Research Groups

A Computational Modelling
B Computer Science
C Fire Safety Engineering Simulation
D Parallel Computing

RA3a: Research student details

Year	Full-time	Part-time	Total FTE	Masters degrees awarded	Doctoral degrees awarded
1996	32.00	11.00	37.50	0.00	2.00
1997	32.00	20.00	42.00	0.00	4.00
1998	28.00	19.00	37.50	0.00	5.00
1999	32.00	8.00	36.00	2.00	2.00
2000	28.00	12.00	34.00	6.00	12.00

RA3b: Research studentship details

Source	1996	1997	1998	1999	2000
UK central government	0.00	1.00	0.00	0.00	0.00
UK industry, commerce and public corporations	0.00	3.00	1.00	1.00	0.00
Institutional self funded	9.00	5.00	7.00	8.00	9.00
Overseas	0.00	2.00	3.00	0.00	0.00
Other - self-funded	3.00	4.00	1.00	1.00	5.00

RA4: Research income details

Amounts shown are in pounds

Source of income (Net VAT)	Partial 1995-96	1996-97	1997-98	1998-99	1999-2000	Partial 2000-01
OST research councils et al	223,752	252,379	263,704	297,191	322,466	129,623
JREI - Other external sponsors	0	151,649	0	0	0	0
JREI - Funding Councils	0	125,000	0	0	0	0
UK central government bodies	201,786	141,262	159,079	116,392	43,466	16,138
UK industry, commerce and public corporations	79,331	128,772	219,752	227,313	173,302	46,709
EU government bodies	32,651	106,941	153,455	284,015	216,785	41,940
Other overseas	13,500	46,596	150,209	185,467	140,017	66,857
Other - Source	132,302	224,737	415,435	389,987	411,686	13,114

RA5a: Structure,environment and staffing policy

This entry represents the profile of a world class team of research academics and their students **in Computational Science and Engineering (CSE), with a specific interest in the development of software technologies and their application in the modelling and simulation of engineering processes**. The research activities of this team have had a significant impact upon its international academic and industrial user communities, in Europe, USA, and Australasia as well as in the UK.

The university is structured as a set of academic schools and research departments. The School of Computing and Mathematical Sciences (CMS) has about 1800 students with 250 on MSc and PhD programmes. The school's research is essentially multi-disciplinary. As such, in this RAE the school's staff are represented in entries to a number of panels. However, the majority of the school's research is reflected through two RAE entries; a small one into Statistics and OR plus the current entry which comprises an interdisciplinary mix of Computer Scientists, Computational Mathematicians, Computational Engineers and Scientists. This team was conceived with the intent of developing and exploiting advanced computer technologies in the solution of important practical engineering problems. To this end the team is structured into subgroups specialising in the underwriting application domains (computational modelling and fire safety engineering), and those specialising in computer technologies (parallel computing and computer science), with some ~30 research active staff supported by 15+ PDRAs and ~50+ research students. These subgroups provide focus for researchers, but they are symbiotic in their operation, the computer technology groups supporting the application groups on all projects. For example, the Computer Science group has provided two artificial intelligence components for the SMARTFIRE project in the fire safety domain, and the Parallel Computing group has developed parallelisation techniques contributing to the PHYSICA computational modelling software. The cohesive nature of the team as a whole is perceived as a strength in our approach to problem solving, and is deliberately reinforced by joint membership of subgroups (involving some ~35% of staff), and cross team authorship of published articles submitted (~40%). The team's infrastructure has recently been enhanced by CMS's move into the fully refurbished campus at the Greenwich World Heritage site; the team is located in the historic buildings designed by Wren in the late 1600's, but just refurbished with 21st century facilities and interior.

Through the development of novel techniques and unique software tools the CSE team has addressed some of the most intellectually challenging problems in their sphere of interest. In many instances, the research output from this team defines the state-of-the-art globally (see below for examples). Each group within the team enjoys an international reputation; these claims are not made lightly or without careful consideration. However, the work of this team does not map neatly onto the RAE panels. Although all its research is based upon the development and exploitation of computer software technologies, most of this is primarily targeted at the development of computational techniques and tools to facilitate the computational modelling and/or analysis of complex engineering processes. As such, the publications in the CM and FSE groups would benefit from being seen by the Mechanical Engineering (notably by panel members with expertise on computational methods in engineering, manufacturing and process engineering) and Civil Engineering panels (particularly by the panel members with expertise in computational mechanics).

The team has forged strong links with academia, industry and government departments in the UK, but most notably throughout Europe, the US and Australasia. Its applications are in the aerospace, automotive, manufacturing and energy industry sectors as well as suppliers of high performance computer (HPC) systems, in both Silicon Valley and Japan. Our simulation based research activities are entirely synergistic with Foresight's objectives with regard to wealth creation and quality of life.

Following a rapid expansion between 1992 and 1996, the team has consolidated its position by retaining its more experienced RA's in academic positions, and has at the same time diversified its research programme. Although the size of the team has largely stabilised, its total output has since continued to grow and its international profile strengthened. The table below summarises the research output over the three most recent consecutive evaluation periods:

88-92 92-96 %change 96-00 %change
Total external income (£M) 1.41 1.91 +35 6.2 +225
Papers published 139 282 +102 475 +68
PhD (equiv) grads 5 19 +280 29 +52
Team size 13 26 +100 27 +4
The most striking difference between the 92-96 and 96-00 periods is in the percentage income growth of over 300%. This income is mainly from highly competitive EPSRC, JREI and EC grants, evidence of the high regard and confidence placed in the team in the UK and Europe. Additionally, research income from US industry and government organisations (including NASA), as well as substantial collaboration with Australian companies, shows true international recognition.
The number of PhD graduations has also increased by ~50%. PhD students are each supported by two supervisors (frequently from separate groups); a post-graduate supervisor for the host school is responsible for keeping track of their progress and providing pastoral care. Most students attend aspects of the CMS school's MSc programme in preparation for their PhD studies – incidentally, this programme has just been made an EPSRC-MTP award for some ~£0.5m to develop a suite of e-based remote learning packages for CSE. A series of internal post-graduate seminars enables students to develop their presentational skills in front of their peers and supervisors. A parallel programme of External Speakers enhances awareness of relevant research beyond the university; this programme has featured many major figures from the international CSE community (see http://www.gre.ac.uk/research/cms). PhD students also expect to attend at least one international conference during their studies, as well as various national meetings, such as organised by ACME, for example. The University has a well developed procedure for registering and monitoring approved PhD research programmes (including all aspects of the supervisory support, infrastructure requirements, etc.) which is managed through its Research Degrees Committee, and chaired by the Pro Vice Chancellor responsible for Research.

Staffing policy
There is a strong commitment to the support and development of young staff and those new to research. Examples here include Dr Kate Finney who, returned after a family break and having completed a PhD on formal methods, has joined the Fire Safety Engineering group, and Dr Alison Williams who comes from a PhD at Aberystwyth to extend her experience from non-Newtonian fluids to multi-physics simulation. Experienced staff have come to support initiatives in parallel computing and financial modelling (Prof Parrott), magneto-hydrodynamics simulation (Dr Bojarevics) and in multi-scale modelling (Drs Lu and Rafii-Tabar). Over 50% of the team are under 40 and ~50% have gained their PhD's since 1990. Naturally, over the RAE period a number of staff have moved into academic and industrial research careers elsewhere in the UK, Europe, Japan and the USA, notably R-Tabar (Tohoku U.), Taylor (Brunel U.) and Wheeler(National Institute of Standards and Technology, USA).
The research programme relies on extensive high performance computing hardware and software to underwrite its operation. Aside from excellent collaborative links with major supercomputer centres around the world (including Stuttgart, NASA, and the USAF), the team has some 60+ workstations and high grade PC's for the research staff and students, plus a series of major parallel computing resources acquired over a 10+ year period. The current HPC system involves 20 processor Compaq Alphas and was funded primarily by a 1997 JREI award. Indeed, the team have just been awarded a further JREI grant to purchase a state of the art parallel cluster (EPSRC GR/R05536). Collaborative arrangements with Computer aided engineering (CAE) software suppliers ensures that the team has leading edge AI, visualisation, geometric modelling, mesh generation, and analysis (CFD, FEA) tools available.

Research Strategy

1. Computational Modelling
Headed by ***Profs Cross and Pericleous*** this group is concerned with the development of new numerical algorithms, procedures and software tools for the simulation of complex industrial engineering processes based upon continuum physics phenomena. Core members of the group include ***Drs Bailey, Bojarevics, Djambazov, Lai, Leboucher, Lu, McManus, Patel, Williams and Prof Parrott.*** Drs Rafii-Tabar, Taylor and Wheeler have recently left and replaced by young researchers who have yet to establish themselves.

For well over a decade, the main research theme of this group, has been the simulation of complex engineering processes that feature the close coupling of a range of continuum phenomena and length scales – ***multi-physics simulation***. From the software perspective, we perceived, some years ago, that an object-oriented modular 'plug-and-play' toolkit was required which enabled a range of phenomena models and their interactions. From our extensive experience of CFD simulation, it was our view that the partial differential equations describing non-linear phenomena are best solved by finite volume methods. But, to describe complex geometries, unstructured meshes typical of finite element methods are required. In the space of ten years, the group has developed appropriate finite-volume methods on unstructured meshes (FV-UM) addressing ***a range of such phenomena*** (fluid flow, heat transfer, combustion, phase change, electromagnetics, solid mechanics, acoustics) ***and their interactions***. These methods have been embedded into a ***multi-physics*** software simulation environment, ***PHYSICA*** (http://physica.gre.ac.uk/). With this system, the analysis of complex 3D geometries is possible, in scalar or in parallel, on HPC systems. The strategies developed by the Parallel Computing Group, and OO software engineering techniques explored with the Computer Science group have been instrumental in PHYSICA's development. Not yet commercial, PHYSICA has about 60 installations world-wide at present.

We believe that PHYSICA is presently the most advanced parallel multi-physics simulation toolkit in the world – the development and evaluation of PHYSICA are the most significant outputs from this group over the period. Other significant key achievements (frequently in the context of PHYSICA and its prototypes) over the current period include:

- computational model of shape-casting that predicts macro-defects through the interactions of the component continuum physics (free surface flow, heat transfer, solidification/melting phase change, and non-linear solid mechanics) [EPSRC GR/K42370]
- Fully coupled models of aero-acoustic behaviour (involving fluid flow, sound generation and propagation) with aerospace applications [EPSRC GR/M60804]
- Computational models of welding processes: interactions of fluid flow, heat transfer, phase change, electromagnetics and prediction of component distortion [Brite-Euram D-SIGN]
- Computational models of electromagnetic induction melting for Titanium, involving fluid flow, heat transfer, melting, in a dynamically distorting free surface envelope (EPSRC GR/L97483, GR/N14136, US Industry)
- Computational models of granular flow where, depending on local conditions, the material behaves either as a fluid or solid [EPSRC/IMI GR/M1507] as well as erosion modelling [EPSRC GR/M04980]
- Models of metal processes, e.g. continuous casting for steel and • DC casting of aluminium, that involve fluid flow, heat transfer, reactions, phase change, solid mechanics [French and US industry]
- Fully coupled dynamic fluid structure interaction in the simulation of aircraft flutter and other flow induced vibrations [USAF]
- Electronics processing, involving solder mechanics and new processes involving lead-free solder [EPSRC GR/M09292, GR/N14095, NIST(USA), British Council (Hong-Kong)]
- Developing thermal stress modules and life prediction models for use in a commercial Electronics packaging code (Flotherm) in a succession of TCD schemes (TCS 2341, 2976).
- Models of the complete Aluminium electrolysis cell and stability analysis in the face of magneto-hydrodynamic interactions. [EC Copernicus – ALEL project]
- Simulations of electromagnetic fields, heat and mass transfer in microwave heating, freeze drying of foods and related processes
- Simulation of copper extraction procedures using the leaching process [US Industry] and iron ore smelting using the HIsmelt process [Australian Industry]
- Domain decomposition in heterogeneous models [British Council, EPSRC, LMS]

2. Parallel Computing

Core members of this group are ***Profs Cross and Parrott, Drs Johnson, Ierotheou, Leggett, Lai, McManus and Walshaw.*** The key objectives of this group are to develop techniques and tools to support the parallelisation of computational mechanics software. This work has divided between the issues surrounding legacy code parallelisation (a major issue for many organisations that previously exploited CRAY vector systems, such as, NASA, US-DoD centres, etc.) and novel techniques. Key achievements through the late 1990's include:

Continuing on the development of whole program (inter-procedural dependence) analysis of Fortran application codes from the early 1990's, **these techniques define the state-of-the-art in parallel compiler technology.** They enable comprehensive dependence graphs of Fortran software to be defined and form the basis on which accurate and efficient parallel code can be generated.

The development of a thin message passing layer (***CAPLib),*** that maps onto libraries such as PVM, MPI and shmem has been designed and implemented to meet the needs of Computational Mechanics software to enable a single generic parallel version to be created. This allows maintenance of the software on current and future HPC systems.

The development of an environment (***CAPTools***), that enables the semi-automatic parallelisation of Fortran application codes. CAPTools uses the dependence analyser and message passing library CAPLib to help create parallel code that will execute effectively on distributed memory parallel platforms. More recently, the tools capability has been extended to allow the generation of OpenMP directives for shared memory platforms. CAPTools has been evaluated extensively and enhanced to enable the rapid parallelisation of large industry codes with 100K+ lines of Fortran source. This work is done in collaboration with many industries including NASA (who have provided $+0.5m), US-DoD and SGI, as well as EPSRC and the EU. ***CAPTools has been beta-licensed to some 50+ user sites world-wide*** and plans are already underway for commercialisation. Current work is targeted at the generation of efficient hybrid, message passing-OpenMP directive, parallel code to enable execution on the future generation parallel platforms.

The development of an interoperable suite of parallel support tools including CAPTools, VAMPIR, DIMEMAS, AIMS in the context of EC and NASA funded projects, respectively.

The development of tools for partitioning of unstructured meshes and dynamic load balancing of computational mechanics codes. The ***JOSTLE*** toolkit runs scalably in parallel and maps partitions onto processor topologies so as to retain nearest neighbour connectivity to minimise inter-processor communications. ***JOSTLE has been licensed by over 100 users worldwide***. These tools have also underwritten the development of parallelisation strategies for codes with one or more of multi-block, multi-dimensional partitioning of single block, unstructured meshes and heterogeneous loads (caused by contact or multi-physics procedures, for example) through the EC-DRAMA programme. All these strategies are being embedded into CAPTools and evaluated on full-scale application codes developed by our international collaborators

Multi-physics simulation is at the limit of engineering computations and requires significant computational resources in terms of both machine cycles and memory. Hence, the parallelisation of the multi-physics code, PHYSICA, so that it runs essentially in parallel with high scalable efficiencies on a variety of HPC hardware and is naturally extensible to represent a wide range of computational models is another key development. Strategies developed for the generic parallelisation of heterogeneous unstructured mesh codes using a distributed memory, message passing, SPMD model have been developed and engineered into PHYSICA. Technologies crucial to the success of this effort are CAPLib to provide a portable and highly efficient communication harness and parallel JOSTLE to allow fully distributed data partitioning/load balancing.

The BSP paradigm has been both exploited and assessed through the parallelisation of electromagnetic and financial computation codes. This work has involved both the analysis of numerical approximations used in these computations together with the development and implementation of parallel algorithms. The issue of accuracy versus computational cost has been addressed both by careful consideration of the potential for parallel performance (making use of the BSP cost model) and the optimal choice of approximation and numerical solution procedures (e.g. a variational formulation of scattering cross-section integrals).

The development of domain decomposition based techniques for inverse analysis

3. Computer Science

This group is headed by ***Professor Knight and includes Drs Nissan, Petridis, McKenzie, Soper, and Finney***. The development strategy has aimed at the evolution of internationally recognised academic research related to applications. The direction of the research has aimed to combine work on theoretical underpinnings with real software applications. To this end there has been close collaboration with other groups both in this team and elsewhere. The Computer Science group has proved to be an integrating agent for the whole Greenwich team, and has collaborated on projects with all of the other groups.

The main field of the group is artificial intelligence, and in this field, theoretical work on temporal reasoning, case based reasoning, genetic algorithms, and heuristic search techniques has gone hand in hand with practical industrially based projects. Case based reasoning (CBR) has been applied in two major projects, resulting in production software:- IDA, a materials selection system produced for Alcatel systems, and SMARTFIRE, a fire modelling system supported by EC, EPSRC and UK Home Office as well as industry; **we believe this work defines the leading edge of CBR 'practical' applications**. Heuristic search and data mining techniques have also been applied in SMARTFIRE for the automatic dynamic control of the solution process. FUELCON is a software system resulting from an international collaboration between the Universities of Greenwich and Ben Gurion (Israel), together with expert users from Siemens AG, and British Energy PLC. The system combines several innovative AI components to provide a solution to the critical problem of optimization of fuel loading patterns in nuclear generating plants. These components include interactive knowledge discovery, hybrid symbolic and non-symbolic neural features and a genetic algorithm. FUELCON's genetic algorithm approach to optimization, FUELGEN, is a continuing collaboration with British Energy. A first production system dealing with a single loading phase is currently operational, and work is continuing on the problems of multi-phase optimization. Genetic algorithms have also been applied in the development of mesh partitioning techniques in collaboration with the Parallel Computing group. Theoretical work on temporal reasoning has advanced the new temporal theory developed by the group during the previous RAE period in several ways. Applications of the temporal logic have been developed in terms of a logic based process controller, which has been incorporated into the work on dynamic control of the SMARTFIRE software (developed with the FSEG below). It has also formed the basis of an application in a computational approach to legal evidence, as a temporal consistency checker. A new impetus to the group's activity has focused on artificial intelligence applications in the law. These include temporal representations, and integrated AI architectures in the support of legal evidence discovery and organisation (a new field). Our initiative here was recognised to be seminal, and editorial initiatives on behalf of international journals enabled us to commission specific conceptual components from leading international scholars in AI and legal domains. This international collaboration, conceived and co-ordinated at Greenwich, resulted in a broad architecture which is expected to the form the basis of substantial future collaborative research.

The group has also aimed to develop individual research in a range of other areas, including:- an assessment of formal methods in a practical programming context, an investigation of network performance problems by simulation (e.g. congestion control in ATM Networks, performance problems with multimedia traffic), and developing enhanced image processing techniques in the context of satellite technology (with applications to pollution control and other measures to protect bio-diversity in Africa).

4. Fire Safety Engineering Simulation

The ***Fire Safety Engineering Group (FSEG)***, founded by ***Prof Galea*** in 1986, initially focused on the development of CFD based fire simulation techniques. Over the years the research interests of the group have expanded to include the computer modelling and simulation of evacuation, combustion, fire/smoke spread, structural response to fire and its extinguishment. Application areas include the built environment, aerospace, marine and rail transport. FSEG is one of Europe's leading centres of excellence and one of the largest in the world dedicated to, the mathematical modelling and simulation of fire and related phenomena. Aside from Prof Galea, key members of the group are ***Drs Patel, Lawrence, Ewer, Jia, and Gwynne***, with contributions by ***Prof Knight, Drs Petridis, Finney*** and ***Bailey***. Key developments of the group during this RAE period include:

a) Research into the simulation of human behaviour during evacuation situations. This work funded by a combination of the EPSRC (GRK38250) and various industrial and government groups such as UK CAA, NHS, Ove Arup, RINA, Airbus, Boeing, Daimler-Chrysler, etc has lead to the ***development of the EXODUS suite of evacuation models. This is arguably the most sophisticated evacuation simulation tool in the world with users in 17 countries.*** Current research in evacuation and behaviour modelling includes the development of communication behaviour, reaction to signage, group behaviour and reaction to smoke. The modelling techniques are currently being extended to include adaptive routines and game theory. In the past 4 years FSEG projects in evacuation include design, safety and/or certification advice to Airbus for the A3XX super jumbo and A340-600 aircraft, the Millennium Dome, Ascot Race Course and Bombardier Canada. These developments are of such importance to Airbus that they have seconded a senior engineer to FSEG for 12 months.

b) Research into fire development and combustion. This work, funded by a combination of EPSRC) and various industrial and government groups such as EU under1(GR/L56749/0 FWkV, Rockwool, UK Home Office, LPC, etc has lead to ***the development of the SMARTFIRE fire field simulation tool in collaboration with the Computing Science group above. This is one of the most innovative CFD based fire field models available, currently with users in 9 countries.*** This software system uniquely combines developments in a number of research areas, including expert systems for intelligent automatic mesh generation, group solvers to reduce the computational overheads in the solution of the CFD equations, pattern recognition and data mining techniques for the automatic dynamic control of the solution process, combustion modelling for the prediction of solid fuel combustion, the on-set of flash-over and backdraft conditions.
c) Other research projects include: water mist modelling funded by the EU-FWkIV, the development of the AASK relational database containing data relating to human factors in aircraft evacuation situations funded by EPSRC (GRK38250) and CAA, virtual reality tools for fire and evacuation applications, dynamic response of structures to the impact of fire for composite steel members,
d) FSEG expertise in fire/evacuation modelling and human behaviour is sought by national and international standards bodies such as the BSI (UK), Human Behaviour Task Group of the Society of Fire Protection Engineers (USA) and ISO (International). Lord Cullen, as chairman of the Ladbroke Grove Rail Inquiry, called Prof Galea as a neutral expert witness, which involved him in an extensive assessment of the evidence supplied by the investigation team.
e) Since 1997, the group have run two short course programmes aimed at those members of the fire safety engineering community interested in improving their understanding of fire and evacuation analysis techniques; over 130+ have attended these courses from 18 countries.

Uptake by beneficiaries
The key practical outputs from team's research are software tools. The team takes a professional approach to the development and maintenance of its software tools. The school's MSc in Software Technology has provided an opportunity to provide exposure to state-of-the-art software design, implementation, testing and maintenance strategies for the team's research staff. Altogether there are 8 major research-led software tools developed by the team: PHYSICA, CAPTools, CAPlib, JOSTLE, FUELGEN, IDA, Smartfire, Exodus. These tools together have well over 300 international user sites, which are a mixture of research intensive universities (e.g. Cambridge, Oxford, Imperial, UCSD, Caltech), industry (e.g. Rio Tinto, Airbus, SGI, Compaq) and government labs (e.g. NASA, Argonne, Sandia, Los Alamos), who not only are provided with continuing technical support, but in many cases both continue to stimulate and contribute to further research. R&D teams are associated with each software tool, who continue to support the technology, and to expand its capability as new research comes to fruition.

Reflection and projection
The 1996 RAE entry by this team (to Mechanical Engineering) set the following suite of objectives:
Enhancement and exploitation of the multi-physics tools in a parallel environment plus their application to a wide range of engineering processes which feature interacting continuum phenomena – achieved in its entirety

Developing techniques for effective coupling across length scales – achieved in part; good progress made in leaching, granular flow and crack propagation, for example
Develop techniques and tools to automate the process of parallelising a wide range of application codes to give scalable parallel performance – substantially achieved
Extending the evacuation models using game theory and neural nets plus the development of an integrated environment for fire simulation – substantially achieved
The development and implementation of case based reasoning systems and temporal database systems for engineering applications – achieved
All the key research issues identified in 1996 as significant have been thoroughly addressed through externally funded research programmes and much progress has been made in each case. These programme themes are now mature; they are well supported by external sponsors and we expect to see them grow even further in the next few years:
Having produced a parallel multi-physics simulation environment we expect to improve its physical functionality, effect its implementation in a GRID environment, and apply it to the modelling and analysis of ever more complex engineering processes that require substantial levels of computing power, notably multi-scale phenomena
Improving the parallelisation tools to cope with mixed shared-distributed memory systems (typified by mixed use of MPI-OpenMP) and the load balancing tools to deal with ever more complex load balancing problems, especially in a GRID computing context
Having identified a need for graph based retrieval, we expect to extend it to case based retrieval, extending work on existing competence models to objects with no embedding n dimensional vector space, which will include instance based data mining techniques based on graph based metrics.
The development of a complete temporal theory of actions and change based on the new reified temporal logic, and implement a system in the context of fact investigation and legal evidence.
Extend the CFD fire safety simulation tools to include a variety of combustion models (e.g. toxic product development) and dynamic control of flame spread and evacuation model.
Evacuation models to include a variety of new features such as human factors (e.g. physical fatigue, family group dynamics) and extensions to other systems such as the marine environment and non-emergency people movement in large spaces (e.g. airport terminals).

Self Assessment
This entry represents the work of four strong interacting and interdependent groups that have significant international collaborations and mutually support each other's programmes. Through 'international':- archival journal publications, collaborations, leading participation at conferences, etc, editorial activities, sources of external income and exploitation of the team's software tools by leading industrial, academic and government research organisations, the team overall provides compelling evidence of a major international research profile and impact, largely in the context of computational science and engineering.

RA6a: Additional observations, Evidence of esteem

All staff in this entry are active in attending and speaking at international conferences, reviewing for archival journals and examining PhD students, etc. Here we only have space to highlight the profiles of the more senior staff in the team.
Centre Director, **Prof Mark Cross**, has 30 years of experience in all aspects of the computational modelling of continuum physics processes (and their associated software technologies) in the context of materials/metals processing/manufacture. He has served on the 1992 Applied Maths and the 1996 Mech. Engg. RAE panels, on EPSRC colleges continuously since they were established (being a member of a number of panels), referees 30+ applications from EPSRC, the Canadian, South African, Australian and US equivalents annually, as well as acting as an external assessor for many professorial and tenure applications. He has examined numerous PhD's during this RAE period in the UK, Canada, USA and Australia. Since 1984 he has edited the archival journal, Applied Mathematical Modelling, published by Elsevier, is on the editorial board of and referees for several others.

He currently chairs the UK branch of the Assocn. of Computational Methods in Engg (ACME), organised the 2000 conference at Greenwich, following on from the 1998 incarnation of the Intl. Conf. on Grid Generation for Numerical Field Simulation, which attracted some 150 attendees from 20+ countries, including the Director of NASA-Ames, as the opening speaker. Both these meetings yielded published proceedings, as did the intl conf. on Domain Decomposition Methods, jointly organised with Dr Lai. He has served on innumerable intl conf. committees and is a member of 3 EPSRC funded networks. He holds one of the largest EPSRC project grants currently awarded, jointly with Dr Patel (and others) on Quality in Particulate Manufacturing (QPM) and has been a keynote/invited speaker at some 30 international meetings in the past 5 years. He has consulted for a range of international organisations including Rio Tinto, Phelps Dodge, US Steel, Svedala and Howmet (mining/minerals/metallurgical companies), USAF, NASA and SGI (US aerospace and HPC user/supplier organisations).

1. Computational Modelling and Simulation

Prof Koulis Pericleous, an aeronautical engineer by training, has specialised in CFD since 1979. Currently a member of the IMA, ASME and BCS (with CEng status), he exemplifies the multi-disciplinary nature of the team's research focus. A member of the IMA Engineering panel that liaises between Mathematicians and the Engineering Institutions, he has been involved in many intl conferences as a member of the technical /organising committee, session chair and invited speaker, e.g. MCWASP VIII (San Diego CA), CSIRO Conf. I & II on CFD in the Mineral/Metals Industries (Melbourne Aus.), PAMIR II & III (France), 27th Israel Conf. Mech. Engineering (Haifa). He regularly referees tenure applications in the UK and Australia, and many EPSRC, etc grant applications, plus examines many PhD students in the UK and Australia. He is on the editorial board of the AMM, reviews for many other journals. Together with Dr Bojarevics he leads an international activity with Drs Leboucher and Djambazov on MHD simulation. **Dr Bojarevics** came to Greenwich from the Institute of Physics in Latvia some years ago. A regular invited speaker at MHD meetings on simulation, he has recently become the only UK member of the editorial board of the International Journal of Magneto-hydrodynamics (Plenum Press). He has consulted and collaborated with a number of academic/industrial MHD groups over the last few years (including Alcoa & Howmet[USA], Birmingham Univ. and Riga). **Dr Bailey's** sustained effort is on multi-physics modelling with his current focus on predicting the defects associated with electronic packaging during manufacture, where he is the PI on a number of EPSRC, TCS and internationally funded projects. He has established international collaborations in the Far East (with the City University of Hong Kong and a cadre of international companies), the UK where he is a core member of the EPSRC-Emernet academic/industry network on electronic packaging, and the USA where he is a core part of the NIST IAG-network on electronics processing. He has been an invited speaker at many intl conferences & modelling workshops, notably 3rd Pan Am Conf in Industrial and Applied Maths, Peru and the IMM Conf. on Developments in Processing. As well as reviewing for a number of international journals, he has consulted for a number of organisations including Alcatel, Celestica, GEC-Marconi, Intarsia(USA), Britannia Refined Metals, National Institute for Standards and Technology(NIST) (USA), National Physics Laboratory. **Dr Patel**, as a Reader in CFD, is involved within both the FSEG and Computational Modelling groups. He has been involved in both the core teams that developed both SMARTFIRE and PHYSICA. He currently manages 3 EPSRC and one EU Fwk4 project, including a major £1m+ IMI programme on granular flow (QPM). He has been a speaker at a large number of international (e.g. ASME) meetings, included chairing sessions, and referees for several intl journals concerned with CFD. **Dr Lai** is very active in the intl domain decomposition community. Vice chair of the 11th Intl DDM Conf. at Greenwich, July 1998 (sponsored by EPSRC) and editor of the fully refereed proceedings, 'Domain Decomposition Methods in Sciences and Engineering XI', published by DDM.Org, 1999, he served on the organising committee of UKPAR96, Surrey, July 1996, and the biennial Intl Conf. on the Applicns of High Performance Computing in Engg. He has a wide community of intl visiting collaborations, funded by British Council, EPSRC, Royal Society, LMS, with Bergen, Groningnen, NASA – ICASE, Chinese Academy and Florida State Univ. He and Prof Tam(FSU) recently organised a one-day Symposium on Computational Aero-acoustics, at Greenwich. He has given invited lectures at Leuven, Shanghai, Hong Kong, Bergen, Grongingen and at the ICFD Workshop on Computational Aero-acoustics,

Reading, 1999.

2. Parallel Computing

Prof Parrott's focus is upon applied numerical analysis and parallel computing. For 10 years he was in the 5* rated CS group at Oxford University Computing Laboratory and has an established international profile. His work appears regularly at international conferences (COMPUMAG 97, PIERS 97, DD11 98, ICIAM 99) and he has a longstanding collaboration with Peter Monk at the University of Delaware in computational electromagnetics. Most recently he has been an invited participant at the Isaac Newton Institute Programme on Moving Boundary Problems in Industry (Cambridge, July 2000) and invited speaker at the EPSRC-sponsored Boundary Integral Methods Workshop (Bath, Sept 2000). He is a member of the Scientific Committee of the Smith's Institute for Industrial Mathematics and its Faraday Partnership. He has recently been a panel Member for the EPSRC Computational PDE's Initiative (1999). He is a frequent seminar speaker at UK universities (Bath, Brunel, Oxford, Cambridge, Warwick, Leicester). Editor of the proceedings, 'Approximation and Numerical Methods for the Solution of Maxwell's Equations', published by Clarendon Press, Oxford (1998)

Drs Johnson, Ierotheou and Leggett have a strong profile, collaborating in the US with: NASA, USAF/DoD and SGI, and in Europe with: ARA, Aerospatiale, NEC, and Fujitsu. They have organised and participated in many workshops on CAPTools and CAPLib, particularly at national laboratories and supercomputer centres in the US (e.g. NCSA, Pittsburgh Supercomputer Center, Ohio Supercomputer Center, Argonne National Labs) and in the UK at Manchester. They have presented at/organised technical sessions on Parallel Computing tools and their applications at many international conferences. Dr Ierotheou is a committee member of the international workshop on Parallel and Distributed Scientific and Engineering Computing with Applications, and a co-editor of the proceedings of the Intl conference on Parallel & Distributed Processing Techniques and its Applications. The importance of their work has resulted in collaborations with a number of international workers including D.Keyes (ICASE), B.Groppe (Argonne National Labs), R.Hempel (NEC) and B.Chapman (Houston Univ). They have hosted a large number of extended visits, including J.Yan NASA (sponsored by EPSRC), B.Hood (NASA), J.Michalakes (NCAR) and L.Meadows (Sun) co-founder of the Portland Compiler Group.

Drs McManus and Walshaw are often invited speakers at Parallel Computing conferences (with a numerical focus), including for McManus PCFD99 (Williamsburg), the ISPCES97 (Tokyo), and the Parallel and Distributed Computational Mechanics Workshop'97 (Lochinvar). The only UK panel member at the Intl Symp. on Parallel Processing in Engg/Science (ISPCES'97), Tokyo, 1997 he was also an Evaluator for step 1 and rapporteur for step 2 evaluation of proposals for ESPRIT 4th framework - HPCN Simulation. Dr. Walshaw's is recognised internationally for his development of the parallel public domain toolset, JOSTLE, and his invited presentations include the 3rd Euro. Conf. on Parallel & Distributed Computing for Computational Mechanics (Weimar, Germany, 3/99) and the Workshop on Parallel Unstructured Mesh Generation & Partitioning (Univ of Minnesota USA, 10/97).

3. Computer Science

Prof. Brian Knight's work focuses upon artificial intelligence applications and temporal logic. He has been invited editor for several special issues of international journals subjects in these areas including:- (a)"Temporal Logic in Engineering" for Artificial Intelligence for Engineering Design, Analysis and Manufacturing, Vol. 13, No. 2, (1999), (b) "Intelligent Technologies for Electric and Nuclear Power Systems" Computers and Artificial Intelligence, Vol. 17, No. 2/3, 1998, (c) "Case-Based Reasoning", Vol. 5 (1999) of the New Review of Applied Expert Systems. He referees extensively for scholarly journals concerned with temporal systems and artificial intelligence. He is an active member of the UK Temporal Reasoning, Artificial Intelligence and Logic (TRAIL) Group, where he has presented several invited talks on temporal logic, and currently serves on the programme committee of AICIVIL-COMP2001 (6th Intl Conf. on the Applns of A.I. to Civil and Structural Engineering). He manages several AI research projects involving international collaboration, including: Case based reasoning system for material selection, for Alcatel Systems; EU EuroCompetence - Distance learning; EPSRC - SMARTFIRE (with E Galea).

Dr Nissan's research focus is in artificial intelligence, particularly for legal reasoning and for engineering, where he has edited several special issues of international journals, including:-

(a) The New Review of Applied Expert Systems (1998); (b) "Formal Models of Legal Time", Information and Communications Technology law 7(3), (1998); (c) "Formal Approaches to Legal Evidence" New Review of Applied Expert Systems (to appear). He is active in intl conferences; co-organising several workshops, e.g: AI & Law in Amsterdam, 1999, chairing a session at ISA'2000 in Australia, one at the Int. Symp. on Methodologies for Intelligent Systems (1997), serving on the committee for the IASTED LawTech Conf. in 1999 and 2000; and at the Symposium on AI & Legal Reasoning at AISB'2000.. He was an invited speaker at the workshop on `Logic, Computation, Law' in Pisa, Italy (1996). Journal refereeing activities are extensive.

4. Fire safety Engineering Simulation

Prof Galea focuses upon computer modelling in fire safety engineering (FSE). He has given many invited/keynote presentations at Intl confs, including:- Safety of Large Passenger Ships, Inst. of Marine Engrs Conf., London 2000 and the Howard Emmons Lecture at WPI in USA in 1998. He serves on a number of inter/national committees in the area of FSE, e.g. BSI committee on Fire Safety (FSH/24) and FSH/24/5 (life safety) and FSH/24/2 (calculation methods). He is the nominated UK expert in Life Safety and in fire model validation to the ISO committee TC92 and the only non-US member of the Human Behaviour Task Group of the Soc of Fire Prot. Eng. In April 2000 he was an expert witness to the Cullen Rail Inquiry. He is very active in intl conf organisation and participation e.g. he served as joint chair of the cabin safety workshop organised by the JAA/FAA on Very Large Aircraft (1998), and facilitated the student workshop at INTERFLAM '99. He referees for a number of academic journals concerned with FSE e.g. Fire Safety Jnl, Fire and Materials, etc. and regularly acts as referee for funding bodies such as EPSRC, Australian ARC, etc. He has appeared in the Intl media as a commentator concerning fire related issues in over 16 major TV programmes since 1996 e.g. EQUINOX, 1996; Dispatches, 1999. His R&C activities and that of his team are supported by a range of organisations including the UK CAA, Home Office, Ove Arup, EU, EPSRC, NHS, Rockwool, Airbus, Bombardier and Boeing. He is currently managing two EU FWkV research projects, Safety First and Fires in Tunnels and numerous privately funded projects. *Drs Lawrence, Gwynne* and *Prof Galea* and *Drs Ewer, Jia, Patel* and *Prof Galea* represent the key software development teams for EXODUS and SMARTFIRE, these efforts being lead by *Drs Lawrence* and *Ewer* respectively. Both products are applied to the aviation, building and marine industries and are used by engineers, universities, research laboratories and regulatory authorities all over the world. This work is highly regarded by the worlds major aircraft manufacturers, all of which have funded projects with the team. Airbus have also seconded a senior engineer to join the team for 12 months from October 2000 and BOEING sent two engineers for extended visits in 1999. In 1998, a paper by *Galea and Lawrence* published in the Aeronautical Journal won the Hodgson Prize of the Royal Aeronautical Society. *Drs Jia, Ewer and Gwynne* – recent PhD graduates – have given papers at the IAFSS symp (France 1999) and at a number of other Intl confs including the INTERFLAM series and Intl conf on Human Behaviour (Belfast 1999). *Dr Gwynne* is currently managing a Canadian Government sponsored project to enhance the marine capabilities of EXODUS and *Dr Lawrence* recently completed a project sponsored by Ove Arup to develop non-emergency applications of EXODUS. Since 1997, both teams have organised and presented short courses in fire and evacuation attracting over 130 fire safety professionals from 18 countries.

5.Conclusions

Key objectives of our research programme include:

Developing a critical mass in a variety of themes and encouraging • (driving) inter-disciplinary collaborations – over 8 staff and research students

Generating a dynamic culture (a buzz) that attracts researchers • from all over the world – double figure inter/national conferences and meetings organised by our staff, with many at Greenwich in this RAE period, and over 100K per year spent on travel to interact with collaborators

Developing • long-standing partnerships with funding collaborators, involving much repeat business, etc (e.g. Rio Tinto, CAA, Boeing, Alcatel)

Working to push back • the disciplinary boundaries (through driving CS techniques into computational modelling tools and applying these to real world problems) rather than just fill in knowledge gaps – we want our research to make a difference to the user applications communities, and finally,

To generate high esteem from our • relevant peer groups internationally.
We believe that these objectives have been substantially achieved over the past few years and that the evidence submitted here supports that assertion.

RA6d: Additional observations, Additional information

No RA6d was submitted for this submission. Institutions may have included relevant information in other parts of the submission.
