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# Beyond procedures: Team reflection in a rail control centre to enhance resilience

A.W. Siegel [a,*], J.M.C. Schraagen [a,b]

[a] University of Twente, The Netherlands
[b] TNO Earth, Life, and Social Sciences, The Netherlands

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ABSTRACT

Resilience engineering concepts can complement proceduralization of complex sociotechnical systems (STS). Proceduralization aims at defining precise and quantified system objectives, and at defining a process that describes and prescribes how to achieve those objectives. Although proceduralization has been successfully implemented to capture knowledge and experience, it is limited when the unexpected and unforeseen occurs. Resilience engineering focuses on this drawback and seeks for concepts to enable adaptive responses in these situations. We propose a team reflection process to enhance resilience of a rail STS, complementing its proceduralization. In the present study, we describe how rail signallers used team reflection, supported by a tool that allowed in-depth post-shift inspection of train movements. A near accident, occurring during a one-week observation, is described and used for two purposes. First, it was used as an example to explain the usage of the support tool. Second, it was used as a reference case of topics playing a role in evolving accidents. The analysis showed that the topic categories discussed during the team reflections were similar to the incident categories. This means that relevant topics are available, when things go right, to learn from and anticipate on. In addition, we showed that rail signallers, over the course of the observations, increasingly analysed and reasoned about their work. This enriched knowledge beyond procedures, enhancing the ability to cope with the unexpected and unforeseen.


## 1. Introduction

The approach of resilience engineering (RE) seems contrary to the proceduralization approach enabling sociotechnical systems (STSs) to cope with variability of external events. Resilience engineering deals with the ability of STSs to manage their spare capacity to cope with the unexpected and unforeseen (Leveson et al., 2006; Madni and Jackson, 2009). Margins are needed to manage the adaptation to these situations (Branlat and Woods, 2010; Cook and Rasmussen, 2005) when procedures do not exist for the unforeseen or are inapplicable during the unexpected. The emphasis in these situations is on the management of available abilities, for which RE seeks methods and tooling with relevant data to manage. On the other hand, the proceduralization approach focuses on procedures capturing knowledge on "how to do", job rules, ingenuity and know-how (Fucks and Dien, 2013, p. 27). Rules and procedures are key features for a modern organisation to function (Bourrier and Bieder, 2013) and can lead to confidence in task performance, but also allow a retreat from initiative and responsibility (Fowler, 2013; Schulman, 2013). Proceduralization aims at defining precise and quantified system objectives, and at defining a process that describes and prescribes how to achieve those objectives (Bieder and Bourrier, 2013). This contrast can also be seen as the search for balance between stability and flexibility in operations (Grote, 2014). The procedures have a stable character while the resilience approach has a more flexible one.

Combining both resilience and proceduralization may be beneficial despite seemingly divergent starting points: the rigidity of procedures capturing past experience may be joined with the flexibility to manage available nontangible capacities. Procedures embody the knowledge base of an organisation with respect to the operation of its technical system but rigidify behaviour and may result in mindless routine (Langer, 1989; Schulman, 2013; Taylor, 1911). Resilience promotes mindfulness but is as yet less tangible due to the complexity it is dealing with (Madni and Jackson, 2009; Woods et al., 2007). We propose to combine these approaches for a team in a rail control centre.

Rail signallers continuously fit unplanned train movements in the real-time flow of trains. They are responsible for their own part of the system, a particular geographical area in which they monitor

* Corresponding author.
*E-mail addresses:* A.W.Siegel@UTwente.nl (A.W. Siegel), J.M.C.Schraagen@UTwente.nl, jan_maarten.schraagen@tno.nl (J.M.C. Schraagen).

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the traffic situation or cope with a disturbed situation (Farrington-Darby et al., 2006; Heath and Luff, 2000; Steenhuisen, 2012). Within their decision space, they are expected to work according to prescribed procedures. When they have a break or finish their work, they transfer the status to the next signaller. Procedures with their deviations and other irregularities, at the moment of transfer, are communicated as facts and are seldom discussed. This type of information during their shift is only discussed when things go wrong and need justification and explanation. The results of these discussions, in some occasions, are fed back into procedure updates. The tools rail signallers work with support real-time operations, but offer few opportunities to look back to the past and discuss details. The log information is only available to analysts in the back-office, who analyse requested situations. Neither the tooling nor the regular process provide opportunities to the rail signaller to step out of the procedure space to learn to cope with its limitations. Their professionalism is mainly focused on following procedures. During training and inquiries, they can use their professionalism and think beyond procedures. This happens occasionally and even then the organizational directive to follow procedures remains. It would be desirable to be able to regularly distance oneself from procedural thinking (Norros et al., 2014), to see the continuous minor deviations of procedures, to be critical and open minded, and to share knowledge beyond procedures, which may be used when the unforeseen and unexpected occurs. We propose that before going home the whole signaller team will reflect (Reymen, 2003; Schippers et al., 2007, 2014; West, 2000; Wiedow and Konradt, 2010) on their shift with help of weak resilience signals (Siegel and Schraagen, 2014a). Team reflection includes behaviours such as questioning, analysis, making use of knowledge explicitly, reviewing past events with self-awareness, and coming to terms over time with a new awareness (West, 2000). Team reflection, in a loop with planning and action, is used in a broader reflexive process (West, 2000) where team members collectively reflect upon the team's objectives, strategies, and processes. This concept aims to improve the effectiveness of the team itself and stimulates organizational innovation in the context of the team's work. We extend this well-established reflection process in two directions. The first one is the scope of reflection and the second one is the subject to reflect on. The scope of reflection has so far mainly been limited to the reflecting team itself. We expand this to the whole STS, where the team is part of. Rail signallers operate at the sharp end of the system and are aware of the operating system beyond their scope of control (Flin et al., 2008). For example, they are aware of missing personnel on the trains, which, although not their responsibility, may cause a delay they do have to deal with. Second, the subject to reflect on are weak resilience signals (WRSs) (Siegel and Schraagen, 2014a), which contrasts to previously studied strong and explicit objects of reflection such as plans and performance failures (Schippers et al., 2014; Wilson and Norris, 2005). The knowledge made explicit through the reflection process may also relate to objectives, strategies, and processes but is not limited to these elements it and should go beyond them (Siegel and Schraagen, 2016). This resilience related knowledge, beyond the knowledge embedded in procedures, will enrich professionalism as well as knowledge for learning, acting and anticipation purposes. These abilities are three of the four resilience building blocks (Hollnagel, 2009), learn, act, anticipate and monitor, and as such are expected to enhance resilience.

A WRS is a resilience related signal which needs further investigation, as opposed to a strong signal which demands immediate action. We have developed a model measuring weak resilience signals of a rail STS (Siegel and Schraagen, 2014a). The WRSs are derived from movements of the operating system towards its boundaries. We adjusted the boundary categories initially proposed by Rasmussen (1997) for a rail system: performance, workload and safety. Each category was modelled to enable quantification and identification of relative movements – changes in value during the working shift compared to a previous period like a week, month or year. These changes can visualize unnoticed drifts, which may contribute to a failure (Dekker, 2011). These relative movements do not need absolute values of the boundaries, which exists in theory but are not known in the real world. The workload measurement model was split into two. The first component was an objective model measuring data from the operational system and was based upon the cognitive task load model (Neerincx, 2003). The second workload component was a subjective unidimensional model (IWS – integrated workload scale; Pickup et al., 2005) measured through a real-time App for each rail signaller. The workload models were tested during an observational study with off-line data. A discrepancy between both models stimulated additional inquiry by rail signallers in that study, which revealed an underlying operational obstacle concerning shunting (Siegel and Schraagen, 2014a). The performance measurement model, related to train punctuality, was tested through a second observational study with off-line data. An identified movement towards the performance boundary triggered further investigation and revealed an operational obstacle, which in that study concerned the communication between the police and rail signaller during a hooligan case (De Regt et al., 2016). The performance model has subsequently been extended to measure the punctuality of a controlled *area* and translated into a real-time application, which was used by rail signallers to reflect at the end of each shift during a third observational study (Siegel and Schraagen, 2016). We showed how reflection made resilience related knowledge explicit and how the reflection progressed throughout the observation week.

The aim of this paper is to investigate the influence of team reflection, at the end of each shift, on relative system movements with respect to *all* three boundaries. We are interested in capturing team knowledge used during the shift that goes beyond procedures. In addition, we are interested in comparing team reflection on three boundaries, one boundary and without any tooling. Our research question is how team reflection complements procedures and how that possibly influences resilience of the STS. How does the reflection progress in time? Do the three boundaries make a difference in the type of topics discussed? In order to answer this research question, we conducted a fourth observational study at a rail control post with a real-time prototype presenting system movements towards the three boundaries with analysis functions to support the reflection. As it happened, at the start of the observation a near-accident occurred, which we analysed for types of topics discussed as they naturally occurred and used this as a reference to the reflection processes occurring later on that week. We analysed whether there is a relationship between the reflection and the near-accident to answer the first question above. In the next section (2) we describe the methods used, which include the design and requirements of the reflection tool, and the observational setup and analysis. In Section 3, we present the results including the reporting and analysis of the near-accident case. In the last section (4) we discuss the results to address our research questions and their theoretical implications.

## 2. Methods

### 2.1. Requirements and design of the reflection tool (Resiliencer)

Team reflection needs a tool to support the process of identifying weak resilience signals (WRS; Siegel and Schraagen, 2014a) and making resilience related knowledge explicit (Siegel and