

# Assessing the effects of institutional change: Coping strategies as operational indicator

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## **Abstract**

The time has come to assess how institutional reforms, unbundling and liberalization have affected infrastructure operations. This article reports on the results of an empirical study of real-time processes in rail operations and the interactions between an infrastructure manager and service providers. Using a new framework to identify various types of coping behavior, this paper outlines how institutional reforms have changed the way value-conflicts are 'solved' in operations. The findings are put in a broader perspective and related to literature on the management of large complex socio-technical systems. The conclusion assesses important implications of these findings for the management and oversight of rail operations.

## **Key words**

Infrastructure operations; Coping behavior; Impacts of the reforms

## **Introduction**

An international wave of institutional reforms absorbed the Dutch rail sector in the nineties, like it did with many other sectors and in many other European countries. Thirteen years later, the Dutch rail industry finds itself in a completely new institutional landscape. The reform transformed the sector from a monolithic whole into an institutionally fragmented system with *many* operators and *many* oversight bodies. At the same time, a completely alien market-rationality has landed in the operational processes of the rail industry.

Times have been tumultuous since the reform. The Dutch rail industry has constantly been receiving enormous amounts of media and political attention. Many operational problems have led to large-scale interruptions of train traffic. The industry had to deal with many unforeseen computer crashes, major strikes of train staff, riots on the Queen's Birthday, snowstorms etc. Simultaneously, the number of passengers and the transported tons of freight grew rapidly. The number of train companies in the sector increased, too, from one to more than thirty.

Currently, the industry seems to have found its way up again. Performance figures of Dutch Railways (NS), by far the largest provider of train services to passengers in The Netherlands, are generally increasing. Financial results are considerable, a return on investment about 6%. As the new institutional outline seems to settle down, time is ripe to see how the reform actually affected infrastructure operations.

In general, there are major concerns about this impact of the institutional reform. These concerns mainly regard the public interest and values such as safety and quality of service (Bozeman 2007, De Bruijn and Dicke 2004). The concern is that the reform puts public values in private hands, or at least at a larger distance from government, which might cause that the costs of public values are sooner evaded. The crucial question is *how* this trade-off affected or changed in the new situation and whether this is desirable.

Additionally, the reform has been criticized for the specific complexity of the rail sector. Its highly specific socio-technological features require more consideration than just a standard market reform (e.g. Finger, Groenenwegen and Künneke 2005). In particular the tight technological and managerial interfaces that exist between trains and rails have been identified as obstacles to unbundling and the opening up of

markets for trains. It is, therefore, interesting now to analyze in detail how operations actually cope with these tight interfaces under unbundled conditions.

As an illustration of these post reform conditions, this article empirically analyzes the current structuring of operations in the rail industry, focusing primarily on operators of ProRail, the Dutch rail infrastructure manager, and NS, provider of train services to passengers. We study the convergence of three core processes: driving trains, transporting passengers and traffic control. These intricately connected processes raise many inter-organizational coordination issues. The central question is how trade-offs occur in operations in relation to the public interest.

The paper first introduces three connected operational processes. Then, we outline our research method and explain how the public interest is identified in the data. Next, to accurately describe the trade-off behavior in operations, the concept of ‘coping’ with regard to competing values is introduced. Subsequently, the core of the paper empirically describes operational dilemmas and responses in relation to the post reform settings. In conclusion, we identify a trade-off pattern that undeliberately emerges in these new settings. In a follow-up discussion, we relate this to literature that addresses the management of large complex socio-technical systems.

### **Interrelated core processes in rail operations**

The provision of train services mainly take shape in three interrelated operational processes: driving trains, transporting passengers and traffic control. These processes are primarily operated by train staff and controllers from ProRail and, in our case, NS. This article focuses on the controllers.

Since the reform, the institutional design of these operational processes changed considerably. Passengers do not necessarily notice many differences. For example, it is not directly visible which company provides their travel information, which company causes a delay or whether delays occur for good (i.e. mandatory safety procedures with regard to ongoing track maintenance) or bad (i.e. train off schedule as a result of poor planning) reasons. Technologically operations did not change that much either. The main operational change is the institutional design of the traffic control process. It has been redesigned in unbundled ‘traffic control squares’. These squares have separated controllers of the train companies and ProRail that used to share the same control rooms. Next, these controllers are connected again in communication relationships that form a square per location (see also Figure 1).

### *Controllers at ProRail*

The traffic control process is coordinated by the 'Traffic Control department' at ProRail. There are regional and local control rooms. Together local and regional traffic controllers, and their analysts, decide on the routes trains take. Four regional control rooms plan and re-plan train routes and decide on alternative scenarios in case of disturbances. Seventeen local control rooms oversee smaller parts of the network. Which exact part depends on the situation at hand. A local traffic controller either oversees a set of rail tracks, a few small stations or only part of a main station. It also depends per person and per situation whether traffic controllers passively monitor how computers take the necessary decisions to control traffic or whether controllers actively control traffic and manually optimize situations managing signals and switches. Simultaneously, ProRail employs several other control rooms to monitor and control maintenance activities and to deal with calamities.

### *Controllers at NS*

At the side of train companies, transport controllers make real-time mutations in the time table to cope with new demands or situational surprises. At four regional transport control centers, analysts are responsible for the actual planning and communication with other controllers. Working in the same room, there are planners for rolling stock and personnel, information coordinators and, recently, customer coordinators. At the local level, junction controllers work in separate control rooms. These local NS controllers implement the plans of transport control, such as planning and coordinating shunting activities in detail.

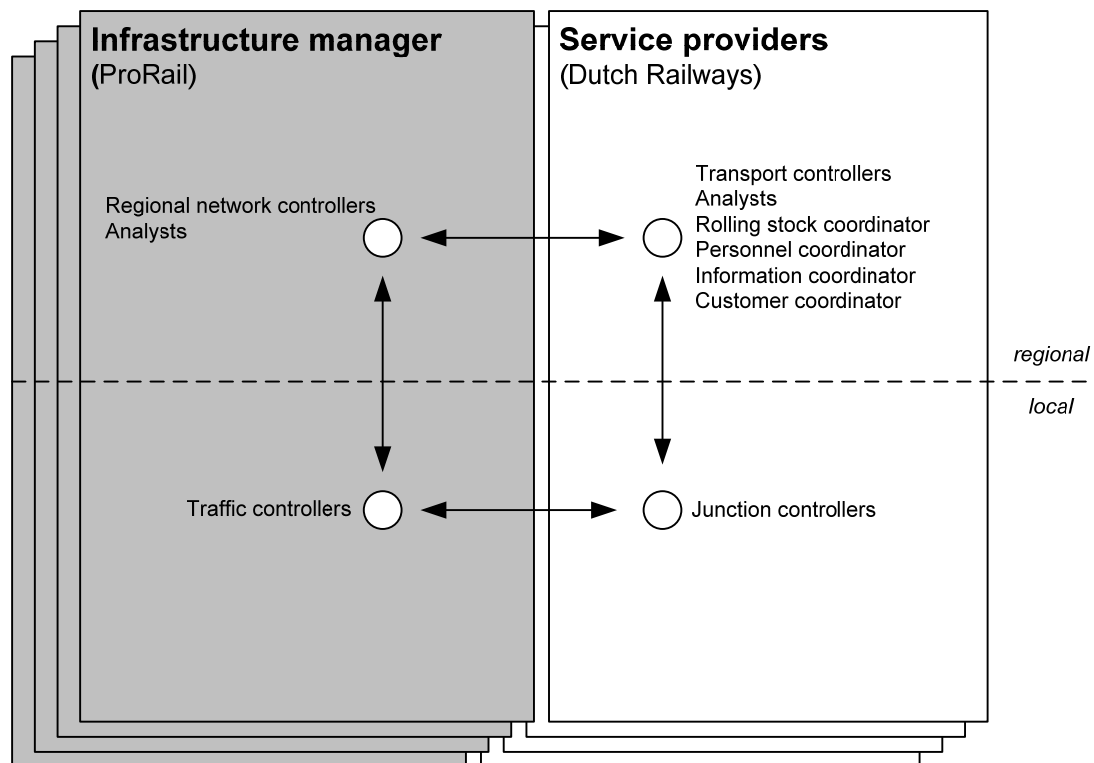


Figure 1: Schematic outline of traffic control process in 'squares'

### *Reconnecting controllers in the traffic control squares*

The idea behind the traffic control squares is to guide cooperation between controllers. The institutional design assigns each controller separate tasks and responsibilities. Regional traffic controllers take care of the flow of trains. Regional transport controllers have an eye for train punctuality and personnel flows. Local traffic controllers monitor and safeguard safety. Conductors and train drivers are directly concerned with passenger interests in the train.

The square guides communication among controllers, but also restricts it. The hundreds of controllers, conductors and drivers cannot simultaneously talk to each other, although the processes they work in are intricately related. The square intends to centre the crucial decisions in the communication between train companies and ProRail on a regional level. Therefore, it rules out the communication over the imaginary diagonals of the square between regional transport controllers and local traffic controllers as well as between regional traffic controllers and local junction controllers.

Controllers generally work facing three or four computer screens that support and coordinate cooperation among the various operators in the larger system and plan.

One screen plots the time table in a graph of routes versus time to see if adjustments are necessary and possible, to plan for extra trains or to deal with ad hoc problems. Next, there is a silent communication system for all controllers to signal obstructed rail tracks, new trains and mutations in the time table. Another planning screen shows proposed mutations for controllers to check and tick off if there are no conflicts in sight. Multiple detailed screens show the rail tracks in real-time with trains moving from one rail section to another including the indicated positions of signals and switches. Most important, finally, is that each controller has a phone. Particularly during disturbances, much communication is done by phone.

Train staff mostly communicates with their own regional transport controllers and local traffic controllers at ProRail. Outside the traffic control square, train staff, too, communicates with platform managers, service employees, cleaning employees, mechanics and (railway) police. Train staff communicates either face-to-face, by mobile phone or silently by means of the 'rail pocket', a standardized palm computer.

Thus, a tightly coupled system of trains and infrastructure is operationally managed by multiple companies in multiple control rooms with specific tasks. There is no clear coordination centre. In the meanwhile, there is restricted communication between these controllers. Multiple traffic control squares define the parallel communication lines between controllers.

### **Research method**

The two main data sources were interviews (80) and observations (20 shifts). In the latter case, the researchers joined operators in their daily work. Five groups of workers have been interviewed and observed in their daily work at ProRail and NS. These groups are local and regional traffic controllers, regional transport controllers, train conductors and train drivers. We inquired into their daily work, the requirements they face, the dilemmas they encounter for interacting requirements, how they cope with these dilemmas and what trade-offs result from them. Additionally, we interviewed many managers surrounding operations.

Open interview questions triggered a wide variety of answers, encompassing a broad group of values that people perceived and pursued. Elaborate field notes were combined with literal transcripts of the interviews. Field notes describe what operators do, how they explain what they do and the consequences in action if possible. This combination is an established approach (similar organizational studies are i.e.

Gouldner 1964, Ancona and Caldwell 1993, De Bruijne 2006). Interviews are helpful to focus on the research questions. Observation adds a deeper understanding of the practical context of operations, testing the validity of interview data and discovering alternative as well as contradictory explanations.

Afterwards, public values are identified in this data. In short, the researchers critically interpreted the practices in relation to public values, based on the interests oversight bodies articulate in various laws, policy documents, standards, procedures and performance agreements (see Table 1). These substantive public values come down to, but are not limited to, reliability, safety, efficiency, environmental issues and customer protection for price and quality. Oversight interests seldom directly concern public values, but mostly aim for derived norms, performance standards or conditions. For example, the government lays great emphasis on a 3 minute train arrival punctuality norm, while the underlying passenger interests are richer and more specific and in times of crises possibly opposite to punctuality. Next, regulating fair competition aims to improve market incentives and, *through that*, the customer interests in train services.

Table 1: Oversight interests in the rail sector

<p><i>Oversight interests concerning infrastructure manager ProRail</i></p>	<p>Quality of traffic control, quality of information, availability and reliability of rail infrastructure, personal security of transients at stations, the quality of capacity distribution, efficiency, safety, environmental issues, security issues, tidiness of stations, non-discriminatory distribution of capacity</p>
<p><i>Oversight interests concerning service provider NS</i></p>	<p>Punctuality, personal security of crew and passengers, availability of seats, information services, tidiness, growth of passengers, accessibility of regions, safety, affordability, non-discriminatory access for passengers with reduced mobility, consumer protection, capacity, return on investment, fair competition, interoperability</p>

Thus, we use these oversight interests (Table 1) as a focus but with an open mind to interpret the more ambiguous aspects of values underlying the norms and

pursued conditions. This ‘value-critical qualitative analysis’ (Thacher 1999, p.81-7) makes an appeal to the researchers’ judgment to verify what public values are concerned in operational dilemmas. In the empirical examples, the affected public values will be further illustrated.

### **Theory on coping**

To interpret operator behavior, we introduce the concept ‘coping’. In a most broad sense, coping describes the response of operators to value conflicts. In principal-agent literature, the behavior of operators has dominantly been interpreted in terms of shirking (Leibenstein 1966, Wood and Waterman 1994). Conflicts between the values of principals (oversight bodies) and the values of agents (network-based companies) are presumed to explain the ineffectiveness of agents. Agents are presumed to take advantage of their discretion by maximizing their own interests.

Studies on the Multiple Principals Problem have indicated major limitations of ‘shirking’ to explain agents’ behavior (see e.g., Shapiro, 2005, p. 278, Miller...). These studies address the effects on agents of multiple incentives from multiple principals simultaneously in the absence of a prearranged hierarchy among principals. What at first may seem random behavior or shirking, can prove inevitable due to competing principals. Waterman and Meier (1998) describe that agents can be automatically forced to act as a political institution in a multilemma (p. 180). Mitnick (1986) hypothesizes apolitical factors that might influence the agent’s behavior, such as to favor the principal first encountered, the most cognitively salient incentive, the easiest objective to perceive and understand, the most standardized interests or the most simplified ones (p. 15).

Next, searching for literature on ‘coping behavior’ adds to broaden the idea of dealing with competing values. Coping leaves the idea that values belong to either agents or principals or both. There neither is a predetermined distinction between private and public values. Coping just describes how persons or organizations deal with competing values.

A literature review<sup>1</sup> yielded a wide variety of coping strategies. Lipsky (1980) was the first to describe the behavior of Street-Level Bureaucrats in terms of coping,

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<sup>1</sup> We used the *ISI Web of Knowledge* citation index to search for articles about coping between 1 January 1999 and 10 March 2008. The search resulted in tens of thousands of scientific articles. The majority of these articles have been published in psychological and psychiatric journals. We then

including strategies like creaming off, rationing, routinization and triage. Brunsson (1989) described coping strategies on an organizational level, such as finding a niche with less inconsistent environmental demands, establishing coalitions of external groups with shared norms, rituals, myths and double talk. A long list of other coping strategies can be found, including smokescreens, buck-passing, procrastination, demagoguery and depoliticizing (Tetlock 2000), enacting occupational identities and bonding among workers (Maynard-Moody and Musheno, 2003) and the enticing convergence of values (Nielsen, 2006). Thacher and Rein (2004) started an incomplete typology distinguishing cycling, firewalls and casuistry. Stewart (2006) extended this typology with incrementalism, bias and hybridization.

Still in absence of a complete typology or list, we dichotomized the currently known variety in coping behavior. A framework of two coping dimensions span the coping strategies found in literature, including the various shirking strategies. These two dichotomies are ‘coupling versus decoupling’ and ‘deliberate versus undeliberate coping’.

Though coping always applies to a multi-value context, the response can nonetheless be mono-value oriented. A mono-value response means to *decouple* competing values, addressing each value separately. Decoupling guards values against conflicts. For example, firewalls and cycling decouple values either in separate institutions or over time. Casuistry, hybridization and hypocrisy are ways of *coupling*. Coupling means to face conflicts, addressing both sides of the trade-off and managing multiple values in conflict. Coupling attempts to safeguard values within a conflict. This first dimension has been the subject of much debate whether institutions are able to couple and whether decoupling is preferable or not (see e.g. Brunsson 1989, Thacher 2001, Van Eeten and Roe 2002).

The second dichotomy to describe coping distinguishes deliberate from non-deliberate responses. Whereas studies on the multiple-principals problem still presumed agents to maximize utility, the literature review on coping adds that coping can be undeliberate as well (see e.g. March 1994). Espeland and Stevens (1998, p. 318), for example, use the explicitness or visibility of trade-offs as a dimension which

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narrowed our search to fields relevant to organizational behavior, as well as sociology, political science and public administration. This resulted in 500 articles on coping. A scan of these articles, including their references, revealed common features of coping across frameworks, journals and research fields.

is quite similar. Thacher and Rein (2004) argued that conventional literature on public policy has come to overemphasize the practice of explicit trade-offs.

### **Coping strategies in operations under post reform conditions**

Since the reform, controllers of ProRail and the train companies cope in separate control rooms. This has an impact on the way controllers deal with operational dilemmas. Many controllers currently experience they have a hard job to couple all the interests of many other controllers, logistically as well as commercially. There are many trains, many train companies, many detailed circumstances around stations, switches, train staff and passenger interests that connect together in a tight schedule.

The two dichotomies, ‘decoupling vs. coupling’ and ‘deliberate vs. undeliberate’ (see above), are considered to span the broadness of known coping behavior and, therefore, we use them to describe a broad range of strategies in rail operations. Crossing both dichotomies leads to four types of coping. We conclude on the underlying logic of these four types under post reform conditions, illustrated with real-life examples of the priorities that emerge in everyday practice of controllers.

#### Deliberate coupling

Immediately after the reform, many quarrels broke out between controllers of ProRail and train companies. In the start up phase of the new traffic control process, these quarrels caused much distrust between controllers. Some quarrels even led to interruptions. At certain moments, controllers were not willing to cooperate anymore with ‘the other side’. Many heated discussions still take place on the phone between controllers. In order to repair the mistrustful atmosphere and also to reduce the burdens of communication, controllers started to *formalize* their responses to conflict situations.

A book filled with scenarios has been drawn up for the traffic control processes. This is a major example of deliberate coupling. The book provides trade-offs in terms of ‘if situation A is at hand, apply measure B.’ For example, when a certain train is delayed with more than fifteen minutes, another train should be cancelled. These scenarios are based on front line experiences and formalized after all parties involved agreed on them.

These scenarios are quite successful in decreasing the communication burdens between controllers and preventing many disturbances to escalate. They, too, run the

risk, however, to be inflexible in dealing with the detailed conflict situation at hand. Controllers who use the standard scenarios too often appear less sensitive to contexts in which conflicts are always cast. A line manager describes that the use of scenarios creates a 'make-believe certainty, as if there is an ideal solution' and 'discourages controllers to think for their own.' In practice, the conflict situation at hand mostly deviates from standard conflict situations. Standard scenarios do not account for detailed circumstances such as an extra unplanned train, transporting 'football fans' instead of common passengers or an unusual distribution of passengers. Weather conditions can make a difference, too. All these circumstances can prove crucial, requiring many detailed adjustments of the scenarios in real-time. This results in incompatibilities with the formalized relationships.

Thus, the use of standard decision rules, though often designed as a coupled response, simultaneously slackens the attention for coupling and discourages controllers to address conflicts. It discharges controllers of gathering information on the up-to-the-minute circumstances. A parallel incentive is that it relieves them from work pressure and communication burdens. While applying standard scenarios is accountable as 'trade-off proof', controllers practically refrain from inquiring into the trade-offs actually taking place.

Besides disturbances, when train companies want to adjust a departure time or a train path to anticipate for an unexpected situation, the transport controller should phone the regional traffic controller at ProRail and request a new departure time. Formally, the traffic control process is arranged for joint coupled adjustments of the plan. A regional traffic controller would consult the local traffic controller on the detailed consequences of such an adjustment and later would instruct him to implement this as the new plan. During busy moments, however, such a formal procedure can easily take 20 to 30 minutes. 'This is unworkable,' controllers at NS say. First, the needs for these adjustments are not always known 30 minutes in advance. Second, the time spent on consultations can disrupt the control process itself. 'Sometimes you loose a rail track for 10 minutes, because of consultations,' NS transport controllers experience. It is often a matter of minutes whether conflicts can still be prevented or become unavoidable. 'What used to be dealt with in one second now takes a whole circus of calling and calling back with the risk that you can not even reach somebody,' a transport controller explains.

Furthermore, controllers experience major difficulties to explain their fellow-controllers on the phone *why* certain decisions should or have been made. What they call ‘warm’ communication skills, preserving that information is up-to-the-minute and rich in detail, has become rather challenging to achieve over the phone and in silent text messages. Controllers are frequently asked to give up the attainment of their interests in exchange of what other controllers can not (or refuse to) explain. A regional transport controller at NS complains ‘when I ask the regional traffic controller why my plan is not feasible, he answers: just because.’ It used to be a cultural feature of traffic control that controllers altruistically place themselves in the service of others. The unbundling has troubled this natural collegiality, as controllers increasingly feel that different perspectives compete and they are not held accountable for all of the values that determine their work.

We argue that the newly created distance between controllers, physically and by means of formalization, impedes the ability to deliberate and coupled coping responses towards value-conflicts in the traffic control processes. Physical distance and increased emphasis to hold operators only accountable for specific aspects of train management deters operators from communicating with each other. As a consequence, conflicts become more obscure. Operators have troubles to see opportunities and threats of their actions (or passivity) for other controllers. They, consequently, displace the negative consequences to other controllers without feedback.

### Deliberate decoupling

Regional traffic controllers at ProRail portray their work as fully compatible, single-issue and with uncontested rules. ‘All we do is isolating delayed trains.’ When scenarios do not apply, controllers prefer to use simple decision rules, such as ‘too late is too late’ in a situation when two trains claim the same rail track. Simple decisions rules make that the controllers’ responses become predictable for other controllers. This is also considered an important ‘value’ for operators, particularly in response to the start up problems of the reforms.

As a result, controllers have increasingly come to act independent of each other. The effect, for example, is that regional transport controllers at NS have less insight in the detailed interdependencies between trains, whether or not a train will hinder other trains. They are familiar with the possibility, but, if other acute needs

arise, directly instructing a train to wait seems worth since the invisible impact on other trains can not be taken into account on a short notice. During real-time operations, transport controllers do not communicate with local traffic controllers who have the most detailed overview whether trains hinder each other or not. This communication line is not provided, because of the decoupled philosophy. A direct communication line would pressurize the safety function of local traffic controllers. Therefore, the 'commercial interests' of transport companies are fenced off.

This decoupling makes it hard for controllers at ProRail to see and judge when passenger interests are served or not. A regional traffic controller at ProRail pleads for the same solution with a different argument: 'If train companies try to explain me the importance of their particular train, that information is overkill for me. (...) It does not give me any more space, anyhow.' In contrast, however, many other controllers state they *want* to restore the 'warmth' of information, as said. They want to communicate 'pauseless' again. They praise the skill of 'post-ears', ears that are always alert to pick up the pieces of their puzzle from the stream of information and non-information in a control room where ten controllers constantly speak out loud, always mixing work and chat. Post-ears hear everything significant that is being said at the same 'post'. In the new decoupled design of the traffic control squares, however, these information qualities are not the case anymore between controllers at the infrastructure manager and train companies. This disables regional controllers at ProRail to make quick and sensible trade-offs with regional controllers at NS. On one hand, controllers deliberately work rather independent from each other. On the other hand, the restricted possibilities to share up-to-the-minute information makes controllers undeliberately overlook conflicting interests.

#### Undeliberate decoupling

Liberalization enabled many train companies to enter the market. Currently more than thirty companies simultaneously operate trains on the Dutch rail network. Infrastructure manager ProRail safeguards the non-discriminatory use of the rails, as assigned in the franchise. Additionally, the Office of Transport Regulation (Vervoerkamer), part of the Netherlands Competition Authority (NMa), oversees ProRail that the conditions for fair competition are met. Train companies can start a case and contact this Office when they feel ill-treated. In the planning phase, train companies receive 'the right' to use a rail track. Next, the non-discrimination

principle is directly operationalized in hard decision rules for regional traffic controllers. ‘A train is a train’ and ‘delayed trains should not hinder other trains.’

In contrast to the non-discrimination principle, how to serve passenger interests is neither operationalized nor sanctioned for traffic controllers at ProRail. Although this interest has been considered ‘commercial’ enough to claim operational room for its own, passenger interests are vulnerable in the many conflicts with non-discrimination.

Since local lines are taken over by small train companies, new trade-offs arise. When such a local train competes with a delayed NS intercity train for the same rail track, traffic controllers strikingly reverse the trade-offs they used to make. In the former situation, NS would commonly favor the intercity train over the local train, considering the passenger interests of both trains. Moreover, delaying intercity trains often has much more consequences on the stability of the total network compared to delaying a local train. In the new situation, traffic controllers are obliged to favor the local train over the intercity on the threat that train companies go to court, whereas the task to optimize many passenger interests on a system level seems displaced. If controllers want to fill in this gap, as many try to do, they deviate from hard decision rules within their discretion.

Thus, the logic of train companies that ‘own trains go first’ undeliberately decouples many value-conflicts. Individual decisions of market players induce trade-offs on a system level in real-time without paying attention to it. Reasonable arguments on the amount of affected passengers on a system level do not always incite train companies to cooperate for the common good, particularly not when this gain by far is not that concrete as the hard decision rules for non-discrimination. The reform introduced a new procedural value how to deal with multiple train companies that undeliberately pushes traditional values into jeopardy. Controllers are instructed to treat trains equally, although the passenger interests and the influences train have on system stability do not at all make them equal.

### Undeliberate coupling

Controllers, thus, are incited to find decoupled routines, as described above. Perceived on a higher level, however, they control traffic flows in interaction or in tune with each other. This system of controllers responds in a coupled way, though without deliberate coupling necessarily.

The traffic control square assigned separate values to specific controllers. Regional traffic controllers streamline the traffic flow. Local traffic controllers oversee safety. Regional transport controllers at the train companies optimize for train punctuality and, partly, passenger interests. The coupling of these interests in real-time is not a task. Consequently, many tasks of other controllers tend to funnel to local traffic controllers when coupling is required, because they usually have the most complete overview of situations. This is the busiest place at the front line, too. During crises local controllers often lack the time and the information to make deliberate choices, but out of routine the system forces these controllers in the role to couple multiple interests. Local traffic controllers are frequently overloaded with work during a crisis.

*'A local traffic controller does his utmost best, but he simply loses control. After eight hours of keeping his nose to the grindstone, he comes home and asks himself: what have I actually done? What has happened to me today? They miss the confidence that they are in control of a logistic process. They do not see if their decisions work out positively or negatively. They do not know what is going on.'*

A staff manager at Traffic Control

When a train collides with a cow, several trains find their route obstructed. Local traffic controllers are the first to deal with the problem and also the first to find a logistical way out of the mess. The controller first needs to oversee the situation. Many trains need to be re-routed immediately. When the controller does not withstand the work pressure, however, he rigorously disposes of less critical tasks. So, the informal coupling task that adds to these pressures tends to slip into undeliberate decoupling. Then, the local controller focuses on safety solely ignoring the new plans of regional traffic controllers or bluntly refusing the requests of train companies.

*'You need to be thick-skinned as a local traffic controller for the people who call. During some peak moments you play deaf to the phone that keeps ringing.'*

A local traffic controller

This conflict situation becomes even less manageable when it is not fully clear *if* rail paths are actually blocked, what frequently occurs too, let alone that it is known how much rail paths are blocked and for how long. For example, ‘there is cow on the rails’ can be the message a local traffic controller receives from some operator in the field. It happens that the message does not even specifically indicate the location of the cow. Probably, safety is at risk, as well as the continuity of traffic, but taking measures, as if rail paths were blocked, will severely interrupt traffic, too, and perhaps unnecessary.

There are two options for the local traffic controller to respond. First, the controller can assign the first train driver that approaches the cow to inquire into the situation. Perhaps the cow disappeared in the meanwhile, because a herdsman intervened. If the cow is still there, the rail paths still need to be blocked. In the mean time, the disruptive effects of this obstruction increased exponentially. The number of trains that need to be rescheduled, including the time that this takes, has increased as a result of the time it took to inquire about the potential problem. It is highly unpredictable whether this option is successful or not. Even if a local controller has success with this measure, because the cow disappeared into thin air, the controller has bluffed his way out of the conflict. This coupled response does not allow seeing the actual risks.

The second option is not to wait for more information but to start rescheduling the trains. Then, the relatively small disturbance is still manageable compared to the mess they get in when they respond five minutes later. This second option is much more robust than the first, but the response is even blinder towards the actual situation and whether the sacrifice was necessary. This option couples competing risks, too, without considering the actual conflict situation at hand.

Controllers increasingly avoid a late response given the risk of an uncontrolled rise in work pressures. More general, controllers say they act more rigorously to disturbed situations in order to secure the manageability of work pressures. The post reform conditions can explain this changing preference. First, the restricted and time consuming communication in the ‘squares’ makes that local traffic controllers cause more harm and need more time to recover when they overload themselves with work. Second, local controllers get more work. The opening of markets for freight and passengers has led to an increasingly dense utilization of the rail network.

Accordingly, controllers deal with more trains, face more disturbances that are less predictable and have less improvisational room to restore system stability, which again leads to more work and more precautionary coping. Moreover, some train drivers even game with the workload of local traffic controllers as they find out they get their way when burdening local traffic controllers with repeated phone calls.

### Interim conclusion

The reform in the Dutch railway industry changed the way value-conflicts are coped with in operations. The industry designed a new traffic control system with new communication lines between controllers increasingly relying on silent cooperation and formal instructions. We used the coping framework to describe four groups of coping strategies (see Figure 2). We found that the newly designed traffic control squares seemed to 'push' the system into undeliberate and decoupled coping behavior. In other words, controllers increasingly isolate themselves from conflicting interests, reducing the visibility of the cause-effect chains they act in. Moreover, this lost consciousness of the interests of other controllers again triggers a vicious circle to share less information instead of more.

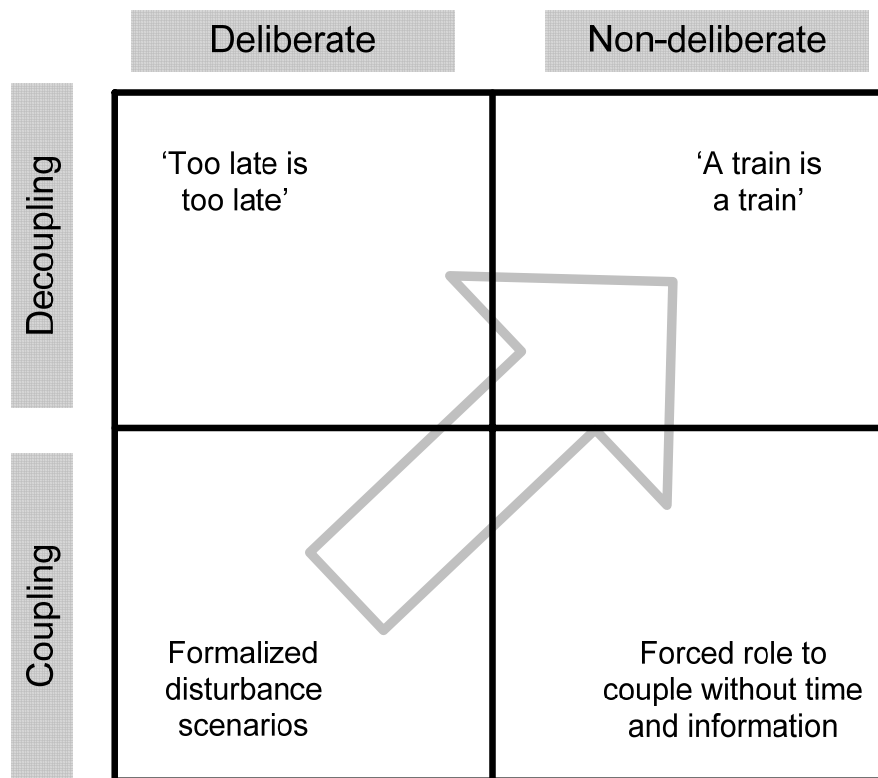


Figure 2: The reform induces undeliberate decoupling.

### Explaining the new coping status

This ‘push’ towards a new coping strategy (see Figure 2) can be explained and put into perspective when we consider the changed nature of the technological system in more detail. We argue that the increasing use of undeliberate decoupling strategies in rail operations may serve as an indicator to identify the changes that the reforms induced in the management and operation of this large socio-technical system..

In his groundbreaking work *Normal Accidents*, Charles Perrow (1999a, p. 62) outlines “[a] theory of systems and their potential for failure and recovery.” Reviewing a number of (near)accidents in various industries, Perrow explains why a specific category of highly complex and large-scale technologies are inherently prone to malfunctions that lead to catastrophic failures.

Perrow claims that disasters occur when systems experience multiple unanticipated events that spread, cascade and interact. These interactions are unforeseen by either system designers or those operating large-scale complex systems. All it takes to create a disaster is a certain amount of time – allowing multiple unanticipated events to occur and interact with each other in a sufficiently complex and tightly coupled technical system.

Perrow, thus, distinguishes two important systemic characteristics – complex interaction and tight coupling – that have a strong influence on the reliability of the system. Readers should note that coupling in this context refers to a new dimension that differs from the coupling-concept in the previous parts of the article. The dimension reflects the amount of coupling in the system, which Perrow (*ibid.*, p. 89-90) defines as “[a] mechanical term meaning there is no slack or buffer or give between two items.” Systems are either loosely coupled or tightly coupled. Perrow (*ibid.*, p. 73-77) defines interactive complexity as the ability of parts of a system to interact in an ‘unanticipated’ manner, and he distinguishes systems on a scale ranging from predictable, linear interactions to unanticipated, highly complex interactions. Interactive complexity creates uncertainty, limiting what can be known or reasonably assumed about technology behavior ahead of time (Pool 1997, p. 9). Perrow (1999a, p. 93) considers the two characteristics largely independent and uses both concepts as dimensions to plot large-scale technical systems. When offset against each other, another four-cell matrix appears (Figure 3).

In his 1984 edition (which was subsequently reprinted), the railway industry is characterized by Perrow as a relatively tightly coupled, yet linear system. Assuming that the Dutch railway industry may be more or less comparable in nature to the U.S. railway system, it may be interesting to assess the effects of the institutional reforms in Perrow’s diagram. Since the technology of train operations in the Netherlands did not change significantly as a result of the institutional reforms, the coupling of the system did not significantly change. Safety rules and procedures that largely determine train operations still are applied in the same way as in the situation where the trains were operated before liberalization. One could argue that the coupling between trains gradually becomes tighter, as the network is used more densely, but this does not change the mechanical nature of the coupling between trains in comparison to other technologies. The level of coupling would change more fundamentally when train companies abandon the idea of a fixed timetable, for example.

However, as a result of a range of factors, the interactive complexity of the Dutch railway did change significantly. The increased number of organizations presented a much more complex and fragmented system that has proven far more difficult to manage and operate safely and punctually than before (cf. De Bruijne 2006). Instead of being in charge of all railway traffic, rail operators at Prorail have to

console the demands of dozens of organizations under conditions of ‘equal access’, thereby losing much of their ability to ‘control’ railway traffic. As a result of these conditions railway controllers found themselves confronted with the need to significantly redesign many operational processes in the railway industry. The institutional changes doubled the number of control rooms needed to operate the system thereby diffusing available information over more entities and people. This information is also less comprehensive and fragmented in bits and pieces. To nevertheless ‘seamlessly’ connect the increased amounts of organizations, their systems and their technologies, require the use of more information technology (telephones, computer systems, etc.) to operate, coordinate and monitor the complex interactions in the railway system (cf. Coutard 1999). What emerged after the reform, thus, is a relatively more complexly interactive operational process in which more organizations with sometimes conflicting interests become involved.

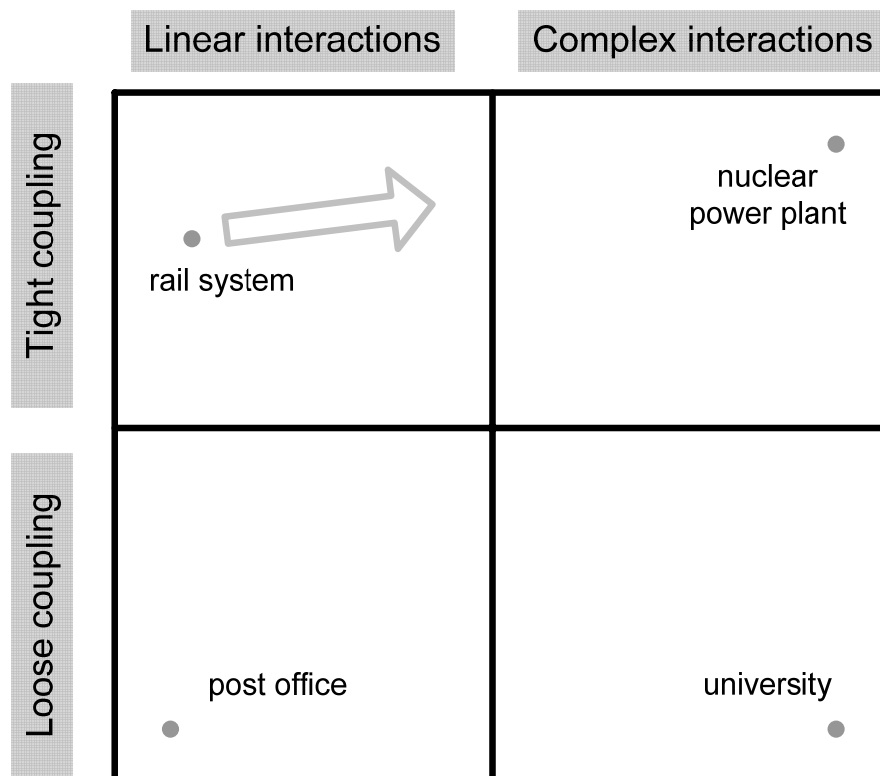


Figure 3: The reform changed the rail systems’ complexity (based on Perrow 1999a), arrow added.

The implication is that the rail system shifted towards a complexity that is less manageable. Perrow encounters a seemingly unsolvable puzzle about the way

organizations should deal with complex technologies in the upper-right quadrant, because dealing with complexity *and* coupling requires mutually exclusive organizational responses (see Figure 4).

On one hand, systems that are tightly coupled must be operated through a highly centralized authority structure, with operators reacting immediately using predetermined Standard Operating Procedures. “Decentralized systems are too slow to respond to widespread multiple failures, because the units cannot be instantly and unquestioningly controlled from the top where often there is a superior view” (Perrow 1999b, p. 152).

On the other hand, a high degree of interactive complexity of the system requires decentralized management because “[d]ecentralized units are better able to handle the continual stream of small failures” (*ibid.*, p. 152).

	Linear interactions	Complex interactions
Tight coupling	<p><i>Centralization</i> desirable for tight coupling, which is compatible with linear interactions</p>	<p><i>Centralization</i> desirable to address tight coupling, but <i>decentralization</i> is needed to deal with unplanned interactions</p>
Loose coupling	<p><i>Centralization or decentralization</i> possible</p>	<p><i>Decentralization</i> desirable for complex interactions, which is compatible with loose coupling</p>

Figure 4: The manageability of large-scale complex systems (Perrow 1999a, p. 332)

The managerial dilemma, thus, is a paradoxical managerial catch-22 for tightly coupled and complexly interactive large-scale technological systems. They require a decentralized *and* a centralized form of management.

When we match Perrow’s observations with the way operators cope in the Dutch railway industry, one sees confirmed that the interactive complexity of the

system has undergone significant changes. The reform seems to have led rail operations towards Perrowian-type problems of conflicting centralized and decentralized management needs. Granted, these conflicts are not nearly as disastrous as in say electricity systems or nuclear power plants, but they increasingly experience these conflicting features nevertheless.

The observed coping strategies highlight the difficulties to make many small deliberate and balanced adjustments in operations because of a more complexly interactive system. Indeed, the original task specifications in the traffic control squares were designed for tight coupling, but not for more complex interactions. Besides the recognized coping strategies, new, more decentralized, and often considered deviant, strategies have evolved in the industry to cope with the increasing disturbances and surprises.

## **Conclusion**

The institutional reform, unbundling and liberalization promised to improve overall performance. As the common argument goes, financially more autonomous service providers in a competitive environment would be more eager to minimize the necessary trade-offs and to optimize the inevitable ones. Thirteen years after the reform initiated, now that the teething troubles seemed to have settled down, we assessed how the reforms affected daily trade-offs between the many interests in rail operations.

We looked at daily, small coping strategies of operators in the face of conflicting values. The reform considerably changed the way trade-off occurred. In terms of our two-by-two framework, the reform has driven operators to the quadrant of 'undeliberate' and 'decoupled' coping. This means that operators more narrowly construe their role within the networked operations. As they cope, they do not oversee the trade-offs they induce and when they induce them, the underlying value-conflicts are structurally not addressed. The reform, thus, led to less attention for optimizing conflicting interests in operations. In an ideal market situation, this is common. Then, trade-offs automatically rise from the interactions between demand and supply. In the case of rail operations, trade-offs are left to the less ideal mechanisms of decoupling.

In a follow-up discussion, we could explain the new coping status with literature that addresses the management of large complex socio-technical systems. The new status of coping seems to have signaled an increase in complexity that has

been anticipated in the wrong way. Perrow would predict that this increased unpredictability and instability in train operations is not solvable by design in terms of planning, stricter task specifications, etc. Indeed, the observed push to more undeliberate decoupling is a sign that the system needs more decentralized trade-off management capacity, such as more lively interactions between controllers.

Oversight bodies generally believe that ‘trading-off is the expertise of the industry.’ In contrast, trade-offs appeared not necessarily be managed at all. In fact, the manageability of trade-offs seems to have subsided undeliberately. This arguably made the rail system more brittle. Unmanaged and undeliberate trade-offs may induce failures that seem harmless at first but, under certain conditions, while controllers do what they always do, these failures may increase in scale and ripple through the large-scale complex system until, eventually, the entire system fails (cf. Snook 2001). Oversight bodies might be surprised to find themselves stimulating this new coping status, as their accumulating interventions and their lack of interest in trade-offs unconsciously add to the operational complexity.

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