International Association of Oil & Gas Producers

REPORT 509 | JANUARY 2018

The use of behavioural markers of non-technical skills in oil and gas operations: supporting material

Acknowledgements

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Revision history

VERSION	DATE	AMENDMENTS
1.0	January 2018	First release

Contents

Scope

This report supports the guidance on the use of behavioural markers to support non-technical skills in oil and gas operations contained in IOGP Report 503 [1].

It summarizes a number of considerations behind the content of Report 503, including learnings from the scientific literature and existing industry guidance on the use of behavioural markers in Crew Resource Management (CRM) applications. It also draws on experience gained during the preparation of IOGP Reports 501 [2] and 502 [3].

This report is aimed at personnel in IOGP member companies who have a need for a deeper understanding of the scientific and technical background to the guidance published in Report 503. It has been prepared and released separately from Report 503 to keep the recommendations in 503 as clear and simple as practical.

1. Background reading

The first stage in developing Report 503 involved reviewing as much existing published material as could be readily accessed on the topic of behavioural markers for CRM (using the term broadly, rather than specific to any application or industry). The purpose was to ensure that guidance on behavioural markers for the IOGP community is informed by knowledge and experience from previous applications in other industries.

The sources found to be of most relevance and/or thought provoking in terms of behavioural markers for oil and gas applications are listed as references.

- Appendix A includes a brief summary of some of the key sources.
- Appendix B contains a summary of some of the key points in the literature about the nature and characteristics of good behavioural markers.
- Appendix C contains a comparison of two sets of non-technical skills (NTS) and their skill elements against the NTS elements defined for Well Operations Crew Resource Management in IOGP Report 502: the NOTECHs system widely used in aviation [4], and the ANTS system for surgeons [5].

2. Considerations and Issues

The background reading, as well as experience in the preparation of IOGP Reports 501 and 502, raised a number of considerations as well as some issues that underpinned the development of the guidance in Report 503.

Foremost among these were:

- expectations of the application of CRM to the oil and gas industry in the long term
- the need for context
- CRM focuses on Standard Operating Procedures
- uses of behavioural markers
- users of behavioural markers
- collaborative use of behavioural markers
- Quality assurance.

The following sections briefly describe each of these and set out some of the rationale behind the content of Report 503.

2.1 Expectations of WOCRM in the long term

Clearly, some other industries have made significantly more use of CRM than is typically the case in the upstream oil and gas industry. Aviation and medicine in particular, at least in some countries, are relatively rigorous, structured, and formalized in the way they assess and certify professional competence.

It was clear in the discussions surrounding development of 502 that it will be some time, if at all, before NTS and behavioural markers are capable – even if it is considered desirable – of being used as part of the formal assessment of competence of personnel in the oil and gas industry. Even aviation still struggles to use CRM assessments in certification of flight crew. While acknowledging that the use will be mainly informal, there are still a range of potential uses of behavioural markers that can support the implementation of CRM principles across the industry. Assuming the CRM principles are adopted by member companies, it is envisaged that the use and impact of those principles will change and develop as experience is gained.

It was felt to be important for IOGP to indicate some vision of the way it expects, or hopes, to see the implementation of CRM developing over the coming years and decades. Doing so would help the industry mange its expectations of what can be achieved by implementing the guidance in Reports 501, 502 and 503. It would also allow it to better understand what is expected, to build awareness into long-term thinking and planning, and to work together to transition from current reality to what IOGP believes is a desirable state of eventual good practice.

IOGP therefore anticipates that the implementation of CRM in the oil and gas industry is likely to pass through a number of more-or-less identifiable stages, as illustrated in Figure 1.

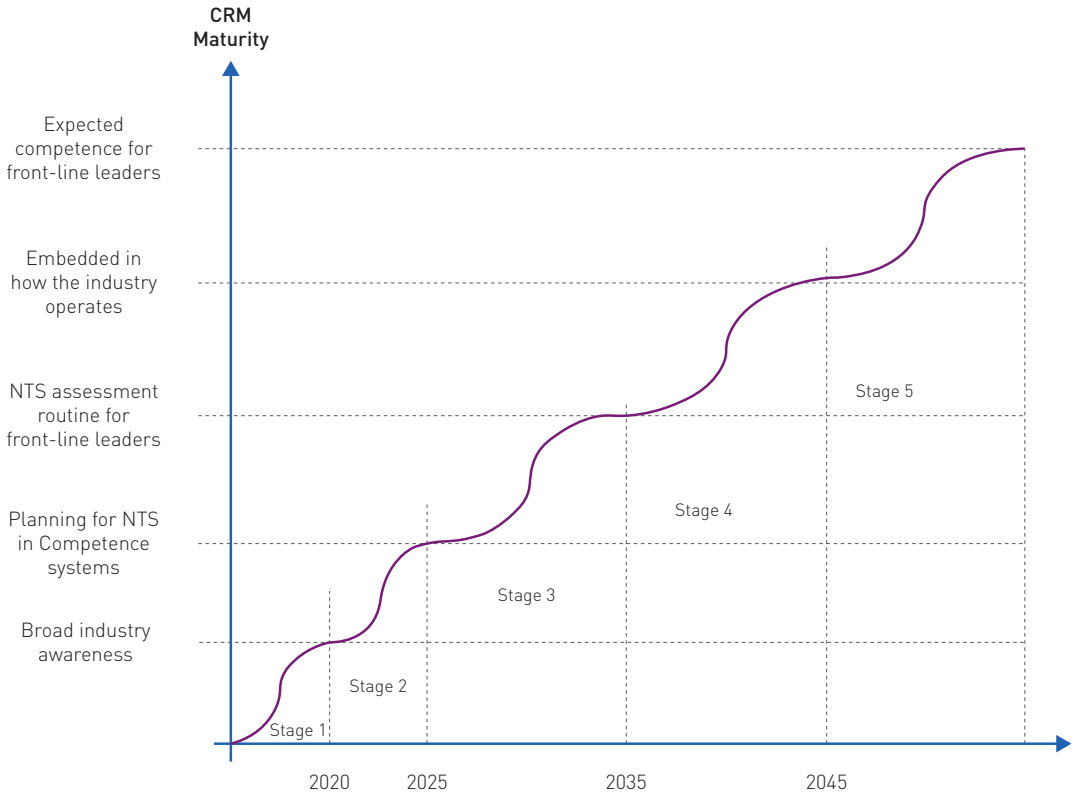

Figure 1: Possible progress of CRM development in the oil and gas industry

- In Stage 1, the aspiration is to achieve broad awareness across the industry of the importance of NTS, such that there is general sensitivity to the nature and importance of the skills, and awareness of the impact they can have on safety and production. During this stage, providing specific training and assessing the possession of the relevant skills is likely to be limited to leaders in front-line positions among the larger operating companies and in the highest threat operations (likely to be at most the well crew positions identified in IOGP Report 501). Stage 1 is about getting off the ground: it is no more than a first step. Likely time-scale: up to five years.
- Like Stage 1, the aspiration in Stage 2 may still be largely to raise awareness and sensitivity, though embedding that awareness more deeply and more broadly across the industry. Specific training and assessment is still likely to be limited to those in front-line leadership positions. Companies may have started planning to embed the skills in relevant parts of their corporate competence management systems. Likely time-scale: 5 to 10 years beyond Stage 1.

- In Stage 3, most leaders in front-line safety critical positions would possess the skills and be routinely assessed (at least informally) in their ability to apply them in normal, routine operations and associated activities. They would also be actively coaching and mentoring their teams in the skills. Lower level positions could be receiving role-specific NTS training. Company management systems may have incorporated NTS in their competence assessment processes and be using them as part of normal working practice, including competence assurance of personnel in front-line, safety critical roles. Likely time-scale: 10 to 20 years beyond Stage 2.
- By Stage 4, NTS may have become 'second nature' and be an integral part of how the industry operates (much like aviation in some countries today). Operational working practices affecting safety would routinely include consideration of NTS. Likely time-scale: 20 to 30 years beyond Stage 3.
- The final stage is an aspiration that demonstration of NTS is formally assessed as a necessary competence for every individual assigned to a safety-critical leadership role.

Having some clarity of the long-term vision can make the intended role and purpose of 503 clear, and sets the scope, constraints and limitations of its intended usage. It also puts the guidance in 503 (as well as 501 and 502) into context: IOGP recognizes and is fully aware that developing good practice in implementing the principles of CRM across the industry will take a significant time and require considerable effort.

Against that background, IOGP reports 501 and 502 provide a basis for development, though the level of detail is only intended to support what is described above as Stages 1 and 2. These reports are expected to become increasingly outdated as the industry gains experience in the application of CRM. In terms of behavioural markers therefore, the role of IOGP Report 503 is:

1) to support broad awareness of the type of behaviours that reflect the performance, or lack of performance, of the CRM NTS
2) to provide the basis for work to develop training and assessment of non-technical skills among senior front-line operational leaders.

Additionally, Report 503 suggests that NTS can be taken into account in activities such as incident investigations and safety auditing.

2.2 The need for context

One of the most important issues to come out of the review of background material was a difference between the way IOGP (and most others) define 'non-technical skills', and the way aviation (and again, other industries) define 'Crew Resource Management'. IOGP Report 501 equates CRM and NTS: it defines them as being the same:

> ***"Crew Resource Management or non-technical skills (also called CRM, NTS, or human factor skills) is a term that came from the aviation industry and can be defined as 'the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance".*** (Flin et al., 2008) [2]

The same definition is contained in Report 502, as well as the guidance on CRM produced by the Energy Institute [6]. And the same, or a similar definition is generally used wherever the focus is on non-technical skills as such (including by the UK Rail Safety Standards Board in connection with train drivers [7], as well as for officers in the Merchant Navy [8].

The original definition of CRM, which is still current in the aviation industry, is however different. According to the Federal Aviation Authority [9]:

> ***"CRM refers to the effective use of all available resources: human resources, hardware, and information".*** p.6 of [9]

In [10], Robert Helmreich provides a slightly expanded definition that he also attributes to the FAA:

> ***"CRM can broadly be defined as the utilization of all available human, informational, and equipment resources toward the effective performance of a safe and efficient flight. CRM is an active process by crewmembers to identify significant threats to an operation, communicate them to the PIC, and to develop, communicate, and carry out a plan to avoid or mitigate each threat. CRM reflects the application of human factors knowledge to the special case of crews and their interaction".*** p.677 of [10]

The second sentence in that definition is of particular importance. CRM is *"...an active process..."* that utilizes all available resources (NTS are a key element of those resources):

- ...to identify significant threats...
- ...to communicate them to the PIC (person in charge)...
- ...to develop, communicate and carry out a plan...
- ...to avoid or mitigate each threat.

The definition of NTS that has been adopted by IOGP is therefore not equivalent to CRM as the aviation industry, at least, views it. They are not the same: and the difference is important. CRM is the *process* of utilizing all available resources to identify and manage threats, while NTS are a *skill set* that support and enable that process. What seems to have been lost is the importance of CRM as a process that focuses on identifying and managing threats *in a context*. In 2001 the Group Interaction in High Risk Environments project (GIHRE) held a workshop, attended by many of the leading thinkers on the subject, to develop a set of general guidelines on the use of behavioural markers for practitioners and researchers [4]. In the context of the use of markers in Line Operations Safety Audits (LOSA), the workshop noted that:

> ***"...the non-technical skills measured addressed by the behavioural markers are defined as threat and error countermeasures".*** p.8 of [4]

And in their answer to the frequently asked question of what makes a good behavioural marker, the GIHRE workshop also advised, among other things, that a good marker:

> ***"...has demonstrated a causal relationship to performance outcomes***
>
> ***- it does not have to be present in all situations***
>
> ***- its appropriateness depends on context".*** p.10 of [4]

Non-technical skills are described in IOGP Reports 501 and 502 as things that exist in all situations, and are expected to be performed in their own right, out of context of the process of managing threats. That is a significantly greater burden than emphasizing the importance of the performance of the skills in situations known to be associated with heightened threats. (At least, so long as those situations are recognizable in advance: though it might be debated whether all situations where heightened threat exists are actually identifiable.)

The skills defined in Reports 501 and 502 are essentially generic, context independent, and open-ended: they describe NTS in a generic way, independent of any specific threat, task or operation. One consequence of this is that being able to assess the extent to which an individual possesses and performs those skills is opportunistic: it relies on opportunities arising in training scenarios or ongoing operations where the skills are needed.

In the aviation industry, the use of behavioural markers and the assessment of NTS are focused around specific threats. The assessment of CRM skills – and the use of behavioural markers – as currently applied in aviation draws heavily on the model of Threat and Error Management (TEM) developed by Robert Helmreich and Associates at the University of Texas. In terms of flight safety, threats are associated with specific flight segments, which are essentially the same across

all (at least civil) airline operations. The FAA's Advisory on Line Operations Safety Audits (LOSA) in 2006 [11] identifies four flight/threat segments:

- predeparture/taxi
- takeoff/climb
- cruise
- descent/approach/land/taxi.

In performing a LOSA assessment, crew behaviours are assessed independently during each of these segments, as well as for the overall flight.

> ***"Observers code observed threats to safety and how they are addressed, errors and their management, and specific behaviours that have been associated with accidents and incidents".*** p.678 of [10]

That is, the markers are used to assess the application of the non-technical skills specifically in the context of managing known threats to safety, including the human errors that can be introduced in planning and carrying out a response.

The same argument applies to oil and gas operations: for example, different stages and different types of events during a drilling campaign provide the context that makes specific demands on CRM skills. Identifying the relevant operational phases with varying threat profiles will make it easier both to set up situations that probe specific NTS, and to assess the extent to which the skills are possessed and performed.

So the focus of CRM training as it is applied in aviation focuses on the *identification* of specific threats, *planning and management* of threat avoidance, and the *management of errors* that may be introduced by the crew during identifiable flight segments. Because of the way Well Operations Crew Resource Management (WOCRM) has been defined to-date (refs 2 and 3), the need for and application of the NTS has been de-coupled from managing specific threats. That has meant that there has been a lack of focus on specific situations, or threat scenarios, when the NTS might be i) needed, ii) trained, iii) observed and iv) assessed.

For the oil and gas industry to progress effectively with implementation of CRM it needs to be presented in a way that is aligned to the management of specific threats. The essential starting point is to identify what the equivalent operational threats and phases are for oil and gas operations. For example:

- shift handover
- planning
- Job Safety Assessments or ToolBox talks
- steady-state operations
- SIMOPS
- managing unexpected well control events
- Emergency response and Crisis Management.

In a manufacturing operation, high threat scenarios may include things like start-up and shut-down of process units, which are known to be especially high risk activities associated with many major incidents.

Clearly, different types of threat phases in operations may lead to a need for different types of training: training how to avoid poor NTS impairing the effectiveness of a shift-handover, or how to avoid the potential for communication errors in planning an operation will require different type of exercise material – and may be carried out at a different time and place – from training on how to perform a drilling operation. Though the behavioural markers used in each threat scenario, and the ways they are to be assessed, might be similar.

2.3 CRM focuses on SOPs

There is another major difference between the principles and philosophical basis of CRM as it is implemented in aviation, and the proposed implementation in the oil and gas industry.

A distinction that reflects the different ways safety critical operations are carried out and managed between the two industries: specifically, the expected degree of compliance with Standard Operating Procedures (SOPs). In aviation, virtually every activity flight crew carry out during the high-threat flight segments (pre-departure/taxi; take-off/climb; descent/land) is expected to be carried out in accordance with a well-defined SOP. Most, if not all, of those SOPs are specifically intended to support communication and coordination between crew members with the aim of detecting and correcting any errors before action is taken based on them. Here is how the FAA [9] puts it:

> ***"The National Transportation Safety Board (NTSB), the FAA, and many other parties have identified SOPs as a persistent element in these problems, which sometimes have led to accidents. SOPs define the shared mental model upon which good crew performance depends. Too often, well-established SOPs have been unconsciously ignored by pilots and others; in other cases, they have been consciously ignored. In still other cases, SOPs have been inadequately developed by the operator for use by its pilots, flight attendants, or aircraft dispatchers, or a significant SOP has been omitted altogether from an operator's training program".*** p.4 of [9]

In the same Advisory Circular, the FAA goes on to note, as one of the essentials for successful CRM training:

> ***"CRM training is most effective within a training program centred on clear, comprehensive SOPs".*** p.9 of [9]

Oil and gas operations are very different. Procedures are certainly expected to be followed, though, compared with aviation, those procedures are generally less prescriptive. Procedures in the oil and gas industry usually capture the expected, or required, way of carrying out an activity: they are not generally designed or written to support detailed coordination and cooperation at the level of specific actions and communications performed by and between team members, including checking of each other's actions and decisions.

Part of the success of CRM in aviation in some countries (including LOFT and LOSA) is precisely because aviation SOPs provide observers with a very clear statement of precisely what the flight crew are expected to do at any time, and how they are expected to cooperate in checking each other's decisions and actions. Individuals assigned as CRM (including LOFT and LOSA) assessors in aviation are also required to fully understand the SOPs that provide the basis for the training or flight segments they are observing. So it is, relatively, easy to identify when what the individuals being observed do is not in compliance with the SOP. That is far from the case in oil and gas operations. The challenge of training observers to apply CRM behavioural markers in oil and gas operations may be even greater than in aviation.

It is also clear from the above quotations that CRM and associated non-technical skills in aviation and other industries is focused on individuals working in a team setting: specifically it focuses on communication and coordination between team members.

2.4 Uses of behavioural markers

The fourth consideration arising from the background literature is to do with the expected uses of behavioural markers. It's worth beginning this consideration with a remark by Fletcher et al. [12] about the general usage of behavioural markers:

> ***"In addition to providing a tool for assessing aspects of performance traditionally judged on gut feeling, behavioural marker systems supply a common language for discussing non-technical skills and can function as frame-works to structure teaching and debriefing".*** p.581 of [12]

Prior to Report 503, IOGP's thinking around CRM focused around training: the contents of a WOCRM training syllabus; how training should be delivered; who should be trained; the competence of WOCRM trainers and observers, and so on. Behavioural markers, though, have the potential to be of value beyond only in a training environment. By providing a common language for communicating information about the definitions of the skills, their importance to safe and effective performance, how to assess them, and recognizing when they have broken down, they have the potential to open up a much wider and richer set of uses.

A key requirement in all of the literature and existing guidance is that the material used to teach the NTS that CRM relies on must be evidence-based. This is also included in the previous IOGP and Energy Institute material:

> ***"...the teaching material is evidence based".*** p.5 of [2]

> ***"The material for refresher training should be evidence-based".*** p.22 of [6]

What does "evidence-based" mean? It means the material used in training – and in the way training is evaluated – needs to be grounded and informed by the organization or industry's experience of what actually goes wrong in the real world of their day-to-day operations. Robert Helmreich [10] puts it like this as far as aviation is concerned:

> ***"CRM training is based on accurate data about the strengths and weaknesses of an organization. Building on detailed knowledge of current safety issues, organizations can take appropriate proactive or remedial actions, which include topics in CRM. There are five critical sources of data, each of which illuminates a different aspect of flight operations. They are: 1) Formal evaluations of performance in training and on the line; 2) Incident reports; 3) Surveys of flightcrew perceptions of safety and human factors; 4) Flight Operations Quality Assurance (FOQA) programs using flight data recorders to provide information on parameters of flight. (It should be noted that FOQA data provide a reliable indication of what happens but not why things happen.); and 5) Line Operations Safety Audits (LOSA)".*** p.677 of [10]

While IOGP Reports 501 and 502 are focused on training, Report 503 proposes a broader set of uses. Report 503 recognizes and, where it can, provides guidance on the use of behavioural markers beyond only the training situation. In particular, it proposes that they can be used in:

- raising wide awareness of the importance of NTS
- incident investigations
- Safety Audits.

If incident investigators and auditors were able to use the CRM behavioural markers in their work, and, by using them, identify situations where either a weakness in one or more of the NTS may have contributed to incidents, or where they were found to be lacking in observations of real-time operations, that learning could be fed back to improve the CRM training material. As well, of course, of being a potentially important source of direct learning for the organizations involved.

There are a variety of other situations where behavioural markers reflecting the CRM NTS could be of value, with relatively little effort. Not least in training people to lead and support Job Safety Assessments or ToolBox talks (there are a variety of different phrases in use to describe essentially the same, or similar, front-line safety and risk awareness raising activities). The CRM NTS are at least as important during those and other operational activities that are reliant on team communication as they are in the direct operational interaction with facilities and equipment.

2.5 Users of behavioural markers

After considering the usage of the markers, the next step is to be clear about *who* needs to use them. The answer to that depends on the decision about the intended usage. Based on the arguments in the previous section, it could be anticipated that the following stakeholder groups are potential key users even in Stage 1 of CRM maturity (as described earlier):

- training designers
- training Instructors and observers
- trainees
- Incident Investigators
- Safety Auditors.

In addition, groups such as local supervisors and team leaders could potentially make use of the markers to improve communication and coordination skills within their own teams. Groups such as HSE professionals, technical safety, and others who may prepare safety awareness programmes or specific safety events, could potentially use the markers as the basis of awareness campaigns.

Clearly, the training community will need to use the behavioural markers: that includes those who design training programmes, as well as those who deliver them and assess the performance of trainees. They will need to generate training scenarios (whether simulations, exercises, or whatever) that incorporate events ('probes') where the trainees would be expected to draw on appropriate NTS in response to specific events built into the training scenario. These users will also need to assess the extent to which individual trainees possess and demonstrate the skills during training, as well as situations where weaknesses in performance of the skills were identified.

Assessment will probably (at least in the early stages of oil and gas CRM maturity) be largely by direct real-time observation of trainees. Potentially, at least in the more advanced simulators, and as experience is gained in the application of CRM in the industry, it will also involve de-briefs based on video or audio recording of training sessions. The demands on trainers/observers to apply behavioural

markers, and the challenges in ensuring they are applied correctly, effectively and consistently are not to be under-estimated. Standardization, both of the behaviours, and of the method of assessment is likely to be needed to meet those challenges.

Collaborative use

Much of the focus in the discussions around CRM for oil and gas operations, as is true in most other applications, focused on the use of behavioural markers by independent NTS observers. That is, by people who are judged to be competent and who are assigned to observe and make judgements about the extent to which the individuals they are observing possess and perform the NTS. That is clearly one use, and an important one. But it need not be the only use. And relying on a sole observer brings with it significant challenges, of competence, consistency and validity.

Thinking more broadly around the style of use and users has the potential to extract additional value from the behavioural markers, as well as providing much deeper insight, learning and improvement in collaborative and cooperative team working.

Here are some thoughts on other ways behavioural markers could be used in assessing a situation (whether training, real-time operations, or assessing the effectiveness of safety briefings, shift handovers, etc.):

- *Self-assessment:* i.e. used by individuals to reflect on their own behaviour as part of the team
- *Peer assessment*: using the markers during de-briefing sessions to reflect on the performance of colleagues and others who formed part of the operational team
- *Leader assessment*: allowing individuals to use the markers during de-briefing sessions to give feedback on the performance of their leaders or supervisors.

This variety of potential users and usages offers the opportunity to move away from a situation where virtually all of the reliance on using the markers falls on an observer, or a pair of observers, who is/are assumed to be trained and competent. Observers who, even with the greatest experience of the operation and understanding of NTS and behavioural markers, will never be able to observe many cases of breakdown in cooperation and communications, because so many of them are inherently unobservable.

NTS assessment can be viewed more as a collaborative exercise. One in which all of the relevant stakeholders can use the same frame of reference (the behavioural markers) to discuss and reflect on their experience of an exercise, operation or team activity. And to do so with a focus on team communication and collaboration and whether all available resources were deployed effectively.

2.6 Quality assurance

The final major consideration behind the content of IOGP Report 503 is to do with issues around the quality assurance of the use of CRM behavioural markers. As with any form of inherently psychological assessment, there are real challenges around assuring the accuracy, validity, reliability, completeness and usability of behavioural markers as a means of assessing – and especially trying to measure – CRM NTS.

In their 2003 paper reporting on the experimental evaluation of a behavioral marker system for anaesthetists' non-technical skills (ANTS) [12], Fletcher et al. noted that:

> ***"Cultural differences at the organizational, professional or national level have been found to have a considerable impact on crew resource management attitudes and behaviours and should be taken into account when developing a behavioural marker system".*** p.581 of [12]

The ANTS study was limited to UK anesthetists. It seems reasonable to anticipate that the range of organizational, professional and national factors likely to be a source of cultural differences in CRM among the IOGP member companies (and their contractors) will far exceed those of professional anaesthetists in the UK.

Furthermore, being able to validate a behavioural marker system for oil and gas CRM would itself be a major challenge. The evaluation of the ANTS system involved preparing ten scenarios, of from 4 to 21 minutes each, and filming each of them being performed in a high- fidelity surgical simulator. Twenty-nine consultant anaesthetists viewed each of the films and rated the non-technical skills shown using the ANTS marker system. Being able to perform a remotely similar validation of a behavioural marker system for oil and gas applications would be a significant challenge.

Similarly, Devitt, et al. [8] reported on a study to validate a behavioural marker system for non-technical skills in merchant navy officers. The system comprised sixty-five individual elements. The validation involved studying sixty simulator exercises over a four-month period, with forty-five trainees. Unlike the ANTS scenarios, the exercises were not specifically designed to test non-technical skills, so the researchers relied on opportunities afforded by each scenario to observe or comment on performance of the skills. Over the six month period; *"In total, the research team made 145 observations"*.[1] That represents a relatively small data set on which to draw conclusions across the full range of skills and behaviours, and seems to provide a low return on the investment needed to generate the data.

[1] Note that there is a lack of clarity in one of the figures in the report – which seems to suggest they gathered 145 observations for each of the 65 elements of the scale.

Those two studies only hint at the level of effort that IOGP could need to go to if it wanted to be in a position to confirm, with anything approaching scientific rigour, the validity of a behavioural marker system for CRM for oil and gas applications.

Aspiring to such scientific rigour in the application of CRM to oil and gas operations is unrealistic. However, significant progress can be made towards IOGP's objective by providing a well-thought out marker system, that is subject to sufficient expert and operational review. It is, however, important that the system is designed, and understood, as being intended to be used as the basis for discussion and exploration and, from that, hopefully, learning and insight among operational teams. Aspiring for a CRM behavioural marker system for oil and gas that can be viewed in any way as a measurement tool is some way beyond the current level of knowledge or resources.

2.6.1 Behavioural markers can provide insights, no more

Aside from the technical and logistical issues of developing a validated measurement tool, experience from aviation and other industries is clear that, even if scientific validity is achieved, there can still be significant barriers preventing or limiting the use of the tools. Not least is acceptance by unions and other professional bodies representing the interests of the employed workforce.

In its final report on the validation of the NOTECHS system for assessing CRM in flight crew within Europe, the JAR TEL consortium [13] concluded that, rather than aspiring to be a means of formally assessing flight crew competence:

> ***"The NOTECHS method is designed to be a guiding tool to look beyond a failure during recurrent checks or training, and help to diagnose possible underlying deficiencies in NTS competence in relation to technical failings... In the event of a crewmember being assessed as performing badly for any technical reason, NOTECHS can provide useful insights into the human factors' source of the technical failings. Used in this way, the method can provide valuable assistance for debriefing and subsequently orienting tailored retraining, provided that a suitable period of dedicated instructor training has been allocated for calibration and best practice".*** p.25 of [13]

The proposed uses of behavioural markers set out in IOGP Report 503 – not only in training of non-technical skills, but to support safety audits, incident investigations and assessment of the quality of shift handovers and other front-line safety critical meetings – follows the same philosophy. It can provide insight and suggest areas for improvement, but it should not be viewed as a means of formally assessing competence in the performance of non-technical skills.

2.6.2 There may be no single best behavioural marker system for WOCRM

The two principal CRM and behavioural marker systems used in aviation (the University of Texas system, and NOTECHS) have different structures in terms of the range of skill elements and behavioural markers included. Their practical application is also different. Despite these differences, a workshop held by the GIHRE consortium however demonstrated a high degree of similarity between the fundamental behavioural components of the two systems [4].

Similarly, and although they were derived from the same structure set out in the original

NOTECHS for aviation, a number of quite different implementations of behavioural marker systems for healthcare applications have been developed by different research groups. These include systems reported by Fletcher et al. (for anaesthetists, [5] and [12]), Sevdalis et al. (for surgical teams, [14]), as well as the OXFORD NOTECHS systems developed by Mishra et al. (also for surgical teams, [15]). There are differences between the descriptions of the skill categories, elements and behaviours used in each of these systems, as well as in the methods used to rate observations. Nevertheless, they each report high levels of experimental validity and reliability[2]. As with the UT system and NOTECHS, they all appear to reflect the same fundamental behavioural components.

In its briefing note on a method for developing training for non-technical skills in air traffic management [16], Eurocontrol notes that: *"The fact that the language is explicitly and clearly defined is more important that the specific terms and exact wording included in it"*. Also in the area of air traffic management, Kontogiannis and Malakis [17] produced a behavioural marker system and set of non-technical skills for air traffic management that are different from any of the alternative systems that have been developed for aviation, health care or maritime applications.

These findings suggest another important lesson for the application of CRM to the oil and gas industry: i.e. that there is no single set of unique behavioural markers, or a unique behavioural marker system for CRMs that must be used in every case, even within the limited operational context of well operations. Rather, a variety of approaches may be equally feasible and valid, both in terms of the actual skills and elements included and how they are observed and reported. Provided, at least that they draw on the same fundamental behavioural components and have the necessary technical rigour and operational validity. The way those skill

[2] There is little cross-referencing between these different approaches in their published experimental validations.

components are expressed, and the specific behavioral elements of interest need to be customized both to the nature of the activity of interest and, probably to some extent, to the organizational culture and expected operating procedures and practices of the organizations involved.

What may be most important – assuming a reasonable degree of operational validity and technical consistency – is the organization's commitment to the skill elements and the behavioural marker system used. That includes the thoroughness and consistency of the behavioural definitions and the clarity and meaningfulness of the language used in the user community, as well as the quality of training provided to teach the observers and other raters how to use whatever system is adopted.

Appendix A

Summary of key reading

The publications listed below provide important background, as well as lessons and limitations about the use of behavioural markers in implementing approaches to CRM in other industries. Although they do not represent a comprehensive review of the literature on behavioral markers, they are included here as a starting point into the literature for IOGP member companies who wish to investigate the background to IOGP Report 503 in more detail.

The context of oil and gas operations is very different from these industries in important respects, including: the extent of regulation over the industry; recruitment and selection standards; regulations covering training and competence assurance; the nature, role and extent of expected compliance with standard operating procedures; as well as the commercial and contractual environment. Not least, the reach of the oil and gas sector covers a range of professional, organizational, social and cultural contexts that may be orders of magnitude more complex than in aviation and health care. Nevertheless, provided they are read and applied with care, and mindful of the cross-industry differences, the references cited below contain important information that organizations seeking to implement behavioural markers for CRM in oil and gas operations may wish to consult for a deeper insight than is possible in this guide.

- Flin and Martin (2001) *Behavioural Markers for Crew Resources Management: A review of current practice* [18]:
  - Reviewed current practice in the development of behavioural markers and reliability and training of raters using them in aviation prior to 2001
  - Discusses practical, logistical and theoretical issues in then use of markers.
- Civil Aviation Authority (2014) *Flight Crew Human Factors Handbook* CAP737 [19]:
  - Sets out comprehensive guidance on all aspects of CRM for air crew from a UK perspective.
  - Defines procedures for issue and revalidation of CRM instructors and examiners
  - Chapter 20 deals with behavioural marker systems and reviews and compares the two major marker systems currently in use in aviation – the University of Texas (UT) system and the NOTECHs system. Though CAP737 does not recommend any specific behavioural marker system.
- The JAR TEL Consortium (2002) *Final report – JAR TEL – Consolidation of Results* [13]:
  - Final reports on work carried out by the JAR TEL (Joint Aviation Requirements: translation and Elaboration of Legislation) consortium to support implementation of Joint Aviation Requirement codes that refer to Human Factors

  - Provides both experimental and operational support for the validity, consistency and reliability of the NOTECHS behavioural marker system for assessing non-technical skills
  - Includes experimental validation that NOTECHS is sufficiently robust to differences in national, professional, organizational and safety culture.
  - Includes full details of the details of NOTECHS, including skill categories, elements, and behaviours that reflect both good and poor practice in each skill element.
- Klampfer et al. (2001) *Enhancing performance in high risk environments: Recommendations for the use of behavioural markers* [4]:
  - reports on a joint workshop held to share research experience and discuss the development and utilization of behavioural marker systems
  - sets out general guidelines on behavioural marker systems for practitioners and researchers
  - organized as a series of 17 Frequently Asked Questions, along with the workshops answers to them.
- Eurocontrol (the European organization for the safety of air navigation) has prepared a briefing note on non-technical skills for pilots [16] that describes out a method for setting up a system for training NOTECHs in aircrew. The system is based on the following six principles:
  1) Coupling of technical and non-technical skills. I.e. technical and non-technical skills should be assessed in relation to each other. The assessment of non- technical skills must be carried out in an operational context that integrates both technical and non-technical skills.
  2) Measurement through the technical outcome and its consequences. I.e. assessment of non-technical skills should start by assessing the technical outcome of a training or observed scenario. Examining what went wrong in technical performance often leads to recognizing weaknesses in non-technical skills as the source of a problem.
  3) Observable facts and behavior as basis. Assessment of non-technical skills must focus on observable facts and behaviours. It should not attempt to assess character traits.
  4) Define semantics clearly. The language used to describe and talk about non-technical skills must be well-defined and familiar to its users. Eurocontrol suggests there can be benefits if companies prepare their own definitions of the behaviours to be observed, using its preferred vocabulary.

5) Repetitive behavior observation required. A judgement of an individual's non-technical skills should only be made when there has been observation of multiple instances of relevant behaviours.

6) Access to training of non-technical skills. If an individual is assessed as being weak on some non-technical skills, there must be access to remedial training must be available to increase competency.

- Fletcher et al. (2004) *Rating non-technical skills: developing a behavioural marker system for use in anaesthesia* [5]:
  - Describes the method used to develop behavioral markers for individual anesthetists
  - Defines four design criteria for good markers
  - Describes the 4 categories and 15 elements in the NOTECHs scale for anesthetists, and includes examples of behavioral markers identified for both good and poor practice.
  - Fletcher et al. (2003) describe how the validity, reliability and usability of the scale were validated experimentally [12].
- Sevdalis et al. (2008) *Reliability of a revised NOTECHs scale for use in surgical teams* [14]:
  - Analysis of the reliability of a revised NOTECHs scale to assess non-technical skills in surgical teams surgeons and other operating room professionals) in a manner similar to aviation
  - Demonstrated that the NOTECHs scale can be used both for assessment by a trained observer, as well as in self-assessment
  - Suggests there may be a need for variations in the skill Categories to suit different professional groups
- O'Connor and Long (2011) *The development of a prototype behavioural marker system for US Navy Officers* [20]:
  - Reports on a task analysis to identify the non-technical skills required by the Officer of the Deck (OOD) in US warships
  - Sets out a prototype behavioural marker system (comprising 4 skills and 10 elements, with examples of each element) for evaluating OOD non-technical skills
  - Reports on a literature review of non-technical skills shown to be necessary in a range of high risk domains
  - Emphasizes how non-technical skills and behavioural markers need to be relevant to the organization's existing culture and practices.

- O'Connor (2011) *Assessing the effectiveness of Bridge Resource Management training* [21]:
  - Evaluated the effectiveness of the US Navy's Bridge Resource Management training program
- Kontogiannis and Malakis (2013) *Strategies in coping with complexity: Development of a behavioural marker system for air traffic controllers* [17]:
  - Developed a behavioural marker system for air traffic controllers that reflect the strategies controllers use to adapt to changing task demands in complex air traffic scenarios.
  - Presents a taxonomy of strategies used by controllers to mitigate the effects of complexity organized around four strategies. Demonstrates how a different perspective on nontechs and markers can be needed to capture the operational challenges faced by a specific profession.

Appendix B

The nature of good behavioural markers

This appendix summarizes learnings from published literature about the characteristics of good behavior markers and behavioural marker systems used in the main body of the guide, giving credit to the authors.

The Group Interaction in High Risk Environments (GIHRE) consortium defined the term 'behavioural marker system' as follows:

> ***"The term 'behavioural marker system' is used to refer to a taxonomy or listing of key nontechnical skills associated with effective, safe job performance in a given operational job position (e.g. flight deck crew), with some decomposition of major skill areas (e.g. decision making) usually illustrated by exemplar behaviours".*** p.7 of [4]

The Group Interaction in High Risk Environments (GIHRE) consortium[3] also offered an answer to the question "what are behavioural markers?". They are, they proposed:

> ***"Observable, non-technical behaviours that contribute to superior or substandard performance within a work environment (for example, as contributing factors enhancing safety or in accidents and incidents...)***
>
> ***Observable behaviours of teams or individuals***
>
> ***Usually structured into a set of categories***
>
> ***The categories contain sub-components that are labelled differently in various behavioural marker systems (e.g. NOTECHS: "elements" and "markers" = UT (LOSA): "anchors").*** p.10 of [4]

The consortium also offered an answer to the question "What makes a good behavioural marker" as follows:

> ***"It describes a specific, observable behaviour, not an attitude or personality trait, with clear definition (enactment of skills or knowledge is shown in behaviour.***
>
> ***It has demonstrated a causal relationship to performance outcome***
>
> - ***It does not have to be present in all situations***
> - ***Its appropriateness depends on context.***
>
> ***It uses domain specific language that reflects the operational environment.***
>
> ***It employs simple phraseology.***
>
> ***It describes a clear concept.***

[3] The JAR TEL consortium included most of the key academic researchers in the area, as well as representatives from most major European airlines.

Fletcher et al. (2004) adopted four criteria to support the design a of behavioural marker system for anesthetists:

1. ***The skills should be observable.***
2. ***The system should have a hierarchical structure to make it easy and versatile to use.***
3. ***The system should be simple and usable with minimal training.***
4. ***It should be complementary to the competency-based approach being adopted in medical education in the UK."*** p.167 of [5]

In developing a provisional behavioural marker system for air traffic control, Kontogiannis and Malakis (2013) also noted:

> ***"It is important that behavioural markers describe observable behaviours and have a causal relationship with the performance outcome. Markers should exemplify concepts in a clear manner and relate to each other in a meaningful way (e.g. they may relate to a theoretical model of performance)."*** p.28 of [17]

Appendix C

Comparison of non-technical skills from aviation, anaesthesia and WOCRM

NOTECHs [4]			NOTECHS for Anaesthetists [5]			WOCRM NTSs (from IOGP Report 502 [3])		
Category	**Definition**	**Elements**	**Category**	**Definition**	**Elements**	**Category**	**Definition**	**Skills**
Cooperation	Cooperation is the ability to work effectively in a crew	Team building and maintaining Consideration of others Support of others Conflict solving	Teamwork	Working with others in a team context, in any role, to ensure effective joint task completion and team satisfaction; focus is particularly on the team rather than the task	Coordinating activities with team members Exchanging information Using authority and assertiveness Assessing capabilities Supporting others	Teamwork	The ability to work effectively and interdependently in groups of two or more to achieve a shared goal	Effective team coordination Cooperation and collaboration Recognize when team members do not have a common understanding of a shared situation or goal Avoid creating situations of unnecessary conflict within a team Detect and resolve disagreements and differences within a team Show courage and ability to challenge when necessary
Leadership and managerial skills	Effective leadership and managerial skills help to achieve joint task completion within a motivated, fully- functioning team through coordination and persuasiveness	Use of authority and assertiveness Providing and maintaining standards Planning and coordination Workload management	Task management	Managing resources and organizing tasks to achieve goals, be they individual case plans or longer term scheduling issues	Planning and preparing Prioritizing Providing and maintaining standards Identifying and utilizing resources	Leadership	The ability to successfully influence others to achieve a shared goal by providing guidance, direction, coordination and support	Provide feedback, motivate and support the team and individual team members Set and communicate expectations appropriate to the situation Convey the importance of leadership decisions and the reasons for them Adopt leadership styles and practices suitable to the situation.
Situation awareness	Situation awareness relates to one's ability to accurately perceive what is in the cockpit and outside the aircraft. It is also one's ability to comprehend the meaning of different elements in the environment and the projection of their status in the near future	Awareness of aircraft systems Awareness of external environment Awareness of time	Situation awareness	Developing and maintaining an overall dynamic awareness of the situation based on perceiving the elements of the theatre environment: patient, team, time, displays, equipment, understanding what they mean and thinking ahead about what could happen in the near future	Gathering information Recognizing and understanding Anticipating	Situation awareness	Developing and maintaining a dynamic awareness of the situation and the risks present during a Wells Operation, based on gathering information from multiple sources from the task environment, understanding what the information means and using it to think ahead about what may happen next	Actively seeking relevant information Correctly interpreting and understanding information Being able to foresee what is likely to happen next or the effect of current events on future states Recognizing mismatches between your own SA and that held by others

NOTECHs [4]			NOTECHS for Anaesthetists [5]			WOCRM NTSs (from IOGP Report 502 [3])		
Category	**Definition**	**Elements**	**Category**	**Definition**	**Elements**	**Category**	**Definition**	**Skills**
Decision making	Decision making is the process of reaching a judgement or choosing an option	Problem definition and diagnosis Option generation Risk assessment and option selection Outcome review	Decision making	Making decisions to reach a judgement or diagnosis about a situation, or to select a course of action, based on experience or new information under both normal conditions and in time-pressured crisis situations	Identifying options Balancing risks and selecting options Re-evaluating	Decision making	The ability to reach a judgment or choose an appropriate option to meet the needs of an assessed or anticipated situation	Develop decision making skills relevant to Well Operations environments Recognize the situations where a decision is needed Recognize where different approaches to decision making are appropriate Identify personal role and contribution in making decisions Recognize where bias, such as group think, and other factors may result in poor decisions
						Communication	The exchange (transmission and reception) of information, ideas and beliefs, by verbal and non- verbal methods	Creating a clear message (how, what, where, why, when, who) Delivering a clear message Effective listening skills and seeking clarification Tuning in to non-verbal responses Being appropriately assertive for the situation (delivering and receiving communication) Seeking and providing feedback and confirmation of understanding Avoiding jumping to conclusions in time-pressured situations
						Factors that impact human performance	Many factors affect the ability of people to perform reliably. These include stress, fatigue, health, distractions, and environmental stressors. They can arise from sources personal to the individual or can be imposed by external factors such as organizational and task design, team structure and work schedule, and the design and layout of plant and equipment as well as cultural and environmental factors	No skills – only learning objectives

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