

## Developing Human Factors Maturity®

Janette Edmonds, BSc(Hons) MSc C.ErgHF FCIEHF CMIOSH, Director/ Principal Consultant Ergonomist,

The Keil Centre Limited, 18 Atholl Crescent, Edinburgh, EH3 8HQ

Organisations within the chemical and process industries have made much progress in understanding and implementing their own human factors programmes. This has been driven, in part, by a greater awareness across these industries, but is also due to greater focus on regulation in this area and investigation of human factors issues during incident investigation. Organisations are not always clear about what are their priorities for human factors or where they should focus their future efforts. The Human Factors Maturity® Model enables assessment of how mature an organisation is in managing human factors but, importantly, identifies where future efforts need to be applied which can be used to inform an organisation's strategy for implementing human factors. The Human Factors Maturity® Model uses a 5-level scale to determine the level of maturity and includes 12 key elements which reflect key human factors issues within high hazard industries. This paper describes the model and the method of assessment, illustrating its use with a case study in the chemical industry.

### Introduction

Investigations into major disasters such as Piper Alpha (1988), Flixborough (1974) and Chernobyl (1986) have revealed that disasters can occur despite engineering and technical safeguards being in place. This is because people have 'failed to do what they were supposed to do'. Unsafe behaviours, where 'people fail to do what they are supposed to do', will continue to occur if the systems, work environments and tasks that people are asked to perform are poorly designed or organised. This is reflected in the UK Health and Safety Executive (HSE)'s recognition of the 'top ten Human and Organisational Factors' that have been linked to major accidents. The 'top ten' does not reflect every topic within the human factors domain, but it does outline components that are of critical importance within high hazard installations.

Many organisations have been working to tackle the topics in the 'top ten' but how do they know that they are making improvements, that they are going in the right direction, or that these are the priorities of most relevance to their organisation?

It seems reasonable to ask these questions and the concept of defining 'maturity' is not a new concept. Indeed, The Software Engineering Institute developed this concept in relation to improving the build quality and maintenance of software (Paull, 1993).

The concept of 'maturity' was used to define an organisation's safety culture in response to the findings of Piper Alpha. At the turn of the century The Keil Centre worked with the HSE to develop a model which became known as the Safety Culture Maturity® Model (Lardner, 2001). The term 'safety culture' was first used after Chernobyl but at that time there was no concept for defining how 'mature' an organisation was. Several models have spawned from research undertaken at that time, but the model has been an important contributor in achieving a step change in safety. The Safety Culture Maturity® Model enables an organisation to measure itself and identify the means to make improvements in their safety culture. Nearly two decades on, the Safety Culture Maturity® Model remains an effective method for improving safety culture in many different industries and countries around the world.

Safety culture is a part of the 'human factors' picture but is not the only area that requires attention. The need to define human factors capability and maturity was recognised by the HSE in relation to the offshore industry (Nickleby, 2002). The Human Factors Maturity® Model described in this paper is intended to be generically applied across the high hazard industry sectors, and its development as an assessment tool was initiated on request from an energy sector client, Duke Energy International, in the USA in 2014.

The concept of maturity has also been used in relation to risk management, as defined in the Risk Management Maturity Model (RM<sup>3</sup>) by the Office of Rail and Road (ORR) and the Health & Safety Laboratory (HSL) in 2017.

### Development of the Human Factors Maturity® Model

The expertise of the human factors team at The Keil Centre was pooled to ensure the tool captured the latest best practice for the key topic areas using a 5-level capability maturity structure. The structure was reflective of the key aspects that are expected to be in place (according to Nickleby, 2002), including a process/ policy; organisation and planning; relevant methods according to the human factors issue(s); measurement of the implementation; and audit/ review.

Human Factors Maturity® became a registered trademark of The Keil Centre Ltd in 2014 and two years later, a paper was published by Duke Energy International and The Keil Centre to describe the development of the tool (Mitchell, Bernard & Villagran, 2016). The general structure and framework of the tool remains the same but has undergone significant refinement since its inception.

### Description of the Human Factors Maturity® Model

A 5-level scale is used to determine an organisation’s level of maturity, as shown in Figure 1.



Figure 1 – The 5 Level Structure of the HFM® Model

At the lowest level of maturity, Level 1, the organisation would typically have an ad-hoc and unplanned approach to human factors with no policies or procedures to define how it is managed. At the transitional level, Level 2, the organisation would have a template for implementing its effort, but this would not be implemented in a planned or systematic way. At the planned level, Level 3, the effort would be more planned and systematic. At the proactive level, Level 4, the effort would involve more engagement at different levels in an organisation, and a system that is proactive and preventative in reducing human factors risks. Lastly, at the leading level, Level 5, the organisation has a planned and systematic programme which is monitored for its impact and is continuously striving to improve.

Within the Human Factors Maturity® Model, there are 12 key human factors elements, each of which are measured on the 5-level maturity scale. A matrix of the 12 key elements within the 5-level scale is shown in Figure 2.

Human Factors Key Elements	
Level of Human Factors Maturity®	Level 5 - Leading
	Level 4 - Proactive
	Level 3 - Planned
	Level 2 - Transitional
	Level 1 - Emerging
Managing Human Failure	
Human Factors in Incident Investigation	
Staffing and Workload	
Design and Development of Procedures	
Training and Competence	
Managing Organisational Change	
Fatigue and Shift work	
Safety-Critical Communications	
Human Factors in Design	
Safety Culture and Behaviour	
Contractor Management	
Managing Performance under Pressure	

Figure 2 – Matrix of the Levels and Elements within HFM®M

This means that it is possible to achieve a good level of Human Factors Maturity® in some elements, whilst being less mature in other elements. The aim is to sustain and improve performance in elements where the maturity is good, whilst improving the weakest elements so that a more uniform level of maturity is achieved.

This is subject to the degree of relevance that an element has to the organisation and its priorities. For example, if there is no shift work or extended hours of work other than normal day time working hours and appropriate rest provision, fatigue management is less likely to be a priority for development. If an organisation does not engage in designing or procuring systems or equipment, then human factors in design is also less likely to be a priority. Similarly, if an organisation does not use contractors, then, again, this is unlikely to be a priority.

The 12 key human factors elements were identified from research and data mining of human factors literature, including the UK HSE's 'top ten'. The Energy Institute uses a similar list of human factors topics. The HSE's 'top ten' was originally based on the HSE's experience of the common themes that have repeatedly been identified during regulatory inspections and through research and consultation with industry. The 'top ten' also present recurring themes for major accidents that have happened in the past. The Health & Safety Laboratory (2012) published a review of major incidents, including Bhopal, Herald of Free Enterprise, Texas City, and Three Mile Island, examining the recurrent themes across these incidents. The review identified some of the human factors themes captured within the HSE's 'top ten' such as 'procedures' and 'safety communications', 'management of change' and 'training and competence' but also highlighted the role of additional factors that are often captured within the topic of 'safety culture', such as 'commitment to safety' and 'complacency'. Additionally, 'learning from previous incidents', was listed as a separate category rather than as a sub-category of 'managing human failure'. The Keil Centre often uses past major accident case studies to illustrate the relevance of the HSE's 'top ten'. Eight such accidents have been reviewed and mapped to the 'top ten' in Table 1.

Major Accident	Human failure (human errors and violations)	Staffing and workload	Procedures	Training / Competence	Managing Organisational Change	Fatigue / shift work	Safety-Critical Communications	Human Factors in Design	Organisational Culture	Maintenance, Inspection and Testing
Oil & gas										
Piper Alpha, 1988			X	X			X		X	X
Buncefield, 2005	X	X	X	X	X	X	X	X	X	X
BP Texas City, 2005	X	X	X	X	X	X	X	X	X	X
Nuclear										
Three Mile Island, 1979	X		X	X				X		
Chernobyl, 1986	X		X	X	X					
Chemicals and plastics										
Flixborough, 1975	X			X						X
Bhopal, 1984	X	X	X	X	X		X		X	X
Formosa, 2005	X		X	X				X		

Table 1 – Review of the 'Top Ten' Human Factors for Eight Major Accidents

The Human Factors Maturity® Model includes twelve key elements which overlap with the HSE's 'top ten'. 'Contractor management' and 'incident investigation' are included in the HSE's 'top ten' as sub-categories under 'staffing' and 'human failure' respectively, but the 'top ten' does not include managing performance under pressure. This was included in the model as it can have a significant influence on human performance.

The 12 elements within the Human Factors Maturity® Model are described as follows:

- **Managing Human Failure (including maintenance error):** This focuses on undertaking structured analysis of the potential for human failure, including both unintentional 'errors' and intentional 'non-compliances'. Potential human failure risks are then controlled to prevent the error in the first place, improve detection and recovery and/ or mitigate it if it does occur.

- **Human Factors in Incident Investigation:** Human failure during an incident or near miss indicates a deeper failure which is linked to work tools, tasks and working environment. This requires thorough investigation as part of the overall investigation process and includes a specific focus on the human behaviours contributing to the event.
- **Staffing and Workload:** Staffing must be optimised to ensure the right people, with the appropriate skills, knowledge and experience, are in the right place at the right time to operate safely. It includes having enough staff, and an even allocation of tasks, as well as the required competence to operate safely.
- **Design and Development of Procedures:** Procedures present the documented agreed safe and correct ways of performing tasks; they include work instructions, method statements and other task-based job-aids. They guard against error and non-compliance if they are well designed and involve end users in their development.
- **Training and Competence:** Effective training and competence development are fundamental for achieving the desired standard of task and safety performance. Training is one means of aiding competence development.
- **Managing Organisational Change:** Organisational change refers to any change to business processes, structures, staffing levels or culture within an organisation. There needs to be a focus on understanding and guarding against human factors risks during the planning and implementation stages.
- **Fatigue and Shift work:** Fatigue is caused by insufficient quality or quantity of sleep, or an excessive time awake. Fatigue can increase the likelihood of error and risk-taking behaviour and therefore the risk of fatigue needs to be understood and managed.
- **Safety-Critical Communications:** This relates to a broad spectrum of within-team and inter-team communications which vary by form and operational scenario. Control of work systems and shift handovers are examples of safety critical communications. The communication systems and methods need to be adequately designed to reduce the risk of error in communication.
- **Human Factors in Design:** The design of work systems and equipment directly influences how people behave and perform at work. Human Factors needs to be integrated with the engineering management system which follows a structured user centred design approach to reduce the potential for human error, accidents and ill-health, and to increase productivity. This is also known as ‘human factors engineering’ and ‘ergonomics’.
- **Safety Culture and Behaviour:** Culture is defined as shared attitudes, beliefs and ways of behaving. Safety culture is concerned with the way people in a given culture think and behave in relation to personal, process, product and third-party safety. There is a need to understand the level of maturity of an organisation’s safety culture and implement strategies to ensure continuous improvement.
- **Contractor Management:** Any organisation using contractors should have sufficient capability to be an ‘intelligent customer’ in contractor management. This means understanding and being knowledgeable about the product or service being supplied, so that contractor performance can be effectively managed.
- **Managing Performance under Pressure:** Chronic and acute stress have the potential to affect safe performance and health/ wellbeing. Effective pressure management relates to implementing a structured programme for prevention, management and treatment of staff.

The framework has been developed to capture a description of what would be expected to be in place at each of the 5 levels, for each of the 12 elements. The human factors tools, techniques and processes relevant to a specific element are outlined. The expected level of human factors knowledge, expertise and resources is also described.

### Implementing the Assessment Tool

A human factors practitioner facilitates the Human Factors Maturity® assessment with a designated focus group of participants from the organisation. The group need to have sufficient knowledge of the organisation’s arrangements in relation to human factors. This includes the policies, practices and processes but also who they are implemented by and the degree of knowledge across the organisation. Sometimes, the organisation’s practices are not labelled as ‘human factors’ but may come under a different title, such as engineering, health and safety or human resources. A focus group typically includes in-house human factors coordinators (if there are any), safety managers, engineering/ project managers, and operational managers. Human Factors Maturity® is about capturing a description of what the organisation has in place.

The facilitator provides a brief introduction to the Human Factors Maturity® Model and the workshop format. The Human Factors Maturity® Model includes cards with the description of each element across the 5 levels. The focus group participants are asked to review the 12 sets of cards in turn together as a group in a card sort activity. The card sets relate to the key elements and there are 5 in each set which represent the level of maturity for that element. For each set of cards, the group discuss and select which of the 5 cards best describes the organisation’s arrangements.

During this part of the assessment, the facilitator’s role is to tease out practices and processes which may not be recognised as being linked to the human factors scope. It also involves prompting discussion about the depth and breadth the

organisation has achieved in relation to the topic areas to determine how comprehensive the organisation's work is for a given element.

The level ratings for each of the 12 elements are presented on a chart and the group's rationale for choosing these ratings is recorded. The level ratings and rationales are used to agree which elements represent the organisation's top 3 priorities for improvement. This is in recognition of the need to concentrate the future effort rather than trying to tackle everything at once, which could dilute the organisation's efforts. The facilitator will also recommend the sequence in which to tackle the elements and key activities that need to be achieved to enable progress. For example, an organisation needs to understand its own vulnerabilities in relation to human failure before determining the priority competencies and procedures that need to be in place. Typically, this is achieved through implementing safety critical task analysis which enables an organisation to identify its safety critical tasks, analyse them and implement risk controls through implementing engineering and human controls, which may include competence management and procedure development. Part of the decision is also about what is relevant to the organisation. If a specific topic area receives a low rating it does not necessarily mean that tackling issues related to that area is a priority.

Once the priorities are defined, an action plan is discussed which enables the organisation to improve its level of Human Factors Maturity®. The action plan is derived from a broad set of recommended actions within the tool which are defined by level of maturity for each element.

### Case Study at a Chemical Processing Site, North America 2018

A Human Factors Maturity® assessment was conducted in 2018 with operational managers and EHS professionals of a chemical processing site in Northern America. The introduction to the assessment included an explanation of each of the human factors elements and the structure of the 5 levels. The participants were then asked to undertake the card sort activity to select the most representative level for each of the 12 key elements. The Human Factors Maturity® levels selected for the 12 key elements are presented in Figure 3. This shows that the elements of greatest Human Factors Maturity® were 'safety culture and behaviour' and 'contractor management'. However, the elements of least Human Factors Maturity® were 'human factors in design' and 'managing organisational change'.

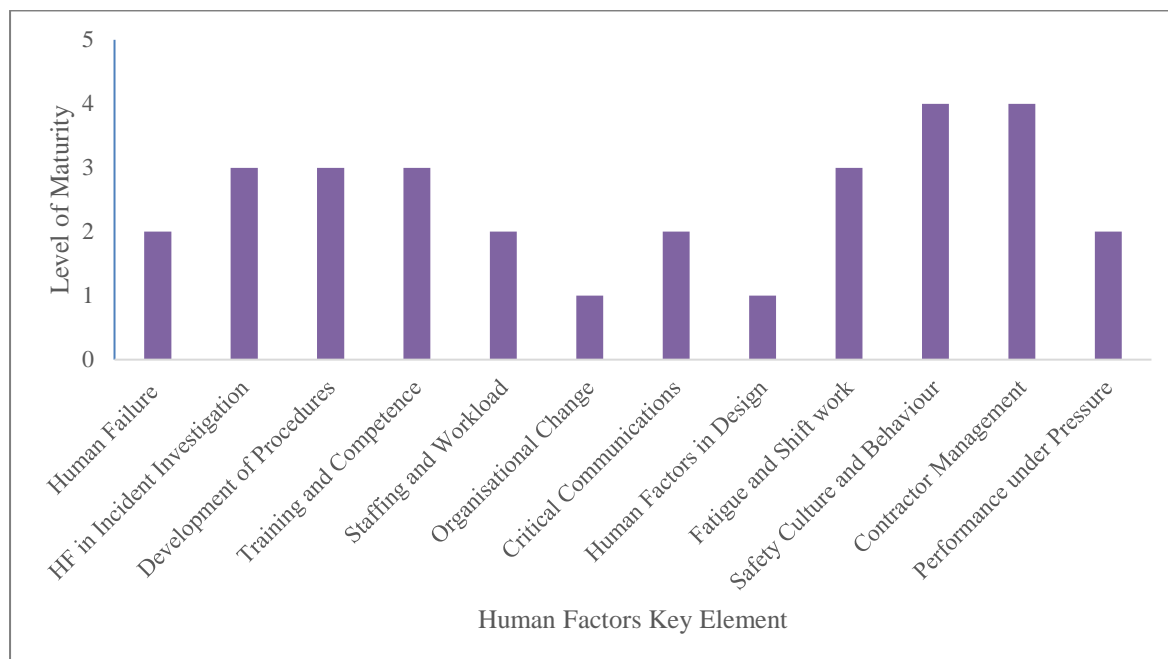


Figure 3 - Selected Levels of Maturity by Element

The rationale behind each of the level ratings was discussed and recorded to ensure that there was a consensus across the focus group participants. As an example of these discussions, the group recorded the following rationale for rating 'managing organisational change' at Level 1:

*'There is some consideration of the impact of change on staff, but there is not a structured approach to managing the transition. There is insufficient appreciation of the ripple effect of change. Where new roles are assigned that is reasonably well managed, but the wider impacts are not fully understood. The consultation with the workforce is insufficient.'*

The elements that were selected for action were:

- managing performance under pressure (Level 2);

- managing organisational change (Level 1);
- staffing and workload (Level 2).

Specific actions were identified and discussed to improve the level of Human Factors Maturity® for each of these elements. The key themes were:

- **formalise a structured approach for implementation, planning and monitoring.** For managing organisational change, this included a risk assessment process specifically related to the management of organisational change (as opposed to the typical technical process for the ‘management of change’) that enables the existing organisational situation (baseline) to be established and understood, as well as the proposed end point and the transition to that end point.
- **implement element-specific assessment tools and identifying triggers for their use.** For ‘staffing and workload’ this included techniques such as timeline analysis, subjective workload assessment (such as the NASA Task Load Index (TLX)) and the HSE’s Staffing Assessment.
- **develop internal capability to use the relevant tools and techniques and improve general awareness.** This included specific training for different occupational groups, for example, for ‘managing pressure’, training for managers for managing pressure, including the tools they can implement, and for the wider staff team training and coaching to develop personal resilience.

## Conclusions

Many organisations understand the importance of human factors for improving health and safety, and some have been working to tackle the range of topics in the HSE’s ‘top ten’. They do not necessarily know whether they are making the right type of improvements, or whether they are going in the right direction.

The Human Factors Maturity® assessment methodology provides an opportunity for organisations to measure their ‘maturity’ in terms of managing human factors. Importantly, the structure enables an organisation to identify their gaps and next steps in support of a human factors strategy.

The lower levels (particularly Level 1) in the 5-level scale are characterised by having an ad-hoc approach to implementing human factors. At the higher levels (Level 3 and above) human factors management is planned, systematic and monitored.

The assessment uses a card-sort activity to enable organisational representatives to determine their level of maturity for each of the 12 key elements. Participants are asked to define the existing practices and arrangements that they believe accurately reflect the level rating they have selected. The group then select the top 3 priorities for action based on their organisational priorities for human factors at that time, which is not necessarily the lowest scoring element. The outline actions captured within the Human Factors Maturity® framework are then used to guide the development of appropriate actions for the three priority elements selected.

One of the key learning points during the development work with Duke Energy International was that the assessment had the indirect benefit of developing awareness and motivation for managers to integrate human factors. The Human Factors Maturity® Model enables an organisation to benchmark their own human factors arrangements and clarify their way forward. The model is intended to support organisations in developing a strategy and management framework which captures what they already do, and to highlight gaps and improvements that need to be addressed.

## References

- Mitchell, J.D., Bernard, M., & Villagran, J.C., 2016, Developing a Model of Human Factors Maturity®, Chemical Engineering Transactions (AIDIC), Volume 48.
- Nickleby HFE, 2002, Framework for Assessing Human Factors Capability, HSE Offshore Technology Report 2002/016, HSE Books.
- ORR & HSL, 2017, Risk Management Maturity Model (RM3), Version 2.0. Crown Copyright.
- Paulk, M.C., Curtis, B., Chrissis, M.B. & Weber, C.V. (1993) Capability Maturity Model, Version 1.1. *IEEE Software* 10 (4) 18-27.
- The Keil Centre, 2001, Safety Culture Maturity Model, HSE Offshore Technology Report 2000/049, HSE Books.