PROPOSED NEW INITIATIVES IN

COMPUTING AND COMPUTER APPLICATIONS

Report of a Science Research Council Panel

March 1979

PROPOSED NEW INITIATIVES IN COMPUTING AND COMPUTER APPLICATIONS

Report of a Science Research Council Panel

PREFACE

This Report presents the findings of a Council Panel, under the Chairmanship of Mr D H Roberts.

Following a survey undertaken in April 1978, the Panel has proposed a major programme of additional academic research and training to help the UK to gain maximum benefit from the advent of low cost microprocessor systems and programmable electronic technology generally. The Panel's recommendations are broad-ranging, and encompass schools and undergraduate education, as well as postgraduate training and specific research topics on the technology and application of computers. Some of the recommendations thus go outside the Council's remit and responsibility for these lies primarily with other bodies such as DES and UGC. Where appropriate, however, the Panel has recommended that SRC should play a contributory role.

The Council has accepted the Panel's recommendations in principle, subject to the formulation of detailed, costed, proposals, and to discussions with other relevant bodies to define the extent of SRC's role in some of the areas covered. Action on the recommendations will also, of course, depend on the financial resources made available to the Council.

An Implementation Group of the Engineering Board, under the Chairmanship of Professor John Brown, has been appointed to oversee the preparation of detailed plans. These plans will be submitted to the Council later this year. Meanwhile comments on the recommendations, or expressions of interest in the areas covered, would be welcomed by the Implementation Group*.

Since the Panel completed its work in October 1978, other bodies have also put forward proposals in some of the areas covered by the Report. In particular DES has proposed a microelectronics education development programme for schools and colleges, and DoI has announced initiatives in the field of industrial robotics. The Council welcomes these developments, which it sees as complementary to the recommendations of this Report.

The Council expresses its thanks to the Chairman and Members of the Panel and to the many other individuals who assisted in the initial survey.

*Comments should be sent to Dr P C L Smith, Computing Project Implementation Panel, Engineering Division, Science Research Council, PO Box 18, North Star Avenue, Swindon SN2 1ET, Wiltshire.

PROPOSED NEW INITIATIVES IN COMPUTING AND COMPUTER APPLICATIONS:

REPORT OF A SCIENCE RESEARCH COUNCIL PANEL.

CONTENTS

1. INTRODUCTION

In October 1977, the Council's Engineering Board appointed a Panel under the Chairmanship of D. H. Roberts (Plessey), to formulate a new programme of research and training in computing and computer applications, specifically aimed at being of benefit to the country. The work was undertaken in close collaboration with DoI and British Industry, since their participation will be essential to any programme which the Council may mount.

At its initial meeting the Panel decided that the two very important topics of Networks and Distributed Computing were already well covered by other committees, and it would therefore turn its attention to other matters.

The Panel identified three main areas on which the proposed new programme should focus attention. In order of importance, they are:

(i) Education and Training

(ii) New Computer Applications and

(iii) New Computer Technology

The Panel circulated 1500 copies of a paper to Government Departments, Universities, Polytechnics and U.K. firms, seeking views on the relative importance of these three areas. Over 250 replies were received.

Overwhelming support was given to the idea of the new programme and the replies made it very clear that there is an urgent need for an Education and Training initiative to increase, greatly, computer expertise throughout the whole educational spectrum, from schools to higher education and in-service training, together with vastly improved training facilities.

New computer applications were also regarded as very important and there was a consensus of opinion that the main areas which should be supported are industrial robotics, microprocessor applications and the simplification of the interaction of people with computers (the "man-machine interface").

The support for new hardware technology was more limited, and came mainly from Universities. New software technology recieved more support. The panel considers that there is a more urgent need at the present time to concentrate support on Education and Training, on New Applications, and on Software, rather than on Hardware, due to the enormous rate at which hardware technology has advanced in the last few years. This situation may change when the balance has been restored.

As might be expected, the large number of replies produced many suggestions, too diverse and numerous to mention. The Panel has decided to concentrate on topics and areas where there was a clear consensus of views.

2. EDUCATION AND TRAINING

The Panel believes that the potential impact of low-cost microprocessor systems on a very wide range of activities - both in employment and socially - far exceeds the effects already brought about by the use of computers. This impact might well be on a scale comparable to that of the Industrial Revolution.

If the UK is to take full advantage of this new technological revolution substantial changes in our educational and social systems are essential, to provide:

1) a sufficient supply of technically educated people to enable the country to exploit the revolution and
2) a much wider appreciation of the role and applicability of micro-electronics throughout the whole industrial, administrative and social area.

To state the problems is not to solve them. Ever since the war there has been a shortage of highly intelligent people willing to undertake engineering in its widest sense as a career. It will be necessary for many such people who normally go into other professions, now to enter the engineering profesession. This is unlikely to happen unless the status and standing of engineers in the country as a whole receives much greater recognition than heretofore. Secondly, the panel envisages a situation where many more people not commonly regarded as engineers will be involved in some sort of computer programming. This has consequences for the sort of research the Panel would wish to support and on which this Report comments later, but also means that an appreciation of the role and applicability of micro-electronics must be introduced to a much wider community at a very early stage.

There are thus two problems; the first which can only be solved by Government institutions and industrial firms recognising and rewarding engineers in an appropriate manner, and the second, which the Panel believes will only be solved by a parallel educational effort in the following four areas:

(i) Education in Schools
(ii) Undergraduate Training
(iii) Postgraduate Training
(iv) Industrial Retraining

Many other bodies have responsibilities in these areas and will have to be fully involved if the educational aspect of our proposals is to succeed. However, the Panel believes that it is proper for SRC to play a leading role in stimulating a fully co-ordinated approach in view of its responsibility for supporting the research which, in this rapidly changing technological field, must underpin education and training at all levels.

Some microprocessor based systems are already available and are being exploited in the UK; hence the Panel sees an urgent need to start on a major programme of Education and Training without delay; even then, the expected timescale of benefit from such a programme is likely to be of the order of 5-15 years.

2.1 Schools and Further Education

The Panel firmly believes that the wide-spread and intelligent use of computers in schools and further education will do more than anything else to ensure the U.K. obtains a full and proper advantage of the possibilities offered by the new technology. The need is not to teach computing per se but to create an awareness throughout the whole community of the opportunities and potential of the new technology. Indeed, it is through this process, at an early stage, that we may expect to create the much larger body of potential recruits to the wide range of professions whose future competence will depend on the effective application of computing.

A start has been made through the activities of the National Development Programme in Computer Assisted Learning, the Schools Council Project, the Council for Educational Technology and the MUSE group. However, the Panel believes that the valuable initial momentum created by these activities will be wasted and peter out unless a new initiative is taken, and that in any case a greatly increased effort is required now to meet the challenge of the microprocessor revolution.

A meeting held by the Panel to discuss schools computing established that in the wake of NDPCAL there is a great deal of interest and acitivity, but that this is of mixed quality, and lacks adequate direction, co-ordination and funding. There is, on the other hand, no shortage of ideas, or enthusiasm.

The main requirements are for:

(i) Central co-ordination. Responsibility for education in schools and further education is devolved from D.E.S. to Local Education Authorities. It is both unrealistic and wasteful of manpower to expect each and every Local Education Authority to tackle the problem independently. Nor would the necessary manpower be likely

to be available. Furthermore, a piecemeal approach hampers the production and spread of useful software. Therefore, in this particular area, the Panel thinks central co-ordination by DES to be essential.

(ii) The design of much more imaginative problem solving languages, particularly suitable for work in schools. This is vital to achieve the wide-spread understanding of the capabilities of computers which the Panel see as an essential aspect of their proposed educational programme.

(iii) The development of extremely reliable, portable software packages. Without these the maintenance effort required could cause the whole scheme to collapse.

(iv) The provision of the necessary modern computer facilities. The Panel's whole thesis is based on the continuing fall in the cost of hardware due to the development of microprocessors. As a result in five to ten years time the cost of very sophisticated computer equipment will be within the budget of schools and colleges. It is vitally important that we anticipate the situation by providing facilities now, which will match the expected performance of future equipment even though the present cost is higher than the normal level of equipment funding in secondary and further education.

(v) Research to define what needs to be taught and the training of teachers to teach it. These two should go hand in hand. It is only in this way that a proper wide-ranging educational programme will be produced. Further, we expect the trained teachers not merely to teach computing but to involve other teachers in their school in the use of computing in their own fields. They are much more likely to be successful in this if at least some sub-set of them have been involved establishing what can and should be done.

Clearly some of these requirements fall outside the remit of SRC. However, the Panel is so firmly convinced of the importance of this area, that it strongly recommends a major programme on a national scale in which DES and other relevant bodies would be centrally involved, and to which SRC could contribute as part of the joint effort.

On this basis, the Panel proposes a programme of six five-year projects, each based on existing centres of activity and involving a University/Polytechnic group and a cluster of interested schools and Further Education Colleges, with LEA and Teacher Training College participation.

These projects would have, as their theme, the future use of modern computing technology in secondary and further education. They would study requirements for course material at 'O' and 'A' level, for software, hardware, and teaching training. As a rough breakdown of effort, two projects might concentrate on teaching about computing per se, one on the mechanisms and methodology of using computers as teaching aids, and the remaining three on the use of computers to teach specific, non-computing, subjects. Field testing would be an essential part of each project and to this end the financial support should be sufficient to provide each project with sufficient "work stations" for this pilot scheme (probably 1-2000 such stations over the 6 projects), in addition to funding the University/Polytechnic-based research providing the software support, assistance with teaching training, and project monitoring.

In parallel with the projects (or as part of them) research should be encouraged on new approaches to "easy-to-use/high reliability" packages. This will involve a fresh approach to "problem-solving" languages, to simplify the human-machine interface. The concept must be to use the increased sophistication of today's technology to reduce the level of computer expertise required by tomorrow's user.

Co-ordination and evaluation must be a central objective of the programme and an overall Programme Director should be appointed at an early stage.

The close involvement in the projects of DES, the Open University, Local Education Authorities, the Schools Council and the Council for Educational Technology would, in the Panel's view, be crucial to the success of the programme.

The role of DES in the national programme is particularly important. The Panel considers that DES should accept responsibility for managing and co-ordinating the programme and in particular the Programme Director should be appointed and funded by DES. In addition, DES should be asked to provide direct funding of the "work station" element in the total project costs, and should help nationally by indicating its support and encouraging all other interested parties (including LEAs) to recognize and consult with the Programme Director.

A number of unsolicited draft proposals for projects along the lines suggested have already been received and there are clearly sufficient capable groups interested in this area to undertake a programme on the scale proposed.

Recommendations

2.1 (a) The Panel recommends that SRC should discuss with DES, and other relevant bodies, detailed arrangements for a programme of the kind proposed, and for the appointment of a Directorate to manage and co-ordinate this programme.

2.1 (b) The Panel recommends that the SRC should encourage research on new approaches to "easy-to-use/high reliability" software packages.

2.2 Undergraduate Training

As long ago as 1970, it was argued that the deepening and accelerating penetration of computers into our everyday lives was making it essential for all educated men and women to have at least a sufficient understanding of the use, powers and limitations of computers to be able to assess their potential, and the risks attending their use. The University Grants Committee and the Computer Board published a report "Teaching Computing in Universities" which recommended that all undergraduates should have some education in the use of computers. Eight years later, this laudable aim is still far from fulfilled (little computer education takes place outside Computer Science Departments) and the need is now much greater. The Panel believes that a similar programme to that proposed for schools should be mounted in the undergraduate sector, and would urge the Computer Board and the UGC to give consideration to this.

There is also an urgent need to ensure an adequate supply of graduate computer and microelectronics specialists to meet the future requirements of industry. Already the signs are that demand exceeds supply, and there will be major additional requirements as a result of the advent of microprocessor based systems and a dramatic increase in the number of firms using computers. The Department of Industry believes that over the next five years there will be a need, in the microelectronics industry alone, for some 3000 additional graduate specialists. The additional requirement for qualified engineers and scientists in the wider areas of microelectronics applications is likely to be very much larger and could easily exceed 10,000.

The Panel therefore considers that it is vital that a study be undertaken, without delay, to determine the balance, number and size of computer science and related departments needed to meet the UK's future needs of graduates with specialised training in computing and microelectronics, and that this study should then be implemented immediately.

Recommendations

2.2. (a) The Panel recommends that UGC and the Computer Board give serious consideration to a national programme, similar to that proposed for schools and further education, aimed at increasing the computing awareness of all graduates, especially those in non-scientific disciplines.

2.2 (b) The Panel recommends that an immediate study should be undertaken by the UGC and the Computer Board to determine the future UK need for graduate computer specialists, and steps urgently taken to meet this need by providing appropriate ear-

2.3 Postgraduate Training

The Panel believes that attention should be directed very specifically toward the provision of scientists and engineers with an adequate technical training in modern computing, with major emphasis on microprocessors and programmable electronics.

2.3.1 Research Training

In parallel with the need for graduates, there will be major additional requirements for post-graduates with advanced knowledge of the new technology, both to enter the expanding computer/microelectronics industry and to research the next generation of microprocessor-based systems. There is a need therefore to increase substantially the number of PhD students working in this area. It will not be sufficient simply to increase the number of available studentships (although this is essential) but also to provide clear incentives for students to work in this important area. The Panel suggests therefore that an additional 50 research studentships per year should be made available for this area (this does not appear unreasonable in the light of the Department of Industry's estimate for additional graduates) and that financial incentives be devised to ensure that these studentships are taken up. These incentives could take the form of an industrial scholarship. Alternatively, since it is vital that students work with Industry in this area it is suggested that a period should be spent in a relevant company as a condition of the award but that during this period the students should receive appropriate industrial salaries. A major publicity campaign should be mounted to attract students. However, none of this will have any serious effect unless the careers prospects of engineers and the possibility of them reaching senior management are much greater than exist at present.

2.3.2 Advanced Course Training

There will also be a need (on a smaller scale) for additional postgraduates with MSc course training. There is not necessarily, however, a need to increase the number of MSc courses or studentships in this area. Many courses are already undersubscribed with below-threshold student numbers. What is required in the first instance is a review of training needs at this level, followed by a change in the range and relevance of existing computing/microelectronics courses, with financial incentives to students to attend them. The policy in supporting existing courses (or encouraging new ones, if shown to be necessary by the review) should be to build on success and support Departments with strong, relevant, research activities and successful undergraduate teaching.

2.3.3 Conversion Courses

In addition to the need for PhD and MSc training the Panel sees a requirement for shorter (6 month) courses for arts graduates (or unemployed teachers) to provide them with the necessary expertise for a career in modern computing. In addition there would be merit in providing short computing courses for specialists in those other branches of science and engineering which are or will be influenced by developments in digital electronics. On the face of it, this could cover all branches of science and engineering and it could easily be argued that a PhD in Social Science or Business Studies is valueless without a demonstrable capability to at least comprehend the pervasive impact of modern computing technology.

Recommendations

2.3 (a) The Panel recommends that SRC seek DES funding and approval for suitable incentives to attract PhD and MSc students to this area.

2.3 (b) The Panel recommends that the Engineering Board should allocate an additional 50 research studentships per annum to computing/microelectronics.

2.3 (c) The Engineering Board should take action to improve the range and relevance of the MSc Courses it supports in this area.

2.3 (d) The Council should consider the setting up of short conversion courses for arts graduates and unemployed teachers, and the provision of computer awareness courses for PhD students in other branches of engineering science.

2.4 Industrial Training

The advent of the microprocessor will mean that a wide range of products will contain such devices and the number of companies and individuals needing to have a knowledge of computers will increase rapidly. The need for awareness may be much greater than is generally appreciated.

In the long-term, schools and universities can play their part in providing a higher level of computer expertise and awareness in school leavers and graduates. In the short-term, it is quite clear that if UK industry is to extract the maximum advantage from advances in computing technology (including those at the '1 silicon chip level') there will have to be a fairly massive programme of engineer-retraining. The magnitude and timescale of this task will have to be set out by industry itself, with inputs from the EITB, Department of Employment and Department of Industry. The Panel had distinguished two levels of industrial training and retraining; the skill level, which must be the responsibility of the EITB, and advanced training, in which Universities and Polytechnics could play a major role, especially in providing short or part-time courses. At the advanced level a strong link between research and training is essential, and the Panel therefore believes that it would be appropriate for SRC to identify academic "centres" for industrial retraining; these would probably be closely aligned with those institutions providing relevant MSc and PhD training.

There may also be a need for financial incentives to encourage industry to send such students on courses.

Recommendations

2.4 (a) SRC should discuss with the DoI and EITB the need for short/part-time University or Polytechnic based courses for industrial training/retraining.

2.4 (b) SRC should discuss with UGC the allocation of specific resources to specified academic centres and/or to industrial students to enable required courses to be run.

3. NEW COMPUTING APPLICATIONS

Many suggestions for computing applications worthy of special support were put forward in response to the paper circulated by the Panel. In proposing the areas below the Panel recognises that these are not the only possibilities; it is, however, agreed that selectivity is essential for any initiatives to be effective and the Panel based its choice on the following factors: relevance to a wide range of industry, timeliness, and appropriateness for SRC support.

Microelectronic technology will underpin many new applications of computing and the impact of the microprocessor, in particular, on all branches of industry will be enormous in the next decade. The Panel fully recognises the central role of the microprocessor in this context and considers that pioneering the use of microprocessors in new areas is a highly appropriate field for a co-ordinated University/Industry programme.

The DoI Microprocessor Application Scheme adds its weight to that view - and also provides a possible focal point for establishing a mechanism for industrial collaboration. The SRC Collaborative Grants Scheme could also be very relevant in this area.

Apart from supporting worthwhile new ideas as they arise, the Panel believes there are four particular areas where there should be an SRC initiative:

(i) Industrial Robotics

(ii) Measurement and Instrumentation

(iii) Microprocessor work-bench/teaching aids

(iv) Man-Machine Interface

3.1 Industrial Robotics

The Panel considers that there is an urgent need for a co-ordinated programme of research and development in the field of industrial robotics. Current activity in the UK (both industrial and academic) is disturbingly weak when compared with the situation in USA, Germany and Japan. The scale of effort in these countries is massive and will, inevitably, have a significant effect on the competitiveness of British products. Whilst the Panel would not advocate a policy of trying to do everything in the UK just because our powerful competitors are, nevertheless the Panel believes this is too significant an area for the UK consciously to avoid (or worse, fail even to consider the options).

The Panel recognises two broad areas of robotics interest (these are clearly inter-related):

(i) Intelligent usage in UK industry.

(ii) Serving selected world markets with UK designed and manufactured robot components.

If UK industry can be persuaded to apply robot technology, it will be in a far better position to compete with the countries already using this technique.

Robot production exploits high technological skills and has high added value. For these reasons, industrial robotics is an area well suited to the United Kingdom. Furthermore, it has relevance to a broad spectrum of industry, and the Panel believes that a joint positive effort by academics and industry could have a significant impact in the future.

Although considerable progress has been made in the use of robots, there are still many unsolved problems and existing research is fragmented. Current systems have little sensory feedback, no adaptive behaviour, limited vision and no voice communication. There is also a need for software modularity and special languages. Size, accuracy, cost, strength and reliability are further problems. As well as the technical problems there are social effects to be studied.

Robot technology has so far been developed without much regard for its social consequences, and these have been faced only when the robots have been introduced into their industrial environment. There is an urgent need for research into techniques which are both productive and socially acceptable. It is clear that SSRC, as well as SRC, will have a role to play here.

However, whilst the Panel firmly believes that there is a prima facie case for a major SRC initiative in industrial robotics, it has not yet been able to define a programme of academic research in this field. A meeting on this topic with members of the UK robotics community failed to throw up ideas of major significance or to provide clear pointers to the direction of a special initiative. The Panel has no doubt that the reluctance of the present community to take up the challenge is due at least in part to the general discouragement of Artificial Intelligence which took place in this country several years ago and that it is now up to SRC to take steps to remedy the situation.

Recommendations

The Panel recommends that:

3.1 (a) SRC should agree to take a major initiative in this field.

(b) SRC should appoint a Robotics Programme Director as soon as possible with the terms of reference to carry out an in-depth appraisal of the situation in the UK and abroad in 12-18 months.

(c) SRC should collaborate with the DoI in commissioning a study aimed at identifying research priorities in this field.

(d) SRC should publicise the above two actions widely throughout the academic community, as indicating a positive approach by SRC to this area.

(e) SRC should consider the appointment of an SRC Professorship in this field in a major location.

(f) SRC should review the position in 12-18 months time when the Programme Director has reported - and in the light of progress on the closely related topic below.

3.2 Measurement and Instrumentation

This is an activity which was highlighted in discussions on Robotics, but apart from that it is an area of industrial application for cheap, microprocessor based computing, which offers major scope for research.

The guidelines for increased research effort are suggested as follows:

(i) Encouragement of novel approaches to instrumentation based on microprocessors/ programmable electronics.

(ii) Close user-relationship required in support of such research. Ideally this should be with industry or Industrial Research Associations, but could also be with "process-oriented" university departments - e.g. chemical engineering.

(iii) Identification of research topics on new transducers aimed at maximising the benefits from cheap electronic processing power. As an example, novel sensors/transducers utilising purely optical phenomena would more effectively exploit the use of optical fibre links.

As a means toward implementing such a programme a focus to co-ordinate this area of interest is desirable. The Panel suggests that in view of the multi-disciolinary range of skills which are needed the Rutherford Laboratory could provide such a centre.

Recommendations

3.2 (a) SRC should encourage research on novel approaches to instrumentation based on microprocessors and programmable electronics.

(b) SRC should consider the use of Rutherford Laboratory as a focus for activity in this field.

3.3 Microprocessor Work-Bench User Aids

In the case of conventional computers, the basic software is provided by individual manufacturers. The level of investment they make means that it is inappropriate to attempt to replace their software by a "generalised" service. The Panel believes, however, that the situation with microprocessors will be different, and that there will be a clear need for machine independent software, compilers for high level languages, cross-compilers, simulators etc, as part of a microprocessor workbench. Making such a facility available to industry, with the necessary training and advice, may be crucial for microprocessors to be accepted by industry at large.

The Panel has noted that the Computer Board intends to provide such a service to University users as part ot its existing centralised facilities. The Panel endorses this intention and would urge the Department of Industry to perform the same function for Industry. Academic experts could help both bodies on a consultancy basis.

In addition the Panel considers that this is an area where further academic research is justified, aimed at improving the sophistication of existing facilities and providing the next generation of microprocessor user-aids.

Recommendations

3.3 (a) SRC is invited to note and endorse the Computer Board's proposals to establish a centralised microprocessor advice centre for University users, and to encourage the DoI to provide a similar service to Industrial users. Both bodies should be encouraged to use academic experts as consultants.

(b) SRC is invited to encourage longer term research for the next generation of such user-aids.

3.4 Man-Machine Interface

As the impact of computer technology expands to all sectors of industry and the home, an important area of research is the man-computer interface. Some of the social aspects have been touched on already, in the sections on Industrial Robotics and Education and Training. As well as educating people to use computers, however, more needs to be done to educate the computer expert to adjust and design software for the unsophisticated user.

In addition to the social aspects there are technical problems to be investigated, including better ways of communicating with computers (pattern recognition, analysis and processing; speech recognition and generation; improved graphics and displays). Work in this area would have considerable relevance in the context of robotics, and computer education, particularly schools computing.

Recommendation

3.4 SRC should encourage research on a variety of topics aimed at improving man's ability to use and communicate with computers.

4. NEW TECHNOLOGY

In spite of the overall priorities which the Panel has given to Education and Applications, there are four technology topics which are considered of major significance, both in their own right and with regard to the emphasis on Education and Applications. These are:

(i) Silicon chip design

(ii) Software technology

(iii) Database utilisation

(iv) Resilient systems

In recommending increased effort in these areas the Panel fully recognises that some work is already supported by the Council's Computing Science and Electrical Engineering Committees, and that the responsibility for any additional support may more appropriately lie with these Committees (perhaps with a central, earmarked, source of funds). On the evidence available to the Panel, insufficient work is being undertaken in the above areas, but the Panel has not carried out a detailed study of existing support and clearly this should be done before major additional funding is agreed.

4.1 Silicon Chip Design

The attraction of the microprocessor is that it offers in principle a significantly lower design cost (for complex, modest performance, digital functions) than a "hard-wired" approach to the same function. There can be ancillary benefits from the facility to program and re-program in use; there are matching problems in terms of reliability.

The economic trade-off for using an existing "standard" microprocessor versus a customised chip is dependent upon the required performance, production volume and the relative design and test

costs between customised program and customised chip.

Research on design and test automation is relevant to both the program and the chip case and is an area of major significance to the future competitiveness of both the integrated circuit industry and - even more important - the user industries.

This is certainly an area where good research should be encouraged and funded. At the same time it is an area where close collaboration with industry is essential - not just between any one university group and any one company, but rather on a total UK basis to provide UK users and manufacturers with standard design interfaces for the next generation of this activity. To assist in achieving this UK-wide collaboration it would be advantageous to recognise a major role for the Rutherford Laboratory, where this activity could be considered a logical extension of their electron beam lithography unit. The role of the Rutherford Laboratory would not be to come between the silicon processor and the silicon user, but rather to act as a focal point to strengthen this vital relationship.

Recommendations

4.1 (a) The SRC should encourage research on the next generation of silicon chip design and test automation.

(b) The SRC should consider a major role for the Rutherford Laboratory as a centre of activity in this field.

4.2 Software Technology

Already the cost of software is frequently greater than that of the associated hardware, and this trend will be accentuated by the continued reduction in (silicon) hardware costs. Software production must be one of the few industries where no adequate tools exist for specification, design, production up-dating and re-engineering. Despite the high cost, and long development cycle of most large systems, no serious attempt is being made to develop new software methods and standards which could reduce both cost and timescale. Add to that the need for improved hardware independence and more user-oriented approaches to high level language development and it is clear that this should be a major area for SRC support. The Panel is aware that the Computing Science Committee has devoted significant funding to this area but considers that more should be done, particularly in exploiting existing research and applying this in Industry. As with Silicon Chip Design, there may be a need for a mechanism to bring Universities, Software Houses and Industry together and maximise the benefit of academic research, taking full account of the major contribution industry is able to make in this area.

4.3 Database Utilisation

There are a number of initiatives at the moment aimed at making large scale databases available both to the general public and within specific disciplines (eg Viewdata). It has been recognised that most of the work, so far, has concentrated on the production of the database and the access methods rather than increasing the intelligence of the response to user queries. There is, therefore, a need for research into knowledge-based intelligent information retrieval systems; these have a particular relevance to the man-computer interface and to computer assisted learning, two other areas considered important by the Panel. Whilst database utilisation may be an expensive area for research, the present high costs of application may be expected to fall dramatically in the future in the light of advancing technology.

4.4 Resilient Systems

One area of computer technology that has been identified by the Panel as worthy of increased study is the development of highly resilient, fault tolerant systems. Both software and hardware are involved here, and the problem is brought sharply into focus by the advent of programmable

microelectronics. In particular, since the reliability of microprocessors themselves may never reach an acceptable level, there is a need for systems with a capability to perform globally despite local failures. In general, there is a need to develop modular systems where any particular task only uses a subset of hardware/software elements and there is always an alternative route. One important aspect of this problem is to develop systems which can detect and recognise faults within themselves.

The Panel is aware of the major effort being devoted to this area at Newcastle University but considers that there is a need for more work, with an emphasis on ultimate industrial exploitation.

Recommendations

4.2)
4.3) SRC should stimulate additional, good quality, research of major significance to industry
4.4) in these areas.

5. CONCLUSIONS

5.1 The Panel believes that its proposed special programme of research and training in the computer/microelectronics field will, if implemented in full, make a significant contribution to meeting the challenge of the microprocessor revolution. The Panel's recommendations are wide-ranging but linked by two common threads. The first is the advent of microprocessors and programmable electronics technology generally, which will have such a profound effect on our society over the next decade. The second thread is that of significant national benefit, which has been at the forefront of the Panel's thinking throughout its discussions. In the Panel's view the topics selected are those which will best provide this benefit in the light of the rapidly changing computer technology. The backing of industry for this programme has manifested itself in three main ways: through the membership, on the Panel, of prominent industrialists from the electronics, telecommunications, hardware and software industries, through the response of industry at large to the survey undertaken by the Panel, and through the Panel's links with the Department of Industry, especially in the fields of Industrial Robotics and Microprocessor Applications, where complementary programmes are proposed.

5.2 The Panel attaches particular importance to Education and Training at all levels. It is by increased, co-ordinated, effort on this front that the Panel believes the UK will most effectively meet the future challenge of microelectronics. To do this, however, it should be appreciated that it may be necessary for SRC to step outside its accepted role, since the problem is greatest at the schools level. Clearly, further discussions must be held with DES before any action is taken. On the postgraduate training front, the Panel believes there will be a need for additional advanced course and research studentships, and for incentives to persuade students (and industry) to use these.

5.3 The Panel would emphasise the need, whatever the outcome of its specific recommendations, for SRC to stimulate all subject Committees to be receptive to the impact of microprocessors and silicon technology in their fields of activity. There may, in fact, be a case for a central pool of funds for "applications of microprocessors".

5.4 On the Technology front it is important to recognise that there are significant relationships between the four key areas of technology identified and it may not be entirely satisfactory if they are each tackled separately and in isolation from one another. Whilst not wishing to recommend a major technology driven project for the reasons given earlier, the Panel does suggest that a mechanism should be evolved to co-ordinate research on the above four topics and to explore the optimum relationship between them.

PANEL MEMBERSHIP AND TERMS OF REFERENCE

MEMBERSHIP

D H Roberts (Plessey) (Chairman)
I M Barron
A A Benjamin (Computing Services Association)
Professor D B G Edwards (Manchester University)
C A P Foxell (Post Office)
G Haley (International Computers Ltd)
Professor F R A Hopgood (SRC)
P Hughes (Logica)
Professor M Rogers (Bristol University)
Professor H H Rosenbrock (UMIST)

Assessors :

D Harrison (Department of Industry)
Dr D Kiely (Ministry of Defence) until June 1978
Dr D P Jenkins (Ministry of Defence) from September 1978
Dr H Norton (Computer Board)

TERMS OF REFERENCE

"Taking account of the relevant financial provisions in the SRC Forward Look 1977-82 and the possibility of raising additional funds:

(a) to prepare proposals for the scope and organisation of a special SRC programme of collaborative research in computing science and computer applications;

(b) to consult appropriate bodies in academy, industry and government about these proposals with a view to securing the necessary participation or co-operation in the proposed programme;

(c) in the light of these consultations to make costed proposals to the Engineering Board by June 1978 for a special SRC programme in computing science and computer applications."