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Directive 90/270/EEC - A Job For Human Factors?

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Abstract: The minimum requirements of Directive 90/270/EEC with regard to workstations, environment and operator/computer interface for display screen based tasks are discussed. Difficulties attendant upon implementation of the Directive are considered. It is argued that the minimum requirements for design of the operator interface will put ergonomic design of computerised systems on a statutory footing for the first time. Employers should seek advice from qualified ergonomists when specifying new systems. Lawyers are advised to pay more attention to system usability when drafting contract documentation for bespoke software.

Introduction

Traditionally information technology and data processing have been technology driven rather than user led. By "technology driven" we imply that the design of the instruction manual or the user interface is an afterthought. It is secondary to the functional design of the machine or its software.

One does not have to look far to find the evidence for this. Copying the DOS operating system to a hard disk requires the user to type:

COPY A:*.* C:\DOS

Moving a block of text with the WordStar word processor requires one to place the cursor at the beginning of the block, type ^KB, move to the end and type ^KK, then move the cursor to where the block is to begin and type ^KV. Interfacing a printer to a microcomputer requires minute dip switches to be set with a stylus. What could be simpler or more convenient?

Recently there has been an expansion of research into what constitutes good design in computer systems. The application of ergonomics - or "human factors" as the field is more commonly known in the United States - to the design of the man-machine interface has become an area of increasing importance. Until now proper recognition of human factors' place in the design process has been confined largely to military applications. All too often system designers have seen the human factors engineer as someone to be brought in at the end of the day to tidy up a technically-oriented system.

A glance through back issues of *'The Ergonomist'* [1] reveals constant ill-founded optimism that "ergonomics is about to achieve a breakthrough". However the adoption of Directive 90/270/EEC (Official Journal, 1990) by the Council of the European Communities is set to change this.

Cinderella may yet go to the Ball.

The Directive

Section I

Section I comprises two articles:

Article 1 excludes application of the Directive from a variety of equipment including (inter alia): that in drivers' cabs or on board a means of transport, systems for public use, certain 'portable' systems, calculators, cash registers and thin window typewriters.

Article 2 defines display screen equipment, workstation and worker.

Section II

Section II sets out employers' obligations in a further seven articles: analysis of workstations (Article 3), workstations put into service for the first time (Article 4), workstations already put into service (Article 5), information for, and training of, workers (Article 6), daily work routine (Article 7) worker consultation and participation (Article 8) and protection of workers' eyes and eyesight.

The analysis required by Article 3 requires employers to evaluate the safety and health conditions to which their workstations give rise. They are particularly obliged to consider possible risks to eyesight, physical problems and problems of mental stress. Employers must take appropnate measures to remedy the risks identified by the analysis.

Article 7 charges employers with planning their workers' activities so that daily work on a display screen is periodically interrupted by breaks or changes of activity reducing the workload at the display screen.

The combination of Articles 3 and 7 will require many employers to address a number of problems they have not considered previously. Research (Johansson and Aronsson, 1980) has identified a number of factors which contribute to stress in the computerised office. These include slow computer response time, unreliable equipment and uncertainty as to the duration of breakdowns. Other research (Johansson, Aronsson and Lindstrom, 1976) suggests that monotonous, repetitive work coupled with a high level of mental stress results in adverse health reactions for the workers concerned.

Article 9 provides that workers are to be entitled to appropriate eye and eyesight testing before commencing work with display screen equipment and at regular intervals thereafter. They can claim an ophthalmological examination if tests indicate this is needed. If the results of the test or examination show it is necessary and normal corrective appliances cannot be used, workers must be provided with special corrective appliances appropriate for their work. In no circumstances may workers be involved in additional expense for compliance with these measures.

Articles 4 and 5 oblige employers to take steps to ensure that their workstations meet the minimum requirements laid down in the Annex to the Directive. Workstations first put into service after 31 December 1992 must comply (Article 4) and workstations already in service on that date must be adapted to comply no later than four years after that date.

The educational, consultative and participative provisions are to be found in Articles 6 and 8.

Section III

Section III provides that strictly technical adaptations to the Annex may be adopted to reflect current thinking in the field (Article 11) and that Member States shall introduce appropriate legislation to give effect to the Directive by 31 December 1992.

Publication of the Directive has been noted in the Press (e.g. see Pearce, 1990 and Smith, 1990) but is unlikely to make a real impact until implemented in UK legislation. This will almost certainly be done under the existing framework of the Health and Safety at Work Act 1974.

The Minimum Requirements

The minimum requrrements set out in the Annex are to be applied so that the required components are present at a workstation. Additionally, the inherent characteristics of a task must not preclude attainment of the Directive's objectives. The requirements are listed under three heads: Equipment, Environment and Operator/Computer Interface.

The minimum equipment requirements are stated under the sub-headings: display screen, keyboard, work desk or work surface and work chair. Each requirement is expressed as a goal to be attained rather than as a formula to be followed. So,

> 'The characters on the screen shall be well-defined and clearly formed. of adequate size and with adequate spacing between the characters and lines."

It remains to be seen how the UK Government will implement the Directive. It could choose to specify precisely how compliance is to be attained but is more likely to set goals for industry to reach.

Some assistance can be got by adopting equipment complying with relevant British Standards or following guidelines laid down in such standards. These are B55459 (pt 2, office chairs 1990) and the soon to be published B57179 (VDU usage and workplace design).

Lawyers must take care to advise their clients that the duty to evaluate a workstation and plan work routines lies with the employer. Safety officers in industry and commerce are likely to find that their work has acquired a new dimension. They will have to familiarise themselves with ergonomic aspects of the workplace. Fortunately help is at hand in the shape of texts from distinguished ergonomists which cover both workstation evaluation (Grandjean, 1987) and job design (Eason,1988).

Minimum requirements for the environment in which display screen equipment is used should present few difficulties. These are listed under the headings: space requirements, lighting, reflections and glare, noise, heat, radiation and humidity.

Perhaps the only surprise is paragraph 2(f) dealing with radiation:

> All radiation with the exception at the visible part of the electromagnetic spectrum shall be reduced to negligible levels from the point of view of the protection of workers' safety and health

Visual display screens emit radiation through a wide spectrum. The following description of these emissions and their levels is derived from, and is more fully discussed in, Grandjean (1987).

The highest frequency components are x-rays which are known to have carcinogenic properties. Good design minimises these emissions but some low energy ionising radiations do escape. Measurements show these levels to be well below accepted occupational health and safety limits. There is also a small ultraviolet content but this is far lower than that emitted by fluorescent tubes.

There are lower frequency components beneath the frequency of the visible spectrum. These include infrared, microwave and radio-frequency emissions. Infrared frequencies are detected by us as heat and levels are less than 1% of outdoor or indoor levels. Microwave frequency radiations have been measured at insignificantly low levels. Finally there are emissions in the radio-frequency part of the electro-magnetic spectrum. These are at a similar level to those coming from radio transmitters in urban areas.

There have been persistent allegations which seek to make a correlation between work as a VDT operator and the incidence of cataracts, birth defects or spontaneous abortions. Grandjean (op. cit.) could find no evidence to support these allegations. They remain the subject of investigation and there is some conflicting evidence.

The directive leaves it to the employer to determine whether or not display screens' emissions pose a health hazard to workers. Until such time as clear evidence of harm is widely published in the Health & Safety literature, employers will be justified in relying on authors such as Grandjean. If their equipment subsequently proves harmful, they will be able to take advantage of the "state of the arttknowledge" defence to a claim in negligence.[2]

Monitoring compliance with the Equipment and Environment sections of the Annex should not prove troublesome to the Health and Safety Executive or safety officers. Once these staff have familiarised themselves with the ergonomic consensus, checking for compliance should be an objective process.

The British Standards Institution will come under pressure to publish new standards appropriate to equipment used by workers within the protection of the Directive. Employers without ergonomics trained staff are likely to favour purchases of equipment which carry a relevant BS kitemark.

The Annex concludes by stating the minimum requirements for the Operator/Computer Interface. These are stated in broad terms. Many of the phrases used clearly call for ergonomic solutions, e.g. "... must be suitable for the task", "... must be easy to use", "must display information in a format ... adapted to operators" and "...principles of software ergonomics".

Employers are obliged to take into account five principles when "designing, selecting, commissioning and modifying software, and in designing tasks using display screen equipment."

The first principle is that the software must be "suitable for the task". This phrase is ambiguous: does it refer to the software's functionality or its usability? Since the principle is found in a section dealing with the operator/computer interface, we can have some confidence in deciding that it refers to its usability.

What then is the required degree of usability? The Directive simply says that it must be "suitable" for the task at hand. There can be no certainty that the same word will appear in the UK implementation of the Directive. However, one cannot help thinking that "suitable for the task" may be interpreted by the legislature or the judiciary as "reasonably fit for the purpose intended". Such a familiar phrase may be a comfort to lawyers but something less than satisfactory to the intended beneficiaries of the Directive.

Software houses and industry would no doubt welcome a "reasonably fit" interpretation of "suitable". However it is submitted that something more than this will be required if the spirit of the

Directive is to be implemented Ergonomists' major complaint about existing systems is that they are high on functionality but low on usability. The effect is that people have to be fitted to the computerised task rather than the task being fitted to them[3].

A further possibility is that courts might chose to interpret "suitable" as meaning commercially fit". "Suitable" has been interpreted in this way in some US cases, e.g. *White et al v. United States* (l895) 69 F. 93 and later cases.

Many employers would be content to use systems that are difficult to learn or inconvenient to use. Re-writing poorly designed software can be very expensive for the employer; the human costs of using poor systems are mostly borne by the employee.

The second principle is that software must be easy to use. If appropriate, it must be adaptable to the operator's level of knowledge or experience. Additionally, no quantative or qualitative checking facility must be used without the knowledge of workers.

It requires little imagination to foresee that a criterion of "easy to use" will cause difficulties. Workers with display screen equipment will always want to apply a subjective test. The designer has to be objective - she cannot please all of the users all of the time.

The advantage of this provision is that it will force employers and designers to study the target user population rather than make assumptions about it. Designers will need a "user characteristics statement" to aid their system design. Once this is prepared, the designer can aim to produce a piece of software which a specified proportion of the user population will find "easy to use'. Ergonomists often aim for systems to be readily usable by 90 or 95% of the target population. User trials are conducted on a sample of the population which can be polled subsequently as to its subjective impressions of ease of use.

The requirement that software should be adaptable, where appropriate, to the operator's level of knowledge is helpful in reducing operator stress. It is all very well to design a detailed, step-by-step, menu for the novice - but it is tedious for the experienced user to use. These users need to be able to take short cuts. Again, some software may have a bewildering number of options available. In this case the novice user needs a cut-down (or "training wheels") version to prevent cognitive overload.

The stipulation that a quantitative or qualitative checking facility should not be used without a worker's knowledge is to be welcomed. If the tachograph is the "spy in the cab", this is the electronic equivalent!

Whilst this paper has pointed out some of the difficulties of stipulating ease of use, the outlook is not entirely bleak. Tools (e.g. BS 6719,1986 and HUFIT Toolset, 1988) are available to help designers map user characteristics and requirements.

Many human factors practitioners have studied ease of use (or usability) and determined its parameters. These parameters are discussed in such papers as Miller's seminal report "Human Ease of Use Criteria and Their Tradeoffs" (Miller, 1971), by Shackel (1987)and by Holter (1988). Shackel (1984) has done much preparatory work analysing the concept of usability and restating it so that usability metrics can be produced.There is now a proposed ISO standard (Marshall, 1989).

The third principle states that systems must provide feedback to workers on their performance. Again this provision is aimed at reducing operator stress. Its practical implementation should be one of the less troublesome minimum requirements.

The fourth principle requires systems to display information in a format and at a pace which are adapted to operators.

Practical implementation of this requirement will require the application of the principles of cognitive psychology to design of the user interface. Design aids, like the HUFIT Toolset, aim to help designers without a formal training in human factors to design usable interfaces. Nevertheless, it is difficult to see how this stipulation can be satisfied for complex systems other than by the involvement of ergonomists or occupational psychologists.

The fifth, and final, principle states that the "principles of software ergonomics must be applied, in particular to human data processing". This would appear to be a generalisation that encompasses the fourth principle.

It seems to contain a particular plea that designers should take account of the strengths and weaknesses of human information processing in software design. This focuses on the perception, attention, memory and problem solving aspects of human perception. The present author would not like to say whether "software ergonomics" goes any further than this.

The UK Government must decide whether to implement the Directive by detailed, prescriptive legislation or by a simple, exhortatory restatement of the Annex.

An immediate problem is the shortage of persons with a human factors training. There are around 700 active members of the Ergonomics Society. A sample of 53 names drawn from the 1989-90 membership directory disclosed the following affiliations:

Living outside the UK	17
Employed by central government	4
Employed in indusry	9
Employed in an academic institution	11
Private practice	7

Whilst a number of academics may be available for private consultations, there is the problem that design of the operator/computer interface is a speciality. It would be surprising if more than 200 ergonomists qualified in the field were available for consultation.

Faced with such a shortage, the attractions of a prescriptive course are seemingly obvious. Employers can be assured of compliance by buying items of equipment made to the relevant British Standard. When designing or selecting software or designing tasks, the employer simply follows or specifies appropriate published guidelines.

There are a number of published standards, e.g. ANSI/HFS standard 100 (1988) and MIL-STD-1472C (1983), and guidelines, e.g. ANSI/IEEE standard 830 (1984) and HF Guidelines (1988).

These documents are often targetted at users who are not human factors specialists. Thus in the HF Guidelines (op.cit. at 2/0104) one document is aimed at "... the "general practitioner" of human factors ... [who typically] . . will have a background in physical sciences or engineering but will have been trained in human factors by such means as these Guidelines and associated training."

Standards and guidelines have been attacked recently by two American practitioners (Chapanis & Budurka, 1990) who observe that these must necessarily be non project-specific but that the act of interpreting them for project-specific applications requires human factors expertise. They instance para 5.15.1.2.1 in MIL-STD-1472C:

> Where operators are required to make entries into the system, an easy means for correcting erroneous entries shall be provided

and comment, "What seems easy to a computer programmer may be confusing to a typical user."

Whilst the standards and guidelines approach is superficially attractive, it has important disadvantages:

It encourages employers to believe that specialist human factors expertise is unnecessary. Guidelines are generalisations and cannot provide for every eventuality. Conceptual errors in interface design propagate throughout the user population. Innovative design is restricted and design becomes petrified.

Since the approach is interpretative, there is a danger that the ECJ may declare that the legislation does not reflect the spirit of the Directive.

Compared with EC Directives in other technological fields, the generality of this Directive is quite striking. Its broad expression of goals suggests that the EC Council members had difficulty in reaching a consensus. However the Government chooses to implement the Directive, there are certain to be challenges to the sufficiency of employers' compliance.

Planning for implementation of the Directive

There can be little doubt but that implementation of Directive 90/270/EEC will come as a cultural shock to many software houses.

Attentive observers of the EC's ESPRIT programme would have noticed that the Commission has placed considerable emphasis on means of improving the match between user expectations and systems delivered. One project within ESPRIT was HUFIT - "Human Factors in Information Technology". Part of that project was the dissemination of human factors methods, knowledge and practice within the IT industry.

We should not be surprised that the EC is now seeking to see some of the deliverables it has paid for put to use.

One cannot spend any time with human factors engineers without realising how much they are resented by systems engineers with a background in hard technology. Ergonomists are trained in the human sciences of physiology, psychology and ergonomics. Their role is not perceived as that of a professional colleague but rather as that of a persistently complaining customer.

It is beyond the scope of this paper to consider all the reasons why human factors principles have not been incorporated into design. The interested reader will find some enlightenment in Chapanis & Budurka (1990).

The present author would suggest one reason is that their incorporation has not been stipulated in contractual documentation. Most solicitors who practice in computer/software law are, to use a human factors term, naive within the users' work domain. By dint of many attendances upon clients they acquire an associative expertise in the process of commissioning software. However their model of the socio-technical system in which the software will operate is moulded by their technical or managerial client's perceptions of it.

A typical scenario is that a company's Board decides to computerise an existing function. That decision is likely to have been taken on the basis of a technical feasibility report prepared by a systems analyst or, even worse, a Data Processing Manager. The Board delegates the detailed implementation of its decision to its technical staff. The company's solicitor receives her instructions from a systems analyst or DP manager who stands as a representative of the company's technical

system.

Most unsuccessful implementations of IT systems founder upon misunderstandings of, or wrong assumptions about, users' tasks or requirements. What is required is effective user consultation and participation in the design process.

The heart of the problem is that the technical system's representative believes he can also be a representative of the social system. His reasoning must run something along the lines: Users are human; I am human; humans think; ergo, I can think like a user.

An ergonomist has described the experience of watching a systems analyst attending a first user trial of a system he had designed. As the user floundered in the complexities of the analyst's "user friendly" interface, the analyst's impatience grew. Eventually he rushed out shouting, "No, you fool. You do it THIS way!"

How then will industry and commerce satisfy the Directive?

It has already been suggested that the Annex's sections specifying minimum requirements for equipment and the environment could largely be dealt with by appropriate BSI Standards and Guidelines.

Compliance with the operator/computer interface requirements poses a greater problem. There seem to be two aspects to the problem: one is the interface to "off-the-shelf" software, the other to "bespoke" software.

In the case of consumer software, one suggestion might be for the BSI to devise usability guidelines for generic software applications. So, there would be a British Standard Guideline for wordprocessor/spreadsheet/database packages. There is already a BS specification (BS 7137, 1989) for user documentation and cover information for consumer software packages.

If such standards were devised, software houses could submit their packages to "usability laboratories"[4] for certification. The onus of evaluating and analysing workstations would still lie upon employers but their task would be eased.

In the case of bespoke software systems, lawyers must take the initiative. The investment in these systems is so heavy and the lead time so long that systems being commissioned now will have to comply with the Directive.

A glance at some published texts (Edwards,1983; Wolk & Luddy, 1986; Gordon 1986) shows that practitioners in the field of computer contracts concern themselves almost exclusively with the functionality of commissioned software. Usability as a criterion for acceptance of the deliverable is scarcely mentioned.

Research into the legal specification of usability has been undertaken by Birmingham Polytechnic Business School. A symposium and briefing for computer law practitioners will be held in Autumn 1991.

Conclusion

The implementation of Directive 901270/EEC will mark the coming of age of human factors in information technology.

In addition to informing themselves about the legislation, solicitors, as employers, will have to inform themselves about basic ergonomics if they are to discharge their duty to their staff.

The Directive will pose a number of interesting challenges to the contractual documentation draftsman. Acceptance testing of software functionality alone will do nothing to satisfy the minimum requirements of the Directive. Practitioners would be well advised to insist that their clients employ a qualified human factors consultant to ensure that user characteristics and requirements are properly represented in the design specification.

They should also be advised to do so quickly - there is sure to be a rush.

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1 The newsletter of the Ergonomics Society.

2 It is easy to have 20/20 hindsight. See Denning L.J. in *Roe v Minister of Health* [1954] 2 QB 66 at 84, "We must not look at the 1947 accident with 1954 spectacles."

3 That this is directly contrary to the fundamentals of ergonomics can be judged from the title of one of the leading texts in the field, "Fitting the task to the Man" (Grandjean, E., 1980, London: Taylor & Francis)

4 Usability laboratories are a relatively recent innovation, A few major companies (e.g. British Telecom) operate them and an independent laboratory has been set up by the HUSAT Research Centre at Loughborough.