Human factors assessment model validation study

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This document contains the final report of work performed for the Health and Safety Executive, Offshore Safety Division (HSE OSD) under contract number D3989. The purpose of the work was to validate a provisional Human Factors Capability Maturity Model for the oil and gas Industry (HFCMM). The provisional model was prepared in an earlier feasibility study, reported in reference 1.

The current document builds on the work presented in reference 1. Specifically, the study set out;

- to validate the various elements of the provisional model
- to evaluate the practicality and potential usefulness of the model by applying it to exemplar organisations or projects from across the offshore industry
- to assess what changes would be needed to make the model applicable to other safety-critical industries, in particular the railway industry
- to produce supporting material and guidance to assist in using the model.

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HSE BOOKS

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1. Introduction

This document contains the final report of work performed for the Health and Safety Executive, Offshore Safety Division (HSE OSD) under contract number D3989. The purpose of the work was to validate a provisional Human Factors Capability Maturity Model (HFCMM). The provisional model was prepared in an earlier feasibility study, reported in reference 1.

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- ∆ to evaluate the practicality and potential usefulness of the model by applying it to exemplar organisations or projects from across the offshore industry
- ∆ to assess what changes would be needed to make the model applicable to other safety-critical industries, in particular the railway industry
- ∆ to produce supporting material and guidance to assist in using the model.

For reasons explained in the report, principally to avoid confusion and conflict with other Capability Maturity Models, the title of the model has been changed to the Human Factors Assessment Model (HFAM). This title is used throughout this report.

In summary, the objective was to complete development of the HFAM by validating, and, if necessary, amending it based on industry input. A further objective was to prepare material to support use of the model.

The result is a practical method, supported by case studies and other material, for assessing whether organisation involved in the UK offshore industry adopt good practice in taking account of human issues when designing or making significant changes to equipment or processes.

The document includes the results of an series of 'gap analysis of four large companies to assess whether the offshore industry already adopts good practice in Human Factors.

A1.1 Structure of the document

Following this introduction, the report is in five sections. The model itself is presented in sections 2 and 3;

- ∆ Section 2 summarises the objectives of the study, clarifies the scope, and defines ten requirements which the HFAM needed to satisfy
- ∆ Section 3 presents the final version of the HFAM, including guidance on how it should be applied and a summary of compliance against the ten requirements set out in section 2. This is the result of Study Task 3 (Update the model).

Sections 4, 5, 6 and 7 present supporting material generated during the study;

- Section 4 describes the results of a series of investigations carried out to establish where gaps appear to exist between what is reasonable best practice in Human Factors, and what companies operating in the UK offshore industry currently do in considering human issues during design projects. This forms part of the result of study Task 4 (Guidance and user support)
- Section 5 presents a series of Case Studies, in the form of examples of reported health and safety incidents which reflect lack of consideration of human issues during design. This also forms part of the result of study Task 4.

The document is supported by four annexes;

- Annex A summarises the results of Study Task 1 (Apply the draft model) to validate the Human Factors Assessment Model
- Annex B contains a procedure, including a questionnaire, for carrying out a Human Factors Assessment using the model. This forms part of the result of study Task 4 (Guidance and user support)
- Annex C contains the results of study Task 2 (Key performance indicators). The annex presents material developed during the study reflecting possible indicators of lack of consideration of human issues during design. The section also illustrates a possible framework for considering the business level impact of investment in Human Factors
- Annex D contains the results of study Task 5 (Review cross-industry applications) to review applications of the model in other industries.

A1.2 Acknowledgements

The study was conducted with support from CONOCO UK Ltd.

In addition, the following organisations provided input to the study, either by supporting, or offering to support, the industry validations (reported in Annex A), by assisting in the series of gap analysis (reported in section 4), or by supporting the investigation of the potential relevance of the HFAM model to other industries.

- BP
- Shell Expro
- TotalFinaElf
- Halliburton Brown and Root
- Weatherford Group
- Wood Group
- MMASS
- BP/CONOCO Underbalanced Drilling Joint Venture
- DNV
- Rowan Drilling
- Railway Safety
- Railtrack
- HSE Hazardous Installations Inspectorate

A number of Inspectors from the HSE OSD also provided comment on the work.

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2. Rationale and objectives

A2.1 Background

Duty holders in the offshore and other safety critical industries are required under the Health and Safety at Work Act, 1974, and subordinate legislation, to ensure the risks associated with their operations are reduced to a level which is as low as reasonably practical (ALARP).

The Health and Safety Executive (HSE) is tasked with assessing whether duty holders have achieved this level of risk reduction. As well as looking at the nature of operations and how risks are to be controlled operationally, the HSE seeks to ensure that duty holders adopt good practice. The HSE's guidance to its inspectors (reference 25) requires that “HSE staff should ensure that duty holders are using good practice which is appropriate to their activities, relevant to the risks from their undertaking, and covering all the risks from that undertaking”.

Good safety management recognises the importance of human actions and behaviour in managing health and safety, and the contribution of organisational behaviour and culture to a safe working regime.

Safety management systems can only achieve so much however, since the inherent design of equipment is a significant contributor. Indeed, accepted good practice in safety engineering is that wherever practical, potential health and safety risks should be controlled in the first instance through design. Reliance on training, procedures and other organisational controls should be considered as fall backs where control by design is not feasible.

The HSE Offshore Safety Division (OSD) is seeking to develop means of establishing whether equipment intended for use offshore can be considered to be "inherently safe" because of the way it was designed and developed. Specifically, there is a desire to push assessment of whether risk has been reduced to levels which are ALARP earlier into the design process.

The present study was part of the OSDs effort to improve identification and management of human-related issues affecting health and safety during the design and development of offshore platforms and systems. Based on experience from other industries, the view is that it is both reasonable and practical to expect the offshore industry to put more effort into identifying and controlling human issues affecting health and safety during design.

Specifically, the aim was to provide a straightforward means of assessing where an organisation stands with respect to 'best practice' in applying Human Factors Engineering (HFE) in the development of new or modified equipment, platforms or systems. The model was intended to be used either by HSE Inspectors, or by company's wishing either to improve their own processes or to assess the competence of their suppliers.

Initially, the aim was to ground the approach in the pre-existing framework of Capability Maturity Models. In particular the aim was to be compatible with existing thinking about Capability Maturity Models for design (reference 2) and Safety Culture (reference 3)[1].

A2.2 Scope: interpretation of 'Human Factors'

It became clear during the course of the study, that there is misunderstanding and confusion in the offshore and other safety-critical industries in the way the term 'Human Factors' is used.

2.2.1 The socio-technical systems view

In its' traditional usage, and the way it is used by many of those who would identify it as describing their professional discipline, Human Factors is a systems-oriented discipline. The human, individually and collectively, is seen as an element of dynamic, goal-oriented systems. Human Factors is concerned with taking proper account of the characteristics and abilities of the people who operate equipment, including their attitudes and likely behaviours, as an integral part of equipment design and procurement, from the earliest stages. The objective is to 'design in' safety and operability and to 'design-out' potential incidents that might arise from people's interaction with equipment.

In this usage, the term Human Factors relates not only to the contribution the human makes to system capability, but to the short and long-term effects the system has on the human, in terms of fatigue, health and well-being, etc. It is also concerned with what is needed to ensure the human is an effective system component, including recruitment, training, and support.

This usage is very broad in scope, drawing on many disciplines, including engineering, applied psychology, physiology, and biomechanics. The defining characteristic however is that it is a <u>systems</u> view and that Human Factors is something that forms an inherent part of the process of developing or modifying systems. More correctly, it is a socio-technical systems view, recognising the interaction between social (including inter-personal as well as management and organisational influences) and technical elements in most work systems.

2.2.2 The behaviour-centred view

The other usage of 'Human Factors' in safety critical industries tends to focus on the psychology of human behaviour and attitude. This emphasis tends to de-couple the human element from the technical system: i.e. while not ignoring it, it places less emphasis on the role of the human as an element in a socio-technical system.

In this view "human factors" is treated very broadly as those people-related factors which are thought to cause problems in operations. One current view treats 'Human Factors' as an approach to tackling the behaviours and attitudes associated with violations of procedures. The view is that human error can be avoided through a

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[1] While reference 3 provides a framework, it recognises that further work is needed; for example, it does not go into how an assessment would actually be made, what evidence and how much time or resource might be needed to make an assessment, the competence required of the assessor, validity and reliability of assessment, and so on.

combination of good information, clear procedures, memory aids, training, clear objectives, avoiding distractions and a good working environment.

2.2.3 Interpretation for the study

The study reported here aligns 'Human Factors' with the first of these interpretations. It is concerned with proactively seeking to reduce equipment, or organisationally-induced human 'errors' and making equipment and the associated work inherently safe, without exposing workers to avoidable hazards, through good engineering and design practice.

The Human Factors maturity of an organisation is therefore defined in terms of what action it takes to minimise the potential for human contribution to incidents and the impact on the health of the workforce through the way it designs and implements equipment and its associated training and procedures.

The scope of Human Factors covers;

- ∆ Design, development and implementation of new or modified equipment and associated training and procedures
- ∆ Consideration of human issues arising from changes to the way equipment is used, the way it is manned or operated, or the context of use.

Safety & Environment or Occupational Health ?

O'Donnell (reference 26) pointed out that during the early 1990s, there was a major drive in the UK to improve safety in the offshore industry, including recognition of the need to improve safety through design. He expressed concern that similar emphasis had not been placed on seeking to improve occupational health through design.

The Human Factors Assessment Model is intended to cover best practice associated with both the potential for human contribution to accidents and environmental damage, and the impact of equipment and operations on the health and safety of the people who work with equipment.

A2.3 Requirements

Development of the HFAM has sought to satisfy a number of requirements. Some of these were clear at the start of the project, though a number emerged or have been revised on the basis of feedback and comment during the study. The ten principal requirements the model has sought to satisfy are listed below;

1. **Business relevance:** clear relevance to the nature of the business carried out by the organisation being assessed.
2. **Assessable:** it should be possible to produce evidence reflecting compliance with the element which can be interpreted and understood by an assessor with some awareness, though little direct experience of Human Factors
3. **Reasonable and Practical:** the model should only assess activities that it would be reasonable and practical to expect an organisation to carry out. The level of investment, expertise or sacrifice required should not be disproportionate to the risks in the operation.
4. **Understandable:** elements should be expressed simply and be free from technical jargon. They should be able to be understood without specialist knowledge or experience either in Human Factors, or in Capability Maturity Models.

5. **Easy to apply:** it must be possible to carry out an assessment relatively quickly, using few resources, and using information which can be expected to be readily at hand in most organisations. A maximum of 1 hour to complete an assessment was considered acceptable by most of the stakeholders involved in the study.

6. **Informative and diagnostic:** the model must be informative and have some diagnostic capability. It is not sufficient simply to conclude that an organisation is or is not adopting good practice. The assessment needs to make clear what activities would constitute good practice, and, if an organisation scores badly, what action they could take to improve the assessment.

7. **Reliable:** different assessors, given the same information, would be expected to make more or less the same assessment of an organisation.

8. **Focus**: the model should focus on areas which are specific to human issues. The model should avoid elements which can be answered in terms of generalities about how an organisation goes about its business. For example, the validation exercises demonstrated little value in assessing whether Human Factors processes, if they existed, would be regularly reviewed, as this tended to evoke general responses that all business processes are kept under review as part of company quality systems.

9. **Traceability:** elements assessed should be traceable to credible sources, particularly legislation, standards and other guidance.

10. **Grounded in Good Practice:** the model should be grounded in good practice, as well indicating what would constitute best practice. Some organisations, particularly the operating companies, are keen to be seen to be setting and meeting best practice in all areas of their business. It is not however reasonable to expect all companies involved in the offshore industry to aspire to best practice in all disciplines. Establishing good practice is therefore often more credible.

3. The Human Factors Assessment Model

This section presents the Human Factors Assessment Model (HFAM). Some background material however needs to be presented first to explain the rationale behind the selection of the elements used in the model. The first two sub-sections therefore explain;

- ∆ how the elements of 'good practice' in Human Factors were arrived at, and
- ∆ the basis for deciding what it is reasonable and practical to expect design projects to do.

The model itself, including a description of how it should be applied and interpreted, is presented in the third sub-section. Annex B contains a questionnaire and procedure which can be used to carry out assessments.

A3.1 What is 'good practice'

A general reaction from many of those who took part in the industry validations (see Annex A), was that the offshore industry probably already complies with what would be considered Human Factors 'good practice', though it doesn’t necessarily refer to it as Human Factors.

At the suggestion of one of the operating companies, a series of gap analyses were therefore carried out to establish what companies involved in design in the offshore industry expect their projects to do, and how this compares with what would be considered good practice in Human Factors. Results of these gap analyses are reported in section 4.

To be in a position to asses this gap, a model of what it would be reasonable and practical to expect was clearly required. A statement of good practice, starting with the elements included in the provisional Human Factors Capability Maturity Model (reference 1) was therefore developed. This drew on a wide range of published material, as well as the experience available in Nickleby's team and other specialists consulted in the course of the study.

There are many - indeed, a growing number - of Human Factors standards, although there are as yet none specifically tailored to the UK offshore industry. The closest are possibly two US Marine engineering standards for Human Factors which have been adopted by a number of US oil companies (references 5, 6 and 7). Two standards implemented in the Norwegian sector of the North Sea (references 8 and 9) are also directly relevant. A number of International Standards have relevance, particularly for control rooms and the design of software intensive systems (references 10, 11 and 12). The Usability Maturity Model (reference 27) describes an internationally agreed model of best practice in user-centred design for software-intensive systems.

A number of guidance documents published by the HSE and others (references 13, 14, 15, 16 and 17), the American Bureau of Shipping (reference 18), the US Department of Health and Human Services (reference 19) and the International

Association of Oil and Gas Producers (reference 20) are also relevant. There is a large amount of experience in the general published literature, both conferences and refereed journals (for example, references 21, 22 and 23) which capture problems and experience of best practice in the offshore industries. There are also established defence industry standards (such as reference 24). Finally, Nickleby's study team has a great deal of experience applying Human Factors in design projects in a variety of industries.

Following a number of iterations, including feedback from industry and assessment against the ten requirements set out in section 2 of the report, twenty-one elements considered to describe good practice in Human Factors were eventually settled on. The emphasis was on seeking to identify what it would be reasonable and practical to expect offshore projects to do in thinking about the human contribution to health, safety and environmental protection during engineering projects (including during software development projects).

These twenty one elements therefore form the core of the Human Factors Assessment Model.

A3.2 What is reasonably practical ?

To be acceptable and useful in the context of the offshore industry, the HFAM needs not only to provide a framework of good and best practice. Critically, the elements covered by the model need to be ones that it is both reasonable and practical to expect the offshore industry to comply with.

As an obvious example, it would be neither reasonable nor practical to expect organisations to invest in Human Factors if it required significant extra capital expenditure (what the industry refers to as "CAPEX") or if it added significantly to the duration of design projects, without clear reduction in risk or return to the business. Return in this context need not necessarily be directly financial. Apart from the need to comply with legal requirements and avoidance of costs associated with lost production, lost working time and litigation, protecting the company's reputation is a very high priority for many offshore companies.

Similarly, it would not be reasonable to expect organisations to divert large amounts of effort from operational staff onto every design project. The numbers of operational staff needed to support high levels of operational involvement in every design project simply do not exist in the offshore industry.

As with interpretation of health and safety legislation generally, establishing what is reasonable and practical is subjective and can involve widely different judgements.

The principals used by the HSE in assessing whether duty holders have reduced risk to ALARP are reasonably straightforward in concept (though clearly significantly more difficult to execute). These principles are set out in reference 25. Essentially, the decision is based on a judgement about whether there is a "gross disproportion" between the risk involved and the sacrifice needed (in terms of money - including lost production - time or trouble) to avert the risk. Duty holders are generally considered to have discharged their responsibilities if the risks involved are judged to be insignificant in relation to the sacrifice needed to control them. The phrase "gross disproportion" is clearly subjective, although the bias is expected to be on the side of safety when considering if cost is grossly disproportionate to risk.

In general, the greater level of risk, the greater degree of rigour expected, although duty holders should not be overburdened where the risks involved do not justify it. An important principle is that the risks to be considered can only be those that the duty holder can exercise control over or mitigate.

Reference 25 contains a number of important points which are particularly relevant to considering what is reasonable and practical in the area of Human Factors. For example;

- ∆ while duty holders can only be expected to assess hazards which are a reasonably forseeable cause of harm, they should take account of reasonably foreseeable events and behaviour.
- ∆ risk should be assessed in relation to a hypothetical person. The duty holder may be expected to consider a number of hypothetical persons with different characteristics ("good health", "young persons" , "fatigued", "stressed", "cold").
- ∆ the actual persons exposed should be considered when control measures are determined (such as the age range, or incidence of colour-blindness in the workforce).
- ∆ duty-holders are expected to consider the full picture when assessing risk and not a partial view from considering hazards in isolation, in a slice of time, or location by location rather than across the whole system.
- ∆ universal practice is not necessarily good practice. New technology for example may make a higher standard reasonably practical. The HSE expects duty holders to keep relevant good practice under review.

In some cases, legislation is itself specific about what is required. For example, the supply of machinery regulations (reference 4) make clear that it is the responsibility of the manufacturer of machinery to carry out the necessary research or tests to determine whether by its design or construction a machine is capable of being erected and put into service safely.

The industry adopts financial criteria or models to assist in determining whether the cost involved in mitigating HSE risks are likely to be justified by the potential harm. These are usually expressed in terms of cost per life saved. For example, one company adopts a rough figure that costs of less than £0.6 million per life saved is clearly worthwhile, while costs of more than £6 Million per life saved is unlikely to be worthwhile. Costs between these limits are considered to be probably worthwhile, recognising that the onus is to demonstrate gross disproportion.

A3.3 The Model

3.3.1 Levels

The aim of an HFAM assessment is to determine which of the following five levels of Human Factors capability best describes the organisation or project being assessed;

1. Definitely not following good practice
2. Some elements of Good Practice achieved, but not enough to be confident that it will be applied consistently.
3. Good Practice
4. Good Practice achieved, towards best practice
5. Best Practice

For reasons set out in Annex A, the model has deliberately avoided using the same five levels of maturity descriptors as the various Capability Maturity Models. This emphasises that the HFAM approach does not have the same rigour, depth or conceptual background as the Capability Maturity Models. On the other hand, HFAM has been developed to be useful, accessible, understandable and easy to apply without substantial background knowledge.

3.3.2 Elements

HFAM is based on twenty one elements covering 'good practice' in Human Factors[2]. The activities conducted to develop and validate the model starting with the provisional Human Factors Capability Maturity Model (presented in reference 1) are described in Annex A.

The twenty one elements are defined in table one. In summary, they are as follows.

Elements aligned to HSG(65) element 1.0 Policy;

- Recognition

Elements aligned to HSG(65) element 2.0 Organising;

- Responsibility
- Contractors
- User involvement
- Competence

Elements aligned to HSG(65) element 3.0 Planning and Implementation;

- Risk screening
- Exposure to hazards
- Human Factors Planning
- Understanding the operational context
- Recognition of established work patterns
- Assumptions and Constraints
- Operator characteristics
- Manning and roles
- Operational tasks
- Maintenance tasks
- Training needs

Elements aligned to HSG(65) element 4.0 Measuring performance;

- Human requirements
- Design review
- Operability validation

Elements aligned to HSG(65) element 5.0 Auditing and reviewing performance;

- Learning from experience
- Operational feedback

Each of the elements included in the final model have been assessed for compliance against the ten key requirements for the model set out in section 2. All of the elements in the final model are considered to satisfy all ten requirements.

[2] To the Human Factors practitioner, there are some very obvious omissions from this list. Most notably the absence of activities such as Allocation of Function, and possibly Human Reliability Analysis. These are not included either because they were considered to be specialist activities which it was not "reasonably practical" to expect most projects to conduct, or because they did not meet the ten requirements set out in section 2.

For each element, table one gives examples of the sort of information which might be available to demonstrate that the organisation or projects satisfies that element. These examples are only offered as suggestions. Different organisations and projects will hold different sorts of information, and will call analyses (Task Analysis, Training Needs Analysis, etc) by different names. The onus is on the assessor to determine whether the organisation has demonstrated that they satisfy the element.

Table one also defines the relative priority, in terms of a weighting, associated with each element. These are defined below.

3.3.3 Weightings

Feedback from the validation activities, and in particular comment from HSE staff, made clear that the model needed to recognise that while all of the elements included are important, some are more important than others. The model therefore incorporates a weighting scheme to reflect the relative importance of each element.

The three levels of weighting (1, 2 and 10) are used, as follows;

- ∆ A weighting of 1 means that the element is a basic component of good practice in human factors. These elements will not, of themselves, ensure that Human Factors effort delivers the expected impact, though they each make an important contribution. The following elements have been given a weighting of 1:
  - 2.2 Contractors
  - 3.2 Exposure to Hazards
  - 3.5 Recognition of established work patterns
  - 3.6 Assumptions and constraints
  - 3.7 Operator characteristics
  - 3.8 Manning and roles
  - 3.9 Operational tasks
  - 3.10 Maintenance tasks
  - 3.11 Training needs
  - 4.3 Design review
- ∆ A weighting of 2 means that the element is of more than basic importance but is not in itself sufficient to achieve best practice. The following elements have been given a weighting of 2:
  - 2.1 Clear responsibility
  - 2.4 Competence
  - 3.1 Impact on the human
  - 3.3 Human Factors Planning
  - 3.4 Understanding the operational context
  - 4.1 Human requirements
  - 5.2 Operational feedback
- ∆ A weighting of 10 means that the element is considered disproportionately important, and is a Necessary condition for achieving best practice in Human Factors. If these are not met, it is unlikely that investment to achieve the other elements will achieve the expected impact. The following elements have been given a weighting of 10:
  - 1.1 Recognition
  - 2.3 User Involvement
  - 4.3 Operability Validation
  - 5.1 Lessons Learned

In language, a company which does not, at the management level, recognize the need to consider Human Factors during design; does not adequately involve users representatives; does not test its designs for operability and which does not seek to learn lessons from experience is likely to be wasting its time and money investing in specific activities, such as Task Analysis, in isolation.

3.3.4 Conducting an assessment

The procedure for carrying out an assessment involves the assessor coming to a judgement on whether he or she is satisfied that the organisation satisfies each individual element in the model. For each element, the assessor applies a rating of 1, 2 or 3, as follows;

1. Not satisfied: The assessor is confident, from the information available, that the element **has not** been met.
2. Unsure: The assessor is unsure or has insufficient information to make a definite judgment one way or the other
3. Satisfied: The assessor is confident from the information available that the element **has** been met

Experience during the study indicates that it should often be possible to complete an HFAM assessment within one hour.

Calculating HFAM scores

Producing an overall HFAM score involves calculating a summary score across all 21 elements. Once the assessor has formed a judgment on each element, the individual ratings are combined to produce the overall HFAM score as follows;

- For each element, the assessors rating (1, 2 or 3) is multiplied by the relative weighing of that element (1, 2 or 10). For example, if the assessor was "Satisfied", from the evidence offered, that the "Recognition" element had been met, he would give a rating of 3 for that element. Multiplying that by the relevant weighting of 10 (from table one) gives a weighted score for that element of 30.
- individual weighted scores are then summed across all twenty one elements. This total figure is normalised by dividing it by 192. This number (192) is the total weighted score that would be achieved if the assessor was satisfied that all elements had been achieved (i.e. all elements were rated as 3).

Table one; Summary of the Human Factors Assessment Model (HFAM)

HSG65 Key Element	Human Factors Elements	Examples of possible evidence	Weight
1.0 Policy Effective policies set a clear direction.	**1.1 Recognition** The organisation recognises that design projects need to consider the role of the human in operating or maintaining equipment or facilities or the impact of the equipment on the operators and maintainers.	Explicit in reference to human contribution to safety in company engineering or design policy statements. Human Factors/ Ergonomics or similar recognised as a technical area in projects. Reference in engineering or other company procedures. Evidence from projects.	**10**
2.0 Organising Management structure and arrangements in place. Underpinned by staff involvement and participation Sustained by communication and competence.	**2.1 Clear responsibility** The organisation ensures responsibility for human issues is delegated to managers at an appropriate level and that they have the authority to take effective action whenever there are significant changes to equipment, procedures or working practices.	Explicit mention in Terms of Reference or Job Descriptions Inclusion as competence requirements for project managers, etc. Defined in role responsibilities in procedure manuals	**2**
	2.2 Contractors The organisation ensures that contractors scope of work and working practices also reflect good practice where their scope of supply has an impact on human issues, and that they have the resources to carry out the necessary work.	Requests for evidence of Human Factors competence as an item in tenders, RFQs, etc. Inclusion of human-related requirements in technical contractual documentation Requests for contractors to produce HF programme plans.	**1**
	2.3 User Involvement The organisation ensures involvement of representative members of the operational workforce with relevant current experience, and who will be affected by changes. The organisation does not assume that managers or engineers are representative of all workers.	Indication that operational users attend project meetings and design reviews Names of operational staff allocated to design projects Inclusion of operational users in standard circulation lists Notes from user group meetings, etc.	**10**
	2.4 Competence **T**he organisation provides opportunities for individuals to acquire competence in appropriate professional skills and ensures individuals who have competence in identifying, understanding and accounting for human issues in design are involved in projects.	Inclusion of relevant competency statements for design team members Evidence of design staff attendance at relevant professional meetings training courses, etc. Evidence of use of specialist contractors on design projects.	**2**

HSG65 Key Element	Human Factors Elements	Examples of possible evidence	Weight
3.0 Planning & Implementation A planned and systematic approach. Risk assessment used to decide on priorities. Where possible, risks are eliminated by selection and design. Performance standards are established and used.	**3.1 Risk screening** The organisation establishes early on whether projects may introduce significant change to the role of the human, the work to be performed or how it is to be supported in any important aspect of the operation	Inclusion of relevant human-related elements in, for example, change screening checklists, concept review checklists.	**2**
	3.2 Exposure to hazards The organisation establishes early on whether projects may change the hazards to which operators are exposed or the way in which exposure to existing hazards is controlled.	Inclusion of relevant human-related elements in HAZID/ HAZOP guidewords. Human issues logged in risk register/ hazard log.	**1**
	3.3 Human Factors planning The organisation ensures am organised programme of work is put in place whenever a project introduces or significantly changes the risks associated with the role of the human in the operation.	Inclusion of relevant task(s) on project plans. Existence of a Human Factors/ Ergonomics Management plan.	**2**
	3.4 Understanding the operational context Project teams make an effort to understand the context in which people will work with the change. Includes, for example, where individuals or teams with different contractual responsibilities need to communicate or work together, likely operator workload, fatigue or other factors influencing human performance.	Evidence of site visits to review working context Documentation describing conditions of work, the work environment, sources of pressure/stress/fatigue, communications, etc. Documented scenarios of use, or incident scenarios for design reviews. Evidence that project members or advisors have visited the work site and have first hand experience of the work environment.	**2**

HSG65 Key Element	Human Factors Elements	Examples of possible evidence	Weight
3.0 Planning & Implementation (continued)	**3.5 Recognition of established work patterns** Project teams make an effort to understand established patterns of working, operator expectations or behaviours which may influence what operators assume or expect.	Existence of documentation/ meeting notes/ descriptions/ illustrations capturing existing working practices. Evidence that project members or advisors have visited the work site and have first hand experience of working practices.	**1**
	3.6 Assumptions and Constraints Project teams make explicit their assumptions which constrain or otherwise influence decision making about the role of the human explicit (such as availability of competent personnel, number of personnel, down manning, multi-skilling or expected work patterns).	Inclusion of human issues in project assumptions log Existence of material (memo/ e-mails/ minutes) showing that human-related assumptions and constraints have been raised, discussed and actioned.	**1**
	3.7 Operator characteristics Project teams explicitly consider whether design options are likely to change the skills, characteristics or competencies needed of the operators, the number of operators needed, or the ways they are organised and managed. Where the design cannot reasonably avoid requiring different skills or abilities, project teams ensures those responsible for delivering competent personnel are kept aware and involved.	Project documentation describing anticipated characteristics of user population Material demonstrating contact with sources of information about user characteristics (personnel, training, occupational health, etc). Evidence that the design team has informed those responsible for delivering competent personnel if the design cannot reasonably avoid requiring different skills or abilities.	**1**
	3.8 Manning and roles Project teams explicitly define the expected manpower, the way it is likely to be organised and supervised, allocation of roles and responsibilities and anticipated shift patterns.	Documentation describing expected manning policy Computer models or simulations of manning and workload levels Evidence that the design team has held discussions with relevant departments (operations, personnel) to review anticipated manning arrangements.	**1**
	3.9 Operational tasks Project teams explicitly assess what work the operators are expected to do in conducting or supporting operations. They make an effort to understand the nature of the operator's tasks, particularly any likely to be hazardous, demanding, critical or novel.	Documented operational task descriptions, operational task analysis, etc.	**1**

HSG65 Key Element	Human Factors Elements	Examples of possible evidence	Weight
3.0 Planning & Implementation (continued)	**3.10 Maintenance tasks** Project teams explicitly assess what work the operators are expected to do in maintaining equipment. They make an effort to understand the nature of maintenance tasks, particularly any likely to be hazardous, demanding, critical or novel.	Documented maintenance task descriptions, maintenance task analysis, etc.	**1**
	3.1 1 Training needs Project teams explicitly identify and investigate the impact of design solutions on training needs and competency development and ensures those responsible for delivering competent personnel are kept informed.	Documented Training Needs Analysis Meeting minutes/ memos, etc discussing potential changes in training arising from design solutions.	**1**
4.0 Measuring Performance Performance is measured against standards to reveal where improvement is needed.	**4.1 Human requirements** Project teams ensure human-related requirements necessary to support safe and effective working are captured and documented and are used to evaluate the acceptability of proposed solutions.	Human related requirements and objectives documented in requirements or design specifications.	**2**
	4.2 Human Factors design review Project teams explicitly review the design to ensure it meets human requirements, important areas of human concern are adequately resolved and that affordances[3] offered by a design will not encourage risky behaviours.	Notes/ minutes demonstrating that designs are reviewed to ensure they meet human requirements and that mportant areas of human concern are adequately resolved Evidence of actions raised and completed to resolve concern over human factors aspects of designs.	**1**
	4.3 Operability validation Project teams carry out suitable activities to test the design to validate operations or maintenance tasks where the human has a potentially critical role or which may expose the operators to hazards or stress.	Existence of operability test plans Notes/ results of trials or other operability validation activities Computer models simulating human behaviour or performance.	**10**

[3] The concept of 'Affordances' is explained in section 5.16.

HSG65 Key Element	Human Factors Elements	Examples of possible evidence	Weight
5.0 Auditing and Reviewing Performance Organisation learns from all relevant experience and applies the lessons. Systematic review and Assessment by internal comparison with KPIs and external reference to best practice.	**5.1 Learning from experience** Project teams actively seek to find out whether there are lessons from comparable equipment or existing operations which should be taken account of in the design.	Notes/ meeting minutes of review of comparable equipment. Inclusion of items in hazards/ risks with reference to experience from other equipment or operations.	**10**
	5.2 Operational feedback The organisations actively monitors operator experience during training and initial use of the equipment, and makes changes and improvements to overcome operability problems as appropriate.	Minutes of meetings held to review experience after equipment becomes operational Correspondence from operational staff concerning experience with the in-service equipment.	**2**

Interpreting the scores

Conceptually, interpreting the HFAM score is relatively straightforward: the closer the score is to 100%, the better the assessment.

However, the aim of the method is not simply to produce a score. Rather, it is to allow projects and organisations to benchmark themselves against what might be considered good and best practice. Table two therefore provides a means of interpreting different ranges of HFAM scores, in terms of the five levels of Human Factors capability defined above.

Table two: Interpretation of HFAM scores

Level	HFAM score	Description
5	91% or more	Best Practice
4	76 - 90%	Good Practice achieved, towards best practice
3	66 - 75%	Good Practice
2	46 - 65%	Some elements of Good Practice achieved, but not enough to be confident that it will be applied consistently.
1	45% or less	Definitely not following good practice

An important challenge has been to ensure that the assignment of scores to levels of capability is credible, meaningful and useful in terms of the conclusions drawn about the capability of the organisation being assessed. This needs to reflect the fact that over the twenty one elements assessed, organisations will inevitably be better at some than others.

Assessment of how to assign HFAM scores to capability levels was carried out empirically. A set of forty four possible combinations of scores was developed. Experienced Human Factors professionals made judgements on the level of capability reflected by each combination. For example, it was considered not to be possible to be rated as "Best Practice" if the assessor was definitely not satisfied on any one of the four top weighted elements, even if all of the other elements are fully satisfied. This combination produces an HFAM score of 90% which, from table 2, gives a capability of Level 4.

The assignments in table two therefore provide a basis for interpreting HFAM scores which is considered to provide a reasonable alignment with experienced judgement about the Human Factors capability reflected by different possible combinations of HFAM scores.

4. The gap with current practice

A general reaction from many of those who took part in the industry validations (see Annex A), was that the offshore industry probably already complies with what would be considered good practice in Human Factors, though it doesn’t necessarily refer to it as Human Factors effort.

A series of 'gap analyses' were therefore carried out with the support of four companies who took part in the industry validations (reported in annex A). The aim was to try to identify what activities each of these companies expected their engineering projects to carry out to take account of the human contribution to Safety, Health and Environmental protection during the development of new or modified equipment or operations.

The approach taken was a pragmatic one: it was concerned with what work was expected to identify and control human issues, not whether the label 'Human Factors' or similar labels were used.

A4.1 Scope

The gap analyses were based on what relevant information could be gathered for each of the companies during a single visit to the company offices. During these visits Nickleby's researcher was provided free access to the company intranet.

In all cases, the intranet sites provided access to very large amounts of company information. Nickleby's researcher was free to carry out searches, identifying and exploring a large amount of material and following links and cross references as appropriate.

Those documents and other information sources (such as process diagrams) identified during the site visits as being particularly relevant to the purpose of the analysis were reviewed in detail.

There was no opportunity to audit or investigate what actually happens in practice on typical projects. Each of the companies involved has been provided with a document summarising the information gathered concerning their processes. In all but one of the cases, a meeting was held to discuss the results.

In each case, the analysis was constrained to the engineering and safety management processes. Other areas - in particular Human Resources - are likely to have relevant procedures to do with recruitment, training and competencies although there was no opportunity to review material from these areas.

The section therefore presents an impression of the industry based on 'snapshots' of information. The results and conclusions are clearly not definitive. The intention was to try to assess the claim that the offshore industry already puts sufficient effort into seeking to mange human issues in design, whether or not it is referred to as 'Human Factors'.

A4.2 Results

The results of the gap analysis are organised into three parts;

- ∆ A brief summary of each company
- ∆ Discussion of issues which were common across the four companies
- ∆ Results of a retrospective application of the HFAM to the four companies.

Because of the limitations of the review, it was considered to be unfair to the companies who took part to identify them. The companies are therefore referred to as Company A, B, C and D respectively.

4.2.1 General overview of the companies

In all four cases, and in compliance with good Health and Safety management practice, the company Health and Safety policy makes clear that wherever possible, hazards are to be eliminated through the design of facilities, equipment and processes, or mitigated by the use of physical control measures. Where this is not possible, risk is expected to be minimised through systems of work and the use of personal protective equipment.

Nearly all of the information included in the detailed review had issue dates within the past 3 years.

Company A

The review of Company A was based on a detailed review of six documents accessed from the company's Management System. Clarification of some of the material was possible through brief discussions with one of the company's safety managers. The review was also informed by consideration of activity on a current major project.

At the organisational level, Company A is clearly aware of the need to take account of human issues during design and development. There was however, little indication in any of the material reviewed that engineering projects are encouraged by company procedures to consider human issues formally during design.

There was evidence that projects take more account of human issues informally as a result of operational input than was suggested by the documented procedures. For example, although there was no specific requirement in the engineering procedures, one of the company's current major projects had a high level policy on Human Factors and was actively conducting relevant studies.

The company was clearly aware of the role of Human Factors in Safety, and of the HSE's concerns about it. This was particularly reflected in guidance on preparing safety cases. In one area, this guidance states that *"Developing cost-effective measures and ALARP can be difficult as human factors can figure largely in the risk and the methods of assessing those risks are fairly simplistic".* In another; *"Human Factors is an area which is not well developed in terms of understanding its impact on major hazards. ALARP demonstration therefore poses a challenge in terms of gaining assurance that human factors have been addressed in the design and ongoing operation".*

These quotes reflect a lack of mature understanding of Human Factors as an engineering discipline at the organisational level. Understanding the impact of Human

Factors on major hazards is well developed and the principal causes underlying incidents are reasonably well understood.

In summary, the importance of human issues is recognised by Company A at least in preparation of safety cases. Although there was a lack of evidence of a mature understanding of Human Factors as an engineering discipline at the organisational level, there was clearly awareness and concern at the working project level.

Applying HFAM, Company A achieved a score of 64% (see table three). This represents a Level 2 capability. While there were elements of good practice in Human Factors, there was not sufficient to be confident that it would be followed consistently across the company's design projects.

Company B

The review of Company B was based on a detailed review of eleven documents accessed from the company's Management System. This was followed up by a meeting with relevant managers at which the conclusions reached were reviewed.

At the organisational level, Company B has a reasonably mature awareness of the need to take account of human issues during design and development. The company is part of a group that maintains a team of Human Factors specialists. There is also a reasonable history of conducting Human Factors studies.

There were references throughout a variety of process documents to activities that would be recognised as elements of Human Factors 'best practice'. For example, guidance on conducting Safety and Operability Studies includes; *"Consideration of probable tasks to be undertaken during normal and upset conditions",* and *"The usability of equipment and clarity of instructions are reviewed with the aim of reducing the potential for human error to ALARP".*

The Safety Management procedures include a requirement for Ergonomic Design Reviews, whose aim is "..to review new projects at various milestones during design and construction process to ensure the design meets sound ergonomic principles and that the installation will be as operable and human friendly as possible".

The company's Quantified Risk Assessment (QRA) process presents an informed and commercially mature view of the value and cost-effectiveness of attempting to quantify human reliability. The view was that the cost and complexity involved often does not justify the value of the assessment. It does however recognise that there are occasions where attempting to quantify human reliability is appropriate.

Guidance on design of human machine interfaces in control rooms appears to follow best practice, and calls up appropriate international standards.

Applying HFAM, Company B also achieved a score of 64% (table three) representing a Level 2 capability. As with Company A, while there were clearly elements of good practice in Human Factors, there was not sufficient to be confident that it would be followed consistently across the company's design projects.

Company C

The review of Company C was based on a detailed review of seven documents accessed from the company's Management System. This was followed up by a meeting with relevant managers at which the conclusions reached were reviewed. As with Company A, the review of Company C was also informed by consideration of activity on a current major project.

Although no explicit references to Human Factors or related terms were identified, the evidence available indicates that Company C recognises the human contribution to safety throughout the engineering development process, and aspires to control the resulting risks through design wherever possible. There was little direct evidence of good practice in Human Factors, although there were indications that elements of good practice are expected.

The company's Health, Safety and Environmental Policy is the reference point for business decisions, from selection of resources to design and operation of working systems. This policy has a strong influence on the engineering process, from the initial screening of change, and at every step in the development process. The Safety Management System requires that all reasonably practical steps are taken to identify hazards and risks and that employees are actively involved in safety cases.

The company procedure for managing changes which impact on Health, Safety or the Environment includes specific consideration of human-related issues. Changes can originate from individual Assets, from Engineering or from Management (i.e. changes to manning, roles and responsibilities, abilities, competence). Mixed Discipline reviews are supported by a guidelist for considering effects of changes on personnel.

The company's guidance relating to the design of offshore facilities includes;

- ∆ developing a conceptual design package (including a Process description, equipment list, and control philosophies)
- ∆ details of operations (including draft operations and maintenance philosophy, automation, manning)
- ∆ other (Personnel, facilities, accommodation)

The company recognises that physical and/or mental fatigue increases the risk of loss of safety. Although there is guidance on duties and responsibilities for managing offshore working time, there was no reference to the need to consider fatigue or working time during design. Based on the guidance from the HSE in Safety Notice 4/96, the company notes that Human Factors should be considered in the design of operational procedures. It does not however make any link with issues such as change screening, design, or test and evaluation.

Applying HFAM, Company C achieved a score of 58% (table three), also Level 2. As with Company's A and B, while some elements were in place, there was not sufficient evidence to suggest that the company could be expected to follow good practice in Human Factors across its projects.

Company D

The review of Company D was based on a detailed review of eleven documents accessed from the company's Management System. There has been no opportunity for a follow-up meeting to review results.

The material reviewed indicates that Company D recognises the human contribution to safety throughout the engineering development process, and aspires to control the resulting risks through design wherever possible. The company recognises 'Human Factors' as a specialist technical topic. There was evidence of activities that reflect good practice, although there was no specific framework or process concentrating on 'Human Factors' activities during design.

The company's risk management procedure includes assessing the impact of permanent and temporary changes, including changes to organisation/ workforce and training and reviewing the impact of change on the Safety Case/ Safety Report.

Top level expectations for the design and construction of facilities state that "*The degree of dependence on 'human factors' shall be considered in the design process*". No lower level engineering processes which systematically implement this top level expectation were identified, although the company's HAZOP procedure includes a reference to a "Human Factors Task Analysis". No details of what this meant were identified.

In screening proposed changes (to equipment, operations, manning, etc) the company adopts the principal that any change potentially introduces risk, and that changes should only be authorised where there are clear benefits and safety is either not compromised or is improved. No specific material was identified providing guidance on screening for human factors aspects of changes other than reliance on operator experience. However, the procedure for reviewing modifications involves a site visit to review the problem and scope requirements for further study or engineering work. This process draws on operational experience and is carried out on site, in the context in which the change will be used.

Identification of safety critical elements for new projects or major modifications does not refer to human issues as being potentially safety critical, or to the human having a role as part of safety systems.

The procedure for Hazard Reviews (the first formal safety review of a new design), is supported by an Impact Check sheet which includes human-related items. The review focuses on critical issues, but is expected to identify where there are other areas of concern. An important aim is to decide what further work or study is required. The check sheet include topics such as manning and simultaneous operations, as well as location, working environment, materials handling and slips, trips and falls. The Assessment Check Sheet, used to document follow-up work, refers to the use of "Human Factors Task Analysis" as a method for Hazard and Consequence Analysis.

The Company procedures place a lot of emphasis on learning lessons and sharing experience across the company. For example, it is expected that experience from previous projects, and feedback from current company operations, the group and other operators are to be taken into account throughout design and construction. None of the material reviewed provided any detail of how design projects are expected to locate relevant experience or apply it to their project.

Responsibilities of Projects and Engineering Technical Authorities are clearly defined for many engineering disciplines, such as; Process, Piping/ Mechanical, Corrosion/ Material, Structural/ Civil, Instrument, Electrical, Rotating Equipment, Commissioning. The role of the human as a system component appears to be outside the scope of responsibility of Technical Authorities.

Applying HFAM, Company D achieved a score of 70% (table three), representing a capability at Level 3. The evidence reviewed suggested that the company operated in the range which would be considered Good Practice in Human Factors.

4.2.2 Observations

The following observations were to some extent common across all four of the companies reviewed.

HAZOP Process

All of the company's adopt formal Hazard Identification (HAZID) and Hazard and Operability Studies (HAZOP) processes. Although designed to be carried out when a design is essentially complete, they are increasingly used earlier in the process, so that problems can be addressed during detailed design phase. The processes are generally applied to plant Piping and Instrumentation Diagrams (P&IDs) as well as to Procedures.

In carrying out a HAZOP, the system is divided into small elements and the design intent of each is explained. Checklists of guidewords are then used to identify potential hazards and operability problems that might arise from deviation from that design intent.

The HAZOP process is recognised as having limitations. Further guidance is recognised as being needed on conducting preliminary HAZOP studies early in the design of a new project and the role of HAZOP in the Capital Value Process (CVP).

All of the company's HAZID/HAZOP processes provide some recognition of human-related hazards through the list of guidewords to support the review process. These include a variety of relevant prompt words for human issues. However, the treatment of these issues is generally limited in scope and superficial. More importantly, it is highly unlikely that a reviewer without a lot of experience and competence in the area, with a very good understanding of the operational context from the point of view of the operators, and with adequate supporting information, will be capable of making other than very superficial assessments of these aspects.

There is therefore scope for significant improvement in both the content and process for reviewing designs against human criteria.

The "design intent" potentially provides a powerful opportunity to make a significant improvement in thinking about human issues earlier in design. It could be used to encourage design teams to explain their thinking, and capture assumptions about the role of the operator in the concept. If a design team is expected to be able to explain the intention underlying a design, it should be a relatively small step to ask them to also explain the role of the human. Although it may not have been made explicit, much of this information is likely to be part of the designers thinking already.

Design review checklists

All of the companies used a wide ranging set of checklists intended as 'aide-memoires' for individuals involved at each stage of a project review.

Typically, checklists include a variety of relevant prompt words for human issues (for example, being operable "with ease", "review from ergonomics point of view", "Is there enough space for repair"). However, the treatment of these items tended to be limited in scope and superficial.

One of the companies had produced a 'Human Factors Checklist', intended for use in reviewing equipment once it was operational. The checklist was intended as the basis for discussion at an on-site review at an operational facility and contained 36 review items, covering a large part of the scope of Human Factors.. A brief assessment of this checklist suggested that;

- 30 of the 36 items could reasonably be expected to be addressed during design
- the importance of addressing the issue during design was considered as 'Very High' for 12 of the items, and 'High' for a further 19 items.
- for at least 20 of the items, there was concern that the item could not reasonably be assessed by an on-site review alone.

Task Risk Assessment

The companies all operate a Task Risk Assessment procedure in some form. The process is applied in the workplace on existing operations and tasks, in compliance with the Management of Health and Safety at Work (MHSW) regulations.

There seems no reason in principle why a Task Risk Assessment procedure could not be brought forward as a technique to be used in ALARP assessments during design and development. While some modification is likely to be needed, the basic approach could probably be largely unchanged.

Fatigue and Working Time

The HSEs Safety Notice 4/96 requires operational risk assessments to take into account;

- Δ the nature and demands (physical and mental)of work.
- Δ the working environment
- Δ the work activity
- Δ sleep deprivation

All of these factors can reasonably be taken into account to some extent as part of the HAZOP process during design. In particular, it is reasonable to expect the possible effects of fatigue on operator performance (particularly cognitive performance such as, decision making or maintaining situation awareness) to be considered during design test and evaluation. Assessing effects of sleep deprivation is a highly specialist activity. It seems unlikely that people without detailed knowledge in this area would be able to make other than highly superficial assessments of the effects of sleep deprivation on operator performance (other than, of course, that individuals who are sleep deprived are clearly a higher risk).

Where fatigue is considered a reasonably likely occurrence, there are steps which a project can take to mitigate against them, in the design of individual controls and displays, as well as task and job design.

Test and Evaluation

Test and evaluation is a key element of good practice in Human Factors. Ideally, aspects of a design which depend on or have an impact on the human would be evaluated progressively as a design developed, using whatever instantiation of the design is available at the time. Computer simulation (of anthropometrics, human performance, workload or human error), usability reviews, design walkthroughs and user trials are all routinely applied in other industries. There is a growing tendency in some industries to require formal demonstration of usability and operability as part of contractual acceptance procedures.

It is assumed that similar activities are carried out as part of the design validation process on most offshore projects. At the least, designs are likely to be assessed for basic ergonomic features (the ability to see, reach and operate controls and displays). There was however little direct reference to such validation in the material reviewed.

Lessons Learned

All reportable incidents and accidents occurring on assets are assumed to be investigated. Results are expected to be used to improve awareness, training, and procedures and where necessary to implement engineering controls. Incident reviews in themselves usually have the capability to initiate engineering projects.

The results of safety reviews, as well as general experience and lessons learned from operational equipment and operations is an extremely rich and valuable source of information for reducing and controlling HSE issues in new equipment. Near misses, and the type of frustrations and problems which operators routinely put up with, though knowing they could be improved, can often be even more informative about poor aspects of a design than reported incidents.

Only one of the companies (Company D) required or suggested that design projects should make an explicit effort to seek out lessons learned or feedback from current operations, to seek input from operational staff about known design weaknesses, or to investigate incident reports associated with comparable equipment. There may be an implicit assumption that members of a project team with operational background bring this knowledge with them, though that is unlikely.

From the information available to this review, there appears to be a significant opportunity to improve offshore design process by increasing, and providing suitable support for, the effort to benefit from lessons learned from operational experience and records.

A4.3 Summary and conclusions

The HFAM technique was applied retrospectively to the four companies who were assessed in the Human Factors gap analysis. Table three summaries these HFAM assessments.

Not surprisingly given the relatively close nature of the UK offshore industry, there was very little difference in ratings across the four companies.

From the evidence available, Company D scored slightly better then the other three in terms of making more effort to understand the operational context and established working patterns, and placing more emphasis on projects making an effort to learn lessons from experience. (Note that while this illustrates the ability of the HFAM approach to be diagnostic and informative, the actual assessment is likely to have been biased by the particular information available to the review, and the way in which each company documents its working practices).

The gap analysis, and application of the HFAM to the information located, tended to contradict the view that the industry already does what is reasonable and practical in considering human issues in design. There are clearly some elements of good practice in place, including recognition of the need to consider human issues early in design and in the assessment of hazards. There is also a lot of operational input in design projects, although there were some doubts about the nature and impact of this involvement.

There are, however, many areas where there was little or no evidence of good practice; in particular, lack of validation that human issues have been adequately resolved throughout design, and little explicit effort on behalf of design projects to actively seek lessons from previous incidents or comparable operational equipment. Recurrence of examples of poor design was readily and widely cited as an issue during the study.

The assessment was carried out on some of the major companies operating in the UK industry. They were all global companies who explicitly aspire to best practice in the way they do business. It might be assumed that if these companies are operating at or below the lower level of good practice in Human Factors, other companies in the industry are likely to be at even lower levels.

Finally, the material also suggested that the industry is comfortable with Human Factors (or similar) as an engineering discipline, although there are differences in interpretation (as discussed in section 4.4)

The gap analysis, as well as the industry validations (see annex A), identified a number of assumptions that seem to be implicit in many offshore engineering projects about the contribution of humans in the new equipment or operation. These include;

- Δ that the equipment will be operated by people who have essentially the same characteristics as the existing workforce,
- Δ because of this, members of the design team, (and particularly those who have an operational background or are operational representatives to the project) will be able to reflect operational experience in the design team and to adequately consider the operational impact of design decisions.
- Δ that there will be a sufficient supply of operators possessing the necessary skills, knowledge, experience and aptitudes needed to operate the equipment safely within acceptable shift patterns
- Δ that it will be possible for the existing workforce to acquire any new skills, knowledge or competencies needed
- Δ that the asset will be managed and operated in such a way that safety management is effective, including generating an appropriate safety culture
- Δ that design solutions, working practices and equipment which are already used operationally will be acceptable as components of a new design without introducing new hazards or risks.

Table three: Summary of HFAM Assessment for four companies involved in Human Factors 'Gap Analyses'

HF Element	Sub-element	Weight	Company A Rating	Company A Score	Company B Rating	Company B Score	Company C Rating	Company C Score	Company D Rating	Company D Score
Commitment	Recognition	*10*	3	30	3	30	3	30	3	30
Management	Responsibilities	*2*	1	2	1	2	1	2	1	2
	Contractors	*1*	2	2	2	2	2	2	1	1
Resources	User involvement	*10*	2	20	2	20	2	20	3	30
	Competence	*2*	1	2	1	2	1	2	1	2
Risk screening	Impact on the human	*2*	2	4	2	4	2	4	2	4
	Exposure to hazards	*1*	3	3	3	3	3	3	3	3
Planning	Planning	*2*	2	4	2	4	2	4	2	4
Implementation	Operational context	*2*	2	4	2	4	2	4	3	6
	Recognise established work patterns	*1*	2	2	2	2	2	2	3	3
	Assumptions and constraints	*1*	2	2	2	2	2	2	2	2
	Operator characteristics	*1*	3	3	3	3	1	1	1	1
	Manning and roles	*1*	2	2	2	2	2	2	2	2
	Operational tasks	*1*	2	2	2	2	2	2	2	2
	Maintenance tasks	*1*	2	2	2	2	2	2	2	2
	Training needs	*1*	1	1	1	1	1	1	1	1
HF Objectives	Human requirements	*2*	1	2	1	2	1	2	1	2
Monitoring	Design reviews	*2*	2	4	2	4	2	4	2	4
	Operability validation	*10*	2	20	2	20	1	10	1	10
Organisational learning	Lessons learned	*10*	1	10	1	10	1	10	2	20
	Operational feedback	*2*	1	2	1	2	1	2	2	4
	Total			123		123		111		135
	HFAM Score (=Total/192)%			64		64		58		70

5. Case Studies

One of the original objectives of the study was to produce a series of case studies demonstrating application of the Human Factors Assessment model to current industry projects. This objective provided impossible to meet.

The industry validations (annex A) however suggested that there was a need to prove, possibly through examples, that a problem currently exists which more effort on Human Factors in design can help to resolve. There was a clear need to be able to demonstrate the sorts of situations in which lack of consideration of human issues in design actually leads to operational difficulties or incidents.

This section therefore presents summaries of fifteen reported incidents which reflect lack of consideration of Human Factors in design. All but one of these are incidents which could potentially have been avoided if the elements of good practice in design set out in the HFAM (and other relevant standards and guidance) had been adopted. One incident (incident 3), illustrates a situation where applying Human Factors in design could not have made a difference.

The section also includes examples of two Human Factors issues (Labelling of parts, and the concept of 'Affordances') which were associated with many of the other incidents reviewed, though not summarised here.

A5.1 Sources

The case studies presented in this section were derived from a review of incidents contained in the following sources;

- The HSE OSD's Incident database, Orion, as well as a number of 'Early Day Reports'
- The Safety Alert Database and Information Exchange (SADIE) run by Step Change in safety (available at www.step.steel-sci.org)
- The incident database of one of the offshore Operating Companies.

In the case of the Operating Company, summaries of 331 reportable incidents were reviewed covering the period from 1 April 2001 to 15 April 2002. Of these, 28 incidents (8.5% of the total) were identified as being of interest as examples. Review of the investigations of eleven of these (3% of the total) suggested they could probably have been avoided through better consideration of human issues in design. The potential consequences of these 11 covered lost time injuries, loss of life, lost production and environmental damage.

There is clearly a danger in presenting case studies of this sort of simply being wise after the event. While this is always possible, the incidents presented have tried to indicate how elements of good practice in Human Factors could reduced the likelihood of the incidents occurring.

A5.2 Incident 1: Non-standard materials

Notes from the incident report

A 10.5 tonne lifting frame toppled, injuring two people. The incident occurred because operators had used the wrong size of drillpipe (5.5" instead of the required 4.5"). According to the HSE, the potential was extremely high, including fatalities or severe injury as well as the possibility for a major hydrocarbon release or explosion.

All of the workforce involved, including the manufacturers representative on the rig, believed that 5" pipe was required. This was discussed and agreed prior to starting work. The roughnecks at the rig however wrongly selected 5.5" pipe. Throughout the North Sea, the most common size of drillpipe is 5". 4.5" pipe is seldom used.

Points to note

- ∆ There was nothing unusual about the task or the work environment at the time.
- ∆ The design included non-standard 4.5" pipe, though neither the rig site nor the company's own representatives had been told.
- ∆ The work team intended to use 5" rather than the required 4.5" pipe. They selected 5.5" pipe in error. The job had been done before using 5" pipe without incident.
- ∆ There was no easy means of visually discriminating between 5 and 5.5" pipe; they were physically separated in storage preventing relative visual comparison. Identification marks were covered with numerous layers of paint.
- ∆ Operators noticed nothing unusual while rigging the frame.

What could reasonably have been expected of the design team ?

- ∆ To identify the lifting joint as a potential drop hazard (through HAZID/ HAZOP) and to identify the importance of using the correct dimension pipe.
- ∆ To recognise the role of the operators in selecting the correct pipe
- ∆ To recognise that there was a possibility of operators using the wrong size of pipe (i.e. recognising that because the pipe diameter was unusual, there was a reasonable chance that operators might assume it was 5")
- ∆ To design the fitting such that it would not be possible to connect the wrong diameter pipe, or to clearly indicate the required pipe size on the frame.
- ∆ To design the pipe identification in some way to avoid it being obscured by overpainting.
- ∆ To ensure opertors and maintainers were made aware of the non-standard dimension
- ∆ To ensure knowledge of the correct pipe dimensions was reflected in training material.

Would good practice in Human Factors have helped avoid the incident ?

Yes, provided the HAZID identified the feature as having a potential risk associated with it.

- ∆ A Human Factors design review should have identified that the use of 4.5" pipe would conflict with user expectations.
- ∆ Task analysis would have identified the task as potentially hazardous, and identified the potential for error in selecting the correct pipe.
- ∆ Task or Training Needs analysis would have identified the operators performing the task as needing to know, and probably be reminded, that the pipe was non-standard
- ∆ An operability trial should have identified the problem.

A5.3 Incident 2: Crane wire rope failure

Notes from the incident report

The main hoist wire rope failed on a pedestal type offshore crane resulting in serious injury to a crew member and structural damage to the rig. The failure occurred due to the rope being overwound. The overwind limit switch, designed to prevent the wire rope from overwinding, was out of order. These switches were known to be unreliable.

Two levers control the crane's hoist and slew motions. Operators have difficulty knowing when these controls are in the "neutral" position. Because of this, the hoist is known to be prone to 'creeping'.

The crane had been "parked". The console included a brake release on-off switch. For "practical reasons" (not known) operators tend not to use the brake between routine operations.

Because of the known unreliability of the overwind limit switch, it is recognised that there is a considerable risk "should the crane operator fail to be constantly vigilant". The operator was in the cab, talking to a supervisor nearby.

In the event of the overwind limit switch not functioning, the operator is the only barrier to a serious accident. Over a 12 hour shift, the chance of human error is high.

Points to note

- ∆ The overwind limit switch was known to be unreliable.
- ∆ The driver was distracted by the supervisor.
- ∆ The hoist is known to be prone to creeping due to the poor control ergonomics
- ∆ It is common practice for operators not to use the brake between routine operations.
- ∆ The operator was being distracted by a supervisor.

What could reasonably have been expected of the design team ?

- ∆ To be aware of the operational experience that the overwind limit switch is unreliable.
- ∆ To design the controls so that the crane operator has positive and effective feedback, both visually and by feel, about the state of the crane controls
- ∆ Not to assume that the crane operator will be fully vigilant at all times over a 12 hour shift
- ∆ To provide a suitably designed operator alert before an overwind occurred.
- ∆ To find out what problems crane operators experience with existing crane designs.
- ∆ (Assuming similar designs existed on existing cranes) to be aware of common working practices (for example that operators do not use the brake between routine operations).

Would good practice in Human Factors have helped avoid the incident ?

Yes.

- ∆ A HF review of the design would have identified the poor control ergonomics and unreasonable reliance on operator vigilance.
- ∆ Awareness of the context of use, and established work practices, should have raised doubt over whether use of the brake could be relied on.
- ∆ An operability trial would almost certainly have identified the issues

A5.4 Incident 3: Breach of electrical procedures

Notes from the incident report

A senior authorised electrical person received burns to his face and hands after putting a metal brazing rod into a 440 volt circuit-breaker to override a micro-switch. The rod came into contact with live conductors.

This method of over-riding the micro-switch was custom and practice on the installation.

Points to note

- ∆ Senior authorised electrical person.
- ∆ Clear breach of procedures.
- ∆ Risks must have been obvious.

What could reasonably have been expected of the design team ?

- ∆ Probably very little, although there may have been design solutions which avoided the need to over-ride the micro-switch
- ∆ It would not be reasonable to expect a design team to assume that an experienced electrician would attempt an activity with such clear potential for personal injury.

Would good practice in Human Factors have helped avoid the incident ?

Unlikely.

A5.5 Incident 4: Hand-held remote control unit

Notes from the incident report

During a routine operation using a hand held remote-control unit (RCU), operators laid the RCU down in order to move/adjust hoses. The RCU rolled over, possibly due to cable tension, activating a button which operated the winch.

Points to note

- ∆ The RCU buttons protruded and had no protection from inadvertent operation.
- ∆ Operating the RCU only formed a part of the operators role.

What could reasonably have been expected of the design team ?

- ∆ To be aware that the RCU would be used intermittently and would need to be put down regularly in unpredictable locations
- ∆ Because of this, to recognise the likelihood of it operating inadvertently.

Would 'best practice' in Human Factors have helped avoid the incident ?

Yes.

- ∆ Understanding the context in which the RCU would be used, and the tasks and roles performed, would have identified the need for the operator to put the RCU down regularly
- ∆ A Human Factors design review, user involvement, or operability trial should all have identified the likelihood of the problem.

A5.6 Incident 5: Use of wrong plug types

Notes from the incident report

A gas leak from a wellhead valve manifold occurred because a fusible plug, which was not designed to withstand high pressures, had been fitted instead of a blanking plug. Subsequent review found that blanking plugs had often been used in situations where fusible plugs were required.

Points to note

- ∆ Fusible and blanking plugs were stored together and are easily mistaken
- ∆ Fusible plugs are identified by a spot of paint, colour coded by the failure temperature. The paint is easily scratched off.

What could reasonably have been expected in design of the well head manifold ?

- ∆ To recognise that the blanking plug is a critical feature in avoiding gas release.
- ∆ To recognise the critical role of the human in ensuring the correct type of plug is fitted.
- ∆ To recognise the potential for human error
- ∆ To ensure the importance of using the correct type of plug was reflected in training material and procedures
- ∆ To recommend that different types of plugs are clearly perceptually distinct.
- ∆ To explore the possibility that the fitting could be designed such that it would not be possible to fit the wrong type of plug
- ∆ To discuss with suppliers the possibility of designing plugs to support the design solution
- ∆ To provide prompts and reminders as part of the design of the manifold.

Would good practice in Human Factors have helped avoid the incident ?

Yes, provided the HAZID identified the plug type as being a critical element.

- ∆ An analysis of maintenance tasks should have identified the task as being potentially critical.
- ∆ Understanding of the wider context of use should have recognised the potential for error in selecting or fitting the wrong type of plug
- ∆ Operability trial would have identified the possibility of confusion.

A5.7 Incident 6: Operator distracted by alarms

Notes from the incident report

Drilling a directional hole with mud, the motor stalled and was pulled off the bottom to restart it. While lowering back to bottom, the operator was distracted by a high level alarm. The operator continued to lower the drill drive while checking the alarm. The drill bit bottomed out and approximately 100k Lbs was lowered onto the bit. This caused the drill pipe to bend putting extra force on the top drive alignment cylinder. The cylinder sheared and a 5lb piece of steel fell approximately 60ft.

Points to note

- ∆ The task requires the operator to pay close and continuous attention to the drilling and respond quickly to any indication of problems at the drill

What could reasonably have been expected of the design team ?

- ∆ To recognise that the task required close attention and concentration on the part of the operator
- ∆ To recognise the possibility that the operator could be distracted by alarms
- ∆ To avoid the operators attention being distracted by unnecessary alarms
- ∆ If the alert is so important that the operator must be distracted, investigate ways of preventing simultaneous drilling.

Would good practice in Human Factors have helped avoid the incident ?

Probably

- ∆ Understanding of the operators tasks would have identified the need for close and continuous attention to the drilling task
- ∆ HF design review should have identified the potential for the operator to be distracted by alarms
- ∆ Follow the HSE guidance on alarms (reference 16)

A5.8 Incident 7: Drill hole operations

Notes from the incident report

Well service operations were in progress. The operator was about to run in hole with a gauge cutter, but found that when he moved the control level forward the reel did not spool out. He moved the control level back to neutral and, it is believed, inadvertently moved it through the neutral position into the 'pull out of hole' position. The tool string ran up to the stuffing box and fell down to the deck.

Initial investigation concluded that the operator had made an error manipulating the control lever and also by leaving residual hydraulic pressure in the system, through not having the so-called "double A" valve backed off.

Points to note

- ∆ It appears that the operator did not have an indication from his working position, other than from the physical position of the control lever, of the state of the reel.
- ∆ It is assumed that the operator could not see, or did notice, the direction of movement of the drum containing the tool string.
- ∆ Why the control lever did not spool out initially is not reported.

What could reasonably have been expected of the design team ?

- ∆ Recognise that the operator needs clear feedback on when the tool string is moving, and in which direction
- ∆ Ensure that the control lever provided adequate feedback on its status

Would good practice in Human Factors have helped avoid the incident ?

Yes.

- ∆ Consideration of the operator tasks would have identified the need for clear feedback on the position of the control and on the movement of the drum.
- ∆ Human Factors design review would have ensured the proposed solution was appropriate.
- ∆ Operability trial would have determined whether the feedback provided was adequate

A5.9 Incident 8: Error in operating control panel

Notes from the incident report

An operator noticed what was assumed to be trapped pressure being vented on the drill floor. He made his was to the control panel to function the BOPs to closed position but inadvertently functioned the UMGV to the open position instead. This allowed well pressure to vent up the riser onto the drill floor causing a gas release.

Points to note

- ∆ The operator was responding to an abnormal, potentially dangerous situation
- ∆ The operator is assumed to have been hurrying given the nature of the situation
- ∆ Details of the control panel design are not reported

What could reasonably have been expected in designing the control panel ?

- ∆ Understand the type of task contexts and situations in which the various controls would be operated, including abnormal and emergency situations
- ∆ Recognise the relative importance of the valve open and close controls in emergency situations and the consequence of operating the wrong controls
- ∆ Recognise that operators may need to interact with the control panel while feeling under pressure, distracted and possibly stressed
- ∆ Design the controls, by positioning, feel or physical protection, to minimise the likelihood of mistakenly operating any that have the potential to cause incidents.

Would good practice in Human Factors have helped avoid the incident ?

Probably (details of the control panel not available)

- ∆ Consideration of the operational context, operator tasks and operator characteristics would have identified those controls which the operator needed to access and operate quickly and accurately in abnormal and emergency situations
- ∆ Consideration of operator characteristics would have highlighted the need to operate some of the controls while rushed, stressed or distracted
- ∆ Human Factors review, or operability trial should have raised concern over the possibility of operating the wrong control in an emergency

A5.10 Incident 9: Residual hazards following operations

Notes from the incident A

The accident happened during the re-certification of the PSV. After a routine pre-test of the valve, the test rig was blown-down in preparation for the disassembly of the valve. Because of the design of the valve, gas pressure remains in the dome of the valve. The injured party began to undo the instrument tube fitting which is connected to the valve dome. The tube then blew out of the fitting.

Notes from the incident B

While tripping first stand of drillpipe out of the hole after crew change, the drillpipe had been set in the slips and the connection broken at the rig floor. The injured party attached make-up tong to drillpipe to allow the Top Drive to be spun out . He believed the Top Drive had been completely spun out and went to remove the tong. When the pipe was picked up out of the bottom pipe connection, torque remaining in pipe caused the tong to strike the injured party.

Points to note

- ∆ It is assumed that the tasks were routine.

What could reasonably have been expected of the teams?

- ∆ Be aware of the need for the operator tasks involved
- ∆ Recognise the hazard associated with the tasks arising from residual pressure or torque
- ∆ Either design the items to remove residual pressure/ torque, or
- ∆ Investigate designing the items to prevent the tasks being performed while there is residual pressure/ torque
- ∆ Provide clear indication when there is residual pressure/ torque.

Would good practice in Human Factors have helped avoid the incidents ?

Probably

- ∆ Consideration of operator tasks, combined with HAZOP analysis may have identified the potential hazards associate with the task.
- ∆ Design review should have recognised the importance of the operator knowing whether there was residual pressure/ torque.

A5.11 Incident 10: Electrical pump isolation

Notes from the incident report

Following completion of maintenance on two pumps, one of them was electrically reconnected (A), while the other (B) remained electrically isolated, with its electrical supply cables disconnected. This gave the "available" status to the control room. Control room operator gave a start command to pump A, but it failed to start.

An electrical technician (who did not place the original isolations on) went to the switch room and concluded, from the status of breakers and fuses, that pump A was the unavailable pump. He advised the control room that they had tried to start the wrong pump.

Control room operator then gave a start command to pump B believing it to be the available unit (which it was not). Upon receiving the start command, the cable for B, which was disconnected, was energised, causing significant sparks and a loud crack. Pump technicians were in the immediate vicinity.

Points to note

- ∆ The control room operators initial action to start pump A was correct. Why the pump did not start is not reported.
- ∆ The control room operator could not discriminate between the status of the two pumps.
- ∆ The electrical technician had to work out which pump was isolated, but came to the wrong conclusion (details why are not recorded)

What could reasonably have been expected in the design?

- ∆ Recognise that the control room operators need to be able to discriminate between the two pumps, and provided appropriate displays in the control room.
- ∆ Investigate the possibility of providing clear direct visual indication at the pumps when they are isolated (though this may not be possible).

Would good practice in Human Factors have helped avoid the incident ?

Probably. It may have been possible to avoid the need for a relatively complex process to diagnose which pump was isolated.

- ∆ Understanding of maintenance tasks would have identified tasks associated with isolating and energising pumps as potentially hazardous (this was probably done)
- ∆ Understanding of operator tasks would have identified the need for control room operators to know which pumps were isolated
- ∆ Consideration of the working context and working patterns would have indicated that different technicians might be involved at different times.

A5.12 Incident 13: Exhaust fan lid

Notes from the incident report

With help of a mechanic, the injured party wanted to adjust the lid of the exhaust fan from a 90 degree to a 45 degree setting. The injured party was supporting the weight of the lid so that the mechanic could install the lock pins. At a certain moment, he could no longer support the weight and got his left arm trapped below the lid.

Points to note

- Δ Contributory cause was identified as being Inattention and Inadequate work procedures.
- Δ Deck vent hatches are usually opened with a minimum of two people
- Δ The design allowed for the operators to change the settings of the exhaust fan lid and lock pins were supplied

What could reasonably have been expected of the design team ?

- Δ Recognise that the task required the heavy lid to be supported.
- Δ Provide some means of supporting the lid to allow the task to be performed safely.

Would good practice in Human Factors have helped avoid the incident ?

Yes.

- Δ Consideration of maintenance tasks would have identified that this task required the heavy lid to be supported.
- Δ Consideration of operator characteristics (and manual handling legislation) would have recognised that the lifting the lid manually was potentially hazardous
- Δ A HF design review would have identified the lid as requiring support and considered possible design solutions.

A5.13 Incident 14: Thread tape fitted the wrong way round

Notes from the incident report

A hydraulic leak was detected coming from a 3/4 inch supply fitting to the masthead valve actuator. Two hundered litres of oil had run into the sea. The investigation team found that the 3/4 inch fitting had been assembled wrongly, as the thread tape used had been applied the wrong way round. This made the tape come off the thread and gather in the bottom of the fitting, which in turn did not allow for a good seal.

Points to note

- Δ The incident investigation identified the contributory causes as lack of knowledge, and inadequate maintenance.
- Δ The root cause was considered to be inadequate training and competence
- Δ Thread tape is understood to be in widespread use in many industries.

What could reasonably have been expected of the design team ?

- Δ Realise that avoidance of a leak was critically dependent on a simple operator task, with clear error potential
- Δ Be aware that the thread tape required in the design solution would only be effective if fitted the correct way
- Δ Recognise the potential for human error and assume that at some time, the individual fitting the tape might be tired, distracted or simply make a mistake
- Δ Design-in additional protection to avoid the risk of oil release, or base the design on a different fitting which does not depend on correctly fitted tape
- Δ Provide clear and easily interpreted indications on the valve about the importance of applying the thread the correct way round.

Would good practice in Human Factors have helped avoid the incident ?

Yes.

- Δ Consideration of maintenance tasks would have identified the potential for human error in applying the thread tape
- Δ As thread tape is in widespread use, investigation of operational experience would probably have indicated that operators are well aware that tape is frequently incorrectly fitted.

A5.14 Incident 15: Unsecured electrical isolation

Notes from the incident report

Planned maintenance required both Mechanical and Systems Work permits, and involved electrical isolation of an oil and water heater. A qualified electrician carried out the isolation, before the maintenance work commenced.

The electrician was unsure where the oil and water heater was fed from as this detail was not stipulated on the list, nor could he find it in the schedules. He extended his search and found the correct two suitably labelled on/off control switches for the heaters situated on the compressor control panel within the compressor house. These he duly turned to off.

Having done this, he concluded that, as they were situated on the compressor control panel, which was already isolated, this was where the heater supply originated from. So, unaware that there was a second feed to this panel facilitated by a circuit breaker located elsewhere, he completed the rest of the isolations.

The Systems work leader, who happened to know where the equipment was isolated from, checked the isolation before commencing work. He found the circuit breaker to be in the on position.

Points to note

- ∆ The electrician clearly breached procedures and the scope of the work permit
- ∆ Contributory causes considered to include unfamiliarity and inexperience with the equipment, lack of communication, inattention
- ∆ Investigation concluded that the individual unintentionally went beyond his limits of authority due to the time since training, lack of experience, a moments inattention, and lack of clear confirmation of the limits of his competency. This combined with less than clear information from various sources led to the mistake. Given the circumstances and information to hand on the night, the individual was considered to have carried out the isolation correctly to the best of his knowledge and ability.

What could reasonably have been expected of the design team ?

- ∆ Recognise the task of isolating the heaters as being safety critical for maintenance
- ∆ Provide a clear visual indication on each heater showing whether they are isolated.
- ∆ Provide clear indication on each heater of its source of power and how it should be isolated

Would good practice in Human Factors have helped avoid the incident ?

It would probably have simplified the task, though could not remove reliance on procedures and work permits.

- ∆ Maintenance task analysis should have identified the task involved as being relatively complex
- ∆ Operability review, or task validation would have identified the task as having the potential for confusion and error.

A5.15 Incident 16: Positioning of valves

Notes from the incident report

An operator was operating a valve to modulate the flow for meter tests. Upon opening the valve, the injured party struck his elbow on the projecting pointed section of a steel I-beam used to support the associated pipework/valve.

Points to note

- The investigation suggested that the contributory cause was inattention on the part of the operator.

What could reasonably have been expected of the design team ?

- Review the design to identify whether there are any protruding objects in working areas which are at or near working height

Would good practice in Human Factors have helped avoid the incident ?

Yes.

- Human Factors review would have identified potential for harm
- Operability trial would have demonstrated the problem.

A 5.16 Affordances offered by design

Many of the incidents reviewed were associated with operators using structures in ways which were not intended and are clearly risky. Typically, individuals sustained injury while standing, sitting, leaning or sitting on objects which, while convenient, were not intended for that purpose. For example;

- ∆ A service engineer operating a mud centrifuge system stood on top of small (14" high) pump in order to reach and close a 2" ball valve. He slipped off the pump housing and fell, injuring his wrist.
- ∆ a member of the vessel crew stood on a tugger winch support bracket with his foot protruding slightly from the support flange. As the drum rotated during operation, the securing bolts caught the crew member’s boot, crushing the steel toe cap. The result was the loss of half an inch of the left big toe.

While these were clearly inappropriate and risky behaviours on the part of the individual, behaviour of this sort is highly ingrained and would be exceedingly difficult to change.

More importantly, in many cases, behaviours of this sort can be considered to be actively encouraged by the way things are designed. Psychologists refer to this using the term "affordances".

The concept of "affordances" refers to the relationship between the way things in the world look to an observer, and how the thing could possibly be used. It has been defined as "a visual clue to the function of an object".

The concept initially came out of the area of experimental psychology, though it has since become a powerful concept in the design of man-machine (and particularly human-computer) interfaces. In the words of its originator, the psychologist J.J. Gibson; "If a...surface is nearly horizontal…nearly flat…and sufficiently extended …and if its substance is rigid … then the surface affords support...".

Examples of the sorts of affordances which common items of equipment and machinery offer would include;

- ∆ a reasonably sized horizontal area between knee and waist height is a seat
- ∆ a reasonably sized horizontal area around waist height is a table
- ∆ a small flat horizontal area below knee height is a step
- ∆ a flat horizontal area above shoulder height is a hand hold
- ∆ a gap between two physical objects is a space into which the fingers or hand can be put
- ∆ A thin area protruding vertically is a hand hold.

What could reasonably have been expected of a design team ?

It seems reasonable for design teams to review proposed designs from the point of view of what sort of affordances it might hold for operators, which were not intended, and which could potentially encourage risky behaviour leading to accidents.

A5.17 Incorrect labelling

There were many reported incidents associated with equipment being mislabelled. Four examples are given below. Incident 1 (above) also illustrates the difficulty of correctly identifying and discriminating between variants of equipment when the labelling is inadequate;

- ∆ New wire rope slings were received from a supply boat. On inspection, and before being checked into rigging loft, it was discovered that although certification was correct, the sling ferrules were stamped incorrectly. Eight 1 tonne slings were stamped as 3te SWL.
- ∆ Tanks of de-oiler and deoiler catalyst arrived onboard both labelled "de-oiler". Records of code numbers had to be checked to distinguish between the two.
- ∆ Flammable gas cylinders recently received from supply vessel were manifested as non-flammable gas and the rack was labelled as non flammable gas. The rack was landed in the storage area for non flammable gas.
- ∆ During boat operations, two cargo baskets were being offloaded. One of the lifts received was overweight by approx 1 ton compared to the weight on the manifest. The lift was carried out in exemplary manner, avoiding incident. The manifest producer and work party leader were confident of their ability to produce accurate manifest. During debate at the investigation, Work Party Leader indicated that a combination of workload, changing priorities and additional tasks may well have contributed to or caused the lapse resulting in the error. "There may well be underlying Human Factors that contributed to the error".

Annex A: Development of the model

This annex summarises the activities conducted to validate the Human Factors Capability model. As the main objective of the report has been to present the model and explain its application and support its use, this material, although a large part of the study effort, has been reported in this annex.

Validation of the model was carried out in two stages:

4. A critical review of the original draft model
5. 1st round of walk-through validations with representatives from the offshore industry

Critical review

Table A1 repeats the definitions of the five levels of maturity adopted in the provisional model (reference 1), and table 2 lists the 18 elements proposed in the provisional model and maps these to the key elements in HSG 65 (reference 15)[4].

A critical review of the provisional model was carried out by members of Nickleby's study team. This review began by identifying areas of ambiguity and duplication both across the five levels of maturity within a element and across the eighteen elements.

The review also sought to scope the range of maturity covered to better reflect the realities of the offshore industry. This recognised that Human Factors as an organised discipline is not widely recognised or adopted in the offshore industry. It also recognised that Human Factors needs to be viewed in the context of the many other professional disciplines which contribute to safety engineering. The elements used should be appropriate to this context.

[4] All reference sin this annex are to the reference list contained in the main body to this report.

Table A1: Levels of capability maturity (from reference 1)

Level	Title	Level description
5	Optimised	This level typifies 'best practice' within the industry. There is clear organisational commitment to improving the human contribution to safety that goes beyond minimum HSE expectations. HF processes are well integrated into the way the organisation does business. Monitoring of HF processes forms part of the organisation's normal business practice.
4	Managed	This level typifies 'good practice' within the industry. There is clear organisational commitment to improving the human contribution to safety that goes beyond minimum HSE expectations. HF processes are well integrated into the way the organisation does business, but there may not be sufficient monitoring and feedback across the organisation to ensure the processes are carried out to best effect.
3	Defined	Commitment to HF is sufficient to meet minimum HSE expectations. The organisation does have its own procedures for ensuring effective implementation of HF processes. There are few feedback mechanisms for the improvement of HF processes across the organisation.
2	Repeatable	No established policy or processes but the organisation has a record of carrying out HF activity, and can repeat what it has done before, at least within projects. The organisation does not plan ahead or track what has been done.
1	Initial	Consideration of the human contribution to safety is conducted in an ad hoc, unsystematic way, usually only as a response to specific incidents. In general, these organisations are only beginning to be aware of the need to consider HF.

Table A2: Summary of elements included in the provisional Human Factors Capability model (reference 1).

HSG65 Key element	HF Characteristics
1.0 Policy	1.1 Policy and strategy on human issues
	1.2 HF processes
	1.3 Investment
2.0 Organising	2.1 HF planning
	2.2 Training and competence
	2.3 Integrated teams
	2.4 Application of HF resources
3.0 Planning & Implementation	3.1 Integrated plans
	3.2 HF goals
	3.3 HF issue identification and management
	3.4 Risk assessment
	3.5 HF requirements/objectives
	3.6 Involvement of stakeholders
	3.7 Use of competent staff
	3.8 Impact
4.0 Measuring	4.1 HF targets
	4.2 Test and evaluation
5.0 Auditing and Reviewing	5.1 Organisational learning

The higher levels of the model (see table A1) need to reflect levels of maturity which not only reflect best practice in the Human Factors profession, but which companies and projects could realistically be expected to see as relevant to their business, and to strive for. Similarly, the lower levels should reflect levels of activity which are clearly less than could reasonably be expected for a company seeking to adopt good practice.

Review of the draft model from this perspective suggested that the original definitions were probably too aspirational. They set a standard of maturity which was too far removed from current practice in the offshore industry, and which it was unrealistic to expect organisations to meet, or probably even to try to meet. It seemed likely that the great majority of assessments would end up using only the bottom 1 or 2 levels, and that organisations would see little value in investing to achieve higher levels.

While the concept of Capability Maturity models (CMMs) is intuitively appealing, many aspects of the execution are conceptually difficult, and require a high degree of familiarity with the underlying principles. Some of these conceptual difficulties include;

- ∆ appreciating differences between the various levels of maturity
- ∆ gathering objective evidence needed to make an assessment, as well as coming to an overall view of the organisation
- ∆ the degree of knowledge and experience needed in an assessor to be able to make a valid judgement
- ∆ concern that the time and resources needed to make a fair and valid assessment is out of proportion to the value of the assessment

The critical review also identified problems with the scaling procedure and how assessments on individual elements could be combined to form a single assessment. Finally, the review identified issues to do with the extent of knowledge and competence likely to be needed of an assessor to be able to make fair and valid decisions.

Based on this critical review, the model was re-organised and simplified, removing scope for ambiguity, and wherever possible minimising the need for specialist knowledge or experience to be able to make an assessment. It also sought to focus on elements which seemed to be of clear relevance to the offshore industry. The revised model was reduced to 10 elements from the original 18.

Guidance was produced indicating the sort of information an organisation being assessed might be able to produce as 'evidence' of its maturity on each element. At the same time, examples were produced, based on the Planning element (item 3) to provide a basis for assessing the type and level of material which could potentially be used to support the model.

Industry walk-throughs

Following revision and simplification of the model based on the critical review, a series of meetings were held with representatives from companies involved in the offshore industry. The purpose of these meetings was to seek to validate the revised model in terms of its relevance, accessibility, practicality and potential usefulness.

Efforts were made to carry out validation meetings with organisations representing a variety of roles across the industry (duty holders, design houses, equipment suppliers, contractors and consultants, etc). Eight organisations took part in the validation meetings, comprising four operating companies, a major drilling project, a contractor organisation, a drilling company and a safety consultancy. A further three organisations expressed interest in taking part, but were unavailable at the time.

Meetings took the form of a walk-through assessment. The company representative chose either to base the assessment on a hypothetical project (usually based on a real project), or to respond on behalf of their organisation as a whole. Nickleby's researcher played the role of an assessor.

After making sure that the representative understood each element, the representative suggested the type of evidence that he would expect to be able to produce indicating whether or not they felt they complied with it. The assessor and representative jointly agreed a rating, based on the evidence likely to be offered, of the extent to which assessor would be likely to be satisfied that the project or organisation met the element. Three ratings were used;

1. Satisfied that the project or organisation complied with the element
2. Possibly satisfied, though some doubts or concerns
3. Not satisfied that the project or organisation complied with the element

After the rating had been agreed for each individual element, the representative from the organisations being 'assessed' indicated the extent to which they agreed or disagreed with each of four statements about that element;

- The element is easy to understand
- The element is relevant to the organisations business
- It will be straightforward to get hold of evidence
- It will be easy for an assessor to form a judgment based on the evidence available.

Results

Table A3 summaries the results of the walk through assessments. In all cases, there was an interest in improving their capability in Human Factors. The elements included in the revised model were easily understood and considered relevant.

Table A3: Summary of results of industry validations

Type	Comments
Consultants	All elements understood and relevant. Couldn't produce evidence as it isn't done. Very supportive. Expected strong, though covert, resistance within the industry to any new initiatives, given the back log of changes still to be implemented.
Drilling company	All elements understood and relevant. Believed they would be able to produce evidence in all cases, though nothing with the title 'Human Factors'. Generally supportive of the concept, though didn't see the need for further processes. Believed human issues are well covered by company culture, based on operational involvement throughout design and development, and high standards of engineering excellence. Investment in improving Human Factors capability would need to be driven either by avoiding damage to the company reputation, or avoiding the cost of potential litigation.
Contractor organisation	Most elements understood and considered relevant, though less agreement that there needs to be explicit management responsibility. Equivalent specialities do not have explicit management responsibility. No feedback from operational designs, so difficult to learn from experience. All elements believed to be implicit in existing procedures and work practices. No explicit Human Factors processes: too low a level of technical detail to be made explicit.
Drilling project	Very supportive of the concept, particularly for assessing suppliers. Most elements understood though some clarification needed. All considered relevant. Could produce evidence in all cases, including activity called 'Human Factors'.
Operating company	All elements understood and considered relevant. All elements believed to be implicit in existing procedures and work practices. No explicit Human Factors processes.
Operating company	Very supportive due to recent 'near miss' arising from human causes. All elements understood and considered relevant. Currently little compliance. Major change underway. Expect to eventually be able to demonstrate compliance on all elements.
Operating company	Most elements understood and considered relevant, though less agreement that there needs to be explicit management responsibility. All elements believed to be implicit in existing procedures and work practices. No explicit Human Factors processes: too low a level of technical detail to be made explicit in procedures.
Operating company	All elements understood and considered relevant. All elements believed to be implicit in existing procedures and work practices. Believe the subject is "culturally understood", and that company personnel are aware of the issues. No explicit Human Factors processes: too low a level of technical detail to be made explicit in procedures.

There was almost no claim to use term 'Human Factors' as a technical activity in the design process. Most of the respondents thought that taking account of human issues in design formed a normal part of their engineering practices. There was seen to be little need - and indeed, likely to be strong resistance - to adopting new processes or activities unless there was a very clear and strong case for doing so.

It quickly became clear in most cases that there was little point in attempting to capture or analyse all of the data planned in the walk through assessments.

Key users: Inspectors or Industry ?

While HSE Inspectors are clearly an important user group, it became clear that there was potentially strong interest within the offshore industry itself, and particularly among duty holders, for a quick and simple means of assessing whether they are following 'good practice' in Human Factors. Discussions with HSE Inspectors also indicated that, while a simple assessment method would be useful to them, the most effective approach would be if industry took the initiative.

The interest from industry was in three areas;

4. confirming to themselves that they are adopting good practice and being able to benchmark themselves against 'best practice'
5. being able to demonstrate to the HSE that they were adopting good practice
6. ensuring that their suppliers and design contractors reflected their own good practice

Capability Maturity Models

The validation meetings indicated that there was some, though little, prior knowledge of existing Capability Maturity Models among the target user group for the model (engineering, design and safety managers). Most of the safety professionals involved had some awareness of the Safety Culture Maturity model (reference 3).

Investigations and a large body of research following Piper Alpha made an overwhelimg case that safety was strongly influenced by the perceived and expressed attitudes and behaviours towards safety at all levels of an organisation. It was also clear that major change was needed to improve in these areas. The case for making a major commitment to improve safety culture has therefore been difficult for the industry to ignore. Using an approach such as the Safety Culture Maturity Model to assess performance and measure improvement is reasonable and commensurate with the perceived importance of this area.

In contrast, the business case for organisations needing to make a significant improvement in accounting for human issues during design and development has not yet been either made or accepted. There is as yet no overwhelming commercial, health and safety or environmental imperative. Indeed, the prevailing view in the North Sea oil and gas industry seems to be that most design projects (and there are relatively few of them) already carry out most aspects of Human Factors good practice (see section 4 of the main report for a gap analysis).

Currently, design projects have little justification to do more in considering human issues as part of design. There is little feedback about human-related problems with existing operational systems. Similarly, there is little clear evidence suggesting that lack of consideration of Human Factors in design is leading to safety or environmental incidents or health problems in offshore operations. This is partly due to the relative lack of consideration of human issues in root-cause analysis of incidents. The Human

Factors Investigation Technique (HFIT) also being developed for the HSE OSD should help to capture relevant information.

Unless this link can be made, Human Factors as an organised approach to design will continue to be appear as an academic activity, with little value to the industry. There is very little incentive, other than meeting HSE requirements, for the offshore industry to invest in developing or improving their Human Factors engineering capability.

The study therefore concluded that a HF CMM is unlikely to be an appropriate tool for the offshore industry at this time. There is however likely to be significant value in providing a simple method which can be used to help both external (inspectors, buyers) as well as internal agencies (safety engineers, project managers, etc) assess where they stand with respect to good and best practice in applying Human Factors in design.

Annex B: HF Assessment questionnaire

The questionnaire contained in this annex can be used to carry out an assessment using the Human Factors Assessment Model. The basis of the approach is for an assessor to make a judgement about whether or not he or she is satisfied that the organisation or project being assessed satisfies each of twenty one questions. Each question represents one element on the Human Factors Assessment model (HFAM).

The Assessor

Before carrying out an assessment, the individual appointed as assessor should review each of the questions, and the procedure described below, to ensure he or she is confident that they understand the questions and the procedure. If the individual does not feel confident in being able to carry out the assessment, either some background training or awareness raising may be required, or another individual should be appointed as assessor.

The Representative

The person representing the organisation or project being assessed should have a sufficiently broad knowledge and awareness to be able to provide answers and locate supporting information. This will include knowing who to ask, or where to look for information.

Assessment Procedure

The suggested procedure to conduct an assessment is as follows;

1. Arrange to meet with one or more representatives from the organization or project to be assessed. Provide them with a copy of the questionnaire in advance so they can prepare any material needed.
2. During the meeting, read each question and ensure it is understood before attempting to answer it.
3. Make a judgement based on whatever information has been offered, on whether you as the assessor are satisfied that the question has been met.
4. Write the number underneath the rating you choose in the space provided for each question.
5. When you have answered all 21 questions, copy the number for each answer into the table on the last page of the questionnaire and complete the three steps to calculate and interpret the HFAM score.

Q1: Recognition

Am I satisfied the organisation expects its employees and contractors to consider the role of the human in operations and maintenance, and to consider the impact of a design on the human, whenever it carries out design or development projects?

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(30)	(20)	(10)

Examples of possible evidence:

- Δ *Explicit in reference to human contribution to safety in company engineering or design policy statements.*
- Δ *Human Factors/ Ergonomics or other relevant title recognised as a technical area within engineering and safety procedures, processes or guidance.*
- Δ *Reference to human issues affecting SHE in project documentation.*
- Δ *Reference in engineering or other company procedures. Evidence from projects.*

Write the score for Q1 here: -------------

Q2: Responsibility

Am I satisfied the organisation ensures responsibility for considering human issues in design projects is delegated to individuals who have the authority to take effective action whenever there are significant changes to equipment, procedures or working practices which affect the human contribution to HSE.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(6)	(4)	(2)

Examples of possible evidence:

- Δ *Explicit mention in Terms of Reference or Job Descriptions*
- Δ *Inclusion as competence requirements for project managers, etc.*
- Δ *Defined in role responsibilities in procedure manuals*

Write the score for Q2 here: -------------

Q3: Contractors

Am I satisfied the organisation ensures contractors scope of work and working practices also reflect good practice where their supply impacts on human issues.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(3)	(2)	(1)

Examples of possible evidence:

- ∆ *Requests for evidence of Human Factors competence as an item in tenders, RFQs, etc.*
- ∆ *Inclusion of human-related requirements in technical contractual documentation*
- ∆ *Requests for contractors to produce HF programme plans.*

Write the score for Q3 here: -------------

Q4: User involvement

Am I satisfied the organisation ensures members of the workforce with relevant current experience, and who are likely to be directly affected by changes are actively consulted and involved in design decisions. (I.e. that the organisation does not assume that managers or professional engineers are representative of all workers).

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(30)	(20)	(10)

Examples of possible evidence:

- ∆ *Indication that operational users attend project meetings and design reviews*
- ∆ *Names of operational staff allocated to design projects*
- ∆ *Inclusion of operational users in circulation lists for project material*
- ∆ *Notes from user group meetings, etc.*

Write the score for Q4 here: -------------

Q5: Competence

Am I satisfied that the organisation ensures design projects include individuals who have competence in addressing human issues during design.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(6)	(4)	(2)

Examples of possible evidence:

- ∆ *Inclusion of relevant competency statements for design team members*
- ∆ *Evidence of design staff attendance at relevant professional meetings training courses, etc.*
- ∆ *Evidence of use of specialist contractors on design projects.*

Write the score for Q5 here: -------------

Q6: Risk screening

Am I satisfied that the organisation takes action to find out whether proposals for changes to equipment, staffing or operating procedures may introduce significant change to the role of the human, the work to be performed or how it is to be supported?

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(6)	(4)	(2)

Examples of possible evidence:

- Δ *Inclusion of relevant human-related dimensions in, for example, change screening checklists, concept review checklists.*

Write the score for Q6 here: -------------

Q7: Identifying hazards

Am I satisfied that the organisation takes reasonable steps to establish whether project may change the hazards to which operators are exposed or the way in which exposure to existing hazards is controlled.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(3)	(2)	(1)

Examples of possible evidence:

- Δ *Inclusion of relevant human-related dimensions in HAZID/ HAZOP guidewords.*
- Δ *Risk register/ hazard log.*

Write the score for Q7 here: -------------

Q8: Planning

Am I satisfied that whenever a project introduces or significantly changes the risks associated with the role of the human in the operation, or the risks to which the human may be exposed, the organisation plans an appropriate programme of work during design and development to control the risks involved.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(6)	(4)	(2)

Examples of possible evidence:

- Δ *Inclusion of relevant task(s) on project plans.*
- Δ *Existence of a Human Factors/ Ergonomics Management plan.*

Write the score for Q8 here: -------------

Q9: Understand the operational context

Am I satisfied that project teams make an effort to understand the context in which people will interact with, or be affected by the result of the design project.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(6)	(4)	(2)

Examples of possible evidence:

- Δ *Evidence of site visits to review working context*
- Δ *Documentation describing conditions of work, the work environment, sources of pressure/stress/fatigue, communications, etc.*
- Δ *Documented scenarios of use, or incident scenarios for design reviews.*
- Δ *Evidence that project members or advisors have visited the work site and have first hand experience of the work environment.*

Write the score for Q9 here: -------------

Q10: Recognising established work patterns

Am I satisfied that project teams make an effort to understand established patterns or habits of working with existing equipment or procedures.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(3)	(2)	(1)

Examples of possible evidence:

- Δ *Existence of documentation/ meeting notes/ descriptions/ illustrations capturing existing working practices.*
- Δ *Evidence that project members or advisors have visited the work site and have first hand experience of working practices.*

Write the score for Q10 here: -------------

Q11: Assumptions and Constraints

Am I satisfied that project teams make assumptions which constrain or otherwise influence decision making about the role of the human explicit (such as availability of competent personnel, number of personnel, down manning, multi-skilling or expected work patterns).

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(6)	(4)	(2)

Examples of possible evidence:

- Δ *Inclusion of project issues in project assumptions log*
- Δ *Existence of material (memo/ e-mails/ minutes) showing that human-related assumptions and constraints have been raised and discussed.*

Write the score for Q11 here: -------------

Q12: Operator characteristics

Am I satisfied that project teams explicitly consider whether design options are likely to change the skills, characteristics or competencies needed of the operators, the number of operators needed, or the ways they are organised and managed.

Where the design cannot reasonably avoid requiring different skills or abilities, project teams ensures those responsible for delivering competent personnel are kept aware and involved.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(3)	(2)	(1)

Examples of possible evidence:

- ∆ *Project documentation describing anticipated characteristics of user population*
- ∆ *Material demonstrating contact with sources of information about user characteristics (personnel, training, occupational health, etc).*
- ∆ *Evidence that the design team has informed those responsible for delivering competent personnel if the design cannot reasonably avoid requiring different skills or abilities.*

Write the score for Q12 here: -------------

Q13: Manning and roles

Am I satisfied that project teams think about the expected crew size, the way it will be organised and supervised, roles and responsibilities and anticipated shift patterns.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(3)	(2)	(1)

Examples of possible evidence:

- ∆ *Documentation describing expected manning policy*
- ∆ *Computer models or simulations of manning and workload levels*
- ∆ *Evidence that the design team has held discussions with relevant departments (operations, personnel) to review anticipated manning arrangements.*

Write the score for Q13 here: -------------

Q14: Operational tasks

Am I satisfied that project teams make adequate effort to identify and understand the tasks the operators are expected to do in conducting or supporting operations.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(3)	(2)	(1)

Examples of possible evidence:

- ∆ *Documented operational task descriptions, operational task analysis, etc.*

Write the score for Q14 here: -------------

Q15: Maintenance tasks

Am I satisfied that project teams make adequate effort to identify and understand the tasks the operators are expected to do in conducting or supporting operations.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(3)	(2)	(1)

Examples of possible evidence:

- Δ *Documented maintenance task descriptions, maintenance task analysis, etc.*

Write the score for Q15 here: -------------

Q16: Training needs

Am I satisfied that project teams explicitly identify the impact of design solutions on training and competency development and ensure those responsible for delivering competent personnel are kept informed of potential changes in training demands ?

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(3)	(2)	(1)

Examples of possible evidence:

- Δ *Documented Training Needs Analysis*
- Δ *Meeting minutes/ memos, etc discussing potential changes in training arising from design solutions.*

Write the score for Q16 here: -------------

Q17: Human requirements

Am I satisfied that project teams ensure requirements necessary to ensure operators can carry out their work safely and without risking damage to their health are documented and used to evaluate the acceptability of proposed solutions.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(6)	(4)	(2)

Examples of possible evidence:

- Δ *Human related requirements and objectives documented in requirements or design specifications.*

Write the score for Q17 here: -------------

Q18: Design review

Am I satisfied that designs are reviewed to ensure they are operable, meet the Human-related requirements and are suitable for the working context.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(6)	(4)	(2)

Examples of possible evidence:

- ∆ *Notes/ minutes demonstrating that designs are reviewed to ensure they meet human requirements and that mportant areas of human concern are adequately resolved*
- ∆ *Evidence of actions raised and completed to resolve concern over human factors aspects of designs.*

Write the score for Q18 here: -------------

Q19: Operability validation

Am I satisfied that project teams carry out suitable activities to test designs to validate operations or maintenance tasks where the human has a potentially critical role or which may expose the operators to hazards or stress.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(30)	(20)	(10)

Examples of possible evidence:

- ∆ *Existence of operability test plans*
- ∆ *Notes/ results of trials or other operability validation activities*
- ∆ *Computer models simulating human behaviour or performance.*

Write the score for Q19 here: -------------

Q20: Learning from experience

Am I satisfied that project teams make reasonable effort to find out whether there are lessons from comparable equipment or existing operations which should be taken account of in the design?

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(30)	(20)	(10)

Examples of possible evidence:

- ∆ *Notes/ meeting minutes of review of comparable equipment.*
- ∆ *Inclusion of items in hazards/ risks with reference to experience from other equipment or operations.*

Write the score for Q20 here: -------------

Q21: Operational feedback

Am I satisfied that the organisations actively monitors operator experience during training and initial use of the equipment, and makes changes and improvements to overcome operability problems as appropriate.

	Yes, I am satisfied	Not sure	No, I'm not satisfied
Score	(6)	(4)	(2)

Examples of possible evidence:

- ∆ *Minutes of meetings held to review experience after equipment becomes operational*
- ∆ *Correspondence from operational staff concerning experience with the in-service equipment.*

Write the score for Q21 here: -------------

End of Questionnaire. Now complete steps 1 to 4 over the page.

Assessing the results

Step 1: Copy the scores you wrote down for each of the questions into the table below.

Question	HE Element	Score
Q1:	Recognition	
Q2:	Responsibility	
Q3:	Contractors	
Q4:	User involvement	
Q5:	Competence	
Q6:	Risk screening	
Q7:	Identifying hazards	
Q8:	Planning	
Q9:	Understand the operational context	
Q10:	Recognising established work patterns	
Q11:	Assumptions and Constraints	
Q12:	Operator characteristics	
Q13:	Manning and roles	
Q14:	Operational tasks	
Q15:	Maintenance tasks	
Q16:	Training needs	
Q17:	Human requirements	
Q18:	Design review	
Q19:	Operability validation	
Q20:	Lessons learned	
Q21:	Operational feedback	

Step 2: Add up the total score over all 21 questions ....

Step 3: Divide the total score (from Step 1) by 192 then multiply by 100. ....%
This is the final HFAM score.

Step 4: Interpretation. Use the table below to find out which level of Human Factors Maturity describes the organisation or project you have assessed.

Table two: Interpretation of HFAM scores

Level	HFAM score	Description
5	91% or more	Best Practice
4	76 - 90%	Good Practice achieved, towards best practice
3	66 - 75%	Good Practice
2	46 - 65%	Some elements of Good Practice achieved, but not enough to be confident that it will be applied consistently.
1	45% or less	Definitely not following good practice

Annex C: Key performance Indicators

This annex reports on work performed under Task 2 of the study contract. The purpose of the task was to try to establish what indicators might reflect lack of consideration of human issues during design.

The annex is in two parts.

7. The first part presents the outline of an approach which could potentially be used to try to map investment in Human Factors activity to the potential impact on issues which matter to the business.
8. The second part discusses possible indicators which might reflect the lack of consideration of human issues during design.

The business case

It is clearly important that the Human Factors Assessment model is realistic and reliable and that the conclusions arrived at by applying the model are believable. An assessment using the model may lead to the conclusion that organization x is or is not following good practice in Human Factors. To have real value, that conclusion needs to be reflected in some sort of real-world indicators about that organisation.

If a company is mature, and puts appropriate and well directed effort into consideration of Human Factors this effort should be reflected in some business-relevant indicators. Conversely, if an organisation or project pays little attention to human issues, this should again be traceable to some sort of business-level indicators.

The aims of the task therefore were;

1. To seek to identify a range of practical, and potentially measurable, indicators which could be used to reflect how effective investment in Human Factors activity has been in improving operational safety and delivering other business benefits
2. To investigate the potential content of a persuasive argument (or 'business case') to encourage senior management level decision makers that it is in an organisation's commercial interests to seek to improve on their assessed Human Factors capability.

The approach taken involved the following steps:

1. Identify Key Business Issues
   Seeking to define those business level issues which are of most concern to senior management in the offshore industry. The industry validations of the HFAM (see annex A) sought to identify business level issues likely to be of concern across the offshore industry. There were however commercial issues in gaining access to some of this information.
2. Map Business Issues to HF Impact
   Producing a mapping between the key business issues and those aspects of an operation which effective application of Human Factors can impact.

3. Identify potential HF Indicators
   Where a relationship between a key business issue, and an area of HF impact is identified, investigating potential measures or indicators which might reflect the effectiveness of the contribution of HF effort on that item to the business issue.

4. Estimate Scale of Costs
   For each key business issue, seeking to estimate the potential scale of cost to the organisation if they fail to satisfy the issue. For reasons of commercial sensitivity in the industry, this proved not to be achievable in the context of the current study.

5. Estimate scale of HF Contribution
   For each key business issue, seeking to estimate the potential scale of cost which could be incurred solely as a consequence of lack of adequate consideration of issues within the domain of Human Factors.

Figure C1 illustrates one approach to mapping investment in Human Factors activities to business level drivers. The top of the figure indicates the sort of activities typically included in a Human Factors programme, grouped in three areas where the benefits are most likely to be realised: in more efficient and cost-effective training, and in more productive operations and maintenance, with reduce risk to health, safety and the environment.

The left hand side of the figure indicates a number of possible issues which tend to drive investment. The cells of the matrix can then potentially be used to indicate where investment in Human Factors may have an impact on business level issues.

The mapping shown on figure C1 only identifies a potential relationship between Human Factors activities and business issues. It says nothing about the relative importance of Human issues to business.

Figure C2 attempts to illustrate conceptually how the relative importance of human issues to business level issues might be approached. The left hand side of figure three shows the same business level issues as on figure two. In this case however, the top of the figure attempts to quantify the order of magnitude of risk, expressed in money, which might be associated with that issue. For each business issue there are two sets of 'data'[5], shown as rows along the fgiure. The top set indicates the possible level of financial risk which might be incurred if the business issue was catastrophically not met. The lower set indicates the possible contribution which issues which are influenced by Human Factors activity could make to the overall business risk.

[5] All of the financial 'data' shown on the figure are purely illustrative only. Although attempts were made, it did not prove possible to obtain realistic figures in the course of the study.

		Training				Operations								Maintenance							
		Time	Content	Complexity	Resources	Manning	Speed of human task performance	Reliability of human task performance	Sustainability of human task performance	Quality of human task performance	Resources	Health	Safety	Manning	Speed of human task performance	Reliability of human task performance	Sustainability of human task performance	Quality of human task performance		Health	Safety
Production	Rates																				
	Sustainability																				
	Reliability																				
	Product quality																				
Cost	Manpower																				
	Development																				
	Drilling																				
	Production																				
	De-commissioning																				
HSE	Health																				
	Safety																				
	Environment																				

Figure C1: Illustrative mapping between key business issues and area of HF Impact.

For example, the top line on figure C2, 'Transition', reflects a possible business level issue associated with the relatively new Under Balanced Drilling technology (UBD). The issue is one of being able to successfully make the transition from drilling a new well, to producing oil from that well using the same platform and, potentially, crew[6]. The figure illustrates (using the hypothetical data), that if Transition is not achieved for whatever reason, there could potentially be a loss running into hundreds of millions of pounds.

The lower set of 'data' for Transition suggests that, in this hypothetical example, failing to adequately consider human issues in developing the new technology could potentially lead to a loss in the order of £50 million. A possible scenario might be, for example, if an unexpected incident occurred at a critical stage, and the humans were simply not able to cope with the amount of work required because the manning levels had been under-estimated.

[6] This example is used purely for illustration as it is conceptually relatively straightforward. It is not known whether Transition is in fact a concern for those companies involved inn Underbalanced drilling. Its use as an example is not meant to suggest that it is.

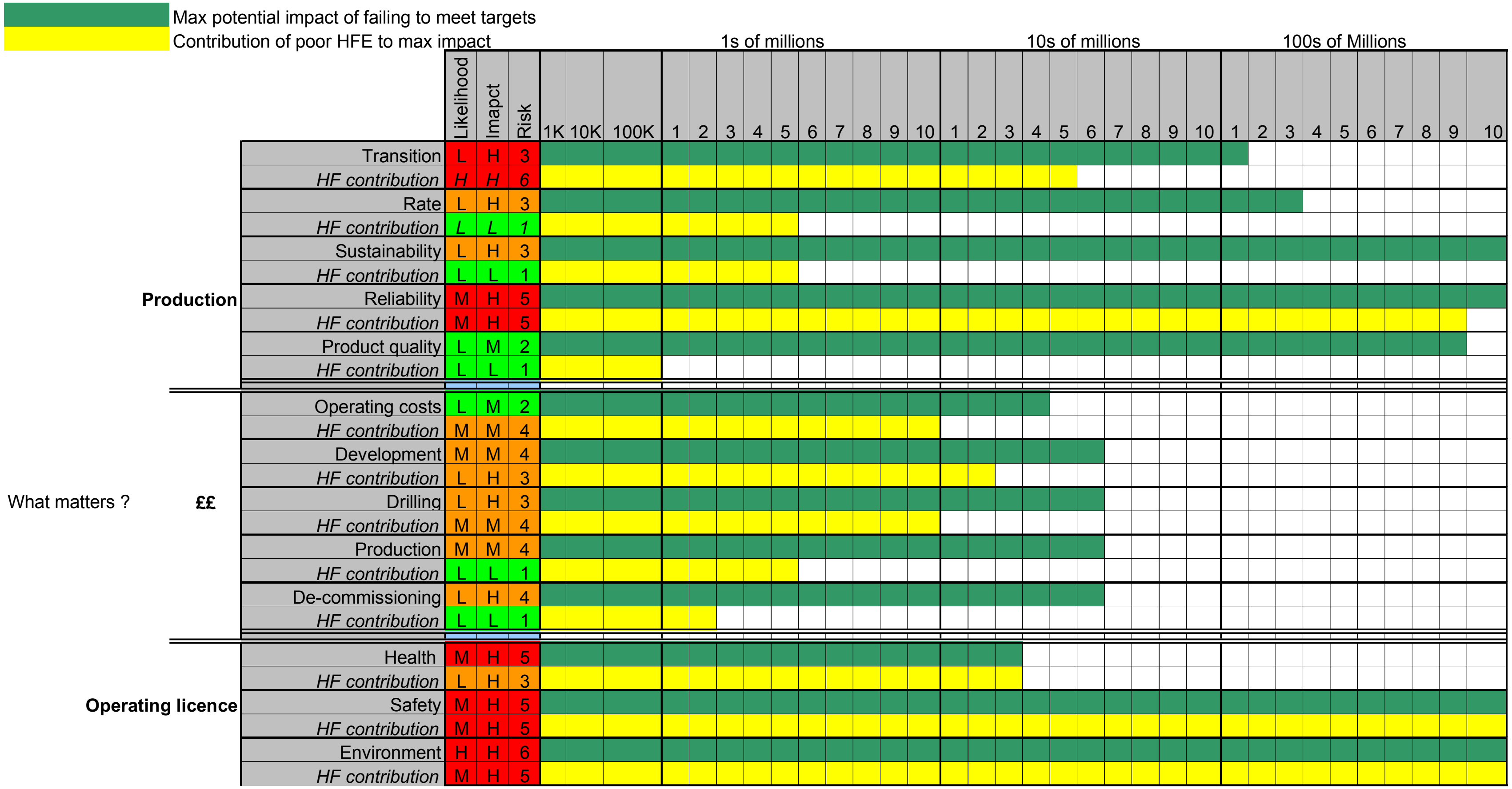

Figure C2: Hypothetical illustration of the potential impact of lack of consideration of Human Factors in Offshore operations.

Human Factors Indicators

This section discusses potential operational indicators which might reflect lack of consideration of human issues in design.

Potential Human Factors Indicators are grouped into three categories:

- Δ Recordable events (Accidents, illness, incidents, near misses, equipment breakdowns, productivity losses)
- Δ Other objective measures
- Δ Subjective measures.

Many of the potential objective and subjective indicators reflect precisely those issues that a well planned and balanced HF programme seeks to tackle. These are typically to do with ensuring human tasks are properly thought out and supported, are integrated into the overall system, are easy to learn and perform, and can be carried out without risk to health and safety. Importantly, they are concerned with ensuring tasks and expected standards of performance, and interaction with equipment and other people, are appropriate for the anticipated user population and in the intended operational context.

A Human Factors programme includes ensuring that humans will be adequately protected if hazardous situations arise. Where the human has a role in managing emergencies and other unplanned situations, Human Factors is concerned with ensuring that the human contribution is properly planned and designed.

Figure C3 shows a 'mind-map' which summarises thinking on possible HF indicators.

Recordable events

Recordable events cover all of those categories of events which are routinely recorded. These include; accidents, illness, near misses, equipment breakdowns, productivity losses. They also include items such as concerns, and issues discussed at safety meetings.

Many, though probably not all, recordable events will have some form of follow-up investigation, particularly where there is a significant effect on production, operating costs, a request for investment, change in training, change in procedures, or other significant change.

Other than in major events, or where there is a very obvious human problem, it is unlikely that these events are fully investigated from an HF perspective. Investigators could potentially consider whether Human Factors (as defined herein) contributed to the event. It is understood that the HFIT project is developing a technique for investigating the HF contribution.

Objective measures

Objective measures are those which are potentially amenable to gathering information without having to resort to asking workers their opinion. While many are not quantitative, they should at least be amenable to being identified and assessed by drawing on independently verifiable facts.

Data in some of these areas may already be routinely gathered, or readily available. In most however this is unlikely: active information gathering exercises would probably need to be initiated, either on a routine basis or as part of one-off inspections.

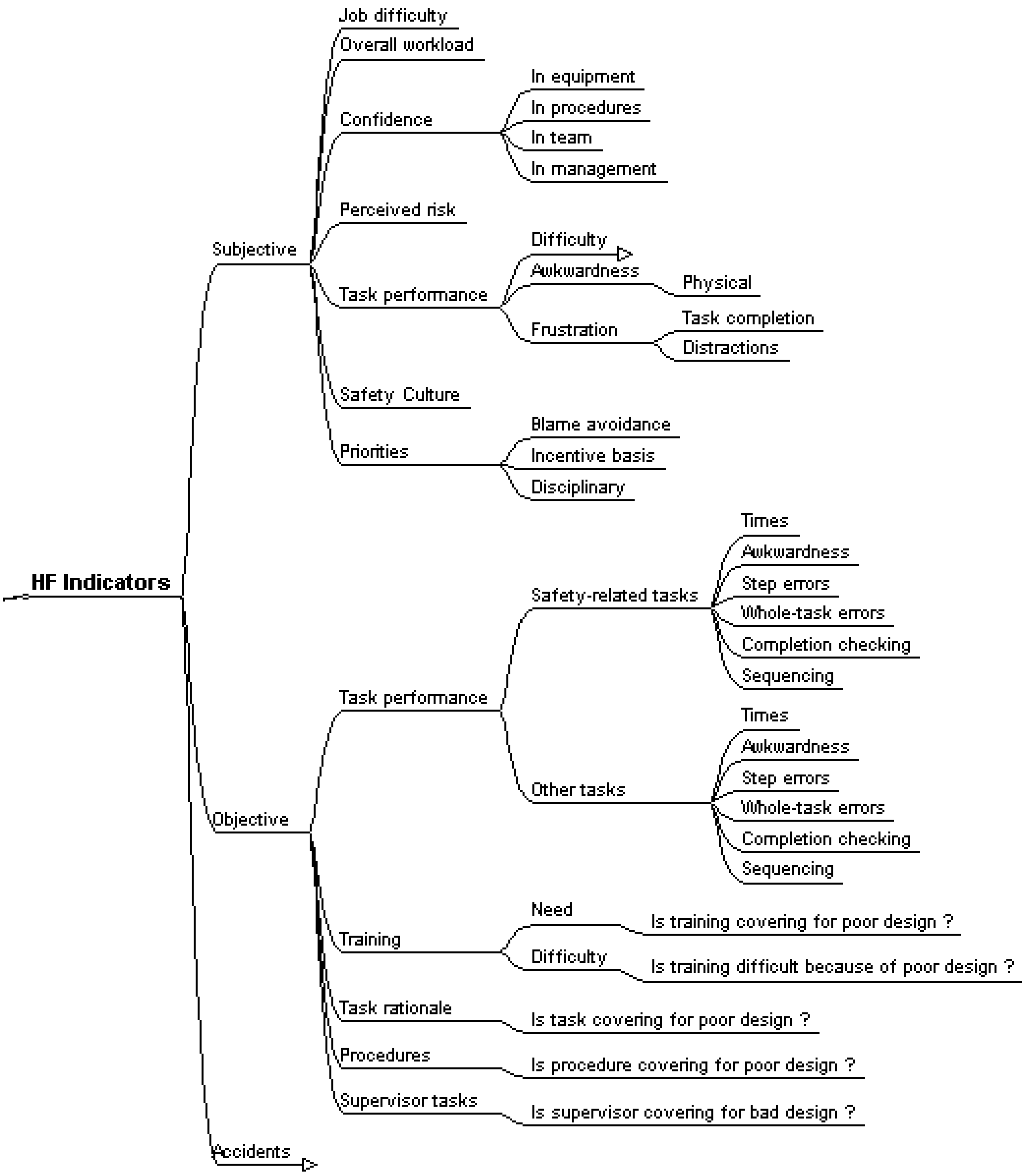

Figure C3: Mind-map summarising scope for possible HF Indicators

Potential objective measures fall into a variety of areas. The following sub-sections outline potential indicators in the following areas:

1. Task work
2. Team work
3. Training
4. Task rationale
5. Rationale for procedures.

Task work

"Task-work" refers to tasks performed by individuals working on their own. While they may be organised as part of a team, task-work refers to those activities which are performed without reference, interaction or dependence on any other team members, at least at the time the work is carried out.

There are a number of objectively observable aspects of task work which would be expected to be directly affected by the quality (or lack) of HF effort during system design. These include:

- ∆ Awareness of hazards and risks associated with the task
- ∆ Time to perform a task
- ∆ Whether the individual needs to adopt awkward postures
- ∆ The frequency with which errors are made in completing steps within the task, and the nature and potential severity of those errors
- ∆ The frequency with which errors are made in completing the whole task, and the nature and potential severity of those errors
- ∆ How the individual knows when the task has been successfully completed
- ∆ Whether the task requires careful sequencing and co-ordination with other tasks.

Potentially, indicators of task-work could be gathered separately for tasks which have an impact on safety, as well as for those which do not have a safety impact.

Team-work

In contrast to task work, "team work" refers to tasks that require co-ordination, sharing of resources, or joint performance from two or more individuals. Team work gives rise to objective indicators which are independent from task-work.

Potential team-work indicators include:

- ∆ Communication failures; failing to communicate, failing to confirm a communication has been received and correctly understood, communicating the wrong information, incorrectly understanding a communication, communicating ineffectively
- ∆ Timing and sequencing; performing tasks at a time, or in a sequence which does not support or interferes with effective team working (e.g. products not being available when co-worker needs them, or being available so early that they interfere with other tasks, or become damaged/ lost while waiting)
- ∆ Awkward postures or space constraints, insufficient or poorly design workspace to allow joint working, or equipment layout which does not allow for comfortable team working
- ∆ Confusion about responsibilities

Training

Very often, a large proportion of the costs of training (as well as procedures) are doing little more than covering up for lack of consideration of human issues in design.

Data about the costs of training, and assessment of training content will often reveal areas where training is being used to cover up for poor design.

Task rationale

Finding out why, in the overall context of a system design, humans are expected to perform the tasks they are can illuminate a great deal about the design of a system. Situations in which humans are allocated a wide range of disconnected, and unrelated tasks, in order to cover for things technology can't do, wasn't thought about, or could not be afforded will often be associated with human risk.

Similarly, highly automated systems, in which the role of the human is simply to supervise and monitor, intervening only on rare - though often critical - occasions are known to be associated with high levels of risk. While this allocation may be entirely rationale and understandable, there should be evidence that attention has been given to supporting the human in the supervisory role.

Rationale for procedures

Procedures are very often developed to cover up for weaknesses in design, or to help control identified risks. In this context, reliance on procedures reflects a failure of design. In the same way as for tasks therefore, exploring the rationale behind procedures can often illuminate lack of consideration of human issues in design.

Apart from the possibility that procedures will not be properly followed, and the costs of developing, maintaining and validating them, and training staff to follow them, procedure based tasks can often be slow and inefficient. Productivity will often be significantly better if equipment and systems are designed from the start to ensure safe operation. And where human error is possible, many systems can be designed to capture and correct (or help the human to correct) errors before they have any effect.

Annex D: Relevance to other industries

As part of Task 5 of the study, discussions were held with a number of individuals involved with Human Factors in the rail and other safety-critical industries. The aim was to try to establish whether the model developed for the offshore industry might potentially have relevance to other industries.

Organisations consulted were;

- Railtrack
- Railway Safety
- The HSEs Hazardous Installations Inspectorate

The response to the model was generally favourable in principle, although with general caution over differences in the management, engineering and safety cultures in different industries.

The rail industry, for example, is going through a period of rapid and major change and investment, including change in engineering and safety management procedures. Significant work is going on to develop Human Factors standards and guidance which is specific to the industry.

The overall reaction therefore was that while the Human Factors Assessment model seems potentially useful to other industries, as yet they are probably not sufficiently mature in their approach to Human Factors generally for the assessments to have much value.

It was hoped to find an opportunity to apply the model to a current rail project, although this ultimately proved not to be possible in the timescale of the study.

The visits indicated the importance of recognising that some aspects of the model are clearly more important than others in ensuring that good intentions are carried through on engineering projects. This has been reflected in the weighting procedure now incorporated in the model.

There was also concern over whether the model should attempt to assess best practice or good practice. There was a feeling that in most cases, achieving good practice would represent a sufficient challenge, and achieving it would represent a major improvement. Based on this, the model has concentrated on defining elements of 'good practice'. 'Best practice' is considered to be achieved when most of the elements of good practice are in place.

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