MAKING WORK INVISIBLE. NEW PUBLIC MANAGEMENT AND OPERATIONAL WORK IN CRITICAL INFRASTRUCTURE SECTORS.

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ABSTRACT

Based on a study of reliability consequences of new public management (NPM) reforms in Norwegian critical infrastructure sectors, this paper suggests that the discourse of work found in NPM renders essential aspects of operational work invisible – including practices that are known to be of importance for reliability. We identify two such organizationally 'invisible' characteristics of operational work: The ever on-going *situational coordination* required for keeping a water supply system or an electricity grid running and the aggregating *operational history* within which this happens. In the reorganized infrastructure sectors, these crucial aspects of operational work fit poorly in market oriented organizational models and control mechanisms. More generally, our analysis provides contributes to the understanding of how some types of work fit poorly within the discourse of work found in NPM.

INTRODUCTION

To an increasing extent and in increasing detail, what we do in our workplaces is subject to standardized procedures, checklists to be ticked and reporting systems in which work is represented as standardized items. In the public sector, this development is often part of new public management (NPM) reforms. In this respect, NPM is part of a more general trend towards increasing reliance on standardization and accountability (e.g. Power 1997). This is based on a discourse in which work can be broken down into delimited, standardized, measurable tasks that can be bought and sold on a market. While this rationalistic understanding of work is a cornerstone of NPM, it ranges far wider than NPM only, and is common both in public and private sector organizations.

In this article we show that there are certain types of work that are hard to describe, prescribe and control and are thus rendered invisible in organizations based on this model of work. Operational work consists of continuous work processes that have no clear beginning or end and where the tasks involved are notoriously hard to delimit and standardize. By inspecting details in operational work the paper illustrates how 'bringing work back in' (Barley and Kunda 2001) to studies of structural reforms may contribute to a renewed understanding of their successes and shortcomings.

The empirical basis of the article is a study of organizations operating critical infrastructures: electricity distribution and water supply systems. Critical infrastructures are systems on which a society is dependent in order to maintain its vital functions. While all parts of the public sector provide important services to citizens, these are services on which the functioning of society as a whole relies. Although the consequences of NPM have been described and debated for decades, surprisingly little research has been devoted to analysing

how NPM affects the operation of critical infrastructures (see de Bruijne and van Eeten 2007, Antonsen et al 2010).

The analysis presents the following line of argumentation: The rationalistic model of work in NPM fails to represent and control certain aspects of organization related to the continuous nature of operational work. These aspects have been found to be beneficial for reliability in previous safety research (e.g. Rasmussen 1997, Weick and Sutcliffe 2007). Making such aspects invisible may thus influence the functioning of organizations operating critical infrastructures. The "dependent variable" of our analysis is thus not direct measures of reliability, but organizational properties that are regarded to be "intermediate variables" for the reliability of a system

The scientific and public discussion of the consequences of NPM reforms is typically structurally oriented. Although the literature is voluminous, there is still little empirical evidence of how the structural changes actually affect work on the shop floor (Pollitt 2009; Andrews and Boyne 2012). This paper is a contribution in this respect as we discuss how structural changes associated with NPM affect work at the sharp end of the organizations. Importantly, we seek to go beyond merely stressing the uniqueness of the individual settings to which reforms must be adapted. Based on our case studies, develop generalizable descriptions and conceptualizations of this uniqueness that can be employed to understand implementation issues with structural reforms more generally.

Our discussion is based on interviews, visits, observation, document studies and meetings with operative personnel and managers in two Norwegian infrastructure sectors.

KEY CONCEPTS AND THEORETICAL BACKGROUND

In this section the foundations on which our analysis rests are described through four main steps. First, the key concepts for the analysis need to be clarified. These concepts are partly

derived from the empirical analysis but will be introduced briefly pending elaboration throughout the paper. Second, we give a brief account of the organizing logic of NPM as an example of what we have labelled a rationalistic model of work. Third, we describe existing research related to the differences between visible and invisible work with an emphasis on so-called 'articulation work' (Strauss 1985). Fourth, we link the notion of invisible work to literature on safety and reliability. This is included to highlight that the aspects of work rendered invisible in rationalized models of work may have important reliability functions related to critical infrastructures.

Operational work, situational coordination, historical continuity and reliability

We have studied *operational work* in critical infrastructure sectors. This refers to the continuous flow of tasks and interventions undertaken to keep a system up and running. We will argue that *situational coordination* and *historical continuity* are two key aspects of operational work. By situational coordination, we refer to the informal coordinative work that is done to perform a task in a concrete situation, weather conditions, available resources, concurrent activities, and other situational contingencies. By historical continuity, we refer to the fact that the infrastructure systems we have studied are continuously running (and have been running for decades) and that work is situated in this temporal flow of aggregating operational history.

Our project was designed to investigate possible consequences of structural reforms on the *reliability* of critical infrastructures. For the purposes of this paper, we have defined reliability, admittedly somewhat crudely, as the absence of disruptions in the supply of the products and services produced by means of a critical infrastructure. Reliability is dependent on several technological and organizational factors. This includes the technical robustness of the infrastructure (e.g. level of redundancy and quality of maintenance) and the organizational

resilience (e.g. the human actions and adaptations making it possible to avoid errors and to 'bounce back' from perturbations).

NPM, organizing and a rationalistic model of work

NPM reforms in the Norwegian infrastructure sectors are based on an organizing logic in which work is seen as consisting of standardized entities that can be specified, standardized and traded as products. This is also found in the private sectors, so when we refer to the 'commoditization' (Almklov and Antonsen 2010) of work and to a rationalistic model of work, this is not limited to NPM. It is a ubiquitous trend in organizing by which NPM reforms are inspired.

NPM refers to a broad trend of institutional developments, implying that principles of governance inspired by private organizations replace the hierarchical structures of old bureaucracies in the public sector (see e.g. Hood 1991, Christensen and Lægreid 2001, 2007, Dunleavy et al. 2006). The key motive of the NPM movement was to reduce the running costs of the public sector, although recent research seriously questions whether significant cost reductions have actually been achieved (Hood and Dixon 2013). Typical organizational consequences of NPM are that integrated hierarchical bureaucracies are split according to functions and are coordinated by market mechanisms. This can be in the form of internal buyer–supplier models, outsourcing or full-blown privatization. Although often referred to as a de-regulation of the public sector, NPM is arguably a shift to new forms of bureaucracy, or re-regulation (Hood and Jackson 1992; Sheil 2004). There has been a shift from being *responsible* for a broadly defined public service, to being *accountable* for the production of a limited set of specified results. The organizations' performance is typically followed up (by owners, buyers and the authorities) through selected measurable outputs, and they are held accountable for their performance. The 'paper audit trails' and their electronic equivalents

(Hood 2007, p. 197) are auditable accounts (Power 2007, p. 161ff), usually in the form of standardized, measurable items. Work is ordered and controlled by means of such items.

We have elsewhere proposed describing the fragmentation of post-NPM organizations in infrastructure sectors as 'modularization' (Almklov and Antonsen 2010, p. 134). Formerly integrated organizations are split into functionally focused entities with standardized interfaces (in the form of specified inputs and outputs). In a modular system, individual components can be replaced without altering the others. This interchangeability is favourable for outsourcing and for obtaining competition between vendors. In deregulated industries there is also a tendency to standardize tasks and make them as limited as possible (in order for a buyer to have detailed control). Rather than ordering a diffuse package of work, for example the maintenance of a part of the electricity grid, it is broken down into a series of standardized atomistic tasks such as changing a single pole (Almklov and Antonsen 2010). The present paper builds on the realization during our studies of NPM in infrastructure sectors that these processes tend to be controversial predominantly when applied to operational departments and more specifically the work of continuously operating the infrastructure. Commoditization works quite smoothly when tasks are easy to delimit and standardize, but operational work tends not to conform to these processes. Operations in the infrastructure sectors mean performing the on-going tasks and coordination that maintain the production of services 24 hours a day, 365 days a year. The extensive use of contractors was uncontroversial in most cases, but there seemed to be *something* in operational work that was hard to specify as products. By identifying and discussing these qualities, we contribute to an understanding the consequences of market-oriented reforms for work generally. We also argue, more specifically, that it renders important reliability-generating aspects of operational work organizationally invisible.

Visible and invisible work

Transparency and accountability are central motivations for NPM reforms. Accountability can be understood as rendering 'all work "visible" through reporting systems and procedures' (Gregory 1995, p. 60). Organizations are built around systems with measurable targets and reporting according to these. These are information infrastructures that shape what kinds of information are organizationally visible and invisible, what is transported most easily across contexts (Suchman 1995; Bowker and Star 1999), and what reaches the manager's office or ends up in the regulator's report.

Work in operational departments consists of a continuous flow of circumstances to which adjustments and adaptations are continually made. Infrastructures are networks that are open to external forces and perturbations from the society they serve. Operating them is a dynamic adaptive process (see Schulman and Roe 2007). Due to society's dependence on infrastructures, stopping them for maintenance or reconfiguration is seldom an option and operations must always be done in the context of the aggregated history of earlier operations. Operators keep them running by integrating a flow of tasks – big and small, planned and unplanned, proactive and reactive. In addition, operational work involves situational coordination between such tasks, and of such tasks in relation to the varying external circumstances. This balancing and coordination may be trivial and, as long as nothing goes wrong, organizationally invisible, but it is crucial for the integrity of the system. It is a prerequisite for dealing with the variability that will always be present when performing tasks under changing conditions. Consequently, it also is pivotal in terms of understanding reliability.

The connection between work as represented and work as performed in situated contexts is not trivial. Rationalized accounts of work such as plans and procedures do not represent action but are resources drawn upon in specific situations in which work is performed

(Suchman 1987). For researchers interested in reliability and robustness, this point is crucial, as procedures and compliance are important resources for reliability. However, Suchman's observations are not a mere insistence that one cannot expect the plans or procedures to be followed exactly. They are also clues to understanding how informal and invisible aspects of work are positive resources for work performance.

Within the sociology of work, informal work practices have been scrutinized (e.g. Orr 1996, Barley 1996). Of particular interest is the concept suggested by Strauss (1985) to describe the informal work practices of situational coordination: 'articulation work'. Articulation work refers to the coordination activities necessary to integrate various specialized tasks into a working whole. Always situation-dependent, this 'meta-work' is something which is not possible to describe fully in formal procedures. It is, according to Star (1991 p. 275) the 'work that gets things back "on track" in the face of the unexpected, and modifies action to accommodate unanticipated contingencies'. She continues: 'The important thing about articulation work is that it is invisible to rationalized models of work.' You can get only so far with prescriptions, procedures and plans: 'No matter how detailed the requirements are they must be aligned with or tailored to a set of implementation conditions that cannot be fully specified ahead of time' (Gerson and Star 1986, p. 258).

Articulation work can be understood as a generalized description of coordinative efforts – the work to achieve coordination so to speak. Most scholars have, however, employed the term to describe situational, ad hoc alignment and improvisation in concrete situations, and not so much coordination through structural means and artefacts (Schmidt and Simone 2000). We employ the phrase 'situational coordination' to refer to this understanding of articulation work as informal, situational and invisible in rationalistic models.

In sum, these considerations suggest that work as performed always contains an element of *informal, situational coordination of tasks, resources and information*. As we will show, this is a particularly important characteristic of operational work on critical infrastructures.

Invisible work in safety research

Rasmussen's (1997) work has been influential in describing the dynamics by which human behaviour and system operation is influenced. He describes several factors that constitute constraints for human behaviour, including management pressure towards efficiency, prescription of practice through procedures and employees' wish to perform their work with the least effort. Importantly, these constraints by no means predetermine the actions of operators:

> '[M]any degrees of freedom are left open which will have to be closed by the individual actor by an adaptive search guided by process criteria such as work load, cost effectiveness, risk of failure, joy of exploration, etc. The work space within which the human actors can navigate freely during this search is bounded by administrative, functional, and safety related constraints.' (Rasmussen 1997, p. 189)

The implication of Rasmussen's perspective is that pre-defined plans and standards for safe operation are only one set of a number of constraints or resources that guide the way in which operators or decision makers adapt their actions to local contexts. The actions chosen are influenced by several constraints, some of which cannot be specified in advance of a given situation. Rasmussen's work on the 'adaptive search' involved in any normal operation within sociotechnical systems has seen somewhat of a revival in safety research. Several authors have emphasized the role of such adaptation for the ability of a sociotechnical system to absorb strain and 'bounce back' from minor and major disruptions. Authors like Hollnagel and Woods (2006) and Weick and Sutcliffe (2007) have all discussed the importance of local,

continuous adaptation and 'normal' work performance in producing the robustness of a system.

Reliability is a dynamic non-event (Weick 1987); that is, it is the *continued absence* of disruptive. This is explained by Reason (2000) as follows:

> '[H]uman variability in the shape of compensations and adaptations to changing events represents one of the system's most important safeguards. Reliability is "a dynamic non-event." It is dynamic because safety is preserved by timely human adjustments; it is a non-event because successful outcomes rarely call attention to themselves.' (p.770)

Moreover, the events not occurring are not a stable, well-defined group of events. They are the possible downside of every normal operation that involves some sort of risk. This does not, of course, imply that all risks are unknown. Many of the great improvements that have been achieved in the safety levels of high risk industries can be attributed to the ability to devise technical and operational barriers against *known* risks. To paraphrase the title of the book by Weick and Sutcliffe (2007), safety is as much about the ability to 'manage the expected', as it is about dealing with the unknown. Nevertheless, the avoidance of accidents and incidents can never be reduced to a set of pre-planned actions or technological design. There will always be a component of human adaptation taking place in the continuous strings of day-to-day operations, ensuring that bad things are not allowed to happen. This adaptation is also the reason safety researchers often find a divergence between the way tasks are described in rules and procedures and the way they are performed in practice (Dekker 2006; McDonald *et al*. 2006; Antonsen 2009). This literature is thus in line with the above discussion in terms of indicating that how work is actually performed may be largely 'invisible' in an organizational discourse based on standardization (Suchman 1995).

The continuous adjustments to situational characteristics have traditionally been viewed as a problem for safety management, as violations or 'rule-bending'. However, these adaptations

are increasingly seen as a resource for reliability and safety. For instance, Roe and Schulman (2008) show how control room operators in the Californian electricity system are crucial for reliability by operating as 'reliability professionals' making dynamic situational adjustments. Reliability professionals are middle-level personnel with broad experience of the electricity system that enables the balancing of energy generation and the load on the grid in more or less real time. This illustrates that the reliability of critical infrastructures is influenced by the continual, micro-level adjustments that constitute operational work. Within the same strand of research, de Bruijne and van Eeten (2007) have discussed whether restructured infrastructure systems are 'systems that should have failed' according to theory, without doing so in practice. Their conclusion is that despite operating closer to the edge, the skills of reliability professionals keep the systems up and running. By pointing to the way in which informal aspects of organizing can provide a source or reliability, this line of research continues the emphasis on the ability of organizations to combine the need for centralization and hierarchy with situational flexibility. The balancing of strategies of anticipation and strategies of resilience is a topic that can be traced back to Wildavsky's (1988) classical works, as well as the original research on high reliability organizations (e.g. Rochlin *et al.* 1987; La Porte and Consolini 1991).

NPM, critical infrastructures and reliability

NPM entails changes in the regulatory framework within which the infrastructures operate, as well as changes within the organizations themselves. The possible consequences of these changes for societal safety were noted early, for example by Hood and Jackson (1992, p. 110), who suggested that NPM contained the 'organizational ingredients for socially created disasters'. The most prominent concerns raised from a reliability viewpoint can be organized along two key axes: a) fragmentation effects - new interfaces can lead to coordination

problems; b) redundancy effects - more functionally oriented and lean organizations may lead to less slack and redundancy, both locally and at a more systemic level.

Accountability and transparency is achieved, as we will also see in our cases, by fragmenting organizations into entities that produce standardized products and services that can be counted and monitored. The fragmentation is designed to improve control and transparency, but it is so from the accountant's not (necessarily) an engineer's perspective. Thus, activities that from an engineering perspective could very well be managed by one organization are divided among different actors to generate (transaction) data and control options; to improve accountability from an economic or regulatory standpoint. The advantages are increased control in the form of better reporting and stronger adherence to standardized work processes. An important downside is the fragmentation of informal networks between practitioners. This narrows channels of communication, thus damaging important arenas for learning and risk identification, and for creative cooperation in emergencies (Almklov and Antonsen 2010).

CASES: OPERATIONAL WORK IN CRITICAL INFRASTRUCTURES

The empirical basis of our study is semi-structured interviews: 35 and 49 in Norwegian water supply and electricity network organizations respectively. This is supported by document studies, visits and subsequent discussions with industry representatives. We interviewed people on all levels in the organizations, with varying degrees of experience and on both sides of the buyer-supplier relationships.

Water supply in two Norwegian cities

We conducted comparative studies within water supply services in two Norwegian cities and how these had been reorganized as a part of NPM reforms. These organizations manage water treatment facilities, pumping stations, sources (nearby lakes), reservoirs and pipelines. The

technical infrastructures are heterogeneous. In both cities the oldest parts of the grid are from the 19th century. Moreover, the distribution system is interwoven with the activities of the city, other infrastructures, industries that may be sources of pollution, buildings and customers with specific vulnerabilities. Knowing the grid is thus also a matter of knowing its surroundings. Reliability is a matter of upholding continuity in the delivery of water and maintaining the quality of the water to avoid diseases.

The operators do not have to *do* that much to keep the water running in normal situations. They operate water treatment plants, inspect water quality, undertake minor repairs and inspections and generally monitor the grid with sensors and inspections. Sensors give indications of pressure development, filling of reservoirs, pumping efficiency and leakages. When external companies perform minor modifications or other services, such as camera inspections, operators give them access to the system, close and reopen valves and oversee their work. They plan modifications and monitor the entrepreneurs' work (e.g. to ensure compliance with hygiene standards). They also monitor and adjust the system in situations that may increase the chance of pollution, e.g. when the fire department draws water, as this may cause underpressure and ingress of surface water or even sewerage through leaky pipes. The operators also have key roles in emergency management.

The operational department works to balance the general orders and specifications in development plans and drawings with the local operative conditions and challenges that arise. They align the need to perform maintenance and modification of the infrastructure with the public's need for a continuous supply of water. They coordinate and supervise the various contractors that are involved in constructing, maintaining and modifying the infrastructure. Their activities must also be coordinated with outside parties, such as the public, the fire department, road administration, and construction work that may be going on nearby.

Projects, such as the construction of new infrastructure, specialist services and major maintenance, have been carried out by external contractors for decades in both municipalities. In the cities we studied, NPM reforms led to splitting of the previously integrated water supply departments into an internal buyer and a supplier unit, performing planning and execution, respectively. The rationale for this organizational change was improved control over costs and quality. The buyer was essentially in charge of the system, ordering specific tasks from the supplier. The organizational changes severed tight relations between former colleagues and introduced a formal relationship between contractual partners interface where tasks were treated as products over the counter.

In both cities the first visible consequence of the buyer–supplier model was a physical separation of planners and operative personnel. One operative informant observed: 'I think this is how it is expected to be with the system we have. [...] You know, we are not co-located any longer. That is not an option.'

The split of the operational department and the attempts to commoditize their work turned out to be problematic in both cities. The physical infrastructures of the water supply systems are heterogeneous and notoriously hard to document sufficiently. Water and sanitation infrastructure in an urban setting is a patchwork of pipes and pumps which have emerged over a span of 50 or 100 years and the different parts of the infrastructure have their own peculiarities. As a consequence of this most tasks were hard to specify in detail. The lack of documentation means that much of the knowledge regarding the infrastructures remains an undocumented part of the professional knowledge of operative personnel. Moreover, this knowledge is a product of close involvement in operations over time, so the split between planning and execution may reduce the feedback of operational knowledge to the planners.

Partly due to a political change the NPM regime was kept mostly in name in one of the cities. The units cooperated quite informally, as before, with little focus on the economic

pseudo-transactions of the buyer–supplier model. In the other city, however, substantial efforts were made to improve documentation and standardization in order for the buyer to gain control down to the task level. Here, too, it was hard for the buyer to control operational work by detailed specifications. The change process dramatically severed trust-based relations that crossed the buyer–supplier boundary. As such, we observed this city in limbo where the trust-based informal organizing had broken down, while the transaction-based control and coordination regime was not yet in place. This city planned to eventually outsource operations, standardizing the tasks so that the buyer could choose from different comparable vendors, but the buyer would need to have functioning control systems before that would happen.

A manager in this city discussed how outsourcing of *projects*, which they had done for decades, contrasted with outsourcing of *operations*:

> 'When you have a building project or something else that you can describe, you can describe quality and methods of execution. Then it is ok to do it [outsource]. Then you can compare prices. You have calculated the same thing. When you outsource operations, then it's a completely different matter. First of all, it depends much on the quality of the object that you are supposed to operate. And here the quality varies. We have pipelines from the 1860s and lots of pumping stations that were built around the 1980s, and they are getting old. It's like when you have an old car that needs more and more servicing. That's one thing, the condition of the object. And the second thing that is very important is the competence of the man who is supposed to come in and do the job. That he actually knows enough. So, to describe that in a way that makes it unambiguous and that you can calculate it, and that you can calculate it up against another contractor, that is not that easy.' (Manager, water supply)

This complexity, he concludes, means that you have to rely on broadly defined functional agreements and leave the responsibility with the operator, while the buyer does not interfere with the details. This, of course, does *not* fit neatly with the regime of control by detailed specification and measurement that the city politicians desired.

The history and local uniqueness of the infrastructure makes it hard to formulate continuous operations as standardized tasks. Effective operation of these systems relies on close interaction with them over time. Efforts to control operations with strict specifications and standardization led to an explosive increase in bureaucracy.

When it is hard to specify what operations consist of, a possible solution is to outsource the operations as one package, and this was seen as the most likely outcome in this city. This, however, produces another problem: When knowledge of the system is dependent on experience, it is very hard to obtain real competition as soon as one vendor is established. Several informants reminded us that most of their funds already go to external contractors for projects and specialist services. In other words, they did not view outsourcing as problematic *per se*. It was when trying to outsource core coordinating and monitoring activities in *operational work* that these problems occurred. The systems for describing and controlling work weren't able to capture the history of the system, manifested both in technical variation and in the extensive experience of managing the system.

The above account illustrates how the ability to keep a water infrastructure running is dependent on knowing the infrastructure's 'operational history', as well as adapting to local conditions and coordinating resources and tasks according to the situation.

Power network operators

Norway has vast resources of hydroelectric power and extensive grids in rugged terrain. Electricity was deregulated in Norway in 1991. It is now organized as with strict separation

between production (the power stations) and transmission and distribution (the grid). The companies are, in principle, private listed companies, though most have extensive public ownership. We studied how two network operating companies had reorganized their business by outsourcing operational work in one case and by implementing a buyer–supplier model in the other. Both companies sought to specify the elements of operational work as tasks that could be bought and sold.

The acceptance of disruption is very low in electricity systems. Thus, the work of monitoring and adjusting the state of the system, the loads that are distributed on the grid, the technical condition of different components, and not least, possible threats in the surroundings, is crucial. Due to technical redundancy most errors or problems will not manifest themselves as outages. As reliability is so important, a keen eye on potential perturbations or threats to the system is important. This can be trees or human activity near the grid or stations, secondary barriers and backup systems that are poorly maintained, and so on. Much of this work requires physical presence and inspections. The former operations department typically consisted of fitters, a control room and engineers who planned modifications and how the grid should be operated. The interaction and informal relations between personnel were close, and fitters often had careers that led them to office jobs as planners, control room operators or managers. Teams of fitters had great authority on how to operate 'their' part of the grid, and assumed personal responsibility for its integrity. They, somewhat romantically, describe as the time when they always had their pole-climbing shoes in their private cars.

With the changes, their work has become more centralized and run on a task-by-task basis, and the fitters do not operate on one section of the grid only. As in the case of the water system, the power networks are heterogeneous. In order to standardize tasks, the network companies undertook immense efforts to document the grid.

> ‘We have used a terrible amount of money on obtaining good documentation. We depend on this as long as we don’t have people that are earmarked for each specific area.’ (Manager, network company)

To be able to outsource operations, they must be able to reduce the dependence on local knowledge

> ‘The advantage of local knowledge is that they [the operative personnel] will understand if there are holes in the documentation. The moment we fully trust our documentation, our specifications and descriptions, then it’s easier.’ (Manager, network company)

The leaders stress that outsourcing operations relies on documenting and standardizing equipment and components. A problem, though, is that an operational infrastructure cannot be turned off to be replaced or upgraded. It has to be modified in batches over time. Many components are durable, so grids consist of combinations of components dating back at least three to four decades. This means that standardization has to focus on specific sections or components. In this industry, too, documentation cannot include all the operational history of old equipment. Although standardization is much more widespread in the electricity sector than within water supply, some local peculiarities of the grid and its surroundings were elusive to documentation.

Important changes in the industry are driven by the opportunities provided by new information and communication technologies (ICTs). Much of the operation of the grid has been centralized and moved to central control rooms due to improved remote control and monitoring abilities. As such, much of the monitoring and balancing of loads, turning sections of the grid on and off (e.g.for maintenance) is handled by the control room. This part of operations is typically not subject to outsourcing and some leverage is left for situational adjustments in the control room. A result of the functional unbundling is that the practical experience with the grid is organizationally severed from the work of controlling the system

remotely, and relates to a business interface that specifies the fitters' jobs in detail. The operational personnel describe a situation where they have less overview of the system:

> 'Over the last years, I have been thinking sometimes that I have kind of lost the system I had and the overview of what we should do next. Now it is the network owner who has it [the overview] and then we do as we are told.' (Manager and former fitter, internal supplier)

Fitters voice frustrations about no longer being able to deal with problems as they arise. Instead of putting the condition of the grid at the centre and making situational adaptations as the need arises, the need for maintenance must now be reported by the fitters and ordered by the network company before work can be performed. This involves an increase in paperwork and less autonomy regarding how to organize the workday. On the upside, many note that they have become more professional and are drilled to perform and document their tasks properly. Through improved technical documentation, a distinct improvement in the outsourced regime, and better instrumentation of the grid, the central control room have taken on many of the coordinating tasks that were previously handled locally. As experienced control room operators retired and were replaced by engineers with few ties to the operational context, the fitters were concerned with the risk for misunderstandings and problems:

> 'Up there they have a flat form with the lines on. They have a line entering a square. [...] It is very important to know what that square is! Whether it is an old antique transformer station from 1951 or a modern installation, right? And these old experienced guys know that.' (Fitter, outsourced supplier)

This hints to a problematic relationship between planning/control functions and the execution of operational tasks. As an example, fitters' describe working on high voltage systems simultaneously as construction work is being performed around them. This is common, particularly during construction of large buildings and when cables are installed underneath

roads and other infrastructure. This is called ‘work nearby’, a label conveying the presence of several actors working in the vicinity of a high voltage system. In such situations, the fitters must coordinate their work with other involved parties. They may have to undertake on-site adult education of external parties on the dangers of high voltages and they need to find measures to secure the electrical equipment and protect workers from injury. Importantly, dealing with this situational complexity is extremely hard to plan for in advance, as neither the work site nor the activities performed nearby are fully known in advance. The coordination activities related to external parties thus need to be dealt with locally and depend on the characteristics of the situation..

A similar point can be made related to the coordination between the different actors within the electricity system. Though one of the network companies had outsourced operational work for a few years, the remaining personal networks still facilitated coordination across formal boundaries, especially when local knowledge was important. One fitter described how he used the experience and expertisehe of a retired colleague:

> ‘I am standing down in the city, wondering what the heck do I do now, then I’ve called this guy that’s 71 and said, “Now you’ve got to come down to me. Now I am really wondering why this switch is falling out all the time.” And he rushes down in his old Volvo, faster than the fire department [laughs].’ (Fitter, outsourced supplier)

The formal information that flows between the units comprises standardized task orders given to the operational personnel and standardized reports and documentation sent back to the buyer. The modular organizational model, with commercial interfaces between different functions, gradually leads to a loss of local experiential knowledge and of personal networks between the systems side (planners and central control room) and the fitters. As they are now contractual partners, new informal relationships are not encouraged.

Though the overall level of robustness may have improved due to technical standardization and improved documentation, these losses may harm the ability to identify and understand certain risks (e.g. when local problems interact with system-wide issues) and to improvise in emergencies demanding cooperation across organizational boundaries. These are organizational qualities described as important for the resilience by researchers examining high reliability organizations (e.g. Weick and Sutcliffe 2007). Such concerns have also led the supervisory authorities in Norway to demand that the network must have a minimum level of personnel with operational knowledge *within* their organization. In this sector, too, we see that ad hoc coordination and the aggregated technical heterogeneity make it hard to describe and control work as standardized products.

DISCUSSION

Models of work and operational work

Table 1 summarizes the rationalistic model of work as we see it in NPM reforms in the infrastructure sector, and contrasts it with characteristics of operational work in the infrastructure sectors.

TABLE 1 *Rationalistic models of work vs. important characteristics of operational work*

Rationalistic model of work	**Operating a critical infrastructure**
Visible output	Invisible outcome
Measurable performance	Dynamic non-event (reliability)
Managing the expected	Managing the unexpected
Discrete tasks	Continuous operations
Detached from operative historicity	Embedded in operational history

Managers in both sectors struggled to identify good measurable outputs that captured the essence of operational work. The proxies they were able to come up with, such as the number of maintenance jobs or inspections performed, gave outputs whose connection to the desired outcome (reliability of the system) were slender at best. Consequently, tight regulation of work, focused on such tasks, would not guarantee improved reliability.

Although they have other tasks, a key role of the operational departments we have studied is to keep the system operational. In Wilson's (1989) terminology[i] an important part of an operational department's task is *coping*, while the reorganization is based on an understanding of their work as *production* (see also Gregory 1995). Coping with disturbances and problems is not a visible and measurable task in itself and can only be measured by proxies. One such proxy is statistics of disturbances in the past. These can identify weak spots in the system and improve work practices. In particular, such indicators are common in the electricity sector where they are part of the price cap system, thus regulating the income of the companies. They are quite useful, but the great heterogeneity of the quality of the grids and their context in terms of customers and natural surroundings makes it very hard to connect these to the quality of operational work itself.

As the power grid or water system cannot be stopped and reset to a known state, operations on it are always unfolding in time. Thus, the individual tasks are always dependent on the tasks that have been performed before and how these have influenced the state of the system. While procedures and documentation are standardized irrespective of time, the work of integrating tasks and activities into the temporal flow of the system is not. Throughout our interviews, operational workers were keen to insist on the non-standard nature of their systems and how knowledge and understanding of aggregated idiosyncrasies of the systems were intrinsic to effective work. We quoted one of the informants who contrasted the outsourcing of projects to that of operations. Here the difference can be explained by the

aggregated operational history. While a project can start from a state that is quite well known and documented, and develop from there, operational personnel do their work on top of the unstable foundation of a continuously aggregating history.

Informal situational coordination

Work as performed is not the same as work described in procedures and models. We have argued that the dynamic juggling that keeps an old heterogeneous infrastructure up and running is invisible in the dominant ways of describing work today. In rationalistic models of work, that which cannot be clearly described tends to be ignored (Bevan and Hood 2006). Interestingly, as an increasing number of tasks are commoditized, the situational coordination of tasks and resources seems to remain the centre of a shrinking core of operational work. The amount of physical work performed by in-house operators is reduced, but they tend to facilitators, and coordinators of the work performed by outsiders. The invisibility of these practices may, if not contravened, have a negative impact on reliability. Attempts to describe and control it as standardized tasks, as we have seen in our cases, also tends to lead to much administrative work.

Historical continuity: technical history and operational experience co-develop

For an infrastructure in continuous operation, situational adjustments are always done as part of a continuously aggregating history. As it is run over time, both documented and undocumented work is performed, and the technical system and the workers' knowledge co-evolve. Small adaptations and minor changes in the system accumulate over time. The production-oriented ways of organizing requires tasks that are ahistorical and standardized and not dependent on the historical knowledge of the workers performing it. This independence was the explicit goal of the managers seeking to commoditize tasks. Even if the

water supply unit in our first case were able to specify work as commoditized tasks and outsource it, the subsequent accumulation of the operational history would not necessarily be shared with the system owner. This information may actually be seen as strategically valuable as a way of preventing competition. Put simply: if you a) have a system that you cannot fully standardize, b) cannot stop operations in order to 'reset' it, and c) cannot describe work to be done on it exhaustively once and for all, then the condition of the facilities and knowledge about it will drift over time. Over time, the technical and operational history becomes increasingly important parts of the context in which work is performed.

Systems that should have failed?

How do our findings fit with the existing research on the relationship between public sector restructuring and the reliability of critical infrastructure? The findings of the afore-mentioned research of Schulman *et al.* (2004), de Bruijne and van Eeten (2007) and Roe and Schulman (2008), point in a somewhat different direction. They describe how infrastructure systems seem to keep working despite being subjected to major structural changes. Their findings indicate that new forms of reliability emerge in the new structural forms. While this may seem contrary to our findings, on closer inspection, it is actually not. The importance of informal relationships and system knowledge is evident also in our data. It seems, however, that restructuring into more fragmented organizational forms risks eroding the mechanisms that produced these reliability professionals in the first place (e.g. the system knowledge created by gaining experience from several parts of the infrastructure system). If the reliability professionals are products of the *integrated* model of organizing, the reliability of restructured infrastructure sectors may be a form of cultural lag that is likely to disappear with the retirement of the current generation of reliability professionals. Also, the NPM reforms have positive sides, particularly in terms of improved documentation, that might strengthen the

overall reliability of the system. Though the net effect in terms of reliability cannot be determined, we have identified definite *changes* in the strengths and weaknesses of the organizations operating the infrastructures.

Importantly, the problems related to rationalistic models of work are not limited to infrastructure sectors. Similar misalignment between organizing logic and the key elements of work can be found in a variety of organizational contexts, including health care (e.g. Bevan and Hood 2006; Christensen *et al.* 2006; Pollitt 2007), law enforcement (Gregory 1995) and children's services (Halvorsen 2009; Shaw and Clayden 2010). When studying other sectors, looking for the fate of situational coordinative work and work in which historical continuity is important may be a good place to start.

Limitations and further research

At this stage of the argument, some counterfactual questions should be raised: If NPM had not been introduced, would the centralization and bureaucratization have occurred anyway? Similar trends in other sectors suggest that this is a part of a broader turn towards detailed control through standardization and objectification. Although we focus here on NPM, it can be seen as an instantiation of broader societal trends, and partly also ICT developments. However, the changes were clearly identified as NPM-related by our informants and the split of operational departments was explicitly installed to generate transaction data, i.e. to transform operational work to controllable products.

It could also be argued that the observed effects are linked to the change processes themselves. This might be, since a real life case study cannot perfectly isolate effects. However, it also seems that modularization led to series of reorganizations rather than one single change. The disaggregated units were easier to move around, and replacing vendors is obviously a key aspect of a buyer-supplier relationship. Frequent reorganization seemed to be

a part of the new regime. One informant linked this to managerialism: ‘So I think that this is often about showing that “now here is a new Sheriff in town, now we have a new structure, now we are going to change the way we think!”

As both infrastructures are increasingly digitalized, with more sensors and ICT-based control systems, the conditions of situational coordination change. A topic for further research is the role of ICTs in supporting situational coordination, whether the physical presence and local experiential knowledge can be replaced or transformed. While recognizing the importance of situational and local knowledge, Monteiro *et al*. (2012) argue that the empirical reality in a digital world necessitates studies that account for how situational adaptive work occurs also beyond typical local settings. This may also contribute to the understanding of ‘real-time resilience’ (de Bruijne and van Eeten 2007, p. 25) as this is likely to depend on well-functioning information infrastructures.

CONCLUSION

We have discussed how the discourse of work in NPM reforms in Norwegian infrastructure sectors fail to capture core work processes in operational work. The ways work is represented and controlled in organizations render situationally unique aspects of operational work invisible. The logic of standardization and measurement introduces a form of organizational “ontology”, in which situational adaptations become invisible as they, by definition, resist standardization and measurement. To explain the friction experienced when restructuring operational departments in the water and electricity sectors in Norway, have identified two aspects of operational work that are elusive of description and control within this ontology. *Situational coordination* and *accumulated history* are elements of all kinds of work, but in some contexts, like the ones described here, these aspects are the *raison d’être* of the work itself.

Our study has relevance for the discussion of how NPM influences the reliability of infrastructures. The aspects of work that are rendered invisible are important for the organizations ability to handle variability and external perturbations. In addition, the fragmentation into more specialized entities may make it harder over time to reproduce the reliability professionals with the knowledge and networks necessary to handle variability and crises.

This does not mean that after NPM reforms no situational coordination or adaptation to operational history takes place in the organizations we studied. It does mean, however, that this is less visible in the organizational discourse. Control measures and incentives address these aspects of operational work indirectly at best, as they aim for more visible targets. After all, you can't control what you can't see.

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