Purpose
We want to understand the effects of drastic institutional reform, in the realm of liberalization, on the provision of public services in rail infrastructure operations. Operational control is vital for the reliability of train services. In control rooms, controllers are trained and equipped to cope with a constant stream of real-time, discordant situations that require specialist skills, knowledge and judgment. We study this professional practice under changing conditions.

Approach
In order to understand the possible impact of institutional reform – more particular the unbundling and re-bundling of control rooms – on the professional practice of controllers, we focus on what controllers actually do, how their professional practice works. Our in-depth ethnographic study of controllers results in a detailed, naturalistic account of their discretionary decision-making.

Findings
We first show the difficulties in gaining a more explicit understanding of what these professionals essentially think and do. Next, we inductively conceptualize our findings. Our open-dynamic account of professional practice sharply contrasts with a private-cognitive account widespread in literature. Our account of professional practice has major implications for how susceptible it is to institutional reform and organizational change.

Value
Only few studies empirically describe how professional practices, including judgment, tacit knowledge and tacit skills, work as a whole. We try to do so. This study encourages managers as well as scientists to get more sensitive to the import of professional practices in infrastructure operations, and its radical instability.

Keywords
professional judgment, organizational change, focused go-alongs, infrastructure operations
Introduction

Drastic reforms have completely transformed the rail sectors up to the very operational level in the Netherlands and the UK, ten to fifteen years ago. An alien, universal market-rationality was adopted, like in many other liberalized utility sectors (Ten Heuvelhof et al. 2009). In the UK, British Rail has been split up and fully privatized. In the Netherlands, Dutch Railways has been split up as well but not privatized.

A decade or more later, there is rather wide consensus among practitioners, politicians and scientists that this market reform did not fit the sector specificities of rail sectors very well. Successive crashes and derailments in the UK (Pollitt and Smith 2002) and disappointing punctuality figures in the Netherlands (from 2001 to 2006) nourished fierce debates on the premises of market reforms and how they disturbed operational control. A manager at the Dutch rail infrastructure company described infrastructure operation directly after unbundling as ‘a muscle that first has been cut and then contracts’ (Van den Top and Steenhuisen 2009).

Monolithic rail sectors with a, formerly, single integrated enterprise have been ‘unbundled’, subdivided in one independent rail infrastructure company and many train operating companies. This forced the new companies to completely re-design their core operational processes and control rooms. Controllers who used to work for the same organization, sharing the same control room, needed to continue their work in separate control rooms using phone and text messages to communicate among each other instead.

Due to the disappointing results of unbundling, various initiatives have been set up, and partly implemented, to ‘re-bundle’ control rooms again during the past years. In both countries, the infrastructure company and train operating companies allowed some of their controllers to cooperate under the same roof again, within integrated or co-located control rooms, while the companies remain unbundled as organizations. In the UK, rail infrastructure company Railtrack was re-nationalized and named Network Rail.

Extensive ethnographic research has been performed to study controllers at work in both Dutch and British control rooms between 2007 and 2011. This period features a large variety of unbundled, partly re-bundled and fully re-bundled control rooms. This diversity functioned as an interesting natural experiment to see how different organizational settings affect the professional practice of controllers.

This article starts with an introduction of the daily work of controllers in the rail sector. Next, we discuss how to further operationalize the discretionary decision-making of controllers by means of the literature on one hand and our ethnographic research approach on the other hand. The aim of this study is to give our account of the professional practice of controllers and reflect on its susceptibility to institutional reform and organizational change.
Meet the controllers

A control room generally consists of a few to tens of controllers sharing an office space with modular ceilings and striplight, sitting in comfortable chairs behind large, slightly-curved desks. Each controller disposes of about five computer screens with dynamic and static diagrams and tables, navigating and operating various programs, using a keyboard, a mouse, a phone, paper forms and reference books (see Figure 1).

Figure 1: Workstation of a controller

The complexity of what controllers do in this setting is perplexing. It starts with operating trains, transporting passengers and traffic control. These three tasks are interlinked in a tight web of many dynamic real-time interdependencies between passenger flows, trains, rail paths, train staff, signals, switches, travel information, rail capacity and gate capacity. Coordinating many tight couplings between these interlinked units is quite a puzzle. Additionally, a ceaseless stream of irregularities, ‘hot’ situations, incidents and crises needs to be coped with. This real-time control takes place in multiple cooperating control rooms on a 7/24 basis.

Controllers, with various task descriptions, constantly study and tweak the trains and traffic flows as multi-faceted, interrelated logistic puzzles. Most of the time, controllers are busy with monitoring their part of the system, constantly searching for information on the status quo and the nature of emerging problems, if any. On a regular basis, controllers intervene by fitting new trains in the timetable, canceling, rescheduling or rerouting trains, tolerating delayed trains, changing arrival platforms, turning switches, clearing signals, warning other controllers, instructing train drivers to slow down or speed up, etc. The quality of these type of interventions are critical to reliable train services.
Controllers are more than just logistic puzzlers. They simultaneously act as negotiators, as team players and as street-level bureaucrats. They need to be negotiators as each controller tries to optimize performance for their own company partly at the expense of other companies. Train operators compete for scarce rail tracks. The interests of train companies also compete with the interests of the infrastructure company on a regular basis and in various ways. For example, a train company prefers to keep driving trains after a disrupting incident. An infrastructure company, by contrast, prefers to cancel as much trains as necessary in order to recover train services according to the timetable as quick as possible. There often is an option to keep a few trains passing the areas where incidents occurred. While this may ensure continuity of train services, it may significantly slow down the recovery of disturbances.

At the same time, controllers need to work together as a team to make sense of what they oversee and how to intervene, as Heath and Luff (2000) also note in their study of the London underground line. Controllers constantly interact among each other to chat, to inform, to consult, to advise etc. They speak aloud for other controllers to hear what problems may be emerging. Many interventions require some form of coordination among controllers also. They even pick up each other’s phone incidentally.

Last but not least, controllers are also forced to function as street-level bureaucrats, partly isolated in their own discretion, working under time pressure and compromising competing claims of their own organization and multiple clients. Claims that daily compete in various contexts relate to safety, security, continuity of traffic, non-discriminatory access, costs and gains, efficient use of capacity and many other imponderable public values.

Multiple studies describe the work of controllers as ambiguously structured practices full of emergent norms (e.g. Heath, Luff 2000, Roth, Multer, Raslear 2006, Steenhuisen 2009, Van den Top 2010). As some kind of routine nonconformity (Vaughan 1999), these operational processes seem to function remarkably well without a uniform, protocolled model, either implemented beforehand or codifiable afterwards. We assume that by studying this ambiguity more intensely, we get a deeper understanding of controllers as professionals and their craftsmanship, judgment, specialist knowledge and skills.

This study concerns two types of control rooms: unbundled and re-bundled. The individual work processes we focus on, further explained below, are highly comparable between different control rooms. The essential difference is that the direct working environment of controllers has a different composition of colleagues. In unbundled settings, controllers share the room with a rather uniform group of colleagues from the same organization and with largely the same tasks. In re-bundled control rooms, controllers are surrounded by controllers from other organizations with essentially different priorities.
Towards an operationalized account of ‘it’

An extensive group of scholars has marvelled at the professional competence specifically in control rooms operating highly complex large scale socio-technical systems (e.g. Roberts 1989, LaPorte and Rochlin 1994, Von Meier 1999, Van Eeten and Roe 2002, Perin 2005, De Bruijne 2006, Schulman and Roe 2008, Steenhuisen 2009, Salmon et al. 2009). This competence has been analysed in various ways, as individual mindfulness, situational awareness, tacit knowledge as well as more collective concepts like cultures of control and distributed situational awareness.

Managers overseeing controllers have plenty names for it: ‘expertise’, ‘the skill’, ‘the gift’, ‘an antenna’, ‘gut feeling’, ‘the instinct’ or just ‘it’. These essential qualities professionals are attributed, stereotypically come in metaphors and vague understandings.

Scientific descriptions add relatively limited extra conceptual clarity to these occupational specific qualities. We discuss this literature and show it offers, for the purpose of this paper, a point of departure to operationalize (i) how professionals make decisions and (ii) what may affect it.

A cognition-oriented view on professionals has always been dominant in which a professional is thought of an expert who disposes of a mix of specialist knowledge, skills and judgment that allows to make the right decisions in a certain job. Furthermore, these professionals are generally considered, more or less, autonomous in deciding, and all the more when they face uncertain, instable and unprecedented value conflict. In such situations, following protocols often has shortcomings. What else to do, remains at the discretion of professionals who ‘know’ what to do and typically without being able to explain how.

What guides professionals in their decisions, is a tough nut to crack in this private-cognitive account. Major concepts like ‘tacit knowledge’ or ‘judgment’ can hardly be made specific (Davis 2010). Brown (1988) describes judgment as essentially ‘non-rule guided’. Klein (1998) describes similar decision-making as a form of ‘intuition’. Freidson (2001) considers it ‘esoteric, complex and discretionary’. Tsoukas (2005) claims that tacit knowledge can never be made explicit. These non-specific views on professional practice are ubiquitous in scientific literature, yet not concrete enough for us to start observing and learning what may affect it (Ambrosini and Bowman 2001).

A popular line of thinking contrasts professionalism with protocols. Reflecting on medical doctors, Coles (2002), for example, pinpoints that ‘being professional starts when the protocol no longer helps’. This dichotomy is, however, easily contested and immediately refuted by a real-life example. In the case of controllers, there are plenty planning rules, contingency protocols and priority rules that cannot be applied without drastic interpretation. To interpret a rule like ‘inform a train driver when a trespasser causes a safety risk’ requires controllers with experience, craftsmanship, tacit knowledge and judgment. Following protocols is often contrasted with
professional behavior, but other scholars show that following protocols, instead, requires and includes professional practice and vice versa (Davis 1999, De Bruijn 2010).

‘Tacit knowledge’ is also a highly popular concept. It suggests ‘knowledge’ as the essence what enables professionals to do the right thing in difficult situations. This metaphor is contested (Schön 1983, p. 28, Ambrosini and Bowman 2001). Though there are many kinds of knowledge, the metaphor generally implies an abstract, objective, a priori resource professionals individually possess to deduce what to do. These implications deny more than explain the micro-political and micro-creative aspects generally ascribed to professional practice. Ambrosini and Bowman (2001), therefore, prefer the term ‘tacit skills’ above tacit knowledge. Skillfulness is indeed generally associated, if not radically equated, with how professionals accomplish their valued performance (Mintzberg 1983, Gladwell 2005, Kay 2010, p. 147-8). Skills, however, are neither micro-political nor do they provide professionals guidance when to use what skill. This suggests that what we look for is more than just a certain mix of skill of knowledge.

Another contestable feature of both skills and knowledge is that they are essentially individual dispositions. It is not entirely clear to what extent professional practice should be seen as purely individual. Tetlock (1992) emphasizes the difference between professionals autonomously producing judgments (count noun) as the result of a mental process and contextualized professional judgment (mass noun). Various other scholars have emphasized professional practice as essentially interactive and structured by external resources and institutions, as opposed to being guided by a purely individual disposition (Lipsky 1980, Vaughan 1999, Noordegraaf 2007, De Bruijn 2010, Labatut et al. 2012).

The naturalistic study of Klein (1998) focuses on the individual decision-making in difficult cases. He provides an exceptionally detailed operationalization of excellence in decision-making summarized by a rich landscape of activities. This includes pattern matching, imagining, storytelling, improvising, detecting anomalies, thinking in terms of analogies, situational awareness, rational analysis among many others. But after empirically unpacking what decision-makers do, after peeling the whole onion, it remains hard to see its core, how these landscapes of activities should organically connect to ensure professional practice.

Our discussion of the dominant private-cognitive view on professionals has shown that it confuses more than answers our initial question, how organizational change affects professionalism. Professional decision-making is of course a notorious black box, but we are nevertheless helped with two general suggestions. First, if professional practice consists of an organic aggregate of connected activities, similar to Klein’s observations, we need to further explore how these activities connect. Second, we are made aware that the private-cognitive view of ‘it’ as a mix of knowledge and skills is in need of complementary concepts, perhaps from an open-interactive view.
Method

Organizational ethnography sheds more light on the discretionary decision-making in the daily work of controllers. According to Tsoukas (2005) and Kay (2010), talking with professionals about how they do what they do tends to distort it. Instead of merely interviewing like Klein (1998), we use an ethnographically inspired approach – to ‘gain access to one another’s vocational lives’, in the words of Geertz (1982).

We visited over twenty rail control rooms and sat for twenty-five full days in total next to various controllers at work. We conversed with up to sixty controllers in the UK (2010) and the Netherlands (2007-2008). We sat aside controllers and indicated to be interested in their work, their craft and particularly in their trade-offs, assuming that their professional judgment is particularly relevant in face of value conflicts. In order to generalize across various controllers with many different tasks, we focused on how they fit unplanned train movements in the flow of trains. We further focused on the disturbances and problems controllers actively monitor and solve themselves.

Ambrosini and Bowman (2001) suggest that focusing on actions makes conversations about tacit skills less fuzzy. So, we asked controllers to ‘think aloud’ as they worked. We also encouraged controllers to tell stories on what they considered interesting to illustrate the subtleties of their work. These conversations were captured in elaborate field notes. We noted down what controllers did, thought aloud and talked about, but also the daily events visible on the screens and the whole working atmosphere and environment. Each conversation was open to a unique dynamic, without a preconceived interview protocol. Conversation threads started either on the initiative of the controller or the researcher. Managers and colleagues incidentally joined conversations for a while.

This ‘focused’ kind of ethnography is similar to workplace studies (Heath, Knoblauch and Luff 2003) and similar to the ‘go-along’ method (Kusenbach 2003). The go-along method contrasts with a classic fly-on-the-wall type of observing. The researcher is much more present in a go-along setting with the risk of intruding in the daily life of controllers, and spoiling the data. In control rooms where many other people work, however, the intrusion of a researcher is relatively limited compared to a one-on-one go-along. Moreover, there are bigger challenges than not spoiling the data, namely gaining some perception of professional practice at all.

Kusenbach (ibid.) writes about go-alongs that they ‘intentionally aim at capturing the stream of perceptions, emotions and interpretations that informants usually keep to themselves’ and that they allow us ‘to focus on aspects of human experience that tend to remain hidden to observers and participants alike.’ She further writes that ‘because they can help blur the seemingly static boundaries between individuals and environments (...) go-alongs ultimately point to the fundamental reflexivity of human engagement with the world’ (emphasis in original). These
methodical qualities – revealing what happens internally within a contextualized setting – fit our needs expressed in the previous section.

‘The thing is…’
The first challenge was to get data on professional decision-making. After familiarizing ourselves with controllers, we tried to focus on the trade-offs made. Almost all controllers found it a ‘difficult’ or ‘strange’ question to speak in terms of trade-offs, even when we could see them making all kinds of trade-offs. A controller with a relatively generous account explains his daily trade-offs that concern safety: ‘In our professionalism, safety is a gray area, even though it is black and white. The thing is to have the guts to make a decision, but guts is not the right word, because then you are taking risks. The thing is to keep a few barriers between safe or reliable. The question is: how many barriers are enough for you?’ This comes through as veiling what professionals do, or even as ‘unprofessional’.

Some controllers simply ignored our interest to talk about trade-offs and started talking about the screens, the computer systems and the forms they worked with. Others started summing up a provisional, incomplete lexicon of situations and decisions: if this is the situation, I do that. For example: ‘Freight gives way to passenger trains, but not when a freight train needs to catch a slot for the Eurotunnel or a boat,’ a controller said. ‘When an engineer working on the tracks gets another five minutes, he takes twenty,’ a controller estimates. What usually followed was: ‘But actually it really depends’. Controllers got generally hesitant, when we asked them to further codify their rules of thumb and estimations. They stressed that ‘what they do’ is beyond these rules, beyond heuristics. ‘Our controllers think on their feet,’ a manager explained. ‘What you do is: simply take all into consideration’, a controller said bluntly. ‘You have lots of factors at the back of the mind, not at the front,’ a controller further specified. Many controllers reproduce the metaphor of tacit knowledge, as if they simply ‘know’ what is at hand and what to do. ‘I just see whether an extra rail path fits.’

A handicap for our research was this ubiquitous difficulty to get beyond general, veiling statements about the daily work of controllers. ‘If it fits, it is fine.’ ‘All I do is puzzle.’ ‘You just do it, hard to say how.’ ‘It’s feelings, situations, personality, alternatives.’ ‘There is no science to what we do,’ a controller digests. Her colleagues call her ‘the juggler’.

‘I always prioritize safety…’
Another handicap to study our subject is that professionals tend to transform the nature of what they do as they try to put it into words (Tsoukas 2005, Kay 2010). Here is an elaborate example of a specific kind of transformation.
While a Dutch controller explained his decisions, his actions told a different story. During one of our observation shifts, the controller put together a plan to direct Train A, running between two stations, to the parallel track and back. This is a common operation to prevent rust formation on the intermediate switches on a two-lane track. In this case, there also was a second train, Train B, on the parallel track traveling towards Train A. The traffic controller first expected Train B to pass before Train A started its maneuver switching tracks. If Train B were late, the computer would automatically give way to Train A. Then, both trains would face each other nose to nose for a few moments, at speed, on the same track, with only a few kilometers between them. By the way, the computer screens of controllers are not very accurate in showing where exactly trains are. In theory, this is not a problematic situation, according to the controller: ‘Decisions the computer makes, are always safe’. He means that the computer would never allow two trains to coincide nose to nose. This is to say that trains would face red signals. It looked like Train A arrived first as Train B was late. In response, the controller switched off the computer and instructed Train A nevertheless to stop. We asked why. The controller explained: ‘These trains might get in each other’s way.’ This answer is remarkable, because the controller directly hindered Train A while both trains supposedly could have passed each other without hindrance. It remains unclear how conscious the controller himself is about this inconsistency.

This is just an example, and can easily be explained as a moment of confusion or a socially acceptable answer. In general, the flow of anecdotes we heard in most conversations indicated few barriers to talk about sensitive issues and conflicts. Only in their own rationalization of how they acted, controllers would seldom call it a matter of making trade-offs (see also Steenhuisen 2009). Controllers display a remarkable tendency to explain what they do as common sense, because driven by one goal, for example ‘safety’ or ‘deliver what is promised’. Various controllers ensured us they actually do not make trade-offs at all.

In practice, however, they constantly encountered many competing values, as the case above also illustrates. Controllers tend to transform the trade-offs they make into a ‘mono-objective’ enterprise. This changes the nature of what they do dramatically. They regularly cancel trains for some reason. They may be too busy with one issue to pick up a phone call for another possibly urgent issue. All these daily decisions are not neutral. While balancing rather imponderable values and uncertainties, controllers see themselves optimizing one criterion. So, not only what guides decisions but also the decisions themselves may remain implicit to professionals.

‘Let’s see if… oops… probably not a problem…’

What helped in our empirical endeavor, was when controllers were busy with a, small or large, incident and talked aloud. What further helped, was to ask them many follow-up questions in quick
succession focused on the what, how and why of the concrete situations at hand. Then controllers typically gave qualitative accounts of their actions, every two or ten seconds, like: ‘I check whether...’, ‘Let’s see if…’, ‘Oops…’, ‘Probably this is not a problem, but I keep an eye on it,’ etc.

As controllers keep an eye on an incident, what they constantly do resembles an unsteady, path dependent process closing in on decision points, preparing to intervene, not necessarily intervening eventually. When controllers spot a disturbance, they start scanning, testing, estimating, interpreting and tweaking the situation at hand. This process consists of a countless multitude of constant actions and thoughts, generally explicable in common sense terms, largely resembling the general model of Klein (1998), but what essentially guides or structures this process is not directly evident.

The most striking observation in these processes is the absence of distinctive decision points that clearly require such a thing as tacit knowledge. As controllers see disturbances emerge and fade again, they either incrementally adjust the flow of traffic or they decide by means of rather clear rules. Controllers consider it fairly easy to explain the reasons for the adjustments they make. ‘Let’s clear this signal to prevent a conflict.’ Or: ‘A delay of more than fifteen minutes prescribes to cancel that train’. There is not much of a creative climax visible in this professional practice. Creativity is instead more spread out and processed in an improvised web of actions and thoughts before the decisions are made. How this works, how controllers arrive at decision points, they find much harder to explain than the decision rules themselves.

A process of eight activities
We now sketch this practice of preparing for decisions in direct response to disturbances more systematically. As said, we focus on fitting unplanned train movements in the flow of trains. In roughly 80% of these situations, controllers have minutes or more to monitor the developing situation before they intervene, if at all. In these minutes, controllers go through a rather disorderly process of micro-activity. We distinguish eight activities.

- **Looking for trouble**: eyeballing traffic flows on multiple screens, keen on anything unusual. Being open to all signs. Scanning real-time announcements of other controllers. Reading special announcements of the day: maintenance plans, weather conditions, previous performance etc. Pursuing the effects of passing trains by clicking through their detailed time tables. The identification of a deviation triggers the other activities.

- **Looking after a deviation**: marking an irregularity as a priority. Intensifying attention for the prioritized irregularity by adjusting screens in such a way that relevant information is visible or close at hand. Controllers start informing themselves on the context of the deviation.

- **Looking for a cause**: making assumptions of the deviation at hand and testing them,
verifying possible causes. As soon as controllers identified a deviation, they start to look for the cause of it. This is often puzzled out just by watching the irregularity develop. Controllers also inquire with other controllers, train operators or maintenance workers.

- **Looking into the problem**: identifying plausible scenarios with negative consequences. For example, ‘if that train delays a few minutes more, it will compete for the same track with another train.’ As soon as controllers labeled a deviation as a potential problem, a rough classification of simple, difficult or catastrophic problems is used to decide on what performance mode should follow.

- **Looking for serious trouble**: remaining particularly sensitive to what can suddenly complicate the situation or completely mess up the situation, what can make a small problem big. ‘I look at that, because that would be mega,’ a controller says.

- **Looking for options to act**: having some options is generally considered sufficient. Most controllers are not particularly eager to create more options but rather nonchalant about the available options they have within their own sphere of influence. A rough selection of the options is constantly updated, as their usability is rather contingent and temporary. ‘You exclude what is not going to work,’ one controller explains.

- **Looking into the consequences**: estimating for some options what would be the (intended) effects and what would be significant drawbacks. Doing nothing is generally used as a reference point to value the intended consequences of an option. Controllers are not very keen on precision and completeness when mapping possible effects, perhaps because it is not unusual that options work out differently than intended. Controllers neither dispose of advanced computer-based support to help them compare the consequences of trade-offs in real-time, as is more common in air traffic control.

- **Intervening**: carefully adjusting the flow of trains or simply eliminating unplanned train movements. Many incremental adjustments are precautionary. The more drastic adjustments are generally protocol-based. Timing and type of interventions are mostly triggered by the course of events. Controllers often consider their interventions as ‘common sense’ or ‘simply no choice’. Effects of interventions are monitored closely.

This naturalistic account of the professional practice of controllers seems to jump over its quintessence. How are decisions made? How are options compared? How do controllers balance imponderable values? Though the work of controllers includes complex optimization problems, we do not see controllers solving them. If professional judgment is not actively used to optimize difficult trade-offs, what can be its purpose of existence? Professional judgment, by means of these eight activities, does not so much effectuate in making the right decisions but in preparing for the
right decision.

**A messy process: zooming in, zooming out**

The main activities controllers display are rather easy to make explicit. A sequential completion of these activities – going from problem identification to investigation, to plan creation and, finally, to implementation – would create conditions for controllers to optimize trade-offs in a fully systematic manner that is not essentially ‘tacit’. But instead of going through these classical decision-making steps (Farrington-Darby et al. 2006), we observed that controllers constantly go back and forth between these eight activities. Instead of eventually ‘knowing what is going on around you’ (emphasis added), as Endsley and Garland (2000) define situational awareness, the process we described does not systematically produce surveys of the current and future state of the traffic flow. Time pressure is an important reason for this. ‘If you would go through all the variables, you’ll be too late to decide and will not decide at all,’ a controller says. Another reason for controllers to perform these eight activities in parallel on trial-and-error basis, is to cope with constantly changing contingencies and remaining uncertainties. Controllers jump from one activity to another, without clearly finishing activities, as new irregularities turn up, interact with others, aggravate and fade unpredictably, or when actions are suddenly required.

Though the exact way controllers mix up these eight activities in parallel is hard to explain, it is not because there are no underlying behavioral rules for it, or because it is ineffable. By and large, controllers go through an iterative process of zooming in and out. Controllers zoom in on a deviation, on a causal scenario, on an option to intervene and on some of the consequences, but zooming in always obscures the broader picture with many alternative deviations, scenarios, options and consequences. Controllers zoom out when they include new deviations, new scenarios, new options, but zooming out always compromises the attainable degree of in-depth precision. So, the method in ‘zooming’ is intrinsically dilemmatic and as messy as trying to focus on an obscure object under a microscope while it moves, shrinks and grows. What makes this method hard to codify, is the quick succession of a multitude of interdependent micro-decisions and the variety of reasons that may trigger these decisions: hunches, best guesses, playfulness, serendipity, routines, recognition of patterns, anomalies and analogies etc.

**An open process: effects of unbundling and re-bundling**

What does this naturalistic account so far learn about how organizational change may affect professional practices of controllers? We conceptualized this as a process, essentially. This conceptualization implies radical susceptibility to organizational change. The dynamics of this professional practice are fundamentally open to its environment. Its quality becomes a direct
function of the direct environment of controllers. Differences between unbundled and re-bundled
control rooms illustrate this openness of professional practices.

A main influence in the environment of controllers are their direct colleagues. They actively
participate in each other’s activities. In our understanding, this collectivity is not outside their
professional practice, as it is not external to the messy process they are in when responding to a
disturbance and preparing for decisions.

That is why the organizational setting in which this messy process takes shape, matters. Unbundling control rooms to allow for markets in rail services has been a bad design for controllers
to do their work. Working in separate control rooms seriously restricts the ability of controllers to
profit from what other controllers know. Information cannot be shared quick enough by phone or by
text messages across control rooms. Controllers structurally risk zooming in too quickly or for too
long and intervening too early or too late because of a poor understanding of the emerging incident.
Receiving little and delayed feedback directly affects their professional ability to zoom in and out.

Re-bundled control rooms allow for more direct cooperation, integrated judgment, richer
real-time feedback on the fly. Involved managers and controllers are unanimously enthusiastic
about re-bundling control rooms as a panacea for controllers to do their job right. ‘Immeasurably
better,’ one controller says. Infrastructure company Network Rail measured a significant
improvement after re-bundling, as Figure 2 sketches.

![Graph showing the ability of controllers to minimize delay minutes](image)

Figure 2: the ability of controllers to minimize delay minutes as measured by Network Rail (2006)

The graph above clearly confirms what we already expected, that re-bundling improves
performance of controllers. Our conceptualization of professional practice, however, suggests that
re-bundling has much more effects than just improving cooperation between controllers. ‘Quality in,
quality out’ after re-bundling compared to ‘garbage in, garbage out’ in unbundled settings, with respect to the information controllers base their decision on, seems an obvious explanation for the measured improvement. This explanation, however, simply treats the professional practice of controllers as a private-cognitive black box processing the available information instead of an open process that actively shapes the context for information to be available, decisive and valid.

These so-called integrated or co-located control rooms do not simply enable professionals to presume what they used to do under more supportive circumstances. This re-bundled environment, instead, actively shapes the professional process in detail and directly affects professional judgment in many, subtle ways. How much and what kind of cooperation between controllers has many positive and negative implications for the nature and the dynamics of the messy processes controllers daily perform. We identified five unintended and undesirable tendencies among controllers working in integrated control rooms, in comparison with unbundled control rooms.

- Controllers increasingly learn to be reactive instead of proactive towards controllers of other companies when working in the same integrated control room. ‘If they do not agree, they will come and talk to me,’ a controller says. New default options are to go and chat with one another instead of relying on individual knowledge and skills.
- Controllers in integrated control rooms also emphasize the value of ‘one version of the truth’, as they call it. It is not entirely clear how mindful and productive this emphasize on consensus is for the messy process controllers are in. When working in separate control rooms, it is more common to disagree on the problem situation with controllers elsewhere.
- Controllers in integrated control rooms emphasize the importance of one common goal for all controllers, namely to ‘minimize delays’. It can again be doubted how mindful and productive this sharp articulation of a single norm is and how this affects the process of controllers implicitly treating many more relevant aspects.
- Controllers spend more time talking, negotiating and compromising with other controllers in integrated settings. This has many implications for the professional process. Shared situational awareness may increase but at the expense of in-depth, individual situational awareness. Shared problem solving may reduce the discretion and the degrees of freedom controllers have to tame their messy processes. Coordinating these processes in groups instead of individually creates a different dynamic that is partly less agile and less iterative.
- Collective decision-making is not a neutral activity. As different controllers pursue partly competing interests, they learn how to use rhetoric qualities to make other controllers see the situation in one way or another. Technical and logistic issues generally make more powerful arguments than soft stories about diffuse passenger interests. The situation and work pressure inside the control room often provides more powerful arguments than less visible
problems experienced elsewhere. These rhetoric qualities may get more weight and increasingly bias the trade-offs re-bundled control rooms produce.

Seeing professional practice as an open process sensitizes us to see how organizational context shapes it. Unbundling and re-bundling control rooms, as well as any other radical change in the working conditions of controllers, is likely not to leave an aspect of professional judgment untouched. Even re-bundling, though generally considered a success, has many diffuse, subtle and instable effects on the long term that require checks and balances. These changing organizational settings – including new communication lines, new incentives, a new lay-out of the control room, new power structures, new routines, new norms – cannot transplant but essentially transforms ‘the gift’ of controllers. Organizational settings do not passively facilitate but actively co-shape professional judgment in real-time.

**Conclusion**
Reliable train services depend on an army of controllers with craftsmanship, judgment and specific knowledge and skills. In order to minimize disturbances for passengers, a controller may, for example, decide not to cancel a delayed train, although a rule prescribes to do so, but to reroute the train instead. How do such decisions come about within the discretion of controllers? How does radical organizational restructuring impact the quality of these decisions? We provide inductive answers to these questions, after intensively observing and conversing with rail controllers.

It proved hard to derive an account of how professional judgment works from the literature. To gain empirical data on how controllers exercise judgment proved also hard, but eventually it did not remain ineffable and invisible. We could produce a naturalistic conceptualization of how controllers deal with disturbed situations. This empirical account sharply contrasts with the private-cognitive view dominant in literature.

In the moderately disturbed situations we studied, controllers exercise judgment by means of a skillful back-and-forth process of basic cognitive activities closing in on decision points. Controllers do no turn to their tacit knowledge to decide on best solutions for particular trade-offs. Instead, their decisions, interventions in the flow of trains, follow from a unique process that solidifies immersed in doing rather than from some tacit form of knowing what to decide. In other words, their expertise or experience does not pay out at decisive moments. Instead, controllers conduct a hands-on process in which prudence is more a virtue than decisiveness; and when decisions eventually need to be made, common sense appears more useful than specialist knowledge. This professional practice is less about what decisions to make and more about how well-informed to arrive at certain decision points. Consequently, conducting this practice in reliable
ways should not be understood as an autonomous disposition of professionals but essentially open to its environment, in the midst of protocols, team work and organizational context.

Rethinking professional practice along these lines yields major implications for the Dutch and British rail sectors. The current initiatives to re-bundle control rooms might cause a jump in performance once, but then, the work is not done. New work conditions encroach deeply into the very nature of their professional judgment, as controllers will be exposed to a thoroughly new web of factors and forces that shapes their way of working. The effects are expected to be multiple, diffuse and not necessarily stable over time. This dampens optimism to optimize performance of control rooms by design only and draws attention to how managers can retain and incrementally develop their controllers’ competences.

Managers should recognize their direct complicity in how controllers lose or improve their competences over time. Our account of professional practice points at new appendages for managers to sense the impact of their interference and how to co-shape the capacity of controllers to excel in their job. Trimming the competences of controllers with micro-feedback loops will be particularly challenging for at least two reasons. First, the difference between an effective and an ineffective controller appears fundamentally fuzzy, not only to managers but to controllers as well. We revealed that the tacit knowledge of controllers is generally unrelated to the substantial outcome of their decisions. Regardless of how well controllers gained an overview of conflict situations at hand, their decisions remain justifiable by means of straightforward, more or less formal, decision rules. Second, we only studied controllers under rather moderately disturbed situations. Some competences in moderately disturbed situations may as well be counterproductive in more drastically disturbed situations. To ensure a fruitful learning environment for controllers, the current notion of what distinguishes good from bad practice is uncomfortably relative and contextual.

This study has been mainly explorative. Further study into the detailed variety of how controllers exercise judgment, is recommendable, in particular, the way controllers adapt to different circumstances. Relevant questions then are: What are the main performance modes of controllers zooming in and out? How do these modes relate to changing circumstances (e.g. system stability, system maneuverability, procedural clarity, value base, time pressure, discretion level, team work, risk profile, managerial involvement etc.)? What triggers controllers to adapt their performance mode? And ultimately, how to design and manage the organizational contexts of controllers to maintain and maximize their competences?

This study focused on one particular occupation. What about other professions? Of course our findings are imbued with occupation specific particularities. In general, we see no reason to rule out analogous eye openers for other professions because of the widespread use of similarly ill-defined competences in the sphere of judgment, tacit knowledge and professionalism.
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