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Punctuality problems from the perspective of timetable planners in Sweden

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Abstract

Previous research has shown that timetables are important for punctuality, and research is ongoing on how to improve timetables through more simulation, optimization techniques, better scheduling of track works, and data analysis. Relatively little attention has been given to the actual planners. In this study, we have conducted interviews with timetable planners in Southern Sweden, and analyzed the interviews with the perspective of explaining Swedish punctuality problems. From these we have identified four common errors in timetables, such as “conflicting train paths at stations” and “insufficient dwell or meet times at stations”. These errors cause, increase and spread delays, and require recurring interventions from traffic control. We also identify 11 reasons for such errors, such as “insufficient time for quality assurance of timetables” and “missing tools for track allocation and conflict management”. We discuss three themes among these reasons: “missing tools and support”, “role conflict”, and “single- rather than double-loop learning”. New tools and processes are currently being rolled out, which is expected to improve the situation with regards to the first of these themes. While the role conflict will remain, the new tools can perhaps also help to elevate the planners from first- to double-loop learning, allowing them to focus on quality control and on finding better rules and heuristics.

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1. Introduction

Railways are an important part of the transport system. In Sweden trains travelled 153 million km during 2015, which is an increase of 9 % over five years (Transport Analysis, 2016). The amount of passenger traffic has increased by 16 % over the same period, and in 2015 passenger trains made up 83 % of all trains. The amount of freight traffic was the lowest since 1990, although the freight transported by rail has risen slightly as the loads have increased. The capacity is most heavily utilized around the three major metropolitan areas of Stockholm, Gothenburg and Malmö-Lund. A quarter of the metropolitan lines are very heavily utilized, at levels associated with high sensitivity to delays, low average speeds and little time for infrastructure maintenance (Grimm, 2017). On the rest of the network, only about five percent of segments are utilized to the same extent. When measured during peak loads, these figures are higher across the board.

The punctuality of trains in Sweden has been close to 90 % for the last several years (Transport Analysis, 2016). This is considered too low by the industry, which has set a goal that it should be 95 % by 2020. This ambition to increase punctuality is the backdrop for our research, and for this paper. Many factors influence punctuality, such as weather (Xia et al., 2013; Brazil et al., 2017; Qin, Ma & Jiang, 2016), congestion (Gorman, 2009), other operational factors (Olsson & Haugland, 2004; Olsson et al., 2015), and infrastructure (Veiseth, Olsson & Saetermo, 2007).

Previous studies also indicate that properties of the timetable can have a large impact on delays and punctuality, that delays often occur at station stops and that dwell times are systematically underestimated (Parbo, Nielsen & Prato, 2016; Wiggenraad, 2001; Nie & Hansen, 2005; Palmqvist, Olsson & Hiselius, 2017). Thus, there is reason to believe that errors in the timetable may affect punctuality, and to investigate these errors and their causes. While extensive research has been carried out on the human-machine interface in train traffic control in Sweden, see for instance (Kauppi et al. 2006; Tschirner, Sandblad & Andersson 2014; Sandblad, Andersson & Tschirner 2015), and some work has been done on the integration of timetable planning and traffic control (Hellström, 2013), relatively little research has been done on timetable planners and their tools. Watson (2008) covered timetable planning in the UK, which has many similarities to the Swedish context, and ONTIME (2014) contains some expert judgment on the state of practice in Sweden. A large project is currently in progress at the Swedish Transport Administration, developing new tools and routines for timetable planning, increasing national interest in this topic. These tools are intended to modernize the interface between train operating companies and the Transport Administration, support more flexible and optimal planning, improve capacity and punctuality, shorten planning lead times, improve transparency and the handling of engineering works, and more (Swedish Transport Administration, 2017).

The aim of this paper is to identify the most common errors in Swedish train timetables influencing the punctuality, the reasons behind them, by interviewing the timetable planners. Both the errors and the reasons behind them are important to understand and consider, as the new tools and routines are implemented.

2. Background

2.1. *The timetable process and planners*

Watson (2008) discusses time table planning as a process by which a ‘demand’ for rail transport (passenger and freight) is connected to the ‘supply side’ constraints (especially available infrastructure capacity) in order to produce timetables that meet the demand. Through train planning, railway administrators aim to meet the needs of customers whilst utilizing available resources as well as possible. Efficient and effective train planning is the key to get the best possible performance on a railway network.

Infrastructure management supply the available capacity on the railway, while train operating companies represent the demand for transport. Timetable planners are squeezed in between these needs, which sometimes conflict (Wood & Robertson, 2002). The interaction between infrastructure, capacity and timetable planning is found on a strategic, tactical and operational level. The strategic level is typically long term, over several years, and can be related to new infrastructure or new timetable structures. The tactical level is related to producing a timetable implemented in a shorter perspective, typically one year. This paper mainly studies tactical timetable planning. Operational timetabling is related to timetabling within a defined time table period, making short term changes to a timetable, often a few weeks or days in advance.

Timetable planners prepare train timetables and other documentation related to planned changes for passenger

and freight trains. Planners are often faced with the challenges of working with complex timetabling (Watson, 2008). In addition to the complexity of the planning itself, they must be able to deal with different stakeholders in the railway sector and have conflict resolution skills. Timetabling has largely been studied from a technical and optimization perspective (see for example Pahl, 2002; Hansen, 2009). However, timetabling can also be studied from an organizational perspective. For instance, Avelino et al. (2008) study politics of timetabling, comparing Dutch and Swiss experiences. One aspect they study is the level and type of privatization, where Switzerland and the Netherlands have different characteristics. Watson (2008) found that the privatization of British Rail had a negative effect on the timetabling processes. The problems were a result from poor planning and rushed implementation of new organization of the British railway sector. Since then, both the British and Swedish railways have gained experiences from the new structures with a division between infrastructure and train operation. However, the inherent characteristics of the divided structure remain.

A final timetable must satisfy the needs of travelers, public and private parties, while maintaining the fairness, transparency, reliability and safety of the railway system. The train service specifications are passed to the timetable planners, who produce the timetables. However, these specifications can be in violation of guidelines, or there can be conflicting needs of different train operators. Watson (2008) found that the complexity of the timetabling and capacity allocation processes can hinder effectiveness, highlighting the conflicting nature of objectives for timetable planning, especially in the privatized railway.

2.2. The basis for timetable planning, the capacity allocation process

The annual capacity allocation process in Sweden corresponds to the tactical level of planning described above. The process as described here follows from the Network Statement published by the Swedish Transport Administration (2016), and from an excellent account in Hellström (2013). First the train operating companies send in requests for the capacity they want in the next year. The timetable planners at the Transport Administration combine these requests and, following their rules and guidelines for how to plan timetables, come up with a draft that contains all the train timetables for one year. In case there are conflicting requests, such that not all trains can be run when and where the train operating companies desired, there is first a step where the parties are encouraged to coordinate amongst themselves. If this coordination is unsuccessful, there is a process where the Transport Administration together with the parties tries to settle the dispute. If these attempts are also unsuccessful, parts of the infrastructure can be declared to be saturated, and the planners at the Transport Administration use prioritization criteria to determine which train has priority over the other, sometimes entirely rejecting the other requests. In yet another step, the train operating companies can appeal the decision of the planners to an administrative court, if they are unsatisfied with the planners' decisions.

2.3. Tools for timetable planning

The Swedish Transport Administration currently uses the tool Trainplan to create timetables, a tool which is also used in the UK railways (Watson, 2008), and is reviewed by Hammerton (1996). RailSys is increasingly being used to perform limited test runs of parts of the timetable using stochastic simulation, on a more detailed infrastructure model, and can address many of the issues presented in this paper. As in the UK, the group of trained users is small and used only as a complement to the main planning process. These software packages, their use, and their limits are discussed in depth by Watson (2008). One of the most important constraints is that Trainplan does not provide automatic conflict detection, requiring planners to check for these manually. As each planner plans for thousands or tens of thousands of trains per year, this is a recurring issue. New tools and processes, intended to improve the quality and efficiency of the timetable process roughly along the lines discussed in ONTIME (2014), are under development at the Swedish Transport Administration, and are to be rolled out gradually from 2018 through 2020.

2.4. Routines and learning processes connected to timetable planning

Timetabling is governed by several restrictions, such as safety requirements and organisational policies. A routine or heuristics perspective can be applied on the activity. Routines can be defined as “a repetitive, recognizable pattern of interdependent actions, involving multiple actors” (Feldman and Pentland, 2003, pp.96).

Heuristics (Kahneman et al., 1982) are cognitive rules of thumb or shortcuts or that people apply, consciously or unconsciously (Bazerman, 1998). Argyris and Schön (1996) presents learning as understanding and eliminating the gap between the expected result and the actual result of an action. This gap can be eliminated either by making changes (taking corrective measures) within the existing values and norms, or by changing the existing values and norms. The former is called single-loop learning and the latter is called double-loop learning. Single-loop learning is connected to doing things right, in accordance with the existing values and norms. Double-loop learning is about doing the right things, by questioning the existing values and norms. This is a concept we return to throughout the paper.

According to Loock and Hinnen (2015), organisational heuristics are the results of collective learning processes. They found that successful organizations refine their heuristics over time, as a result from feedback-loops. Organizational heuristics can also interact with individual heuristics and with improvisation in the decision-making process (Bingham and Eisenhardt, 2014). Kirkebøen (2009) shows that heuristics can be biased, such as a bias to rely on the information that is most available or a bias to search for information that confirms rather than contradicts a decision.

3. Methodology

The aim of this paper is to identify the most common errors in Swedish train timetables, and the reasons behind them. For this, interviews with timetable planners are carried out. We use a qualitative method since this allows us to effectively study the values and priorities of those involved, as well as processes, power relations and interactions. In this choice of method, we thus apply a qualitative approach on a topic that is typically studied using quantitative methods. We prepared an interview guide with roughly forty open-ended questions and conducted interviews with four time table planners, working at the Transportation Administration's office in Malmö. Each interview was approximately an hour long, recorded, and transcribed in full, resulting in a written material of around 50 pages. The results were analyzed by manual categorization and concentration of meaning.

The process of analyzing the transcribed material was carried out in sequence. The first step was to sort the differences exchanges by topic, rather than chronologically, what (Kvale 1997) and (Hammersley & Atkinson 2007) call categorization. The second step was to concentrate the meaning of the answers (Kvale 1997), cutting superfluous words and sometimes reformulating entire paragraphs into a few sentences. This was a time-consuming process, taking about as long as the transcribing. It was also a necessary process, to make it feasible to get an overview of what was said, and the volume of text was reduced from 24 500 words to only 4 500. We kept copies of the full transcripts, so as not to lose material and potential quotes. All these steps were performed manually.

Having concentrated the interview answers, we made a more detailed sorting, and 16 new sub-categories were identified. Following this we summarized the contents, topic by topic, also manually. This reduced the volume from 4 500 to 500 words, and made it manageable to get an overview of the contents. Based on this we identified instances in the interviews where the planners described feedback from traffic control, about errors in the timetable, and we identified the ones that were mentioned most frequently. We also identified several statements that could explain why errors sometimes occur in the timetable, and condensed these into a list of eleven reasons. At this point we looked for different ways to group and categorize the answers, looking for themes on a higher analytical level, and came up with the three following categories, which we use in the analysis: “missing tools and support”, “role conflict”, and “single- rather than double-loop learning” (see Argyris and Schön (1996) and section 2.4 above). These themes are used to explain and discuss the reasons behind the errors more deeply.

4. Results

The Swedish timetable planners describe receiving daily feedback from traffic control, primarily centered on four areas: (a) crossing train paths at stations, (b) wrong track allocation of trains at stations, especially long trains, (c) insufficient dwell and meet times at stations and (d) insufficient headways leading to delays spreading. Based on the interviews, we have identified 11 reasons that the timetables sometimes lack in quality, allowing the errors to occur. These reasons were not explicitly stated or described as such, but were identified by reading and sorting through the transcripts. We have also identified three common themes that run through the list: “missing tools and support”, “role conflict”, and “single- rather than double-loop learning”. This is all summarized in Table 1 below.

Table 1. Reasons that errors occur in timetables. The four types of associated errors are: (a) crossing train paths at stations, (b) wrong track allocation of trains at stations, especially long trains, (c) insufficient dwell and meet times at stations and (d) insufficient headways leading to delays spreading. (a) - (b) make the timetable infeasible without intervention from traffic control and are therefore considered the most critical, and can be described as inadvertent mistakes. (c) - (d) systematically leads to delays occurring, increasing and spreading, and are made intentionally to accommodate the train operating companies, even if the consequences are not fully understood. Note the high extent that these errors are focused around stations.

#	Reason for lacking quality, description	Associated errors	Theme 1. Missing tools and support	Theme 2. Role conflict	Theme 3. Single- rather than double-loop learning
1	Insufficient time for quality assurance of timetables	a, b, c, d			X
2	Too many issues to keep in mind manually for planners	a, b	X		X
3	Work is becoming more difficult due to increasing congestion	a, b	X		
4	Congestion on stations, especially large and complex stations	a, b, c, d	X		
5	Missing tools for track allocation and conflict management	a, b	X		
6	Liberal interpretation of the planning rules and guidelines	c, d		X	
7	TOCs ask for shortcuts to fit more trains into the timetable	c, d		X	
8	TOCs want short dwell times to avoid trains waiting	c		X	
9	No clear strategy for the location and size of time supplements	c, d		X	X
10	Poor feed-back and evaluation of timetables, no routine for continuous improvement	a, b, c, d			X
11	Poor knowledge transfer to new planners, poor documentation	a, b, c, d			X

The leftmost column in Table 1 contains an identifying number, used in the following sections, the second column from the left describes the reason for lacking quality, and the centremost column identifies which of the four common errors (a) - (d) is associated with this reason, these errors are discussed further in the table text. The three rightmost columns illustrate how the eleven reasons map onto the three themes we have identified. Each of these themes is discussed in the following sections.

4.1. Missing tools and support

One theme running through the interviews is that the proper tools to perform timetable planning are missing. This is most clearly illustrated by reasons #2-5 in Table 1. Based on the answers given, it is clear that such tools would free up time and allow a shift in focus from the details to quality assurance and a better overview of the timetable. The planners state that they must keep track of which model of signaling control is present at each location and how it works. This is complicated and the planners describe that there is very little support available.

The main tool used by the planners in Sweden also lacks functions for track planning, conflict management, and does not inform about the topography. They say that these functions were intended to be part of the tool when it was procured in the early 2000's, but the implementation of these modules was cancelled, allegedly because the quality of infrastructure data was too poor. New tools for both planning and control of traffic are under development, and the planners hope that these important functions will be implemented in the coming years.

The guiding document for timetable planning was mentioned by all four planners, but was not very helpful and is interpreted liberally. A new version is said to be arriving soon, but this has been said for several years. The planners also state that the problem of insufficient capacity is worsened by operational timetable planners being less rigorous in following the guiding documents, when inserting new trains into existing the gaps that do exist.

4.2. Role conflict

Another underlying theme is the inherent role conflict of timetable planners, which is best illustrated by reasons #6-9 in Table 1; an overly liberal interpretation of the planning rules and guidelines and that train operating companies ask for shortcuts to fit more trains into the timetable and want short dwell times to avoid trains waiting.

One example of this is how the decision to deny a train request, because of capacity constraints, is described as

very difficult and controversial. Denied requests can be, and often are, challenged through the formal capacity allocation process described in section 1.4, which leads to a lengthy and difficult legal process of showing that everything was done correctly and transparently. Producing a timetable which cannot in practice be executed as scheduled, and which is likely to cause delays, is not subject to the same formal procedures or complaints.

Another example is how the more experienced planners focus more on discussions with the train operating companies than a strict application of the guidelines. In Sweden, the train operating companies mostly agree between themselves and apply with detailed timetables, which the planners only adjust when necessary and then in dialogue with the companies, doing what they can to squeeze the trains in. For instance, insufficient dwell times and negative margins are often given to local trains on single tracks, on request from the train operating companies. The rationale for this differs from planner to planner, but “it has always been done like this”.

4.3. *Single- rather than double-loop learning*

The last theme is best illustrated by reasons #1-2 and #9-11 in Table 1, and refers to the concept described in Argyris and Schön (1996) and section 2.4. The timetable planners have a large amount of individual responsibility: in the number of timetables that they must create, in learning the relevant signaling control systems, in applying the rules and guidelines, in assigning margins, in creating robustness, and in controlling the quality. They describe that it takes a long time to learn the geography, and that there is no time for quality control. The task gets harder and harder because the number of trains and engineering works are increasing.

There is no systematic evaluation. This is up to planners individually, and they say that they do not have the time. Important preconditions change from year to year, making it difficult to compare between different timetables, and to transfer the notes made about feedback and errors from one year to the next one. This contributes to the conditions described in ONTIME (2014, p.37), also commenting on the timetabling process in Sweden, for instance that “the accumulated know-how of train dispatchers and train drivers is not fed back to the timetable construction process to any larger extent”. It is also difficult to transfer long experience: even though some education and transfer of knowledge to new planners is happening, it is described as insufficient and too short.

The planning work in Sweden is centered on finishing the timetables in time, keeping in mind all the technical details and constraints of different signaling control systems and rolling stock, the topography, crossing train paths, track allocation and so on. This is a direct parallel to the situation in the UK described by Watson (2008, p. 112), where “achieve all timetable production timescales” is listed as the number one priority among timetable planners at Network Rail, and “error free” only as number six, in a ranked list of eight priorities. The lack of support and proper tools means that there simply is not enough time or energy left to assess whether the rules and guidelines are the best or most appropriate ones to use. There is not enough time to consider what would make the timetable better, or to ensure that the errors from previous years are not repeated.

5. Discussion

Based on interviews with timetable planners in Sweden, we find that the most common errors in timetables lead both to infeasible timetables which necessitate intervention by traffic control, and to delays occurring, increasing and spreading. The situation is very reminiscent of the one described by Watson (2008) in the UK, preceding our study by almost a decade. In the reasons behind these errors we find three themes.

The first is that proper tools and support are missing, mostly a technical issue. Conflicting train paths, track allocation and constraints due to different signaling control systems could all be handled well through software, but the tools currently used to not do this. As new tools and routines are implemented, it is important to ensure that these important functions are included, and that enough high-quality data is provided for the systems.

The second theme is that of a role conflict for planners, which is mostly an organizational issue. On the one hand, they must strive to meet the demands and of the train operating companies. On the other hand, they must be unbiased and create a timetable that has a very high quality overall. While the conflict cannot be entirely avoided by technology, new tools and processes can diminish the consequences by no longer permitting some of the things which train operating companies often request, such as negative margins and very short dwell times. In this way, the more egregious errors can, perhaps, be eliminated. The planners would then also have more support when saying no to some requests from the train operating companies, but this support could be given in other, less technical ways.

The third theme is that planners, both individually and as a collective, appear to be stuck in single- rather than double-loop learning (see Argyris and Schön (1996) and section 2.4). This is both a technical and organizational issue. Because the tools are lacking, planners are hard-pressed merely to finish their work, the time is simply not sufficient for perform quality control. And because there is no systematic review of the quality and outcome, there is no way to begin to improve the rules and guidelines, to create a better timetable, supporting findings in Watson (2008), Hellström (2013) and ONTIME (2014). Because the tools do not provide enough assistance the focus is, and must be, on creating a timetable before creating a *better* timetable. Creating a better timetable is what we imagine the timetable planners of the future will be tasked with doing, when more of the work has been automated and the software tools provide far more assistance. Choosing which heuristics, goal-functions and constraints to apply in different scenarios, to achieve the best overall results, rather than trying to manually execute all the details.

6. Conclusions

From interviews with timetable planners in Sweden, we conclude that the most common errors in timetables are (a) crossing train paths at stations, (b) wrong track allocation of trains at stations, especially for long trains, (c) insufficient dwell and meet times at stations, and (d) insufficient headways leading to delays spreading.

Reading through the transcripts of the interviews we have identified 11 reasons that contribute to errors occurring in the timetable, and running through these reasons, we have identified and discussed three themes: missing tools and support, role conflict, and single- rather than double-loop learning (see section 2.4).

New tools and processes are under development and about to enter use in Sweden, and we believe that these can do much to improve the situation. The tools and support will no longer be missing to the extent that they are now, and this will help planners, individually and collectively, to move from single- to double-loop learning. This is likely to increase the quality of timetables. The role conflict of timetable planners, and their position in relation to the train operating companies, is however likely to remain. As is the need to systematically review the performance of timetables, to learn whether and how the rules, guidelines and heuristics used can be improved over time.

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