Annex 4:

Best Practice Guidance on Task Design for Small and Medium Sized Enterprises

for

The PRISM Project

Prepared by Helen Jones & Rob Cotterill
Human Factors Consultant
DNV Consulting
Highbank House
Exchange Street
Stockport UK
SK3 0ET
Tel: +44 161 477 3818
Fax: +44 161 477 3819
Email: rob.cotterill@dnv.com

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1 INTRODUCTION

1.1 Background

In everyday life, we often encounter situations were we are constrained by designs rather than aided by them. People complain they do not have enough leg-room on flights, or that they find sitting at their desk uncomfortable. Poor design can lead to injuries and medical problems so it is important to strive to get it right. Within the process domain, a poorly designed task can increase the likelihood of human error and occupational injury and ultimately can increase the likelihood of incidents occurring. However, a well-designed task can increase productivity, improve morale, reduce work-related incidents and injuries and optimise the people within the system.

There are a wide range of human factors topics that come under the umbrella of "task design": workplace design; work environment; equipment and tools; task workload and overall job design.

1.2 Objectives

This guide sets out to present best practice in task design for small and medium-sized industries. As task design is a wide-ranging subject, drawing on many different disciplines, it is impossible to provide complete guidance in a digestible form. Instead, this document aims to provide high level guidance in the following key areas:

- Designing for people
- Task context
- Environmental factors
- Social factors
- Working context.

Where appropriate, reference sources are provided to allow the reader to explore the topic in greater detail. The four human factors topics (procedures, training, human-computer interaction and task design) inevitably overlap and therefore each guidance document should be used in conjunction with the other three and also the guidance produced by PRISM focus groups 1, 3 and 4.

2 Key elements of Task Design

2.1 Defining the Task

2.1.1 Task requirements

The first step in any design process is to define the task requirements. This can be achieved by asking the following questions:

- What are the task's aims and objectives?
- How will the objective be achieved?
- Where will the task take place?
- When will the task be performed (continuously, night time, day time)?
- Who will perform the task (skills, training, competence)?
- Why is the task required – overall context of the activity?

This list is not exhaustive but such questions help to define the context of the task and the scope of the activity to be addressed. It can be very useful at this point to perform a task analysis on the activity to gain an understanding of the task. This will also allow the task to be analysed for human errors. There are several methods that can be used to achieve this, each with pros and cons depending on the level of task definition (see Kirwan & Ainsworth, 1992). If available, background data on existing systems, photographs and diagrams can be a useful input to the process.

2.1.2 Allocation of Function

One of the first decisions that must be made relates to the sharing of roles between man and machine. Most tasks now use computers or machinery to support humans in their role. Machines have many advantages over people, e.g. they are reliable, they do not get bored, they can perform 24 hours a day. On the downside, they cannot vary from programmed action, they cannot adapt to new circumstances or solve problems and they cannot detect danger. Humans are good at problem solving and adapting to new circumstances. We are less good at maintaining task performance for a long period especially during the night. Humans make errors more often than machines, yet when we do, we also are better at recovering from them. Most crucially, humans operate in a social context which can have both a positive and negative effect on task performance.

The ideal task design will identify key task requirements and allocate the task roles between man and machine to optimise strengths and minimise weaknesses in each case. This balance will also be influenced by the criticality of the task, the level of reliability required and the urgency of recovering from errors or malfunctions. A basic procedure for allocating function is given in ISO 11064-1 and is reproduced below.

No.	Step	Procedure
1	Mandatory allocation Allocation to meet safety / regulatory requirements	• For mandatory automatic functions, allocate to machine. • For mandatory manual functions, allocate to human.

2	Attempt at preliminary allocation in terms of human traits, abilities and characteristics with a view to ensuring the safety and reliability of the system's performance. Allocation according to performance characteristics.	• Re-design system to avoid tasks which cannot be carried out satisfactorily by humans or machines. • Allocate functions which cannot be satisfactorily carried out manually to machines. Treat as mandatory automatic functions. • Allocate functions which cannot be satisfactorily automated to humans. Treat as mandatory manual functions. • Initially, allocate machine preference and human preference functions to machines & humans respectively. • Initially, leave without preference functions unallocated.
3	Allocation according to cognitive and affective support criteria. Complementary or flexible allocation from the viewpoint of ergonomics and system efficiency.	• Consider reallocation of preference functions according to cognitive and affective criteria. • Consider complementary or flexible allocation, which gives users the ability to change the allocation.
4	Ascertain feasibility of automation.	• Determine whether functions allocated to humans can be implemented effectively using available automation technology.
5	Ascertain feasibility of human performance. Select tasks which are to be supported by operator support systems to assist with signal detection, information acquisition and decision making.	• Assess whether functions allocated to humans can be implemented effectively assuming the availability of operator support systems. Determine whether such systems san be implemented using the available level of technology.
6	Evaluate allocation. Determine need for iteration and revision.	• Repeat allocation procedure if the proposed allocation of functions is impractical or requires further refinement o if there are unacceptable technical limitations.

For more information on allocation of function, see also Hollnagel & Bye (2000)

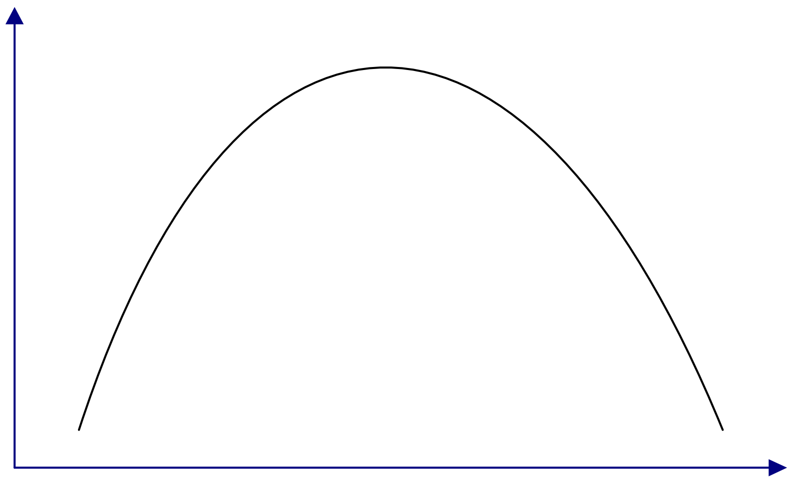
2.1.3 Identify Hazards Associated with the Task

Once the task has been defined and the human and non-human roles have been outlined, the next step is to identify all possible hazards associated with the activity. Only by identifying and anticipating hazards at this stage, can they be managed or eliminated through careful task design. Typical hazards might include: noise, vibration, lighting, temperature, humidity, constrained working position, repetition, stress or boredom. For example, levels of repetition should be examined to see whether the process will introduce occupational injury hazards. Similarly, the task may involve exposure to another form of hazard and if this is the case, this must be managed. In other job roles such as packing, physical workload and manual handling assessments may be required to ensure that the task does not exceed recommended working limits. In most cases, tasks should be assessed to identify what impact these hazards might have on plant and operator safety. In some cases, there are guidelines as to levels of exposure: see the PRISM FG4 application guide for some examples, but also Pheasant (1987), the UK Def Stan 00-25 and the US MIL-STD-1472F

Human error potential can also be considered at this stage if the task is sufficiently defined. Opportunities for errors can be explored and any safety critical errors can be managed through the task design. A useful reference is Lees (1996).

2.1.4 Designing the Task

Once the task objectives and potential hazards have been identified, the next stage is to manage these potentially conflicting factors throughout the design process.



As the figure above shows, the maximum level of work efficiency is reached when the task is neither too complex nor too boring. However, the level of task complexity which gives this maximum output will vary from person to person. Some people prefer more monotonous tasks since they allow them to ‘escape’ or to engage in conversation with their colleagues. Other people prefer to use their brain to tackle complex tasks and dislike monotonous work. It is important to try to strike a balance and provide variation within any job role therefore. Each task should provide sufficient stimulation to allow the worker to maintain concentration and effort without leading to excessive fatigue and stress. The following sections describe some of the key factors that must be considered in order to achieve this.

2.2 Workplace design

2.2.1 Working Posture

It is necessary to decide early on whether the task should be performed standing up, sitting down or in either position. Other postures should also be considered, e.g. in maintenance tasks it may be necessary to perform the task lying down. There are many factors to consider when deciding the best working posture for a task. These include the length of the task or shift, level of repetition involved, manual handling requirements and use of tools and equipment. As well as deciding whether the task should be performed in a seated or a standing position, there are other postural decisions to be made. There are many different factors that must be considered (see Kroemer & Grandjean (1997); Pheasant (1996)), however some general rules are provided below:

- People should be able to perform the task with their arms below shoulder height for the majority of the time.
- All required equipment should be positioned within reach where practicable.
- Prolonged lifting or load-bearing should be performed between chest-height and waist-height.
- Avoid excessive bending or twisting of the spine during normal task activities.

2.2.2 Workstation Design

The work area should be carefully designed with both the task and the workforce in mind. The work area could be anything from a desk, an assembly line or work bench to a driving cab. The workstation also includes any equipment required for the task, e.g. VDU's, power tools, parts, etc.

The work station should be able to accommodate the majority of the workforce population (90%). Anthropometric data (data on body dimensions) allows designers to accommodate the differences between people's size and shape within the workplace and ensures that the majority of the population can do the job within the environment provided. For typical anthropometric data, see Pheasant (1996) or Def Stan 00-25 Part 2. Deliberation of such data can produce a design which prevents tall people having to stoop and smaller people having to stretch to reach things, etc. Such a design will reduce the risk of work-related musculoskeletal disorders and improve productivity. When planning the location equipment, consideration should also be given to trip hazards caused by training cables (for example telephone lines, network cables, power cables). Where possible, equipment should be located so that cables do not have to stretch over open areas of floor. Otherwise, methods of guarding or covering the cables should be employed.

2.2.3 Communication Requirements

Most tasks will involve some form of communication. Data gathering and propagation can be optimised by combining different communication modes, e.g. electronic, verbal, and written. The communication types should be structured to minimise human workload whilst ensuring the requirements are successfully met. This will generally involve a mixture of the communication modes given below:

- Face-to-face verbal communication
- Telephone
- Loud speakers
- Radio
- Video or CCTV

- Email
- Alarms or warning sirens
- Procedures and checklists
- Letters or memos.

This list is not exhaustive. Whichever modes are available, no one mode should be overloaded. For example, if all communication is done by telephone, the channel will be blocked quickly and no longer be effective. If any one channel is overloaded, the person involved will become less efficient at communicating via this mode. A variety of verbal and non-verbal channels works well to overcome this. Certain communication modes are best reserved for immediate or urgent communications (e.g. radio) whereas others are better suited to less transient information that may be relevant to more than one person, e.g. letters or procedures. By choosing the communication channels carefully for each type of information, an efficient system can be engineered.

2.3 Workload

2.3.1 Physical Workload / Manual Handling

There are guidelines available for the limits of the following human capabilities:

- static strength,
- lifting,
- pushing,
- pulling,
- torque, etc.

Each of these limits will vary with respect to age and gender and therefore the data must be matched to the workforce in question. Other factors such as task pacing, frequency and levels of repetition must also be taken into account when assessing physical workload. Expert input may be required to identify the optimal physical work rate and ensure that injuries are avoided, but see the NIOSH guide on lifting, and Def Stan 00-25 Parts 2 & 3.

2.3.2 Mental Workload

This is an area that will require expert input from a psychologist or an ergonomist. The factors comprising mental workload will depend on the task. Vigilance, attention, memory, problem solving, data gathering and interpretation, speaking, listening, reading, writing, keying, watching, etc. can all play a part and the level of workload will depend on how these factors and others combine.

2.4 Interfaces

2.4.1 Tools and Equipment

In situations where the task requires the workers to exceed safe physical workload limits, tools must be provided to assist them. Alternatively, the design can be changed to make the task easier to perform. For example, if a valve is difficult to open and close a longer handle or larger wheel will increase leverage and reduce the amount of force required. The tools must be compatible with the people, the task and the work environment. For more information, refer to the HFRG Guide to Improving Maintenance (2000) and Def Stan 00-25 Part 11

2.4.2 Human-Computer Interaction

Automated systems or computer systems can support a person in a task thus reducing mental workload. The interface must be carefully designed to ensure that the person is always kept aware of any changes in task status or operating conditions. There must be plenty of feedback available therefore. However, the feedback must be prioritised to ensure that the operator is not overloaded with information. It will be necessary to determine which feedback is mandatory and which is supplementary. In a control room environment, an assessment of mental workload might be necessary to create optimal levels of feedback for normal and abnormal states. The level of feedback can be modified to increase in 'quiet' times and be carefully prioritised under high workload conditions.

For more information relating to interface design and human-computer interaction, see the PRISM FG2 guidance on human-computer interaction.

2.5 Understanding the Task Context

The task must also be considered in a working context. "Task design" is not restricted to the design task itself. Environmental factors such as lighting, noise, temperature, etc can all impact on task performance and should therefore be given proportional consideration. Similarly, team and social factors should be taken into account. Job rotation and enlargement may be required if there are ergonomic hazards associated with the task. Also manning levels and other resource requirements must be defined as part of the task design process.

2.5.1 People

The whole discipline of organisational psychology is dedicated to this area so it is difficult to condense such a complex subject into a paragraph.   Instead, the aim is to outline some issues that should be considered within the context of task design.

The first question is whether the task is performed by an individual or by a team. If there is any partnership or teamwork involved, then these must be accommodated when the task and work areas are designed. Additional social factors are likely to take effect, e.g. status. The nature of leadership or supervision of the task must be planned.

Staffing levels for the task as a whole whether as individuals, pairs or teams must be devised. The workforce population must be matched to the task requirements in terms of age, dexterity, flexibility, skills and experience. If there is an existing workforce the existing skills must be examined. Where there are skills gaps, the workforce's openness to training must be managed as part of the process.

2.5.2 Job Design

The task must also be considered in a wider job context. Where does the task fit within the overall job role and does it conflict with any other tasks that the individual must perform? Shift patterns may have to be adjusted to fit the new task demands. Levels of fatigue may increase. All these indirect influences must be managed as well as the direct affects.

In order to retain trained staff, the task should be fitted into a job enlargement / job enrichment programme and options for staff progression or skill transfer should be identified early on. This will help to increase job satisfaction, morale and relieve stress and boredom

2.5.3 Workspace

The work area must be designed to accommodate the task, peripheral work activities and the workforce. Although the design process aimed to eliminate hazards where possible this is not always possible. The final workplace must also minimise any residual hazards associated with the activity. Environmental factors such as temperature, lighting, noise, vibration must be managed. Additional hazard management equipment such as anti-fatigue mats can be used to reduce the risk of occupational injuries. Rest areas, personal storage and smoking areas must be provided for the workforce to accommodate non-task activities. Quality and availability of refreshments and catering will heavily impact on morale and productivity. These aspects of work are not given much attention, yet they have a strong influence over workforce performance.

2.6 Develop Documentation to Support the Task

Once the task has been designed, procedures must be written and training requirements identified. This demonstrates that the four good practice guides are not intended to be used individually.

3 Resource Requirements and Typical Time-scales

3.1 Data Requirements

This will vary greatly depending on the tasks that are being designed; however, the objectives and the context of the task in question must be clear.
If similar systems are in existence, then these should be reviewed to gather information on hazards, incidents, accidents and occupational injuries associated with the activity.

3.2 Expertise Requirements

The human factors expertise needed in the design of work tasks will vary according to the scope of the project, but should include:

- Designers.
- Operators.
- Maintainers.
- Managers/supervisors.

In more complex design situations, human factors experts should be included in the design team or may be called in for specific topics related to different parts of the assessments. The team can thus change as the project proceeds. For issues of mental workload and stress, it is advisable to consult a qualified occupational psychologist.

3.3 Techniques

Although there are several techniques which are applicable to each area of task design (for example, anthropometry for workstation design), the basis for any ergonomic approach is task and error analysis. There are several tools from which to chose, but task analysis techniques such as those listed below will be useful:

- Hierarchical task analysis
- Link analysis
- Activity analysis
- Timeline analysis.

For information on these and other models of analysis, please see the PRISM FG3 report on task analysis techniques and also Kirwan & Ainsworth (1992): see the useful references section for details.

3.4 Timescale

The timescale associated with task design will depend on whether the task is new or already existing. Modifications often take longer to complete than fresh designs. In either case, the initial design will require modifications before implementation and these revisions can prolong the process.

4 Benefits And Potential Problems

The main benefit of good task design is to optimise human performance within the system. Increased productivity, quality and operability are benefits that few businesses would decline. Therefore although task design may be time consuming and require investment up-front, the subsequent benefits outweigh these costs.

A well-designed workplace helps to prevent work-related injuries such as back and neck pain caused by poor posture in sedentary jobs, carpal tunnel syndrome, tendonitis or tenosynovitis. It will also reduce the number of sickness days taken by staff and possible subsequent medical costs. A carefully designed workplace also helps to reduce the number of personal injuries resulting from incidents and accidents. This will lead to fewer lost time injuries and a safer environment. A good design can also increase efficiency, e.g. time savings. It has generally been shown that occupational stress levels are lower in a well-designed environment and levels of job satisfaction increase. This is especially true if the workforce is consulted during the design process.

5 Further reading

DEF STAN 00-25 *human factors for designers of equipment*: http://www.dstan.mod.uk/

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