Journal of Rail Transport Planning & Management xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Rail Transport Planning & Management

journal homepage: www.elsevier.com/locate/jrtpm

Differences and similarities in European railway disruption management practices

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ARTICLE INFO

Keywords:
Disruption management
Rail systems
International comparison
Complex socio-technical systems

ABSTRACT

Disruptions severely undermine the reliability of railway systems. Consequently, a lot of investments are made to improve disruption management. Much has already been written about disruption management, often with the purpose of supporting operators in their decision making. However, to the best of our knowledge, this literature doesn't consider the structural differences of disruption management in different countries. An overview of the various ways in which disruptions are solved and conditions under which that happens could help rail infrastructure managers and train operating companies to reconsider the ways in which they operate. This paper takes stock of the similarities and differences in how disruptions are managed in Austria, Belgium, Denmark, Germany and the Netherlands. Of importance is not only how these systems work on paper, but above all what happens in practice, i.e. the habits and routines that operators have developed for solving disruptions.

1. Motive and research question

Train service disruptions pose an important challenge to railways as a reliable mode of transport (Golightly and Dadashi, 2017). European railway infrastructure managers (RIM) and train operating companies (TOC) have invested considerably in technology to help operators solve disruptions. Despite the automation of certain tasks and increasingly sophisticated information systems, railway traffic control remains a labour-intensive process performed by many thousands of operators working in control centres (Roets and Christiaens, 2015). Over the last decades these operators have experienced fundamental changes to the environment in which they operate. The introduction of market mechanisms (e.g. Council Directive 91/440/EEC), followed by regulations on a single railway market (e.g. Directive 2012/34/EU) have eroded national railway monopolies. The most important change has been the separation between RIMs and TOCs, and emergence of many private and semi-private or corporatized TOCs. It is therefore justified to speak of a networked instead of an integrated system for dealing with disruptions.

In such networked systems, reliable services require more than sound technical equipment and infrastructure. The operators of the RIM and the many TOC's still need to work closely together to provide reliable services. Interdependency becomes especially pressing during disruption management, when operators at different control centres have to solve the complex puzzle of rescheduling timetables, train crews and rolling stock in a coordinated manner. Coordination between control centres can be achieved through predefined plans and procedures, but ad-hoc measures are often necessary due to the dynamic and uncertain conditions under which operators work (Johansson and Hollnagel, 2007). There are many studies on railway unbundling and privatization in the academic literature (e.g. Link, 2012 this journal), but not much attention has been paid to the effects of these policies on the daily operations of

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https://doi.org/10.1016/j.jrtpm.2017.12.003
Received 10 July 2017; Received in revised form 12 November 2017; Accepted 18 December 2017
2210-9706/

controllers managing rail traffic and disruptions (See Steenhuisen and De Bruijne, 2009 for an exception to the rule). This is an important topic, since these restructuring policies and how they have been put into practice, have greatly impacted disruption management structures and practices in different countries (De Bruijne and Van Eeten, 2007).

Practical experience suggests that there are major differences and similarities in how rail systems have structured disruption management processes. A thorough literature search showed that there is currently very little research into those differences and similarities. We therefore ask: *what different types of structures and practices of railway disruption management have been developed in European railway systems?* We will take stock of both disruption management structures and practices in Austria, Belgium, Denmark, Germany, and the Netherlands. Since formalized plans set out in documents don't tell much about what happens in reality, our focus will be on *actual practices*. We will first discuss the main elements of the complexity of managing railway disruptions in Section 2. The research method is discussed in Section 3. Country characteristics are presented in Section 4 and then categorized in Section 5. The conclusions are presented in section 6.

2. Managing large complex infrastructure systems

Although restructuring policies have had a major impact on the ability of infrastructure industries to provide reliable services, not much is known on how these networks of organizations have been organized to reliably operate these systems (Berthod et al., 2017; De Bruijne, 2006). We start from the premise that disruptions in rail services will occur, and that their impact has to be minimized in order to return to normal services as soon as possible. We therefore want to understand how these disruptions are managed in different systems and how operators coordinate their actions *during* the process of managing disruptions. We thus see reliability as the ability of an organization to anticipate and contain incidents in the course of its operation (Berthod et al., 2017). This places an emphasis on how systems manage their adaptive capacity to successfully manage disruptions (cf. Branlat and Woods, 2010; Hémond and Robert, 2012; Mattsson and Jenelius, 2015). Complex systems have to deal with trade-offs that bound their adaptive performance (cf. Hoffman and Woods, 2011). In this paper, we focus on *two* such trade-offs: (a) decentralized versus centralized structure, and (b) anticipation versus resilience.

The occurrence of unexpected disruptions in complex systems places an emphasis on a decentralized structure, because detailed knowledge of the local context and direct control over resources give local actors the flexibility required to deal with these non-routine situations (Perrow, 1999). However, Perrow (1999) warns against the tight-coupling of complex systems and the risk of cascading failures. Disruptions can severely compromise the capacity of local operators to keep an overview of and control over the situation (Schipper, 2017). As a result decisions made locally don't always contribute to the overall performance of the system. One solution for this problem is to centralize control in order to facilitate rapid and decisive coordinated action. Centralized control, however, is not without its difficulties. Decisions require that a considerable volume of information is shared between the different levels of control; something that is not always possible when working under stress (Branlat and Woods, 2010; Schipper, 2017). Consequently, decisions may be perpetually lagging behind the actual local situation. It is therefore necessary to find the right balance between decentralized and centralized decision making.

The second trade-off concerns anticipation versus resilience (Vogus and Sutcliffe, 2007; Wildavsky, 1988). The anticipation approach involves the prediction of potential failures or disruptions in order to plan ahead (Stephenson, 2010). Part of this planning is the development of pre-defined coordination mechanisms, e.g. contingency plans, rules, and procedures, that specify roles and tasks for all operators. Pre-defined coordination mechanisms reduces coordination issues between actors, subsequently increasing responsiveness. However, it remains impossible to anticipate every situation. For instance, the type, location, and timing of an incident will influence the effectiveness of the response (Golightly and Dadashi, 2017). Consequently, there needs to be discretionary room for operators to modify plans to the specific situation through mutual adjustment and improvisation (Faraj and Xiao, 2006). Real time adaptation can be considered a resilience[1] approach that substitutes foresight for the reactive capacity of control room operators and focuses on their expertise and tacit knowledge (Roe and Schulman, 2008). However, an improvised response still needs to be swift and coordinated when dealing with a rapidly changing environment. Hence, anticipation and resilience are not mutually exclusive but constitute a trade-off when developing an effective response (Comfort et al., 2001).

There is not one single, optimal way of dealing with these trade-offs in general; and each railway systems will balance these trade-offs in specific ways (Woods and Branlat, 2011). Yet, the extent of these trade-offs in various European countries is currently unknown. This, then, is the motive of the current research. We will categorize the different national structures and practices of disruption management, with a focus on the trade-offs discussed above. Disruption management happens within the specific context of a country that (dis)allows for certain solutions. We will first look at the characteristics of the different railway systems, i.e. the length of the rail network, the number of train operating companies, the average daily number of trains being operated, and the relationship between the RIM and TOCs. Next, we will present the different roles and teams involved in disruption management and the relationships between them (section 4). Please note that our focus is on the rescheduling of resources (timetable, train crew, rolling stock), i.e. we only consider operators working at the control centres, not those directly involved in the management of an incident or emergency, e.g. emergency services or repair crew. We will then turn to the actual disruption management process itself and categorize the countries in terms of centralization vs. decentralization, and anticipation vs. resilience (sections 5 and 6). For both trade-

[1] We acknowledge that this is a simplified application of the concept of resilience, aimed at addressing the fact that disruptions fall outside the design principles of systems and systems thus require additional adaptive capacity. For a more elaborate discussion on resilience, see e.g. Boin and van Eeten, 2013; McManus, 2008; Stephenson, 2010; Vogus and Sutcliffe, 2007.