Let us go back to the map and territory and ask: “What is it in the territory that gets onto the map?” We know the territory does not get onto the map. That is the central point about which we here are all agreed. Now, if the territory were uniform, nothing would get onto the map except its boundaries, which are the points at which it ceases to be uniform against some larger matrix. What gets on the map, in fact, is difference, be it a difference in altitude, a difference in vegetation, a difference in population structure, difference in surface, or whatever. Differences are the things that get onto the map.

In this chapter I further zoom in on what I believe lies at the core of how organizational actors cope with complexity in infrastructure breakdowns: 1) how we think of complexity in general and, more specifically, in organization science and, 2) how this has rendered certain ideas and beliefs on how complexity can or should be managed. I first provide some general remarks on how we can understand infrastructures as a recursive process, being in this continuous state of both functioning and breaking down. I then explain how complexity as a concept emerged in the literature on organizational systems, after which I argue that, despite opening promising different avenues in our understanding of organizations, this also has had several problematic consequences for how we think of management in terms of being able to reduce complexity through representational devices.

2.1 Complex infrastructures: Beyond stable representations

Infrastructures, as the basic structures allowing for the flow or transportation of people, things, or ideas in space, often evoke images of grandiose technological accomplishments through which ‘society’ has been able to escape the limits as set by ‘nature’ (think of spacefaring, or the famous Dutch Delta Works protecting the land from catastrophic flooding). Yet, they are also in a constant state of decay and simultaneous rebuilding. This is, what Howe et al. (2016) call, the paradox of infrastructure:

The view that infrastructure is simply the scaffolding for, rather than constitutive of, our current environmental and energetic conditions appears increasingly dubious. Any theory of infrastructure, then, ought to be a theory of paradox. The paradox of infrastructure is its double quality as both solid and durable and evaporative and itinerant; it is built and grown, rigid and fluid, meant to last but doomed to be outmoded, ruined, and exceeded. Therefore, it is in these nodes of paradoxical intermingling and entanglement that we can rethink the complexity of infrastructure... (Howe et al., 2016, p. 559).

As Graham and Thrift (2007) argue, the idea of complex infrastructures as orderly and well-functioning systems is a myth; it takes immense organization, repair and maintenance work between human as well as non-human actors – work that itself, usually, remains hidden (see Henke, 2000) – to make infrastructures operate as we expect them to.
The paradox of infrastructure is elaborated by Howe et al. (2016) as one of ruins, retrofit and risk. This is a useful starting point for our enquiry to understand what it means to say that infrastructures are recursive processes. The paradox, so these authors argue, highlights the constructive as well as deconstructive nature of infrastructure. It should be noted here, once again, that we are talking about infrastructure breakdowns as ‘daily disruptions’ and not ‘dramatic disasters’. Harvey and Knox (2012), for instance, describe this paradox in the context of roads in Peru. Roads promise growth, speed, connection, and progress. However, these promises may also disappoint as they can generate negative consequences that undermine the rational plans of engineers or bureaucrats. Infrastructures as ruins is, perhaps, best understood once we consider that, no matter how ‘modern’, ‘progressive’, or ‘ambitious’ our projects are, they are inextricably bound up and must be retrofitted with the ruins of our past. We build new infrastructures on already existing structures to try and keep up with changing societal demands.

Cycling through an old city as Amsterdam, for instance, reminds of the fact that its roads – often too narrow, steep, or bumpy – were never built anew but always within the confines of a space that was set generations before us. In a similar vein, the construction of a new underground line, meant to establish an efficient circulation in the transportation of people, eventually nearly succumbs due to prolapsing historical buildings above and archeological findings below the ground (van den Ende et al., 2015). Moreover, infrastructures are usually constructed to fit human purposes; they enable certain kinds of behavior by creating things while at the same time destructing other things (Howe et al., 2016). Transportation systems allow for growth in terms of economic progression but also create new risks that, for example, are related to global warmth and climate change.

The paradoxical nature of infrastructure as briefly discussed above suggests we...

---

16 In the context of the railways: although we generally assume that the first trains and railroads are products that emerged as an effect of the Industrial Revolution, it is by no means that it was only at this point that they were suddenly invented. Already in the Middle Ages, certain European mining areas used wooden boards as tracks to push carts up and down hills. In parts of Wales, wood – quickly deteriorating due to the heavily loaded carts – was slowly replaced by tracks made of cast-iron. Later, still, steam engines replaced, from which it was only a small leap to progress to the trains and tracks that we know today (Veenendaal, 2004, p. 14).

17 It must be added here that this is arguably a rather biased observation. ‘Younger’ nation-states may lack this legacy of spatial confinement; some countries build and rebuild their infrastructures with such maddening pace that we can hardly speak of infrastructure gone to ruin; while other parts of the world still lack fundamental infrastructures (Graham, 2010; Howe et al., 2016).
should cease treating infrastructure as a thing or object. Breakdowns in infrastructure are
not the same as breakdowns in, say, a glass vase. The glass vase, sitting on the edge of the
table, is an object that functions like we expect it to (it holds our flowers, decorates our
living room, etc.). The moment it drops to the floor, however, the vase ceases being a vase:
as a functional object it has now become mere matter, scattered in pieces over the floor.
Infrastructure, on the other hand, is neither ever fully available nor ever eternally lost. What
is built is always built upon something, and what goes to ruins is eventually the basis for
other things to exist. Hu (2015), for instance, illustrates how the 21st century virtual ‘Cloud’ as
a network is constructed underneath and within much older and often already deteriorated
infrastructures such as railroad tracks, sewer lines, or television circuits. A crucial point,
then, when thinking infrastructures, is to find a perspective that moves beyond the idea of
infrastructure as some sort of material or technological object.

Infrastructure is not a stable condition – although we may very much perceive it to be
so – but is in a continuous state of repair and development. Star and Ruhleder for example,
in invoking a processual terminology, state that rather than asking ‘what is infrastructure?’
we need questions concerned with ‘how becomes infrastructure?’, because ‘infrastructure
is a fundamentally relational concept’ (1996, p. 113). It is not just a lifeless ‘thing’ out there
waiting to be used by humans but it emerges from within the practices of interrelated and
heterogeneous actors. A focus on practices from a relational understanding may reveal the
relationships between infrastructures as technological matter and as social worlds. This
remark resonates with Edward’s (2003) observation on the relation between infrastructure
and, what he calls, the ‘modern condition’:

Building infrastructures has been constitutive of the modern condition, in almost every
conceivable sense. At the same time, ideologies and discourses of modernism have helped
define the purposes, goals, and characteristics of those infrastructures. In the other words,
the co-construction of technology and modernity can be seen with exceptional clarity in
the case of infrastructure (Edwards, 200, p. 191).

Foucault (1970) explains this ‘modern condition’ as a matter of a fundamental paradigm-shift:
knowledge in the epoch of modernity means to think in functional systems, in all spheres of
life. Its concerns lie with finding universal, generalizable truths. In the context of organization,
the manager becomes one of the central ‘characters’ of modernity, one that is concerned with the gradual replacement of complex human experience to objective laws in order to pursue efficiency and effectiveness (Macintyre, 2007).

The paradoxical and dynamic nature of infrastructures – and all organizational systems, for that matter – triggered an increasing need for its management. Remarkably, the first appearance of such system thinking in organizational life emerged in the late 19th century on the railroads. Yates (1993), in her case study on the Illinois Central Railroad, analyzes the importance of several managerial and technological tools, such as carbon paper, vertical file cabinets, and document archives. She shows how supervisors, through these tools, were able to simplify the complex nature of railway organizations, being geographically dispersed over large distances and primarily concerned with safety within a decentralized network. Processes could finally be standardized. Distant work could finally be controlled. It was at this point in time that ‘the rise of system’ in management started and ways to reduce complexity were found (Yates, 1993). In this dissertation, however, I argue for an understanding of complexity that goes beyond aims to reduce it.

2.2 What is complexity?

When we refer to something as complex, we mean that certain phenomena are hard to understand or that it seems impossible to find any causal relationship in the middle of things. The term complexity is derived from the Latin prefix ‘com-‘, meaning ‘together’, and the verb ‘plectere‘, meaning ‘to weave’ or ‘to braid’. When we say that something is complex, we thus mean to refer to an interweaving, something consisting of multiple parts that are interrelated. Think of it as something woven together like a tightly knitted scarf. The parts are inseparably entangled; undo the knit of the scarf and the scarf is gone. We say it is complex to file tax return; to understand certain mathematical formulas; to grasp how fractals, which are created by the continuous repetition of a simple process, can have such an amazingly

18 MacIntyre (2007) identifies three such ‘characters’ (the Aesthete, the Therapist, and the Manager) which he puts central in explaining contemporary moral culture. These characters, so he argues, eschew questions related to values while giving privilege to instrumental questions related to the rational achievements of ends. The notion of ‘character’, should be understood as ‘a fusion of a specific role with a specific personality type in such a way that it emphasizes and celebrates the moral ideas of a particular culture’ (Mangham, 1995, p. 181).
complex and never-ending pattern; etc.

One of the traffic coordinators I spoke during this research explained complexity in the following, more metaphorical way: ‘Our railway system is like a big bowl of spaghetti: it looks orderly, but pull one of the strings of the spaghetti and the whole starts to move until we’re left with one big lump of pasta that seems to be randomly thrown around in the bowl’. What he referred to, in the context of infrastructure breakdowns, is that all elements of the infrastructure seem tightly interrelated making it difficult, if not impossible, to find a cause and solution to the breakdown. The breakdown consists of an infinite range of elements that are not only difficult to grasp individually but, moreover, all hang together in such a way so that it is impossible to understand it without understanding the totality of the infrastructure.

In a less colloquial sense, Nobel laureate physicist Gell-Man defines the degree in which something is complex as:

...the length of the shortest message that will describe a system, at a given level of coarse graining, to someone at a distance, employing language, knowledge, and understanding that both parties share (and know they share) beforehand (Gell-Man cited in Chia, 1998, p. 343).

Chia (1998) draws two important conclusions from this definition. The first one is that defining something as complex refers to the fact that we experience a particular phenomenon as complex rather than that this is the objective state of that phenomenon (see also Bateson, 1987; Cooper, 1986). Following Weick (1979, 1995), it is thus in interactive sensemaking of that what we cannot grasp, that we socially construct an apparently objective reality that we label ‘complex’. In other words, we assume a system should have some sort of order but, once confronted with perturbations and a disorderly world, we narrate complexity – as a ‘solution’ to the encountered disorder – into being (Tsoukas and Hatch, 2001). There is a remarkably uncanny implication here, if we take this conclusion seriously: there never was any complexity to start with, only a gap in our knowledge about a particular phenomenon. But voilà! In the process of addressing this knowledge gap we actually created or, rather, enacted (Weick, 1988) ‘complexity’ into the world. This is why Tsoukas and Hatch (2001) claim so strongly that studies on organizational complexity should not just focus on the system itself (first-order-complexity) but also take into account the ways that theorists and practitioners think about this system (second-order-complexity).
Second, complexity as ‘the shortest message to describe a system’ implies that the complexity of a system is non-reducible: there is no shorter or more compact way to describe it. This is also the point where the distinction between ‘complex’ and ‘complicated’, often used indistinguishably, should be made. Complicated stuff can be solved. It may also be made up of many interrelated parts, but the whole can be taken apart and put back together. In complicated systems there is a clear causal connection between the elements, and the system can thus be organized or made simpler by means of mathematics, computational models, rules or procedures. Physicist Baranger explains this by comparing a non-complex system (gas in a container) with the complex system of the human body:

Take away 10% of its constituents [of the gas container], which are its molecules. What happens? Nothing very dramatic! The pressure changes a little, or the volume, or the temperature; or all of them. But on the whole, the final gas looks and behaves much like the original gas. Now do the same experiment with a complex system. Take a human body and take away 10%; let’s just cut off a leg! The result will be rather more spectacular than for the gas (Baranger, 2000, p. 9).

Complex systems cannot be taken apart or reduced without affecting the whole system, as the elements that make up this system are entangled or interwoven. In other words, complexity should be seen as a quality that allows the system to exist in the first place.

It is at this point then that how organizational actors cope with complexity – being a social construct that to some extent is unknowable and non-reducible to causes and effects – becomes a key concern. Even more so once we observe that many theories in organization and management studies suggest that complex systems can be managed, thereby starting from the implicit premise that they can be taken apart, analyzed, modeled, to make them simpler. Following this logic, the complexity of an organization can be represented in abstract formulae that, in turn, reduce the complexity. However, coping with complexity also means that we must attend to how complexity turns up in practice – not solely how it is represented – and this hinges upon how we deal with an inherently indeterminate and unintelligible world. In the sections below, I further argue why management techniques to contain complexity and organize infrastructure by means of representations cannot fully capture infrastructure as a complex and interrelated system.
2.3 From complexity science towards organizational complexity

The notion of ‘complexity’ has become an established lens to study management, systems, or infrastructures (Anderson, 1999; Farjoun and Levin, 2011; Morel and Ramanujam, 1999). These studies often refer to the field of complexity sciences, which is mainly concerned with naturally occurring complex systems such as the anatomy of the brain, the behavior of ant colonies, or the structure of fractals. In a very basic way, complexity science allows to move beyond a deterministic view on organizations in order to make sense of organization as a dynamic system (Morel and Ramanujam, 1999). Departing from ‘general systems theory’, Simon (1962), for instance, draws on complexity to highlight dynamism as an outcome of the hierarchic nature of biological as well as social systems: systems consist of many parts that can themselves be seen as complex systems and, moreover, interaction takes place within and between these sub-systems. For example, the quest in quantum mechanics for discovering the ‘elementary particle’ (i.e. a fundamental particle that is not made of other particles) has shown that all elements (that we know of) are nested: like a Russian doll, the universe houses the earth, the earth houses molecules houses atoms, nuclei and electrons, protons and neutrons, Higgs boson parts, etc. An organizational analogy depicts organizations as such nested systems, consisting of departments, business units, individuals, decisions, etc. (Maguire, McKeelvey, Mirabea and Oztas, 2006).

Although terms such as complexity or chaos may seem quite familiar, they have remarkably and for a long time been rejected – or at least not been recognized – in ‘classical’ scientific disciplines such as physics (Baranger, 2000; Prigogine, 1989). For Morin (2005), this rejection happened as complexity challenged some fundamental explanatory principles of the sciences: i) that of universal determinism and that future events can be predicted; ii) that we can know ‘the whole’ by generating knowledge about all of its parts; and iii) that the world can be split up in distinctive elements in the first place (see also Tsoukas, 2016). These three principles, all closely related to each other, will be briefly elaborated below in order to see how ‘complexity sciences’ have provided alternative scientific explanations.

First, systems are said to portray emergent behavior, meaning as much as that the whole system is enabled a property that is not reducible to the individual elements or sub-systems (Holland, 1995). For instance, the fact that I, as an anatomical system, can talk is an emergent property of sub-systems as diverse as my brain, my mouth and tongue, language acquisition as a cultural and educational system, etc. The separate sub-systems individually
cannot do any of the talking, but in interaction they allow me to talk. In a similar vein, the mere fact that organization takes place is an emergent property of the many sub-systems that make up this organization. A core thought behind emergence is that we cannot fully predict how the individual parts will interact and, consequently, that the emergent behavior of a system is non-linear without clear causes and effects that can be determined (Baranger, 2000). The outcome of the ‘behavior’ of systems, then, can be extremely sensitive to the initial conditions in that system. Made popular by meteorologist Lorenz as the ‘Butterfly Effect’, a slight deviation in parameters may result in a completely unpredictable or disproportionate outcome: the butterfly flapping its wings on a Caribbean island may significantly change – not cause – the weather patterns in Europe several months from now. Studying organizations as complex systems may help us to account for the fact that how ‘organization’ happens is not always completely in our control.

However, and this relates to the second point, describing the behavior of systems as surprising or disproportionate is also slightly misleading as it implies to claim something about the state of this system. In fact, it may tell us very little about the system itself but mainly be reflective of our own interpretive stance, i.e. that we find some outcome particularly surprising because we are limited in our knowledge of that system we want to describe. In other words, the system itself does not behave in surprising ways, but we find its behavior surprising: ‘the surprise rests on our perspective and in our violated expectations, not in the system we describe this way’ (Tsoukas and Hatch, 2001, p. 989). Notions of complexity thus challenge a common scientific principle, one in which the understanding of a certain phenomenon happens based on causal inquiry. This rationale – where a system can be split up in neutral and independent parts, and understanding these parts may lead to an understanding of the complete phenomenon – does not hold once ‘complexity’ is taking seriously, since the entire system is more than the sum of its parts.

Third, although current organization studies that depart from the tradition of complexity sciences breach with some important notions that can be found in the more classical Newtonian sciences (e.g. from determinism to emergence), this breach has been incomplete. On an ontological level, organizations are still understood as assemblies of elements or parts (departments, individuals, procedures, etc.). The complexity of organizations, so to speak, is thus still approached from within a ‘restricted’ paradigm (Chia, 1998; Heylighen, Cilliers and Gershenson, 2007; Prigogine, 1989; Tsoukas and Hatch, 2001). As Morin explains: ‘When one
searches for the “laws of complexity”, one still attaches complexity as a kind of wagon behind the truth locomotive, that which produces laws’ (2005, p. 6). It is in this sense that McKelvey (2001) states that complexity science is in fact order-creation science. While acknowledging the indeterminate nature of reality, studies on organizational complexity still look for ways to generate universal laws that represent, determine, predict, or order the complex reality. In other words, they draw distinctions between parts of a system to understand how these ‘parts’ are interrelated, thereby failing to acknowledge that the behavior of the system is emergent, that is, non-reducible.

There have been several calls that studies on organizational complexity need to be explored from a more profound perspective, for instance by taking note of the philosophical presuppositions of a science of complexity (Chia, 1998; Heylighen et al., 2007). The idea behind this remark is that one needs complex ways of thinking rather than simplified representational thinking in order to cope adequately with complexity in the environment in the first place (Ashby, 1956; Lorino et al., 2011). Put simply, such a perspective should take more seriously what it means for something to show up as complex: rather than decontextualizing and cutting up a complex world, complexity needs to be studied as an entangled or interwoven complexus that is made up of relations (Cooper, 2005; Shotter, 2013; Tsoukas, 2017; Tsoukas and Dooley, 2011).

In the chapters that follow I respond to these calls by showing the complexity of the railway infrastructure in all its complexity. Of course, this is impossible. The very act of researching and writing up an argument based on empirical data is a matter of making sense of and representing the indeterminate flow of life. I believe, however, that I was able to resist interpreting my data from a reductionist stance too easily. Rather than drawing causal connections between events and practices, I believe all cases show instances of the performativity of organizing complexity: organizational actors cope with complexity in numerous ways, and each strategy has a different effect onto how organizational complexity comes into being. In other words, the level to which one copes with complexity as a matter of reduction shapes how the complexity of infrastructure breakdowns emerges. The consequences of reducing complexity, as we see in the following chapters, may very well be counter-intuitive: taming the Monster may strengthen the beast, and tidying the Mess annihilate its invisible order. To understand this better I have at various points referred to the map-territory relation as a thinking tool. Below, I will briefly elaborate what this thinking tool entails, and in the final chapter of this book I will use it as a way to discuss my data.
2.3.1 A brief note on maps and territories

In 1893, Lewis Carroll wrote his novel ‘Sylvie and Bruno Concluded’. One of the stories in the book concerns the dilemma of a pocket-map. The idea that is playfully put forward in this story is one about the accuracy and usability of maps. Though central to navigation – and on a more general level central to making sense of the world – maps are per definition inaccurate.

One of the characters in the book, Mein Herr, says his country once produced a map that was so accurate that it had the scale of a mile to the mile. However, two problems arose. First, the map was as large as the world it represented so that if it were ever to be spread out it would block all sunlight and crops would go to waste. Second, for the map to be truly accurate of the world, it also needed to map the map that was now in the world and, much like the Droste-effect, a map of the map on the map ad infinitum.

The idea of maps representing a territory has inspired many others in disciplines ranging from novels (Houellebecq, 2012; Pirsig, 1992), to anthropology (Bateson, 1987), philosophy (Baudrillard, 1994), general semantics (Korzybski, 1933) and the visual arts (Rene Margritte’s ‘Ceci n’est pas un pipe’ as arguably the most famous example). Even cartographers struggle daily with the fact that it seems impossible to accurately represent the world on a map without some kind of faulty distortion (e.g. a trade-off must be made between the distance between points and the shape of countries). The observation, originally put forward by Korzybski (1933), that the map is not the territory it represents, has been a central and recurring sensitizing idea during my research. Organizing can fundamentally be seen as a form of map-making, as ‘representing work is the stuff of which organizations are made’ (Suchman, 1995, p. 61). Thus, during my research, I was often intrigued by the question how breakdowns are managed through representational maps, and with what consequences once we consider that maps are not the same as the territory they claim to represent. In this dissertation I use maps to refer to those representations that are used to make sense of a complex reality, such as rules and procedures, handbooks, guidelines, performance indicators, visual representations, plans, etc. When I talk about the territory, I mean to indicate how this complex reality is encountered and experienced in practice. In other words, the territory refers to a phenomenologically experienced world in which we deal with organizational

---

19 There is a short movie showing how such distortions may have actual consequences in the world, as maps still reflect imperialist ideals (e.g. the fact that North-America or Europe are central on most maps, or that Africa is generally mapped much smaller than it is). See: https://www.youtube.com/watch?v=kIJD5FDi2JQ
complexity pre-reflectively, whereas maps refer to those representations through which we try and understand this complexity.

In each empirical chapter I study different territories of the railway infrastructure. All start from the idea that complexity, being a socially constructed phenomenon, should not be treated from fear of an unknowable, indeterminate world. If we do so, we enter a territory where we encounter Messy situations full of Monsters; in the face of such disorder, we may be tempted to tidy the Mess and tame the Monster. Tidying and taming, as attempts to order and categorize an indeterminate territory, fails to embrace the fact that complexity may also be a quality of many sociotechnical phenomena. The Mess may be functional, the Monster helpful. The world is intrinsically related, and understanding infrastructure breakdowns means to understand relationships and entanglements rather than causes and effects between discrete elements. Coping with complexity, then, is not just a matter of map-making. It is the territory with its relations as much as the maps that purport to represent this territory that should be considered when studying how people try and make sense of a complex world. In the list below, I have described some of the characteristics of how we can understand the logic of how maps and territories operate (see table 3). The list is not exhaustive and only meant to be informative for this point of the argument. In fact, so I will argue in the discussion (chapter 8) of this dissertation, the clear-cut distinction between maps and territories may itself be problematic. But before I can reach this conclusion, we must first dive into the empirical territory of the Dutch railway infrastructure.

<table>
<thead>
<tr>
<th>The logic of the map</th>
<th>The logic of the territory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reducing complexity</td>
<td>Embracing complexity</td>
</tr>
<tr>
<td>Abstract representations</td>
<td>‘Raw’ reality</td>
</tr>
<tr>
<td>Cutting up in parts</td>
<td>Entangled and related wholes</td>
</tr>
<tr>
<td>Stability</td>
<td>Change (or rather: movement)</td>
</tr>
<tr>
<td>Disjunctive theorizing</td>
<td>Conjunctive ‘theorizing’</td>
</tr>
<tr>
<td>Causality</td>
<td>Indeterminacy</td>
</tr>
<tr>
<td>Systems</td>
<td>Situations</td>
</tr>
<tr>
<td>Unexpected surprises (in a negative sense)</td>
<td>Astonishment (in a positive sense)</td>
</tr>
</tbody>
</table>

*Table 3. Some characteristics of maps and territories*