

Group Evaluation Report,
Department of Mathematical Methods and Models for Scientific
Applications (DMMMSA)
16th - 17th July 2007.

September 1, 2007

1 Executive Summary

The Department is comparatively small but with an overall reasonable mix of staff at different stages of career development. A commendably large proportion of research is of significantly high international standard. The Department performs a valuable role in the University and, as originally intended, actively bridges theory and applications. It undoubtedly is capable of successfully responding to future demands, and merits continued strong University support.

For ease of reference, the Panel's agreed ratings for the constituent groups and for the Department as a whole are shown in Table 1. Detailed accounts are contained in the following Sections which also note concerns. Recommendations are proposed in the final Section.

Criteria	MAT/03	MAT/05	MAT/07	MAT/08	Overall
Quality	VG	G-VG	VG-Ex	Ex	VG-Ex
Productivity	G	G	G-VG	Ex	VG
Relevance	G	G	VG	Ex	VG
Future Possibilities	G-VG	G-VG	VG	Ex	VG

Table 1: Group and Overall Ratings ([G] - Good, [VG] - Very Good, [Ex] - Excellent)

2 Organisational details

The evaluation panel consisted of:

Professor Aline Bonami, University of Orleans, France.

Professor R J Knops, Heriot-Watt University, Edinburgh, Scotland, UK.

Professor George F. Pinder, University of Vermont, Vermont, USA.

Professor Alessandro Verra, University of Rome 3, Rome, Italy.

Unfortunately, a close family bereavement prevented Professor Verra from participating in the actual Evaluation Visit, but the remaining panel members had the benefit of his preliminary Individual Report.

Arrangements for the visit were excellent, and *ad hoc* requests were promptly and willingly satisfied. The panel's timetable was as scheduled but additional meetings were organised with the Director and with some postgraduate students. A friendly atmosphere was created for constructive dialogue and the Panel's diverse questions received comprehensive replies. The Department and University are cordially thanked for their help and hospitality that contributed to a successful and pleasant visit.

The documentation supplied in advance thoroughly described the Department and its activities. The lack, however, of background information on university and national procedures somewhat hampered initial understanding by panel members. Explanations were supplied by the Director and others but brief descriptions in the papers distributed beforehand would have been useful. Suggested topics are listed in the Appendix .

The Report now submitted was collaboratively prepared by all four panel members and represents their agreed opinion. Revised individual reports will be submitted separately by Professors Bonami, Knops and Pinder.

3 Historical Perspective

The Department was formed in January 1989 as part of the Faculty of Engineering and replaced the previous Institute of Applied Mathematics consequent upon University restructuring. Its undergraduate

mathematics teaching, exclusively to engineering students principally in their first year of study, is determined by the Faculty. The Department is, however, responsible for the conduct and development of its own research.

It is worth noting that laudable reasons for the Department to be established separately to the Department of Pure and Applied Mathematics, is to *achieve better coordination of the mathematics courses taught to Engineering students and to foster the field of mathematical research applied to engineering problems.*

The Director appears to exercise a largely administrative role, and is not formally responsible for the development of either general or particular future policies.

Research is in the key areas of problem solving, derivation of mathematical models, and the application and development of relevant basic mathematical techniques, and is organised into four main groups:

1. MAT/03 Geometry.
2. MAT/05 Mathematical Analysis.
3. MAT/07 Mathematical Physics.
4. MAT/08 Numerical Methods.

A significant proportion of the research has successfully achieved wide international recognition, and commendably includes problems of local interest. Active but mainly informal interaction occurs with appropriate sections of the Faculty of Engineering and of the Faculty of Science, and with various distinguished external groups. A joint colloquium is organised with the Department of Pure and Applied Mathematics, with whom the library is also shared.

The Department is not large but there is an acceptable mix of postgraduate students, research associates, and junior and senior professors. Individual teaching loads average about 100 contact hours per academic year which is below that in many other universities known to panel members, although it should be remembered that teaching in the Department is usually to classes in excess of 100 students and consequently generates additional work. Moreover, certain staff voluntarily contribute extra courses, including those to engineering doctoral programmes of study.

The impression is of a congenial, stimulating working environment, with excellent interaction between departmental members who are mutually supportive. Several retirements are due, but it is uncertain at this stage whether the Department will be able to secure replacements of its choice. Failure to do so will adversely affect its research efforts.

4 Constituent Groups

The Panel decided at a preliminary meeting what issues should be discussed with each research group. After these discussions, panel members arrived at consensual ratings for the requested criteria which are listed in Table 1. Comments appropriate to individual groups are presented below, and a general assessment is contained in Section 6. Conclusions and recommendations are set down in Section 7.

4.1 MAT/03

This is a small group whose specialised research is focussed on the flourishing fields of classical algebraic and differential geometry. Certain aspects are fundamental to the rigorous mathematical formulation of continuum and related theories. Other research includes studies relevant to string theory and quantum mechanics. Because of the classical techniques employed in some research projects, difficulty is sometimes experienced in having the corresponding papers accepted for publication. But even so, research publications in all areas are of very high quality and of reasonable quantity. The group has become somewhat isolated both nationally and internationally, despite previous excellent formal links with outstanding foreign centres. Nevertheless, there are collaborative projects in engineering (electrical and coding theory), and with the Department of Pure and Applied Mathematics (a joint grant application). Interaction with other groups both

in the Department, especially MAT/08, and elsewhere in the University, is informal but effective. Research income is modest and derived mainly from University grants. Conference participation is acceptable, while a weekly series of departmental seminars has been organised.

The group has been considerably strengthened by the addition of an active young researcher, although research in differential geometry is weakened by the recent resignation of an associate professor.

Apart from the relative isolation noted above, another difficulty experienced by the group is with the recruitment of postgraduate students and young staff. At the same time, its future policy appears confined to a continuation of present research. Development of projects with more topical appeal may help to resolve some of these difficulties.

Ratings are shown in Table 1 above.

4.2 MAT/05

This group, which also is small, seemingly lacks a coherence more readily discernible in the other three groups. Its members include some who are extremely active with excellent international reputations for innovative contributions. Indeed, one member is outstandingly influential worldwide and may safely be ranked amongst today's top Italian mathematicians. The successful research has led to strong personal links with distinguished groups in other universities both in Italy and abroad. Although such links bring obvious benefit, if allowed to become too dominant, they might significantly curtail intellectual leadership essential not only for staff commencing their careers, but also for the scientific welfare of both the group and the Department as a whole.

Apart from external links, there is meaningful but limited interaction within the Faculty of Engineering, while stronger ties exist with the Department of Pure and Applied Mathematics that include the joint organisation of a weekly seminar. Other especially noteworthy features are the voluntary organisation and presentation since 2002 of annual mini-courses in mathematical analysis, and contributions, again voluntary, to the engineering doctoral programmes and latterly to the Scuola Galileiana di Studi Superiori. These demonstrate the extra effort the group willingly undertakes to share and communicate its expertise. However, with respect to postgraduate recruitment, these commendable efforts have met with a disappointing response, caused also by difficulties encountered with gaining access to relevant student groups.

Future policy concentrates on existing research projects, and does not envisage any significant new initiatives. Nor does there appear to be an integrated strategy for securing replacements of impending retirements.

The Panel's ratings are displayed in Table 1.

4.3 MAT/07

This group is somewhat larger than the previous two. The major part of its research is centred on the crystallography of materials and is of enormous international importance being highly relevant to the development and production of purpose designed new materials. Other research interests include wave propagation in coupled theories (applicable to earthquakes), and optimal control theory applied to discrete systems. Interaction with engineering departments has been limited due probably to the rather fundamental abstract character of most research undertaken.

Research output is of commendably high quality, although somewhat lower in quantity in comparison with groups of similar size and reputation. Moreover, the group is working hard to replace external research grants that have now expired, and are fully aware that its currently modest income severely impedes associated activities such as travel and invitations to outside experts.

The group conveyed to the Panel its firm resolve to seek approval to appoint a suitable replacement for a forthcoming senior retirement in order to maintain and enhance the quality and quantity of research output.

Like the previous groups, recruitment of postgraduate students and young researchers is believed to be seriously hampered by limited access to undergraduate courses, and to having no official membership of various Doctoral Schools. Removal of these constraints is being actively considered.

Other future policies are restricted to the continued study of existing projects. There are apparently no plans for major new developments.

The Panel's ratings are recorded in Table 1.

4.4 MAT/08

The outstanding scientific achievements of this coherent group are of international renown. Many of their results have become classical and regularly feature in university courses taught throughout the world. Fundamental numerical techniques are developed for the solution of problems in subsurface flow, contaminant transport, and soil deformation, all of which are of enormous contemporary importance not only internationally, but also locally. The output, reported mainly in leading research journals, is of impressive quantity, and research income is steadily increasing in line with the group's reputation. Just as significantly, senior professors, exercising proper leadership and sensibly directing research of junior members, demonstrate acute awareness of likely future developments and how resources might optimally be deployed to confront new challenges.

There is appropriate interaction with other members of the Department, and with groups elsewhere in the University. It was, however, unclear to the Panel whether numerical analysis is a major component in any other University department and if so what formal relations might exist. The group's research is well-represented at international conferences of high repute.

In the group discussion with the Panel, junior staff expressed concern that the national process for promotion to a senior professorship was inflexible and did not favour a broadening of interests. Only refereed research publications in the strict field of numerical analysis and its applications apparently qualify for consideration. The Panel is unable to conclude whether or not this is a fair comment, but the perception is sufficient to cause serious concern. Young staff should be encouraged to acquire new knowledge and participate in the evolution of appropriate emergent or established subjects.

Ratings may be found in Table 1.

5 Postgraduate Teaching

A meeting was especially arranged with a small group of MAT/08 postgraduate research students in various years of study. The students, who expressed immense satisfaction with the supervision and support they receive, appear well-motivated, enthusiastic, and excited with their respective projects. The topics are appropriately chosen, reflect current problems of significance, and provide scope for the acquisition of transferable skills keenly sought by industry. The Panel believes it is reasonable to conclude that similar exceptional care and guidance are offered by the other groups within the Department. Given these admirable conditions, it is difficult to understand why demand for postgraduate places is not higher, and this aspect is further discussed below. Several students aspire to academic careers but are discouraged by the limited number of research positions, many for only two years with no clear prospect of renewal, and the added uncertainty of gaining a permanent academic appointment.

It is understandable why in these circumstances many successful postgraduate students decide to abandon ambitions for an academic career. A regrettable consequence for the Department and University might be the restricted ability to select and appoint high quality junior staff.

6 General Assessment of Department

The Department, although of modest size, has consistently produced high quality innovative leadingedge research that is internationally recognised. Group MAT/08 and parts of MAT/07 deserve special mention. It is praiseworthy that five books, some omitted from the list of Departmental publications, have been published during the evaluation period, but the overall number of research articles, most admittedly in

leading research journals, while satisfactory perhaps in future total numbers should be improved. Conference participation, the presentation of results, and general internal and external interactive networking are each commendable. Departmental group seminars are regularly organised, and a Departmental series of general interest recently has commenced.

The location of the Department within the Faculty of Engineering creates an effective bridge between theory and application, and facilitates access to both mathematics and engineering projects. Furthermore, as already mentioned, the Department is well-integrated and encourages congeniality, willing mutual support, and lessens competition for resources, not always found in larger departments. Consequently, staff expressed considerable satisfaction with the present arrangements, and prefer the Department to the Department of Pure and Applied Mathematics.

Unfortunately, external research income, apart from that for MAT/08 which is exemplary and masks the deterioration in that of the other Groups, exhibits a recent appreciable decline and now mainly depends upon University grants. The reduction is beginning to adversely affect travel and the ability to invite outside experts to present seminars and spend extended visits, all crucial enriching networking activities.

Only MAT/08 provided evidence of a well-conceived cogent future policy. Policies for the other groups aim to continue and complete existing research projects with little apparent regard for new research initiatives or directions. For example, although many important problems nowadays demand a multidisciplinary approach, there are no evident plans for new professorial appointments specifically tasked with broadening Departmental interests in these combined directions.

The recruitment of good quality mathematically articulate research students is seriously affected by restriction of undergraduate teaching to the Faculty of Engineering, and is compounded by inflexibility in the courses that a given professor may teach. Some postgraduate courses are taught as part of the Doctoral programmes organised by other University departments, but entirely on a voluntary basis. The Department is therefore deprived of access to suitably qualified students essential to maintain balanced activities and to ensure an adequate supply of young researchers who subsequently can be trained to become academic staff.

The current mix of researchers, associate and full professors, while not uniform throughout all groups, is at present satisfactory but easily could become distorted. Several retirements are due in the next few years. Without appropriate senior level replacements, the Department's age structure will become skewed and scientific leadership severely jeopardised.

7 Conclusions and Recommendations for Future Policy

7.1 The Department is highly successful, especially in innovative research of practical relevance. Its staff is dedicated, generally active, and mutually cooperative. The Department serves as an excellent bridge between scientific theory and technological applications.

It is recommended that university support be continued and indeed strengthened, and that the Department remains within the Faculty of Engineering.

7.2 The Department, although recognised as a single unit by the University, nevertheless creates the impression of a loose federal structure with senior professors having virtual autonomy over the respective research groups. This fragments departmental effort and militates against its proper integration. In particular, it results in the possible disjointed development of future policy. Diversity is both valuable and essential, but should be permitted only within an agreed uniform policy.

Accordingly, and in order to improve the Department's overall effectiveness, it is recommended that the Director's duties should be enlarged beyond the present apparently largely managerial and financial functions, to include responsibility for effective overall scientific leadership. The Director should be given the authority to develop, in consultation with senior departmental colleagues, a unified vision, future directions, and appropriate supporting strategies. The present narrow restriction has perhaps delayed, for example, the introduction of multi-disciplinary research which, as already mentioned, is now widely promoted elsewhere.

7.3 The reduced research income of Groups MAT/03, /05 and /07 should be reversed by renewed determined efforts to gain competitive funding not only from national and international Research Councils, but also from novel grant awarding bodies. Meanwhile, the University should ensure that funds are sufficient to maintain crucial networking essential to the continued vitality of the Department. On the other hand,

MAT/08 is congratulated on maintaining a steadily growing income from diverse sources, including local organisations.

7.4. At present the Department's formal teaching is confined broadly to beyond first year engineering courses. It is recommended that the possibility be explored, along with funding implications, of extending its mathematics teaching to subsequent years of the engineering undergraduate programme. Moreover, the Department should be allowed entry by right into all Doctoral Schools of legitimate interest. The Department's senior professors should be properly engaged in masters' and similar advanced courses in their respective subjects, and the opportunity should be provided for junior colleagues both to similarly participate and to develop their teaching skills.

7.5. By the same token, consideration should be given to the Department becoming a full member of the Faculty of Science while still retaining its present membership of the Faculty of Engineering. In part, this will facilitate improved relations with the Department of Pure and Applied Mathematics, and in part, will enhance official recognition of its valuable bridging function.

7.6. The Department is recommended to expand its postgraduate course provision either alone or, preferably, in conjunction with departments internal and external to the University. The increased choice of available courses, possibly delivered by video link, should be additionally attractive to potential students leading to increased recruitment. This in turn should help expand the eventual supply of suitably qualified candidates for university, industry, and government positions. Furthermore, the sharing of courses should reduce individual teaching loads. Cooperation of this kind could lead to a regional consortium gaining recognition as a European Centre of Excellence.

7.7. The Panel is uncertain whether theoretical aspects of numerical analysis are studied elsewhere in the University and if so what links might exist between these groups and MAT/08. In the event of there being no such activity, then MAT/08 should be encouraged to expand its present interests in this area supported if possible by additional funding to the Department for this specific purpose.

7.8. Subjects important to engineering disciplines that apparently are under-represented, or absent altogether, in the Department include statistics and probability theory, although there is some activity in stochastic processes, and, to a lesser extent, mathematical computation. It was unclear to the Panel whether these subjects are studied or taught in other departments, and if so how this work relates to that of the Department.

Given their absence elsewhere, it is recommended that as far as possible the named subjects are either strengthened or introduced into the Departmental structure.

7.9. Although it may be outside its remit, the Panel nevertheless wishes to record its concern regarding the nationally centralised system for academic promotion. The Panel's foreign members recognise its benefits, but to them aspects of the system appear cumbersome, unpredictable, and slow. It severely constrains the ability of an institution to plan effectively for its own future. Equally, it seems to exclusively support existing subjects rather than encouraging the organic evolution of new fields and multi-disciplinary collaborations increasingly demanded by much modern research. An independent locally controlled system would better nourish flexible research, respond more immediately to grass-root initiatives, enhance motivation, improve career prospects, and reward success. The Panel believes that the present system is causing some frustration and partially may account for a slight lack of excitement normally expected in highly achieving departments.

7.10. As noted in Section 5, non-replacement of impending retirements will have inevitable detrimental consequences for research output. Consequently, the Department along with the University is strongly urged to ensure that the positions are retained in the Department and suitably filled in accordance with a properly developed and discussed departmental future strategy. Furthermore, in line with previous remarks in Sections 6, 7.2, and 7.9, it also is recommended that one or more of these new appointments should be in multidisciplinary subjects preferably connecting areas already studied in the Department.

It must be emphasised that these comments and recommendations are by no means intended to detract from the immense success so far achieved by the Department. On the contrary, their object is to assist continual developments and to help consolidate the Department's regional, national, and international reputation for leading-edge research.

8 Appendix. Information on University and National policies including those for promotion: Suggested topics.

It is suggested that brief descriptions of the following are included in information provided beforehand to panel members.

- Factors determining the amount of University finance available for research funding, and the method of allocation to departments and departmental groups.
- Internal procedures and scope for rewarding excellence, including those for promotion to associate and full professorships.
- The University and national processes for the creation of, and appointment to, chairs.
- University policies on retirement, and for replacement of staff who retire.
- Allocation of undergraduate and postgraduate teaching courses.
- University regulations for departmental membership of the governing boards of doctoral schools.
- Opportunities for introduction, funding, and implementation of new initiatives.