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Immediacy Lost: Managing Risks in Oil and Gas Production

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Abstract. This paper presents material in support of the position that risk management in oil and gas (O&G) production is characterized by a loss of immediacy to the production process. We illustrate how loss of immediacy is an outcome of the O&G information infrastructure's mediation of the production process, and how engineers cope with the loss of immediacy when managing risk situations.

1 Introduction

This paper reports on research in progress. It presents material in support of the position that risk management in oil and gas (O&G) production is characterized by a loss of immediacy to the production process.

O&G production has been characterized as infrastructure work (Hepsø et al. 2009). Risk management is inextricably intertwined with the daily activities of this infrastructure work. Offshore installations recover O&G from subsea wells deep beneath the seabed. An extensive information infrastructure (II) collects real-time data from sensors along the production line and distributes it throughout a large network of specialized computer systems offshore as well as onshore.

Engineers in onshore production centres plan and optimize offshore O&G production. Physically removed from the offshore installations, the onshore engineers reach across this boundary with ICTs. These ICTs range from advanced expert applications visualizing real-time data from offshore O&G installations, to simple spreadsheets with historic production data. These ICTs are part of the larger O&G II, and are the same ICTs that engineers use to manage risks during operations.

As a society, we are concerned with technological accidents and the risks we shoulder through increased technological dependence (Beck 1992). Within computing research, this concern has spawned the subfield of software safety engineering. Software safety engineering is concerned with the construction of software for safety-critical systems. Safety-critical systems are systems whose failure may lead to human injury or environmental harm (Leveson 1995). Risk management in software safety engineering emphasises the need to identify risks to system safety, and to design software to detect, prevent, and recover from system failures.

Software safety engineering is based on the risk management strategy of anticipation. Anticipation is understood as "sinking resources into specific defenses against particular anticipated risks" (Wildavsky 1988, p. 220). Anticipation makes sense in stable and predictable environments where risks and their remedies can be anticipated. Yet, anticipation has clear limitations as a risk management strategy for IIs. IIs support a wide range of activities, with multiple actors continuously adapting the installed base with limited centralized control over the evolution. Unexpected events are likely to arise in such an environment and quickly propagate through the II (Hanseth et al. 2006). For safe and reliable operations in IIs anticipation needs to be complemented with other risk management strategies.

We therefore ask: How does an O&G company manage risks during operations?

Drawing upon materials collected during an ongoing study of ICT use for managing risks during O&G production, this paper emphasises how organizations mobilizes its information infrastructure to cope with unexpected events as they arise during operations. This is a shift of focus from anticipating risks during software design and planning. The object of study is therefore risk situations rather than risks themselves. Risk situations are understood as situations that hold the potential of human injury or environmental harm.

Managing risk situations requires the engineer to balance between safety and other organizational concerns such as the survival of wells and production goals – all of this in an ICT-mediated environment with a lack of immediacy to the production process. To argue the position that risk management in O&G production is characterized by a loss of immediacy to the production process, this paper is organized as follows. Section 2 presents the research setting and methods.

Section 3 offers a preliminary analysis of the collected data in support of the position argued here. Section 4 concludes the paper with a brief discussion the presented materials.

2 Research setting and methods

This paper reports from an ongoing study of ICT use in risk management during O&G production in Alpha Petroleum Company (APC). APC is a global energy company with much of its O&G operations on the Norwegian Continental Shelf (NCS). O&G production started on the NCS in the early 1970s. Many of APC's original fields have therefore entered tail-end production. Tail-end production is the last phase of an O&G field's lifecycle. Yet, new production technology, increased knowledge about the reservoirs, and better recovery methods have extended the lifetime of the fields. Tail-end production, however, is more expensive than regular O&G production. Not only does tail-end production require closer monitoring. The technical condition of the original, now aging, systems is also degrading. Increased production costs coincide with an increasingly competitive market situation.

APC has invested heavily in technological and organizational changes to meet this challenge. In addition to making better use of personnel, the transition to centralized onshore production centres is also regarded as a key to saving production costs. While there have always been onshore staff, these are now co-located with personnel that have traditionally be offshore. Co-located onshore, engineers from multiple disciplines work to together in cross-disciplinary teams. The transition to onshore production centres therefore requires closer integration and collaboration across geographical, organizational, and professional boundaries.

The purpose of our study is to develop a substantive theory on ICT use in managing risk during O&G operations. We therefore draw upon the grounded theory approach developed by Glaser and Strauss (1967) and elaborated by Strauss and Corbin (1998). Grounded theory is a *constant comparative method* for generating theory from data. With basis in coded interviews and fieldnotes, we have identified conceptual categories and their properties. The material presented in the next section is taken from our ongoing conceptualization of ICT use for managing risks during O&G production.

3 Loss of immediacy

This section presents material in support of the argument that risk management in O&G production is characterized by a loss of immediacy to the production process. This is inherent in the infrastructural work of O&G production. Since our conceptualization is still in early phases, we draw upon a concrete incidence as springboard into the conceptualization.

As reservoirs on the NCS are entering tail-end production, sand in the well flow becomes an increasing concern. O&G is recovered from reservoirs deep within geological formations beneath the seabed. Through this process the formations loose their integrity, and sand particles start mixing with the O&G flowing out of the well, the *well flow*. Sand production emerges in situations when the sand content in the well flow is high.

Sand production is a significant safety problem. The well flow moves through the piping towards the surface at high speeds. Sand increases the erosion on pipes and valves. Unchecked sand may erode through the equipment, with the potential of significant human injury and environmental harm. Sand production may also interrupt production, and is a threat to operational reliability. Sand weighs down the well flow. Too much sand makes the well flow too heavy to lift towards the surface. In these situations compact sand may fill hundreds of meters of the subsea pipeline. This stops the production, and may even mean the end of the well.

The incidence we draw upon here starts when an onshore engineer on call duty receives a call from the offshore control room. Being on call duty means that the engineer has to be available to the offshore personnel in case of unexpected events in production.

> The phone calls around two a.m. It's the offshore control room. They have an erosion alarm. Their onboard sensors register the highest erosion rate ever measured on the platform. The engineer gets out of bed and goes downstairs to the kitchen.
>
> Interviewing the engineer two days after the incident, I ask: "Are you at home when this happens?"
>
> "Yes", the engineer answers, "I am sitting at home in my kitchen. It is important that we have proper VPN access to our software applications in these situations. If I had to get in the car and drive to the operations centre in the middle of the night, I would have been inclined to tell the offshore control room to await the course of events somewhat. You know, there is a certain resistance to getting up in the middle of the night to start the working day."
>
> The engineer turns to his computer and points at an application window on the desktop: "On all flow lines, in all wells, we have a probe. Or a set of probes. Erosion probes that detect sand. When we have erosion on the probes, resistance changes."

3.1 Mediating the production process

In the above example, the O&G II takes us from wells deep beneath the seabed, along the flow line leading the O&G topside onto the offshore platform, all the way to the laptop on the engineer's kitchen table. Situated between the production process and the engineers, the O&G II forms a connection between the two. The II mediates between the non-quantified well flow and the quantified world of engineering. Mediation is not merely a matter of data circulation, but also of data transformation (Latour 1999). *Mediating is therefore the socio-technical process where a mediator transforms a source to a representation*.

A. Mediation chain

The erosion probe in the above example is only one of many sensors placed along the production line. Sensors are place along the production line from the wells deep in geological formations beneath the seabed along the pipeline onto the platform. Other sensors measure the well flow pressure, temperature, and chemical mix of the fluid pumped up from the well. The sensors transform aspects of the well flow into electrical signals.

Engineers, however, never relate to the electrical signals generated by the sensors. Rather, between the well flow and the engineers there is a chain of mediators taking the representation of the previous mediator as the source of its own transformation. This chain of mediators consists of production control systems, corporate production reporting databases, expert applications to support production planning and operations, as well as electronic document systems containing reports. Data undergoes multiple transformations along the mediation chain of the O&G II.

B. Transformations

The ICTs that engineers use are found at the end of the mediation chain, where each mediator along the chain performs different transformations. We will mainly focus on two of these transformations here: deconstruction and visualization.

By placing sensors along the production line, the well flow is deconstructed. It is deconstructed in two ways. First, sensors are localized at specific points along the production line. This reduces the continuous stream of the well flow to data points. Second, the sensors decompose the well flow by measuring a single aspect of it like temperature, pressure, sand content, as well as mix of oil, gas, and water. The well flow is the source of this transformation; sensors are the mediators that represent the well flow as electrical signals. The electrical signals represent changes in the well flow over time.

As the data passes along the O&G II's mediation chain it undergoes a series of transformations. The raw data of the sensors are timestamped and stored in production databases. To save storage space and bandwidth during onshore transmition, data is chunked by calculating average values or simply by picking a single value at regular intervals.

At the end of the mediation chain are the ICTs that engineers use in their daily work. These ICTs can be production control systems, expert applications, or even Excel spreadsheets. These systems visualize the data. Expert applications usually visualize time series data as graphs. These graphs enable engineers to see changes in a single sensor reading over time. It is also common that time series from multiple sensors may be displayed at the same time, enabling engineers to compare multiple measurements for similarities and differences. While time series is the most common form of visualization, visualizations can also be represented in form of standard reports ready to be printed on paper or gauges in the expert application.

C. Loss of immediacy

Each mediator along the mediation chain removes the data from the production process that it is to represent. Through the process of mediation, there is therefore a loss of immediacy. Immediacy is used in an epistemological sense: that of knowing the represented objects directly (Bolter and Grusin 1999). Engineers often talk about this loss of immediacy as an issue of data quality. However, rather than being a property of the data, loss of immediacy is a product of the mediation process. Loss of immediacy has multiple dimensions. We will limit our presentation to two dimensions: loss of necessary causal relations and fragmentation.

Returning to the sand production incident, we see how data may lose necessary causal relations to the represented object:

This effect (points to a spike in the graph in the application) may be caused by erosion, but it can also be caused by a change in the velocity of the well flow.

With no necessary causal relation between the data visualized in the expert application and the represented object, it is difficult for the engineer to fully determine what is happening offshore. Fragmentation is another dimension:

The focus may be on the erosion probe where you actually measure erosion, but you need to relate the data from the erosion probe to the whole system. [The probe is in] the ten inch flow line topside. Subsea you have six inch piping to the ten inch manifold. The erosion potential subsea is therefore thirty times higher than topside.

Deconstructing is necessary in order to quantify the well flow. Yet, it provides engineers with fragmented data of the well flow. In reaching across the physical boundaries separating engineers from the objects they are working with, the O&G II offers data on the well flow. Yet, for the engineers to have knowledge and understanding of the mediated phenomenon, they need to reach across the boundary between representation and the represented.

3.2 Determining situation trajectory

Let's return to the concrete incident at hand. When the onshore engineer receives the call, it is still unsure whether or not they have a risk situation at hand. The offshore control room has received an erosion alarm, but the onshore engineer is not convinced this means there is sand production. There is no necessary causal relation between the measure erosion and sand in the well flow:

> The effect may be caused by erosion, but it can also be caused by a change in the velocity of the well flow. Yet, something is usually amiss when we the data spikes like this.

When unexpected events occur, like a spike in erosion data, it is the onshore engineer's task to clarify the situation. Risk situations develop over time. When unexpected events occur, responsible engineer has to *define the temporal dimension* of the situation:

> It is important that we have quick access to data about the situation. We will then look at the data to see if this may be a false alarm, and await further developments. On the other hand, if the situation is critical, we have to act immediately.

Defining the temporal dimension of the situation is linked to *possible outcomes of the situation*: "An option could be to say 'let us await further developments until tomorrow, and keep producing oil as normal', but if there is sand in the well flow it may flow back and block the pipe and a well costing like 40 to 50 million dollars would be lost". Yet, to determine possible outcomes of the situation, the engineers need to determine what the situation at hand really is.

Through mediation the available data is fragmented and lacks necessary clear causal relations. The data is available through multiple ICTs that offer only a partial view of the situation. Downhole data from the subsea well is available through the onshore engineer's expert applications, but the offshore control room's control systems may also offer relevant data. While the data offered by multiple ICT's available to the O&G engineers lacks immediacy, the *act skilfully together* to assemble the data into a sufficiently working picture of the situation:

> We (the onshore and offshore engineers) sit down together to figure out what we need to do. You can say, they (the offshore engineers) do not analyse pressure data like we do. They look at erosion data, and measure sand in the well flow.

3.3 Risking

At some point, even though the situation is not entirely grasped, a decision has to be made:

> There is a bit of qualitative data evaluation, but then there is a matter of guesswork, too. It is simply a matter of daring to act. Taking a change. Not saying 'I have to wait until tomorrow to check with my supervisor'. Making a mistake here is expensive. Drilling a new well could cost about 40 to 60 million dollars. On the other hand: not acting is not an option either.

Such *risking* is accompanied by an *organizational non-accountability*. There is an explicit understanding within the organization that loss of immediacy often makes it difficult to fully grasp risks situations. Risking is therefore necessary.

Indeed, it is even encouraged. In a risk situation an onshore engineer reacted to what he found to be undue caution on behalf of another engineer: "What have you got to loose? Go for it, man!".

It is important for the organization to review after the fact, but individual engineers are never held directly accountable for their risking. Instead, the organization has focus on *developing routines* for handling similar situations in the future. There is focus on developing new expert applications that inscribe standard ways of combining information to deal with the loss of immediacy in known risk situations.

4 Concluding remarks

We have presented material in support of the position that risk management in O&G production is characterized by a loss of immediacy to the production process. This material illustrated how loss of immediacy is an outcome of the O&G II's mediation of the production process (Section 3.1). We then illustrated how this loss of immediacy creates uncertainty during risk situations, and how O&G engineers skilfully use ICTs to handle these situations (Section 3.2). Finally, we illustrated how the organizational practices of risking and situational non-accountability are necessary to manage risks in situations of uncertainty (Section 3.3).

Software safety engineering view safety and reliability as a systems property (Leveson 1995). Yet, the above conceptualization illustrates how safety and reliability is achieved in the interaction between engineers and ICTs. Safety and reliability is therefore better understood as the organization's ability to respond to and recover from risks that can lead to failure in performing the required activities. Safety and reliability is not a residual factor of well-designed production systems (Hepsø 2006). Rather, the above conceptualization suggests that *safety and reliability is an organizational capability*.

Amit and Schoemaker (1993, p. 35, italics in original) define capability as "a firm's capacity to deploy *Resources*, usually in combination, using organizational processes, to effect a desired end". Capability is therefore more than people acting knowledgably to achieve organizational reliability. It is also matter of mobilizing appropriate resources to achieve safety and reliability in risk situations. Data is among these resources. Safety and reliability is therefore not a system property, but rather a continuous achievement.

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