The SRC should know a lot about this one

2

CONFIDENTIAL

Prime Minister

Robert Armstrong may have some comments next week.

Qa 04410

To: MR LANKESTER

From: SIR KENNETH BERRILL

Information Technology

25/1

1. The last meeting of the NEDC, which was chaired by the Prime Minister, was largely concerned with the need to speed up the adoption in Britain of the new technologies. There was an impressive (perhaps, indeed, surprising) unanimity of view from all round the table, and at the end of the discussion the Prime Minister pledged that the Government would do all in its power to help.

2. If that undertaking is to be implemented there is, in the view of the CPRS, much to be done. (The Prime Minister picked out one issue at E last Wednesday when she commented on the slow take-up of new technology office equipment by the Civil Service.)

3. The attached note and annex sets out the opportunities in the most important field of the new technology - information technology. It is concerned particularly with the inadequacies, as we see them, of the interdepartmental machinery in Whitehall for handling the complex and inter-related issues. Our main objective is to wave a very large red flag indicating trouble in this area. Whether our particular proposal for improved machinery of government is right is another matter. But we are convinced that the matter needs urgent attention and, if the Prime Minister accepts this, she might ask Sir Robert Armstrong for his views both on the adequacy of present central arrangements and how the question of deciding what changes are needed should best be handled.

4. I am sending a copy of this minute and the attachments to Sir Robert Armstrong.

KB

25 January 1980

Atts

CONFIDENTIAL

INFORMATION TECHNOLOGY

A Note by the Central Policy Review Staff

Introduction

1. Governments in the United Kingdom are always in danger of spending too much time on the problems of the declining sectors of the economy (steel, shipbuilding, motor cars) and not enough on the potential growth sectors. This Government has done its best to keep a balance and to pursue its strategic growth objective of reducing the size of the public sector and, at the same time, creating a better framework within which management in private enterprise can respond dynamically to the growth possibilities as they see them.

2. The CPRS has contributed to this work on trying to improve the framework both at the macro-level (the need for further reductions in public expenditure) and at the micro-level (the detailed 'priorities' work in MISC 14 and MISC 15). But certainly at the micro-level considerably more needs to be done if the economic framework is to be adequately improved. We are particularly concerned that the effort should be adequate in what is now widely accepted as the two main areas for potential development - small firms and information technology. We have expressed elsewhere our fears that the 'small firms package' will prove to be inadequate. In what follows we set out our worries on information technology.

3. It has, suddenly, become received wisdom that small firms and information technology are the most hopeful areas for future growth. The EEC Commission has recognised the crucial importance of information technology and having secured a 'fair wind' from the Dublin European Council is in the process of producing detailed proposals for a Community strategy in this area. The French had a mammoth one week conference in Paris opened by Giscard and concluded by Barre. Each European country is fearful lest it may lose out to the sheer weight of the United States and the skills and drive of the Japanese. All have programmes to improve the prospects for development of information technology.

4. But what have we in the United Kingdom done to improve the framework within which the information technology revolution might hope to progress in

Britain at least as fast as elsewhere? The CPRS believes that so far our response has been worryingly inadequate and that, as so often in the past, we are falling behind and missing the opportunities which our technology offered us (System X and Prestel). In part the problem of improving the framework lies in the complexity of the subject and the very large number of Ministries involved. (To give some idea of the breadth of the subject we attach a brief "Child's Guide" for those who are not completely clear what is meant by 'information technology' and how the range of issues it covers is much wider than that of the more familiar microprocessor or 'chip'.)

The Possibilities

5. The attached brief guide illustrates how several technologies are converging and unlocking many new possibilities. In this revolution the United Kingdom has some advantages (English is the common language of data processing and London is an important centre for commercial services). Against that we are notoriously bad at moving from new invention to production and marketing; we are not at present a major manufacturer of key products such as office equipment and our professions are often disinclined to depart from traditional practices and techniques.

The Role of the Government

6. We do not argue that the Government needs to intervene in the sense of providing industrial support. Equally, however, there is an irreducible minimum of areas where the Government needs to maintain an active interest in order to provide the right framework for the rapid take-up of information technology. In some cases this is a matter of regulation; in others of example. We list them below, commenting in each case on the adequacy of present interdepartmental arrangements for handling.

(a) Manpower - the social and retraining problems caused by changing requirements for skills; making sure that skilled manpower is available on an adequate scale and balancing the military requirements against the civil (this last could be increasingly important).

- E(EA) can handle civilian training issues; no Committee exists to balance civilian and military needs for manpower and contact between MoD and Employment/MSC in this area is, as far as we know, non-existent.

(b) The telecommunications system - the United Kingdom must have a first class telecommunications system. In the past the Post Office has always underprovided and if this occurs again there will be pressure for private satellite based networks provided by the United States or EEC multinational consortia.

- The Official Cabinet Committee, T, has the limited remit of looking at departmental requirements for telecommunications. The Department of Industry is the lead Department but Trade (good telecommunications vital for our trade in services) and Transport (telecommunications can be a substitute for transport) also have an interest.

(c) Transmission frequencies - the frequency spectrum is a vital yet limited resource and the Government must plan and control its use.

- An Official Cabinet Committee, T(F), exists; heavily dominated by the Home Office with limited FCO and no DoI (for equipment manufacturers) representation.

(d) Technical standards - standards are needed to make different systems compatible but standards may also be used by our competitors as a barrier to trade. We need to be alert to this in formulating a United Kingdom response, particularly in the EEC context (see below).

- Existing activity on standards covers an enormous field but there are gaps, e.g. no policy on compatibility of educational computer programmes for use in schools.

(e) Public sector purchasing policy - used strategically by other countries but not so far by the United Kingdom, e.g. the French are launching a cut-price Visual Display Unit (VDU) on the back of a programme to transfer directory enquiries from directories to a computerised system. A co-ordinated approach to the purchasing of word processing systems by Departments would provide a strong lead to the British office equipment industry, as well as laying the foundation for electronic document transfer between Departments.

- Handled by the Central Computing Agency and HMSO for central government with an awkward interface where they meet. Various sponsor Departments also involved. No equivalent for local government, the NHS or nationalised industries - one of the few existing examples of good co-ordination, the University Computer Board being under threat of closure.

(f) Public sector usage - the public sector as demonstrator of how efficiency can be improved by information technology.

- Handled by the CCA and HMSO with wide variations between Department and some practices which would be scarcely credible to the private sector, e.g. the manual handling of prison officers' pay. DoI has an interest as manufacturers' sponsor; CSD because of implications for staffing.

(g) R & D - the need to ensure that the balance of research effort, e.g. between government and industry, civilian and military is right and best possible use is made of foreign as well as United Kingdom results.

- Again civilian research is co-ordinated by the Advisory Board of the Research Councils but no forum exists for assessing the balance between civilian and military research.

(h) Reducing the vulnerability of information flows to strikes, sabotage, or fraud.

- Level of protection decided on a case by case basis by relevant Department and CCA; no forum for ensuring consistency of expenditure or methods.

(i) Privacy - policies on privacy, copyright, defamation (e.g. inaccurate credit rating).

- Home Office in lead on privacy; H Committee a possible interdepartmental forum. No Department appears to claim responsibility for copyright/patenting of intellectual property which has important implications for the level and flow of international trade in information services.

7. A glance at this list shows the large number of Departments involved. Leaving aside the effectiveness with which individual issues have been handled (in our view patchy) there is a major 'machinery of Government' problem of how best to ensure that related issues are considered together. An analogy might be drawn with energy in the early 1970s. Individual Departments (coal, power, etc.) were more or less active in their own sectors but before the creation of the Department of Energy there was no powerful

machinery for developing policies for energy as a whole. With the setting up of the Department it became, in principle at least, possible to bring together the interests of a number of different Departments and develop a coherent Government approach on a number of secondary issues such as energy conservation, We do not recommend the same solution in this case (i.e. a new Ministry) but we do believe that the subject is every bit as important and the arguments for improving on the present machinery similar.

8. Under our present arrangements, many examples can be quoted of inadequate and sluggish response. Prestel, which has been described as the most important British invention since the Hovercraft, is being cold-shouldered by the Department of Industry and the Central Computing Agency at the same time as the CoI is trying to promote its use within Government and in our Embassies abroad. Policies on privacy and data protection are slow to emerge from within the Home Office - at least one major foreign data processing contract has been lost as a result of the absence of United Kingdom legislation in this area. The British Standards Institute is keen to develop badly needed data processing standards which the DoI would be prepared to fund; but the Department of Trade - the sponsor Department - accords this low priority. The involvement of the Foreign Office in briefing for the World Administrative Radio Conference last year was very late and perfunctory. The Department of Education and Science does not advise on the selection of equipment for use in schools. Different education authorities are therefore acquiring different and incompatible brands of microcomputer, and are likely to do the same for video equipment. This inhibits the development of a compatible software library, be it of computer programmes or video-cassettes.

9. There is also the important European dimension. The Council of Ministers has already adopted a four-year data-processing programme which includes work on 6(a), (e) and (h) above (manpower and training problems, technical standards, and privacy). The detailed proposals being formulated following the Dublin European Council will include further work on all these aspects as well as direct encouragement to the development of the basic technology. The United Kingdom approach to discussion of these proposals in the Community will need

careful consideration. On standards the Commission's approach is essentially to complement existing national standards. There may however be a danger that those nations which have already committed large sums of public money to developing their domestic industries will seek to use Community discussion to get their standards imposed on the Community as a whole and to delay the development of potential European competitors while common European standards are agreed. But the United Kingdom industry could benefit from the opening up of European markets if acceptable and compatible European telecommunications and hardware standards could be agreed. There may also be areas, e.g. data banks in which co-operation at European level is necessary to meet American and Japanese competition. What is essential is a clear view of what our attitude to Community policy should be and how best to go about achieving the results we want.

10. As is clear from the above, the CPRS believes that improved machinery is urgently needed in Whitehall to focus attention in the information technology field and to co-ordinate government policy and improve departmental awareness. Four possibilities present themselves immediately (there may be others):

(i) The creation of an advisory body, on the lines of a Standing Royal Commission. This would allow the Government to tap expert advice, at little cost in manpower, money and administrative disruption. Its drawbacks would be that, like many non-departmental public organisations, such a body might produce only occasional Olympian reports, too narrow or too cosmic, and would not exert real, daily authority. Not recommended.

NO

(ii) The establishment of a Ministry of Information Technology. This would have the advantage that a Minister and his officials would embody and constantly demonstrate the Government's commitment in this sector. There would, in principle, be plenty for this Ministry to do but it would have to spend its time pushing every other Ministry to do it. Again not recommended.

NO

(iii) Setting up a new Cabinet Committee. An economical solution and there may indeed be a case for creating a special Cabinet Committee but that, of itself, hardly seems an adequate response, for information technology needs a lot of detailed work and co-ordination as well as broad brush policy discussions.

NO

(iv) Setting up a central unit. The activities of most Departments are affected by information technology policy. There is a case for co-ordination and direction by a central unit - on the lines of the European Unit in the Cabinet Office. To be successful a central unit needs to have a small but good staff, to have plenty to do, and to be seen to be doing it. There is no shortage of issues to consider and decisions to take in this field. The importance of these matters, as well as the character of such a unit's staff, should ensure that its work will not be ignored. It could offer a valuable source of co-ordination and expertise on which all Departments might draw, as well as servicing the relevant Ministerial and Official Committees.

Conclusion

11. In the view of the CPRS, the Whitehall approach to information technology is fragmented and inadequate. Improving the framework in this area is perhaps the most vital issue in positive micro-strategy. The machinery of government to handle it urgently needs reconsideration.

25 January 1980

INFORMATION TECHNOLOGY

A brief description

1. This note by the CPRS describes the principal techniques for handling information and the technical revolution in that handling which will increasingly affect every aspect of life. We begin by defining information and data.

2. From information we acquire knowledge. The raw material of information is data. Information processing assembles and structures data to convey knowledge.

3. We are used to data being encoded in a systematic way (letters, words, numbers, pictures, sounds) which are immediately intelligible to the human observer (the sentences on this page, a road sign, recorded messages or music).

4. With modern information technology, however, the technology itself dictates the use of coding systems which are not directly intelligible. For example, the data may be magnetically encoded, as is the magnetic stripe on a credit card, which contains the account number.

5. Data is generally presented according to a (defined) structure, which gives it a particular significance or information content. For example, we always order the date, 23/1/80, and numbers at the bottom of a cheque are always ordered - cheque number, branch number, account number. The existence and form of such structures are usually obvious to the human observer but a computer has to be programmed to recognise them.

6. In discussing the revolution in information technology, we are chiefly concerned with machine-readable data, encoded magnetically, according to a data structure which is contained in a computer programme. The programme, then, is the key to unlock the information contained in the data.

7. So although in the broadest sense the tools of information technology include everything from pencils to postal services, dictionaries to computers, in this note on the revolution in information technology we are mainly interested in:

- telecommunications, which uses radio waves and cables to extend face-to-face communication, whether broadcast (i.e. spread out) or point-to-point;

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- telecommunications, which uses radio waves and cables to extend face-to-face communication, whether broadcast (i.e. spread out) or point-to-point;

- storage technology, which enables us to store very large quantities of data cheaply and compactly;
- the processing of data by computers, which amplifies and accelerates data processing by people;
- display technology, by which information can be presented on screens instead of on paper.

In all four areas, techniques are advancing rapidly, and unit costs falling - as has been the case for at least fifteen years. A more recent trend is for the encoding systems used in telecommunications to become digital - that is, to break the data down into a succession of discrete 'bits'.

8. Communications engineers are thus able to take advantage of digital techniques which are already commonplace in the computer industry and to implement their ideas quickly in low-cost microelectronic devices. This is bringing about a convergence of communications and computing. The combined subject is known as 'telematique' in France, and as information technology in this paper. The two disciplines are expected to feed on each other and maintain or increase the historical growth rate of over 15 per cent which this sector of the economy has enjoyed (i.e. a 400 per cent growth over the next 15 years). One example is Prestel, bringing together computer, telephone and television to create a new publishing medium. Another is the word processor, which today brings together keyboard, microprocessor, storage technology and visual display and tomorrow will add a communications link, thereby creating the 'electronic office'.

Areas of technical development

9. In each of the four areas, much exciting work is occuring:

A. Telecommunications:

(i) Radio:

Radio communication depends on electromagnetic waves of various frequencies, collectively known as the frequency spectrum. The spectrum is a global resource of fixed size. The available frequencies are in constant and increasing demand for television, telegraph, telephone and telex services, for fixed and mobile point-to-point communication between aircraft, ships, police and emergency services, taxis and other motorised services, for satellite communication. New techniques are enabling us to make more efficient use of the spectrum. These include techniques for putting data into digital form and super-imposing it on a carrier wave, so that the data-carrying capacity is increased; and techniques for squashing frequency bands more closely together, without interference. Such developments do not, however, reduce the need for disciplined use of the spectrum, which it is the task of the International Telecommunications Union to promote.

(ii) Satellites:

As well as being celestial repeater stations, bouncing radio signals from one part of the Earth to another, satellites can be used for 'remote earth sensing', to monitor land, sea and air pollution, inspect agricultural and marine stocks, seek out mineral deposits, and predict the weather. A possible future application is power generation from the sun.

(iii) Cables:

Cable transmission is no more than a way of constraining a radio signal to travel between two points in a closed container. This can be done with a fraction of the power that broadcasting requires, and a reasonable degree of privacy.

Since the information-carrying capacity of an electromagnetic wave increases with its frequency, the demand for increased transmission capacity has driven communications engineers to exploit the higher frequencies in the spectrum.

Thus the twisted pair of copper wires, used in today's low-frequency telephone network, will gradually be displaced by coaxial cables, operating at similar frequencies to the household television; waveguides, using microwave; and, the highest of all, optical fibres, using visible light. Light is an electromagnetic wave like the rest; it just happens to be detectable by the eye.

The light source used is the laser, until recently a laboratory curiosity but now found in computer printers and supermarket cash-tills as well as optical fibre transmission systems. Optical fibre cables can simultaneously carry hundreds of thousands of telephone conversations, or equivalent amounts of data; they will be the motorways of the future telecommunications network. Based on glass rather than copper, optical fibres are manufactured from cheap and plentiful raw materials and are immune to eavesdropping or interference.

Despite these evident advantages, the deployment of these new technologies will be slow because of the enormous capital investment in yesterday's equipment and the cost of re-equipping in bulk.

(iv) Switching:

Traditionally, telephone callers have been connected with one another by telephone exchanges, which step by step make the links through the network. Much of the British telephone system still uses the Strowger automatic

exchange, invented by an American undertaker in 1899, or the electro-magnetic Crossbar system, first installed in Sweden in 1926. Since most calls today require dialling of at least seven digits, and for international calls up to fifteen digits, such exchanges are now very slow and prone to inaccuracy.

The programmable microprocessor is taking over from the Strowger exchange, just as it has from so many other conventional electro-mechanical devices. Not only does it perform the traditional functions faster, and more reliably; it does so at lower cost, in less space, and with less power. It can also do things which were impossible before - store frequently used numbers; re-dial until a wanted number is free, switch a caller to an alternate number, and much more. It gives us the 'intelligent telephone'.

In System X, the Post Office implementation of electronic switching, a family of electronic modules can be arranged in many combinations to make an exchange of the capacity and characteristics desired - like electronic Lego. Separate modules are responsible for call routeing, accounting, overload control, fault diagnosis and the compilation of statistics for system planning.

(v) Packet Switching:

This is a specialised way of running a telephone network, suitable only for computer data, not voice, communications. The aim is to make the best use of all the network resources - lines, switching centres and so on, which should mean lower charges to the customer. The method of operation is analogous to the postal service, in that a data message is broken into packets, which are each given the address of the recipient, and posted into the network. The paths they follow through the network are computer-controlled, and depend on how busy the various parts of the network are. If the direct line is busy, another route is chosen.

In contrast to the postal service, however, delivery of the packets is in the order in which they were sent. Moreover, delivery times have to be kept within a fairly narrow range - up to about a quarter of a second - or the equipment at each end will not work properly.

The Post Office has invested £150m. in this between 1976 and mid-1979; by mid-1980, there will be nine packet-switching centres in Britain.

B. Storage Technology:

Typing words on paper is an everyday example of storage technology. The unit of information is a letter, the storage medium is paper, and the storage device operates by colouring the storage medium according to certain arbitrary but recognisable patterns.

The storage technologies with which we are concerned are in a sense much more primitive than this. Because they rely on physical phenomena such as magnetism, the unit of information with which they deal is the very smallest possible: the bit (binary digit), which can have only two values, 0 or 1. This can be represented by magnetisation: North = 0, South = 1; by voltage: on = 0, off = 1; and so on. More complex units of information, such as decimal numbers and letters of the alphabet, are built up from patterns of binary digits: groups of four, six or eight, depending on the coding system used.

There are many techniques and technologies for storing binary data, from microelectronic circuits and magnetic devices to optical devices now being developed, in which information is stored by burning holes in an opaque film, using a high-powered laser, and retrieved by sensing the pattern of holes with a low-powered laser.

No single storage technology will emerge as dominant, because the designer must select the best compromise between cost and the physical characteristics he wants: storage capacity, time to access a bit, and data transfer rate. Faster devices cost more and have lower capacity. However, in all technologies that are now available the cost per unit of stored information is falling by about 25 per cent per annum. It seems likely to continue to do so for several years to come.

Optical storage devices, just around the corner, offer the possibility for cheap archival storage of reference materials on a vast scale.

C. Data Processing by Computer:

Computers used to be large, centralised, and remote from most of their users. Such central systems will continue to exist and expand, as the guardians of corporate data. In coming years it will be necessary to devote increasing attention to safeguarding the data from unauthorised alteration or disclosure.

Meanwhile, many simple operations (and about 90 per cent of a computer's work-load consists of these) can now be done economically on much smaller, office-based computers, which may refer to the central complex only when they need to. This is known as distributed processing.

Word processing, in which documents can be prepared and revised using a screen and keyboard, is a special case of distributed processing. Its use is growing rapidly, because of the enormous productivity gains which it brings - typically 100 per cent. Not all word processors are connected to a central complex, but in the electronic office of the future, a completed memo will be sent to the central complex for copying, mailing and filing - all done electronically.

D. Visual Display:

Just as the keyboard is the predominant device for putting data into a computer, so the visual display is, and will remain, the predominant device for getting information out. Widespread use of voice input and output, the next major development, is still some years away. Visual displays are fast and versatile; they can use colours and diagrams; and their cost is falling.

These developments do not only benefit professional computer users; they also assist the ordinary user of 'viewdata' services, at home, at school and in the workplace.

We are already familiar with 'teletext' services, allowing subscribers to summon textual messages (like news headlines) on to a television screen. Now a whole range of new information services is being made available to the business and domestic consumer with the introduction of viewdata (notably the British Post Office's 'Prestel' service, now challenged by France's 'Antiope' and Canada's 'Telidon'). Words, figures and pictures are stored in a computer in such a way that they can be displayed on a modified television set. A user of either a private or a public set presses buttons on a key pad (like a pocket calculator) which connects him to the computer, summoning an index page With this, the user is guided through a set of subsidiary index pages to the information he wants (or, using a printed directory, he can obtain the desired page directly). Different organisations (some 150 by the end of 1979) contract with the Post Office to provide several hundred thousand pages of information; the Post Office manages the computer system and acts as the carrier. An information provider may charge the customer for the right to review a page; the Post Office will bill the user and pay the provider.

The potential uses of these services are many: to offer timetables, telephone directories (as France is now planning), stock market prices, classified advertisements and information on library contents and current affairs. As printing and distribution costs rise and communications and computing costs fall, viewdata may in some respects replace the daily newspaper.

As well as a general service, viewdata can offer a system for 'closed groups' of users to store information and transmit it to a limited number of users, who are given an appropriate password. Individuals or different categories of individuals within the group can be barred, if necessary, from receiving certain material.

Further developments, already in an advanced stage, enable users to answer questions from the computer by pressing buttons signifying yes or no (and, eventually, by means of an alphabetic keypad, to answer back); to control a pointer on the screen or to type figures to fill in designated spaces in the frame; and to type in a credit card number. New uses of viewdata will thus include shopping, opinion survey, medical self-diagnosis, and study.

Developments in the four areas we have chosen exemplify the marriage between communications and computing with which information technology is concerned. What will be the effects of the information revolution?

10. Implications of the Communications Revolution

(i) Immediacy/Delay - financial: many businesses exist on the leads and lags which are now an integral and unavoidable part of commercial life (the clearing banks and money markets, for example). Instantaneous fund transfer may eliminate the concept of credit and the services which depend on it.

(ii) National/International: much of our 'invisible' trade is in information; if we grasp this opportunity, it will grow. We will have to prepare to charge others for services hitherto underpriced or free and in turn to be charged ourselves. We must be on the lookout for 'data havens' (on a par with tax havens), where internationally accepted regulations of copyright, privacy, etc. will not apply.

The speed with which information technology is adopted is influenced by the degree of compatibility between devices and systems. International co-operation on 'standards' is important but it must not be taken only at face value, since some of our competitors will seek to take advantage of negotiations and agreements here.

There is already enormous international competition for sales of new telecommunications and information equipment and of the services that go with it. We have a short lead in some areas but we need to press ahead. The Post Office in particular must be encouraged to apply new techniques and the public to use them.

Such competition extends to the medium on which telecommunications depends - the electromagnetic spectrum. Ever increasing demands on the radio frequencies that are available and exploitable make it all the more important that sensible international accommodation is reached in the regular meetings of the International Telecommunications Union and in the constant debate of other international conferences. Less developed countries, moreover, are anxious not to be excluded from the communications revolution; it is essential that they should not be.

What have hitherto been discerned as merely national concerns will be seen more and more as international.

(iii) Central/Local: new communications systems will reduce the necessity for travel to offices, schools, libraries and shops in order to handle paper, to see people or to view goods. Patterns of travel and work will change. Location of housing, shops and office building will be affected. We will change our perception of what is 'central' and what is 'local'.

(iv) Industrial/Professional: jobs now done by people can be increasingly entrusted to self-monitoring machines. These can be tasks of industrial production (e.g. assembly of vehicles; production of glass and sheet-metal; spinning, weaving and stitching) or professional services (e.g. the giving of legal, medical and architectural advice; teaching and other instruction; editing and publishing). We will change our perception of the difference between 'industrial' and 'professional' occupations.

(v) Immediacy/Delay - political: events can be reported in words and pictures as they happen. We are acquiring different notions of what is shocking and what familiar. Public reaction will be easier to sample and analyse; moreover, individuals and groups will in many ways be better able to communicate their views to each other. All this will affect 'accountability', 'representation', the 'doctrine of the mandate', and the operations of pressure groups.

(vi) Access/Privilege: people may be harmed by the disclosure of inaccurate or irrelevant information; on the other hand, much of our activity will depend on the availability and use of timely, relevant and correct information about individuals, families and corporate bodies. We need to develop methods for protecting information systems against intrusion, abuse and theft and to consider to what extent data systems can and should be connected or kept separate. Government and industry, as well as individuals

and other institutions, will find that electronic records are easier and cheaper to use but more vulnerable. We will find ourselves reconsidering rules and conventions regarding secrecy, copyright and privilege.

(vii) Civil/Military: modern systems of record-keeping and transmission, of surveillance and communication give governmental and other authorities efficient means of informing the public, containing crime, fighting terrorism and organising national defence. But such systems are particularly vulnerable to strikes and sabotage. Furthermore, they are vulnerable in new ways: for example, the radiation from a nuclear explosion twenty miles above the Earth would leave human beings and buildings unscathed but would knock out electronic equipment of all sorts. Not only those who design and use military equipment but also representatives of the broadcasting organisations and manufacturing industry are already instructed in techniques of 'nuclear hardening'. We will need to reconsider our distinctions between civil matters and military defence.

(viii) Skilled/Unskilled: Able/Inadequate: the new information technology will have far-reaching effects on employment and on society. Some governments (notably Sweden) are consciously seeking ways in which telematics can help, not hinder, the old, the disabled, the ill, the slow or confused, the innumerate, those who are frightened of technology or who find it baffling. We will need to do the same.

The information revolution is already re-shaping society; this time we can try to anticipate and direct the changes that are upon us.