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Fantasy planning: the gap between systems of safety and safety of systems

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Abstract

Numerous man-made disasters have revealed fantasy plans—safety artefacts which do not represent the reality of operational risk. In contrast to “drift”, where operations gradually become less safe, fantasy planning describe protections that have never been fully implemented, understood, or operated as intended.

The theory of fantasy planning originally comes from sociologist Lee Clarke. Clarke described how the oil spill contingency plan for the Port of Valdez, Alaska, claimed that approximately 130 k barrels of oil could be recovered from the sea after a spill. This was tested in 1989, when the Exxon Valdez tanker ran aground, spilling 260 k barrels of oil. Despite the plan’s claims, no amount of oil even close to that amount had ever been recovered from open waters.

In the city of San Bruno, California, 2010, a buried gas pipeline owned by Pacific Gas and Electric (PG&E) ruptured in a massive explosion. Hayes and Hopkins in their book 'Nightmare Pipeline Failures' noted that despite PG&E’s strong commitment to safety and use of bespoke risk modelling techniques, PG&E’s understanding of risk was not aligned to “actual” field risk.

Both the oil spill contingency plan and the IMS had little grounding in reality. They were, in part, fantasies—but not deliberately by people. Most concerning is that sometimes risk protections may never be implemented or capable of being effective.

This paper explores why, contrary to efforts towards safety, organisations create systems that describe a physical reality that may never exist. It also speculates on ways to close the gap between safety systems and operational reality.

Ultimately, this paper seeks to sensitise risk practitioners to the problem of fantasy planning, and the vulnerability it creates.

1 Introduction

Numerous large-scale disasters have revealed fantasy plans—safety artefacts that are intended or believed to reflect the reality of operational risk and work practices but do not. In contrast to “drift”, where operations gradually become less safe, fantasy plans describe protections that have never been fully implemented, understood, or operated as intended.

The theory of fantasy planning originally comes from sociologist Lee Clarke. Clarke noticed that, in some high-profile situations, risk planning became more of a symbolic activity rather than a functional one. A key example was the oil spill contingency plan for the Port of Valdez, Alaska. The estimates in the plan were far beyond any previous open water oil spill recovery. As the Exxon Valdez disaster showed, there was no basis in reality for this optimism.

Fantasy planning offers a lens to examine situations that otherwise might be dismissed as recklessness or blatant dishonesty. Closer examination through this lens suggests that fantasy planning is not only understandable, but may be happening routinely in safety practice.

The purpose of this paper is not to offer immediate solutions, but to sensitise risk practitioners to the problem of fantasy planning, and the vulnerability it creates.

This literature review seeks to answer the following questions:

- What is fantasy planning?;
- What factors underlie fantasy planning?;
- How can system vulnerabilities to fantasy planning and symbolic safety be revealed?

Because fantasy planning is a relatively under-developed concept, this paper necessarily speculates on probable connections between the contributory factors, influences and their impacts.

The paper also discusses how concepts like meta-monitoring from Resilience Engineering, High Reliability Theory, drawing distinctions between epistemic and aleatory uncertainty, and use of possibilitic risk methods may help close the gap between (fantasy) safety systems and operational reality.

2 What is fantasy planning?

2.1 Artefacts that may diverge significantly from reality but are believed to be true

Clarke (1999) asserts that fantasy documents are artefacts (plans and risk assessments etc.) that make wildly optimistic and unrealistic statements about how organisations can control highly uncertain risks, in an effort to convince stakeholders that the uncontrollable (or at least the very difficult to control) can be controlled.

Fantasy plans can be many types of artefacts and activities, including:

- Risk assessments or design-criteria using risk scores based on little more than guesses or containing overly optimistic assumptions;
- Failure probabilities suggesting that events are too improbable to occur, yet these events have occurred elsewhere;
- Emergency plans that specify in great detail things people will recognise and actions they will take during difficult and indeterminate circumstances;

- Risk meetings that omit credible failure modes or misrepresent the significance of certain issues;
- Risk models that produce scores not validated or not strongly correlated to actual risk;
- Risk registers that describe a plethora of risk controls, but only a fraction of which are used or can be used in practice; and
- Overly positive audit findings that assessed physical and structural safety factors but omitted social and system factors.

The paper now explores examples of fantasy planning.

2.2 Examples of fantasy planning

The contingency plan covering oil spills around the Port of Valdez, Alaska, claimed to be able to recover a 130k barrel spill into the ocean, should it occur (Clarke, 1999). Nonetheless, no amount of oil even close to what was claimed had ever been successfully recovered in open waters—it had no precedent. The plan legitimised beliefs on the controllability of oil spills—a "rationality badge". Since the plan was documented and appeared rational, the company and regulator were motivated to believe it.

In the city of San Bruno California, September 2010, a 76 cm diameter buried steel gas pipeline, owned by company Pacific Gas & Electric (PG&E), ruptured, resulting in a massive fiery explosion and the loss of eight lives. Using Clarke's "fantasy" lens, Hayes and Hopkins (2015) point out that despite PG&E's strong commitment to safety and use of bespoke risk modelling techniques, their understanding and control over risk was not aligned to actual field risk. PG&E's asset integrity management system (IMS) was in some ways more symbolic than functional (Hayes and Hopkins, 2015). Whilst the company thought that risk calculations provided a robust understanding of major risk, they fell short in some critical ways. Hayes and Hopkins (2015) called this "fantasy planning", to better reflect the full gamut of activities that go into the formation of false beliefs and symbolic artefacts in safety.

Both the Valdez contingency plan and the San Bruno risk modelling had little grounding in reality. The claims appeared rational and realistic, but were more symbolic than functional. This is not to say, however, that the artefacts were purposely created to obfuscate or deceive. Instead, the companies believed (to varying degrees) that the claims were true or would become true if put to the test. During the process of artefact creation and interpretation, the authors were unaware of the limits of their knowledge and the extent of uncertainty.

Symbolic artefacts can justify risks and decisions by giving assumptions or beliefs an observable form (Ross et al., 2016). In the case of responding to large oil spills in the Port of Valdez, the emergency plan provided the illusion of control over these problems (Clarke, 1999). Meanwhile, the fantastic nature of the plans and claims were not recognised by the organisations involved.

Fantasy plans can appear rational and even prescient in their detail and knowledge over future events. In many cases the claims in plans may be justified based on the best available knowledge and experience. In other cases, the claims are works of fiction that reflect what the writer thinks will or should happen. Sometimes the level of detail specified in plans about what will go wrong, or the actions of people and how technology will be used, far exceed what realistically could be predicted in advance. Although people may not purposefully create misleading or inaccurate artefacts, fantasy plans may still inadvertently rationalise the group or organisation's perceived knowledge and control over the problem (Clarke, 1999).

Overall, however, a key factor in the creation of fantasy plans is the need for certainty. Humans reconcile uncertainty through planning, irrespective and often unaware of whether their planning reflects reality.

Studying fantasy plans raises some important points about the function and utility of artefacts, which will now briefly be covered.

2.3 Artefacts provide assurance

Artefacts are not just functional specifications of work. Many safety artefacts, whilst they are written as if they have been developed to guide action or provide information, have a primary audience outside the immediate design or work team. These artefacts influence stakeholder perceptions about the safety or riskiness of an issue. This suggests that artefacts may have a more symbolic purpose – providing certainty rather than constraining or supporting functional actions.

To say that something is "symbolic" does not question its value, or even suggest that it lacks a functional purpose. Safety artefacts may be sincerely intended to guide or support patterns of action, such as completing checklists or inspections, filling in paperwork or undertaking work activities. However, organisations may inadvertently create artefacts (as they are relatively easy to create) when really what they wanted was a new pattern of action (Pentland and Feldman, 2008). Moreover, there may be an implicit belief that the artefacts mirror reality or that the meaning of artefacts is uniform within the organisation.

Once an artefact has been created, it can communicate and reinforce the implicit beliefs that it represents, even if these beliefs do not reflect the reality of operational work.

3 What factors underlie fantasy planning?

Fantasy planning may involve a concatenation of information and perceptual distortions at a cognitive, group and organisational level. Influences from institutional levels (e.g. regulatory systems etc.) may also be involved, but the paper focusses primarily on organisational and below levels.

The following questions frame the subsequent discussions:

- How does something known not to be true get recorded as if it were real?; and
- How does something not known to be true become recorded as if it were real?

Note that, in making sense of (often ambiguous and uncertain) information in the world, people are “driven by plausibility rather than accuracy" (Weick, 1995, p. 17). Consider this when reading the next sections on why fantasy planning and safety symbolism form.

3.1 How does something known not to be true get recorded as if it were real?

3.1.1 A deliberate attempt to mislead

Fantasy plans are not usually written to purposefully deceive people - although they may have that effect (Clarke, 1999). Nevertheless, sometimes documents may be written in full knowledge that the stated claims are not true or have little chance of being successful. Such claims may be produced by safety departments to persuade a regulator or external auditor, or by organisations to persuade public stakeholders. Deliberate attempts to mislead may not be complete lies or fabrications, but may be selectively choosing the most optimistic assumptions in safety analyses despite the analyst knowing that this model does not sufficiently account for real circumstances.

While malfeasance and misconduct are seductive explanations—descriptions of disasters (e.g. Challenger disaster; Vaughan, 1996) describe how various internal and external pressures can influence organisational decision-making and re-frame perceptions of what is acceptable and risky.

This question is left underdeveloped in the paper in order to focus on the more common phenomena below.

3.1.2 An attempt to provide an "acceptable" answer to someone not willing to discuss or accept the real state of affairs

Influencing the decisions of others is an inherent part of organisational work. Management influence the strategic direction that an organisation takes regarding markets or products. Supervisors influence workers on how they undertake their duties and the safety team influence design decisions of equipment.

Correspondingly, artefacts are used as a way to influence routines or beliefs through implicit or explicit values. Fantasy plans are therefore a way for some groups or elites of an organisation (e.g. senior management) to exert control over those that may not readily accept the desired decisions.

However, although fantasy plans are often believed to be true—they need not entirely be so. People may not wholly believe or disbelieve these plans (Clarke, 1999, p. 142). So while fantasy plans may be designed to be maximally persuasive (Clarke and Perrow, 1996) and incorporate many optimistic assumptions about the issue (Clarke, 1999), they do not *need* to be maximally persuasive to have their effect. Fantasy plans need only provide an *acceptable* level of persuasion.

3.2 How does something not known to be true become recorded as if it were real?

3.2.1 It was believed to be true

3.2.1.1 <u>Cognitive factors shape our perception of an “objective” world</u>

Research suggests that people do not necessarily think logically or methodically about problems and then formulate a list of options based on optimal conditions (Kahneman, 2011; Klein, 2008; Lipshitz et al., 2001). Instead, people when arriving at decisions often rely on a series of mental heuristics (cognitive shortcuts or rules of thumb) by intuitively incorporating prior experience and known or assumed information, recognised patterns and a process of satisficing (finding the first workable option; Klein, 2008).

Cognitive processes are also prone to systematic distortions, called biases[1]. Biases may reduce individual risk perception and increase risky decisions of individuals and teams (Houghton et al., 2000). Perhaps over a 100 cognitive biases exist and are prevalent in situations of higher uncertainty.

Biases include (Rehak et al., 2010) where an event or risk is considered more likely/relevant if it is easier to imagine (availability bias), or how people systematically overestimate the benefits and underestimate the risks (planning fallacy). Similarly, people may underestimate the likelihood of an adverse outcome occurring, such as a process upset, believing the likelihood is more likely elsewhere than at their own facility or under different circumstances (optimism bias; Slovic, 2000); potentially leading to overconfidence.

Biases can also shape the perception of risk information. Studies (Fischhoff et al., 1978; Silvera et al., 2005) show that people can be insensitive to missing information in fault trees (e.g. missing branches) or alter the significance they place on branches by how the branches are presented.

Recognising the impact of perceptions on risk interpretation is paramount to understanding why planning may not match the reality of operations. Much like with cognitive biases, a need for certainty involved in fantasy planning may be more related to organisational features than individualistic needs. The next section will cover some of these broader organisational-level features.

[1] Not everyone agrees with the idea of a bias in the negative sense. Gigerenzer (1991) maintains that there is unlikely to ever be one, right and logical choice in human judgements. If there is no correct option to use as a base of comparison then it is misplaced to say that a bias caused a deviation away from that logical choice. Biases can also be considered a strength since they enable rapid decision making under high uncertainty (Gigerenzer and Brighton, 2009). This paper agrees and adopts the idea that a bias is not negative or positive but simply a deviation from an intended outcome during decisions and judgements.

3.2.1.2 Organisational and social factors also shape our perception of an "objective world"

Many different, but often complimentary, concepts explain why an organisation's understanding of risk becomes misaligned to the actual state of affairs. Turner's man-made disaster hypothesis (Turner and Pidgeon, 1997) drew on the idea of an "incubation period": a period of time before a disaster occurs where there is a growing discrepancy between how well risks are believed to be controlled versus their actual state (Dekker and Pruchnicki, 2014; Pidgeon and O'Leary, 2000); leading to increasing system vulnerability to failure.

Turner (Turner, 1976; Turner and Pidgeon, 1997) identified from numerous accidents common organisational themes including rigidities in the accurate perception of possible danger; focussing on certain issues at the expense of other issues ("decoy phenomena"); discounting of warning signs; and instances where certain information about issues is filtered.

Vaughan (1996) in her extensive analysis of the Challenger space shuttle disaster opined that social forces—rather than just technical issues—played major roles during the incubation of the event. Social forces included "normalising" potential warning signs of the solid rocket booster joints over time such to be seen as an expected and normal outcome, and thus an acceptable risk. Vaughan (1996) called this unspectacular downgrading of risk the normalisation of deviance, where people and groups gradually become less concerned about issues that began as potential sources of harm.

All of these factors ultimately led to warning signs being misinterpreted, missed or ignored.

3.2.1.3 People see what they expect to see

An aspect of how beliefs are framed is that people see what they expect to see. People can ignore, misperceive or deny things that do not fit their worldview (Vaughan, 1996, p. 62). Signs which in hindsight indicated significant danger may be difficult for groups to identify before the fact.

Confirmation bias is another perceptual distorter that appears regularly in accident reports and helps to explain why things are believed to be true despite operational experience that it may not be. It describes where people favour or seek information that confirm their existing beliefs (Rehak et al., 2010) and more likely to discount contrary information; permitting people to operate in a type of cognitive tunnel vision (Rehak et al., 2010).

3.2.1.4 Human subjectivity underlies the trustworthiness of technology

The individual and organisation factors that influence beliefs also affect the use and interpretation of risk systems. One belief is that these systems, and particularly quantitative risk methods with ostensibly precise numbers and probabilities, provide an objective process ordered by formal rules and algorithms; purportedly allowing measurements and deductions grounded in "incontrovertible, reproducible, and value-free truths" (Downer, 2009, p. 9). With this belief (called the "ideal of mechanical objectivity"; Downer, 2013, p. 6), the uncertain future seems predictable, people will behave rationally based on rules, and planning for risks means they can be controlled (Bea, 1996).

Many aspects of organisational practice (including risk systems) may give the appearance of being based on objective truths—contrasted against the subjective aspects of judgements and expert knowledge. But the dichotomy is a myth: the incontrovertible data and technical conclusions mask the underlying ambiguities and social processes that shape these methods (Wynne, 1988). In times of high uncertainty, use of Quantitative Risk Assessment (QRA) may seduce analysts to model information not present in the source data (Aven, 2017).

Technology is said to amplify the illusion of certainty (Gigerenzer, 2014). So by relying too heavily on a belief that risk systems are purely governed by rational, logical rules and measuring "truths", organisations may be lulled into a false sense of safety instead of being sensitised to the possibility of failure.

3.2.1.5 Risk calculations give the veneer of objectivity and truth

If knowledge about potential harm was based on truly objective facts, then similar estimates of risk should be seen between experts with the same information (Clarke, 1999). This does not seem to be the case, at least regarding QRA estimations. A series of risk benchmarking studies (Amendola et al., 1992; Fabbri and Contini, 2009; Lauridsen et al., 2002) found that multiple groups of experts using the same source data had widely differing outputs from their risk assessments.

Bea (1996) explains that in order to model increasingly complex and high-risk systems, increasingly more complicated QRA models are needed. This technological singularity results in computations defying human understanding or validation. But since organisations have the numbers they are seduced (and perhaps politically and economically constrained) to believe them (Bea, 1996). On this, QRA may only provide a snapshot of system risk at a particular time and if those risks change over time—or are influenced significantly by human and organisational factors (HOF)—then excess reliance on QRA (without understanding its limits) can be "very misleading of the actual risk of a system" (Rae et al., 2014, p. 77).

Next the paper expands on the issue of expert risk forecasts.

3.2.1.6 Expert practice reveals and conceals risk

Rae and Alexander (2017a) covered the validity and limitations of expert risk judgements. From their literature review, they conclude that expert judgements under certain conditions should be given special standing, e.g. when involving local causal mechanisms that are well-understood. But caution is advised when acting on forecasts under high uncertainty since experts may be overconfident in their abilities and methods (Rae and Alexander, 2017a).

There is another darker side of expert practice relevant to fantasy planning. Experts are highly-specialised in their fields. Specialisation brings further expertise, but it also tends to develop esoteric vocabulary and more rigid beliefs that are resistant to change (Vaughan, 1996).

The esoteric vocabulary and beliefs highly specialised experts have can make communicating and sharing information difficult across departments and externally (Vaughan, 1996). Specialisation can conceal system vulnerabilities to outside groups.

The majority of technical experience is intuitive and tacit. Accordingly it becomes difficult for people to express this knowledge (Vaughan, 1996; Wynne, 1988) in explicit forms, like discussions and artefacts. This supports Clarke's (1999, p. 70) comment that the knowledge about how social and technical systems work frequently does not filter down to daily operations and vice versa; this information void feeds fantasy planning.

3.2.1.7 Things are believed to be true when the risk analyses do not represent actual risks

A defining feature of fantasy planning is that, in certain aspects, the understanding of or actual control over the problem exists more in the head of the author than it does in reality. In the case of the San Bruno pipeline explosion, the outputs from PG&E's bespoke risk algorithm was used to inform the inspection schedule; namely, prioritising how and which pipeline segments to inspect.

The problem is that the model was not validated and was only tenuously correlated with actual field risk (Hayes and Hopkins, 2015). The risk-based system (using their own esoteric proxy for risk) was believed to be an accurate purveyor of reality when instead it was "divorced from field data" (Hayes and Hopkins, 2015, p. 114). Risk analysis methods may involve elaborate models that can calculate probabilities to incredible magnitudes, but in their construction analysts may unwittingly omit major failure modes (Redmill, 2002; Suokas, 1988).

Here lies an issue with risk models: the results may be representative of the model but less so of reality (Redmill, 2002); with few validated ways to accurately gauge the divergence.

In these examples and many others, there was undue confidence that good performance and lack of major safety events was due to the risk system working as intended—but beneath this confidence, disaster can incubate due to people serving the system instead of focussing on more pressing operational issues. This was likely the case in the San Bruno and Longford disasters. They were, in effect, fantasy systems.

A recurring theme in disasters is the finding that plans and documents frequently claimed that some action was supposed to occur (inspections, maintenance etc.) or particular equipment should be present and functioning (relief valves etc.). The finding that "things were expected to become true, but didn't", will now be explored.

3.2.2 It was expected or intended to become true, but didn't

3.2.2.1 There is frequently a gap between work-as-imagined and work-as-done

There is now a body of literature showing that work frequently differs in two ways (e.g. Albery, Borys, & Tepe, 2016; Cowley & Borys, 2014; Hollnagel, 2014; Hollnagel, Braithwaite, & Wears, 2015). One way is the belief (e.g. by managers, experts, procedures) of how work occurs out in the field (work-as-imagined [WAI]). The other is the reality of how work is actually done in the field (work-as-done [WAD]). Believing that systems work as designed and that people just need to follow the rules can be a dangerous disposition in complex systems.

Sanne's (2008) study of railway maintenance teams from Sweden found that teams regularly deviated from rules and procedures, and took actions that management would consider risky and not approve of.

Two studies from Borys (2012, 2009) looked at the use of risk management methods like Safe Work Method Statements (SWMS) and risk awareness programs in industry. Unsurprisingly, he found some gaps between the documented risk control processes and the work practices. Also found was a perceptual gap on the utility of risk management methods; workers felt that it was not the paperwork that kept them safe but their common sense. Management saw the paperwork as assurance that workers were working safely. Both a faith in the paperwork and systems (for management) and reliance on common sense (for workers) could lead to an illusion of safety (Borys, 2009). This is a critical point in fantasy planning: people believe that systems provide a level of safety in the absence of confirmatory evidence.

Organisations may be confident that their risk systems are working as intended, or designed or as documented in risk assessments and plans—but the reality in workplaces may be significantly different. Key risk controls may not be implemented or operating as expected; operators may not be following all of the safety-critical procedures; and system performance indicators may not be measuring the precursors to failure that they are thought to be.

To summarise, gaps frequently exist between real conditions and how work is believed to occur, how technology is used, or how risks are controlled. A bigger issue is that this gap goes unnoticed, denied or misunderstood.

3.2.2.2 Humans have a need for certainty

Ultimately, many of these cognitive and organisational distortions occur because society demands certainty. Doctors, stock analysts, political leaders and even risk analysts are expected to give predictions of the uncertain future: but what they often deliver is the illusion of certainty (Gigerenzer, 2014, p. 26). Planning helps achieve this need by facilitating the impression that organisations must sufficiently understand the problem to be able to document how to manage it (Clarke, 1999).

3.2.3 Unintended consequences of safety precautions

3.2.3.1 Intended things don't come true because of unintended consequences of safety precautions

Before many disasters, the organisation involved tried earnestly to manage safety. NASA's commitment to safety is evident in the case of Columbia by the fact it tracked over 5,000 critical items on the shuttle (Leveson and Cutcher-Gershenfeld, 2004)[2].

But this is not to say that safety programs or perceptions cannot drift over time or that all safety activities have their desired effect. The Columbia Accident Investigation Board (2003, p. 180) report describes the slow and unintentional erosion of NASA's safety program over time, where independent robust processes to increase safety were replaced with ones that produced massive amounts of data but impaired communication and increased uncertainty. These superficial or misapplied safety practices have been referred to as "cosmetic system safety" (Leveson and Cutcher-Gershenfeld, 2004).

Rae and Alexander (2017b) observed that not all safety activities necessarily have a positive effect on safety, stating that some activities "neither reduce the risk of harm associated with a system, nor provide more accurate understanding of that risk" (p.190). Further, if these activities are "believed to be effective, they result in false assurance" (p.190); thereby resulting in an unjustified or false belief that safety objectives have been met.

These concepts discern why organisations with a motivated and proactive safety focus may face major failure. Risk methods may not add to margins of safety or increase knowledge of risk, despite beliefs to the contrary.

3.2.3.2 Intended things may not be getting measured like they are thought to be

Summarising what has been covered so far, it is evident that false beliefs can build around the actual level of system safety. Even where performance indicators or risk models exist to measure safety and risk, indicators may not exactly measure what the organisation thinks is being measured (e.g. PG&E's pipeline risk model).

The point is that organisations may become comfortable when little appears to be happening, confident that system integrity and risks are controlled. Meanwhile, they are unaware that their indicators are not calibrated to the probable failure mode. While process indicators may in fact be pre-cursors to many failure modes, this may give little indication of socio-technical features of organisations which can insidiously erode system defences.

Uncertainty is one of the key factors in fantasy planning. The impact uncertainty can have on planning and how it can be reconciled is covered next in the paper.

3.2.3.3 Uncertainty and assumptions

Uncertainty is an inevitable feature of a complex world, no less risk. Risk systems necessarily contain uncertainty and numerous safety assumptions.

The level of uncertainty (acknowledged or otherwise) and the assumptions made in risk analyses can affect the: a) type of data produced; b) degree of perceived threat; c) resources afforded to the threats, and; d) decisions to be made. High levels of uncertainty are conducive to fantasy planning, where Clarke (1999, p. 16) suggests even the best planning can be more the "imaginative fictions" of what people think can or cannot happen. Despite the importance of these factors and their potential for catastrophic surprises (Downer, 2011), the complexity inherent in organisations can increase the opacity of modelling assumptions and parameters in risk models (Rae and Alexander, 2017a).

Many types of uncertainty exist, but can conveniently be described as aleatory (related to intrinsic randomness of a phenomenon) or epistemic (related to a lack of or incomplete knowledge about a phenomenon; Kiureghian and Ditlevsen, 2009). Whereas aleatory uncertainty may be easier to recognise and integrate into models (Aven, 2016; Paté-Cornell, 1996), epistemic is less so.

Downer (2011) describes the role epistemic uncertainty played in the explosive decompression incident of Aloha Airlines Flight 243, where a 35 square metre section of the plane's fuselage was torn off. The investigation concluded that the failure was due to multiple site fatigue cracking around the fuselage skin adjacent to rivet holes (National Transportation Safety Board, 1989). According to Downer (2011), this incident challenged aeronautical engineering beliefs on how cracks can propagate and revealed a common, but misplaced, industry belief that pressurisation cycles was the key determinant of metal fatigue in airplanes. They did not know that they did not know.

This paper has advanced the idea that planning, and particularly documenting things in artefacts, helps organisations believe that they have reconciled uncertainty. One way that organisations achieve this perceived uncertainty reduction, according to Clarke (1999), is by matching highly uncertain phenomena (things that are not particularly well known) to phenomena that are well understood and appear similar, e.g. using small spills in lakes to inform large ocean spills.

This section is not evidence against innovating or pushing the boundaries of technology, but that organisations should be mindful of when they are outside their base of knowledge or expertise with high-risk technologies. If so, they should be seeking to better clarify,

[2] What people and organisations focus on and consider significant was termed their "perceptual horizon" by Turner and Pidgeon (1997).

document and discuss the assumptions that form the models and expert opinions.

3.2.3.4 In an age of probabilities, sometimes there is a need to think in possibilities

An enduring belief said to exist is the aura of precision, objectivity, rationality and value-free truths surrounding risk analysis methods (Clarke, 2006; Downer, 2013); particularly probabilistic methods. Thinking with statistical probabilities tries to solve questions like "what is the chance of a nuclear meltdown?". Probabilities may help to justify risky systems by making the future appear safe (Clarke, 2006). Conversely, possibilistic thinking asks "what is the worst thing possible if the nuclear plant has a really bad day?" (Clarke, 2006, p. 5); a type of worst case thinking. Importantly, possibilistic thinking is an addition to—not a replacement for—probabilistic methods.

The key here is that focussing exclusively or haphazardly on more linear methods, like probabilities, may convince organisations that the improbable is impossible. For Fukushima, it was assumed that the plant would never lose all electrical power for more than a short while. Perrow (2011) ascribed many failures at Fukushima as failures to adopt a possibilistic mindset and directly points a finger at the reliance on probabilistic methods in the inadequate design height of the plant's seawall.

Next the paper explores how systemic vulnerabilities to fantasy planning can be revealed.

4 How can system vulnerabilities to fantasy planning and symbolic safety be revealed?

This section speculates on how practitioners may expose system vulnerabilities regarding symbolic safety and fantasy planning.

Note that much has been written about risk management, system safety and resilient performance. This research will not be rehashed and instead focus is given to several concepts specific to this paper's theme.

4.1 By seeking to understand normal everyday work

Fantasy planning involves a divergence between perceptions of risk and knowledge versus the true state of affairs. Therefore, organisations seeking to understand how this gap occurs could follow a grounded approach to better understand operational risk and normal work.

In essence, spending more time in the workplace observing work, meetings and decisions and speaking with people that interact with the risks can reveal considerable intel; a "sensitivity to operations" per High Reliability Organisation (HRO) theory (Weick and Sutcliffe, 2015).

Focussing on normal work for example could reveal the informal and formal work practices in use (including instances where workers "finish the design" of technology via workarounds and improvisation; Dekker, 2014). Also discoverable is the state and knowledge of risk protections and technology. Organisational pressures and decisions/trade-offs that influence risk can also be revealed. Key here is that the groups seeking to understand the true state of risk understand it from the perspective of how work occurs, each day, instead of only relying on assumptions or official artefacts like plans.

A grounded approach may also reveal cultural cues, norms and assumptions embedded in work routines. For instance, what things are taken for granted when assessing risk; the uncertainty and state of knowledge surrounding issues; and what issues are ignored or not seen as relevant. Other factors could be to assess the extent that warning signs are not reported or perceived by workers; barriers to reporting; and if safety issues raised at safety meetings are tokenistic or representative of reality (Gunningham, 2007).

Furthermore, critically evaluating the wording, assumptions, conclusions and the degrees of evidence needed to disprove or support arguments in safety artefacts may also illuminate belief systems and symbolism at play. How quickly can authors discount hazards based on argument or justify the significant sources of uncertainty or assumptions?

These socio-technical features of organisations can indicate risk blindspots. If an organisation's current auditing and inspection regime only reviews physical systems and plans, without observing cultural cues, routines and work under normal conditions, then vital intel is likely to be missing.

In addition, organisations must resist temptations to simply constrain work to follow procedures without better understanding why the gap exists. Studies (Dunford and Perrigino, 2017; Sanne, 2008) suggest that people perform workarounds of procedures not because they do not care—but exactly because they do.

Together, these are the nuances of work that should be understood to better plan for reality.

4.2 By organisations monitoring how they monitor (meta-monitoring)

Organisations typically measure numerous safety and performance activities. Nevertheless, other kinds of intel may be fruitful—including meta-monitoring.

Meta-monitoring (monitoring what is monitored), is a Resilience Engineering concept that suggests organisations should "invest in an awareness of the models of risk it embodies in its safety strategies and risk countermeasures" (Dekker and Pitzer, 2016, p. 21).

It may be possible for an organisation to partially reveal miscalibrated beliefs about its vulnerability to failure by reflecting on the way safety and performance are measured (Dekker and Pitzer, 2016).

Meta-monitoring has pragmatic implications. An organisation could seek to understand the embedded assumptions in its risk models and tools. For instance, if risk software is used, are the software model assumptions known? Additionally, what processes does an organisation have to independently review safety-critical decisions or ensure a diversity of opinions and expertise? (A "deference to expertise"; Weick and Sutcliffe, 2015.)

Another consideration could be to critically assess the information and performance indicators used to measure risk and system performance. What is the validity of these measures? Have they ever been tested? Are they linked to the actual sources of potential failure (as can best be determined) or are they upstream pre-cursors to the failure or even indirectly inferred from the data?

Because systems are in constant change, what was measured last week may not have sufficient resolution to inform next week (Saurin et al., 2013). Where possible, then, measures should be as close (temporal-spatially) to the hazard as relevant—with preference to real-time monitoring (Saurin et al., 2013).

Final questions could be to ask why the organisation has the level of confidence that it does in the system or process? Is the confidence based on reasoned and appropriate data, analysis and interpretation or skewed towards assumptions and unrecognised uncertainty? Is the prevailing belief that the system is already safe or that a lack of incidents confirms it is safe? In the latter, misplaced confidence can be found by extrapolating historical safety as evidence for future safety.

4.3 By evaluating risk methodologies and their trustworthiness

Firstly, regarding major risks, organisations need to understand why they are managing risk the way they are. Stated differently, are risks being addressed in a way that actually increases the amount of safety or knowledge about the risk (Rae and Alexander, 2017b) or are safety activities occurring just because the process says so? Simply undertaking activities as per the process without being sensitive to the purpose may be s sign of cosmetic safety.

Secondly, regarding risk methodologies, lack of technique validity is an extant issue (Goerlandt, Khakzad, & Reniers, 2016; Rae et al., 2012). Without further discussing this complicated topic, one way for organisations to pragmatically gauge the validity of their application of risk techniques could be to apply some trustworthiness checks. These include benchmarking exercises, reality check, independent review and quality assurance (Goerlandt et al., 2016). Reality checks (where the results of the analyses are compared with real data or operational experience) and independent reviews (multiple experts using *a priori* specifications evaluate the method and results) may be relatively simpler techniques for organisations to apply.

4.4 By understanding the strengths and limitations of expert predictions

Much was written about excess confidence in risk methods and will not be rehashed. It is enough to say that organisations must be critical of their risk methods and surrounding beliefs.

Expert judgements provide powerful intel to sources of failure, but should not exclusively be relied on for accurate understanding of risks (Rae and Alexander, 2017a).

A key strength in expert opinions may not lie in their specific quantifications of risk per se, but more the sharing and discussion of information. Experts can reflect on different information and assumptions, debate causal mechanisms, and agree/disagree on the state of knowledge and uncertainty (Rae and Alexander, 2017a). Organisations must actively foster these exchanges.

Experts need not simply be the conventional types (e.g. engineers and scientists), but also include front-line operators and people with the most practical experience with the technology and hazards. Deferring to people from different backgrounds, experience, and departments can be a resilient quality to foster (Weick and Sutcliffe, 2015).

Concluding on a pessimistic tone: facilitating expert reviews and discussions may ultimately have little impact on organisational risk if expert advice is not heeded, nor are experts given authority, autonomy and resources to drive major change.

4.5 By expanding definitions of uncertainty

Humans have an innate desire for certainty. Yet they are surrounded by uncertainty in complex environments. This desire for certainty can foster symbolic planning.

According to Taleb (2009), organisations can take their knowledge too seriously, meanwhile ignoring what they do not know. In other words, reflecting on ignorance can be enlightening since it demarcates the limits of knowledge, and makes clear the numerous unrecognised assumptions in beliefs and risk practices.

Differentiating the types of uncertainty may also assist organisations understand their ignorance. Treating aleatory and epistemic uncertainties as approximately equivalent could have disastrous effects (Downer, 2011).

Recognising epistemic uncertainty has particular value in fantasy planning, as carefully performing certain tests and simulations and collecting additional data may reduce these types of uncertainties (Aven, 2016; Paté-Cornell, 1996). Yet caution is advised, as performing more “safety work” may not provide any new or contextually important information for managing that risk beyond what the organisation already believes or knows. When dealing with uncertainty, a cautious approach should be taken where there is resistance to simplifying interpretations about risk and uncertainty (Weick and Sutcliffe, 2015) based on operational history or perceived knowledge.

Our understanding of risk, too, needs more nuance. In Aven's (2013) view, risk can still contain events, consequences and probabilities. But it should also be bolstered with: a) an assessment of the strength of knowledge of risks; b) uncertainty intervals, and; c) consideration of surprises (black swan events; Taleb, 2009). If risks could impact members of public, then considering dread risks is worthwhile (Slovic, 2001).

In summary, considering uncertainty may be prudent for understanding vulnerability to symbolic planning as it can expose surprises. Surprises is now covered.

4.6 By considering the impact of surprises and possibilities

Surprises, which may take several forms including epistemic and black swan events, expose systems to potential failure. Surprises are evidence that organisational beliefs have some way diverged from reality.

There are challenges with the identification of surprise events. One is that it is very difficult to know what is not known—but not necessarily impossible. Two is that surprise events may be highly improbable based on probabilistic methods, but improbable is not impossible.

A starting point could be for an organisation to have more critical thought and robust peer review of decisions surrounding credible major risks. What are deemed credible or non-credible by the organisation and why?

Surprise events and black swans by their nature are very difficult to predict in advance. This suggests that incorporating possibilistic methods in to risk assessment/control processes may have utility. Possibilistic methods for risks with major consequences may prepare organisations for the unexpected, as probabilities alone might convince them that certain events could almost never occur. If an event is possible in the life time of a system then some consideration should be given despite its perceived likelihood (Leveson, 2015). To avoid surprise, assumptions used in plans and risk assessments should also be made explicit and justified (Leveson, 2015).

Possibilistic thinking can be seen as exercising a type of “safety imagination” (Pidgeon and O’Leary, 2000), where organisations can counter and update beliefs around failures and their vulnerability to them (Pidgeon and O’Leary, 2000). Similarly, Hale (2002) suggests that organisations should focus more on managing accident scenarios in order to avoid unexpected events.

It may seem unusual to counter fantasy planning with further use of speculative imagination. However, the key difference is that safety imagination and possibilistic thinking seek to expose our beliefs around vulnerability to failure. Fantasy planning in contrast tends to be more optimistic in its assumptions and relies on more optimistic or misplaced beliefs about the world.

4.7 By facilitating capacity for resilient performance

Managing the unexpected is said to be a core principle of HRO. HRO involves being sensitive to actual operating conditions and being preoccupied with failure (Weick and Sutcliffe, 2015). Resilience Engineering similarly suggests that organisations ought to know what to look for and what to expect (Hollnagel et al., 2011). Major risks should be carefully prioritised and communicated instead of a broader approach enamoured with considerable safety work focussing on lower risks and administration tasks (e.g. cosmetic safety).

These factors tie in with building the capacity for resilience. It cannot be known in advance what exact accident scenarios will occur, despite all best intentions and planning. Therefore, organisations should be committed to building in organisational capacities to identify and monitor loss of systemic control, and the ability to arrest loss of control and then recover if it occurs (“commitment to resilience” as per HRO; Weick and Sutcliffe, 2015). The capability and competency of people may be the most important factor in resilient performance.

Resilience Engineering also posits an interesting view. This philosophy suggests that focus should equally be placed on how work normally occurs and how to buffer and amplify processes to ensure as many things as possible go right, instead of just targeting the limited circumstances when things can fail (Hollnagel et al., 2011). When considering that each day, thousands of things normally go right—and only very occasionally wrong, studying only failure may omit a majority of information to learn from.

5 Conclusion

Fantasy plans can essentially be seen as a way for organisations to claim control over certain issues by seeking the semblance of certainty. The plans and artefacts are also a way for an organisation to inadvertently distance itself from beliefs that may catastrophically realign perceptions about its vulnerability to disaster.

Fantasy plans and symbolic safety are not aberrant or unusual—nor necessarily the sign of a bad company or sloppy management. Fantasy plans are usually the result of good people, trying their best to navigate uncertainty under various organisational and regulatory pressures. Importantly, people tend to believe fantasy plans not because they are incompetent or indifferent, but because they have little reason to doubt the claims.

Unfortunately, because fantasy plans are tangible or the planning that encompasses them real, they appear to be authoritative on the issue and may lull organisations in to a false sense of safety. Because of numerous individual and organisational distortions of information, perceptions and beliefs, people may not know their expectations of safety diverge significantly from reality.

Only by studying the institutionalised by-products of normal routines and artefacts can organisations hope to nurture capacity for resilience and understand why, contrary to efforts towards safety, organisations create systems that describe a physical reality that may never exist.

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