



Best Practice Guidance on Teamworking and Safety

Final Report

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1 Executive summary

The guide to teamworking and safety is designed to inform readers in educational establishments and commercial organisations in the European process industries. It sets out to provide information on the state-of-the-art in teamwork theory and practice across industry domains to enable this information to be used to improve safety performance.

2 About this guide

This Application Guide to the safety implications of teamworking is one of the documents forming part of the Process Industries Safety Management (PRISM) Thematic Network on Human Factors co-ordinated by the Project Co-ordinator, the European Process Safety Centre (EPSC). The Guide has been produced by The Keil Centre Ltd, one of the two Principal Contractors of Focus Group 1. The other Principal Contractor of this Focus Group is John Ormond Management Consultants Ltd.

The production of guidelines on the safety implications of teamworking and their management was a sub-objective of Work Package 1 (Cultural and Organisational Factors) of the PRISM programme.

The guide is aimed at industry, educational establishments and commercial organisations in the European process industries. It sets out to provide information on the state-of-the-art in teamwork theory and practice across industry domains to enable this information to be used to improve safety performance.

The remainder of this document is set out as follows:

Section 3: An introduction

Section 4: Defining teamwork

Section 5: Potential benefits of teamworking

Section 6: Defining teamworking approaches in the process industries

Section 7: Identifying the links between teamworking and safety

Section 8: How poor team performance can affect safety

Section 9: How working in teams can reduce accident risk

Section 10: How to improve both teamworking and safety through addressing situational awareness, planning and decision making, workload, human error, communications, stress and emergency response.

Section 11: A summary of interventions to improve team safety performance

Section 12: Assessing the performance of teams

Section 13: Conclusions

Section 14: References

3 Introduction

Successful teamwork is achieved when the output of the team is greater than that which could be achieved by the sum of the efforts of the individual team members acting in isolation - a process known as synergism. Synergism is produced by interaction between team members, whereby each individual is empowered and encouraged to contribute in the most effective way to the overall task of the team. Interaction is unlikely to occur, however, unless all individual members of the team fully understand their role within the group and how this role may vary depending on the circumstances under which decisions are being made and action taken. Consequently, good communications within the team, a high degree of situational awareness and a comprehensive understanding of the decision-making process by all members of the team are all prerequisites for the creation of synergy and the effective performance of the team as a whole. For operational reasons, many team members form part of a new team on every shift, so it is important that the overall organisation culture encourages and fosters a climate in which good teamwork can flourish.

4 What is teamwork?

Teamwork is a set of behaviours that two or more people demonstrate when working collaboratively or co-operatively on some common task or pursuing some common goal. Teamwork involves communicating, being aware of each other's actions and how they affect the working environment and making use of each other's competencies and expertise to make decisions and solve problems.

Teamwork can be described both in qualitative and quantitative terms. Qualitatively, teamwork exists when two or more people are closely knit around a common purpose, work easily together, exhibit a good level of trust toward each other, respect each other and have positive work relationships. In quantitative terms teamwork can produce a specified result or perform a specified task that could not be achieved by one person alone. Teamwork therefore encompasses the quality of the process (i.e. how well team members work together) and the quantity and / or quality of the resulting product.

5 Why implement teamworking?

Teamwork is used by organisations for improvements in five key areas:

- 5.1: Productivity**
- 5.2: Quality and innovation**
- 5.3: Taking advantage of opportunities offered by the use of new technology**
- 5.4: Motivation and commitment**
- 5.5: Improving health and safety performance**

5.1 Improving productivity

Teamworking can help to make more effective and efficient use of personnel, which helps to increase productivity in several ways:

- Maximises the different strengths and skills of team members to allow a greater variety of tasks to be tackled;
- Delegates the order and allocation of tasks to the group;
- Devolves some managerial control to the work group or the team leader to reduce the number of levels of management;
- Encourages employees to undertake a wider range of tasks making team members more directly accountable to customers.

Teamworking may also present difficulties as traditional promotion paths and demarcation lines are threatened. These difficulties are sometimes compounded when the pressure to drive down costs to maintain competitiveness leads to the need for reductions in the workforce at the same time as teamworking is introduced. If the full benefits of teamworking are to be gained, its introduction must be carefully handled.

5.2 Improving quality and innovation

Establishing quality and customer satisfaction is at the top of the agenda for most companies and has been the driving force behind many teamworking initiatives. Staff involvement can make a major contribution to improved quality.

Increased autonomy together with training in diagnostic and problem solving techniques allows teams to take more responsibility for quality. This can lead to reductions in waste, a move towards continuous improvement and product or process innovations. Where teams develop their own recommendations for improvements or solutions to problems, they are much more likely to implement them successfully.

5.3 Taking advantage of technology

Traditional mass production techniques required large numbers of identical products to be produced in order to be economical. In such cases jobs tended to be broken down into simple tasks, but this is not necessarily suitable for modern ways of working. New technologies mean that workers need to be more flexible, to co-operate with other workers, supervisors and managers throughout the organisation, to operate sophisticated technology and to be more adaptable. The complexity of new technologies places them beyond the expertise and control of any one individual. In these circumstances, some form of teamwork becomes not just desirable but essential.

5.4 Improving motivation and commitment

Traditional production line work was characterised by monotony and boredom, with jobs broken down into small repetitive tasks requiring little skill and resulting in minimal job satisfaction. Motivation levels tended to be low and there was a need for close supervision.

Modern production and service industries require workers who, apart from being multi-skilled and well trained, are able to make many of their own decisions. To do this properly, it is best for workers to be motivated by the desire to do a good job and be recognised for their contribution to a successful organisation. This has led to a new emphasis on redesigning jobs to provide greater job satisfaction and improved quality of working life.

The organisation of work into teams provides an opportunity to fulfil many of the principles of good job design. These include:

- Variety of tasks and skill requirements;
- Autonomy of the operator in deciding the order or pace of work;
- Identification of the individual's contribution to the whole job or a large part of the whole job;
- Responsibility for what is produced;
- Feedback on how the operator is performing;
- Constant opportunities for social contact and interaction with colleagues;
- Balanced workload through co-operative working;
- Reduced role ambiguity or conflict – the team has the opportunity to deal with problems associated with the division of responsibility. (It is important, however, that the team is not given an unrealistic idea of the extent of their authority);
- Sense of achievement through visibility of the finished product.;
- Changes to the required skill set for teamworking provides good opportunities for learning and development.

5.5 Improving health and safety performance

Clearly one of the major motivations for the implementation of teamworking in an organisation is the prospect of improving health and safety performance. One recent study (Hechanova-Alampay & Beehr, 2002) investigated the correlation between teamworking and safety performance. This study found a negative correlation between the level of self-management and both unsafe behaviours and team injuries. The results of this study suggest that the more self-managing a team is, the safer that team will work. Although studies such as this are able to identify apparent links between teamwork and safety performance, few explain why this is the case. Are there, for example, certain aspects of working as part of a team that affect safety performance more than others?

Parker and Turner (in press) summarise the results of a number of studies examining the relationship between teamworking and improving health and safety. Such studies suggest that the main benefits of working as part of a team are:

- Involvement in safety activities;
- Task autonomy;
- Group processes (e.g. group co-operation, planning and co-ordination, willingness to approach other group members);
- Co-operation between team and supervisor.

It is suggested that it is these qualities of teamwork that can lead to improvements in safety performance. This intuitively makes sense, especially when considered in conjunction with the literature on safety culture, which also suggests that employee involvement in safety is important for safety performance improvement.

6 Teamwork in the process industries

The implementation of teamwork initiatives in the process industries has been approached in a number of different ways by a number of different organisations. Some have changed their approach to teamworking without implementing a change in organisational structure, while others have taken steps to change the organisational structure to facilitate the change in working practices. Self-managed teamwork has been particularly popular in the process industries, and positive benefits have been noted in several organisations. The primary benefits seem to have been commercial in nature, with evidence in some cases that employee morale, motivation and sickness rates were beneficially affected.

7 Links between teamwork and safety

There is evidence from previous research in the fields of teamworking and safety that teamwork has a positive impact on safety within an organisation. Improved safety performance, in terms of the number of lost time accidents (LTAs) has been recorded in a number of studies examining the benefits of involving employees in teams to develop solutions to known safety issues. There is also research concentrating on teams working in operational settings which suggest that safety performance is higher when people work in teams rather than work independently. Such research suggests that the reasons for this are the increased levels of ownership, the increased levels and quality of communication, and an increase in the level of knowledge about other workers' tasks. This last point relates to the topic of situational awareness, which describes the maintenance of a 'picture' of the working environment, including the activities of co-workers and their progress towards their goals.

Research conducted jointly by UK industry and the UK Health and Safety Executive (HSE) identified that a strong, positive relationship can exist between self-managed teamworking and safety (HSE, 1999). A self-managed team can be defined as a high-performing team having technical skills, knowledge and a certain level of autonomy. They are appointed by management to manage themselves on the basis that they are most familiar with the tasks they perform, and therefore in the best position to manage them.

The HSE's evidence is drawn from a number of case studies from the mining, telecommunications, heavy engineering, manufacturing and petrochemical industries. The findings of these case studies suggested that removing self-management unnecessarily could have an adverse effect on safety. Also, when safety was a specific goal of introducing self-managed teams, then safety could be measurably improved. However, when safety is not a specific goal of implementing self-management, safety improvements will not necessarily be achieved, but safety will not necessarily suffer either. These studies also suggested that implementing self-managed teams in a new plant could lead to good safety performance. Overall, research findings suggest that the use of self-managed teams either has a positive or neutral impact on safety performance. Trist et al (1977) describe for example the introduction of self-managed teams in the US mining industry. Following implementation, safety behaviours were seen to have improved, with fewer safety violations. However, there does seem to be a lack of empirical research which has included safety performance data in the analysis of the benefits of self-managed teams.

8 Impact of poor team performance on safety

Research conducted by Sasou and Reason (1999) proposed a taxonomy of team errors and related this taxonomy to over 70 accidents across several industry sectors, including the chemical process industries, to present a convincing argument. They suggest that team errors fall into one of two categories, each of which has two sub-categories:

	Individual Error (no other personnel involved)	Shared Error (made collectively by some or all of the team members)
Independent	all information available is correct	all information available is correct
Dependent	part of available information is missing, incorrect or inappropriate	part of available information is missing, incorrect or inappropriate

As well as making the error in the first place, Sasou and Reason suggest that there are three ways in which the error recovery process can fail:

- Failure to detect (rest of team don't notice error and actions based on this error are carried out);
- Failure to indicate (error noticed, but not brought to the attention of the team, therefore actions based on the error may be carried out);
- Failure to correct (indicated errors are not corrected by the team).

A breakdown in teamwork can lead to the occurrence of individual or shared errors, or failures in detection, indication and correction, or both, leading to accidents.

Sasou and Reason quote an example of a power station control room team deciding that an alarm was false due to inconsistencies between two different alarm systems. In this case the error was shared because the team arrived at the erroneous decision collectively. It was also a dependent error because the information presented to them was inappropriate. In this example, the two alarm systems were physically separate and located in different parts of the plant. As a result, the control room team did not detect their own error for some time (failure to detect).

Generalising from this example, poor teamwork can impact safety both through the occurrence of errors made by individual team members, or by the team as a whole and through failing to detect, indicate or correct such errors when they occur.

Sasou and Reason's research identifies a number of characteristics of teams that tend to make errors. These can be used to inform the introduction of teamworking in the process industries. If any of the following characteristics are identified for a given team, then there is an increased likelihood that the team will make errors. These issues should be resolved in order to obtain safety benefits from teamworking:

- Deficiencies in communication (not keeping other members of the team informed and hence denying them the opportunity to detect errors);
- Excessive authority gradient (large difference between the authority level of one member of the team and others which can lead to junior members of a team accepting the decision of the senior member without evaluating that decision);
- Excessive belief in the abilities of other members of the team (ideas, opinions, decisions, actions, etc.);
- Excessive professional courtesy (reluctance to have a frank discussion with someone of equivalent rank);
- Excessive adherence (to own ideas, opinions, decisions, actions, etc.);
- Over-reliance (on indicators, warnings, etc);
- Inadequate resource / task management;
- Low situational awareness;
- Inadequate design of the human-machine interface;
- Low task awareness.

9 Using teamwork to reduce accidents

9.1 *Lessons from aviation*

The aviation industry led the way in researching teamwork in safety critical operations over 20 years ago. A number of reports were published revealing the primary cause of aircraft accidents at that time as flight crew errors (e.g. Foushee, 1984; Cooper, White and Laiber, 1980; Helmreich, 1987). Up until this point, the authorities and airlines tended to assume that all accidents occurred due to technical failures, but the recent introduction of cockpit voice recorders and flight data recorders resulted in the production of evidence to the contrary. These were not individual human errors such as forgetting a step in a procedure or pressing the wrong button. Instead, the sorts of errors that were causing accidents were those involving a breakdown in the ability of the cockpit crew to work coherently as a team. Detailed analysis of the problem pointed towards communication and co-ordination as the main aspects of teamwork that were prone to failure.

It was clear that something needed to be done which would help crews to manage their collective resources more efficiently and effectively, resulting in the inception of the term “Crew Resource Management” (CRM).

Several studies have shown that CRM has had a positive effect on aviation safety since its introduction, but the biggest causal factor for aircraft accidents remains human error, both individual and team-based. So how could the lessons learned from aviation be transferred to other industries? The following section describes CRM in more detail and explains how the approach could be adapted to improve teamwork across industry sectors. The CRM approach covers many of the attributes associated with good teamwork and therefore has been used as the basis for this guide.

9.2 Crew Resource Management (CRM) overview

CRM encompasses a wide range of knowledge, skills and attitudes and contextual factors including:

- Communications;
- Situational awareness;
- Problem solving;
- Planning and Decision making;
- Teamwork;
- Emotional Climate;
- Stress Management.

The elements which comprise CRM are not new but have been recognised in one form or another for many years. In the past, however, these terms have not been defined, structured or articulated in a formal way and CRM is an attempt to remedy this deficiency. CRM can therefore be defined as a team management system which makes optimum use of all available resources - equipment, procedures and people - to promote safety and enhance efficiency.

CRM is not principally concerned with technical knowledge and skills, but rather with the cognitive and interpersonal skills required to meet job performance requirements. In this context, cognitive skills are defined as the mental processes used for gaining and maintaining situational awareness, for solving problems and for taking decisions. Interpersonal skills are communication and a range of behavioural activities associated with teamwork. These skill areas often overlap with each other and also with technical skills requirements. Furthermore, they are not confined to multi-person teams, but also relate to single person operations where there is a need to interface with other operators remotely in order to perform their tasks.

Although originally developed as an intervention for cockpit crew, as the name suggests, the concepts behind CRM have been applied in a number of

different industries where teamwork has formed an integral part of safety related activities. Examples of such industries include Air Traffic Control, the nuclear industry, medicine and the offshore petrochemical industries (e.g. Flin & O'Connor 2001). In each of these examples the original concepts have been adapted slightly in order to fit more closely the operational requirements placed on teams in these specific domains.

9.3 Reduction in accident rates through CRM

A great deal of research has been conducted in the aviation industry to assess the effectiveness of CRM and decision making training programmes in terms of the reduction in human error and accident rates.

Worldwide there have been six government-sponsored, independent evaluations of such training programs. Specially trained observers placed subjects in a series of specific situations (e.g. rushing pre-flight inspections, or suggesting steep manoeuvres at low altitudes) and then recorded the errors on these judgement items. The experiments were "double-blind" in that the observers were not informed which subjects had received decision-making training, while subjects were unaware of the real purpose of the flights beforehand (e.g. subjects might be led to believe they would be evaluating new map designs).

The effectiveness of training varied widely depending primarily upon the comprehensiveness of the training (see Table 2). For the six studies, the improvement ranged from 8% in a voluntary, minimally structured, situation to 46% for a well structured, comprehensive, ground school environment with simulator training.

Table 2: Decision Making Training Experimental Evaluations

Sponsor/Subjects	Methods	Results/Researchers
Australian Gov't. Private Pilots	Manuals, Lectures, Flight Training	8% fewer errors (Telfer and Ashman, 1986)
Transport Canada Private Pilots	Manuals only	9% fewer errors (Buch and Diehl, 1983)
US FAA Private Pilots	Manuals only	10% fewer errors (Diehl and Lester, 1987)
US FAA Student-Pilots	Manuals, Lectures, Flight Training	17% fewer errors (Berlin, et al., 1982)
Transport Canada Civilian Cadets	Manuals, Lectures, Flight Training	40% fewer errors (Buch and Diehl, 1982)
USAF Instrument Students	Manuals, Lectures, Simulator Training	46% fewer errors (Connolly and Blackwell, 1987)

These experimental evaluations provide strong statistical evidence that such training can change team safety performance, and thereby reduce pilot error. But the fundamental criteria for evaluating the effectiveness of CRM training programmes is their ability to reduce the accident rates in the broader "operational world."

Bell Helicopters Textron Inc. (BHTI): This major rotorcraft manufacturer provides extensive initial and recurrent training in both the US and abroad. They have utilised decision-making materials in their training programmes since they were first published.

They have also developed a "Cockpit Emergency Procedures Expert Trainer." Fox (1991) described this system as an artificial intelligence based software package which allows a pilot to use a personal computer as a Decision-Making simulator.

The results of BHTI decision-making training efforts are impressive, especially when their accident rates are examined. Fox (1991) compared the 1983-1986 period (before training was begun) with the 1987-1990 period. The worldwide human error accident rate (per 100,000 hours) declined by 36% for the Bell Jetranger. Note for comparison purposes, the rate for mechanically caused accidents declined by only 8%.

Petroleum Helicopter Inc., (PHI): This organisation is the largest commercial helicopter operator in the US with approximately 300 helicopters and fixed-wing aircraft. The company historically has had an excellent accident rate, well below the industry average. The results of the using of decision making / CRM training show a reduction in the accident rate from 2.3 accidents per 100,000 flight hours between 1980 and 1986, to 1.86 in 1987 and 1.05 in 1988. Decision making training started in 1986, and was the only change made to their training syllabus. This translated to a 54% reduction in their overall accident rate.

US Navy: In 1986, the Naval Safety Center reviewed the CRM programmes which were underway at several airlines and the USAF Military Airlift Command. They began formal CRM training at all Navy and Marine Corps helicopter training units in 1987. CRM was then initiated in some fighter-bomber training units in 1988.

Aircrew error rates for helicopter fixed-wing communities declined dramatically after the introduction of the new training. For fighter-bombers, their 1990 aircrew error rate for all mishaps was 1.43. Compared with their 1986 rate of 7.56, this represents an 81% improvement. Similarly, for their helicopters, the 1990 rate of 5.05 versus-the 1986 rate of 7.01 represents a 28% improvement.

USAF Airlift Command: The safety record for the five fiscal years before CRM (1981-1985) was compared with the five years (1986-1990) after they adopted this training. The total number of aircraft destroyed dropped from 21 to 10 (a 52% improvement). This improvement far outpaced the rest of the USAF which saw the number of aircraft destroyed decrease by 18%.

Table 3: Decision Making / CRM Operational Evaluations

Organisation/Subjects	Materials	Accident Rates
Bell Helicopters Inc. World-wide, Jetranger Pilots	Decision Making	36% Decrease
Bell Helicopters Inc. US Only, Jetranger Pilots	Decision Making	48% Decrease
Petroleum Helicopters Inc. Commercial Pilots	Decision Making & CRM	54% Decrease
US Navy All Helicopters, Crewmembers	CRM	28% Decrease
US Navy A-6 Intruder, Crewmembers	CRM	81% Decrease
US Air Force MAC Transports, Crewmembers	CRM	51% Decrease

Conclusion: There is a strong body of research evidence from the aviation industry to indicate that significant reductions in errors and accidents can be made through the implementation of CRM to improve team performance. Although this research originates in a different domain, these findings are highly relevant to the process industries, particularly when considering the effective handling of process upsets or emergencies.

10 Improving teamwork and safety

In the previous three sections, research into self-managed teams, team errors and CRM have been discussed. A number of similarities from these three independent streams of research exist relating to the characteristics of effective self-managed teams, low error teams and effective CRM. By drawing together these characteristics, it is possible to provide an indication of the features of safe teams, as illustrated in Table 4.

Table 4 shows five features were considered important in all three streams of research, namely:

- Team composition – the team should be composed of personnel with similar levels of authority to avoid reluctance to question other team members' actions and unrealistic belief in the capabilities of other team members;
- Teams should have pre-defined objectives and boundaries to their tasks with responsibilities of team members clearly defined;
- Team members should be involved collectively in planning, problem solving and decision-making. Individuals should show an appropriate level of adherence to their own ideas and decisions (i.e. should not allow themselves to be led blindly by other team members and should not try to lead other team members without allowing them to consider all sources of information);
- Teams should hold the responsibility for task and resource management;
- Team communications should be adequate considering the tasks being performed.

Good levels of task and situational awareness were identified as important factors by two of the three streams of research.

Table 4: Features of Safe Teams

Feature	Body of Evidence		
	Self-Managed Teams	Low Error Teams	CRM
Team comprised of peers (similar levels of authority, appropriate levels of belief in other members' capabilities, team members not afraid to question actions)	✓	✓	✓
Pre-defined objectives & boundaries, clear responsibilities	✓	✓	✓
Team planning, problem solving and decision making with appropriate adherence to own ideas, decisions, etc.	✓	✓	✓
Team responsibility for resource and task management	✓	✓	✓
Adequacy of communications	✓	✓	✓
Good levels of task and situational awareness		✓	✓
Interface between operators and systems (includes feedback on performance, Human-machine interface design and reliance on system indications)	✓	✓	
Team responsibility for identification & implementation of performance improvement	✓		
Effective stress management			✓

The following sections of this guide provide guidance on developing teams to embody these key features of safe teams.

To maximise their effectiveness, team members not only need to acquire a sound grasp of the technical knowledge and skills necessary for the fulfilment of their particular role, but they also need to understand and develop the cognitive and interpersonal skills which are a prerequisite for good teamwork. The nature of these latter skills, however, is such that they cannot readily be taught by the didactic training methods normally used to impart technical knowledge - methods sometimes referred to as 'chalk and talk'. Cognitive and interpersonal skills are mostly concerned with understanding and interpreting behaviour, particularly behaviour that occurs in a group context, so they are more appropriately developed through a process known as experiential learning. Successful experiential learning occurs when an individual reflects on his or her past behaviour in a given organisational situation and gains sufficient insight to form a rational basis for behaving in a more effective way when faced with similar circumstances in the future. Consequently, teamwork training should take place in groups and led by a trained facilitator who is equipped with the relevant knowledge, skills and techniques to foster the learning process. The performance standards required by CRM instructors have recently been defined in the aviation industry by an accreditation focus group under the auspices of the Royal Aeronautical Society. For both historical and practical reasons, CRM skills have up to now been taught separately from technical knowledge and skills, but the considerable area of overlap between the two disciplines suggests that the training would be more effective if it was integrated from the earliest stages of the training regime.

The following steps are considered essential to the successful introduction of a teamwork training programme:

- Agree competency standards;
- Agree trainer and examiner competency standards;
- Develop training programmes to ensure instructor standards;
- Develop training programmes to address competency standards;
- Develop and agree appropriate assessment methodologies;
- Ensure corporate cultures support the implementation of the above;
- Integrate or link training in technical knowledge and skills with training in teamwork skills at the earliest possible stage in training.

There are a number of practical approaches that can be taken to improve teamwork and safety performance based upon the lessons learned from the adoption of CRM and teamwork training programmes across a number of industry domains. Drawing the recommendations of these various programmes together, improving teamwork can be achieved through the following interventions, dependent upon the area requiring improvement:

- Situational Awareness;
- Planning and Decision Making;
- Workload;
- Human Error;
- Conflict Resolution;
- Communication;
- Stress;
- Emergency Response.

The following sections provide some guidance on improving team performance by addressing these factors.

10.1 *Situational Awareness*

Situational awareness involves conscious recognition of all the factors and conditions (operational, technical and human) which affect safe working practices. In order to establish situational awareness, human beings take in information through the 5 senses - touch, hearing, smell, sight and taste - and also sub-consciously or intuitively. This information is then transformed into a mental model of the situation. The perceptive process depends not merely on current information for its evaluation of the situation but also takes account of past experience and sensations. Perception is therefore a product not only of immediate sensations but also of cultural and social influences acquired through a lifetime of experiences. Accordingly, individuals interpret situations differently. Furthermore, they can also be unduly influenced by false information derived from the senses, such as illusions. Because of these factors, a high degree of situational awareness can be said to be achieved only when an individual's perception of events approaches the reality of the situation.

In complex systems such as petrochemical and process plants, the information from which situational awareness is derived comes from a variety of sources (e.g. instruments, observation, other team members, etc). The process of constructing an accurate mental model of current system status and the condition of other members of the team is therefore subject to a number of degrading influences. These may include inattention, distraction, under-arousal, stress, boredom and fatigue to name but a few. In these circumstances, confirming the accuracy of mental models with other team members by sharing information and perceptions about the situation, or by stating intentions, becomes of paramount importance in safe operations. Furthermore, sharing knowledge and information not only helps to avoid the

more obvious incidents and accidents arising from loss of situational awareness, but also lays a firm foundation for high quality decisions regarding the overall management of work. There are a number of process industry examples of how failings of team situational awareness and co-ordination have led to accidents. One of the most prominent is the Texaco Milford Haven explosion and fire. In this case the lack of an overview by the team of the situation was cited in the investigation as a significant contributory factor, which in turn was influenced by the lack of co-ordination within the team (see for example Loss Prevention Bulletin Issue 138).

Although situational awareness may differ from one person to another and may be partially the result of experience, personality, other inherent characteristics, and motivation, there are actions that team members can take that help build and maintain situational awareness.

In designing training to help team members' awareness and maintenance of situational awareness, the following considerations should be taken into account:

- Team members with different levels of experience are likely to define and conceptualise situational awareness differently. As people gain experience, they tend to expand their understanding of the factors that influence their awareness of the situation. For example, someone learning to drive a car will probably focus on information from their driving mirror and wing mirrors, and obvious indications from other drivers as to their intentions. A more experienced driver will also take into account environmental conditions, more subtle signals of driver intent (e.g. direction of gaze) and cues such as engine noise. Therefore:
 - (i) consider separate training for different experience levels;
 - (ii) ensure that instructors are aware of the possible differences;
 - (iii) carefully review existing materials for their relevance to the level of team member experience that will be represented in the training
- Design the course to emphasise the active role that team members must take to gain and maintain team situational awareness.
- Design all the course elements (information, scenario events, de-briefing guides) to reflect the same training philosophy and the same skills. That is, introduce an important element in the 'Information/Demonstration' phase of training and design 'Practice' to include that element. Follow up with specific Feedback on that same element.

Lessons learned from the aviation industry provide valuable guidance as to useful content for any training in situational awareness, such as:

- Inform trainees that approximately 40% of reported aviation incidents occur when only one team member has a problem with situational awareness. This suggests that team members need to monitor one

another and talk about the situation (as well as listen to one another) so all individuals in the team can maintain a level of situational awareness sufficient for the required tasks.

- Establish the importance of knowledge for gaining and maintaining situational awareness. There are three important activities for situational awareness: preparation, communication, and monitoring. All help maintain a high level of knowledge for a particular task.
- Emphasise the active role that team members need to take to maintain situational awareness. Most who study situational awareness agree that awareness is built by multiple situation assessments. That is, observing the situation as it unfolds, comparing each observation made with other observations, expectations and plans, and seeking more information.
- Refresh team members' knowledge with information about teamwork-related actions that help them develop and maintain situational awareness (e.g. leadership, communications, preparation, planning, and adaptability).
- Provide specific examples of leadership actions that help improve transfer of information. Leadership actions include those in which the team leader takes actions that help the team members become (and remain) a functioning team. These include making introductions and accepting input and suggestions from team members. They also include assigning tasks and re-assigning tasks to ensure no team member is overloaded.
- Discuss communication actions and how they may affect situational-awareness. Emphasise the importance of verbalising actions and intentions. By letting the other team members know what you are doing and what you are planning to do, two things may be accomplished: 1) the other team members are made aware of what is going on from your perspective; and 2) if your actions and intended actions are indicators that you are not performing effectively, it gives the other team members an opportunity to help forestall an ill-advised action. Good communications for situational awareness include confessing to a loss of awareness.
- Emphasise preparation and planning to ensure team situational awareness. This refers to personal preparation, familiarisation with procedures, knowing something about the experience of other team members (have they done this before?) and refreshing knowledge on the location of various items of equipment.
- Give examples of adaptability of team members and encourage team members to discuss how that affects situational awareness. Ensure that adaptability actions are observed in active practice and that they are debriefed. Team members have to be open to information that suggests their plans need to be changed. They need to be able to recognise when a plan is not working or not likely to work. This includes recognising that they need to alter their own tasks to assist a team member who may be having a problem.
- Demonstrate that planning, with preparation for possible contingencies, should encourage adaptability. Although developing a plan is crucial, not

being ready to deviate from this plan may interfere with awareness. A team committed to a pre-specified plan may not recognise information that suggests that the plan needs to be revised.

- Introduce the actions that can be observed and that indicate the level of a team's situational awareness. Follow up with practice and feedback. When a team is interacting, there are some actions that indicate the level of the team members' awareness. Researchers have identified three general actions that can be observed in team members that are related to situational awareness. These actions include identifying problems and potential problems; demonstrating knowledge of the actions of other team members; and verbalising actions and intended actions. Knowing these actions helps team members to assess their own levels of awareness and the awareness of the other team members. It also provides information on what can be done to improve awareness. By using a videotape of a team that displays these actions, team members can begin to see how those actions help keep one another alert to the situation.
- Present examples of how situational awareness in routine tasks is related to handling decisions that may be required as the result of an emergency. Monitoring the situation and checking to see if it is matching expectations, leads a team to detect an abnormal situation more rapidly. Having a high level of situational awareness when an abnormal situation occurs allows the team members more options in making decisions.
- Introduce team members to the idea that one of the main purposes of building a team is to reduce the consequences of human error. The team must be structured with clear leadership and roles so that it will not deteriorate into a group when under pressure, but not be so structured that it cannot be flexible. Aviation accident reports dramatically demonstrate that putting two or three people together in a cockpit does not make them into a team. Research in other industries has shown that when an abnormal situation occurs, often the team, designed to catch and reduce human error, functions less like a team with interdependent tasks and a common overall goal and more like a group of collected individuals. However, care must be exercised to ensure that the team is not too tightly structured. A team that has a rigid structure may not be able to respond to an abnormal situation.
- Emphasise that good team situational awareness helps reduce accidents caused by human error. Merely having more than one person present does not ensure that errors and accidents will be reduced. Individuals need to be encouraged and taught to work as a team and to carry out team processes that ensure team situational awareness.
- Give team members examples of basic problems in situational awareness and how those problems can be connected to classes of errors.
- Emphasise to team members when pointing out a loss of situational awareness to another team member, they need to consider the other person. What appears to you as a loss of situational awareness on the part of another may actually be your own confusion. Even if the other has

actually lost some awareness, by pointing this out with tact it reduces the chance of defensiveness or bad feelings and helps maintain the team.

- Inform team members of the need to be alert to certain situations that have been found to be particular threats to situational awareness. Situations that are particularly threatening to the maintenance of situational awareness include: high workload, breakdown in communication or co-ordination, occurrence of improper procedures, maintenance problem or equipment malfunction, unusual conditions and fatigued team members.
- Discuss the need of team members to find out about the experience level of others. This way, the team members who are more experienced will anticipate problems and be more alert to the awareness of the other team member. Unfamiliarity or lack of experience lowers the situational awareness of the team. They should also be encouraged to confess their own lack of experience in a situation. Humans have limited attention capacity. As we become familiar with tasks and situations, we tend to devote less attention to them and can be alert to other things. Someone who is not familiar with the task, the equipment, or the environment, for example, will have to attend closely to the unfamiliar and may not notice something else.
- Ensure that team members discuss how to overcome some of the effects of fatigue so that they may maintain awareness as a team. Communicating and co-ordinating as a team will help overcome the performance decrements caused by fatigue. When team members are fatigued they need to increase their efforts in communicating and co-ordinating with one another.
- Remind team members that often these problems don't occur in isolation and that two or more are usually combined in a situation. Often, high workload and an unusual problem combine to compel team members' attention. Fatigue causes attention to be lowered and this can lead to a problem if anything out of the ordinary happens.

10.2 Planning and decision making

In many industries, including aviation, decision-making has historically been seen as a skill that develops with experience rather than a skill that can be trained. A central aim of CRM is to ensure that high quality decisions are taken across the whole spectrum of tasks. In this context, thorough planning will not only provide a yardstick against which decisions can be made but will also allow all members of the team to manage successfully their own specific areas of responsibility. Understanding the plan also allows individual team members to contribute in the most effective way to decisions made. It is important, therefore, that the team leader updates the team members at regular intervals on any changes to the original plan, so that individual team members can maintain good situational awareness. This is particularly important during abnormal operations or in an emergency situation, where conditions affecting progress and safety are likely to change rapidly. (See also the work conducted under PRISM Focus Group 3 on the management of high-

demand situations). In these circumstances, regular updates on status allow each individual team member to be sufficiently aware of the situation and needs of the moment to contribute in the most effective way to the decision-making process.

Allowing subordinate team members to participate in the decision-making process does not mean that all decisions have to be made by committee. The degree of participation or otherwise from subordinate team members depends to some extent on the type of behaviour which underpins the decision. There are therefore three basic types of decision-making:

(i) Skill-based behaviours rely to a large extent on prior learning and any associated decisions are made mainly subconsciously. In this situation, other team members provide a passive monitoring role, although this may call for assertive intervention if the level of skill being displayed by the decision-maker falls below a safe standard. Experienced individuals tend to exhibit skill-based behaviours more than less experienced personnel, and therefore tend to make decisions by comparing the observed situation to their experience. This is known as Recognition-Primed Decision Making (RPDM).

- Good situational awareness is required for RPDM, to maximise the amount of information about the current situation. From this information, the experienced user can spot situational cues which give clues as to the courses of action that have worked in the past. The experienced operator can then retrieve from memory a few possible courses of action, the expected outcomes and goals and very quickly implement a plan of action. Checking assumptions and maintaining good situational awareness throughout is necessary in order to be able to react and adapt the approach if the initial solution is unsuccessful. RPDM tends also to be applied to rule-based situations, but may be supplemented by more in-depth analysis.

(ii) Rule-based behaviours rely on previously considered courses of action such as Standard Operating Procedures (SOPs), manuals, etc. The associated decisions are made largely with reference to previous experience and training, but also by comparing previous learning with the realities of the current situation. In these circumstances the participation of another team member may be required to provide verification of the situation and validation of the course of action being proposed by the decision maker. A typical example is the use of checklists in the cockpit of a passenger aircraft, where team members verbalise their decision making process and the other team member provides validation and verification.

(iii) Finally, knowledge-based behaviour is utilised in a situation which has not previously been encountered. In these circumstances, the team is called upon to make a decision based upon a rational appraisal of the facts, so there may be considerable scope for the involvement of other team members and - if time and circumstances permit - even outside agencies.

The degree of participation in the decision-making process also depends to a considerable extent on the organisational culture, as well as current social

norms. These factors include the team leader's perception of his or her role and authority, and the way in which this perception is shared by other team members and the various supporting agencies. In today's climate, team leaders who manage in an open and affiliative style, and who state their intentions from time to time, are more likely to secure the co-operation and participation of other team members than those who are overbearing and autocratic. Leadership style, however, is normally based on a perception of what the company or organisation expects from each individual team member, and effective CRM will therefore flourish only where an organisational culture exists which empowers and encourages subordinate team members to assist the team leader by participating appropriately in the decision-making process whenever the need for them to do so arises.

Training for decision-making will depend upon the circumstances described above. There are a number of interventions that can be used to improve individual and team decision-making, the main themes of which are:

- Use of heuristics;
- Metacognition (how to think);
- Perception;
- Pattern recognition.

These themes break down into two broad training strategies, namely:

- Attempt to teach novices to work like experts; and
- Attempt to keep novices safe until they learn to think like experts from experience.

The best approach may be a hybrid strategy: accelerate the transition from novice to expert whilst teaching rules to keep the novice safe. There are several characteristics that a training system for decision-making should possess.

In practice, people become experts in a domain and learn to make good decisions by watching others (modelling) and through reinforced practice. Individuals are more likely to develop good decision-making skills in environments that pose a variety of problems that have solutions with clear and immediate consequences. Under these conditions, individuals may not only learn solutions to a wide variety of problems but also how to solve new problems.

Programs intended to improve judgement and decision-making may be designed to either mimic a natural environment that is conducive to learning decision-making skills and/or they may be designed to teach the skills directly. In the latter case, the programme may be designed to teach general decision-making skills or to focus on a particular domain. The third option is teaching the students rules that will keep them safe while they learn decision-making skills on their own.

10.2.1 *Training to improve general judgement and decision-making skills*

The ancient Greeks believed that the study of mathematics improved reasoning. Roman thinkers agreed with them, and also endorsed the study of grammar as a useful discipline for improving reasoning. The medieval scholastics added logic, especially the study of syllogisms, to the list of disciplines that could formally train the mind.

The evidence for the utility of formal training in statistics, logic, or general decision rules (e.g., cost/benefit analyses) for improving judgement and decision-making is mixed. For example, training in statistics appears to improve individuals' reasoning on some problems that rely upon statistical concepts (e.g., Fong, Krantz, & Nisbett, 1993) but not on others. The central problem with this type of training is that people frequently have difficulty realising when the concepts apply (Jepson, Krantz, & Nisbett, 1993).

Training in general decision-making principles may be useful, but only if it is accompanied by instruction that clearly connects the general principles to real-life problems.

There have been several systematic attempts to develop and assess training programs designed to provide training in judgement and decision-making. Some of the best have been in aviation (e.g., Buch & Diehl, 1984, Wignins & O'Hare, 1995). Many of these programs have been successful in improving decisions. For example, Buch & Diehl (1984) demonstrated that students who had participated in a flight training programme that integrated decision training into both classroom and flight regimens made better flight judgements on a post private test flight.

In general, for decision training to be effective, it appears to require hands-on practice in addition to formal instruction (Schaafstal, 1993). Training that emphasises the perceptual aspects of the tasks also appears to enhance learning and performance. Individuals who are given training in recognising relevant cues and ignoring irrelevant cues tend to learn faster and to work better under time pressure (Gaeth & Shanteau, 1984; Kirlik et al., 1996).

10.2.2 *Model Training Programme*

Clearly the current state of knowledge regarding training in decision-making is insufficient. A great number of questions must be answered before a decision-training programme that is based firmly on scientific findings can be developed. However, it is possible to briefly sketch an outline for a decision-training programme here, based on what is known about human decision-making.

10.2.3 Some Criteria

The programme should be broad. Decision training programs should include training in all components of the decision-making process: assessment, decision, and consolidation.

Immediate feedback should be provided to trainees in order to encourage them to assess their own degree of success as training progresses. In cases where an individual has not been successful, encourage them to identify potential reasons for their lack of success.

The programme should be eclectic. Because situations vary on factors that affect the effectiveness of different decision strategies, decision-training programs should include training in more than one decision strategy.

Training in decision-making strategies should be approached with caution. Such training could encourage students to act like experts before they have all of the requisite knowledge and ability. For example, experienced pilots are sensitive to cues that they have made an error of judgement. Students may be able to learn to recognise situations and implement solutions before they are able to detect evidence that they have erred. If this were the case, this training could have hazardous consequences.

The programme should be adaptable. Individuals vary on factors that affect their ability to learn and utilise different decision strategies. Therefore, decision-training programs should either be adaptable to the needs of different students or thorough enough to offer training in different decision strategies sufficient for most students to learn to use more than one strategy.

The programme should be domain specific. Although there is some evidence that individuals may benefit from generalised decision training, there are enough negative findings to argue in favour of domain-specific training. The design of each training module should be driven by the decisions that must be made in that particular area of practice, the situational cues to which the individual must attend, and the factors or concepts which may be deceptive or difficult to understand.

The programme should include a mixture of direct instruction, modelling, and reinforced practice. The most effective method for training decision-making appears to be “hands-on” practice but the most efficient methods involve direct instruction and modelling. Some combination of methods would probably provide the most cost-effective mix.

The programme should include practice under varied conditions. Because decision skills may not readily transfer from routine environments to situations where there is time pressure or emotional stress, practice in making decisions under these conditions should be provided.

Decision-training should be integrated into the technical training curriculum. Exposure to situational cues improves the speed with which domain-specific

analytical and associative decision strategies are learned and it improves the resilience of this training to time pressure and probably emotional stress. The simplest way to obtain this exposure is to integrate the decision training with other aspects of the curriculum.

Short and long-term effects of the programme should be evaluated. Programme evaluation could include pre- and post-testing, and perhaps evaluation of user's progress in successfully completing simulated activities.

Individuals learn good judgement through reinforced practice. Individuals who work in “decision-rich” environments with ample reinforcement and who have the requisite cognitive and affective processing abilities will be more likely to learn better decision-making skills and do so more quickly. Cognitive science research on aviation judgement suggests that training should address different types of decisions, stages of decision-making, emotional and cognitive elements of decision-making, and time management.

10.3 Workload implications

Working as a team can have advantages for workload levels for all members of the team by avoiding underload and overload situations, but this is highly dependent on the nature of the task that is being performed. Workload is a very powerful influence on the occurrence of errors, particularly in those sorts of tasks that are particularly demanding on mental resources. It is therefore advisable to understand the sorts of team tasks that are likely to have an impact on perceived levels of workload, and therefore on the occurrence of errors.

First, it is important to ensure that the types of task that are allocated to teams are actually suitable for collaborative working. The need to assign tasks to teams rather than to individuals is often identified when the scope of the task is extensive, and therefore too much for one person. This is, of course, a key consideration, but the degree to which a task can be meaningfully divided also needs to be taken into account. For example, building a house can be divided up into multiple parallel tasks, whereas carrying a heavy object cannot be divided into sub-tasks.

In reality, there are few tasks where a series of parallel sub-tasks can be defined and carried out by separate personnel who all come together when they have completed their assigned work. More often, individuals need to co-ordinate their efforts for the completion of a number of sub-tasks. It is the level of complexity of the task that in part determines this. The more complex a task, the more interconnectivity there will be between the components of that task.

The types of dependencies between sub-tasks can be divided into the following categories:

- Independent (can be divided into multiple sub-tasks completed by separate people);
- Redundant (must be done by all team members – e.g. reading procedures);
- Sequential (tasks that must be performed in a specified order, clearly defined co-ordination requirements);
- Mutually exclusive (tasks that can be performed in any order, co-ordination needs to be managed within the team).

There are differences in the workload implications in each of these cases. With independent tasks, if workload increases for any reason then it is pretty much like working alone – there will be little support unless more than one team member has the necessary skills to help. In more complex tasks when there is a high degree of co-ordination between team members, there is more potential for support. However, there is also potential for additional sources of workload. Co-ordination alone, on more complex tasks such as air traffic control, can significantly add to workload and can negate the effect of having others to support you. This is one reason why the development of good situational awareness in teams is essential. Good situational awareness allows team members to maintain a picture of each other's workload, and therefore to offer support when necessary.

10.4 Human error

In the section on situational awareness, the importance of teamworking and awareness for safeguarding against human error was discussed. The use of team members as safety nets for one another is something that should be clearly communicated to teams (e.g. teach production line operators to check each others' work). Good team situational awareness helps to reduce human error by ensuring that team members are aware of the activities of others and thus can act as safety nets. Teams and their members need to be capable of maintaining their level of situational awareness as a means of reducing human error.

Whilst situational awareness can help to reduce human error when working as part of a team, human error can disrupt the process of maintaining a good level of situational awareness. Researchers have developed different classification systems that connect situational awareness and errors. Two different approaches are given here as examples of those connections.

The first was described by Endsley (1995) and is a classification system built on her definition of situational awareness that includes three levels:

- Perception;
- Understanding;
- Projection.

At the first level, Perception, an error may occur because the team member simply fails to perceive the information. This may come about through problems in the environment (the information is not available) or it may be because the individual does not look for information that is available to him/her. This latter case can be the result of such things as a failure to divide attention, high workload or inexperience (for example the individual does not know that the information is needed).

At level two, Understanding, the individual may perceive the information but does not understand its significance. A simple example would be when a novice pilot is given information about cross winds at his/her destination and does not understand that he/she cannot land there. At a higher level of experience, team members may hear certain engine sounds and mis-interpret the problem.

Finally, at the third level, Projection, team members may correctly interpret the problem that they have but be unable to visualise how that will affect their task if certain conditions occur. In all of these cases, additional team members who are well trained and are actively engaged in the task should help in overcoming the problems.

A second scheme, developed by Rouse and Rouse (1983) breaks the handling of a system problem into six stages:

- Observation of the system;
- Choice of hypothesis (for what could be wrong);
- Testing the hypothesis;
- Choice of a goal;
- Choice of a procedure;
- Execution of the procedure.

At each stage, they describe opportunities for errors. Those that are closely related to situational awareness are mis-interpretation of readings; failure to observe; choice of hypothesis irrelevant to the situation; reaching the wrong conclusion; and required steps omitted. It should be clear that a team should be able to avoid some of these errors in many situations. If one team member, through inattention, or a failure to perceive the information that is available, mis-interprets an instrument reading, another should be able to interpret it correctly.

One aspect of teamwork and human error that has received scant attention (with the notable exception of Sasou and Reason, 1999) is the analysis of how human relations led to errors. The research of Sasou and Reason is discussed in Section 8 of this guide.

10.5 Communications

From the foregoing discussion on cognitive skills, it is evident that effective communication between team members is an essential prerequisite for good teamwork. Research has shown that in addition to its most widely perceived function of transferring information, the communication process fulfils several other important functions as well. It not only helps the team to develop a shared mental model of the problems which need to be resolved, thereby enhancing situational awareness, but also allows problem-solving to be shared amongst team members by enabling individual team members to contribute appropriately and effectively to the decision-making process. Most importantly, it establishes the interpersonal climate between team members and is therefore a key element in setting the tone for the management of operations.

The communication process invariably takes place in a social and organisational context and is therefore profoundly influenced by company culture. Its effectiveness also depends on the experience level of the team leader or team members involved in the transaction and their perception of their roles and position in the chain of command. The effectiveness of the communication process also depends on the nature of the task and operational context in which it is taking place. In addition, it is affected by the mode of speech employed and the linguistic context in which the transaction takes place. In this context, individual styles, body language, grammatical styles and speech patterns all have their part to play. Because of these complexities, team members need to be aware of and sensitive to the nuances of effective communication. They also need to understand and avoid where possible those elements which constitute a barrier to effective communication.

In order to establish effective communications the ability to share knowledge and experience with a positive attitude, the quality of listening skills, and the time dedicated to relationship building are essential factors. Effective communications facilitate the creation of a constructive work atmosphere where individuals can develop and work effectively. Staff who feel they are well managed are more likely to be engaged and be motivated to be an asset to the organisation.

10.5.1 Effective team communications training

Effective team communications training is focused on developing an understanding of individual styles of communication, and on providing tools to enhance team members' ability to communicate effectively. The aim is to provide team members with the opportunity to develop a framework that will support their communication style.

10.5.2 Training objectives

Effective team communications training should provide participants with:

- An opportunity to explore issues related to communications in the workplace;
- An opportunity to clarify the expectations of their roles;
- Strategies to enhance communications effectiveness in the workplace;
- Increased confidence in ability to establish positive work relationships;
- An opportunity to work together which could lead to the establishment of peer support.

10.5.3 Typical training content

Effective team communications training should include the following topics in order to deliver a well-rounded understanding of the topic area:

- Communication styles;
- Positive communication behaviour;
- Blocks to effective communications;
- Understanding and managing emotions;
- Listening skills;
- Coaching skills;
- Problem-solving skills;
- Dealing with conflict ;
- Application of concepts in specific work situations.

10.5.4 Format

There are a variety of training delivery formats available to organisations, but some of the more effective courses employ a mixture of training delivery techniques, e.g. a combination of presentation, group discussion, and skills practice. It is recommended that time to allow for skills practice be considered an essential part of any such training course.

10.6 Stress

A factor, which can quickly undermine morale, is stress - defined as a state of highly unpleasant emotional arousal associated variously with overload, fear, anxiety, anger and hostility - all of which threaten both individual performance and teamwork. Stress often arises as a result of a perceived gap between the demands of a situation and an individual's ability to cope with these demands. As stress involves the processes of perception and evaluation, it impinges directly on the cognitive and interpersonal skills which form the basis of good teamwork. Both arousal and alertness are necessary to enable each individual to achieve optimum performance in team skills, but too much or too little arousal will have a significantly adverse impact on the ability to function effectively as a team. It is therefore important for team members not only to be aware of the symptoms of stress in themselves and others, but also to understand the effects which stress can have on teamwork, and to mitigate these effects where possible by taking measures to counter them.

In high pressure situations, stress can be relieved by establishing priorities and by delegating tasks to other members of the team, but this technique can be successfully implemented only if an organisational culture has been established in the first instance which empowers subordinates by training them in the cognitive and interpersonal skills which will enable them to take on additional responsibility when the circumstances call for it. In a low-pressure situation, where fatigue, boredom and over-familiarity with the task are the greatest hazards, careful attention to environmental conditions such as heat, humidity noise, vibration and lighting can help to maintain alertness. Concern of individual team members for their own physical well-being by keeping fit and maintaining a healthy life-style, in so far as the demands of the job allow, will also help to ensure that they are best able to contribute to the team effort when the need arises.

10.7 Emergency response

A significant factor in emergency situations is the impact that stress will have on individuals and hence on the performance of the team as a whole. It is recommended that any teamwork development activities include training material designed to improve the understanding of the causes and effects of stress, recognising the signs of stress, and coping with the effects of stress.

Helping team members to understand the potential sources of stress in an emergency situation is a way of forearming them. If you can recognise the onset of stress yourself, and you know why it happens and how to combat it, then you have a greater chance of remaining effective than someone without this knowledge. Such knowledge also helps in dealing with others suffering from stress, by avoiding conflicts within the team, sharing highly stressful tasks within the team, etc.

Once more, maintaining a good level of situational awareness is essential to being able to spot the indicators of stress in other members of the team.

11 Summary of interventions

The preceding sections of this guide have provided a number of suggestions for improving team safety performance. Guidance has been provided on improving situational awareness, dealing with workload, improving communications, reducing human error, managing stress and dealing with emergency situations. In order to determine which of these aspects of teamwork require attention, it is necessary to assess team performance. Equally, team performance assessment is necessary following any such intervention in order to evaluate their effectiveness. The following section provides some guidance on the issue of team performance assessment.

12 Avoiding Pitfalls when Implementing Team Working

Earlier sections of this report have indicated many of the benefits, including improved safety performance, which can be achieved by the implementation of team working. In seeking to achieve these it is most important that management establish team working within an appropriate structure.

12.1 Planning

As with any other organisational changes, the introduction of team working requires careful planning. Factors which need consideration include the following:

- Workload, both total load & load on individual team members;
- Competence & experience of team members;
- Training needs;
- Communication with other teams;
- Communication with management;
- Resources for problem solving;
- Team roles and responsibilities.

The above factors need to be considered for both routine and non-routine operations. In general routine operations should not prove a problem but non-routine operations are likely to require more detailed consideration. Management must take account of both the practical and theoretical experience and expertise of the team, such as experience of infrequent start-ups or shutdowns, as well as the access to sources of expertise outside of the work team.

12.2 Limits to Authority

For safety critical tasks procedures must be clearly defined as well as the limits to the authority of the team. Too liberal or too restrictive an approach to limits of team authority can lead to problems, as illustrated by the following case studies.

12.2.1 Speciality Chemical Manufacturer

Management changes had been implemented on a site which involved 'de-layering' and an increase in the authority of the operational team. Operational problems resulted in a decision to remove build-up from the base of a still boiler, an operation which had not been carried-out before. Preparations were made by the operating team and work started which involved the heating of the residues. Within a few hours this led to overheating of the residues and a major fire with the loss of 5 lives. Whilst experienced in operations, the staff responsible for defining the procedure for cleaning the boiler did not have the relevant scientific training to assess the hazards and risks involved.

12.2.2 Piper Alpha

When the fire started on Piper Alpha, the platform was linked into a network of other platforms sending oil and gas to the onshore terminal. These linked platforms continued to send oil and gas to Piper Alpha. Offshore management on the other platforms did not feel that they had the authority to stop these flows and attempts were made to contact onshore management. When, after considerable delays, contact was made with the onshore management instructions were given to stop the flows immediately.

12.3 Control of Change

Whilst the skills and experience of the process team need to be fully utilised, procedures necessary for safe operation must be clearly defined by management. An open culture which raises problems and questions unnecessary procedures needs to be encouraged alongside the implementation of strict controls to ensure that changes to working practice and equipment are not made without the full consideration of all the implications and risks. This is likely to require input from management, specialist staff and from other teams.

Companies in the process industries will have in place 'Management of Change' procedures which will cover changes to equipment, working procedures, personnel and materials. Failure to follow such procedures can lead to problems as indicated in the following case study.

12.3.1 Fire following changes to procedures.

A site received materials from a number of sources. Following the introduction of team working the team was encouraged to question unnecessary procedures. This resulted in the discontinuance of some checks on the quality of materials being received without a detailed risk assessment being carried-out. Errors arising off-site resulted in incorrect materials being delivered, the error not being recognised until offloading had started. A major fire occurred, resulting in both onsite and offsite damage.

Whilst 'Control of change' procedures are required whether or not team working is implemented, it is most important that the need to follow such procedures continues to be emphasised.

12 Team performance assessment

There is no 'standard' for the assessment of team performance, how any individual organisation goes about this task will depend on the organisation's own performance requirements.

Having established a policy the first step in assessing team performance is to specify the performance indicators that will be used. In the case of assessing the safety performance of teams these will relate to operational and team safety performance within the organisation.

The next step is to specify the means of measuring team performance against the chosen performance indicators. Teams can be difficult to assess because of the complexity of interactions between team members and also with members of other teams or parts of the organisation. For this reason, it is recommended that any assessment of team performance should involve multiple forms of data collection. For example, supplement a survey with interviews, workshops, observation or reviews of team performance metrics to gather both breadth and depth of information. For the assessment of interpersonal relationships within teams, it is usually more beneficial to use observational measures which have a pre-defined rating system rather than to rely on subjective self-assessments from within the team. When deciding on the measures to be used, it is worth considering the requirements for training that this will generate (e.g. for observers, interviewers, analysts, etc) as an input to the planning process.

The Team Performance Questionnaire measures teams on a series of factors that have been shown to significantly affect achievement of performance targets. They are:

- Motivating task with effective feedback;
- Application of effort;
- Availability of adequate knowledge and skills;
- Development of appropriate task performance strategies;
- Quality of interpersonal relationships.

Team members complete a short questionnaire which results in a team performance score which translates to the likelihood that the team will be capable of meeting its performance targets. Guidance which accompanies the questionnaire helps the administrator to decide on the most appropriate intervention for low scores on any of these factors.

The Team Performance Questionnaire and a number of other measurement techniques for examining specific aspects of team performance are available via the Smartteams website (www.smartteams.co.uk). The Smartteams website was developed as a resource for the process industries and provides access to a wide range of advice and materials to help maximise the effectiveness of team-based working. It is a free resource which includes a toolkit covering the preparation, development and maintenance of effective teamworking. This toolkit is supplemented by case studies and lessons learned from a variety of process industries.

When considering individual membership of teams, the Teamwork-KSA test can be used to select individuals who have the knowledge, skills and abilities that facilitate good teamworking. These fall into the following categories:

- Conflict resolution;
- Collaborative problem solving;
- Communication;
- Goal setting and performance management;
- Planning and task co-ordination.

The Teamwork-KSA test has been validated against subjective ratings of team performance by managers and team members, but there is no indication from the developer as to whether it is a good predictor of objective performance measurements. Further details can be found at www.pearsonreidlondonhouse.com/tests/teamwork.htm

13 Conclusions

The concepts which underpin good teamwork are not new; rather they are an attempt to distil old axioms into a more coherent form. Safe and efficient operations depend for their success not merely on the acquisition of sound technical knowledge and skills but also on the mastery of the cognitive and interpersonal skills which form the basis of good teamwork. Cognitive skills not only allow for the development and maintenance of good situational awareness but also underpin high quality problem solving and decision making techniques. In addition, interpersonal skills, which depend for their effectiveness on good communications, encourage the creation of synergy and the development of successful teamwork. Both cognitive and interpersonal skills are enhanced by a good emotional climate, but they are also easily degraded by stress, so management of the emotional climate and stress becomes an integral and important element of good teamwork.

Currently, technical training and training in teamwork skills tend to be carried out separately. In view of the crucial part which each aspect plays in safe and efficient operations, both types of training need to be integrated. Moreover, teamwork training would be considerably enhanced if a satisfactory and universally agreed set of behavioural standards could be developed. To ensure that the training is effective, teamwork skills also need to be assessed in conjunction with the evaluation of technical knowledge and skills, although certain safeguards will need to be put in place until a satisfactory method of assessing teamwork skills has been devised and accepted.

Teamwork and CRM are not, therefore, merely an abstract management concepts. They embrace principles and skills which, if combined with a high degree of technical knowledge and skill, will enable the teams to make best use of all available resources to achieve optimum efficiency in the conduct of operations whilst at the same time maximising safety.

14 References

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