Operational Implementation Of The Bow–Tie: Managing Business Optimisation Through Improved Safety and Risk Control.

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The paper presents the results of a project, in a High Risk Working Environment (HRWE), which aimed to improve:

- Safety management – leading to improved team performance (and cost reduction)
- Team performance – leading to improved operational effectiveness (and cost reduction)
- Operational effectiveness – leading to improved business optimization (and increased income generation)

This project was developed in reaction to a number of complex and overlapping circumstances including:

- Increased demands for national workforces in MENA (Middle East and North Africa) countries
- Oil price variations
- Significant pressures on organisational systems
- Need to reduce costs
- The ongoing requirement to ensure work is carried out in a safe and efficient manner

The Bow-Tie model was maintained as the core of this Change Management project. This model was considered, tested, challenged and applied in several different and new ways to inform the project.

The paper records the steps taken to manage holistic change in the specific context of Land Drilling in the Middle East across multiple drilling sites.

Keywords: Process safety management; Operational risk assessment; Safety leadership; Safer plant operations.

Introduction

When an industry faces demands for significant cost reduction and Government pressures for national workforce development, there are significant implications for:

- People – how/what they learn (skills and competence) and how they apply it (behaviours)
- Systems – how to control work activities, risk mitigation/control, management oversight and Control of Work
- Technology – how to develop innovative software solutions which bring tangible benefits and outcomes
- Safety – how to establish meaningful and sustainable linkage between training and work place activities

These are the challenges facing the oil and gas drilling sector across many countries in MENA and elsewhere, where many governments are enforcing stricter standards for local employment at a time when oil prices have fallen to as low as 30 % off peak prices per barrel.

Operating in such a challenging environment places significant demands on management. This paper presents the lessons and observations from trials on an approach that aims to optimize the work activities through:

- Improved risk management
- Improved team and organisational performance
- Improved operational effectiveness

For the drilling sector these became imperatives as a result of market drivers. The origins of the project date back to the period following on from the 2011 Arab spring, which raised the pressure on Governments to improve employment prospects through MENA (Middle East and North Africa) when many countries were hit by a wave of protests calling for political reforms. The governments typically responded (ref.1) by:

- Promising the creation of thousands of jobs and employment benefits
- Reinforcing the need to push forward programmes for workforce nationalization
- Increasing the pressure on the private sector to both create jobs and reduce dependency on expat workers.

At the same time the industry was still coming to terms with the investigations in to the Deepwater Horizon blowout when failure to control a well led to eleven deaths and the Gulf of Mexico oil spill.

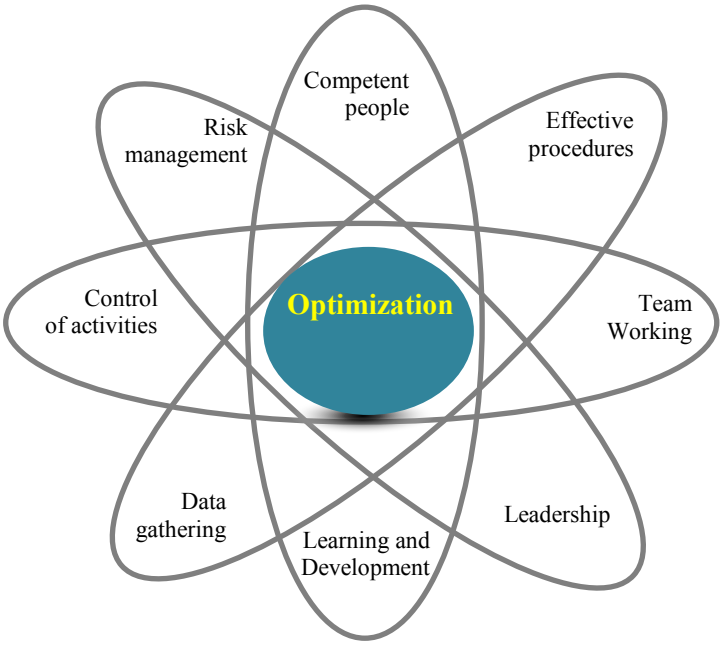
The oil price collapse in 2014 increased pressure on the sector. However, it could also be argued that with this pressure came significant rewards for organisations that could demonstrate the drive for cost control and workforce development. National oil companies and Governments are very important stakeholders and the need to improve training and support new entrants to the sector became both a CSR issue and an economic imperative.

The approach adopted treats the issues holistically rather than as separate problems. This is significant as it avoids 'working in silos' and allows:

- Shared vision and clarity on direction of travel
- Information sharing, cross-fertilisation of ideas and cultural convergence
- Clear oversight of the project
- Identification and understanding of challenges at individual, team, site, operational and management levels.

This paper records the evolution of a new approach to the operational implementation of the bow tie moving from a traditional safety support tool to full operational engagement. Recognition that organizational failures are one of the main contributing causes of accidents is the principle behind tools such as Tripod Delta (ref. 2) and the development of techniques such as the Bow-Tie. In setting out to challenge existing operational programmes one of the key issues that needed to be addressed was to ensure that any changes to the way work was conducted would both improve efficiency and safety.

Figure 1: activity areas for business optimization



Many organisations commit significant investment in tools, systems and processes to underpin process safety, addressing the interplay between technical, organisational and management factors. In many instances these initiatives struggle to create a cohesive story for the people who deliver front line services by failing to adequately link business/operational demands, the competence and capability of the workforce and the reality of the work place.

Eight areas were selected for intervention as shown in figure 1, these reflect the competence and knowledge of people, the definition and control of work activities and the organisations management processes.

Expectations and targets for the project initially focused on improved efficiency, improved safety management and competence development of staff. To achieve these points, consistency in application combined with support for rig crews were essential components. For the first stages of the project a team was formed using a mix of operational personnel from the drilling company, external experts in drilling and software developers.

The significant number of rigs and the demands for information management meant that software solutions were investigated early in the project. A review of commercial software solutions was conducted, in particular the application of PTW, SOP, Checklist and SMS tools. Internally it was recognised that (over time) the process manuals, site procedures and safety instructions had become remote from the work place, infrequently used, difficult to access, seen as a tool of last resort and a hindrance rather than accessible and useful for delivering improved performance. These findings echoed those of the Deepwater Horizon review (ref 3)

Following the review a decision was made to create a bespoke solution in order to ensure that:

- Tasks, procedures and checklists were accurate and supported rig crews to work as teams not as individuals
- Information supplied was easy to understand
- Activities and tasks reflected the risks involved
- Management oversight was improved
- A learning and development system supported competence in the workplace.

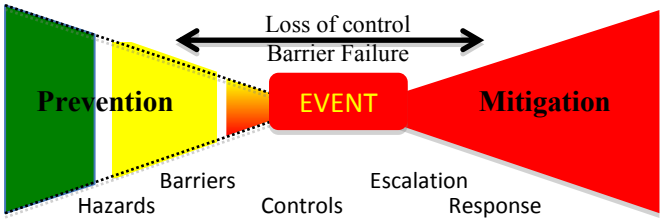
The scope for the project took in to account not only the business and operational activities, but the hazards and risks, team interactions and long-term support and development of individuals.

Step one –Optimisation and the Bow Tie model

In recent years the Bow-Tie model has been used by many organisations to help demonstrate the linkages between hazard, risk, mitigation and incident response. The Bow-Tie helps to visualise the relationship between the causation of accidents, and the preventative measures including safety barriers and event escalation (Figure 1). The development of Bow-Ties is well documented (ref. 11,12,14).

Much of the published research has focused on the development of the model and in particular the left hand side with an emphasis being placed on causation, the provision of barriers and the opportunities for prevention. Output from the Bow tie is often characterised as improved communication with personnel, with focus on safety critical tasks and implementation of change through the safety management system. Typical of statements (ref. 11) found in publications on the Bow-Tie include:

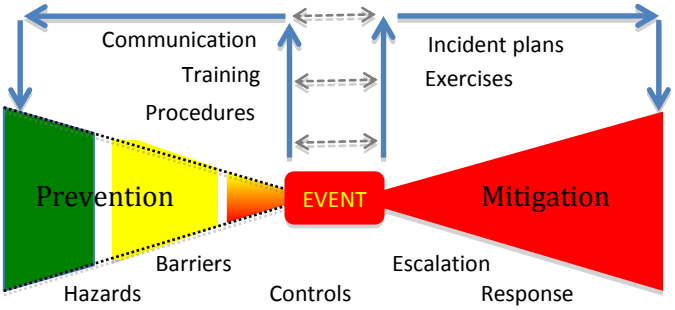
Figure 2 : The Bow-Tie



> "*the Bow-Tie is ideal for structured assessment and communication of risks, it clearly demonstrates the link between control measures and management system arrangements* "

One of the key strengths of the Bow-Tie lies in its visualization of hazards, barriers and consequences and as such it has found an increasing application across many industries. Documented studies (ref. 11,12) often focus on delivering control through the implementation of detailed analysis of the left hand side of the Bow-Tie (figure 3), resulting in management change for improved hazard control through communication, training and revision of procedures. There are linkages to the right hand side but this area receives much less treatment and comment in research and publications and, from personal observation, is often treated as separated for training and procedural development.

Figure 3: Traditional Bow Tie Implementation



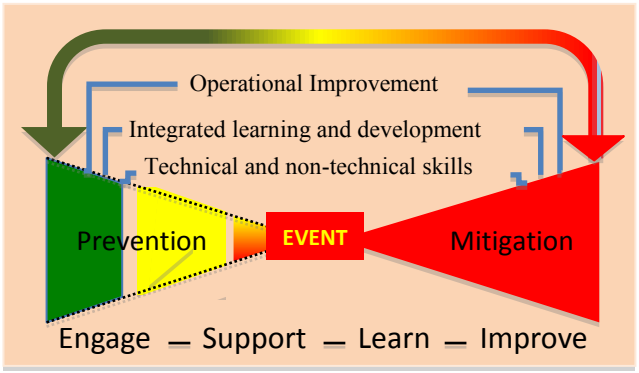
A decision was taken early in the project to ensure that the Bow-Tie was treated as a holistic model (figure 4) for provision of information, guidance, training and competence development, and that work activities would act as the driver to reinforce the linkages between prevention and mitigation.

The opportunity to adopt this approach arises because the business optimisation project allowed a fundamental rethink for the approach to control of work activities and hazard management.

The National Commission report on the BP Deepwater Horizon Oil Spill and Offshore Drilling (ref. 3) highlighted a number of issues that were directly relevant to this project. The report mentions a safety culture survey that had been carried out just a few weeks before the blowout that indicated significant organizational issues. The reviewers found Deepwater Horizon "relatively strong in many of the core aspects of safety management." B ut there were also weaknesses. These included:

- Some 15 percent felt that there were not always enough people available to carry out work safely.
- Some Transocean crews complained that the safety manual was "unstructured," "hard to navigate," and "not written with the end user in mind"; and that there is "poor distinction between what is required and how this should be achieved." According to the final survey report, Transocean's crews "don't always know what they don't know."

Figure 4: Optimization of the Bow-Tie Model



The report went on to say that rig crews are potentially working with a mindset that they believe they are fully aware of all the hazards, when it's highly likely that they are not.

Step two - Business optimization and work activity

A review was conducted of the current issues of concern across multiple drilling sites with the support of Dalma Energy and the sponsorship of specialist consulting firm Well Engineering Partners. Of initial concern was how to ensure procedural arrangements and controls at the drill site were fit for purpose. There were strong indications of significant operational variations across the different sites affecting completion times, project costs, variations in incident and accident records all pointing to significant differences in local work patterns. These variations could in part be explained by the difference in drill crew experience, leadership styles of the toolpushers and drillers etc. It was obvious that the variations in "team" competency and differences between the safety culture at the sites gave rise for concern.

Whilst the drivers for the project were cost reduction, workforce development and safety the sum of these elements created the need for a change in the management process to deliver business improvement and control of work in a complex high-risk environment. The balance of achieving management control and avoidance of accidents is a subject dealt with in research in to High Reliability Organisations (HRO). In a review for the Health and Safety Executive on HROs, Dr Lekka (ref.7) suggested, "In recent years there has been a huge increase in the literature talking about the control of major hazard risks, in particular the philosophies of high reliability organisations, resilience management and safety culture."

In the conclusions to RR899 Lekka identifies a number of important components for an HRO including:

- Systems in place to ensure that safety critical tasks are carried out safely (e.g. procedures, supervision)
- Training and competence, including responding to emergencies
- Incident/near miss reporting and investigation
- Learning from incidents both within and outside the organisation
- Dealing with and recovering from errors (including decision-making in safety-critical situations)
- Management commitment to safety.

Drilling for oil and gas requires the management and control of risks at all stages of the operation. Rochlin (ref.5) observes that HRO activities contain inherent technological hazards in cases of error that are "varied, highly consequential, and relatively time-urgent." The processes by which an HRO deals with risk and accomplishes its mission are inherently complex and a high degree of obedience to rules and procedures is demanded. Whilst the project is not designed to deliver a HRO, the principles helped to inform the balance of requirements for safety, competence and procedural control.

Complex operations require team interaction. Success cannot be based on an individual completing one task if the others in the team are not engaged with the activities and objectives. Whilst drilling is a high-risk complex process with many variations, each step in the drilling of a well can be broken down in to a series of tasks and activities.

With multiple drilling rigs it was possible to analyse variations in operational performance and allow for the baseline data to be gathered for business optimization to understand where delays were occurring and to build a picture over time of the activities that were influencing effective operations. This created a basis for the detailed review of procedures and the interaction of rig crews. It also informed the control and monitoring of activities and signalled an opportunity to link safety critical tasks with operational performance.

Step three – Procedures and process; designing the information and support systems

One of the first steps taken in this project was to engage specialists alongside the operational teams in order to simplify all procedures and make them available at the work site. The delivery mechanism would **require an innovative software solution to be developed** which would allow the interaction of people with information. A review was conducted of the commercial systems available on the market these tended to focus on the individual in terms of tasks, procedures and checklists, and, whilst proving effective at information management, the tendency was towards instructional engagement with individuals.

The style and structure chosen for the procedures was based on Simplified Technical English (STE) adapted from the airline industry and developed specifically to promote understanding of people with English as their second or third language.

This is in turn supported with the use of info-graphics and clear direction between an individual's tasks and the relevant hazard and safety information.

So far the steps taken for project development are fairly logical. As it becomes more operational the focus moves from the individual and the tasks they must complete to the status and activities associated with drilling a well i.e. the timeline and team interactions. At this point, the system adopted can be viewed from the perspective of the individual and that of the team lead/manager.

The Individual	The Team Lead
Receives the information they need to complete their own task	Oversees what activities are being carried out against the timeline
Receives information on how preparation and execution of that task relates to the work and safety of other relevant team members	Receives feedback on the completion of tasks.
Receives information on hazards and barriers	Knows the individual competencies and current status of team members
Linkage to training courses is provided	Has focused information available for team briefings
Competency development is automatic	Can access the latest briefings (safety, SOP etc)
Contributes to team briefing (toolbox talks)	Facilitates the team briefing (toolbox talks)

Briefings and team interactions are built in to the system, the individual is reminded of current competencies they have and, where a high risk activity has not been undertaken for some time, supervision and detailed information support can be allocated.

Opportunities for reducing exposure to human factors risks have been considered both in the development of the tool and the supporting management arrangements. In studies by Flin (ref. 2) it has been demonstrated that a significant proportion of incidents are not technical in nature but **are due to weaknesses in the NTS (Non Technical Skills).** The implications of this are that learning and development models that support the roll out of **the optimization programme must include a direct linkage to NTS training.** This is being achieved by linking at appropriate points back to the Bow-Tie models and ensuring that training objectives tie hazard and barrier information (ref. 10,11) to NTS and competence development.

What is important in the context of this paper is to signal the evolution of behavioural and NTS approaches to a reduction in accidents and improved decision making in complex situations.

Step four – Workplace learning and development

People are the common theme. Each stage of the optimisation process and the project set out to ensure engagement of people as individuals and teams would be assured. Operational improvement requires that individuals know what tasks they need to do, when they need to do them and to be competent in that task. In terms of the competence elements of the system, the definition of competence was taken from the Offshore Petroleum Industry Training Organisation (OPITO) which defines competence(ref.8) as “possessing the necessary skills, experience, knowledge and attitude, and being able to apply them in a particular work environment to perform defined tasks to a predefined standard”.

In summary, a competence assured workforce is one in which the employees know what is expected of them to be competent in their role and where their competence is assessed. This applies across both sides of the Bow-Tie and the model was used to reinforce the expectation that for each task the measures required for completion and risk reduction would be captured, including issues with regards to emergency response. To achieve this procedural information, guidance and training were made available to personnel at the worksite to support their activities. The software system allows the matching of the capability to undertake a task with the individuals allocated to the task.

This capability to match individuals with work activities would also allow for the individual to be supported, to learn and to demonstrate competency; in effect supporting the individuals by matching activities and procedures and to the individuals nominated to fill the crew roles.

The approach taken was to capture this information on an IT system that would allow monitoring through a number of KPIs:

- Percentage of people competent compared to plan, by facility, region, company
- Percentage of individual competencies achieved and report on gaps by exception
- Expired competencies and competencies that are due for expiry
- Minimum site competencies required per facility and gaps

The system builds on the integration of teams by mapping individuals’ competency against the drilling programme and allows for changing patterns of the shifts, personnel absence and new starters.

To deliver an optimal business performance the system is both dynamic and up to date, it provides an analysis to management of who is available today, who needs additional support and how this affects the planning process. Information used to achieve this includes:

- Team and role definitions from the organisation's documentation (includes the ability to cover site activities)
- Information on individuals assigned to the roles, including the minimum numbers that could be required to support critical roles for a particular team
- Competence profiles for each role which are agreed with the organisation and relate to the appropriate organisational, national and/or international standards of performance
- Company requirements for competence assurance defined/delivered by training, assessment and exercising.

This required changes to be made to existing learning and development programmes, to support competence across the full range of activities and to allow blended learning which included classroom, e-learning and onsite supervision and direction.

Current Status and Future Development

Roll out of the system is now well advanced with real time application running on multiple rigs. Some 200 plus managers and supervisors have received training in the system; thousands of procedures and sub-procedures have been reviewed, simplified and tested. These form a library of information, which support each well and provide, alongside the procedures, training and guidance material for rig crews.

Whilst the programme applies an innovative software solution as a tool the project recognizes that culture and leadership will play a significant role in the successful implementation of the programme. Leaders develop and 'sell' the vision and those within the organisational structure make it happen. However, all rests on the safety culture and rig crews have been closely engaged at all aspects of the project. Fleming and Lardner (ref.6) created a three-stage model for an offshore operating company. The three stages of safety culture in this model are (i) dependent, (ii) independent and (iii) interdependent. In a "dependent culture" there is an emphasis on management and supervisory control, with a heavy focus on written rules and procedures. Their study states that if an organization with such a culture wants to improve its maturity it needs to develop an "independent culture" where the focus is on a personal commitment to and responsibility for safety. Whilst there will still be rules and standards, employees look after their own safety. The final stage is "interdependent" where there is a team commitment to safety with everyone having a sense of responsibility for safety beyond their own work and by caring for the safety of others. In this model, the drivers of the safety culture improvement process are teamwork, trust and the ownership of safety by the workforce.

Management of change across these models will be monitored over the longer term. Data is currently being gathered within the systems that will allow operational effectiveness to be studied across the business and on a rig-by-rig basis.

Conclusions

The project sought to establish a system, which allowed management control and oversight of operations, allowing optimization, staff learning and development and improved HSE across multiple teams and locations. This has been achieved by creating a system that engages at the point of work delivery through focus on the individual as part of a team. Monitoring the status of hazards against the activities by ensuring people, competency and consistent implementation of approved procedures.

The newly developed system provides an auditable trail that can be used to monitor the competencies of the teams and individuals and promote learning and development. It delivers support to national workforce development by embedding training courses with on the job learning and support and provides for team development through improved communications and briefings.

Central to the success of the project has been the application of the Bow-Tie model not only for matching activities against hazards, barriers and competency, but as the key linkage across the project providing integration with a revised learning and development process and informing the development and communication of procedures.

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