CLRC

Progress Report of the EPSRC Computational Fluid Dynamics Community Club

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April 1995 – March 1996

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Summary

The EPSRC 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 sixth year of operation. This report covers the period April 1995 to March 1996 over which the membership of CFDCC has remained steady at around 400 members. The membership 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 activities of the Club this period include:

- **Technical Meetings:** There have been two technical meetings and two workshop organised during the year. The seminars were on Solution Strategies and Grid Generation. In general the meetings have been well attended by both the academic and industrial communities.

- **Workshop on Data Exchange in CFD:** This workshop was a notable success. 42 attended an interesting and lively workshop which consider the need for formal data exchange techniques in and between CFD software.

- **Quality Assurance in Fortran:** The two-day hands-on workshops on QA in Fortran 77 was run again. Although the attendence was lower than expected those that did attend enjoyed a very stimulating two days.

- **Common Academic Software Library:** The provision of public domain and other software on HENSA has continued. The number of accesses to this archive over the year has been large.

- **Commercial Software:** The Club continued the support of CFDS-FLOW3D, FLUENT, PHOEN-ICS, STAR-CD and FEAT on the super-computer at RAL for use by the academic community. All these were transfered to the Cray J90 when it came into service.

- **Problem and Data Set Catalogue:** The catalogue has grown slowly during this period. The gathering of data and results has proven quite difficult. However references to more than 50 sources of flow data and test problems have been collected for use by the community. The CFD community continues to make considerable use of the data provided. There have been over 3000 accesses to the Catalogue and the data files.

- **Electronic Pre-Print Service:** This was a new venture during the year. The main goal of the E-Print Service is to provide a quick and simple mechanism for research results to be disseminated.

The Club co-operates with complementary CFD organisations in the UK in all its work in order to benefit the CFD community. This is reflected through a number of joint meetings and representation on the Steering Group which oversees the operation of the Club.

The direction of CFDCC has continued to provide opportunies for the CFD community to meet and discuss topics of interest in modelling, test problem and data, and the rapid developments in computing and information technology now available to them.

1 Introduction

This is the fourth report of the Computational Fluid Dynamics Community Club (CFDCC) set up by the Computing Facilities Committee of the SERC Engineering Board. It covers the period April 1995 to March 1996 in the CFD Community Club's activities through which it has be funded by Engineering and Physical Sciences Research Council (EPSRC).

CFDCC is one of three such Clubs set up under the Engineering Applications Support Environment (EASE). The Club has continued to grow and has now over 400 registered members having undertaken a major membership review. The CFD Community Club continues to 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 early 1990 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 a number of 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.

Since this first meeting the Club has organised over eighteen major technical meetings on subjects ranging from numerical accuracy in CFD computations to the visualisation of CFD results. Many of these meetings have been in co-operation with other bodies such as ERCOFTAC, IMechE and DRA. Coupled with these meetings a core technical programme has been developed including establishing access to commercial CFD packages, a common software library and a catalogue of experimental data and test problems.

The Club is continuing to develop its programme and to broaden the scope of its support to the CFD community under the direction of a Steering Group who's members are leading experts from the CFD community. EPSRC provides funding 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 but have broadly remained the same. A summary of the current objectives of the Club are:

- to organise specialist technical meetings on subjects of interest to UK researchers in CFD which can provide a forum in which to present and discuss research interests of the CFD community,

- to increase the awareness of the community of advanced computing and software engineering techniques by an exchange of views and information,

- to propose new activities to the EPSRC programme managers 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 membership in the community.

4 A Review of Activities during 1995/1996

The Club's programme has continued to develop the range of events organised and the scope of technical work performed. 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: the technical meetings and workshops, the common software library, software assessment and development, data sets and test problems.

4.1 Club Meetings

Over this period CFDCC has held five technical meetings organised during the year. These have built on the meetings programme of previous years. Titles have included:

- Solution Strategies

- Improving the Quality of Fortran Programs

- Recent Developments in Grid Generation

- Data Exchange for CFD

- A School on an Introduction of CFD

The attendance at these meetings has ranged from around 30 to over 90 depending on the subject. This is what might be expected. In general the audience at the meetings has reflected the size of the community working in these areas.

At all meetings there have been general discussion periods. These have in general been very lively and have developed some interesting debates. These open discussion periods and the feedback questionnaire, given out at all meeting, have given rise to suggestions for future meeting subjects. Below is a more detailed report on *Data Exchange for CFD* meeting.

4.2 Common Software Library

As part of the Club activities a library of common CFD software has been set up. The software has been contributed by members of the CFD community and is intended to encourage the exchange of software between research groups. After the initial set of programs was made available a number of requests for further contributions have been made. It is disappointing that no suitable offers were made so this library has remained static throughout the year. Even so the number of accesses to these programs continues to be very high. There have been over 3700 accesses to the software files from some 600 different sites.

The software library currently holds the following software:

The TEAM Suite (Turbulent Elliptic Algorithm Manchester): which consists of four two-dimensional programs originally developed at UMIST.

FLUX : The program was developed by Prof S Fiddles at Bristol University and is primarily intended for teaching purposes. It solves the one-dimensional linear advection equation with unit speed or the inviscid Burgers' equation.

NAV2D : A program which solves the two-dimensional Navier-Stokes equations in their primitive variable formulation, using the NAG/SERC Finite Element Library.

VORTEX : A program for solving incompressible laminar flow based on vortex methods.

The availability of public domain software has always been high on the agenda of UK academics.

4.3 Data Sets and Test Problems

A catalogue of data sets and test problems has been compiled. It consists of a list of published reports and papers containing well-characterised and carefully carried out experiments or computations. In addition a collection of results from turbulent flow experiments which were collected by flow experts for the Stanford conferences on Complex Turbulent Flows held in 1980 and 1981 have also been included in the data catalogue. This data will be updated as new information is gathered. Once again, although CFDCC has not been able to expand the scope of this catalogue, the accesses to the information have been significant. Over 990 accesses have been made to the files from some 142 different sites.

4.4 Availability of Software and Data

Both the common software library and the catalogue of data sets and test problems are available on the Higher Education National Software Archive (HENSA). HENSA can be accessed over the network using the address `unix.hensa.ac.uk` and login name archive. Access can be made made either through `telnet` or anonymous `ftp`. You will be asked for your e-mail address. The HENSA file store is navigated using standard Unix commands such as `cd` and `ls`. The chapter provided by CFDCC is in the archive under a directory `/pub/misc/cfd` which contains two sub-directories `data` and `software`.

The HENSA archive can also be accessed through the World Wide Web (www) using the address `http://www.hensa.ac.uk`.

4.5 Access to Commercial Software

Requests have been received from research council grant-holders for access to some of the commercial CFD packages such as PHOENICS and FLOW3D on the Cray at RAL Atlas Centre. CFDSG have negotiated special licenses with the software vendors so that the academic community can use the software on the Cray for academic research purposes, without obtaining a separate Cray license.

These packages are being transfered to the Cray J90.

Further information on which packages are currently available and how to access these programs can be obtained from Dr RG Evans at the Atlas Centre (contact details are given in Appendix I).
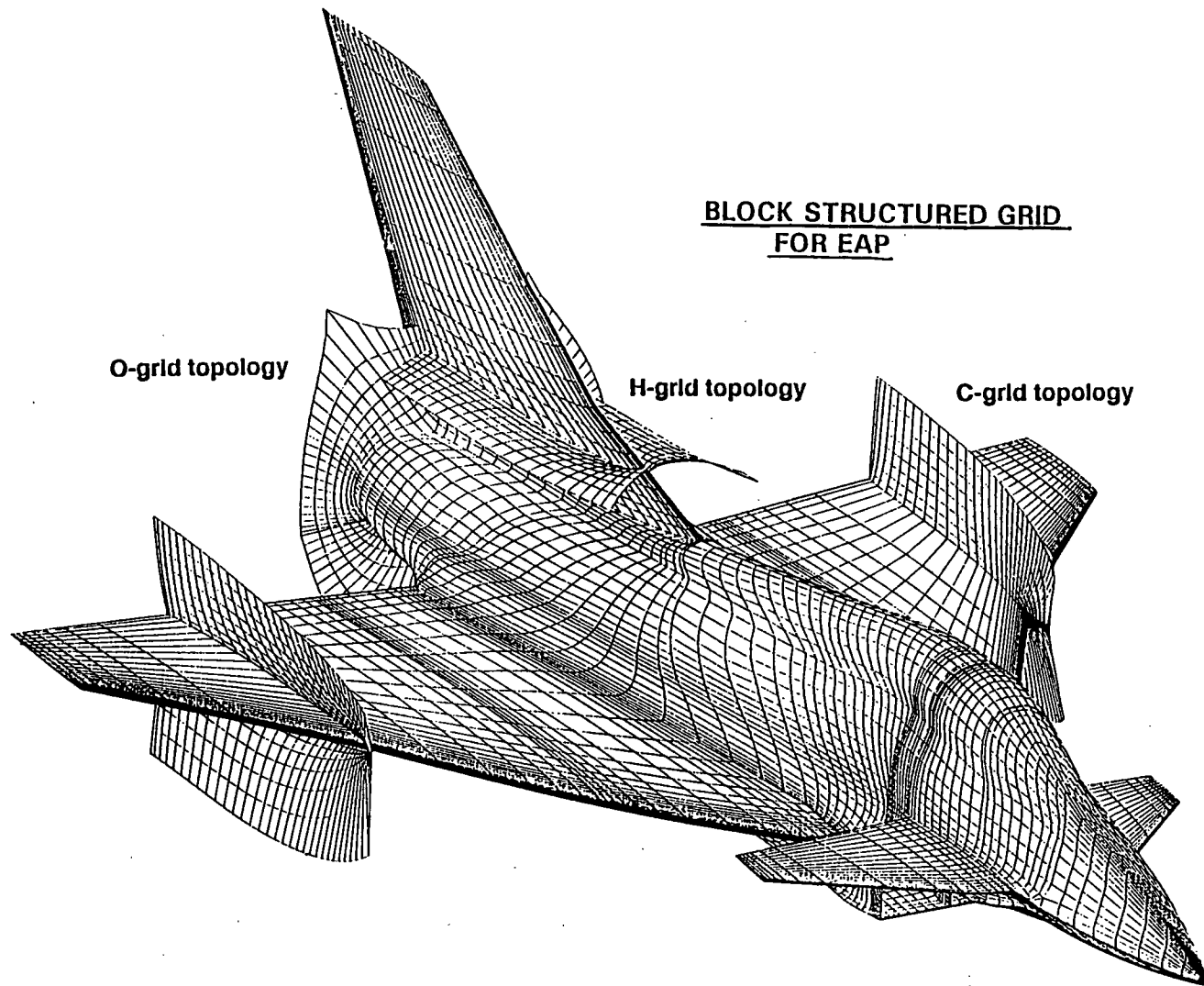
BLOCK STRUCTURED GRID
FOR EAP

O-grid topology

H-grid topology

C-grid topology

Figure 1: Block Structured Mesh for EAP (*Courtesy of ARA Ltd, Bedford*)

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4.6 CFDCC Handbooks

An important part of the CFDCC programme is to collect and disseminate information to the CFD community. Although the technical meetings are the main avenue for this it was requested that CFDCC compile two handbooks.

This first of these was on the availability of courses on CFD and the second a survey of the major commercial CFD packages used within the UK. Each of these handbooks were compiled by advertising and circulating a questionnaire to the UK community and collating the responses. As with all these types of reviews they become out of date very quickly so CFDCC will be updating them regularly.

5 Workshop on Quality Assurance for Fortran 77 Programs

It has long been recognised by the CFDCC Steering Group that the promotion of good software development standards were essential in modern scientific and engineering research. The design, development and modification of large software systems is an important skill required by most research staff. This was thought particularly true of CFD.

CFDCC has now run three two-day workshops on software quality. The last of these was in July 1995. Each workshop includes, on the first day, both introductions to the concepts of software quality an introduction to some practical methods of software design and testing. Subjects such as Fortran 77 portability and coding styles are also covered. Because of the introduction of the Fortran 90 standard a lecture on the Fortran 90 language has been included.

The emphasis of the workshops has been on practical solutions and throughout the two days the participants have the opportunity to use both commercial and public domain QA tools. The second day of the workshop is given over to using these tools on software developed by the participants.

To date these workshops have been well attended and the participants have indicated that the time was well spent.

6 Data Exchange Workshop

A one-day Workshop on the timely topic of Data Exchange in CFD was held at The Cosener's House, Abingdon on February 13th 1996 and chaired by Prof. Brian Williams of DRA, Farnborough. The impetus behind the meeting was the emerging STEP STandard for the Exchange of Product model data which among other areas now covers CAD data and will shortly encompass Finite Element Analysis. It was therefore thought to be appropriate to ask whether STEP was an appropriate technology for data exchange in CFD and what steps should be taken to promote its use.

Two discussion sessions were held during the workshop. The first session investigated the requirements for data exchange in CFD. Current methods of data exchange ranged from use of IGES down to paper! The unreliability of these was clearly recognised, as was the existence of incompatibility between systems. The importance of standards, particularly for small companies, was stressed.

The second session focused on the potential of STEP to meet these data exchange requirements and what steps could be taken to achieve this. The value of STEP was seen as allowing developers to concentrate on algorithm and model development, allowing comparison with others through, for example, exchange of grids. For users it was hoped that it would increase the transparency of data exchange. The emphasis on conformance testing in STEP increased confidence in its use.

The workshop produced the following recommendations as a result of its discussions:

- generate an activities list for the CFD world;

- clarify CAD/CFD data exchange requirements;

- produce a data model for Finite Elements, Finite Volumes, Finite Differences;

- seek involvement of delegates in drafting requirements;

- develop a small pilot Application Protocol to demonstrate data exchange/integration;

- produce interface libraries to STEP compliant data repositories;

- use results from other projects where possible;

- seek involvement of Software vendors;

- facilitate the discussion through e-mail co-ordinated by the CFDCC.

CFDCC is now considering these recommendations of the Workshop to see what practical steps can be taken to improve the lot of CFD in this area.

7 The CFD Community Club Membership and Steering Group

The registered membership of the Community Club has been steady and stands at some 400 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 GP Thompson – Binnie & Partners (Chairman)

- Prof DM Causon – Manchester Metropolitan

- Dr RB Dean – WS Atkins (Industry)

- Dr EH Fisher – Newcastle (IMechE)

- Prof AD Gosman – Imperial

- Prof P Hutchinson – Cranfield

- Prof MA Leschziner – UMIST

- DJ Nicholas – RAL (ERCOFTAC)

- Prof BR Williams – DRA, Aerospace (MOD AGCFM)

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

- Dr D Emerson – Daresbury Laboratory (Secretary of CCP12).

- Ms RM Eden – EPSRC Swindon Office.

- Dr C Greenough (Project Co-ordinator) – Rutherford Appleton Laboratory.

- Mrs D Thomas (Secretary) – Rutherford Appleton Laboratory.

- Dr JV Ashby (New Secretary) – 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.

Mrs D Thomas retired from the post of Secretary as she has movedto a new post within the Laboratory and Dr JV Ashby has taken over from her.

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.

8 Membership Review and Survey

Over the past year CFDCC has undertaken a review of its membership to ensure that its mailing list is up to date. The review required that those wishing to remain members of CFDCC need to positively respond to RAL staff organising CFDCC. Although this has resulted in a reduction of the CFDCC mailing list it has ensured that those who are interested and active are highlighted.

The review is the first for sometime and has been an important mechanism in determining the programme of CFDCC for the future. Of the around 700 existing names on the CFDCC mailing 55% (over 400) asked to remain in the Club. Of these 25% came from UK industry and the rest coming from the UK academic community. In particular mechanical engineering and mathematics featured strongly in the responses. The split between users and developers of CFD software techniques was about even although some described themselves as both developers and users of CFD technology.

An important element of the review was to assess the current activities of CFDCC in the light of the community requirements. Within the core of the present CFDCC programme are: meetings and courses, data catalogues, CFD software and package provision. Of these the programme of meetings and the collection of CFD software came out highest. The interest in the meetings and software is in fact borne out by the numbers attending meetings and the number of accesses to the CFDCC sections of the HENSA archive. It is disappointing to note that the UK community has become less willing to make software developed in research projects available in a public domain manner.

Of all the subjects suggested for future meetings the following came high in priority:

1. Unsteady Flows

2. Turbulence Modelling

3. CFD Visualisation

4. Grid Generation for CFD

5. Environmental Flows
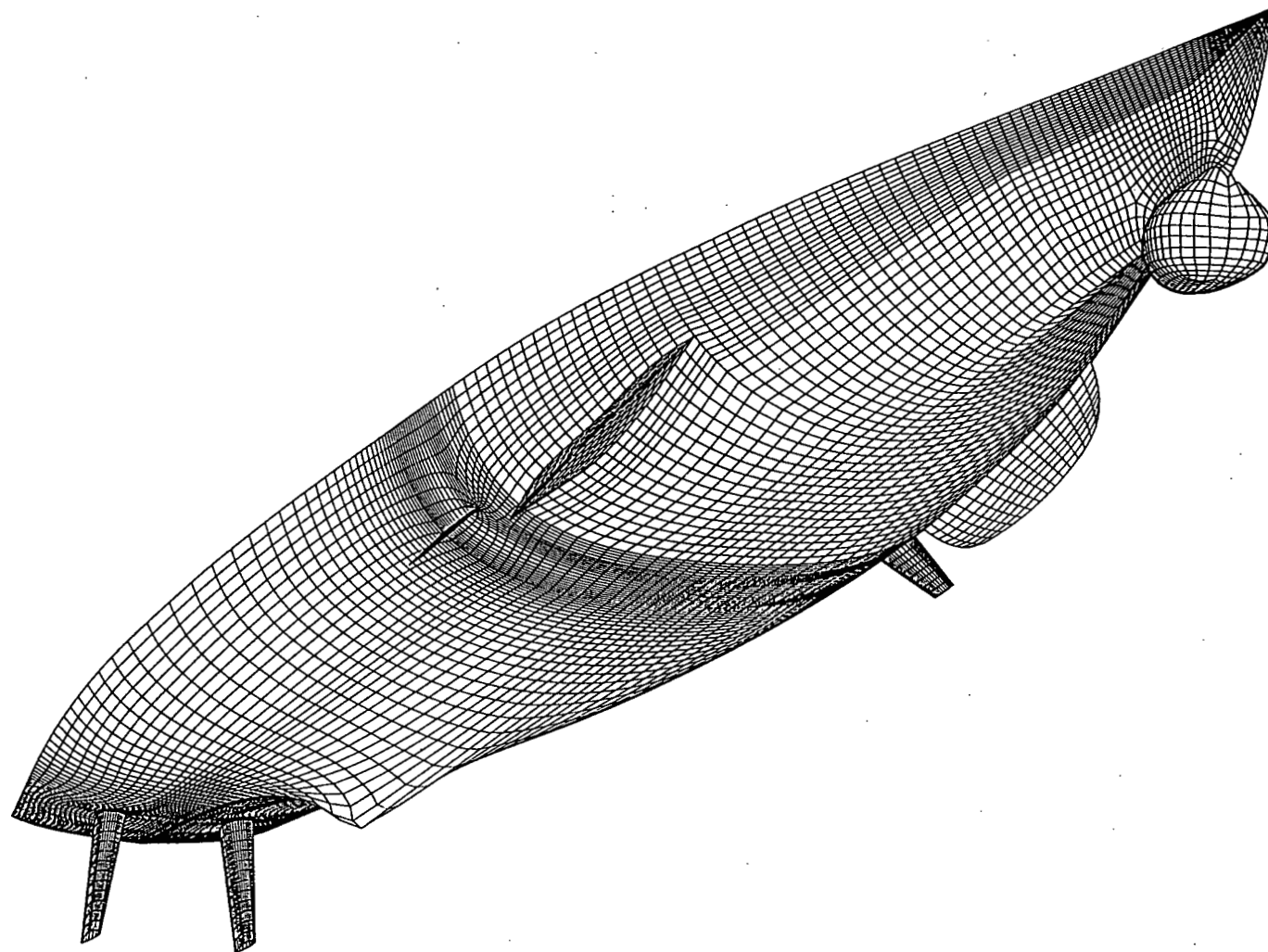
BLOCK STRUCTURED GRID ON SHIP'S HULL

Figure 2: Block Structured Mesh for Ship's Hull (*Courtesy of ARA Ltd, Bedford*)

What appeared to be clear from this part of the review was that the community was more interested in the applications of CFD rather than the underlying computational techniques.

The review has provided the CFDCC Steering Group with some very important information concerning the requirements of the UK CFD Community and their thanks is expressed to those who took the time to reply.

9 Relationship with other Complementary Organisations

There are many organisations within the United Kingdom and Europe that foster co-operation between research workers in CFD. Among these are the European Research Community on Flow, Turbulence and Combustion (ERCOFTAC), the Advisory Group on Computation Fluid Mechanics (AGCFM), IMechE, the EPSRC Engineering Board Collaborative Computational Project 12 (CCP12) and more recently the NAFEMS Working Group on CFD.

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 CFDCC 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.

10 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 continue to be on technical meetings and workshops. However with the reduction of funding from EPSRC the level of activity will be reduced.

The main elements of the programme will be:

- **Technical Meetings** This programme will continue and include meetings on topics suggested by the CFD community and the CFD Steering Group.

- **Test Problem and Data Sets Catalogue** The Data Catalogue will be developed during the year as new material is identified.

- **Common Academic Software Library** This library will be augmented during the year and made available to the community through HENSA. In addition a catalogue of available commercial and public domain CFD programs.

- **Commercial Software** The range of commercial CFD software available to the community will continue to be supported on the Cray J90 at RAL.

- **Information Booklets** The two information booklets produced by CFDCC will be updated and re-published.

- **CRISP** The Community Club's Information Service will be introduced containing information of interest to the CFD community.

11 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*. CFDCC has a World Wide Web page at `http://www.cis.rl.ac.uk/cclubs/CFD/index.html`. The authors can be contacted on Abingdon (01235) 445307 or 446834.

Appendix I – CFDCC Contacts

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Appendix II – CFDCC Workshops and Seminars

1. Solution Strategies for Computational Fluid Dynamics

   Venue: Rutherford Appleton Laboratory

   Date: Tuesday, May 2nd 1995

   Chairman: Prof AD Gosman (Imperial College)

   Speakers: Dr J Reid (RAL), Dr P Sweby (Reading), Prof H van der Vorst (Utrecht), Dr K Badcock (Glasgow), Prof EF Toro (Manchester Metropolitan), Dr C-H Lai (Greenwich)

   Attendance: 36 (32 Academic, 4 Industrial)

2. Improving the Quality of Fortran Programs

   Venue: Rutherford Appleton Laboratory

   Date: 13 – 14 July 1995

   Speakers: Dr SK Robinson (DRAL), Dr C Greenough (DRAL), RE Thomas (DRAL), Dr J Reid (DRAL), Mrs D Thomas (DRAL). Additional vendors presentations during demonstration sessions.

   Attendance: 8 (3 Academic, 5 Industrial)

3. Recent Developments in Grid Generation

   Venue: University of Bristol

   Date: 14 September 1995

   Chairman: Prof N Weatherill (Swansea)

   Speakers: JA Shaw (ARA), J Peiro (Imperial College), P Childs (Intera Information Technology), P Selwood (Leeds), P Bull (DRA Haslar), R Smith (UMIST), S Hartle (Nottingham), C Allbone (DRA Farnborough)

   Attendance: 29 (17 Academic, 12 Industrial)

4. Fifth CFDCC Introductory School in Computational Fluid Dynamics

   Venue: The Cosener's House, Abingdon

   Date: 8 – 12 January 1996

   Speakers: SP Fiddes (Bristol), Prof DM Causon (Manchester Metropolitan), Prof JJ McGuirk (Loughborough), Dr BA Younis (City), Prof WR Jones (Imperial College)

   Attendance: Event not held due to lack of numbers

5. Data Exchange for CFD

   Venue: The Cosener's House, Abingdon

   Date: 13 February 1996

   Chairman: Prof BR Williams (DRA Farnborough)

   Speakers: Dr J Owen (Leeds), Dr D Lovell (DRA Farnborough), N Eccles (Loughborough), Mrs D Thomas (RAL), J Simkin (Vector Fields Ltd), Dr S Bloor (Leeds)

   Attendance: 43 (20 Academic, 23 Industrial)

Appendix III – 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. An Introduction to Computational Fluid Dynamics, CFDCC Proceedings 19, January 1995

2. Solution Strategies for Computational Fluid Dynamics, CFDCC Proceedings 20, May 1995

3. Recent Developments in Grid Generation, CFDCC Proceedings 21, September 1995

4. Data Exchange for CFD, CFDCC Proceedings 22, February 1996

5. Improving the Quality of Fortran Programs, CFDCC Proceedings 23, July 1995

Appendix IV – 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.

1. Turbulence Modelling for CFD, *MA Leschziner*, ECN No. 55 (March 1995)

2. Introductory School in CFD - The Academic View, *CF Scott*, ECN No. 55 (March 1995)

3. Introductory School in CFD - The Industrial View, *E Pasqualotto*, ECN No. 55 (March 1995)

4. Improving the Quality of Fortran Programs, *D Thomas*, ECN No. 55 (March 1995)

5. CFD Electronic Preprint Service, *JV Ashby*, ECN No. 56 (May 1995)

6. Directory of CFD Training Course, *D Thomas*, ECN No. 56 (May 1995)

7. Improving the Quality of Fortran Programs, *D Thomas*, ECN No. 56 (May 1995)

8. Catalogue of Academic CFD Software on HENSA, *D Thomas*, ECN No. 56 (May 1995)

9. Report of Solution Strategy Seminar, *A Kokkalis*, ECN No. 57 (July 1995)

10. Recent Developments in Grid Generation, *JV Ashby*, ECN No. 57 (July 1995)

11. CFDCC E-print Service, *JV Ashby*, ECN No. 57 (July 1995)

12. Some Algorithm Development for Computational Aerodynamics at Greenwich, *C-H Lai*, ECN No. 58 (September 1995)

13. Non-Newtonian Computational Fluid Dynamics, *P Townsend*, ECN No. 58 (September 1995)

14. An Introduction to CFD, *D Thomas*, ECN No. 58 (September 1995)

15. CFD Data Exchange, *D Thomas*, ECN No. 58 (September 1995)

16. Pre-Print Service, *JV Ashby*, ECN No. 58 (September 1995)

17. Improving the Quality of Fortran Programs - A Review, *S Bryant*, ECN No. 58 (September 1995)

18. CFD and the Built Environment, *H Aubi*, ECN No. 59 (November 1995)

19. Recent Developments in Grid Generation, *TJ Pemberton*, ECN No. 59 (November 1995)

20. Data Exchange for CFD Meeting Report, *JV Ashby and D Thomas*, CCnews No. 1 (April 1996)

Appendix V – Terms of Reference of the CFD Steering Group

The Terms of Reference of the EPSRC 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 Programme Manager to the Engineering and Physical Sciences Research Council (EPSRC) on the activities of the Community Club and on the provision and use of existing computing facilities for CFD research at least annually.