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## Identifying and Training Non-Technical Skills

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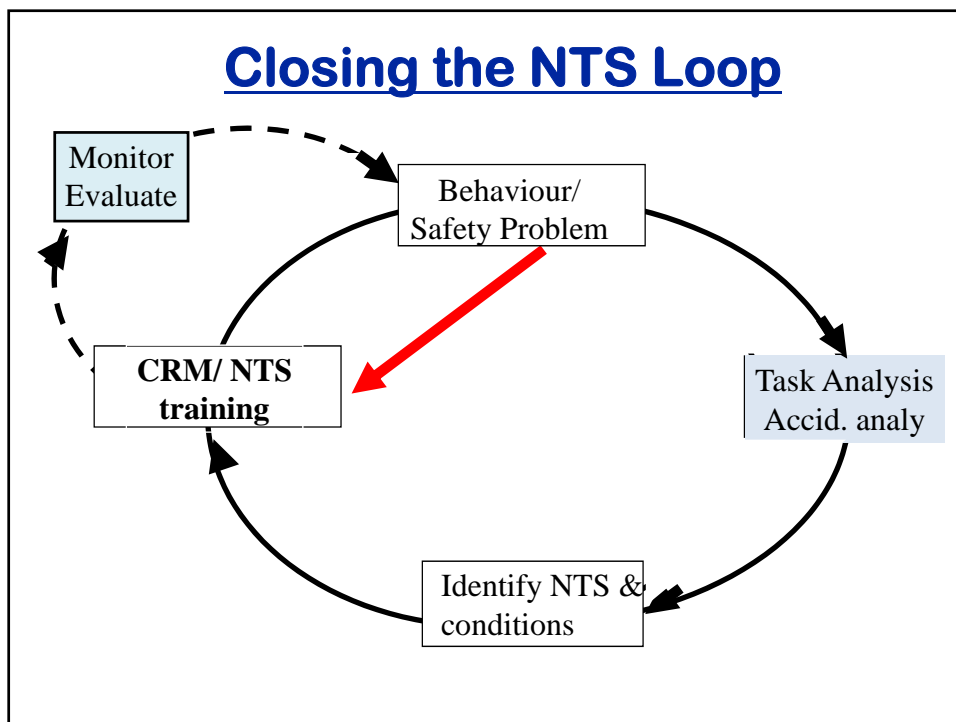
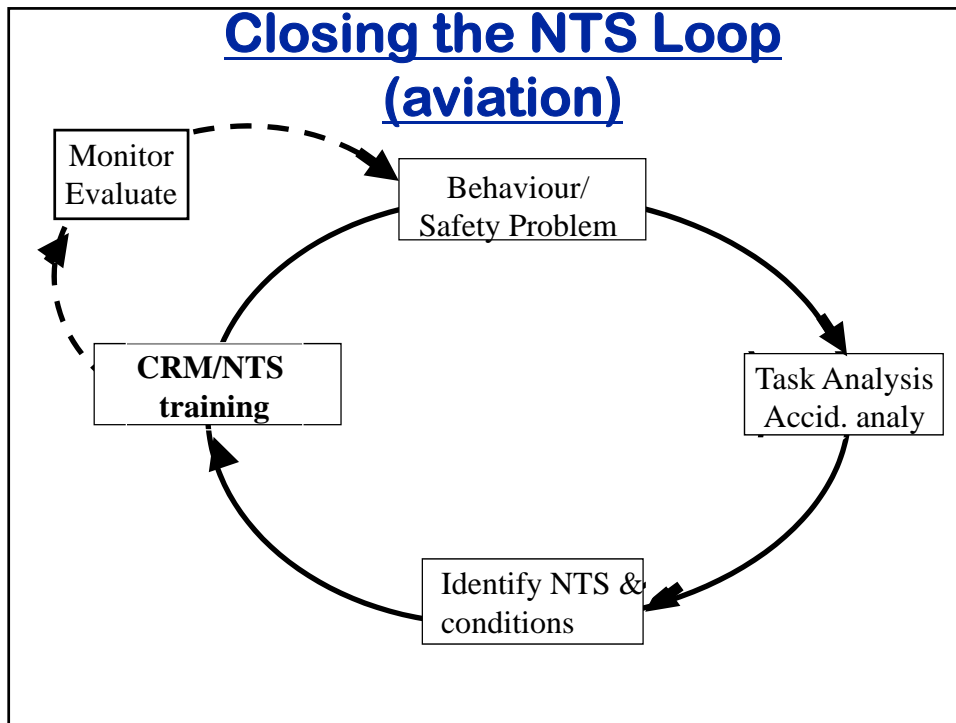
HFC Forum, Bergen, April 22-23 2015  
Training for Unexpected and Emergent Situations



## Non-technical skills



- Formally trained and assessed in aviation, nuclear and other industries
- Cognitive and social skills to reduce error/ enhance safety
  - e.g. decision making, situation awareness, team co-ordination, leadership
- Behaviour rating systems eg NOTECHS for pilots
- These have now been introduced for anaesthetists (ANTS), surgeons (NOTSS), scrub (SPLINTS) and anaesthetic practitioners (ANTS-AP), emergency physicians etc.
- Now being introduced in drilling for well operations
  - e.g. WOCRM (IOGP, 2014)



## Kegworth (1989)

British Midland, Boeing 737-400

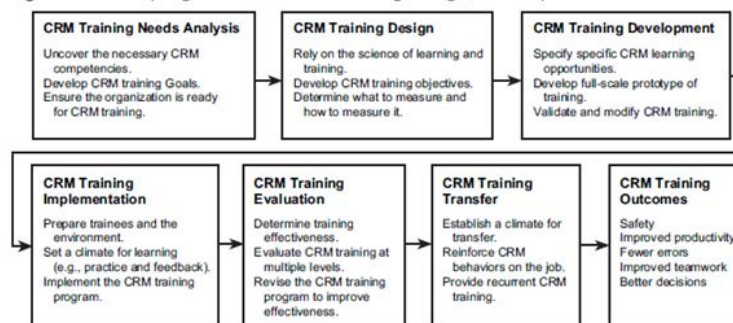
47 fatalities



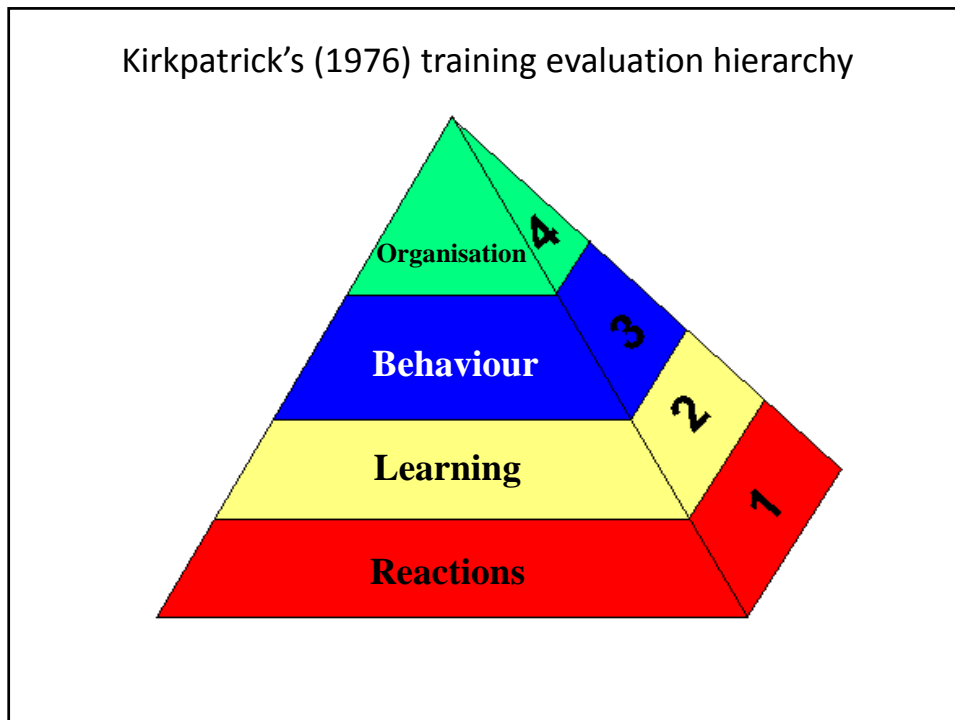
The Kegworth plane crash (where the pilots mistakenly shut off the good engine when the other was on fire) was such a strong demonstration that human error and teamwork failures were contributing to fatal accidents, that the CAA took the view that CRM had to be introduced.

## CRM Training Design Method

Figure 7.2 The progression of CRM training design, development and evaluation.



Source: (Adapted from Salas et al., 2006a)



### Evidence for CRM effectiveness

(Salas 2006; O'Connor 2008)

- Reactions to training
- Attitude shift
- Learning
- CRM skills (behaviour) measurement
- Organisational indicators eg accident data
- Accounts from pilots

*Results - limited empirical evidence but what there is, is positive*

## Pilots' Non-Technical Skills

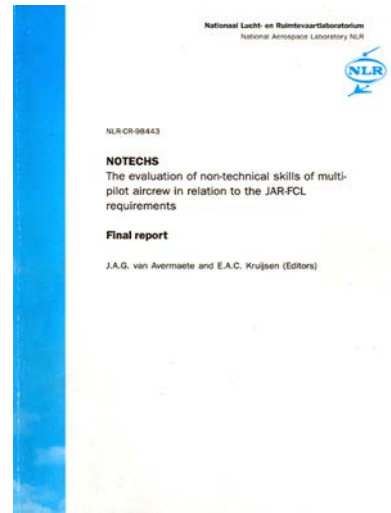
NOTECHS system (1998)

Pan-European

Behaviour rating method to assess a pilot's non-technical (CRM) skills.

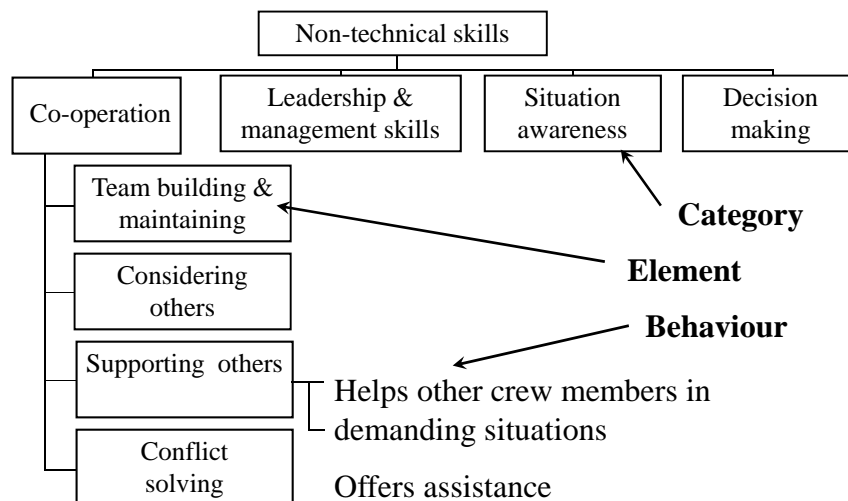
Recommended by CAA

Adopted by some airlines, adapted by others.



See also Flin, Goeters, et al (2003) *Human Factors and Aerospace Safety*, 3, 95-117

## The NOTECHS framework



## Pilots' Non- Technical Skills

- Term non-technical skills first used in European civil aviation (1990s).



**Non-technical skills are the cognitive and social skills that complement technical skills, and contribute to safe and efficient task performance.**

**Aka: Crew Resource Management (CRM) skills. Formally trained and assessed in aviation and nuclear industries**  
**Skills identified by:**

- Flight deck or simulator observations
- Interviews with pilots
- Surveys of pilots' attitudes, experiences
- Confidential safety reporting systems
- Accident analysis, especially analysis of cockpit voice recorder



### **Air France AF447**

### **Crash into Atlantic**

**2009**



Autopilot disconnection warning sounds.

One of the plane's externally-mounted sensors has iced over, which automatically turns off the auto-pilot.

**BONIN:**  
I have the controls.

**ROBERT:**  
Alright.

Bonin inexplicably pulls back on the stick, causing the plane to climb. The report issued Thursday by the Bureau d'Enquêtes et d'Analyses said Bonin's attitude in the minutes leading up to the autopilot being disengaged added to their highly-charged emotional reactions. "Three seconds after the autopilot disconnection, surprise was a pilot's natural reaction," the report read.

**BONIN:**  
Ignition start.

**SYNTHETIC VOICE**  
Stall. Stall.

**ROBERT:**  
What is that?

**BONIN:**  
We haven't got a good... We haven't got a good display of speed.

**ROBERT:**  
We've lost the, the, the speeds so... engine thrust ATHR engine lever thrust. ... Alternate law protections (low)... Wait we're losing... wing anti-ice... Watch your speed.

**BONIN:**

## BEA AF447 Report

- Investigators surmised that *“the excessive nature of the PF’s inputs can be explained by the startle effect and the emotional shock at the autopilot disconnection.”* Of course, the PF’s initial, startled reaction was not the sole problem, but it did play a *“major role in the destabilization of the flight path,”*.
- The rapid increase in crew workload in an unusual and unexpected situation led to the degradation of the quality of communication and coordination between the pilots.

## BEA AF447 Report

- In recommending that the European Aviation Safety Agency review the requirements for initial, recurrent and type rating training for pilots “in order to develop and maintain a capacity to manage crew resources when faced with the surprise generated by an unexpected situation,” the BEA authors of the AF447 final report said: “Initial and recurrent training as delivered today do not promote and test the capacity to react to the unexpected. Indeed, the exercises are repetitive and well known to crews, and do not enable skills in resource management to be tested outside of this context.”

## **European Aviation Safety Agency NPA 2014-17 CRM p24**

### **4) Surprise and startle effect**

CRM training should address unexpected, unusual and stressful situations. The training should cover:

- (i) surprises and startle effects; and
- (ii) crisis management, including:

#### *3. Proposed amendments*

- (A) the development and maintenance of the capacity to manage crew resources;
- (B) the acquisition and maintenance of adequate automatic behavioural responses; and
- (C) recognising the loss and re-building situation awareness and control.

## Startle Effects



- Distinction: startle/ surprise with fast recovery and startle with associated fear response
- High emotional component from fear disrupts cognition
- Ongoing research into this topic applied to pilots
- Martin, W. - Virgin Australia 777 pilot/ CRM instructor. PhD Griffiths University '*Pathological Behaviours in Pilots During Unexpected Critical Events: The Effects of Startle, Freeze and Denial on Situation Outcome*'



## Martin, Murray & Bates, 2011

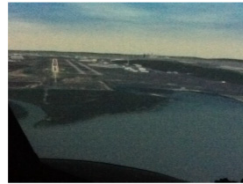
- Ten week study at New Zealand airline
- Pilots encouraged to discuss novel emergency scenarios during cruise phase of flight.
- Questionnaire with 57 respondents showed that most of them did this occasionally (34) or regularly (15).
- Most said this raised their expectation level for surprise and they had learned new information
- *Aeronautica* , 1, 8-22

## Martin (in prep)

- 70 case studies of critical events from accident reports/ interviews with pilots – majority of effects involved startle and often led to undesired aircraft states or even accidents
- Simulator flight startle experiments showed some very adverse reactions in a third of pilots, mildly negative responses in a third and a third were largely unaffected.
- New study of training interventions for managing startle

## Startle Research in an Airline Flight Simulator (Martin 2012)

- In June 2012, simulator research was conducted in a modern flight simulator using 18 type rated pilots. Each pilot flew an identical exercise involving two instrument approaches with the cloud base requiring a missed approach. On the first approach a startling stimulus was introduced at 40 feet above the decision altitude.
- No stimulus was introduced on the second approach.
- Approximately one third (n=5) participants performed nominally; one third exhibited a slightly delayed reaction (n = 6) and approximately one third (n=7) displayed behaviours which were either significantly delayed or dangerously unstable. In the latter group three pilots continued descent so far that they became visual, with two receiving EGPWS warnings "Pull Up, Pull Up". Two continued with their unstable approaches and landed, while one went around from a very low altitude.



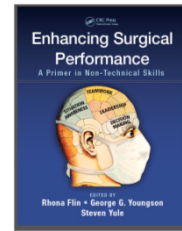
### Relevance for the operating theatre?



# Non-Technical Skills for Surgeons

## NOTSS skills taxonomy

Categories	Elements
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 Co-ordinating team
Leadership	Setting and maintaining standards Coping with pressure Supporting others



Yule, Flin et al (2006) *Medical Education*, 40, 1098-1104

Flin, Yule & Youngson (2015, in press) *Enhancing Surgical Performance: A Primer on Non-Technical Skills*. CRC Press.

## NOTSS evaluation: Reliability testing

### Method

44 consultant surgeons in Scotland trained to use NOTSS and then they rated the behaviours of operating surgeons in 7 video scenarios



### Results: rwg reliability level

- Situation Awareness & Decision Making: **Acceptable/Marginal**
- Communication & teamwork/ Leadership: **Good**

Yule, Flin et al (2008) *World J Surgery* 32, 548-556

Yule, Flin et al (2009) *ANZ J Surgery* 79, 154-160

## NOTSS as workplace assessment tool

- **Aim:** Test NOTSS as workplace assessment tool
- **Method:** Observations /ratings of 715 operations, England
  
- **Results: for reliable and generalizable results**
  - Same procedure: 6 assessments per trainee required
  - Mix of procedures: 8 assessments per trainee required
  
  - Procedure-specific factors exert a lesser influence on NOTSS compared with either PBA or OSATS (technical ratings)

Crossley, Beard et al (2011) *BJS* 98, 1010-1020

### Hull et al (2012) The relationship of non-technical skills to technical performance

Review of 28 medical studies

The evidence suggests that receiving feedback and effectively coping with stressful events in the OR has a beneficial impact on certain aspects of technical performance. Conversely, increased levels of fatigue are associated with detriments to surgical skill.

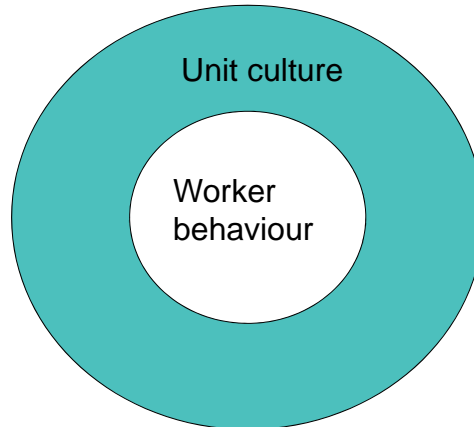
One study assessed the impact of anesthesiologists' nontechnical skills on anesthetic technical performance, finding a strong positive correlation between the two skill sets.

Six studies assessed the impact of multiple nontechnical skills of the entire OR team on surgical performance. A strong relationship between teamwork failure and technical error was empirically demonstrated in these studies.

**CONCLUSIONS: Evidence suggests that certain nontechnical aspects of performance can enhance or, if lacking, contribute to deterioration of surgeons' technical performance. The precise extent of this effect remains to be elucidated.**

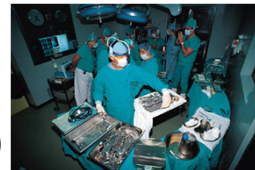
*J Am Coll Surg*, 214:214–230.

Is the culture reinforcing or toxic  
for safe behaviours/ NTS?



CRM / NTS training for surgical teams

- Before/ after study of NTS / CRM training
- Nine hour course and coaching (n=54 staff)
- Pre and post measures
- NOTECHS, technical errors, safety climate measured for 48 ops before and 55 after training
- Non-tech skills and safety attitudes improved after training
- Sig reduction in errors post training
- Investigators noted that “considerable cultural resistance to adoption was encountered, particularly among medical staff”.



McCulloch et al (2009) The effects of aviation-style non-technical skills training on technical performance and outcome in the operating theatre. *Qual Saf Health Care*, 18:109-15.

## Does CRM influence culture?

- Systematic review of 22 studies with outcome measures of patient safety culture
- Selected culture dimensions – mainly positive effects
- Wider range of culture dimensions – mixed effects

– Van Noord et al, 2014, *Sage Open Medicine*

## Surgeons' intraoperative decision making



How do surgeons make decisions and assess risk during operations?

Interview study of 24 consultant general surgeons in Scotland  
Elective vs Emergency cases. Protocol: Critical Decision Method  
plus 26 specific questions. Thematic coding of transcripts  
Key decision: Rapid intuitive (46%) or Comparison of options (50%)  
Decision strategy not associated with surgical method,  
context or time pressure.

Risk management factors emerged as influential:  
threat assessment, judging impact, personal risk tolerance

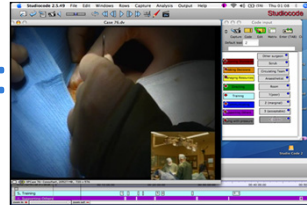
Pauley, Flin, Yule & Youngson (2011) *American Journal of Surgery*

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## Switching decision mode

- Observational and interview studies
- Experienced surgeons recognising cues to 'slow down' to switch from a more automatic (intuitive) mode to slower (analytical, effortful) mode.
- Moulton et al (2010) 'Slowing down when you should' *J Gastrointestinal Surgery*, 14, 1019-1026.
- Cf Kahneman (2011) *Thinking Fast and Slow*

## Surgeons' Leadership:



### Use Surgeons' Leadership Inventory (SLI)

Henrickson-Parker, Flin, Yule, McKinley, *American Journal of Surgery*. (2011; 2012); *BMJ QS* (2011)

#### Measure lead surgeon's leadership behaviours (inc. decision making)

During the whole operation

Before and after a key stage in surgery (the Point of no return- PONR eg. Cutting a duct)

Compare cases with 'event' (e.g. unexpected bleeding) and non-event

Videos of live operations in general surgery (n=29) from 3 teaching hospitals in the UK

Unexpected surgical event (n=5)

57 hours of video coded (*Studiocode*) – two coders - IRR (Overall  $\kappa=0.7$ ). (1118 behaviours)

Objective: preliminary testing of SLI rating tool

Hypotheses: 1. More leadership behaviours prior to PONR

2. More directive leadership behaviours post-event

## Results



- In total, 1118 behaviours coded - only 5% behaviours coded as decision making; mainly training, directing, communicating behaviours
  - Significant decrease in 'Maintaining standards' leadership behaviours after point of no return
  - Did not engage in 'Managing Resources' behaviours before an event, but did after - with the nursing staff only
- Surgeons essentially engaged in the same leadership behaviors throughout the operation
    - “One size fits all” ?
    - regardless of the team or situation?
- Henrickson Parker, S., Flin, R., McKinley, A., Yule, S. (2014). Evaluating the effect of stage of operation and intraoperative events on surgeons' intraoperative leadership: A video study. *World Journal of Surgery*, 38, 4-10.



## Good Handovers: Better Preparation for the Unexpected?

- Structured observation of 117 handovers
  - 50 theatre to recovery room
  - 25 theatre to cardiac ITU
  - 42 recovery room to ward (40 matching cases)
- Participants
  - 31 anaesthetists, 36 scrub nurses, 21 recovery room nurses, 12 cardiac ITU nurses, 31 ward nurses
  - Maximum of 5 observations per clinician to avoid bias




Better handovers transferred assessments of the situation, not just facts and figures.

Manser, Foster, Flin & Patey (2013) *Human Factors*








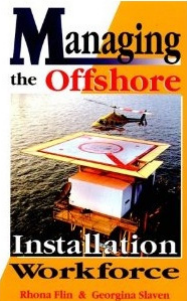
## Deepwater Horizon – Non-technical skills?

- Situation awareness – of level of risk/ time, understanding of the well, meaning of signals, anticipation?
- Decision making – for the well, for the emergency response, between beach and rig?
- Team - coordination, communication; shared 'mental model', speaking up?
- Leadership – supervisors, managers on rig and on the beach? Risk calibration of leaders?  
(Companies' culture/ rig safety culture).






Reader & O'Connor (2014) *Journal of Risk Research*, 17, 405-424

# Crew Resource Management/ Non-Technical Skills for Offshore Crews



**Managing the Offshore Installation Workforce**  
Rhona Flin & Georgina Slaven

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**Crew Resource Management training for offshore oil production teams**  
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Department of Psychology, University of Aberdeen, Industrial Psychology Group, King's College, 100 Aberdeen AB24 2UB, UK

**Abstract**

This paper describes a project to adapt a form of human factors training designed to improve safety-critical Crew Resource Management (CRM), which is widely used in aviation, to the training of offshore oil platform teams. The aim of the project was to design, deliver, and evaluate an offshore CRM training course. A total of 77 offshore workers from three different North Sea production platforms attended the course. Their feedback was generally positive indicating that CRM training can be adapted for this industrial sector. There was some evidence of a change in attitude towards decision making and personal limitations. However, there is a need to develop sensitive evaluation measures to be able to draw more conclusive evidence of the effects of CRM training on safety performance.

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**Keywords:** Crew Resource Management; Human factors; Training; Training evaluation; Offshore

**1. Introduction**

This paper describes a project to develop Crew Resource Management (CRM) training for the offshore oil industry and extends previous human factors research with the offshore oil industry carried out by Meardon et al. (1997).

The aviation industry recognised the significance of human error in accidents almost 20 years ago and has been instrumental in the development of training programmes designed to reduce error and increase the effectiveness of flight crews known as Crew Resource Management (CRM; Wiener et al., 1993). CRM can be defined as "using all the available resources – information, equipment, and people – to achieve safe and efficient flight operations" (Lathrop, 1984, p. 20).

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## Crew Resource Management for Wells personnel



- OGP (Oil and Gas Producers) commissioned project at Aberdeen University (Flin, Wilkinson & Agnew) to outline a basic non-technical (CRM) skills syllabus for drill crews and other wells personnel.
  - WOCRМ Syllabus Guidance (OGP: 501, 2014)
- Identify the key categories of non-technical skills required by wells personnel, in order to develop guidance for a generic training syllabus.
- Literature review – human factors in wells operations
- Interviews 33 wells personnel in 17 wells roles



### WOCRМ: Skills Flin et al (2014)

Figure 1: Percentage of data related to NTS categories

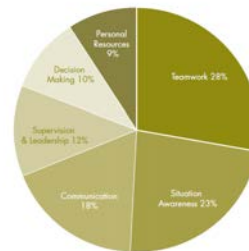


Table 4: Proposed skill categories by wells role group from interview data

	DRILLERS	SUPERVISORS	SUPPORT
CRM SKILLS			
Situation Awareness	✓	✓	✓
Decision Making	✓	✓	?
Communication	✓	✓	✓
Teamwork	✓	✓	✓
Leadership	✓	✓	n/a
Stress & Fatigue	✓	✓	✓

## OGP Recommendations (Report 501, Flin et al 2014)

[www.ogp.org.uk](http://www.ogp.org.uk)



- CRM training to a wide range of wells op roles
- Integrate with tech training
- Technical and behavioural science instructors
- Three days with practical exercises and feedback
- Refresher training
- Generic CRM for a wells team

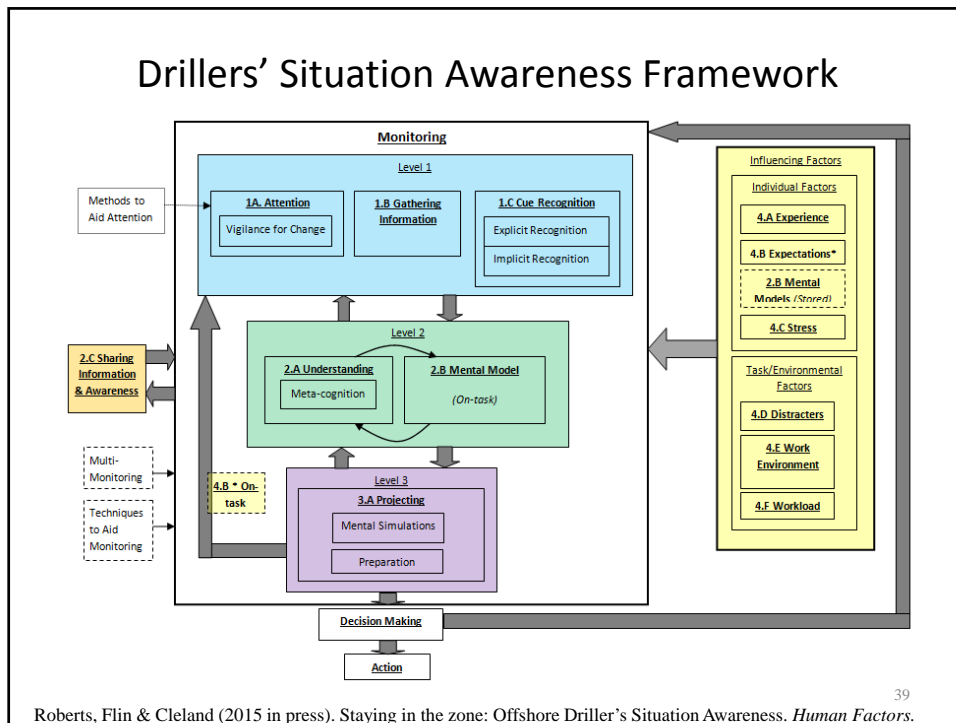
## Drillers' Situation Awareness

Ruby Roberts,  
Prof Rhona Flin  
Prof Jen Cleland



PhD project  
sponsored by Maersk Drilling





### Fire Commanders' Decision Making Hatton-Cohen et al, 2015 *Human Factors online*

**Method:** Incident commanders, attending 33 incidents across six U.K. Fire and Rescue Services, were fitted with helmet-mounted cameras, and the resulting video footage was coded and used to prompt participants to provide a running commentary concerning their decisions.

**Results:** The analysis revealed that assessment of the operational situation was most often followed by plan execution rather than plan formulation, and there was little evidence of prospection about the potential consequences of actions. This pattern of results was consistent across different types of incident, characterized by level of risk and time pressure, but was affected by the operational experience of the participants.

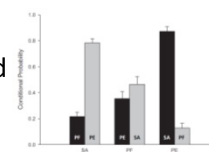
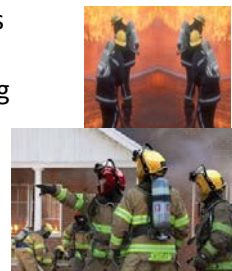


Figure 1. Top: operational situation; bottom: results. Mean ± SD. Condition 1: distribution of responses from situation assessments (SA, PE or PR); left bar of

### Issues: CRM training

- Is new research (e.g. plan-continuation error, working memory capacity, startle effects) being incorporated into CRM training?
- Linkage of safety data from SMS to CRM?
- Linkage of CRM training/ assessment to SMS?
- Limited published data from aviation on evaluation of CRM training/ assessment of NTS.

### Issues: CRM (NTS) skills assessment

- Predictive validity of identified behaviours for outcomes – e.g. efficiency, safety
- Reliability of raters (observation , rating consistency, bias effects)
- Number of observations required
- Rating inconsistent performance
- Professional considerations e.g. licences
- Cross cultural effects

## **A lovely sunny day and a routine operation...**



## **‘dropping one’s guard’ ‘forgetting to be afraid’**

Fruhen, L., Flin, R. & McLeod, R. (2014) Chronic unease for safety in managers: A conceptualisation. *Journal of Risk Research*, 17, 969-979.

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