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Integrating human factors training into safety management and risk management: A case study from aviation maintenance

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Abstract

Aviation is facing the challenge of integrating new regulatory requirements on safety management systems with a range of existing processes addressing human factors in line with regulations. This article presents an approach to using mandated human factors continuation training as a tool for risk management within the safety management system. A three-phase blended learning programme was designed to address identified human and organisational hazards within the operation, to enhance knowledge and application of risk management strategies, and to build a stronger safety culture within the operation. The article outlines how the programme is designed to address regulatory, organisational and pedagogical requirements. The 'Wobbly Steps' concept, which is elaborated in this article, is used as a central metaphor for conveying the link between organisational resources and individual risky behaviours or unsafe acts. The training programme is embedded in an evaluation process designed to guide the effective design, development and delivery of the programme as well as assessing the impact of the training on the safety culture and performance of the operation.

Keywords

Human factors, training, risk management, safety culture, Wobbly Steps, unsafe acts, safety management, hazard identification, Safety Management Systems

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Introduction

Aviation has for many years been one of the leading industries in addressing human and organisational factors (HOF) within its different sectors – flight operations, air traffic control, ground operations and maintenance. In particular, aviation has led the way in mandating a range of measures that address HOF issues such as reporting systems and shift-handover procedures.[1] A key element of the regulation has been the mandating of initial and continuation training in HOF for virtually all personnel working in aviation maintenance. By contrast, the development of the practice and regulation of risk and safety management in aviation has lagged behind process, power and nuclear industries.[2,3] International Civil Aviation Organization (ICAO) published its requirements for Safety Management in 2009,[4] and these are still being translated into regulations by local aviation authorities. For example, the European Aviation Safety Agency (EASA) regulations required implementation of Safety Management Systems (SMS) in airlines by 2013. As a consequence of this historical sequence – the development of HOF regulations prior to safety management regulations – organisations are facing the challenge of integrating two programmes with related objectives developed to meet the requirements of different regulations. HOF training in aviation maintenance, in the European context, normally comprises of a 2-day initial training classroom–based workshop supplemented by a 1-day continuation training workshop every 2 years. Continuation training typically comprises a refresher of key HOF concepts and information about company-specific challenges. E-learning and blended

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learning are sometimes used for continuation training, but their acceptance by the local aviation authorities is variable. This article reports an initiative to integrate HOF continuation training within a risk management context in an aviation maintenance company; it extends and updates a previous article.[5]

Organisational context

This article describes an initiative in an aviation maintenance company to employ HOF training as a targeted risk management intervention rather than as simply a regulatory requirement. The company carries out maintenance in a number of different sites globally employing in excess of 3000 people in its maintenance operation. Phase 1 of the training focussed on four of these sites; Phase 2 has seen its extension to additional sites.

Before describing the current initiative, some historical background is required. Initial HOF training was introduced into Phase 1 sites in 2004, and all relevant staff had received initial training by 2006. Continuation training, comprising a workshop similar to the initial training, was provided on a bi-annual basis. In 2009, a fundamental review of the quality systems was initiated. Quality data from a range of databases within the global network – incidents, voluntary reports, customer complaints, etc. – were integrated to comprise a substantial dataset of quality and safety information. Analysis of the root causes in these data identified a number underlying themes related to HOF. These themes represent organisation-level HOF hazards since these related to some of the foundational strategies of the organisation for ensuring its safety and quality. This analysis led to a range of initiatives to address these hazards under a single brand. In 2011, the employees were scheduled to undergo an iteration of HOF continuation training. However, the quality department decided that rather than re-training their staff in generic HOF for maintenance, there was an opportunity to use the HOF training requirement to complement and enhance the quality programme to address their organisational risks. This programme described in this article was designed for this purpose is currently being rolled out.

Evaluation programme

The development of scientific basis of human factors training has been hampered by the lack of investment in the evaluation of human factors training. The industry invests a huge amount in compliance with the regulatory requirements for training without investing in ensuring that training is achieving any significant impact in the organisation.[6,7] At the start of the project, an evaluation methodology was defined with the following objectives:

- To further profile the HOF risks at operational and organisational level;
- To analyse the training needs related to these challenges;
- To generate content for the training;
- To ensure the training was delivered effectively and adjusted efficiently as required;
- To gauge the effectiveness of the training;
- To provide a range of indicators of HOF risks.

The methodology is adapted from Warr et al.[8] Six different types of data were identified – Context, Input, Process, Reaction, Outcome and Performance (see Figure 1). This approach to evaluation ensures that evaluation is an integral part of the programme.

Context information was needed in order to design a programme which would address key organisational objectives and effectively work, given the current situation and previous history of the organisation. Context information included the following:

- Quality/safety data – incidents and quality reports;
- Previous analyses of the quality challenges facing the organisation and the hazards identified;
- The other initiatives under the quality programme;
- Previous HOF training;
- Current HOF, safety and quality processes – reporting, procedures for addressing operational problems, etc.
- The context was also prepared through meetings with different levels of management, unions, quality teams and the aviation authority inspector.

Input data were required to inform and generate relevant training content. This was elicited from interviews, observations and video recordings made at each of the organisation's sites. The input data contributed directly to the content of the training programme.

During the roll-out of the training, the *process* is being closely monitored by the trainers and the company quality team to ensure improvements can be made as required. Trainer and trainee *reactions* are gathered to determine how the training was received. Trainee feedback forms are completed by all trainees, and verbal and written feedback were elicited from the trainers.

Outcome measures provide an indication of the impact of the training in the organisation in terms of perceptions, attitudes and behaviours and ultimately safety performance. There are a number of safety/quality performance indicators used in the company; during the next phase of the project, the impact of the project on these will be assessed. A number of organisational measures are being monitored:

- A maintenance culture survey administered in 2009 was repeated at the start of the training so as not to be contaminated by the messages in the training. The comparison of the 2009 data with the 2011/2012 data provides an indication of how the culture in the organisation is changing. This will be repeated again at the end of the training to reveal

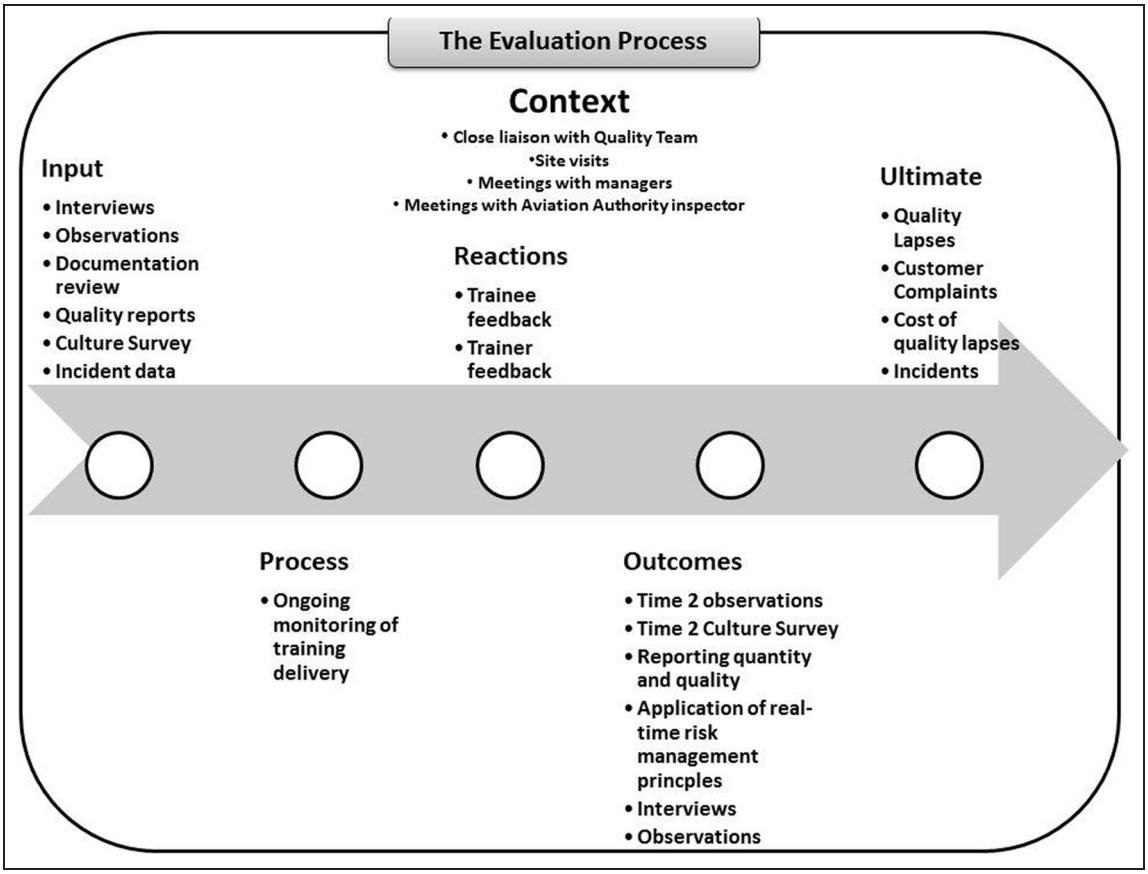

Figure 1. Evaluation process.

any continued cultural changes associated with ongoing training and other improvement initiatives.

- In the initial evaluation visits, a total of 44 tasks were observed across the three sites using a tool called the 'Operational Performance Audit for Maintenance' (OPAM).[9] The OPAM is a tool designed for use in aviation maintenance to gather a holistic view of normal operations. It is not an evaluation of the individual but of the operation - addressing issues such as whether resources are available and whether they are used effectively.
- The first e-learning module included a short survey of participants' perceptions of the adequacy of operational resources and the frequency with which they use 'Wobbly Steps'. Wobbly Steps (explained in detail in the section on training content below) are risky behaviours or unsafe acts such as hurrying or not consulting procedures, which are often used to compensate for a perceived or actual short-fall in resources. A follow-up survey is planned at the end of training to gauge if perceptions have changed.
- The HOF workshops resulted in a large number of suggestions being presented to managers at the end of the workshops.

Training strategy

In order to meet the objective of using HOF as an agent of change within the organisation, a training strategy was defined at the start to guide the development and implementation of the programme. It is depicted in Figure 2; the elements of which are explained below.

The training content is being specifically tailored to the company in a number of ways. It is built around the company's specific requirements, both those made explicit in meetings with the quality personnel and those derived from observations and interviews. Company-specific examples are used – this includes videos of a range of personnel in the company recounting examples of the key HOF hazards identified and applications of safety management strategies. The training is aligned with other initiatives under the quality programme – for example, providing extended training in a real-time risk management approach specified in another initiative. The terminology is carefully adjusted to that which is current within the company, and the training is thoroughly piloted and adjusted according to the feedback.

To promote the objective of moving from a reactive understanding of HOF (focused on understanding of incidents and accidents), which is common in HOF training, to a proactive one, the emphasis in the training is on recognising and effectively responding to HOF hazards. The specific hazards addressed are the following:

- Those HOFs identified by the company in their analysis of quality data;

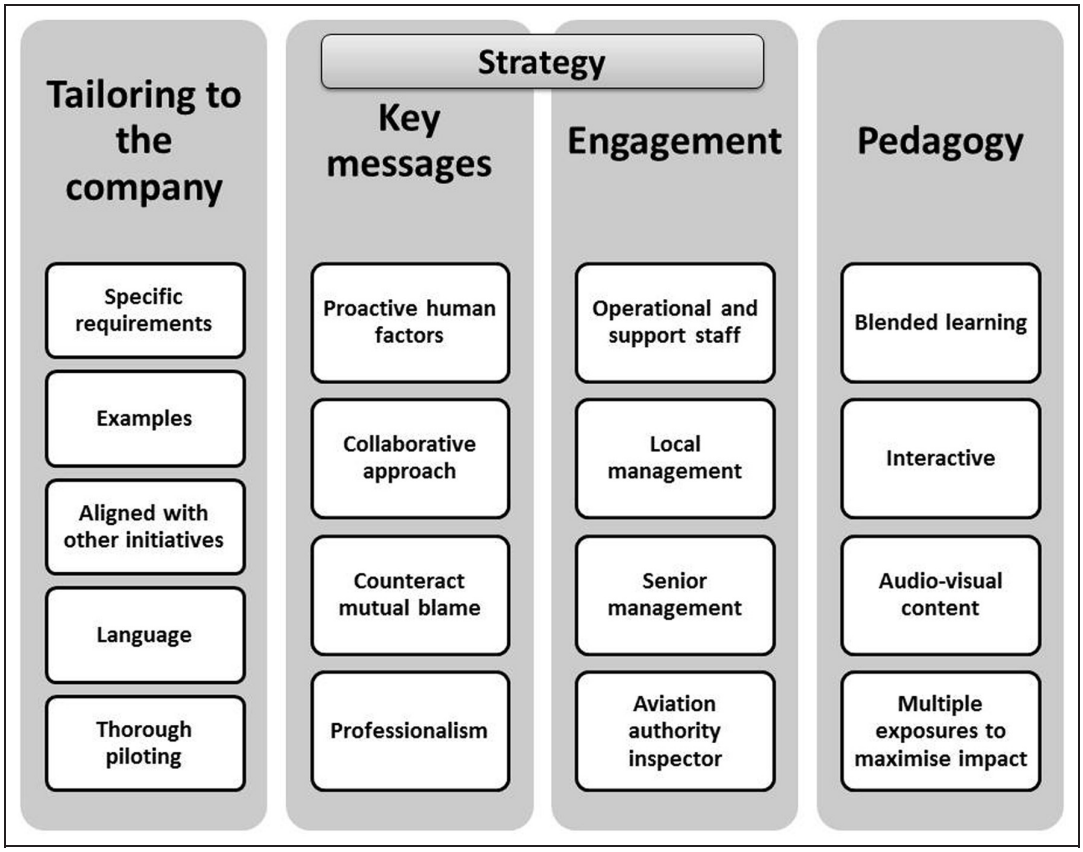

Figure 2. Training strategy adopted.

- Occasional short-falls in resources provided to carry out a task – equipment, tools, documentation, competence, time, etc.
- Wobbly Steps may be introduced to compensate for a short-fall of resources – for example, deviation from a procedure, hurrying.

The training embeds key messages for effective management of the risks represented by these hazards. One risk is that management and operational staff will, explicitly or implicitly, blame each other for the hazards. The training addresses this by seeking to foster a collaborative process whereby both groups acknowledge and take responsibility for their contribution to these hazards. Professionalism was identified as a key concept to be elaborated in the training, including taking responsibility, reporting, making and taking suggestions constructively.

Engagement of staff at all levels is considered important for the success of the programme. This was fostered through the delivery of targeted workshops. Engagement of local management in particular was considered critical. In Phase 1 of the programme, managers took it in turn to participate in an engagement-with-management session in the all-employee workshops. Senior management needed to be thoroughly engaged in the programme and were given a dedicated workshop in advance of the roll-out to the rest of the employees.

The pedagogical bases of the blended learning programme are as follows:

- Consistency of delivery of the key messages was ensured through the use of e-learning to supplement workshops;
- All training modules had a two-way interaction; the training was organised to capture the inputs of the trainees and feed them into a management process;
- Key concepts were delivered through e-learning so as to free up workshop time for interactive exercises and discussions;
- Multiple exposures to the content are used to maximise retention and facilitate the integration of knowledge into operational practice over time;
- Audio-visual material is developed specifically for both the e-learning and workshop components.

Training programme

The programme is divided into three phases targeting HOF and safety management, respectively, in the first two phases, and following up with a brief review phase to refresh the concepts and to provide an opportunity for gathering Time 2 survey data (see Figure 3). Phase 1 has been completed, and Phase 2 delivery has commenced.

Phase 1 comprised (in sequence) the following:

- A 2-h workshop with senior management from all sites. This workshop highlighted the role of senior

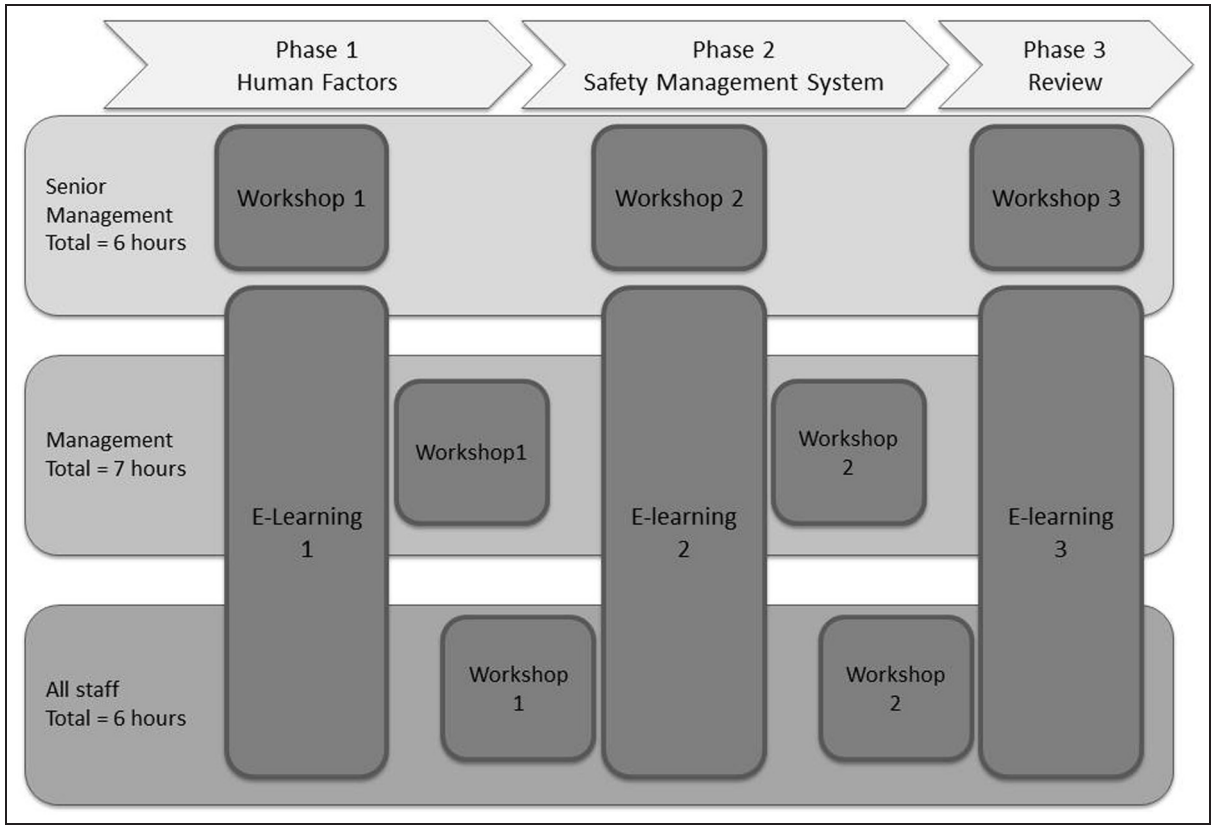

Figure 3. A graphical representation of the training programme.

management in fostering a positive safety culture, supporting good human factors practice and, in particular, in actively promoting the HOF training.

- A 45-min e-learning module for all staff. The module introduced the key HOF concepts – the key root causes identified in the organisation, 'Wobbly Steps' as HOF risks, a simple concept for effective management of HOF risks and the necessity of a collaborative 'working together' approach to addressing these risks.
- A 2.5-h workshop for operational managers was designed to expose them in advance to the content their staff would be encountering in their workshops. It also prepared them for their role in the all-employees workshop.
- A 2-h workshop for all operational and support staff. This workshop was based around the same content as the e-learning module but employed the workshop format to engage the participants in collaborative exercises to explore the application of the concepts they had been introduced to. The end of the workshop was devoted to a discussion with an operational manager. The manager's contribution was to describe what he or she had learned from their own workshop – the 'Wobbly Steps' they can use and how they can manage their risk. The participants' role was to present to the manager one suggestion for a HOF improvement that could be tackled as a 'working together' project.

Phase 2 has now commenced in the sites that have completed Phase 1. This comprises the following:

- A 1.5-h briefing with site senior management. This briefing is to ensure that the senior management understands the objectives of the training and what is required of them to ensure that it is implemented effectively and that the learning can be effectively translated into the operation.
- A 60-min e-learning module for all staff. The module provides an introduction to three key safety concepts – risk assessment, safety culture and just culture. Audio-visual content of three types is employed – a presenter narrates the training through video and voiceover, company personnel share their experiences on video, and a fictional video using professional actors is presented in several scenes illustrating the key concepts. This audio-visual content is interspersed with interactive quizzes to aid engagement with the content.
- A 3-h workshop for operational managers exposes them in advance to the content their staff will be encountering in their workshops. It additionally helps them focus on the critical role required of them in ensuring transfer of the concepts to the operation.
- A 2-h workshop for all operational and support staff. This workshop is based around the same content as the e-learning module but employs the

workshop format to engage the participants in collaborative exercises to explore the application of the concepts they had been introduced to. The module includes a practical risk assessment game, a safety culture assessment exercise and a just culture scenario for the participants to adjudicate.

Training content

The trainees have all completed an initial human factors training course, and many of them have experienced at least one iteration of 'continuation training' refreshing the same concepts. Thus, the basic concepts of human factors and their contribution to human error and the role of error accident causation are assumed to be familiar. The curriculum for initial human factors training in aviation maintenance is set by the authorities.[1] Conceptually, then, the objective of this training programme is to progress the understanding of HOF and safety management to a more sophisticated level which should act as the foundation for more effectively managing HOF and safety in the operation.

To this end, the following key concepts were identified as central. Phase 1: 'Wobbly Steps', routine risk management, and reporting and working together. Phase 2: risk management, safety culture and just culture. These formed the 'curriculum' of the training. Most of these concepts are well elaborated in the Human Factors and Safety literature and do not need explanation here. The specific approach to communicating them is described below.

Wobbly Steps

However, 'Wobbly Steps' is a concept not previously articulated in the literature and is described in more detail here. Typically, managers get frustrated when operational staff deviate from procedures, work outside their competence or use unapproved tooling. They tend to attribute these actions to internal or personality variables such as complacency. On the other hand, operational personnel typically complain about the resources provided to them – short time-frames allowed for tasks, difficult to follow procedures, not enough tooling. This can easily lead to a 'blame game' in a human factors training course. McDonald et al.[10] discovered that deviation from procedures by aviation technicians was not, as a rule, wilful risk taking, but was mostly related to deficiencies in the documentation quality or availability, the adequacy of the procedure itself or the feasibility of doing it in the time allocated.

'Wobbly Steps' is a metaphor to communicate that there is often a link between individual risky behaviours and organisational resources. The metaphor is based on a simple scenario in which the main actor (Sam) needs to change a broken light bulb. The bulb is too high for him to reach, so he has to get some steps to reach the light bulb. The supplied steps are still not high enough, so he has to add some of his own which are Wobbly. They will allow him to reach the light bulb but introduce risk to the operation in that they might collapse causing injury to Sam.

Figures 4 and 5 illustrate the translation of this metaphor into operational terms. The height of the light bulb represents the demands of the task (Figure 4) – the steps required, the time it takes, the design of the tools and equipment, the requirements of the customer and the market, the nature of the product and any regulatory stipulations. This is applicable to all tasks which operate within explicit and implicit constraints.

The first set of steps Sam uses (Figure 5) are the resources provided by the organisation – tools, equipment, facilities, materials, personnel, training and documentation. If these are adequate, they will get Sam up close to the light bulb. However, normally Sam would need to contribute a few of his own steps – his competence, effort, flexibility and coordination with others.

In a well-resourced operation, the combination of organisational and individual resources is sufficient for Sam to reach the light bulb. However, where some of these are inadequate (thin or absent), they leave him short. It is at this point that Sam is tempted to introduce a few extra (Wobbly) Steps to give him the extra height he needs. These 'Wobbly Steps' could be working outside the procedure, using incorrect tooling, hurrying and juggling several tasks. There are immediate rewards for using these Wobbly Steps for both the individual and the organisation – the task is done on time and within budget, and the operator can be seen as a flexible and efficient worker. However, these Wobbly Steps are hazards which build risk into the operation with a probability that, over time, they will lead to a negative consequence.

The concept of 'Wobbly Steps' is virtually synonymous with the widely used concept of 'unsafe acts'. In the safety literature, unsafe acts are understood as being often provoked by latent failures – inadequate conditions or resources.[11] However, the term itself refers exclusively to the riskiness of the behaviour. The advantage of the term 'Wobbly Step' is that, for those familiar with the underlying metaphor, it simultaneously denotes both the riskiness (Wobbly) and the operational utility of the behaviour (Step).

The 'Wobbly Steps' metaphor was introduced to the trainees using graphics and a voiceover during the first e-learning programme. During the workshops, this learning was built upon by a team exercise. An internal company incident, together with the result of the investigation, were presented to the trainees via a video. Care was taken to select an incident with a number of contributory factors and Wobbly Steps at management and operational levels of the organisation. Having watched the video, the teams were each given a set of physical steps labelled as in the graphic in Figure 5, with some thick steps representing adequate resources and some thin steps representing inadequate resources. They were asked to re-construct the incident using these steps. This formed the basis for a group discussion

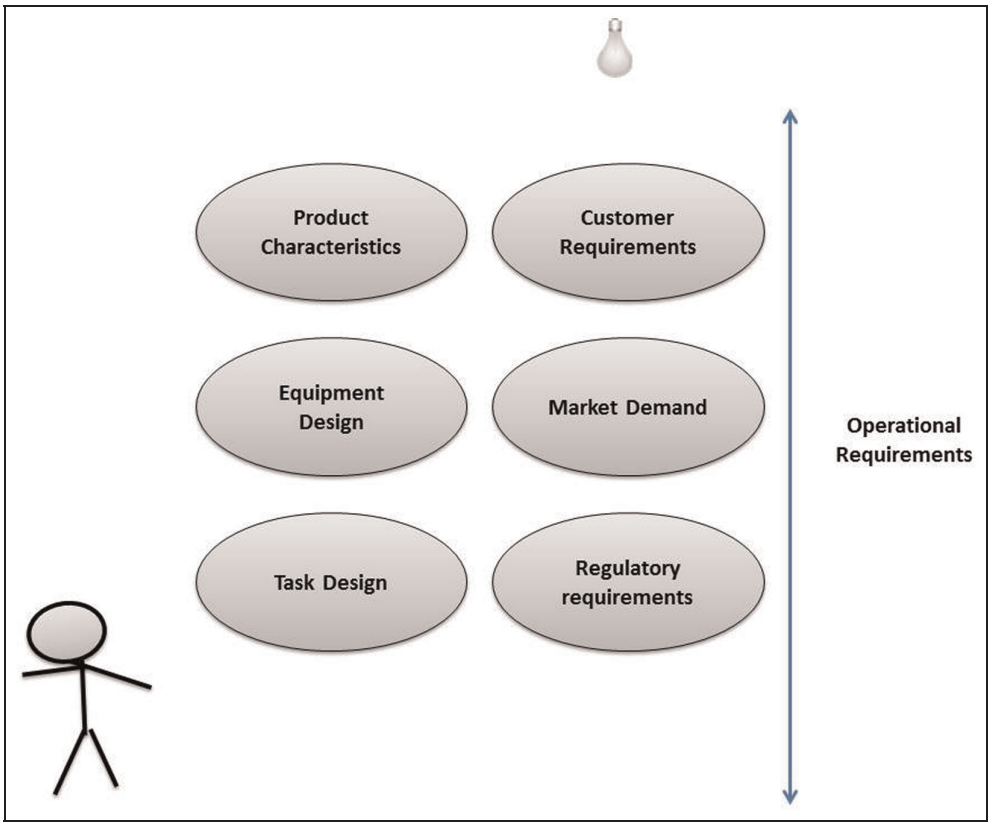

Figure 4. Wobbly Steps metaphor: the initial challenge.

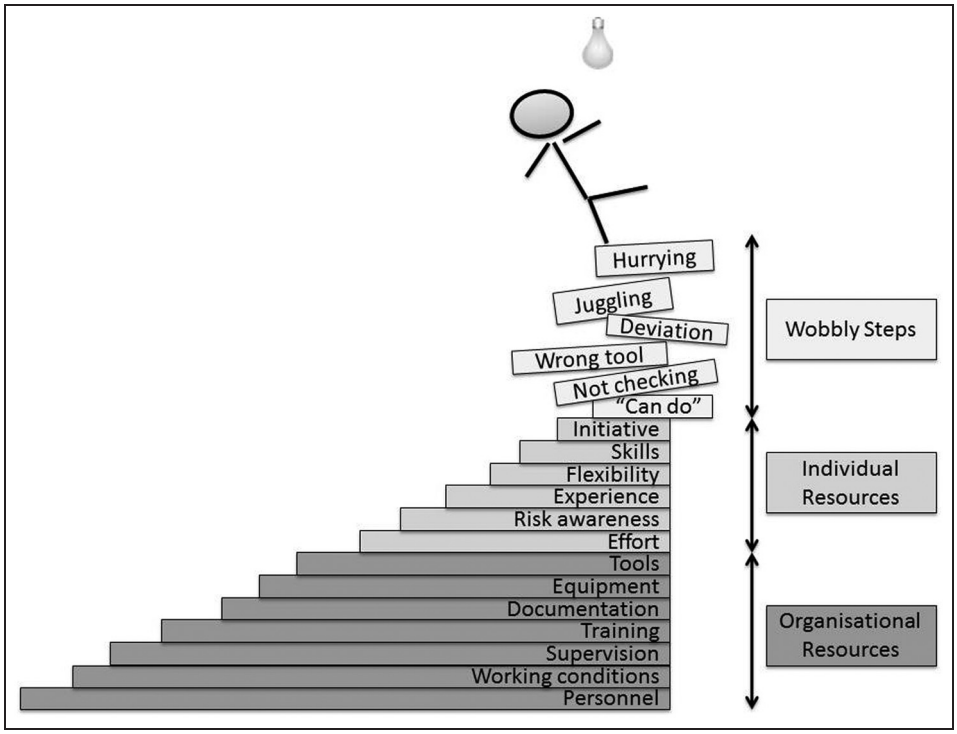

Figure 5. Wobbly Steps metaphor: the different steps used.

comparing the towers different teams had created and making concrete how the Wobbly Steps metaphor can be used to understand the development of an incident.

Working together

The 'Wobbly Steps' formed a solid basis for exploring ways of 'working together' to address the type of

challenge illustrated. Each workshop was tasked with coming up with one suggestion for improvement to be presented to a manager. The idea was that this would form the basis for a working group of management and staff to explore, enhance or amend the suggestion before applying it.

Routine risk management and reporting

Frequently, human factors training encourages reporting of all hazards and errors either through a formal reporting system or to front-line managers.[12] This can have the effect of instilling passivity in the operational staff and turning managers into constant trouble-shooters. In line with their team-based working philosophy, the company had introduced a simple informal risk management approach for their personnel. While this concept had been widely disseminated within the company, the application of the concept was not at the desired level. Hence, the current training re-introduced the concept through the e-learning element and explored its application in the workshops. In the workshops, teams were presented with a large vinyl poster of the company's risk management approach. They were tasked with populating this poster with examples under each element – elements of the operational task they should assess, strategies for managing the risk and methods of risk reporting.

Risk management

Phase 2 of the training is moving to more explicitly address safety management. The ICAO safety management manual breaks down the mandated SMS into a number of elements – safety policy, risk management, safety assurance and safety promotion. In developing brief training for all personnel concerning the SMS, there is a significant danger of focussing on the system and its elements rather than on the key functions. The decision was taken not to attempt to present the SMS but to emphasise a key function – risk assessment.

Risk management can be a very elaborate and technical process, and indeed, the company already has a range of risk management processes at different levels of complexity. The objective of this training is not to train all personnel to be expert risk assessors. Rather, the training challenge is to present the key concepts of risk assessment in a comprehensive and yet in a simple and concise enough way to enable all personnel to grasp and apply the concept. In order to do this, risk assessment is presented as a simple three-step process – hazard identification, risk assessment and risk control. A risk assessment matrix is not used, just a three-point scale was used – low, medium and high. Hence, the concept is explained through the e-learning element, and its application is explored in the form of a simple risk assessment game in the workshop. In the game, the participants are given a scenario in which they are asked to carry out a specific task; they are given the procedure, the objects for the task and description of the context in which they are asked to carry it out. Their job is not to carry out the task, but to risk assess the task and propose appropriate risk controls. A range of physical and human factors hazards are built into the task including trip hazards, time pressure, poorly written labels and inadequate equipment.

Safety culture

An effective safety management system depends on a positive safety culture. However, safety culture can be a very abstract concept to convey in training, and knowing the nature of the safety culture in a company does not necessarily give trainees any means to try to improve their culture. Hence, the training was designed to make the concept as concrete as possible. This was done in two ways. In the fictionalised video, storyline hints are inserted into the story, suggesting the nature of the safety culture in the organisation. Trainees are asked to profile the fictional company across seven dimensions of safety culture (as identified by Sun et al.,[13]– priority, standardising, teamwork, learning, reporting, flexible and just culture). They are also asked, in the workshop, to profile their own site in terms of each dimension. If they deem a dimension of culture good, they are asked to cite evidence to support their assessment, and if they say that a dimension needs improving, they are asked to specify how it could be improved.

Just culture

Just culture is a dimension of safety culture. But it is addressed separately within the training because it is considered to be of critical importance. The failure to effectively foster a just culture can put all the other dimensions of safety culture at risk. The concept is trained in a very similar way to safety culture. The abstract concept is translated into a list of concrete beliefs and duties. A number of fictional incident scenarios are used to illustrate how it is easy to jump to a blame conclusion based on the consequences and basic facts of an incident, but that a greater understanding of the context in which the participants acted often makes their actions more understandable and softens the urge to discipline. An incident from the fictional video is elaborated and analysed in depth in the workshop to explore the differences between genuine errors, risky behaviour and reckless behaviour.[14]

Conclusion

This article has presented a unique approach to HOF continuation training. What is innovative about this

approach and what can process industries learn from it? A key feature is the integration of HOF training with risk management:

- The training is designed specifically to address HOF risks that had been identified by the company's quality and safety data, and those that were identified in the initial profiling of the organisation.
- The training is not just about awareness and knowledge but designed to strengthen specific safety barriers – proactive risk management by individuals, collaboration in addressing problems and establishing common language about HOF risk (Wobbly Steps).
- Training is seen as a source of information on risk. Data are gathered through the training on organisational culture, resources and Wobbly Steps, and suggestions for HOF improvement.

Two other innovations worth noting are the integration of the evaluation strategy into the training programme and the pedagogical approach.

Has the programme been effective in meeting its objectives of enhancing the management of HOF risks in the organisation? The programme has only started Phase 2; Time 2 data have not been collected on operational, organisational and outcome measures, so the impact of the programme cannot yet be assessed. Data to date[15] show that trainee reaction to the programme was generally very positive, and many very useful suggestions came out of the workshops. In addition, the trainee feedback and the workshop suggestions have highlighted areas of HOF risk that were not previously prevalent and have enabled the company to initiate specific measures to address them.

Although other industries operate in quite a different regulatory context, many of the same HOF are of concern[16]– documentation[17] risk communication.[18] While aviation stands to learn from the approaches to risk and safety management developed in the process industries, there is much that process industries can learn from the innovations in addressing HOF risks in the aviation sector, such as the approach documented in this article.

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References

1. CAA. *CAP 716 Aviation maintenance human factors (EASA/JAR145 approved organisations). Guidance material on the UK CAA interpretation of part-145 human factors and error management requirements*. CAA, 2003, http://www.caa.co.uk/docs/33/CAP716.PDF
2. Gambetti F, Casalli A and Chisari V. The human factor in process safety management. *Chem Eng Trans* 2012; 26: 279–284.
3. Leva MC, Pirani R and Demichela M. Human factors issues and the risk of high voltage equipment: are standards sufficient to ensure safety by design?*Chem Eng Trans* 2012; 26: 273–278.
4. ICAO. *Safety management manual (SMM)* (Doc. 9859). 2nd ed.Montréal, QC, Canada: ICAO, 2009.
5. Cromie S, Liston P, Ross D, et al. Human and organisational factors training as a risk management strategy in an aviation maintenance company. *Chem Eng Trans* 2013; 33: 445–450.
6. Cromie S. A comprehensive approach to human factors training. *J Prof Aviat Train* 1999; 1(4): 10–13.
7. McDonald N, Cromie S and Ward M. The impact of safety training on safety climate and attitudes. In: Soekkha H (ed.) *Aviation safety*. Utrecht: VSP, 1997, pp. 649–660.
8. Warr PB, Rackham N and Bird MW. *Evaluation of management training: a practical framework, with cases, for evaluating training needs and results*. London: Gower P, 1972.
9. Liston P. *Human factors competence in aircraft maintenance*. PhD Thesis, Trinity College Dublin, Dublin, 2005.
10. McDonald N, Corrigan S, Daly C, et al. Safety management systems and safety culture in aircraft maintenance organisations. *Safety Sci* 2000; 34: 151–176.
11. Wagenaar WA, Hudson PTW and Reason JT. Cognitive failures and accidents. *Appl Cognitive Psych* 1990; 4: 273–294.
12. Douglas E, Cromie S, Leva MC, et al. Modelling the reporting culture within a modern organisation. *Chem Eng Trans* 2014; 36: 589–594.
13. Sun R, Wang L and Zou M. Safety culture survey report. Unpublished report of the HILAS project, Trinity College Dublin, Dublin, 2009.
14. Marx D. *Whack-a-mole: the price we pay for expecting perfection*. Plano, TX: By Your Side Studios, 2009.
15. Cromie S, Liston P, Ross D, et al. *Evaluation report on phase 1 of [The Company's] human factors and safety management programme*. Dublin: Trinity College Dublin, 2012.
16. Koumaditis K, Themistocleous M, Byrne P, et al. Investigating human factors in biotechnology and pharmaceutical manufacturing industries. In: *European, Mediterranean and middle eastern conference on information systems*, Brunel University & Piraeus University, Athens, 30–31 May 2011, pp. 294–305.
17. Agnello P, Ansaldi S and Bragatto P. Plugging the gap between safety documents and workers perception, to prevent accidents at Seveso establishments. *Chem Eng Trans* 2012; 26: 291–296.
18. Di Mauro C, Bouchon S and Torretta V. Industrial risk in the Lombardy region Italy: what people perceive and what are the gaps to improve the risk communication and the participatory processes. *Chem Eng Trans* 2012; 26: 297–302.