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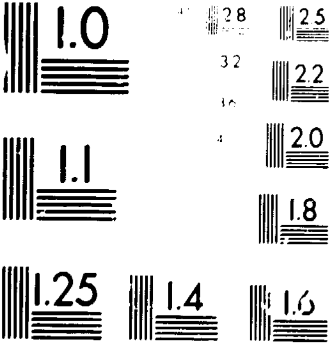
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org



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TECHNOLOGY AND MARKET TRENDS IN THE PRODUCTION AND APPLICATION OF INFORMATION TECHNOLOGY

A review of developments during the years 1982--1983*

by

John Bessant **

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** Head, Innovation Research Group, Department of Business Studies, Brighton Polytechnic, Brighton, UK.

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INTRODUCTION

It was in the mid-1970s that the adjective "revolutionary" began to be applied to microelectronics technology. Implicit in this was the notion of change of a discontinuous nature, altering the world industrial perspective. Since then we have seen the area of interest broaden to encompass a wide range of convergent technologies which have collectively been termed "information technology" - computing, microelectronics, telecommunications and, more recently, optoelectronics and artificial intelligence. Nevertheless the essential character remains the same; significantly the UK electronics entrepreneur Clive Sinclair drew the parallel between the iron foundry as the driving force behind the first industrial revolution and the silicon foundry behind the current second one. Change is above all very rapid and whilst the pace may be slowing slightly as the problems become tougher to solve and the resource demands greater, it is still possible to apply the rule which the semiconductor industry calls "Moore's Law"-that is, the complexity of chips doubles every year (though the interval may be closer to 18 months now).

In technological terms change is taking place in two dimensions; deepening and extending knowledge within particular fields but also integrating that knowledge with other fields. In market terms the pattern of change has been just as dramatic with very fast growth rates-around 20% per annum in many sectors. Most predictions see this pace of change continuing although the rate of growth of competition for a share of these markets is, if anything, even faster. Once again the parallels with the first Industrial Revolution are clear. Associated with this growth in competition is a convergence and concentration on the supply side of the IT industry-partly this is a result of the technological pattern of convergence which leads to integration amongst companies.Partly it is also due to the very high R and D and capital investments which have to be made and which are driving firms to try and achieve economies of scale-a trend favouring the larger transnational organizations. However there is still a niche for small high technology firms; there is also evidence that even very large and well-resourced firms sometimes prefer to have at least some R and D carried out outside their control and then buy into it once the technology becomes established. In the longer term this pattern is likely to continue but the rising costs and strategic importance of IT are bringing ever higher levels of state involvement in the development process-through direct funding,procurment polciy and public ownership.

This report provides a brief outline summary of the changes which have taken place during the past two years and tries to identify emerging trends for the future.

I. THE MICROELECTRONICS INDUSTRY

In common with other industries semiconductors have experienced a cyclic pattern of boom and recession;this has certainly been true over the past few years.During 1979 and early 1980 demand far outstripped capacity and there was a serious world shortage of chips.Yet by 1982 the industry was in the depths of recession with major manufacturers like Texas Intruments and National Semiconductor announcing huge losses,closing facilities,laying off workers and cutting back on development work.The situation was exacerbated by severe price competition-particularly from

Japanese firms--on standard components in which there was serious overcapacity.

In early 1982 there was a slight upturn but this provided only temporary respite and the industry declined for the rest of the year.However 1983 saw the beginnings of a steady recovery which has continued and has left the industry in a strong position.One indicator of the rate and extent of growth is the BBR-the "book to bill" ratio which the semiconductor industry uses as a measure of orders against sales completed.In the USA this rose to an all-time high of 1.49 in June and continued to rise throughout the summer,with individual firms reporting even higher figures.(This was after the previous two years in which the ratio was almost always negative).In the Far East this growth has been even more spectacular with BBRs as high as 5:1.

The recovery seems to be based on two trends;in the short term a major boom in consumer electronics and particularly personal computers-although this is already showing signs of slowing down and will certainly drop back in early 1984. Backing it up,however,is the long-term trend in capital goods markets towards long-run supply contracts with manufacturers of telecommunications and computer equipment which looks like bringing more stability to the industry.

As far as sources of supply are concerned,the trend is very much in favour of Japanese producers who are taking a growing share of world markets.(see table (1)).Until recently this was based on production of a relatively small range of standard components such as memories which are essentially volume production items;however evidence now suggests a concentration on more specialised products and components such as custom chips based on gate array technology.

Although the US still dominates the industry with over half of world production,table (3) shows the erosion of their position and the growing Japanese pressure.Many commentators feel that the Japanese industry is in a much better position to exploit the upturn because they have continued to invest at a high level throughout the recession.For example,in 1982 they raised capital investment by 27% to $838m whereas the US cut back by 11% to $1.2 bn.In terms of percentage of sales returned as investment the Japanese are putting back almost twice as much as the US-21% as opposed to 11.6%.

The Japanese strength can be seen in a field like memories which are the largest part of the semiconductor market (see table (2).The race for the 64K RAM was effectively won by the Japanese and although superior US technology (eg in terms of faster access time,lower power consumption and generally higher performance devices) has recaptured much of the domestic market the pattern is likely to repeat itself with the 256K RAM.Although at least six major US producers have announced products in this field,it is the Japanese firms which have achieved volume production first and many industry analysts feel that success in this area will signal the end of mass production in the USA,to be replaced by a concentration on more specialised,shorter run products.

Table (2) World market shares of 64k RAMs (1982)

	%	Location
Hitachi	40	Japan
Fujitsu	20	Japan
Motorola	19	USA
Texas Instruments	7	USA
Nippon	6	Japan

Source:Financial Times

This has already been the pattern in much of the European industry where volume production is limited but where specialist product technology-such as custom chips and gate arrays-is relatively strong.

Table (1) World sales of semiconductors-leading firms

Firm	Location	1980 ($m)	1983 (estimates) ($m)
Texas Instruments	USA	1580	1310
Motorola	USA	1100	1500
National Semiconductor	USA	770	690
Nippon Electric	Japan	769	1084
Hitachi	Japan		820
Toshiba	Japan	629	705
Intel	USA	575	685
Fairchild	USA	566	400
Philips	Netherlands	558	500
Siemens	FRG	420	
Fujitsu	Japan	419	500
Signetics	USA	384	
Mostek	USA	330	
Matsushita	Japan	300	

Mitsubishi	Japan	254
AEG-Telefunken	FRG	196
Thomson-CSF	France	190
Sanyo	Japan	180
SGS-Ates	Italy	150
Plessey	UK	49
Ferranti	UK	48

(Sources: 1980 figures-Datapost 1981

1983 estimates- Financial Times)

Table (3) World production and trade in integrated circuits ($bn)

Country	Production	Internal consumption	Exports	Imports
USA	9.3	7.52	(a) Europe 1.08	0.1

			(b) Japan	0.36	0.15
			(c) RoW	0.34	0.03
Japan	3.13	2.23	(a) RoW	0.28	---
			(b) Europe	0.17	---
			(c) USA	0.15	0.36
Europe	0.79	0.65	(a) USA	0.1	1.08
			(b) RoW	0.04	---
			(c) Japan	----	0.17
Rest of world	0.16	0.13	(a) USA	0.03	0.34
			(b) Japan	----	0.28
			(c) Europe	----	0.04

(Source:Mackintosh Consultants)

The pattern of market development indicates three main trends in the semiconductor industry.First is the continuing spiral of capital and R and D costs;estimates suggest that as much as 30% of sales revenue has to be ploughed back into this activity.Costs for setting up a new plant now run into several hundred million dollars with the development costs for new devices even higher.This makes it difficult for even large firms to be "universal companies designing and making a complete range of semiconductor products,and there is a growing trend towards specialisation and co-operation via joint ventures,"technology for market swaps" and so on.So,for example,IBM-still thought to be the world's largest producer of chips for internal use-is also now a major purchaser,particularly for some of the newer technology devices:the most recent example has been the deal with Intel to supply 64K RAMs.

The second trend is towards concentration and specialisation.Firms like National Semiconductor and Intel,primarily semiconductor firms,are increasingly the exception and can only survive on the basis of a technological edge which they can trade for market opportunities-such as in the above IBM deal or Intel's links with Philips.Most semiconductor producers are now part of larger groups and able to draw on financial resources and captive markets-a pattern which has always characterised the Japanese industry.Examples include Fairchild (part of the Schlumberger organisation),Texas Instruments and Motorola (both with a wide range of interests in the electronics field),and nearly all of the European producers.

Alongside this trend is the integration of other IT activities,reflecting the technological convergence;again this pattern has always been present in the Japanese industry,but is now-particularly since deregulation in the USA-emerging strongly.So IBM are involved in semiconductors,computers,telecommunications,satellites and application products for service and manufacturing sectors;ATT look set to enter the computer industry to add to its semiconductor and telecommunications interests;General Electric have a declared aim of being "number one in factory automation by 1990" and have investments in CAD,robotics,computers and factory automation software to match their semiconductor involvement.And so on.

The third trend is towards polarisation of the industry into a small number of volume producers with the remainder involved in specialist products which are required in small volumes.This is the most rapidly growing end of the semiconductor market and even some of the major volume suppliers are now entering the so-called "Silicon foundry" business.Essentially the silicon foundry is a term to describe spare manufacturing capacity which can be used to make small batches of custom integrated circuits-rather as jobbing iron foundries operate.However,the biggest growth area is beyond custom fabrication of special circuits in the field of "semi-custom" chips.These are in fact standard products until the last stage of the manufacturing process when they are "customised" to suit a particular client's needs.The devices are uncommitted logic arrays-chips with a large number of logic circuits on them but the interconnections between those circuits are only made at the final stage.The major advantage of such technology is the lower cost and development time involved;their popularity can be seen in the fact that the UK firm of Ferranti-probably the world leaders in ULA technology-are currently the fastest growing semiconductor firm in the world.

Future growth in the industry is likely to accelerate-for example,the SIA (Semicondutor Industries Association in the USA) forecast in October that semiconductor sales in the USA amd Europe would rise by around 15% from $9.4 bn to $10.8bn with the US increase as high as 20% and with the likely growth in the Far East even higher.

In terms of products the near future will see extensive exploitation of the 256K RAM markets as more and more products come on stream.This may be followed by relatively early entry of 1m bit devices-prototypes have already been announced by several major manufacturers although samples have yet to appear in the marketplace.

In microprocessors there are currently around 60 devices on the market ranging from 4 bit to 32 bit.The 16 bit market is expected to grow significantly-and,with the announcement by National Semiconductor of its 32 bit device (which will be closely followed by several others) there will be competition for the high power/high speed end of the market in telecommunications and advanced computing.The losers will be the 4 and 8 bit devices except in specialist applications.

Technical trends

In an industry worth around $20bn worldwide and with 7-10% ploughed back into R and D it is inevitable that rates of innovation are high;at any time the industry is pursuing a number of different avenues although not all bear fruit.Although this is by no means an exhaustive catalogue,some important emerging trends are discussed below.

One of the most important areas of work has been into increasing capacity of semiconductor devices,particularly in the field of memory chips.This requires the packing of more components on a single chip-for example,in moving to the 1m bit RAM-but making this move introduces a number of major technical problems.First is the requirement for manufacturing technology to work at what are now sub-micron levels in producing the chips;this is reaching the limits of photolithography and work is going into alternative wave sources such as electron or x-ray beam lithography-both highly complex and costly technologies.

Second is the major problem of heat-the more active elements packed densely on a chip,the more heat is generated which must be removed.Apart from "conventional" solutions to the problem-such as applications environments with heat sinks,water or other coolant systems etc-some more fundamental solutions to the problem of increasing component count have been sought.One of the most significant is that of wafer scale integration (WSI) which uses an entire silicon wafer (perhaps 3-4"in diameter) rather than a chip from a wafer.Such an approach has the advantages of fewer heat dissipation problems,faster inter-function communications and the space to implement not only complex circuits but also redundancy so as to increase overall reliability in operation and yield in manufacture.This is not a new idea but the main problem has always been in the manufacture of WSI circuits which require high precision techniques.Nevertheless the technology is attracting considerable interest;the "flagship" project is the Trilogy venture in Ireland,initiated by Gene Amdahl-a respected figure with a strong innovative track record in the semiconductor industry and the founder of the Amdahl Corporation-a major IBM competitor for mainframe computers. This is a joint venture with investment from a number of major IT firms including Sperry (15%) and DEC(9%) and from other international sources:the target is a wafer scale device with perfomance characteristics to match the expected next generation IBM machine.

The second major thrust in research is into ways of increasing operating speeds-particularly of more complex chips-to meet the growing demands for real-time complex applications.Three major technologies are in competition here-gallium arsenide,bipolar and CMOS-together with a host of longer term possibilities such as Josephson junction technology.Gallium arsenide semiconductors are inherently faster than silicon (about one hundred times faster) but although all major manufacturers are working on this technology(and it is especially popular in Japan) there are major problems in scaling up from laboratory to volume production.Nevertheless with its added advantage of optoelectronic properties,it looks like the prime candidate for the fifth generation applications in the 1990s,once the manufacturing technology improves.

Bipolar technology was popular in the early days of the semiconductor industry but has largely been displaced by MOS technology except for specialist applications.However interest has recently been revived because of its inherent speed advantages which make it suitable for analogue applications such as process control.However it faces two major disadvantages-relatively high power consumption (at a time when the trend is to lower power circuits) and a low packing density-in other words the number of components which can be placed on a chip.

MOS (metal oxide semiconductor) technology is the basis of most current production and a number of variants (based upon different ways of "doping" silicon atoms) are in use.Interest is currently very strong in complementary metal oxide semiconductors (CMOS) which although more complex to produce than conventional NMOS technology have significant speed advantages.They also have much lower power consumption and are thus suitable for battery driven products;they were first applied in digital watches for this reason.

The third major area of development is in the field of custom and semi-custom chip manufacture.Even during the recession the demand for customised products to meet specific needs remained buoyant and many manufacturers are now concentrating on this end of the market.Custom chips have the advantages of lower costs (because many functions can be placed on a single chip),reduced space and power requirements,improved reliability (because of reduced component count) and proprietary protection-the chip design is hard to copy without expensive"reverse engineering".

Costs of custom chips have fallen in recent years as a result of improvements in design techniques and the growing availability of capacity in so-called silicon foundries.Relatively speaking,however,they are still high and this has focussed interest on semi-custom logic technology where the standard uncommitted logic array devices are only configured in the final stage of manufacture to the customer's special requirements.Such devices have considerable advantages including low cost and low lead times-often as little as sixteen weeks for circuit design and manufacture.This is the fastest growing end of the semiconductor industry because it offers new opportunities;when Sinclair launched the new pocket television in the UK they acknowledged that it was only possible to make to that size and price because of the ULA chips supplied by Ferranti. It is generally held that Sinclair's earlier success with the ZX80 and ZX81 home computers was also due in large measure to massive reductions in chip count through using ULAs.

In microprocessor technology the major change has been towards improving processing power;the past two years have seen the maturing of the 16 bit device in a wide range of applications and supported by sophisticated operating systems such as UNIX.More recently the 32 bit microprocessor has been announced as a commercial product and this offers several advantages of speed and processing power which make it attractive for telecommunications and for the new generation of mini-computers.

The continuing high demand for memory devices has led to concentration of resources on high capacity devices;most manufacturers are already well-advanced with 256k RAM chips and several have announced laboratory prototypes of 1m bit devices.Nippon Electric already has volume production of a 1m bit ROM (which is a simpler product than a RAM) and have announced that they have a new technology which will permit them to produce a 4m bit RAM in volume shortly.Toshiba have announced that they are in fact giving up work on their 256k device and committing their 20bn Yen investment programme to volume production of a 1m bit RAM by 1984.

For passive large capacity storage the bubble memory approach has persisted despite the withdrawl of major manufacturers like TI.There appears to be a small but stable market for the 256k and 1m bit devices produced by Intel and Motorola but it is unlikely that this technology will develop much further because of the growth in alternative st media,particularly optical discs.

In the longer term a number of technical trends look like becoming important:amongst these are:

-Josephson junction technology for high speed (although a recent announcement (November 1983) by IBM that they are pulling out of research in this area has cast some doubt on this)

-optical computer techniques

-thin and thick film hybrid circuits

-superlattice materials rather than single crystal wafers

-biologically-based information processing systems

-the Transputer ,announced at the end of 1983 by Inmos,offering a 10 million instruction per second computer on a single chip,with a novel and advanced architecture and a new software language.

II. THE INFORMATION TECHNOLOGY INDUSTRY

Although growth in the field of semiconductors has been rapid,the major expansion has come in those industries exploiting IT-computers and peripherals,telecommunications and the software services to support IT.The dominant trend amongst all of these sectors has been towards concentration and integration so that many IT firms are involved across the entire spectrum.It will be useful to review the key sectors separately.

(a) Telecommunications

This industry has been dramatically affected by the convergence of computing and communications and "intelligent" systems are now being developed to cater for the full range of information types-voice,data,graphics,text and video.The current world telecommunications market is worth around $50 bn and is projected to grow to around $65 bn by 1987,with particularly fast growth in Asia.(See table (4).

Table (4) Market growth forecasts for the next ten years

Country	%growth	%market share
Asia	10	28
N.America	8	42
Latin America	8	3
Africa	8	1
Europe	7	25
Oceania	7	--

(Source:A.D.Little)

Growth in telecommunications equipment markets to 1987 ($bn)

	1977	1982	1987
Switching systems	10.0	13.0	20.0
Transmission/local distribution	11.4	17.0	25.0
Terminals,mobile radio,private systems,etc	9.0	15.1	20.3
Total	30.4	45.1	65.3

(Source:A.D.Little)

In the face of such large markets it is inevitable that there is strong competion.The pressure is compounded by the need to search for scale economies because of the high and rising costs of telecommunications equipment development;although component and hardware costs are generally low,software development is extremely expensive.For example,the latest ITT System 12 electronic switching system cost over $1 bn to develop and Northern Telecom of Canada spent over $700m on their latest product.

Gaining access to world markets is not straightforward in telecommunications,however.Few countries allow free entry and most local telecommunications markets are dominated by PTTs which maintain a monopoly over much of the equipment market and tend to favour national suppliers.Developing countries are also becoming more selective and are trying to build up indigenous capability or at least acquire local manufacturing.Although there are signs-with deregulation in the USA and liberalisation in the UK-of a gradual breakup of the monopoly,it is still a restricted market.A recent OECD survey estimated that there were currently 16 major systems on the world market whose combined devlopment costs were around $6 bn.They were competing for a potential world market of $ 12bn -but only half of this could be considered as truly open market,the rest being subject to national monopoly and preferential procurement.

With developments in technology also moving rapidly,R and D costs are escalating and this puts further pressure on firms.The result is a squeeze on access to both markets and technology and this has forced many firms out of the industry and others into various forms of alliance-joint ventures,technology sharing deals etc.Even IBM-which has,arguably,sufficient strength in both technology and marketing to go it alone-has recently bought a stake in Rolm,a small but technologically advanced supplier of PBX (private branch exchange) equipment.Table (5) indicates some other collaborative ventures.

Table (5) Examples of current collaborative ventures

Firm	Collaborator	Technological area
ATT	Philips	Transmission and switching systems
	Olivetti	Office products
	Various	UNIX operating system developments
CIT-Alcatel (France)	CSF-Thomson-Brandt	Semiconductors
	Philips	Cellular radio
Ericsson (Sweden)	Datasaab	Computer systems
	Facit	Office products
	Atlantic Richfield	Cable making and software
	Honeywell	Voice and data systems
	Sperry	Banking terminals
	Thorn-EMI (UK)	PBX systems
GTE (USA)	Ferranti	Equipment
	Italtel	" " "
IBM	Rolm	PBX systems and office products
	Satellite Business Systems (33% share)	Satellite communications
Mitel (Canada)	ICL (UK)	PBX systems
Northern Telecom (Canada)	Data General Sperry	Computer systems and software
Plessey (UK)	Stromberg-Carbon (USA)	Equipment
	Scientific Atlanta	Satellite receivers and cable equipment
	Burroughs	Computer systems

The importance of telecommunications as a component of future infrastruucture is illustrated by the conclusions to a recent report by the consultants,Logica:".....every W.European country will be obliged to undertake the massive initial investment to install these new networks-or risk losing its place in the ranks of the advanced industrialised countries".Table (6) gives some figures for European investment which indicates the level of investment required-much of it coming from public sources.Of perhaps greater significance is this to newly-industrialising countries which are now well to the fore in installing such advanced systems.For example,the most recent major contracts for all-electronic exchanges have been in Mexico,Egypt,Saudi Arabia and Singapore.with others on order for the Caribbean ,India and China. (See table(7)).

Table (6) European investment by PTTs (converted to US$) 1982

Country	Investment ($m)	Investment per head ($)
UK	2460	44
FRG	5843	95
France	3520	65
Italy	2760	49
Sweden	557	67
Spain	769	20
The Netherlands	561	39

(Source:Logica)

Table (7) Recent contracts for all-electronic exchanges

Country	Supplier	System cost (approx)
Saudi Arabia	Philips/Ericsson	$3 bn
Egypt	Siemens/CIT Alcatel	?
Jordan	CIT-Alcatel	$145m
India	CIT-Alcatel	$200m
Mexico	ITT System 12	?
Norway	ITT System 12	?
FRG	mostly Siemens	$100m
St Vincent	System X (UK consortium of Plessey/GEC and others)	

(Source:Financial Times)

On the technology front there are a number of important issues which have emerged during the past few years. In the field of switching systems concentration has been on competing sophisticated all-electronic switching with products like System 12 (ITT), System X (GEC/Plessey) and E 10 fro CIT-Alcatel. However recent interest has been in the field of private branch exchanges (PBX) which dominate company level communications. With advances in technology these have become, in effect, switching computers and many suppliers see them as the basic element in the development of local area networks (LANs). Since something like 70% of all business communications takes place within a 30 mile radius-and most of that within the same site-the market potential for LANs is considerable. A recent IDC forecast for W.Europe suggested that the present 3000 LANs would increase tenfold by 1984 and be as high as 250,000 by 1987. More important, LANs are an essential part of the infrastructure for integrated office automation; with long-distance networks they will facilitate the full range of information transmission-voice, data, text, graphics and video.

Inevitably the competition for LANs is intense but it breaks down very roughly into two camps-the computer industry and the telecommunications industry. The former-represented by systems such as Ethernet (a joint development by Wang, Xerox, Intel and DEC and made available to any interested manufacturer in the hope of establishing it as a de facto standard for LAN) depends on a computer system for its operation whereas the latter-represented by telecommunications firms like Northern Telecom, Mitel, Rolm and Plessey-base it on an advanced PBX. Significantly IBM appear to have gone for the PBX route with their investment in Rolm.

The battle still has to be fought, not only between these two camps but also within them in terms of the architecture of such LANs-whether they should be based on a ring,star or wheel configuration,etc.There are many major technical problems still to be resolved but it is clear that the most significant in the short term will be that of standardisation.Any network must have some standard way of getting information into and out of the network and a number of attempts at a standard protocol have been made.The computer lobby favour a system called Carrier Sense Multiple Access with Collision Detection (CSM/CD) but the PBX alternative favours a system known as token passing;recent developments in a special purpose token passing chip may favour the latter group.

The International Standards Organisation has been trying to arrive at what is termed the Open Systems Standard (OSI) for worldwide use.This has the aim of allowing information to be exchanged between computer systems regardless of manufacture or geographical location.It is based on a reference model of seven layers,each layer building on the one below to make more advanced facilities available.Suppliers of LANs have been lobbying this group extensively over the past two years to get their standards accepted but despite pressures for an exclusive ruling the field is still open.

Apart from LANs considerable developments have taken place in the field of wide area networks (for long distances) and broadband (for high capacity) telecommunications.Here the interest has been in fibre optics for high capacity/high speed/high integrity communications, cable systems to provide new infrastructures to support an information society,and satellite systems- especially with the recent successes of the Space Shuttle and the European Ariane project which look like reducing the costs of satellite launches considerably.

On a local level one of the other breakthroughs has been in the field of cellular radio which offers a large number of frequencies for local radio communications-eg portable telephones within a city.Advanced computer control manages the transfer of signals and frequencies to give high capacity and such systems are beginning to emerge in many cities in the US ,Europe and Japan.

The future

Most commentators believe that telecommunications will be the fastest growing IT sector in the near future.For example,HiTech Reports-an investors' service combining data from various forecasts and surveys-estimates that the growth will be fastest in voice storing and forwarding,electronic mail and LANs,with compound growth rates for the next decade of 165%,145% and 130% respectively.

Two issues will dominate the industry in the short-term future:liberalisation and standards.The liberalisation issue stems from moves like de-regulation in the USA which attempt to introduce more competition into telecommunications.The question is an open one as to the effect this will have on the range,cost and distribution of services.

Standardisation is an acknowledged urgent issue-with so many systems coming onto the market and so much potential communication of different types.Yet as the recent Geneva conference on telecommunications showed,it is increasingly difficult to obtain agreement on standards;there must now be a real danger that proliferation of systems without standards will lead to the equivalent of a twentieth century Tower of Babel.

(b) Computer systems

Growth in computer sales is still very rapid, although 1982 was a poor year for many manufacturers in the traditional leading firm group; table (8) shows their decline in profits.

Table (8) DP equipment revenues 1982

Company	$bn	% profit change
IBM	31.5	+19.5
DEC	4.0	-14.4
Burroughs	3.8	-21.1
CDC	3.3	-9.4
NCR	3.2	
Sperry	2.8	-36.8
Hewlett-Packard	2.2	
Honeywell	1.7	
Wang	1.3	
Xerox	1.3	

(Source: Computer Weekly)

IBM continues to dominate the world market with 71% of the mainframe market and around 50% of all the systems worldwide; its growth of 20% is doubly impressive because of the relatively poor fortunes of the rest of the industry-although it must be said that it has undergone radical reorganisation in recent months to retain its edge. As tables (9), (10), (11) show, the US continues to dominate the world supply of computers, having shipped a record 215,000 units in 1982 and with a domestic market which grew from $59.6bn in 1981 to $69.2bn in 1982 and predicted 1983 figures around $83.7bn. The Japanese and W.European industries have strength in their domestic markets but it is clear that in terms of exports they will have most impact in specialist markets or where there is some co-operative venture or partnership.For example,Fujitsu sales to the USA are not themselves very strong but the company has a 30% share of the Amdahl Corporation which is a major competitor of IBM.

Table (9) US exports and imports of computer systems (by value,$000)

Country	1982 (exports)	1981 (exports)	1982 (imports)	1981 (imports)
Japan	63 382	56 338	112 342	62 318
UK	135 879	140 487	31 135	22 191
Canada	104 325	89 587	100 735	101 934
France	76 666	90 673	52 812	10 626
W.Germany	76 695	93 718	8 052	3 773
Australia	60 512	64 768	-	-
Italy	28 045	48 899	11 698	10 392
Netherlands	21 404	33 153	6 661	2 578
Belgium/ Luxemburg	13 102	28 757	5 500	5 281
Ireland	14 875	10 120	16 411	373
Sweden	20 610	22 363	2 996	4 136

(Source:Computing)

Table (10) Major suppliers in Japanese market (1980)

Supplier	Market share %
IBM	28
Fujitsu	19.6
Hitachi	15.4
NEC	14.3
Univac (USA)	10.8
Burroughs	4.3
Mitsubishi Electrical	3.2
NCR	2.2
Other	1.5

(Source:Electronics Times)

Table (11) Major suppliers in W. Europe, 1982

Supplier	Location	Sales $m
IBM	US	9747
Olivetti	Italy	1310
Siemens	FRG	1270
CII/Honeywell/ Bull	France	1200
DEC	US	1041
ICL	UK	994
Burroughs	US	970
Sperry	US	813
Nixdorf	FRG	796
CDC	US	794
Philips	Netherlands	787
NCR	US	702
Hewlett-Packard	US	694
CIT-Alcatel	France	517
Honeywell	US	478

(Source:Logica/Datamation)

It is also clear that the price war which has led to some cuts of 20% and more in price will continue;an indication of its effect om the industry is that the value of US exports remained static at $9^0m,despite the record growth in volume.Market growth has also been significant in Latin America and the Middle East,as well as other developed countries like Canada,Australia and W.Europe.

The key market development during the past two years has been at the personal/business microcomputer end of the market which has grown extremely rapidly.With the rise in power of memory and processor chips and the fall in costs it has become increasingly difficult to identify a clear distinction between mini and microcomputers.A large market has opened up at the lower price end of the market,a field which was dominated by games machines.Until recently the market was occupied by firms like Apple,Tandy and Commodore but the explosive growth in the market has led to the entry of over 400 suppliers.IBM entered the race late and with what many commentators regarded as a safe and proven technology rather than a state-of-the-art machine.However its track record on marketing and software support led to its quickly establishing market leadership with around 28% of the market,well ahead of its next rival,Apple,with around 17%.Inevitably this has shaken the competition and many analysts agree that In early 1984, there will be a major fall-off in orders and failure of several companies.Already casualties include Texas Instruments which recently pulled out altogether from the market,Victor Technology which has been forced to make layoffs and economies in the USA,Apple whose profits fell by 73% and,in the UK,Dragon,Camputers and Grundy.Even Acorn whose BBC microcomputer has had considerable success in the educational market has suffered falling share prices since its launch on the UK Unlisted Securities Market in October.

In technological terms the bulk of development attention has gone into the so-called fifth generation projects (see later).These are to develop a "super computer" with very high speed logic processing and capable of working to a rule base of around 10,000 rules-that is,of supporting artificial intelligence at near-human level.Certainly all the fifth generation projects are heavily supported by the major firms in Japan,W.Europe and the USA.The level of R and D commitment in the computer industry can be seen in the fact that six of the top ten R and D spenders in the USA in 1982 were computer firms-and the top,in expenditure per head-was Cray Computers which spends around $21,000 per employee to maintain its position as the fastest computer in the world.

The main technological issues have concerned the increasing blurring of the lines and roles of computers.With 16 and 32 bit processing power,even a microcomputer can now approach many mainframe performance characteristics and the role of the traditional mini computer-once the "enfant terrible" of the industry-is becoming hard to identify.This concentration and convergnece of power and performance has shifted the emphasis to software ,to distributed multi-user network systems and to advanced peripherals.

Overall the trend in computer technology reflects that already observed in telecommunications and semiconductors,with high R and D costs and rapid rates of change forcing firms to collaborate on technology and marketing.For example,IBM's successful personal computer only has an IBM assembled keyboard;all remaining items are bought in-the 16 bit chips from Intel,the operating system software from Microsoft and the CRT from Matsushita.

With the growth in distributed systems has come a demand for more peripherals and the market looks healthy for printers,graphics terminals modems,storage devices (especially hard disc systems for microcomouters and,in the longer term,optical discs).

(c) Software

Software is usually divided into two categories-bespoke (written for a particular application)and packaged.Of the two there is no doubt that most growth has come in the second area-and within the field the competition between packages supplied by hardware manufacturers and independent bureaux has grown.Hardware suppliers still dominate the field for utilities and operating system related programmes but the growth in specialisation and experience of the independents is giving them the edge on applications software.An IDC survey estimated the ratio of packaged to bespoke software rising to around 10:1 by 1990.

Overall software continues to grow as the major item in computer users budgets;two recent studies confirm this pattern.

Table (12) Percentage of budget spent on software

	USAF study	Siemens study
1955		5-10
1970	20	50
1980	80	90
1985	90	90+

The major growth markets are in manufacturing ,education and some aspects of administration.In education the increasing availability of microcomputers for schools and of languages like LOGO has boosted interest in computer literacy and computer aided learning to the point where one US survey forecasts a market of $8.7 bn by 1990.

In manufacturing there is considerable pressure to automate production management functions as the most cost effective first stage in factory automaton.Table (13) indicates areas of growth.

Table (13) Manufacturing software-areas of application (%)

Application	Computerised	Manual	Not done
Inventory control	75.1	21.2	3.7
Bill of materials	65.6	25.9	8.5
Material Requirements Planning	61.4	30.5	8.1
Production Cost Estimation	53.6	37.5	8.9
Purchasing	52.2	44.8	3.0

Production scheduling	49.3	45.6	5.1
Job cost reporting	47.2	31.7	21.1
Production routing	42.0	42.5	15.5
Capital Requirements Planning	39.5	41.3	18.7
Production forecasting	36.9	46.3	16.8
Variance plan reporting	36.2	38.4	25.4
Shopfloor reporting	33.4	52.3	14.3
Process control	26.4	33.3	40.3
CAM	14.0	na	86.0
CAD	9.6	na	90.4

(Source: IDC)

Much effort continues to go into software development and this has taken two main directions.First is the attempt to make the process more productive-software productivity is notoriously hard to control and has not been amenable-in the way that manufacturing hardware has-to improvement through innovation.The software process usually has four stages:analysis and problem definition,coding,debugging and testing and development.Although the first requires an expert system type approach and will not be practical to automate for some time,the other three have been significantly improved with various technological inputs including structured programming,programme generator software,automated testing etc.

The second growth area has been in developing new approaches ranging from new languages-ADA,LISP,PROLOG,OCCAM,C,etc-which are suitable for particular applications and advanced uses such as artificial intelligence-to new concepts such as logic processing.Much of the fifth generation computing money is being spent on advanced software engineering,aiming at speed,flexibility and reliability;for example,the US Department of Defence have recently committed £40m to their STARS project which aims to develop reliable software using novel approaches.

The other main area of concern is with software protection and this has been dealt with in two main ways. Technologically considerable effort has gone into making systems piracy proof-via encryptation, use of firmware etc. On the legal side the international position on software copyright-whilst still relatively weak-has improved-particularly following the IBM/Hitachi incident.

IV. APPLICATIONS IN MANUFACTURING INDUSTRY

The past two years have been characterised by two factors; the maturing of technologies for factory automation (including cost falls and performance improvements) and the growing trend towards convergence into computer-integrated manufacturing (CIM). To understand this second point it is worth looking briefly at the pattern which factory automation has taken. Manufacturing can be broadly grouped into three activities-preparation, production and management. In the first group are those activities like design and preparation work-mouldmaking, toolmaking, etc. In the second are the actual production operations-machining, cutting, moulding, heating/cooling, etc. In the management group are the operations necessary to manage the process-stock control, production control, planning and scheduling, etc. As figure (1) shows, much of the early effort in automation has gone into these areas to produce a wide range of automation technologies for discrete elements in these areas-eg computer-aided design, process controllers, handling robots etc. The trend to CIM essentially involves integrating these discrete automation technologies into complete production systems-as shown in figure (2).

Figure 1 Discrete Automation Areas

Preparation

- computer aided designs
- computer aided scheduling
- computer aided engineering
- computer aided toolmaking/ mouldmaking etc

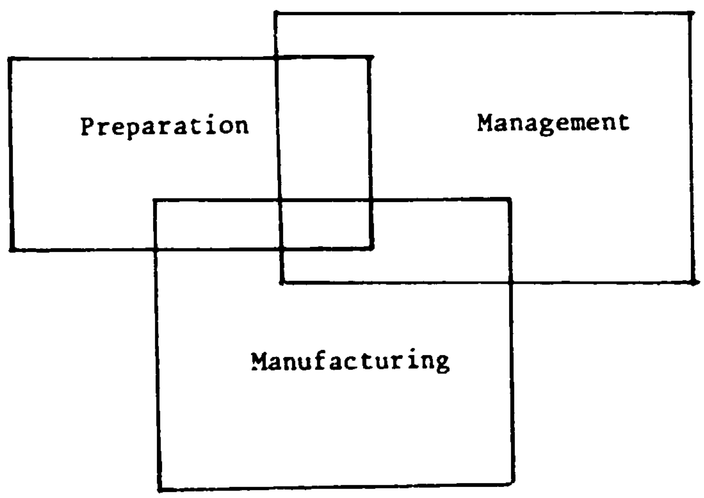
Management

- computer based systems for: stock control
- MRP
- production control
- vendor scheduling
- order processing
- etc

Manufacturing

- CNC machines
- programmable controls
- programmable manipulation - robotics
- programmable handling - pallets, AGVs
- automated warehousing
- etc.

Figure 2 Integrated Automation Areas



eg Flexible Manufacturing Systems

Source: Microelectronics in Industry, by R. Kaplinsky, Longmans, London 1984.

A good example of this can be seen in the metalworking sector of the engineering industry.Here the changes have been from discrete manual machining,to automated machining on NC and CNC machine tools,to multiple machining on CNC machining centres (ie able to carry out several different operations on one machine instead of passing the workpiece amongst several different machines),through to group technology cells (grouping similar kinds of products into manufacturing sub-systems to optimise use of capacity),to direct numerical control(DNC) with a supervisory shopfloor computer running several different machining centres,through to flexible manufacturing systems which connects machining centres with handling systems (robots,automatic guided vehicles,programmable conveyors,etc) and warehousing systems.The whole is under hierarchical computer control and is linked in to the computer-based management systems for stock control,purchasing,production planning and control,etc;future systems will also integrate the preparation stage through CAD/CAM (computer aided design and manufacture) systems,so that it becomes possible to move from the original idea through to the finished product in a continous flow.

The value of such integration is that it brings all manufacturing industry-even the traditionally batch-oriented industries-close to the process industry model characteristic of industries like petrochemicals.Important characteristics include continuous or near continuous operation (high plant utilisation),high levels of control (to produce high and reproduceable quality and tailor production to specific customer needs),high reliability (most maintenance problems occur on start-up or shut-down of processes rather than in operation),improved utilisation of inputs of labour,energy,materials,etc) and high flexibility with rapid response to changes in the production plan.

Whilst the trend is well advanced,there are major problems involved in linking up the various systems in CIM,including software and hardware compatibility and organisational problems associated with the need to move to a radically different philosophy of production.So far there are relatively few flexible manufacturing systems in operation-around 100 worldwide-and nearly all of these have been major projects in the metalworking industry.Nevertheless most commentators predict rapid acceleration as the technology matures on the supply side and as the experience base of users is developed.By 1985 flexible manufacturing systems and other examples of CIM are likely to be common in several industries including food processing,aerospace,electronics and automobiles.

In general terms progress in manufacturing automation has been very rapid,driven by a mixture of forces including the gradual upturn in the world economy,cost falls and performance improvements in the technology,strong pressure from the supply industries and the effects of recessionary shake-out which forced firms to invest in advanced technologies not only to improve productivity but also to put them in a stronger competitive position-eg by facilitating smaller batch work or greater product differentiation,quality,etc.The pattern in the supply side reflects once again the convergence and concentration seen in other sectors-often with the same names emerging.Most forecasts indicate sustained growth in manufacturing automation in all its aspects.For example,the US firm of Predicasts suggest that the US market will grow from its current (1982) level of \$7.3bn to around \$15bn by 1987 and again to \$37bn by 1995.

It will be useful to look at some of the key manufacturing automation technologies individually.

(a)Robotics

During the past two years the market has grown considerably for industrial robots,at approximately 30% per year.However this growth has been accompanied by an even larger growth in the number of suppliers;many of these are small high technology firms and their survival chances are poor.In general the industry is beginning to resemble other IT sectors with a small number of large firms with other IT interests-firms like IBM,Westinghouse,Cincinnati-Milacron,Fujitsu-Fanuc and Hitachi.The other main supplier group is the early users,mostly from the car industry,who are now in a position to sell their experience and technology-firms like Volkswagen and Renault.Table (14) gives figures for market shares.

Table (14) Market shares of major robot builders (1981)

Firm	USA% ($250m)	Europe% ($230m)	World%
Unimation	32	24	16
Cincinnati	32	7.4	3
ASEA	-	24	13
Kawasaki	-	-	14
Fanuc	-	-	13
Mitsubishi	-	-	2
Yasukawa	-	-	7
Hitachi	-	-	12
Kuka (FRG)		19.1	
DevilBiss (Norway)	5	14.1	
Other	5	11.4	18

(Sources: CSI)

Market share in Europe (1982)

Firm	Units %	Value %
Unimation	24	24
ASEA	17	15
Tralfa (Norway)	9	9
Volkswagen	9	10
Kuka (FRG)	8	10
Cincinnati	5	6
Acma-Cribier (France)	5	6
Comau (Italy)	4	5
Kaufeldt (Switzerland)	3	1
Nimak (FRG)	2	2

(Source:Frost and Sullivan)

One key trend has been the broadening of the range of applications from a few tasks like welding and paintspraying to multiple roles,often demanding more sophisticated programming;this has opened up new markets.Examples include arc welding as opposed to spot welding,inspection,complex and delicate manipulation and automated assembly.The Ingersoll Robots Report in the UK identified the main application areas as:

-spot welding

-pressure diecasting

-plastic injection moulding

-paint and powder spraying

-forging and extrusion

-loading/unloading

-investment diecasting

-heat treatment

The current major user sectors are automobiles (around 60%),electrical/electronics (12%),mechanical engineering (10%) and plastics(9%). International diffusion has grown considerably although Japan remains the heaviest user.Significantly several developing and industrialising countries have been investigating robots and some-like India-have actually produced their own.Tables (15) and (16) give current and predicted figures for robot population.

Table (15) Robot population (end 1982)

Country	Number of robots	
Japan	13000	
USA	6250	
USSR	6000	(1981 figure)
FRG	3500	
Sweden	1300	
UK	1152	
France	950	
Italy	700	

(Source:British Robot Association)

Table(16) Predicted robot population

Country	1985	1990
Japan	16000	29000
USA	7715	31350
FRG	5000	12000
Switzerland	600	5000
Sweden	2300	5000
Norway	1000	2000
UK	3000	21500

(Source:Robot Institute of America)

In technology the basic level of robotics is now well established with programmable multi-axis manipulation and an increasing degree of precision.Considerable R and D is going into the next generation which will have much improved sensory technology-especially vision systems and touch sensitivity for precision automated assembly.Although a number of advanced prototype systems are in existence,there has been,as yet,no commercial scale launch of a second generation robot and most commentators expect this to remain the case until 1985.In the longer term the trend will be towards highly intelligent expert system backed robots which are capable of "learning" rather than simply following a programme.In Japan,for example,there is a major MITI project,costing $70m to run for 7 years to develop such learning robots for hostile environment work-on the sea bed,in nuclear and space work,etc.

(b)Computer aided design

In the case of CAD/CAM systems growth has been equally spectacular and is predicted to continue at around 40% per year until 1986;table (17) illustrates this.

Table (17) Predicted growth of CADCAM systems

	1976	1980	1986
Installed turnkey CAD/CAM systems	1000	4000	24000
Sales ($m)	69	480	4000

(Source:Dataquest)

After the rapid growth in the late 1970s most of the independent suppliers of CAD/CAM systems have been taken over by large corporations-again illustrating the convergence and concentration pattern.As with robots this group is also joined by those early users of the technology who are now selling their experience and systems on the open market-for example,the major aerospace users such as McDonnell-Douglas (McAuto) and semiconductor designers such as IBM (CADAM). Table (18) indicates the current top ten US firms.

Table (18) US top ten firms in CAD/CAM (1982)

Firm	Sales (units)	Value ($m)	Total installed base (units)
Computervision	833	325	2253
IBM	160	250	300
Intergraph	315	155	696
Calma (General Electric)	228	138	1084
Applicon (Schlumberger)	210	95	1210
Auto-trol	130	44	542
McAuto	96	43.5	275
Scientific Calculations	50	21	175
Gerber Systems	60	18	350
Gerber Scientific	235	16	350

(Source:Datatech Associates)

The main user areas for CAD/CAM are in chemicals (pipework layout etc),metal fabrication,machinery design,electronics and transportation equipment,and in mapmaking and related fields.Costs of CAD/CAM systems have fallen especially for smaller systems,but they remain relatively high and this restricts the access of smaller firms to the technology.Unlike most computer applications,CAD/CAM still has a high hardware cost component-often as much as 80%-involved in specialist terminals,plotters,tablets,digitisers,etc,rather than direct processing power.With the emergence of 16 and 32 bit power for even small machines it is likely that the future will see rapid growth in low cost systems for smaller firm applications;there are already some simple systems on the market for microcomputers such as the Apple.

(c) Other applications

Automation of other manufacturing operations has grown significantly with applications right across the industrial spectrum.In general terms these applications can be classified into four groups;monitoring,process control,integrated control systems and management systems.In each case the technology is well-advanced,both for retro-fitting to existing plant and for embodiment in new plant.Control equipment varies enormously from simple programmable logic controllers monitoring or controlling a single parameter and costing around $1000 or less through to advanced distributed manufacturing systems based on mainframe processing power. The forecast for 16 and 32 bit microprocessor markets up to 1987 indicates that most growth will be in the area of industrial automation-around 21% of the expected $1.4bn market.

One set of figures which gives an indication of the diffusion of automation technology across different industrial sectors comes from the Policy Studies Institute in the UK (see table (19)).Their survey (based on 1200 firms in the UK covering all size and sector ranges) also identified the main problems and benefits and these compare well with experience in other European countries.(Tables (20) and (21)).

Table (19) Diffusion of microelectronics across industrial sectors (1983)

Sector	% use in products	% of user's output	% use in processes	% of user's process affected
Food,drink,tobacco	0	0	75	31
Chemicals,metals	0	0	69	24
Mechanical engineering	39	29	72	19
Electrical and instrument engineering	61	43	85	31
Vehicles	34	37	70	25
Other metal goods	6	27	55	27
Textiles	0	0	47	23
Clothing	0	0	38	20
Paper and printing	0	0	70	41
Other	4	15	54	26

Table (20) Problems in applying microelectronics

Problem	% of firms experiencing it
Shortage of skills	45
General economic climate	43
Development costs	29
Lack of sources of finance	30
High production costs	16
Software problems	18
Sensors	13
Communication with suppliers	9
Problems with chips	8
Trade union resistance	7
Management resistance	5
Other resistance	4

Table (21) Benefits of applying microelectronics

Benefit	% of firms reporting
(a) Product users	
Better product performance	70
Flexibility in product development	66
Lower product cost	47

Customer appeal	42
(b) Process users	
Better process control	75
Consistent/better quality	74
Better use of labour	66
Better use of capital	48
Better use of materials	45
Better use of energy	35
Improved speed in production	49
Reduced production costs	54

Source: Microelectronics in Industry, by J.Northcott et.al., Policy Studies Institute, London 1982.

The future

The pattern for the future will be one of increasing convergence and concentration on the supply side and of increasing concentration and packaging of total systems for the user.Overall capital costs are likely to rise but these will be offset by the major savings in space,the increase in flexibility and productivity,plant utilisation and so on which advanced systems provide.The main force for change in Europe and the USA will continue to be the example of Japan and investments will be made principally to try and achieve comparable levels of productivity.

(5) Applications in the service and public sectors

Growth has been rapid here especially in banking,retailing and in office applications.The main applications have been point-of-sale (POS) systems in retailing,automated telling machinery (ATM) in banks and word processors and database systems in office/administrative activity. All of these sectors have been characterised by a very strong supply side push to move into new technology and it is significant once again to note the dominance of major firms with other IT interests.Associated with this has been the somewhat misleading argument regarding productivity and technology in the service sector.

In essence this says that there is a relationship between investment per head and productivity;figures for agricultural investment of $40,000 per head are related to a 200% increase in productivity since WW2,in manufacturing of $30,000 per head giving a 100% increase and in services only $2500 per head being used to explain the low-around5% growth in productivity.While plausible ,this ignores the fact that growth is much more complex than a simple technological factor.It also takes no account of non-quantifiable factors like quality.IT can certainly increase the amount of information generated but there is nothing to suggest that even major capital investment can <u>of itself</u> improve quality:more of the same does not necessarily equate to better.

In the office automation field this approach is beginning to give way to a more realistic appraisal of what the technology can and cannot do and the moves which need to be made on the way to the integrated office of the future.Table (22) indicates the present distribution of technologies,from which it can be seen that reprographics still dominate the field.By the 1990s this is expected to fall to around 20% and the bulk of concentration around 50% will be in text generation and transmission equipment.The figures are for the UK but are comparable with those for most of Europe,falling between the more advanced FRG and the less advanced smaller countries:for the USA the rate of diffusion has been faster.

Table (22) Office products in current use in the UK

Equipment	In use KFI study	In use PSI study	Planned
Photocopiers	97.6	98	
Electronic typewriters	85.5	81	
Word processors	78.9	62	18.8
Microcomputers	77.5	79	
PBX (advanced)		60	28.3
Intelligent workstations		29	16.4
Local area networks		15	16.1
Electronic mail		12	15.0
Telex machines		78	
Microfilm/fiche		64	
Viewdata/videotex		19	

(Sources:

PSI study,250 firms,all sizes,1982
KFI study 255 large firms,1982)

Three areas of office automation can be identified in similar fashion to our three in the manufacturing sector:as in that example,the longer-term picture will see these integrated into the office of the future-but there are major problems still to be overcome,including the standardisation of communications.

The overall market for office automation products has been estimated for 1982 at around £3bn and is expected to form about 15% of the future IT market-especially as the convergence with telecommunications develops and multi-function workstation terminals covering text,voice,data,and picture transmission become available.The market is expected to grow at around 15% per year.

In terms of the pattern of technological development the most significant factor has been the above-mentioned convergence with telecommunications and particularly in the field of LANs which allow multi-user systems,access to shared resources and common databases,etc.Although there are some prototype systems in use,usually based on advanced PBX systems,the difficulties of standards and network compatibility have still to be resolved.Indeed,in several European studies (PSI,KFI,Butler-Cox,EOSYS),the point has been repeatedly made that after financial considerations,the biggest barrier to using IT is the lack of standards and compatibility.

In banking automation the field of ATM is growing rapidly with a market worth round $2.5bn from banks,building societies and other financial agencies.Table (23) gives some idea of this rapid growth.

Table (23) Distribution of ATM worldwide

Country	1975	1977	1981	1995
USA		6300	25400	90,000
Europe	3800		11000	
Japan			27000	

The pattern of supply is again dominated by IT related firms,although one firm,Diebold have specialised from the earliest days in this technology and can be said to have pioneered its use.Table (24) indicates the market share distribution.

Table (24) Market shares of ATM producers

Firm	USA %	Europe %
Diebold	47	

IBM	25	34
Docutel	19	8
NCR	6	17
Transac		12
Dassault		11
Chubb		5
Others	3	13

(Sources:USA-Diebold
Europe-Battelle)

There seems little doubt that the growth will continue in numbers and that there will also be an expansion in the range of services offered;some US machines are already offering up to 125 different options.It also seems likely that other financial institutions will be drawn into the use of "through the wall" banking of this kind and that technology will increasingly become a competitive weapon within the financial sector.

In the longer term the major development will be in electronic funds transfer (EFT)-so-called on-line banking.Such systems are theoretically possible now but a number of problems remain to be solved,particularly in the area of getting agreement between major retailers and the banks to implement the system.Trials have been carried out in a variety of locations and activities-garages,restaurants,shops,etc and recent announcements in the UK indicate that a major national level trial will take place in February following agreement on standards and systems amongst the major banks and retailers.

Within banking operations the use of advanced IT systems and especially telecommunications networks continues to grow and international arrangements such as the SWIFT system for transfer payments and transactions will certainly develop.This has significant implications for development and participation in world trade;just as advanced nations will need to belong to the telecommunications network infrastructure,so they will need to make the necessary investments to participate in the financial one.

In the area of retailing the diffusion of first-generation POS systems is well-advanced and very few shops do not have some form of electronic system.These may be simple cash registers or they may carry advanced data capture and information display facilities.However the major development is now in bar code reading systems,usually involving laser scanning.This is widely used in the USA and in large European shops;a recent NEDO survey in the UK suggested that by 1985 about 1000 retailers would be using the system.Much depends on the availability of coded products;at present around 70% of goods in Europe are bar-coded and this figure is as high as 90% for certain products.

Within the public sector there is considerable growth in IT usage,mainly in the form of administrative support via computers and office automation.For example,in the UK the Department of Health and Social Security is spending around £700m to bring the installed base of IT up to 2700 microcomputers and 680 mini and mainframe systems from their present levels of around 900 microcomputers and 1250 word processors.These moves will save around £2bn by 1990-although there are likely to be around 25,000 redundancies as a result of this automation.

Similar administrative automation projects can be found in most countries.Other public sector uses of IT include the provision of public viewdata systems,the development of expert systems to calculate benefit payments,the provision of public access to databases and other applications such as facsimile transfer.

V. EMPLOYMENT EFFECTS

The debate about the employment effects of IT has continued to rage;the main difference has been that recent years have seen the availability of a growing body of empirical evidence so that discussion takes place on a more informed level.

In quantitative terms it is clear that the recession has been responsible for the majority of job losses in all developed countries.Where there has been an effect due to IT it has been masked by the much bigger losses due to falling demand,overcapacity,etc.What is now beginning to happen is that with the upturn in the world economy firms are meeting growing demand by investing in new machinery,often embodying IT,rather than taking on new labour.In other words there is a de facto labour displacement due to new technology;manufacturing industry is increasingly coming to resemble the process industries pattern of employment of a relatively small number of skilled men and with a high reliance on advanced technology.

Within services the picture is gloomy because,unlike manufacturing which has seen gradual employment decline for many years,they have traditionally been sources of employment as they expanded.Indeed,within the context of IT they have often been cited as a kind of sponge to absorb labour displaced from the manufacturing sector by advanced technology.In practice this is not the case;much of the service industry is characterised by information activities which are amenable to automation,and we have already seen that growth and diffusion is as rapid there as in the manufacturing sector.Many sectors such as banking have in fact been characterised by jobless growth or at most a very small employment expansion;recently there have been a number of redundancies announced in the insurance industry as a consequence of the switchover to word processing technology and many commentators fear that this is only the beginning of a major period of technological labour displacement.

In the information technology industry there is a pattern of skill shortage at the higher levels-software engineers,semiconductor circuit designers,etc.In many cases this is critical and may represent a rate limiting factor on the rapid growth of IT and its applications.However,such job creation is in fact relatively small compared to the losses in traditional sectors-and there is a major skills mismatch between those displaced and the requirements of new jobs created.

On the qualitative side there is a growing body of research evidence to suggest that whilst IT might have implications for the erosion of skills and increasing the division of labour,there are also opportunities for a much more flexible approach to work organisation design and the use of skills.Whether management actually make use of this choice or not in their systems design is,of course,another matter-but work in Germany,for example,showed not only that there were five alternative modes of using CNC technology and organizing work around it,but that each could be economically justified under certain conditions.In other words,it is more a case of trying to get the most appropriate fit between technology and organisation than the case that there is only one "best" way.

In terms of the arguments about polarisation of skills,a recent (1983) report by NEDO in the UK covering IT applications of various kinds ranging from CAD/CAM,text and data processing,remote sensing,teleconferencing and database systems concluded that;"....despite the wide range of systems involved,the broad effects on jobs were very similar.On balance, a higher level of discretionary skills was required after introduction,greater job satisfaction was recorded and a few new routine jobs were created......the majority of new jobs created were concerned either with systems development or information management.....there were comparatively few cases where career patterns had been altered significantly.....the two types of job universally affected were managerial and clerical..."

VI. GOVERNMENT ACTIVITIES

The influence of government has been felt in two main directions with regard to IT-promotion and control.In the first case we have seen an acceleration in the pace and extent of public spending in support of IT development and application;current European spending is around $12bn ,for example,and this is more than matched by Japanese and US initiatives-and all the expenditure to date is dwarfed by the prospective Fifth Generation projects (see next section).

Of interest is the growing industrial participation in many of these initiatives;this is essentially following the pattern which has always characterised Japanese development work.It reflects the rising costs of R and D which mean that very few firms can afford to undertake it alone.As with the early development of the semiconductor industry,much of the government funding is defence-related,either via direct support or procurement policy or by various forms of tax concession.

Beyond this pattern,however,it is possible to discern a strong strategic policy line which sees development and use of IT as an essential element in remaining competitive in international markets.Such a concern for staying in the race has led to development of policies aimed at what can best be described as a national IT capability.Although it varies from country to country,the basic components usually include the following elements:

-education policy,aimed both at general awareness raising and at developing computer literacy.Mechanisms include public seminars and events like IT'82 in the UK,provision of computers in the classroom,access by the public to database,viewdata and other applications of IT.

-support for domestic production of VLSI-most European countries have at least one chip-maker,even though the market is dominated by the USA and Japan;their survival often depends on government support.

-support for major IT applications producers-eg computers and telecommunications via procurement policy,direct funding,R and D support,etc

-support for industrial applications through education programmes,consultancy funding and tax and direct financial support for projects,

On the <u>control</u> side the big issue has been the de-regulation of telecommunications.In the USA this has meant the break-up of ATT,in the UK it is likely to involve the privatisation of British Telecom and the opening up of the market to competitors,and even in Japan there are moves afoot to denationalise the major telecommunications firm Nippon TT which has been the monopoly supplier of exchanges The intention of such moves is to stimulate more competition and promote better service,although the policy has fierce critics in all countries affected who argue that the result will be a decline in services,incompatibility of systems and a general weakening of the industry.

Concern has also been expressed about high technology exports and a number of national level moves have been made to counter this.Subsequently the legislation in various countries has been backed up by international co-operation to ensure its enforcement-although again,there are critics of these policies,seeing them as a restriction of trade.

Despite calls for greater protection especially during the recession there has been no escalation of tariff barriers-although with the likely future picture being one of increasing competition, this may change.

Attempts have also been made to tighten the laws regarding copyright and other forms of protection of software and hardware designs;in particular the IBM/Hitachi case showed clearly the extent to which industrial espionage is now a threat .However,there are considerable difficulties in providing a legal framework to cope with issues like property rights on programmes and control of software piracy and much more work is needed.

VII. THE FUTURE

There is little doubt that whatever shape developments within individual; industrial sectors take they will be embraced by the provisions of the Fifth Generation computer projects now being undertaken in Japan,Europe and the USA.It is important to appreciate that these are not just about building a "super computer" but about developing the major constituent elements of information technology-VLSI,artificial intelligence software,advanced peripherals,etc.Possession of this technology will be essential to any exploitation of what is predicted to be a market fcr IT of around $300bn worldwide by 1990.

Table (25) illustrates the character of a typical fifth generation system and indicates its relationship to earlier generations.

Table (25) Characteristics of successive computer generations

Generation	Hardware	Software	Storage (kbytes)	Speed (instructions/ second)
1st (1946-56)	Valves etc	Machine code	2K	2k
2nd (1956-63)	Trnasistors Magnetic store	High level eg Fortran,Cobol	32k	200k
3rd (1963-81)	Family of machines Integrated software	Advanced applications languages eg Pascal,Lisp.	2Mb	5m

	Semiconductor circuits	Timesharing		
4th (1982-89)	VLSI Optical discs	ADA Expert systems	8Mb	30m
5th (1990-)	Parallel architecture 30 ics or less Gallium Arsenide chips	Concurrent languages Reasoning programs Symbolic processing	10	10

In Europe,Japan and the USA similar types of project are being carried out;table (26) gives an outline of some of them.

Table (26) Fifth generation projects

Country	Project	Funds and timescale
Japan	VLSI-joint development by MITI and major semiconductor firms.	1976-1980 £160m
	Basic technologies for next generation (including bio-electronics)	£450m over 10 years
	Optoelectronics scheme Mobile robots Picture processing	? £40m
	National Superspeed Computer Project,principal aim to make a computer 1000 times faster than the 1981 fastest (Cray1)	£133m over 8 years
	Fifth Generation project,based at Institute of New Generation Computer Technology,backed by MITI and all major electronics firms	£600-900m over 10 years (£1.5 1982 £10m 1983 £20m 1984)
USA	Microelectronics and Computer Technology Corporation.Venture by 13 major IT firms (not IBM or ATT).Based at Austin,Texas,255	£50m per year starting 1984

staff laboratory.Projects include:

-artificial intelligence	£10m p.a.
-CAD/CAM for VLSI	£7m "
-software development	£5m "
-chip packaging	£5m "

Semiconductor Research Corporation Venture of 23 major IT firms (not ATT) Contracts placed with 30 universities Targets: 1987 1mbit RAM 1990 4m bit 1996 16m bit	£20m in 1984
Department of Defence Advanced Project on Strategic Computing and Survivability Aim to develop high performance software for multiprocessor applications. Further application before Congress for artificial intelligence project.	£750m over 10 years £650m

Europe	ESPRIT-European Strategic Programme of Research on Information Technology Funded jointly by EEC and 12 major firms. Five main activities: -VLSI -software engineering -man/machine interface -intelligent knowledge based systems	£1000m over 5 years with an initial £15m for pilot projects,main projects start 1984

The pattern is very clear;the rising costs of R and D and investment in manufacturing facilities in these areas means that individual firms-even the largest-will have to pool their resources and share technology.The scale of investment and the strategic importance of IT also means extensive government involvement-with the result that there are now clear national/continental concentrations in the field of IT.Some commentators argue that this lays the foundation for a growing international trade war in IT-of which the fierce battle between the US and Japan on semiconductor products is just one of the early shots.

VIII. SUMMARY AND CONCLUSIONS

It is impossible in such a brief review to give more than an outline of the important trends within information technology. Nevertheless, the pattern described illustrates clearly the general trajectory likely to be followed in the future-and this is exemplified in the issues raised by the fifth generation projects described above. In essence the key elements of this pattern are:

-rapidly growing markets in all IT related fields, with growth rates often over 20% per annum. In particular, major development of the Asian market and in newly-industrialising countries.

-rapidly expanding competition for a share of these markets, with comparative advantge lying strongly with a small number of firms within Japan, the USA and Europe. This advantage is based upon product and process technology and on marketing strength and experience and there are major entry barriers to any other country wishing to enter the field.

-increasing costs for both R and D and production plant, the scale of which is forcing even major actors to enter into joint ventures or to seek government participation in order to share the costs.

-increasing convergence between IT industries, with computers, telecommunicatons, microelectronics, optoelectronics and other related new technologies fusing together into an integrated technology.

-increasing concentration of actors within the IT industry, partly as a result of the above technological convergence. Thus a few major firms, highly integrated in both vertical and horizontal ways are coming to dominate the IT industry-perhaps as few as 40 firms worldwide.

-increasing involvement of governments in major " strategic " IT projects-such as the fifth generation development-with the growing possibility of some form of international trade war between the three major actors, Japan, Europe and the USA.

Although as yet there is relatively little protectionism or restrictions on the export of technical intelligence or advanced equipment, the first moves towards this state of affairs are being made-for example, the US ban on high technology exports. It may well be that this pattern becomes more dominant in the next ten years as competition increases for what will very shortly be the largest industry in the world.