Information Technology Industry and Skill Demand - the European Community’s Policy in Education and Training

* Errata *

P. 7 (1st paragraph) Académie Française should read Académie Française

P. 76 (note 95) Mathématique Appliquées à la Planification should read Mathématique Appliquées à la Planification

P. 76 (note 95) Institut für Wirtschafts should read Institut für Wirtschafts

P. 86 (3rd paragraph) With the exception of ISCOL, and to some extent the Council for Educational Technology and the IT 86 Committee, should read With the exception of ISCOL, Kairamo and the IT 86 Committee and to some extent the Council for Educational Technology

P. 93 (9th line from the end) The Commission and the Council have already agreed should read The Commission and the Council "have already agreed"

P. 116 (note 50) Association pour la Recherche Avancée en Microélectronique et Intégration de Systèmes should read Association pour La Recherche Avancée en Microélectronique et Intégration de Systèmes

P. 127 (3rd Paragraph) delete "e" should read Respondents were

P. 149 (3rd paragraph 3rd line) ; 2 organisations should read 2 organisations

P. 153 (last paragraph) Training UK participants were particularly positive on their view of existing national; should read Training, UK participants were particularly positive in their view of existing national schemes.

P.176 (4th paragraph) Académie Française should read Académie Française.
Information Technology Industry and Skill Demand – the European Community’s Policy in Education and Training

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A thesis submitted for the degree of Master of Philosophy

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Abstract

Information Technology (IT) has become a significant industrial sector for the European Community. To remain competitive, Europe’s IT industry needs manpower with the necessary IT skills. For some time, concern has been expressed over manpower shortages.

Since the latter half of the 1980s, the European Community has been supporting IT training, principally via COMETT (Community Action Programme in Education and Training for Technology) and the ESPRIT (European Strategic Programme for Research and Development in Information Technology) VLSI Design Training Action.

The present study aims to provide an overview of skills availability in the European IT industry, and to assess the effectiveness of the European Community’s efforts to provide a greater supply of IT manpower. The study builds on and adds to research already conducted in this field. It is based on literature research in published sources, and on a dedicated survey carried out in five EC Member States in 1992. The survey covered 230 IT firms, of which 68 completed the questionnaire.

On the basis, in particular, of the survey findings, it is concluded that a shortage of IT manpower, of critical importance in providing competitive advantage, exists and is expected to continue, if not grow worse, in the short term.

While EC IT education and training programmes (COMETT and ESPRIT) have led to an improvement in the availability and quality of IT manpower, more effort is required at European level. Future efforts need to concentrate on SMEs and on the computer services sector.
Abbreviations used in the text

CEC: Commission of the European Communities; also referred to in text as European Commission or simply Commission.

COMETT: Community Action Programme in Education and Training for Technology.

COREPER: Committee of Permanent Representatives (assists Council of Ministers)


CREATE: Centre for Research in Employment and Technology in Europe (UK).

CREST: Scientific and Technical Research Committee (Comité de la Recherche Scientifique et Technique).

DELTA: Developing European Learning through Technological Advance.

DG: Directorate General (of the European Commission); equivalent to Government Department

DG XII: Directorate General for Science, Research and Development.


EC: European Community.
ECU: European Currency Unit.

KECU: Thousands of European Currency Units;

MECU: Millions of European Currency Units.

EFTA: European Free Trade Association.

ESPRIT: European Strategic Programme for Research and Development in Information Technology. ESPRIT VLSI is the Very Large Scale Integrated Design Training Action.

EUROSTAT: Statistical Office of the European Communities.

FAST: Forecasting and Assessment in the field of Science and Technology.

GDP: Gross Domestic Product.

GMD: German National Research Centre for Computer Science

HMSO: Her Majesty's Stationery Office.

IFO: Institut fur Wirtschaftsforschung (D).

IMS: Institute of Manpower Studies (UK).

IPRs: Intellectual Property Rights.

IRDAC: EC Advisory Committee on Research and Industrial Development.

IT: Information Technology.

IT R & D: Information Technology Research and Development.

ITSA: Information Technology Skills Agency (UK).

MERIT: Maastricht Economic Research Institute on Innovation and Technology (NL).

MSC: Manpower Services Commission (UK).
PSI: Policy Studies Institute (UK).

R & T D: Research and Technological Development

SEFI: European Society for Engineering Education.

TFHRETY: Task Force for Human Resources Education, Training and Youth.


Note In general, the text reproduces terms used in Commission documents, in accordance with accepted EC usage. One example is the use of the term "enterprise" for what would in normal English usage be referred to as a company or economic operator.
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I would like to thank all the individuals and companies whose cooperation made this study possible.

Special thanks go to John, my husband, for his dedicated patience over the years and his assistance in the evaluation of the questionnaire returns.

Particular thanks go to my supervisor, Karl Koch MA, who was a never failing source of encouragement and support throughout, and to Niall Leonard who skilfully and patiently proof-read the final text.

Last but not least special thanks go to my children, Daniel and Kilian for understanding why I was not always available to play with them.
CHAPTER I: INTRODUCTION

The development and efficient application of Information Technology (IT) is essential for a successful economy. Technological and industrial developments are rapid, and new generations of computers appear every 3 to 4 years. IT is one of the largest industrial sectors worldwide (about 4.5% of world-wide GDP); its importance for the European Community is due not only to its size, but also to its role as a catalyst in other areas. The impact it has on employment is considerable; an estimated 60 to 65% of the working population is directly or indirectly dependent on these technologies and their applications.

Technological development requires a skilled workforce, capable of mastering the complexity and opportunities of IT and its applications. Since the early 1980s, concern has been voiced over widespread shortages of such manpower in Europe. The Information Technology industry requires professional IT manpower to carry out research, and to transform the results into profit-generating products and services. Shortages of such manpower affect the output and delivery of products, preventing industry from competing efficiently.

In response to the perceived manpower shortage, the European Community launched a large scale training programme (COMETT) in 1986, and on a lesser scale but equally important, the ESPRIT VLSI Design Training Action in 1989.
The overall objective of this study is to assess the effectiveness of these programmes in meeting the skill requirements of Europe's Information Technology industries.

This study aims to provide an exhaustive evaluation and assessment of published sources, principally primary EC sources. The theoretical element has deliberately been kept to a minimum, given the practical intention of the study; it aims to contribute to and consolidate work already done by others. The field examined is a vast one, and it is not suggested that this text asks all possible questions, let alone provides all possible answers. It is a small contribution to the body of research in this area but, it is hoped, a useful one.

The specific objectives of the study are:

- to report on Europe's Information Technology industry, tracing the historical development of IT, and analysing the significance of IT for Europe, and the state of its IT industry;

- to determine, firstly on the basis of research in published sources, the form and content of IT skill demand and skill shortage;

- to examine the importance of education and training for industry, and EC policy in Education and Training for IT;

- to assess the effectiveness of EC policy in meeting the skill requirements of industry; this assessment is based on the results of a survey, carried out by questionnaire, of IT industries in five EC Member States;

- to derive, from the above, conclusions on the shortage situation, and outline suggestions for possible improvements, within the framework of EC programmes.
Published sources used fall into three categories: primary EC sources (publications by the EC Commission or its specialised offices); published academic studies, largely of the last ten years; and thirdly, articles, bulletins and reports of conferences.

The main original contribution of this study is the survey of IT companies participating in the EC COMETT and ESPRIT programmes. The questionnaire used was designed following the examination of questionnaires used in previous IT surveys. The methodology and design of the questionnaire is explained at length in chapter VIII. The level of replies from COMETT participants was surprisingly low. Of those who replied, however, the general tone broadly resembled that of replies to the two evaluations of COMETT carried out in 1989 and in 1991.

Chapter II examines the meaning of "Information Technology" and introduces the definition used in this study. This definition embraces the IT sectors covered by the COMETT and ESPRIT programmes: Microelectronics, Information Processing Systems (including Software), Office and Business Systems, Computer Integrated Manufacturing and Basic Research sectors.

Chapter III traces the history of Information Technology, sketching the principal technological developments. These technological developments are analysed in terms of size, cost, and speed; the analysis shows how, as computers became smaller, cheaper and more powerful, demand for them increased enormously. This demand has been particularly significant in the office and manufacturing environments, resulting in greater efficiency in the former, and in increased productivity, lower cost, and higher quality products in the latter.

Chapter IV explains the significance of the IT industry for Europe, underlining its growth potential, size and pervasiveness, as well as the benefits accruing to organisations from the introduction of IT systems.
The ESPRIT programme is then described. The poor state of Europe's IT industry in the early 1980s led to the launching by the European Commission in 1984 of a European collaborative research programme (ESPRIT), the overall objective of which is to improve the competitiveness of the European IT industry; this is achieved by pooling R & D efforts on a European scale. ESPRIT has been successful in nurturing Europe's Information Technology Research and Development base, and has helped increase human resources, given that R & D funding is channelled to the employment of more people. More significantly, in qualitative terms, it has raised skill and knowledge levels. Nevertheless, a shortage of IT skills persists. This shortage threatens the competitiveness of Europe's IT industry.

Chapter V examines the shortage issue in depth. Different approaches to the meaning of a skill shortage are explored; the employer-based approach, which determines shortages in terms of recruitment difficulties faced by individual firms, is the method most widely used. Several interrelated factors (e.g. supply not meeting demand, skill mismatch) can contribute to the skill shortage level; these, in turn, are affected by demographic trends. As Europe's population ages, with a projected annual reduction of 1.7% in the active labour force (aged 20-30) over the period 1965-2020, the outlook must cause concern.

The extent of IT shortages at a national and European level is examined. At a national level, reports and studies point to the existence of IT shortages. Studies and reports at a European level, however, have found it particularly difficult to obtain reliable, comparable Member State data on the demand for and supply of IT manpower.

Chapter VI discusses the importance of education and training, and traces the development of its relationship to industrial success. The forms of education and training required by Europe's IT industry are briefly analysed, on the basis of available sources.
Chapter VII examines the role played by the EC in education and training for technology, and describes and evaluates the two principal EC programmes (COMETT and the ESPRIT VLSI Design Training Action). The principal objective of COMETT is to stimulate and strengthen cooperation between higher education and industry in order to advance training in new technology and to respond to the needs of industry for qualified manpower. The VLSI Design Training Action was launched in response to the increasing need for engineers capable of designing very large scale integrated microelectronic circuits.

Chapter VIII describes the methodology of an empirical survey conducted by questionnaire in spring 1992, intended to obtain more information on the skill shortage position and to assess the effectiveness of the COMETT and ESPRIT (VLSI) programmes in educating and training IT manpower. The questionnaire was established following the examination of questionnaires used previously in similar or related surveys. These questionnaires are analysed, and the design of the questionnaire used is explained. The survey sample comprised 230 IT companies in five EC Member States: France (F), Germany (D), Greece (EL), Spain (E) and the United Kingdom (UK). As the survey sought to achieve an EC-wide overview, its recommendations deal with EC action, rather than with specific national contributions to a common effort.

Chapter IX evaluates the results of the survey, notably the importance of IT staff in providing a competitive advantage for organisations; skill shortages and expected demand; the effectiveness of COMETT and ESPRIT; and the European Community’s role in improving the availability and quality of IT staff.

On the basis of the survey results, together with evidence from published sources, Chapter X seeks to judge the effectiveness of COMETT and ESPRIT in meeting the skill requirements of Europe’s IT industries. In conclusion, a number of suggestions for future action are presented.
NOTES


3. Professional IT manpower are people in jobs at graduate level or equivalent whose main activity is associated with the development or application of IT.


5. The survey did not cover the former GDR.
The term "Information Technology" is a relatively recent addition to the English language. It has its counterparts in the French "informatique" and the Russian "informatika". The Russian term seems to have first been used in 1966, while in April 1967 the Academie Francaise defined "informatique" as: "the science of the rational handling of information, particularly through computers and particularly in support of knowledge and communications in the technical, economic and social fields".

Definitions of information vary; dictionaries disagree. For the Oxford English Dictionary, information is "that of which one is apprised or told, knowledge, news". It is also "intelligence given", while the definition of intelligence is "information communicated". Other definitions emphasise the knowledge transfer aspect of information, referring to it as "the communication of instructive knowledge", or "the knowledge conveyed to the mind by a statement of fact". Barron and Curnow relate information to energy, stressing that information is a basic resource essential to the operation of an economy. They believe that the provision of a cost-effective information system is just as important as the provision of a cost-effective energy system.

To Large, information is wealth; he supports this view by the example of the management of sewers and water mains in the West of England. In the late 1970s, the Wessex Water
Authority introduced computer controls, via a computer network covering five counties. The computer not only measures and controls the flows along the pipes and at source in rivers and reservoirs, but contains a databank on the regional water supply and sewage system, with four thousand maps, indicating every pipe and hydrant. The introduction of this system has brought savings in electricity consumption, water wastage, staffing costs (by the reduction in emergency overtime), and capital expenditure.

For Stonier, "a country's store of information is its principal asset, its greatest potential source of wealth". Stonier explains how any object or material can be made more valuable by adding information; "waste desert land plus information becomes productive crop land. Idle capital plus information becomes revenue-yielding investment".

Jones and Dowsland examine the current and future role of electronic information services in Europe. They identify the growing importance of information; "information provision in its many forms has for the past 25 years become of increasing importance to all, and currently in excess of 40% of the UK workforce are directly or indirectly involved in information related activities. The corresponding figures for other European countries are just slightly lower".

Technology has been described as man's toolbox. Once, technology was wood, stone and animal skin. Today, technology includes not only hardware made from tangible materials, but also analytical techniques, mathematics, computer programs and even thought processes.

Information Technology could usefully be defined as man's use of tools to acquire knowledge. This is perhaps too vague a definition, considering the scope and significance of IT; a more detailed definition is justified. An IT literature search and assessment of over thirty publications (Appendices I-IV) reveals a number of definitions; while
many are similar, there is no agreed definition of Information Technology. Definitions vary, depending on subject matter, and may be grouped as follows; 1) technical (machine oriented); 2) technical / sector-linked (Appendix I); 3) industrial definitions (Appendix II); 4) product-linked definitions (Appendix III); 5) broader definitions which consider social and economic factors (Appendix IV).

1) Technical definitions are machine oriented and refer to the capabilities of machines (computers) i.e. data collection, data input, information storage and information processing. King has taken a technical definition in For Better for Worse, the Benefits and Risks of IT: "Information Technology describes the whole range of processes for the acquisition, storage, transmission, retrieval and processing of information".9

2) Technical/sector-linked definitions extend beyond the technical definition to include certain IT sectors; for example, "IT covers the electronic processing of information as well as office and factory automation (robotics), process control and telecommunications".10

3) Industrial definitions focus on IT industries; Friebe and Gerybadze use this type of definition in their review of Microelectronics in Western Europe: "Information Technology comprises the following fields of industrial activity: microelectronics, semiconductors, components; application of microelectronics in industrial products, processes, subsystems and systems; telecommunications, data processing, computer technology; artificial intelligence".11

4) Product-linked definitions involve everything from "a video tape to a direct broadcasting satellite, from a pocket electronic calculator to a missile guidance system; from a tiny silicon chip to a mainframe or supercomputer, from a digital watch to a robot, from software to a CAD/CAM system".12
5) Some definitions go beyond the technical/industrial layers and consider social and economic matters: "the scientific, technological and engineering disciplines and the management techniques used in information handling and processing, their applications; computers and their interaction with men and machines, and associated social, economic and cultural matters". This is UNESCO's definition.

Some authors presume that the reader already understands what is meant by Information Technology, and hence give no definition. Appendix V provides examples of reports and studies on Information Technology where no definitions have been provided.

Which Definition?

This study is concerned with EC efforts in Education and Training for Information Technology. The principal Community IT programme is ESPRIT - European Strategic Programme for Research and Development in Information Technology. The main advanced technology education and training programme is COMETT. COMETT and ESPRIT fund projects in key technology sectors. Given the subject examined here, ESPRIT or COMETT's definition might seem to be the obvious choice. Research on a selection of published documentation on both programmes (Appendix VI for ESPRIT and Appendix VII for COMETT) revealed a sectoral definition for both.

For the purpose of this study, a technical/sectoral definition has been chosen, covering the use of Information Technology in those IT sectors funded under ESPRIT and COMETT. This definition is: "the use of modern technology for the acquisition, storage, transmission, retrieval and processing of information, covering the sectors of Microelectronics, Information Processing Systems, Software, Office and Business Systems, Computer Integrated Manufacturing and Basic Research".
NOTES


4. Large, op.cit., pp. 41-42.

5. Stonier sees the three major ways by which a society increases its wealth significantly: 1) the slow and steady accumulation of capital; 2) military conquest or other territorial expansion; 3) new technology which converts 'non-resources' into 'resources'. Stonier, T., *The Wealth of Information. a Profile of the Post-Industrial Economy*, Butler & Tanner, Frome & London, 1983, p. 12.


8. Ibid. p. 4.


14. The sectors funded in the ESPRIT programme are: advanced microelectronics, information processing systems (software), office & business systems, computer integrated manufacturing and basic research. The IT sectors funded under COMETT were the same as under ESPRIT in the period 1986-1988; for the period 1989-1992 the IT sectors were modified to include telecommunications and data communications.
CHAPTER III: ORIGINS, DEVELOPMENT AND IMPACT OF INFORMATION TECHNOLOGY.

1. Origins and development

The Industrial Revolution established the rule of the machine. Many see today's Information Technology Revolution as the successor of the Industrial Revolution, the significant difference being that while the latter replaced and amplified man's physical labour, the IT Revolution is replacing and amplifying mental labour.

This chapter briefly examines the history of IT. While the origins of the computer (the backbone of the IT revolution) can be traced to the sand table and abacus of ancient times, it was in the 17th century, when more and more people began making their living by compiling and manipulating numbers, that the need for a machine capable of performing arithmetical tasks was felt, and mathematicians and scientists addressed the problem.

The first machine capable of performing arithmetical functions was developed by the French philosopher and mathematician Blaise Pascal in 1646. The Pascaline, as it was known, consisted of a set of interlocking cogs and wheels and had an input device, a set of calculating mechanisms and an output device. The user dialled the
numbers to be computed, the action of dialling caused the gears to move, and the answer appeared at a window. Though a primitive form of computer, the Pascaline lacked three important features: it had no memory, no decision-making unit, and was not programmable.

Thirty years later, Gottfried Wilhelm von Leibniz invented the Leibniz Wheel. The latter could not only add and subtract fully automatically, but also multiply and divide. The operation of multiplication was performed automatically by repeated additions. Leibniz's machine was the first prototype of the modern desk top calculator. The device was viewed with the greatest interest both by the Academie des Sciences in Paris, and by the Royal Society in London, to which Leibniz was elected a Fellow in 1673. Leibniz made a copy of his machine at the request of Peter the Great of Russia, to send to the Emperor of China.

In 1822 Charles Babbage, "father of computing", invented his Difference Engine; "it was pondering the time-wasting and desperately routine nature of logarithm calculations which led him to conceive that a machine ought to be able to do it far more easily and far more accurately". The Difference Engine was capable of solving polynomial equations by calculating successive differences between numbers. Although the Difference Engine was more advanced than its forerunners, it was still basically a calculator rather than a computer.

In 1833 Babbage designed his Analytical Engine. This device had the five essential characteristics of a computer (a set of input devices, an arithmetical unit, a control unit, a store or memory and an output mechanism). While the prototype Difference Engine was hand-powered, Babbage planned to use steam power for the Analytical Engine. For a number of reasons, including the lack of government financial support, the Analytical Engine was never built. Babbage devoted the rest of his life to designing a universal digital calculator. This, too, was never built,
for though his plans were correct in theory (his notes show that his engine contained in mechanical terms all the elements of today's electronic computers), they were decades, if not a century ahead of the technology required to put the theory into practice.

Shortly after Babbage's death, a new form of motive power - electricity - was developed. A machine powered by electricity, and similar to Babbage's Difference Engine, was built by George Barnard Grant, an American engineer, and exhibited in 1876. Its size, however, made it unsuitable for office use. Grant later built smaller, more practical machines, which could be used for office purposes. They still suffered from two drawbacks: numbers to be calculated had to be entered, a time consuming task, and the act of multiplication was performed laboriously.

In the late 19th century, the legal requirement to hold a census every ten years placed an enormous burden on the US Census Bureau. The problem was amplified by continuing immigration. The way in which the information was handled left much room for error and the results were often out of date before publication. In 1887 the Bureau held a competition to find an improved method of recording and counting. The successful candidate was Herman Hollerith, who developed a method of storing information using holes punched in cards; electrical power was then used to drive the tabulating machines. Hollerith's system was selected for the 1890 census, which was completed in time. In addition to performing calculations which would otherwise have been impossible in so short a time, the tabulating machines provided a much more complete presentation of the statistics of population than was made at any preceding census. To handle the increasing demand for his system (the railways were among his first big customers), Hollerith established the Tabulating Machine Company in Washington DC. In 1911 it became part of a new conglomerate, the Computing Tabulating and Recording Company. By Hollerith's death in 1929, the company had become the International Business
The computing devices described above were digital devices; analogue devices were capable of much more. The first useful analogue computer, built in the 1870s by the British physicist Lord Kelvin, was successfully used to predict the tides around Britain. Kelvin believed that it would be possible to build a machine capable of solving general problems associated with the solution of differential equations.

Kelvin's proposed "Differential Analyser" was similar to Babbage's Analytical Engine, but did not become a reality for fifty years. Vannevar Bush, a professor at the Massachusetts Institute of Technology (MIT), produced a prototype in 1930. While the main components were little different from those used in Pascal's first calculator, Bush replaced some mechanical components with thermionic tubes or valves in which values would be stored as voltages, making him the first to introduce electronic components into a computing system.

In 1937 George Stibitz, of the Bell Telephone Corporation investigated the use of telephone relays to perform arithmetic operations. With a number of relays, flashlight batteries and bulbs, he built a one digit binary adder. He then drew up a circuit for the "carry" digit, coupled the system up to two small light bulbs to act as "output", and thus invented the elementary unit of an electric calculator.

In 1936, the British mathematician Alan Turing produced a computational model, setting out the nature and theoretical limitations of logic machines. His paper described in theory a machine which could perform any calculation that could be done by a human being, or by another computing machine. According to Bolter, Turing's 1936 work was a "forbidden forest of symbols and theorems, accessible only to specialists". Because of his later involvement with computer design and construction, Dr. Turing is today considered a major figure in the history of computing.
The Second World War brought a new era for computing. The development of computers was pursued independently in Germany, the UK and the US. In Germany, Konrad Zuse sought to design a universal computer. His first machine, the Z1, had a binary method of operation, a memory, a central processor, a keyboard to input numbers, and a system of electric bulbs to signal the results of the calculation in binary form. In a later, more advanced machine, electro-magnetic relays replaced the mechanical switches which had constituted the Z1’s memory. This was the first application of such relays in any computer system. Zuse also replaced the keyboard input with a system using punched paper tape. Zuse’s machines were used in aircraft and in missile design.

The UK developed Colossus, a fixed program special purpose electronic digital computer, designed to break codes. This machine, put into operation in 1943, was the world’s first electronic digital computer, and its performance in terms of speed and computation was in advance of any mechanical or electro-mechanical device. Huskey believes, however, that the secrecy which surrounded Colossus meant that it had no direct effect on the development of computing machines other than through the experience gained by those who worked on the project.

In the US, Howard H. Aiken, an Associate Professor of Mathematics at Harvard, constructed a modern version of Babbage’s Analytical Engine, known as the Harvard Mark 1. Used during the war to solve naval problems, it was extremely large, slow and noisy.

Both the Colossus and the Harvard Mark 1 were to a large extent machines of war. After the war, however, computing machines continued to receive government funding. The most important and successful was ENIAC (Electronic Numerical Integrator and Calculator), built at the Moore School of Engineering in Pennsylvania by Dr J. Mauchly. The Moore School project began as a top secret military effort. Its goal was to develop an extremely rapid machine capable of
the thousands of computations necessary to compile ballistic
tables for new guns and missiles. ENIAC, an electronic
digital computer, was the result; when demonstrated in 1946,
and set to multiply the number 97,367 by itself five
thousand times, the machine completed the task in less than
half a second.

ENIAC had certain limitations. It had a very small memory,
and could only with difficulty be switched from one kind of
task to another. It also weighed 30 tons, filled the space
of a small gymnasium and contained 18,000 vacuum tubes,
which failed on average at the rate of one every seven
minutes.

The power of a computer can be assessed not only in terms of
capacity and speed, but also by the number of tasks it can
perform. Colossus was powerful in speed and capacity, but
weak in terms of flexibility; its usefulness was limited to
code-breaking. ENIAC was more powerful on all three counts,
although it had difficulty in changing programs.

John Von Neumann, a mathematician who assisted Mauchly,
introduced the idea of storing programs within the computer.
The stored program enabled computers to become dynamic
flexible information processing systems, capable of
performing numerous different tasks. EDVAC, the next Moore
School model, incorporated a stored program. In the UK, a
stored program was included in the Mark I, developed at
Manchester University, and claimed to be the first
commercially available computer. A government contract was
given to Ferranti in 1948 to make a production version.
With the development of the stored program, progress
accelerated. In the USA, IBM, Bell Telephone and Sperry
Rand designed computers for the marketplace. Costs remained
high, and while computers were useful and powerful, they
were still excessively large, expensive and difficult to
maintain.

Computing was transformed by the invention of the transistor
at Bell Telephone Laboratories in 1947 by Bardeen,
Brattain and Shockley. The transistor had no cogs or wheels, no separate pieces to be soldered together, was durable, consumed little power, could be made very small and produced cheaply in large quantities. It thus represented a major advance. IBM marketed a commercial computer in 1955 which replaced 1,250 hot valves with 2,200 transistors. Size decreased, the need for cooling was removed, and power consumption dropped by 95%. Computer memories became larger, moving from the hundred or so bits (binary digit) of store in the earliest devices to hundreds of thousands, and eventually to billions of words in store. Computers could now be used to store information.

In 1958 the integrated circuit was invented. Many transistors could now be incorporated into a single silicon chip. Integrated circuits were compact and cheap and led to a further reduction in the size of computers.

Between 1950 and 1970, the scope and power of computers increased dramatically. Evans sees three reasons for this technological progress: the arms and space races between the US and the Soviet Union, and the general increase in economic activity and industrial growth. By the mid 1960s, all large commercial organisations used computers.

Although integrated circuits were compact and cheap, their tasks were limited, and they had to be soldered into a rigid pattern on a printed circuit board; the Central Processing Units (CPUs) of large computers contained hundreds or thousands of integrated circuits. Subsequently, integrated circuits were combined to form the microprocessor, the first of which went on sale as the Intel 4004 in 1971. Advances in chip production enabled more and more complex circuits to be placed on smaller and smaller surfaces. Modern chip technology meant that by the early 1980s hundreds of thousands of circuits could be packed into a chip.

The 1980s brought new developments. Personal computers had a huge impact; the APPLE Corporation founded in 1976, by 1981 was selling personal computers to the value of 300
million dollars a year. The personal computer boom led in turn to the production of portable and home computers. At the other end of the scale are supercomputers, expensive machines designed for speed. These are used for high performance, numerically intensive computation. According to Julia Vowler, "scientists and engineers of all disciplines, both in industry and academia, have become dependent on the power of these machines, which are used to solve problems as disparate as working out how much stress can be put on a mechanical component to designing a new drug".

Other developments in the 1980s included the Japanese fifth-Generation Computer Project, intended to produce the first of a new generation of knowledge information processing systems which would rapidly supercede conventional computers, and the European ESPRIT programme, launched in 1984.

The 1990s have seen further new developments, especially in the production of new and more advanced chips. The Intel 860 microprocessor one of the most complex chips ever made, contains 1 million transistors, while a recent 32 bit Hitachi microprocessor uses a new semiconductor technology called Bicmos. Its potential is enormous; lower power consumption means that chips run at lower temperatures, so that computers built with these chips would not need noisy fans or large cases. Its speed creates the potential for very powerful computers in very small boxes. Thus, each new decade brings further progress towards the ultimate information processing machine.

2. Measuring the development and impact of IT

The development of technology can be measured in terms of size, cost and speed.
Size is very important; very small computers have enormous advantages; they consume minute amounts of power, are cheap, and because they are portable their tasks are numerous. The earliest computers were large and mechanical, and although the arrival of the transistor brought a significant reduction in size, powerful computers were still extremely large. Transistor engineers then designed whole 'logic units'—complete electronic circuits, consisting of between twenty and a hundred connected components on a chip of silicon about a centimetre square. Miniaturisation did not stop here. With the technique known as large-scale integration, followed by very large-scale integration (VLSI) and super-VLSI, first hundreds, then thousands, and even tens of thousands of individual units could be amassed on one slice of semi-conductor. These trends in miniaturisation may be illustrated by the analogy of a street map (figure 1.1).

In the 1950s information about one street could be placed on a chip or board; in the 1960s the street map of a small town could be placed on the same size chip. In the 1970s the street map of a smallish city, and in the mid 1980s that of a very large city could be placed on a chip. By the late 1980s, it was possible to put the street map of the entire North American continent on just one tiny chip. Today, the power of the original Ferranti computer (Mark I) is contained in a pea-sized silicon chip.

With decreasing size, computers became cheaper. In 1956 a transistor cost around three pounds in the UK; this was halved a year later, and today a transistor costs a few pence. The same applies to integrated circuits, which cost around twenty pounds in 1960, but were nearer twenty pence by 1970. Large shows how through the 1970s the basic cost of computing power dropped by 40% a year every year as circuits were packed ever more tightly on the chip. According to Forester, the price of storing a single digital unit of data in a memory chip fell from one-tenth of a cent in 1976 to one-thousandth of a cent in 1986.
**Figure 1.1**

**Trends in Miniaturisation**

1950s Transistors

1960s Integrated circuits (ICs)

1970s Large-scale integration (LSI)

1980s Very large-scale integration (VLSI)

Late 1980s Super-VLSI

Speed can be measured by the time taken to perform a given task; in computing terms, speed is often measured by the number of operations that can be performed per second. Babbage's Analytical Engine might have managed a calculation a second faster than a human. Later, electrically driven machines could perform several calculations a second, while even the earliest true computers such as the Harvard Mark 1 could cope with dozens. With the introduction of electronic valves there was an immediate change: switching speeds increased from dozens to thousands of cycles per second. By 1983 storage chips which held nearly 256,000 bits of basic information (equivalent to around 5,000 English language words) were becoming available. The chip means that microcomputers today are over fifty times faster than the ENIAC machine of 1946, and processing speeds continue to rise.

By making computers smaller, cheaper, and more versatile, the chip has made it economic to bring wider automation to the office, factory and to the home. Demand for computers grew in the 1970s and has continued to rise. Forester\textsuperscript{22} quotes US sales of computers (minis, mainframes and personal) as having increased from $12 billion in 1979 to $28 billion in 1983. O'Brien shows how personal computers grew in a short time to become a substantial industry, from zero in the late 1970s to a 30.6% share of the world market by 1984. (figure 1.2).

Sales of mainframe computers worldwide grew from $40 billion in 1985 to $50 billion in 1989,\textsuperscript{23} while sales of PCs worldwide over the same period doubled from 4 to 8 million units.\textsuperscript{24} As for robots, Europe increased her share of the world robot market (sales) from 30% in 1981 to over 50% in 1991.\textsuperscript{25}

The continuing impact of Information Technology is huge. Two major sectors of interest to this study are the office and factory environments.
Figure 1.2

Shift in World Computer Market
1975-1984
(% of total sales in each product area)

1975
- Mainframes: 86.5%
- Minicomputers, etc.: 13.5%

1980
- Mainframes: 63.8%
- Minicomputers, etc.: 29.8%
- Personal Computers: 6.4%

1984
- Mainframes: 32.5%
- Minicomputers, etc.: 30.6%
- Personal Computers: 36.9%

The office is the primary locus of information-handling. Almost 60% of the European labour force are now white-collar workers, engaged in the processes of gathering, storing, manipulating and transmitting information in one form or another. The "mechanised office" started in the second half of the 19th century, with the introduction of the typewriter and the telegraph. The rise of electronics during and after the Second World War brought about a gradual replacement of mechanical equipment by smaller more versatile electronic equivalents.

Further technological developments led to a decrease in the cost of processing information; as a result the use of information-processing technology increased, and brought about a major transformation in the office, resulting in the emergence of the "electronic office".

The main role of office technology is to support information handling activities. In 1983 the International Data Corporation compiled a table, showing the breakdown of office activities, which retains its validity today. (figure 1.3). These activities include: documentation preparation and presentation, distribution, and storage and retrieval. The preparation of documents in the electronic office is aided by a keyboard linked to a computer and printer; text is created and manipulated on screen and, when completed, is sent for printing. The presentation of documents has been greatly improved since desk top publishing became a reality. A personal computer, special software and a laser printer enable complex documents to be printed rapidly and economically, to a quality previously only achieved by a trained typographer.
Figure 1.3

Office Activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Managers etc.</th>
<th>Others</th>
<th>All office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Writing</td>
<td>26</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>Taking dictation</td>
<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Reading</td>
<td>13</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Proofreading</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Searching</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Filing</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Copying</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Distribution</td>
<td>4</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Operating equipment</td>
<td>4</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>Spoken</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phone</td>
<td>5</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Meetings</td>
<td>18</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculating</td>
<td>6</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Scheduling</td>
<td>3</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Instructing</td>
<td>4</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Travel</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>


Established electronic methods for the distribution of documents are telex and facsimile systems. Computer-based document transmission methods enable people to transmit and receive messages and reports via a network of interconnected
computer terminals. In addition to document transmission, computer-based message networks offer the possibility of computer conferencing. In a computer conference, a discussion takes place between participants in separate locations.

In most offices, documents are stored in filing cabinets, or in the case of personal computers on floppy discs. In 1980 it was estimated that the equivalent of 20 billion pages of A4 paper was stored in offices in the USA. In 1989 Cane observed that there were some 318 billion paper documents on file in the USA, and that each executive had an average of five filing cabinets. The storage of great quantities of documents is a headache for office managers, particularly when space costs money. A technological solution available since the early 1980s has provided a cost effective way to clear the paper jam. Document Image Processing (DIP) comprises scanners, high resolution workstations, and computer networks, together with microfilm and optical disks to archive the information. European organisations which have adopted DIP include British Airways, Western Provident Insurance company, DHL international courier service, and the police force of Liege in Belgium. The latter found that installing a microfilm-based system allowed them to reduce storage requirements by almost 98%. DIP not only guarantees substantial savings in space, it also reduces the time spent searching for files and reduces costs on stationery and photocopying. As a result productivity and speed of response are increased.

Meetings have been greatly facilitated by video conferencing. Participants in a videoconference can hear and see each other, and can display documents, technical drawings, computer graphics or products. The main benefit is to make face-to-face meetings possible while avoiding the high costs, inconvenience, stress and wasted time involved in travel. Finally, Information Technology has revolutionised office management, by a wide range of effective computer aids. These range from personal
computer-based financial planning (spreadsheet) and cash management packages to large-scale decision support systems. Spreadsheet programs permit the manager to set up mathematical models of various aspects of the organisation (e.g. cashflow) and to investigate the effect of particular decisions or strategies. Cash management software brings information on budgets and bank balances. Decision support systems extend computerised assistance to the strategic planning tasks of senior managers. By interacting with a database of current and past information, it is possible to construct projections and to examine the outcome of hypothetical courses of action.

The same technology that has automated the office has also paved the way for an increase in the number of teleworkers. In May 1991, the UK Department of Employment estimated that there were 750,000 teleworkers, of which 250,000 were full-time. The Henley Centre for Forecasting estimates that by 1995, nearly 50% of the workforce could be teleworking. To work from home, a teleworker requires a home computer (compatible with the office network) or a portable PC. Working from home saves time and money, improves productivity and staff retention, is helpful for disabled people and kind to the environment. Haughton explains how ICL and DEC have estimated the practical costs of one person's office space at around 7,000 pounds a year. DEC saved between 28,000 to 43,000 pounds a year in relocation costs when it decided to introduce teleworking for its sales and marketing section based in Reading (UK). DEC's human resource consultant explained that "with people working a 50-hour week in the office, you basically get 25 hours work. At home for every 45 hours put in you get about 40 hours which are actually productive". The Business Equipment and Information Technology Association (BEITA) in the UK believes commuter traffic jams could be eliminated if companies were able to switch their staff from public to data highways and work from home.
Competition in world markets has increased the demand for higher productivity, higher product quality at lower cost, better customer service and more flexibility in manufacturing. IT applications, affecting as they do all industrial activity, provide the means by which industries can compete. Computers have assumed an increasingly pervasive role in the control of production processes and manufacturing equipment. Integrating design with manufacturing makes it possible to turn out new product designs much faster. It is also possible to program the computers to ensure that the designs provide quality and reliability as well as the lowest possible manufacturing costs. Robots, computer-aided design and manufacture (CAD/CAM) and flexible manufacturing systems have created the conditions for computer integrated manufacturing (CIM), in which computers control fully integrated factories.

The Japan Industrial Robot Association defines a robot as "a machine capable of performing versatile movements resembling those of the upper limbs of a human being or having sensory and recognition capacity and being capable of controlling its own behaviour". Robots are useful in almost all sectors of industry, but their impact is best seen in manufacturing. First generation robots were used for dull and repetitive tasks like spot-welding, paint-spraying, loading and stacking. As a result of improvements in software, second generation machines were able to see and touch, while the third generation have intelligence and massive computing power, enabling them to work out for themselves how to do something. A report by the UK Policy Studies Institute in 1986 on Robots in British Industry identified the main benefits as improved quality, more consistent products, lower labour costs, greater output,
improved work conditions, safety and increased technical expertise. More importantly, robots can replace humans in hazardous and monotonous jobs.

**CAD/CAM** is the integrated use of advanced computer technology in engineering and manufacturing. Computer-Aided Design (CAD) reduces the time required for design and drafting, improves quality and simplifies the revision and alteration of derived designs. A designer or drafts' man can make detailed drawings of machinery, parts or circuits without ever touching a pencil, ruler or compass. A user can check the operation of machinery not yet constructed, and automatically produce drawings from a graphics terminal. With CAD, designers can turn drawings around, enlarge and colour them. CAD systems offer the facilities of three-dimensional or solid modelling, engineering analysis and testing, and simulation and interfacing with machine tools, as well as automated drafting. Thus, manufacturers can design and build life-like models (e.g. of a new car) on the computer screen, and test how they would behave under certain conditions. Once the geometric model has been completely defined, instructions for manufacturing it can be derived from the system's database. CAD and CAM are merged. In the UK, major users include Ford and Austin Rover. CAD was initially used by manufacturing industry and architects' offices, where the high costs involved in motor car manufacture or in building construction could justify the expense of a system which cost thousands of pounds. Today CAD/CAM does not concern large products only, but is used in the electronics industry to design and test microchips. CAD packages like Autosketch and MegaCAD can be bought for a few hundred pounds. These packages enable users to perform tasks varying from keeping track of office equipment, to working out the simplest way of wiring new LAN users.39 CAD/CAM offers intelligent and more scientific design, taking into account a series of factors (i.e. materials, performance, functionality, weight, dimensions, form, energy, cost, and the environment).40 It has many advantages for users. It can increase productivity,
eliminate boring and repetitive tasks, reduce design and manufacturing errors, cut the lead-time from design stage to final product, increase product quality and enable orders to be repeated with little or no delay.

Flexible Manufacturing Systems (FMS) include a variety of production equipment, linked by robots, automatic transfer systems and communication lines. A central computer controls the whole process and keeps a check on the whereabouts of each part. FMS allows automated production processes to be applied to small batches of products, enabling a company to produce goods in small volumes as cheaply and efficiently as if it were using mass production methods. It also provides flexibility of production and better, more consistent product quality.

Computer Integrated Manufacturing (CIM) is based on the principle that the entire manufacturing process from product design to field service is a single activity, made up of a series of data processing functions. CIM allows a company to entirely automate and computerise the manufacturing process. Arthur D. Little in 1983 defined the ideal CIM user as "a company with batch manufacturing operations and a fair amount of custom engineering, carrying many complex products and product variations and introducing new products frequently". A CIM-based manufacturing strategy addresses the question "how can we, as a manufacturer, compete more effectively?". A CIM-based manufacturing strategy addresses the question "how can we, as a manufacturer, compete more effectively?". Design and drafting, monitoring, testing and quality control are just a few of the areas where CIM may be applied. According to Cheek, "CIM can improve significantly the manufacturing process by increasing productivity, reducing cost, producing higher quality products, lowering inventories and improving accounting and purchasing procedures".
3. Summary

The development of the modern computer began in the 17th century. Significant advances in the last fifty years included the development of the transistor and the integrated circuit, these advances have led to the spread of computers to all areas of life. The development of technology can be measured in terms of size, cost and speed, all of which have continually been improved.

In the office, Information Technology has modernised information handling activities, thereby increasing speed and efficiency. In manufacturing industry, IT has improved product quality and reduced costs.
NOTES


2 It was exhibited at the Centennial Exposition in Philadelphia in 1876.


4 The idea of coding personal information about people came to Hollerith while watching a train conductor punch holes in passengers' tickets to indicate where they had got on, whether they were male or female etc.

5 Evans, op.cit., p. 41.

6 Ibid., pp. 17-18.

7 Digital, pertaining to digits or the representation of data or physical quantities by digits.

8 Analog, pertaining to the form of continuously variable physical quantities. For e.g. a telephone conversation can be represented fully in analog form by a voltage derived from the telephone transmitters.


10 Turing was associated with the Colossus project.


12 Braun and Macdonald explain why the transistor was developed at Bell; among the reasons they give are its size, (they employed 57000 people in the late forties), and reputation as a research organisation which enabled it to recruit the best talent. Braun, E., Macdonald, S., *Revolution in Miniature: The History and Impact of Semiconductor Electronics*. Cambridge University Press, (UK). 1978, pp. 38-39.

13 A transistor is a slice of semi-conducting material (a material which is not such a good conductor as metal, but better than say wood), which when it contains certain impurities in its structure, can act as an amplifier and a solid-state switching device. Valves or tubes rely on a heater electrode for their power. The electrode has to be manufactured from metal, and it becomes inoperative if reduced beyond a certain size. In contrast, the transistor relies on tiny structures which form inside silicon crystals, and can act as very powerful electronic amplifiers. Because they do not rely on heat to drive their electrons they consume far less energy. They are also faster, and much more reliable. Evans, op.cit., pp. 80-89.

14 Braun and Macdonald, op.cit., p. 78.

15 In binary notation, either of the characters 0 or 1, often abbreviated to 'bit'.

16 Large, op.cit., p. 102.

Bicmos is a combination of two types of transistor: bipolar which is fast but tends to be power-hungry, and CMOS (Complementary Metal Oxide Semiconductor) which uses little power but is slower. Their combination, pioneered by Hitachi, creates a fast, low power device.


Ibid.


Incoming mail is fed into scanners, after which it is indexed and directed through the computer network to those delegated to deal with the contents. Each document can then be copied, amended and distributed within the organisation until all action has been taken and the item can be filed in the electronic archives.


At Western Provident in 1989, 4,000 claims a week passed through nine stages - almost 40,000 document movements. Under the old paper-based system, it would have taken up to three hours to reply to a customer query. After the installation of the DIP system, information could be given immediately. Abrahams, P., "Throwing Away the Paper-Based System", Financial Times, London, 26.4.1989, p. 16.

Portable computers enable managers to continue working on word-processing, spread sheets and graphics outside the office.


Haughton, "Top Marks", op.cit., p. 41.


Quoted by Colombo, U., and Lanzavecchia, G., in The Transition to an Information Society, a paper prepared for a conference on Information Society: for Richer for Poorer held in London 25-
They consist of many parts and sub assemblies, are partly made to stock and partly to order and are sold to different types of customers.


CHAPTER IV: THE SIGNIFICANCE OF INFORMATION TECHNOLOGY AND THE STATE OF THE IT INDUSTRY IN EUROPE

Section 1 - The Significance of IT

The IT Industry is a strategic sector for the European Community for several reasons.

1.1 Growth potential and size

IT is one of the fastest developing and most influential areas of industrial activity. With a growth rate of around 15% per annum in the 1980s, it caught up with other major Community industries such as chemicals and motor manufacturing (figure 1.4).

IT industrial output in Europe represents around 5% of European GDP, and is likely to reach 10% by the year 2000. The IT sector is expected to become the largest industry in the European Community, in terms of annual turnover, by the year 2000 (figure 1.5).
1.2 The dynamics of technology.

On average, a new generation of products is launched every three years.\(^2\) This has a great effect on the performance, price and capabilities of the final product. In the case of mainframes, examination of the evolution in price/performance in the period 1980-1990 reveals that the improvement factor in 1990 was five times higher than the performance for the same price in 1980. In the case of

micro computers, which arrived on the market during the 1980s, the improvement was much greater. These figures would be quite unimaginable in any other industry.

Figure 1.5

1.3 The catalytic effect of IT

IT is not an independent industry isolated from others, but
is transforming every aspect of economic activity. An
estimated 60 to 65% of the working population is directly or
indirectly dependent on these technologies and their
applications. Their products and services provide a vital
part of society's infrastructure, and their technologies are
now used in virtually all economic and social activities.

Organisations benefit in many ways from Information
Technology. Benefits include increased staff productivity,
increased administrative efficiency, better managerial
effectiveness, improved competitive position, greater
product quality, better service to customers, and reduced
costs. Clearly, IT does not automatically bring advantage.
It is essential that the most cost-effective technology is
used and that there is a degree of fit between
manufacturing, management, and marketing strategies. The
1989 Data Processing Expenditure Survey of 400 UK
businesses reported that 50% of respondents rated their
return on IT investments as "very good" or "good". A
survey of over 650 UK manufacturing firms, conducted in 1990
by Kew Associates with the assistance of the Confederation
of British Industry, reported that 50% of companies believed
IT was making a substantial contribution to their business
objectives. Clearly, Information Technology has a major
role to play in maintaining and strengthening the
competitiveness of European industry.

1.4 Limited energy, and raw material requirements It brings
few environmental problems, and improves safety levels,
especially in the workplace.

The EC Single Market will remove the physical, technical and
fiscal barriers to trade, creating the potential for
increased prosperity in Europe and according to the Cecchini
report will provide new opportunities for "growth, job
creation, economies of scale, improved productivity and
profitability, healthier competition, professional and
business mobility, stable prices and consumer choice". The Single Market poses a challenge to maintain and improve European competitiveness. Information Technology is of crucial importance to its success, in that IT can strengthen Europe's competitiveness by assisting in the design and production of higher quality, wider variety and more innovative goods.

Section 2 - The State of the IT industry in Europe

2.1 European Community action in the field of IT (1980s-1990s)

Since 1990, the world IT industry has been in unprecedented turmoil. Prices of semiconductors and personal computers have fallen, growth in data-processing and consumer electronics has been stagnant, and restructuring and layoffs widespread. Although the market is slowing down, however, technology is not. The present rate of technological advance is expected to continue at least into the first decade of the next century. The reason why the technology race remains fierce is that companies want to be first on the market with new products once the market picks up again. For a proper view of the present conditions and trends within the European IT industry, a review of the history of EC action in this area is warranted.

Appendix VIII provides a summary of the developments of EC IT Policy.

At the beginning of the 1980s, the situation aroused great concern. Europe's IT industry was characterised by 1) a lagging IT market: in 1982 the EC balance of payments in IT products and services showed a deficit of over $10 billion, doubling the $5 billion of the previous year; 2) low market shares: the European Community supplied around 40% of its own market and 10% of the world market; 3) fragmented
R&D: Europe’s R&D effort in IT was fragmented and lacked a united and long-term strategy; and 4) low capital investment.

An analysis of the performances of two groups of companies, including the largest US and the largest European IT companies, showed that from 1980 to 1984:

- the revenue growth rate of US companies was higher, worldwide and on the European market;
- the profitability of US companies was consistently higher;
- both capital expenditure and R&D were higher in the US than in Europe, and growing at a faster rate;
- the projected growth of the leading US companies would have enhanced their dominant position in the Information Systems market by the end of the decade.

It was generally recognised that the only practical level for concerted action was at the European scale; the fragmented national markets were too small to provide the economies of scale required to compete, and national companies could not find sufficient space for expansion in their national market alone. Inspired by the Japanese experience with inter-firm research consortia, and empowered by Article 235 of the Treaty of Rome to promote the competitiveness of European industry, EC Commissioner Davignon (responsible for IT affairs at that time) wrote to the twelve leading European electronic and IT companies inviting them to a meeting to discuss how the European technology gap could best be closed. This was the start of a series of discussions among what came to be known as the "Big Twelve." A Steering Committee was established, and precompetitive research was singled out as an area of strategic importance. Discussions continued and resulted in the identification of five areas where it was felt a European programme was essential. ESPRIT, the European Strategic Programme for Research and Development in
Information Technology, was launched in 1984 (a pilot phase ran for one year prior to the main programme). The overall objective of ESPRIT is to improve the competitiveness of the European IT industry.

The programme has three specific objectives: to provide the European IT industry with the basic technologies to meet the competitive requirements of the 1990s; to promote European industrial cooperation in IT; and to pave the way for the development of standards. The programme comprises collaborative pre-competitive research and development projects, carried out across frontiers by Community companies, universities, and research institutes. Projects are selected from public calls for proposals and based upon an updated work programme. To be eligible, a proposal is required to involve at least two industrial partners, not established in the same Member State. The first phase was agreed for an initial four years (1984-1988) and concentrated on five sectors: microelectronics, software technology, advanced information processing, office systems and computer integrated manufacturing. During this phase, more than 1,200 proposals were received, resulting in 227 R&D projects. The total R&D cost of the first phase amounted to 1,500 MECU, 50% from the Community budget, and the remainder borne by participants in the programme.

The changing competitive and technological environment created a need for a second phase of ESPRIT, with a shift in priorities in some areas and the launch of a new initiative: Basic Research Action. The entry into force of the Single European Act in 1987 reinforced ESPRIT's objectives, stating that "the Community's aim shall be to strengthen the scientific and technological basis of European industry and encourage it to become more competitive at international level. In order to achieve this, it shall encourage small and medium sized undertakings, research centres and universities in their research and technological development activities".

The second phase was approved on 11 April 1988 for a period of five years. It is a larger scale operation and places greater emphasis on the industrial nature of the programme. It nevertheless preserves the objectives\(^*\) and mechanisms of ESPRIT I - the cost-sharing between the Community and partners, the work programme, management of the programme \(^*\) and the on-going assessment principle. 3.2 billion ECU was approved for ESPRIT II, and a further 153 projects were accepted for funding. Work is focused in the areas of microelectronics and peripheral technologies,\(^{20}\) information processing systems\(^{21}\) and IT application technologies.\(^{22}\) Within these sectors a limited number of technology integration projects were undertaken, aimed at well-defined industrial targets and requiring large-scale industrial efforts at European level.

The Basic Research Action was launched during the second phase to ensure a reservoir of scientific knowledge and skills necessary for the vitality of European industrial R & D. Its objectives are to support collaborative fundamental research in selected IT areas, and to increase the involvement of leading research teams in ESPRIT. The action covers areas which are upstream from pre-competitive research and which have a clearly identifiable potential for industrial impact and future breakthroughs. The four main areas of activity are Microelectronics, Computer Science, Artificial Intelligence and Cognitive Science, and VLSI Design Training Action. The latter is a common effort to overcome the acute shortage of adequately trained VLSI design engineers in Europe, and is discussed in chapter VII.

In addition to each Action, there are networks of institutions,\(^{23}\) "with close cooperation between them which address much broader and interdisciplinary areas than those of any individual Action".\(^{24}\) A specific programme in IT followed the second phase.\(^{25}\) This includes an increased level of user involvement, a new dimension of technology take-up, especially in the software area, and greater emphasis on critical components (i.e. JESSI).\(^{26}\) ESPRIT is
now approaching completion, and is due to be followed by new initiatives under the Community’s fourth framework programme for research and technological development (Appendix IX), scheduled to start in 1994.

Evaluation

ESPRIT has involved over 600 projects and over 1,500 participants, and has been successful both in nurturing Europe’s IT Research and Development base and in creating an atmosphere of cooperation between European companies. The final evaluation of ESPRIT considered all aspects of the programme, and found that in most projects, trans-European cooperation has been a success and that the European technology base has improved as a result of ESPRIT. The most recent evaluation of the programme, conducted in the period 1991-1992, also supports this view.

This successful cooperation mechanism has helped overcome the handicaps caused by fragmentation. ESPRIT created an awareness of the technological potential that existed in other European countries, and thereby stimulated the growth of inter-firm and firm-research ties across Europe. ESPRIT has also played a catalytic role through industrial restructuring on a European scale. Mergers and acquisitions have been significant within IT related industries in recent years, and are contributory factors in increasing the competitiveness of Europe’s overall industrial base. In 1989 the European IT industry was more competitive than in 1984 (when ESPRIT was launched). European market share increased from 47% in 1984 to 55% in 1989 (figure 1.6).

The largest leading European computer companies grew as fast as corresponding Japanese companies over the same period. One European semiconductor manufacturer (Siemens) reached a world market share of 6% in the highly demanding DRAM (Dynamic Random Access Memory) chip market. Another European manufacturer (SGS-Thomson) ranked number 2 in the world in the equally competitive EPROM memory chip market.
In comparison with Japan and the USA, Europe has performed well. A study published in 1989 by the US Department of Commerce,\textsuperscript{11} assessing the situation of emerging technologies in terms of product introduction, noted that 10 of the 13 identified emerging technologies were in IT. Europe is ahead or on par with Japan in 6 and ahead or on par with the US in 7 of these 10 technologies (figure 1.7).

Figure 1.6

\begin{center}
\textbf{EUROPEAN I.T. MARKET}
\end{center}

<table>
<thead>
<tr>
<th>Year</th>
<th>Market Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>67 BECU</td>
</tr>
<tr>
<td>1989</td>
<td>118 BECU</td>
</tr>
</tbody>
</table>

47 \% EUROPEAN COMPANIES MARKET SHARE

55 \%

Source: \textit{Is the European IT Industry Capable of Competing?}
Speech by Mr Cadiou, Director ESPRIT, ESPRIT Conference, Brussels, 15.11.1990.
## EMERGING TECHNOLOGIES

<table>
<thead>
<tr>
<th>E.C.</th>
<th>vs U.S.</th>
<th>vs JAPAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHEAD</td>
<td>Digital imaging technology</td>
<td>Flexible CIM</td>
</tr>
<tr>
<td></td>
<td>Flexible CIM</td>
<td>Software technology</td>
</tr>
<tr>
<td>EVEN</td>
<td>Advanced semiconductors</td>
<td>Artificial intelligence</td>
</tr>
<tr>
<td></td>
<td>High-density data storage</td>
<td>Digital imaging technology</td>
</tr>
<tr>
<td></td>
<td>Sensor technology</td>
<td>Sensor technology</td>
</tr>
<tr>
<td></td>
<td>Superconductors</td>
<td>Superconductors</td>
</tr>
<tr>
<td></td>
<td>Advanced materials</td>
<td>Biotechnology</td>
</tr>
<tr>
<td></td>
<td>Software technology</td>
<td>Medical devices</td>
</tr>
<tr>
<td>BEHIND</td>
<td>Artificial intelligence</td>
<td>Advanced semiconductors</td>
</tr>
<tr>
<td></td>
<td>High-performance computing</td>
<td>High-performance computing</td>
</tr>
<tr>
<td></td>
<td>Optoelectronics</td>
<td>High-density data storage</td>
</tr>
<tr>
<td></td>
<td>Biotechnology</td>
<td>Optoelectronics</td>
</tr>
<tr>
<td></td>
<td>Medical devices</td>
<td>Advanced materials</td>
</tr>
</tbody>
</table>


ESPRIT has led to many outstanding technological advances.32 As of mid-1992, 721 major results had been reported.33 Of these, 417 contributed directly to products or services, 72
contributed to international standards and 232 to tools and methods used outside ESPRIT.34

In addition to the evaluations of ESPRIT carried out at the Commission’s request, independent evaluations have also been conducted; in general they have been very positive towards ESPRIT. A report prepared for the Canadian Administration in 1990, for example, presents a favourable judgement of the programme.35

2.2 State of the IT industry in Europe in the 1990s.

The sharp decreases in unit prices and the emergence of open systems36 have established a new and harshly competitive playing field, which has led to a complete reorientation of business, and a considerable reduction in the manufacturers’ profit margins.37 These factors, together with the recent slowdown in demand growth, have forced severe industrial restructuring.38 Continued effort is necessary at European level to encourage European industry during this difficult period, in order to ensure that it is at the forefront when the market picks up again. This has been recognised by Europe’s policymakers and concrete proposals for action have been formulated.39

3. The skills issue

A further weakness which has confronted the IT industry for some time is the shortage of IT skills. This has been extensively documented on a national and European scale (Chapter V). Indeed, all three evaluations of the ESPRIT programme have highlighted this problem.40

ESPRIT’s success and that of the IT industry depends to a great extent on the availability of IT skills. Trained engineers and researchers are required to carry out the research work in ESPRIT and to bring the results of the
projects quickly and efficiently to industrial exploitation. Shortages of such personnel limit the diffusion of IT and impede the realisation of the potential output and productivity gains. ESPRIT has made a significant contribution to sustaining and augmenting the pool of IT skills in Europe, in quantitative terms, via R & D funding channelled to the employment of more people, and more significantly, in qualitative terms, through raising skill and knowledge levels. Nevertheless, the skill shortage continues. Skill shortages can be related in part to inadequate higher education outputs, and in part to the lack of adequate training and re-training arrangements by companies. Chapter V examines the shortage issue in greater depth, while Chapters VI and VII discuss education and training for Information Technology.
NOTES


2 In the DRAM case, for instance, this means that every three years the capacity of a chip is increased by a factor of four.

3 SEC(91) 565, op.cit., p. 7.

4 It is important that IT is developed and used according to precise criteria with clear objectives. Alan Howard, lecturer in IT development at Leeds Polytechnic, emphasises the importance of understanding the role IT serves in an organisation. He identifies four tasks for all IT managers: 1) to identify the kind of department: support, factory, etc.; 2) to work out what type of department it should be; 3) to make the necessary changes in structure, attitudes and personnel to make the transition to what the department needs to be; and 4) he identifies strong leadership and good communication skills as being vital for all IT managers. Mr. Howard concludes that "computer systems are not just technical products, they are a balance between business benefit, user benefit and technical merit". Howard, A., "Knowing What IT Does", Computer Weekly, Reed Business Publishing/BPCC Consumer Magazines, Watford, 20.8.1992, p. 10.


7 Physical barriers - intra-EC border stoppages, customs controls and associated paperwork;

Technical barriers - meeting divergent national product standards, technical regulations and conflicting business laws; entering nationally protected public procurement markets;

Fiscal barriers - differing rates of VAT and excise duty.


8 Ibid., foreword, p. xiii - xiv.


12 "If action by the Community should prove necessary to attain, in the course of the operation of the common market, one of the objectives of the Community and this Treaty has not provided the necessary powers, the Council shall, acting unanimously on a proposal from the Commission and after consulting the European Parliament, take the appropriate measures." Treaties Establishing the European Community. Abridged Edition, Council of Ministers, Office for Official Publications

13 GEC, Plessey, ICL, Thomson, CII Honeywell Bull, Philips, AEG, Telefunken, Siemens, Nixdorf, Olivetti and STEF.

14 Precompetitive = far from the market, to reflect the fair competition rules imposed by the Treaty of Rome, precompetitiveness became and remains a characteristic of many of the Commission's cooperative research programmes.

15 The work to be undertaken is planned in more detail in the work programme, which is produced following intensive dialogue between European IT industry and academia. The work programme sets out the detailed objectives and types of projects to be undertaken.

16 In ESPRIT II, a Basic Research sub programme was introduced where this was no longer a requirement.


18 The objectives of ESPRIT II are to provide the European IT industry with the basic technologies to meet the competitive requirements of the 1990s, to promote European industrial cooperation in pre-competitive R & D in information technology, and to pave the way for internationally accepted standards. Council Decision of 11.4.1988 on ESPRIT II, Official Journal of the EC L 118, Office for Official Publications, 6.5.1988, p. 33.

19 Management of ESPRIT is a cooperative effort between the Commission (which undertakes all day-to-day organisational tasks), the Round Table of IT firms, an ESPRIT Advisory Board (comprising representatives from industry, universities and research organisations), and the ESPRIT Management Committee (consisting of Government representatives from the Member States).

The ESPRIT Advisory Board was created for the purpose of counterchecking the work programme and its execution. It has a strong influence on the strategic direction of the programme, allocation of funding, and the selection of projects. The ESPRIT Management Committee is the link between ESPRIT and the Governments of the Member States. It is the channel for information flow between ESPRIT and the national IT programmes. The EMC gives formal opinions on the work programme, allocation of funds, and on the selection of projects.

20 In this area, work is primarily aimed at improving the competitiveness of Europe's microelectronics industrial sector, to enable it to provide the IT industry with full system capability based on state of the art semiconductor technology. This includes R & D in the design, manufacture and testing of all types of silicon integrated circuits (ICs), complemented by work on specialised IC manufacturing equipment and materials.

21 The main objective of IPS is to bring tools and technologies together from the hardware and software domains to facilitate the design and development of the information processing systems of the 1990s.

22 This area aims to enhance European capabilities in the investigation of IT information systems capable of use in a broad range of applications, to evaluate the results in selected realistic projects.

23 These are known as "networks of excellence". A network of excellence is a grouping of research teams with common long term technological goals, coordinating their research as well as their training policies closely. This linkage between the nodes of the network means that access to any node gives access to the resources of the whole network. This has great impact on industrial innovation/technology transfer, human resources, and cohesion.

JESSI; Joint European Submicron Silicon is a programme which deals with submicron silicon, one of the most advanced parts of the microelectronics industry. The objective of the programme is to strengthen the whole European microelectronics industry chain.

The ESPRIT Review Board was established in October 1988 and presented its findings in May 1989 in The Review of ESPRIT 1984-1988. Its objectives were to assess the extent to which ESPRIT I was meeting its objectives, to determine the effects of the programme, and to assess the need for changes affecting ESPRIT or future IT-related programmes.

"ESPRIT has had a major impact on European cooperation between companies, industry and academia and between organisations in different Member States." ESPRIT the Report of the Information and Communication Technologies Review Board, Brussels, June 1992, p. 19.

BULL/Zeith, Siemens/Nixdorf, Sema/CAP, SGS-Thomson/Inmos.


In ESPRIT all parties have equal rights and access to all results and intellectual property rights (IPRs). These are subdivided into foreground and background IPRs. Foreground IPRs are the property of all participants, whilst rights to background IPRs can be limited. Subcontractors do not have the right to the full project results, only to IPRs resulting from their own work.

ESPRIT Specific Research and Technological Development Programme in the field of IT. Results and Progress 1991/1992. CEC, Office for Official Publications of the EC, Luxembourg, 1992, p. 8

Results are classified into three broad categories: projects which may produce advanced technology to be incorporated into products or services sold to end users; projects which may produce tools, methods or processes which enhance the development of manufacturing operations within industrial enterprises; projects which may produce results which contribute to international standards. These major results include:

- a new chip design method allowing reduction in the size of CD player circuitry from 100cm2 to a single chip implementation (1 cm2). Simultaneously, the time to design the circuitry is reduced from one month to one week;

- the SUPERNOVA project has developed the fastest mini-supercomputer in the world in its price range;

- a new standard for Office Document Architecture (ODA) has been developed in a project and adopted by ISO, the International Standards Organisation.


- pocket computers: the Newton "personal assistant", an all-in-one portable electronic notebook, wordprocessor, fax machine and computer launched by Apple is based on a microprocessor chip developed in ESPRIT, (MULTIWORKS project 2105). ESPRIT Specific Research & Technological
Open systems allow customers to integrate equipment made by a variety of manufacturers.

Even large and famous companies are experiencing difficulties; in 1991 IBM posted a loss and a turnaround in sales for the first time in its history.


Commissioners Bangemann (Industrial Policy) and Pandolfi (IT Policy) in their Communication of 3.4.1991 (SEC(91)565) proposed practical steps to enable industry to face up to international competition.

The industrial dimension; the aim of improving the competitive position of European industry, enshrined in the Single European Act, has been further emphasised in the Treaty on European Union.

In 1990 the Commission outlined in a Communication to the Council and Parliament the guidelines for a Community approach to industrial policy in an open and competitive environment (CON(90) 556).


This has also occurred through the special actions aimed at redressing specific skill shortages. One example is the VLSI initiative, which focuses on the need to train graduates and postgraduates in chip design.
CHAPTER V: INFORMATION TECHNOLOGY SKILLS: THE POSITION IN EUROPE.

The skills issue is presented in three sections. Section I outlines the importance of access to a skilled work-force, explains the term "shortage", identifies the factors which can contribute to shortages, and looks at the influence of demographic trends. Section II looks at the shortage issue from a national perspective, while Section III approaches the problem from a European perspective. Section IV concludes the Chapter noting the lack of an adequate statistical base.

Section 1

1.1. The importance of a skilled work-force

Technological development demands a skilled work-force capable of mastering the complexity and opportunities of IT and its applications. The IT industry requires skilled staff in two capacities: "as innovators to carry out research and/or introduce, develop and adapt new technologies and applications; and implementers: engineers and technicians to use new inventions and tools, and to transform them into profit-generating products and services".1
Such staff have collectively been referred to as informaticians in France, or knowledge workers in the UK. Irrespective of title, such workers have certain basic attributes: a high level of qualifications, and intellectual skills which make them good at creating new services and at solving complex technical problems.

Shortages of IT staff can cause major problems for companies. In 1986 a survey conducted in the UK by the National Computing Centre and the IT Skills Agency found that over 20% of IT users, and over 25% of software suppliers, stated that they were "crippled" or had their survival threatened by shortages of skilled staff. A survey conducted in November 1987 by the Confederation of British Industry and the Manpower Services Commission, involving 1,225 companies, found that the number of manufacturers whose output was likely to be limited by skill shortages reached 34% in 1986-1987. The Institute of Manpower Studies (IMS) 1989 survey of over 200 UK IT organisations found that shortages of professional IT staff had extended delivery or implementation periods in over 40% of cases. In 1991 the EC Commission produced a paper on the state of the European Electronics and IT industry, drawing attention to the lack of qualified staff (systems engineers and staff trained in computer-aided management). This meant, according to the report, that "industry is unable to make the most of competitive openings arising in the IT field."

Trained engineers and researchers are also required to carry out the research work in R & D programmes (e.g. ESPRIT) and to carry project results quickly to industrial exploitation. The mid-term review of ESPRIT, conducted in 1985, reported the concern of industry over its ability to continue to participate in collaborative R & D projects, given inadequate human resources. Most published reports on the ESPRIT programme have highlighted the shortage problem. The IRDAC report refers to a survey conducted in France among 1800 selected technologically advanced companies: 70%
reported severe difficulties in recruiting experienced staff for R & D activities.9

1.2. Skill shortage - definition

Different definitions and approaches exist.10 We may, for example, see the question as one of demand and supply, estimating actual or forecasted labour demand in particular occupations, and comparing this with actual or projected supply, taking account of flows from the education and training system. Some economists have seen this approach as inadequate, since it relies on labour demand forecasts and demographic projections, and fails to take account of possible market adjustment mechanisms. They prefer an approach which takes account of market adjustment mechanisms, especially price adjustments. The more extreme forms of this approach simply use relative price changes as the defining criteria for the existence of shortages; thus, an occupation or skill is in shortage if, and only if, relative pay levels in that occupation are rising. Atkinson and Meager11 found this approach unsatisfactory, seeing reliance on price adjustment data in diagnosing shortages as unnecessarily restrictive. They substantiate their view by giving examples of economic studies which produced different and often contradictory results.12 The market-perspective approach uses survey data and aggregate published data, and the employer-perspective uses employer-based surveys to determine shortages in terms of recruitment difficulties faced by individual firms; they therefore tend to adopt a demand and supply definition.

Many of the studies on skill shortages conducted by the UK Manpower Services Commission (MSC)13 in the 1970s and 1980s adopted the employer approach.14 The 1983 Institute of Manpower studies (IMS) and MSC report,15 however, argues that the term shortage is never used as an operational concept by firms. Through discussions with firms, the IMS tried to establish what was understood by "shortage". The IMS found that most companies concentrated on vacancies.16
Further analysis showed that a shortage meant any vacancy impeding production. To establish at which point vacancies became shortages, the IMS created a three layer classification system comprising transactions shortages (which cause actual loss of, or severe delays in, output), precautionary shortages (which cause no actual output loss, but which anticipate probable need) and speculative shortages (which relate to inability to meet some hypothetical demand). Atkinson and Meager believe there is no unambiguous definition of a shortage which can easily be used in employer-based research. They supply the most frequently used definition: "when to a greater or lesser extent an individual employer experiences a greater or lesser extent of recruitment difficulty for a particular post". The advantage of this definition is that it corresponds to employers' understanding of shortage, and relies on information readily available to all employers.

1.3. Factors contributing to skills shortages

Several interrelated factors can contribute to skill shortages. The Industrial Research and Development Advisory Committee of the EC Commission (IRDAC) has identified these as:

- the supply of new manpower on the market does not meet the demand for new or existing jobs, either in terms of quantity or in terms of type of qualifications;

- there may be a mismatch between the available stock of skills and qualifications, and the numbers required by the economy (e.g. lack of Very Large Scale Integration (VLSI) designers against surplus electronic technicians);

- the changing demands caused by rapid technological development require adaptations in skills (training) which frequently fails to take place. Existing skills may be employed below and outside their full capabilities (e.g. engineers used as technicians),
high employment in one sector or profession might be the cause of skills shortages in another (e.g. financial and other services attract engineers, thereby exacerbating problems in manufacturing industry).

These interrelated factors are in turn affected by demographic trends.

1.4 Demographic trends

The supply side of the labour and skills market is largely determined by the potential labour force, which in turn is dependent on the demographic situation and its evolution. The Statistics Office of the European Commission, (Eurostat) analyses and forecasts demographic developments in Europe. The most recent available demographic statistics reveal that Europe's population by the year 2020 will be only 4% of the world total, a fall of 35.5% over 30 years, and that the age pyramid is growing older, with the base shrinking as a result of the fall in the birth rate while the top expands as a result of a lower death rate. The age structure in 2020 is likely to be noticeably different from that of 1991, with an estimated 24% of men and 29% of women 60 years old or more compared with 17% and 23% respectively in 1990.

Eurostat shows the evolution and forecasts for the period 1965 - 2020 for four age groups: 0-14 years, 15-44 years, 44-64 years and over 65 years. The age group 15 - 64 years is normally considered as the potential labour force. In 1990, total population in this age group for the twelve Member States, as estimated by Eurostat, was 220 million. The projected population for 2020 is 211 million. For the younger part (aged 20-30) of the labour force, known as the active labour force, the outlook is particularly dim, with a continuing annual reduction in numbers of 1.7%. The significant ageing of the population, the decline in the potential labour force and the serious decline in the active labour force will have serious consequences for industry. Many skill demands will be unmet. The decline in the active labour force is likely to have the greatest impact,
particularly since this age group is a major source of innovation.

The demographic factor will thus play a major role, and companies are already aware of its importance. In the UK Policy Studies Institute (PSI) surveys²⁶, respondents were asked in what way the decline in the numbers of school-leavers and graduates in the first half of the 1990s would affect their companies. In most cases, respondents felt that the demographic pinch was a serious problem affecting recruitment and retention of skilled staff, especially those already in short supply (electronics engineers, control engineers, systems engineers, design engineers with microelectronic expertise, software engineers, data processing staff, electronics technicians and instrumentation technicians).²⁷

Section 2

Skills required and evidence of shortages: a national perspective

Since the early 1980s concern has been expressed over shortages of IT skilled manpower. Only limited statistical data is available on the extent of skills shortages on a European scale, principally due to the lack of comparable national data. At a national level, most evidence of skills shortages is available from reports and studies carried out by public and private organisations.

Evidence of skills shortages provided in national reports and studies sometimes lacks statistical data. This is explained by the limited capacity of national databases to clearly identify IT skilled manpower, its distribution and flows between sectors, and trends over time. Where statistics on shortages have been provided, they are generally based on employers' projections. A view of the
shortage situation in Belgium, France and the UK can be obtained from the reports discussed below.

At the conference on "Enterprise and People Aspects in the Information Technology Sector", held in Brussels in April 1991, a representative of INSEA, the Belgian Computing and Software Engineering Association, presented a report on the skills required by the IT sector in Belgium. The report confirmed the growing increase in the number of IT workers in Belgium and identified a greater need for people with hybrid skills, that is technical as well as business skills.

In March 1982, a report on the electronics sector in France by Filicie Electronique concluded that for the period 1986-1990, the shortage of IT specialists in France would be between 191,000 and 325,300. The growing shortage of VLSI (Very Large Scale Integration) designers became evident in France in the late 1980s. The French National VLSI Education Committee estimated a yearly shortage of 500 VLSI designers, when the French VLSI committee trained more than 500 students per year. In 1990, a report prepared by CERCA (Universite de Paris VIII) on the labour market for computer professionals in France estimated a shortage in France of about 20,000 computer professionals.

In the UK, the PSI surveys on the diffusion of microelectronics over the period 1981-1987 found that the most common difficulty, experienced by nearly half the users in all four surveys (1981, 1983, 1985, and 1987), was the lack of people with specialist microelectronics expertise. A shortage of 40% was reported in all four surveys. Another survey, conducted by the National Computing Centre, reported that computer users in the UK were short of around 19,400 skilled staff, and would need at least another 80,000 over the period 1988-1993. The survey was based on 777 user installations. The PROTOCOL industry survey (1989) on staff and skill shortages, involving over 500 managers in the computer services industry in the UK, reported that 67%
felt shortages were getting worse and would continue over the next decade.35

These reports and surveys point to the existence of shortages and the increasing need for more hybrid (technical as well as business) skills.

Section 3

Skills required and evidence of shortages: a European perspective.

Most of the studies carried out on a European scale in the early 1980s emphasised the need for Community action in IT, but while attention was drawn to the skills problem, the issue was not discussed in much detail.36 In the second half of the 1980s, Europe’s leaders became increasingly aware of the skills issue, and studies and reports were commissioned to analyse and report on the situation.

This section examines a selection of these studies with a view to establishing trends and ascertaining the extent of the shortage of IT manpower in Europe. The objectives of the studies are outlined, their approach is explained and the findings and recommendations are indicated; an evaluation of the individual studies is not made here.

3.1 Technical Change Centre report

In 1985 the Information Technologies and Telecommunications Task Force of the EC Commission requested the Technical Change Centre, London, Professor Jean Donio of the University of Paris VIII, and the VDI Technologiezentrum, Berlin to carry out a study on the availability of highly qualified personnel for the development of Information Technology in the European Community. The authors were requested to "assess the requirements for graduate (and equivalent) people in electronics engineering, computer science and related fields; relate this to the needs of industry, the service sector, government, education, research and development and compare the European situation
with that in the US and Japan."\textsuperscript{37}

The study considers the shortage situation (in the mid eighties), labour demand in IT-related industries, the supply of highly qualified manpower (HQM), and the availability of such manpower in the European Community.

The authors confirmed the existence of a shortage of highly qualified manpower,\textsuperscript{38} and illustrated the shortage situation in France and the UK.\textsuperscript{39} Because of the unreliability of comparable available data, the demand for labour in IT related industries could not be established, though certain data (employment-vacancy) for Germany and the UK pointed to a growing increase in the demand for highly qualified manpower. Comparative data extracted from various sources (NSF, UNESCO, Van den Berghe)\textsuperscript{40} provided information on the supply of HQM.\textsuperscript{41} This revealed that Europe produced proportionately fewer graduates in IT related disciplines than Japan, and that this gap was even greater for electronic and electrical engineering graduates.\textsuperscript{42} As statistics on the destination of graduates were difficult to find, the authors were unable to follow what happened after graduation.\textsuperscript{43}

To establish the availability of HQM in the Community, the contractors undertook a survey by interview. In all, sixty-nine\textsuperscript{44} organisations were visited in 10 Member States. Interviewees included both users (manufacturing and services)\textsuperscript{45} and producers (education and training institutions)\textsuperscript{46} of highly qualified manpower.\textsuperscript{47} The authors reported strong demand for highly qualified personnel, likely to continue rising over the next five years.\textsuperscript{48} In their analysis, the authors suggest that their findings in certain cases contradicted general assumptions. Some companies indicated that there were no serious shortages at all;\textsuperscript{49} this reflected, in the view of the authors, variations of method in investigating shortages in manpower and heterogeneity within the market place.

As to the first element they identify the method of simply
extrapolating employment growth in highly qualified manpower as error prone, believing that the identification of a past growth rate and its simplistic projection into the future is naive. The output of university graduates as a measure of supply was also found to be inadequate.\textsuperscript{50} The authors found it particularly difficult to provide hard, quantitative evidence relating to the issue of variations of labour shortage in different sub-sectors of the HQM market place.\textsuperscript{51} They found the classification systems (occupational) inadequate in the IT field.

In conclusion, the study underlined the importance of skilled manpower for the competitiveness of European industry, reiterated the inadequacies of the classification systems of employment by economic sector and occupation, and recommended that national employment data be harmonised and standardised under the supervision of the European Statistical Office.\textsuperscript{52}

3.2 Social Europe: the Degimbe report

The second report to be reviewed here is that on the status of the \textit{Software Industry in Europe}\textsuperscript{53} compiled for the Commission in 1986 by Jean Degimbe.\textsuperscript{54} The report first details the Commission's activities in the software field, describing the software initiatives within the ESPRIT programme. In order to gain a clearer picture of the size of the software sector, growth trends, the quantity and quality of employment generated, and the problem of skills shortages and work organisation, information was gathered in the Member States and presented in the form of national reports. The latter were prepared in 1985, before the third enlargement of the Community, and therefore excluded Spain and Portugal.

The lack of official statistics prevented the authors\textsuperscript{55} from presenting a clear picture of size, numbers employed, and the demand for skills in the software and computer services industry. In Italy, estimates of the number of companies in this sector varied between 1,000 and 5,400.\textsuperscript{56} Estimates of
the manpower employed in software related activities were difficult to obtain; no official statistics were available on employment levels in most Member States, and estimates provided by professional organisations had to be used instead.

In the skills area, the report found "the demand for highly qualified computer specialists was still high and in most countries largely unsatisfied". This statement is based on the studies and reports quoted in national reports. The Belgian report stated that there was a shortage of suitably qualified personnel in the software development and production field. Similar statements were made in the Greek and Dutch reports. Denmark, France and the UK supported their statements on shortages with some statistical evidence. Denmark highlighted the shortage of programmers; "in 1965 there were three programmers for each computer, by 1985 the ratio was expected to have declined by one programmer for every 5 computers". The French report referred to a survey carried out in 1984 on demand for computer specialists, showing a 20% shortfall. The UK report relied on evidence from two reports, the 1982 National Economic Development Office (NEDO) report, which indicated a shortage of software skills, and the 1985 IT Skills Shortages Committee Final Report, which highlighted the skills needed in the IT users sectors.

The extent of software skill needs in Europe cannot be reliably assessed on the basis of the data provided in the national reports. Although most reports give evidence of shortages of software specialists, the shortages identified vary from the overall general demand for computer specialists (Belgium and France) to the more specific: programmers (Denmark), automation experts (the Netherlands), systems project managers and systems designers (UK). For Germany and Italy no shortage data is indicated. The lack of official national comparative statistics and the reliance on some private studies made it difficult to present an overall picture of the European software industry.
3.3 CREATE report

A third study was carried out by CREATE (Centre for Research in Employment and Technology in Europe). In 1988 CREATE undertook to carry out for the Commission a study on Employment and Working Conditions in High-Tech Producer Services Industries. The study examined employment and skill trends in all the Member States of the Community, with more detailed emphasis on Belgium, France, Germany, and the UK. The study concentrated on producers of IT, covering both hardware and software, and on major users of IT in the manufacturing and service sectors. CREATE encountered difficulties in establishing employment levels and skill trends in the Member States. Faced with the poor classification of high-tech industries in the national statistical systems of the four countries, the task of CREATE was difficult. The problem was even worse for inter-country comparisons, due to different definitions of technical functions within these industries and of the work occupations performing these functions. CREATE found a need to upgrade the skills of systems analysts, project managers and telecom specialists. In addition to upgrading these skills, CREATE underlined the growing demand for workers with hybrid skills.

3.4 IRDAC report

In November 1990 the European Community’s Advisory Committee on Research and Industrial Development (IRDAC) presented a report on Skills Shortages in Europe. The study was performed in close cooperation with DG XII, DG XIII and the Task Force on Human Resources, Education, Training and Youth. The working party charged with carrying out the research for IRDAC was requested to "advise on questions related to the implementation of actions on or affecting European education and training". The terms of reference identified "skills" as one of the areas to be researched, and the working group was requested to "recommend measures aimed at identifying skills shortages and measures to
redress them, in particular in priority sectors in relation to Community policies.\textsuperscript{75}

Sections I and II of the report discuss the demographic situation and changes in the demand for skills. Potential labour supply is seen as dependent on the demographic situation and its evolution. The report, which relied on Eurostat projections, forecasts a decline in the potential labour force (age group 15-64) in Europe after the year 2000, with drastic consequences for Europe.\textsuperscript{76} To determine the changes in the demand for skills, the group\textsuperscript{77} relied on national reports, as no Europe-wide data was available. These reports indicated the need for a much more highly skilled labour force.\textsuperscript{78} The research carried out by the MERIT organisation for IRDAC, referred to briefly in the report, found strong overall demand in Europe for engineers, scientists, and skilled labour, and in particular for engineers (1.2\% compared to 0.6\% on average).\textsuperscript{79}

Section three of the IRDAC report looked at the skills issue in specific sectors.\textsuperscript{80} Given the lack of reliable data on skills and the incompatibility and inconsistency of available data, "the texts on the different sectors are descriptive and include no quantitative forecasts".\textsuperscript{81} For the IT sector, IRDAC outlined the main characteristics of the sector,\textsuperscript{82} and noted "an increasing demand for new skills and services in design, development, software engineering and microelectronics".\textsuperscript{83} They reported "large shortages of advanced IT specialists"\textsuperscript{84} though no data was provided as to the extent of the shortages (e.g. numbers required were not indicated).

In conclusion, IRDAC found that a skills shortage problem had arisen, and without appropriate action would worsen. The need to improve the supply of skills, in particular in areas of technological advance, was seen as necessary if Europe was to maintain its competitive position. The importance of the relationship between education, training and industrial competitiveness was reiterated, and a series
of recommendations presented:

- "Maintain and increase the supply of highly skilled people in Europe; university curricula should be sufficiently broad and guarantee that graduates have flexible attitudes and skills."

- Improve educational productivity (new technology should be used in the production and delivery of training materials).

- Develop a European approach on skills shortages.

- Standardise data to allow better understanding of skill requirements; European and national authorities should develop consistent and comparable approaches with regard to data collection and forecasting.

- Studies should be undertaken to ascertain manpower requirements, related training and skills implications in specific sectors, and on the cost of non-investment in education."

3.5 EPOS report

The fifth report to be reviewed, on The labour Market for Information Technology Professionals in Europe, was prepared for the Commission in 1990 by a team of correspondents from the Member States. The overview was conducted in order to obtain information on developments in computer-related professions within the EC. The document contains the principal findings, in addition to a summary of each of the twelve national reports. The authors considered the term "computer professional" and the job market for computer professionals in Europe. They were unable to locate a single, internationally recognised definition or criterion, which would have enabled them to pinpoint the various types of computer professionals working in Europe. Each country classified these professions in one or more ways, and in many cases the classifications were not even used for statistical purposes. Furthermore, as none of the
national reports quoted a set of coherent statistical sources, it was not possible to obtain an overall view of the job market for computer professionals. Despite these problems the authors found a shortage in computer skills in most countries. The shortages varied; in France and Denmark the shortage of application analysts was greatest, whereas in Germany, Spain and the UK, systems analysts were the most sought-after specialists. In Belgium and the Netherlands, more sales managers were required, while network specialists tended to be in short supply everywhere.

3.6 IFO-MERIT report

The final report to be reviewed is the Macro-economic and Sectoral Analysis of Future Employment and Training Perspectives in the Information Technologies in the European Community. Commissioned by the CEC, it was carried out by two research teams during 1990-1991; the Munich based IFO-Institut Fur Wirtschaftsforschung (Economic Research) and the Dutch Maastricht Economic Research Institute on Innovation and Technology (MERIT). The IFO team concentrated on the quantitative trends in employment and on sectoral aspects of the diffusion of information and communication technologies, while the MERIT team looked at work organisation, skills implications and educational requirements. The skills implications are considered below.

The research conducted by MERIT indicated changes in the skills structure during the 1980s in Europe. There was strong growth in technical, scientific, and related professional occupations, followed by growth in managerial and administrative occupations. While demand for unskilled production workers, labourers, and agricultural workers had declined. MERIT predicted the outlook for skills in selected industries (telecommunications, electrical engineering, and office machinery) for the year 2005. While a relatively stable demand for basic skills was seen as quite conceivable for telecommunications, a distinct rise in the demand for persons with management and professional
The office machinery industry in 1990 had a significantly higher proportion of management and professional skills than the electrical engineering industry, and MERIT projected a rising demand for professional skills in this sector. MERIT pointed to the increasing importance of multi-skilling (including communications skills) and notes the persistent shortage of technical and scientific skills, in particular software skills. In conclusion, the report emphasised the need for training to keep pace with these developments.

Section 4

The problem of statistics

National data indicates the existence of IT skills shortages. Studies and reports from a European perspective stress the difficulty encountered in obtaining reliable, comparable data on the demand for and supply of IT manpower in Europe. The lack of official statistics, the reliance on professional bodies for data, and inadequate classification systems in the Member States made it extremely difficult to determine the extent of the shortage of IT manpower on a European scale.

The inadequacy of national classification systems is compounded by a lack of suitable slots in the NACE coding system. NACE (General Industrial Classification of Economic Activities within the European Community) classifies economic activity in terms of the nature of goods and services produced or by the nature of the production process employed. The lack of suitable slots in NACE for certain IT sectors make it difficult to obtain data. For example, electronic components are classified together with consumer electronics, so that, other specialist and general sources (e.g. BIS Mackintosh, Dataquest) have to be consulted to obtain production, trade and employment data. Similar difficulty is encountered with computer services and
The Technical Change Centre (1986) and IRDAC (1991) both called for a standardisation of data so that skill requirements could be better understood. A conference on "Higher Education and 1992: Planning for the Year 2000", held at the University of Siena on 5-7 November 1990, called on the Commission "to develop, on the basis of agreed definitions, an extensive database on higher education, including information on highly qualified manpower supply/demand and on the changing profile of graduate employment, and to analyse this data regularly so as to be in a position to assist Member States in the development of policy in higher education generally throughout the Community".

Two years later, in December 1992, the Commission called for a "European approach to skills shortages across the Community and the monitoring of manpower needs and supply". While steps have been taken by the Commission towards monitoring skill needs via the Skill Needs Project (c.f. Appendix X), obtaining data on the demand and supply of highly qualified manpower on a European scale remains a major problem. This is principally due to the differences in national higher education systems, so that statistics are not mutually comparable; differences in the duration of degree courses, in the subject classification system, and in methods of calculating the number of persons graduating in the various disciplines; and to a lack of official statistics on demand for highly qualified manpower.

The education department of the Statistical Office of the European Communities (Eurostat) applies the ISCED system for calculating the number of higher education students graduating in various disciplines in Europe. Under this system, many categories are grouped within one heading, e.g. graduates in IT-related disciplines may be found under two headings: "mathematics and computer science" and "engineering". The former includes students graduating in...
mathematics, statistics, actuarial science and computer science, while engineering comprises all students graduating in chemical engineering and material techniques, civil engineering, electrical and electronics engineering, surveying, industrial, metallurgical, mining and mechanical engineering, agricultural and forestry engineering and fishery engineering. Taking the data in its present form, it is not possible to deduce the number of students graduating in computer science and electrical and electronics engineering, which are disciplines of relevance to the IT sector. Despite the recommendations put forward for improving the present system, contacts with Eurostat officials in January 1993 indicated no new developments had taken place or were expected to take place in the classification of higher education data in the immediate future.
NOTES


2 IT users comprise industrial users (engineering, chemicals and other industries) and service users (retail, finance, public sector, transport and utilities)

3 Quoted in Information Technology: the National Resource a Plan for Concerted Action, the report of the IT 1986 Committee (UK), November 1986, p. 35.


5 Persons in jobs at graduate level or equivalent.

6 Connor, H., Buchan, J., Pearson, R., The Changing IT Skills Scene. The IT Manpower Monitor 1989, Institute of Manpower Studies (IMS), Brighton, 1989. p. 77. This survey was carried out in 1989 in order to monitor the changing pattern of supply and demand for professional IT skills.


8 "A further and critical weakness is the lack of trained personnel. Estimates of the required number of trained personnel vary widely, but it is clear that not enough people with the right skills are being trained." ESPRIT Annual Report 1988, CEC, Office for Official Publications of the EC, Luxembourg, 1989, p. 4.


10 The Board identified concern in large companies and national administrations that there is a growing shortage of skilled staff in engineering and IT." The Report of the Information and Communications Technologies Review Board, Brussels, June 1992, p. 21.

11 IRDAC, op.cit., p. 19.

12 A good description of the various definitions and approaches to shortages is provided by Atkinson and Meager, in their Skill Shortages Survey. This survey is based on work undertaken by the Institute of Manpower Studies for the Department of Employment and the Manpower Services Commission, Skill Shortages Survey IMS Report No 100, University of Sussex, Brighton, 1985.

13 Ibid., p. 40.


15 Manpower Services Commission (MSC).


"1) Any vacancy, 2) any vacancy unfilled after exhausting internal and external channels, 3) any vacancy notified externally but remaining unfilled for a specified period, and 4) any unfilled vacancy threatening production." Atkinson and Meager, op.cit., p. 51.

Ibid. p. 55.

Ibid. p. 55.

IRDAC, op.cit., pp. 3-4.


Ibid. p. xxiii.

Ibid. p. 171.


Ibid. p. 170.

IRDAC, op.cit., p. 8.

The four PSI surveys of the use of microelectronics in industry were undertaken in 1981, 1983, 1985 and 1987. The sample consisted of 1,200 manufacturing firms.


The conference on "Enterprise and People Aspects in the Information Technology Sector", held in Brussels on 11-12 April 1991, was sponsored by the Commission. It highlighted recent and prospective trends in human resource development in the IT sector in the Member States.

Employees in high-tech areas need increasing business awareness and understanding if they are to deliver systems that bestow competitive advantage on their users.


EUROCHIP Information, issue No 1, July 1990, p. 3, newsletter produced for the VLSI Design Training Action by the EUROCHIP Secretariat (German National Research Centre for Computer Science (GMD)), Sankt Augustin, Germany.

El Pakir, A., Azoulay, N., Economics Department (CERCA), Paris University VIII; a summary of the report (pp. 87-98) is included in Labour Market for Information Technology Professionals in Europe, Social Europe supplement 1/90, Office for Official Publications of the EC, Luxembourg, 1990.


39. Highly Qualified Manpower are those qualified to levels 6 (first degree level or equivalent) and 7 (higher degree) who become qualified by gaining work experience in industry which is specific to a particular job or occupation.

40. For France, the authors quote the findings of the Tebeka report (La Formation des Specialistes Informatiques - March 1980) and the report on the electronics sector by Filicie Electronique. Both reports estimated that there would be a deficit of between 40,000 and 60,000 highly qualified manpower in France over a five year period. For the UK, the findings of the Butcher report and the National Computer Centre Survey of its Members conducted in 1984 are indicated. The NCC survey estimated that the total number of computer professionals in industry and commerce fell 6% short of demand, and was expected to be 25% short in 1986. Technical Change Centre et al, pp. 1-3.

41. National Science Foundation (NSF), United Nations Educational Scientific and Cultural Organisation (UNESCO), and Her Majesty's Stationery Office (HMSO).

The National Science Foundation showed the number of natural scientists and engineers in the labour force in West Germany, France, UK and the USA in the early 1980s. All four countries had about the same proportion of natural scientists and engineers in the labour force. Over the period 1970-1980, the proportion of natural scientists and engineers in the labour force increased in each country. The NSF reported that they had found "some tight labour market situations and/or shortages, particularly of electronics and computer specialists in France and the UK".

UNESCO compared education at third level (graduate level 6 (first university degrees or equivalent and 7 (post graduate university degrees or equivalent)) in selected OECD countries and found that the Japanese produced nearly 5 times as many engineering graduates as the UK and 4 times as many as West Germany. Considering the sizes of the labour forces in each country, Japan produced far more graduate engineers per unit of population than any of the European countries (Belgium, Denmark, FRG, Greece, Ireland, Italy, The Netherlands, Portugal, Spain, and the UK). UNESCO findings are based on data collected for 1981/1982.

Van den Berghe (Manpower for Technology. 1985) produced comparative data on the proportion of first degree university graduates in electrical or electronic engineering for eight of the EC Member States (Belgium, France, West Germany, Greece, Italy, The Netherlands, Spain and the UK), Japan, and the USA. The proportion of engineering graduates in the USA and Japan was over 26%, whereas in the EC countries it was below 20% in all except Belgium (27%), West Germany (24.7%) and the UK (20.6%).

41. Highly Qualified Manpower.
Japan produced 20,000 graduates per year, while West Germany produced 4,500, and the UK 3,000, as quoted in The Technical Change Centre et al., op.cit., p. 27.

The UK was the only Member State which provided detailed data on the first destinations of graduates e.g. numbers entering employment, category of employer (industry), occupation of those entering employment, the number continuing with further education, and those unemployed or who dropped out of the labour market.

In Belgium, 6 in Denmark, 8 in the Federal Republic of Germany, 11 in France, 2 in Greece, 6 in Ireland, 9 in Italy, 6 in the Netherlands, 6 in Spain and 11 in the United Kingdom. These were distributed within four main sectors: 18 manufacturers of information and communications equipment, 13 software and consultancy organisations, 17 IT users within other economic sectors (e.g. government), and 21 education/training institutions.

Users were divided into; IT manufacturers, software houses and consultancies and other IT users.

The 21 education or training institutions visited, comprised 11 traditional universities, 8 technical institutions, 1 industrial research association, and 1 national training authority. The main scientific/technical departments of relevance to IT were visited.

The majority of staff employed by the software houses and consultancies were highly qualified while the levels within the IT manufacturers varied, relative to the grading and the number of technicians.

The Technical Change Centre et al., op.cit., p. 39. The number or percentage of companies who reported this quantitative demand is not indicated.

Ireland is quoted as an example where the number of graduates in electronics engineering and computer science far exceeded demand, as quoted in The Technical Change Centre et al., p. 60.

"Available labour may be overestimated because not all suitable graduates seek employment in IT occupations. Supply may also be overestimated because increases in demand are not concentrated in junior posts appropriate to those first entering the labour market". The Technical Change Centre et al., p. 61.

"Evidence from Germany, Denmark, and the Netherlands showed that there were substantial shifts in employment and professional structure which could not be captured adequately by available statistics". Ibid, p. 63.

They also recommend (a) further studies on the processes which most centrally influence the supply of labour and (b) in-depth studies into manpower planning for highly qualified manpower in Information Technology. For Higher Education, recommendations include: improving curricula and increasing concentration on technical knowledge. The authors also recommend that university staff in new technology subjects should spend some time in industry or in consultancy work, and suggest the establishment of tripartite schemes (backed by universities, employers and unions, and the EC or government agencies) to improve and facilitate the flow of competent graduates into IT related employment. Technical Change Centre et al., op.cit., pp. 71-75.


Software production and software services are of paramount importance in the development of IT because of their complementary role to the functioning of any computing equipment.

Mr. J. Dégimbe is Director General of DG V, the Directorate General for Employment, Industrial Relations & Social Affairs.
A paper is also included by Dr. A.J. Hingel on Social Change in the Software and Computer Service Industry, Overview and Introduction, 1986.

Ibid. p. 32.

Belgium, Denmark, Germany, Italy, The Netherlands and the United Kingdom had no available official statistics on employment levels.

Hingel, op.cit., p. 36.

No indication is given of the personnel type (e.g. programmers or analysts) or numbers required.

Ireland was an exception, in having more qualified trainee programmers than the computer industry could absorb. The reports on Germany and Italy made no reference to a skill shortage. According to the Greek report; "one of the most serious problems for the future growth of informatics in Greece was the acute shortage of properly trained and experienced computer personnel (Degimbe J, op.cit., p. 82)". The report on the Netherlands pointed to the shortage of "automation experts" (Degimbe J, op.cit., p. 102).

Dansk Databehandlingsforening, EDB-branchens hoved-problemer. Denmark, 1983, p. 8. The approach/methodology used by Dansk Databehandlingsforening is not indicated.

SYNTEC Informatique: Rapport sur les besoins en informaticiens des SSII (Report on Software/Systems house information worker requirements, Paris 1984). The survey was carried out in 1984 on the demand for computer specialists. The results revealed the yearly number of graduates with higher level university education (A-level plus 4-5 years third level education) as being 20% below the need of the software and services industry in France.

Electronic Equipment Sector Working Party, Real Time Software, R & D in the UK, NEDO, (UK), 1982. The report was based on an interview survey in eleven companies covering 4400 software staff.


Systems project managers, systems designers, systems engineers, systems analysts, systems programmers, installation engineers, installation technicians, maintenance hardware and software technicians and operators. CEC, Social Europe (Degimbe), op.cit., p. 115.


Value added networks in France can be equally regarded as databases in the UK.

The defined functions of a programmer in Germany can be equally attributed to a systems analyst in Belgium.

Essentially, these skills combine three areas; technical skills specific to the technology in use, business skills related to a company's products, markets, and working methods, and social skills covering interpersonal communication skills. CREATE, p. 108.

IRDAC's role is to advise the Commission in the preparation and implementation of Community policy with regard to industrial R & D, including the industrial and social impact thereof. Set up in 1984, IRDAC consists of more than 20 members, all having substantial experience in industrial R & D.

Directorate General XII (Science Research and Development) of the Commission of the European Communities.

Directorate General XIII (Telecommunications, Information Industries and Innovation) of the Commission of the European Communities.

IRDAC, op.cit., p. 1.

Ibid. p. 1.

75 A comparison between countries in the Far East and Europe showed the former to have a much better demographic pyramid than Europe. They will thus be in a much better position to compete, having a much younger and cheaper work-force.

Working Group.

IRDAC, op.cit., p. 13. Extracts are quoted from six national studies (Denmark, France, Germany, The Netherlands, Portugal, and the UK). The following elements are, however, excluded: 1) the source of the studies (titles, authors, and when published), 2) the number of participants considered in the survey sample; 3) the group profile is not defined; (unskilled, skilled workers, managers and administrators).

MERIT (for IRDAC) forecasted the demand for scientists, skilled people and engineers in seven Member States; Denmark, Greece, France, Italy, the Netherlands, Spain and the UK. No further details are given as to the content and findings of this study in the IRDAC report.

Other sectors covered by IRDAC not discussed in this study include: biotechnology, materials and industrial technologies, aeronautics and the service sector.

IRDAC op.cit., p. 23.

"A continuing high rate of technical change in electronics-related industries, as well as in a wide range of applications. The convergence of a range of technological developments means that the power to communicate, process, control and store information is still increasing very rapidly at a price that continues to fall.

The capability to improve the quality of products, processes and services, as well as the development of completely new processes and services.

The capability to link up networks of component and material suppliers with assembly-firms (e.g. motor-car industry) or with service firms. Such links permit savings in inventories, and a more rapid and sensitive response to daily changes in consumer demand.

Much greater flexibility in rapid model changes and design, which makes small production runs more economic and thus improves the prospects for small and medium-sized firms."


Ibid. p. 24, these shortages include VLSI designers, software engineers, and data communications professionals.

IRDAC, p. II.

Ibid. pp. I-IV.
Correspondents from all Member States except Luxembourg, participated in the EPOS network (New technologies and Social Change in Europe).


In countries like the Federal Republic of Germany, Denmark or the Netherlands, very detailed classifications were available which incorporated twenty five to thirty headings.

The classification devised by the Belgian National Employment Office was rarely used. This classification comprised twenty eight professions and included a detailed description of each profession.

Sources varied from official statistics (which in any case in many European countries did not take account of IT occupations) to private studies.


These shortages were also cited by Mr P. Senker of SPRU (Science Policy Research Unit, University of Sussex) in his paper on "The Skills Implications for ICT (Information and Communication Technologies) for the EEC" presented at a conference on Information and Communication Technologies: Social Aspects - Impact on Employment and Training, held in Brussels on 17-18 October 1991.


This team brought together the Coventry-based Institute of Employment Research, the Paris-based Bipe Conseil and the Bologna-based PROMETEIA.

The team headed by MERIT brought together researchers from seven different EC countries, including Science Policy Research Unit (SPRU, Brighton), Centre D'Etudes Prospectives D'Economie Mathematique Appliquees a la Planification (CEPREMAP, Paris), Institute of Production (IKE, Aalborg), Wissenschaftszentrum (WZB, Berlin), and Institut fur Wirtschafts und Sozialforschung (IWS, Vienna), University College Dublin, Politecnico di Milano, and Associacao para o Desenvolvimento de Estudos Europeus e Africanos (ASEUROP Lisbon).


These are the results of their research into the different types of skill pyramids in Europe. MERIT identified three types of skills: basic, complex, and management and professional skills. Basic skills comprise general labourers, shop cashiers and porters. Complex skills lie between the basic and management-professional levels and consist of managers, supervisors, foremen and technicians. The professional layer contains engineers and scientists. MERIT drew up skill pyramids (1981-1986) to show the changing skill structures in various EC Member States (France, Germany, and the UK). Some sectors of IT industry were included (computer and organisational consulting, office machinery, electrical engineering, electronics as well as services (banking)). In each case, MERIT found a shift in favour of management and professional workers.


Ibid. p. 52. In 1990, some 30% of all employees in the industry possessed these skills.

IFO/MERIT, op.cit., p. 20; this is the only reference to a specific shortage in the report.
NACE is arranged on the decimal system and is subdivided into divisions (1-digit codes), classes (2-digit codes), groups (3-digit codes), sub-groups (4-digit codes) and items (5-digit codes).

The Technical Change Centre recommended that national employment data be harmonised and standardised under the supervision of the European Statistical Office (Eurostat). IRDAC (1991) called for the standardisation of data in order that skill requirements could be better understood (e.g. European and national authorities should develop consistent and comparable approaches with regard to data collection and forecasting).

Conclusions of the Conference on "Higher Education and 1992: Planning for the year 2000", University of Siena, Italy, 5-8 November 1990, p. 6. The conference was organised by the EC Commission and the Italian Ministry of the University and of Scientific and Technological Research, in cooperation with the European Parliament.


In some Member States, many young people continue upper secondary level education one or more years after finishing school at 18.

International Standard Classification of Education, higher education (ISCED levels 5, 6, 7,) comprises universities and all other types of higher education.

The success of the IT industry depends to a great extent on the availability of skilled manpower. In the IT area, the period between new idea breakthroughs and maturity, or obsolescence, may be less than two years. Thus, industries need to adapt quickly. Shortages of manpower can be related partly to output from higher education. This chapter looks at the importance of education and training (E & T), and the relationship between higher education and industry, and examines a selection of available literature on education and training, in order to establish the type of education and training needed by Europe’s IT industry.

1. The importance of education & training

Education develops the ability to think, relate and appreciate. Training is the directing of that ability to the mastery of specialised knowledge. This study looks at education and training at higher level.

The link between the size and quality of a nation’s workforce and its economic wealth is well established. Since the industrial revolution, in particular, productivity has been linked to a skilled and educated workforce. In 1776 Adam Smith pointed out that "the skill, dexterity, and judgement with which the nation’s labor is generally
applied", is the primary determinant of "the fund which originally supplies it with all the necessities of life".\textsuperscript{2}

In 1868, a British parliamentary committee, charged with investigating the causes of rapid industrial growth in the United States, attributed much of America's industrial success to the superior education of the American worker.\textsuperscript{3} Subsequently, the Devonshire Commission (1872-1875), investigated scientific and technological education within universities, and concluded that the output of graduate scientists and engineers was inadequate, that "the present state of scientific instruction in our schools is extremely unsatisfactory", and that this situation was likely to have serious consequences for "the material interests of the country".\textsuperscript{4} Perhaps the most important of these nineteenth-century investigations was the Royal Commission on Technical Instruction (the Samuelson Commission, 1882-1884), which explicitly linked economic performance and the education system. The Commission concluded that other industrialised nations were adapting better to technological and structural change, and that in Britain, part of the problem lay in the relatively low importance given by the state to education and training.\textsuperscript{5}

The 1920s brought more studies on the role of education. A penetrating study by the Cambridge economist, Alfred Marshall, entitled \textit{Industry and Trade}, emphasised the role of education. Marshall believed that, in general, British industry was still the most efficient in Europe, but foresaw that Germany's system of education and training was likely to give it an increasing advantage in the more technical and scientifically based industries of the future.

Each new decade has brought further reports and studies emphasising the role of education and training.\textsuperscript{6} Kari Kairamo and the Round Table of European Industrialists in \textit{Education for life a European strategy} (1989) expressed the view that "a competitive advantage can be gained by raising employees' level of education and thus their competence.
Skilled and well-educated people are seen as vital for success. Another major contribution was made by Michael Porter in *The Competitive Advantage of Nations*. In Porter’s view, the main economic goal of a nation is to produce a high and rising standard of living for its citizens. The ability to raise the standard of living depends on productivity, defined as "the value of the output produced by a unit of labour or capital". As to where the competitive advantage of nations lies, Porter lists four factors which promote or impede the creation of competitive advantage, namely: 1) factor conditions, 2) demand conditions, 3) related and supporting industries and 4) firm strategy, structure and rivalry. Factor conditions include manpower, infrastructure, the scientific base, natural resources and climate. Porter explains that having a generally educated workforce does not necessarily bring advantage; a supply of people with relevant skills does. Following research in ten countries, Porter confirms that education and training are the single greatest long-term leverage point available to all levels of government in upgrading industry.

The European Community has been consistent in underlining the importance of education and training. Jean Monnet, one of the founders of the EC, said many years after he had begun the construction of the Community: "If I had to do it again, I would start with education. Only a Europe of learning will ensure that we have the human resources which survival and prosperity will increasingly demand". In 1988 the Commission expressed the view that "systems of education and training must contribute to the Community’s economic and social cohesion. A Europe which fails to invest in its human resources, in its skills, in its adaptability and in its entrepreneurial spirit will find that its capacity for innovation, its competitiveness and its ability to create wealth and prosperity have been undermined". Education and training achieved greater prominence in the IT era, as new needs and opportunities were recognised. A workshop in Brussels in March 1981 on
the potential of Information Technologies for job creation reported that the satisfactory functioning of an information society could not be achieved without considerable effort from the educational system.  

2. Higher education and industry - relationship

Cooperation between higher education and industry is not a new idea. In some countries, it has been a feature of many universities and colleges since their foundation. In 1958, the President of Johns Hopkins University, observed that "higher education and business are basically interdependent. One needs money to produce educated people and the other needs educated people to produce money". The pressures in the early 1980s gave great impetus to the improvement of cooperation between industry and higher education. In March 1987, the UK Council for Industry and Higher Education published a report entitled Towards a Partnership: Higher Education-Government-Industry. The report argued that the UK’s prosperity and vitality depended upon its becoming a more highly educated nation. Next day, the UK Government’s White Paper Higher Education: Meeting the Challenge was published. The White Paper stated that higher education should aim "to serve the economy more effectively, to pursue basic scientific research and scholarship in the arts and humanities, to have closer links with industry and commerce and to promote enterprise". The nature of the technological skills needed and their fast rate of change meant there was no way in which companies, either individually or collectively, could meet the challenge through their own efforts. As a result, industry sought new ways to tap expertise in higher education, while higher educational institutions began to think more positively about their relations with industry. A wide variety of cooperative efforts developed. Some were research-oriented. Some were limited to the sale of courses, and
some involved participation in courses, including the exchange of personnel. Examples of the partnerships forged include, in the UK, Manchester University and ICL, and Portsmouth Polytechnic and IBM. In France, the Institut Universitaire de Technologie of the University of Angers is one of the many higher education bodies offering courses in electronics, where one third of the teaching is carried out by university staff, one-third by staff of research establishments and one-third by industry.

Although initial UK Government motives for encouraging higher-education cooperation links had to do with improving the quality of education and increasing national prosperity, financial considerations also played a role. In 1991 the Department of Education and Science noted, in Higher Education: A New Framework, that "the Government believes that it is in the interest of universities, polytechnics and colleges to continue to look for increased levels of funding from private sources, in particular from industry and commerce, from benefactors and alumni, and from present sources of fee income. Such private income can enhance considerably the independence of individual institutions". More recently the EC, in its Memorandum on Higher Education in the European Community, called on Member States to "provide the framework for cooperation in their higher education policies and also to adopt fiscal policies which would stimulate investment by companies in training and research and development in partnership with higher education". Williams believes the fundamental underlying reasons for closer links between higher education institutions and industry go beyond the short-term financial benefits of the relationship.

The importance of maintaining cooperation between higher education and industry was underlined by the Commission in its 1992 report on European Higher Education-Industry Cooperation. In the report, higher education institutions are advised "to adopt cooperation with industry as part of their fundamental mission, especially in the continuing
training field". Companies are called on to "undertake an explicit education and training strategy as well as an organised interface with higher education which will encourage and facilitate access and dialogue".27

2.1 Benefits of cooperation

Benefits to industry include access to knowledge, facilities, and expertise in higher education, privileged access to high-quality potential recruits, an opportunity to influence the content and quality of higher education courses and cooperation possibilities with foreign higher educational institutions. For academics, cooperation offers new outlets for their talents and opportunities to learn about the latest developments in industry and to develop marketing skills. Other benefits include additional resources; regular and direct feedback on business needs; improved coordination of training supply and demand, and cooperation possibilities with foreign companies.

2.2 Barriers to cooperation

Weimer identified communication as being the "single most important element in developing any cooperative effort".28 If there is good communication between education and industry, the needs of both will be easily identified and cooperation can take place.

Unwillingness to change can, however, make cooperation difficult. Universities may sometimes, for example, be unwilling to run short courses which would better suit the needs of industry.

The absence of appropriate higher education personnel to bridge the gap (attitudinal and operational) between the academic world and industry was seen as another obstacle to effective cooperation at a workshop on training needs convened by the EC Commission in 1988.29

If higher education-industry cooperation is to thrive, it must be based on a clear understanding of the nature of
higher education and business. Partners must respect the differences in the primary functions of each side.30

3. Education and training requirements of Europe’s IT industry.

Chapter V ("IT Skills, the position in Europe") provided evidence of skills shortages. Systems software manpower, engineers (microelectronic, software design and VLSI design) and manpower with hybrid skills were mentioned as being in short supply. These skills are in principle acquired at third level, i.e. first degree level or higher, although some workers become qualified by combining study with work experience. In the context of the present study, those possessing these skills are described as professional IT manpower.31 A representative selection of available literature on education and training is examined below, with a view to obtaining information on the type of education and training required by Europe’s IT industry.

Literature on skill shortages, also covering education and training (e.g. the IRDAC report Skill Shortages in Europe) makes broad recommendations. The IRDAC report calls for "a massive investment in upgrading the existing workforce",32 meaning "a reassessment of educational policies and priorities with increased emphasis on continuing education..."33 University curricula "should be sufficiently broad and guarantee that graduates have sufficiently flexible attitudes and skills".34 On "improving educational productivity", the recommendations are too broad to be of any great value.35 For distance learning, they state that "a large structural effort in distance and flexible learning is required in Europe",36 but the authors do not elaborate on what this structural effort would involve.
Literature on education and training includes the IRDAC report *School and Industry.* This report calls for the setting up of a school/industry interface, and outlines the issues to which school/industry links should be addressed. The latter are listed but are not adequately explained. And while IRDAC recommends "raising the overall level of technological literacy", the means of raising technological literacy via education and training are not discussed.

*Visions and Scenarios for Education and Teacher Training*, compiled in 1987 by the Council for Educational Technology (CET) for the Commission's FAST (Forecasting and Assessment in the field of Science and Technology) programme, is slightly ahead of the IRDAC report in its approach. The report attempts perhaps to cover too many subjects, and only in Chapter VIII are education and training covered. Skills necessary for the future are identified as "a sound understanding of information processing and retrieval", and the authors highlight the need for investment in equipment for educational institutions; the need for research and development in the processes of learning, including at teacher education institutions; and the need for sharing of know-how at the European level. Kairamo's *Education for life; a European strategy* investigates the different levels of education and training in Europe. To meet company needs in higher education, universities are called on "to develop and implement continued education in close cooperation with industry" and "to produce flexible engineers with good knowledge of basic technology, capable of dealing with changes and new challenges".

Much of the literature on Information Technology and education concerns the impact of IT on the latter in terms of newly available tools, rather than how students should be educated in IT disciplines. There are, however, some reports on educational and training needs. Thus, the ISCOL report attempted to identify such needs for the microelectronics and software sectors: "microelectronics
technology results in the integration of the elements of a production process and of the information systems of organisations. The knowledge and skills required when dealing with such integrated systems cut across traditional knowledge and skill boundaries. For example, microelectronics-based process control systems may incorporate mechanical, hydraulic, electrical and electronic elements. The design and operation of such systems requires basic understanding of all these specialities, in addition to specialist knowledge appropriate to the particular industry. "46 For the software sector, ISCOL relied on the UK NEDO report on Computer Manpower in the 1980s.46 NEDO underlined the need for courses taking a more conceptual and user oriented approach to computers, and found that the creation of an informatics institute would be beneficial.

The 1986 UK report on Information Technology: The National Resource; A Plan for Concerted Action states that many user organisations found existing computer science based courses inappropriate to the needs of their staff. The report called for courses combining "IT and business skills".47

The reports briefly examined here reflect industry’s concern at shortages of manpower. With the exception of ISCOL, and to some extent the Council for Educational Technology and the IT 86 Committee, their authors fail to focus on the type of education and training required by industry. Industry, however, can voice its opinion via involvement in EEC programmes.
NOTES

1 University or equivalent.


3 Report From the Select Committee on Scientific Instruction, Parliamentary Papers, 15, (1867-1868) Q 6722, cited by the Office of Technology Assessment, Ibid. p. 140.


6 The Educational Environments for the 1990s, this report finds that the poor performance of British industry in technological innovation is due to a general lack of emphasis on scientific education and training, and to an overriding emphasis on fundamental science and basic research at the expense of applications-oriented technology. Duke, J., Management Education & Training Consultancy, Surrey, 1983.

Maddison (1983) highlights the scant attention paid to education in microelectronic literature and cites the first industrial revolution; "it is generally recognised that the failure of the educational system to meet the demands, human and economic, of industrial change worked eventually to the great disadvantage of Britain and her position in the world". Maddison, J., Education in the Microelectronics Era. The Open University Press, Milton Keynes, 1983, p. 20.

The CEDEFOP (European Centre for the Development of Vocational Training) study in 1986 linked productivity to the available stock of skills and found that if the appropriate skills for the implementation of modern production technology were not available, production processes with comparatively low productivity would be retained and inhibit the growth in output per worker. It found also that "a highly qualified labour force was better suited to influence productivity positively than less qualified manpower. Although a greater amount of training was more costly, the investment would yield a more economical use of human capital". CEDEFOP, Relation between Education, Employment and Productivity and their impact on Education and Labour Market Policies - A British - German Comparison, Berlin, 1986, p. 63 and p. 72.

7 The European Round Table of Industrialists established in 1987 a standing working group on education to identify the main problems related to European education and training from industry's point of view. A summary of the findings of the study was published in 1989. Kairamo, K., Education for life: a European strategy. Butterworth Scientific in collaboration with the Round Table of European Industrialists, London and Brussels, 1989.

8 Ibid. p. 1.


10 Nations are competitive in industries whose domestic market is competitive.

11 Firms and their suppliers have the same home base. Porter gives, as an example the Italian leather footwear industry

12 Sustained investment and an effectively functioning market for risk capital are necessary.


15 The workshop was organised by the FAST programme (DG XII Science Research & Development), and took place on 3-4 March 1981.


17 Growing technological change and economic pressures for industry.


20 Various means of cooperation were identified by W. Weimer of SEFI (European Society for Engineering Education) Belgium, in the report Collaboration in Continuing Engineering Education, series of occasional papers 1, Helsinki University of Technology, Centre for Continuing Education, Helsinki, 1988, p. 14. The means of cooperation identified include:

  1) Industry purchases courses or classes from education. 2) Industry purchases curricula development or course development. 3) Joint projects to develop courses or curricula. 4) Joint research projects. 5) Exchange of sabbaticants, in either direction. 6) Purchase of consulting services, in either direction. 7) Industry purchases consulting or courses on pedagogy. 8) Joint development of research or teaching networks. 9) Participation of an academic on an industrial academic board. 10) Industrial employees attending a university or other educational institution. 11) Industrial employees teaching in academia as faculty or adjunct staff. 12) Industrial retirees joining faculties.

21 ICL's links with Manchester University have led to sharing staff. Since 1985, a member of ICL's staff has spent half his time as Professor of Software Engineering at the University, and the other half as senior research fellow at ICL.

IBM has been involved since 1988 in a joint degree course with Portsmouth Polytechnic. IBM recruits the students for the course, with advice from the Polytechnic, and pays them a salary for three years while they study. The study is partly at the Polytechnic, partly at IBM's own training centre and partly on the job at IBM. IBM is also involved in a Master's programme in computer integrated manufacturing with Strathclyde University, with teaching taking place at the IBM Greenock plant.


22 The Universities of Nancy and Grenoble in France and the University of Kiel in Germany are among those universities offering courses involving industrial participation.

23 Mattison, op.cit., p. 29.


The kinds of communication seen as appropriate by Weimer include: "industry participating in academic reviews and education participating in industry education reviews and planning boards," (p. 15).

29 The workshop was convened by the European Commission and held in Brussels on April 5-7 1988. It discussed the "Training Needs of Higher Education Staff in the Community collaborating with industry, and the establishment of a Community-wide network to facilitate collaborative ventures". The report of the proceedings and recommendations of the workshop was prepared by European Research Associates. The report identifies the training needs of "Liaison Executives" in higher education and industry. "Exploitation of higher education resources is seen as being too vital for the Community's future economic prosperity to be left in the hands of personnel who have not been properly trained to effect this exploitation" (p. 8). The uniqueness of the position of the liaison executives placed between Academe and Industry, and facilitating the links between both sectors, necessitated the provision of training specifically geared to their needs.

30 The primary function of higher education may usefully be defined as the advancement of learning through teaching and research, whereas the primary function of business is to achieve business success and profitability through the sale of products and services.

31 The term "professional IT manpower" is used to describe people employed at graduate level or equivalent, whose main activity is associated with the development or application of IT and includes both IT graduates and experienced IT manpower.


33 Ibid. p. II.

34 Ibid. p. II.

35 IRDAC calls for "improved productivity of education and training wherever it takes place. The European Community should foster educational research and experimentation into effective ways of using information and communication technology in order to obtain the required improvements" p. 44.

36 Ibid. p. III.


38 "strengthening vocational/technical elements in the curriculum, developing the teaching of new technologies, improving teaching methods and links with guidance, increasing integration of education and training in the workplace and working life, and developing continuing education and training."

The first seven chapters discuss a very wide range of topics: the breadth of social change (demands caused by multiculturalism), the impact of NICT (New Information Communication Technologies) education tools, the importance of NICT for the economy, employment and unemployment, and the scenarios put forward by various authors concerning technology and the demand for greater learning skills.

Gwyn, op.cit., p. 56.

Kairamo, op.cit., p. 92.


Ibid. p. 9.

Computer Manpower in the 1980s. NEDO (National Economic Development Office), UK.

1. The EC and IT: early days

What role has the European Community played in the field of education and training? At first, little thought was given to education. International lawyers were unable to agree on whether the EC could take action in the field of education, or whether this was precluded by the Treaties establishing the Community. Although the Treaties did provide for certain forms of training, it was only in the early 1970s that a Community cooperation policy in education was drawn up.

In January 1973, education was included for the first time in the special responsibilities of a Commissioner (Ralf Dahrendorf), and a new Directorate for Education and Training was created (DG XII; Research, Science and Education). In February 1973, Professor Henri Janne, a former Belgian Minister of Education, presented a report to the Commission entitled Towards a European Education Policy. Professor Janne had been asked by the Commission to look into the feasibility of an EC education action programme. Over a year later, the first outline of such a programme, entitled Education in the European Community, appeared. Presented by Commissioner Dahrendorf, it stressed the need to develop cooperation in the field of education and to promote a systematic exchange of information.
June 1974, the Ministers of Education, meeting within the Council for the first time, adopted a resolution on education policy, and in February 1976 an action programme on education was adopted by the Council of Ministers. The initial thrust of the programme was to increase mutual understanding and promote closer relations between the different education systems of the Member States. It covered six topics: 1) better facilities for the education and training of nationals and the children of nationals of other Member States of the Communities and of non-member countries; 2) promotion of closer relations between educational systems in Europe; 3) compilation of up-to-date documentation and statistics on education; 4) cooperation in the field of higher education; 5) teaching of foreign languages; and 6) achievement of equal opportunity for free access to all forms of education.

The period 1976-1982 saw attention concentrated strongly on the links between education and social policy. From 1982 onwards, the programme was influenced by the need for policies to develop a European technological Community able to compete successfully with Japan and the USA. The ESPRIT programme, introduced in 1982, acknowledged the increasing importance of Information Technology in all sectors of the economy, as well as the relative weakness and fragmentation of European IT production. The need for professional IT manpower was identified as one important factor necessary for the success of Europe's IT industry.

A strategy of continuing education and training was seen by the Commission as essential to achieve the flexibility and adaptability of the workforce as required by IT. The Commission therefore proposed, and the Council adopted, a series of measures in the training field. Measures were also proposed on the introduction of new information technologies (NITs) in education. As these measures were, however, aimed at secondary and vocational education, third level education remained untouched. Since universities and higher education institutions are chiefly responsible for
providing the initial and mid-career training of engineers and researchers, action on a European scale was necessary, given the increasing demand for IT manpower. This need was recognised, and in March 1985 at the European Council meeting the importance of strengthening the technological base and competitiveness of industry was emphasised. The Council underlined the need to make better use of human resources, in particular by means of increased cooperation between higher education and industry. The Commission, in announcing its work programme for 1985, stated its intention to present proposals to the Council in Summer 1985 for strengthening cooperation between universities and other higher education institutions on the one hand, and industry on the other, so that the Community might better respond to the challenges posed by technological and social change. The purpose was to improve the initial training of undergraduate and post-graduate students, and to foster continuing training of skilled technical and managerial staff, so that European firms could apply modern and efficient equipment and production processes. The Commission’s proposal was sent to the Council in August 1985. The core message of the proposal underlined the need for Europe to generate stronger technological cooperation in order to renew its competitive strength. The Commission and the Council have already agreed on the necessity to exploit the potential which is there, by means of a substantial commitment to scientific and technological research. This substantial commitment must be matched by an equally vigorous policy of investment in the Community’s human resources. The result was a new Community action programme known as COMETT (Community Action Programme for Education and Training for Technology), approved by Council Decision on 24 July 1986.
2. The structure of COMETT

The COMETT programme is intended to last until 1994. The Council Decision of July 1986 approved a preparatory phase (1986) and an operational phase (1987-1989). Phase II (1990-1994) was agreed by the Council on 16 December 1988. The principal objective of COMETT is to stimulate and strengthen cooperation between universities and other higher education establishments and industries in order to develop training in new technology and to respond to the needs of industry for qualified manpower.

COMETT II aims at reinforcing training in particular in advanced technology, and at developing highly skilled human resources. It is centred on the changing skill requirements of industry and its personnel, and is concerned with needs which can and should be met through cooperation at European level. COMETT assures the development of high level human resources as a complement to the Community's broader technological programmes, such as ESPRIT.


The structure of COMETT contains four main operational areas (known as Strands). Strands are relatively unrestricted in their coverage of different technological sectors. In COMETT I, over 20% of the projects supported were in Information Technology (c.f. Appendix XII). Details of the sub-areas supported within IT and other sectors are provided in Appendix XIII. Each project supported involves at least one university and one enterprise.

2.1 Strand A: Development of University-Enterprise Training Partnerships (UETPs)

The purpose of Strand A is to develop the infrastructure for the COMETT programme as a whole. This Strand is designed to
foster the development of University-Enterprise Training Partnerships in the framework of a European network. UETPs are cooperative initiatives between universities and enterprises, providing a focus for dialogue and action on skills and training requirements. These organisations collaborate to meet the specific needs for qualified personnel. Activities include the organisation of student placements in companies, the exchange of personnel, trainees and trainers, the organisation and delivery of training courses, and the dissemination of information. The latter includes direct visits to members and potential partners, regular mailings, the issue of brochures and the organisation of information days. Some UETPs have undertaken market studies to be able to respond better to training needs and to support training strategy. UETPs may be regional, sectoral or mixed.

Regional UETPs bring together groups of universities and enterprises, within a particular geographical area, to engage in a joint training venture, with a significant impact on training efforts within the area. EUROTEAM - East Midlands UETP is an example of a regional UETP which brought together universities and enterprises in the East Midlands to meet the training needs for highly qualified personnel (project 1542).

Sectoral UETPs are partnerships of a transnational character within a given technological field or an industrial sector, bringing together organisations specialising in that field to order to improve training. An example of a sectoral UETP is the Association for Enterprise Development and Innovation (Asociacion para el Desarrollo Empresarial y la Innovacion) in Spain, which developed close links between universities and enterprises towards training in the field of advanced technology (project 686).

Mixed UETPs have a specific sectoral scope, but are limited to a national, regional, or even local base.

COMETT I UETPs varied enormously in the way in which they
were organised and operated. Some operated on the basis of written agreements between partners, others were legal associations or organisations, and a certain number were non-profit-making companies limited by guarantee. At the UETP conference held in October 1989, a number of discussions took place to determine if it was possible for the Commission to establish a definite model for the operation of a UETP. Given the different regional and sectoral situations, it was decided that no single model for UETPs could be put forward; nevertheless considering the level of funds flowing through a UETP, a separate legal status (as an independent new association or as a company) was seen as necessary. The UETP network is seen as the backbone of COMETT, "being an essential carrier for the specific training actions and acting as a highly localised filter and catalyst for stimulating, executing, and evaluating university-industry cooperation both regionally and sectorally." 

Links between university and industry bring benefits to both sides. Industry gains access to knowledge, research and facilities in higher education. This enables companies, especially small and medium-sized companies, to avail of the expertise universities have to offer; without COMETT such access would be too costly. Higher education, on the other hand can learn from the latest industrial developments. COMETT I led to the establishment of 125 UETPs. A further 158 were approved in 1990, the first year of COMETT II, and in 1992 an additional 42 new UETPs were set up. Of the 125 UETPs supported in COMETT I, 9 were in the field of Information Technology (Data Processing, Software Technology, Expert Systems, Telecommunications), 7 concerned training in Microelectronics Technology (in particular Semiconductor Technology, VLSI and ASICs Design), 7 UETPs were in Advanced Manufacturing Technology (Automation, CIM, Robotics) and 1 was in Graphic Information Technology. The remaining UETPs were in non IT sectors.
2.2 Strand B: Transnational exchanges

Cooperation between higher education institutions and enterprises begins with the exchange of human resources. Strand B of COMETT was set up to foster exchanges between companies and universities in different countries. Strand B supports transnational exchanges of three types:

2.2.1 Student placements in enterprises in another Member State (Strand Ba),

These placements offer students a period of structured on-the-job training in companies located in an EC Member State other than that of their university of origin. The objective of the placements is "to familiarise the student with career prospects in the technological or technology-related or management field concerned, bring a European perspective to his/her training, and stimulate his/her entrepreneurial abilities". To be eligible for such placements, students must be either in the course of their university studies, registered at a university in a Community Member State, or new graduates, having just graduated from a university in a Member State of the Community. The duration of the placement varies between 3 and 12 months. Placements may be compulsory or optional. In the former case, the placement in an enterprise is a compulsory part of the student’s overall training, and is required to obtain a given diploma or degree. Optional placements, on the other hand, are not required for obtaining a diploma or degree, and the period of industrial training is considered as a complementary component of the student’s overall programme. To take one example, Project 2065 (1989) a Strand Ba project, gave technology students from Plymouth Polytechnic in the UK a European dimension to their studies by enabling them to obtain practical industrial experience in French and German engineering companies. The engineering disciplines involved were electrical and electronic engineering, communications engineering, engineering systems, mechanical engineering and...
Over the three years of COMETT I, a total of 4,298 student placements were achieved. The breakdown by year was 1,067 in 1987, 1,240 in 1988 and 1,991 in 1989. In 1990 a further 246 projects were accepted, which resulted in a total of 3,731 student placements. In 1992 the number of transnational student placements substantially increased and 6,816 placements were accepted for Community support.

2.2.2 Placement of qualified persons in enterprises in another Member State to undertake an industrial project (Strand Bb),

These placements are known as advanced training placements and were first introduced in COMETT II. Participants must be undertaking work at advanced level, i.e. initial university training must have been completed and the student must be pursuing activities at the most advanced training level. An industrial project is organised for the student by the receiving enterprise. The duration of the placement is between 6 and 24 months. 13 such projects were accepted in 1990, one involving the integration of a Spanish postgraduate student in a UK engineering company, to work in the robotics sector.

2.2.3 Fellowships for university staff seconded to enterprises in another Member State or for the staff of enterprises seconded to universities in another Member State (Strand Bc).

The objective of these secondments, as defined in the Application Package 1986/1987, is for university staff "to extend their practical experience of enterprises in a European context, participate in training activities, enrich their teaching activities, and build up possibilities for subsequent cooperation". The staff of enterprises can share in teaching responsibilities, contribute to the diversification of teaching activities, benefit from
continuing education, and assist in developing links with enterprises".\textsuperscript{39} It is expected that the increased mobility of enterprise and university personnel within the Community will facilitate the transfer of technologies and improve technological training, making workers more mobile and adaptable. The Development of COMETT I\textsuperscript{39} describes in detail the advantages of placements. The report notes that "certain fellowships contributed significantly towards developing university-enterprise relations".\textsuperscript{40} Thus, some of the results in the development of training activities were subsequently submitted as projects under Strand C of COMETT.\textsuperscript{41}

To be eligible, staff should have at least 5 years previous employment experience relevant to the work programme for the fellowship. Fellowships may be for a minimum of 2 months or a maximum of 12 months. In the four rounds of COMETT I, 221 projects were accepted, and 232 fellowships awarded.\textsuperscript{42} 66 projects were approved in 1990, enabling 94 staff members to have an advanced training secondment in an organisation abroad.\textsuperscript{43} In 1991, 124 applications were accepted for support, and 89 persons were able to participate in exchanges in the different Member States.\textsuperscript{44} In 1992 a further 124 personnel exchanges were accepted.\textsuperscript{45} To take one example, project 2058\textsuperscript{46} involved the placement of a Fellow from the UK Technological Educational Institution in an IT company (Ilford UK) for training in the field of computer-aided graphic design and electronic publishing.

2.3 Pool schemes

Pool Schemes were introduced in 1988, allowing COMETT university-enterprise partnerships to receive from the Commission a "pool" of grants to be allocated flexibly over the ensuing academic year. Initially designed for student exchanges only, the scheme has since 1991 been extended to personnel exchanges and the organisation of courses. The pool scheme is intended to facilitate the work of UETPs.
2.4 Strand C: Joint projects for continuing training in, in particular, advanced technology and for multimedia distance training

Strand C was conceived to provide financial aid for joint university-industry projects for continuing training in technology and multimedia distance learning. Professionals need to update their specific skills frequently. Initial professional education must therefore be complemented by ongoing training, in order to keep personnel in enterprises and universities at the forefront of development during their whole professional career. Strand C responds to these requirements by promoting the adequate means for ongoing training. Projects within this Strand, concern technologies which have a significant impact on industrial development throughout the Community. The projects are directed at the training of staff responsible for innovation development in industry, including training officers.

There are three types of projects:

2.4.1 Strand Ca: Crash training courses.

Strand Ca provides financial support for crash training courses with a European dimension in technology (particularly advanced technology). These courses are designed for the rapid dissemination of research and development results in the field of new technologies and their applications. Project 3122 provided funding for an intensive training course for twenty people (70 teaching hours) on CMOS ASIC design (training in semi-custom design using Computer Aided Design tools). The course was organised in 1990 by the University of the Balearic Islands in Majorca.

2.4.2 Strand Cb: Joint training projects.

In comparison with courses supported under Strand Ca, joint training projects under Strand Cb are more substantial in scope and duration. Projects may comprise training
materials or training courses, or both. Training materials comprise all types of outputs produced to transfer know-how on given topics; for COMETT these topics are technology-oriented and relevant to the user of the material. Examples of training materials include documents, books, video-cassettes, audio-cassettes, training and simulation software. A training course has to have a European dimension involving a European partner, and has to address, in particular, advanced technology. Thus, project 3960 provided European industrial engineers with advanced short courses in the latest CAD/CAM applications, including the development of multimedia teaching materials based on the lecture notes.

2.4.3 Strand Cc: Pilot projects

Joint training projects in this area are intended to support multi-media training systems using new information and communication technologies. The objective is to enhance the development of open learning and distance-learning systems at EC level. Organisations submitting applications in 1990 under Strand Cb were given the opportunity to indicate if they wished their proposal to be considered for possible development as a pilot project. These pilot projects are similar to Strand Cb (joint training projects), but are of a more substantial nature, and more limited in number (27 projects in all) than the joint training projects. They also have a longer time scale and are funded at a higher level. There are four categories of projects:

(1) those which focus on European skills and qualifications in a specific technological sector. The AMES project (Advanced Microelectronics Educational Service) brings together organisations from Belgium, France, Germany, Portugal, Spain and the UK to develop and disseminate self-learning packages in the field of microelectronics.

(2) Projects to develop close and continual cooperation between industry and universities. Through EUROPIC (Manufacture of Microelectronic Technology), higher
education institutions and industry in France, the UK, and the Netherlands are developing a European training programme in the manufacture of integrated circuit technology. The programme is particularly targeted at advanced technicians, engineers and trainers. One of the objectives of the partnership is to build a network in at least three European countries, stimulate collaboration between industry, universities and SMEs and so fulfil their training needs in skills and technology in the area of Integrated Circuit manufacturing.

(3) Projects to support appropriate industrial training programmes for SMEs (Small and Medium Sized Enterprises); the self-learning packages set up under the AMES project are to meet the needs of SMEs in the field of microelectronics.

(4) Transfer projects, which focus on the transfer of qualifications, skills and methodologies; here APEC (Advanced Production Engineering Continued Education) is a unique partnership of universities, enterprises and engineering federations throughout Europe. The partnership is developing and testing six course modules which will comprise a European continuing education programme in Production Engineering developed for distance learning. Universities participating will evaluate the possibility of student and personnel exchange with industry on a transnational basis. Engineering federations and enterprises will also promote the exchange of students and personnel.

Under COMETT I, 329 joint continuing training projects and multinational initiatives to develop multimedia training systems were supported. In 1990 a further 124 Strand Ca projects, 192 Strand Cb projects and 27 pilot projects were accepted. In 1991 there was no call for application for joint training projects or for pilot projects. In 1992 applications were received for nearly 3,000 short training courses, of which 1,400 were selected for Community funding.
2.5 Strand D: Complementary measures

This element is intended to assist the Commission in promoting the exchange of experience and ideas throughout the Community.

Activities include support for pre-project visits or meetings; structural exchange of information and experience particularly through the creation of COMETT Information Centres linking projects by electronic mail; and continuing evaluation of the programme.

Community funding under COMETT is, with some minor exceptions, allocated on the principle of cost-sharing between the Community and those undertaking the project. The Community also specifies the maximum amount which can be provided for each project. Projects are submitted by applicants in response to a call for proposals. Applications are then considered by the Commission on their merits and assessed in terms of their potential in meeting the objectives of the COMETT programme.

The Task Force for Human Resources, Education, Training & Youth (TFHRETY) is responsible for the implementation of the programme. It is assisted by a COMETT committee, Expert's Group, Technical Assistance Office and Information Centres.

3. COMETT's achievements

COMETT's most significant achievement is the building up of a base for cooperation in training between higher education and industry. The large number of applications show that universities and industries are anxious to participate in the creation of this base. During the three years of COMETT I (1987-1989), more than 5000 projects were submitted. In 1990 a further 2,300 projects were submitted (including
156 projects from the EFTA countries), and in 1991 414. The 1992 report on the results of COMETT I (COMETT Catalogue of Outputs) provides key information: "more than 1200 training courses provided more than 56,000 training hours and reached over 30,000 highly qualified staff throughout the European Community".

It is difficult to measure the value and effectiveness of placements, fellowships, and courses for organisations, considering that most of the documentation produced by the Task Force and the COMETT Technical Assistance Office is descriptive, showing the popularity and impact of the programme in terms of the number of placements, fellowships and courses supported. These COMETT reports include the Final Report of the Commission on COMETT I, the Report of 1990 Activities, the Report of 1991 Activities and the COMETT Catalogue of Outputs (1992). In addition to these internal reports, COMETT has been subject to two external evaluations. The first evaluation of COMETT I was carried out by a joint team from Coopers & Lybrand, C&L Belmont and the Science Policy Research Unit at the University of Sussex. The evaluation commenced in December 1988 and a final report was presented in April 1989.

The terms of reference for the evaluation required the consultants to carry out:

"an evaluation of the methods and procedures for implementing the COMETT programme; an evaluation of the development of the COMETT I projects selected in 1987 in the light of both the general and the Strand-specific objectives of the programme; and an evaluation of the initial impact of the programme".

A postal questionnaire was mailed to all 1987 project participants. In-depth case studies were also carried out. Conclusions were, on the whole, very encouraging. The consultants found that many projects would not have been possible without COMETT. The study confirmed that "COMETT had exercised a powerful influence in alerting the
educational sector and, to a lesser extent, industry to the benefits of training in a Community and cooperative framework". The evaluators highlighted the limited industrial involvement in the programme, and called for greater programme rationalisation in the design of COMETT II: "the next stages of the programme need to be more streamlined, and the programme needs to present a clearer and simpler image in order to encourage greater participation by industry".

In June 1990 the Commission issued a Call for Tender for a second external evaluation of the COMETT programme. This evaluation, conducted by ECOTEC research, resulted in a report to the Commission in August 1991. The evaluation covered the last two years of COMETT I (1988-1989) and the early stages of COMETT II (1990-1991). ECOTEC examined the performance of COMETT, focusing on such issues as its support for university-industry cooperation within the context of regional development in the Community, both through the creation of university-enterprise networks and within the sectoral context of industrial development and interaction with Community R & D. The authors praise COMETT's achievements, finding that "a high proportion of the projects examined in the study and undertaken within COMETT I had met their objectives." Commenting on the COMETT sectoral network, the report stated that "COMETT has helped establish a diverse range of sectoral UETPs which have promoted a high measure and variety of university-enterprise cooperation, particularly transnational cooperation". On skills needs, training and training products, the report concluded that the work of training needs analysis had helped improve communication between employers and university trainers. The transnational exchange of students was seen to have "contributed strongly to university enterprise cooperation and the development of transnational networks". However, ECOTEC noted the imbalance in student flows, and identified the need to encourage more placements in the less economically advanced Member States.
Three recommendations were made by ECOTEC to the Commission, the Governments of participant countries, and the UETPs. The Commission was advised "to give emphasis to the development of sectoral COMETT activity, particularly where this activity is responsive to the emergence of European-wide training needs in advanced technology", and "to assist the development of measures for improving the dissemination of Commission funded research and development through advanced technology training".

The Commission noted the observations of Coopers & Lybrand et al, and welcomed ECOTEC's recommendations. In 1991, the Commission launched a series of actions known as positive actions, the first task of which was to analyse the weaknesses in the development of the COMETT network and, on the basis of this analysis, to identify actions that would strengthen and enhance the regional and sectoral UETP network. Certain actions were implemented at European level while others concentrated on individual countries, where the positive actions aimed to identify structural and functional problems in the implementation of COMETT. Within the positive actions, three projects were supported to examine and improve industrial participation in the Programme. The first concentrated on the improvement of Belgian, Danish and Dutch industrial participation in COMETT; the second concerned with the improvement of SME participation from Iceland; the third concentrated on increasing industrial participation from Northern Sweden.

In June 1992, the Commission issued a notice of Invitation to Tender for a further evaluation of COMETT. The main objective of this evaluation will be to examine the performance of COMETT II with reference to the programme objectives. The evaluation report is expected to be forwarded to the Commission in the latter half of 1993.

COMETT, though the principal programme in the education and training field for technology, is not the only Community programme concerned with improving the stock and quality of
highly qualified manpower. Many of the specific programmes under the Framework programmes (Appendix IX) have some component of training and human resource development. The third Framework programme provides for six activities, covering a number of specific programmes. These are Information and Communication Technologies; Industrial and Materials Technologies; Environment; Life Sciences and Technologies; Energy; and Human Capital and Mobility. The first of the above includes the ESPRIT VLSI Training Action discussed below. Two other programmes within the Framework programme concerned with education and training are DELTA (Developing European Learning through Technological Advance) and the Human Capital and Mobility action. DELTA, in addition to promoting the design of computerised teaching equipment, has supported training projects in the multimedia field and has looked into the development of a European network of open universities, based on the existing network and in particular on EADTU (the European Association of Distance Teaching Universities). The Human Capital and Mobility action is concerned with increasing human resources in research and technological development. Appendices XIV and XV describe both programmes.

4. ESPRIT Very Large Scale Integrated (VLSI) Design Training Action

The ESPRIT VLSI Action was launched by Directorate General XIII (Telecommunications, Information Industries and Innovation) of the Commission in 1989, in response to the growing need for engineers capable of designing very large scale integrated microelectronic circuits. This shortage of VLSI designers became evident in the late 1980s when the number of specialist chip designers entering the job-market throughout the Community barely reached 1500 per year. Many
national programmes were set up to remedy the situation," but the problem could not be solved on a national scale.

In Grenoble, on 3 October 1986, representatives of eight European IT institutes urged, in a memorandum on the training aspects of integrated circuit design in Europe, that unnecessary duplication should be avoided and called for a united effort to provide well-trained specialists. The Commission responded by creating the VLSI scheme, and allocated 13.5 MECU to train 3000 students per year in VLSI design. The scheme is seen as a vital investment in the future of Europe. Customising a chip requires considerable skill based on a good deal of experience and this human factor is becoming more and more important. To remain competitive, an economy needs to maintain a breathtaking pace of innovation, especially in microchip technology, and to innovate, needs to constantly replenish its reservoir of skilled design engineers.

The overall objective of the VLSI Design Training Action is to provide a solid basis at European level for the training of highly qualified VLSI designers. Specialists trained in this way are then expected to apply their knowledge to the task of adapting microelectronics to new advanced processes, products and services in industry.

A Call for Tender was issued by the Commission to select universities and polytechnics to take part in the scheme, and to select service organisations to serve the universities and polytechnics. The tendering documentation produced by DG XIII specified the functions of the service organisations. Five leading IT institutes from different Member States were selected, forming EUROCHIP the service organisation of the VLSI action. EUROCHIP’s role is to provide an interface between the academic institutions and the suppliers of hardware, software and circuits. EUROCHIP acts as a broker for a number of technologies, including digital and analog CMOS, advanced CMOS, BICMOS, and Gallium Arsenide; a distributor of software, and a trainer,
organising courses" and workshops. A EUROCHIP secretariat has been set up at the German National Research Centre for Computer Science, to take care of the administrative needs of the service organisation, and overall supervision and advice is provided by a Steering Board, which includes members from industry and academia.

Any academic institution from EC or EFTA countries may join the scheme for a once off fee of 3 KECU. Participants must be able to provide a high quality educational programme in VLSI design. The academic institutions selected for support may be Participating Institutions (PIs), Associated Institutions (AIs) or Other Institutions (OIs). Participating Institutions form a kernel of 58 institutions selected by the Commission. They receive additional workstations, test equipment, CAD software, access to chip manufacture and support for a lecturer post. Associated Institutions form a group of 60 institutions selected by the Commission to receive access to chip manufacture. They also receive special conditions on CAD software, workstations and test equipment on a paying basis, via the EUROCHIP Service Organisation. Other Institutions on an individual basis may have access to chip manufacture, CAD software, workstations and test equipment via EUROCHIP on a paying basis. Participants also receive copies of "EUROCHIP Information" a newsletter which gives details of courses, workshops, and other events.
Since its inception in October 1989, the scheme has developed from a pilot scheme of about 50 academic institutions to an operation providing VLSI training support for more than 250 universities and polytechnics throughout the Community. Some 500 agreements have been concluded between EUROCHIP, academic institutions and industrial vendors. Up to July 1991, 900 Computer Aided Design (CAD) software packages had been installed. Some 80 workstations and integrated circuit (IC) testers had been provided to selected academic institutions and a further 300 stations had been bought by the institutions under a special discount scheme offered by suppliers to those taking part in the
As regards training, by the end of 1991 more than 5000 students had been trained in VLSI design, 500 more than the targeted number; a further 320 academic instructors were trained in the use of CAD software. The scheme's contribution to undergraduate as well as postgraduate training is illustrated by the 400 reports produced following the above courses. Universities are eager to show what participation has meant for them. At a workshop held in the Autumn of 1992, University College London stated that the EUROCHIP initiative had been "invaluable in facilitating change in the VLSI design courses at UCL". Most of the available VLSI documentation describes the impact the programme has had in statistical terms. No evaluation has been carried out to date, although one is pending. The project was renewed in October 1991 for a second phase of three years.

5. The European Community's commitment to education and training.

Since the latter half of the 1980s, as this Chapter has shown, Europe's policymakers have emphasised the important role played by the higher education and training sectors in meeting the need for increased knowledge and skills. COMETT and the VLSI Training Action within the ESPRIT programme, as explained, are the two principal programmes tackling education and training in the advanced technology field. The European Community's commitment to higher education and training does not stop there, however. Europe's policymakers have also been involved in the organisation of workshops, conferences and in the preparation of reports on the situation of higher education in the EC.
In 1988 the Commission made proposals in its medium-term report on guidelines for education and training to initiate a process of reflection and dialogue on higher education.\textsuperscript{93} This was followed, in June 1989, by a workshop sponsored by the Commission at the University of Louvain on "Higher Education and Europe after 1992".\textsuperscript{94} Drawing on the results of this workshop, with the support of the Italian Ministry of University Education and Scientific and Technological Research, and in cooperation with the European Parliament, the Commission organised in November 1990 at the University of Siena a major conference on "Higher Education and 1992: planning for the year 2000".\textsuperscript{95} The aim of the conference was to show how developments in higher education could contribute to European development; Member States were recommended to encourage increased participation in higher education and to improve collaboration with industry.\textsuperscript{96}

One year later, the Commission issued a discussion document: \textit{Memorandum on Higher Education in the European Community},\textsuperscript{97} which outlined the role of universities and other higher education institutions in the development of the Community after 1992. The memorandum, designed to stimulate dialogue in higher education,\textsuperscript{98} among other elements underlines the need for a new partnership between higher education, industry and the professions to meet the training needs of industry, particularly SMEs.\textsuperscript{99} Even greater weight is given to education and training by the Treaty on European Union, signed at Maastricht on 7 February 1992.\textsuperscript{100} The Treaty includes a Chapter on education and training. These new articles\textsuperscript{101} will provide a clear basis to consolidate and further develop the active collaboration which has Progressively been established between education and training systems, and will complement measures taken by the Member States to promote the quality of education and training and to develop a commitment to lifelong learning. This new commitment will encourage further the provision of highly qualified manpower, essential for the competitiveness of Europe’s industry, and the IT industry in particular.
"The ECSC (European Coal and Steel Community) Treaty, signed in 1951, provides for a financial contribution to the vocational retraining of workers (Article 56). The EEC Treaty, signed in 1957, contains provisions relating to mutual recognition of diplomas, certificates and other evidence of formal qualifications (Article 57), and a reference to basic and advanced vocational training as part of cooperation in the social field (Article 118) and a coordination of efforts in vocational training in the agricultural sector (Article 41). The Community further adopted general principles for implementing a common vocational training policy capable of contributing to the harmonious development both of the national economies and the common market (Article 128). Finally, the Euratom Treaty offers a basis for setting up schools for the training of nuclear specialists and an institution of university status (Article 9)." An Education Policy for Europe. European Documentation Periodical 4/1982, CEC, Brussels, p. 6.


2 An Education Policy for Europe, op. cit., p. 7.

3 A Resolution is a declaration with no legally binding force.


6 An Education Policy for Europe, op. cit., p. 7.

7 The Parliament adopted a resolution on 11 March 1982 on a Community action programme in the field of education which considered that the introduction of new technologies necessitated political cooperation in the field of education and stressed the important role the Commission should play in improving understanding of the new information technologies. Official Journal of the EC No C 87, Office for Official Publications, Luxembourg, 5.4.1982.

The European Council, meeting in Copenhagen in December 1982, emphasised the importance of preparing young people to meet the needs of tomorrow's high-technology industries.

The Commission in 1982 financed a study (carried out by the European Society for Engineering Education (SEFI), entitled "Educating the Engineer for Innovation and Entrepreneurship." SEFI emphasised the value of enabling students to spend part of their course in industry tackling real-life problems. SEFI, Educating the Engineer for Innovation & Entrepreneurship, Brussels, 1982.

9 Vocational Training & New Information Technologies : New Community Initiatives during the period 1983-1987, Communication from the Commission to the Council. COM(82)296, CEC, Brussels, 1982, This communication proposed a series of measures designed to supplement and reinforce Member States' policies in the training field.

In 1982 the Commission forwarded to the Council a further proposal entitled Vocational training policies in the European Community in the 1980s. This proposal emphasised the importance of vocational training policies "to master and exploit the potential of the new information technologies, particularly with a view to supporting policies designed to promote job creation, industrial restructuring and innovation and the revitalization of depressed areas". CEC,
In June 1983, the Ministers for Employment, Social affairs and Education adopted a resolution concerning "vocational training measures relating to new information technology"; the resolution recognised the impact new technologies had on employment and saw "a need in this connection to ensure that systems of education and vocational training, both initial and continuing, take into account the potential of new technologies in such a way as to supply the labour market with the necessary skilled manpower for the future". 


The major areas identified for Community action were the incorporation of the NITs in teaching practices and school curricula, and the training of teachers and those who train teachers. Communication on New Information Technology and the School Systems in the Community. COM(84)722, CEC, Brussels, 7.1.1985.


Council of Ministers.

COM(85)431, op.cit., p. 2.

Within COMETT the term "university" is used in its general sense to indicate all types of post-secondary education and training establishments which offer, within the framework of initial and/or continuing training, qualifications or diplomas of that level, whatever such establishments may be called in the Member States.

The term "industry" is used to indicate all types of economic activity, including not only large but also small and medium-sized business (less than 500 persons), whatever their legal status and manner of applying new technologies. The term also covers independent economic organisations, in particular chambers of commerce and industry and/or their equivalent, professional associations and organisations representing employers or employees.

The term "training" is taken to comprise all forms of training at the post-secondary level (undergraduate, postgraduate, short-cycle higher education etc.) and includes both initial and continuing training.


Ibid. p. 390.

The second UETP conference, COMETT II; a new challenge for the UETPs was held in Brussels from the 2nd to the 4th of October 1989, the main aim of the meeting was to draw information from the first three years of COMETT I in order to prepare the second phase of the programme.

In COMETT II more than one MECU for some; COMETT Technical Assistance Unit, Development of COMETT I, CEC, Brussels, 1992, p. 13.


The COMETT programme was directed at the 12 Member States of the EC: Belgium (B), Germany (D), Denmark (DK), Spain (E), France (F), Greece (GR), Ireland (IRL), Italy (I), Luxembourg (L), the Netherlands (NL), Portugal (P) and the United Kingdom (UK). The COMETT II programme has been opened up to countries of the European Free Trade Association (EFTA): Switzerland (CH), Iceland (IS), Norway (N), Sweden (S), Finland (SF), and Liechtenstein (FL).

Students carrying out research projects in industrial laboratories and participating already in European Community research programmes (for which funding is available), are not eligible for funding under COMETT.

Projects submitted in 1992 requested more than 26,000 student placements. (p. 9).

There was no Call for Applications for advanced training placements in 1991 and 1992.

This project was supported under the fourth call for proposals 1989, TFHRETY, Directory of projects 1989, CEC, Brussels, p. 197.
The project funded two courses for 400 people (80 teaching hours); the courses were organised by the Instituto Superior Tecnico in Lisbon.

Multi-media training systems comprise learning systems utilising information and telecommunication technology such as direct broadcasting satellite, two way interactive cable, computers, and audio-visual means.

Association pour la Recherche Avancee en Microelectronique et Integration de Systemes (B), European Silicon Structures (F), Technische Hochschule Darmstadt (D), Siemens Nixdorf Informationssysteme (D), INESC (P), Centro Nacional de Microelectronica (E), and Brunel University (UK).

SEC(91)1016, op.cit., p. 1.


The exceptions to the cost-sharing principle are: (i) actions under Strand D, where the funding may go up to 100%; (ii) under Strands A and C, the COMETT Decision provides that the additional costs incurred by universities in the preparation and implementation of projects may be met up to 100%.

Calls may be either "open" or "restricted". An "open call" is open to any organisation provided the projects submitted meet the COMETT criteria. "Restricted calls" for applications are restricted by type of applicant (the Commission may stipulate that only defined types of organisation may apply), and by type of project (the Commission may stipulate that applications must conform to additional criteria).

The COMETT Committee assists the Commission in the implementation of the programme and consists of two representatives from each Member State, and is chaired by a Commission representative. The members of the Committee are responsible for liaising between COMETT and similar initiatives implemented in the Member States. The Committee delivers its opinion on the general balance of the programme including the selection procedures for projects. Since the launch of COMETT II, the EFTA countries have participated in COMETT and joint committees were established between the European Community and each EFTA country.

The COMETT Experts' Group represents the participants in COMETT, in particular industry and advises the Commission and the COMETT Committee in the execution of the programme. The group also ensures that there is significant participation by industry.

The Technical Assistance Office provides logistic and technical support via information provision, project selection and programme monitoring.

COMETT Information Centres have been established in each Member State (EEC + EFTA) to facilitate and promote the dissemination of information about COMETT. The centres, in addition to responding to information queries on the COMETT programme, produce information material (bulletins and brochures). They also organise information days, workshops and press conferences to help with the preparation of new applications.

SEC(91) 1587, op.cit., pp. 9-10.

The 1991 call was a restricted call for the 158 COMETT II UETPs accepted in the 1990 selection.
The Final Report of the Commission on COMETT I (1986-1990) is mainly descriptive, and documents the background to the programme as well as outlining its rationales, structure, implementation and the impact COMETT has had in the different operational Strands. The report highlights the key points regarding the development of COMETT I; the number of projects and placements supported is indicated, but the effectiveness of these projects and placements is not measured.


The Report of 1990 Activities is very similar in style and structure to the report of COMETT I. The background to COMETT, the objectives of COMETT II, the areas emphasised, number of applications received and technological sectors covered are all described. While the number of OETPs supported and number of placements are indicated, no reference is made to their success or expected success. The report covers the selection process, programme implementation, monitoring and evaluation and links with other Community programmes. COMETT Programme, Report of 1990 Activities, SEC(91)1587, CEC, Brussels, 6.9.1991.


The Catalogue of COMETT Outputs includes output descriptions by technology sector, country and type of support (written materials, support, books, video tapes, etc.). A statistical analysis provides an overview of the main characteristics of COMETT I in terms of distribution of outputs across countries, sectors, attendance etc. Additional details such as sex and origin of training course attendees, and average length of course are also given.


Other recommendations to the Commission include; 1) giving guidance on how equal opportunities can best be achieved through COMETT activities, 2) identifying the long term impact of student placements on labour markets and regional development, 3) exploring further factors underpinning the involvement of different types of SMEs in COMETT activities and 4) exploring ways in which public sector resources committed to training products could be offset through sharing in the financial returns of commercially successful projects.

Main Recommendations to the Governments of Participant Countries

1) improve access to and knowledge of EC resources; 2) further transnational regional cooperation (particularly through the grouping of complementary regions) (p. 3).
Main Recommendations to UETPs and UETP Partners

1) UETPs are advised to build on the links where the needs for cooperation are strongest. 2) University partners are requested to address particularly accreditation procedures for time spent in industry by students. 3) Enterprise partners are seen as having the most to gain from the achievement of COMETT programme objectives, and are advised to increase the part they play in identifying training needs (pp. 2-3).

79 COMETT Programme Report of 1991 Activities, op.cit., p. 14. Regarding transnational student placements, the Commission believes that the 'pool' schemes will enable UETPs to contribute towards balanced movements across the Community.


81 COMETT also has links with other Community education and training programmes. These programmes are:

ERASMUS is the EC's programme for the mobility of university students. ERASMUS was set up in 1987 and aims at promoting cooperation between universities in order to bring about greater mutual recognition of qualifications as well as to encourage greater mobility of students and staff between institutions throughout the Community.

EUROTECNET is an action programme to promote innovation in the field of vocational training resulting from technological change in the European Community. EUROTECNET addresses the impact of technological change on qualification systems and on training methodologies.

FORCH is a Community action programme for the development of continuing vocational training in the European Community.

IRIS (European Network of Vocational Training Projects for Women), supports innovation in vocational training directed at the more effective participation of women.

LINGUA - Action programme to promote foreign language competence in the European Community.

PETRA - Action programme for the vocational training of young people and their preparation for adult and working life. The programme was designed to take account, in particular, of concerns over high youth unemployment and to set new standards for initial vocational training in the Community.

TEMPUS (Trans-European Mobility Scheme for University Studies) was launched by the Community in 1990 to support the transformation of the higher education systems in Central and Eastern European countries.

Youth for Europe was launched by the Community in 1988 for the promotion of youth exchanges in Europe.

82 Universities were supplied with special computers and programs for chip design purposes, and agreements were made allowing them to have prototype chips made by industry, which the institutes could then test themselves.

83 3000 students is the number estimated by the Commission of the European Communities and agrees with some national estimates. The French National VLSI Education Committee estimated a need for a yearly increase of 500, when the French VLSI Committee trained more than 500 students per year in the field of VLSI Design. EUROCHIP Information, issue No 1 GMD (German National Research Centre for Computer Science), Sankt Augustin, Germany, July 1990, p. 3.
1) Invite industry to bid for the provision of processing facilities; 2) check designs and merge for full manufacturing runs; 3) order and monitor the runs; 4) set the rules in advance for the use of CAD software; 5) equip participating institutions with compatible workstations and CAD software if needed; 6) provide participants, if needed, with personnel qualified to support lecturers; 7) provide training support; and 8) establish media to enhance the exchange of information between universities. ESPRIT. Promotion of VLSI Skills. Tendering Documentation for the Provision of Services. CEC, Brussels, 1988, p. 3.

Training is provided to universities for the use of CAD software. Up to September 1991, some 800 courses had been run, leading to 1,700,000 student hours of training. EUROCHIP Information issue No 6, GMD, Sankt Augustin (Germany), September 1991, Press Release p. 3.

The workshops provide a forum for the exchange of ideas. Industries express their needs and universities present their curricula, research and training circuits. The third workshop was held in Grenoble at the end of September 1992. Among the features of this workshop were demonstrations of academic CAD software offered for exchange as well as an exhibition of VLSI teaching material and reports on the design contests.

The reports include about 100 Bachelors' course reports, Ibid, pp. 1-2.


The workshop dealt with general aspects of the development of higher education post-1992.

This conference was attended by over 200 people active in higher education in the Member States. Participants came from all areas of higher education, business, industry and government.

The conference called on Member States "to promote, encourage and provide incentives for the building and equipping of laboratories to be used jointly by educational and industrial interests" (p. 7). In this regard the Commission was urged to support financially the establishment of these joint higher education/industry laboratories. CEC et al, Conclusions of the Conference on Higher Education and 1992 : Planning for the year 2000. University of Siena, Italy, 5-7 November 1990, p. 7.

Articles 126 and 127.
CHAPTER VIII: EMPIRICAL RESEARCH - SURVEY BY QUESTIONNAIRE

1. Introduction

With a view to obtaining empirical data on the effectiveness of the Community's education and training policies, a survey was carried out of European IT companies participating in the COMETT and ESPRIT programmes.

The survey was conducted by questionnaire, prepared in spring 1992. The overall objective of the questionnaire was to assess the effectiveness of Community policy in educating and training manpower for Information Technology. The text of the questionnaire is attached in Appendix XVI.

2. Specific objectives

The specific objectives were:

- to evaluate the importance of professional IT manpower in providing a competitive advantage for the organisation;
- to determine whether a shortage of professional IT manpower existed;
- to gather information on probable demand for professional IT manpower over the period 1992-1994;
- to assess the results of EC efforts, under COMETT and ESPRIT, to increase the availability and quality of professional IT manpower, responsive to the needs of Europe's IT industry;
- to establish whether participation in COMETT and ESPRIT had improved links with Higher Education Institutes;
- to assess the level of satisfaction with the Community's programmes.

3. The example of previous similar questionnaires

To assist in the design of the questionnaire, ten reports and studies which had earlier conducted similar surveys were consulted. Questionnaires used in these surveys were considered in terms of structure, style and subject content. Reports (A), (D), (E), and (F) were eliminated, due either to poor structure and style, or the use of excessively long and detailed questions, more suitable for an interview than for a questionnaire. Furthermore models of the questionnaires used were not always appended to the text of the reports.

Reports (B), (C), (G), (H), and (J) influenced to a certain degree the design and content of the questionnaire used for this study. The Kew Associates report (J), Relating IT Practice to Business Strategy, was based on a survey by questionnaire of over 650 manufacturing companies in the UK. The questionnaire used contains precise definitions of organisation type, ("enterprise" "subsidiary" and "business unit"), the latter have been used in question 2 of the questionnaire used in this study.
In the course of reviews of the ESPRIT programme - *The Mid Term Review (1985)* (B) and *The Review of ESPRIT I (1989)* (C), questionnaires were sent to programme participants. The questions primarily concerned the aims of the programme, i.e. the promotion of European industrial cooperation in precompetitive R & D. Both questionnaires also considered the availability and recruitment of qualified staff. In (C), the final Review of ESPRIT I, participants were asked "to what extent participation (in ESPRIT I) had resulted in the easier recruitment of qualified staff?".

This question influenced the formulation of questions 27 and 31 in the questionnaire used here. Thus, question 27 asks "has your organisation ever recruited additional professional IT staff specifically to work on an ESPRIT project?". Question 31 asks "in your opinion, has ESPRIT assisted in increasing the availability and quality of professional IT staff, responsive to the needs of Europe's IT industry?".

The first *evaluation of the COMETT programme* (G) was carried out in 1989. The evaluators examined the extent to which cooperation had been strengthened, both between educational institutions and between the institutions and enterprises at the national and transnational levels. A postal survey was undertaken. The evaluation report describes the issues addressed in the survey, and the results are presented in the form of tables. Most of the questions concern the administrative framework of COMETT and the collaboration element.

The questions on collaboration, though quite extensive, prompted the inclusion here of a question on collaboration (question 19: "Prior to participating in COMETT was your organisation involved in transnational collaboration with higher education institutions in training for technology?")

The second *Evaluation of COMETT (final report)* (H) was undertaken in 1991 by ECOTEC. The study examined the performance of COMETT in the light of the overall programme
objectives. The questionnaires were not included in the final report, and copies were obtained from the ECOTEC UK office. Two of the questionnaires were useful; they concerned Strands B (transnational exchanges), C (joint projects for continuing training in particular advanced technology and for multimedia distance training), and D (complementary measures).

Part IV of these questionnaires ("progress and future opportunities") influenced the formulation of question 24 ("which of the following best describes the way in which resources available from COMETT have helped in developing student/staff exchanges (Strand B) and training activities (Strands C and D) ?").

The most useful report was the survey questionnaire compiled by the UK Institute of Manpower Studies (IMS) and used in their report *The Changing IT Skills Scene* (I). This report is the result of a three year Government-commissioned research programme, undertaken by the IMS to monitor the changing pattern of supply and demand for professional level IT skills in the UK. Section B (Information Technology Skills) of the questionnaire used (in this survey) is based on a similar section of the IMS questionnaire. However, as the IMS questionnaire was designed to provide the UK Government with data on employment trends, resourcing methods, responses to recruitment difficulties and future skill needs, it sought a higher level of detail. Recipients were requested to indicate the number of IT staff employed, the category (female employees, older employees (over 30) and part-time employees). They were also asked to state the number employed in each category in 1985 and 1988.

4. The questionnaire used in this study.

The questionnaire used in this study included elements of the questionnaires described above but differed in its
concentration on assessing the effectiveness of EC policy in meeting the skill requirements of Europe’s IT industry. Thus, questions on COMETT and ESPRIT concentrated on this issue, in contrast to the broader approach taken in the official COMETT and ESPRIT evaluations. The questionnaire designed by ECOTEC for the second evaluation of COMETT, besides examining the cooperation mechanism, looked at the sources of outside financing obtained. Questionnaires designed by the ESPRIT Review Boards included questions on ESPRIT’s administrative framework (project selection, programme management, and financing).

The questionnaire used in this study contained four sections.

**Section A: Background Information**

This section asked participants to indicate the name and address of their organisation (Q. 1), the type of organisation (an enterprise, business unit, subsidiary or other) (Q. 2), the activities in which they were involved (electronic components, software and services etc.) (Q. 3), and the number of staff employed (Q. 4). The question on geographical location sought to establish Member State views on questions asked in sections A, B, C, and D, and to allow inter-country comparisons. Sectoral activity and size of organisation (large, or small and medium enterprises) are vital elements of information for a study on IT. This data enabled the researcher to ascertain the size of organisation and sectoral activity, for example, encountering most difficulty in the recruitment of IT staff.

**Section B: Information Technology Skills**

This section asked organisations about the number (Q. 6) and type (Q. 7) of professional IT staff employed in the organisation. Organisations were asked about their principal means of filling vacancies (Q. 8), difficulties encountered in recruiting newly qualified graduates and experienced staff (Q. 9 - Q. 12), their view of the
importance of professional IT staff in providing competitive advantage (Q. 13), the effects of shortages on business (Q. 14) and changes in the employment of IT staff (Q. 15).

These questions were included with the intention of gathering new data on the shortage situation in IT skills, and the employment outlook for such skills, and to determine the importance for the IT industry of access to IT staff.

Section C: European Community Programmes

This section, directed at COMETT and ESPRIT participants, included questions on these programmes aimed at assessing their effectiveness in meeting the education and training needs of Europe’s IT industry. Questions to COMETT participants fell into two categories: 1) COMETT’s collaboration element and benefits gained from participation in COMETT and 2) education and training.

Organisations were firstly asked about their involvement, prior to participation in COMETT, in transnational collaboration with higher education institutions in training for technology (Q. 19). It was expected that replies would show that many were already involved in collaboration, showing recognition of the importance of transnational collaboration.

Question 23 asked participants to indicate the benefits gained from involvement in COMETT. Five benefits were listed: 1) easier recruitment of experienced IT staff; 2) easier recruitment of IT graduates; 3) more training and development of existing professional IT staff; 4) more training to upgrade/convert other staff to professional IT jobs, and 5) improved links with higher education.

Questions asked on education and training covered IT industry needs. Respondents were asked whether participation had helped in identifying training needs (Q. 20), whether COMETT had assisted in increasing the availability and quality of professional IT staff (Q. 21),
and whether the needs of the IT industry were now more adequately reflected in undergraduate and postgraduate programmes (Q. 22).

COMETT's ability to develop student/staff exchanges and training activities was investigated in Question 24.

Questions on the ESPRIT programme concerned education and training. Respondents were asked about the VLSI Design Training Action (Q. 28 and Q. 29), whether additional staff had been recruited to work on an ESPRIT project (Q. 27), whether involvement in ESPRIT had improved links with Higher Education Institutes (Q. 30) and whether ESPRIT had assisted in increasing the availability and quality of professional IT staff (Q. 31).

Section D: The role of the EEC

This section contained two questions on the role of the EC, intended to obtain the views of IT industries on the European Community's efforts to improve the availability and quality of professional IT staff. Survey participants were asked whether Europe's efforts had been successful, and if not, what needs to be done.

5. Questionnaire recipients

Between mid-April and mid-May 1992, the questionnaire was sent to a sample of IT companies in five Member States of the European Community (France, Germany, United Kingdom, Greece and Spain). France, Germany and the United Kingdom were selected because of their high level of participation in the COMETT and ESPRIT programmes (Appendices XVII and XVIII). They are also among the largest countries in the Community; Germany and the UK have the largest labour forces, and with France account for over 60% of the
Community’s labour force. With Italy they account for more than 80% of Community GDP\textsuperscript{11}. In terms of technological strength, France, Germany, and the UK (with Italy) in 1989 accounted for 91% of all EC production of computer and office equipment.\textsuperscript{12} Not surprisingly, they are also the main markets in this sector, and represent 87% of the total EC market.\textsuperscript{13}

To obtain a broader sample, two countries from the periphery (Greece and Spain) were also included in the survey. In every country of the European Community there are differences in the level of development of the various regions. Most parts of Spain and Greece have per capita GDP less than 75% of the Community average.\textsuperscript{14} Furthermore, their research potential is considerably lower than that of their northern partners. National spending on R & D is often a means of estimating technological strength. In 1989 Germany spent 502 ECU per capita on R & D, France and the UK followed with 364 ECU and 299 ECU respectively, while Spain spent 67 and Greece a mere 23 ECU.\textsuperscript{15}

The questionnaire recipients were IT companies who participated in the COMETT and ESPRIT programmes. For COMETT, two directories (COMETT Directory 1987\textsuperscript{16} and COMETT Directory 1989\textsuperscript{17}) were consulted for names of companies participating in IT projects. In addition, two project compendia were also consulted for 1989 and 1990. The COMETT project compendium for 1989\textsuperscript{18} includes basic information on all COMETT projects accepted under all Strands and application rounds of COMETT I. All projects within the IT sectors\textsuperscript{19} were checked and names and addresses of the companies concerned\textsuperscript{20} were included in the survey. The 1990 compendium\textsuperscript{21} includes information on all COMETT projects funded under the first application round of COMETT II. The names and addresses of IT companies participating in IT projects\textsuperscript{22} were also included in the survey.

For ESPRIT, a complete list of IT companies participating in ESPRIT was obtained from the ESPRIT data base, located in
Directorate General XIII (Telecommunications, Information Industries and Innovation) of the EC Commission. The list was sorted by country, and within country, by organisation type and size. Participants in the ESPRIT programme are classified as Industry (I), Research Institute (R), University (U) and Other (O). Within the Industry group, there are a further six sub-groups; electronic components (I/EC), computer and office equipment and peripherals (I/E), software and services (I/S), audiovisual consumer electronics (I/C), industrial automation systems (I/A) and professional electronics (I/P). The names and addresses of participants (for D, E, EL, F, UK) were taken from these industrial sub groups.

The final list (COMETT and ESPRIT) contained 230 IT companies: 60 each in Germany and the United Kingdom, 50 in France, 40 in Spain and 20 in Greece. All sizes of organisations were considered. Large organisations made up 56% of the sample. Of the remaining 44%, 19% had 50 or less employees, 8% had between 50 and 100, and 17% between 100 and 500. Thirteen of the top 25 European IT suppliers (Siemens Nixdorf, Olivetti, Bull, NV Philips, ICL, Alcatel, Cap Gemini, Nokia, British Telecom, Racal, Sligos, Norsk Data and GSI) were also considered in the survey. In 1990 these companies had a total revenue of 106,443 million $. 
NOTES

1. As the COMETT programme and the VLSI Design Training Action within the ESPRIT programme are targeted principally at the higher education level (university or equivalent), organisations were asked about "professional IT staff only." These are people in jobs at graduate level or equivalent whose main activity is associated with the development or application of IT in the organisation or in its products and services. Professional IT staff comprise IT graduates and experienced IT staff.


3. Opportunities for Information Technology Based Advanced Educational Technologies (A) used two questionnaires, one designed for industry as employers of trained manpower, and one for educators. The structure and style of the questionnaires are poor, questions are merely listed, and copies of the questionnaires are not included. Questions in general are too long and detailed, concerned only with IT based education and training systems. Under the heading "Costs and Benefits", participants were asked, "where it is possible to apportion overheads, how do your training costs breakdown ? how much is spent on training materials - hardware, software, courseware, general production overheads; whether expenditure (in real terms) is likely to increase/decrease in the next 5-10 years ?"

The authors of The Availability of Highly Qualified Manpower for the Development of Information Technology in Europe (D) carried out an interview survey, involving users and producers of highly qualified manpower. The questions asked are listed in the report. Because they were designed for an interview as opposed to a questionnaire, many of the questions are quite "open-ended" good for face to face interviews or discussions, but inappropriate for a questionnaire.
The report *Skill Needs for Technological Innovation* (E) contains papers on skill needs in various sectors. However, only the paper given by Jin Northcott of the Policy Studies Institute on "Microelectronics in Industry" contains the results of the surveys. These are presented in the form of tables drawn from the PSI's surveys of microelectronics in industry, carried out in 1981, 1983, 1985 and 1987. The survey covered principally the obstacles encountered by the microelectronics industry in adopting microelectronics (one factor identified was the lack of people with microelectronics expertise). Since a copy of the questionnaire mailed is not included in the report, and as the findings are grouped, it is difficult to determine the exact content of the questions posed.

In their report, the ITSA presents the results and conclusions of a survey of Changes in the Employment of IT Staff (F) during the period August 1986 - August 1987. One of the functions of the ITSA is to advise the UK Government on the allocation of resources in order to ensure that adequate numbers of suitably qualified IT staff are available to meet the needs of industry, business and the public sector. As a result, the survey was conducted in great depth. The findings presented in the report show the level of detail investigated: salaries, labour turnover, and resignations are among the sectors featured. It is a good statistical report, but inappropriate for the purposes of this study.


5 Documentation, information flow, COMETT's application and selection procedure.

6 Questions include: attitude to future collaboration, choice of partners for future collaboration, willingness to undertake transnational collaboration without EC funding, Coopers and Lybrand et al pp. 70-71.

7 (A) Postal Questionnaire for Regional UETPs, (B) Postal Questionnaire for Sectoral UETPs, (C) Postal Questionnaire for mixed Regional and Sectoral UETPs, (D) Postal Questionnaire for Strand B projects, and (E) Postal Questionnaire for Strand C and Strand D projects.

8 Strands C and D received the same questionnaire.

9 For an explanation of the term "professional IT staff", see footnote 1.

10 Recipients were asked to return the questionnaire before 30.6.1992.

11 CEC-EUROSTAT, *Europe in Figures*, third edition, Office for Official Publications, Luxembourg, 1991, p. 222. GDP is often used to measure a country's standard of living, and is used as a criterion for the allocation of funds from the Community's Regional Development Fund.


13 Ibid, France (22.5%), Germany (28.4%), UK (23.5%).


15 Ibid, p. 103.


17 CEC, COMETT Directory of Projects, Projects Supported under the Fourth Call for Proposals, Brussels, 1989.

Only IT companies from France, Germany, the United Kingdom, Greece and Spain were considered.


The remaining companies did not appear to participate in either the COMETT or ESPRIT programmes and were therefore not considered. The top twenty five European IT suppliers were identified by Datamation in their review The Datamation 100, European 25, Cahners Publishing, Massachusetts, 1.7.1991.
CHAPTER IX: EVALUATION OF SURVEY RESULTS

1. Questionnaires returned

Of the 230 questionnaires sent, 68 (30%) were returned (figure 1.9): a further 10 were returned giving reasons why the completion was not possible. Reasons varied from insufficient knowledge of or involvement in the EC programmes, to company restructuring.

Figure 1.9

<table>
<thead>
<tr>
<th>Country</th>
<th>Mailed</th>
<th>Returned</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>50</td>
<td>15 (30%)</td>
</tr>
<tr>
<td>Germany</td>
<td>60</td>
<td>21 (35%)</td>
</tr>
<tr>
<td>Greece</td>
<td>20</td>
<td>4 (20%)</td>
</tr>
<tr>
<td>Spain</td>
<td>40</td>
<td>8 (20%)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>60</td>
<td>20 (33%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>230</td>
<td>68 (30%)</td>
</tr>
</tbody>
</table>
Of the 68 returns, 41 (60%) were completed on behalf of enterprises, 15 (22%) business units, 7 (10%) subsidiaries, and 5 (7%) other organisations, (figure 1.10).

Figure 1.10

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Nr</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Enterprise</td>
<td>41</td>
<td>60</td>
</tr>
<tr>
<td>(2) Business Unit</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>(3) Subsidiary</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>(4) Other</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>
27 organisations (40%) employed between 1 and 99 employees; 15 had 100-499 (22%); 3 had 500-999 (4%); 7 had 1000-4999 (10%); and 15 employed over 5000 (22%). (figure 1.11)

Figure 1.11

Numbers employed in organisation (including part-time employees)

<table>
<thead>
<tr>
<th>Size</th>
<th>Nr</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 1-99</td>
<td>27</td>
<td>40</td>
</tr>
<tr>
<td>2. 100-499</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>3. 500-999</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. 1000-4999</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>5. 5000+</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>Not Stated</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Returned questionnaires represented all 7 activities (indicated in question 3). The highest participating activity was software and services with 41 replies (60%), while the lowest was audiovisual consumer electronics with only 3 returns (figure 1.12).

Figure 1.12

Type of Activity

<table>
<thead>
<tr>
<th>Activity</th>
<th>Nr</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Electronic Components</td>
<td>13</td>
<td>19</td>
</tr>
<tr>
<td>2. Software &amp; Services</td>
<td>41</td>
<td>60</td>
</tr>
<tr>
<td>3. Computer, Office Equipment, Peripherals</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>4. Audiovisual, Consumer Electronics</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. Industrial Automation Systems</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>6. Professional Electronics</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>7. Other</td>
<td>13</td>
<td>19</td>
</tr>
</tbody>
</table>
The IT staff employed were computing staff (programmers, systems analysts) (88%), engineers (control, electronic, microelectronic, software, and systems design engineers) (75%), and R & D specialists (84%) (figure 1.13).

Figure 1.13

IT Staff by occupational group employed

<table>
<thead>
<tr>
<th>Occupational Group</th>
<th>Nr</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computing Staff</td>
<td>60</td>
<td>88</td>
</tr>
<tr>
<td>Engineers</td>
<td>51</td>
<td>75</td>
</tr>
<tr>
<td>R &amp; D Specialists</td>
<td>57</td>
<td>84</td>
</tr>
</tbody>
</table>
Questionnaires were evaluated with the help of SPSS (Statistical Package for the Social Sciences); the findings, followed by a summary and evaluation, are presented below.

2. Importance of Professional IT Staff

In the questionnaire organisations were asked about professional IT staff. The survey results confirm that Professional IT staff are of critical importance in providing a competitive advantage for organisations. 57% of respondents found professional IT staff to be of critical importance, while a further 34% believe that they are very important. In all, 69% of French and 75% of UK returns stated that IT staff were critical; this was somewhat lower in Germany (45%), Spain (38%) and Greece (25%). IT staff are seen to be more critical in service oriented activities (computer office equipment and peripherals 79%, software and services 63%, audiovisual and consumer electronics 67%), compared to more engineering and production-oriented activities (professional electronics 50%, industrial automation systems 36% and electronic components 46%).

Interestingly, organisations with more than 5000 employees placed considerably less emphasis on the competitive advantage offered by IT staff (36% against a weighted average of 62% for Small and Medium sized enterprises (SMEs)). This result can perhaps be explained by the fact that for 33% of these organisations, shortages of professional IT staff had not affected business or operations in 1991 (Q. 14).

Question 14 asked participants to indicate the effects shortages of professional IT staff had on their business/operations in 1991. The main effect was longer delivery/implementation periods (cited by 37% of respondents), while 16% incurred lost output. A closer
look at participants who encountered longer delivery/implementation periods as a result of shortages of professional IT staff show Greece and Germany ahead with 50% and 43% respectively, followed by France (40%), the UK (30%), and Spain (25%). When measured by size and sector; small and medium sized enterprises (40%) and organisations in the electronic components sector (54%) suffered the longest delivery periods.

Summary

These results substantiate the findings of the surveys referred to in Chapter V on the effects of staff shortages on industry’s performance carried out by 1) the National Computing Centre (UK) and the IT skills Agency (UK) in 1986, 2) the Confederation of British Industry and the Manpower Services Commission (UK) in 1987, and 3) the Institute of Manpower Studies (UK) in 1989. Findings included: threatening competitive position (National Computing Centre), limiting output (Confederation of British Industry), extending delivery or implementation periods (Institute of Manpower Studies).

3. The European IT manpower shortage

To establish if there is a shortage of IT manpower in Europe, an employer based approach was adopted in the questionnaire. Under this approach, shortages are determined in terms of recruitment difficulties faced by individual firms. Recipients were asked if they had experienced any major difficulties in recruiting newly qualified graduates (Q. 9) and experienced IT staff (Q. 11) in 1991, and how this compared with 1988. The survey findings confirm that shortages of professional IT staff exist. 16% of organisations had major difficulty recruiting newly qualified graduates in 1991. These organisations
employed the following IT staff; computing staff, engineers, and R & D specialists. UK participants had by far the least difficulty with only 5% recording difficulty. This satisfactory position could be the result of the particular efforts made by the UK Government and professional bodies. These efforts commenced in the 1980s with the objective of increasing the flow of students into IT disciplines, and included the Government's 1982 IT Initiative to meet the demand for engineers with IT skills by adding an extra 1,000 IT graduates to the supply in each year after 1983; the establishment of City Technology Colleges; the Women into IT Campaign, launched by the Women into IT Foundation to recruit into and retain more women within the computer industry; the Engineering Council's guidance booklets; and the School Engineering link programme.

The 5% recording difficulty believed their particular industries were less attractive to graduates, and saw this as the principal reason for difficulty. Overall, the main sectors encountering difficulties were the computer office equipment & peripherals (21%) and professional electronic sectors (20%), followed by software and services (18%).

35% had major difficulty in recruiting experienced IT staff in 1991. These organisations employed the following IT staff, computing staff, engineers, and R & D specialists. This must be seen as reflecting a skills shortage. In contrast to the observation on difficulty in recruiting newly qualified graduates, the UK replies show the highest rate of difficulty in the recruitment of professional IT staff (47%). The average in the other 4 countries surveyed was 35%. The main recruitment difficulty for 3 of the UK organisations was in finding candidates to fill specific IT vacancies in software engineering and in networking (telecommunications). Remaining organisations did not indicate the type of IT staff they had difficulty recruiting. The appeal of other sectors (i.e. Banking, Consultancy or Accountancy) with better prospects of pay or training seems the most likely reason for the experienced IT
staff shortage. Personnel are attracted to companies who provide structured education and training programmes and attractive and achievable career paths. Although details on company training policy was not requested in the questionnaire, none of the organisations experiencing difficulty with the recruitment of IT staff participated in COMETT, although 60% state that one of their principal means of filling vacancies for professional IT staff is via the conversion/upgrading and training of other staff transferred within the organisation (Q. 8), indicating that training is provided. Similarly, in reply to Question 27, over 50% stated that they had recruited additional professional IT staff to work on ESPRIT projects, such personnel are trained while working on these high level R & D projects.

While the quality and extent of training cannot be evaluated here, companies who provide structured education and training programmes as part of their recruitment package have greater possibilities of filling IT vacancies.

When measured by activity, 36% of industries in the electronic components sector encountered difficulties in recruiting experienced IT staff in 1991, followed by audiovisual and consumer electronics (33%), software and services (32%), computer office equipment and peripherals (30%), industrial automation systems (30%) and professional electronics (20%).

Comparing 1991 with 1988, 35% of respondents believed it was less difficult to recruit newly qualified graduates in 1991, and 28% found it less difficult in 1991 to recruit experienced IT staff. 36% of French participants found it less difficult to recruit graduates in 1991, whereas a somewhat lower 23% found it less difficult to recruit experienced IT staff. 20

70% of organisations involved in industrial automation systems found it less difficult to recruit graduates and experienced IT staff in 1991 compared with 1988, which was markedly better than the general average of 31%.
Demand for professional IT staff is likely to increase. Over 50% of participants expect their employment of professional IT staff to increase over the period 1992-1994 (Q. 15). Greece, the UK and France lead with, 100%, 60% and 57% respectively. Somewhat lower expectations are found in Germany (40%) and Spain (38%). Highest increases are expected in the software and services, and computer and office equipment sectors (50%). Significant recruitment is expected by SMEs (1-499 employees), 64% expect to recruit more professional IT staff over the period 1992-1994; this was in contrast to 21% of large (5000+) organisations. Recruitment will take place across all occupational groups; computing staff, engineers, and R & D specialists.

Summary

A skill shortage exists in the Information Technology industries (recorded by 35% of organisations), and with a forecasted increase in the recruitment of IT staff (stated by 52% of organisations) in the short term (1992-1994), this shortage is likely to continue if not become worse.

4. COMETT

Section C of the questionnaire (Questions 16-24) concerns the COMETT programme. The response rate for COMETT was poor. Of the targeted sample (60% (146) participated in ESPRIT and 40% (84) in COMETT), only 16 (19%) questionnaires were returned for COMETT, which was disappointing. Furthermore, not all of these 16 organisations answered all questions. Of the 16 organisations, 14 were still participating in COMETT when the survey was conducted (May-June 1992), of which 6 organisations had been participating for over 5 years, a further 3 had been involved for 4 years, and 6 had been participants for between 2 and 3 years. All
five Member States were represented in the returns; Germany (6 participants), France (5), Greece (2), Spain (2) and the UK (1). Respondents participated in each of the four Strands with some participating in more than one Strand. 9 organisations were in Strand A (56%), 6 in Strand B (38%), 8 in Strand C (50%) and 3 in Strand D (19%), (figure 1.14).

Figure 1.14

<table>
<thead>
<tr>
<th>COMETT Areas of participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strand</td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td>Strand A</td>
</tr>
<tr>
<td>Strand B</td>
</tr>
<tr>
<td>Strand C</td>
</tr>
<tr>
<td>Strand D</td>
</tr>
</tbody>
</table>
Prior to COMETT, 12 organisations were involved in transnational collaboration with higher educational institutes in training for technology. Of these 9 were large organisations, 6 of which had more than 5000 employees. All sectors were represented, software and services being the dominant sector with 7 organisations (6 of who had 5000+ employees).

Participants were asked for their views on COMETT's ability to meet their education and training needs, and whether they believed COMETT had assisted in increasing the availability and quality of professional IT staff. It was hoped that the answers to these questions (Questions 20-23) would allow an assessment of the effectiveness of COMETT in providing qualified IT manpower and in meeting the skill requirements of Europe's IT industry.

15 of the 16 organisations believed that COMETT had assisted in increasing the availability and quality of professional IT staff responsive to the needs of Europe's IT industry. 6 participants believed COMETT had assisted greatly. German, Greek and Spanish participants showed particular enthusiasm, stating that "COMETT had assisted greatly". In terms of size, 5 organisations had less than 500 employees; of the remaining 10, 7 had 5000+ employees, and 3 between 1000 and 4999. All were equally positive in their view of COMETT's ability to increase the availability and quality of professional IT staff, with 3 of the 5000+ group and 3 of the 1-99 group stating that COMETT had "assisted greatly". Participants represented all sectors of activity; the software and services sector led with 9 participants.

In relation to education and training, 11 of the 16 confirmed that participation in COMETT had enabled them to better identify training needs. Of the 11 organisations 4 were German, 4 French, 2 Greek and 1 Spanish. All sectors and sizes were uniformly positive that participation in COMETT had enabled them to identify training needs.

As to undergraduate and postgraduate programmes, 12
organisations believed that the needs of the IT industry were now better reflected than prior to COMETT's existence. This is particularly interesting, considering 12 of the 16 respondents rely on newly qualified graduates as a means of filling vacancies for professional IT staff, and 4 rely solely on graduates. The software and services sector with 7 participants was the most positive in its reaction.\textsuperscript{24} There was no variation according to size of organisation; small and medium sized and large organisations alike believed that the IT industry's needs were now better reflected in undergraduate and postgraduate programmes than prior to COMETT. The 2 participants who stated "yes, but poorly" were large companies, one with 5000+ employees.

Participants were asked to indicate the benefits gained from involvement in COMETT projects. Five possible benefits were listed: easier recruitment of experienced IT staff, easier recruitment of IT graduates; more training and development of professional IT staff already employed; more training to upgrade/convert other staff to professional IT jobs, and improved links with higher education.

Easier recruitment of experienced IT staff.

2 organisations (1 large, and 1 SME) from the audiovisual consumer electronics and professional electronics sectors found it easier to recruit experienced IT staff.

Easier recruitment of IT Graduates.

5 organisations\textsuperscript{25} (3 large and 2 SMEs) believed their participation in COMETT had made it easier to recruit IT graduates. 4 of these organisations were in the professional electronics sector.

This would perhaps explain why most participants reported that it was less difficult to recruit newly qualified graduates (Q. 10) and experienced IT staff (Q. 12) in 1991 than in 1988.
More training and development of existing professional IT staff in the organisation.

6 organisations had gained from more training and the development of existing professional IT staff. These organisations represented all six sectors.

More training to upgrade/convert other staff to professional IT jobs.

527 participants believed they had gained from more training to upgrade/convert other staff to professional IT jobs. The majority of participants represented the computer and office equipment and peripherals, and software and services sectors.

Improved links with higher education.

928 organisations large as well as small companies, from all six sectors had improved links with higher education.

The final question asked participants how COMETT resources had helped in developing student/staff exchanges (Strand B) and training activities (Strands C and D). Respondents were given three options: 1) without COMETT the exchanges/activities would not have taken place; 2) without COMETT the exchanges/activities would have developed more slowly; and 3) without COMETT the exchanges/activities would have been of a lower quality. 6 organisations believed that without COMETT the exchanges/activities would not have taken place, while a further 6 believed they would have developed more slowly. Organisations who stated that without COMETT the exchanges/activities would not have taken place represented 5 of the 6 sectors, software and services being dominant. There was no difference in organisation size, with SMEs and large companies equally represented.
Summary

It is clearly possible that the low response rate for COMETT reduces the value of the results obtained to some extent. Nevertheless, the similarity in replies received, and the resemblance of these findings to those of other COMETT surveys, suggest that they are broadly valid.

90% of the organisations surveyed believed COMETT had assisted in increasing the availability and quality of professional IT staff; 70% confirmed that participation in COMETT had enabled them to identify training needs; 75% believed that the needs of the IT industry were now better reflected in undergraduate and postgraduate programmes than prior to COMETT’s existence; and over 50% of the organisations had improved links with higher educational institutes. These findings are very similar to those of the evaluations of COMETT carried out in 1989 and 1991. In the former, 66% confirmed that COMETT had enabled them to identify training needs, while 74% stated that COMETT had led to further collaboration with higher educational institutes. Improved definition of training needs was also cited by over 70% of respondents in the 1991 COMETT evaluation.

5. ESPRIT

In contrast to COMETT, the response rate for ESPRIT was relatively good, with 52 returns (36%), 47 of which were still participating in ESPRIT in 1992 when the survey was carried out. Of the 47, 22 had been involved in ESPRIT for over 5 years, a further 5 for 4 years, 11 for 3 years, 2 for 2 years and 9 for between 1 and 2 years. 13 returns came from France, 16 from Germany, 2 from Greece, 6 from Spain, and 15 from the UK.
All technical sectors were covered. Figure 1.15 shows the number of organisations participating in the different technical areas. 11 organisations were involved in the Basic Research sector, which includes the VLSI Design Training Action.

**Figure 1.15**

**ESPRIT Technical Areas of participation**

<table>
<thead>
<tr>
<th>Area</th>
<th>Nr</th>
<th>% of 52</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Microelectronics</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>2. Information Processing Systems</td>
<td>31</td>
<td>60</td>
</tr>
<tr>
<td>3. Advanced Business &amp; Home Systems</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>Peripherals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Computer Integrated Manufacturing</td>
<td>23</td>
<td>44</td>
</tr>
<tr>
<td>5. Basic Research (including VLSI)</td>
<td>11</td>
<td>21</td>
</tr>
<tr>
<td>6. IES</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Not Stated</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
To determine the effectiveness of ESPRIT and in particular
the VLSI Design Training Action, recipients were asked a
series of questions on training and education (Questions 27-
31).

The aim of the VLSI Design Training Action, as explained in
Chapter VI, is to ensure that Europe has sufficient
engineers trained in the design of integrated circuits.
Recipients were asked if they were aware of the scheme’s
existence (Question 28). Surprisingly, only 14 (27%) or-
ganisations replied in the affirmative; all of these
participated in all six ESPRIT technical areas. German
and Greek companies were more aware of the scheme than those
in other countries. And although 4 of the 6 German
participants had 5000+ employees, in the five Member States
surveyed, SMEs were dominant, with 9 of the 14 having less
than 500 employees.

When asked if an increase in the number and quality of VLSI
design engineers had been noticed since 1989 (Question
29), 2 organisations found there had been "a major
increase", 1 "a marginal increase", 10 "no increase" and 33
"did not know". The 2 companies which saw a "major
increase" were German and British. The former had 5000+
employees and participated in all 6 sectors of activity. The
UK respondent had between 100 and 499 employees, and was
involved in electronic components and software and services.
The "marginal increase" was seen by a French electronics
components company with 100-499 employees. The German and
UK participants were involved in ESPRIT Basic Research
projects (the VLSI Design Training Action is within this
area), whereas the French company participated in advanced
business and home systems peripherals and in computer
integrated manufacturing projects. Of the 10 organisations which found no increase, 8 had less than 500
employees, and the remaining 2 had 500-999. They were
involved in computer and office equipment and peripherals (3
organisations), electronic components (2), industrial
automation systems (1), professional electronics (2), and
software and services (4). 3 organisations participated in ESPRIT basic research projects,39 and also participated in microelectronic projects whose related industries are the employers of VLSI designers.

The low awareness of VLSI is somewhat striking considering that the scheme had been underway for three years when the survey was conducted. One of the objectives of the scheme was to train 3000 students in VLSI design per year, and this, according to the Eurochip secretariat (service organisation of the VLSI Design Training Action), had already been achieved by the end of 1991. The lack of awareness among basic research participants who answered the questionnaire would seem to indicate a serious lack of information on the programme: only 3 of the 11 basic research returns demonstrated awareness of the VLSI action.

In response to Question 27 (recruitment of additional staff to work on projects), 67% stated that they had recruited additional professional IT staff specifically to work on ESPRIT projects. All Greek and Spanish ESPRIT respondents had recruited additional IT staff.40 Recruitment was uniform for all types of industrial activity, though computer and office equipment and peripherals was slightly ahead with 71%.41 Small and medium sized enterprises (1-499) and large organisations (5000+) were the principal recruiters of additional staff. Although ESPRIT does not claim to be a training programme (with the exception of the VLSI action), additional staff recruited are trained while working on ESPRIT projects. This is a significant factor, considering that 80% of ESPRIT respondents recruit newly qualified graduates; as one means of filling vacancies (Question 8), 8% of which rely solely on the recruitment of newly qualified graduates. Small and medium sized enterprises with less than 500 employees are the principal recruiters of newly qualified graduates to fill vacancies. Large organisations are also well represented, with 5% having 500-999 employees, 10% having 1000-4999 and 19% having 5000+. The software and services sector was the
principal recruiter of newly qualified graduates. The organisations relying solely on newly qualified graduates comprise 3 SMEs (1-99 employees) and 1 large company with 5000+. All four organisations are in the software and services sector. The large organisation is also involved in computer office equipment and peripherals.

When respondents were asked for their opinion on ESPRIT's assistance in increasing the availability and quality of professional IT staff, over 75% of ESPRIT respondents stated "yes" that ESPRIT had increased the number and quality of professional IT staff, with 15% stating "yes a lot". 75% of organisations with a positive view were SMEs. Large organisations were somewhat, less positive with only 22% believing that ESPRIT had increased the number and quality of professional IT staff. Software and services was by far the most positive sector.

75% of ESPRIT respondents believed their involvement in ESPRIT had improved links with higher education. The majority are SMEs (73%); 13% of the remaining organisations have 5000+ employees. The computer and office equipment and peripherals was the least positive sector (54%).

Summary

Because of inadequate awareness of the VLSI Design Training Action, an evaluation of its effectiveness in increasing the quality and supply of VLSI design engineers cannot be carried out. The general enthusiasm shown by ESPRIT participants for ESPRIT, with over 75% stating that the programme had increased the supply of professional IT staff, and had also improved cooperation links with higher education, lead to the conclusion that ESPRIT has indeed been effective in the education and training field.
6. The role of the EC.

Questionnaire recipients were asked if they thought the European Community was doing enough to improve the availability and quality of professional IT staff. 55 of the 68 returns answered this section. Only 3 organisations (4%), however, found the EC’s efforts excellent, no extra effort being required. A further 36 (53%) believed that although the efforts were good, more effort was required, while 16 organisations (23%) stated that much more effort was required.

One French and two German organisations believed the EC’s efforts to be excellent; no organisation from Greece, Spain, or the UK was as positive in its assessment. The French company was an SME in the software and services sector, whereas the two German companies were large organisations (5000+) in the electronic components, industrial automation systems and the software and services sectors.

For those who were positive about the EC’s efforts, but felt that more could be done, the results showed over 50% for all countries (France 73%, Greece 100%, Spain 86% and the UK 64%) except Germany (44%). Viewed by activity, computer services (computer office equipment and peripherals, software and services) showed a higher positive reaction (64%), than engineering production oriented activities (professional electronics industrial automation systems, and electronic components) at 55%. When analysed by size, 70% of the SMEs surveyed found the EC could do more, against 44% for the largest organisations (5000+ employees).

German organisations were most negative on EC efforts (44%), followed by the UK (36%), France (20%), and Spain (14%). When measured by activity, 50% of organisations in the electronic components and industrial automation systems sectors believed that much more EC effort was required. The other sectors followed with 44% in professional electronics,
33% in audiovisual consumer electronics, 32% in software and services, and 31% in computer office equipment and peripherals. Viewed by size, 33% of organisations with 5000+ employees had the highest negative opinion, followed by 27% for SMEs, and 25% for the large group (500-4999).

Part B of Question 32 asked participants to specify the actions/programmes they would like to see undertaken by the EC over the coming 5-10 years to encourage the appropriate use of education and training for skills. 24 organisations supplied suggestions falling principally into categories of education/training, skills, and funding.

Education and Training

Most suggestions on education and training concerned bringing education up to date to meet industry’s needs. Despite COMETT’s and ESPRIT’s efforts, it was generally felt that education was still lagging behind the leading edge IT developments. Suggestions put forward included:

- Focusing university teaching more on industrial user needs. In this respect greater cooperation between European universities is called for and more encouragement for academic/industrial interchange is underlined; the approval of a phase III for COMETT is seen as essential.

- The harmonisation of education in the Member States, This would involve the harmonisation of the curriculum of universities throughout Europe, increasing student exchanges and leading to a greater transfer of knowledge.

- Training UK participants were particularly positive on their view of existing national; the British Computer Society’s Professional Development Scheme, and the Department of Trade and Industry (DTI) and Science and Engineering Research Council’s (SERC) Teaching Company scheme are mentioned; returns recommend that similar schemes be encouraged at EC level. The Professional Development Scheme (PDS) is a package for training and career
development for the information systems industry, and ensures that quality control is applied to the practical experience and training of individuals making a career in the industry. The Teaching Company Scheme helps firms to solve key problems which are central to their competitive success, and to improve the quality of industrial training for new graduates.

Skills

The need for more people with technical as well as managerial skills is highlighted.

Funding

Proposals include; greater funding of university departments so that graduates may be trained in a "more practical way"; a need is seen for more funding for educational purposes in current R & D projects (ESPRIT), and to promote the increase of SMEs using IT, and to encourage students to take up traineeships in these companies.
NOTES

1. An enterprise is a total company which may comprise several subsidiary companies.

2. A business unit is a specific site, factory or part of a company with clearly defined profit responsibility.

3. A subsidiary is a legal entity, where the majority or all shares are held by a parent/holding company.

4. 1 organisation failed to indicate the number of employees.

5. Professional IT staff (graduates and experienced IT staff): these are people in jobs at graduate level or equivalent whose main activity is associated with the development or application of IT in the organisation or in its products and services.

6. Global (%) figures are of total respondents (68), while ventilated figures are by attribute (e.g. country, activity).

7. There were 15 organisations with 5000+ employees.

8. SMEs are organisations with less than 500 people. In this survey there are three principal groups, SMEs (1-499), Large group (500-4999), and the Large+ group (5000+).

9. Results for the other sectors show; computer and office equipment and peripherals (40%), audiovisual consumer electronics (33%), professional electronics (33%), software and services (32%), industrial automation systems (27%).

10. Computing staff (16%), Engineers (18%) and R & D specialists (14%).

11. France 21%, Germany 21%, and Spain 12%.

12. The UK Government IT Initiative involved special one-year courses to convert postgraduates from other disciplines into IT engineers. In 1985, 43 million pounds was allocated to create a further 1,000 IT graduates a year from 1988 onwards. The Economist, London, 16.5.1987.

13. In October 1986, Mr. Kenneth Baker, the Education Secretary, announced plans for a pilot network of twenty City Technology Colleges, catering for 11-18 year olds, and concentrating on science and technology.

14. The Women into IT Campaign, launched in 1989, undertook collaborative projects to recruit into and retain more women within the computer industry. Projects included improving career information and advice available to girls at school to encourage girls to start thinking about IT as a career.

The Women into IT (WIT) Foundation was formed by the British Computer Society, British Petroleum, FI Group, Hewlett Packard, STC/ICL and the Post Office. Activities are also supported by other companies.

15. The Engineering Council’s guidance booklets, published in 1989, for staff in schools, colleges, and higher educational institutions, aimed to help staff promote equal opportunities for girls and thereby to encourage them into science and engineering disciplines. Training Agency, Skills Bulletin, Sheffield, Summer 1989, p. 7.
In 1989, the Engineering Council launched a scheme to link 24,000 engineers to 6,000 schools across the country. Local companies gave equipment on loan, supplied materials, organised pupil and teacher visits to their premises and set industry-related projects for the schools. The objective was to help schools and to increase awareness of engineering as a worthwhile, creative and enjoyable activity. Training Agency, *Skills Bulletin*, Sheffield, Autumn 1989, p. 2.

Computing staff (38%), engineers (36%), and R & D specialists (38%).

42% of French, 32% of German, 25% of Spanish and 50% of Greek participants had major difficulty in the recruitment of experienced IT staff.

9 UK organisations had major difficulty recruiting experienced IT staff in 1991.

Less difficulty recruiting newly qualified graduates for IT jobs in 1991 compared with 1988, by country: France (36%), Germany (32%), Greece (75%), Spain (50%) and UK (33%).

Less difficulty recruiting experienced IT staff in 1991 compared with 1988, by country: France (23%), Germany (26%), Greece (75%), Spain (25%) and UK (32%).

52% of organisations employing computing staff expect an increase, 51% of organisations employing engineers expect an increase and 56% of organisations employing R & D specialists expect an increase.

Q 17 (1 not stated), Q 18 (1 not stated), Q 21 (2 not stated), Q 22 (1 not stated), Q 23 (1 not stated), Q 24 (4 not stated).

From the 5 Member States, France (3), Germany (5), Greece (1), Spain (2) and the UK (1).

Computer and office equipment and peripherals (5), professional electronics (5), industrial automation systems (4), electronics components (4), and audiovisual consumer electronics (3).

2 French, 2 German, and 1 Spanish.

3 French, 1 German and 2 Greek organisations comprising 3 large companies and 3 SMEs.

2 French, 1 German, 2 Greek, comprising 2 large companies and 3 SMEs.

3 French, 2 German, 2 Spanish, 1 Greek and 1 UK, of which 5 were large companies and 4 were SMEs.

1 French, 2 German, 1 Spanish, and 2 Greek.

The software and services sector had 4 participants.

The evaluation was carried out by Coopers & Lybrand, C & L Belmont, in association with the Science Policy Research Unit, University of Sussex, *Evaluation of the COMETT Programme*, Brussels, 1989, p. 70.


2 organisations failed to indicate the year, 3 organisations were no longer participating in ESPRIT, 2 of these organisations participated from 1985, and 1 from 1989.

1. Electronic components, 2. software and services, 3. computer & office equipment & peripherals, 4. audiovisual consumer electronics, 5. industrial automation systems and 6. professional electronics.

The German respondent participated in all six ESPRIT technical areas, while the UK organisation participated in microelectronics and basic research.

The 10 organisations comprised 2 French, 4 German, 3 British and 1 Spanish.

The 10 organisations who said "no" participate in the following ESPRIT technical areas: microelectronics (4), information processing systems (8), advanced business and home systems (2), computer integrated manufacturing (1) and basic research (3).

7 of the 13 French ESPRIT respondents (54%), 10 of the 16 German (63%), 2 Greek (total =2), 6 Spanish (total =6) and 10 of the 15 UK ESPRIT respondents (67%) had recruited additional professional IT staff specifically to work on ESPRIT.

Electronic components (67%), software and services (58%), audiovisual consumer electronics (67%), industrial automation systems (67%), and professional electronics (57%).

Software and services (26 organisations) was followed by electronic components (6), professional electronics (6), computer and office equipment and peripherals (5), and industrial automation systems (4). 11 organisations participated in "other" activities.

1 French, 2 German and 1 Spanish.

Country of respondents: France (11), Germany (12), Greece (2), Spain (6) and UK (9).

Country of respondents who stated "yes a lot": France (2), Germany (3), Greece (1), and UK (2).

The number of organisations by activity who believed ESPRIT had increased the number and quality of professional IT staff: software and services (26), computer and office equipment and peripherals (8), electronics components (8), industrial automation systems (6), professional electronics (4), and audiovisual consumer electronics (3).

Remaining sectors were more positive; professional electronics (100%), industrial automation systems (100%), audiovisual consumer electronics (100%), electronic components (89%), and software and services (81%).
CHAPTER X: EUROPE AND INFORMATION TECHNOLOGY OVERVIEW, CONCLUSIONS, AND SUGGESTIONS FOR FUTURE ACTION

Introduction

This final chapter summarises the principal elements of the study, presents the main survey conclusions on manpower shortages, and outlines suggestions for possible improvements within the framework of EC programmes.

1. Overview

Information Technology is a strategic technology and has become a significant industrial sector for the European Community. While IT is one of the largest sectors, (about 4.5% of worldwide GDP), its economic impact is even greater than this would suggest. IT is the basis of much structural innovation in other industrial sectors, in that it influences the quality of services and the efficiency of production processes. By making available a wide range of effective computer aids, IT has revolutionised office management and has had a particularly strong influence on the service sector. Furthermore, IT applications, because they affect all industrial activity, provide the means by which industries can compete; computer integrated manufacturing (CIM), one such application, enables the
complete manufacturing process to be computerised from start to finish, thereby increasing productivity, reducing cost and producing higher quality products. Clearly, Information Technology has a major role in maintaining and strengthening the competitiveness of European industry.

In the early 1980s Europe’s IT industry was in a very weak position vis-a-vis Japan and the US. This was mainly due to the division of national markets by different standards and practices and different ways of solving the same application problems. Although national programmes played an important role in promoting R & D in IT, they had also created some undesirable side-effects; R & D was unfocussed, resources were dispersed and efforts overlapped too much to be effective. The ESPRIT programme was launched in 1984 to combat these negative elements, and thereby to improve the competitive position of Europe’s IT industry.

ESPRIT has been successful in building up a European technology base and in stimulating the growth of inter-company and company-research links across Europe. And although Europe’s technological position has improved, among the factors still threatening future competitiveness is the shortage of IT manpower. Technological development needs IT manpower capable of mastering the complexity and opportunities of the technology and its applications.

The reports and surveys examined in this study point to the existence of IT shortages; the empirical survey carried out confirms that a shortage of IT manpower exists in Europe. Shortage was measured in terms of difficulty encountered by employers in the recruitment of professional IT staff in 1991. The survey findings show that 35% of organisations had major difficulty recruiting experienced IT staff in 1991, while 16% had major difficulty recruiting newly qualified graduates.

Considering that over 50% of survey participants expect their employment of IT staff to increase over the period 1992-1994, this shortage is likely to worsen.
Such shortages cause major problems for industry. 57% of survey participants found professional IT staff to be of critical importance in providing them with a competitive advantage. A further 34% believe they are very important. As a result of shortages in 1991, 37% of organisations experienced longer delivery/implementation periods, while 16% incurred lost output.

Universities and higher education institutions are the principal suppliers of IT manpower. In view of the nature of IT skills needed, their fast rate of change, and industry’s difficulty in meeting these needs through their own efforts, cooperative links developed between industry and higher education, with a view to achieving, among other goals, a greater output of IT manpower.

The EC, recognising the value of cooperation and at the same time the increasing demand for manpower with technological skills, launched the COMETT programme and, somewhat later, the VLSI Design Training Action within the ESPRIT programme. Cooperation has been strengthened as a result; over half of COMETT participants and over 70% of ESPRIT participants in the survey stated that they had benefitted from improved links with higher education. The majority of COMETT participants also believed that participation in COMETT had enabled them to identify training needs. The belief that the needs of the IT industry were now better reflected in undergraduate and postgraduate programmes than prior to COMETT’s existence was also upheld by the majority of COMETT respondents.

The impact of COMETT and the ESPRIT VLSI Design Training Action in raising interest in participation is evident from the reports produced by the EC Commission, the COMETT Technical Assistance Office and the VLSI Secretariat. More importantly, the effectiveness of COMETT and ESPRIT in increasing the availability and quality of IT manpower and in meeting the skill requirements of Europe’s IT industry is evident from the survey findings.
All COMETT returns (but 1), and over 75% of ESPRIT returns, stated that COMETT and ESPRIT had assisted in increasing the availability and quality of professional IT staff.

The lack of awareness of the ESPRIT VLSI Design Training Action meant an evaluation of its effectiveness in increasing the quality and supply of VLSI design engineers could not be carried out.

Although survey participants viewed positively the roles of COMETT and ESPRIT in increasing the availability and quality of IT manpower, only 4% of organisations believed that no extra EC effort was required in this area. The majority (53%) although positive, believed that more could be done by the EC, while a further 23% of organisations, with a negative view of EC efforts, believed that much more effort was required.

2. Conclusions

In all 53% saw EC programmes as positive, but believed that more could be done. In the context of the three other major findings of the survey (57% critical assessment of supply of professional IT staff, 35% having major difficulties in the recruitment of experienced IT staff, and more than 50% of organisations expecting an increased need for IT staff over the period 1992-1994), when these results are classified by sector and organisation size, an interesting trend is observed:

Small and medium sized enterprises (SMEs) had consistently higher indicators for their importance assessment, difficulties in the recruitment of IT staff, increase in IT staff over the period 1992-1994, and evaluation of Community programmes when compared to large organisations. Similarly the computer services sector (computer office equipment and peripherals, software and services) had consistently higher
indicators when compared to the engineering production sector (figure 1.16).

Figure 1.16

Comparative Results for Leading Indicators

(all figures in %)

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>5000+ Employ.</th>
<th>SMEs (1)</th>
<th>Computer Services etc.(2)</th>
<th>Engineering Production Oriented(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance of IT STAFF</td>
<td>57</td>
<td>36</td>
<td>62</td>
<td>67</td>
<td>38</td>
</tr>
<tr>
<td>Critical Assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulties in Recruitment 1991</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experienced Staff</td>
<td>35</td>
<td>39</td>
<td>43</td>
<td>32</td>
<td>29</td>
</tr>
<tr>
<td>Increase in IT employment</td>
<td>52</td>
<td>21</td>
<td>64</td>
<td>51</td>
<td>31</td>
</tr>
<tr>
<td>over next 3 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluation of Community Programs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Positive, but could do more&quot;</td>
<td>53</td>
<td>44</td>
<td>70</td>
<td>64</td>
<td>55</td>
</tr>
</tbody>
</table>

(1) less than 500 employees
(2) Computer office equipment and peripherals, Software and services
(3) Professional Electronics, Industrial Automation Systems, and Electronic Components
In conclusion, the relationship between education and training and industrial competitiveness is vital. Faced with continuing technological change and industry's demand for IT manpower, more EC effort in IT education and training is essential. Future EC action should concentrate, in particular, on the education and training needs of SMEs and the manpower requirements of the computer services sector.

3. Suggestions for future action

In the light of the survey results, along with the other main findings of the study, this section suggests three directions for action.

3.1 Understanding IT skills requirements

From the survey findings, it is clear that an IT skills shortage exists in Europe. To allow action at a European scale to improve this situation, greater harmonisation of data on skills is needed. The lack of official statistics on demand for IT manpower, the present inadequate classification structures of economic activity (NACE), and the number of higher education students graduating in IT disciplines (ISCED) make approaches and potential solutions complex and difficult to implement. It is essential that European and national authorities harmonise data collection and forecasting. Once this has been achieved, effective policies may be put in motion.

3.2 Actions to improve education and training

3.2.1 University curricula

The rate of technological change demands an ongoing effort to keep the level of skills of the workforce up to date. Graduates must therefore learn skills to contribute
personally to their company's success, rather than merely to apply their technical skills at a task level. For universities to turn out "more of the same" will not end the skills shortage. There is a need to teach enterprise skills parallel to the practical subject of study. COMETT should place greater emphasis on bringing university curricula up to date to meet the IT industry's needs. This could be achieved via the biannual organisation of conferences or meetings at which IT industries, universities, and other higher education establishments could exchange views on curriculum content and updating.

There is a need to harmonise the technical curricula of European universities and of other higher education establishments. This would encourage greater student and staff mobility and increase knowledge transfer.

3.2.2 Investment by companies in education and training.

To match demand for increased skill levels, companies should raise skill levels in existing staff who already have a knowledge of the business which new recruits would have to acquire. Companies should be encouraged to develop human resources strategies and to consider training as an integral component of it. In this respect, they should allocate a set number of working days per year for education and training development. Encouragement in this area needs a joint EC/national effort, concentrating on improving existing national efforts.

3.2.3 Encourage more students into IT disciplines

To respond to IT skills shortages, in particular in view of the "demographic ditch", more students should be encouraged into IT disciplines. The EC should, in cooperation with national governments, increase efforts in this direction, in particular by encouraging more women to study IT disciplines. Only in this way can it be guaranteed that in the long term there will be a sufficient pool of graduates.
3.2.4 VLSI Design Training Action

Improve awareness of the VLSI Design Training Action in the Member States, and in the IT industry generally.

3.3 Special efforts to support SMEs

As seen in the survey SMEs had consistently higher indicators for their assessment of the importance of professional IT staff, difficulties in the recruitment of IT staff, increase in IT staff over the period 1992-1994 and evaluation of Community programmes. Small and medium-sized enterprises are a vital part of Europe’s industrial structure, and should be encouraged and assisted in their training efforts. Under COMETT, students and university personnel should be encouraged to take up more placements in SMEs.
NOTES


2. The 1989 US Department of Commerce study on emerging technologies assessed the situation of these technologies in terms of product introduction. Of the 10 identified emerging technologies in IT, Europe is ahead or on par with Japan in 6 and ahead or on par with the US in 7. US Department of Commerce, *Emerging Technologies: A Survey of Technical and Economic Opportunities*, Washington, 1990, p. 11.

3. In Chapter V.

4. Systems engineers, software specialists, systems analysts, VLSI designers, data processing staff and manpower with hybrid skills (technical as well as business skills).

5. Cooperative links also result in industry gaining access to knowledge, facilities, and expertise, while cooperation offers academics the possibility of additional resources and the opportunity to develop marketing skills.

6. These reports are reviewed in Chapter VII.
TECHNICAL MACHINE (ORIENTED) AND TECHNICAL/SECTOR LINKED DEFINITIONS

1. "Information Technology is a recent and comprehensive term which describes the whole range of processes for the acquisition, storage, transmission, retrieval and processing of information".


2. "Information Technology is the acquisition, production, transformation, storage, retrieval and transmission of data by electronic means in vocal, pictorial, textual or numeric forms".


3.1 "Information Technology refers to electronic hardware that is used to create, communicate, store, modify, or display information and to programming, or software that is developed to control the operation of that hardware".
3.2 "Information Technology has been used to refer to the cluster of technologies that provide the following automated capabilities: data collection, data input, information storage, information processing, communications and information presentation".


4. "Information Technology as defined by the OECD in recent studies embraces the application of computer and communications technologies to the collection, storage, processing and dissemination of information: inclusion of the term "computer" in the definition implies some form of electronic "intelligence" or decision capability".

Scott, W.D., and Little, A.D., Information Technology in Australia Capabilities and Opportunities. Volume 1, 1984, p. 12.

5. "Information Technology is the acquisition, processing, storage and dissemination of vocal, pictorial, textual and numerical information by a microelectronics-based combination of computing and telecommunications".


6. "Information Technology is data processing; is automation; is communication; is recording; is knowledge; is artificial intelligence".

7. "new ways of storing, processing and transmitting information brought about by rapid developments in electronics, computing and telecommunications".


8. "Information Technology covers: the processing of information ... the storage of information and the communication of information".


9. "Information Technology is a collective term for the whole spectrum of technologies providing the ways and means to acquire, store, transmit, retrieve and process information".


10. "New Information Technology is defined as the use of modern technology for the collection, storage, processing and transmission of information in digital form and covers a broad field of mechanisms, equipment, capabilities and technologies".

11. "Information Technology - a new technological system for the storage, processing, communication and dissemination of information, based on an inter-connected set of technical and organisational innovations in electronic computers, software, engineering, control systems, integrated circuits and telecommunications".


12. "IT is the construction and operation of information handling systems composed of microelectronics, computers, software and telecommunications".

"IT covers the electronic processing of information as well as office and factory automation (robotics), process control and telecommunications".


13. "The new Information Technologies involve an interconnected set of technical and organisational innovations in electronic computers, software engineering, control systems, integrated circuits and telecommunications, which have made it possible to collect, generate, analyse and diffuse large quantities of information at low cost".

IFO (Institut fur Wirtschaftsforschung), and MERIT (Maastricht Economic Research Institute on Innovation and Technology), Macro-Economic and Sectoral Analysis of Future Employment and Training Perspectives in the Information Technologies in the European Community, Munich and Maastricht, 1991.
14. "Information Technologies comprises: information systems including software and services, electronic components, industrial automation systems/computer integrated manufacturing".


15. "Information Technology covers the electronic processing of information, as well as office and factory automation (robotics), process control and telecommunications".

The European Community and new technologies from ESPRIT to the Biosociety, European file 8, CEC, Brussels, 1984, p. 3.
1. "Information Technology comprises the following fields of industrial activity:

- Microelectronics, semiconductors, components;

- Application of microelectronics in industrial products, processes, subsystems and systems (e.g. robotics, measuring instruments);

- Telecommunications;

- Data processing, computer technology;

- Artificial Intelligence."


2. "IT is defined to include the provision of components and sub-systems for the IT industry, as well as the supply of services made possible by IT.

The IT sector includes: Components; Consumer Electronics; Electronic Data Processing; Telecommunications; Office equipment; Control and instrumentation; Medical and industrial; and Communications."

3. "Information Technologies include microelectronics and optoelectronics, the software industry and all the other disciplines associated with data processing such as artificial intelligence, in other words all the techniques that play an important role in the acquisition, processing, transmission and storage of information ... The main applications of information technologies include telecommunications, defence, computer integrated manufacture and automated office systems and consumer electronics".

1. "Information Technologies involve everything from a video tape to a direct broadcasting satellite, from a pocket electronic calculator to a missile guidance system; from a tiny silicon chip to a mainframe or supercomputer, from a digital watch to a robot, from software to a CAD/CAM system."


2. "For many Europeans the Information Technology (IT) revolution has already arrived. Digital watches, hi-fi, video recorders, electronic credit card banking and word processors mark the first wave of innovative products."

SOCIAL, ECONOMIC AND OTHER DEFINITIONS (BROADER DEFINITIONS)

1. "The scientific, technological and engineering disciplines and the management techniques used in information handling and processing, their applications; computers and their interaction with men and machines, and associated social, economic and cultural matters".


2. "Information Technology is the collection, storage, processing, dissemination and use of information. It is not confined to hardware and software, but acknowledges the importance of man and the goals he sets for this technology, the values employed in making these choices, the assessment criteria used to decide whether he is controlling the technology and is being enriched by it."

3. "Information Technology includes the systems, equipment, components and software required to ensure the transmission, processing and storage of information in all centres of human activity (home, office, factory, etc.), whose application generally requires the use of electronics or similar technology".


"Informatique – science of the rational processing, notably by automatic information machines of information considered as the material basis of knowledge and communication in the technical, economic and social fields."

Appendix V

IT PUBLICATIONS HAVING NO DEFINITION OF IT


Appendix VI

ESPRIT DOCUMENTATION

1. Communication from the Commission to the Council.


COMETT DOCUMENTATION


The European Community came into being on the 9th of May 1950 when the French Minister for Foreign Affairs, Robert Schuman, outlined the aims of the "Schuman plan". The plan aimed to integrate the coal and steel industries of those Western European countries who wished to participate in the scheme. The European Coal and Steel Community (ECSC) was established in 1951, when Belgium, France, the Federal Republic of Germany, Italy, Luxembourg and the Netherlands signed the Treaty of Paris. By integrating the coal and steel industries and thereby the economies of the six Member States, the ECSC laid the foundation stone for greater European unity. Some six years later, on 25 March 1957, the process of integration was taken a step further with the signing of the Treaties of Rome.

These Treaties established the European Economic Community (EEC) and the European Atomic Energy Community (EURATOM). The essential aim of EURATOM is to encourage cooperation in the peaceful use and development of nuclear energy, whereas the aim of the EEC Treaty is to bring Member states closer together, first by economic cooperation and integration, leading gradually to greater political cooperation. The Rome Treaty (EEC) made no provision for industrial and technology policy, what it did provide was a range of policy powers which could be used to determine the regulatory framework and market conditions for European industry. As Information Technology had not yet come to the forefront, there was no reference to the need to develop a European IT policy within the framework of the Treaty of Rome, the Treaty did however by including article 235 provide the
legal basis for the development of such policies at a later stage.

During the 1960s controversy grew over Europe's technological position; J.J. Servan-Schreiber in his book *Le Défi Américain*, translated as *The American Challenge* assessed Europe's position vis-a-vis the United States:

"... Fifteen years from now it is quite possible that the world's third greatest industrial power, just after the United States and Russia, will not be Europe, but American industry in Europe ... the power to create wealth is the power to make decisions... If America is the place where decisions are made, and Europe where they are later put into application, within a single generation we will no longer belong to the same civilisation".

It was in response to these admonitions that the notion of developing a technological Community within Europe arose. The French proposed that the European Commission should undertake a study of industrial and research policies within the six Member States. The question of Britain's membership of the EC was part of the same debate. Britain believed that her technological expertise constituted her strongest hand. The Commission and a report by the Council of Europe also upheld this view. In 1966 the UK Prime Minister, Mr Harold Wilson, in his speech at Guildhall put forward his proposal to create a new technological Community to pool within Europe the enormous technological inventiveness of Britain and other European countries, and to enable Europe on a competitive basis, to become more self-reliant and neither dependent on imports nor dominated from outside.

Various suggestions were put forward as to what form such a technological Community should take. Two of the more influential views emanated from Jean Monnet's Action Committee for a United States of Europe and Christopher Layton's book *European Advanced Technology: A programme for
Integration. Monnet called for a new institution concerned with technological cooperation to be established in conjunction with the EC Commission, while Layton outlined fifteen policy recommendations ranging from basic science to legal and financial support provisions. His suggestions also included a European merger - promoting agency, common purchasing, industrial Community R & D contracts, a European Advisory Council and a Technology Assessment Centre. Layton's premise remained the essential need to pool Europe's industrial and technological resources to meet the American, and would be Japanese challenges. Despite these efforts, technological collaboration was slow to get off the ground. In the computing industry attempts were made to develop cross-national groupings, two such attempts were; 1) the Unidata experiment and 2) the Eurodata consortium.

1) In the mid-1960s, a Franco-German bilateral link led to the Unidata experiment, the aim of which was to create a European IBM and to develop and market jointly a new range of computers. The industrialists involved suggested that thorough collaboration required a merger under a single management. The French Government did not accept this proposal, instead they wanted Honeywell-Bull and CII to merge under 51% French ownership and be party to a global arrangement to market and share products with Honeywell US. This deal was intended to combine French control with access to advanced technology. French failure to consult both the German Government and Siemens contributed to Unidata's collapse. 2) In 1969, the Eurodata consortium comprising ICL, CII, Philips, AEG-Telefunken, Saab and Olivetti was established to tender for an ESRO computer requirement, however eventual pressure from Siemens on the German Government against this move led to the collapse of the deal.

In 1967 another attempt to collaborate was made, this time in the field of scientific and technical research. The Council of the European Communities entrusted the PREST working party (French abbreviation for Scientific and...
Technical Research policy) with the task of drawing up a report on possible cooperation in what they identified as seven important areas; informatics, telecommunications, new means of transport, oceanography, metallurgy, environmental protection and meteorology. The report known as the Aigrain report was submitted with forty seven concrete research projects, when the examination of these projects was completed the Council of the European Communities convened a conference, this was held in November 1971 and was attended by the Ministers responsible for Research and Technology in the nineteen states. At the conference a decision was taken to implement seven projects and the COST initiative was born. COST provides a framework and forum for technical and scientific cooperation and has strengthened European industrial and scientific competitiveness through cross border collaborative research projects between the nineteen countries participating in the action.

At the October 1972 Summit, the seeds of many EEC policies were sown. The Heads of State expressed their determination to promote the development of a common policy in the field of science and technology; "objectives will need to be defined and the development of a common policy in the field of science and technology ensured". An agreement was eventually reached by a Resolution (a declaration with no legally binding force) which committed the Member States to coordinate policy, a committee of national officials; CREST was established to carry this out. The first real positive step towards implementing the 1972 Summit Resolution in the area of Information Technology was taken on the 15th of July 1974, when the Council of Ministers adopted a Resolution for the development of a Community policy in data processing. The Commission recognised that this was the sector of high technology where European weakness was most pronounced and action most needed. The Resolution agreed that the Community should have a medium term systematic programme for the promotion of research, industrial development and the application of data processing. The Multiannual Programme in the field of data
processing (MAP) arose out of the application of this Council Resolution. The programme was adopted on 11 September 1979 for a period of four years. Technical computing projects and a range of economic studies were financed under the programme. The studies comprised three main categories; the processing of statistical data for the information technologies sector, the analysis of the structure of IT industry and the political environment, and the future developments in IT within and outside the Community. Studies along a similar line were also financed under the FAST programme (Forecasting and Assessment in the field of Science and Technology) which was launched in 1978. The results of the MAP and FAST studies carried out in the field of IT later proved indispensable to the Commission in arguing the case for more substantial intervention in IT.

Another IT sector where action was seen as necessary in the 1970s was in the field of microelectronics. In 1978 it was estimated that the first commercial production in Europe of MOS-technology Integrated Circuits lagged some two to four years behind the United States. Europe depended on imports of integrated circuits (ICs) and on advanced digital ICs. Meanwhile in Japan and the US policies were underway. The Council invited the Commission to examine the possibilities and methods of coordinating national projects in the microelectronics sector. The Commission prepared a proposal for a 140 MECU package which would; coordinate national programmes through the creation of an EEC information bank, and through EEC coordination of national aid projects, and develop a manufacturing equipment industry for microelectronics. The proposal was adopted by the Council on the 7th of December 1981.

It was at the Bonn meeting of the Community Heads of State and Government in July 1978 that Information Technology gained momentum. The leaders agreed that new sources of growth and employment should be identified to offset the difficult adjustments that traditional industries (coal,
steel, shipbuilding, etc.) were being forced to undergo. The Commission’s report presented at the meeting; *Report on some Structural Aspects of Growth* identified IT as a vital motor of economic development, and emphasised the Japanese and American Governments efforts to promote research and development and to create markets in electronics/data processing. The report acknowledged that though similar programmes were underway in the Member States and some efforts had been made by the Community, because of the conflicts of interest between Member States and individual enterprises success had been limited. The report underlined the need for a long-term technology programme.19 The Community leaders subsequently at their Strasbourg meeting requested the Commission to study the situation and to report.

In November 1979, Commissioner Davignon (responsible for IT) presented his report to the Dublin Summit, *European Society faced with the Challenge of New Information Technologies: A Community Response*. The report underlined the importance of IT and emphasised the improvements in efficiency that would result from IT, as well as highlighting the threat to Europe posed by Japan and the United States. Pointing to the role of the Community, Davignon argued: "Europe has so far failed to mobilise its major asset, continental scale. Though its total informatics market is half as large as America’s, it is still divided by different standards and practices, and different ways of solving the same application problems . . . the different national programmes have fostered competing national enterprises while leaving key long-term needs unmet . . . there is a need to mobilise and coordinate the efforts made by Member States and by specialised international agencies within a wider framework, to make use of the Community’s normative powers and the purchasing power of public authorities to create new European markets, to catalyse bilateral and trilateral industrial collaboration, to put the new Information Technologies at the service of the Community itself and its institutions . . ."20 A six-point programme was proposed covering 1) a social policy to
prepare the climate for innovation; 2) the encouragement of a homogeneous European public market for telematic equipment and services; 3) the promotion of a European information industry; 4) the fostering of industrial collaboration; 5) a European programme for satellite use; and 6) applying the new technologies to the Community itself. This was the first of many future attempts by Commissioner Davignon to bring Europe's IT problem to the forefront.

By the early 1980s the situation of the European IT industry had deteriorated and concern was growing; in 1982 the EEC balance of payments in IT products and services suffered a deficit of over $10 billion. At that time in the Commission some effort was being made; Roland Hueber of the FAST team initiated the conception and coordination of a research project on Community needs and activities in Long lead-time R & D in Information Technology. The political breakthrough which made it possible for the Commission to intervene in IT on a more serious scale was achieved by Commissioner Davignon who wrote to the 12 leading European electronic and IT companies. He invited them to a meeting ("Round Table"), this was the start of a series of Round Table discussions amongst the "Big Twelve" as they came to be known. Davignon's objective was to initiate debate on how the European technology gap could best be closed.

Davignon believed that Japan's industrial success was due in part to companies' collaboration in government-supported precompetitive research. The work programme being defined not by the Ministry of International Trade and Industry (MITI), but jointly by the companies. This approach had worked in Japan, and Davignon felt it could and should be tried in Europe. In November 1981, Davignon brought the Heads of Europe's main IT companies together and a technical committee was established (which later became the Steering Committee). Precompetitive research was singled out as an area of strategic importance. To work out a concrete programme of action, the Steering Committee set up a number of technical panels and workshops. In parallel to the
panels, the Commission established its own Information Technologies Task Force (initially set up as a temporary department under DGIII). The Task Force members were the deputy chairmen of the Technical Panels. The Task Force was supported by a central office. All three together made up JEPIT - Joint European Planning in Information Technology. Discussions continued and resulted in a consensus on five areas of research where a European programme was deemed essential. In September 1980, the Commission forwarded its first report on new Information Technologies to the Council. The purpose was to describe the broad lines of action which the Commission would undertake. These were based on the proposals in Davignon's report. The first report was followed in 1982 by a Communication; Towards a European Strategic Programme for Research and Development in Information Technologies, which set the wheels in motion for the establishment of the ESPRIT programme. The Communication called for; a "European strategy to reinforce the existing efforts of national authorities to encourage cooperation between European firms . . . such a strategy would be of a substantial scale". The programme would be; "aimed at precompetitive technology, concerted with national activities and of a substantial scale, adequate to catch up with and match the equivalent efforts of Japan and the USA." Pre-competitive R & D was necessary for two reasons, it was permissible under the Treaty of Rome to subsidise this class of activity but not to subsidise product development and companies would be reluctant to share technologies that they were preparing to introduce on the market. Pre-competitive R & D was later identified as that for which commercial possibilities remain five to ten years in the future.

ESPRIT aimed to build on existing Community activities. It was a logical follow-on to the Microelectronics programme and the Multiannual programme, but larger in scale. While national programmes played an important role in support of R & D in IT and related technological domains, they also created some undesirable side-effects of market
fragmentation, dispersion of resources and unfocussed R & D efforts, they overlapped too much to be effective in taking up the American and Japanese challenge. ESPRIT proposed to enhance their effectiveness and reduce these negative effects, through a systematic consultation of all parties interested.

The Ministers of Research at their meeting in June 1982 welcomed the concept of ESPRIT as did the Heads of State at their European Council meeting in Versailles. Encouraged by this outcome the Commission prepared a pilot phase, which was essential given the novelty of this kind of large scale cooperation in research in Europe. A total of fifteen pilot projects were outlined. The Commission added one more for the development of a communications system which would enable ESPRIT participants to communicate quickly and efficiently. The pilot phase was funded for one year.

The wide response to the pilot phase resulted in a full-scale action programme. A proposal for the main phase was prepared by the Commission and forwarded to the Council in June 1983. British and German reservations over budgetary costs delayed the final approval of ESPRIT until 28 February 1984, when a decision was taken to fund a five year programme. This programme represented some 10,000 man-years of research and, concentrated in five sectors; microelectronics, software technology, advanced information processing, office systems, and computer integrated manufacturing. The architects of ESPRIT saw the initial fruits of their efforts when the first call for proposals for the main phase was issued in March 1984, 441 proposals were received in response to the call of which 201 projects were eventually selected for funding.
NOTES

1. Competition policy, freedom of capital and labour movements, the right of establishment, customs union, harmonisation of national laws, and state aids fell within the Treaty's competence, but were not subsumed under a general framework for industrial policy.

2. "If action by the Community should prove necessary to attain, in the course of the operation of the common market, one of the objectives of the Community and this Treaty has not provided the necessary powers, the Council shall, acting unanimously on a proposal from the Commission and after consulting the European Parliament, take the appropriate measures". Treaties Establishing the European Community, Abridged Edition, Council, Office for Official Publications of the EC, Luxembourg, 1987, p. 314.


4. Opinion on the Applications for Membership Received from the United Kingdom, Denmark, & Norway. CEC, Brussels, 1967.


7. It was on the initiative of Jean Monnet that the Action Committee was founded in October 1955 by the Socialist, Christian Democrat and Liberal Parties and non-communist trade unions of the six EEC Member States.


10. Austria, Belgium, Denmark, Finland, France, The Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain Sweden, Switzerland, Turkey, The United Kingdom and Yugoslavia.

By March 1993 the number of countries participating in the action had risen to twenty five.

11. COST is the abbreviation for Coopération Européenne dans le domaine de la Recherche Scientifique et Technique (European Cooperation in Scientific and Technical Research). COST is not an independent international organisation but rather an international association with jointly determined obligations.


13. CREST was established to advise the Commission and the Council in defining a common policy in science and technology. It is now basically a consultative body and provides a forum for
discussion on all science and technology matters (framework programme, specific programme). CREST comprises representatives from the Member States and the Commission.


15 FAST aimed to contribute to the definition of long-term Community R & D objectives and priorities and thus to the development of a coherent science and technology policy in the long term. Under FAST, research institutes in the EEC competed for grants to forecast developments within three main areas: Work and Employment, the Information Society, and the Biosociety.


17 Ibid. pp. 4-5. In March 1976 Japan launched a cooperative project involving five Japanese electronic firms (Fujitsu, Hitachi, Mitsubishi, NEC and Toshiba), Nippon Telegraph and Telephone Public Corporation and MITI, the goal being to develop VLSI technology to beat IBM's next generation computers. In 1978, in the USA, the Department of Defence proposed a six year programme on Very High Speed Integration (VHSI). The aim of which was a ten-fold reduction in size, weight, power consumption and failure rate and a 100-fold increase in throughput with respect to ICs.


21 GEC, Plessey, ICL, Thomson, CII HB, Philips, AEG, Telefunken, Siemens, Nixdorf, Olivetti and STET.


24 Communication from the Commission to the Council Towards a European Strategic Programme for R & D in Information Technologies, COM(82)287, CEC, Brussels, 25.5.1982, p. 5.


The idea of establishing a Framework programme was introduced in the early 1980s, when it became evident that successive research programmes in separate sectors were not particularly helpful in enabling the Community to make the best use of resources. The Commission proposed the implementation of an R & D programme which would embrace all Community research. The Framework programme would not only be a Community programming tool but also one for medium term financial forecasting likely to render it considerably easier to make sectoral programme or budgetary decisions.

The Framework programme lays down the objectives, the priorities and the overall funds for Community action and their apportionment in broad terms, it constitutes a "guide" for decisions on specific programmes to be taken during the five years covered.


The present programme (1990-1994) covers three high-priority areas: 1) enabling technologies, 2) management of natural resources and 3) management of intellectual resources. Within these areas there are six lines of action and
fifteen specific programmes. The total funds allocated to the third Framework programme amount to 5,700 MECU.

Commissioner Ruberti (responsible for R & D and Technology) sees a need for a more selective R & T D\(^6\) policy. In his view, "research activities will have to be concentrated to a greater extent on a limited number of technologies, with multisectoral impact capable of making Europe's industry more competitive and on subjects which concern society in general".\(^6\) The fourth Framework programme will therefore be more selective, supporting four lines of action and only seven themes/programmes, as opposed to fifteen in the third Framework programme.
NOTES


4 1) Information and communications technologies, 2) industrial and materials technologies, 3) environment, 4) life sciences and technologies, 5) energy and 6) human capital and mobility.

5 Research and Technological Development.


7 1) Information and communications technologies and the development of infrastructures; 2) industrial technologies; 3) the environment; 4) life sciences and technologies; 5) energy; 6) research for a European transport policy; and 7) finalised socio-economic research.
Appendix X

SKILL NEEDS PROJECT

The skill needs project is a Commission initiative viewed as a first step towards monitoring skill needs. It was conceived in response to the European Parliament's request in 1990, to organise Europe-wide an exchange of information on skill shortages and future skill requirements. The principal objectives are; to raise awareness of skill shortages, to provide examples of ways to overcome skill shortages, and to initiate action. The project operates within five areas:

1) Assembling and synthesising of existing information

This involves at the EC level, an overview of existing work on the skills and qualifications issue, especially analysis of future skills requirements and the related education and training needs. Sources used include; studies by public or private research institutions and reports published by federations and other international organisations.

2) Regional investigations

A skill needs analysis is being organised in several European regions. To date, 31 regions have participated in these transnational projects which vary from the analysis of specific topics to the specific skill needs of a particular group. One such project involved the creation of four working groups composed of enterprises and training institutions from four regions (Germany, Greece, Portugal and the United Kingdom). The main objectives were; the exchange of information on ways of solving skill gaps, and
their assessment and implementation through the organisation of exchanges between the partners.

3) Sectoral Analysis

An analysis of skills has been undertaken in different industrial sectors: electronics, textiles, the retail trade and tourism. Emphasis is placed on involving organisations, examining the European dimension, and on the development of a vision as to how the sectors could develop. In electronics, a project is underway to improve the number and quality of technicians in Greece and Portugal. A collaboration link has been established between UK trainers/enterprises (where the expertise exists), and Portuguese and Greek trainers/enterprises.

4) Effects of Pervasive Technologies and Environmental Concerns

Three pervasive technologies have been identified; information and communication technologies, biotechnologies and new materials. This area considers the effects of these technologies taking into consideration environmental concerns.

5) Conferences and Seminars

Conferences and seminars are supported to provide a forum for the exchange of ideas and to present the main issues and problems resulting from investigations.

An evaluation of the success of the Skill Needs Project is underway and is expected to be published by the EC Commission before the end of 1993.
The objectives of COMETT I as specified in the Council Decision of 24 July 1986 are:

"to give a European dimension to cooperation between universities and enterprises in training relating to innovation and the development and application of new technologies;

to foster the joint development of training programmes and the exchanges of experience, and also the optimum use of training resources at Community level;

to improve the supply of training at local, regional and national level with the assistance of the authorities concerned, thus contributing to the balanced economic development of the Community;

to develop the level of training in response to technological change and social changes by identifying the resulting priorities in existing training arrangements which call for supplementary action both within Member States and at Community level, and by promoting equal opportunities for men and women".

COMETT II OBJECTIVES

The objectives of COMETT II as specified in the Council Decision of 16 December 1988 are:

"to improve the contribution of, in particular, advanced technology training at the various levels concerned and thus the contribution of training to the economic and social development of the Community;

to foster the joint development of training programmes and the exchange of experience, and also the optimum use of training resources at Community level, notably through the creation of transnational sectoral and regional networks of, in particular, advanced technology training projects;

to respond to the specific skill requirements of small and medium-sized business;

to promote equal opportunities for men and women in initial and continuing training in, in particular, advanced technology;

to give a European dimension to cooperation between universities and industry in initial and continuing training relating to technologies and their applications and transfer".

Appendix XII

Distribution of COMETT I Projects by technology sector and Strand

COMETT SECTORS OF ACTIVITY

1986-1987

1. INDUSTRIAL TECHNOLOGIES
2. INFORMATION TECHNOLOGIES
   - Data Processing,
   - Microelectronics,
   ESPRIT
   - Advanced Microelectronics Capability,
   - Software Technologies,
   - Advanced Information Processing,
   - Office Systems,
   - Computer Integrated Manufacture,
   EUROTRA
   RACE
3. BIOTECHNOLOGIES
4. ENERGY
5. HEALTH & SAFETY
6. ENVIRONMENT
7. IMPROVING EFFICACY OF S/T POTENTIAL
8. MANAGEMENT
9. SOCIAL ASPECTS
10. OTHERS
1. INDUSTRIAL TECHNOLOGIES

2. INFORMATION TECHNOLOGIES
   - Data Processing
   - Microelectronics
   - Advanced Microelectronics Capability
   - Software Technologies
   - Advanced Information Processing
   - Office Systems
   - Computer Integrated Manufacture
   - EUROTRA
   - RACE

3. BIOTECHNOLOGIES

4. ENERGY

5. HEALTH & SAFETY

6. ENVIRONMENT

7. IMPROVING EFFICACY OF S/T POTENTIAL

8. TECHNOLOGIES MANAGEMENT

9. SOCIAL ASPECTS

10. OTHERS
1. BASIC RESOURCES
2. OCCUPATION OF THE EARTH SURFACE
3. APPLICATIONS OF BIOLOGY & CHEMISTRY
4. PRODUCTION & MANUFACTURING
5. INFORMATION TECHNOLOGY
   - General
   - Data & Information Processing
   - Basic Software Technology
   - Artificial Intelligence & Expert Systems
   - Telecommunications & Data Communications
   - Other Software Applications.
6. OTHER APPLICATIONS OF EXACT SCIENCES
7. INDUSTRIAL MANAGEMENT & SOCIAL ASPECTS OF TECHNOLOGY
8. SOCIAL & HUMAN SCIENCE (TECHNOLOGICAL ASPECTS)
9. OTHERS.
1990

1. BASIC RESOURCES
2. OCCUPATION OF THE EARTH'S SURFACE
3. APPLICATIONS OF BIOLOGY & CHEMISTRY
4. PRODUCTION & MANUFACTURING
5. INFORMATION TECHNOLOGY
   - General
   - Data & Information Processing
   - Basic Software Technology
   - Artificial Intelligence & Expert Systems
   - Telecommunications & Data Communications
   - Other Software Applications.
6. OTHER APPLICATIONS OF THE EXACT SCIENCES
7. MANAGEMENT (technology aspects)
8. SOCIAL & HUMAN SCIENCES (technology aspects)
9. OTHERS
1. BASIC RESOURCES
2. OCCUPATION OF THE EARTH’S SURFACE
3. APPLICATIONS OF BIOLOGY & CHEMISTRY
4. PRODUCTION & MANUFACTURING
5. INFORMATION TECHNOLOGY
   - General
   - Data & Information Processing
   - Basic Software Technology
   - Artificial Intelligence & Expert Systems
   - Telecommunications & Data Communications
   - Other Software Applications.
6. OTHER APPLICATIONS OF THE EXACT SCIENCES
7. MANAGEMENT (technology aspects)
8. SOCIAL & HUMAN SCIENCES (technology aspects)
9. OTHERS
1. BASIC RESOURCES
2. OCCUPATION OF THE EARTH'S SURFACE
3. APPLICATIONS OF BIOLOGY & CHEMISTRY
4. PRODUCTION & MANUFACTURING
5. INFORMATION TECHNOLOGY
   - General
   - Data & Information Processing
   - Basic Software Technology
   - Artificial Intelligence & Expert Systems
   - Telecommunications & Data Communications
   - Other Software Applications.
6. OTHER APPLICATIONS OF THE EXACT SCIENCES
7. MANAGEMENT (technology aspects)
8. SOCIAL & HUMAN SCIENCES (technology aspects)
9. OTHERS
Appendix XIV

DELTA PROGRAMME

In 1988 the European Commission launched a two year programme "DELTA"- Developing European Learning Through Technological Advance. The DELTA programme was an exploratory action designed to investigate ways in which Europe could meet the need for greater flexibility in skills training and education through the use of advanced technologies, and in which technology could help large scale training take place in the most cost effective manner possible.

DELTA had five specific objectives:

1) to optimise the use of Community Resources to advance learning technology,

2) to increase collaboration in the development of advanced learning technology,

3) to test and validate Communications, i.e. testing and evaluating the effectiveness of using advanced information technologies in open learning systems

4) interoperability,

5) to promote favourable conditions.

The work initiated under the exploratory action was the first step towards improving the use of information and communication technology and their integration in advanced learning systems in Europe. The experience and results obtained are now being built on by DELTA’s successor;
"Research and technology development of Telematic Systems for Flexible and Distance Learning." This programme aims to establish trans-European flexible and distance learning services based on telematic systems. These will make a major contribution to solving the problems posed by Europe's growing training needs in terms of:

- "flexibility - by increasing adaptability to different needs, learning patterns and settings, and media combinations,

- accessibility - promoting the ability to learn when and wherever necessary,

- learning Support - by ensuring the development of infrastructures to assist learners, trainers and course producers".
Interoperability involves recommendations to standard organisations for the introduction of technical standards for educational technology.

Identification of factors inhibiting the use of distance learning and the actions needed to create a favourable environment.

The Telematic Systems for Flexible and Distance Learning programme falls under line 1.C of the Framework programme 1990-1994. Its objective is to ensure the interoperability of systems, peripherals and telematic networks at trans-European level. This is necessary in view of the realisation of the Internal Market, which is setting new requirements in the field of services and information exchange. Sectors of general concern are: safety, transport, health, problems relating to the handicapped, aged and training. A Community effort in addition to national efforts is needed in research and technological development to meet these requirements.

Brochure on Research and Technology Development of Telematic Systems for Flexible and Distance Learning, CEC, Brussels, 1990.
The Human Capital and Mobility programme is one of the specific programmes under the third Framework programme. Its goal is to increase qualitatively and quantitatively the human resources in research and technological development. The programme aims to train, through participation in high level research, about 5000 researchers over the four years of the programme (1991-1994). The activity is intended primarily for the benefit of young researchers at post-doctoral level.¹

The action will be organised around two main areas; the training and mobility of research staff, and the building-up of networks, which will involve:

1. **The development of a Community system of research fellowships.**

"The purpose of this Community system of research fellowships is to complete and enhance the training activities carried out under other specific programmes, thereby laying the foundations of the European scientific and technical Community".² The Community will grant financial aid to specific research and technological development teams, laboratories and training networks permitting them to award research fellowships to researchers
undergoing training or specialisation there.

2. **Assistance for the creation and development of scientific and technical cooperation networks**

These networks will comprise at least five research laboratories or teams in at least three Community countries working jointly on one or more R & D projects.

3. **Measures to promote the access of researchers to large-scale scientific and technical facilities.**

This activity will increase the training opportunities offered to European researchers by enabling them to become familiar with the use of large-scale scientific and technical facilities in the execution of research projects.

4. **The launching of a Community system of R & D Euroconferences**

The objective is to enable young scientists to participate in high-level conferences. Such participation will enable young scientists to keep up to date with advances.

**Programme approval and research areas to be covered by the programme**

The programme was approved by the Council of Ministers in March 1992. The first call for proposals for participation in the programme was issued on 30 December 1992. Published programme documentation explains that a broad range of topics will be covered "including all scientific and technological sectors." These sectors comprise all areas of the exact and natural sciences, technology and engineering, economic and the social sciences which are important for the competitiveness of the Community.
NOTES

1 Defined as researchers having at least six years of higher education and who hold a doctorate or an equivalent degree, or who have had two or more years of research experience following a postgraduate course. CEC, Human Capital and Mobility Work Programme, and Information Package. CEC, Brussels, 1992, p. 5.


3 Ibid. p. 13. A large scale facility is an establishment which requires substantial initial investment or a group of smaller establishments which have complementary capacities.


5 Ibid. p. 13.
Appendix XVI

QUESTIONNAIRE
Throughout the questionnaire Information Technology (IT) has been defined as:

"technology and systems for the acquisition, storage, transmission, retrieval and processing of information and includes computing, hardware, software, electronics and data processing facilities."

A. BACKGROUND INFORMATION

1. Organisation Name & Address

2. Is this questionnaire being completed on behalf of:

(1) An Enterprise
(2) A Business Unit
(3) A Subsidiary
(4) Other

---Enterprise - the total company which may comprise several subsidiary companies.

---Business Unit - A specific site, factory or part of a company with clearly defined profit responsibility.

---Subsidiary - A legal entity, where the majority or all shares are held by a parent / holding company.
3. Please indicate your type of activity:

1. Electronics Components [ ]
2. Software & Services [ ]
3. Computer & Office Equipment & Peripherals [ ]
4. Audiovisual Consumer Electronics [ ]
5. Industrial Automation Systems [ ]
6. Professional Electronics [ ]
7. Other [ ]

4. (a) Approximately how many people are currently employed in your organisation?
   (include any part-time employees)

1. 1-99 [ ]
2. 100-499 [ ]
3. 500-999 [ ]
4. 1000-4999 [ ]
5. 5000+ [ ]

B. INFORMATION TECHNOLOGY (IT) SKILLS

5. Do you employ any professional Information Technology (IT)\(^4\) staff?

1. Yes [ ]
2. No [ ]

\(^4\)The term "Professional IT Staff" is used in the questionnaire to describe people in jobs at graduate, level or equivalent whose main activity is associated with the development or application of IT in your organisation or in its products and services. Professional IT staff comprises IT graduates and experienced IT staff.
6. Approximately how many Professional IT Staff do you employ?

1. 1-20
2. 21-50
3. 51-100
4. 101-500
5. 500-1000
6. 1000+

7. Do you employ Professional IT Staff in any of the following occupational groups?

Please tick appropriate boxes:

1. Computing Staff- (programmers, systems analysts)
2. Engineers-(control, electronic, microelectronic software, and systems design engineers)
3. R & D Specialists (in advanced technology eg. expert systems, digital techniques)
4. Other

8. What are your organisation's principal means of filling vacancies for professional IT Staff?

Please tick appropriate boxes:

1. Recruitment of newly qualified graduates
2. Recruitment of experienced professional IT staff
3. Conversion/upgrading training of other staff transferred within your organisation
4. Other
Graduate Recruitment

9. Did you experience any major difficulties in
   a) recruiting newly qualified graduates for IT jobs in 1991?
      1. Yes [ ]
      2. No [ ]

   b) If yes in what area(s)?

10. On the whole, how did your experience of recruiting newly qualified graduates for IT jobs in 1991 compare with 1988?

      1. Less difficult [ ]
      2. About the same [ ]
      3. More difficult [ ]
Experienced Staff

11. Did your organisation experience any major difficulties in recruiting experienced IT staff in 1991?

1. Yes [ ]
2. No [ ]

if Yes in what area(s)?

12. On the whole, how did your experience in recruiting experienced IT staff in 1991 compare with 1988?

1. Less difficult [ ]
2. About the same [ ]
3. More difficult [ ]

13. Please indicate the importance of Professional IT Staff (graduate and experienced IT staff) in providing a competitive advantage for your company? please tick one box

1. Critical [ ]
2. Very Important [ ]
3. Moderately Important [ ]
4. Unimportant [ ]
14. What effects, if any, did shortages of Professional IT Staff have on your business or operations in 1991?

Please tick appropriate boxes

1. No effect [  ]
2. Lost output [  ]
3. Longer delivery/implementation period [  ]
4. Lower quality standards [  ]
5. Higher costs [  ]
6. Other (please give details) [  ]

15. How do you expect your employment of Professional IT Staff to change over the next three years?

1. Likely to increase [  ]
2. Likely to stay the same [  ]
3. Likely to decrease [  ]
4. Do not know [  ]

C. EUROPEAN COMMUNITY PROGRAMMES

16. Are you participating in either one of the following Community Education & Training Programmes/Actions?

(please indicate and proceed to answer the questions concerning this programme, for COMETT please go to question 17 and for ESPRIT question 25)

1. COMETT [  ]
2. ESPRIT [  ]
17. When did your organisation first participate in COMETT?

1. 1986 [ ]
2. 1987 [ ]
3. 1988 [ ]
4. 1989 [ ]
5. 1990 [ ]
6. 1991 [ ]

Is your organisation still participating in COMETT?

7. Yes [ ]
8. No [ ]

18. In which strand/strands did / does your organisation participate?

1. Strand A 5 [ ]
2. Strand B 6 [ ]
3. Strand C 7 [ ]
4. Strand D 8 [ ]

19. Prior to participating in COMETT was your organisation involved in transnational collaboration with higher education institutions in training for technology?

1. Yes [ ]
2. No [ ]

*Strand A - Development of University Enterprise Training Partnerships.
*Strand B - Financial support towards the transnational exchange of students and personnel from university and enterprise.
*Strand C - Financial support for joint projects in continuing training in, in particular advanced technology.
*Strand D - Financial support towards promotion and back up measures.
20. Has participation in COMETT enabled you to play a part in identifying training needs?

1. Yes [ ]
2. No [ ]

21. In your opinion has COMETT assisted in increasing the availability and quality of professional IT staff responsive to the needs of Europe's IT industry?

1. Yes, greatly [ ]
2. Yes, a little [ ]
3. No [ ]

22. Do you believe that the needs of the IT industry are reflected now more adequately in undergraduate and postgraduate programmes than prior to COMETT's existence?

1. Yes, very well [ ]
2. Yes, well [ ]
3. Yes, adequately [ ]
4. Yes, but poorly [ ]
5. No [ ]
23. What benefits have you gained from your involvement in COMETT projects? Please tick appropriate boxes, numbering them in order of importance:

1. Easier recruitment of Experienced IT Staff [ ]
2. Easier recruitment of IT Graduates [ ]
3. More training and development of existing professional IT Staff in your organisation [ ]
4. More training to upgrade/convert other staff to professional IT jobs [ ]
5. Improved links with higher education [ ]

24. Which of the following best describes the way in which resources available from COMETT have helped in developing student/staff exchanges (Strand B) and training activities (Strands C and D)? Please tick one box.

1. Without COMETT the exchanges/activities would not have taken place [ ]
2. Without COMETT the exchanges/activities would have developed more slowly [ ]
3. Without COMETT the exchanges/activities would have been of lower quality [ ]

ESPRIT

25. When did your organisation first participate in ESPRIT?

1. 1985 [ ]
2. 1986 [ ]
3. 1987 [ ]
4. 1988 [ ]
5. 1989 [ ]
6. 1990 [ ]
7. 1991 [ ]
Is your organisation still participating in ESPRIT?

Yes [ ]

No [ ]

26. In which technical areas did / does your organisation participate?

1. Microelectronics [ ]

2. Information Processing Systems [ ]

3. Advanced Business & Home Systems Peripherals [ ]

4. Computer Integrated Manufacturing [ ]

5. Basic Research (including VLSI) [ ]

6. IES [ ]

27. Has your organisation ever recruited additional professional IT staff specifically to work on an ESPRIT project?

1. Yes [ ]

2. No [ ]

28. Are you aware of the ESPRIT VLSI Training Action?

1. Yes [ ]

2. No [ ]

29. The aim of the VLSI Training Action is to ensure that Europe has sufficient design engineers for integrated circuits. The Action commenced in 1989, have you remarked an increase in the number and quality of VLSI design engineers since 1989?

1. Yes, a major increase [ ]

2. Yes, a marginal increase [ ]

3. No [ ]

4. Do not know [ ]
30. Has your involvement in ESPRIT improved your links with Higher Education Institutes?

1. Yes [ ]
2. No [ ]

31. In your opinion has ESPRIT assisted in increasing the availability and quality of professional IT staff responsive to the needs of Europe’s IT industry?

1. Yes, a lot [ ]
2. Yes, a little [ ]
3. No [ ]

D. THE ROLE OF THE EEC

32. (A) Do you think the European Community is doing enough to improve the availability and quality of professional IT Staff?

1. Yes, excellent, no extra effort required [ ]
2. Yes, but some more effort is required [ ]
3. No, much more effort is required [ ]

(B) What actions / programmes would you like to see undertaken by the EEC over the next 5-10 years to encourage the appropriate use of education and training for IT skills, please specify:

Thank you for taking the time to complete this questionnaire.
Accepted projects in COMETT I
Distribution by Strand
and applicant Member State

Source: CEC, Development of COMETT, July 1990
Appendix XVIII

COUNTRY PARTICIPATION IN ESPRIT

<table>
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<tr>
<th>Country</th>
<th>Number of Projects</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>279</td>
<td>18.8</td>
</tr>
<tr>
<td>F</td>
<td>282</td>
<td>19.1</td>
</tr>
<tr>
<td>D</td>
<td>268</td>
<td>18.1</td>
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<tr>
<td>I</td>
<td>187</td>
<td>12.6</td>
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<tr>
<td>IRL</td>
<td>36</td>
<td>2.4</td>
</tr>
</tbody>
</table>

INSTITUTIONS OF THE EUROPEAN COMMUNITY

The Commission

The Commission is the executive body of the European Community, it is like a civil service and is responsible for both proposing and implementing Community policy. It is also the guardian of the Community Treaties ensuring that they and the other legal instruments adopted by the Community are compiled with. If they are not, it is for the Commission to take action and, if necessary, bring proceedings before the Court of Justice. It also manages the common policies, implements the budget and directs the administration.

The Commission has 17 Members appointed by common agreement of the governments of the Member States for a renewable four-year period. The President and the Vice-Presidents are appointed by the governments from among the Members of the Commission. The Commissioners undertake to act during their period of office totally independently of both the governments and the Council. Each Commissioner is responsible for a portfolio and has authority over one or more Directorates General (Departments).

The Council

The Council of Ministers is the main decision-making body of the European Community, adopting major decisions on
proposals from the Commission. It also coordinates economic policies and concludes the international agreements to which the Community is a party. It is made up of Ministers from each of the Member State governments who meet several times a year, depending on the subject. It is assisted by the Committee of Permanent Representatives (Coreper) composed of the Ambassadors of the Member States to the Community and their advisers. Coreper is responsible for preparing the Ministers' work.

Since 1975 there have been regular meetings of the European Council, which is composed of the Heads of State or government, the Foreign Ministers, and the President and a Vice-President of the Commission. It meets at least twice a year. The Presidency of the Council is held by each Member State in turn, in alphabetical order, for six months.

The European Parliament

The European Parliament is a democratically elected body of parliamentarians who represent the interests of the European public. It gives opinions on the Commission's legislative proposals and also has budgetary powers which allow it to take part in major decisions on Community expenditure. The Single European Act extended the Parliament's legislative role by giving it joint powers with the Council to approve association agreements with non-member countries and Treaties for the accession of new Member States.

Since 1979, the 518 Members of the European Parliament have been elected by direct universal suffrage according to the voting systems applicable in the various Member States. The number of seats allocated to each Member State depends on the size of its population and elections take place every five years. The Parliament is headed by a Bureau composed of the President and 14 Vice-Presidents elected by the Members.
The Court of Justice

The Court of Justice is the supreme judicial authority of the European Communities. It is an independent body whose task is to uphold the law in the interpretation and application of the Treaties and acts adopted by the Council and the Commission.

The Court consists of 13 Judges assisted by 6 Advocates - General appointed by common accord of the governments of the Member States for a renewable term of six years.

The Economic and Social Committee

The Economic and Social Committee is a consultative body whose role is to advise the Community’s decision-makers on the implications social and vocational issues may have for Europeans.

It consists of 189 members nominated by the Member State governments and appointed by the Council for a renewable four-year term of office. The members are representatives of a number of economic and social fields (agriculture, transport, trade, liberal professions etc.)

The Court of Auditors

The main task of the Court of Auditors is to examine the accounts of all revenue and expenditure of the European Communities and of all organisations established by the Communities. It also has an advisory function enabling it to play a part in the drafting of Community financial and budgetary legislation. The Court is an independent body composed of 12 members, one from each Member State appointed for a renewable six-year term by the Council.
The European Investment Bank

The European Investment Bank is responsible for granting loans and issuing guarantees to finance capital projects consistent with the aims of Community economic policy.

The bank is administered by: a Board of Governors consisting of Ministers designated by the Member States, a Board of Directors consisting of 22 administrators and 12 deputies appointed for a renewable five-year term of office by the Board of Governors on the basis of nominations by the Member States and the Commission, and a Management Committee consisting of a President and six Vice-Presidents appointed for a renewable six-years by the Board of Governors.

The Board of Governors lays down general directives on the Bank’s credit policy. The Board of Directors directs the general administration of the Bank and takes decisions on the granting and raising of loans, the fixing of lending rates etc. The Management Committee controls all current operations, drafts loan agreements and implements the decisions of the Board of Directors.
**TECHNICAL GLOSSARY**

**Analog:** Pertaining to the form of continuously variable physical quantities.

**ASIC Design:** Application Specific Integrated Circuit.

**Artificial Intelligence:** The study of computer techniques to supplement the intellectual capabilities of humans. Artificial intelligence is concerned with the more effective use of digital computers through improved programming methods.

**Basic Research:** Fundamental research.

**BICMOS:** A combination of two types of transistor; bipolar, which is fast but tends to be power hungry, and CMOS, which uses little power but is slower.

**Binary digit:** A numeral in the binary system of notation, usually known as a bit, the digit may be one or a zero.

**CAD:** Computer-Aided Design.

**CAM:** Computer-Aided Manufacturing.

**CAD/CAM:** Refers to the integration of computers into the entire design-to-fabrication cycle of a product or plant.

**Central Processing Unit (CPU):** The part of a computer system that contains the circuits controlling the interpretation and execution of instructions.

**CHIP:** In electronics, a small integrated circuit package containing many logic elements.

**CIM:** Computer-Integrated Manufacturing, the concept of a
totally automated factory in which all manufacturing processes are integrated and controlled by a CAD/CAM system.

CMOS: Complementary Metal Oxide Semiconductor.

CNC: Computer Numerically Controlled.

Component: An essential functional part of a subsystem or apparatus.

Computer: A programmable functional unit that consists of one or more associated processing units and peripheral equipment that is controlled by internally stored programs and which can perform substantial computation, including numerous arithmetic operations or logic operations, without human intervention during a run. A digital computer stores its information in the form of words, finite ordered sets of digits, each of which have only one of a finite set of values. A microcomputer is a stored program digital computer system produced from microelectronic devices and employing very large scale integration (VLSI) circuit design techniques. A mainframe (computer) - designates high capacity computers with processing power in excess of 4 MIPS (millions of instructions per second) with a memory capacity of more than 20MB at the central level. A personal computer is a small computer based on a tiny microprocessor. A supercomputer is a large scale computer which can perform 400 million or so operations per second.

Computer science: The branch of science and technology that is concerned with methods and techniques relating to data processing performed by automatic means.

Consumer electronics: A range of electronic equipment used in the home and includes; video cassette recorders, televisions, compact disc players and home computers.

Databank: Storage of information in a structured form.
Data processing: The systematic performance of operations upon data.

Data processing system: A system, including computing equipment and associated personnel, that performs input, processing, storage, output, and control functions to accomplish a sequence of operations on data.

DRAM: Dynamic Random Access Memory.

Electrode: A piece of conducting material placed in a gas solution, or molten substance, to enable an electric current to enter or leave.

Electronic mail: Can transfer computer-generated texts and files directly.

ENIAC: Electronic Numerical Integrator and Calculator.

EPROM: Erasable Programmable Read only Memory.

FMS: Flexible Manufacturing systems.

GaAs: Gallium Arsenide (semiconductor material).

Hardware: The computer’s hardware is its physical equipment.

Hydrant: Water pipe.

Integrated circuit memory: A storage device composed of transistors, diodes and other circuit elements all fabricated on a chip of crystalline material.

Information processing system: Data processing system.

JESSI: Joint European Submicron Silicon Initiative.

LAN: Local area network. A computer network located on a user’s premises within a limited geographical area.
Liquid crystal displays: A liquid is contained between two sheets of glass, or plastic. Tiny electrodes are placed in the liquid. When the electrodes are connected to an electrical supply, an electric field is formed between them.

Memory: Possibly of different levels, in which both data and instructions are stored.

Microchip: See chip.

Microelectronics: Construction and use of highly minaturised electronic circuits.

Microprocessor: A processor whose elements have been miniaturised into one or a few integrated circuits.

MOS: Metal-Oxide Semiconductor, a type of integrated circuit.

Multimedia: Approaches enable a workstation to access all types of services.


Office automation: Automation in an office environment using systems that transform ideas into written communications via the interaction of people, procedures and equipment.

Office & business systems: Information Technology systems designed to support office and business applications.

Open systems: Allow customers to integrate equipment made by a variety of manufacturers. An open system implements sufficient specifications for interfaces, services and supporting formats to enable properly engineered application software to be ported across a wide range of systems with minimal changes, interoperate with other applications.... and interact with users in a style which facilitates user portability.

Optoelectronics: The marriage of optical processing and electronics.
**Peripheral**: Any device connected to the central processing unit of a computer.

**Peripheral technologies**: Include storage devices, displays, printers and input devices.

**Process control**: The control of a process in which a computer system is used to regulate usually continuous operations or processes.

**RAM**: Random-Access Memory.

**Relay**: A device by which electric current flowing in one circuit can open or close a second circuit, i.e. switch the current on or off in the second circuit.

**RISC**: Reduced Instruction Set Computer Core.

**Robot**: A microprocessor - controlled mechanical device that performs a function or provides an intelligent interface between machines and processes.

**Scanner**: A device that examines a special pattern, one part after another, and generates analog or digital signals corresponding to the pattern.

**Semiconductor**: In electronics, a material with a conductivity midway between that of an insulator and a good conductor. The conductivity is sensitive to temperature, radiation and the presence of impurities. Such materials are used in the manufacture of transistors.

**Semiconductor devices**: In electronics, devices manufactured using semiconductor materials.

**Silicon chip**: Silicon in electronics, a chemical element having semiconductor properties and used in the manufacture of transistors.

**Software**: Intellectual creation comprising the programs, procedures, rules and any associated documentation pertaining to the operation of a data processing system.
Software package: A complete and documented set of programs supplied to several users for a generic application or function.

Submicron: Over one million transistors placed on a single chip.

Symbolic logic: The discipline in which valid argument and operations are dealt with using an artificial language designated to avoid the ambiguities and logical inadequacies of natural languages.

Thermionic tube: Thermionic valve, a device using thermionic emission which is the emission of electrons from hot metals. It is used in cathode-ray tubes, x-ray tubes and thermionic valves.

Transistor: In electronics, a device manufactured from semiconductor material that can be used to control a current flow in a circuit.

Vacuum tube: A device with electrodes within an evacuated glass envelope for the control of current flows.

Valve: Device for controlling the passage of fluid through a pipe.

VLSI: Very Large Scale Integration. In microelectronics, chip technology resulting in packing densities of over 10,000 transistors per chip.

Wafer: A thin slice of silicon cut from a slab.

Wafer Fabrication Plant: A chip factory is called a wafer fabrication plant, because its end product is the wafer with the chips on board.

Workstation: A data processing station that is operated by a person and usually located at an endpoint node.
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