

## Known unknowns in the road-based transport of dangerous goods - Consequences for the risk analysis of tunnel systems.

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The transportation of dangerous goods through road-based systems is heavily regulated to ensure the safety of individuals, property, and the environment. In Norway, the Norwegian Directorate for Civil Protection oversees the certification and education of safety advisers and drivers involved in the transportation of dangerous goods. However, recent studies suggest that regulations in the heavy goods transport (HGV) sector are not always followed, posing unforeseen risks to tunnel safety and the environment. The paper, based on longitudinal observational fieldwork conducted between 2016 and 2020, challenges assumptions about the compliance of rules and regulations in the HGV sector. The author introduces the concept of Adaptive Nonconforming Behaviour (ANB), which includes the violation of safety-related regulations and deviations from established practices. ANB can result from external and internal socioeconomic pressures, such as cost-cutting measures. The author uses ethnographic methodology to examine the day-to-day work of truck drivers, revealing that dangerous goods are often secretly transported with mixed cargo, drivers are unaware of the nature of the cargo they are transporting, and there is a tendency to camouflage the packaging of dangerous goods to cut costs. These findings highlight the importance of considering ANB in the risk analysis of tunnel systems and call for stricter enforcement of regulations in the HGV sector.

*Keywords:* Dangerous Goods, Heavy Goods Vehicles, Adaptive Non-conforming behaviour, Regulation, Empirical study

### 1. Introduction

The road-based transport of dangerous goods is heavily regulated, in both a Norwegian and international context. In Norway the Norwegian Directorate for Civil Protection is responsible for the quality of education and certification of safety advisers and for certificates which allows the individual drivers to transport dangerous goods. Given the potential for accidents it risk assesment is a significant issue in the safety management and of tunnel systems where the transport of dangerous goods is possible (Benekos and Diamantidis 2017. Caliendo, and Guglielmo 2016)

It is often assumed that rules and regulations in the Heavy Goods Transport (HGV)- are usually followed (Njå et al., 2012), yet recent studies show that this is not the case (Kuran and Njå 2016, Kuran 2018). The paper is based on longitude observational fieldwork from 2016 to 2020 (Kuran 2021a) in the HGV-sector. The empirical finding is through the lens of systems theory, (Leveson 2011) intended to challenge an assumption made in the

risk management of tunnels in Norway. This assumption is that safety that rules and regulations pertaining to dangerous goods are not commonly broken and bent, this constitutes a known unknown in the risk analysis of tunnels, and challenges the assumed current conditions of dangerous goods transport in the road system.

### 2. Theory

#### 2.1 Risk management of tunnels

Risk management of tunnels In Norway conforms with Directive 2004/54/EC (European Commission, 2004) and involves identifying, assessing, and mitigating potential risks and hazards that could affect tunnel users, infrastructure, and the environment. The goal of risk management is to reduce the likelihood of incidents and the severity of their consequences (NPRA 2007). Fundamentals of risk management of tunnels according to the Norwegian *Guidance for Risk analysis of Road tunnels* include:

**Hazard identification:** The first step in risk management is to identify potential hazards and risks that could affect the tunnel, its users, and the environment. Hazards can include fire, flooding, structural failure, and the transport of hazardous materials.

**Risk assessment:** Once hazards have been identified, a risk assessment is ideally performed to determine the likelihood and consequences of each hazard. This involves evaluating the potential impact on people, property, and the environment.

**Risk mitigation:** Strategies are developed to reduce or eliminate identified risks. Mitigation measures can include physical changes to the tunnel infrastructure, operational changes, and emergency response plans.

**Monitoring and review:** Ongoing monitoring and review are essential to ensure that risk management strategies remain effective and relevant. This includes regular inspections, maintenance, and testing of emergency response plans.

**Communication and collaboration:** Effective risk management requires collaboration between all stakeholders involved in the tunnel, including tunnel operators, emergency responders, and the public. Communication and collaboration are key to identifying and addressing potential risks. By implementing effective risk management strategies, tunnels can be operated safely, efficiently, and with minimal disruption to users and the environment.

In the Norwegian context the exact method for the risk analysis of tunnels is often delegated to consulting firms that use a variety of methods.

**2.1 Systems theory**

The systems theory perspective uses an approach to feedback and constraint in formalized hierarchies, (Rasmussen 1997, Leveson 2011), while also exploring that informal feedback loops exist (Kuran 2017). In the context of risk management in tunnel systems, the importance of feedback loops in the hierarchical sociotechnical system cannot be overstated. The systems theory

perspective also recognizes the presence of both formalized and informal feedback loops within the system (Kuran and Njå 2016).

Formalized feedback loops refer to the structured communication channels and decision-making processes within a hierarchical organization, see figure 1. This can include regular safety inspections, incident reporting procedures, and emergency response plans. These feedback loops provide a mechanism for identifying and addressing potential risks and hazards, as well as promoting continuous improvement in safety management.

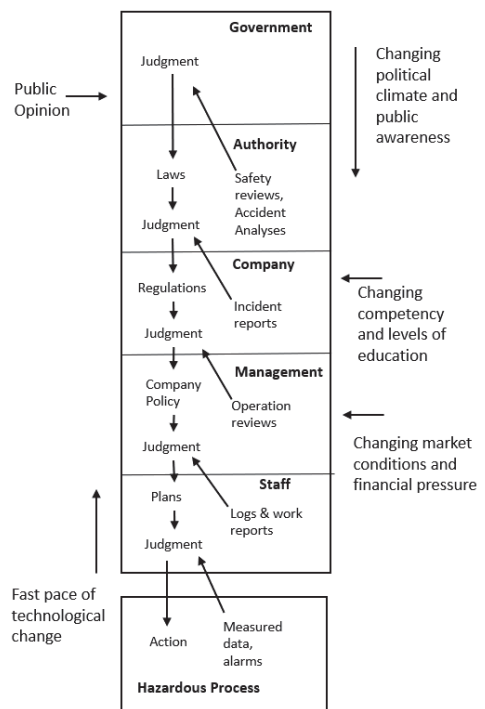


Figure 1 Hierarchical control structure Svedung and Rasmussen (2002)

However, informal feedback loops are equally important in the sociotechnical system, see figure 2. These refer to the unstructured communication channels that exist between actors in the system, such as truck drivers, warehouse workers, and

maintenance personnel. Informal feedback loops can provide valuable information on the day-to-day work processes, practices, and challenges within the system that may not be captured through formal channels.

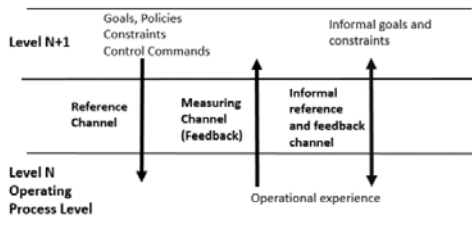


Figure 2 Hierarchic control structure with informal goals and channels (Kuran and Njå 2016, modified from Leveson 2011)

By recognizing and utilizing both formalized and informal feedback loops, risk management in tunnel systems can be strengthened. Informal feedback loops can be used to identify potential hazards and risks that may not be captured through formal channels, and to provide insight into the practical challenges faced by actors in the system. Formal feedback loops can then be used to develop and implement mitigation strategies, and to ensure that risk management strategies remain effective and relevant over time.

Overall, effective risk management in tunnel systems requires a systems approach that recognizes the importance of both formalized and informal feedback loops. By utilizing these feedback loops to identify and address potential risks and hazards, tunnel systems can be operated safely and efficiently, while minimizing the impact on users and the environment.

## 2.2 Adaptive non-conforming behaviour

The term adaptive non-conforming behaviour cuts across all levels in the system and covers the outright violation of safety-related rules and regulations and activities that deviate from established good praxis. Non-conforming behaviour can include strategic adaptations to external and internal socioeconomic pressures. Actors in the industry claim non-conforming behaviour is a prominent characteristic of the day-to-day activities. (Kuran 2021b)

Although noncompliance may sometimes be cited as a contributing factor in accident investigations, it merely describes a symptom and fails to delve into the complex and elusive factors that underlie the causes of heavy vehicle accidents - factors that are often unintended, undesired, and expensive.

The concept of ANB is used to situate the emic concept of rule-bending in an ethical and theoretical context of the sociotechnical systems of the HGV -sector.

The limitations of using noncompliance as a contributing factor in accident investigations highlight the need for a more comprehensive approach to risk management in the heavy vehicle sector. Consideration of ANB as a systemic problem offer a way to move beyond simply describing symptoms and into the complex realm of causality. By focusing on the sociotechnical system and the interactions between its various components, this approach provides a framework for identifying the underlying factors that contribute to accidents. This allows for a more proactive and preventative approach to risk management, rather than simply reacting to accidents after they occur. Therefore, the adoption of ANB as a more complex and sensitive term to describe violation and non-compliance can significantly improve the safety of the heavy vehicle sector.

## 3. Method

The data used in the study is based on ethnographic methodology using fieldwork in a sociotechnical system, the HGV-sector (Kuran 2021a). The presence of the researcher in the field as both observer and actor, together with informants over time allows for a gradually expanding informal exchange of knowledge and access to the day-to-day work of truck drivers, transport managers and forwarders. The time spent in the field gradually makes it possible for the researcher under various conditions to honestly discuss sensitive concepts of the transport of dangerous goods, both when rules and regulations are followed, and when they are not.

The ethnographic researcher acted as both an observer and an actor in the field, which allowed them to collect rich and detailed data through

direct observation and interaction with the study participants. The use of ethnographic methodology provided the researcher with an opportunity to explore and understand the perspectives and experiences of the study participants in their natural context. By spending time with the participants, the researcher was able to build relationships and trust, which enabled them to discuss sensitive concepts related to the transport of dangerous goods in an honest and open manner.

Qualitative research approaches, such as ethnographic methodology, are particularly useful in exploring complex social phenomena and in providing in-depth insights into the experiences and perspectives of individuals within a specific context (Kuran 2021a). The data collected through ethnographic research is typically rich and detailed, providing researchers with an opportunity to explore complex issues and phenomena in depth. Therefore, the use of ethnographic fieldwork in this study allowed the researcher to gather rich and detailed data that could be analysed to explore the challenges and risks associated with the transport of dangerous goods in the HGV-sector.

There are three criteria to evaluate the quality and success of ethnographic contributions in scientific discussions. These include veracity, objectivity, and perspicacity. Veracity pertains to the faithfulness of the contribution to the truth or its successful description. Objectivity refers to the ability of the contribution to provide conclusions that surpass the perceptions of the individual research object. Finally, perspicacity concerns the ability of the contribution to produce insights that can be applied to the study of human behaviour in other research settings.

#### 4. Results

The results from the Ethnographic study suggest that:

1. That pieces of dangerous goods are often secretly transported with mixed cargo.
2. That drivers sometimes do not know the nature of the cargo they are transporting.

3. That there is speculation on behalf of transport buyers, camouflaging dangerous goods in attempts to reduce the cost of transport.
4. That the Norwegian public roads administration (NPRA) often does not find hidden pieces of dangerous goods in their routine controls.

There are especially three explanatory factors for this presented by informants in the study:

1. That the bending of rules and regulations are necessary to survive in the business.
2. That there is a divide between serious and unserious actors in the sectors.
3. That this divide is informed by the perspectives of the actors themselves.

#### 5. Discussion

The findings from the fieldwork in the Norwegian HGV-sector reveal some concerning issues related to the transport of dangerous goods. The research shows that dangerous goods are often transported secretly with mixed cargo, and in some cases, the drivers are not even aware of the nature of the cargo they are carrying. Additionally, some transport buyers are camouflaging dangerous goods in an attempt to reduce the cost of transport.

Despite the strict regulations, the Norwegian public roads administration (NPRA) often does not find hidden pieces of dangerous goods during their routine controls. Informants in the study provide some explanations for these practices, including the need to bend rules and regulations to survive in the business, the existence of a divide between serious and unserious actors in the sector, and how this divide is informed by the perspectives of the actors themselves. These findings highlight the importance of addressing the underlying causes of nonconforming behaviour and the need for effective regulation and enforcement to ensure the safety of individuals, property, and the environment in the transport of dangerous goods.

The relevance of ANB for the risk management of tunnels are apparent. In Norway both the NPRA and Directive 2004/54/EC mandate the utilization of risk assessment to improve tunnel safety. In the national Guideline for the risk analysis of road

tunnels (NPRA 2007) the types of risk analysis recommended are Standard risk evaluation og detailed risk analysis depending on tunnel type, and that the transport of dangerous goods should be considered if it surpasses the normal or expected. The results of this study suggest that the bending of rules (ANB) in the sector pertaining to the transport of dangerous goods is so comprehensive that the idea of the normal is skewed, and that the presence of ANB in the sector at a systems theoretical problem represents a known unknown in risk analysis of tunnels, especially pertaining to tunnel fires.

This calls for an application of ANB in research in the HGV sector to provide more a more accurate picture of the transport of dangerous goods to inform risk analysis of tunnels. Risk managers can address the challenge of non-compliance with regulations and potential dangers posed by the transport of dangerous goods by implementing a comprehensive risk management plan. This can involve identifying potential hazards and risks associated with the transport of dangerous goods in tunnels and developing strategies to mitigate them. Risk managers can work with the relevant authorities, such as the Norwegian Directorate for Civil Protection, to ensure that regulations and guidelines for the transport of dangerous goods are being followed and that drivers and transport companies are adequately trained and certified.

Additionally, risk managers can work with transport companies and drivers to raise awareness about the importance of following regulations and guidelines for the safe transport of dangerous goods. This can include training programs, communication campaigns, and incentives for compliance. Another important aspect of risk management is to continuously monitor and evaluate the effectiveness of risk mitigation strategies and adjust them as necessary. This can involve regular inspections of tunnels and transport vehicles, as well as ongoing evaluation of compliance with regulations and guidelines. Overall, effective risk management requires a proactive and collaborative approach that involves all stakeholders, from drivers and transport companies to regulatory authorities and risk managers.

The concept of Adaptive Nonconforming Behavior (ANB) poses a significant challenge to the risk management of tunnel safety. ANB is an established characteristic of the HGV-sector, where regulations pertaining to the transport of dangerous goods are routinely broken and bent to adapt to external and internal pressures. As a result, pieces of dangerous goods are often secretly transported with mixed cargo, and drivers may not know the nature of the cargo they are transporting. Furthermore, there is speculation on behalf of transport buyers to reduce the cost of transport by camouflaging dangerous goods. These activities may go unnoticed by routine inspections by regulatory bodies, and the consequences of an accident involving these unreported dangerous goods can be catastrophic for individuals, property, and the environment. Therefore, risk managers must address the challenge posed by ANB in the HGV-sector by employing measures such as increased monitoring and inspection, improved communication and training programs, and more effective enforcement of regulations. Failure to do so can compromise the safety of tunnels and put lives at risk.

## **6. Conclusion**

In conclusion, the findings of the fieldwork in the Norwegian HGV-sector reveal that rules and regulations related to the transport of dangerous goods are often bent or broken, leading to potential risks for tunnels and their management. The concept of ANB provides a useful framework to understand why and how these regulations are violated in the HGV sector, which cuts across all levels of the system and covers the violation of safety-related rules and regulations, as well as activities that deviate from established good practices.

Risk managers need to address these challenges by understanding the socio-technical systems involved in the transport of dangerous goods and implementing effective feedback mechanisms to ensure compliance with regulations. Moreover, there is a need to recognize the challenges faced by actors in the sector, including the economic pressures and the divide between serious and unserious actors. The adoption of proactive risk management strategies and continuous

improvement of safety management practices can help mitigate these risks and enhance tunnel safety.

Ultimately, the findings of this paper call for a greater focus on understanding the social element of the socio-technical systems involved in tunnel safety management, and the need for risk managers to consider the broader context of adaptive non-conforming behaviour of the transport of dangerous goods to effectively address these risks.

#### Acknowledgement

Acknowledgement is given to the hardworking and dedicated individuals who work in the HGV sector, who generously shared their time, knowledge and experiences with the researcher. Without their willingness to participate in this study, discuss hard topics this research would not have been possible. Your contributions have shed light on important issues and challenges in the industry and will help inform efforts to improve safety and risk management practices.

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