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The Annual Report of the SERC Computational Fluid Dynamics Community Club

C Greenough and C J Fitzsimons

September 1992

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**The Annual Report of the SERC
Computational Fluid Dynamics
Community Club**

April 1991 – March 1992

C. Greenough and C.J. Fitzsimons

April 1991

Mathematical Software Group
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Summary

The SERC Community Club in Computational Fluid Dynamics was founded in March 1990 as one of four clubs set up under the EASE Programme and has now completed its second year of operation. Over the year the membership has grown steadily to more than 500 and reflects a wide range of interests including the computation of flows around aircraft and in combustion engines, the mixing of chemicals in the process industry, the slow motion of viscous materials in the production of glass and the flow of rivers and tides. The main achievements of the Club this year include

- **Technical Meetings** There have been five: CFD Community Club Plenary Meeting, Parallel Computing in CFD, Software Validation, Evaluation and Quality Assurance, Turbulence Modelling for Impinging Flows, and Visualisation in CFD. The average attendance at these meetings was 66, of whom 20% were from industry.
- **Common Academic Software Library** Three representative CFD packages were identified and the process of collection and quality assurance started. The first package under preparation is the TEAM software from UMIST.
- **Commercial Software** The Club has secured the provision of FLOW3D, FLUENT and PHOENICS on the Cray at RAL for use by the academic community.
- **Problem and Data Set Catalogue** References to more than 50 sources of flow data and test problems have been collected for use by the community.
- **Summer School** The First CFD Summer School was held in September 1991 and provided a highly interactive introduction to CFD for the 24 attendees.

The Club co-operates with complementary CFD organisations in the UK, e.g. the European Research Community on Flow, Turbulence and Combustion (ERCOFTAC), and the Ministry of Defence Advisory Group on Computational Fluid Mechanics (MODAGCFM). This is reflected through the joint organisation of meetings and representation on the Steering Group which oversees the operation of the Club. Other members of the Steering Group are drawn from Engineering Board Subject Committees.

Next year will see the provision of common academic software and test data, including the Stanford data sets, on the Higher Education National Software Archive to ensure their easy access by the community, the publication of a guide on the development of engineering applications software, the Second Introductory School in CFD, and the continuing programme of meetings.

1 Introduction

This is the second annual report of the Computational Fluid Dynamics Community Club set up by the Computing Facilities Committee of the SERC Engineering Board. The Club is one of four such Clubs set up under the Engineering Applications Support Environment (EASE). The Club has now over 500 registered members and held five specialist meetings, two of these being jointly organised with Collaborative Computational Project 12 (CCP 12) and ERCOFTAC UK North Pilot Centre. The CFD Community Club provides a very effective mechanism for research workers in the area of CFD to collaborate and disseminate the results of their research.

2 A Historical Background

The CFD Community Club was founded in late 1989 in response to the recommendations made to the subject committees of the SERC by the Advisory Group in Computational Fluid Dynamics, chaired by Professor Hutchinson (Cranfield). The CFD Community Club was one of four such Clubs set up under the SERC Engineering Boards EASE programme. The Club had its Inaugural Meeting in March 1990 at which the scope and objectives of the Club were set down and discussed. Since that meeting the programme of the Club has developed and it is recognised within the community as a focus of CFD activity.

During its first year of operation the Club organised five major technical meetings on subjects ranging from numerical accuracy in CFD computations to the visualisation of CFD results. Coupled with these meetings a core technical programme has been developed including the establishing of a common software library and a catalogue of experimental data and test problems.

The Club has secured funding from the SERC to continue and develop its programme and to broaden the scope of its support to the CFD community. This funding provides for a small amount of core effort established at the Rutherford Appleton Laboratory to support the programme and funds to take out licenses on software requested by the community.

3 Community Club Objectives

At its Inaugural Meeting the Club developed its initial set of objectives. These have been revised as necessary to reflect the changing needs of the community. A summary of the current objectives of the Club are:

- to provide a forum in which to present and discuss research interests of the CFD community,
- to increase the awareness of advanced computing and software engineering techniques in the community by an exchange of views and information,
- to propose new activities to SERC committees for funding which aid the effective use of advanced computing techniques in CFD research, and
- to promote the exchange of CFD software and data throughout the community.

Through its programme of meetings and technical developments the Club has successfully promoted these objectives and has gained a large following in the community.

4 A Review of Activities during 1991/1992

The year has been spent building on the programme begun last year. Although the basic structure of the CFD programme has remained the same, recommendations and comments from the community have been used to direct the work plan where ever possible. Discussion sessions at Club meetings have also ensured that the Steering Group has been able to plan a programme that addresses the needs of the community. The main elements of the CFD programme have been: common software library, software assessment and development, data sets and test problems and Club organisation.

4.1 Club Meetings

4.1.1 Club Plenary Meeting

The Plenary Meeting of the Club held on 30 April 1991 at the Rutherford Appleton Laboratory and was attended by over thirty Club members representative of a wide variety of applications of CFD in the community.

The meeting had two main aims: firstly, to review the programme of the first year and secondly, to consider and discuss the proposed future programme. The meeting was chaired by Prof. G.P. Hammond (Bath) the Chairman of the CFD Community Club Steering Group. He also gave the review of the Club's first year. To provide a focus to the discussion on the future programme Dr B.R. Williams (RAE) gave *A User's Perspective* of the Club's current programme. Presentations were made on the different elements of the programme and a characterisation of the membership given.

An important element of the meeting was a Keynote Address given by Prof. Ch. Hirsch (Brussels) who reviewed the current state-of-the-art on CFD and the future directions in research. During his presentation he also gave examples showing the importance of visualisation techniques in the interpretation of CFD results. His presentation concluded with some insights into developments within Europe in the funding and organisation of CFD activities.

The final presentation of the day was by Dr C. Greenough (RAL) who gave a detailed account of the proposed future programme of the Club. This presentation led into a discussion period in which the elements of the plan were considered and recommendations made. The discussion included placing the activities in a priority order.

4.1.2 Parallel Computing in CFD

The meeting on Parallel Computing in Computational Fluid Dynamics was jointly organised by Club and the Collaborative Computational Project 12 (CCP 12). It was held at the SERC's Daresbury Laboratory on 22 May 1991 and had an attendance of 68 drawn from both industry and the academic community.

The meeting was chaired by S.P. Fiddes (Bath) and comprised a large number of presentations reviewing the opportunities presented by parallel computing and detailing specific applications. The main review was given by Dr M. Guest (Daresbury) in which he described developments in the conventional range of shared memory multiprocessors and the more scalable distributed memory machines. The subjects of cost, performance and peak performance rates were discussed in detail and were revisited in the discussion period.

Two other invited contributions by Prof. P.M. Dew (Leeds) and Dr J. Reeve (Southampton) reviewed software issues and included a review of general principles of parallel program design and available CASE tools.

The main discussion period focused on the development of portability tools, generic domain decomposition methods and library software. The meeting recognised the importance of parallel processing to the CFD community and encouraged both CCP 12 and the CFD Community Club to organise other such meetings.

4.1.3 Software Validation, Evaluation and Quality Assurance

The CFD Community Club held a Seminar on Software Validation, Evaluation and Quality Assurance in Computational Fluid Dynamics at RAL on Tuesday, 9 July 1991. It was chaired by Dr B.R. Williams (RAE) and was attended by more than 75 people from industry and higher education. The meeting was organised in response to a recommendation arising from the Community Club's Workshop on Accuracy in Numerical Modelling held in November 1990. It was recognised that the validation, evaluation and quality assurance of software were important in the provision of good quality computational data for the designer. The purpose of the seminar was to present a range of approaches to these topics and to provide a forum where other methods and appropriate software tools could be identified.

Dr Williams welcomed the attendees and set the scene by defining what he meant by the terms validation, i.e. the accurate implementation of the mathematical model, and evaluation, i.e. the degree to which the CFD method models the physical problem.

The first presentation set the scene for the rest of the day; Dr C. Albone (RAE) introduced a methodology for validating Euler codes, covering a number of widely applicable topics. For example: does the code satisfy properties of the solution not explicitly satisfied in the numerical formulation, is the solution independent of the choice of time step, does the code provide the predicted order of accuracy for the algorithm. He gave a number of examples, and showed how useful information could be extracted from results which at first sight indicated that there was a problem in the code. Dr Albone finished by noting that although validation was time-consuming it was essential.

The questions and problems highlighted by Dr Albone provided a very effective background to the other presentations during the day. These ranged from the validation of specific applications programs to a more general discussion of the validity of the physical models used in CFD packages. Specific applications covered cavity driven and glass flow problems, transonic aerofoil problems and channel flooding.

The role of Direct Numerical Simulation (DNS) in validation and evaluation was discussed by Dr P. Voke (QMWC). Examples shown where DNS had been used to identify shortcomings in experimental data. However it was concluded that the use of DNS in the evaluation of turbulence codes could only be carried out effectively by those with understanding of real turbulence.

The issues involved in validating commercial programs were address by a number of speakers. The need for quality data and well defined software development methods were highlighted. It was noted that no matter how good the software was, there was no replacement for good, skilled people.

In the final presentation of the seminar a survey of techniques and tools for the quality assurance of Fortran software was presented by Dr T.R. Hopkins (Kent) together with an basic introduction to the subject. Some details on a number of the commonly-used QA metrics applied to software were given and a survey of some public domain or inexpensive software tools which could be used to help improve software quality was made.

In the ensuing discussion session a few points emerged clearly. The quality of much experimental data is insufficient for the purpose of evaluating CFD software, and that it would be helpful if the Community Club gathered information on sources of good quality data. It was also agreed that there is a need for a QA system which doesn't stifle initiative or innovation in CFD software development and research.

4.1.4 Turbulence Modelling for Impinging Flows

The SERC CFD Community Club and the ERCOFTAC UK North Pilot Centre held a one day workshop on Turbulence Modelling for Impinging Flows at UMIST on 30 October 1991, under the chairmanship of Prof. B.E. Launder (UMIST). It was attended by 55 people from industry and higher education. The purpose of the meeting was three-fold: first, to review and disseminate the results of a three-day international workshop, organised by the International Association for Hydraulic Research (IAHR) and the Pepit Pilot Centre of ERCOFTAC, held in Lyon on 2-4 October; secondly, to provide an opportunity for UK researchers to present their results for the test cases considered at the Lyon workshop; and thirdly, to have an extensive panel discussion on the test cases and wider issues affecting turbulence modelling.

Prof. Launder opened the workshop by outlining to participants some of the aims of the Community Club and the ERCOFTAC Special Interest Group on Turbulence Modelling. He went on to outline reasons for considering the impinging flow problem and explained the format of the workshop: the morning would contain invited presentations concerning the Lyon workshop, while the afternoon would provide an opportunity for computers to present their own results and for a wide-ranging panel session.

There were four main invited presentations. These included: a detailed presentation on the physical processes and modelling issues underlying turbulent impinging flows, which discussed significant features such as flow curvature, fluctuating pressure and wall effects, the viscous sub-layer and impinging free jets; a described the experimental arrangements and related specification of boundary conditions for the test cases presented at the Lyon workshop and synopsis of the computational results presented at the Lyon workshop.

Prof. Launder introduced the round table discussion on the present status and future directions for modelling impinging and colliding flows. The panel comprised the invited speakers and Prof. Andersson (Trondheim). The discussion ranged over the possible directions for development suggested by Prof. Launder and moved on to look at how existing models are used in industrial applications, refinements of the existing test cases and ways in which the research could be progressed.

4.1.5 Visualisation in CFD

A one day seminar on Visualisation in Computational Fluid Dynamics on 9 March 1992, under the chairmanship of Prof. P. Hutchinson (Cranfield). It was attended by 90 people from industry and higher education. The purpose of the meeting was three-fold: first, to present the latest work in CFD visualisation in this country, secondly, to inform the community of a recent assessment by the Advisory Group on Computer Graphics (AGOCC) on general purpose visualisation software; thirdly, to report on recent developments in virtual reality. Prof. Hutchinson opened the meeting said he hoped to learn from the day's meeting if the difficulties in visualisation were inherent in the subject, or due to other factors.

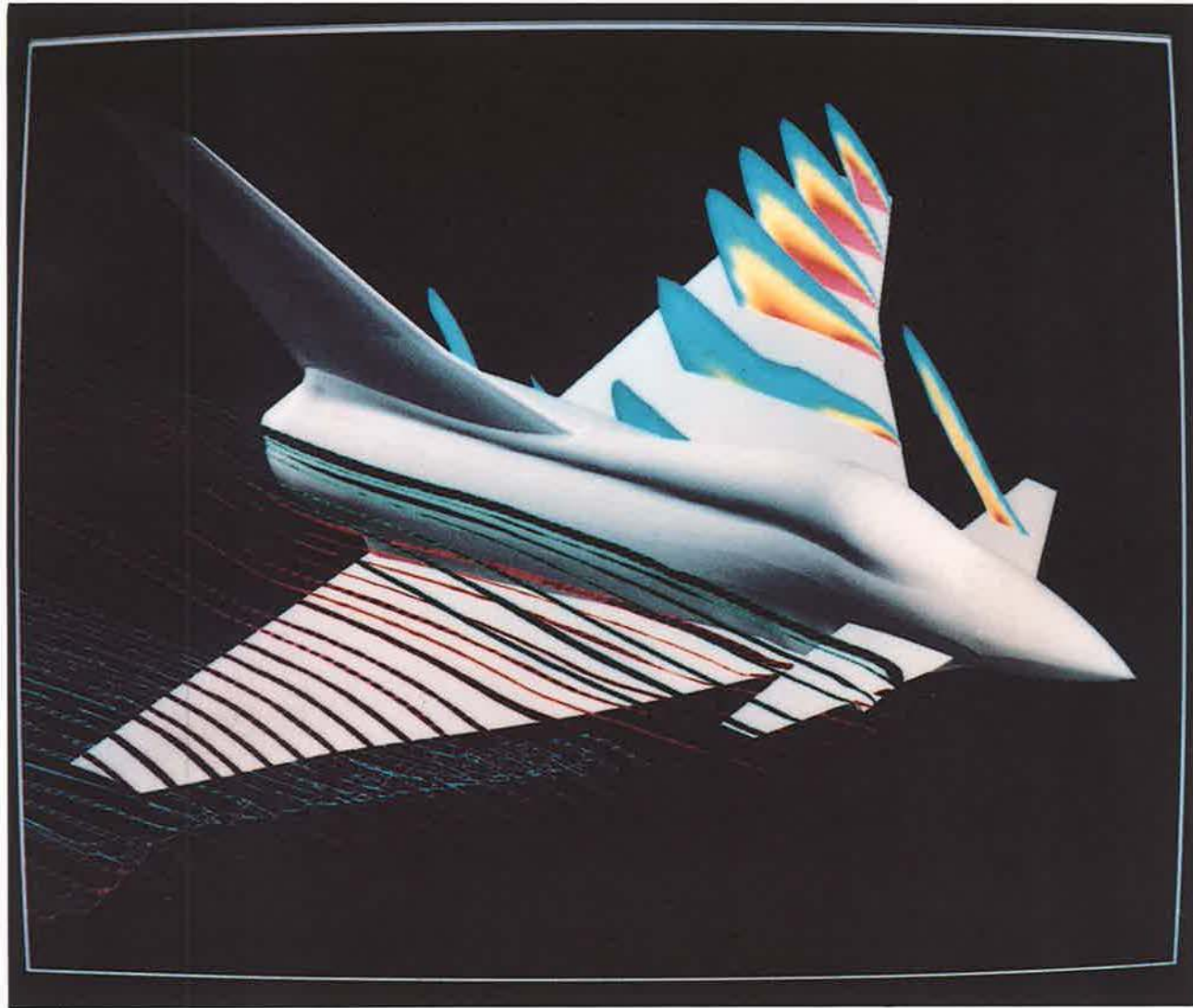


Figure 1: Visualisation of airflow around a prototype of the European Fighter Aircraft (*Courtesy DRA Aerospace Division*)

Dr K. Brodli (Leeds) gave a presentation on the AGOCC assessment of general purpose visualisation software which focused on Advanced Visualisation System (AVS), apE and Khoros. The outcome of the work is that AVS achieved much of the desired functionality and was usable; Khoros was highly commended for the image processing community and for two-dimensional work; apE was broadly similar to AVS but harder to use.

J.R. Gallop (RAL) presented an overview of virtual reality (i.e. the creation of highly interactive, computer-based multimedia environments in which the user becomes a participant with the computer in a *virtually real* world) systems and technology. He explored a number of features of a virtual world, e.g. handling the volume and types of, and relationship between, data and information required. The presentation finished with a report on a virtual windtunnel being developed at NASA Ames.

There then followed a number of presentations on the application of visualisation techniques to specific applications e.g. engine design, blast loading on buildings and mould filling. The use of both the AVS and apE was illustrated and work using the Silicon Graphics GL graphics library demonstrated. The use of modern interaction devices such as dials, button boxes and space balls were discussed.

There followed a wide-ranging discussion period. Participants expressed their concern at the high cost of some of the visualisation systems which precluded their use in teaching and research. The need for PC-based software was emphasised. The meeting was informed about a European visualisation system under development (EuroVis). The following recommendations were made by the meeting:

- a wider survey of visualisation systems should be undertaken, including those available in the public domain,
- links with the USA and Europe should be clarified and an investigation of whether we can cooperate with NASA on the virtual windtunnel,
- a clear link should be established between the Visualisation and CFD Community Clubs in order to improve the information flow.

Each participant at the meeting was sent a copy of the AGOCC assessment of general purpose visualisation software in addition to the customary proceedings.

4.2 Common Software Library

The need for a library of common CFD software has been raised many times. While establishing such a library is a difficult task in view of the large number of different types of CFD programs, this activity is seen as an important one for the Club to undertake.

The CFDCC has received offers of thirteen CFD programs for inclusion in the library. The areas of application of these programs include environmental modelling, compressible gas flows, non-Newtonian flows, and aerodynamics.

Before being placed in the Library each program will be standardised, tested and documented to reasonable quality levels using the test benchmarks to ensure its usability by the community. To that end a quality assurance document has been prepared to help in this process. It is hoped that this document will make a useful tool within the research community in general.

From the initial list of software three representative programs have been chosen for assessment: the TEAM software from UMIST, CORA3 from CHAM and a vortex code from Manchester University. Once the collection and testing has been completed arrangements will be made to include them in the Common Software Library.

Arrangements have been made for the library software and documentation to be distributed through the Higher Education National Software Archive (*HENSA*) mechanism currently being supported by the University of Kent.

4.3 Software Assessment and Development

This small activity has continued through the year and has resulted in a report on the experience gained in using the PHOENICS program. This includes experience gain in using existing test problems, modifying their definitions to solve new problems and in supplying user written code to replace modules within PHOENICS.

This work was started as a result of suggestions by the club membership that one or more of the systems commonly used by the community should be assessed. The main aim of the assessment was to gain experience of the potential of this type of program in CFD research in the context of a common software library looking into not only using it to model a set of test problems, but also modifying the program to use new numerical techniques.

Although the Club programme is not primarily for software development, it may be necessary within the common software project to modify and possibly improve the programs provided by the community.

The Steering Group has already suggested that a TEACH-like program — not restricted to finite volume methods — should be developed to illustrate the different computational techniques used in CFD and to act as a prototype for new research programs. All the software developed will become part of the common software library. However the effort available to the Club is currently insufficient to make progress on this task.

4.4 Data Sets and Test Problems

Throughout the community the importance of having a set of test problems against which new programs can be assessed is recognised. Techniques must be developed to handle the volume of data, means of access to it and the diversity of possible test problems.

Where possible the Club will draw on the experience and information already available within the European community. ERCOFTAC have started a similar activity within Europe and there are a number of BRITE/EURAM projects which are specifying some more specialised problems in their own areas. RAL will liaise with these activities.

An initial catalogue has been prepared and arrangements have been made to distribute the experimental data arising from the Stanford University Conference on Complex Turbulent Flows.

4.5 Access to Commercial Software

Requests have been received from SERC grant-holders for access to commercial CFD packages such as PHOENICS and FLOW3D on the Cray at RAL. RAL are negotiating special licenses with the software vendors so that existing academic license holders can use the software on the Cray, for academic research purposes, without obtaining a separate, usually more expensive, Cray license.



Figure 2: Participants in the First CFD Community Club Summer School held at The Cosener's House, Abingdon in September 1991. *Back row, left to right:* Ala Fakhri Al-Hussany, Russell Manson, Prof. Jim McGuirk, Prof. Derek Causon, Steve Fiddes, Mark Bardsley, Benjamin Yeung, Nick Saiz, Patrick Sharkey, Farhad Ali, Mureed Hussain, Ahsanula Baloch. *Centre row:* Steve Bellamy, Michael Hall, Chris Allen, Tahira Haroon, Manjit Boparai, Saadia Chaudhary. *Bottom row:* Dr Barry Taylor, Dr Chris Greenough, Miles Elsdén, Dr Conor Fitzsimons. *Not in picture:* Prof. Geoff Hammond, Dr Elie Znaty.

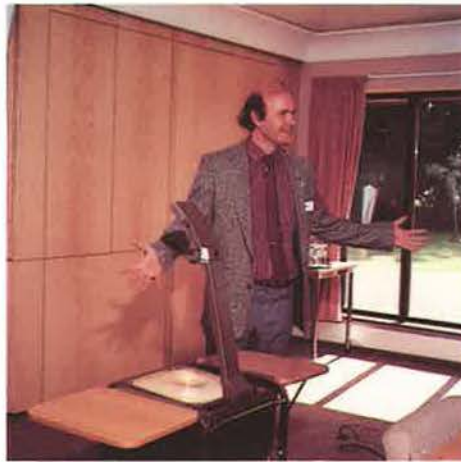


Figure 3: Scenes from the First CFD Community Club Summer School.

Currently four packages have been considered: FEAT (Nuclear Electric), FLOW3D (CFD Services, Harwell), FLUENT (FLUENT Europe) and PHOENICS (CHAM Limited).

FLOW3D and PHOENICS have already been mounted on the Cray XMP/416 at RAL for use by the academic community. Documentation on how to access the programs is being prepared and will be distributed to the community as soon as it is ready.

5 First CFD Summer School

The First CFD Community Club Summer School was held from 16th to 20th September 1991 at The Cosener's House, Abingdon. The meeting was jointly organised by ERCOFTAC UK and the Community Club. There were 24 participants, including the 3 main lecturers. The theme of the Summer School was solution strategies and problem discretisation. The lecturing staff were:

- Professor Derek Causon (Manchester Polytechnic)
- Mr Steve Fiddes (University of Bristol)
- Professor Jim McGuirk (Loughborough University of Technology)

Dr Elie Znaty (Bertin) made a presentation on the industrial applications of CFD in France. Dr Conor Fitzsimons gave a presentation on the computing system and with Ms Manjit Boparai and Dr Chris Greenough acted as a tutor during the week.

The Summer School was intended to be highly interactive, and combined formal lectures and practical sessions to achieve this. During and after each lecture participants were encouraged to ask questions and discuss their research problems with the staff. Each practical session was accompanied by a worksheet and an introductory presentation. In general these sessions were planned to illustrate the lecture content and posed problems to be considered and solved.

The numbers attending were thought low, given the response to the Summer School survey. In practice the attendance of 22 turned out to be a very good number for informal highly-interactive working.

The results of the participants' review indicate that the Summer School was very enjoyable and productive and was well worth repeating in subsequent years.

6 The CFD Community Club Membership and Steering Group

The registered membership of the Community Club has grown steadily and now stands at some 500 academics and industrialists, representing more than 65 higher educational institutes (HEIs) and 60 companies. Approximately 70% of the membership is from the academic community. The membership reflects the wide range of applications found for CFD techniques, from the computation of air flow around complete aircraft to the slow motion of viscous materials in the production of glass.

The membership of the Steering Group tries to reflect the interdisciplinary nature of CFD. The current Steering Group members are:

- Prof G.P. Hammond – Bath (Chairman)
- Dr R.B. Dean – WS Atkins (Industry)

- Prof A.D. Gosman – Imperial (Electro-Mechanical Engineering)
- Prof J.C.R. Hunt – Cambridge (Mathematics Community, Science Board)
- Prof P. Hutchinson – Cranfield (Process Engineering)
- Dr N.P. Weatherill – Swansea (ERCOFTAC)
- Dr B.R. Williams – DRA, Aerospace (MOD AGCFM)

The SERC staff that support the activities of the Community Club and attend Steering Group Meetings are:

- Mr R. Bond / Mrs C.A. Price – SERC Swindon Office.
- Dr D. Emerson – Daresbury Laboratory (Secretary of CCP12).
- Dr C.J. Fitzsimons (Secretary) – Rutherford Appleton Laboratory.
- Dr C. Greenough (Project Co-ordinator) – Rutherford Appleton Laboratory.

The Steering Group continues to meet on a regular basis to discuss and plan the activities of the Club. The Steering Group has agreed to strengthen its industrial representation and is currently considering possible new members.

Besides advising on the operation of the Club, the Steering Group also monitors developments in computing hardware and research issues through the members' own research programmes. In addition to this the Steering Group has a representative of the Collaborative Computational Project in Parallel CFD (CCP 12) to keep it informed of developments coming from this programme.

7 Relationship with other Complementary Organisations

There are many organisations within the United Kingdom and Europe that provide activities for research workers in CFD. Among these are the European Research Community on Flow, Turbulence and Combustion (ERCOFTAC), the Institute for Computational Fluid Dynamics (ICFD) which is a collaboration between Oxford and Reading Universities, the Ministry of Defense Advisory Group on Computation Fluid Mechanics (MODAGCFM) and the SERC Engineering Board Collaborative Computational Project 12 (CCP12). The Community Club has made it a matter of policy to involve such organisations in its programme by holding joint meetings and by having suitable representation on the Steering Group. In this way the Club can ensure that its activities are complementary to the others being organised, and that within the UK CFD activities are co-ordinated. The Steering Group is currently discussing a joint conference with I.Mech.E in September 1993.

8 The Future Programme

The Club's programme will continue to develop under the guidance of the Steering Group and in response to requests from the community. The Club's emphasis will move towards the provision of software and data sets. The main elements of the programme are:

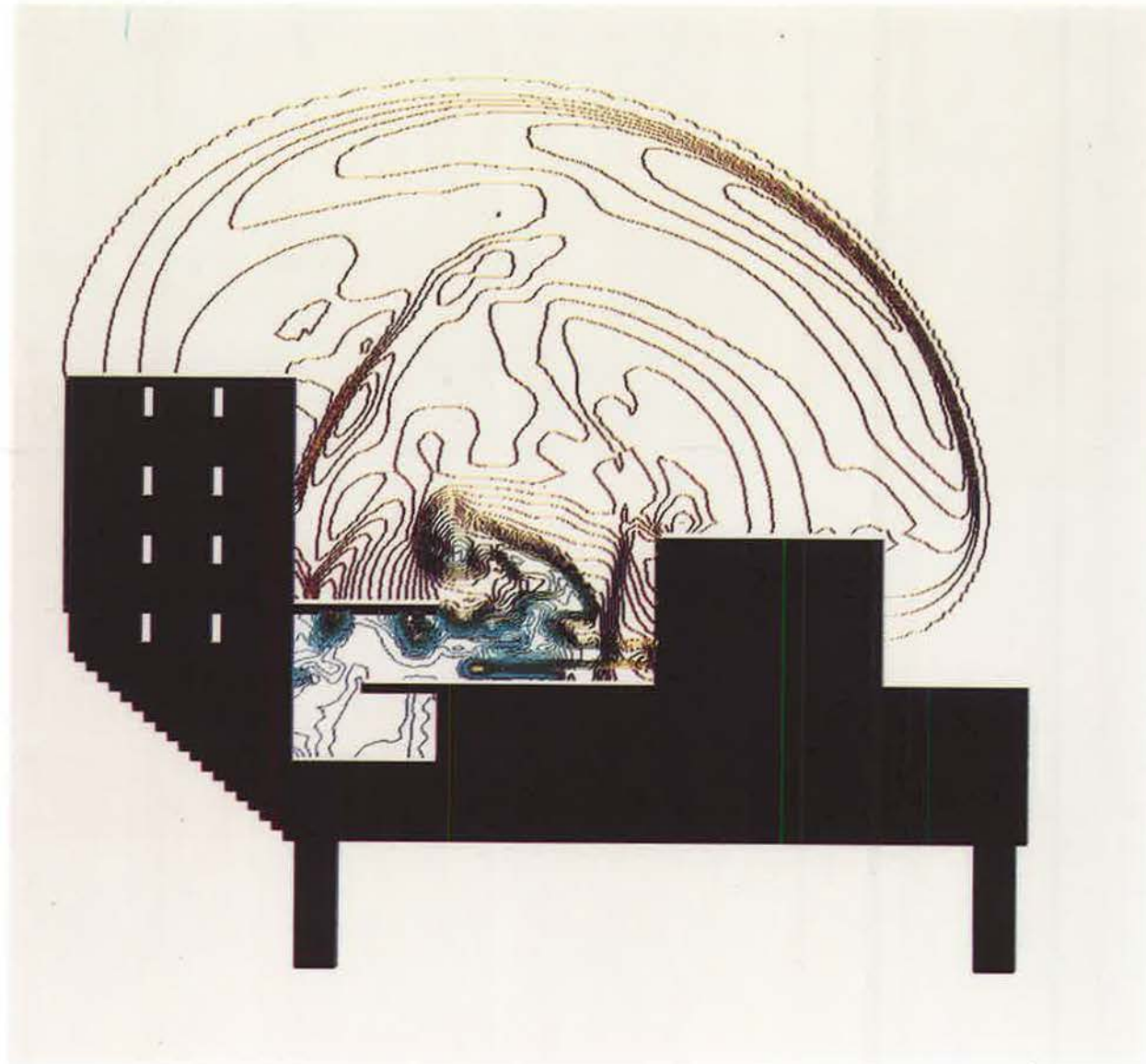


Figure 4: Prediction of blast wave overpressure on North Sea oil-production platform (*courtesy Prof. D.M. Causon, Manchester Polytechnic*)

- **Test Problem and Data Sets Catalogue** The Data Catalogue will be revised during the year and the Stanford data sets will be made available to the community through the Higher Education National Software Archive (HENSA).
- **Common Academic Software Library** This library will be augmented during the year and made available to the community through HENSA.
- **Commercial Software** The range of commercial CFD software available to the community will be enhanced and this service will transfer to the new Cray YMP at RAL in the Autumn.
- **Software Development Guide** following the recommendation from the Club's Workshop on Software Validation, Evaluation and Quality Assurance, a guide for the development of engineering applications software in Fortran will be released.
- **Technical Meetings** This programme will continue and include a seminar on Future Trends and Requirements in CFD, a workshop on the Visualisation of Numerically Generated Data in CFD (with ERCOFTAC), Boundary Conditions (with MODAGCFM), and Vortex Methods.
- **Introductory School** The Second Introductory School will be held on 4–8 January 1993. The objective of the school is to provide a foundation in the physical understanding of fluid flow and the consequences for the numerical solution of fluid flow problems.

9 Further Information

Further information on the activities and reports of the CFD Community Club can be obtained from the authors of this report. E-mail requests for further information and inclusion on the Club's mailing list can be made to cfdcc@inf.rl.ac.uk. The authors can be contacted on Abingdon (0235) 445307 or 445712.

Appendix I – CFDCC Workshops and Seminars

1. CFD Community Club Plenary Meeting

Venue: Rutherford Appleton Laboratory

Date: Tuesday, 30 April 1991

Chairman: Prof. G.P. Hammond (Bath)

Speakers: Prof. G.P. Hammond (Bath), Dr B.R. Williams (DRA), Prof. Ch. Hirsch (Brussels), Prof. A.D. Gosman (ICSTM), Dr N.P. Weatherill (Swansea), Dr C.J. Fitzsimons (RAL), Dr C. Greenough (RAL)

Attendance: 37 (31 Academic, 6 Industrial)

2. Parallel Computing in Computational Fluid Dynamics (Joint Meeting with Collaborative Computational Project 12)

Venue: Daresbury Laboratory

Date: Wednesday, 22 May 1991

Chairman: S.P. Fiddes (Bristol)

Speakers: Dr R. Blake (Daresbury), Prof. G.P. Hammond (Bath), Dr M.F. Guest (Daresbury), Prof. P. Dew (Leeds), Dr J.S. Reeve (Southampton), Dr D. Emerson (Daresbury), Prof. M. Cross (Thames), Dr M. Wilson (Bath), Dr A.G. Chalmers (Bristol), Dr T. David (Leeds), Prof. P. Bettess (Newcastle)

Attendance: 68 (62 Academic, 6 Industrial)

3. Software Validation, Evaluation and Quality Assurance in Computational Fluid Dynamics

Venue: Rutherford Appleton Laboratory

Date: Tuesday, 9 July 1991

Chairman: Dr B.R. Williams (RAE)

Speakers: Dr C. Albone (DRA), Dr M.F. Webster (Swansea), Dr G. Page (UMIST), Dr B.A. Younis (City), Dr I.P. Jones (AEA Technology), Dr P. Voke (QMWC), Dr T.R. Hopkins (Kent), A.G. Hutton (Nuclear Electric), R. Doe (British Aerospace)

Attendance: 77 (55 Academic, 22 Industrial)

4. CFD Community Club Summer School

Organising Committee: Prof. D.M. Causon, S.P. Fiddes, Prof. J.J. McGuiirk, Dr N.P. Weatherill, Dr C.J. Fitzsimons and Dr C. Greenough.

Lecturers: Prof. D.M. Causon (Manchester Polytechnic), S.P. Fiddes (Bristol), Prof. J.J. McGuiirk (Loughborough), Dr E. Znaty (Bertin)

Attendance: 24 (21 Academic, 3 Industrial)

5. Turbulence Modelling for Impinging Flows (Joint Meeting with the ERCOFTAC UK North Pilot Centre)

Venue: UMIST

Date: Wednesday, 30 October 1991

Chairman: Prof. B.E. Launder (UMIST)

Speakers: Dr W.P. Jones (ICSTM), Prof. B.E. Launder (UMIST), Prof. M.A. Leschziner (UMIST), Prof. J.J. McGuirk (Loughborough)

Attendance: 59 (48 Academic, 11 Industrial)

6. Visualisation in Computational Fluid Dynamics

Venue: Rutherford Appleton Laboratory

Date: Monday, 9 March 1992

Chairman: Prof. P. Hutchinson (Cranfield Institute of Technology)

Speakers: Dr K. Brodlie (Leeds), J.R. Gallop (RAL), C. Hill (ICSTM), D. Ingram (Manchester Polytechnic), Prof. M. Cross (Thames), Dr C.S. Biddlecombe (Vector Fields Ltd)

Attendance: 88 (66 Academic, 22 Industrial)

Appendix II – Proceedings of Workshops and Seminars

For each of the workshops and seminars listed the collected papers and view graphs have been collected under a single cover. These are available to all members of the academic and industrial community.

1. **Parallel Computing in Computational Fluid Dynamics, CFDCC Proceedings 4, May 1991**
2. **Software Validation, Evaluation and Quality Assurance in Computational Fluid Dynamics, CFDCC Proceedings 5, July 1991**
3. **SERC CFD Summer School, CFDCC Proceedings 6, September 1991**
4. **Turbulence Modelling for Impinging Flows, CFDCC Proceedings 7, October 1991**
5. **Visualisation in Computational Fluid Dynamics, CFDCC Proceedings 8, March 1991**

Appendix III – CFDCC Reports and Articles

During the year the activities of the Community Club have led to a number of reports and articles describing the membership and activities of the Club. Copies of these are available to all members of the academic and industrial community.

CFD Community Club Reports:

1. Report on the Seminar on Software Validation, CFDCC Report 8/91
2. SERC/ERCOFTAC CFD Summer School Survey, CFDCC Report 9/91
3. Report on the Common Software Library Offers, CFDCC Report 10/91
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2. Computational Fluid Dynamics Community Club Meeting on Mesh Generation, *Dr C.J. Fitzsimons*, ERCIM Newsletter, No. 6 (April 1991)
3. A Year in Computational Fluid Dynamics, *Dr C.J. Fitzsimons and Dr C. Greenough*, ECN 32 (May 1991)
4. Mesh Generation Seminar, *Dr C.J. Fitzsimons*, ECN 32 (May 1991)
5. CFD Community Club, *Dr C.J. Fitzsimons*, ECN 33 (July 1991)
6. The Titan Visualisation Project, *Prof D.A. Gosman and C. Hill*, ECN 33 (July 1991)
7. Parallel Computing in Computational Fluid Dynamics, *Dr R. Blake and Dr D. Emerson*, ECN 35 (November 1991)
8. First CFD Summer School, *Dr B Taylor*, ECN 35 (November 1991)
9. Software Validation, Evaluation and Quality Assurance, *Dr C.J. Fitzsimons*, ECN 35 (November 1991)
10. Workshop on Turbulence Modelling, *Dr C.J. Fitzsimons*, ECN 37 (March 1992)

Appendix IV – Terms of Reference of the CFD Steering Group

The Terms of Reference of the SERC Computational Fluid Dynamics Community Club are:

1. To advise the Rutherford Appleton Laboratory on running a Community Club in CFD under the EASE Programme,
2. To make recommendations on a programme of activities to benefit the CFD research community,
3. To maintain a knowledge of computing requirements for CFD research.
4. To monitor the provision and use of existing computing facilities for CFD research,
5. To make recommendations on the provision of new computing facilities for CFD research,
6. To liaise with other CFD initiatives in the UK and elsewhere,
7. To establish close links with industry to ensure that end-users requirements are taken into account by the CFD research community and that industry is aware of CFD research activities and needs,
8. To encourage, as appropriate, international collaboration in CFD research,
9. To report to the Community Club in CFD at least annually, and
10. To report through relevant Subject Committees to the Engineering Research Commission on the activities of the Community Club and on the provision and use of existing computing facilities for CFD research at least annually.

