Guidance on crew resource management (CRM) and non-technical skills training programmes

energy institute

GUIDANCE ON CREW RESOURCE MANAGEMENT (CRM) AND NON-TECHNICAL SKILLS TRAINING PROGRAMMES

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FOREWORD

The analysis of both occupational and process incidents in the energy industry has repeatedly indicated the risks of human error and unsafe or sub-optimal behaviours. In other industrial sectors, one method of addressing this issue has been to identify and then train behaviours that are protective for safety. These are the non-technical skills (thinking, teamwork and personal resource skills) that workers require for safe and efficient performance. In the aviation industry, where this approach has been adopted for the last 30 years, this type of training is called crew resource management (CRM). Recent incidents in the energy sector have demonstrated the need to introduce CRM training for non-technical skills in the energy industries.

This guidance has been developed for anyone who wishes to know more about why and how to implement CRM and non-technical skills training in their organisation. It was commissioned by the Energy Institute's Human and Organisational Factors Committee (HOFCOM) and based on a research report written by Professor Rhona Flin and Jill Wilkinson of the Industrial Psychology Research Centre, University of Aberdeen.

The information in this publication is derived from the scientific and regulatory literature on CRM/ non-technical skills from aviation and other industries. In addition, interviews were conducted with practitioners experienced in delivering CRM programmes, psychologists involved in CRM research and with members of HOFCOM.

The guidance has been structured into topic areas covering the background and rationale for CRM training, followed by recommendations on how to identify the required non-technical skills for a particular job, what should be included in a training course, how to deliver the training, methods of assessment, and organisational 'barriers' to implementing CRM training. Examples of CRM courses are given, and sources of background information and further reading are provided in the bibliography. As such, this publication provides a high level process and good practice guidance for how an organisation can implement CRM.

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1 INTRODUCTION

1.1 BACKGROUND AND SCOPE

The systematic analysis of both occupational injuries and major process incidents in the energy industry has repeatedly indicated the risks of human error and unsafe behaviours, as well as systemic organisational failures. The need to examine human factors, as well as technical causes of incidents, has been demonstrated in the explosions at the Texas City refinery (2005), Venezuelan Amuay refinery (2012) and Buncefield oil storage facility (2005), a number of offshore oil and gas sector incidents, and the earthquake-induced incident at Fukushima nuclear power plant (2011).

Human error is ever present and therefore remains a constant risk in all workplaces but can be particularly hazardous in industries working with major accident hazards (MAHs), such as the energy industry. Some industries, most notably aviation, strive to minimise human error by the use of crew resource management (CRM), an approach which identifies and trains non-technical skills (e.g. decision making, teamwork) to improve safety and efficiency. As of 2014 CRM has not been widely adopted in the energy sector, although there have been recent recommendations that it should be introduced.

Commissioned by the EI Human and Organisational Factors Committee (HOFCOM), this publication has three main aims:

1. to provide an introduction to CRM and its core features;
2. to set out the case for the use of CRM in the energy industry; and
3. to provide guidance on how to design and implement a CRM training programme.

The reader should expect to find a brief introduction to CRM and non-technical skills, a summary of the use of CRM in other industries and its benefits (based on current research), as well as a step-by-step process for designing and implementing a CRM programme (which may be familiar to those who have designed and implemented other types of training programmes). The reader should not expect to find in-depth information on the different types of non-technical skills (which are readily available from the resources referenced throughout this publication), nor what course content should be taught in the energy sector. Whilst example course syllabuses are provided, it should be remembered that CRM training should be tailored to each organisation and occupational role.

The content of this publication has been derived from good practice and lessons learnt in industries that have significant experience of developing and delivering CRM (e.g. aviation, marine, nuclear), or are beginning to introduce it (e.g. rail, mining). While CRM can be used in many work settings, the most relevant group for the energy industry is the operational crew working in a safety-critical, dynamic environment (e.g. teams in control rooms, production, drilling, and maintenance), although this type of training can be adapted for any type of team.

1.2 WHAT IS CREW RESOURCE MANAGEMENT (CRM)?

'CRM is not … an abstract management concept; it embraces principles and skills which, if combined with a high degree of technical knowledge and skill, will enable the crew to make best use of all available resources to achieve optimum efficiency in the conduct of operations while at the same time maximising […] safety' (UK Civil Aviation Authority (CAA), *Crew resource management (CRM) training*).

CRM originated in the aviation sector and refers to a type of behavioural training course introduced by airlines, initially for their pilots but then expanded to include flight crew as well. It focuses on the **non-technical skills** required to execute a flight safely and efficiently, in addition to the technical flying skills. Non-technical skills are cognitive skills such as situation awareness and decision making, as well as social skills for communication, teamwork and leadership. In addition, personal resource skills for managing conditions that can impair performance, such as stress and fatigue, are covered by CRM.

The Human Factors Group of the Royal Aeronautical Society (RAeS) defines the objectives of CRM training as follows:

– 'To enhance crew and management awareness of human factors which could cause or exacerbate incidents which affect […] safety.
– To enhance knowledge of human factors and develop CRM skills and attitudes which when appropriately applied could extricate an […] operation from incipient accidents and incidents whether perpetrated by technical or human factors failings.
– To use CRM knowledge, skills and attitudes to conduct and manage […] operations, and fully integrate these techniques throughout every facet of the organisation culture, so as to prevent the onset of incidents and potential accidents.
– To use these skills to integrate commercially efficient […] operations with safety.
– To improve the working environment for crews and all those associated with […] operations'. (RAeS, *Quality crew resource management*)

Despite being born out of the aviation sector, the CRM training concept has since been successfully transferred to other higher risk work settings, such as the fire services, shipping, mining, surgery, and the energy industry.

1.2.1 Non-technical skills

Non-technical skills are 'the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance' (Flin et al, 2008). Non-technical skills are especially important in safety-critical occupations.

The following non-technical skills are typically taught on a CRM training course, with an emphasis on how these relate to task performance, human errors and organisational safety; however, the precise set of non-technical skills should be customised for the technical tasks, operational conditions and the workplace culture:

– situation awareness;
– decision making/problem solving;
– leadership;
– teamwork;
– communication, and
– managing stress and fatigue.

Detailed descriptions of the six non-technical skills categories are provided in the *Associated non-technical skills (ANTS)* factsheets (New South Wales (NSW) Government website, http://www.resources.nsw.gov.au/safety/world-leading-ohs/ants), and in EI *Human factors professional development: complete training resource*.

The relationship between non-technical skills and human error and adverse events is illustrated in Figure 1. This shows that deficiencies in non-technical skills (e.g. not thinking ahead, not following procedures, not speaking up when concerned about risks) can increase the chance of human error, which in turn can increase the chance of an adverse event. Good non-technical skills (e.g. high vigilance, effective communication, leaders listening to team members' concerns) can reduce the likelihood of error and so decrease the chance of such an adverse event.

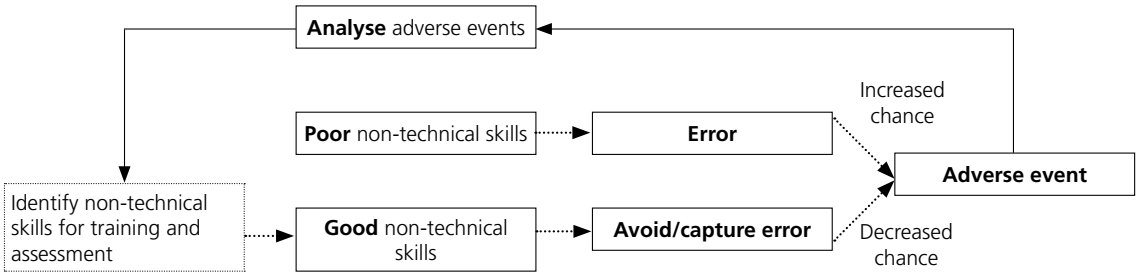

Figure 1: Relationship between non-technical skills and adverse events[1]

In essence, non-technical skills help to reduce the incidence of error, to catch errors that have occurred and to respond effectively when a hazardous situation arises. These skills are not new or unfamiliar to most workers: they are essentially what the best practitioners do in order to achieve consistently high performance.

The emphasis in CRM is on training individuals in non-technical skills to work in whatever team is on duty (as membership may change day to day), rather than on training an established team where the same people always work together. This distinction is appropriate for the energy industry, where crew composition can change across shifts and rotations.

1.2.2 Distinctive features of CRM training

Compared to training discrete skills such as teamwork or leadership, CRM training covers all the non-technical skills in one course and the teaching material is based on scientific evidence (from studies of attention, decision making, group behaviour etc.) and current safety data (corporate or industry).

The focus is on an individual's behaviour at work rather than on personality. We know that personality influences which behaviours an individual prefers, such as being quiet or talkative, cautious or adventurous. In CRM training, the emphasis is on which behaviours are **safest for the current task**. Sometimes it is best to discuss the procedure for a task; at other times it is necessary to be quiet, to allow a colleague to concentrate.

Key features of CRM training are shown in Box 1.

Box 1: Notable features of CRM training

CRM training:

- Is based on current analyses of the non-technical skills required for safe and efficient operations and their role in recent adverse events, from company or industry sources (e.g. reporting systems, audits or incident data).
- Is focused on the individual worker in a team setting – workers need 'portable team skills' to use within any team.
- Addresses behaviour in routine operations with the aim of avoiding critical incidents, as well as skills for dealing with a critical event.
- Is not about someone's personality but about his or her behaviour at work.
- Is founded on current scientific research into human performance, with particular relevance to the specific work setting.

1 Reprinted by permission of Ashgate, from Figure 1.2, in Flin et al. (2008)

It is important to recognise that CRM is more than just a new training course: the ultimate aim of CRM is to improve an organisation's operating culture and safety. Therefore this will take more than a one-off training event or cosmetic changes to existing training that may already address some non-technical skills. It is more correct to think of CRM as a programme rather than a training course.

It should also be noted that, while the CRM training method is part of a human factors approach, it is not equivalent to 'human factors training', which might cover some aspects of non-technical skills, as well as ergonomics, risk management techniques, etc.

2 THE CASE FOR CRM

The case for implementing CRM more widely in the energy industry is threefold:
1. the prevalence of non-technical skills failures in major incidents;
2. the evidence for the benefits of CRM, and
3. the adoption of CRM in a range of industries.

2.1 NON-TECHNICAL SKILLS FAILURES IN MAJOR INCIDENTS

Today CRM is accepted in aviation as a key component of safe operations and many other industries are also adopting the approach, often in response to major incidents.

The reason that the CRM approach has been widely adopted is the realisation that human behaviour can play a key role in both increasing protection from, as well as increasing exposure to, hazards. In the UK, the Kegworth plane crash (where the pilots mistakenly shut off the good engine when the other was on fire) was such a strong demonstration that human error and teamwork failures were contributing to fatal accidents, that the CAA took the view that CRM had to be introduced, even though at the time there were only a few scientific studies on its effectiveness.

In the energy industry, investigations into major incidents often reveal problems relating to situation awareness, decision making, leadership and team work either in the incident causation chain and/or in the emergency response (see Table 1 and more detailed examples in Cases 1 and 2). For example, in the incidents at Chernobyl and Three Mile Island, operator error relating to loss of situation awareness and flawed decision making played a major role. In the UK, the analysis of the accidental release of radioactive material from the Sellafield plant showed similar problems (Case 3).

The introduction of CRM in the energy industry is now being suggested as a means of helping teams prevent or mitigate further major incidents. Most recently the Norwegian Oil and Gas Association (OLF) recommended the introduction of crew resource management in the offshore drilling sector (OLF, *Deepwater Horizon – Lessons learned*).

Table 1: Energy sector incidents with non-technical skills failures[2]

Year	Industry	Incident	Non-technical skills failures
1979	Nuclear power	Three Mile Island	Problem solving, team work, situation awareness
1986	Nuclear power	Chernobyl	Decision making, situation awareness, personal limitations
1988	Oil and gas production	Piper Alpha	Communication, leadership, decision making, team handover

2 Adapted from Flin et al, 2008

Table 1 continued...

Year	Industry	Incident	Non-technical skills failures
2005	Petro-chemical	Texas City	Leadership, decision making, fatigue, communication
2005	Fuel storage	Buncefield	Situation awareness, decision making, leadership
2010	Oil and gas drilling	Macondo	Situation awareness, decision making, leadership, teamwork
2011	Nuclear power	Fukushima	Situation awareness, decision making, leadership, communication

Case 1: Texaco Milford Haven, England, 24 July, 1994

An explosion on the refinery was followed by fires causing injuries to 26 people and severe plant damage. The incident was caused by flammable hydrocarbon liquid being pumped into a process vessel with a closed outlet valve. In addition to organisational, design and management issues, there were flaws in situation awareness and decision making, as well as the quality of supervision (Health and Safety Executive (HSE), *The explosion and fires at the Texaco Refinery, Milford Haven, 24 July 1994*).

Case 2: Esso Longford, Australia, 25 September, 1998

An explosion and flash fires on the gas processing plant killed two workers, injured eight others, took 53 hours to extinguish and interrupted the natural gas supply to the State of Victoria for two weeks. The Royal Commission into the incident found that an exchanger failed after a major process upset, after which hot oil was reintroduced into equipment that was too cold. Again there were a series of management failings, deficiencies in technical training but also misunderstandings between the panel operator and the manager as to which valves were to be closed. The panel operator was unclear about the production manager's intentions. He misheard the manager's radio message 'close valve TRC4' as 'close valve FRC4' and so performed a different action from that expected by the manager (Dawson and Brooks, 1999).

Case 3: BNFL Sellafield Nuclear release, England, November, 1983

At a shift handover during a maintenance shutdown of British Nuclear Fuel Ltd's nuclear reprocessing plant, there was a misunderstanding between crews as to the contents of a tank that included highly radioactive materials. This waste was then discharged outside the plant, contaminating a beach and surrounding environment. The investigation report indicates a number of causal factors, including communication failures. (HSE, *The contamination of the beach incident at British Nuclear Fuels Limited, Sellafield, November 1983*).

Some aspects of CRM training covering social skills may already be provided by some organisations in the energy industry, such as:

– Courses in leadership, teamwork and communication skills, delivered as part of supervisory or safety training.
– Behavioural-based safety programmes which teach workers to conduct worksite observations and give fellow workers feedback on their behaviour (e.g. training on monitoring and challenging behaviours).
– Guidance from occupational health specialists in the management of stress and fatigue.

However, while existing training on single non-technical skills may be effective, it is unlikely to provide a comprehensive understanding of the whole CRM skill set and how the skills are related. For example, social behaviours such as interrupting another worker can have a significant impact on concentration and problem solving. Less attention has traditionally been devoted in the energy sector to training operational staff in the cognitive skills of situation awareness and decision making which are of critical importance for maintaining safety and efficiency.

2.2 WHAT ARE THE BENEFITS?

There have been a number of studies into the effects of CRM training, mostly from aviation or military settings (Salas et al, 2006) but there are other domains now also showing results, e.g. the automotive industry. These evaluations usually compare pre/post training tests of:

– knowledge of CRM concepts;
– attitudes to safety relevant behaviours/safety culture;
– behavioural ratings of non-technical skills;
– error rates, and
– incident rates.

CRM training has been shown to produce:

1. positive reactions to the training;
2. more favourable attitudes in relation to safety relevant behaviours/safety culture;
3. gains in knowledge of non-technical skills and of human performance limitations;
4. desired behavioural changes shown in simulated or real environments, and
5. improvements in observed error rates.

There may also be benefits in operational efficiency.

Demonstrating the effects of CRM training on organisational safety outcomes is more difficult, especially in industries with low incident rates, such as aviation, but some studies have shown positive effects, such as an investigation in the US air force which showed a significant reduction in incident rates after CRM training was introduced.

There are, however, powerful anecdotal accounts from airline pilots who have credited CRM training for helping them to demonstrate very high levels of performance in extreme situations, such as United Airlines Flight 232, which lost all its hydraulics but managed to land in Sioux City by being steered by reverse thrust to the engines, or the emergency landing of a large jet aircraft on the Hudson River (Case 4).

Case 4: US Airways flight 1549 landing on the Hudson River, USA, January, 2009

An Airbus 320 took off from La Guardia airport, New York destined for North Carolina but within the first three minutes of flight, the plane hit a flock of Canada geese resulting in a complete loss of thrust from both engines. Captain Sullenberger and his co-pilot managed to steer the gliding plane onto the Hudson River to ditch and all passengers and crew were evacuated safely. The captain, who was an experienced pilot with 42 years of experience and a CRM trainer, stated that during the short period of time he and his crew had to decide on the course of action he felt that they were all 'on the same page' and that they worked together as a team seamlessly to achieve their goal. The National Transport Safety Board (NTSB) concluded that 'it was due to the professionalism of the crew and their excellent crew resource management during the incident that contributed to their ability to maintain control of the aircraft and increased the survivability of the impact'. (NTSB, Aircraft Accident Report NTSB/AAR-10 /03).

Comments from offshore crew members who took part in a pilot study of a two-day CRM course for platform crews also indicated that they recognised its value (Box 2).

Box 2: Comments from oil platform crew on a CRM course

- 'I can see the requirement to utilise all of the skills and knowledge during the course of my work.'
- 'I will use a considerable amount of this course in my work. It has made me look at myself and my job from a totally different perspective.'
- 'I will get other supervisors to participate in the principles of CRM.'
- 'Good overview which would benefit from more offshore related info/ examples as they become available.'
- 'The topics are relevant ... we perhaps need to look at specific safety incidents and use the techniques to tackle underlying causes.'

(Flin et al, 2003a)

In summary, there is evidence that, when properly applied in a supportive organisational culture, CRM training can have benefits for the safety of operations. There is mounting evidence that incidents in the energy sector have the same patterns of contributing factors relating to human performance limitations, human error and other human behaviours as those in aviation and other industries. Therefore, there seems to be good reason to utilise the available knowledge of CRM training, taken from these other industries, and to use this to customise CRM training for the different types of energy sector work environments.

However, it should be emphasised that CRM training is not a 'magic bullet' for safety or a means of addressing lack of technical skills, poor workplace environments etc. Significant support and commitment from the organisation is necessary for good CRM, and is only one part of a risk management system.

2.3 EXAMPLES OF CRM USE IN INDUSTRY

2.3.1 Aviation

The CRM approach was developed in aviation over 30 years ago (see Case 5) after a series of major aviation incidents in the USA and Europe, without primary technical cause, forced investigators to look for other contributing factors. The development of CRM is most advanced in aviation; therefore valuable lessons can be learned from this sector.

Basic CRM training for pilots is typically a two-day classroom-based course covering a standard set of topics, tailored to the aircraft type and operational conditions. Thereafter, annual recurrent training covers the main CRM topics, typically across a three-year cycle. In addition, pilots' non-technical skills are practised and debriefed in simulator sessions. In a number of countries, there are also regulations that pilots must have their CRM skills formally assessed as part of their regular licence revalidation, using a behavioural rating system. The CRM trainers and examiners must be qualified and approved to meet regulatory standards, and regularly revalidated. The CRM training requirements may also extend to cabin crew, ramp crew and maintenance engineers. Studies in maintenance have indicated that if there are underlying problems with a lack of staffing and equipment, CRM is not the solution to meeting those needs. Moreover the training needs to be maintained or the effects can be short-lived. In air traffic management, team resource management (TRM) training is used, adapted for the role of the individual controller. It should be appreciated how well established CRM has now become across the worldwide aviation industry. It is regarded as a key component of flight operations, pilot training and licensing, set within the safety management system.

Case 5: United Airlines 173, USA, December 1978

The initial emphasis on CRM training was the result of the NTSB analysis of a 1978 aircraft accident in Portland, Oregon. This crash, with 10 fatalities and 23 serious injuries, occurred because the captain was preoccupied with a landing gear malfunction and preparation for an emergency landing, and failed to monitor fuel level. The aircraft ran out of fuel and crashed on initial approach 0,6 miles from the airport – after circling for 23 minutes while trying to resolve the landing gear problem.

The first officer and the flight engineer had both warned the captain of the aircraft's fuel state but did not stress the urgency of the situation. Another potentially contributing factor was the recent installation of new gauges which may have caused confusion on actual fuel level. (Federal Aviation Administration (FAA) human factors website, http://lessonslearned.faa.gov/ll_main.cfm?TabID=1&LLID=42)

2.3.2 Nuclear industry

Some nuclear power organisations have used CRM training since the 1990s, recognising its relevance for their operational personnel. They also assess the non-technical skills of staff in safety-critical positions, such as control room operators and shift supervisors, as part of their licence revalidation and the company's competence assurance process. In addition, there are new human performance courses, similar to CRM, being developed in organisations such as the National Nuclear Laboratory in the USA. In the UK, CRM training is being re-emphasised by companies with nuclear facilities, following the Daya Bay China nuclear incident in which there were clear breakdowns in non-technical skills.

2.3.3 Oil and gas

So far, use of CRM in the oil and gas sector has been limited. However, one drilling organisation established a task force and decided that team based training, adapted from aviation and marine CRM, was a necessary countermeasure for its drilling platforms in light of recent offshore major incidents. The International Association of Oil and Gas Producers (OGP) has also been developing a syllabus for CRM training for wells operations. Non-technical skills have also been identified for electricity field workers in Brazil and CRM courses have been designed for control room operators for high voltage distribution and on power generation plants.

2.3.4 Marine

The shipping industry recognised the importance of training non-technical skills after failures in decision making, situation awareness, leadership and teamwork were shown to be contributing to major hull loss incidents. Some maritime centres, such as Warsash in the UK, had been running this type of bridge team training since the 1980s. By 1992, Scandinavian Airlines System (SAS) was working with maritime organisations in northern Europe to develop bridge resource management (BRM). The grounding of the Cunard QE2 cruise liner at Martha's Vineyard in 1992 led the NTSB in the USA to recommend BRM training. As both bridge and engine room simulators became more widely available, both BRM and engine room resource management (ERM) courses began to be established for training non-technical skills. Many of the larger shipping companies have now introduced this training, and today courses, lasting from two to five days, often including simulation exercises, are taught across the globe, either in-house or using external providers. Some of these courses have engine and navigation crews together in CRM training, which may be called marine or maritime resource management (MRM).

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) code, published by the International Maritime Organisation, was amended following the Manila conference in 2010. The new amendments include requirements for CRM training, now called human element, leadership and management (HELM) training in the UK (see Annex D).

2.3.5 Emergency services

CRM training is used by the emergency services in a number of countries, most notably the fire service. In the UK, the paramedic service is beginning to adopt this approach by identifying key non-technical skills.

2.3.6 Rail

Rail industry companies now run CRM training and this seems to be particularly well developed in Canada and Australia; for example, Queensland Rail hold rail resource management (RRM) courses (http://www.transporterregulator.nsw.gov.au). One Australian rail regulator supported the introduction of a national RRM programme, by providing a 'train the trainers' course with support materials. The need for senior management support and the integration of the training within the broader safety systems were found to be essential for this type of CRM programme to be successfully introduced. The UK Rail Safety and Standards Board (RRSB) recommend CRM training for maintenance crews, and non-technical skills have been identified for train drivers (http://www.rssb.co.uk). The RSSB publication *A list of skills and*

behavioural markers for drivers with guidance notes provides examples of good and poor behaviours in the train driver role.

2.3.7 Healthcare

The world of healthcare has also learnt that serious incidents can occur when there are failures in non-technical skills, especially in the higher risk domains such as anaesthesia (see Case 6) and surgery.

Case 6: Anaesthesia, Mrs Elaine Bromiley, England, April 2005.

Mrs Elaine Bromiley, a 37 year old mother of two young children, died as a result of a problem in maintaining her airway during the induction of anaesthesia prior to elective endoscopic sinus surgery in a private hospital. Some details of the Coroner's report are as follows: 'The management of the 'can't intubate, can't ventilate' emergency did not follow the current or any recognised guidance. Too much time was taken trying to intubate the trachea... The clinicians became oblivious to the passing of time and thus lost opportunities to limit the extent of damage... Not all the clinicians were aware that there was a problem'. The subsequent independent inquiry into her death revealed failures in situation awareness, decision making, leadership, communication and teamwork. Mrs Bromiley was married to an airline pilot and Martin Bromiley has worked tirelessly following her death to establish in healthcare the human factors practices used in aviation, such as detailed human factors incident analysis and CRM training.
(Clinical Human Factors Group, *The case of Elaine Bromiley)*

Now CRM training is being introduced into healthcare, especially in hospitals for the more safety-critical areas of patient treatment, such as intensive care units and operating theatres. Courses have been designed for these professionals at both early and later stages of training, as well as for multidisciplinary teams.

There has also been research to identify and implement the use of non-technical skills behavioural rating systems for evaluation and feedback (e.g. non-technical skills for surgeons (NOTSS) for surgeons, or anaesthetists' non-technical skills (ANTS)) used in operating theatres and clinical simulation centres (see Annex F).

'It makes perfect sense for surgeons to have CRM training for non-technical skills. The choices I have to make during an operation – my sense of the risks posed during the surgery, having my operating team working with me and being almost inside my head – all these things are contained within the non-technical skills programme and make a huge contribution to my ultimate performance and also the effectiveness of the surgical team.' Professor George Youngson, former Vice President, Royal College of Surgeons, Edinburgh.

2.3.8 Mining

The mining industry has begun to endorse a non-technical skills approach as part of its safety management programmes. For instance, in Australia, the New South Wales Mining Regulator advises on the introduction of CRM for this sector and has developed associated non-technical skills framework (ANTS) based on the medical ANTS and NOTSS frameworks, with a set of useful fact sheets: http://www.nswminesafety.com.au/projects/ants

3 IMPLEMENTING CRM

The basic steps to design a CRM training programme are shown in Figure 2.

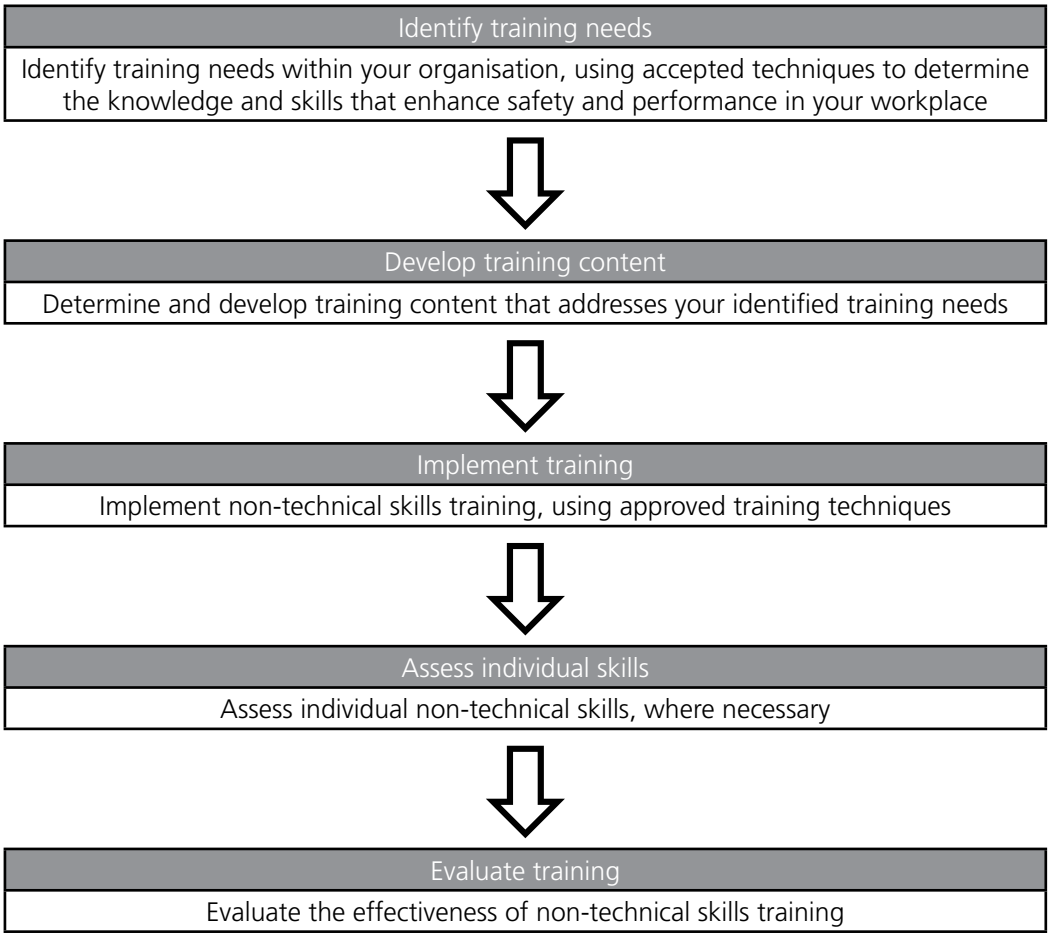

Figure 2: Method to design and deliver CRM training[3]

This section provides guidance on how to implement CRM in an organisation for each of the steps in Figure 2, covering training needs analysis and course design/delivery, and drawing on examples from industry. It should be noted that whilst the guidance is presented sequentially, in reality all steps need to be planned in advance before implementing CRM training. Thus, the steps feed into each other and should be considered holistically.

3.1 IDENTIFY TRAINING NEEDS

First, for any training course, it should be established what knowledge and skills need to be developed. For a basic CRM training course, there is usually a typical set of categories of non-technical skills that are covered (listed in Table 2). They are generally applicable to most

3 Adapted from CASA, CAP SMS-3(1)

safety-critical roles, but the specific non-technical skills elements and component behaviours needed for a given role and work setting should be determined.

3.1.1 Identify non-technical skills for specific roles

Task analysis can be used to identify the non-technical skills required for particular roles. This typically involves examining one or more tasks for a given role and describing the steps needed to achieve task completion (see Stanton et al, 2005). It can also specify the technical knowledge and skills that are required, and can be adapted to discover the key behaviours, cognitive skills, and teamwork skills that are protective or hazardous at the worksite. EI *Guidance on human factors safety critical task analysis* gives some examples of task analysis methods (although it focuses on the technical aspects rather than cognitive and teamwork skills). Various methods of task analysis include:

– interviews with subject matter specialists;
– questionnaires to ask about typical behaviours;
– observations of the behaviour of individuals and teams at work, and
– reviews of accident/incident reports to look for examples of non-technical skill deficiencies or strengths.

Once a list of behaviours has been collated, subject matter specialists can review this and advise on which are most important and how these can be structured into a coherent skill set. A typical non-technical skill set will include the skill categories and component elements in Table 2.

Table 2: Typical non-technical skills categories and component elements

Skill category	Elements
Situation awareness	– Gathering information – Understanding information and risk status – Anticipating future state/developments
Decision making	– Identifying and assessing options – Selecting an option and communicating it – Implementing and reviewing decisions
Communication	– Briefing and giving feedback – Listening – Asking questions – Being assertive
Teamwork	– Understanding own role with the team – Coordinating tasks/workload with co-workers – Considering and helping others – Resolving conflicts
Leadership	– Planning and directing tasks – Managing workload of self and team – Maintaining standards – Supporting team members
Managing stress and fatigue	– Identifying signs of stress and fatigue – Coping with effects of stress and fatigue

3.1.2 Training needs assessment

Once the desired non-technical skill sets have been produced, as with any other kind of training, the actual training requirement for the target group should be identified. In the case of CRM, consider: what level of knowledge about the factors influencing human performance and what levels of competence in non-technical skills does the workforce already possess? A training needs assessment (see Goldstein and Ford, 2002) or gap analysis will indicate what the desired non-technical skill levels are and the gap between that standard and the present levels of competence. To find out about current levels of CRM knowledge, skills and typical behaviours, this might involve:

– interviewing potential trainees and experienced supervisors or managers;
– examining training records;
– looking at behavioural audit data, and
– studying incident reports.

In practice, where there has been no previous CRM training, then a basic course will normally be required to teach the importance of the non-technical skills for reducing error and improving safety in a particular job, to explain what the skill set is and how the related behaviours can be influenced by both the individuals, the workplace conditions, and the organisational culture.

3.2 DEVELOP TRAINING CONTENT

3.2.1 Develop CRM syllabus

Once the non-technical skill set and training needs have been determined, these will form the basis of the CRM training content which will be designed to improve knowledge, attitudes and skills for each of the categories, in relation to the operational tasks and the specific work environment. For example, one such CRM syllabus includes:

– origins of CRM and case studies;
– human limitations including human information processing;
– stress and fatigue;
– human overload and underload;
– teamwork;
– group think;
– conflict resolution;
– communication;
– individual differences;
– human reliability;
– situation awareness;
– decision making;
– oversight;
– leadership, and
– situation awareness in simulator exercises.

The International Association of Oil and Gas Producers (OGP) recently commissioned a report on CRM training which provides a suggested syllabus for non-technical skills training for wells operations (WOCRM); see Annex C. Another source of information is EI *Human factors*

professional development: complete training resource module 5, which covers the main non-technical skills categories (although is not intended as CRM training).

3.2.2 Develop course content

When developing course content, some things to consider include:

– **Normal operations and emergency response**
While major incident avoidance and recovery are of particular concern in the energy sector, CRM is not normally designed as just an emergency management course. More typically, the focus is on skills that are used under routine, normal operational conditions in order to minimise errors and unsafe acts that can contribute to a major incident scenario. Hence the emphasis is on the non-technical skills that are protective for safety. Non-routine situations are discussed on CRM courses in relation to the enhanced skills that will be required to manage such events.

– **Culture**
Cross-cultural issues may have to be taken into account depending on the location and the group of trainees. The aviation industry learnt in the early years of CRM implementation that the required non-technical skills, and hence the CRM course content, should be tailored to the cultural norms of behaviour in the country of operation. For example, the difficulty of speaking up to contradict or challenge a more senior colleague can be greater in cultures with stronger status hierarchies' and this type of intervention may need to be taught with particular reference to company procedures and duty to behave this way (see Helmreich and Merritt, 1998, for examples). Some organisations find Hofstede's model of national culture differences applied to the workplace useful to incorporate into their CRM training if cross-cultural issues are being included (http://www.geert-hofstede.com).

– **Operational conditions**
While the CRM skills may be similar, the training content should be adapted to the operational conditions and task demands, as well as to the needs and existing knowledge of the trainees in question. For instance, the examples given when considering non-technical skills such as situation awareness or decision making should be based on the types of information that need to be gathered and evaluated by the audience for a particular work setting. There is little point in having a detailed discussion of decision making errors in relation to the flight controls and flight management system from an airline cockpit for a drilling rig crew dealing with deck operations or well control procedures.

– **Portable skills**
It should be noted that CRM topics relate to individual skills which are 'portable'. That is, the individual should be able to use these skills in any crew or team that he or she works within on a given day. The focus is on non-technical skills and their related behaviours while the individual is engaged in a technical task, usually as a member of a crew or team.

Information for developing teaching materials for CRM training is located in a number of sources. A general overview of non-technical skills and content for CRM training can be found in Flin et al (2008) *Safety at the sharp end: a guide to non-technical skills*. This also contains information sources for specific skills from books, articles and web sites. Another reference which provides useful background material on core CRM topics is CAA report CAP 737. Similar information is now provided by aviation, rail, marine, healthcare, mining or other industrial regulators in the relevant country, e.g. NSW mining and EUROCONTROL.

The EI has a range of human factors training materials available free of charge on its human factors website and also offers *Human factors professional development: complete training resource* which includes a module on non-technical skills – http://www.energyinstitute.org/humanfactors. Background information to the CRM approach and its scientific and practical development can be found in Kanki et al (2010) or other general texts on CRM training (e.g. LeSage et al, 2011).

3.3 IMPLEMENT TRAINING

3.3.1 Training duration

CRM training material is normally taught over two days (or an equivalent amount of classroom time, if combined with simulation exercises), although one-day courses are found in healthcare, and some of the marine CRM and human element, leadership and management (HELMS) courses (Annex D) are four or five days long (but this can include simulation exercises). Current courses in the energy sector also range from two days to five days if including technical skills and simulator exercises.

The topics can be taught in any order but the sequence given in Annex C has been found to be a useful progression from background knowledge on threats and error, to cognitive skills, to team skills, to performance shaping factors.

3.3.2 Refresher training

Refresher courses in CRM should be provided at regular intervals. In aviation, the UK CAA advised that 'all major CRM topics should be covered at least once every three years. However, it is not essential to re-cover the whole syllabus in detail in this period. Operators should concentrate on areas applicable to their operations'. This could for example involve one to two days' refresher training every second or third year, preferably in a simulator where exercises and skills debriefing can be provided.

The material for refresher training should be evidence-based. It should concentrate on the CRM skills that will be required to manage current risks (revealed in safety databases, recent incidents, unexpected events) and emerging challenges (e.g. new technology, operational changes).

3.3.3 Training methods

A mixture of lectures, practical exercises and case studies can be used during classroom training. Lectures with PowerPoint slides are effective for conveying background and explanatory information. Trainees can be given handouts of the slides (before or after the course) on which to make notes and to keep as a record. These lectures can be interspersed with video clips' e.g. of re-enacted incident scenarios from relevant technical operations, to identify strengths and weaknesses in non-technical skills.

Realistic examples and case studies from familiar technical tasks should be used throughout the training. Case studies, videos or material from other industries can be useful to illustrate that these non-technical skills are also required (or can be deficient) in other work settings, but relevance to the domain should be continuously indicated. Overuse of aviation material should be avoided. Group discussions can help to build understanding of core topics and learn from others. Individual and group exercises can illustrate particular concepts or

key points. Role play can be useful for practising specific skills, such as assertiveness, when simulation facilities are not available.

3.3.4 Trainees' prior experience

The trainees should have demonstrated competence in their required technical skills (at appropriate level of qualification for their roles) and at least several months of relevant work experience. However, no prior qualifications or training in human factors is required. Courses may already be provided on behaviour-based safety or team training and so levels of prior knowledge should have been ascertained from the training needs analysis or at least at the start of the course, and the delivery paced accordingly.

3.3.5 Class size and composition

The optimum number of trainees per course is 10 – 12. This size of group can be divided into three or four smaller teams for exercises but is also small enough to have a discussion with the whole class.

As the objective of CRM training is to teach 'portable' non-technical skills which can be used by individuals in whatever team they are working in, it is not always necessary to train team members together. In aviation, CRM is taught on an individual basis, because in the larger airlines pilots rarely fly with the same crews. Pilots are expected to demonstrate good CRM skills with whoever they are flying with and their CRM skills are checked on an individual basis (but within a team context). As many energy sector personnel do not always work in the same crews, then this model of individual portable skills may be particularly suitable and justifies training individuals who do not normally work together in one course.

Courses may be role-specific (e.g. control room operators, divers) or can include personnel from different roles or departments (e.g. drilling and deck crew, production and maintenance crew) to foster understanding of other team members' activities.

3.3.6 The role of simulation

In addition to classroom based training to teach and discuss the basic CRM concepts, the skills should ideally be practised in simulation exercises, if simulator facilities are available. The addition of realistic scenarios involving course participants requires additional time for briefing, running and debriefing of the non-technical skills (and often also debriefing technical skills). As CRM training should enable trainees to learn, practise and receive feedback on non-technical skills, then classroom training combined with simulator training is ideal and preferable to classroom based training alone.

Scenarios are written in order to create operational situations requiring particular non-technical skills, and then acted out by the trainees. Afterwards, the trainees are debriefed by the facilitators or by other course members about their performance. One CRM trainer suggested that having other course participants partially debrief trainees before the trainer does can be especially effective, as 'course participants are often harder on each other than a trainer would normally be' (although this may not be true in every culture). Alternatively, the trainer can draw attention to a specific part of what happened and ask course participants why that is being singled out (or, if the simulation is video recorded, it can be played back). This way the course participants 'learn by discovery'.

Company or industry incident/near miss databases can provide valuable examples of unsafe situations for scenario writing. Where CRM training takes place in a centre with simulation facilities, then classroom modules can be interspersed with illustrative scenarios in the simulator.

Lower fidelity simulation methods such as role play, decision games or computer-based exercises can be used where simulation facilities are not available, and these methods should not be undervalued.

3.3.7 CRM instructors/facilitators

Technical and non-technical skills and knowledge

CRM instructors should have basic knowledge of the non-technical skills and of the human factors concepts to be taught on the course and should also have knowledge of technical procedures and operational experience.

This combination of specific technical skills with additional skills in training human factors is the model used in other industries, where technical specialists with specific training in teaching CRM usually deliver the courses. For guidance from aviation on training and qualifying technical specialists to be CRM trainers, see CAA *The crew resource management instructor (CRMI) and crew resource management instructor examiner (CRMIE) accreditation framework*. Some energy companies now employ human factors professionals, such as psychologists, and they would provide an ideal resource for CRM training development and co-delivery, in conjunction with technical specialists, particularly in the early stages of course design.

Behavioural observation

Where observation and feedback of non-technical skills from simulation exercises is included in the training for formative (non-jeopardy) assessment, then the instructors should also be trained in behavioural observation and rating. Again, technical specialists along with behavioural scientists, can conduct this component of the courses until technical trainer proficiency levels are established.

In-house or external?

Ideally in-house staff with appropriate technical expertise, who have been trained to teach CRM courses, should deliver the CRM training. They have credibility for the trainees, as they understand not only the organisational culture but also the operational conditions. In one energy company, CRM training is delivered jointly by operators, simulator tutors and human factors engineers with experience of CRM. They run CRM instructors' courses (five days) and CRM evaluators' courses (two days) internally. In another company, trainers include technical instructors and behavioural instructors who have a background in teaching leadership, human resources or psychology. They also run their own internal courses to train and audit these trainers.

However, if the delivery of CRM training by in-house staff is not an option, then external training providers are available but they ideally need to understand the organisational culture and the technical tasks. There are a number of training providers, usually with experience of aviation or marine CRM training, offering courses to the energy industries.

Train the trainer

For any industry beginning to implement CRM training, this will usually require 'train the CRM trainer' courses, either delivered internally, but also available from a number of providers. There are an increasing number of commercial training providers delivering CRM courses. Due to the history of CRM adoption, the most experienced companies will usually be trainers of aviation CRM or maritime courses. However, while these trainers may be knowledgeable about CRM, some care should be taken to ensure that they have sufficient expertise in relevant technical operations in the energy sector to customise their standard CRM course to suit the technical demands and organisational culture of the audience.

Qualification

In the aviation industry, a key strength is a strong focus on the competence and qualification of CRM trainers and examiners. The CAA has provided a set of standards criteria which a pilot must meet to be designated as a CRM instructor and examiner. The US Navy/Marine Corps has also recognised the need for the credibility of CRM instructors and insisted on the requirement of naval aviators to be CRM trainers, rather than contracting the task out to civilian companies. A suitable enthusiast is an individual who has many years of technical experience and commands the respect of his or her peers. In addition, he or she must also have an understanding of, and enthusiasm for, human factors.

3.4 ASSESS INDIVIDUAL SKILLS

While informal or formative feedback is very valuable when non-technical skills are practised during a CRM course, formal or summative (pass/fail) assessment of CRM/non-technical skills should be separated from the CRM training.

The assessment form is usually based on a behavioural rating system, often called a behavioural marker system, which is used to evaluate non-technical skills from observations of on-task behaviour. An example of a generic non-technical skill set and some sample behaviours (behavioural markers) is shown in Table 3. Normally the categories are subdivided into component elements – see Annexes E and F.

Table 3: Examples of categories and behaviours in a non-technical skills framework

Categories	Definition	Examples of good/poor behaviour
Situation awareness	Developing a dynamic awareness of the situation during a task, based on assembling data from the environment, understanding what it means and thinking ahead	Good behaviours: – Liaises with other team members – Watches and listens for hazards and equipment issues – Questions and challenges the unexpected Poor behaviours: – Arrives late for meetings or misses briefs – Does not seek information from team members – Does not check status of current tasks
Decision making	Skills for diagnosing the situation and reaching a judgement in order to choose an appropriate course of action	Good behaviours: – Recognises and articulates problems – Asks for opinion from colleagues – Discusses options Poor behaviours: – No discussion of options – Ignores others' views
Communication and teamwork	Skills for working in a team context to ensure that the team has an acceptable shared picture of the situation and can complete tasks effectively	Good behaviours: – Talks about the progress of the task – Listens to concerns of other team members – Clear and concise handovers given Poor behaviours: – Attempts to resolve problems alone – Does not articulate plan to team – Proceeds with tasks without ensuring team is ready
Leadership	Leading the team and providing direction, demonstrating high standards of practice and care, and being considerate about the needs of individual team members	Good behaviours: – Introduces self to new team members – Gives credit for tasks performed well – Delegates tasks in order to achieve goals Poor behaviours: – Fails to observe standard procedures – Ignores the needs of others – Does not pass leadership when technical challenge requires full attention

There are existing non-technical skills behaviour rating frameworks which provide the basis for both informal and formal assessment tools, such as those devised for European airline pilots (NOTECHS), anaesthetists (ANTS), surgeons (NOTSS) and scrub nurses (SPLINTS),

see Annexes E and F for examples. There are behavioural marker systems which have been developed in the nuclear industry, but these rating frameworks seem to be less common in other sectors of the energy industry.

3.4.1 Informal and formative feedback

Particularly in the early phase of introduction of CRM, trainees should feel confident that they can practise CRM skills in simulation exercises without fear of penalty. Trainers giving feedback should have good facilitation skills and be competent in observing and rating behaviour. They may require specific training in assessment and feedback, such as debriefing skills.

Web-based courses are also now being used for debriefing training in other sectors e.g. the *Debriefing assessment for simulation in healthcare (DASH)* course at the Harvard Medical Simulation Centre–http://www.harvardmedsim.org/debriefing-assessment-simulation-healthcare.php

3.4.2 Formal assessment

Formal assessment of non-technical skills for qualifications or licences requires competent and qualified assessors, a validated assessment system, professional acceptance and appropriate organisational systems for preparation of candidates and procedures for dealing with failures. This is beyond the scope of this document; however, for more information on this topic see Flin et al (2008) or CAA CAP 737.

3.5 COURSE EVALUATION

The training course should be evaluated to determine whether objectives have been achieved: in the case of CRM, to establish whether the knowledge and non-technical skills are transferring to the workplace. FAA Advisory circular No 120-51E: *Crew resource management training* states that for CRM training 'it is vital that each training programme be assessed to determine if CRM training is achieving its goals. Each organisation should have a systematic assessment process. Assessment should track the effects of the training programme so that critical topics for recurrent training may be identified and continuous improvements may be made in all other respects'. The recommended approach to training evaluation is one that is multi-faceted, considering several separate methods of assessment.

Training evaluation methods can be categorised into different levels of training effects, ranging from individual to organisational indicators. Kirkpatrick's (1998) hierarchy is a popular model for guiding training evaluation. It provides a useful framework to assess the effects of a training intervention by considering different levels of evaluation:

1. reaction of students to the training;
2. learning – the resulting increase in knowledge or capability;
3. behaviour – the extent of application of or improvement to behaviour, and
4. organisation – the effects on the organisation as a result of trainees' improved performance.

Each level builds on the previous one, becoming more difficult and time-consuming to evaluate at each higher level, but also providing more valuable information.

Specific examples of evaluation methods, used in a pilot study for offshore oil and gas industry CRM training, included knowledge tests and attitude questionnaires. In some healthcare studies, measures of safety climate are compared before and after CRM training to test whether there has been any effect on the organisational or unit safety culture.

The measurement of CRM behaviours is usually undertaken by rating observations of on-task behaviour at work or in the simulator. The ratings are made on a standard scale such as one of the non-technical skills frameworks, for example NOTECHS for pilots or NOTSS for surgeons (Annexes E and F). An experienced and preferably qualified assessor should make the ratings. A detailed examination of methods of CRM training evaluation is discussed in CAA CAP 737, Kanki et al (2010) and examples can be found in Flin et al (2008).

4 ORGANISATIONAL CULTURE AND CHALLENGES TO IMPLEMENTATION

Depending on the organisational culture, an organisation can misunderstand the objectives of CRM. It should be recognised that CRM is **not** intended to:

– act as a panacea for all organisational problems;
– be a quick fix for dysfunctional individuals or systems;
– replace or compensate for a lack of technical proficiency, and
– be conducted as a passive lecture course.

A case study of the implementation of CRM in an Australian rail company (V Line) identified four threats to the success of CRM:

– attracting management commitment and their financial support;
– finding the right balance between taught course content and time for free discussion;
– pressure to keep to only a one-day course, against the disadvantages this brings, and
– the possibility of disruptive, negative or 'own agenda' participants spoiling the course for others.

It is essential for any training course that the skills being taught in the classroom and the simulator are transferred to the workplace. For a behavioural skills course such as CRM, the level of transfer will depend on the prevailing organisational culture at the worksites. That is, the extent to which fellow workers, managers and supervisors encourage or discourage behaviours such as speaking up, maintaining standards or helping other team members. Observation and feedback on non-technical skills should become part of the normal way of operating. Some recent examples from the early introduction of CRM training to UK healthcare teams showed how important the worksite culture is to the maintenance of the CRM behaviours: without a supportive organisational culture, there may be limited transfer of CRM skills.

It is particularly important that supervisors and managers are fully committed to the programme and understand what CRM training is designed to achieve. It is advisable that those individuals in such positions attend the training and behave in a manner consistent with the principles of CRM, as it is virtually impossible for employees to make lasting changes to their own behaviour when supervisors' or managers' actions do not reflect the CRM training. There is some evidence to show that the introduction of CRM should be carefully managed within an organisation. Supervisors, managers and even technical trainers can be resistant to this type of training because they feel threatened or criticised by the focus on human error, worksite behaviours, leadership and organisational culture. One means of addressing this barrier is to involve them in training design and/or in the pilot stages of implementing the course. Obtaining their input and feedback can be a valuable way of tailoring the course to the organisation's needs and ensuring that they are fully engaged in a CRM approach.

A broad, cohesive set of activities is desirable to integrate CRM principles into an organisation's operating philosophy, policies, procedures, practices, and current training processes (Dedale 2006 a,b). That could include examining CRM-related factors in incident analysis, including references to non-technical skills in technical training/worksite coaching by supervisors, and incorporating non-technical skills into performance reviews. Essentially, a CRM course should form part of the organisation's safety management system. The course content, especially for recurrent training, should be informed by the ongoing human factors analysis of technical performance, especially in relation to incident detection and management. Such analyses provide essential data for recurrent CRM training and scenario exercises.

ANNEX A
REFERENCES AND FURTHER READING

A.1 REFERENCES

Civil Aviation Authority (CAA) (http://www.caa.co.uk)

CAP 737 Version 2 *Crew resource management (CRM) training: guidance for flight crew, CRM instructors (CRMIs) and CRM instructor-examiners (CRMI-Es)*

Standards document No. 29 Version 4 *The crew resource management instructor (CRMI) and crew resource management instructor examiner (CRMIE) accreditation framework*

Civil Aviation Safety Authority (CASA) (http://www.casa.gov.au)

CAP SMS-3(1) *Non-technical skills training and assessment for regular public transport operations*

Clinical Human Factors Group (http://www.chfg.org)

The case of Elaine Bromiley, http://www.chfg.org/wp-content/uploads/2010/11/ElaineBromileyAnonymousReport.pdf

Energy Institute (EI) (http://www.energyinst.org/humanfactors)

Guidance on human factors safety critical task analysis

Human factors professional development: complete training resource

Federal Aviation Administration (FAA) (http://www.faa.gov)

Advisory circular No 120-51E *Crew resource management training*

FAA human factors website, http://lessonslearned.faa.gov/ll_main.cfm?TabID=1&LLID=42

Health and Safety Executive (HSE) (http://www.hse.gov.uk)

The contamination of the beach incident at British Nuclear Fuels Limited, Sellafield, November 1983

The explosion and fires at the Texaco Refinery, Milford Haven, 24 July 1994: A report of the investigation by the Health and Safety Executive into the explosion and fires on the Pembroke Cracking Company Plant at the Texaco Refinery, Milford Haven on 24 July 1994

International Association of Oil and Gas Producers (OGP) (http://www.ogp.org.uk)

Report no. 501. *Crew resource management for well operations teams*
http://www.ogp.org.uk/pubs/501.pdf

National Transportation Safety Board (NTSB) (http://www.ntsb.gov)

Aircraft Accident Report NTSB/AAR-10 /03 *Loss of thrust in both engines after encountering a flock of birds and subsequent ditching on the Hudson River, US Airways Flight 1549, Airbus A320-214, N106US, Weehawken, New Jersey, January 15, 2009*. Washington, DC

New South Wales (NSW) Mine Safety Advisory Council (http://www.nswminesafety.com.au)

Associated non-technical skills website (ANTS)
http://www.nswminesafety.com.au/projects/ants

Norwegian Oil and Gas Association (OLF) (http://www.norskoljeoggass.no)
Deepwater Horizon – Lessons learned, http://www.norskoljeoggass.no/en/Publica/

Railway Safety and Standards Board (RSSB) (http://www.rssb.co.uk)
Non-technical skills for rail. A list of skills and behavioural markers for drivers, with guidance notes

Royal Aeronautical Society (RAeS) (http://www.aerosociety.com)
Quality crew resource management, http://46.65.185.13/crm/reports/qual-crm.htm

Other authors

Dawson, D. & Brooks, B. (1999) *The Esso Longford gas plant accident. Report of the Longford Royal Commission,* Melbourne: VGPS

Dedale (2006a) *National Rail resource management project. Guidelines for rail resource management.* Report to ITSR http://www.transportregulator.nsw.gov.au

Dedale (2006b) *National Rail resource management project: Review of best practice, implementation issues and task analysis*
Report to ITSR http://www.transportregulator.nsw.gov.au

Endsley, M. & Garland, D. (2000) (Eds.) *Situation awareness. Analysis and measurement* Mahwah, NJ: Lawrence Erlbaum

Flin, R, Martin, L, Goeters, K.M., Hörmann, H.J, Amalberti, R, Valot, C. and H. Nijhuis (2003) *Development of the NOTECHS (non-technical skills) system for assessing pilots' CRM skills. Human factors and aerospace safety*, 3(2), 95 – 117

Flin, R, O'Connor, P. & Crichton, M. (2008) *Safety at the sharp end: A guide to non-technical skills*, Farnham: Ashgate

Flin, R, O'Connor, P, Mearns, K, Gordon, R. & Whitaker, S. (2003a) *Crew resource management training for offshore operations*. Vol. 3 of 3. *Factoring the human into safety: Translating research into practice*. Research Report RR 61. London: HSE Books.
http://www.hse.gov.uk/research/rrpdf/rr061.pdf

Goldstein, I. & Ford, K. (2002) *Training in organizations: needs assessment, development, and evaluation*, Belmont, CA: Wadsworth

Helmreich, R. & Merritt, A. (1998) *Culture at work in aviation and medicine,* Aldershot: Ashgate

Kanki, B, Helmreich, R. & Anca, J. (2010) (Eds.) *Crew resource management* (2nd ed), San Diego: Academic Press

Kirkpatrick, D. L. (1998) *Evaluation of training programs*, San Francisco: Berrett-Koehler

LeSage, P., Dyar, J. & Evans, B (2011) *Crew resource management. Principles and practice,* Sudbury, MA: Jones & Bartlett

Salas, E, Wilson, K. Burke, C, & Wightman, D. (2006), *Does CRM training work? An update, extension and some critical needs*, Human Factors, 48(2), 392 – 412

Stanton, N. et al (2005) *Human factors methods*, Aldershot: Ashgate

Tissington, P. & Flin, R. (2005) *Assessing risk in dynamic situations. Lessons from fire service operations. Risk Management*, 7, 43 – 51

University of Aberdeen and Royal College of Surgeon of Edinburgh (2006), *NOTSS: Non-technical skills for surgeons*, http://www.abdn.ac.uk/iprc/notss

University of Aberdeen (2012), *Anaesthetists' non-technical skills (ANTS) system handbook* http://www.abdn.ac.uk/iprc/ants

A.2 FURTHER READING

Civil Aviation Authority (CAA) (http://www.caa.co.uk)

CAP 720 *Flight crew training: cockpit resource management (CRM) and line-oriented flight training (LOFT)*

European Aviation Safety Agency (EASA)

Terms of reference, RMT.0411 *Crew resource management*
http://easa.europa.eu/system/files/dfu/ToR%20RMT.0411%20(OPS.094)%20Issue%202.pdf

European Commission

JRC Report EUR 25646 EN *Safety of offshore oil and gas operations: Lessons from past accident analyses,* http://www.publications.jrc.ec.europa.eu/repository/

International Association of Oil and Gas Producers (OGP) (http://www.ogp.org.uk)

Report 460 *Cognitive issues associated with process safety and environmental incidents*

Report 502 *Well operations crew resource management recommended practice*

International Maritime Organization (http://www.imo.org)

STCW including 2010 Manila amendments

Oil and Gas UK (http://www.oilandgasuk.co.uk)

Guidelines on competency for wells personnel, Issue 1, January 2012

Incident reports

Borthwick, D. (2010) *Report of the Montara Commission of inquiry*, Barton, ACT: Attorney General's Department

Cullen, D. (1990) *The public inquiry into the Piper Alpha disaster (CM1310)*, London: HMSO

HSC (2008) *The Buncefield incident 11 December 2005, the final report of the Major Incident Investigation Board*, Buncefield Investigation Board, London: Health and Safety Commission, http://www.buncefieldinvestigation.gov.uk

INPO (2012) *Lessons learned from the nuclear accident at the Fukushima Daiichi nuclear power station*, special report, Atlanta: Institute of Nuclear Power Operators

National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (2011) *Deepwater: The Gulf oil disaster and the future of offshore drilling. Report to the President.* http://www.oilspillcommission.gov

NRC (1980) *Three Mile Island Special Inquiry Group human factors evaluation of control room design and operator performance at Three Mile Island-2, Volume 1 (Final report (NUREG/CR-1270-V-1))*, Washington, DC: US Department of Commerce

US Chemical Safety Board (CSB), Report 2005-04-I-TX *Investigation report. [Texas City] Refinery explosion and fire,* http://www.csb.gov

ANNEX B
GLOSSARY OF ABBREVIATIONS AND ACRONYMS

ANTS	anaesthetists non-technical skills
ANTS	associated non-technical skills framework
BRM	bridge resource management
CAA	Civil Aviation Authority
CASA	Civil Aviation Safety Authority
CRM	crew resource management
CRMI	crew resource management instructor
CRMIE	crew resource management instructor examiner
DASH	debriefing assessment for simulation in healthcare
EI	Energy Institute
ERM	engine room resource management
FAA	Federal Aviation Administration
HELM	human element, leadership and management
HOFCOM	Human and Organisational Factors Committee
HSE	UK Health and Safety Executive
IMO	International Maritime Organization
MAH	major accident hazard
MCA	Maritime and Coastguard Agency
MNTB	UK Merchant Navy Training Board
MRM	maritime resource management
NOTSS	non-technical skills for surgeons
NSW	New South Wales
NTSB	US National Transportation Safety Board
OGP	International Association of Oil and Gas Producers
OLF	Norwegian Oil and Gas Association
RAeS	Royal Aeronautical Society
RRM	rail resource management
RRSB	Rail Safety and Standards Board
SAS	Scandinavian Airlines System
SPLINTS	scrub practitioners list of intra-operative non-technical skills
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
TRM	team resource management
WOCRM	wells operations crew resource management

ANNEX C
CONTENT FOR A WELLS OPERATIONS CRM SYLLABUS

This annex provides an adapted extract from OGP report no.501, *Crew resource management for well operations teams* © 2014 OGP. Used with permission.

C.1 DAY ONE

Introduction

The aim of this module is to provide the participants with a basic understanding of human factors in relation to workplace safety, the origins of CRM as a human factors/ error management approach, and the relevance of CRM (non-technical) skills to safe and efficient wells operations.

– Explanation of human factors and importance in safety-critical work settings.
– The common nature of human error. Influence of system factors (e.g. Reason's Swiss cheese model) and environmental threats (e.g. Helmreich's threat and error model), as well as of human error, in incidents.
– Brief history of CRM, and its roots in the aviation industry as an error management approach. Examples of failures in CRM/non-technical skills that have been shown to contribute to incidents or where good non-technical skills have contributed to avoidance of/recovery from adverse events.
– The rationale for CRM training for wells personnel (e.g. Macondo, Montara, local wells events, OGP wells competencies).
– Aims of WOCRM course and topics to follow.

Skill 1: Situation awareness

The aim of this module is to give the participants an understanding of the concept of situation awareness, component skills and influencing factors. Typical situations relating to wells operations (e.g. OGP wells incidents database) could be presented for trainees to practise identifying cues, forming an understanding and anticipating how the situation could develop.

– Definition of situation awareness (e.g. developing and maintaining a dynamic awareness of the situation and the risks present during a wells operation, based on gathering information from multiple sources from the task environment, understanding what the information means and using it to think ahead about what may happen next).
– Its application to wells personnel (e.g. well control events showing situation awareness problems).
– Component skills: gathering information, comprehension of situation and risk status (forming a mental model) and anticipation (projection). Situation awareness three-stage model (e.g. Endsley, 2000). Dynamic risk assessment (e.g. Tissington, 2005).
– The causes and symptoms of situation awareness problems (e.g. inattention, distraction).
– Recognising and combating situation awareness problems.

Skill 2: Decision making

This module examines individual decision making. It can describe different ways of decision making, and outline the well control situations to which each type is applicable and factors which have a detrimental effect on decision making. Decision making exercises based on wells scenarios can be used for practice and discussion. It should be acknowledged that some roles have more significant decision making responsibilities than others.

– Definition of decision making (e.g. skills for diagnosing the situation and reaching a judgement in order to choose an appropriate course of action).
– Problems in wells operations with decision errors (e.g. confirmation bias, fixation).
– Component skills (assessing the situation (problem, time, risk) then choosing a course of action, and reviewing the outcome).
– Different modes of on-task decision making (e.g. slower analytical, comparing options vs. procedure-based vs. faster, gut feel, intuitive, pattern matching method) and suitability for different situations.
– The human memory system and how it influences decision making.
– Workplace factors affecting decision making.

Skill 3: Communication

This module focuses on the critical role of communication for safe and efficient wells operations and the factors that influence it. Particular emphasis should be given to feedback, listening, briefing and assertiveness. Communication skills relevant for wells operations could be practised with feedback provided. This module should cover communication issues both on an installation, and with off-site personnel.

– Definition of communication (e.g. skills for the exchange (transmission and reception) of information, ideas and feelings, by verbal (spoken, written) or non-verbal methods).
– Requirements of good communication: examples of problems in well operations relating to communication problems in the crew, with the 'beach' and with the other shift.
– The advantages and disadvantages of one- and two-way communication; the importance of feedback; briefing and debriefing; handovers.
– Internal and external barriers to communication.
– Maintaining effective listening skills.
– Assertiveness, and how it can be achieved in communication.

C.2 DAY TWO

Skill 4: Teamwork

In this module, teamwork is examined for well-crew members. The focus is on key skills that help a team work well to achieve smooth task execution, safe operations and job satisfaction for team members. Team-based exercises can be used to illustrate key points or to practise relevant behaviours. This module needs to encompass team issues both within and between teams.

– Definition (e.g. skills for working in a group, in any role, to ensure joint task completion, these include co-ordination, co-operation and conflict resolution).
– Failures in teamwork leading to incidents; characteristics of high performing teams.
– Who is 'the team' in a wells operation?
– Understanding one's own role within the team.
– A teamworking model could be used to illustrate factors influencing group behaviour.
– Maintaining a 'shared mental model' across members of the team (being 'on the same page') and with the team on the beach/other shift/incoming ('back to back') crew.
– Skills for effective team co-ordination, co-operation and conflict resolution.

Skill 5: Leadership

While only some wells personnel are in team leadership positions, it is suggested that this topic should involve team members as well as supervisors. The focus in this module is on leadership and supervisory skills for managing a crew working on wells procedures and related operations. Leadership exercises with or without a team can be used to coach relevant behaviours.

– Definition: (e.g. skills for directing, managing and supporting a team in order to accomplish tasks for set targets).
– Good leadership and typical problems relating to inadequate leadership.
– Directing the team: what works effectively?
– Setting and maintaining standards.
– Supporting the team and individual team members, especially in remote work locations.
– Liaising with other onsite and offsite managers and specialists.

Skill 6: Understanding performance shaping factors – fatigue and stress

Participants will gain an understanding of how performance shaping factors such as fatigue and stress (acute and chronic) can affect job performance and individual health. The module should cover how to recognise the symptoms of stress and fatigue in themselves and others, and techniques to cope with these factors.

– Definitions of fatigue and stress (acute and chronic) and how they can affect task performance.
– Circadian rhythms and sleep patterns.
– Causes and effects of stress at work.
– Avoiding, reducing and coping with fatigue and stress.

ANNEX D
HUMAN ELEMENT, LEADERSHIP AND MANAGEMENT (HELM) MANAGEMENT LEVEL COURSE

This annex provides information on the marine sector human element, leadership and management (HELM) management level course, courtesy of WrightWay Training Services.

D.1 OVERVIEW

The Manila amendment to STCW has mandated human factors training for seafarers and as an approved Maritime and Coastguard Agency (MCA) training provider, WrightWay has been accredited to deliver HELM courses at the management level globally. As such, its HELM (M) course meets the syllabus requirements laid down by the UK Merchant Navy Training Board (MNTB).

The training examines the crucial role human factors play in high-stress, high-risk environments and encompasses team training, as well as simulation, interactive group debriefings and improvement of crew performance. From a practical standpoint, the HELM programme educates crews about the limitations of human performance. Trainees develop an understanding of cognitive errors, and how stressors such as fatigue, emergencies, and work overload contribute to the occurrence of errors. The course typically requires participants to assess both personal and peer behaviour through case studies and experience. Emphasis is placed on integrating the concepts into daily working routines, which minimise the influences of human factors in incident causation.

D.2 COURSE DESCRIPTION

- A five-day multi-activity course that provides delegates with a programme of approved training to use leadership and managerial skills to control the operation of the ship and care for persons on board at the management level.
- The Management Level course is designed to comply with the requirements as set out in the IMO mandatory requirements in Tables A-II/2 and AIII/2 of the Manila amendments to the STCW convention and code 1978, as amended (2010).
- The course meets the management level syllabus requirements contained in the MNTB syllabus and as accredited by the MCA.

D.3 COURSE AIM

- The emphasis throughout the course is to develop understanding of human factor concepts and understanding of how managerial actions influence, for good or ill, the practical application of those concepts. This understanding, properly applied, then enhances the safe operation of the ship and the care of all persons on board.
- Aimed primarily at senior officers and those seeking management level certification, this course also provides invaluable training for shore-based staff and non-deck or engineering personnel, such as pursers or hotel services people.

D.4 COURSE DURATION

- Five days comprising:
  - 18 hours' classroom-based facilitated instruction;
  - 14 hours' simulator-based facilitated practical activity, and
  - three hours individual case study analysis.

ANNEX E
NOTECHS FRAMEWORK FOR ASSESSING A PILOT'S NON-TECHNICAL (CRM) SKILLS IN THE AVIATION INDUSTRY[4]

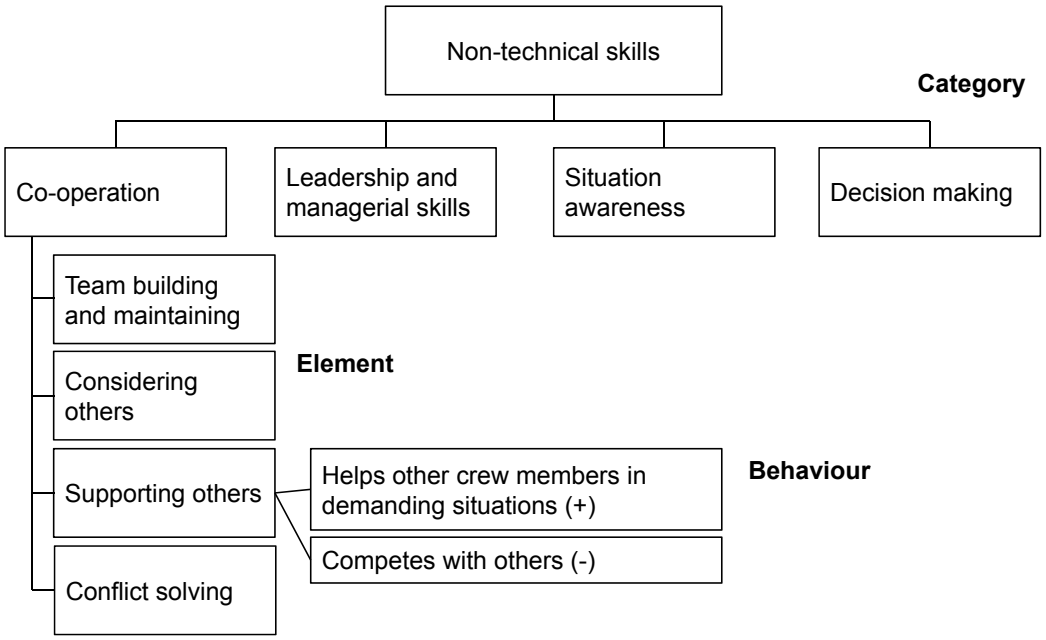

Figure E.1: NOTECHS descriptive framework

The NOTECHS system is a means of assessing a pilot's non-technical skills, developed for the aviation industry. The system involves developing examples of 'behavioural markers' – observable behaviours (either negative or positive) for each identified 'element' of each category of non-technical skill. Figure E.1 illustrates this, showing two of the possible observable behaviours for an element ('supporting others') of the 'communication and teamwork' non-technical skill. (Note, the behaviours are illustrative only). Pilots' non-technical skills are then assessed against these elements and categories.

There are five operational principles that were established by the system designers to ensure that each crewmember (pilot) receives as fair and as objective an assessment as possible with the NOTECHS system:

1. **Only observable behaviour is to be assessed**
   The evaluation must exclude reference to a crewmember's personality or emotional attitude and should be based only on observable behaviour. Behavioural markers were designed to support an objective judgement.
2. **Need for technical consequence**
   For a pilot's non-technical skills to be rated as unacceptable, flight safety must be actually (or potentially) compromised. This requires a related objective technical consequence.

4 Flin et al. (2003)

3. Acceptable or unacceptable rating required

Airlines must indicate whether the observed non-technical skills are acceptable or unacceptable.

4. Repetition required

Repetition of unacceptable behaviour during the assessment must be observed to conclude that there is a significant problem. If the nature of a technical failure allows for a second attempt, this should be granted, regardless of the non-technical rating.

5. Explanation required

For each category rated as unacceptable the examiner must:

a) indicate the element(s) in that category where the unacceptable behaviour was observed;

b) explain where the observed non-technical skill (potentially) led to safety consequences, and

c) give a free-text explanation on each of the categories rated unacceptable, using standard phraseology.

ANNEX F
NOTSS: NON-TECHNICAL SKILLS FOR SURGEONS – ASSESSMENT FORM EXAMPLE

University of Aberdeen and Royal College of Surgeon of Edinburgh (2006), *NOTSS: Non-technical skills for surgeons*

Category	Category rating*	Element	Element rating*	Feedback on performance and debriefing notes
Situation awareness		Gathering information		
		Understanding information		
		Projecting and anticipating future state		
Decision making		Considering options		
		Selecting and communicating option		
		Implementing and reviewing decisions		
Communication and teamwork		Exchanging information		
		Establishing a shared understanding		
		Coordinating team activities		
Leadership		Setting and maintaining standards		
		Supporting others		
		Coping with pressure		

* **1** Poor; **2** Marginal; **3** Acceptable; **4** Good; **N/A** Not applicable

1 Poor	Performance endangered or potentially endangered patient safety, serious remediation is required. Skill may have been required but was lacking.
2 Marginal	Performance indicated cause for concern, considerable improvement is needed.
3 Acceptable	Performance was of a satisfactory standard but could be improved.
4 Good	Performance was of a consistently high standard, enhancing patient safety; it could be used as a positive example for others.

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