Resilience in rail engineering work

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Abstract. This paper discusses an ongoing project that aims at improving the potential for resilience of a system responsible for the planning of rail engineering work delivery. This is being addressed by means of a methodology based on the observation and analysis of "real" planning activities, using resilience engineering concepts as a background. Interviews with planners have been carried out to provide an overview of the planning process and steer more in-depth investigation. Analysis of historic information and observation of planners' main activities is underway. Given the nature of the process under study, information flows and communication issues have been given particular attention throughout the data collection and analysis stages. Initial data confirms that the planning process is greatly reliant on the capability of people using their knowledge and skills to communicate in a dynamic informational environment. Evidence was found of communication breakdowns at the boundaries of different planning levels and teams. The fact that the process is divided amongst several different areas of the organisation, often with different goals and needs, creates potential sources of conflict and tension.

1 INTRODUCTION

Rail transportation is today broadly accepted as a complex and safety critical system as it faces pressures and reliability demands that much resemble those of air transportation or nuclear industry (Amalberti 2001). A need for sustainable transport solutions is contributing to a higher political and public focus on rail transportation throughout Europe. For the UK rail industry, in particular for Network Rail as the owner of rail infrastructure, engineering is facing a remarkable challenge to deliver, not only higher volumes of maintenance work as a response to a more intensive use of rail infrastructure, but also, enhancement projects capable of satisfying demands for a higher capacity of rail transportation. Thus, a balance between the pressures for

higher productivity and the assurance of the required safety standards has become a critical aspect for the sustainability of rail organisations.

The planning of rail engineering work, in a simplistic way, can be described as a system that aims to schedule the delivery of all work requests within a calendar year, whilst optimising the integration and usage of available resources, of which access to the infrastructure could be considered the most critical one. Although planning begins about 90 weeks before foreseen date of delivery, many work requests are brought in at various stages of the process in a response to unforeseeable infrastructural and business demands. Each work item planned is then delivered within a worksite, which is integrated and protected under arrangements designated as possessions (taking control of a section of track for engineering works). A significant volume of less complex maintenance work (in general, those that do not affect the safe running of trains) is often delivered under variations in the protection arrangements.

Part of the industry's response to its current demands is thought to lie with the adoption of more flexible ways of planning and delivering track work, together with ongoing investments in higher output technology. Within this context, engineering work planners are driven to trade-off between work requests and available resources, facing ever more complex decisions whilst the variability of the system increases and any spare capacity that may have previously exist is reduced.

Within an ongoing research project, Resilience Engineering (Wreathall 2006) is proposed as a theoretical background to develop a better understanding of how the increasing complexity of planning may be efficiently and safely managed. The purpose is to improve the ability of the engineering work planning system to respond to its current challenges by identifying opportunities to incorporate resilience engineering concepts and approaches. This paper discusses the initial data collection and analysis methods applied. Based on the results produced so far, it then offers an overview of the identified main factors that potentially determine the level of resilience of his system.

The work under discussion in this paper consisted of an overall identification of main planning issues and the characteristics of the existing process. Given that the system under analysis is mostly based on the production and distribution of detailed information (first in the form of an annual work plan and then as a delivery plan for each possession and respective worksites) to support engineering work delivery, the analysis of information flows within the system was considered a viable steer for this research. Based on this framework, the following objectives were defined for this initial work stage:

1) Identify how resilience engineering concepts may be useful to improve the ability of the engineering planning system to meet its current challenges.
2) Identify actual planning activities beyond their formal procedural description.
3) Identify constraints and issues related to system's performance that may hinder planning reliability or represent a risk for planning failure.

2 METHOD

Semi-structured interviews were conducted with planners at different ranks and levels of the process and from different areas of the country. The interviews were based on a set of ten questions (table 1) and recorded for later transcription and analysis. The analysis focused more on concepts and ideas given by interviewees, to identify major trends and give direction for more in-depth analyses. To avoid any distortion of information, transcriptions were reviewed and checked against original recordings. Whenever necessary sentences were transcribed and in some cases, the person interviewed was contacted again for additional clarification.

Table 1. Topics that formed the basis of the interviews

1. Can you tell me about your job (daily tasks, duties)?
2. Can you explain the planning process from your point of view? How would you describe your influence/role in the process?
3. How often would you say your job changes (How and what changes)?
4. Do you normally feel confident regarding the outcome of the planning activities in which you take part? Can you identify any recurrent uncertainties that you are faced with?
5. What would you say are your main skills and competencies?
6. How would you describe the overall set of rules and procedures applicable to the planning process?
7. What type of information do you use most? How important is it in your job?
8. What do you consider to be the current major challenges for track work delivery? How does the planning process respond to those challenges?
9. What does resilience mean to you?
10. Throughout your professional experience in this area, what success stories come to your mind? What failures?

3 RESULTS

The duration of interviews varied from about 50 minutes up to nearly two hours, depending on how interviewees elaborated on each subject. About 16 hours of recordings were made for a total of 13 interviews, of which 7 were held with managers of planning units at area and territory level (see figure 1).

The age of interviewees ranged from late 20s to 50s, with an average placed between 30 and 35 years old. Even the younger planners had at least three years of experience in planning and the majority had 10 or more years of experience in different roles and levels of the rail engineering industry. A number of issues, below, give further insight into resilience in planning.

3.1 Functions and roles in the planning process

It was recognised by all planners interviewed that the core elements of jobs in planning haven't changed over the last few years. However, at least half of the interviewees referred to the frequent process and organisational changes as an obstacle to the development of solid working relations and often providing little opportunity to consolidate expertise. In particular, one planner stated that it took

him/her some 5 years to develop confidence in the job. Mainly, planners consider part of their duties to monitor the compliance with procedures and verify accordance between access, resources and work requirements at their respective planning level.

Interviewees in management positions reported that one of their main functions was the monitoring of the overall development of planning ("looking at the bigger picture") and support of decisions towards achieving a nationally integrated plan that responds to the industry's needs. In particular, area planning managers (2 of the interviewees) expressed this need as a way to maintain control over financial aspects because of the relation with contractors. Senior managers (3 interviewees) also added the need to buffer and mediate between the team and the outside as part of their functions.

3.2 Uncertainty and unpredictability

Dealing with uncertainty and unpredictability was recognised by all interviewees as part of the daily activity in planning. Six of the planners characterised uncertainty as a major obstruction to reliable planning. This factor is managed, whenever possible, by working on contingency solutions and being prepared for anything that might require rebuilding plans. Job experience and overall understanding of the railways were considered by the majority of planners as decisive, not only to explore different possible contingencies (i.e. different ways of delivering work) but also to adequately integrate these within the planning process (i.e. anticipate and solve potential conflicts). Planners know that some contractors tend to fail more than others in terms of reliability and quality of work. When the possession manager (organisation or function that owns the work requested) is someone they know to be less reliable, planners try to allow additional spare time at the end of the possession for problem recovery (contingency plan).

Planning changes were mentioned by all planners interviewed as the main cause of variability and unpredictability of the job. Although not necessarily affecting their ability to develop a robust plan, this was also considered the main deterrent factor of confidence in the performance of the whole planning organisation. The majority of planners tended to consider that changes are more or less directly originated by priorities that emanate from company board level. These create budget and work scope changes for work items already undergoing planning and cause knock-on effects throughout the entire planning structure. Because changes normally emanate from outside the planning structure, it is beyond the control of planners to try and manage these effectively.

3.3 Skills and job experience

Experience and overall industry knowledge were mentioned by all planners as an important resource to realise what information is required at each step to support planning decisions. According to planners this enables an understanding of what the impact of planning decisions might be on the day of delivery.

Experience also becomes relevant for the building of solid relationships with stakeholders, such as other functions within Network Rail (Infrastructure Investments, Maintenance), Customers (train operators) and engineering contractors among others. By knowing how people work and respond under different circumstances, planners are able to anticipate potential problems. Also, these

relationships establish levels of confidence and mutual trust that support informal discussion of issues and problem solving.

3.4 Rules and procedures

A standardised and mapped process that establishes common time scales for each of the planning stages has been in place at national level for nearly three years. This was considered a major improvement by all interviewed. Three people stated that failing to comply with the planning process was one of the major factors contributing to the erosion of planning robustness. However, rules and procedures are not always seen as helping the process. There is often room for interpretation and business pressures lead to breaches of the planning procedures. Experience and expertise are pointed out as the fundamental tool to tackle the problems arising from this. It provides the ability to develop contingencies and the foresight of the potential problems.

Overall, people involved in short-term planning (possession and worksite planning) mentioned difficulties in keeping up to date with frequent changes to the rule book and understanding how those changes actually affect their activities. All planners in management positions added that following procedures and rules is a safeguard when facing conflicts with stakeholders.

3.5 Information flows and communications

All interviewees pointed out information and communication channels as a crucial resource for planning. One planner stated that the job consisted on collecting and delivering information for 90% - 95% of the day. Two different trends in information problems were identified:

- For long term planning, issues with information are mostly related with the great diversity of formats and sources of work requests that have to be dealt with, as well as the different timings in which functions input to the process. Three planners referred to this high variability in information as a major cause of time loss and of some frustration due to the duplication of work in which it often incurs.

- Within short term planning, in particular at pre-possession stage (usually three days before delivery), the lack of up-to-date and accurate information and frequent uncontrolled late changes are the main cause for concern. Several planners stated that information at this level can be crucial to prevent a possession from overrunning or even causing serious losses or injuries.

There was a consensus amongst all planners that the organisation is able to generate the necessary information to develop a reliable and detailed plan. However, planners were also unanimous when considering that the way in which information is made available and processed does not support them adequately. All interviewees mentioned the frequent need to cross check and chase accurate information. Planners try to mitigate poor quality information issues by developing solid relations with people within stakeholders they feel they can rely on. All planners valued these work relations and tend to go to them, rather than relying on the organisation and its formal communication channels.

3.6 Perception of resilience

The majority of the planners showed little awareness of the concept of resilience. However, after a brief description of the research field of resilience engineering, all interviewees related resilience in planning with the way in which the system is able to reliably and efficiently manage and integrate change. Three planners associated resilience with the ability of people facing up to adversities created by business and operation pressures. All planners considered themselves as a key element for the reliability of planning. They demonstrated being aware of the fact that at some point, making decisions comes down to a judgement call as to whether or not the information provided for each work item is solid enough to undergo planning.

The breakdown of the process, attributed by planners to the fact that it operates divided between investments and maintenance as well as territory and area level teams (figure 1), was mentioned as a major obstruction to planning efficiency and reliability.

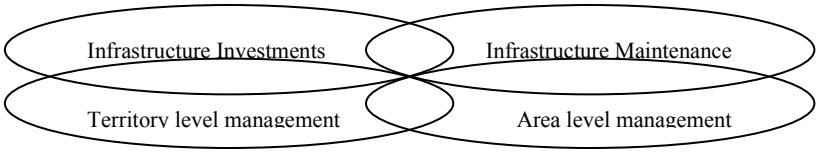

Fig. 1. Main organisational functions and levels of management that compose the planning system. Within each of these structures, independent teams develop specific stages of the planning process, which then exchange information at formally pre-defined timescales.

The planning organisation operates under considerable exposure to business and operation pressures, as it deals directly with critical decisions regarding the delivery of Network Rail's service to its customers (train operators) through infrastructure management and train paths. Planners generally expressed this pressure through the need to solve conflicts created by insufficient access to respond to all requests for maintenance and enhancement works. All interviewees recognised having experienced pressures from stakeholders to get their requests prioritised through planning and optimise resource availability to deliver the job in question. Given that often stakeholders are unable to meet planning requirements, planners are also pressured to overlook procedures and allow jobs to go through.

Because of insufficient track access opportunities for all work demands, investments and maintenance compete with each other for priority. Planners admitted that the fragmentation of the process intensifies this competition, leading to occasional conflicts and tensions, as each team attempts to minimise the impacts of business and operation pressures over their own performance. Nevertheless, most interviewees recognised that the adoption of a national integrating process, together with improved informal communication, have minimised these issues.

4 DISCUSSION

The planning process is greatly reliant on people and their ability to communicate and relate with others within the planning organisation, not only from within Network Rail but also from engineering contractors and train operators.

Planners recognised a continuous improvement to the system over recent years, in particular, to the way in which it produces and manages information. However, the current fragmented organisation clearly generates communication breakdowns at boundaries of different planning levels and teams. This is mainly substantiated by the poor visibility and information that planners claimed regarding how the system performs outside their working teams. This poor information support generates constant planning changes and was identified by all planners as the main source of uncertainty and unpredictability regarding the performance of the planning as whole. Given the importance that planners attributed to information, these issues clearly erode the potential for resilience of this system.

The high focus of the system on information flows gives significant relevance to the decisions made by planners throughout the process. These decisions in effect, are the means through which the system balances the work requests against the available track access. From a resilience engineering perspective, the decision processes employed by planners give shape to the trade-offs of the system.

Considering the way in which planners described their role towards the reliability of the system, we can conclude that the level of experience and the overall knowledge of the rail industry, contributes significantly to the increase of resilience potential. As stated by the majority of interviewees, experience becomes fundamental to establish trustworthy work relations, which then support the development of informal communication channels. Planners draw on these relations to bypass the organisational barriers and all the constraints it may impose on them, aiming to anticipate planning conflicts and build appropriate contingency solutions.

Table 2 briefly illustrates the relation between these factors and the potential for resilience. The planning decisions are given as the crucial element to determining the potential for resilience. Factors that hinder resilience appear to be balanced by a specific behaviour of planners. For instance, planners make use of their experience and overall knowledge of the industry to deal with the constraints imposed by organisational breakdowns. In the same way, Informal communication is directly aimed at minimising the impacts of the poor information formally provided by the process.

Table 2. Factors that influence the potential for resilience

Erosion of the potential for resilience	Enhancement of the potential for resilience
Organisational breakdowns	Planning experience and kills
Variability of inputs from stakeholders	Solid work relations
Poor information flows	Informal communication
High uncertainty and unpredictability	Understanding the impact of decisions
Planning decisions (trade-offs)	
Frequent planning changes	Development of contingency solutions

Further research is required to clarify the role played by these factors and their interdependency within the planning system. The next stages of the project will also help to determine how resilience within planning impacts on the delivery of engineering work.

5 FUTURE WORK

Given the high complexity and broadness of the field under research, several approaches to data collection and analysis are foreseen, aiming to develop a better understanding of the trade-offs that form the background of decisions made by planners throughout the process. The following analysis steps are being considered:

- Analysis of information from archives: The main goal of this approach is to identify what plan changes are made and at what stages of the process these are imported.
- Observation of planning meetings: The goal will be to complement the previous analysis by detailing the origin of change in planning.
- FRAM - Functional Resonance Analysis Method (Hollnagel 2004): A representation of the formal planning process is currently underway. This will then support the mapping out the actual planning of specific work items (using historic data) and potentially, identify critical areas for system failure based on the functional resonance concept.

6 CONCLUSIONS

The environment in which the planning system operates clearly shows high variability and unpredictability. Under these circumstances the identified business and operational pressures create a considerable potential for failure. Although the consequences of planning failure are rarely associated with the risk of human losses, there's a considerable risk for loss of work opportunities and resources which can result in serious financial loss. Within this context, research based on resilience engineering concepts seems relevant.

The methodology devised for this project has so far, adequately met its goals and scope. The possibilities for all the data streams and later analysis to complement each other can support improved understanding of the system's behaviours and performance variability. It is expected that the subject under analysis (information flows) will provide an initial understanding of the potential for resilience and the identification of other significant areas of research towards this end.

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