

# Imagination, distributed responsibility and vulnerable technological systems: the case of Snorre A

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**Abstract** An influential approach to engineering ethics is based on codes of ethics and the application of moral principles by individual practitioners. However, to better understand the ethical problems of complex technological systems and the moral reasoning involved in such contexts, we need other tools as well. In this article, we consider the role of imagination and develop a concept of distributed responsibility in order to capture a broader range of human abilities and dimensions of moral responsibility. We show that in the case of Snorre A, a near-disaster with an oil and gas production installation, imagination played a crucial and morally relevant role in how the crew coped with the crisis. For example, we discuss the role of scenarios and images in the moral reasoning and discussion of the platform crew in coping with the crisis. Moreover, we argue that responsibility for increased system vulnerability, turning an undesired event into a near-disaster, should not be ascribed exclusively, for example to individual engineers alone, but should be understood as distributed between various actors, levels and times. We conclude that both managers and engineers need imagination to transcend their disciplinary perspectives in order to improve the robustness of their organisations and to be better prepared for crisis situations. We recommend that education and training programmes should be transformed accordingly.

**Keywords** Imagination · Responsibility · Vulnerability · Engineering · Snorre A

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## Introduction

Many accounts of engineering ethics discuss codes of ethics and the application of moral principles by individual practitioners. But such an approach faces at least two limitations. First, a focus on individuals alone may neglect the inherently social and contextual aspects of technology design and management. Engineers are part of organisations and technological infrastructures cannot be isolated from the wider managerial, social, economic and political context. An individual-centred ethics of engineering and technology tends to neglect these aspects. Second, while it cannot be denied that rules and principles play a role in moral reasoning, a focus on deductive logic and argument is in danger of leaving out other processes, elements and human abilities that also play a role in human thinking, such as imagination and emotions. Therefore, to better understand the ethical problems of complex technological systems and the moral reasoning involved in such contexts, we need other theoretical tools as well. In this article, we explore the role of imagination in coping with the vulnerability<sup>1</sup> of complex technological systems, and develop the concept of distributed responsibility to capture a broader range of human abilities and dimensions of moral responsibility involved in such practices. This will allow us to suggest changes in approaches to engineering ethics and the professional education of engineers and managers.

First, we look at currents in ethical theory that do not exclusively focus on rules and codes. Some pragmatic philosophers argue that talking about ethics in terms of moral imagination offers a novel approach to ethics. Johnson [10] and Fesmire [5] argue that imagination, rather than rules, principles and codes, occupy and should occupy a central place in moral reasoning. However, on the basis of this literature it remains unclear how precisely moral imagination works in practice.<sup>2</sup> How do people use their imagination in real crisis situations involving complex technological systems? And why should they? Furthermore, when an accident happens in such a context, a complex problem of moral responsibility arises, since such accidents not only harm others but are typically not the result of an individual action alone. How is and how should responsibility be distributed?

To explore these questions we will discuss the case of Snorre A.<sup>3</sup> The case involves a complicated technological installation, operated by Statoil and used for the offshore production of oil and gas on the Norwegian continental shelf. In November 2004 an uncontrolled release of gas occurred while work was being performed on well P31A. The gas, escaping from an underwater source—through holes in the well’s tubing and cracks in the seafloor—and from a source at the

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<sup>1</sup> The term “vulnerability” is a recent conceptual innovation in science and technology studies, coined with the aim to overcome the limitations of technical, calculating risk assessment. It can be defined as “a system’s reduced ability to anticipate, resist, cope with, respond to or recover from undesired events that threaten the achievement or maintenance of performative closure;” [19, 20]. The notion of performative closure can, in this case of geophysical engineering, be understood in a very literal sense as the containment of hot and high-pressured oil and gas.

<sup>2</sup> For a first exploration of this issue in relation to regulation and the autonomy of engineers see [4].

<sup>3</sup> This essay builds on material from Ger Wackers’ empirical research on the Snorre A case. For a full account see [21].

topside installation, engulfed the platform in a cloud of natural gas. Fortunately the gas cloud was not ignited. The majority of the personnel on board was evacuated, but a small group of the crew remained on board and succeeded eventually to regain control over the well. The potential consequences of an uncontrolled, ignited and burning gas blow-out were huge, both for people, company assets and for the environment. The situation developed to the brink of disaster, but was successfully recovered through the way in which the platform crew handled this crisis situation.

The official accident investigation reports of the Norwegian Petroleum Safety Authority (PSA) and of Statoil [2, 17] limit the scope of its analysis to the Snorre A operations unit, excluding the role and responsibility of higher levels in the corporate hierarchy. Due to the PSA' mandate the report lists 28 more or less serious *deviations* from applicable *rules and regulations* that have contributed to the loss of control over the well. Furthermore, the report does not provide an account of the successful recovery from the trajectory to disaster. We approach this case from a different perspective. We will argue that a corporate level lack of imagination (imaginative deficit) played a crucial role as a source of system vulnerability and loss of control. The *responsibility* for increased system vulnerability should not be ascribed exclusively to individual engineers alone, but should be understood as distributed between various actors, levels and times. Furthermore, we will argue that imaginative capabilities were key to the successful recovery from disaster. We will discuss the role of scenarios and images in the moral reasoning and discussion of the crisis management team on the threatened platform.

## Imagination and morality

Most people associate imagination and metaphor with art and literature. But this restriction leaves out of sight the important role they have in our everyday thinking, including moral reasoning and decision-making. A brief discussion of relevant theory in this area will allow us to develop concepts of moral responsibility and imagination that will serve to better understand what happened in the Snorre A case.

### Moral roles of imagination

In the literature on moral imagination, imagination is given several moral roles. First, imagination allows us to explore the consequences of our actions. According to Mark Johnson, imagination does not only allow us to discern various possibilities for action [10, p. 187], we also envision “the potential help and harm that are likely to result from a given situation” [10, p. 302]. Thus, exploring the consequences of our actions is not primarily a matter of calculation, as utilitarians and engineers may believe, but is an imaginative and creative activity that “morally sensitive and perceptive people must do” [10, p. 212]. In *John Dewey and Moral Imagination* [5], Steven Fesmire endorses this view: when we encounter a problem, we imaginatively test alternatives until a solution is found. By means of this “creatively tapping a situation’s possibilities” [5, p. 6] our perception is amplified beyond the immediate environment [5, p. 66]. Second, such enhancement of perception also takes place

when we put ourselves in someone else's shoes. This "entering by imagination into the situation of others" [5, p. 65] allow us to understand the perspective of the other. In the sentimentalist philosophical tradition the capacity to do this is called "sympathy" or "empathy",<sup>4</sup> but pragmatists view the role of imagination in a broader perspective: imagination is not only linked to emotion or sentiment, and morality is not "founded" on sentiment, or a matter of sentiment alone. Imagination is given a central role in a process of moral reasoning that is understood as involving many factors. Third, empirical research in cognitive science and linguistics [11] shows that images are not external to the linguistic process itself, but are interwoven in our moral language. Johnson distinguishes three ways in which metaphor enters our moral deliberation: we use it to conceptualise situations, it provides ways of understanding moral concepts and the nature of morality, and it constitutes a basis for moving beyond prototypical cases to new cases, allowing us to learn from experience [10, p. 10]. Fourth, Fesmire argues that improvisation and tuning are ways to create action options and to reach agreement. He compares moral reasoning with jazz improvisation: to reach coordination one must improvise and harmonise interests [5, p. 94]. A jazz musician catches signals from the other group members while anticipating the group's response. Thus, there is no "right way" of doing things, but it is not arbitrary. "Drawing on the resources of tradition, memory, and long exercise, she plays *into* the past tone to discover the possibilities of future tones in the way moral imagination enables us to see the old in terms of the possible" [5, p. 94]. In Johnson's and Fesmire's view, imaginative moral reasoning is and should do precisely that.

### Implications for morality

Johnson and Fesmire put their view of moral imagination in the context of the pragmatist argument against foundationalism, absolutism and Kantianism in moral theory. Rather than searching for principles and prescriptions, they argue, we should cultivate moral imagination. There is no fixed procedure and no fixed list of obligations. If there is an obligation, it is to cultivate our moral imagination [10, p. 215]. Moreover, we should give up the search for a foundation of morality. According to Fesmire, we should not look for a "bedrock principle" [5, p. 3] but see ourselves as embodied social and cultural beings who evaluate our habits in the light of new changes in our environment. Principles, rules and procedures do have a role in moral deliberation, but they are merely "guiding hypothesis" that are to be tested [5, pp. 58-59]. The main opponent of pragmatists such as Fesmire is Kant. Their objection is that Kant's moral psychology makes imagination into a thing that forms mental images, and a thing that is not to be trusted. "Imagination, on this view, is usually a trusty crafter of images but is given to mischief" [5, p. 61]. Furthermore, they accuse Kant of conceiving of action in isolation, without context. According to Fesmire, following formal rules without taking into account the social context is a mark of autism rather than an ideal of moral reasoning [5, p. 72]. What we need is "a socially responsive imagination that skilfully perceives paths of

<sup>4</sup> See the work of Martha Nussbaum [13, 14], Adam Smith [18] and David Hume [8, 9].

mutual growth” [5, p. 129]. Both Johnson and Fesmire, therefore, argue for a view that puts imagination in the foreground, “a Copernican shift centring ethics on imagination” [5, p. 68].

### Using pragmatist ideas for engineering ethics and the Snorre A case

In this article, we do not defend a particular position in this debate in moral theory, rather we explore what the ideas on moral imagination put forward mean and we do this in the context of engineering and crisis management in the case of the Snorre A gas blow-out. In spite of the pragmatist claim that practices should be of primary interest to philosophers, Johnson’s and Fesmire’s arguments remain rather abstract and vague, unless we can see what they imply in a practical, real-life context. We will examine this in two ways. First, we will make a point about the distribution of moral responsibility based on the work on metaphor and morality by Johnson and others, and based on the concept of “discretionary power”. The concept of distributed responsibility will allow us to discuss issues of moral responsibility involved in the causal history and wider context of the Snorre A case: How could the Snorre A crisis happen in the first place? What made the system vulnerable? Second, we will discuss various roles of imagination as suggested by Johnson and Fesmire in the context of the recovery from the crisis: How did the platform manager and his crew cope with the crisis? Our answer to both questions aims to contribute to an empirically sensible understanding of responsibility, vulnerability and the role of imagination in the context of engineering ethics in general and the Snorre A case in particular.

### **Transaction, discretionary power and distributed responsibility**

#### The transaction metaphor, discretionary power and distributed responsibility

Johnson and Lakoff [10, 11] have argued that our thinking is deeply metaphorical, and that these metaphors are rooted in early bodily experiences. According to Johnson, this holds for our moral conceptions as well. An influential moral metaphor is that of a commercial transaction, which “creates a realm of exchange, debt, credit and balance within our physical and social interactions” [10, p. 41]. Let us explore what it means to understand responsibility along these lines. In Johnson’s pragmatist approach duties and moral obligations are not seen as essences or absolutes, but rather as the outcome of a transaction between two or more parties. Often one party is recognised as having a legitimate authority, for example the state in the case of the offshore industry. Something is distributed by a legitimate authority among actors. The “thing” that is exchanged and distributed—for example through the issuance of a license to produce oil—is discretionary power. A transaction constitutes a discretionary space for an actor. However, such granting of discretionary power is conditional. The legitimate distribution of discretionary power by a legitimate authority establishes the right of the actor: (a) to ownership of some property; (b) to exercise (or not-use) that discretionary power (within the

boundaries of its discretionary space (freedom of action) and (c) freedom from undue interference. The latter also comprises freedom from undue interference from the legitimate authority itself. Hence, the granting of discretionary power itself constrains the legitimate authority's possibilities to interfere with the way in which discretionary power is exercised, as long as this is done in accordance with set conditions. Within the metaphor of a commercial transaction, the obtained rights bring with them the obligation or duty to exercise discretionary power in accordance with the stated purpose and license conditions, without causing detrimental effects to humans and non-humans. Failure to do so leads to requests for explanations, to questions for which answers must be provided. It also makes the actors and the way they exercised their discretionary power subject to review, censure or control by a designated authority (police, state attorney). Eventually this can lead to withdrawal or restriction of discretionary power by the legitimate authority. Thus, with the distribution of discretionary power responsibility is devolved to varying degrees to the companies and people who have applied for and accepted portions of that power (as shares in a field license). If discretionary power is shared or distributed among various actors, we can refer to the resulting pattern of devolved responsibilities as "distributed responsibility", with "distributed" referring to the process of both granting power and sharing responsibility.

#### Distributed responsibility in the Snorre A case

Let us examine what these rather abstract ideas mean in the Snorre A case. Natural resources like oil and gas on the Norwegian continental shelf are owned by the Norwegian state, but licenses to produce are granted by the state as the legitimate authority, usually to a group of oil companies (licensees). They have the right to sell the oil and gas that they produce on the market and make profit. But there are conditions attached to this discretionary power. Sets of rules and regulations are attached to the oil companies' licence to produce oil and gas. Furthermore the oil companies are not only on the receiving end, but act in turn as a legitimate authority distributing discretionary power to contractors and subcontractors, such as a drilling company.

One actor can have various roles that are performed at different moments in time through various institutions. In the Norwegian context, the state does not only grant discretionary power to oil companies when it issues a license. The state also monitors offshore operations through the PSA. It taxes the profits made by oil companies. The state also acts as an investor and licensee in offshore fields through a completely state-owned company, Petoro., Through its involvement in Statoil (completely state-owned until 2002) and Norsk Hydro (half state-owned), it is directly involved in oil and gas production as well. Thus, the discretionary agency of the state has many facets. These facets have to be taken into account in a responsibility analysis.

Snorre A had been build and operated by Saga Petroleum in the 1990s. Towards the end of the decade Saga was taken over by Statoil and Norsk Hydro. In the takeover, a deal was made that Norsk Hydro would assume operating responsibility on Snorre A for only 3.5 years, after which Statoil would take over to integrate

Snorre A in a larger “result unit” comprising nine platforms in the Tampen area [6, 12, 15, 16]. The Snorre A operations unit changed hands two times within the course of 4 years. Its personnel shifted from one company and employer to another two times in quick succession, requiring them to adapt to differences in company cultures and learn new sets of documentation, company rules and regulations. Solutions like these require the approval of the other licensees in the field (including Petoro) and changes of operatorship on a platform require the approval of the state. This implies that the Norwegian state was very much involved at the level of finance, business and industrial politics. After Snorre A’s transfer to Statoil in 2003 the Tampen area result negotiated a new contract and replaced the drilling contractor on Snorre A. Part of this deal was that the drilling contractor was only paid for uptime (effective operational), not for down time. Down time is required to perform maintenance and safety work. Interruption of the work for reasons of safety concerns on the part of a driller would interrupt his employer’s cash flow. Especially after a decade with very low-oil prices time was not seen as a resource for safety, but was increasingly commodified and turned into money.

Machinations like these are driven by the logic of a corporate order. This is a world that is quite different from the world of engineering and day-to-day platform operations. Corporate executive officers, bankers, lawyers, policy makers and politicians have different knowledges, skills and interests. In a strained market the logic of corporate order requires them to reduce costs, improve efficiency and strive for maximisation of shareholder value, whereas the consequences for reliability and safety at the technical level are often not explored. The process of concluding optimal business deals is not linked to the process of assessing its consequences for the organisation’s capability to anticipate and handle undesired events manifesting themselves at the level of a platform. This decoupling is the manifestation of an imaginative deficit: of a trained inability to imagine long-term consequences that may happen at different levels of the organisation. People in both worlds frame<sup>5</sup> and imagine Snorre A in fundamentally different ways. In the business world, Snorre A (the installation and the field) was seen as business asset, imagined as a money machine, contributing to the value per share of the company on international stock markets. The vulnerability of the technological system remained out of sight, unimagined.

The Snorre A gas blow-out was investigated by two other “organs of the state”: the police and the state attorney. One year after the incident, in November 2006, the state attorney issued a fine of 80 million Norwegian crowns to Statoil, the company that was responsible for the operation of the platform at the time of the blow-out. This post-accident attribution of responsibility for the endangerment of people and environment does not follow the pattern of devolved discretionary power and distributed responsibility outlined above. The Norwegian Petroleum Act attributes legal responsibility for offshore operations—including work performed by drilling and other subcontractors—*exclusively* to the operating oil company, which then

<sup>5</sup> We borrow the notion of “framing” from STS literature. A frame constitutes the field of thinking and shapes social interactions. Framing is rooted in education, vocational training and work experience. See also [3, 7].

serves as a proxy for its partners in the field license, including state-owned Petoro. As a consequence, the role and responsibility of other higher-level actors are effectively deleted from consideration and discussion. By accepting the fine Statoil avoided further prosecution in a court of law and the associated public scrutiny.

The ways in which people at various levels and in different “worlds” imagine the technological system and fail to imagine the links between their deals and the vulnerability of that system, contributed to what could have been a disaster with serious human, ecological, and economic consequences. Let us now look at the role of imagination in managing the crisis.

### **Imaginative crisis management**

Turning to the successful recovery of the Snorre A blow-out, we distinguish and discuss the following roles of imagination as an ability used in crisis management: the *representation* of what was happening in the underground, the elaboration and projection of *future scenarios* to assess the possible consequences of action options, the projection of complete and rich *images* used in the collective decision-process and communication within the crisis management team and beyond, and the creation of *new action options* and processes of *improvisation and tuning* with others in the crisis team.

Representation, association and memory: what is going on?

People on a platform are not in direct visual or other human sensory contact with what happens under water, in the seafloor and deep down in the well. In emergency situations, the first role of imagination, therefore, is to create a picture of what is going on. This is not fantasy, but an active, creative process in which people have to make sense of, in this case, a strange pattern of alarms from instrumental monitoring devices and visual observations of the surface of the sea. The crisis started with the instrumental detection of methane gas. But from the unstructured pattern of gas alarms it was difficult to arrive quickly at conclusions concerning the source of the gas. The detection of gas was not immediately associated with the well situation in P31A. Then, looking from the platform down at the sea, somebody first saw gas bubbles rising in the water below the platform. This brought about the association with the well situation and identified P31A as the probable source of the gas. The situation quickly developed from an abnormal, but still contained, well situation with irregular pressure surges and some loss of mud, into a parallel gas blow-out, in which gas was released both on the top-side drilling deck and from some source below sea level. The drilling manager recalled an old casing perforation, about 1.5 km below the seafloor, that had been sealed off (in 1995) with a scabliner that now was being pulled out as part of the overhaul of the well. Now the imagined picture of what was happening was complete: with the well being open to the high-pressure reservoir, gas was escaping through the old perforations, cracking open the seafloor and rising through the water under the platform as a forceful jet stream. Imagination has little to do with free fantasy, as it is often understood; rather,

imagination draws on available epistemological resources: experience, memory, monitors and indicators, etc. In the planning process of the well operation, that was conducted on land, the imaginative deficit and vulnerability consisted in the reduced ability to imagine the consequences of optimising changes in the procedure for the barrier situation of the well.

#### Possible consequences: worst case scenarios

Statoil and its Snorre A operations unit had a pre-established policy regarding the management of a crisis situation on the platform: proactive management. This implied that in handling a crisis situation they would assume a *worst-case scenario* being played out. Since there was little time available in the crisis situation, the platform manager could not engage in some form of probabilistic risk assessment. What he could do, and did, in such a situation, however, is to try to imagine the worst-case scenario itself and its consequences.

The “normal” pre-conceived scenario of the “abnormal well situation” (irregular pressure surges) was the loss of control over the (single) well, a blow-out. Based on previous experiences with blow-outs the site of release of oil or gas was expected to be on the topside, on the drilling deck. This was one of the emergency situations that they trained for in regular on-the-job training sessions. In accordance with pre-established regulations, the platform manager raised the alarm, closed down all production on Snorre A and started the evacuation by helicopter of personnel who were no longer required on board. But what to do next? A subsea blow-out, let alone a parallel blow-out, was not one of the emergency situations that had been anticipated. How is it possible to imagine the worst-case scenario in this situation? Platform management imagined loss of the platform, and the mechanisms that could bring this about: (1) the loss of upward drift due to coalescing gas bubbles under the platform and (2) the loss of one or more anchors in combination with the forceful jet stream under the platform. In either case loss of the platform would mean that it would topple and sink. Due to the stiff nature of tension leg anchors, the platform would go down *on site*. Inherent in its design, Snorre A had no anchor chains that would allow it to float away for some distance, out of harms way. Going down on site, the platform would rip off the oil and gas carrying risers and destroy the steel frame that collected 40 wells and related equipment. This would have severe consequences: the worst case scenario was not a single gas blow-out on a top-side deck, but a massive oil and gas blow-out from multiple wells in water 350 m deep.

#### Rich images: Bravo, Kuwait and Piper Alpha

The imagination exercise did not stop there. In their decision-making, platform management explicitly mobilised three well-known and familiar images to elaborate the consequences and to discriminate this impending scenario from what was known to have happened before in other wells in other oil fields.

The first of these images is the April 1977 Bravo oil blow-out, on the production deck of the Phillips operated Bravo-platform in the Ekofisk-field. It was the first

major oil blow-out in the still young North Sea offshore industry. Many have seen on TV the fountain of oil erupting into the air and spilling tons of oil into the sea for several days. However, this was a blow-out from a single well head on deck, and it was (relatively) easily accessible.

The second image that was mobilised was the equally well-known and broadcasted scene of the multiple oil wells that were destroyed to blow-out and put on fire by the retreating Iraqi army in Kuwait, in the first Gulf War. Bulging black smoke clouded the sky and tons of oil polluted land and water. It took months to regain control over the installations and normalise the situation. Yet, they were on land and far apart, hence readily accessible. In the worst case scenario of Snorre A, the wells spilling oil at the steel frame under the platform were only a few metres apart, in 350 deep ocean water, and probably covered by the wreck of the Snorre A platform itself. Oil would flow freely and contaminate the ocean in massive amounts for months. And the platform manager imagined that the oil would reach the shores of the Norwegian coast and destroy wildlife, nature and tourism for decades to come. Clearing the oil from the coast would incur insurmountable costs for local communities and seriously burden Norwegian society and the state. Statoil would be engaged in cleaning the coast from oil spills for decades, but probably it would not survive and go bankrupt. Furthermore, Norway's reputation and that of its major oil companies (Statoil and Norsk Hydro) would be seriously damaged.

As the parallel blow-out developed company regulations and on-land second and third tier crisis management teams supported full evacuation of the platform. People should not be exposed to danger longer than absolutely necessary. But should the technical systems be trusted to take care of the emergency? Like the captain on a ship, taking full responsibility for the consequences of his actions, the platform manager did not decide to fully evacuate the platform but to try to regain control over the well. In doing so, he knowingly and willingly broke the regulations, risking criminal investigation and charges if people were killed in the attempt to prevent the worst case scenario from playing out. The platform management asked some people to volunteer to stay on board, taking into account the skills needed to handle the situation. Personnel on board was reduced to 35 people. These were people who knew each other well and trusted each other. The platform manager had earned himself a large degree of trust as well. But trust would not go all the way if people felt that they would die in the attempt to save the installation and the company. Another well-known rich image was mobilised that vividly illustrated the circumstances of their death in trying to save Snorre A: the Piper Alpha disaster, occurring in 1988 in the British sector of the North Sea. Following an initial explosion and due to reduced fire fighting capabilities, a series of further explosions and hot gas fires destroyed the complete top-side structure of the platform within a couple of hours. About 165 people were killed, in the fire or while jumping from the platform or drowning in the water before being rescued. If the gas cloud ignited, Snorre A would become a second Piper Alpha, or so it seemed. To make the members of the platform management stay voluntarily, the platform manager had to *defuse* the Piper Alpha imagery. He had to make it plausible that staying on board would not necessarily imply that they would get killed. To do so he made a distinction between, on one hand, the ignition of the gas cloud and, on the other

hand, the hot gas fire that would burn from the surface of the sea under the platform, fed by the jet stream of gas coming from the seafloor.

For each of these components he recruited different images. For the ignition itself, he called upon the experiences of many people who have tried to ignite an under-pressurised gas stove: there will be a dull plop, but not the blasting, violent release of energy that you see in an explosion. Pressurised gas will explode, but not the unpressurised gas in the ambient air. Being dispersed by the wind, this gas will burn away quickly without an explosion. Hence, in case of ignition, they would not die in an explosion. Yet, the ignition would ignite the gas fires that would burn like torches from the surface of the sea under the platform. However, these fires would not necessarily kill those on board either, since fire fighting ships, covering the underside of the platform with a horizontal screen of water, would buy those on board enough time to evacuate the platform by means of helicopters or life boats.

Images played a key role in dealing with the crisis situation. We have shown how images were recruited from a shared pool of experiences. They were used in at least two ways. First, they were used to imagine the possible consequences of a crisis situation. Access to these images and their potential to be mobilised as whole and coherent patterns or scenes or stories made it possible to elaborate a worst case scenario quickly. Second, in the crisis situation it was necessary to defuse one of these images, also by recruiting familiar experiences and images; by recalling images that could *show* that this case was different. This demonstrates that the imaginability of things is always connected to existing knowledge and experience. These patterns of experience must be available in order to be selected and mobilised. We suggest that a model of (disembodied) cognition, moral reasoning and risk perception that neglects the role of images and imagination is incomplete and inadequate.

### Creating more action options; improvisation and tuning

When elaborate projection and assessment of various scenarios is impossible in crisis situations, imagination can still help to create more options based on previous experience and training. To avoid disaster, it is important that the people involved (sharp end workers) have good imaginative capabilities and an adequate action repertoire. Routinisation may decrease this responsive repertoire and the people involved would be less able to respond adequately to unexpected situations. This can be interpreted as an imaginative deficit for the task or situation at hand: a reduction of what Adamski and Westrum call requisite imagination [1]. In the case of Snorre A it was not routinisation as such that brought about the imaginative deficit in the planning process for the well operation, but the frequent hand overs of the operations unit from one company to the other in combination with a concomitant shift in drilling contractor.

This leads us to the question with regard to the responsibility for the maintenance of required imaginative capabilities and a broad responsive repertoire among the sharp end workers. Who is responsible for an individual's cognitive make-up? It follows from our account that, in this context, it is the legitimate authority that grants the license to work, that sets conditions and defines the boundaries of the

workers' discretionary space, that is also responsible for providing the proper conditions for the workers to perform their tasks reliably.

The platform crew's ability to successfully improvise depended on knowledge, skills and experience, and this included *local* knowledge and experience, here familiarity with a particular technological installation. For the Snorre A crew, their familiarity with the installation resulted from an extensive exposure to the installation in frequent corrective maintenance jobs that were due to a sustained emphasis on cost reduction and deferral of preventive maintenance.

On Snorre A, as the blow-out developed, main electrical power supply was shut down in compliance with safety regulations. This further reduced the system's ability to cope with the blow-out, because power was needed to operate the heavy equipment that could "kill" the well by pumping down the well a stream of dense drilling mud. An improvised solution was found: at the risk of causing a total power outage, the electrical system was rearranged and main power supply was re-established. This would have been impossible without extensive local knowledge and experience. In a paradoxical sense, operating Snorre A like a money machine maintained the improvisatory skills that saved the day for the recovery of the blow-out.

In a broader sense, improvisation is part of what goes on in moral and social interaction. Following Fesmire [5], we can understand moral reasoning in analogy with jazz improvisation. People play into the tunes of the past, and try to tune and harmonise with the other players. The crisis decision-process within the team could be understood in these terms. The manager needed to harmonise the various forms of expertise and judgments of the team members to reach a decision. Part of this process of improvisation and tuning may be the use of the images just discussed.

Note that processes of improvisation and tuning do not only rely on existing knowledge but they also generate new knowledge, skills and capacities. Furthermore, improvisation is not rule governed—in this case safety regulations were violated—but coordinates actions by using imagination. The reproduction of existing patterns goes hand in hand with innovative adaptations and the imaginative exploration of new options.

## Conclusion

We conclude that in the Snorre A case and similar cases, imagination can and should play a role in at least two ways. First, imagination can help engineers and managers directly involved in offshore oil and gas production activities to avoid emergent vulnerabilities and handle crisis situations. We have shown that imagination is needed for the representation of what happens in a crisis situation, the creation and discussion of (worst case) scenarios, the mobilisation of images and people, and the creation of new action options and improvisation. Second, having looked at how the crisis situation could happen in the first place, we conclude that imagination can help professionals directly *and* indirectly involved in these offshore activities to transcend the constraints and limitations of their own professional perspective. Our discussion of distributed responsibility in the Snorre A case shows

that coping with ethical problems related to large and complex technological infrastructures is not only a task for offshore engineers, managers and technicians. If many actors have a share in the discretionary power, those actors and the people involved should be held responsible. This includes those who operate on the level of policy, business and finance.

These arguments have implications for ethical theory and education. For engineering ethics, they imply that a rigid separation between engineering ethics, on the one hand, and business ethics and political theory, on the other hand, is an undesirable limit to our efforts to understand ethical aspects of technology management and governance. For education, it means that, apart from its obvious merits, specialisation in professional education and training has disadvantages that should be recognised and dealt with. If we want to educate people who are able to transcend their professional perspective, we need to think how to do that. We suggest the integration of other perspectives into their curriculum, including ethical and social reflection on their disciplinary training and practices. We know that some of this is going on already, but by discussing the Snorre A case, we hope to have shown that it is not just a luxury but a moral and a professional requirement.

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