

Storm preparedness for Mobile Offshore Drilling Units (MODUs): Case studies of decision making under uncertainty.

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Recent Health & Safety Executive (HSE) investigations into incidents of mobile offshore drilling units (MODUs) suffering storm damage have found an absence of underlying technical deficiencies. Rather, delays or gaps in decision making prior to the onset of storm conditions are a common underlying factor. This paper discusses how Human Factors insights and techniques can assist with storm preparedness through establishing, monitoring and maintaining common ground between personnel.

Further, storm preparedness is an example of wider challenges faced by decision makers across the petrochemical sector and wider process industries when there is a transition from operating a *complicated* engineering system under normal conditions to managing problems that arise in upset conditions that are typically *complex* in nature. In particular, dealing with uncertainty and coping with a 'wicked' environment that precludes the development of skilled intuition. Hence, the findings and learnings discussed here are applicable not just to offshore drilling operations, but to all hazardous industries.

Key words: Human Factors, Learning lessons, Critical Task Analysis, Competence, Safety Culture, Extreme weather

Investigation Findings

During storm conditions (Storm Babet) on 21st October 2023 the Spey semi-submersible mobile offshore drilling unit (MODU) working in the UK sector of the Central North Sea lost four of its eight mooring lines (used for station keeping). Subsequently, 45 of the 89 persons on board were evacuated by Coastguard helicopter. The Health & Safety Executive (HSE) investigation into the incident established that delays in decision making – particularly regarding when to disconnect from the well (unlatching from the lower marine riser package (LMRP)) and move to survival draught - had resulted in the mooring systems being operated out with the limits assessed in the well/ location specific mooring analysis. The HSE investigation further found a range of performance influencing factors (PIFs – HSE, 2024a) that negatively impacted decision makers on board the drilling rig and contributed to the decision-making delays including ambiguous and contradictory procedures, gaps in competence assurance arrangements and equipment design issues (layout and settings for control and monitoring equipment). Furthermore gaps in the well operators audit and assurance arrangements, such as a lack of clarity regarding assurance activities that span business functions, meant that these latent conditions were undetected by the client.

Learning Lessons?

Other dangerous occurrences reported to HSE relating to storm damage suffered by MODUs working on the UK Continental Shelf (UKCS) include:

- On 24th December 2016 the Northern Producer Floating Production Facility (FPF – converted from semi-submersible rig) suffered wave impact that shattered 2 mess room windows (resulting in a sudden inrush of sea water and shattered glass fragments to the room) and damaged life raft stations. Ambiguity in the guidance regarding when to move to survival draft meant that the rig remained at operational draft during the storm.
- On 10th March 2021 the Wilphoenix lost a mooring line while the rig remained connected to the well and at operational draught despite the weather forecast indicating that the limits specified in the rig's severe weather procedure would be exceeded. The HSE investigation highlighted that there was a lack of clarity in the guidance provided regarding when to unlatch from the well and no activity/ well specific operating guidance provided.
- On 6th April 2021 the Ocean Endeavor lost two mooring lines. The findings shared with HSE attributed the mooring failures to not slackening off mooring line tensions after unlatching from the well and moving to survival draught in anticipation of storm conditions.

Thankfully, none of the above incidents resulted in serious injury but they each had the potential to result in a major accident or major environmental incident (as defined – HSE, 2015) from either loss of well containment or loss of station keeping ability. Relevant regulatory requirements include ensuring that operational and environmental limits are recorded and made *"readily available to any person involved in its operation"* (HSE, 1996) and ensuring that *"comprehensible instructions on procedures to be observed on the offshore installation are put in writing"* (HSE, 2002). Closely tied to these requirements is the need for accurate Activity Specific Operating Guidelines (ASOG) – defined by The International Association of Drilling Contractors (IADC) as:

"Guidelines on the operational, environmental and equipment performance limits for the location and specific activity. (For drilling operations, the ASOG may be known as the Well-Specific Operating Guidelines (WSOG)."

(IADC, 2024)

In 2022 the IADC produced a safety alert specifically highlighting this need. Yet, the repeating pattern of incidents related to decision making for storm preparedness questions whether organisations are actively learning from such efforts:

"A learning organisation not only values and encourages learning from its own experiences but looks beyond itself for lessons."

(HSE, 2024b)

Providing information such as that provided by an ASOG/ WSOG is clearly a necessary first step to provide a clear basis for decision making when facing the uncertainties posed prior to the onset of storm conditions. However, it is only one step towards developing the 'common ground' (*"The knowledge, beliefs and history we share that let us coordinate smoothly with one another"* - Klein, 2009) between personnel that is necessary to effectively deal with such challenging circumstances. In such a dynamic environment, common ground is constantly being eroded (Klein, 2009) and thus clear instructions, roles and responsibilities must be supplemented by a working environment and ultimately an organisational culture that facilitates 'common ground' being monitored and maintained to promote effective decision-making. This paper will discuss how insights and methodologies from the Human Factors discipline can help to achieve this by addressing key performance influencing factors (PIFs).

Decision making involved in storm preparedness for MODUs.

Firstly, it is important to recognise that the MODU operator is not the only organisational influence on decision making for storm preparedness. The risk management processes of the well operator (the client who contracts the MODU) including preparation of the well notification, oversight and review of the drilling schedule and contractor management arrangements, create the latent conditions that, as per Reason's thirty year plus old axiom, will either set up those at the sharp end of MODU operations to succeed or fail (Reason, 1990).

The HSE investigation into the Spey incident categorised the delay in unlatching from the well (which ultimately led to the mooring line failures) as a **Rule-based mistake** using the human failure taxonomy shown in figure 1 below.

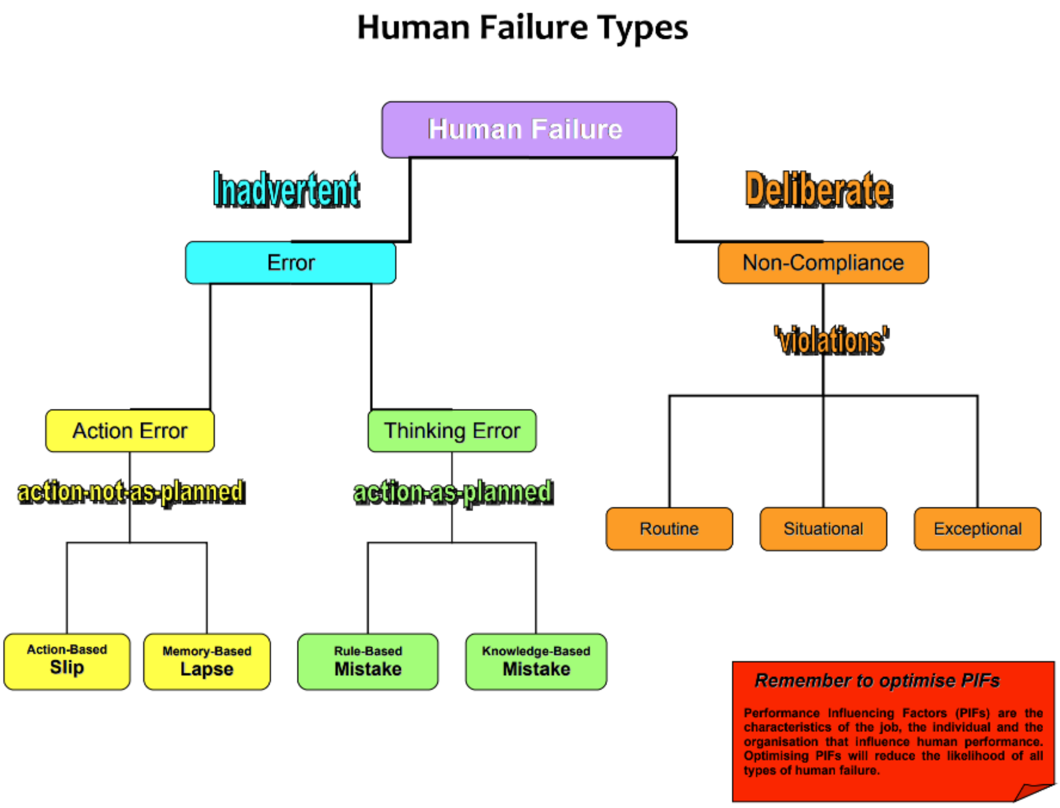

Figure 1. Human Failure taxonomy (HSE,2024b)

It is worth discussing the underlying basis of this model because, despite its ubiquity, in the [HSE Offshore Human Factors] team's experience it can still be misapplied. Firstly, *fundamental attribution error* (Healy, 2020) can lead to a propensity to classify behaviours as deliberate when, seen from the perspective of the individual at the time of the incident, they would properly be recognised as errors that were driven by the context of the situation. Secondly, understanding the order in which levels of cognitive control are typically employed is crucial in soundly applying the taxonomy. Of relevance in this case is the fact that, as *"furious pattern matchers"* humans have a strong tendency to try and find a ready-made solution at the rule-based level **before** reverting to more effortful knowledge-based problem solving (Reason, 1990). Therefore, although it may be tempting to frame the delays in unlatching as either; a deliberate consequential choice – with the immediate positive impact on the drilling schedule (production) of remaining connected being compared against the delayed and uncertain negative consequence of disconnecting too late – or as being due to a lack of knowledge this does not fit with either the evidence gathered or relevant psychological research (Reason,1990, Lipshitz, 1993). In fact, in the case studies presented in this paper the key decisions were made by matching against rules remembered from organisational procedures. The key omissions and delays in these cases were therefore a result of the wrong rules being mistakenly applied and, rather than being due to a lack of *'operational discipline'* these occurred in part due to the attention paid to strict procedural compliance (see discussion regarding organisational culture below).

This matching process is a form of heuristic (mental short-cut) which, in most cases, allow us to make successful decisions despite the varied constraints imposed by the environment and time (Gigerenzer, 1996). The recognition of valid cues in the environment and learning patterns and rules that match these produces skilled intuitions that are the basis of expertise (Kahneman, 2009). Whilst MODU crews may develop such expertise through experience for many tasks on the rig, storm conditions are neither sufficiently frequent nor similar in nature to provide valid cues that can be learnt in this way. In fact, the, unpredictability of storm mechanisms (Bricheno, 2023) means that storm preparedness takes place in a *wicked* environment where cues may be misleading and liable to produce wrong intuitions (Kahneman, 2009). For example, the HSE investigation found that another factor in the delays in unlatching in the Spey incident was the fact that approximately one week prior the rig had 'ridden out' a storm whilst remaining connected to the well without incurring any damage which served to reinforce the heuristic that holding-out and not unlatching too soon was the right course of action. When preparing for the onset of Storm Babet that followed, an initial fixation on the goal of 'riding out' the storm (initial goal bias – Klein, 2009) was further reinforced by the aforementioned matching process. When considering the multiple channels of information provided by the weather conditions, the forecast information and, the procedures containing environmental and operational limits, the decision makers found a single rule (observing a sea state of 6 metres heaves as the trigger to unlatch) that supported their initial plan (to remain connected) until it was too late.

Improving the decision-making processes: Addressing performance influencing factors (PIFs)

The principle of *bounded rationality* (Simon, 1956 - discussed in Gigerenzer, 1996) teaches us that the actions and decisions of individuals in an organisation can only be properly understood relative to their [working] environment. This comprises not just the physical environment but also the organisational structures, policies and procedures that dictate how work is expected to be done. In the Human Factors discipline the concept of bounded rationality is enacted both retrospectively in incident investigation and proactively in risk assessment by the identification (and subsequent optimisation) of performance influencing factors (PIFs). The key PIFs identified for decision-makers on board MODUs in relation to storm preparedness can be divided into those that influence the establishment of common ground prior to storm onset (procedural controls, competency assurance systems) and those that influence the maintenance of common ground following this (equipment design & layout, safety-critical communications, organisational culture).

Establishing 'common ground'

- Procedural controls

The importance of *"operational discipline"* – "*the performance of all tasks correctly every time"* (AIChE, 2024) has become synonymous with process safety in oil and gas operations. This focus further enhances the natural propensity for decision makers to search for a predetermined rule-based (procedural) solution to a problem (as previously described). An expectation of strict procedural compliance further increases the onus on the importance of accurate and usable procedures (HSE, 2024c) and many duty holders discuss compliance with procedures as a key element in their safety culture. Yet, a common finding in the HSE's review of these incidents is that the relevant severe weather procedures were ambiguous, difficult to follow and, at times, contradictory. Due to the different mooring/ position keeping arrangements required for different activities/ locations it is not possible for MODU operators to provide and train offshore decision makers on a single procedure for storm preparedness. However, it is possible for there to be an overarching severe weather procedure to act as a decision aid and this should clearly direct decision makers to appropriate activity/ location specific operating guidelines (ASOG).

- Competency assurance

Comprehensible and usable procedures need to be matched with suitable training and competency assurance arrangements since no procedure, particularly involving decisions under conditions of uncertainty, will cover all eventualities (HSE, 2024c). A particular issue identified was the reliance on seafarer's certification to demonstrate the competence of the Master/ OIM of a MODU in dealing with adverse weather. The result of this approach is that the OIM (who is the ultimate decision maker offshore) may not have sufficient understanding of drilling operations to appreciate the timings required for critical decisions for storm preparedness (such as when to unlatch from the well). As such the OIM is liable to rely on the Senior Toolpusher (senior drill crew member) in this regard who, in turn, is unlikely to understand the actions required by the marine crew (such as the time required for stability calculations prior to moving to survival draught). This *'fractionation* *of skill'* makes it is difficult for decision makers to recognise when they have moved out of the boundaries of their true expertise (Kahneman, 2009) and is another potential source of error.

- Safety and environmentally critical task (SECT) analysis

The tasks involved in storm preparedness are clearly SECTS as they "*contribute to both the risk and management of major accident and environmental hazard scenarios"* (HSE, 2021). Indeed *"safeguarding a well in response to adverse weather"* was included in the original HSE research report outlining a methodology for Human Factors assessments of safety critical tasks (HSE, 2000). The core purpose of SECT analysis is to ensure that risk controls (both existing and those identified as being additionally required) are matched to human failure types, manage identified PIFs and are in line with the principles of the hierarchy of control (remove the hazard or remove the human contribution before implementing measures such as procedures/ competency that aim to assure reliable human performance) (EI, 2020). Further guidance has since been published by the Energy Institute (EI, 2020) and Chartered Institute of Ergonomics and Human Factors (CIEHF, 2023) hence the methodology will not be discussed further here.

SECT analysis can be employed to ensure that, with the involvement (and thereby ownership) of frontline personnel, the format and content of severe weather procedures assists and supports decision making for storm preparedness. Severe weather 'procedures' developed following SECT analysis are not envisaged to be step-by-step instructions as per an operational 'standard operating procedure' (SOP). Rather they should provide a decision aid that structures the decision-making process and ensures that the relevant elements that need to be assessed are defined in advance and then independently assessed (thus delaying and limiting the role of intuitive judgement). Such a structured approach, informed by a proactive Human Factors assessment (SECT analysis) both reduces variability and the effect of biases (such as the initial goal fixation previously described) in decision making and increases the transparency of the process (Kahneman, 2019). Following the Spey incident the duty holder adopted such an approach by undertaking SECT analysis to revise their severe weather procedure(s) and establishing a defined protocol for 'weather assessment meetings'.

SECT analysis also has an important role to play in identifying the skills, behaviours and underpinning knowledge required of decision makers and in ensuring that performance standards and competency assurance arrangements match the criticality and frequency of these scenarios (HSE, 2003). A particular advantage of integrating SECT analysis into training and competency assurance is that the SECT analysis process encourages those involved to consider, and learn from, errors without these occurring in reality. Training involving error-filled scenarios has been shown to encourage critical analysis and problem identification (Joung, 2006) and thus promotes adaptive thinking which is a necessity for decision makers in a complex scenario such as preparing for and dealing with a storm offshore.

Maintaining 'common ground'

- Equipment design

Management of a situation as dynamic as a storm offshore requires common ground to be maintained, not just between individuals on the unit, but with onshore management, client representatives and other parties (e.g. coastguard). This requires effective communication of safety-critical information which, in turn, depends on changes in key parameters (e.g. mooring line tensions, offset from the well BOP (blow-out preventer), riser angle) being easily detectable. It is therefore critical that ergonomic design principles such as self-descriptiveness, compatibility (with human perception and the task to be performed) and error tolerance are applied to the design and layout of relevant equipment. This is particularly important in relation to control room operations because prior to and during a storm, the control room operator (CRO) is required undertake multiple simultaneous activities. These include ballasting and stability calculations, monitoring weather conditions, monitoring mooring line tensions, monitoring hole position and communicating with the Barge Master (who has authority for marine operations). However, in one of the described incidents changes in mooring line tensions were not detected because they did not show in the average tension log that was being monitored and in another the mooring line(s) tension display was not visible from the position where the CRO undertook PC work (e.g. ballasting and stability calculations) rather than condition monitoring activities – see figure 2 below.

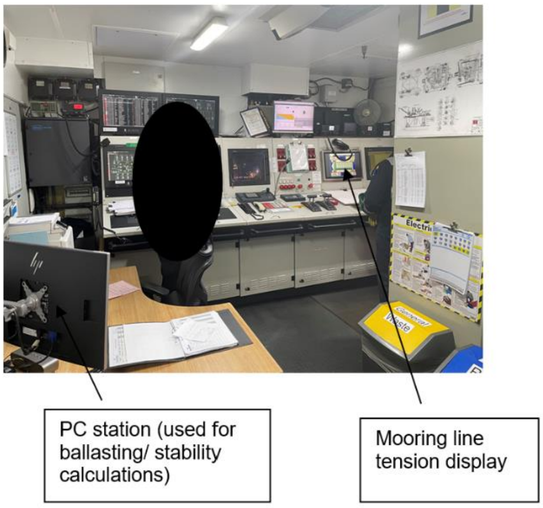

Figure 2. Example of poor control room ergonomics in a MODU barge control room

- Organisational culture

HSE considers health and safety culture as a subset of organisational culture – *"the way we do things around here"* (HSE, 2024a) and further defines a **positive safety culture** as being:

"Characterised by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures."

(HSE, 1999)

The importance of trust between employees at all levels of an organisation is echoed across various models of safety culture. For example, Reason (2000) describes the need for an *informed and flexible* culture that is built upon an adequate *reporting* culture which in turns needs a *just* culture as a foundation. Similarly, a recent review (Bisbey, 2021) found *'psychological safety'* (a work environment in which employees feel comfortable asking questions, reporting and discussing errors) as a key enabler for a positive safety culture enacted through teamwork and collaboration. Therefore, an exaggerated focus on strict procedural compliance, especially without a participatory approach including Human Factors input to the design of procedures, is liable to have unintended consequences leading to blinkered compliance and hindering the development of a positive safety culture. It is noteworthy that in each of examples highlighted in this paper information regarding the specific operational limits (trigger points) that were missed existed within the organisation's corporate knowledge (albeit not in a readily accessible and easily comprehensible form). Decision makers relied instead on procedural rules that were easier to find or recall. This underlines the need to make critical information easy to find, easy to understand and hard to misinterpret, which in turn supports involvement of Human Factors in the design of procedures and critical instructions. Furthermore, an over-emphasis on 'operational discipline' can leave little room for the possibility that errors may be due to the constraints (i.e. PIFs) placed on individuals by the organisation – either in the physical environment (e.g. equipment design/ layout) or through organisational policies and procedures – and instead direct blame back onto frontline operations (Olsen, 2024). Individuals are thereby liable to be discouraged from open and honest reporting - depriving organisations of the 'free lessons' that are crucial to indicating drift towards danger in major hazard risk management (Reason, 2000). Dealing effectively with dynamic and uncertain situations such as storm preparedness requires decision-makers to spend sufficient time acquiring information, considering other opinions and problem solving before reaching conclusions. These are characteristics of 'Actively Open-Minded Thinking' (AOT) which has been associated with making more accurate predictive judgements (Haran, 2013). Therefore, to prepare for dealing with *complex* problems such as these, organisation's need to balance the need for procedural compliance with also encouraging a questioning mindset and open communication founded on trust.

Conclusions: Dealing with complexity

Complicated systems can be understood by being broken down into their component parts and they possess an inherent level of repeatability that allows outcomes to be predicted from the starting conditions if the system is well enough understood. In contrast a *complex* system cannot be reduced to rules or algorithms because of the variation and unpredictability with which its parts interact (Kinni, 2017, Sargut, 2011).

A colleague who has been involved in the HSE response to each of the incidents described in this paper commented following the Spey investigation that it was one of the simplest investigations that they had been involved in whilst working for HSE. This comment reflects the finding that none of the incidents mentioned in this paper occurred due to failures in *complicated* engineering systems. However, the challenge that MODU operators face in preparing for storm conditions is *complex* because of the unpredictability of storm mechanisms (Bricheno, 2023) and the need for an adaptable, human, response.

Dealing with complicated engineering problems is the norm for the petrochemical and wider process industries. Generally, these can be effectively addressed through hierarchical systems, processes and rules. The example of storm preparedness for MODUs is relevant across process safety because it exemplifies the need for organisations to identify when there is a transition from operating a *complicated* system to managing a *complex* problem. Organisations should prepare as effectively as possible for dealing with reasonably foreseeable complex situations such as the storm conditions faced offshore. This can be achieved in part by providing a structured approach to decision making supported by robust competency assurance arrangements as previously described. However, major hazard duty holders also need to develop critical thinking at all levels of their organisation and support the reporting, questioning and challenge that this brings. This is demonstrated by figures 3 and 4. If the need for procedural compliance becomes overly dominant the organisation's decision making process is restricted to the cycle shown in figure 3 – with the resultant risks of 'blinkered compliance'.

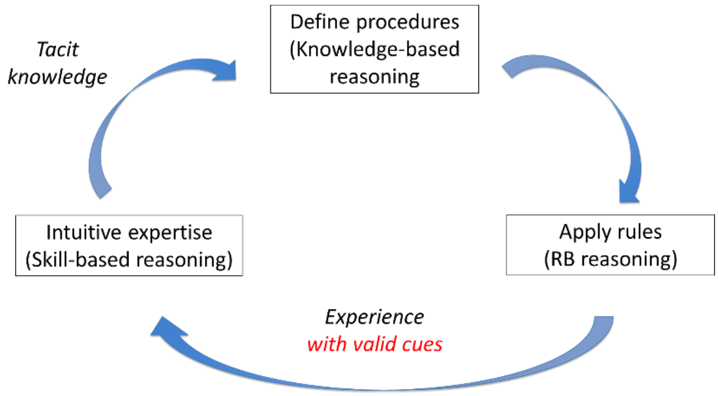

Figure 3. Organisational decision-making process with an **over-emphasis** on strict procedural compliance.

Therefore, this needs to be balanced by support for questioning and challenge to develop co-operation across organisational levels that enables a joint problem-solving approach (figure 4).

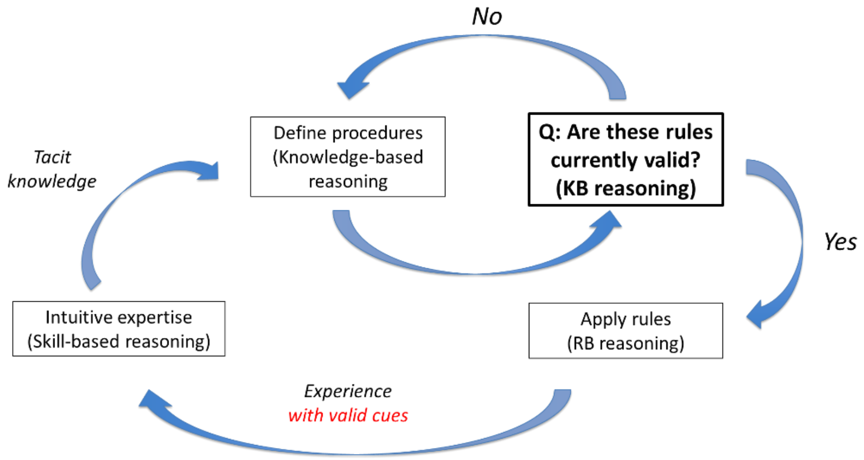

Figure 4. Organisational decision-making with a positive safety culture characterised by trust leading to joint problem solving.

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