

Project description: Critical infrastructures, public sector reorganization and societal safety (CISS)

1 Relevance

The CISS project describes, analyzes and compares characteristics of organizations responsible for the maintenance and protection of critical infrastructure. As society is growing increasingly dependent on critical infrastructures, this is a matter of the highest importance for the ability to uphold and improve societal safety. The project focuses on infrastructures in ICT, electricity supply and water supply. These have (to various degrees) been subject to both technological and organizational changes. The changes represent a radical shift in organizational framework conditions. The main research question for the CISS project is: **What are the consequences of public sector reorganization for critical infrastructures and hence societal safety?** Key organizational dimensions as control, coordination, redundancy and safety culture will be inspected (together with technical specifics of each sector) to evaluate and understand how different organizational forms have impact on maintenance and protection of critical infrastructures.

The main objectives of the SAMRISK program are to 1) increase the knowledge of threats, hazards and vulnerabilities, 2) prevent accidents and incidents, and 3) strengthen crisis management. The CISS project will generate new theoretical, empirical and practical knowledge on the protection of critical infrastructures in Norway, and thereby contributes to all three objectives of the SAMRISK program.

2 Background

In Norway, the concept of “a vulnerable society” has become a major part of both public and political debates, following a report by a government commission headed by former Prime Minister Kåre Willoch. The Willoch commission (JD NOU 2000:24) listed several new challenges regarding societal vulnerability. These included technological changes, increased complexity in society, increased cost- and efficiency pressure, reduced manning in public services and outsourcing of public services to commercial enterprises. These challenges, together with the emergence of “new” threats like terrorism, organized crime and climatic changes, represent a fundamentally changed context for the organizations responsible for the maintenance and protection of critical infrastructures. The CISS project studies the effects of such changes for societal safety.

Critical infrastructures can be defined as *those constructions and systems that are essential in order to uphold society’s critical functions, which in time safeguard society’s basic needs and the feeling of safety and security in the general public.* (JD NOU 2006: 6, Eng. summary, p.2)

The changes emphasized by the Willoch commission are strongly related to restructuring processes in the Norwegian public sector. During the last 20 years, the public sector has been heavily influenced by trends towards *new public management* (NPM). Public monopolies have been transformed into several decentralized, competition-exposed or privatized organizations (Johnsen 2005). These organizational changes, spanning from outsourcing of public services to restructuring into internal transfer-price systems, will in the following be addressed as “Public Sector Restructuring” (PSR). For all these organizational variants, the common denominator is a drift towards management by market mechanisms.

Such processes of restructuration can have at least two possible effect scenarios. As PSR is often accompanied by new audit regimes, one possible scenario is that the organizational

restructuring leads to a clarification of existing regulations and demands regarding safety and emergency preparedness. The combination of explicit demands and strong governmental control might lead to an increased focus on safety and emergency preparedness, and thus a reduction in societal vulnerability (JD NOU 2006:6).

Another possible scenario is that being exposed to competition will lead to increased vulnerability because it imposes a financial logic upon organizations maintaining critical infrastructures: While public organizations have the provision of public services as their main objective, private organizations' ultimate goal is to generate profit.

The discussion as to which of these possible outcomes is the most likely result is highly politicized. Most market liberalists would probably find the first outcome the most plausible, while those on the left side of the political-ideological scale would probably find the latter outcome the most likely. This project is of course not detached from such political discussion. However, it is designed to be as close as possible to the empirical situation in the different sectors. We do not discard either of the mentioned outcomes, nor combinations of them.

Safety research has thoroughly demonstrated the relationship between organizational conditions and safety work. Changes in organizational conditions pertaining to critical infrastructure are therefore highly likely to influence societal safety, given modern societies' reliance on these infrastructures.

3 Frontiers of knowledge

Many European countries have undertaken fundamental reorganizations of their public sectors. At the bottom of this reorganization lies a pressing need to cut the expenses associated with modern welfare states. NPM has been the main response to this need. Although NPM is not an integrated and uniform movement, the drive towards cost efficiency, accountability and market orientation can be said to be common denominators of the different variations of NPM (Dent et al. 2004).

In short, the NPM movement have resulted in what may be labelled a "privatization" of the public sector: Some public organizations have become wholly or partially converted to private organizations, some public services have been outsourced to private companies, while much of the remaining public sector have moved beyond the public-bureaucratic model by adopting "commercial" organizational techniques like management by objectives (MBO).

The effects of this development on societal safety have not been extensively studied. Most of the research on the topic has been carried out in sectors where public monopolies have been deregulated and subsequently privatized. In the following we give a brief account of this research, as well as some previous studies of vulnerability in critical infrastructure in Norway.

3.1 Deregulation in transport

The transport sector is by far the sector in which most studies have been conducted to analyze the relationship between deregulation and safety, particularly in the UK and US. In the UK, the railway transport has received the most attention, after experiencing several serious accidents, such as the Hatfield crash in 2000. Though the number of casualties at Hatfield was relatively low (4 killed and 70 injured), the subsequent restrictions on the rail system lead to severe problems for train operators in Britain in the time after the accident. The accident exposed flaws in the systems for control of the railway infrastructure:

The underlying causes identified by the HSE investigation were that the maintenance contractor at the time, Balfour Beatty Rail Maintenance Ltd (BBRML) failed to manage

effectively the inspection and maintenance of the rail at the site of the accident. [...] The investigation also found that Railtrack PLC, the infrastructure controller at the time, failed to manage effectively the work of BBRML. (ORR, 2006:4)

The exposed systematic failures lead to a speed reduction on the rails (since one could not guarantee their condition) which in turn crippled much of the British railway system.

As a part of the Norwegian research program *Risk and safety in the transport sector* (RISIT), Johnsen et al (2002) produced a knowledge survey on the safety consequences of deregulation. The authors emphasized the need for scientific knowledge on the topic, and identified several negative issues related to deregulation:

- Increased competition coupled with decreasing profitability could lead to reduced maintenance and quality, which in turn could lead to lower safety levels
- The entrance of new and inexperienced market actors could involve increased risk
- Outsourcing can lead to a fragmentation of responsibility

Despite identifying these negative factors, much of the research concludes that deregulation has not adversely affected transport safety. Many of the studies reviewed come from the American aviation industry (e.g Oster & Zorn 1989; Rose 1992). However, these studies have been criticized for relying on too limited post-deregulation data. When extending the analysis to include more recent accident data, results show a reversal of the declining trends in accident rates (Raghavan & Rhoades 2005). This suggests that there might be differences between long-term and short-term effects of deregulation.

Elvik (2006) conducted a meta-analysis that included the results of 25 studies of the effects of deregulation on transport safety. The studies included aviation as well as road and rail transport. Elvik's analysis concludes that deregulation did not appear to have statistically significant negative effects on safety in either of the industries studied. In fact, Elvik's study finds a positive relationship between deregulation and safety in rail transport. However, he recommended that the impacts of deregulation should be continually monitored, as the process of transport deregulation is still in its infancy in most countries.

3.2 Deregulation of electricity supply

In 2000-2001 parts of California were paralyzed by a major power crisis leading to rolling blackouts and skyrocketing electricity prices. This is one of the more extreme examples of the fragility of modern societies when critical infrastructural elements like electrical power fail, but it also provides an example of some of the challenges associated with outsourcing of critical infrastructural functions. The crisis has later been regarded as a consequence of the deregulation of the energy market. The official FERC-report states that "*supply-demand imbalance, flawed market design and inconsistent rules made possible significant market manipulation*". Hence, the market for taking care of the critical infrastructural function of providing energy to California was rendered vulnerable to manipulation. When a situation with supply – demand imbalance occurred, the design of the market was such that manipulation (both legal and illegal) was possible (FERC Final report, Borenstein, 2002).

Researchers have also voiced more general concerns over the reliability of the US electrical supply. For instance, Moody (2004) highlights that the increase in the amount and complexity of traffic on the transmission grid is causing strains on equipment as well as personnel, and that the market mechanisms seem to restrict the level of investment (see also Woo et al 2006).

In general electricity markets are characterized by inelastic supply and inelastic demand, (Borenstein, 2002) so if this infrastructural function is to be maintained by market regulations

it has to be accompanied by a regulation regime and market design that meets the challenges such a market represents.

The California blackout is an extreme example and we do not believe that such willed market manipulation is likely to occur in Norway. But the example nevertheless reveals some important “weak spots” with deregulated systems: The incentives of action and inaction are sometimes conflicting between the market function and the long term societal function.

3.3 Studies of critical infrastructures in Norway

The Norwegian Defence Research Establishment has conducted a series of highly interesting studies of vulnerability in the Norwegian society. Most of these studies deal with vulnerability in critical infrastructures, most notably in telecommunications and electricity supply.

Some of the vulnerabilities identified in the study of telecommunications (Hagen and Nystuen 1999) are related to PSR. For instance, the authors find that companies tend to give significantly more attention to the ability to tackle high probability/low consequence operational disturbances compared to low probability/high consequence events. Prioritizing the short term operational challenges is regarded as a competitive advantage, while protection against the less likely high consequence events are less prioritized as they give little competitive advantage compared to the high costs involved. The CISS study will focus on the handling of both kinds of risk types, and also the prioritization between them, for all three sectors.

Among the vulnerabilities identified in the study of electricity supply (Fridheim et al 2001) are insufficiencies in the protection of the main grid, as well as the ICT systems. The authors therefore conclude that the level of investment has been far too low to be able to handle the expected increases in demand. Also the study notes some concern that the drive to be cost-effective has resulted in the replacement of people with ICT systems. This, in combination with an aging work force and low level of recruitment, may lead the industry into a future lack of personnel and competence.

3.4 Unaddressed research issues

Although the above outline of studies on the effects of PSR on infrastructure hardly does justice to the work cited, it serves to illustrate that the results are inconclusive and that more research is needed. Especially, the organizational aspects of PSR have been under-emphasized. Most studies focus on incident and accident statistics, which of course are important indicators of safety and reliability. However, one should not limit the study of safety and reliability to such aggregated measures. It is quite possible for organizations to have excellent HSE statistics and at the same time be in the incubation phase (Turner 1978) towards a major accident, due to organizational deficiencies like poor communication, under-reporting of incidents or lack of competence. Studies from the British railway sector illustrate this point when they find that the accident rates are decreasing, but that the creation of new organizational boundaries still contributed to major accidents like the one at Hatfield (Evans 2004). This underlines that the evaluation of the effects of PSR should also include organizational aspects.

The research on critical infrastructure has been largely conducted through risk and vulnerability analysis that largely focus on the physical infrastructure. The organizational contexts of these infrastructures have been largely neglected. It should therefore come as no surprise that there is very little knowledge regarding the organizational consequences of deregulation of critical infrastructure. We believe that analyzing the consequences of these changes is crucial for the maintaining and improvement of societal safety.

4 Description of the CISS project

4.1 Problems to be addressed

The general problem to be addressed in the CISS project is: **What are the consequences of public sector reorganization for critical infrastructures and hence societal safety?** Within this broad problem definition, we will formulate four more specific research areas:

Control: Public sector restructuring implies that some of the control over critical infrastructure is transferred from public to private organizations. When functions that used to be performed within a single organization are delegated to more or less independent units, the systems for control and revision change. As illustrated by the California blackouts, there may be significant differences of interests between society at large and private organizations. This highlights the question as to how government is to maintain the necessary control over the provision of basic societal functions. We believe it is important to evaluate the interfaces between regulatory authorities and the organizations responsible for critical infrastructures.

Coordination: PSR can be said to increase complexity by involving more organizationally separate entities hence creating more interfaces. Simultaneously, the different critical infrastructures seem to be growing more tightly coupled. Does this increase in complexity imply reduced coordination and reduced societal safety? Safety is normally dependent on open and dynamic communication about the work process, whereas the requirements and specifications of contracts and reports are standardized, static, auditable and not least, always subject to economic consideration. The CISS-project will evaluate how the long and short term risks pertaining to critical infrastructure is taken into consideration on these boundaries in the different sectors.

Coordination in emergency situations relies heavily on contingency plans. However, emergencies like hurricane Katrina have raised questions about the efficiency and overall realism of emergency planning. This is also emphasized in a study by Clarke (1999) showing that many contingency plans are “fantasy documents” which are virtually impossible to carry out in real life. According to Clarke, the main function of such plans seems to be symbolic: to provide the public with a sense of security in knowing that there is a plan for every event.

Redundancy: Processes of public sector restructuring are usually motivated by a desire to cut costs and increase efficiency. As a result, PSR often involves reducing the number of employees while maintain or increasing the level of production. Are the goals of reducing costs by reducing the number of employees commensurable with the goals of safety? Much safety research suggests that they are not, and claim that lean organizations are more vulnerable because of a lack of organizational redundancy (LaPorte & Consolini 1991; Schulman 1993; Rosness et al. 2000). Although there is by no means a deterministic relationship between the number of employees and safety, the question as to how the organizations responsible for critical infrastructures deal with the drive towards efficiency is highly important for societal safety.

Safety culture: The drive towards efficiency could also have implications on safety culture: Does the introduction of market principles involve a shift in the prioritization between financial and safety goals? As already indicated above, the drive for short term financial profit can sometimes go at the expense of longer term investments in and maintenance of infrastructure. The drift towards economic values has previously been identified as root causes of major accidents (cf Vaughan’s (1996) analysis of the accident with the space shuttle Challenger). However, having a bad safety reputation can be costly for commercial organizations. Thus, competition may induce a higher priority on safety in private organizations and more focus on safety values.

4.2 Theoretical perspective: Increased complexity – reduced safety?

In the CISS project, societal safety is seen as society's capacity to uphold important societal functions and protect citizens' lives, health and basic needs under various kinds of strain (Kruke et al 2005:5). We see the growth of complexity in society, parts of which are results of public sector restructuring, as a challenge to societal safety. Complexity might lead more organizations structural dilemmas, as described by Perrow (1984): Systems characterized by "interactive complexity" calls for a decentralized organization, whereas tightly coupled systems can only be effectively controlled by a centralized organization. In Perrow's view, an organization can not be both centralized and decentralized at the same time. Therefore, it is impossible to effectively control risk in systems with high interactive complexity and tight couplings. With PSR there is a further shift towards pre-specification and standardization of work processes and towards a regime of accountability that transgresses the context of the actual workplace. Hence, since work is specified and measured by standards that are not specific to the given situation, even less leverage is given to the individual's expertise. A critical question is whether PSR may cause changes in the work practise, the professional status and knowledge of the workers maintaining the operation of critical infrastructures.

Although admitting that complexity represents a challenge for societal security, we do not share Perrow's view that one should simply abandon all activities which can imply such organizational dilemmas. In our view, the question is not how to avoid such dilemmas, but how to deal with them. In this respect, we share the views of the researchers of *High Reliability Organizations* (e.g Weick 1987, 1999). We believe that it is possible to develop resilience strategies that make organizations able to deal with a high degree of complexity. This requires, however, that organizations move beyond traditional risk management approaches of planning in advance. In an increasingly complex setting, there is a growing need for organizations to be able to make rapid local adjustments to unforeseen events. In order to deal with complexity, one must acknowledge 1) that unwanted and unforeseen events will happen, and 2) the fact that it is impossible to cover all (but still some) aspects of reality by plans, rules and regulations. The acknowledging of these two propositions opens up the possibility of risk management systems which provide coordination and guidance for action, without aiming to standardize every aspects of work. One of the keys in dealing with complexity is to provide room for workers' professional judgements. Such judgements are to a large extent seen as "disturbances" within traditional approaches to risk management. We see human reflexivity as a fundamental resource for safety.

The CISS project addresses key issues regarding how the current trends in public management may lead to changes in the risk situation for critical infrastructure. Hence, the proposed research will generate knowledge about new risks but also it is our intention to build more general knowledge about the relationship between organizational forms and risk management.

4.3 Research approach and methods

Studio Apertura has a long record of conducting empirical studies on organizational aspects of safety¹. We will base our research design on this experience. A key component of this is thorough pre-studies to gain background knowledge of the sector and case-organization followed by a questionnaire study and extensive use of qualitative interviews. The pre-studies will also provide input from the relevant stakeholders. This will form the basis of questionnaire construction. The questionnaire study is well suited to give a broad assessment as well as a systematic comparison across cases. The questionnaire study serves as an initial problem definition. The results from this study form the basis of focused interviews. Safety

¹ For example projects I, J, E, F, G on the appended list of "Selected projects with participation by Studio Apertura".

work often hinges on details and problems that are hard to formulate, and we regard the interviews as the key source of such information. The triangulation of data is important to cover the width needed to examine the organization as a whole, as well as the depth needed to understand the specific challenges of the organization.

The success of this project is dependent on that we obtain a solid knowledge about the safety and security situation, both from a technical and organizational perspective, for each field before conducting the survey and interviews. Our partners will play a key role here. We intend to address the sectors one by one. We conduct pre-studies in cooperation with our partner with specialist competence on each sector. The partners will also assist in the construction of interview guides and questionnaires with their assistance before conducting the survey and interviews. The partners will be consulted in the analysis of the data. The implementation of the project is summarized in the following project plan.

Table 1: Project plan

	Year	2007		2008		2009					
	Quarter	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Activity	Litterature study	A	A								
	Prestudy Energy sector		AB								
	Empirical study Energy sector			A	A						
	Prestudy Water supply sector				AC	AC					
	Empirical study Water supply sector					A	A				
	Prestudy Telecom sector							A			
	Empirical study Telecom sector							A	A		
	Comparative analysis								ABC	ABC	ABC
	Presentation and discussion of results with partners (continous)	ABC	AB	AB	ABC	ABC	ABC	ABC	ABC	ABCD	ABCD
	Deliverable	Short report: Energy			AB						
Short report: Water supply							AC				
Short report: Telecom									A		
Final report										A(BC)	A(BC)
Report: Metodological considerations										A	A

A: Studio Apertura B: Sintef Energy Research C: Sintef Water and Environment. D: TIK-Centre

Cost specifications and budget is given in the application form.

The project addresses a field that is quite unexplored. Hence we see a thorough empirical investigation and solid documentation of this as being of great value in itself. Still, our design, especially with the comparative data, will also provide leverage for theoretical discussion.

4.4 Project management and organization

The project will be managed by NTNU Social Research Ltd., department Studio Apertura by Professor Per Morten Schiefloe. The partners include both research and business partners where most have cooperated closely at previous projects. The fact that such relations have already been established will be an advantage for effective cooperation in the project. Besides Studio Apertura, the consortium of research partners includes SINTEF Energy Research and SINTEF department of Water and Environment.

Studio Apertura's dominating field of research has been organizational research in the oil industry. This is an industry responsible for critical infrastructure, which also have undergone a restructuring from being under governmental control, to being a private, commercial company. Studio Apertura's research in this field has yielded knowledge on the interfaces between operator and contractor, companies and regulating authorities and between different

occupational groups. The CISS project will compare the knowledge from the protection of infrastructure in the oil industry to other branches of society.

Researchers at Studio Apertura have been involved in a series of research projects relating to the ICT and telecom sector, especially with Telenor. More information on Studio Apertura's research is submitted as attachment to the application form.

SINTEF Energy Research has conducted a wide variety of research related to power production and conversion, transmission / distribution and the end use of energy both onshore and offshore/subsea. Their participation will provide the project with specific knowledge about the electricity industry. SINTEF department of Water and Environment has conducted a wide variety of research related to water resource management, improving water infrastructure and water treatment. Their participation will provide the project with specific knowledge about water supply.

Three organizations responsible for maintenance and protection of critical infrastructures have agreed to participate as case organizations in the project:

1) Telenor is responsible for a large part of the infrastructures within telecommunication and other ICT infrastructure. Telenor is the result of the privatization of the previous state agency Televerket. Telenor is now a highly international and successful business.

2) Nord-Trøndelag Elektrisitetsverk (NTE) is owned by North Trøndelag County Council. The company's principal activity is to produce, distribute and sell electric power. In addition, NTE provides broadband infrastructure and services. This illustrates a tendency of convergence between electricity and ICT infrastructures. ICT and electrical infrastructure are also highly mutually dependent.

3) Trondheim Municipality is responsible for water supply in the city of Trondheim.

The three organizations have followed quite different trajectories of PSR. Telenor are fully privatized (but partly owned by the Norwegian state) and functions more or less like any other commercial organization. NTE are still owned by a governmental body, but the sector is deregulated and the competition is quite fierce. Trondheim Municipality's water supply is a case of public ownership, but has nevertheless undergone processes of PSR. For instance, there is frequent use of outsourcing strategies. The empirical variation between the cases is an analytical strength. It gives an opportunity to analyze both variations and similarities between different trajectories of PSR.

4.5 Cooperation - Building interdisciplinary networks.

Apertura's team of researchers will in itself be interdisciplinary with two sociologists, one anthropologist with a masters degree in environmental engineering, one political scientist and an ICT-engineer, but interdisciplinarity will also be sought by extensive cooperation with technical expertise in the afore-mentioned Sintef departments. It is also a goal to recruit master level students for each part of the project.

Cooperation between expertise in organization- and safety studies and specialists in the technical aspects of the infrastructure is a critical component of our research. The proposed project relies heavily on close cooperation between Studio Apertura and specialists in the sectors involved Sintef as well as the companies. Also, we have established cooperation with Centre for technology, innovation and culture (TIK-centre) in Oslo for experience transfer and a communal presentation and discussion of results. It is a strategic goal to maintain this

cooperation for future projects, most notably within the Security program within EU's 7th framework program.

5 Perspectives and strategic foundation

5.1 Strategic foundation

Studio Apertura's ambition is to develop new scientific knowledge on organizations' challenges and opportunities in times of globalization, technological development and rapid changes. The CISS project is seen as an important way of achieving this ambition. The CISS project is also a part of Studio Apertura's strategy to build the knowledge, competence and networks required to be considered for research funding from the EU, especially the forthcoming call of the Security program within FP7. The project therefore has a strong anchoring in Studio Apertura's strategy.

5.2 Relevance for society

The CISS project will have a high degree of societal relevance, both on a national and international level. On the national level, the CISS project aims to provide knowledge on the robustness and vulnerability of critical infrastructure. The need for research in this field was strongly emphasized by the Willoch Commission (NOU 2000: 24). The knowledge generated in the CISS project may provide important input in future policy development, and thereby making a contribution to improving societal safety. Also, through publishing in international journals and participating on international conferences, the CISS project will make contributions to the scientific debate that forms the basis of the maintenance and improvement of societal safety in other countries.

5.3 Environmental perspectives

The project in itself is not likely to involve any negative environmental impact. The knowledge generated through the project may be form the basis of decisions to modify physical infrastructures. While this may involve some environmental considerations, it will most likely not exceed the environmental impact of any other forms of maintenance of physical maintenance of critical infrastructure.

5.4 Ethical considerations and protection of information

The objectives or methods of the project do not imply any violations of any laws, rules or general values of the Norwegian society. The research methods used in the project will not involve any risks or hazards for the informants. All participants will be informed that participation is voluntary, and that they can end their participation at any stage of the project. All data will be obtained and stored in accordance with good research ethics.

The data gathered in the CISS project will possibly contain highly sensitive information about critical infrastructure. Such information on the wrong hands could imply severe consequences for Norwegian society. The protection of this information will receive the highest attention priority. All data will be stored on secure servers, never on local computers. All interview data will be made anonymous and sound recordings and transcriptions will be destroyed immediately after the project's completion.

5.5 Equal opportunities and gender perspectives

Gender perspectives are relevant for most social situations, and gender perspective are also of relevance to safety (e.g much risk taking behaviour are associated with traditionally masculine values). Although the CISS project is not primarily concerned with gender perspectives, we acknowledge the need for being sensitive towards gender issues, partly because some of the industries involved in the study are traditionally male dominated industries.

Equal opportunities are an integral part of Studio Apertura's recruitment strategy. This is reflected in the fact that around 50 percent of the researchers at Studio Apertura are women.

6 Information and dissemination of results

The project will generate empirical, theoretical and practical knowledge which will be of relevance to all organizations responsible for critical infrastructure. The organizations functioning as cases in the study will receive reports, presentations and suggestions of improvement on the basis of the results. The reports from the empirical studies will also form the basis for articles which will be presented in scientific journals and international conferences and seminars. The project aims for at least four publications in renowned peer-reviewed journals. For each of the empirical reports we will aim to publish in industry specific journals, such as *Energy*, *Telecommunications Policy* and *Water Policy*. The comparative analysis and final report may form the basis of at least one publication in general safety journals like *Safety Science* and *Reliability Engineering and System Safety*.

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