Chapter 6
Contracting Qualities that Challenge Reliability: A Case of the Utility Sector

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Abstract This study uses the utility construction sector as a case to build the argument that specialisation, transience and price competition impede the reliable functioning of supply chains. These three contracting qualities obstruct the establishment of antecedents of mindfulness and the adherence to mindful organising principles. We offer three solution directions to improve contracting practice.

Keywords Reliability · Specialisation · Transience · Price competition · Utility sector

6.1 Introduction

Reliability-seeking organisations continuously put effort into avoiding allowing operational processes to lead to errors and eventually culminate in accidents. Studies of organisations in high-hazard industries, such as on aircraft carriers and in nuclear plants, demonstrate that reliability-seeking occurs in firms with organisational mindfulness and mindful organising practices. Reliability studies have found these characteristics in stable units (e.g. teams and departments) with clear boundaries that define who are internal and external to the organisation. This literature posits various antecedents of a mindful practice: leadership styles that endorse mindful organising, structures that manage the effect of organisational size on fragmentation [15] and the absence of extreme production pressures [20, p. 44].

Contracting supply chains are not as permanent and stable as the classic reliability-seeking organisations. Their outsourcing and contracting practices (here referred to as *contracting qualities*) challenge the realisation of the mindfulness antecedents. Construction is a sector where outsourcing is particularly common. Three typical contracting qualities of this sector are specialisation [3, 4], transience [13] and price competition [21, pp. 106–108]. For example, in the utility construction subsector, long supply chains of network owners and contractors concurrently work on a site

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to construct co-located, buried utility networks. Production pressures often push the performance of such projects to their limits. Based on this example case, we illustrate that contracting qualities can reduce mindfulness.

The remainder of this chapter introduces the concepts of organisational mindfulness and mindful organising. It then defines the case chosen and the utility sector and analyses how three contracting qualities challenge its reliability. We conclude by recommending improvements to existing contracting practices.

6.2 Organising for Process Reliability

Safety incidents, failures and other unexpected events can damage an organisation's health. Reliability-seeking processes aim to effectively cope with these unwanted and unanticipated events and their effect on performance [5, p. 51]. These processes occur on both the operational and strategic levels: Vogus and Sutcliffe [15] argue that, on the strategic level, *organisational mindfulness* arises when higher management shapes enduring practices, structures and cultures that favour mindful ways of thinking and organising. This, in turn, enables the dynamic, continuous, bottom-up process of *mindful organising* by frontline operational-level workers. Weick, Sutcliffe and Obstfeld [18–20] have defined five mindful organising principles that can help organisations identify details concerning potential threats to reliability and cope effectively with emerging unwanted events.

First, *preoccupation with failure* involves organisations treating any failure as an indicator of questionable system health. That is, they aim to learn from regular and thorough analysis of inconsistencies and near-errors. Reporting of errors then becomes more important than blaming individuals for their involvement in them. Second, *reluctance to simplify* contributes to the development of a comprehensive, rather than narrow and simplistic, interpretation of the current situation. Simplifications limit the identification of possible future operational scenarios, restrict precautions that people take against them and may lead to unintended negative consequences. To avoid this, organisations try to 'sense the complexity of the environment' by encouraging a diversity of perspectives, valuing scepticism and challenging assumptions about reality. Third, *sensitivity to operations* refers to the cognitive process that workers accomplish together by continuously developing and updating a collective understanding of evolving operational situations. This allows organisations to detect anomalies and 'catch errors in the moment'. Fourth, *commitment to resilience* reflects organisations accepting that errors will occur due to human mistakes, narrow specialties and complex technology [14]. Consequently, they develop abilities to cope with unanticipated surprises and then re-establish organisational processes. This involves improvising, utilising an individual's knowledge networks and deploying additional technical resources. The fifth principle is *deference to expertise.* With this, top managers acknowledge that expertise is more important than the decision hierarchy when problems in operational processes emerge. This leads to a collective and cultural belief that capabilities to resolve a problem lie in the system and that decision rights need to be given to those (frontline workers) with expertise on the event that has occurred [20].

The principles of mindful organising originate from case studies of stable and well-defined organisations such as aircraft carriers [17] and nuclear power plants [11] and mainstream organisations such as business schools [10] and hospitals [19]. All these studies have in common that they focus on mindful behaviour within an integrated organisational unit that is defined by clear boundaries. The lack of this structural characteristic challenges reliable performance. Vogus and Sutcliffe [15] have argued that the lack of structures through which leaders can share perceptions about the importance of mindfulness across different organisational levels challenges mindfulness. They also argue that a lack of practices to maintain a collective belief among organisational members that mindfulness organising is highly relevant exposes large organisations to fragmentation and lower mindfulness levels. Further, reliability is challenged in organisations with loosely coupled relationships [16] and in those that have functions with low task interdependencies [12]. Production pressure [20] may also overload cognitive tasks and reduce judgement and performance, thereby lowering sensitivity to operations. We now elaborate on these issues as they relate to the context of utility construction.

6.3 Contracting Qualities and Reliability in Utility Construction

The construction industry is characterised by project-based working [4] and a large degree of job specialisation and fragmentation [3, 4]. Along a project's lifecycle, the construction supply chain involves many stakeholders for different coordination, engineering, surveying and construction tasks.

The utility construction subsector builds and maintains networks such as gas and water pipes as well as electricity and telecommunication cables. It amounts to an extreme case of stakeholder fragmentation: most utilities in urban spaces are co-located in shallow trenches below pavements, under roads and along other rights-of-way. This creates physical interdependencies [9] since the relocation of one utility type often necessitates the replacement of other utility lines that are deployed close by. Further, the privatisation of utility networks has increased the number of stakeholders that are involved throughout their lifecycles. While their networks lie together in public space, network owners use distinctive strategies to plan, engineer and execute their own construction work. In addition, they outsource most construction work to a range of specialised contractors. This shapes a multi-stakeholder network involving several distinctive supply chains. This fragmented contracting context is impacted by the reliability-decreasing effects of contracting practices.

Currently, suboptimal alignment of stakeholders in utility streetworks causes network damages, deterioration of infrastructure, delays and project cost overruns. The societal costs of utility streetworks in the UK, for example, amount to 5.1 billion

GBP annually [2]. We now further illustrate the challenges to reliability based on the contracting qualities of specialisation, transience and price competition.

6.3.1 Specialisation

Specialisation moves tasks from within an organisation's hierarchy to the market. It allows vertically disintegrated organisations to focus on their core tasks while mobilising specialists as a flexible resource. For example, utility contractors hire subcontractors for activities such as excavation, welding, gluing cable joints, pipeline inspection, paving and surveying. Such specialisation diffuses the responsibility for the management of risks.

Risk shifting diffuses the coordination of risk along the contracting chain and effectively puts pressure on the risk management capabilities of field personnel [7]. When multiple contracting chains concurrently execute physically interdependent construction activities onsite, they report to distinct clients through different supply chains. This situation requires a formal main principal that is responsible for the coordination of all the organisations that are part of the distinctive supply chains. This coordination *between* supply chains is, however, missing. It makes risk management even more dispersed and uncoordinated.

Further, the involvement of multiple clients, contractors, engineers and trade specialists over time shapes a fragmented, complex and dynamic network where different organisations independently execute tasks. This limits their ability to collectively *sensitise themselves to how their operations interrelate*. Partial assessments of complexities, task interfaces, site risks and diffused decision-making power make it a challenging task for the supply chain to collectively develop a coherent view of existing risks and to develop risk mitigation capabilities.

In utility project supply chains, specialised field personnel will be involved on a site only temporarily and for a limited period. Excavator operators, welders and job supervisors move—often on a tight schedule—between different construction sites. In terms of *commitment to resilience*, this means that projects have limited flexibility in mobilising resources. Consequently, process interruptions may often not be managed directly and effectively. For example, when the discovery of polluted soil requires alternative digging methods (such as vacuum excavation), the required resources cannot be mobilised instantly because the multiple supply chains need to collectively decide on their mobilisation and allocate their costs.

Specialisation further means that network owners and their contractors work within a strict decision hierarchy. Consequently, contractors need formal approval to deviate from the original project plans. This rigid scope creates a tight decision hierarchy that places decision-making responsibility over all operational issues with clients that are distanced from the actual work on the construction site. This challenges the principle of *deference to expertise* since the specialist contractors and personnel onsite, who have the experience and knowledge to foresee and contain emerging problems (such as cable strikes, additional work due to polluted soil or leakages), need to obtain permission from higher up in their hierarchy to deviate from the detailed scope provided, even in the face of an emerging complex event. This process is further complicated since this approval might be needed from the multiple clients in the distinctive supply chains that concurrently work onsite. Overall, the tightly defined scopes reduce swiftness of incident responses.

6.3.2 Transience

Transience influences the reliability of utility projects in two ways. First, the members of stakeholder coalitions often change between successive construction projects [6, p. 3]. Main contractors will often mobilise different crews on different projects. They will outsource work lower down the supply chain by hiring freelance workers and small subcontractors on a project-by-project basis. Furthermore, stakeholders have different backgrounds, experience and expectations [13]. In these diverse and changing constellations, it is a continuous and time-consuming effort for a crew to *sensitise* themselves *to the complex operational interfaces* of their work with the onsite processes of other individuals.

Second, the transient and location-specific nature of streetworks means that contracted field personnel move between project sites. While working on a utility construction site, field workers establish links with other stakeholders, create knowledge networks and gain specific insights into site conditions within an area (such as about unmapped utility locations, polluted soil locations and previously unknown buried objects). This understanding of the local system contributes to the *avoidance of simplifications* regarding the project's reality. However, transience makes it difficult to maintain well-informed and updated knowledge about underground conditions at all the sites where a crew is working. In the Netherlands, for example, network owners hire contractors on a project-by-project basis. This creates transience: crews move between construction sites frequently, and once contractors move to new geographic regions, to a new project, their local knowledge evaporates. Moreover, the costs incurred make it unattractive for (sub-)contractors to fully explore project site complexities and build knowledge networks for each project. Transience thus reduces the return on investment in this knowledge development and reduces the contractor's ability to *commit to resilience.*

6.3.3 Price Competition

Utility contractors compete for work in tendering processes where network owners evaluate bids based largely on the tender prices [21]. Competitive tendering creates pressure on contractors to minimise their bid price. As a result, they may underestimate project complexity and offer low prices to win bids [21]. When contractors accept low-profit margins, they are under pressure to rapidly complete work to minimise financial losses. This, in turn, can inhibit any *reluctance to simplify* since contractors have less budget available to spend on analysing local construction site complexities and obstacles. Specifically, it exerts pressure to bypass error-anticipation activities such as mapping involved stakeholders, verifying utility maps, detecting interference with existing utilities and assessing how external factors (such as weather) might impact the project schedule.

Simplification is further incentivised by the productivity pricing method that contractors use to integrate production and risk coordination costs into a single price-per-metre figure. In the telecommunication sector, for example, contractors may cost work based on a length unit of cable installed or the number of houses connected to a network. This price includes direct construction costs and the additional costs involved in careful excavation work and damage avoidance (e.g. the costs for trial trenching, utility detection and vacuum excavation).

By using a single fixed price per metre of utility deployed, contractors essentially reduce the range of risks that can occur across varying project conditions (e.g. rural, residential, inner-city projects) to one 'standard' risk situation and price. Further, the pressures that result from productivity pricing can also reduce *commitments to resilience* since stakeholders who find themselves on projects that are more complex than 'the standard' have allocated too little time and budget to develop the knowledge and resource capacity required for a flexible and adequate response to emerging incidents.

Production pressures also influence the effectiveness of the health and safety regulations that supply chains use to avoid incidents and low-quality work. When under pressure, field workers seem to make trade-offs by deciding where they should adhere to regulations and where they can cut corners. Sometimes, for example, excavator operators cause minor damage by scratching a cable coating. Although the consequences of this damage are not immediately apparent, rules prescribe that workers should report this error to network owners and authorities. Instead, however, they often 'repair' the cables themselves. In this way, they risk that the network will be damaged further or need unexpected repairs in the future. Both physically and metaphorically burying mistakes, and moving on, thus lead to practices that hamper learning from failure: the *preoccupation with failure* and how to reduce this is reduced. Unequal power relations between the crew, subcontractors and upstream supply chain parties magnify this dynamic since these reduce the likelihood that crew will voice concern or criticise corner-cutting [7].

Finally, competitive pricing impedes *sensitivity to operations* by encouraging stakeholders to mindlessly comply with the bare minimum that rules allow. For example, a rule may require contractors to dig test trenches to verify utility locations before they start full excavation. Although this rule stipulates *that* trenches should be dug, it leaves it open to the crew's judgement as to *where* and *how many* trenches should be dug. Under cost pressures, contractors may underestimate the required number of trenches. Although this does not violate rules, it makes contractors less sensitive to risks and complexity.

6.4 Unintended, Unanticipated Events Occur

Essentially, mindfulness antecedents [15, 20] in supply chains are put under pressure by various contracting qualities. Specifically, specialisation complicates leadership and the establishment of shared perceptions concerning the importance of mindfulness between and within supply chains. In addition, the length of supply chains and the numerous interfaces between stakeholders result in incoherent and inflexible structures that do not create a mindful organisational setting. Third, although one might expect the physical co-location of cables and pipelines to create task interdependencies and necessitate mindfulness in order to coordinate risk, the loose coupling between the different supply chains and their inherent transience inhibits this. Fourth, production pressure and cognitive overload put further stresses on the judgement and performance of the supply chain stakeholders involved.

A logical consequence is that utility construction projects suffer from problematic coordination between and within their various contracting chains. Delays and overshooting budgets occur frequently. Tens of thousands of unexpected utility intrusions occur each year in the Netherlands alone [1], some causing injuries and fatalities. From informal conversations with contractors and networks, it also seems that they consider such damage as unavoidable. This suggests that errors have become unwanted but ‘normal’ by-products of utility construction work.

6.5 Recommendations

We offer three recommendations that may help the utility sector improve contractual conditions and deal better with unwanted events. First, integration mechanisms should be applied by outsourcing parties to address the consequences of specialisation and fragmentation. One way to achieve this would be that network owners in a geographical area (such as a street or district) jointly procure work on their co-located utilities. Joint procurement would introduce a single main coordinating contractor for all the supply chains involved. This would shape a clear line-of-command between contractors and subcontracted specialists and provide clarity over the responsibility for risk coordination. Another means to integrate supply chains is to mobilise a so-called boundary-spanning agent. In the Netherlands, these agents are called ‘utility coordinators’ [8] and have a dedicated task as informal liaison to create awareness of the complexities in collaborative streetworks.

Second, contractors could be incentivised to develop, maintain and share their local knowledge. By developing longer-term relationships, and by rewarding dedicated contractors that repetitively utilise the same crew in a specific region, network owners would reduce the likelihood that local knowledge fades away due to transience. Sharing utility location data in open databases would also contribute to this. Increased knowledge about local site conditions might also help contractors to make more realistic assumptions about existing project conditions and the feasibility of schedules and deadlines. This could also reduce production pressures.

Third, contract styles could be adapted to reduce the effect of price competition. One way would be to allow contractors to use pricing schemes that differentiate between projects that have different complexity levels. Complex projects could then involve higher rates to cover risk anticipation and containment than those in more straightforward projects. Another way could be to develop contracts that split the current tender price into a competitive element that includes only construction costs for the utility lines, plus a component for mindfulness-enhancing activities. Treating these aspects separately could reduce the incentives for contractors to cut costs on mindfulness-enhancing activities.

Finally, we note that these directions for improvement should be interpreted with the understanding that further empirical validation is required. We would therefore encourage future research to study contracting and reliability across different types of supply chains, both within and beyond the utility sector.

6.6 Conclusions

Principles for organising mindfulness to improve organisational reliability are well established but challenged by typical qualities of organising work in a contracting environment. In the utility sector, we see that *specialisation* reduces the development of shared perspectives on the importance of mindfulness and the development of a rich understanding of a project's reality. Next, the *transience* of both crew and the work onsite further disincentivises supply chains from developing resources to anticipate and mitigate unwanted events. Further, *price competition* puts pressure on mindfulness-enhancing activities, reducing resilience. Recommendations are thus to improve overall reliability and so reduce dangerous and costly failures are to reduce interfaces between supply chain organisations through integration mechanisms; create contractual incentives that reduce transience; and separate direct construction costs from mindfulness-enhancing costs.

References

1. Agentschap Telecom, *Code Oranje Blijft van Kracht Voor Graafsector (News Release, 15 May 2018)*, https://www.agentschaptelecom.nl/onderwerpen/kabels-en-leidingen/nieuws/2018/mei/15/code-oranje-blijft-van-kracht-voor-graafsector. Accessed 7 Dec 2019
2. M.H. Burtwell, M. Evans, W. McMahon, *Minimising Street Works Disruption: The Real Costs of Street Works to the Utility Industry and Society* (UK Water Industry Research Limited, London, 2006)
3. R.G. Eccles, Bureaucratic versus craft administration: the relationship of market structure to the construction firm. Adm. Sci. Q. **26**(3), 449–469 (1981)

4. R. Fellows, A.M. Liu, Managing organizational interfaces in engineering construction projects: addressing fragmentation and boundary issues across multiple interfaces. Constr. Manag. Econ. **30**(8), 653–671 (2012)
5. E. Hollnagel, *Human Reliability Analysis: Context and Control* (Academic Press, London, 1993)
6. M. Loosemore, A. Dainty, H. Lingard, *Human Resource Management in Construction Projects: Strategic and Operational Approaches* (Taylor & Francis, London, 2003)
7. V. McDermott, J. Hayes, Risk shifting and disorganization in multi-tier contracting chains: the implications for public safety. Saf. Sci. **106**, 263–272 (2018)
8. L. L. olde Scholtenhuis, T. Hartmann, A. G. Dorée, Exploring networked project coordination in combined utility streetworks. Eng. Proj. Organ. J. **10**(1) (2021)
9. H. Osman, Coordination of urban infrastructure reconstruction projects. Struct. Infrastruct. Eng. **12**(1), 108–121 (2016)
10. J.L. Ray, L.T. Baker, D.A. Plowman, Organizational mindfulness in business schools. Acad. Manage. Learn. Educ. **10**(2), 188–203 (2011)
11. P.R. Schulman, The negotiated order of organizational reliability. Adm. Soc. **25**(3), 353–372 (1993)
12. J.B. Sexton, E.J. Thomas, R.L. Helmreich, Error, stress, and teamwork in medicine and aviation: cross sectional surveys. The BMJ **320**(7237), 745–749 (2000)
13. J. Sydow, T. Braun, Projects as temporary organizations: an agenda for further theorizing the interorganizational dimension. Int. J. Project Manage. **36**(1), 4–11 (2018)
14. D. Vaughan, *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA* (University of Chicago Press, Chicago, 1996)
15. T.J. Vogus, K.M. Sutcliffe, Organizational mindfulness and mindful organizing: a reconciliation and path forward. Acad. Manage. Learn. Educ. **11**(4), 722–735 (2012)
16. K.E. Weick, Educational organizations as loosely coupled systems. Adm. Sci. Q. **21**(1), 1–19 (1976)
17. K.E. Weick, K.H. Roberts, Collective mind in organizations: heedful interrelating on flight decks. Adm. Sci. Q. **38**(3), 357–381 (1993)
18. K.E. Weick, K.M. Sutcliffe, Mindfulness and the quality of organizational attention. Organ. Sci. **17**(4), 514–524 (2006)
19. K.E. Weick, K.M. Sutcliffe, *Managing the Unexpected: Resilient Performance in an Age of Uncertainty*, 2nd edn. (John Wiley & Sons, San Francisco, 2007)
20. K. E. Weick, K. M. Sutcliffe, D. Obstfeld, Organizing for high reliability: processes of collective mindfulness, in *Research in Organizational Behavior*, vol. 1 (Jai Press, Stanford, 1999), pp. 81–123
21. G. M. Winch, *Managing Construction Projects: An Information Processing Approach*, 2nd edn. (Wiley Blackwell, Ames, 2010)