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Human factors integration: Implementation in the onshore and offshore industries

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Human factors integration: Implementation in the onshore and offshore industries

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This aim of this document is to provide guidance to onshore and offshore system designers and assessors with regard to HFI principles and their practical application. The offshore design cycle was mapped to the defence/SMART Procurement cycle. HFI principles advocated by the defence industry were applied to the offshore design lifecycle. A definition of HF is provided and HF techniques and HFI processes are described in detail. A checklist is provided at the end of this document to enable designers and assessors to determine whether a system development process adopts 'Best Practice' in Human Factors.

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CONTENTS

Glossary

Acronyms referred to in this document are defined below.

ALARPAs Low As Reasonably Practicable
EHFAEarly Human Factors Analysis/Assessment
FEEDFront End Engineering Design
HAZIDHazard Identification
HAZOPHazard and Operability Analysis
HCIHuman Computer Interaction/Interface
HFHuman Factors
HFAHuman Factors Authority (≡ HFM)
HFEHuman Factors Engineering
HFIHuman Factors Integration
HFIPHuman Factors Integration Plan
HFMHuman Factors Manager
HFWGHuman Factors Working Group
HSEHealth and Safety Executive
IGPInstallation Guidance Package
MMIMan Machine Interface
SMESubject Matter Expert
TADTarget Audience Description

Chapter 1. Introduction

1.1. Objective

This document was produced in response to reference B2[12] and B3[13], Behavioural and Social Sciences section of the HSE Mainstream Research Market 2000/2001 document. This report was produced on behalf of the HSE Hazardous Installations Directorate, under INO number 843300/001.

This aim of this document is to provide guidance for the integration of Human Factors (HF) principles into the onshore and offshore system design and development process. The guidance contain within, is therefore directed at onshore and offshore systems designers and assessors. The guidance was generated from practical experience and the application of the Government's SMART Procurement programme for the defence industry.

1.2. Overview

For systems to operate safely and effectively, they must be designed to support the people who operate them. Human factors is regarded by the HSE as having an essential contribution during the development and operation of systems. It is increasingly recognised that human factors issues must be considered as a central part of development thinking. Experience shows that it is ineffective to address them as an afterthought. The risks associated with poor human factors can best be avoided by starting human factors activities as early as possible in the design process and continuing them throughout. This document gives guidance on approaches that assist in placing human factors at the heart of system design and development in the onshore and offshore industries.

The nature of the human factors issues varies widely according to the type of system being developed, and across different parts of the system. For example, the issues involved in developing a highly manual process plant are different to those that relate to designing the graphical screens in the plant's control system. This document indicates the scope of human factors, which addresses both the technical and human parts of the system.

Whatever type of system is being developed, the appropriate action is suggested by some underlying principles of good human factors practice. The overall objective should be to ensure that the development process is "Human Centred." An international standard (ISO 13407: Human-centred design processes for interactive systems.) This document outlines the essential features of a human-centred process. The guidance in this document is based on these principles.

Good management is needed to address human factors comprehensively. In many cases, concerted action is needed between different parts of the development team. The UK and US defence industries have implemented successful approaches to controlling human factors activities and ensuring that they are integrated with the mainstream of development. This document outlines some features of this approach which are adaptable to system development in the onshore and offshore oil industries. Human factors activities must proceed in parallel with technical development. Human factors inputs must be timed to maximise influence on the current development questions. As such, different activities are needed at different times. This document outlines the stages of the system development. It discusses the human factors support that is needed at each stage and suggests some specialist techniques.

Finally, the document provides a checklist of questions that address whether the approach to system design and development adopts best practice in human factors. The overall purposes of the guidance and document and checklist are:

- To provide guidance to onshore and offshore systems designers on the best ways to address human factors.

- To support Inspectors in assessing whether system designs have incorporated "best practice" in human factors

Chapter 2 .The Scope of Human Factors

The range of human factors issues which can affect safe and effective performance depends on the type of system and what the system does. It is therefore necessary to focus on the issues that need to be addressed in a particular system and to tailor development activities accordingly. To do this, it is important to understand the full range of human factors issues that *might* be relevant.

2.1. A Definition of Human Factors

There are several definitions of human factors available. The following definition is taken from the NAC first report, June 2000:

"Human factors is a professional discipline concerned with improving the integration of human issues into the analysis, design, development, implementation, and the operational use of work systems."

Human factors is an engineering development which focuses on:

- The interaction between humans and technical system components.
- The design and supply of the human activities and processes required to support the technical system.

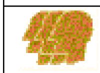
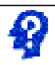
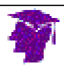
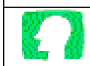
The overall objectives of human factors are to design systems, jobs and organisations that match human capabilities and limitations.

2.2. The Range of Human Factors Issues

Human factors is a wide-ranging discipline. It is concerned with both the human interactions with the technical components of the system (e.g. operating, monitoring maintaining) and the wider human activities required to sustain the system (e.g. training, work organisation). Many readers will be familiar with some of the topics covered by human factors - e.g. workplace layout, screen design or manual handling. In fact, safe and effective system operation requires us to attend to many areas, each of which can be critical to performance.

The full range of HF interests fall into a number of general areas or "domains." A useful check on whether all HF activities are being addressed is to consider the relevance of these domains for a system or piece of equipment. There are 6 human factors domains in the HFI process, shown in Table 1. The nature of the issues in each domain varies from project to project, although the range of topics that might be relevant is listed in Table 1.

Table 1: Human Factors Integration (HFI) Domains

Domain		Issue	Topics to consider
	Staffing	How many people are required to operate and maintain the system?	Staffing levels Workload Team organisation Job specifications
	Personnel	What are the aptitudes, experience and other human characteristics necessary to operate and maintain the system?	Selection, Recruitment and Career Development Qualifications and experience required General characteristics (body size, strength, eyesight, etc.)
	Training	How to develop and maintain the requisite knowledge, skills and abilities to operate and maintain the system?	Identifying requirements for new skills Documentation Training courses Requirements for specialist training facilities Individual and team training Skill maintenance (e.g. refresher courses, drills)
	Human Factors Engineering (HFE)	How to integrate human characteristics into system design to optimise performance within the human/machine system.	Equipment design Workstation/ console design Workplace layout Maintenance access and ease of maintenance User interface design (e.g. computing facilities and screen design) Function allocation (between humans and automation) Working environments (e.g. climate, lighting, noise.
	Health Hazards	What are the short or long term hazards to health resulting from normal operation of the system?	Exposure to: • Toxic materials • Electric shock • Mechanical injury • Musculoskeletal injury (e.g. heavy lifting; repetitive movement) • Extreme heat/cold • Optical hazards • Electro-magnetic radiation
	System Safety	How to avoid the safety risks which humans might cause by operating or maintaining the system abnormally?	Sources of human error Effects of misuse or abuse External and environmental hazards

Chapter 3 . Integrating Human Factors Into Systems Development

The design of human and technical components of the system is usually interdependent. For example:

- Systems should be designed to meet the needs of the user and organisation *but* jobs and organisations should be designed to make the best of technology.

- Automation may be used to allow operators to cope with the volume of work *but* it may be more cost-effective to increase the number of operators.

- Maintainer tasks are determined by technical system, *but* systems must be designed so that maintenance is within human capabilities.

- Equipment should be designed to be operable, given the skills of the target users *but* user skills can be enhanced through training.

- Inherent hazards must be designed out of systems but additional hazards may be introduced by operator or maintainer error.

Furthermore, many human factors issues can only be addressed by attending to several areas of design. For example, operator performance in a control room may be equally influenced by the design of the control system software, the system architecture, the physical architecture of the control room or the design of procedures and documentation.

To address issues such as these, it is necessary to integrate human factors considerations into the processes followed for the design of the technical system. ***Human factors is not a stand-alone activity. Best practice is achieved only when Human factors are integrated into the mainstream of systems development.***

For an individual project, a useful gauge of whether the extent to which HF is properly integrated is to assess where the project lies on a scale of "Human Factors Maturity:" Projects at level 3 or below are advised to consider how to include a fuller range of human factors activities in their plans.

1. Human factors is irrelevant. (i.e. user interfaces are designed or plant items are specified and laid out without any consideration of human factors).

2. Human factors is thought to be common sense (e.g., developers are trusted to place control panels, valves, etc. in sensible places; Graphical User Interfaces are thought to guarantee usability in turnkey control systems).

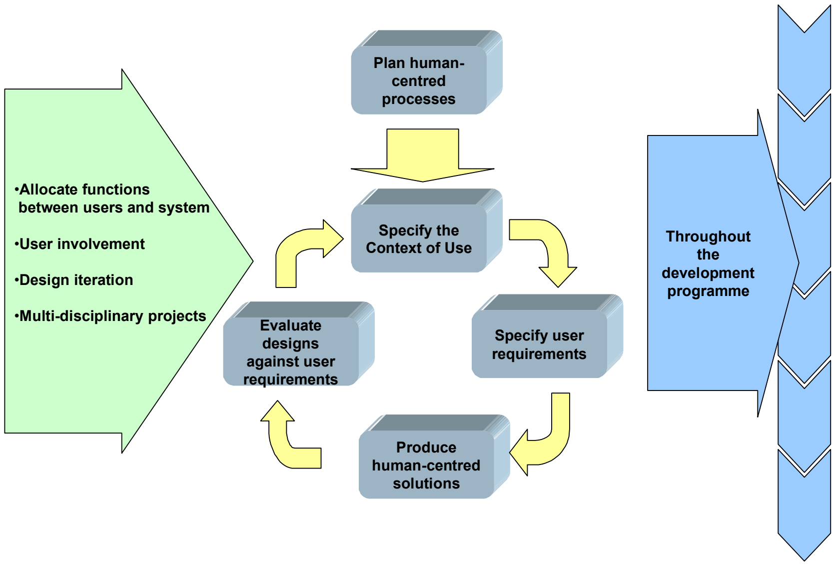
3. Human factors is unfocussed (e.g. Usability is assessed only after design is complete; Screens/ workstations/ control rooms are known to have ergonomic issues, but are designed in isolation; No attempt is made to identify which tasks are critical to safety and performance).

4. Human factors activities are integrated into development (e.g. HF guidelines are applied to the design of equipment and workplaces; Critical HF issues are identified and addressed).

5. Human factors is fully integrated throughout the lifecycle (e.g. human centred design methods (see Section 4) are used to match the system to the users and organisation; Human and technical aspects are addressed in parallel).

Chapter 4. The Human-centred Approach to Systems Development

Figure 1: The Principles of Human-Centred Development and the Activities That Achieve Them



Human factors does not deliver a concrete part of design. Rather, human factors objectives are met by incorporating suitable activities into different parts of the design. While the exact nature of human factors issues varies between designs, the underlying principle needed to address them is **Human-Centred Development.** Best practice in human factors is to ensure that human-centred design processes are adopted throughout the lifecycle, in order to understand, specify and accommodate the needs of users, their organisation and the wider business.

Human centred design processes have the following qualities:

- *Functions are allocated appropriately between users and systems.*
  The design of user tasks is considered along with system functions.

- *Users are actively involved.*
  Designs consider end users' characteristics, preferences and opinions.

- *Design solutions are iterated*
  It is recognised that user requirements are complex and difficult to express. The development process gives scope for clarifying requirements and amending designs as development progresses.

- *Project teams are multi-disciplinary.*
  The wider scope of the human-machine system is addressed by parallel involvement of those responsible for technical aspects (system developers) and non-technical aspects (end users; HF specialists; those writing procedures and documentation; support personnel, trainers; etc).

To achieve these qualities, five essential activities must be included within the overall design process:

1. **Plan the human centred process**
   Ensure that specific human factors activities are built in to project plans and sufficiently resourced.

2. **Understand and specify the context of use**
   Identify who the users are, what they will be doing. Ensure that descriptions of user characteristics and tasks are considered as the basis for design.

3. **Specify the user and organisational requirements**
   Specify the characteristics required of aspects of the system which affect users and their wider organisation.

4. **Produce design solutions**
   Apply HF expertise to generate design options which meet user requirements. Design iteratively. Use prototypes to clarify requirements.

5. **Evaluate designs against user requirements.**
   Test out requirements by involving target users and HF specialists.

These activities can be supported by a range of human factors techniques. Table 2 gives some examples. Plans should be made to incorporate these at the appropriate stages of development. Further information regarding the techniques that are applicable to each stage is found in Section 7.

Table 2: Overview of Human-centred Design Activities

Plan Human-Centred processes	Human Factors Integration planning Usability Maturity Assessment Early Human Factors Analysis
Context of use	Target Audience Description Scenario Identification Task Identification
User Requirements	Task Analysis Function Allocation Style Guide Ergonomics standards and guidelines User performance specification
Design solutions	HCI design Workstation Design Workspace Design Environmental Design Job/ Team design
User Evaluation	User interface prototyping User trials Ergonomic checklists Design walkthrough Workload assessment Anthropometric modelling Human Reliability Assessment Workload Assessment

Chapter 5. Managing Human Factors Integration (HFI)

A well-managed approach is the key to successful HFI. To achieve this:

- Projects should draw up and follow a Human Factors Integration Plan (HFIP).

- Human factors plans and activities should be integrated with the overall project.

- There should be recognised, multi-disciplinary mechanisms for identifying and addressing HF issues.

- There should be a process, which focuses on critical human factors issues and monitors progress towards addressing them.

- Human factors requirements should be included in project specifications.

- An HFI Audit Log should be maintained.

5.1. The Human Factors Integration Plans (HFIPs)

Best practice in HFI is to appoint a Human Factors Manager (HFM) who is responsible for planning, monitoring and co-ordinating HFI activities. For large projects, it is recommended that the HF Manager is a dedicated role, staffed by a specialist. For smaller projects, it may be possible to combine this with other duties. The principle tool for the HFM should be to draw up and manage a HFIP. All projects of a significant size should have a HFIP. The HFIP should tailored to the specific context of the individual project. Typical contents of an HFIP are shown in Figure 2.

The principle aims of the HFIP are:

- Establish a well ordered, structured approach to HFI.

- Avoid a piecemeal approach to human factors by explicitly identifying the full range of issues that need to be addressed, and specifying relationships with other relevant disciplines such as Safety.

- Identify the various parts of the overall project team whose activities need to address human factors requirements.

- Scope the extent of human factors activities which need to be budgeted for and researched.

Figure 2: The Contents of a Typical HFIP

A typical Human Factors Integration Plan should include:

- The HFI issues to be addressed in the project:
  HF issues should be identified for each for each of the HF domains (see earlier).

- HFI constraints
  The HFIP should make explicit any overriding constraints, which limit the degree of freedom of Human-Centred Design and indicate how these will be dealt with in the programme. Examples of constraints might include:

  - Pre-selected or legacy equipment
  - Fixed staffing levels
  - Limitations on training capacity
  - The organisational context in which the system is operated.
  - Safety constraints

- The activities that will be conducted to analyse and mitigate HFI issues.
  The HFI plan should describe a programme of HFI involvement in development. This should include a Work Breakdown for specialist HF activities, tied to appropriate activities in the overall project plan.

- Dependencies to and from other development activities e.g:
  - what HF inputs are needed by developers, by when
  - what aspects of the design are considered when
  - dependencies to and from separate development contracts

- Plans for user involvement, eg scheduling of human factors assessments of designs; Prototyping activities; User Trials; Simulations; etc.

- The method for monitoring and controlling progress against the plan

- Processes, mechanisms and forums for considering human factors trade-offs

- Plans for updating the HFIP

5.2. Project Integration

The HFIP must recognise that human factors is not a stand alone activity. Good human factors will be delivered largely by influencing wider development activities. To achieve this influence:

- The HFIP should align with overall project programme plans.

- The activities specified by the HFIP should be relevant to the development schedule.

- The HFIP must recognise milestones in the programme plan and aim to supply HF inputs at appropriate points.

- HFI activities and processes should be followed by the development team as a whole. There should be a general project requirement to recognise and follow the processes and activities specified in the HFIP. Consideration should be given to including the HFIP as part of project plans. Plans for other parts of the development team should include or refer to the same HFI activities as the HFIP.

- The HF team should be involved in the review and sign-off of design documents. The influence of HF can be further strengthened by imposing a need for the development team to demonstrate good HF within their designs.

5.3. Multi-disciplinary Mechanisms

The HFIP should establish a forum in which HF issues can be discussed by the various stakeholders in the development team. Many HF issues are not specific to individual parts of the design. This can be addressed only by interaction and trade-off between different areas of development (e.g. cost and risk of automation versus staffing costs; incompatibility between off-the-shelf user interfaces; the dependency between workplace layout and equipment fit; etc). It may be useful to set up Human Factors Working Groups (HFWGs) in which the HF team can co-ordinate liaison between the relevant parties.

5.4. Focus On, and Monitoring of Key Issues

It is desirable to address the full range of human factors issues. Failure to do so can have unanticipated consequences. For example, even if poor ergonomics does not directly give rise to an injury, poor design can lead to longer term lowering of human efficiency which may in turn compromise safety.

Notwithstanding, it is important to focus particular human factors attention on issues with a particular impact on performance and safety:

- To demonstrate that all of the critical issues have been identified and addressed.

- To identify where tradeoffs can and cannot be made.

- To ensure that resources are made available throughout development to address areas of uncertainty.

- To identify the different parts of the development team which must be brought together to address human Factors issues.

Best Practice for managing HFI includes maintaining a **Human Factors Issues Register.** This should be set up as early as possible during development and be amended and maintained throughout the lifecycle. The aims of the Human Factors Issues Register are:

- To indicate the range of HF issues to be addressed by the project during current and future phases of the project.
- To provide a running record of the HFI activities that have been carried out and how they have influenced development carried out to address the issues (thus giving assurance that the issues have been addressed).

5.5. Human Factors Requirements

The best way to ensure that human factors issues are addressed is by including specific human factors requirements in development specifications. The embodiment of good human factors thus becomes an issue for the verification, assessment and acceptance of project deliverables.

It is not always possible give detail on human factors attributes in advance of design - some iteration will usually be needed, and different issues apply to design solutions. However, there are various types of HF requirement to consider:

- **Product Requirements**
  Specifications can include details of attributes to be found in equipment of a specific type, e.g. "All user interfaces must conform to the project style guide" ; "All electrical machinery cabinets must be fitted with interlocks which shut off power supply whenever covers are removed; "All computer workplaces must conform to BS3179").

- **Performance Requirements**
  Specifications may include performance statements for equipment used by the target audience of users. Performance requirements should be written so that they are testable, e.g.: "The control system shall be operable by X people without causing excessive workload." "It shall be possible to strip and replace the valve unit within 1 hour"; "Warning displays shall be visible from operators' normal working position".

- **Process Requirements**
  Specifications can define the human factors activities or processes which must be followed to give confidence that the full range of issues are addressed. Eg."Task analysis hall be conducted for all operation and maintenance routines"; "Operator screens shall be prototyped in consultation with users." "The project shall draw up and follow a HFIP."

5.6. HFI Audit Trail

A HFI Audit Log should be produced and maintained. The HFI Audit Log should demonstrate an audit trail of HFI activities to ensure that the design decisions are fully accountable.

6. Involving Human Factors Throughout the Development Lifecycle

6.1. Overview

Human factors activities cannot be left until detailed design of equipment and workplaces. Successful application of human factors depends on a proper process of conducting the appropriate human factors activities into the various stages of the system development lifecycle. It is particularly important to identify the context of use early on. If this is known, system developers can begin to understand the scope of the human contribution to the overall system and hence design the various technical and organisational elements required to support that contribution.

An idealised lifecycle is depicted in Figure 3. Precisely how the lifecycle is divided into stages, and the names given to stages varies from project to project, but the objectives and outputs of the stages should be familiar. In some cases, there will iteration between stages and different parts of the project may be at different stages. Broadly speaking, however, the development lifecycle can be thought of as having 5 main activities:

- **Conceptualisation**
  Recognising the need for a system, determining one or more options for the sort of system needed and deciding on the type of system to develop further.

- **Full Development**
  Defining the attributes of the system that will be implemented, both in functional and physical terms.

- **Delivery**
  Realising the physical system and making it ready for operation.

- **Operation**
  Using the system for its intended purpose, and supporting it so that it continues to operate

It is essential that human factors activities should proceed in parallel with the mainstream of system development. It is important to understand the objectives of each stage in order to ensure that the right HF issues are being addressed at the appropriate time. If a HF issue is not dealt with early enough, problems found downstream will be much more expensive to resolve. Conversely, if detailed HF activities proceed too early, they may miss out on technical constraints that only emerge as technical development unfolds.

Figure 3: An Idealised System Lifecycle

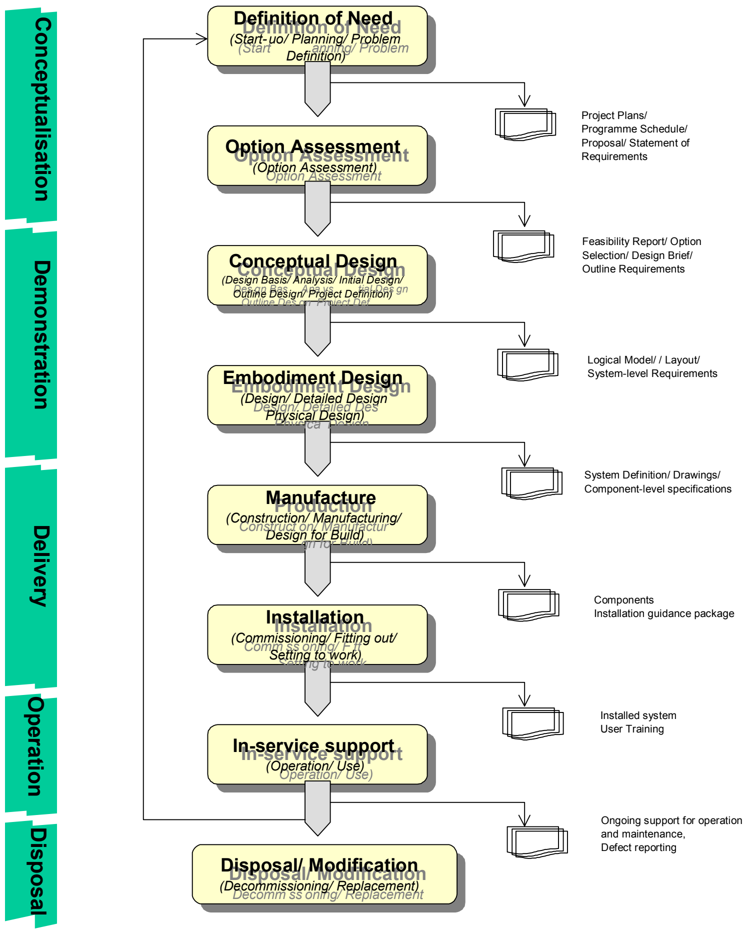


Figure 3 corresponds to the defence (SMART Procurement) and offshore phases as illustrated in Table 3.

6.2. Comparing the Defence and Offshore Lifecycles

It is recognised that the offshore design cycle may vary from company to company, and from project to project. Table 3 depicts an agreed lifecycle that was obtained after consultation with several Offshore project experts. Each offshore lifecycle stage is listed next to the corresponding stage(s) in the defence lifecycle.

Table 3: Defence and Offshore Lifecycle Mapping

Offshore Phase	Defence/SMART Procurement Phase
Feasibility	Concept, Definition of Need
Concept	(Option) Assessment, Conceptual Design
Front End Engineering Design (FEED)	Demonstration, Embodiment Design
Detailed Design/Production	Manufacture

6.3. General HF Considerations in the System Lifecycle

The following paragraphs provide general indications of the types of HF issues and activities that are appropriate to each stage in the system lifecycle. Further details of these are given in Section 7 of this report.

6.3.1. Definition of Need

This is also known as the 'Concept' stage in the defence industry. At the initial stage, the originator of the project will have identified a business need. This will usually arise from experience from operation of an existing system and/ or a change in the wider environment in which the system operates, such as:

- Defects observed during operation (including unanticipated hazards).
- A need for productivity benefits (including increased throughput; decreased down time; staffing savings).
- Equipment obsolescence (including spares shortage; loss of operator/ maintenance skills).
- Changes in safety or environmental standards.

The broad objectives at this stage will be:

- To formalise the business need into a statement of objectives for further development.
- To plan (usually in outline) the future development phases and schedule for delivery.

Although no design has started, it is still useful to integrate human factors activities in this phase. It must be recognised that any new development or change to an existing system will have implications for the people who operate and maintain it. In many cases, there will already be a "target audience" of users, either operating the old system or working elsewhere in the industry. The recommended HF activities are:

- To identify, in broad terms, what are the human factors issues that will need to be addressed during development. This activity is termed "Early Human Factors Analysis".
- To develop strategies to investigate and address HF issues and ensure these are incorporated into project plans.
- To obtain initial data on users and tasks and ensure that user constraints are identified in initial project definition documents.

At this stage, some initial Safety management work should also be commencing, principally to establish a safety management plan, which will be followed and updated as development progresses. Human factors should contribute to safety activities at various stages in the lifecycle. At this stage it will be important to plan the required contributions and liaisons and ensure that they are reflected in the SMP. It is also best practice to commence high-level Hazard Identification at this stage. Human factors expertise should be sought to support to assess the safety implications and the general nature of the hazards which arise from the system objectives.

6.3.2. Option Assessment

This stage is simply known as 'Assessment' in the defence/SMART Procurement process, and maps onto the 'Concept' stage of a typical Offshore system design lifecycle. At this stage, the aim is to scope the project in terms of technical aspects, cost, risk, timescales, demand on resources and hazards. In many cases, more than one system option will be scoped, either within a single study or in separate studies, with a selection made at the end of the stage. In the course of this, it will be necessary to conduct some level of analysis, in order to expose the areas of greatest project risk. A product from this will be high-level system performance requirements, which are subsequently the starting point for design work proper.

As a part of this, it will be essential to ensure that human implications are discovered and hence human performance requirements documented. The human factors work at this stage should be directed to address the main human related risks. Even where these cannot be immediately addressed, requirements can be flagged to ensure that they are de-risked later. Typical high-risk areas include:

- Areas where de-manning is envisaged, resulting in a need for increased automation.

- New equipment and processes which require special skills from operators and maintainers and hence impact on training needs.

- Combinations of functions or increased throughput which have implications personnel roles and workload.

This activity is essentially a continuation of the Early Human Factors Analysis (EHFA) started in the previous phase. There will however be greater emphasis on scoping the level of HF risk, with a view to supporting the assessment of project feasibility, selection between options and budgeting the HF contribution downstream. Depending on the HF risks identified, it may also be necessary to begin more detailed specialist HF investigations into the higher risk areas.

In support of these activities, it will be useful to refine the data collected on users and their tasks. This can be done by conducting initial task analyses, based on the previous or similar systems. This information can feed the identification of HF risks by allowing the project to highlight areas where human tasks are likely to change. It also provides valuable information on the "Context of Use" - an understanding of how personnel will interact with the system. This understanding will be extremely helpful in informing later work.

If Hazard Analysis has not already started, it will be important to do so at this stage. Human factors input to safety management activities is important in the following areas:

- Specialist HF input regarding hazardous environments (e.g. noise, heat, vibration, toxicity) and their impact on health and performance.

- Information on the context of use (who is doing what, where and when), which allows areas to be identified where human error has hazardous potential.

It should be noted that a human factors engineer would never carry out a hazards analysis. This would be the responsibility of the safety engineer(s).

6.3.3. Conceptual Design

This stage refers to the 'Concept' stage of a typical Offshore system design lifecycle. At this stage, the aim is to define what is required of a system, which meets the objectives identified previously. Part of this work will involve further verification of approaches and assumptions made during Feasibility, with further investigations focussing on the high-risk areas. The principal purpose, however, is to refine the system requirements to a sufficient level of detail to give a basis for development. This is done by designing a high-level model of the system. For physical elements, this might define the main processes or plant items. For software-based elements, it would be a "logical model" of the system. Note that it is not the intent to design the physical solution at this stage, although some degree of physical design will inevitably be needed to stimulate and test out logical designs. In most cases, requirements will be designed for systems or parts of systems that will be designed and supplied by separate contractors.

It is important to include personnel functions within modelling. A Task Analysis model should be developed at this stage, in parallel with other "views" of the system. Task Analysis is a representation of the human tasks carried within the system, the sub-steps within the tasks, the sequences and dependencies within and between them and factors, which affect their performance. **Task Analysis is fundamental to successful Human Factors Integration.** It provides input to several areas of detailed design which directly impact users (e.g. training, procedures, workplace and user interface design). It is important to note that Task Analysis describes the work system as a whole - it may incorporate human-only tasks (such as communication between team members) and tasks involving the use of other systems. As such it provides inputs to design on what is required for system components to support the work system as a whole. Even when human involvement is implicit in other models, it is important to keep this wider overview and provide a context against which the full implications of technical design can be assessed.

At this stage, work will also continue to de-risk human factors issues. Task Analysis will support de-risking activities by providing details of the tasks to be supported by the system. In accordance with the objective of the phase, work will focus on yielding concrete requirements to be embodied during development. Issues to be investigated may include:

- Personnel workload and definition of automation facilities (including remote control and monitoring equipment) needed to achieve appropriate levels of workload. A requirement to demonstrate this satisfactory workload may be useful.

- Identification of the range of user interfaces to the different parts of the system accessed by individual users and the potential impact of inconsistencies between them. A human factors requirement may be generated for a Style Guide specifying the look and feel of common elements.

Note, however, that detailed HF requirements will not necessarily be completely bottomed out at this stage. The work started in Early Human Factors Assessment (EHFA) should continue to identify areas where risk or uncertainty remains. HF requirements should also include a requirement to continue and demonstrate user-centred development processes during the remainder of development, particularly in high-risk areas.

During this phase, Safety Management activities will be well underway. Typically, HazOps studies will start, as will the planning of the Safety Case. Human factors activities will support Safety management in a number of ways:

- Safety and HF should share a common understanding of the context of use, based around shared Task Analyses.

- Human factors inputs will be made to HazOps on the process where human error has potential to cause error.

6.3.4. Embodiment Design

This stage is also known as ‘Demonstration’ in the defence industry, and ‘FEED’ in the Offshore industry. In this stage, the purpose is to design *how* to implement a system, which meets the requirements defined in the previous stage. The output is a detailed specification, which will provide a basis for subsequent manufacture. Human factors activities will support the detailed design, and topics considered will include the ergonomics of equipment, user interfaces, workplaces and the working environment, to which HF specialists can supply specialist knowledge. There are some elements of the wider system, outwith the technical components (e.g. job design, training, documentation, procedures) which will also require attention from HF or related specialisms. In all cases, designs should pay heed to the context of use and specifically be designed to support the users' tasks, as specified in the Task Analysis.

This is an important time for design iteration and user involvement. In many cases it will be useful try out different prototypes, seeking inputs from users or HF specialists.

It will also be important to demonstrate that user needs have been met, and prototypes, models and simulations can support this.

An important issue for human factors is that design often consists of selecting Off-the Shelf or turnkey components to supply all or part of the functionality. It is especially important to ensure that these do not compromise user requirements, especially where they lack scope for tailoring. Assessments will need to be made of, for example, whether off-the-shelf user interfaces match the Style Guide, whether subsystems impose working procedures, which are compatible with users' jobs, or whether the workload required to use a component fits in with overall workload. It can be difficult to get evidence from suppliers, but willingness to supply HF data is often a good indicator of the component's suitability. "Human Centred Maturity Assessment" of potential suppliers can also give a warm feeling as to the extent to which their products have been designed with human factors in mind or will be adaptable to the various contexts of use.

The safety management activities at this stage will include putting together the Safety Case. As part of this, it will be essential to demonstrate that the potential for hazards resulting from human error or sub-optimal human performance have been identified and mitigated. Providing Task Analyses as part of the safety case will provide a useful indication that human involvement has been properly identified. Evidence will also be needed that the probability of human error is acceptable, and specialist quantitative risk assessments may be warranted. Evidence of human factors involvement in critical design areas may also bee needed as evidence that risks have been mitigated (e.g. workload systems have been run for critical areas; User interfaces have been prototyped; etc.)

6.3.5. Production

This stage is known as 'Manufacture' in the defence industry. The aim in the production phase is to realise the design as physical components. This will consist of either fabrication of bespoke components or, often, purchase of off-the-shelf products. In either case, some degree of detailed design may be required; to fully bottom out design details or to customise purchased components.

Typically at this stage, attention will be needed to the physical detail of user interfaces (HCI or physical panels) and workplaces, much of which cannot be finally decided until the physical components are known (e.g. the hardware on which user screens are implemented; the equipment to be fitted at the workplace). The design and prototyping activities started in the previous stage should continue.

Often this stage will be conducted by different contractors than the previously. It is important to ensure that work on then detail continues to meet the overall Human factors requirements, whether through formal assessments (demonstrations, user trials) or via evidence of the quality of human factors inputs to the design process. It is therefore advisable for the customer organisation to keep human factors specialist involvement in the acceptance. A HF Acceptance Checklist should be administered during the trials. Guidance for producing the checklist can be found in Section 7.3.7 of this document.

In this stage, it is also necessary to define operating procedures, produce documentation and design training courses. It is important that these are written in a way, which supports users' goals and tasks (as opposed to, say, purely technical descriptions of equipment). Input should be sought from Task Analysis.
Safety activities will also continue, to confirm that all hazards are identified and properly quantified, to ensure that they are mitigated and thus to confirm that risks are ALARP. As previously, human factors specialists should be involved in this process. There may also be specialist input into the design and assessment of hazard mitigation features, which may include physical measures (alarms, guards, interlocks, etc), procedures and training.

6.3.6. Installation

Once the component parts of the system are available, they are assembled and integrated to form the overall system. Requirements for installing components will often be supplied in the form of an Installation Guidance Package. (IGP) IGPs should also include human factors requirements where appropriate. Factors to be considered will include layout issues (e.g. equipment accessibility and collocation with, related other equipment) and requirements for the operating environment (e.g. lighting and ventilation requirements for control rooms).

However, it is also good practice in human factors to consider the equipment and its integration separately to ensure that the whole is not compromised by individual parts (e.g. access to equipment being impeded by other fittings; workload for one task interfering with another; Equipment noise interfering with audible alarms and warnings, etc). Workplaces should be treated as distinct components of the design, with overall responsibility given to human factors specialists. If workplaces have not been formally laid out previously, they should be at this stage (although it is preferable to do so earlier, to influence the design and selection of equipment). In either case, human factors assessments should continue as equipment is installed. For large or complex systems especially, it may be necessary to conduct walkthroughs or team trials, to give assurance that the parts of the system can be operated properly together.

6.3.7. In service

It should be recognised that systems inevitably evolve during their operation. It is worthwhile to conduct human factors usability trials periodically, to ensure that changes in equipment or workplaces do not compromise users' tasks. A HF Acceptance Checklist should be administered during the trials. Guidance for producing the checklist can be found in Section 7.3.7 of this document.

7. Human Factors Techniques

The objective of this section is to describe the human factors techniques that are recommended for application at each stage of life-cycle design. These activities are summarised for quick reference in Table 4 at the end of this section. The techniques should be applied by human factors experts.

7.1. Feasibility

This stage is sometimes known as ‘Concept’ but is referred to in Section 6 as ‘Definition of Need’.

7.1.1. Produce Human Factors Integration Plan (HFIP)

The HFIP is a management plan for human factors activities. The recommended contents of the plan are described in detail in Section 5. An updated HFIP should be produced at every stage of the design process.

7.1.2. Produce HFI Audit Log

The HFI Audit Log provides an audit trail of HF activities, and is intended to ensure that the design decisions are fully accountable. The log should be updated throughout the design process.

7.1.3. Identify Human Factors Issues

The objective of this exercise is to identify human factors issues, as part of Early Human Factors Analysis (EHFA). Strategies for the investigation of those issues should be incorporated into project plans. The identified issues could be recorded in a **Human Factors Issues Register**, a living database of HF issues associated with the design. It is recommended that the Human Factors Issues Register be cross-referenced with the project’s Safety Risk Register where appropriate.

7.1.4. Produce Target Audience Description (TAD)

A TAD is simply a definition of the target user population. When developed the document will contain information about the characteristics of the personnel who will operate and/or maintain the equipment. Specifically, the TAD provides details of the physical dimensions (anthropometry), strength limitations, skills and abilities of the target personnel.

7.1.5. Outline Usability Scenarios

An outline of the likely scenarios under which the system equipment is to be used; the context of use; is necessary in order to facilitate other activities such as the initial task analysis.

7.1.6. Conduct High Level Task Analysis

At this stage, a high level description of the tasks the user would be required to perform is recommended. It is difficult to produce a detailed task analysis until more is known about the design. However, an initial task breakdown based on similar systems would provide a useful indication of potential 'problem tasks', or human activities that may be replaced/modified by automation.

7.2. Concept

This stage is also known as 'Assessment', and 'Conceptual Design'.

7.2.1. Identify Human Factors Issues

This activity would be a continuation of the initial issues identification activity from the Feasibility stage. As before, the identified issues could be recorded in an ongoing Human Factors Issues Register.

7.2.2. Refine TAD

The objective of this stage would be to update the TAD developed in the previous (Feasibility) stage, if necessary. This may be required in the light of additional information regarding the design and/or human tasks.

7.2.3. Refine Usability Scenarios

This represents a progression from the corresponding activity from the previous design stage. It may be necessary to update the scenarios in the light of additional information regarding the design and/or human tasks.

7.2.4. Produce Detailed Task Analysis

The high-level task analysis from the previous design stage would serve as a basis from which to expand. Task analyses are developed by HF experts in conjunction with Subject Matter Experts (SMEs); the end users of the system. The operability scenarios would be consulted as part of this process. The result is a breakdown of user tasks and their sub-tasks, which in turn, is used to guide other activities such as the workload analysis, MMI/HCI design, workstation and workspace design.

7.2.5. Produce Human Factors Style Guide

The style guide would comprise detailed specifications and human factors requirements. The HF requirements would be derived from HF guidelines such as ISO 13407: '*Human-centred processes for interactive systems,*' ISO 9241: '*Ergonomic requirements for office work with visual display terminals*', or DEFSTAN 00-25: *Human factors for designers of equipment*;' a defence industry standard. The generic requirements identified in these standards would be reproduced in so far as they are relevant to the specific design project. The style guide would be presented in a format that could be interpreted by the equipment designers. For example, ISO 9241, Part 12, paragraph 5.3.7 provides specific requirements for the format of overlapping windows on a display:

"An overlapping window should be used in cases where:

- *the task requires variable or unconstrained types, sizes, numbers, contents and/or arrangements of windows;*
- *the visual display is small or of such low resolution that users cannot view meaningful amounts of information in individual tiled windows."*

A human factors engineer would incorporate this requirement into the project style guide if it was applicable/likely to be applicable to the design of the user interface. Similarly, an extract from DEFSTAN 00-25, Part 7, Paragraph 15.1.3 reads as follows:

"*The designer should avoid positioning displays beyond 40^o above 20^o below the user's line of sight, and beyond 30^o either side, depending on the viewing distance*."

The important words here being 'depending on the viewing distance.' A human factors engineer could calculate the optimal viewing distance if the size of the displays and personnel is known. Any engineering constraints, such as the size of the room could also be taken into consideration.

The document would be disseminated amongst the designers for use as a reference tool.

7.3. Front End Engineering Design (FEED)

This stage incorporates the 'Demonstration' stages, as it is known in the defence industry. In Section 6, this stage is described under the heading of 'Embodiment Design'.

7.3.1. Identify Human Factors Issues

This activity would be a continuation of the initial issues identification activity from the Concept stage. As before, the identified issues could be recorded in an ongoing Human Factors Issues Register.

7.3.2. Update TAD

The TAD from the previous design stage would be updated according to the progressing design.

7.3.3. Update Usability Scenarios

The aim of this activity is to revise the operability scenarios from the previous design stages in accordance with developments in the design.

7.3.4. Update Task Analysis

The detailed task analysis from the previous design stage should be updated as necessary according to design developments. It is important that an up-to-date understanding of the tasks is provided, as an input to the other activities such as the workload analysis, MMI/HCI design, workstation and workspace design.

7.3.5. Conduct Workload Analysis

At this stage in the design process it is advisable to produce a predictive workload model. There are software tools available for this, such as 'Wincrew' or 'Micro-Saint'. Paper-based methods include the NASA Task Load Index (TLX) or the Prediction of Operator Performance (POP) technique (CHS, DERA). These activities would provide a strong indication of peaks and pits in user activity. This is a necessary input to the function allocation process. Overloading or underloading the human user are both causes of human error. An overloaded operator/maintainer may be unable to perform important tasks accurately, or to time. Similarly, an *under*loaded operator, in a monitoring task for example, may miss important information and directly or indirectly cause a system failure.

7.3.6. Conduct Function Allocation

The objective of this task is to successfully distribute the tasks and functions amongst the automation and the human user(s). Peaks of user overload indicated by the workload analysis might be selected as targets for allocation to other, underloaded users, or automation (total or partial). The function allocation is an essential input to the MMI/HCI design.

7.3.7. Produce Man-Machine Interface/Human-Computer Interface (MMI/HCI) Specification

Inputs to this stage are the function allocation, task analysis, workload analysis and the human factors style guide. All of these inputs would influence the types of controls and displayed information on the MMI/HCI. The latter, would provide guidance regarding the optimal positioning and design of controls and displays. More specifically, the style guide would provide advice regarding the recommended monitor size; appropriate number, size and appearance of on-screen windows; text size; font type; use of colour; grouping of information; design of graphical icons; menu/navigation design; alarms/alerts design and positioning; etc. The output from this stage would be a paper-based design specification that is the main input to the user interface design activity.

7.3.8. Produce Human Factors Acceptance Checklist

The acceptance checklist would be applied in this stage during simulation and modelling trials. Essentially the checklist would comprise questions that test the extent to which the design is compliant with human factors principles and standards and the users' abilities. Subject Matter Experts (SMEs) might conduct a walkthrough of their tasks using the prototype and simulations. The checklist would be applied during or immediately after these activities. SMEs might be asked to rate various aspects of the interface such as the type, positioning, and labelling of controls; the ease with which they are able to navigate around the system, and other aspects that enable them to interact with the system in order to perform their tasks successfully. The checklist is designed to guide them through this process.

7.3.9. Undertake Prototyping and Modelling of User Interfaces and Workspace Layout (HFE)

Human Factors Engineering (HFE) principles are applied during workstation and interface design activities (see Table 1, Section 2 for a definition of HFE).

User Interface Prototyping

An interactive user interface prototype would be modelled from the paper-based MMI/HCI specification. HF experts would not generally undertake the modelling activity, (this may be conducted by rapid prototyping experts) but would be responsible for ensuring that the prototype adequately incorporates human factors. This is achieved by administering the human factors acceptance checklist.

Workspace Layout Modelling
The workspace layout could be modelled using 3D ergonomic modelling tools such as 'JACK'. Tools such as this allow scaled mannequins to interact with a scaled model of the proposed workspace. The workspace can therefore be ergonomically designed to optimise human interaction with the system. The tool can highlight potential problems such as obscurations to the user's sightlines, maintenance access, ingress and egress issues, space constraints etc. In this way costly mistakes in the manufacture of the equipment can be avoided.

7.4. Detailed Design/Production
This stage can also be referred to as 'Manufacture'.

7.4.1. Identify Human Factors Issues
This activity would be a continuation of the initial issues identification activity from the FEED stage. As before, the identified issues could be recorded in an ongoing Human Factors Issues Register.

7.4.2. Revise Human Factors Acceptance Checklist
The HF acceptance checklist is particularly useful during user interface and workstation/workspace trials, using physical mock-ups of the equipment, or the equipment itself. The checklist from the previous stage may require updating in accordance with developments in the design. The principles remain the same.

7.4.3. Conduct User Interface/Workstation/Workspace Trials (HFE)
The HF acceptance checklist would be administered here. SMEs representing the end operators or maintainers of the system would perform the operability scenarios using physical mock-ups of the equipment. They would be questioned about the usability of the equipment using the structured checklist. Workstation and workspace trials would allow the integrated equipment to be assessed together, in a mock-up or a prototype of the destination environment. Ergonomic aspects such as ability to access the equipment controls and displays, optimal reach zones, lines of sight to displays, response to alarms and alerts etc can be measured and tested. The data collected using the checklist would then be analysed by a HF expert, and recommendations for improvements to the design would be generated.

7.4.4. Conduct Workload Assessment
During the trials a workload assessment may also be conducted. Tools such as the NASA TLX may be applied. SMEs would be required for this activity. The 'actual' workload results can then be compared with the predicted workload from the previous stage. If the workload were deemed unsuitable, recommendations for improvements to the design could be generated.

7.4.5. Produce System Operating Procedures
User guides would be produced for each piece of equipment/software that the users would be required to utilise. The guides should be in a format that is compatible with the users' expectations and level of understanding. For this reason it is recommended that they be produced by a human factors expert.

7.4.6. Produce Environmental Specification

Environmental conditions such as appropriate levels of light, temperature, noise, vibration (if applicable), dust and air quality in the system operating environment etc should be specified. This may be completed by a human factors expert in conjunction with a safety expert.

7.4.7. Produce Training Specification/Design Training Courses

Operators and maintainers are likely to require additional training in the use of the new equipment. It is first necessary to identify the training gap, or the exact amount of training required. Then appropriate training methods and media would be specified, and training courses could be designed.

Table 4: Summary of HF Techniques in Life-cycle Design

Design Stage	Recommended Human Factors Techniques
Feasibility (*Concept, Definition of Need*)	• Produce HFIP • Produce HFI Audit Log • Produce HF Issues Register • Produce TAD • Outline Usability Scenarios • Conduct High Level Task Analysis/Task Identification
Concept (*Assessment, Conceptual Design*)	• Update HFIP • Maintain HF Issues Register • Maintain HFI Audit Log • Refine TAD • Refine Usability Scenarios • Produce Detailed Task Analysis • Produce HF Style Guide
FEED (*Demonstration*, *Embodiment Design*)	• Update HFIP • Maintain HF Issues Register • Maintain HFI Audit Log • Update TAD • Update Usability Scenarios • Update Task Analysis • Conduct Workload Analysis • Conduct Function Allocation • Produce MMI/HCI Specifications • Produce HF Acceptance Checklist • Undertake Prototyping and Modelling of User Interfaces and Workspace Layout
Detailed Design/Production (*Manufacture*)	• Update HFIP • Maintain HF Issues Register • Maintain HFI Audit Log • Revise HF Acceptance Checklist • Conduct User Interface/ Workstation/Workspace Trials • Conduct Workload Assessment • Produce System Operating Procedures • Produce Environmental Specification • Produce Training Specification/Design Training Courses

8. Checklist For Human Factors Best Practice

This section provides a set of questions aimed at determining whether a system development process adopts Best Practice in Human Factors.

The checklist has two purposes:

- An aide memoire for system developers on what human factors they should undertake.

- A means for assessing whether human factors is properly covered in the course of a development programme.

The checklist is not intended to indicate a pass or fail mark. It is a heuristic assessment. Judgement will be required as to whether the responses give confidence of the Human Centred Design maturity of the development organisation. Naturally, the more questions that are answered "yes", the greater the confidence will be that the project has addressed human factors issues. *However;*

- Positive answers should be backed up by evidence.

- There may be reasonable justifications for negative answers.

As a guide, the priority consideration(s) in each section are highlighted in bold. The specific human factors techniques recommended for each stage of design are summarised in Table 4.

8.1. Coverage of Human Factors Issues

Has the project considered the relevance of the 6 human factors domains to the project?

8.1.1. Staffing

Has the number of people required to operate and support the system been identified?

What evidence is there that the system can be operated and maintained by the available personnel?

- Are the workload demands for individual tasks known?
- Have assessments been of the ability of staff to cope with the anticipated workload levels?

Have the jobs to be carried out by individual members or groups of staff been identified?

Has the structure of the organisation that will run the system been identified?

Are the relationships and communications between parts of the organisation known?

8.1.2. Personnel

Is the Target Audience known, i.e. have the types of people who will operate and support the system been identified?

Is the pool from which staff will be supplied known?

Have the skills and experienced required of personnel been identified?

Does the project have access to sources of information on human characteristics, body size and strength; reach; cognitive abilities; educational attainment)? Is this appropriate to the target audience?

Have the characteristics of the target audience been considered in the design of operational and support tasks?

8.1.3. Training

Does the system require new skills to operate and support it (i.e. skills which are not currently found in the target audience) e.g:

- **Will equipment be unfamiliar?**
- **Are new procedures required to operate and support the system?**

Is separate training required for individuals and teams?

Has the means by which personnel will be trained been considered?

Has attention been given to the design and supply of:

- Training courses?
- Documentation and manuals?
- Job aids?
- On-line help systems?

Will refresher training be needed for infrequent procedures which are critical to safety or performance?

Have measures been identified for supplying this training?

8.1.4. Human Factors Engineering (HFE)

Are any of the following within the system scope? If so, has human factors been considered in their design?

- **Controls, displays and operating panels?**
- User interfaces to computing facilities? (e.g. screen designs; Provision of functionality to the appropriate users?
- **Workstations or consoles?**
- **Workplace layouts (e.g. control rooms; maintenance spaces)?**
- Maintained equipment (e.g. maintenance access; ease of maintenance)?

8.1.5. Health Hazards

Has the potential for the following hazards been identified?

Have measures been included to protect personnel from them?

- **Toxic materials?**
- **Electric shock?**
- **Mechanical injury?**
- **Musculoskeletal injury (e.g. heavy lifting; repetitive movement)**
- **Extreme heat/cold**
- **Optical hazards?**
- **Electro-magnetic radiation?**

8.1.6. System Safety

Has human factors input been included in Safety Management activities?

Have task analyses been provided as input to Hazard Analyses?

Has the human involvement in safety critical tasks been identified?

Has the potential for human error been identified?

Have measures been included to minimise error and maximise performance?

Has the impact of external factors on human performance been identified (e.g. environment. workload)?

Has the potential for equipment misuse or abuse been identified?

8.2. Human Factors Management

8.2.1. Human Factors Planning

Is there a Human Factors Integration Plan (HFIP) as part of project documentation?

Have the human factors issues which need to be addressed been identified?

Have appropriate human factors activities been identified within the development process?

Has a schedule been defined for human factors activities which will be carried out in an effective, efficient and timely manner?

Is there a process for monitoring progress against human factors activities and updating the HFIP?

Has a HFI Audit Log been produced and maintained?

8.2.2. Human Factors Responsibilities

Has an individual been appointed to co-ordinate Human Factors Integration across the project?

Has a forum been defined for discussing and addressing human factors issues between parts of the design team?

Are there sufficient resources for specialist human factors activities?

8.2.3. Human Factors Integration into Projects

Have human factors activities or inputs been included within technical development activities?

Do specialist technical design teams liase with human factors specialists?

Have dependencies between human factors and technical design been identified?

Are schedules for human factors and technical activities compatible?

Do specifications and other requirements documents include human factors elements?

Do human factors specialists work closely with the remainder of the team?

Do they interact on a day-to-day basis?

Do they have ready access to design documents?

Are they involved in technical meetings and design reviews?

8.2.4. Human Factors Risks

Have the human factors issues with the greatest implications for safety or performance been identified?

Has the extent of the human factors risk been assessed?

Are human factors and technical design activities focussed on all significant human factors issues?

Have areas been identified where further effort is needed to investigate human factors issues? Are investigations planned?

Does the project have a Human Factors Issues Register?

Is there a process for identifying human factors issues as they arise during development? Are clear records kept of how these issues have been resolved?

8.3. Human Centred Approach to Development

Does the project exhibit a Human Centred approach to development: i.e. do project plans, processes or activities include:

- **Specification of the context of use?**
- **Inclusion of user requirements in system or project specifications?**
- **Human factors specialist input to design?**
- **Evaluation of design against user requirements**

Do development activities consider how best to allocate functions between users and system?

Are users involved in development?

Is there scope to iterate designs to clarify and achieve user requirements?

Is there a multi-disciplinary approach to determining the human implications of system designs?

8.3.1. Context of Use

Have the types of people who will operate, maintain and support the system been identified?

Have different groups of people been identified (e.g. operators, maintainers, subcontractors, etc.)?

Have user characteristics been identified?

Is information available to the development team on:

- The skills, training and experience expected of users?
- The physical characteristics of the user population (e.g. size, strength)?

Have the human tasks required to operate, maintain and support the system been made explicit?

Have Task Analyses been conducted?

Are they maintained and refined as development progresses?

Do task analyses identify:

- The workload imposed by tasks (e.g. their frequency, duration or throughput required)
- Required sequences of or dependencies between tasks?
- Interactions between users?
- Which user or group of users will carry out which tasks?

Have the characteristics of the "working environment" been identified?

Is information available to the development team regarding:

- **The system location, workplace equipment and ambient conditions?**
- **Other tasks carried out by the same users?**
- **Other equipment used by the same users?**

Has the impact of external factors on human performance been identified?

Has the workload for these tasks not involving direct use of the system been considered?

Is information on user characteristics, tasks and working environment available to the development team?

Is it documented in a useful form?

8.3.2. User Requirements

Has the human performance required to operate the system been specified?

Have the following been documented:

- Duration or throughput of user tasks?
- Speed of human response?
- Expected or tolerable error rates?

Do technical specifications include specific user or human factors requirements? eg:

- Have ergonomic standards and guidelines been made mandatory?
- **Is there an HCI Style Guide?**
- Is it made explicit when specifications for physical attributes are based on user requirements?

Are design teams or suppliers required to demonstrate the usability of their designs?

Are there requirements to conduct user trials or other human factors assessments?

Do project specifications include requirements to adopt appropriate processes for identifying and addressing human factors issues?

Is there a requirement to implement a HFIP?

Are user requirements applied to *both* the technical *and* the supporting parts of the system e.g training, documentation, etc)?

Is there scope for the development team to clarify or revise user requirements iteratively, in the light of feedback on prototype designs?

Are user requirements applied to all relevant parts of the system, e.g:

- Component/ subsystem specifications.
- Requirements documents for separate parts of the development team (including subcontractors)

8.3.3. Human Factors Input to Design

Are human factors specialists involved in design teams?

Are sources of human factors data (e.g. ergonomic guidelines) available to the design team?

Is there evidence that human factors issues have been considered when selecting between design options?

Are user' tasks considered as an explicit design product?

Has attention been given to designing *both* the technical *and* the supporting parts of the system e.g training, documentation, etc)?

8.3.4. Evaluation Against User Requirements

Are users and/or human factors specialists involved in assessing prototype designs (e.g. HCI screens; Workplace models or mock-ups)?

Are users and/or human factors specialists involved in design reviews?

Are the workload implications of designs assessed? (through trials, simulations or expert assessment?)

8.3.5. Allocation of Function

Has the design of users' tasks been considered alongside system functions?

Do design documents identify *both* the functions carried out by the technical system *and* the human users?

Are user tasks identified in a Task Analysis?

Does the design of user tasks consider:

- User characteristics (e.g. physical attributes, cognitive abilities, skills, experience)?
- The performance required in the task, relative to users' capacities and limitations?
- The workload imposed by the task, against users' overall capacity?
- Interactions with other tasks carried out by the same users?
- Users preferences?

8.3.6. User Involvement

Are users or user representatives (eg. human factors specialists) included within the development team?

Are users or user representatives adequately involved in clarifying areas where user requirements are uncertain?

Has information on context of use been obtained from users of previous or similar systems?

Are users involved in prototyping and assessing designs?

8.3.7. Design Iteration

Is there scope to modify requirements following prototype design activities?

Is there scope to modify designs to take account of evaluations?

8.3.8. Multi-disciplinary Teams

Are non-technical aspects of the system, (e.g. job design, organisation, procedures, training), developed in parallel with the technical components?

Are non-technical implications considered as part of technical development?

Are there opportunities to address human factors issues through trade-off between different areas of (technical or non-technical) development?

Do design reviews address both technical and non-technical aspects?

8.4. Through-life Involvement of Human Factors

Have human factors activities been included at each stage of the development lifecycle?

Are human factors activities compatible with other development activities in the current development stage?

Do human factors inputs focus on the development decisions and products produced?

Are inputs available in time to influence development?

Are human factors needs for subsequent stages anticipated?

Are human factors Integration Plans updated?

Are requirements defined for the continuation of human factors activities?

8.4.1. Feasibility Stage

Has the Context of Use been identified:

- **Has the Target Audience for the new system been defined?**
- **Have other tasks carried out by the target audience been identified?**
- **Are the numbers of people available to operate and support the system known?**

Has information been obtained about users and tasks for current or similar systems?

Have the human and organisational implications of the system been identified?

Have the human processes needed to support users been identified (e.g. training, organisation)?

Are there plans to address these as part of overall development?

Have the major human factors issues for system development been identified?

Have plans been made to investigate these further?

Has human factors input been included in identifying high-level hazards?

8.4.2. Concept Stage

Have the main human factors issues been identified for each system option?

Has their impact been assessed?

Have they been considered in selection between system options?

Have human factors issues been identified that require further investigation?

Are there plans to address these issues?

Have the impact of system options on users and organisations been considered?

Have task analyses of system options been produced?

Has the levels of human performance required for tasks been considered?

Are human performance requirements been included in requirements specifications?

Have the human elements needed to support systems been identified?

- Have any new skills required to operate and support system options been identified?
- Have the implications of system options for workload and/or staffing levels been considered?
- Is the potential impact on the users' roles and organisation known?

Have task analyses and descriptions of the target audience been provided to the Safety Manager?

Has human factors input been included in early HAZID assessments?

FEED/Demonstration Stage

Does development consider both the technical and human parts of the system?

Are users' tasks and jobs designed explicitly?

Does technical design take account of requirements for jobs and tasks?

Is prototyping used to clarify user requirements?

Is it possible to iterate requirements in the light of feedback from users?

Are human factors specialists involved in design reviews?

Are designs explicitly reviewed against human factors requirements?

Is there a Task Analysis of the system?

Does Task Analysis form the basis of the design?

Is the Task Analysis used by the development team as an essential model of the system?

Are other models and analyses consistent with the Task Analysis?

Do system design specifications include specific human factors requirements:

- Do they refer to human factors standards or guidelines?
- Do they specify the performance required for human tasks?
- Do they specify further human factors activities during the remainder of development?
- Has an HCI Style Guide been produced?

Are mock-ups, models or simulations used to assess:

- **ergonomic aspects (eg. equipment design & accessibility; HCI design; workplace layout; environmental issues)?**
- **workload?**

Is explicit consideration given to which functions should be carried out by the system and which by people?

Does the allocation of functions take account of human characteristics and job context?

Are explicit records kept of how human factors issues have been investigated and resolved? Is there a Human Factors Issues Register?

Has the design considered ergonomic aspects e.g:

- Equipment design and accessibility?
- HCI Design?
- Workplace layout?
- The working environment?

Are the human elements which support the system designed in parallel with the technical system (e.g. training, procedures)?

Are human factors issues considered when selecting off-the-shelf components?

Is evidence sought of human factors input to their design? Has the Human-Centred maturity of suppliers been assessed?

Have human factors specialists been involved in safety analyses (e.g. HAZOPS)?

Have task analyses been used to inform safety analyses?

Do safety analyses consider the potential for human error?

Is evidence of human factors involvement supplied as part of the Safety Case?

8.4.4. Production Stage

Are human factors issues considered in acceptance?

Are human factors specialists involved in acceptance process - specifically user interface trials and workstation/workspace trials?

Does the process include user trials?

Are human factors requirements considered when selecting or tailoring equipment?

Are HCI designs assessed against a system-wide Style Guide? Are user screens prototyped?

Are human factors issues considered in the development of procedures, documentation and training materials?

Are these tailored to users' tasks?

Have task analyses been referred to during their development?

8.4.5. Installation

Is integration of equipments into workplaces considered as an explicit item of design?

Has somebody been identified with overall responsibility for workplaces?

Do Installation Guidance Packages include human factors requirements?

Do requirements cover accessibility, layout within workspaces and location relative to other equipment? Is the operating environment specified?

Are specialist human factors assessments carried out at installations?

Are team trials or dry runs carried out once the system is installed?

8.4.6. Operation

Is a system in place to record feedback from system users? Is user feedback acted upon?

Are periodic human factors assessments planned?

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