

## Summary

Breakdowns in infrastructures are usually thought of as disrupting an organized order: when the train refuses to start, the railroads do not deliver their services. In academic literature, as well as in the media, much attention is given to these breakdowns. In this dissertation, I challenge a core assumption on breakdowns by questioning whether they indeed disrupt the orderly nature of infrastructures. I do so through an ethnographic study on the Dutch railways, and argue that the two states of infrastructure – functioning and broken down – should not be thought of as a dichotomy but as two sides of the same coin. This implies that breakdowns are not exceptional to but constitutive of infrastructures; breakdowns always already occur, and the system is always already in repair. This approach captures the complexity of whole systems better, as it urges us to look at the dynamic relationships *within* the system rather than at the clearly discernable elements *of* the system. Whereas the aim of the latter view is to reduce complexity, the former view refuses to see complexity as an enemy – as ‘Monsters’ or ‘Mess’ – that has to be overcome. It takes complexity seriously by embracing it and theorizing how to live comfortably alongside complex phenomena such as breakdowns. The dissertation unravels the work it takes to make infrastructures function and how breakdowns are dealt with, specifically by understanding how this work is done in collaboration at different points of the sociotechnical system. I thus aim to answer the following question: *how do organizational actors cope with the complexity of breakdowns and how does this shape the functioning of the railway infrastructure?*

For two years I participated, for two days a week on average, in the daily lives of those organizational actors who are, in one way or another, involved in dealing with infrastructure breakdowns. The main method of the study was observation, and I would generally ‘follow’ employees for several shifts to get an understanding of the following aspects of their job: the practices comprising their occupation; how their work relates to others’ within the network; which tools or materials are used in the practices; how complexity is encountered and how it is coped with; and how these strategies do or do not relate to the procedures describing how work ‘should be done’. I also conducted 35 semi-structured interviews to gain a deeper understanding of these observed practices and to contextualize and check my interpretations. Moreover, I read numerous documents – internal texts such as handbooks or strategic plans, and news articles, opinion pieces, or documents produced by the Ministry of Infrastructure and Environment – to gain a feel for what it means to work in an organization

where breakdowns are closely scrutinized. Two main narratives emerged that describe how people, at various places and positions within the system, cope with complexity: the *experience* of complexity in practice versus the *representations* (e.g. rules, indicators, plans, etc.) used to make sense of and reduce this complexity. These coping strategies and how they relate make up the empirical core of this dissertation.

The first study identifies what it means to encounter and cope with complexity in practice. I follow how train dispatchers deal with breakdowns in the train service and how they communicate their professional knowledge with apprentice dispatchers. I argue that understanding dispatchers' knowledge as purely cognitive or theoretical leads to a view where knowledge can relatively easily be transferred. This view is flawed if we want to know how dispatchers learn and communicate this knowledge in practice. The data show that dispatchers' knowledge is inherently embodied and embedded within their experience. Dispatchers use their bodies and senses to invoke past experiences in the here-and-now to make decisions for future-oriented actions on how to deal with emerging breakdowns. This highlights the inherently *temporal orientation of knowledge*. Dispatchers translated their embodied knowledge into three practices through which they taught apprentices the details of their jobs: *know your equipment*, *read your equipment*, and *imagine your equipment*. These strategies complemented more formal models of learning, showing how dispatchers cope with complexity by drawing on knowledge that, in practice, is intimately embedded in concrete material artefacts and experiences.

These decision-making processes also appear in the second study, where I explore how coordinators at the Operational Control Center Rail (OCCR) make sense of a potentially disruptive winter-storm. We follow a team of coordinators in the days preceding a storm and, like the previous chapter, we see how they draw on past experiences of breakdowns to carve out decisions on how to react accordingly. The chapter shows that coordinators' decisions are shaped by several representations of the potential breakdown, such as a weather matrix and a decision-making tree. However, the meaning of these representations is ambiguous: they are necessary to make sense of an evolving event, *but they describe this event inaccurately*. Coping with complexity involves both what is encountered in a practical sense and through representations aimed to reduce complexity. Infrastructure breakdowns are, thus, not one-off occurrences, but the potentiality of the storm *as a breakdown* and the ways in which coordinators appropriate the ambiguous nature of representations disrupts the infrastructure.

The third study zooms in further on the inaccurate nature of representations and how they affect the daily practices of coordinators in the OCCR. I focus on the performance indicator 'punctuality', which captures the managerial logic on how to cope with complexity. Through indicators, managers sought ways to disentangle and categorize the complexity of an unpunctual train service into discrete elements of input and output, attempting to causally connect the two and improve performances. So, whereas the previous chapters showed how a great deal of work and knowledge is tacit and based on experiences, this chapter shows how indicators aim to make this work visible and measurable. The study illustrates that dealing with punctuality is a *sociomaterial practice* and that the indicator is *performative* by changing how coordinators work. This study thus contests that representations are 'neutral' tools for reducing complexity, and it argues that representations, to some extent, *create more complexity*. They change practices and elicit responses by coordinators, such as working around the performance indicator or resisting the representation.

The last two studies show how the different coping strategies relate in practice. Chapter 6 unravels the emergence of the OCCR as a place to establish new ways of collaboration by drawing on insights from the literature on organizational space. I show how the organizations decided to design a co-located control center to improve inter-organizational collaboration and to facilitate informal communication. However, the intentions and the design of the building (its representations) were contested in practice: rather than a co-located control center, the OCCR emerged as dis-located. Through several *territorial practices*, coordinators drew new and resurrected old boundaries between organizations and departments to preserve existing organizational or professional identities. These practices, moreover, resisted the representations that reduced the complexity of railway operations through spatial interventions too easily. Interestingly, coordinators did lift boundaries when practical needs demanded, suggesting that coping with complexity in practice is highly *situational* and that complexity is *embraced* rather reduced.

In the last study I tie everything together by treating the infrastructure breakdown as one affecting the railroads as an entire system. I investigate a breakdown 'disrupting' the infrastructure on an almost daily basis: railroad suicides. The chapter looks at how the complex nature of suicides is organized and experienced from different points in the system (i.e. train drivers, dispatchers, coordinators and the emergency services who restore order in the most physical sense). The focus on how railroad suicides are phenomenologically experienced in practice is then contrasted with examples of how such potentially traumatic

events are managed in rational ways, so the infrastructure can recover as efficiently as possible. In other words, the chapter shows how *diverse ways of coping with complexity are entangled*; the breakdown is experienced and dealt with in practice as well as through ‘rational’ representations. An overreliance on one of the two strategies can lead to ineffective solutions: taking the traumatic experience as the leading strategies results in inaction (i.e. emotional employees unable to decide how to move forward), whereas an overreliance on representations leads to exactly what they attempt to avoid (i.e. irrationality, more complexity, paradoxes).

Combined, these five studies challenge the dominant understanding of breakdowns in infrastructure as a sudden disruption of an organized order. I show, instead, how these two conditions of infrastructure (functioning and broken down) should be thought of as part of the same process. Zooming in on the daily practices of actors in the railway system and showing the organization work that it takes to keep the railroads running, this dissertation illustrates that the ‘state’ of the infrastructure is never fully broken down nor functioning exactly as it should. On the contrary, infrastructure is a process – rather than an object – that is always simultaneously breaking down as well as a system in repair. In the conclusions of this dissertation I argue that a deeper understanding of how organizational actors cope with complexity is valuable in theorizing how complex systems, such as infrastructures, are organized and how breakdowns are managed. I offer three lenses through which we can see how ‘complexity as experienced’ and ‘complexity as represented’ are related, and suggest that complexity should be managed in gentle ways. Focusing too strongly on the representational side of complexity and forgetting that it also is an inherent quality of our evolving, dynamic world, paradoxically leads to exactly what we want to reduce: more complexity.

This also has important implications for practice. This dissertation indicates that Dutch railway organizations prefer to cope with complexity in infrastructure breakdowns through abstract representations, such as procedures, rules, handbooks, or indicators. A reconceptualization of infrastructure breakdowns such as I propose, however, raises the question as to what extent this approach is effective. Eventually, organizations responsible for complex systems need to find a delicate balance between coping with complexity in practice and coping with complexity through representations. This suggests that governmental policies as well as managerial practices should create more room and stimulate opportunities for the professional and situational judgment of organizational actors in dealing with breakdowns.