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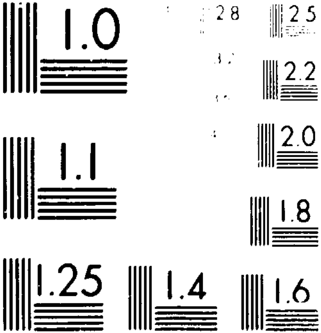
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org



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MICROELECTRONICS AND GOVERNMENT POLICIES : THE CASE OF A DEVELOPED COUNTRY*

by

Ernest Braun, Kurt Hoffman and Ian Miles**

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The British Government sponsors a number of programmes designed to stimulate the manufacture and use of micrcelectronic technology. Four separate areas of support can be discerned:

1. Awareness, education, training

2. Manufacture of electronic components

3. Manufacture of electronic equipment

4. Use of microelectronics in factories and offices.

Awareness, Education, Training

In mid 1978 the Government of the United Kingdom became extremely concerned about the lack of awareness among British managers of the opportunities and challenges offered by microelectronics. A survey conducted at the time found that about half the firms in manufacturing industry were aware of the existence of microelectronics technology and that only 5 per cent of firms were actually doing something about it. In July 1978 the Department of Industry (DoI) then initiated several new support programmes for microelectronics under the Microprocessor Applications Project (MAP)1/ with an allocation of £25 million and one important aspect was "to alert managements to the industrial scope and potential of microprocessors and to assist in re-training staff ....". Under this scheme numerous conferences were organized, supported by DoI funds and publicity material, including specially commissioned video films. Training courses in colleges and universities also received support under the scheme. It is thought that the awareness and training programmes, combined with substantial media coverage and the publication of numerous books, did raise the awareness to a significantly high level during the next two years. At the 1980 Labour Party Conference the National Executive Committee of the Labour Party presented a report on Microelectronics in the 'Socialism in the 1980s series'. This document had been prepared in response to the 1979 Conference decision to produce a policy statement in consultation with the Trade Union Congress (TUC). The document stated that only socialist planning can ensure that the new technology serves the people. The Conference considered that British industry should learn of semiconductor developments at least a year before their availability, and should plan and design future products accordingly.

Other government departments are making their contributions to the training and eduction programmes. The Department of Education is supplying all schools with small computers (though difficulties seem to arise from a shortage of cash to buy software and books). The Department of Employment, through its Manpower Services Commission (MSC) is supporting many training courses for young people and re-training courses for unemployed older workers. The latest development in this activity will be long-term courses (6-12 months) for young people run in conjunction with so-called Technology Centres. These

1/ A relevant MAP project is MAPCON providing up to £2,000 of consultancy fees for feasibility studies; another project reimburses 25% of the development (capital expenditure) of microelectronics applications.

are advisory centres on the use of microcomputers and are administered by the National Computing Centre. The Department of Industry is providing initial financial support, but within two years the centres will have to earn enough income from consultancy and training services to become self-supporting.

Manufacture of Electronic Components

Traditionally, the manufacture of electronic components has been supported in great measure by the Ministry of Defence (MoD). The MoD has paid and pays for much advanced research and development work and also is a customer of electronic components and devices. Plans are being made for a huge investment of £50 million into the development of very high speed integrated circuits; a path the U.S. Military have also been treading recently.

The MoD is by no means alone in its support for the electronic component industry. Even in early 1978 DoI support for the industry was running at £20 million per annum - 40 per cent of this for semiconductors. In July 1978 a scheme called Microelectronics Industry Support Programme (MISP) was announced.2/ This scheme is additional to MAP and aims at helping companies to establish the manufacture of both special purpose and standard micro-electronic components. MISP also aims to support potential supplies of manufacturing equipment for the microelectronics industry and possible radically new alternative processes which may be important for the industry.

In September 1978, the Advisory Council on Applied Research and Development (ACARD)3/ published a report on "Applications of Semiconductor Technology". The report recommended the Government to recognize the importance and impact of the new technology. The Science Research Council then developed a programme for microelectronics research jointly with the Department of Industry. As a result four university-based research centres were set up, with a chair of microelectronics at Edinburgh.

The picture would be very incomplete indeed without mention of INMOS. This is a company founded in 1978 and is being financed to the tune of £50 million by the National Enterprise Board (now British Technology Group, (BTG)). The purpose of the company is to manufacture VLSI (very large scale integration) chips, so as to be specialists in the high technology end of this high technology industry. The first products announced by the company are a 16K static RAM and a 64K dynamic RAM. These are to be followed by very advanced microprocessors, probably single chip computers.

Although BTG money essentially comes from the DoI, the enterprise was set up by three entrepreneurs and two of these are American. In fact the company has manufacturing and design facilities in both USA and Britain and, arguably, this dual base and with it access to American know-how is a necessary condition to make eventual success possible. A table comparing INMOS and its counterpart "Eurotechnique" in France, reaching different product and commercial strategies as published in Electronics Weekly is reproduced below:

2/ It has an allocation of £55 million over five years and is intended to support manufacturing of microelectronics components and devices in the UK.

3/ ACARD advises ministers on science policy.

INMOS (UK)	EUROTECHNIQUE (France)
Born July 1978	Born April 1979
Aim: to provide a domestic capability in standard leading-edge volume circuits	Aim: to provide a domestic capability in standard leading-edge volume circuits
Direct subsidiary of government-owned British Technology Group	Joint ventures between St. Gobain of France and National Semiconductor of US
100 per cent government funded	25 per cent government funded
Investment: £90m (said to be nearly all spent)	Investment: £22m so far. Total investment to 1984 budgeted at £55m, of which £14m comes from the French government
Water fab and assembly in Colorado Springs, USA and Newport, Wales. Wants to manufacture in Japan	Water fab in Rousset, South of France. Assembly in Far East. No plans to manufacture abroad
Directly hired US design talent	Under the partnership with Natsemi the latter trained 20 French designers in US. Out of its 400 employees, 160 trained in US.
Initial product strategy: high-cost products for low-volume 'niche' markets	Initial product strategy: low-cost circuits for high-volume markets
Present product range: two product families designed in-house	Present product range: six product families designed by Natsemi.
1981 sales: (estimated) 125,000 circuits	2.5 million circuits
Employees: Colorado 650 Bristol 75 Newport 75	Employees: 400 at Rousset
Lithographic technique: by GCA wafer steppers (at Newport the number of these will be in "the low teens")	Lithographic techniques: by 8 Perkin Elmer aligners and by 3 GCA steppers this year rising to 15 steppers in 1983
Expectations of trading at a profit: 1984	Expections of trading at a profit: 1984

Manufacture of Electronic Equipment

Many observers believe - and some official reports support this belief - that it is more important to apply microelectronics than to manufacture integrated circuits and other microelectronic components. Outstanding among the applications is, of course, the manufacture of electronic equipment of all kinds: telephone exchanges and other telecommunications equipment, computers large and small, instruments of all kinds, process control equipment, electronic office machinery, electronic games, and all the rest of the known and still to be invented electronic gadgetry. Many of the items listed above, are in a loose sense, free standing and self-contained items of electronics. No less important are applications of microelectronics in conjunction with mechanical machinery. To list but a few: computer numerically controlled machine tools, robots, computer controls for automobile engines, electronic weighing machines, computer controlled warehouses, and many more.

It is argued that the addition of modern electronics to many traditional machines can breath new life into them and thus create new markets on the one hand and ensure competitiveness on the other. These considerations are reflected in several policy measures. Thus the previously mentioned Microprocessor Application Project (MAP) has, in addition to its information function, two strands in support of microelectronics applications. One consists of help with feasibility studies, normally carried out by consultants registered by the DoI for this purpose. By late 1980 nearly 800 such studies had been completed and 75 per cent of their projects were being further pursued. The second strand consists of financial help to firms developing products using microelectronics. By late 1980, 345 such developments had been supported with grants of up to 25 per cent of qualifying costs or an alternative cost sharing arrangement.

More recently, both the British Technology Group and the Department of Industry have re-stated their faith in microelectronics application and have expressed their willingness to back their faith with money. BTG is giving high priority to firms wishing to develop and market innovations using, or related to, microelectronics and information and the DoI is planning to spend £80 million over the next four years on the support of information technology, under their Product and Process Development Scheme.

Use of Microelectronics in Factories and Offices

The Product and Process Development Scheme runs across the very narrow boundry between the development and diffusion of new technology; both aspects of the complex process of technological innovation. While the DoI will encourage the applications of certain new manufacturing technologies, e.g. Computer Aided Design (CAD), Computer Aided Manufacture (CAM)4/, and robots, it will also assist firms wishing to develop these technologies. In fact the interaction between supplier and user of advanced techniques is a vital one and many a project has failed because of inadequacies in this relationship. The Product and Process Development Scheme recognizes these facts in assisting user trials through financing pre-production orders for new equipment.

4/ A £6 million Government campaign is designed to promote awareness of these systems in British industry, the present world market being estimated by a recent American Survey to amount to £350 million.

Most recently robotics has been recognized as a priority area for government assistance and this spans the whole wide range of activities from fundamental research to development of robotic technology to the support of users of robotics. It must be stressed here that government is by no means the main agent of change; an association of industrialists and researchers, the British Robot Association, certainly plays an important promotional role.

Similarly, British industrialists have joined together to form the United Kingdom Information Technology Organisation (UKITO) and one of their specific aims is to influence government policy on information technology by presenting an industrial viewpoint.

1982 Information Technology Year

Whether as a result of this lobby or otherwise, the government has become very active in the promotion of information technology.5/ 1982 has been designated Information Technology Year. One of the ministers in the DoI has responsibility for this area and the I.T. year is co-ordinated by a committee with industrial membership and industrial chairman. £1 million of government resources will be allocated to exhibitions, seminars, demonstration projects, etc.

Amongst the many activities envisaged, the DoI is creating an electronic show office, where all the latest advanced office equipment will be demonstrated and, presumably, advice will be available.

Government's Role

In general, government activities related to microelectronics were influenced by the change from a Labour to a Conservative administration in mid 1979. The Labour Government did adopt a much more interventionist approach to industry than the Conservative Government which is promoting direct investment. The Conservatives in contrast have been more concerned with regulating trade union activity. However both Governments adopted the view that microelectronics would not necessarily lead to unemployment: large-scale unemployment would only follow a lack of innovation and loss of competitive performance.

Public ownership of the microelectronics and other high technology industries is advocated by the present Labour opposition, calling for more public spending on knowledge-intensive industries such as computers, robotics, machine tools, telecommunications etc. The Conservative Government, on the other hand, plans to cut down state intervention in the formation of new industries. An example is the NEXOS case: in January 1979 the National Enterprise Board (now British Technology Group, BTG) invested £13 million in a new subsidiary the NEXOS office systems6/ intended to manufacture word processors and fax machines in preparation for developing office automation systems. An expensive agreement was reached with DELPHI, a California-based company and its massive computer, the Delta.

5/ A Minister for Information Technology was one of the new posts established by the Conservative Government.

6/ Total investment over three years amounted to £35 million.

In October 1981 it was clear that the NEXOS experiment was not succeeding. With the Government warning that no further funds were forthcoming and putting constant pressure on BTG to carry on with privatization, the Delphi deal was called off and a deal with Gestetner, a private UK company in conventional office products, had to be completed.

Budget Policies

The present Government's budget, presented in March 82, allocates an additional amount of £100 million over the next three years for high technology, plus £30 million in tax allowances for television rental companies that buy teletext sets. £55 million of the extra allocation will go to information technology.

The new "micros in schools" programme, under which secondary schools can claim half the cost of a microcomputer back from the Department of Industry, will expand at a cost of £5 million to include primary schools.

Britain's space effort is to get a further £15 million. The money will be used to increase the national satellite effort. Fibre-optics and opto-electronics have also been singled out for extra funds.

Much of the money will go toward schemes that the government has already announced - for example the plan to open 100 centres for training unemployed school leavers in information technology. Other existing projects to benefit include the Microprocessor Application Project and the Software Products Scheme, both of which are intended to aid the commercial development of computing. Both schemes have tended to be undersubscribed in the past.

The Department of Industry, which is administering the money, is also to announce a scheme to help small engineering firms buying capital equipment. More support will also go to computerised manufacturing techniques, such as robots.

Some of the extra money for space projects will finance a national programme in the area of remote-sensing satellites. The project will use data from the European Space Agency's remote-sensing satellite which, from 1987, will send back to ground stations information collected from space about, for example, the height of waves in the North Sea and the growth of crops.

A committee of academics and industrialists is finalising the details of the programme, which will then go to the government for approval. At present the Natural Environment Research Council and the Science and Engineering Research Council spend about £1 million each in the area per year. With the new programme, the total annual spending could rise to £5 million.

A detailed table of Government budget allocations to information technology is as follows:

Government support for information technology[7]

Robotics	£10 million over 3 years (1981)	
CAD/CAM	£6 million over 3 years (1981)	
CADMAT	£9 million over 3 years (1982)	
MAP	£55 million over 3 years - now extended (1978)	
Micros in schools	£5 million for primary £4 million for secondary (1981)	
Software products scheme	£5 million committed (1972)	)£55 million
IT Training Centres	£9 million over next 2 years (1981)	)extra allocation
Fibre optics	£25 million over 5 years (1981)	)in 1982 Budget
Health		
Microelectronics industry support programme (MISP)	£55 million over 5 years (1978)	
Space technology	£50 million for next two years £15 million additional in 1982 Budget	
IT equipment and systems	£80 million over 4 years (includes some of above - micros in schools, IT Centres, software products)	
Capital allowances for purchase of teletext and viewdata televisions		

Note: Figures do not take account of inflation

In 1981 a support scheme for robotics in British industry was launched. This provides financial assistance for feasibility and design studies as well as for the installation and leasing of robots.

The Department of Industry's support for information technology is expected in 1983 to represent an annual expenditure of over £60 million. The DoI's space research programme of £45 million/yr. and the British Telecom's research programme financed at £100 million/yr. will contribute to the development of the UK capability in information technology.

Education Policy

In March 1979 the Labour Government's Department of Education and Science set up a five-year programme to increase school and college awareness and use of microelectronics with a budget of £12.5 million. Subsequent Conservative expenditure cuts reduced this to £9 million.

In 1981 £1 million was allocated to set up school computer networks over 1981-84. Fourteen regional centres are to be established and linked together, each being equipped with word processors etc. After 1984 it is hoped that local authorities or private industry will support these centres.

Most recently, a subsidy of 50 per cent of the costs to schools buying microcomputers has been approved.[8]

7/ Source: Computer Weekly, 18 March 1982.

8/ In mid-1980 some 1,500 microcomputers were already available in schools (1:6000 children).

The Greater London Council (GLC) plans to set up a computer demonstration workshop for Londoners to learn about new technology, as part of its commitment to the Government's Information Technology '82 programme.

Both GLC staff and the public will be able to gain first-hand experience of word processors, Prestel terminals, microcomputers and terminals linked to the GLC's mainframes.9/

The GLC is also involved regionally as part of the London and South East IT '82 committee which plans to run a series of information technology weeks.

Creating Public Awareness

MAP has stimulated press and TV coverage of new technologies. A programme of seminars was organized in 1979, which reached some 7,000 people and support was given to commercial and professional meetings with an estimated audience of 100,000. Support to the TUCs education programme meant that another 50 thousand was reached. The British Broadcasting Corporation started a course on computer and programming in 1982.

NEDO Software Plan

The National Economic Development Office (NEDO) published a report in 1982 recommending to the Government to co-ordinate existing support for real-time software research and development.10/ The report underlined that individual suppliers or customers cannot finance the investment needed to develop the new software tools and management methods needed to maintain the UK's competitiveness.

A new initiative in the area of software engineering has been launched by the Science and Engineering Research Council (SERC). The initiative will run for five years and, according to SERC, is both a recognition of the seriousness and industrial importance of the software crisis and a positive contribution to its solution.

Software was one of the areas that the Roberts Panel Report (Proposed New Initiatives in Computing and Computer Applications: SERC 1979) recommended should be the subject of a major new initiative.

The Council's Information Engineering Committee and its computing and communications subcommittee have identified three major objectives:11/ (1) to improve the academic software technology base; (2) to stimulate more

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9/ David Perry, Information Systems Manager at the GLC, explained the thinking behind the initiative: 'Information technology is very much a growth industry in London but the level of public knowledge is very low. 'We want non-commercial organisations like youth groups or charities to phone up and come along to find out about devices like word processors.'

10/ Real-time software accounts for an increasing proportion (up to 50 per cent) of the value of capital equipment.

11/ In order to go about satisfying these objectives, SERC has appointed R.W. Witty, of the council's Rutherford Appleton Laboratory as software technology co-ordinator.

high quality academic software engineering research; and (3) to facilitate two-way technology transfer between industry and academia.

As a ground for the initiative the CCSC has adopted a common base policy. The common software base comprises the language Pascal and the Unix operating system, while the hardware will consist of the ICL Perq which will be networked via Cambridge Rings, SRCnet and PSS.

Software Market

Britain's lack of success in selling computer software is the fault of those who run computer systems, according to the Information Technology Minister Kenneth Baker. The 'Not-invented-here' syndrome is still deep-rooted among British computer users. There is still a tendency to generate new software on every available occasion - almost as a reflex action," he told an audience at the Software Information International exhibition at Wembley in London, the first software show to be held in Britain.

Baker's remarks were made against a background of increasing American domination of the market in software packages. Some 70 per cent of packages sold in Britain are written in the US, and the show itself was packed with exhibitors demonstrating software that originated there.

The term software package refers to a programme or group of programmes that has been designed for several different customers. The package will usually include manuals and expert help in mounting the software on a computer.

The alternative to buying a package is for the computer user to write his own software, but this is becoming increasingly difficult as skilled staff become scarce and the number of applications for cheap hardware proliferates. According to Baker, computer users do not understand the role that software packages have to play in "overcoming the many financial and human problems which beset the production and maintenance of computer software systems - problems that are beginning to create chaos".

Software packages account for only one-tenth of sales made by British software companies. This poor performance is usually ascribed to the fact that these firms cannot sell enough packages in Britain to justify development costs - that can sometimes be as high as £500,000. In contrast to those in the US and France, British software companies tend to be small - 80 per cent have less than 30 staff - again making it difficult for them to raise the finance needed to write software packages.

At the moment, expensive programmes costing anything between £10,000 and £150,000 account for most package sales, but software for microcomputers is becoming increasingly important. Here British companies have been more successful.

CAD/CAM Techniques in Industry Encouraged by Government

The Department of Industry will review further assistance to industry in using computer-aided design and manufacture techniques. The Department is encouraging a wider appreciation of the benefits of CAD/CAM techniques for manufacturing industries with a £6 million campaign. According to a recent survey only 47 members of the Construction Industry Computing Association were using CAD/CAM. The £6 million will be spent over the next three years to set up awareness courses and aid in consultancy.

Government Encourages Foreign Investment

In the wake of the Conservative Government's efforts to combat inflation, investment bankers are encouraged to invest in new business opportunities in Britain. American venture capitalists are forming partnerships with promising young high technology companies, attracted by tax benefits under the new Finance Act, passed by Parliament in summer 1981 allowing a write-off of 75 per cent of a £10,000 investment in start-up companies.

This and other incentive programmes such as MAP and MISP mentioned before have promoted the development of a new electronics manufacture centre in Scotland. A 65 mile-long belt stretching from Edinburgh to Greenrock is the site of 200 electronics companies. Over 50 per cent of these are Scottish-owned; followed by US, other UK, Europe and Japan-owned. A first class infrastructure built up over the years adds to Scotland's attraction to the electronic industry.

UK Government Attempting to Liberate Telecommunications Monopoly

The 1981 British Telecommunications Act radically reduced British Telecom's monopolistic power. For the first time in Europe there will be a private rival to the publicly owned basic network transmission service. The monitoring of standards to ensure quality of equipment will be shifted to the indepenoent British Standards Institute; the British Electrotechnical Approvals Board will ensure an efficient method of private sector approvals. Full liberalization is scheduled for July 1983 when large Private Automatic Branch Exchanges (PABXs) will be freed. Other equipment, including Value Added Networks (VANs) (electronic mail), will be liberalized this year.

The most significant liberalization initiative is a private network offering direct competition to British Telecom's transmission services. It is being run by a consortium of cable and wireless, a recently denationalized communications company; British Petroleum and Barclays Merchant Bank.

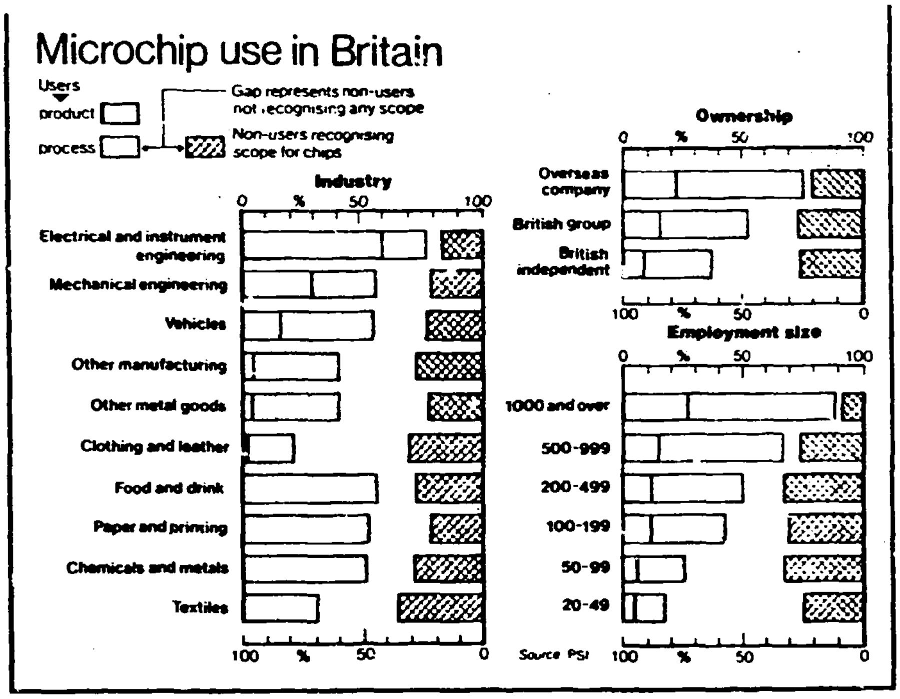
The British approach may become a model for the rest of Europe.

Use of Microelectronics in UK Manufacturing Industry

A recent survey by the Policy Studies Institute of London 12/, looked at the usage of microelectronics in products and processes within manufacturing industry. Based on case studies and a survey of 1,200 manufacturing establishments they found that a total of 49% were using microelectronics technology in products or processes. The following graph shows the current use of microchips in Great Britain. 13/

12/ Microelectronics in Industry: What's Happening in Britain, by Jim Northcott with Petra Rogers.

13/ Source: The Economist, 27 March 1982.



Since the larger establishments tend to be the more important ones, an alternative indicator of the extent of use is the share of total manufacturing employment represented. The survey figures suggest that establishments using microprocessors in their products or production processes, or planning to, account for somewhere in the region of 55 per cent of total manufacturing employment in Britain and about 59 per cent of employment in the establishments employing 20 or more people.

About 13 per cent of the establishments in the sample are using, or planning to use, microelectronics in their products - a reflection partly of the lack of scope for using chips in many kinds of products (e.g. foods, clothes, textiles, raw materials) and possibly also a reflection of the greater difficulty involved in some product applications or of a lesser awareness of what scope there might be.

A much higher proportion of the establishments in the sample (about 45 per cent) are using microelectronics, or planning to, in their production processes.

While 49 per cent of the establishments in the sample are using microelectronics in their products or production processes, or planning to, only 36 per cent have their application actually in production already. A further 6 per cent expect to be in production within the next 18 months and about 7 per cent are at earlier stages of development or are still investigating the feasibility of their applications.

The proportion of establishments using microelectronics increases markedly with size, the difference between the smallest size band and the largest rising from 5 per cent to 28 per cent with product applications and from 14 per cent to 85 per cent with process applications.

About 58 per cent of the establishments in electrical and instrument engineering have applications in their products, 29 per cent of those in mechanical engineering and 16 per cent of those in vehicles, but very few in other industries. Altogether the electrical and instrument engineering industry accounts for just over half of all the establishments with product applications, and the mechanical engineering and vehicle industries for a further 41 per cent, with only 9 per cent distributed between other industries.

Production process applications are much more widely distributed across the whole range of industries, but with particularly high proportions in electrical and instrument engineering (60 per cent) and food and drink (56 per cent), and particularly low proportions in clothing and leather (21 per cent) and textiles (31 per cent).

Of the establishments with applications in their products, 35 per cent design and make their own microelectronic equipment for the products, 33 per cent have it made to their own specifications by an outside sub-contractor, and rather more (49 per cent) use standard catalogue items from an outside supplier. (The percentages add to more than 100 because some establishments use more than one kind of source.) With process applications, on the other hand, only 9 per cent design and make their own microelectronic equipment, 29 per cent set their own specifications for an outside sub-contractor and no less than 74 per cent rely on buying in standard items, for example in the form of electronic controls built into machine tools.

The time required to develop product applications has tended to be slightly longer (a mean period of about 26 months, a median of about 20 months) than for process applicatons (a mean of about 19 months and a median of about 14 months).

The costs involved in developing microelectronic applications vary greatly - of the users providing information, 40 per cent report development costs of £20,000 or less, but 30 per cent report costs of £100,000 or more and 12 per cent costs of £500,000 or more.

Costs have tended to be slightly higher with product applications (mean level about £260,000, median level about £40,000) than with process applications (mean level about £230,000, median level about £35,000). Costs have tended to be appreciably lower for the smaller establishments than for the larger ones, particularly with product applications.

With the establishments using microelectronics in their products the main advantages are considered to be better product performance (rated very important by 70 per cent of the establishments) flexibility in new product development (66 per cent), a more consistent, better quality product (54 per cent) and lower production costs (47 per cent). Other advantages, less often mentioned spontaneously, but still reckoned to be very important by substantial proportions when prompted, are the greater customer appeal of the chip-based product (42 per cent), increased sales (31 per cent) and higher profit margins (23 per cent). Other advantages, mentioned spontaneously by some as very important, although not on the prompt list, are reduced size of product (14 per cent) and reduced labour requirements (6 per cent).

The main advantages most frequently mentioned spontaneously by the establishments using microelectronics in their production processes are better control of production (rated very important by 75 per cent), a more consistent, better quality product (74 per cent) and more efficient use of labour (66 per cent), but greater efficiency in use of capital equipment, materials and energy are far less often given spontaneously as important advantages. Lower production costs and greater speed of output are seen as very important by 54 per cent and 49 per cent respectively, but improved work conditions are seldom volunteered as a major consideration.

Lack of people with microelectronics expertize is the difficulty most widely regarded as impeding the use of microelectronics by both product users and process users and is mentioned spontaneously as often as all the other problems combined. Altogether 48 per cent of product users in the sample and 46 per cent of process users regard it as a very important problem.

38 per cent of product users and 22 per cent of process users have actually experienced difficulties as a result of theses shortages. The most important skill shortages giving rise to difficulty (particularly for product users) is engineers with microelectronics expertize, but there are also difficulties as a result of shortages of technicians, programmers and other kinds of specialists.

Of the establishments in the sample, 42 per cent of those with product applications and 65 per cent of those with process applications had no engineers at all with microelectronics expertize at the time they first started looking into the feasibility of applications; 10 per cent and 45 per cent respectively still have none at all now; 47 per cent and 32 per cent respectively would like to have more now. Of the non-users in the sample, over 90 per cent have no microelectronics engineers at all.

The general economic situation is a very serious problem impeding the adoption of microelectronics, second in importance only to the lack of people with specialist expertise, in the view of the users in the sample, with 40 per cent of all users regarding it as a very important disadvantage and as many as 59 per cent of the smallest ones employing only 20-49 people.

Of the users providing information, 30 per cent report development costs of £100,000 or more and 12 per cent costs of £500,000 or more. The high level of development costs is the problem mentioned spontaneously by users more often than any other except the lack of people with specialist expertise, with altogether 30 per cent of them regarding it as a very important problem.

The use of microelectronics has resulted in little change in production costs for the majority of the establishments in the sample, but for 19 per cent of the product users it has led to a reduction in costs of 10 per cent or more (compared with an increase of 10 per cent or more for only 9 per cent of them), and for process users the corresponding figures are 23 per cent and 3 per cent.

Altogetner software problems are regarded as potentially very important by 20 per cent of the product users in the sample and 14 per cent of the process users.

With both product and process applications the three software problems regarded as the most important are programming taking longer than expected, costing more than expected and turning out to be more difficult than expected. Other problems are the lack of suitable standard packages, lack of a satisfactory development system and inadequate chip storage capacity.

Problems with sensors appear to be less widespread than problems with software, being regarded as very important by 16 per cent of product users and 11 per cent of process users.

The main problems, in order of frequency of occurrence, are inadequate robustness to cope with a hostile environment, lack of a suitable model for the particular application desired, excessively high costs and inadequate performance.

The types of sensor most commonly used are those for measuring temperatures, speed, pressure, position and weight, and it is with these types that the problems are most commonly experienced.

Process applications tend to use only very small numbers of chips (compared with the very large numbers needed for some product applications) and tend also more often to make use of chips incorporated in bought-in standard catalogue pieces of control equipment. Accordingly, problems are less often regarded as very important by process users (8 per cent) than by product users (10 per cent).

The main problems, in order of frequency of occurrence, are difficulty in choosing the most appropriate chip, chips that are faulty in use, delivery difficulties, excessive prices, the inability to get the latest models early enough in Britain, the lack of testing facilities, and inadequate support from the chip supplier.

Opposition from the shopfloor or trade unions appears to be less frequently a problem than skills shortages, economic difficulties and technical problems, with only 2 per cent of product users regarding it as very important and only 9 per cent of process users.