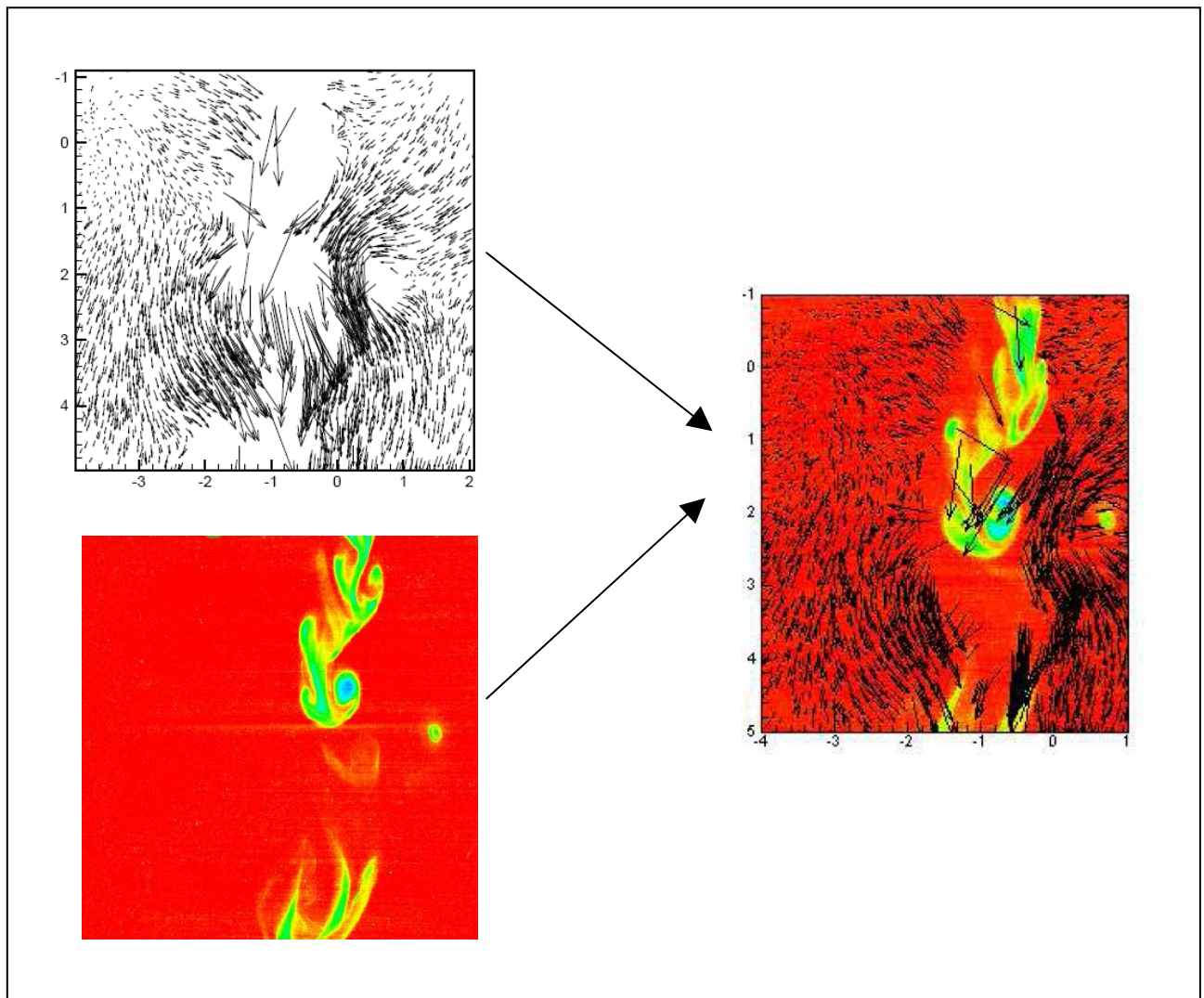


J.M. BURGERSCENTRUM

National research school for fluid mechanics

Application for re-accreditation 2007-2013

Research School Accreditation Committee (KNAW-ECOS)





The saddest news came to us on 18 May 2005, when professor Frans Nieuwstadt died suddenly at the age of 59. Frans was professor at Delft since 1986, and chairman of the Executive Board of FOM. His contribution to fluid mechanics in The Netherlands, and to the field of turbulence research in particular, was extremely large. We experience his passing away as a great loss for science, and for the J.M. Burgerscentrum. We all miss him.

Cover illustration: Combined Planar Temperature/Velocity measurements, L. Thomas, M. Ren, C.C.M. Rindt and A.A. van Steenhoven (TU Eindhoven).

The pictures show results of an experimental method to measure simultaneously velocity and temperature fields. A laser sheet goes through a tank filled with water, seeded with particles (for PTV method (velocity)) and with Rhodamine B fluorescent dye (for LIF method (temperature)). Two cameras are needed: one to measure the light emitted by the fluorescent dye and one to measure the light diffused by the particles. The two light sources are separated using optical filters. When velocity and temperature fields are obtained, the two fields are spatially matched. This is realised by taking images of a grid that is used as a reference.

DATA SHEET

Year of application: 2006, for the period of 1 July 2007 – 1 July 2013

Years in which the previous accreditations have been granted: 2002 1997 1992

Name research school (Dutch): J.M. Burgerscentrum – nationale onderzoekschool op het gebied van de stromingsleer

Name research school (English): J.M. Burgerscentrum – national research school for fluid mechanics

Address research school

Contactperson: Prof.Dr.Ir. G. Ooms, scientific director

Address: Mekelweg 2, 2628 CD Delft

Telephone: 015 – 278 3216

Telefax: 015 – 278 2979

E-mail: g.ooms@wmbt.tudelft.nl

Secretary of the research school: Technische Universiteit Delft

Address of the Secretary:

Contactperson: Prof.dr.s. M. Waas, Dean of the Faculty of Werktuigbouwkunde, Maritieme Techniek and Technische Materiaalwetenschappen

Address: Mekelweg 2, 2628 CD Delft

Telephone: 015 – 278 5401

E-mail: M.Waas@tudelft.nl

Institutes participating in the research school:

1. the Technische Universiteit Delft with the faculties
 - Werktuigbouwkunde, Maritieme Techniek en Technische Materiaalwetenschappen
 - Civiele Techniek en Geowetenschappen
 - Electrotechniek, Wiskunde en Informatica
 - Luchtvaart- en Ruimtevaarttechniek
 - Technische Natuurwetenschappen
2. the Technische Universiteit Eindhoven with the faculties
 - Technische Natuurkunde
 - Werktuigbouwkunde
 - Wiskunde en Informatica
3. the Universiteit Twente with the faculties
 - Technische Natuurwetenschappen
 - Electrotechniek, Wiskunde en Informatica
 - Construerende Technische Wetenschappen
4. the Rijksuniversiteit Groningen with the Faculty of Wiskunde en Natuurwetenschappen
5. the Radboud Universiteit Nijmegen with the Faculty of Natuurwetenschappen, Wiskunde en Informatica
6. the Universiteit Leiden with the Faculty of Wiskunde en Natuurwetenschappen

Industries and technological institutes formally collaborating with the research school:

Formal collaborations with industries and technological institutes are primarily defined on the level of individual projects. Examples of these collaborations are given in Appendix 2. The University of Maryland (UMD) has established the Burgers Program for Fluid Dynamics, coordinated by professor Jan V. Sengers. A description of the Burgers Program and the UMD-JMBC Collaboration can be found in Appendix 3.

EXPLANATION OF ABBREVIATIONS

2D	: Two-dimensional
3TU	: Confederation of the three technical universities Twente, Delft and Eindhoven
BBOS	: Buys Ballot Research School
CalTech	: California Institute of Technology, Pasadena CA
CFD	: Computational Fluid Dynamics
CoE	: Center of Excellence
ECN	: Energy Research Centre of the Netherlands
ECOS	: Research School Accreditation Committee
ERCOFTAC	: European Research Community On Flow, Turbulence And Combustion
EUROMECH	: European Mechanics Society
EZ	: Ministry of Economic Affairs
FOM	: Foundation for Fundamental Research on Matter (NWO Physics)
GTI	: Large Technological Institute (e.g. WL, GeoDelft, NLR, ECN, MARIN)
JMBC	: J.M. Burgerscentrum
KIVI	: Royal Institution of Engineers in the Netherlands
KNAW	: Netherlands Royal Academy of Arts and Sciences
LDA	: Laser Doppler Anemometry
MARIN	: Maritime Research Institute Netherlands
NIZO	: Netherlands Institute for Food Research
NLR	: National Aerospace laboratory
NMC	: Netherlands Mechanics Committee
NWO	: Netherlands Organisation for Scientific Research
OSPT	: Research School for Process Technology
OTP	: Open Technology Programme of STW
PGEF	: Platform for Physics of Geophysical and Environmental Flow
PIV	: Particle Image Velocimetry
RUG	: Rijks University Groningen
RUN	: Radboud University Nijmegen
SIG	: Special Interest Group
STW	: Technology Foundation (=NWO Technology)
TNO	: Netherlands Organisation for Applied Research in the Sciences
TUD	: Technical University Delft
TU/e	: Technical University Eindhoven
UT	: University Twente
UL	: University Leiden
UMD	: University of Maryland
WL	: Waterloopkundig Laboratorium Delft Hydraulics

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1. Mission of the J.M. Burgerscentrum (JMBC)

- Coordination of research and educational programs in fluid mechanics in the Netherlands. It is the ambition to be one of the leading institutes for fluid mechanics in the world.
- Stimulation of the cooperation between research groups with respect to their research efforts.
- Organisation of advanced courses for PhD-students. Researchers from industries and technological institutes also attend these courses.
- Cooperation with industries and technological institutes to promote the mutual exchange of knowledge on fluid mechanics.
- Strengthen the contacts between Dutch fluid mechanics research groups at universities and the international fluid mechanics community.

2. Changes and trends in the years 2002-2006

2.1 General trends

In 2002, the JMBC was re-accredited by the Royal Dutch Academy of Sciences (KNAW) on the basis of an evaluation by an international peer panel. In the executive summary of the report the panel wrote: *"The JMBC lives up against its goals extremely well, and is exemplary for how a wellfunctioning and low-overhead organisation can lift the quality of scientific education and research to an international top level. The panel fully and unanimously recommends reaccreditation by the KNAW for the next period of five years."*

In these five years the role of science in society has changed. Fundamental research as a *l'art pour l'art* is much less obvious, and science is more thematically tuned to economical and societal issues. With science budgets decreasing, 'new' money for science in The Netherlands has come from the Ministry of Economic Affairs, under conditions characterised by public-private consortia, focus and mass, and valorisation. For the field of fluid mechanics, this paradigm shift is not problematic *per se*. Dutch fluid mechanics is a traditionally very strong field but we observe that the international recognition has come from its groundbreaking fundamental contributions to a better understanding of the behaviour of fluids. The Netherlands is one of the leading countries world-wide in that respect.

It is the task of the JMBC to coordinate the shift towards (long-term) application oriented research while preserving the scientific quality and international standing of the field. Two-way structural ties with industries and technological institutes on and above program level have therefore been strengthened in the past period. The JMBC has stimulated nation-wide thematic discussions, streamlined research strategies and has organised workshops for representatives from industry, technological institutes and projectleaders to discuss the needs of industries with respect to scientific research.

The leading role of Dutch fluid mechanics is acknowledged in the new 3TU confederation of the three technical universities (TUD, TU/e, UT) in which the JMBC (together with Engineering Mechanics, the national research school for solid mechanics) acts as a Centre of Competence. The top groups in the JMBC take the lead in a so-called Centre of Excellence (CoE), thematically centred around the challenging topic of *multiscale phenomena*. The ambition is to solve a number of major problems both on the fundamental and the application side, thereby being recognised as a leading center in this area on a world-wide scale and contributing in a major way to the Dutch industry and society. In this way, we will achieve a better understanding of the macroscopic behaviour of fluids on the basis of the underlying structure and forces on smaller (e.g. microscopic) scales.

This requires a combined effort of experimental, theoretical, and numerical techniques, and an increasing interaction between these approaches is foreseen within the CoE. The 3TU confederation, the Centre of Competence and the Centre of Excellence will stimulate new developments in research as well as in the educational/courses programme.

2.2 Changes and trends in the educational/courses programme

The JMBC course programs are a continuing success thanks to the enthusiasm of the organisers and teaching staff. Our PhD-students show a great interest in the courses and also staff members from industries and technological institutes participate.

The programme contains courses for the MSc degree, as well as PhD degree courses. The MSc degree courses are intended for PhD students (or other interested persons), who have had no earlier formal training in fluid mechanics. The courses will bring those PhD students to the same level of knowledge in fluid mechanics as PhD students who did receive their MSc degree in fluid mechanics.

The purpose of the PhD programme is to provide a framework for the development of PhD students into independent researchers in the field of fluid mechanics. Each of the PhD degree courses are usually given once every two years by senior staff members of the JMBC, but also by other internationally renowned (guest) lecturers. All PhD students are advised to participate in the workshops, summer schools and seminars that are organised on a less regular basis. Also the courses organised by affiliated organisations (Von Karman Institute, ERCOFTAC, EUROMECH) are highly recommended.

The topics and contents of the courses follow the research trends. In recent years, courses on the physics of granular matter, geophysical fluid dynamics and 2D turbulence have been added to the programme. Courses on experimental methods and CFD have been taught as well as in-depth courses on *specific* techniques such as LDA, perturbation techniques and lattice-Boltzmann schemes. In 2004/05 a new course on biological fluid mechanics was given. Furthermore, despite decreasing research efforts, we maintained our course in polymer melt rheology because of the industrial relevance.

2.3 Changes and trends in the research programme

2.3.1 Organisation and positions

Presently, 39 full chairs participate in the JMBC, including 250 PhD students. The total annual input in permanent scientific staff amounts to about 60 fte. Close contact to industry and technological institutes is guaranteed through the JMBC's Industrial Advisory Board and Programme Committee.

In order to further strengthen its international position, so-called *Burgers professorships* have been the prominent tool of the JMBC already since 1998. The goal of these professorships is the direct involvement of world-leading scientists in specific key areas of the scientific programme. Prominent examples of Burgers Professors are Professor Günther Schnerr (Munich/ECN/UT), Professor Andrea Prosperetti (Johns-Hopkins/UT), and Professor Julian Hunt (Imperial College/TUD). In the past period Professor John Brady (CalTech) was appointed as Burgers Professor at Twente and, as recently as 2005, professor Marcus Aldén (Lund) was appointed as Burgers Professor at TU/e.

In the future, in contrast to these examples, the new Burgers professors will be appointed from the 3TU confederation and will therefore spend part of their time at *each* 3TU location, thus fostering the exchange and collaboration between the 3 TUs in the field of fluid mechanics. In the context of the 3TU confederation, five new chairs will be established from the extra funding for the CoE:

- Computational multiscale turbulence dynamics (TUD)
- Reliability of structures and processes (TUD)
- Computational physics of multi-scale transport phenomena (TU/e)
- Small-scale structural dynamics (TU/e)
- Mechanics of interaction phenomena at multiple scales (UT)

A cooperation with the Burgers Program of the University of Maryland (UMD) has been set up (see also Appendix 3). UMD has a strong history in fluid mechanics and via the Burgers Program it strives to emphasise its interest in this field of science. The JMBC wants to develop a close connection between the scientific staff of the JMBC and the staff belonging to the Burgers Program. The

Burgersdag 2006 was devoted to this cooperation. Exchanges have taken place (see Appendix 3) and more are planned for the near future.

In 2005 the JMBC expanded to Leiden University when the group of Professor Wim van Saarloos joined the research school. New groups from Professor Suzanne Hulscher (UT) and Fons de Waele (TU/e) joined the JMBC in that same year.

2.3.2 Developments in research programme since the previous evaluation

In the previous self-assessment report, the main themes in the research programme 2003-2007 were:

1. Complex dynamics of fluids
2. Complex structures of fluids
3. Mathematical and computational methods for fluid flow analysis

As emerging fields in the research programme were identified:

- I Bio-fluid mechanics
- II Granular matter
- III Measurement techniques
- IV Advanced numerical techniques

I Bio-fluid mechanics

A national JMBC Symposium on bio-fluid mechanics was held on 15 June 2001, at which fifteen presentations were made, and about 100 people from a wide range of institutions attended. A proposal was submitted to FOM to set up a thematic programme in this area. Unfortunately, the programme was not approved and the large-scale efforts planned for bio-fluid mechanics in The Netherlands were not realised. Nevertheless, various interesting projects have arisen from collaborations between fluid mechanics researchers and biologists or medical researchers. The group of Professor Anton van Steenhoven in Eindhoven is particularly active in the field of bio-heat transfer. In 2003 Van Steenhoven was appointed part-time professor of bio-heat transfer in the department of Bio-Medical Engineering. In Delft, the group of Jerry Westerweel performs PIV measurements of microcirculations in chicken embryo hearts. This latter research is carried out in close collaboration with medical groups from the Leiden and Rotterdam universities. Other examples can be found in the Annual Reports. Due to the sudden decrease in 2004 for funding of fundamental research by FOM, we expect that it will not be possible in the near future to set up an extensive thematic research programme in bio-fluid mechanics in The Netherlands.

II Granular matter

During the panel evaluation in 2001, this topic was still limited to only a small number of projects. It was therefore a great success for the JMBC that a new FOM-programme *Physics of granular matter* was approved in 2003 with a budget of 3.7 million euros over the years 2004-2011 (0.45 M€p.a.), after which the research efforts in this area increased steeply. Programme leader is Detlef Lohse (UT). Goal of the programme is to explore the physics of granular matter as to better understand its behaviour. Research in the programme is focussed into three main themes:

- What are the order parameters that characterise granular matter?
- Which conditions allow a continuous description of granular matter?
- How can statistical fluctuations be characterised?

Flow of and pattern formation in granular matter is also the central theme of the research group in Leiden of Professor Wim van Saarloos, that joined that JMBC in 2005.

III Measurement techniques

The development and sharing of advanced measurement techniques, especially laser-based optical techniques, was described by the review panel in 2001 as “one of the triumphs of the JMBC”. The plan to designate this as a new ‘focal point’ or emerging field was therefore warmly welcomed. A new Contact Group on experimental techniques was initiated in 2002, headed by Michel Versluis (UT), Koen Schreel (TU/e) and Jerry Westerweel (TUD). The Contact Group regularly organises meetings to discuss new developments in the practice of experimenting. The application and understanding of experimental techniques is the main focus of the contact group. Funding for new large investments in

imaging techniques has been granted within the FOM-programmes “Turbulence and its role in energy conversion processes” (for combustion research), “Physics for technology” (for holographic PIV) and “Dispersed multiphase flow”(for diagnostics in bubble columns). The large success of these funding requests is owed to the mutual distribution of tasks, and the concentration of the various technical expertises (“focus and mass”), as discussed in the JMBC Contact Groups.

IV Advanced numerical techniques.

Particle based modelling techniques, such as dissipative particle dynamics and lattice-Boltzmann techniques, have progressed at a fast pace. The rapid further development of new numerical techniques has been a high priority in the past period, and efforts in this field have been substantially reinforced. New courses in the JMBC in these areas have been set up to train talented young researchers in the exciting developments. A highlight was the appointment of Professor John Brady as Burgers Professor in Two-Phase Flow Instabilities at the University Twente. Though being an allround researcher, Brady is especially renowned for his contributions to numerical research, among which Stokesian dynamics, and multiscale physics. Applications of CFD were further strengthened when the Energy Technology section at TUD joined the JMBC in 2003. In the FOM-programme “Turbulence and its role in energy conversion processes” funding for parallel computing facilities opened up new horizons in multiscale modeling of transport of mass and heat in geophysical turbulence. This research will be of utmost importance for large-scale prognostic models in environmental applications. All these developments add up to a substantial reinforcement of the activities in numerical techniques within the JMBC.

2.3.3 Research developments outside the emerging fields

Dispersed multiphase flow

From 1998 on there has been an 8 million Euro programme, jointly financed from FOM, STW, the Ministry of Economic affairs, and Dutch industry (with each one contributing 25% of the total budget). Funding was based on individual proposals, refereed by an international peer panel. The most successful groups in this respect were those of Lohse, Kuipers, Westerweel, van den Akker and Mudde. The mid-term evaluation of this programme in 2003 was very positive. Note that it has not been a problem to get 25% of direct support from industry for the individual projects. The above outlined new detection techniques and the advances in massive parallel computing now offer new opportunities to go much beyond of what already has been achieved. As the current research programme ends in 2007, the JMBC plans to initiate a new programme in the field of dispersed multiphase flow. First talks with STW have already taken place and the feedback has been positive.

Turbulence

Within the FOM working communities “Stroming en Warmte” (until 2001) and “Phenomenological Physics” (2002-present) two turbulence programmes have been financed since 1998 involving in total 4.5 million Euro. The personal programme on “Two-Dimensional Turbulence” (van Heijst) consists of 4 PhD projects and substantial infrastructural support. The mid-term evaluation of this programme was very positive. Funding in the programme “Turbulence and its role in energy conversion processes” was based on individual proposals, refereed by an international peer panel. The groups of Lohse, van der Vegt/Geurts, Westerweel/Ooms, Mudde/van den Akker, van Steenhoven, and van Heijst/Clercx received large subsidies from this programme. New three-dimensional imaging techniques (such as holographic PIV) and parallel computing facilities will open up new horizons. The JMBC has the ambition to initiate new programmes on (geophysical) turbulence (FOM).

Multi-scale analyses

The Technology Foundation STW has already pointed out the importance of multiscale analyses. Indeed, in the Open Technology Programme (OTP), which functions as a radar for emerging technologies and new trends, multiscale methods have been recognised as being a new paradigm in the engineering sciences. Careful numerical work in the group of Kuipers in Twente has been of utmost importance in joining the fundamental model experiments and the engineering practice. Kuipers’ successes in various funding schemes, and the subsequent growing number of projects in his group, has lead to a strong pillar for multi-scale research in The Netherlands.

Multi-scale phenomena in the natural environment

Together with the Buys Ballot research school, the JMBC has been involved in setting up a new platform Physics of Geophysical and Environmental Flow (PGEF). In line with the central theme of the CoE, the JMBC intends to set up a program on the modeling of multi-scale phenomena in the natural environment. Applications include: (a) geophysical forecasting from large to small-scale fluid phenomena and their interactions; (b) coupled chemistry and fluid transport prediction; and (c) complex wave phenomena in fluids, or both fluids and solids. The focus of this initiative will include combinations of analytical and mathematical, (large-scale) numerical, and laboratory modeling.

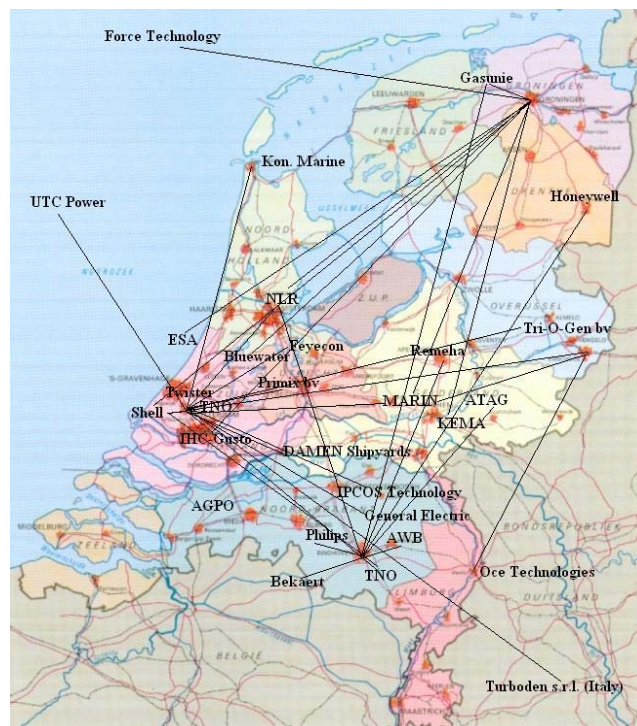
In addition to these research developments the JMBC (together with Engineering Mechanics) plans to submit a Smartmix proposal on multi-scale analysis and phenomena to NWO/SenterNovem in September 2006.

3. Educational programme

After the introduction of the Bachelor-Master system at the Dutch universities, the JMBC has become increasingly involved in education at the MSc level. In recent years new MSc tracks for Fluid Mechanics have been developed at the three technical universities. In the context of the 3TU confederation, a nation-wide two year Master's degree program Fluid and solid mechanics has been designed. The program lasts two years. Each year consists of 60 ECTS (European Credit Transfer System). The program is organised on the basis of a joint curriculum and four specialisations. These are:

- Fluid Dynamics
- Engineering Dynamics
- Mechanics of Materials
- Structural Optimisation & Computational Mechanics

For each of these specialisations the joint curriculum is compulsory and differentiation takes place on the basis of an individual selection of courses. The JMBC courses programme and teaching staff are central to all these tracks. Likewise, MSc students are involved in the research groups and take part of the core research activities at the respective universities.



Examples of industrial collaborations within the JMBC and collaborations with technological institutes. For details, see chapter 5 (Collaborations) and Appendix 2.

4. Board, management and organisation

Except for some personal changes, there has been no major change in the JMBC Board of Directors, the Industrial Advisory Committee nor in the Programme Committee. The group of PhD student representatives and the PhD students Contact group increased in size somewhat, thanks to Leiden University joining the JMBC. The Management Team was decreased in size from five to three members, and now consists of Van Heijst, Lohse and Ooms. The Burgers Program for Fluid Dynamics at the University of Maryland, is coordinated by Professor Jan V. Sengers, distinguished University Professor Emeritus and Research Professor (see Appendix 3).

5. Collaborations

As stated in the mission of the JMBC, the research school strives to stimulate the collaborative research between the participating groups. Examples of mutual projects are given in Appendix 1. Also, cooperation with industries and technological institutes is pursued to promote the use of up-to-date knowledge on fluid mechanics for solving practical problems. Examples of formal contacts between JMBC groups and these external industries and institutes are given in Appendix 2, and shown in the figure at the previous page.

6. Staff members responsible for themes and programmes

The Contact Groups in the JMBC are a forum where senior and junior staff members, as well as PhD students discuss results and trends in their area of expertise. There are Contact Groups on:

- Turbulence, coordinated by Boersma
- Two-phase flows, coordinated by Oliemans
- Computational Fluid Dynamics, coordinated by Wesseling
- Combustion, coordinated by Roekaerts
- Experimental techniques, coordinated by Versluis, Schreel and Westerweel
- Lattice-Boltzmann techniques, coordinated by Derksen
- Micro fluid dynamics, coordinated by Westerweel

The Contact Groups meet once or twice a year at various locations in the country.

Several JMBC staff are responsible for large research programmes, as a programme leader at FOM, NWO, and STW. The FOM-programme ‘Two-dimensional turbulence’ (1998-2007, M€1.0) headed by Van Heijst (TU/e), already existed during the last evaluation in 2001. The FOM/STW/EZ-programme ‘Dispersed multiphase flow’ (2000-2007, M€4.8) was freshly set up. A Programme Committee including several JMBC staff coordinates this program, in which industry funds 25% of the research costs. New programmes since the evaluation in 2001 are:

- FOM-programme ‘Turbulence and its role in energy conversion processes’ (2002-2010, M€3.5), led by Van Steenhoven (TU/e),
- FOM-programme ‘Physics of granular matter’ (2004-2011, M€3.7), led by Lohse (UT),
- NWO/FOM-programme ‘Dynamics of patterns’ (2005-2010, M€0.8), led by Van Saarloos (UL),
- SHELL/FOM-programme ‘The physics of fluids and sound propagation’ (2003-2009, M€2.2), led by a Programme Committee including Van Heijst since 2005 (until 2005: Nieuwstadt).

The FOM Werkgemeenschapscommissie Fenomenologische Fysica, important for research policy issues, includes Van Heijst (TU/e), Lohse (UT), and JMBC Board member Van den Brule (Shell).

7. National position of the research school

The JMBC collaborates closely with the research school Engineering Mechanics in the Center of Excellence of the 3TU confederation. A mutual nation-wide two year MSc programme “Fluid and solid mechanics” is in the stage of preparation, and a joint Smartmix proposal is being developed. Together with the KIVI (Royal Institution of Engineers in the Netherlands) Department of Mechanics and the research school Engineering Mechanics, the JMBC has established the Netherlands Mechanics Committee (NMC) in February 2004. The NMC is a coordinating platform for all scientific and

engineering activities in The Netherlands in the field of fluid and solid mechanics, and proposes the formal representation of the Dutch mechanics community in international organisations. Both research schools exchange information on their scientific and educational programmes and admit each others members to these activities as if they were their own members. The NMC plans to coordinate the activities for the nation-wide MSc program on Fluid and Solid Mechanics. A large fraction of the JMBC groups also are a member of the OSPT, the research school for process technology. OSPT and JMBC share a number of courses, e.g. on particle based modelling. In this way there is a natural interaction between the two research schools.

The JMBC has been involved in setting up a new platform Physics of Geophysical and Environmental Flow (PGEF) together with the Buys Ballot research school (BBOS). BBOS is the research school for the study of fundamental processes in the climate system. JMBC and BBOS will collaborate within the CoE-theme of multi-scale phenomena in the natural environment.

8. International position of the research school

The Dutch Fluid Mechanics is a traditionally very strong field and internationally well recognised. The Netherlands is one of the leading countries world-wide. This is reflected in the high fraction of Dutch articles in the top journals in this field and in the representation of Dutch scientists in the Editorial Boards of these journals and in the Boards of the International Councils in this field. The scope of Dutch Fluid Mechanics is very broad. This holds both contents-wise and method-wise. The employed methods are experimental, theoretical, and numerical, with both fundamental and applied character. Involved university departments include (applied) physics, mechanical engineering, maritime technology, chemical engineering, applied mathematics, civil engineering, aerospace engineering, and biomedical engineering. Contents-wise, Dutch Fluid Mechanics includes turbulence, multi-phase flow, microfluidics, acoustics, biofluidics, combustion, granular flow, fluid-structure interaction, nonlinear and multibody dynamics, geophysically inspired problems, and many other subjects.

The individual groups of the JMBC have active collaboration with research groups in other countries. The multitude of scientific contacts is reflected by many external visitors to the JMBC groups. Likewise, JMBC staff also regularly visit fluid-mechanics groups abroad, and present their work at international conferences.

Various JMBC groups collaborate in projects funded by the EU (Sixth Framework Programme), and participate in European COST actions. The JMBC is the ERCOFTAC Pilot Centre for Fluid Mechanics in The Netherlands. The goal of ERCOFTAC is to promote joint efforts of European research institutes and industries with the object of exchanging technical and scientific information. Out of 24 pan-European Special Interest Groups (SIGs) at ERCOFTAC, 11 have a JMBC staff member either as SIG-coordinator or as member of the group's organising committee.

The new cooperation with the Burgers Program of the University of Maryland will further enhance the role of the JMBC in the field of fluid mechanics on an international scale.

9. Finances

	1 st money stream		2 nd money stream		3 rd money stream		Total	
	Amount in 1000 × €	%	Amount in 1000 × €	%	Amount in 1000 × €	%	Amount in 1000 × €	%
2001	1920	20	5760	59	2160	22	9840	100
2002	1680	13	7440	60	3360	27	12480	100
2003	1680	12	8640	61	3840	27	14160	100
2004	3600	31	5040	44	2880	25	11520	100
2005	2880	32	4560	50	1680	18	9120	100
2006*	960	10	4800	50	3840	40	9600	100

* best estimate November 2006.

The table shows the amount of the three ‘money streams’ in the JMBC. The 1st money stream consists of university funded projects, the 2nd money stream contains projects from FOM, STW and NWO. The 3rd money stream contains projects sponsored by industry, TNO and technological institutes. The numbers have been calculated on the basis of granted projects per year. The average project is assumed to be a four-year PhD project of 60 keuros per year.

Most prominent feature are the successes in 2002 and 2003 in the 2nd money stream, thanks to the large FOM-programmes on dispersed multiphase flow and on turbulence. Also, the contribution from the 1st money stream has been substantially increased from 2004 on.

10. Guarantees for material budgets and personnel

Apart from personnel and material budgets financed by external funding, the participating universities commit themselves to provide the following annual budgets for JMBC research:

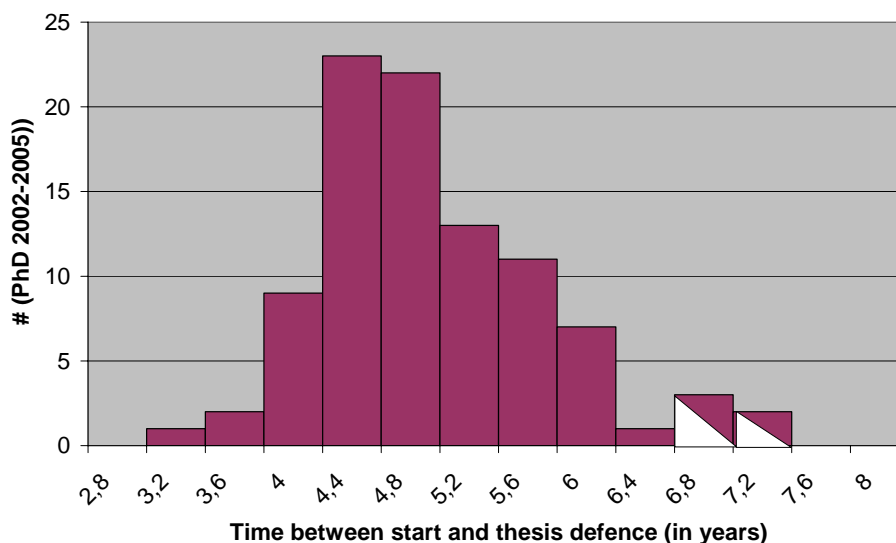
	TUD	TU/e	UT	RUG	RUN	UL	Total
Scientific staff (fte)	26.0	17.0	17.1	2.2	1.0	0.7	64.0
Support staff (fte)	15.4	7.5	4.6	-	1.0	-	28.5
Ph.D. students (fte)	10.0	5.0	10.0	3.0	1.0	0.5	29.5
Material budget/yr (in 1000 × €)	300	200	200	25	25	17	767

For more details we refer to Appendix 4 (Gemeenschappelijke regeling (verlenging) inzake de interuniversitaire onderzoekschool voor stromingsleer het J.M. Burgerscentrum).

11. PhD output and efficiency

In the years 2002-2005, the JMBC has delivered 95 highly qualified researchers with PhD degrees to society. The figure shows the time it has taken these students to obtain their PhD. On average it takes 4 years and 9 months to obtain a PhD degree, counting from the start of the four-year contract. This average includes five students (shown in light/dark triangles around 7 years) that were ill for an extended period of time or chose to take a pregnancy leave.

Since at all universities there is a substantial time lag between finishing the PhD thesis and the public defense, we estimate that the average time it takes to complete JMBC PhD research is less than 4.5 years. Also note that some PhD students prefer a 5-year 80% contract. The figure has not been corrected for this effect, so that the actual performance is even better.



The following table gives the PhD-efficiency 2002-2005 in numbers and percentages. The table shows the situation at January 1, 2006. The numbers shown in the central box are incremental from left to right.

Influx of PhD students	#	After 4 yrs	After 5 yrs	After 6 yrs	After 7 yrs	Ongoing	Stopped
2002	52	0 (0%)	-	-	-	52 (100%)	0 (0%)
2001	41	4 (10%)	24 (59%)	-	-	13 (32%)*	4 (10%)
2000	39	3 (8%)	18 (46%)	34 (87%)	-	1 (3%)**	4 (10%)
1999	30	6 (20%)	20 (67%)	25 (83%)	25 (83%)	2 (7%)	3 (10%)
1998	31	1 (3%)	13 (42%)	20 (65%)	25 (81%)	3 (10%)	3 (10%)
Total	193	14 (7%)	75 (53%)	79 (79%)	50 (82%)	71 (37%)	14 (7%)

* for 3 out of these 13, a date for the thesis defense has already been definitely set in 2006.

** on pregnancy leave (zwangerschapsverlof)

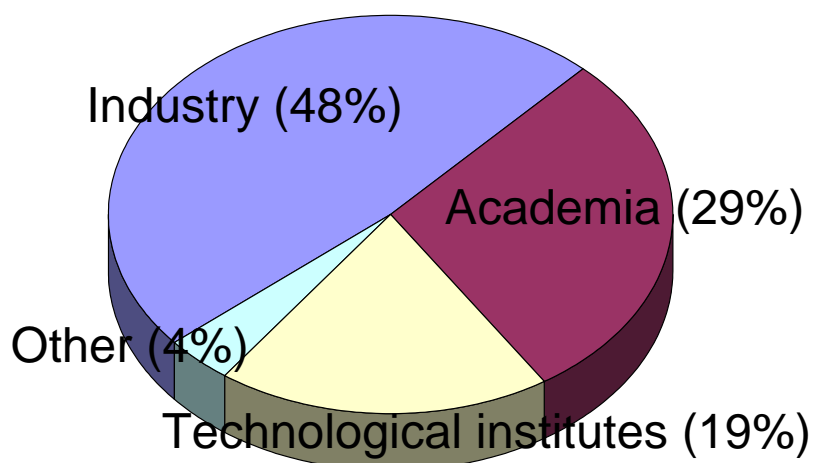
N.B. Percentages in the bottom row of the central box are calculated relative to influx in the relevant years only.

From the table it then can be concluded that a substantial fraction of the PhD students finish their PhD thesis while working for their new employer. Despite the good *overall* PhD-efficiency (only 7% of the students have stopped), and *average* time it takes to receive a PhD, the JMBC Board will give extra attention to improving the underlying numbers. It is important that individual attention is given to the PhD students and their opportunities for obtaining a PhD in time.

12. Career opportunities for JMBC alumni

The JMBC follows the careers of their alumni with great interest. Delivering young bright people to society is the main vehicle for the transfer of scientific knowledge to application-driven areas.

- Half of the JMBC alumni work in industry in the Netherlands and abroad. Important employers for our alumni are Shell and Philips, as well as – to a lesser extent – ASML, DSM and Corus. More than one-third of JMBC alumni working in industry are employed at one of these five companies.
- One third of JMBC alumni take up an academic postdoc position after their PhD, 60% of which work at a university abroad.
- One fifth of JMBC alumni obtained a position at a technological institute (TNO, ECN, WL, RIKZ, MARIN, NIZO, NLR) out of which most (one third of them) work at TNO.
- A few alumni work in policy related areas (science funding), banking, as a school teacher or in science promotion.



The figure shows current employers of JMBC alumni, per category

13. Measures taken in consequence of the previous peer panel's recommendations

Based at the recommendations of the 2001 peer panel, the JMBC has taken the following actions:

1) The JMBC should have an assured, and somewhat enhanced, central budget.

The Board of the TUD has definitively regulated the payments to the JMBC via three so-called 'spear points' at Delft. This funding is now fixed without the need for annual applications. The financial contributions from the JMBC groups have increased. There are now modest funds for financing the central activities of the JMBC, including the salaries of the scientific director and the JMBC secretary, as well as for organising courses and for visiting scientists.

2) The JMBC should add its voice to the pressure on the universities to ensure that their resource allocation models do not discriminate against large scale experimental departments, either through "rent for space" or through reducing the technical support staff.

JMBC representatives have discussed this topic with various Deans and University Boards. The situation varies from one university to another. At UT, finances distinguish between experimental and theoretical groups, at TUD it is decided that the 100% marginal costs model may be used for EU-funded research, which is profitable for experimental groups. Despite the dedicated discussions at all levels, this topic deserves continued attention.

3) The JMBC should continue to strive for increased collaboration in CFD, to maximise the efficiency of the many research groups using CFD methods.

The Contact Group Computational Fluid Dynamics has adopted the explicit goal to improve interaction between the relevant JMBC groups. The Contact Group also contributes to the PhD courses CFD1, CFD2 and CFD3. At the Contact Group meetings, JMBC staff attend as well as researchers from industry and GTIs/TNO.

The JMBC has investigated the possibility to start a CFD centre, together with a number of commercial CFD companies. After some interesting meetings, we have concluded that most companies prefer to collaborate directly with one JMBC group for the sake of confidentiality. We therefore have decided not to pursue a CFD centre in the JMBC in a top-down manner. Many groups however now have contacts and put their software at the disposal of other parties.

The JMBC will continue to stimulate the contacts between companies, institutes and JMBC groups. We organised a 'software day' in Delft, where JMBC groups were given the opportunity to demonstrate their software. Also, the JMBC website now has the possibility for JMBC groups to upload their software for general purposes. See at www.jmburgerscentrum.org.

4) The visiting professor programme should be enhanced by supporting more short-term (1-4 weeks) visits, in either direction, including (if possible) the institution of an annual JMBC lecturer who would give a seminar in each participating institution, and elsewhere.

The successful Burgers Professors program was continued. New Burgers Professors are John Brady and Marcus Aldén. The exchange of staff with the University of Maryland's Burgers Program is very fruitful (see Appendix 3). As a central activity, the JMBC regularly finances travel and subsistence of guests in JMBC groups.

5) Consideration should be given to extending the provision of short courses and summer schools to (a) international students and (b) MSc students

All JMBC courses are now advertised internationally via the ERCOFTAC bulletin. All MSc-level courses are also given in the Courses Program, published by the JMBC annually. MSc-students now regularly participate in the JMBC courses, of which there are roughly six per year.

6) In their international contacts, the JMBC director and project leaders should be aware that for researchers abroad, it needs explanation that the JMBC is a national research school, present at various locations in the country. This is quite a unique structure, and worth explaining.

The Scientific Director as well as the project leaders have explained the national structure of the JMBC to their foreign colleagues. The new collaboration between the JMBC and Maryland is a direct consequence of this. The enthusiasm at Maryland for the way the JMBC operates, was the key ingredient for the decision to mirror the JMBC overseas.

7) *The new focal point in Biological Fluid Mechanics (BFM) should, if possible, be more coordinated, with genuine research objectives originating in biological or medical science. Proposals in BFM should be co-authored and co-assessed by biological or medical scientists as well as by fluid dynamicists.*
See paragraph 2.3.2 under Bio-fluid mechanics

8) *The JMBC should explicitly recognise its ongoing research strengths in turbulence, combustion, multiphase flow, etc. while it also seeks to develop new “focal points” (perhaps a better word might be: “emerging fields”).* There have been strong developments in various field, see paragraph 2.3.2. Also, since a few years there is an enhanced collaboration at TUD, TU/e and UT in the area of combustion. New groups have joined the JMBC and have increased topical coverage, e.g. Hulscher (UT), de Waele (TU/e) en van Saarloos (UL).

9) *The JMBC should consider and develop a long term vision on rheology. Rheology needs to maintain its critical mass within the JMBC by bringing together groups working in this area of research. Rheology will also play an important role in development of the “focal points” Biological Fluid Mechanics and Granular Matter.* The JMBC has attempted to enforce research in rheology in The Netherlands. Two promising candidates were introduced to the potential sponsor (FOM) of a new chair in rheology at TUD. In the process however both researchers withdrew their candidacy for personal reasons. After that, FOM retracted their intended subsidy.

Professor Mellema, now emeritus, was succeeded by professor Mugele. The latter focuses more on micro fluid dynamics but will also continue to some extent the rheological research of his predecessor. New directions, such as the dynamics of granular materials and biological fluid dynamics, all have rheological aspects. It is therefore important to continue to strive for a university chair dedicated to rheology. In the coming period the JMBC will attempt to set this up with the financial help of industries and technological institutes.

10) *Although the information on the JMBC website is rather complete, its appearance should be made visually more attractive and the language used can be restricted to English.*

The JMBC website has been thoroughly improved and modernised. The users of the site are very pleased at the moment. The site is user-friendly and can be maintained by the JMBC secretary.

14. Measures to be taken in consequence of the present peer panel’s recommendations

See Appendix 6.

15. Male/Female ratio within the JMBC

Category	Male	Female	Total
<i>Professors</i>	54 (96%)	2 (4%)	56
<i>Associate Profs</i>	41 (93%)	3 (7%)	44
<i>Assistant Profs</i>	78 (94%)	5 (6%)	83
Tenure staff	173 (95%)	10 (5%)	183
Postdocs	38 (83%)	8 (17%)	46
PhD students	221 (86%)	35 (14%)	256

Appendix 1: Examples of formal collaboration between JMBC-groups in joint projects

- 1) Simulation of a realistic industrial burner
Boersma (TUD, 3mE_P&E), Jonker (TUD, TNW_MSP), Roekaerts (TUD, TNW_MSP)
- 2) Dynamic behavior of multi-burner excess enthalpy combustion systems for industrial process furnaces
de Jong (TUD, 3mE_P&E), Tummers (TUD, TNW_MSP), Roekaerts (TUD, TNW_MSP)
- 3) Nonideal Turbulence
Lohse (UT, TNW_phys), Ooms (TUD, 3mE_P&E)
- 4) Two-phase flow with free surfaces
Lohse (UT, TNW_phys), Prosperetti (UT, TNW_phys), Kuipers (UT, TNW_chem), Van der Vegt (UT, EWI_math)
- 5) Monodisperse drop formation
Lohse (UT, TNW_phys), Luding (TUD, TNW_chem)
- 6) Heat transport in rotating thermal convection
Lohse (UT, TNW_phys), Clercx (TUE, TN), Van Heijst (TUE, TN)
- 7) Spearhead program “Two-phase flow”
Lohse (UT, TNW_phys), Hoeijmakers (UT, CTW), Mugele (UT, TNW_phys), Van der Vegt (UT, EWI_math), Kuipers (UT, TNW_chem)
- 8) Core-annular flow through a pipe
Vuik (TUD, EWI), Ooms (TUD, 3mE_P&E)
- 9) Efficient solution methods for stiff systems of advection-diffusion-reaction equations: application to chemical vapor deposition and combustion
Vuik (TUD, EWI), Kleijn (TUD, TNW_MSP), Wesseling (TUD, EWI)
- 10) Direct numerical simulation of oil-water mixtures using front-capturing techniques
Vuik (TUD, EWI), Segal (TUD, EWI), Wesseling (TUD, EWI), Boersma (TUD, 3mE_P&E)
- 11) Coherent and chaotic transport in rotating Rayleigh-Bénard cells
Geurts (UT, EWI_math), Clercx (TUE, TN), Van Heijst (TUE, TN)
- 12) Greening of gas
Levinsky (RuG, combustion group), Mokhov (RuG, combustion group), Gersen (RuG, combustion group), Anikin (RuG, combustion group), De Goey (TUE, Wtb), Bastiaans (TUE, Wtb), Hermans (TUE, Wtb)
- 13) Laser diagnostics for turbulent combustion and thermo-acoustics
De Goey (TUE, Wtb), Van der Meer (UT, CTW), Hanjalic (TUD, TNW_MSP)
- 14) Noise in central heating systems
De Goey (TUE, Wtb), Mattheij (TUE, W&I)
- 15) Towards a sustainable hydrogen economy: the emission of NO_x by the combustion of natural gas premixed with hydrogen
De Goey (TUE, Wtb), Ter Meulen (RUN, Phys)
- 16) Bubble transport (void drift) between sub-channels in a nuclear, boiling water reactor
Van der Hagen (TUD, TNW_R3), Rohde (TUD, TNW_R3), Mudde (TUD, TNW_MSP)
- 17) Discrete particle simulations of an electric field enhanced fluidized bed
Coppens, Van Ommen (TUD, TNW_chem), Kuipers (UT, TNW_chem), Deen (UT, TNW_chem)

- 18) Production of mesostructured FCC particles by spray pyrolysis
Coppens (TUD, TNW_chem), Schmidt-Ott (TUD, TNW_chem)
- 19) Dynamics of transitional mixed-convection wake flows
Van Steenhoven (TUE, Wtb), Van Heijst (TUE, TN),
- 20) Air film cooling through laser drilled nozzles
Van Steenhoven (TUE, Wtb), Mattheij (TUE, W&I)
- 21) Shear bands, yielding, and creep in biaxial geometries: experiment and theory
Luding (TUD, TNW_chem), Van Hecke(UL, Phys)
- 22) Rapid granular matter at its edge: exploring critical phenomena and ratchets
Luding (TUD, TNW_chem), Lohse (UT, TNW_phys)
- 23) Continuum and discrete modeling of microflows
Luding (TUD, TNW_chem), Westerweel (TUD, 3mE_Wtb)
- 24) Multiscale modeling and geometrical optimization of catalysts-on-a-chip
Kleijn (TUD, TNW_MSP), Coppens (TUD, TNW_chem), De Leeuw (TUD, TNW_chem)
- 25) Hydrodynamic wave loading on floating and moored constructions in steep waves
Veldman (RUG, MNSc), Pinkster (TUD, 3mE_MT)
- 26) Axial segregation of binary particle mixtures in a rotary kiln
Kuipers (UT, TNW_chem), Hoeijmakers (UT, CTW), Kruyt (UT, CTW), Van Heijst (TUE, TN)
- 27) Newton versus Stokes: competing forces in granular matter
Lohse (UT, TNW_phys), Van der Weele (UT, TNW_phys), Van der Meer (UT, TNW_phys), Kuipers (UT, TNW_chem), van der Hoef (UT, TNW_chem)
- 28) Three-phase flow through a horizontal pipe, with special emphasis on inversion
Oliemans (TUD, TNW_MSP), Mudde (TUD, TNW_MSP), Westerweel (TUD, 3mE_P&E), Delfos (TUD, 3mE_P&E), Ooms (TUD, 3mE_P&E)
- 29) Simulation modules for anisotropic turbulent transport
Clercx (TUE, TN), Mattheij (TUE, Wisk), Kuerten (TUE, Wtb)
- 30) Transport of suspended particles with gravitational settling in a horizontal turbulent flow
Mudde (TUD, TNW), Portela (TUD, TNW), Stelling (TUD CiTG), Uijttewaal (TUD, CiTG)
- 31) Stirling type pulse tube refrigerators for the 4K region
De Waele (TUE, TN), Mattheij (TUE, Wisk)
- 32) High amplitude oscillatory gas flow
De Waele (TUE, TN), Molenaar (TUE, Wsk)
- 33) Finite volume solvers for the simulation of transport processes
Heemink (TUD, EWI), Stelling (TUD, CiTG), Wilders (TUD, EWI)
- 34) Dutch coastal ocean laboratory
Heemink (TUD, EWI), Stelling (TUD, CiTG), Pietrzak (TUD, CiTG)
- 35) Writing in turbulent air
Van de Water (TUE, TN), Dam (RU, Phys), ter Meulen (RU, Phys)
- 36) Turbulence measurements over a large range of Reynolds numbers
Van de Water (TUE, TN), Dam (RU, Phys), Ter Meulen (RU, Phys), Boersma (TUD, P&E)

Appendix 2: Examples of high-impact collaborations of JMBC-groups with industries, technological institutes, and governmental research institutes

In a joint project carried out by the Physics of Fluids group at Twente and Océ Technologies in Venlo, microbubbles in piezo electric elements are investigated. The obstacle in achieving higher precision and higher frequencies in printer heads are microbubbles that are entrained at drop-pinchoff and grow by rectified diffusion. Océ Technologies supplies part of the funding as well as adjacent research efforts.

The Shiphydrodynamics Department at Delft has proposed a significant change in the prevailing design trends by introducing the Enlarged Ship Concept in 1995. First results of a more radical concept in 2001 raised serious interest and in 2003 the Royal Netherlands Navy, the US Coast Guard, DAMEN Shipyard and MARIN supplied funds for extensive experimental validation of the predicted performance of this new design according to the AXE Bow Concept. The results were so promising that in 2004 the first 5 fast Crew Suppliers according to this concept have been sold by DAMEN and a number of new Patrol Boats are under development.

In the department Multi Scale Physics at Delft, heat and mass transfer in static mixers is investigated both experimentally and numerically in a joint research effort with PRIMIX BV. The outcome of the research allows for better design of these mixers and improved heat transfer at a given pressure drop. The knowledge generated can also be used to intensify application in e.g. (waste) water treatment.

A study at the Laboratory of Aero- and Hydrodynamics at Delft showed how pores in a porous material can be blocked by particles much smaller than the pore size and how such particles can be removed by high-frequency acoustic stimulation. This has impacted on Shell technology for cleaning the near well bore region and for oil extraction.

The section Physics of Nuclear Reactors at Delft has set up a cooperation with General Electric Company. A scaled model of a new generation boiling water reactor has been constructed, which has been used to study the boiling, two-phase flow and stability characteristics of such a reactor. Among other things, it was found that the reactor shows a significant margin to instable behavior.

At the department Multi Scale Physics at Delft a study is conducted on the effects of droplet entrainment in gas-oil transport in inclined pipes. This research is a cooperation with Shell and has a positive impact on the liquid loading problems encountered in the production of natural gas.

A project in the Numerical Analysis group at Delft recently resulted in a reduction by a factor 100 of computing time for solving wave problems in seismic data processing. This has generated interest from the oil exploration world. The work was funded by Shell, Philips and Senter-Novem.

In cooperation with Shell, a study has been made in the Engineering Fluid Dynamics and the Physics of Fluids groups at Twente of sound propagation in oil/water pipe flows. Modern optical techniques now make it possible to measure pressure fluctuations in pipes deep down in oil wells; the study is an important first step to extract information on such flows.

At the Department of Multi Scale Physics at Delft particle based numerical methods and codes have been developed for the simulation of reacting rarefied (high Knudsen number) gas flows. These methods have been implemented into TNO's computational fluid dynamics code X-Stream, which has largely widened the possibilities for TNO to do development and consultancy in microfluidic gas flow systems and vacuum equipment, for which TNO has many customers.

In a study at the Energy Technology section at Delft it was investigated whether, for some particular fluids expanding in the gaseous state at high pressure and temperature, shock waves can be avoided as opposed to what happens for common fluids like air and steam in similar conditions. The results have a high impact on ORC (Organic Rankine Cycle) manufacturers Turboden s.r.l., Triogen B.V. and UTC Power, which are extensively involved in this research project.

In a study at the Energy Technology section at Delft, the zFlow CFD code is used to study super-critical processes such as those used in particle production technologies and in general processes which involve fluids in real gas conditions such as in compressors for refrigeration, compressors and expanders in the chemical and oil industry. A tight cooperation with Feyecon B.V. is in place.

Research in the Laboratory for Fuel and Combustion Science at Groningen has resulted in a methodology for the analysis and prediction of the changes in combustion behavior with varying fuel composition. The methods have contributed to understanding and determining the limits of hydrogen addition to natural gas for use in gas turbines (together with KEMA) and for domestic and industrial burners (together with the N.V. Nederlandse Gasunie).

The Applied Analysis & Mathematical Physics group at Twente has an intense collaboration with MARIN. A numerical wave tank had been developed that is used to simulate waves to be generated in wave tanks, thereby reducing the number of actual experiments needed to obtain the desired wave field. Theoretical investigations on 'freak' waves leads to determine input for wave flaps that generate wave fields to test ships in extreme sea conditions.

At the DelfChemTech Department at Delft a methodology has been developed for monitoring dispersed multiphase flow, using non-linear analysis of pressure fluctuations. This 'attractor comparison method' is able to give an early warning for undesired phenomena, such as particle agglomeration and foaming. Together with IPCOS Technology B.V., the method has been implemented in a commercial software package.

At the Department of Multi Scale Physics at Delft the two-phase flow in a 150m-long, horizontal flow line is investigated. The goal is to understand the behavior and development of long liquid slugs that are formed in these flow lines. This research is a cooperation with Shell and has a positive impact on e.g. off-shore operations.

In a long-year cooperation with MARIN (Wageningen) and FORCE Technology (Norway), the group Computational Mechanics and Numerical Mathematics at Groningen is developing a CFD method that can predict the impact forces of steep waves on offshore platforms. The project is supported by EU, STW and several offshore-related companies worldwide. Dutch industries involved are IHC Gusto, Bluewater and Shell. A related version of the program is used to predict liquid sloshing onboard spacecraft (in cooperation with NLR and ESA).

Supported by the research in the Laboratory for Fluid Dynamics at Eindhoven and the Engineering Fluid Dynamics group at Twente, unique expertise has been built up at TNO in the field of flow-induced pulsations (FIPs) in pipe systems. The quantitative prediction of FIPs at Eindhoven has been used for the design rules of Gasunie transport systems. Philips has used this expertise in the development of a Bass-Reflex Port system for compact loudspeakers (US Patent, US6-275-597B1). The same theory has been applied to analyse combustion instabilities in the solid propellant motors of the ARIANE V rocket. Recently an efficient algorithm has been developed at Twente, that can be used to measure aero-acoustical sound sources, which is the subject of a collaboration with NLR.

The group Gas Dynamics of the Department of Applied Physics at Eindhoven has developed a nucleation pulse wave tube with which accurate nucleation rate data and droplet growth data can be obtained for a wide range of mixture compositions, temperatures and pressures. The work has been done in close collaboration with Twister B.V. in Rijswijk. At present, effects of the addition of carbon dioxide on the nucleation behaviour of alkanes and of water is being investigated with support by STW, Twister B.V., Shell and Gasunie.

Two STW projects on thermo-acoustic noise are carried out by the Combustion Technology Group, Dynamics and Control Group and CASA at Eindhoven in collaboration with Gasunie, TNO-TPD, ATAG, Remeha, AWB, Bekaert Technology, AGPO and Honeywell. The interaction of acoustics and flames has recently been resolved for flames stabilized on surface-stabilized burners and partly also for Bunsen-type burners. This knowledge can be used to develop silent, clean and efficient boilers both using detailed analysis of the flame and boiler system but also by active model-based control concepts to damp flame instabilities in a large parameter range.

The Numerical Analysis group at Groningen has an intensive collaboration with the CFD group at IMAU (Utrecht). Numerical models are used to study transitions in ocean flows, which will influence the earth climate. Progress in sparse-matrix solvers has resulted in a magnitude speed-up of these transition studies, allowing to increase their quality.

In a joint project carried out by the Process Technology group at Eindhoven and Nestlé for the improvement of the design of a hot-gas dryer, an analyzing method has been developed that is based on LDA and visualization experiments in a mock-up in which parts of its geometry are varied. Trends have been identified and design

recommendation has been based on the understanding of these trends. Nestlé has applied some of the recommendations in an actual, large-scale dryer. This project is funded by Nestlé.

In a joint project carried out by the Process Technology group at Eindhoven and Unilever on direct steam condensation, maximum shear rates and velocity field evolution have been measured by PIV in the jet that is created by injection of steam in a vessel. This project is completely funded by Unilever. In 2005 a sequel, a new steam injection project, involving two Ph.D. students, was funded by STW. This time injection is in a small channel with a flowing stream of fluid.

In a joint project carried out by the Process Technology group at Eindhoven and BASF Ludwigshafen distribution phenomena in cocurrent upflow of gas and a high-viscous liquid have been studied. At present, gas flow through safety valves is studied both numerically and experimentally in a joint project between these two partners. This PhD-project is completely funded by BASF.

The Process technology group at Eindhoven and Shell cooperate on centrifugal separation for cleaning well gas streams. While initially the focus was on centrifugal induced gas/gas separation, attention has now been shifted to thermodynamic treatment of the gas/gas mixture to create a phase change of one component followed by centrifugally induced two-phase separation. This project is completely funded by Shell.

The Process Technology group at Eindhoven and Wärtsilä Propulsion Netherlands cooperate in two projects related to hydrodynamics in centrifugal pumps, in particular waterjet pump installations. The first project is an experimental study which focuses on the effect of a non-uniform suction flow on dynamic forces on the impeller shaft. This project is partly funded by Wärtsilä. The second project is an investigation in which the effect of a non-uniform suction flow on the performance of a waterjet pump is studied by computational fluid dynamics (CFD). This project is completely funded by Wärtsilä.

Appendix 3: The Burgers Program for Fluid Dynamics at the University of Maryland

The Burgers Board was established at the University of Maryland (UMD) in the spring of 2003. Inspired by the intellectual heritage of J.M. Burgers, the mission of the Burgers Board is to enhance the quality and international visibility of the research and educational programs in fluid dynamics and related areas at the University of Maryland. Fluid dynamics in this context is viewed to include a broad range of dynamics, from nanoscales to geophysical scales, in simple and complex fluids.

The current members of the Burgers Board are:

James M. Wallace (Chair, ENME), Jan V. Sengers (liaison with JMBC), Anil Deane (DOE), Daniel P. Lathrop (IREAP/IPST/PHYS), Rajarshi Roy (IPST), Katepalli R. Sreenivasan (ICTP in Trieste/IPST), James H. Duncan (ENME), C. David Levermore (IPST/MATH)

The first initiative of the Burgers Board was to establish an annual Burgers Lectureship starting in the fall of 2003. The first Burgers Lecturer was Frans Nieuwstadt from Delft. A second major development was the establishment of an interdisciplinary Burgers Program for Fluid Dynamics. About 60 faculty spread over 18 different units in the College of Computer, Mathematical, and Physical Sciences and the Clark School of Engineering are currently participating in the Burgers Program. Further information can be found on the website of the Burgers Program: <http://www.enme.umd.edu/burgers/>.

The establishment of the Burgers Program for Fluid Dynamics was celebrated with an Inaugural Burgers Symposium at UMD in November 2004. It was a joint UMD-JMBC Symposium with several speakers from the JMBC. Because of the success of that symposium, a joint JMBC-UMD symposium was held at January 12, 2005 at Delft during the so-called Burgersdag.

Graduate School

Interdisciplinary research in fluid dynamics through the Burgers Program was formally recognized by the Graduate School as a field of graduate study in the fall of 2005. In January 2006 the Burgers Program received a grant from the Graduate School for the enhancement of graduate education in fluid dynamics.

Interactions with the JMBC and Europe

The Netherlands has an outstanding research program in fluid dynamics that grew out of the centuries-old need for water works. The famous Dutch physicist Hendrik Lorentz already applied his scientific talents to this need. Jan Burgers, born in 1895 and a Ph.D. student of Paul Ehrenfest at Leiden University, founded the Laboratory for Aero- and Hydrodynamics at the Technical University in Delft. In the 1930's William Durand ranked Burgers, Prandtl, Taylor and Von Karman as the "big four" in fluid dynamics. In 1955 Jan Burgers joined the University of Maryland, where he remained active until his death in 1981. Hence, the Burgers Program has a natural partnership with the J.M. Burgerscentrum (JMBC) in The Netherlands because of its common heritage through Jan Burgers.

The Burgers Visiting Faculty Program

The Burgers Visiting Faculty Program provides a vehicle for attracting outstanding scholars to spend some time at the University of Maryland. Professor Bruno Eckhardt of the Philipps-Universitaet in Marburg, Germany, stayed at the University of Maryland during the entire 2004/05 academic year as the first Visiting Burgers Professor. He interacted with Daniel Lathrop, his primary host, and also with many other faculty in the Burgers Program including Thomas Antonsen, Wolfgang Losert, Edward Ott, and James Yorke.

In 2005/06 two Burgers Visiting Associate Professors were welcomed. The first is Serge Simoens from the CNRS in Lyon, France. His primary hosts were Richard Calabrese, Kenneth Kiger, Daniel Lathrop, and James Wallace. The second is Sasa Kenjeres from Delft. His primary host was Dmitry Chalikov.

The Burgers Program was a cosponsor of the International Conference on Parallel Computational Fluid Dynamics that was held at the University of Maryland Campus in May 2005.

Annual Burgers Symposium

The 2005 Burgers Symposium was held November 17, 2005 with Charles Meneveau of the Johns Hopkins University as the Burgers Lecturer. Also, both Burgers Visiting Scholars, Serge Simoens and Sasa Kenjeres, spoke at this symposium. Frans Nieuwstadt, the first Burgers Lecturer, died tragically earlier that year. Frans Nieuwstadt was an outstanding scholar, who also with J.A. Steketee has edited the collected works Burgers and authored a biography of Burgers. James Wallace talked about the Legacy of Frans Nieuwstadt at the 2005 symposium. The 2006 Burgers Symposium will be held November 16, 2006 with Gijs Ooms, Director of JMBC as the Burgers Lecturer.

Burgers Seminar Program

In 2005 it was decided to embark on a monthly Burgers Seminar Program. The purpose of the Burgers seminars is to facilitate intellectual and social interaction between faculty, postdocs and students of the Burgers Program. The seminars are held the first Friday of each month in an informal atmosphere. The Burgers Visiting Scholars are speakers at the Seminar Program.

Interactions with Johns Hopkins University

The Burgers Program has made an arrangement with the Center for Environmental & Applied Fluid Dynamics (CEAFM) of the Johns Hopkins University for an annual joint research symposium. The first CEAFM-Burgers Student and Postdoc Symposium was held in May 2005 at the campus of Johns Hopkins University. The second Symposium was held on April 28, 2006 at the UMD Campus.

Liaison with JMBC:

Jan V. Sengers

Institute for Physical Science and Technology and Burgers Program for Fluid Dynamics

University of Maryland

College Park, MD 20742

United States

phone: 001 - 301 405 4805

fax: 001 - 301 314 9404

email: sengers@umd.edu

<http://www.ipst.umd.edu/Faculty/sengers.htm>

Appendix 4 : Formal regulations and guarantees, signed by the Boards of Governors

For the formal regulations and guarantees, signed by the Boards of Governors, we refer to the separate appendix.

Report of the peer panel

Assessment of the J.M. Burgerscentrum, national research school for fluid mechanics

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Executive summary

The panel is extremely impressed with the quality and scope of fluid mechanics research in the Netherlands. The research is clearly of an international stature, highly visible through high-quality publications in high-quality journals, and yet of great relevance to Dutch industry. The JMBC provides Dutch industry with scientific personnel who are highly qualified in fluid mechanics. The JMBC plays an instrumental role in sustaining this high level of research and education, by creating a critical mass and a coherent network of fluid mechanics research groups in the Netherlands. The Burgers professors have become an established and pivotal instrument for increased international visibility of Dutch fluid mechanics.

The JMBC significantly enhances interaction between industry, technological institutes and academic institutions through the activities of the Industrial Advisory Board, the Programme Committee and the subject-based Contact Groups. The JMBC is important for creating networks among PhD students and between students, professors and industrial partners. This is achieved through the excellent PhD courses, the annual Burgers Day, and the contact group meetings. All these activities have a very positive effect on fluid mechanics research and education in the Netherlands.

On the basis of our assessment we strongly and unanimously recommend that the JMBC be reaccredited for the period 2008-2013.

1. Introduction

The J.M. Burgerscentrum (JMBC), national research school for fluid mechanics, will apply for re-accreditation by the ECOS committee of the Royal Academy of Sciences (KNAW) in 2007. A positive recommendation as a result of an international peer review is a prerequisite for receiving this re-accreditation. The JMBC has invited an international peer panel to assess the quality of the research school.

1.1 Composition of the peer panel

The international peer panel consisted of the following members:

- Prof.Dr. Timothy J. Pedley FRS (University of Cambridge), chairman,
 - Ir. Hans Reinten (Océ Technologies bv),
 - Prof.Dr. Elisabeth Guazzelli (École Polytechnique Universitaire de Marseille),
 - Prof.Dr. Arne V. Johansson (Kungliga Tekniska Högskolan, Stockholm),
 - Prof.Dr. Paul F. Linden (University of California, San Diego),
- and Dr. E.E.W. Bruins (Universiteit Leiden), Secretary to the panel.

Professor T. J. Pedley is G.I.Taylor Professor of Fluid Mechanics and was until recently Head of the Department of Applied Mathematics & Theoretical Physics (DAMTP) of the University of Cambridge. He is an expert in the field of biological fluid mechanics.

Ir. H. Reinten is senior technologist/scientist at Océ Technologies bv in Venlo. He is an expert in the field of inkjet printing.

Professor E. Guazzelli is scientific leader of the group Ecoulements de Particules at the Institut Universitaire des Systèmes Thermiques Industriels (IUSTI) at the École Polytechnique Universitaire de Marseille. She is an expert in the field of particulate multiphase flows, such as granular matter, avalanches, suspensions, sedimentation.

Professor A.V. Johansson is Professor in Mechanics at The Royal Institute of Technology in Stockholm. He is an expert in modelling and simulation of turbulent flows.

Professor P.F. Linden is Blasker Professor of Environmental Science and Engineering and Chairman of the Department of Mechanical and Aerospace Engineering at the University of California, San Diego. He is an expert in environmental engineering such as geophysical turbulence, and architectural fluid dynamics.

Dr. E.E.W. Bruins is chief administrator at the Leiden Institute of Physics (LION) of the Universiteit Leiden. He is the former Secretary to the Research Division for Fluid Mechanics and Heat Transfer of the Foundation for Fundamental Research on Matter (FOM).

1.2 Schedule, methods and information used by the panel

Before starting the review procedure, the panel members have studied the following documents, delivered by the JMBC:

- Annual Reports and Research Programmes 2002, 2003, 2004/2005, 2005/2006
- Course Programme 2005/2006
- Self-evaluation report, written by the Management Team and Board of the JMBC
- List of publications 2002-2006 of all JMBC research groups
- Research programme of the 3TU Centre of Excellence Multiscale Phenomena in Fluids and Solids
- Peer panel assessment of the JMBC 2001
- Information brochure of the JMBC 2006

as well as the JMBC's website <http://www.jmburgerscentrum.org>.

During the two-day panel review of the JMBC, the panel had discussions with

- the chairman of the Board of Directors, prof.dr. Henk Tjeldeman (UT),
- the Scientific Director, prof.dr. Gijs Ooms (TUD),
- a member of the Management Team, prof.dr. GertJan van Heijst (TU/e),

- theme leaders of scientific programmes, prof.dr. Marijn Warmoeskerken (Unilever/UT), prof.dr. Philip de Goey (TU/e), prof.dr. Anton van Steenhoven (TU/e), prof.dr. Wim van Saarloos (UL), and prof.dr. Jerry Westerweel (TUD),
- chairmen of the JMBC Contact Groups, dr.ir. Bendiks Jan Boersma (TUD), dr.ir. Jos Derksen (TU/e), dr. Michel Versluis (UT) and prof.dr. Jerry Westerweel (TUD),
- representatives of the JMBC Industrial Advisory Board and Programme Committee, dr. Frits Dijkman (Philips Research), ir. Peter Veenstra (Shell) and ir. Albert Dalhuijsen (NMI),
- and representatives of the PhD student contact group, R. Nelissen (UT), A. Donkerbroek (RU Nijmegen), W.A. Kleefman (TUD) and R. Wemmenhove (RUG).

Preliminary conclusions were drawn on Tuesday 5 September and the panel report was made available to the JMBC Board and Management Team later that month. A detailed time schedule of the panel days can be found in Appendix B.

2. Assessment of the J.M. Burgerscentrum

2.1 Assessment of the educational/courses programme

The jewels in the JMBC crown are the excellent PhD courses, given by the leading experts anywhere in the country. They provide a uniformly high level of education. The topics of the courses are timely and well-chosen. The courses attract many students from all the participating universities, but also from other institutions inside and outside the country, including researchers from industry and technological institutes. In addition to their educational function, the JMBC courses have an important networking role for the PhD students in fluid mechanics. An active alumni policy may further enhance this role.

The actual courses being given in a particular year depend on the availability of the respective teachers. On average the courses are organised once every two years. One recommendation is that the JMBC should consider teaching certain core courses annually so that every student will be able to follow a logical sequence, e.g. CFD1, Turbulence and Dispersed multiphase flow from the start of their PhD contract. The JMBC should also review the course structure to see if some of the courses would be better delivered over an extended period rather than concentrated in a single week. Furthermore it is important that supervisors stimulate their PhD students to follow a broad range of JMBC courses, not only those on topics of direct relevance to their PhD research.

In the JMBC, the average period for obtaining a PhD degree is 4.5 years from the start of the contract. The panel considers this to be a very good result, considering that a) there is a time lag of several months at Dutch universities between finishing the PhD thesis and the public defense, b) public defense usually takes place some time after the student has already acquired a position elsewhere, and c) the average includes students with part-time (0.8fte) positions on 5-year contracts.

2.2 Assessment of the research programme

Dutch fluid mechanics research is of excellent quality and has a very high international reputation. Several Dutch professors play a leading role in their international subject communities; they and their groups are prominent at major fluid mechanics conferences. JMBC group leaders have been successful in raising substantial research funding from both 2nd and 3rd money streams which is an important indicator of the high quality of their groups' research. The large number of recently required Vernieuwingsimpuls-grants is a further sign of the individual quality of JMBC-researchers. The internationally renowned Burgers-professors play a pivotal role in the fluid mechanics community.

In the past period JMBC's research programme has been largely defined by the success of acquiring funds for FOM and STW programmes. Research programmes on dispersed multiphase flow, two-dimensional turbulence, turbulence with a focus on energy conversion processes, and granular matter have been very successful in obtaining significant scientific

results. Combustion research has taken new and challenging directions, and new measurement techniques have been developed in the Netherlands but are now used worldwide.

Biological fluid mechanics has not been a formal programme, due to rejection of a programme proposal by FOM. Nevertheless, a substantial number of interesting projects in this area has been started. The panel is very happy to learn that other groups in important interdisciplinary fields such as biological fluid mechanics are being considered for JMBC membership. In order to accelerate this process, a new contact group in Biological Fluid Dynamics may be considered. Such a contact group could function as the seeding ground for a new coherent research programme in Biological Fluid Dynamics. The panel feels strongly that the establishment of such a programme should be an objective for the near future.

In the coming years, the 3TU Centre of Excellence will dominate the direction of new research through establishment of new chairs at each of the three technical universities. The proposed research in the Centre of Excellence "Multiscale Phenomena in Fluids and Solids" is very appropriate and timely.

The Dutch fluid mechanics community, extremely well-organised in the JMBC, is in a very strong position to exploit fully the new trend in research support towards the funding of larger groups collaborating in programmatic themes ("*focus en massa*").

2.3 Assessment of the JMBC's role in national coordination

The JMBC is a very active networking organisation. There are an impressive number of collaborations with Dutch industries and technological institutes, stimulated by the existence of the Industrial Advisory Board and the Programme Committee, though whether these two bodies need to exist separately should be considered. Currently their meetings always occur together. On a managerial level, regular contacts exist with the research school for Engineering Mechanics, the Netherlands Mechanics Committee, the research school for process technology OSPT, and the Royal Institute of Engineers (KIvI).

As written in paragraph 2.1, the JMBC courses provide an important networking function for PhD students in fluid mechanics. The JMBC contact groups are an effective instrument for national coordination of research plans and for providing links with industry.

The JMBC's annual reports and Course programme booklet are well-designed and extremely informative. These, and their electronic counterparts on the web, have become standard sources of information for the field of fluid mechanics.

This year there is a substantial number of PhD student vacancies in fluid mechanics. Since the funding is available and industry is eager to recruit well-educated PhDs coming out of the JMBC programme, it would seem to be desirable to fill these vacancies, with excellent students, as soon as possible. One difficulty is that the same industries are keen to recruit good science and engineering students at the end of their first or Masters degrees, with the result that fewer good fluid dynamics students are available to recruit into the PhD programme. All vacancies are advertised on the JMBC website. It may be increasingly beneficial to the field to use the JMBC as figurehead in national recruitment activities. The JMBC can make MSc students aware of its excellent PhD programme and career opportunities. JMBC group leaders should actively look around for potential candidates, at home or abroad. Recruitment could be improved if the JMBC were to further enhance coordination activities on the European level. Its cohesion and visibility make the JMBC the ideal organisation to act as representing body for FP6-, FP7-, or ERC-applications. Also the new Center of Excellence and Center of Competence give new opportunities for funding on a European scale. The presence of professors Suzanne Hulscher and Hester Bijl in the JMBC can help to increase further the number of female PhD students. Women should also be encouraged to apply for senior staff and PhD positions.

2.4 Assessment of the JMBC finances

Finance of the present number of central JMBC staff is adequate thanks to the 'spear-points'-policy in Delft. However, after deducting the fixed financial obligations, the budget for additional activities is very small. The panel feels that a relatively small increase in budget can further enhance the JMBC's impact on fluid mechanics in the Netherlands through

funding of new ambitions: extra administrative support at the central office for central (web based) registration for courses and an active alumni policy, increased financial support for international exchanges, travel, and study books supporting the JMBC course materials.

The JMBC is very active in attracting research funding. Also, the new Center of Excellence will lead to new, well-chosen focal points that are financed at an adequate level. The Burgers professors can be used and selected to explicitly stimulate the focal points. In this way the JMBC has direct influence on the success and rapid growth of these new groups.

2.5 Other issues to be discussed

The panel welcomes the growth of the JMBC since the panel evaluation in 2001. The policy of the JMBC is to be open to new developments and to new groups in fluid mechanics. The inclusion of the group from University Leiden is a very positive example of the organic growth of the JMBC. The panel welcomes the JMBC policy of fostering smaller groups from general universities.

Rheology is still considered to be an important field which may be further stimulated. In the Netherlands, with Mellema retired and Van den Brule back in industry, this activity is currently embedded in chemistry more than in fluid mechanics.

The panel is positive towards an increased interaction with the Engineering Mechanics research school through the new CoC/CoE. The enhanced collaboration is visible in e.g. a shared MSc-track. This track, together with free entrance to each others courses seems to be the optimal level of collaboration. A further merger above that level would be unwise, because of the danger that coherence within each respective research school would be lost.

The JMBC has greatly extended its international visibility through the new Burgers Programme at the University of Maryland. Further to enhance the visibility, JMBC membership should be routinely acknowledged in publications and conference contributions from participating groups.

The panel feels it is important that there is a continuing discussion on the applicability of the research performed. Through the Industrial Advisory Board, industrial partners have a mechanism for influencing the choice of research topics considered by members of the JMBC. The general opinion of the panel is that the best science leads to the best applications. Therefore it is most important to foster the best researchers, and not to focus on either fundamental or applied research too much. Certainly in fluid mechanics it is not necessary for such a dichotomy to exist.

The members of the Industrial Advisory Board have real advantages: they know and meet all the PhD students, and they have the opportunity to influence the research. Also seats are offered at the courses for free. One might consider initiating a real fee-based membership for industries who wish to be affiliated with the JMBC, since industry derives such clear benefit from the JMBC's production of highly qualified scientific personnel. This might be a way to modestly increase the JMBC's income. Also, SMEs could be interested in this construction.

3. Recommendations of the peer panel

1. The panel strongly and unanimously recommends that the JMBC be reaccredited for the period 2008-2013.
2. The panel recommends JMBC's core courses are taught annually so that every student will be able to follow these at the start of their PhD contract.
3. The panel recommends that course provision should be reviewed in case some courses would be more effective if spread over an extended period rather than compressed into a single week.

4. The panel recommends that the JMBC sets up a new Contact Group in Biological Fluid Mechanics. This Contact Group may function as a seeding ground for a new research programme in this field.
5. Considering the recent successes on a national scale (3TU Center of Competence/Center of Excellence), the panel recommends that the JMBC investigates the possibility of the research school playing a central role in large EU funding schemes.
6. The panel recommends that the JMBC acts as figurehead in national recruitment activities, since the research school can make MSc and foreign students aware of its excellent PhD programme and career opportunities in fluid mechanics.
7. The panel recommends that the excellent JMBC initiative to attract Burgers professors should be explicitly used to stimulate the focal points.
8. The panel recommends that JMBC membership will be routinely acknowledged in publications and conference contributions of each JMBC group member.
9. The panel recommends that the JMBC's central budget be slightly increased in order to further enhance the JMBC's impact on fluid mechanics in the Netherlands through funding of new ambitions: central (web based) registration for courses, an active alumni policy, increased financial support for international exchanges, travel, and study books supporting the JMBC course materials. Extra administrative support is needed for some of these activities. Either this should be provided at the central office, or the JMBC groups might consider lending part-time secretarial staff for these tasks.
10. Offering membership to industries (including SMEs) in the Industrial Advisory Board and subsequent advantages, may be a way to generate some income. The panel recommends that the JMBC Management Team investigates these possibilities.
11. The panel recommends that consideration be given to merging the Industrial Advisory Board and the Programme Committee, which fulfill identical roles for industry and the technological institutes.

Information on the members of the peer panel

Professor T. J. Pedley

- G.I.Taylor Professor of Fluid Mechanics
- Head of the Department of Applied Mathematics & Theoretical Physics of the University of Cambridge (2000-2005)
- Chairman of the World Council for Biomechanics (2002-2006)
- President of the Institute of Mathematics and its Applications (2004-2005)
- 2005 Fellow of the American Physical Society
- 2001 Fellow of the American Institute of Medical and Biological Engineering
- 1999 Foreign Associate of the US National Academy of Engineering
- 1995 Fellow of the Royal Society of London
- 1995 EPSRC 5-year Senior Fellowship
- 1977 Adams Prize, Cambridge University
- Co-editor of the Journal of Fluid Mechanics

Ir. H. Reinten

- Senior technologist/scientist at Océ Technologies
- Member of the FOM Special Committee for Applied Physics (until 2002)
- Member of the FOM Advisory Committee for Phenomenological Physics (from 2002)

Professor E. Guazzelli

- Director of Research at the Centre National de la Recherche Scientifique
- Part-time Professor at Ecole Polytechnique
- Associate Editor of the Journal of Fluid Mechanics

Professor A.V. Johansson

- Professor in Fluid Mechanics at the Royal Institute of Technology, Stockholm
- Secretary General for Natural and Engineering Sciences at the Swedish Research Council
- Chairman ('prefekt') of the Department of Mechanics at The Royal Institute of Technology (1992-2004)
- Member of the KTH Board of directors 'Universitetsstyrelsen' (1998-2001)
- 2000 Member of the Swedish Royal Academy of Sciences

Professor P.F. Linden

- Blasker Professor of Environmental Sciences and Engineering
- Chairman of the Department of Mechanical and Aerospace Engineering
- 2004 Fellow of the American Physical Society
- 2002 G.K. Batchelor lecturer
- 1986 Fellow of the Royal Meteorological Society
- Associate Editor of the Journal of Fluid Mechanics

Programme of the peer panel visit to the J.M. Burgerscentrum

Sunday, September 3

18.00-22.00 First discussions and preparations
Present: panel + Chairman of the JMBC Board + Management Team
(*Tijdeman, Van Heijst, Ooms*)

Monday, September 4

09.30-10.00 Preparations by panel and discussion about procedures

10.00-11.30 Representatives of JMBC Board and Management Team (*Tijdeman, Van Heijst, Ooms*)
- Presentation by G. Ooms
- Discussion about self-evaluation report, annual reports and strategic choices

11.30-12.00 Break + wrap-up and first conclusions

12.00-12.30 Discussion with representatives of the Industrial Advisory Board & Program Committee (*Dijksman, Veenstra, Dalhuijsen*)

12.30-14.00 Lunch with representatives IA and PC (continued discussion)

14.00-14.30 Wrap-up and first conclusions

14.30-15.30 Discussion with representatives of the PhD students contact group (*Nelissen, Donkerbroek, Kleefsman, Wemmenhove*)

15.30-15.50 Break and wrap-up + first conclusions

15.50-16.30 Dispersed multiphase flow in the JMBC (*Warmoeskerken*)

16.30-17.10 Combustion research in the JMBC (*De Goey*)

17.10-17.50 Turbulence research and Biological Fluid Dynamics in the JMBC (*Van Steenhoven*)

17.50-18.15 Wrap-up and first conclusions

18.30-21.30 Dinner and continued discussion

Tuesday, September 5

- 09.00-09.40 Dynamics of patterns and granular matter in the JMBC (*Van Saarloos*)
- 09.45-10.25 Turbulence research, microfluidics and instrumentation in the JMBC (*Westerweel*)
- 10.30-12.00 Discussion with representatives of JMBC Contact Group coordinators (*Boersma, Derksen, Versluis, Westerweel*)
- 12.00-12.30 Wrap-up and first conclusions
- 12.30-14.00 Lunch and discussion with representatives of JMBC Board and Management Team (*Tijdeman, Van Heijst, Ooms*)
- 14.00-15.00 Last opportunity for questions and additional information from Board and Management Team
- 15.00-17.00 Writing draft-panel report
- 17.00 Leave for Schiphol Airport

Reply of the JMBC Board to the report of the peer panel: Measures to be taken in consequence of the present peer panel's recommendations

The Board and Management Team of the J.M. Burgerscentrum are thankful to the international review panel for their unreserved and unambiguous positive appraisal of our national research school. We agree fully with the assessment as given in the peer panel's written report. We appreciate in particular the panel's comments on the high quality of the JMBC's research and course programme, in combination with the great relevance for Dutch industry. We feel strengthened by the opinion of the panel that 'the best science leads to the best applications'. We agree with that vision, and interpret the panel's words as a stimulus to pursue the plans as discussed with the panel. Below please find our reply to the 11 recommendations of the panel.

1. *The panel strongly and unanimously recommends that the JMBC be reaccredited for the period 2008-2013.*
We agree.
2. *The panel recommends JMBC's core courses are taught annually so that every student will be able to follow these at the start of their PhD contract.*
The availability of JMBC courses depends strongly on the availability of expert teachers. Since JMBC teachers are active researchers of an international stature with many other obligations, as well as local teaching duties, it is quite a burden to teach a JMBC course once every year. Nevertheless we will investigate the possibility of giving some core courses on an annual basis, e.g. by alternating the teaching load between the various experts in the same field.
3. *The panel recommends that course provision should be reviewed in case some courses would be more effective if spread over an extended period rather than compressed into a single week.*
We will give serious consideration to the option of spreading courses over an extended period. We will discuss the pros and cons with the assembled JMBC group leaders as well as with the students representative of the PhD student Contact Group.
4. *The panel recommends that the JMBC sets up a new Contact Group in Biological Fluid Mechanics. This Contact Group may function as a seeding ground for a new research programme in this field.*
We appreciate this recommendation very much. To accelerate the startup of a Contact Group in Biological Fluid Mechanics, the Management Team has invited the groups of Johan van Leeuwen (Experimental Zoology) and Jaap Molenaar (Biometris, applied mathematics in life sciences) of Wageningen University to apply for JMBC membership. We will start the new Contact Group as soon as possible.
5. *Considering the recent successes on a national scale (3TU Center of Competence/Center of Excellence), the panel recommends that the JMBC investigates the possibility of the research school playing a central role in large EU funding schemes.*
We agree that the JMBC as an entity can have an added value on a European scale, as it has on a national scale. With FP7 starting soon, we will prepare ourselves so that the JMBC can coordinate the necessary actions, and make optimal use of EU funding opportunities.

6. *The panel recommends that the JMBC acts as figurehead in national recruitment activities, since the research school can make MSc and foreign students aware of its excellent PhD programme and career opportunities in fluid mechanics.*
We thank the panel for their positive appraisal. At this moment all vacant PhD positions and announcements of courses are published on the JMBC website. Further actions are being considered, e.g. job advertisements in national newspapers, and an increased presence on various national and international websites. Definitive actions will be taken after consultation with the JMBC group leaders.
7. *The panel recommends that the excellent JMBC initiative to attract Burgers professors should be explicitly used to stimulate the focal points.*
We agree and we will act accordingly.
8. *The panel recommends that JMBC membership will be routinely acknowledged in publications and conference contributions of each JMBC group member.*
Already from the start of our research school, it has been a rule that the JMBC is acknowledged in publications and presentations. As a consequence of the panel's recommendation, we will once again enforce this rule for the sake of the JMBC's visibility. We fully agree with this recommendation.
9. *The panel recommends that the JMBC's central budget be slightly increased in order to further enhance the JMBC's impact on fluid mechanics in the Netherlands through funding of new ambitions: central (web based) registration for courses, an active alumni policy, increased financial support for international exchanges, travel, and study books supporting the JMBC course materials. Extra administrative support is needed for some of these activities. Either this should be provided at the central office, or the JMBC groups might consider lending part-time secretarial staff for these tasks.*
The financial situation of the JMBC is much better than five years ago. Nevertheless, also for the JMBC more income means more activities. We agree with the new ambitions as listed in the recommendations, and as such would like to pursue these actively. We opt for lending secretarial staff instead of expanding the central organisation. Any increase in budget can subsequently be spent on extra activities for the research school.
10. *Offering membership to industries (including SMEs) in the Industrial Advisory Board and subsequent advantages, may be a way to generate some income. The panel recommends that the JMBC Management Team investigates these possibilities.*
There certainly may be possibilities. We will discuss this issue with the members of the Industrial Advisory Board and the Programme Committee, as well as with the JMBC group leaders, during the upcoming meetings.
11. *The panel recommends that consideration be given to merging the Industrial Advisory Board and the Programme Committee, which fulfill identical roles for industry and the technological institutes.*
The Industrial Advisory Board and the Programme Committee usually meet simultaneously. We expect that both committees will not object to a formal merger of the two. We will discuss this with the members during the next meeting.