Zürcher Hochschule
für Angewandte Wissenschaften

School of
Engineering
Institut für Datenanalyse
und Prozessdesign

- SBB Research Funds call Spring 2021 -

"How to relate the productivity of train drivers with their job satisfaction and the quality of train services?"

Final report

Valerio De Martinis
Marius Huber
Thomas Herrmann
Raimond Matthias Wüst

Gabrio Caimi
Michael Kaelin

27. November 2022

List of contents

1 Executive Abstract

In this report, the evaluation of optimization potentials for increasing productivity, robustness and job satisfaction is discussed, as well as the relation between those three dimensions. The results are presented in a holistic approach, starting from current conditions:

- Train drivers' productivity is currently evaluated through the different KPIs of SBB. After an extensive search in the current practices and in the literature, it can be deduced that current KPIs used by SBB are in line with the most advanced theories and practices. This has been confirmed by a workshop in collaboration with Swiss International Airlines, which adopt a similar approach (i.e. consideration of productivity, flexibility, job satisfaction aspects in duty scheduling of cockpit crew). The main KPIs are the average number of tours per day computed on a monthly basis, and the variation between realized and planned performances in terms of times for the activities linked to driving and train preparation. By coupling of train productivity data with EFA (i.e., in German "Erfassung Fahrplanabweichung", the system for reporting delays or cancellations, together with their motivation) reports, it can be deduced that the productivity performance variation is given mostly by the train cancellation and large train delays (in general over 10 minutes).
- The EFA reports have been used to compute the MTBF (Mean Time Between Failures) index on a depot basis. This has been used as KPI for evaluating the robustness of the train drivers' service on a monthly basis. Results show that, as expected, bigger depots have worse MTBF values (i.e. lower values) than smaller one. This means that the depot's dimension with respect to the number of train drivers must be taken into consideration before evaluating schedule and rostering's robustness. However, 74% of the tours affected in the EFA system have been reported only once, and 15% only twice. This indicates that the events related to cancellations and big delays do not depend on systematic system misconfigurations (e.g., timetable, train driver schedules, rosters), but are random events caused by everyday problems. Moreover, the monthly trend of EFA reports and reported depots suggests that there are external factors that influence both of them (e.g. seasonality).
- Job satisfaction has been evaluated through the survey analyses. Results have been reported to a numerical scale to mathematically compute a weight for each macro-topic tour construction, tour sequence, disposition, and work environment. With help of those four macro-topic weights a percentage of reached satisfaction could be computed. From the survey it turned out, that the aspects related to tour construction, tour sequence and disposition have almost the same weight, while the work environment has a lower weight. The satisfaction has been evaluated as % of reached satisfaction, where the extremes indicated complete dissatisfaction (0%) and complete satisfaction (i.e. 100%). Two areas were identified, the first is between 0 and 69.67% and identifies the area of dissatisfaction. In this area, there is no aspect rated positively, but drivers may be more or less dissatisfied. The second area is between 69.67 and 100% and it identifies the area where there is a partial satisfaction. In other terms, a lower value but still close to 69.67% may indicate dissatisfaction that with a small effort can turn into partial satisfaction, and the more the satisfaction is close to 100%, the less there are aspects that generate dissatisfaction. The current satisfaction results to be 80.10%. In addition, information on potential aspects for increasing job satisfaction have been retrieved. Among others, it is worth to mention that, concerning tour construction, ensuring a good variety of train types and routes in a single tour or a sequence of tours is fundamental for train drivers. This aspect has been evaluated through the survey (multiple answer questions) and confirmed both in the interview phase and the free text answers. We conclude therefore a strong motivating factor: train drivers (or those who choose this job) like to see different places, to travel, to drive different vehicles –

they like variety and dislike homogeneous, repeating work. In addition, most train drivers ask to enhance their knowledge regarding routes and/or train types to drive.

From these results, a framework for identifying possible enhancement areas in which all the three afore-mentioned perspectives may be positively affected can be defined. Specifically, a strategic level and a tactical level are foreseen, and for each level a possible area for enhancement is identified.

It can be summarized: The main driver on a **strategic** level to increase productivity as well as job satisfaction and customer satisfaction is the flexibilization and individualization of resource and shift planning. For the implementation, the concepts of crew and depot have to be revised and redesigned.

Increasing productivity means that either the same level of output must be achieved with less input resources or the available resources must generate a higher output level. However, the output is pre-defined by the train rides given in the timetable. This means that productivity increases can only be achieved, if the share between the time to drive trains and the total work time is maximized for each train driver. Hence, on a strategic level it has to be discussed how the available time for driving trains can be maximized, or vice versa, how dead time (breaks, pauses) can be minimized. Hence, current shift patterns, shift contents and to some extent the timetable itself and other constraints have to be relaxed in order to increase the productivity. With the current SOPRE implementation only marginal productivity increases seem possible. Therefore, if the increase of current productivity performance indicators is desirable, then the flexibility in shift planning must be increased.

A higher level of job satisfaction is strongly related to variable shift contents and a personalization of shift duties. Moreover, if the tour can be therefore composed in a way that a good balance between S-Bahn and long-distance train rides is achieved, then an important part to increase job satisfaction is addressed. Again, the composition of a shift is thus the crucial driver to increase (or decrease) the job satisfaction. While enhancing the knowledge of routes and train types are motivating factors, they also help to increase the productivity and robustness indicators. Moreover, having more people that are able to drive different trains over different routes increases the flexibility in reassigning specific tasks in daily operation. Having a pool of generalists has therefore a positive influence on robustness aspects – in principle. Thus, robustness in operation can be enhanced, if train and route knowledge is shared broadly inside a crew or a depot respectively.

However, as many depots and crews already share all common routes and train types for that depot, further enhancements can only be achieved if the concept of depots and crews are made more flexible: A shared knowledge of trains and routes (over an area, a region, etc.) may lead to the development of new crew management concepts over routes, and depot management concepts which may exploit the added flexibility to enhance the productivity itself. With more flexibility, it might be necessary to involve more and different organizational units in the definition of specific strategies (e.g. labor rules and agreements) and the productivity per depot might also be redefined in its concept.

The data analysis performed over all the datasets related to tour productivity, events reporting (EFA) and job satisfaction show some interesting findings that can be appositely used to enhance the current planning system on a **tactical** level. As-is productivity is largely affected by the number of cancelled trains and, in second place, by delayed trains. As seen from the data analysis, the events are not directly related to the timetable construction. Robustness increasing measures include the knowledge of how to reschedule and re-roster the affected tasks/duties. Job satisfaction is mostly affected by the variability of tour sequences and of tasks within a tour. This has been also highlighted in the free text answers, where 42% of the answers correlated to requests of more variation in train types and routes (ca. 40% of the total answers received) asked explicitly less S-Bahn services and more long-distance tours, or even a good mix between the two. As a higher variation in the shift duties is initially a higher risk with respect to robustness (more risk of missing a connection due to delays or train cancellations), this risk has to be mitigated with new design of tour schedules and rosters, which allow for quick recovers. Moreover, this redesign might have a positive effect to productivity, in terms of more adherence to the planned conditions. This aspect not only enhances the satisfaction of train drivers, but also might become a motivating factor for them. In addition, if individual preferences could be respected during planning phases and if re-roster and re-schedule of human resources are exceptional events, then productivity increases don't lead to job satisfaction or robustness problems.

Possibilities to increase productivity, job satisfaction and robustness are limited on a tactical level. They all encompass the management of buffers times to some extent. Hence the possibilities are strongly related to the design of the shift patterns and shift planning, as well as the tour composition for each train driver.

Possible measures to adopt for enhancing the planning system are seen in the implementation of new models in the SOPRE system, which should include a system for train type assignment and new reserve and buffer times constraints. Another possible measure to consider presumes a further investigation for identifying best practices among depots. The aim is to collect successful experiences that make the difference in terms of productivity indicators, EFA and train driver satisfaction, and finally reproduce them in a new tour planning system.

2 Introduction

Train driver's productivity is usually measured per person, as a ratio of the driving time to the working time, and it follows contract regulations. This measure, however, gives only a partial information on the rail operators global productivity regarding train drivers. In particular, the productivity described above must be compared also with other aspects, such as availability and reliability of services (i.e. robustness of the operation), and the buffer times derived from timetables and rostering schedules, which have an impact on productivity indicators as well. In this view, the job satisfaction of train drivers is closely related to the times available for fulfilling all tasks; these times must be analyzed transparently. This allows an understanding of available leverages related to train driver productivity. Therefore, a thoughtful distinction between commercial, customer-related tasks, required tasks for handling train runs, and standby tasks (reserve time) to cope with deviations, is needed. This comprehensive picture is missing today.

Most of the past and current studies are focused on providing a mathematical solution to the crew scheduling problem only. The current modeling is well described in Caprara et al. 1998 as well as consolidated algorithms in Caprara et al. 1997; these have been widely used in different context such as in London (Sodhi et al., 2004), the Netherland (Fioole et al., 2006), and Copenhagen (Rezanova et al. 2010). On the algorithmic side many proposals have been done in the field, specifically to overcome the long computation times, which are mostly due to the complexity explosion when considering multiple depots. The column generation approach (Barnhart et al., 1998; Huisman, 2007; Potthoff et al., 2010) has been used by many researchers and it seems one of the most performing solutions. Other approaches have been proposed in the past, especially in the field of agent-based modeling (Fioole et al., 2006; Shibghatullah et al., 2006, Abbink et al. 2009, Rezanova et al. 2010) in the past other approaches that have been proposed. Typically, coordination between agents is reached through a team formation process in which possible (re)scheduling alternatives are evaluated, based on constraints and preferences of involved human train drivers and dispatchers. Considering productivity and its relationships with robustness of the operation and job satisfaction has been mostly studied in those environments where specific applications were already under design and implementation from the industries. This is the case of the Nederland and of NS, which funded specific research on this topic (Abbink et al., 2004-2011; Doellevoet, 2013; Hartog et al., 2009; Kroon et al. 2001-2009). Studies in this field have been mostly qualitative, and neither KPIs nor benchmarks on the three dimensions are provided in the relative reports.

It is clear that a part of the knowledge required as reference for conducting the research aspects related to this project is missing. Nevertheless, the identification of the relations between these three dimensions (Produictivity, Robustness, Job Satisfaction) is now a requirement for “the final users”, i.e. rail operators. The relations between robustness and productivity related to train drivers and affecting the overall rail operation have to be deepen, as well as the role of personal motivation and job satisfaction within the strategies for enhancing the productivity itself.

2.1 Project goal

The identification and evaluation of optimization potentials by including train driver and customer perspectives, such as job satisfaction and punctuality into productivity objectives is the main activity of the project. In this report, possible strategies for exploiting optimization potentials are also illustrated.

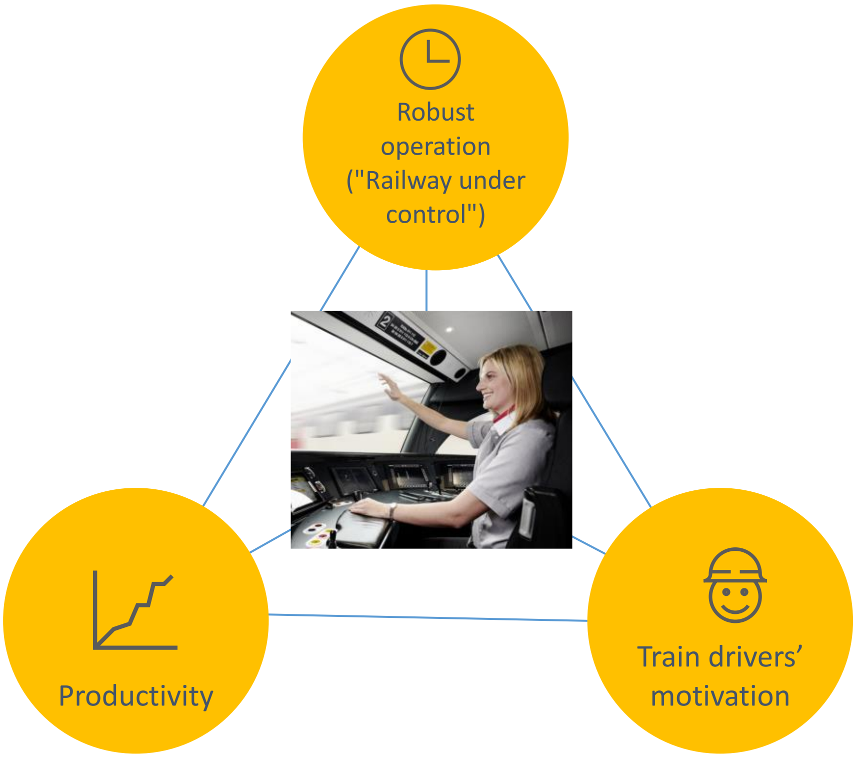


Figure 1. Triangle of the productivity aspects under investigation.

The improvements are mostly deduced on the analysis between the current state and the desired state, which allow evaluating the gaps between them and specifically defining which aspects may contribute to the system improvements and to which extent. Specifically, operators, customers and train drivers' perspectives have been considered. A comprehensive view of organizational, crew related, and customer related aspects can better describe the train drivers' productivity and its potential enhancements within the rail operation and the rail services offered to customers. The simple interactions between two of the three dimensions may not give information about e.g., the train drivers' satisfaction related to the scheduled tasks, the expected service quality related to the timetable, or the efficient/inefficient use of human resources.

Operators' perspective is here considered through the main concepts that the total train drivers' costs must be as small as possible. These costs directly relate to the number of train drivers needed to operate the schedules. In this aspect, a tour sequence is more efficient when fewer tours are scheduled to operate all tasks. Next to the number of tours per day, an indicator for the efficiency is the average driving time within a duty. At SBB, this is about 50%. The remaining time is spent on other tasks, which can be directly or indirectly related to the driving activity, or be unproductive (e.g. holidays). Because the amount of work is given by the timetable, a higher percentage of driving time means that fewer tours are scheduled.

Customers' perspective is seen as the perception of customers about the good or bad operation of the train services. The main aspect to take into consideration is that customers do not know whether the delay/cancellation of a train is due to crew management problems or to other problems related to other processes, e.g. traffic management, rolling stock failures, etc. Since the evaluation of robustness in general terms is out of scope for this project, only the robustness of the train drivers' duties is considered. The robustness of the train drivers' duties, i.e., preventing the propagation of delays via schedules, depends on several elements, including the transfer times of the crew when transferring from one train to another. Robustness is often addressed in the crew duty scheduling problem by using constraints. It is hard to define a value to robustness, which can then be optimized, but it is clear that buffer time between tasks on two different trains will limit propagation of delays.

Train drivers' perspective is here evaluated as the satisfaction perceived by the train drivers regarding their job. This is addressed via labor rules and company agreements, for example, on the amount of variation in the tours and in the tour sequences. Together with the aspects more directly connected with the operation (tour schedule, composition, variation), the grade of expectations fulfilled, which is related to personal wishes, motivating factors (e.g. career), work life balance, is also to consider.

To do so, the activities of the present projects are represented in the following points:

- We start from the discussions about the initial organization analysis, to determine the current needs to be changed and how.
- We collect and analyze data of the present state to quantitatively relate, when possible, the relations between the three dimensions. This task is addressed also with the analyses of KPIs.
- We define a desired (future) state together with our project partners (SBB), to identify possible gap to fill, necessary formal structures for change, the informal organizational aspects, the change recipients, and the change agents.
- The fourth phase is development of plans for the action and implementation. Our targets is, for the present study, to identify in which direction there is possibility to develop an effective strategy for productivity enhancement.

3 Potential enhancements – prerequirements

The previous chapters focused on analyzing the available data and current status of the train drivers' productivity, the impact of their activities on the timetable operation (i.e. punctuality) and therefore on passengers, and their satisfaction about their working condition, with specific focus on the tour and duty planning. This chapter focuses on the possible directions to take for enhancing the system without penalizing any of the three points (i.e. productivity, job satisfaction and robustness). To do so, a general framework developed by Cawsey et al. (2011) is taken as reference to understand where the enhancement(s) will take place and which measures are required (see Figure 1).

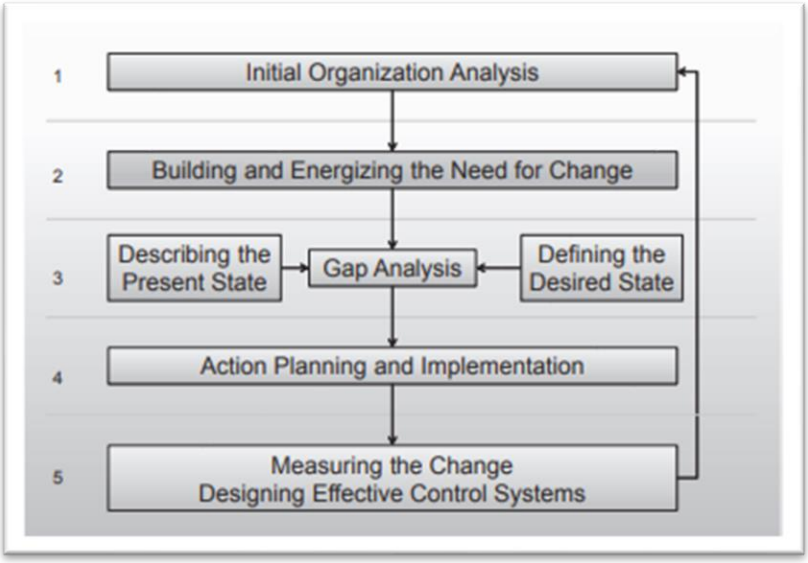


Figure 1. framework for the definition of measure to take for system improvements

The first phase of the framework starts with an initial organization analysis to determine a well-grounded sense of what needs to be changed and how, given that there is a problem. Second, based on an evaluation of the need for change, a sound rationale for the change and a compelling vision of a possible future is developed. This to unfreeze organizational members. Third, based on a description of the present state and a definition of the desired (future) state, a gap analysis is performed, identifying necessary formal structures for change, the informal organizational aspects, the change recipients, and the change agents. The fourth phase is the action and implementation. Here, an activity plan is developed, including contingency and communication planning. The transition is managed, and at the end there is a planned moment of celebration and after-action review. The fifth and final phase is the measurement of the achieved change over time.

In this document, and in the project itself, the first and the third step are under analysis.

3.1 Initial organization analysis

The productivity targets of SBB have always been very ambitious and will remain so in the future. The main reason relies in the cultural environment of Switzerland, which sees in the rail network the main pillar for mobility of people and goods. This has brought to a large development of services and offers, which has let Switzerland become one of the countries with the most utilized rail network in the world.

The decline in demand due to the Corona pandemic has hit SBB hard financially, and despite the current recovery, the future course of development remains uncertain. In this context, also the railway production and thus the locomotive personnel performances have suffered from a large replanning, due to the unexpected measures that have been taken to support the seesawing demand and at the same time to guarantee the minimum services.

Together with the aspects linked to productivity, also the robustness of the services has become an even more relevant topic to be related to productivity. From the train driver perspective, robustness mostly means that the tour schedules and the associate rosters are well defined from the train timetable and its variations during the operation. This aspect has an effect on train drivers, which may have more or less stress depending on how good tour schedules and rosters are associated to the timetable, e.g. they might have enough or not enough time to drop off from a train and jump in on the next train to drive. If the driver cannot jump in the train on time and start the journey, for whatever reason, the consequence will be that the passengers will experience a delay due to the delay of the train driver.

Another aspect that has come to the fore in recent years and which the pandemic has helped to make increasingly central to the management of rail services is job satisfaction and motivation, which is also linked to productivity. The salary, the working environment, security, the possibility of establishing personal relationships are all context-related elements that may well affect job satisfaction, but not always motivation. The motivating factors of a work environment are linked to the actions the individual takes to change his or her status, e.g. the possibility of moving up the career ladder, gaining recognition and reaching higher and higher levels of responsibility and autonomy. In practice, the motivated worker is the rewarded (or satisfied) worker, who perceives and experiences the opportunity to grow as a professional and as a human being. In this context, the job of train driver is shrinking in terms of supply. Fewer and fewer people are interested in becoming train drivers and the turnover between retirees and new recruits is unbalanced. This makes it necessary, on the one hand, to optimize current resources and, on the other hand, to make the job of train driver a more attractive and more motivating one.

In this context, it is necessary to understand the main elements related to productivity, operational robustness and job satisfaction/personnel motivation and their interrelations to increase all these three aspects together to fulfill the current and future needs.

3.2 Gap analysis

3.2.1 Current state “as is” - Evaluation of the planning process

Train driver's productivity is usually measured per person, as a ratio of the driving time to the working time, and it follows contract regulations. This measure, however, gives only a partial information on the rail operators global productivity regarding train drivers. In particular, the productivity described above must be compared also with quality aspects, such as availability and reliability of services, and the job satisfaction of train drivers, in terms of times available for fulfilling all tasks, which have an impact on productivity indicators as well.

Very few references put into correlation these three dimensions (e.g. see Erwin Abbink (2014), “Crew Management in Passenger Rail Transport“, PhD Dissertation). Moreover, these dimensions have different meanings (and weight) depending on the specific level of design: planning the available number of train drivers for the amount of work that needs to be performed in the strategic planning horizon, planning the train drivers schedules in the tactical planning horizon, and real-time dispatching of the train drivers in case of an unforeseen event.

For the scope of the present report, the strategic and tactical planning level is here discussed. The strategic level has a horizon from one to 5 years or more. The main aims are to develop the major measures that bring to changes in the availability and/or in the management of the resources (i.e., new hirings). The tactical planning phase has a horizon of 2 months up to a year. In this phase, the details of the plan are determined, but major changes in availability of resources are not possible. Moreover, a detailed plan is created for generic days, i.e. a generic Monday, Tuesday and so on.

The most important resources to set during a railway planning process are rail-infrastructure (timetabling), rolling stock and train drivers (together with the crew). In general, these resources are not planned in a single step, due to the complexity of the overall railway planning problem. A common approach is to split the problem by resource and to solve the sub-problems sequentially. For the tactical planning level, this means that the timetable, the rolling stock scheduling and the train drivers scheduling problems must be addressed.

The train drivers scheduling process in the tactical planning includes two major steps: (1) duty scheduling, and (2) roster planning. A duty starts and ends in a depot and describes the consecutive tasks for a train driver. For each day, a set of anonymous duties is generated. Rosters prescribe how to assign the anonymous duties to train drivers on consecutive days. Within the description of the duty scheduling and the roster planning, it meaningful to highlight the need to prescribe a sufficient variety of work within the duties. About this, it is worth to mention the concept of repetition-in-duty (RID). By dividing the railway timetable into a number of routes, the RID_d of duty d is computed as follows:

$$RID_d = \frac{\#\, routes\ in\ duty\ d}{\#different\ routes\ in\ duty\ d}$$

It is reported that the overall average RID of all duties should be less than 2.7. For each train drivers belonging to a depot, the average RID should be less than 3.0. In other words, each duty should contain on average a certain route at most three times. Finally, is good to mention the aim of the three dimension:

Productivity. Main aim is that that the total costs are as small as possible. These costs directly relate to the number of crew members needed to operate the schedules and the rosters. In this aspect, a duty schedule is more efficient when fewer duties are scheduled to operate all tasks. Next to the number of duties, an indicator for the efficiency is the average working time within a duty. The efficiency of the rosters is quantified by the number of crew members assigned to the rosters to be operated or the amount of work assigned to the rosters.

Robustness. A robust planning of the train drivers' duties aims at preventing the propagation of delays via the train drivers' schedules. The robustness of a schedule depends on several elements, including the transfer times of the train drivers when transferring from one train to another, and it is often addressed in the scheduling problem by using constraints on minimum buffer times to limit propagation of delays. For the rosters, the operational robustness can be improved by adding spare train drivers' duties, to be used in case of disruptions in real time operations. A higher number of spare duties increases robustness, but, on the other hand, reduces the efficiency of the rosters because more train drivers are planned to be needed.

Job satisfaction. The job satisfaction is the perceived quality of duties by the train drivers. This is addressed via labor rules and company agreements, for example, on the amount of variation in the duties. In crew rostering, the quality of work can be measured by computing the number of preferred and non-preferred patterns of consecutive days of work.

3.2.2 Productivity

The current state takes into consideration the productivity indicators as defined by SBB.

The aim of the productivity indicators is to measure the productivity of the train driving personnel with driving performance or driving readiness, and with the development of the number of tours per day. Considered together, these key figures show how the productivity develops in the context of the necessary tours.

These key figures can be broken down into the individual drivers (e.g. main and secondary activities or tours) for analysis purposes. When computing the productivity indicators, activity times are placed in relation to paid time to measure profitability from the company's point of view. E.g., the driving time results from driving performance, the paid time corresponds to the total working time including breaks and supplements.

Concerning the purpose of this document, the most relevant key figures are therefore reported.

Figure 1 shows the monthly deviation between realized and planned conditions, in terms of number of tours per day. The graph shows a decreasing trend of the tour effectively operated. The extra trains have not increased the performances for seasonal needs as planned.

August shows a daily decrease of -33 tours (about -51 FTE) below the planned value. There were test runs 8% (in July 0%), as well as 16% of the tours were planned for historical and sporting event.

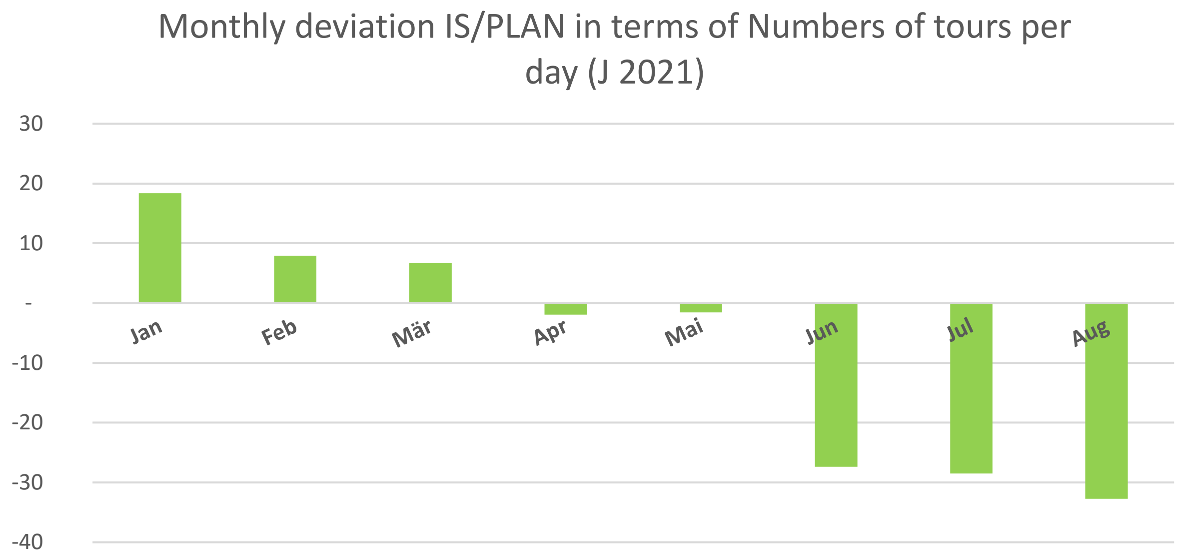


Figure 1. Monthly deviation between realized (IS) and planned (PLAN) number of tours per day

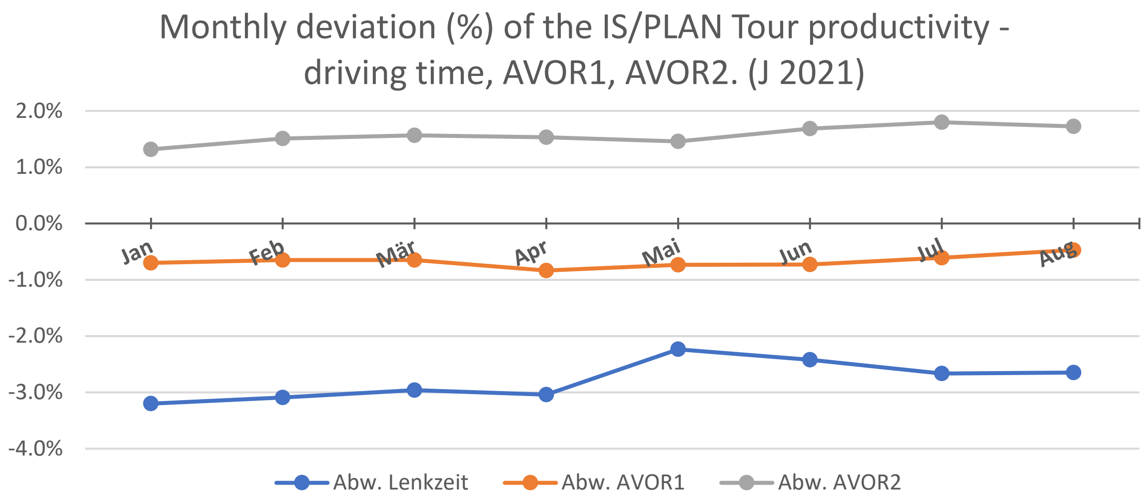


Figure 2. Monthly deviation between realized (IS) and planned (PLAN) tour productivity, with specific focus on driving time, time to work preparation directly linked with driving time (AVOR1), time to work preparation not directly linked with driving time (AVOR2).

Figure 2 shows the trend of the monthly deviations between realized (IS) and planned (PLAN) tour productivity. Specifically driving time, time to for work preparation directly linked with driving time (AVOR1), time for work preparation not directly linked with driving time (AVOR2) have been considered. Typical examples of AVOR2 times are times for: picking up/returning equipment, Briefing, travel time to workplace, coupling/decoupling. Similarly, examples of AVOR1 times are set up/reset times, disposition train times, turnaround times.

To ensure operations, Dispo trains are heavily used in events like strikes, delays, disruptions. However, from the productivity perspective, train cancellations and delays reduce driving time and thus productivity itself. The increase in AVOR2 in comparison with the planned conditions is due to the additional replacement tours (deployment in another depot), which are more likely to come after a train cancellation, which lead to more service trips and travel times. In Figure 3 an example of the effects of cancelled trains is presented. Specifically, figure 3 shows the data collected by the system about tours and times (first column "Ist") for a specific tour of a specific depot in a specific day, in which a train cancellation happened, and the data inserted in the system as planned operation (first column "'SW_3_FP2021…"). The driving times are highlighted in green, and it is possible to see that the planned time was 213 minutes and the resulted time with the train cancellation is 142.97 minutes. In orange, the preparation times are reported, and specifically the travel times (Wegzeit) associated with AVOR2 increased from 24planned minutes to to 87. The Dispo runs (DFahrt) have consequently increased the time to 64 minutes. The AVOR1 turnaround times (Wenden), which are directly linked with the train preparation, have been decreased, since the train has been cancelled. Additionally, in blue the filling times (Füllzeiten), which are times not related with the service production and therefore considered unproductive, grow due to duty replanning times.

This example has been developed by relating the EFA reports with the tour productivity details collected for the specific depots. Similar conditions can be found also for delayed trains, although the effects are not so evident as in the cancelled trains. EFA is the system that collects, among others, data on variations to the planned conditions (train cancellation, delays), together with motivation, time, entity of the delay (if any), primary and secondary delay (if any).

Szenario Name	Wochentag	Tour Startzeit (	Tournummer	ZF Produktivitätskategorie	Tourenbestandteil	Basisdauer (Reporting)
Ist	Dienstag	10.08.2021	118	AVO	Briefing	8.00
Ist	Dienstag	10.08.2021	118	AVO	**Dfahrt**	**64.00**
Ist	Dienstag	10.08.2021	118	AVO	IBN	63.00
Ist	Dienstag	10.08.2021	118	AVO	Kuppeln/Entkuppeln	1.00
Ist	Dienstag	10.08.2021	118	AVO	**Wegzeit**	**87.00**
Ist	Dienstag	10.08.2021	118	AVO	**Wenden**	**39.27**
Ist	Dienstag	10.08.2021	118	AVO	Übergabe	15.00
Ist	Dienstag	10.08.2021	118	AVO	Übernahme	13.77
Ist	Dienstag	10.08.2021	118	LNK	**Zug**	**142.97**
Ist	Dienstag	10.08.2021	118	PBT	AU	11.00
Ist	Dienstag	10.08.2021	118	PBT	Pausenzuschlag	6.30
Ist	Dienstag	10.08.2021	118	PUB	Pause unbezahlt	42.00
Ist	Dienstag	10.08.2021	118	UPO	**Füllzeit**	**75.00**
Ist	Dienstag	10.08.2021	118	ZUS	ND1	30.60
Ist	Dienstag	10.08.2021	118	ZUS	NDZ-10%	16.20
SW_3_FP2021_(17.0	Dienstag	19.01.2021	118	AVO	Auf-/ Rückstellen	10.00
SW_3_FP2021_(17.0	Dienstag	19.01.2021	118	AVO	Briefing	8.00
SW_3_FP2021_(17.0	Dienstag	19.01.2021	118	AVO	**Dfahrt**	**3.00**
SW_3_FP2021_(17.0	Dienstag	19.01.2021	118	AVO	IBN	63.00
SW_3_FP2021_(17.0	Dienstag	19.01.2021	118	AVO	**Wegzeit**	**24.00**
SW_3_FP2021_(17.0	Dienstag	19.01.2021	118	AVO	**Wenden**	**87.00**
SW_3_FP2021_(17.0	Dienstag	19.01.2021	118	AVO	Übergabe	12.00
SW_3_FP2021_(17.0	Dienstag	19.01.2021	118	LNK	**Zug**	**213.00**
SW_3_FP2021_(17.0	Dienstag	19.01.2021	118	PBT	AU	29.00
SW_3_FP2021_(17.0	Dienstag	19.01.2021	118	PUB	Pause unbezahlt	40.00
SW_3_FP2021_(17.0	Dienstag	19.01.2021	118	UPO	**Füllzeit**	**26.00**
SW_3_FP2021_(17.0	Dienstag	19.01.2021	118	ZUS	NDZ-10%	11.50

Figure 3. comparison between planned (bottom) and realized (up) times for a cancelled tour with specific highlight on Driving times, AVOR1, AVOR2 and filling times.

3.2.3 Robustness

The time interval between two customer dissatisfaction events, for which train drivers are responsible, indicates how robust the planning of train drivers' activities is. In SBB this information is available through the EFA system, which records the details of every deviation from the planned scenario. The usual "dissatisfaction event" that may occur for customers are train delays and train cancellations. For the forthcoming considerations, it can be safely assumed that, from the customer's perspective, the reason is not relevant. There is currently no reference in similar projects or in the literature that evaluates the customer perspective based on data about a part of the service production (here specifically about the service of the train drivers).

The KPI used to evaluate the Robustness of the train drivers' scheduling is the Mean Time Between Failures (MTBF), i.e. the elapsed time between inherent failures of a system (here crew management), during normal operation. MTBF can be calculated as the arithmetic mean time between failures of a system within a reference time period, and it is adopted in the RAMS analyses. RAMS (Reliability, Availability, Maintainability, and Safety) are commonly used in engineering to characterize a product or system, in terms of operation at given conditions.

$$MTBF[t] = \frac{\sum t_{EFA}(i+1) - t_{EFA}(i)}{N}$$

For what concern the customer perspective, EFA data on for the months June-October show that the events affecting the normal operation might have a stochastic nature and not depend on systemic errors, e.g., on wrong tour planning. This must be however confirmed through the analysis of a larger dataset, which may allow for a seasonal analysis as well. From the 5 months dataset, 74% of the records referred to different tours, i.e. the delay/cancellation event happens only one time for a given tour in the reference period, 15% of the records is referred to events that happen twice for a given tour.

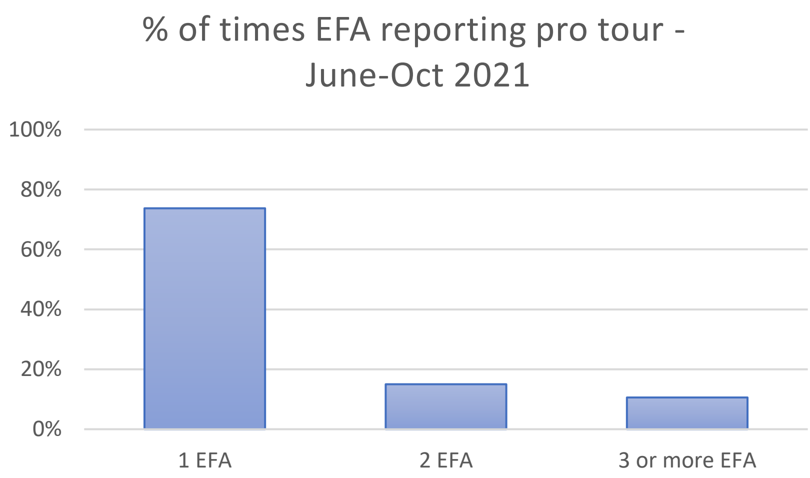


Figure 4. number of times a EFA reporting for a given tour has been submitted

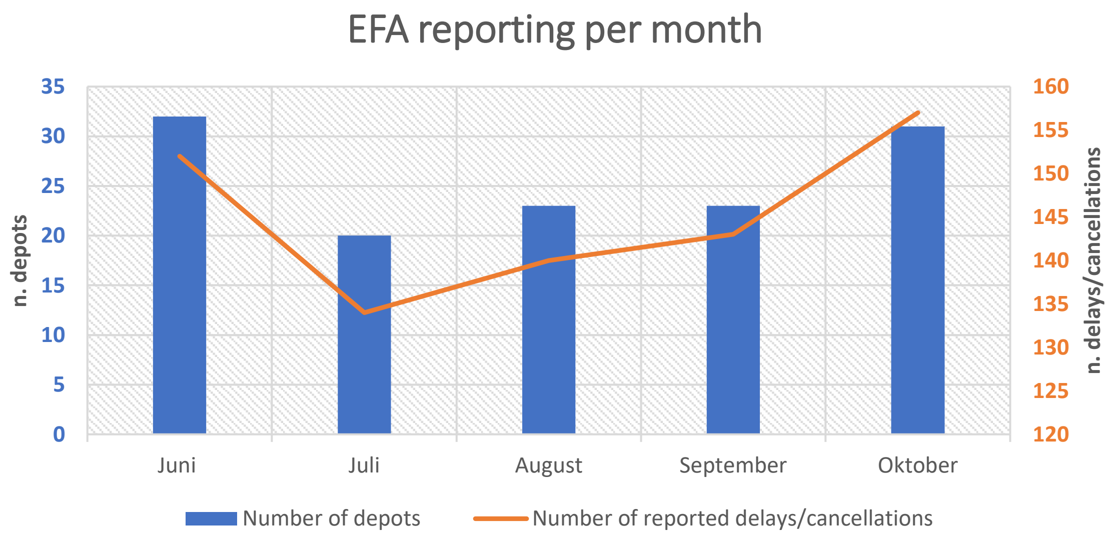


Figure 5. Number of depots that have at least one event per month compared with the number of reported EFA

In figure 5, the number of depots that have at least one event per month is shown, and the trend is compared with the number of reported EFA. The month of July has been the best month in terms of number of events related with delays and number of depots which have reported a delay. The two trends seem quite similar, and this suggest that there is a correlation between the two trends or that might be an external factor that affects the two trends (e.g., operation through seasonality). This also means that there is no specific depot that works better/worse than the other.

Figure 6 shows the depots that have reported more than two events per month in all the considered months. It is worth to remind that two events per month are necessary for computing the MTBF (Mean Time Between Failures) for the specific month. As it is possible to see and to immagine, there is a correlation between the dimension of the depot/station and the events that occur. Zurich reports the worst MTBF in all the months, second place for Basel, Geneve and Lausanne, which have similar values.

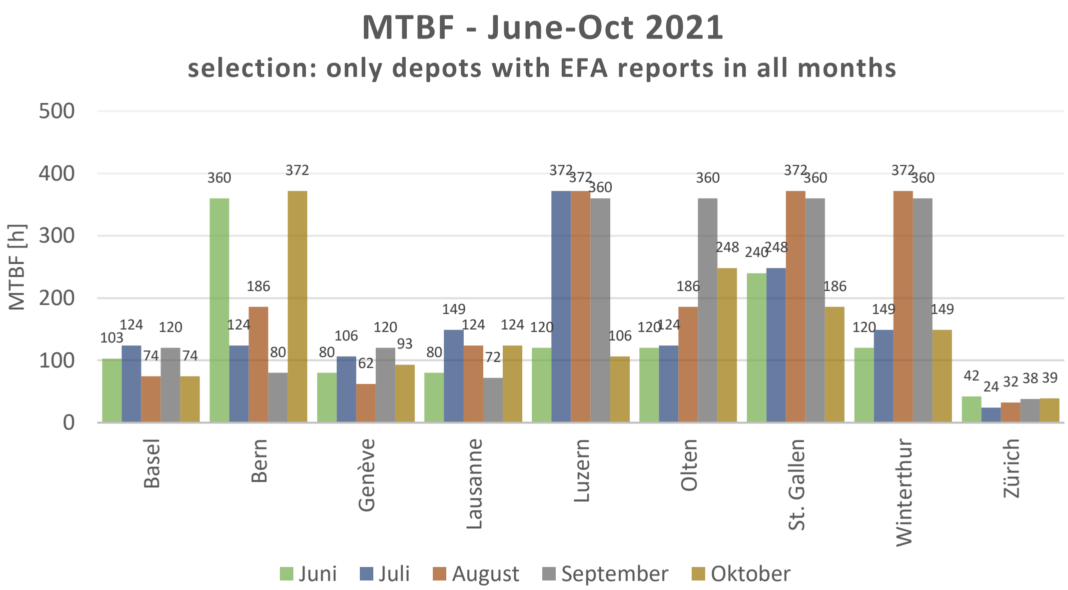


Figure 6. MTBF computed for those depots which have EFA reports in all months of the reference period

3.2.4 Job Satisfaction

Job satisfaction has been evaluated through a specific survey for the entire train driver category in Switzerland. The main steps for the survey's design are:

1. **First exploratory phase.**

   In this phase a first definition of the variables is given. This is often performed through prior analyses or collection of information, also in an unstructured form. The next step is to select a probe population for face interviews with open questions.

2. **Pre-Test phase.**

   In this phase the macro topics of the survey are identified as well as the aspects pertaining each macro topic. It is worth to mention that there might be aspects that can be relevant for more than one macro topic; in this case it is essential to clearly state the question about that aspect by including a reference to the macro topic. After this phase, a first version of the questionnaire is developed.

3. **Preparation**.

   In this phase, the questionnaire is subject to review, implementation and revision processes. Differently from the other phases, in this phase all stakeholders (e.g. planners, administration, managers) are involved until an agreed form of the questionnaire is reached. Clearly, together with the questionnaire also the following elements are shared:

   a. definition of the aim of the research,

   b. explanation of the questionnaire.

c. preparation of applications.

Within the different methods for evaluating job satisfaction (Lepold et al., 2018; Gambacorta et al., 2012), the % of satisfaction perceived as KPI has been chosen. Its formulation in the present work takes inspiration from the Workshop with Swiss International Airlines, whose details are in the following section 3.2.1.5. The workshop showed similar conditions for job satisfaction evaluation, especially when comparing European flights and intercity routes in Switzerland (e.g. Lausanne-Zurich). This KPI is also proposed in job satisfaction and customer satisfaction questionnaires to indicate how far the current satisfaction level is from the maximum satisfaction level (Hohmann, 2017). Specifically:

$$\%\,Zufriedenheit = \frac{IZ - \sum_C SDR_C}{IZ}$$

$$\sum_c SDR_c = \sum_{c=1}^{C} W_c \left(\frac{\sum_{i=1}^{n} \left| B_{i,c} - I_c \right|}{n} \right)$$

Where:

C =Macrothemes

n= number of answers received for the specific Macro theme.

W=Weight of a given Macrothema

G= Minkowsky’s Average distance (with $\lambda = 1$)

The SDR (Sum of Weighted Distances) index measures the distance between the ideal conditions for being completely satisfied and the perceived satisfaction, at the moment of the survey. The distance is measured through the Minkowsky’s Average distance, which is a generalized formulation of the distances. The parameter λ can be either 1 or 2 and it returns the Manhattan or the Eulerian distance respectively.

The answer rate has been ca. 20% (480 surveys have been completed), which makes this survey a best case in the field. The satisfaction has been evaluated as % of reached satisfaction, where the extremes indicated complete dissatisfaction (0%) and complete satisfaction (i.e. 100%). Two areas were identified, the first is between 0 and 69.67% and identifies the area of dissatisfaction. In this area, there is no aspect rated positively, but drivers may be more or less dissatisfied. The second area is between 69.67 and 100% and it identifies the area where there is a partial satisfaction. In other terms, a lower value but still close to 69.67% may indicate dissatisfaction that with a small effort can turn into partial satisfaction, and the more the satisfaction is close to 100%, the less there are aspects that generate dissatisfaction. For the above-mentioned journey four macro topics have been identified: Tour composition (e.g. set of activities within a tour on a generic day), Tour sequence (e.g. tour planning on a weekly basis, free days, work life balance), Disposition (e.g. communication of the duties, of the modifications to the planned services), Working environment (e.g. workload, stress). Results are represented in figure 7.

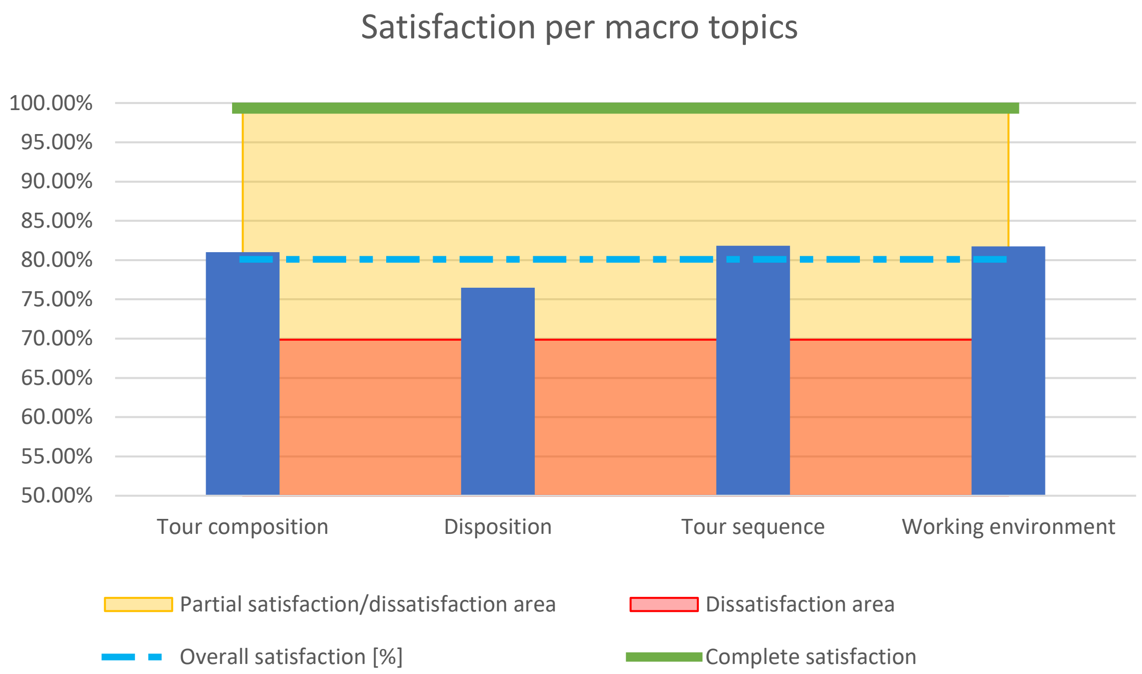


Figure 7. % of Satisfaction deduced from the survey performed between March and April 2022

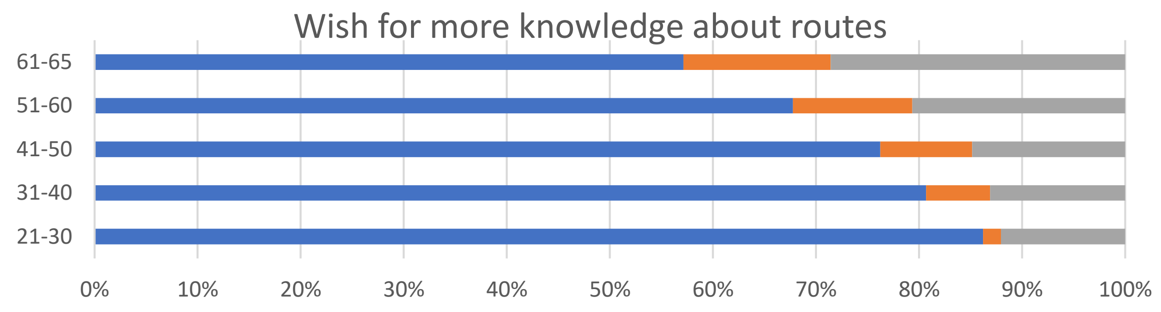
One of the main outputs from the survey is the identification of the aspects that have an impact on job satisfaction. This aspect has been considered for the definition of possible leverages towards the enhancement of job satisfaction. Specifically (between brackets the weight of each macro topic contributing for the general satisfaction):

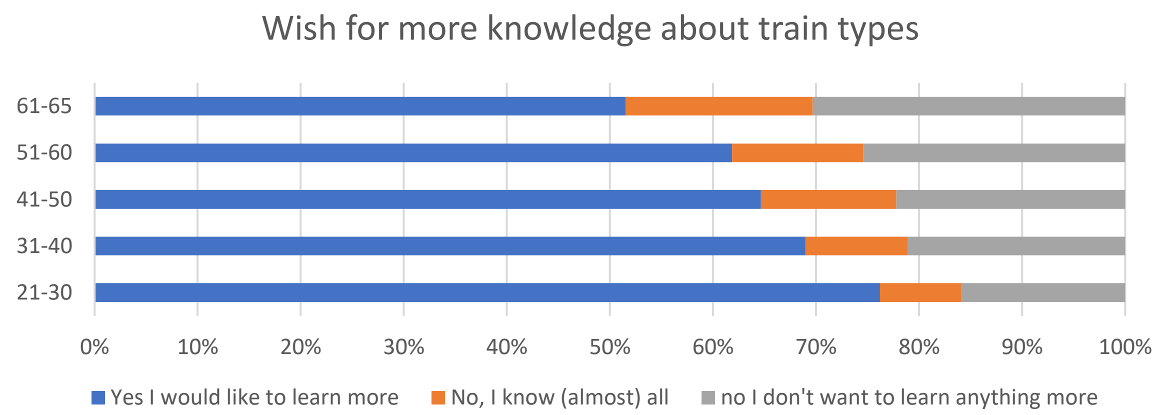
- **Tour composition (0.293)**. Potential enhancement of job satisfaction can come from 1) increasing the variability of routes and train types within the driving tasks assignment and 2) time of the day of the tour (early or late tour).
- **Tour sequence (0.264)**. This topic can contribute to the enhancement of job satisfaction by increasing 1) the consideration of the tasks compatibility with private life / family, and 2) the real rest between two tour sequences.
- **Disposition (0.277)**. Main aspects refers to the communication systems. Enhancements of job satisfaction values are linked to an increase of 1) the communication speed regarding the modifications inside a tour (tasks) or in a tour sequence, and 2) of the possibilities for tasks exchange also regarding specific wishes from train drivers.
- **Working environment (0.161)**. Aspects that can potentially enhance the job satisfaction are 1) a balanced workload and 2) the workplace layout.

The survey results have been subject of deep cluster analyses. As expected, the heterogeneity of working conditions and private life conditions/preferences of each train driver does not allow to clearly identify a set of clusters. However, among all the clustering options considered, age-based clusters showed different preferences between young and old train drivers. An example is reported in figure 8, in which train drivers' preferences about routes and train types are reported by clusters.

Specifically, within the tour composition and in the tour disposition, the young people are more satisfied of the current condition, for what concern times dimensioning (specifically, correct dimensioning of the times for train preparation), are more willing to accept variations and are less stressed than older train drivers. On the other hand, they are more interested to learn new routes and to drive new trains (see figure 10) than the older ones, mostly because the older train drivers already have a wide knowledge of the routes. From these results, it is reasonable to enhance the knowledge transfer policies to speed up the learning phase of young drivers regarding different routes/train types.

-





- *Figure 8. Train drivers preferences about routes and train types*

3.2.4.1 Workshop with Swiss International Airlines

It is worth to mention that, within the project activities, a workshop with Swiss International Airlines has been organized. The main aim was to identify possible similarities and/or affinities in the definition of productivity KPIs. Results show that Swiss IA has a similar approach to productivity and its relations to robustness and job satisfaction concerning the cabin cockpit crew management.

Specifically, the most important KPI is the rate between Crew block hours (CBH) and Full-time equivalents (FTE). Crew block hours are computed from brake release from the gate at the departure airport to brakes set and main cabin door open at its destination. CBH includes also the Flight time, i.e. the time from the wheel leaving the ground to the time they touch back down. Flight time can be assimilated to driving time in railway. On short haul flights, the planned rate between flight time and FTE is about 30%, under normal circumstances (for comparison target SBB: driving time / FTE about 50%).

Robustness in operation is evaluated by Swiss IA through Flexibility concepts. In other words, an increase of flexibility in operation means an increase of robustness because the capability of the system to absorb the operation variability also increases. This is pursued through a set of measure such as:

- For every 3 vessel units of an aircraft type, 1e reserve crew must be scheduled to ensure the necessary robustness of the flight plan.

- Reserve capacity in particular and crew capacity in general are planned per aircraft type and airport type (proficiency).

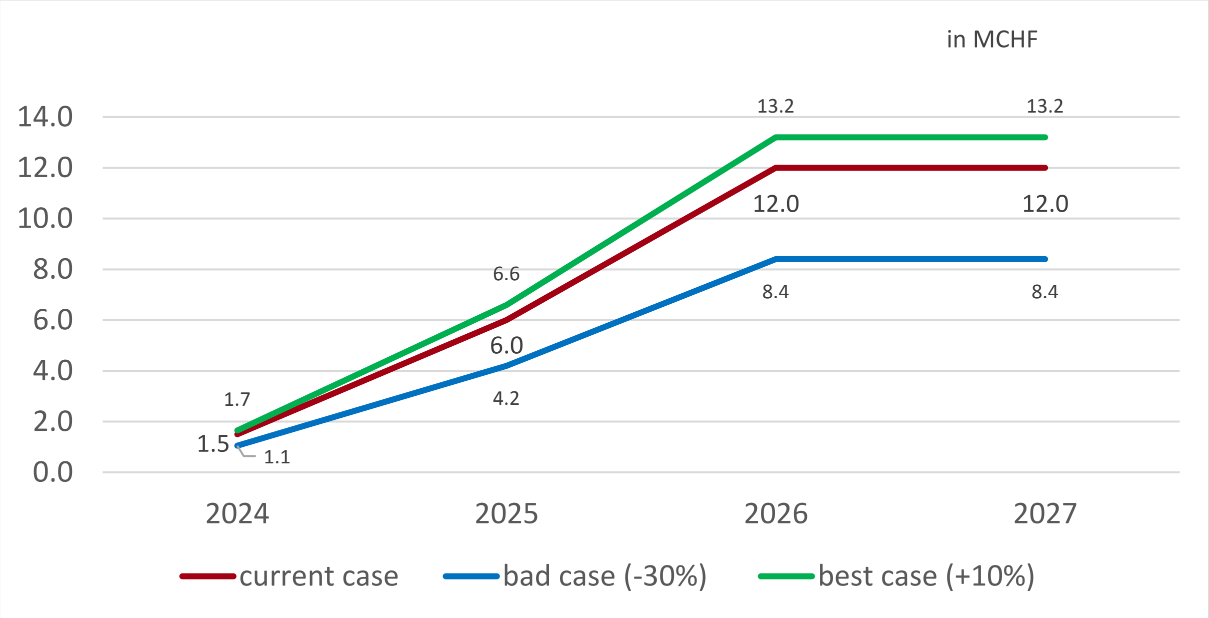
Reserve time can be spent by crew members at home. At the end of a reserve shift, an assignment can be scheduled. Zurich is the general home base for all SWISS pilots. Travel (e.g. from Geneva or for an assignment in Geneva) will be charged via expenses.

Job satisfaction is related to the work scheduling. At the beginning of the year (but also during the year) requests can be entered, which are allocated algorithmically by the personnel planning team. It is important to know how many employees with the same or a similar request profile have already been scheduled for missions corresponding to the request profile. In addition to the desired profile, there are many other factors such as statutory or collective agreements on working time requirements, fatigueness rules, skill requirements, etc. that are considered. The degree of wish fulfillment (with the wish profile as a reference value) can be shown as a mathematical value.

Swiss IA computes the mathematical evaluation of job satisfaction as degree of wish fulfilment on duty scheduling. It has been however clarified that employee satisfaction is an objectively difficult quantity to grasp, since it means something different for each employee.

3.2.5 Desired state "to be"

SBB's productivity targets are currently very ambitious and will remain so in the future. One reason for this is the decrease in demand due to the Corona pandemic. This has hit SBB severely in financial terms. Despite the current recovery, it is uncertain how long it will take before there are again as many passengers as before the pandemic. This is likely to take several years.
To alleviate the situation, rail production and thus locomotive personnel are also expected to make a contribution. Figure 9 shows the ambitious productivity targets.



Assumption	2024	2025	2026	2027
Increase in planned productivity	-1.5	-3.0	-6.0	-6.0
Approach of actual productivity to plan	-0.0	-3.0	-6.0	-6.0
Total	**-1.5**	**-6.0**	**-12.0**	**-12.0**
In FTE	-12.5	-50.0	-100	-100

Figure 9. forecasting trends regarding SBB productivity Source: SBB-ZHAW_Kickoff_LF neue Version, slide 5; 14.9.2021

However, optimizing productivity cannot be done in a separate way from other essential performance characteristics. These include the robustness of the operation and the motivation of the personnel involved.
By improving robustness, it should be ensured that the effects of disruptions do not propagate unnecessarily, and delays can be minimized. This can save costs and improve customer satisfaction. In order to remain attractive as an employer, it is important that the satisfaction and desires of the train drivers are taken into account in the optimization process. In this way, the attractiveness of the profession and the company can be increased, and high costs due to fluctuation can be prevented.

Since these three topics are in conflict, it is important to find suitable measures that do not disadvantage any of the three topics.

4 Action planning – Identification of the potential areas for enhancement

The main target of the action planning is to identify the main areas in which apposite measures can enhance the current state of the system. The current state of the system has been described through KPIs train drivers' productivity, robustness of the operation and job satisfaction. These three topics are in conflict to each other, and therefore actions increasing one of the three without decreasing the other two have to be identified.

Starting with productivity aspects it has to be stated that current productivity can only be increased if the available resources are lowered. The common notion of productivity is

$$\text{Productivity} = \frac{\text{Output}}{\text{available Input}}$$

The output cannot be increased as the number of train rides is fixed by the timetable and assumed to be not negotiable. In this context the available inputs are the resources from the train drivers, i.e. their available time to work. However, as mentioned above, the available time is divided into time to drive a train ("Lenkzeit") and all other time needs to perform a ride on the one hand and break times that are not directly related to train rides. The latter amount of times has to be reduced as this time is not given by the timetable but due to rostering activities.

Two different dimensions of productivity have to be considered: (i) What is the planned productivity? And (ii) what is the realized productivity?

If planned productivity is increased, this doesn't automatically mean, that realized productivity is increased as well: Assume that available buffer times are shrunk during planning of the activities. Therefore, the planned productivity is increasing. However, the risk of failures is increasing as well, as the decreased buffer times necessitate reschedulings and re-rosterings in daily operation. However, these disposition decisions are at most as good as the optimized planning, usually the realized productivity is hence affected negatively. Hence, a natural decomposition of the analyzed productivity into strategical and tactical level is sensible. Regarding the productivity aspects, two main types of enhancements can be taken into consideration:

1) increase of productivity within the planning phase (strategic level), i.e., increase the share of planned driving time with respect to the overall available time,
2) minimization of the differences between planned and realized productivity (tactical level), i.e. increase the driving time during operation to meet the expected (as planned) performances.

Regarding the second type of enhancement, it has been shown that the difference between planned and realized productivity is mostly due to the disruptions that occur during operation (heavily delayed train, cancelled trains), which lower the driving time value and let the AVOR 2 value grow due to train drivers transfers. The reasons behind disruptions may vary and may not depend on train drivers' activities. Increasing the robustness therefore means, that large train delays and train cancellations have to be avoided as far as possible in order to prevent reschedulings and re-rosterings. However, if an incident happens, then reschedulability and re-rosterability should be high, meaning that resources are geographically and timely flexible. From a management perspective, the train drivers' shift plans and tours have to be designed in such a way that time buffers and flexibilities are manageable and useable if needed.

The robustness has thus been evaluated through the MTBF (mean time between failures) – a well-known and widely used value in manufacturing and service operations management. In the context of train rides the MTBF is a measure indicating the time between two rescheduling/re-rostering events either inside a depot (crew view) or of a single tour (tour view). A low MTBF value shows, that either in a depot (crew view) or on a specific tour (tour view) a disposition decision has to be made. In the context of tours, "risky" tours can be identified, if the MTBF value is low. In the context of crew views, the needed flexibility of the crew is measured; again, a low MTBF showing a high required flexibility for crew members on duty. It goes without saying that frequent rescheduling means that more crew resources have to be kept available. If a higher number of resources is not available then only two general measures can be taken into account to increase robustness: (i) the flexibility of the train drivers must increase so that a single incident can be dealt with by many different means – adapted to the situation These measures are on a strategic level. (ii). the variability of failures must decrease, i.e. the number and amount of rescheduling processes, which are directly connected to the number of tasks to be performed during a duty This view is on a tactical level.

The job satisfaction KPIs show a partially satisfying working condition, which can be enhanced through specific leverages in each component (i.e. macro topic). According to what has been already identified through the survey on job satisfaction, two main areas for enhancement are therefore considered. The first regards the variability in the tasks that compose the tour (on a strategic level), which is a priority to train drivers, and the second refers to the aspects related to communication of tasks (i.e., punctuality, correctness, detail level, etc.), within the Disposition topic and thus on a tactical level. Dealing with those communication issues shall reduce some of the aspects like stress and time pressure and therefore enhance job satisfaction of train drivers. Moreover, the robustness in terms of flexible task assignment is addressed as well. It must be mentioned that the technological component plays an important role, i.e. modifications on the planning and rostering on a strategic level may not bring relevant enhancements, if on a tactical level the measures are not realizable.

4.1 Increasing the overall flexibility through depot groups– Strategic level

In the introduction of the previous chapter different measures on strategic and tactical levels have been introduced and the relationship between them has been shown. In this chapter, a couple of measures on a strategic level are identified and discussed in detail.

Through the EFA reports the train delays and train cancellations due to train drivers' activities have been selected, and the MTBF has been therefore calculated. Results show that the deviations from planned conditions are most likely not related to the planning process of tours and of the rostering process. By analyzing the motivations of delays due to train drivers, it has been noted that the most frequent reason for delays is due to communication failures (e.g. incorrect information on: parking place, departure time, transfer connections, etc.). Moreover, according to the analyzed EFA dataset, it is possible that some external factors associated with the operating conditions, such as seasonality, can affect the number of reported trains cancellations/delays. However, this consideration must be confirmed through further in-dept analyses of a larger data set on punctuality of train operations.

Therefore, the current SOPRE system with goals and requirements to be met is a solid system regarding robustness and planned productivity. Increasing job satisfaction, however, without decreasing planned productivity and robustness is therefore a very hard task, if the conditions to be met cannot be relaxed. In the current system, i.e. within the current unrelaxed condition set, new strategic improvements to all three dimensions are assumed to give only limited benefits – just marginal benefits. In order to generate additional benefits, drivers beyond the current borders have to be found. Identifying drivers to increase any of the three dimensions is therefore equal to identifying relaxations potentials, i.e., conditions that are not hard but, in some way, negotiable. The following proposals of measures are considered and discussed in more detail:

- From single depot to flexible depot: The key idea is that all or at least a large group of train drivers are not assigned to a single depot anymore but to a group of a few depots. This measure shall increase the flexibility and hence increase the robustness and job satisfaction.
- Identifying good, individualized tours: The key idea is to identify a good mix of variable tours so that on a daily basis as well as on a monthly basis a good mix of tours is provided to all train drivers. This measure aims directly to job satisfaction and increases today's job satisfaction.
- Individualizing buffer, break and AVOR times: The key idea is to individualize needed times to perform certain non-driving activities. Behind this idea is the goal to increase job satisfaction as well as increase the productivity indices, as non-driving times can be reduced.

4.1.1 Flexible depot allocation

A long-term action is foreseen in the transformation of the tour assignments from a depot concept to a depot group concept. A depot group is composed by two or more depots which have routes and train types in common and for which the travel time between them is small enough. Currently, at the planning level, it is assumed that rain drivers inside a depot have a general knowledge of all routes and train types that start and end at this depot. However, increasing the flexibility in the depot allocation for train drivers opens a pool of larger resources at the planning stage to assign all tasks to a broader group of train drivers. It is, though, required that train drivers do not have a single depot as it is the case mostly today. Some legal issues have to be clarified beforehand – however, the survey showed that a fixed assignment of a train driver to a single depot has the second lowest weight (out of eight). Hence, it is concluded that the resistance to relax today's fixed depot allocation is low.

In particular, it would have to be defined whether a tour for a train driver has to start and end at the same depot and whether or not a sequence of tours (e.g. a 5 day shift) has to be assigned to the same depot or whether start and end depot are completely free inside the depot group for every single tour. Nevertheless, this increase of flexibility is assumed to increase the robustness directly as long as the buffers remain the same (see next subsections).

Moreover, as most train drivers like variation in their tours and duties, this measure helps to increase job satisfaction. It is assumed (however not proved yet) that the variety of route rides is increasing for the train drivers.

Given the route and engine knowledge of the train drivers, this flexibilization aims to increase two of the three dimensions: job satisfaction and robustness. More in-depth analyses have to be made in order to decide whether or not productivity increases or decreases. One key question is, how productivity in future is defined. On an individual level, the productivity can decrease, if transfer times within the depot group have to be paid by SBB. However, both planned and realized depot productivity can increase, as the same amount of work (output) is achieved with probably less input resources.

As an example, Depot Zürich and depot Winterthur are considered. In both depots, there are train drivers able to drive between the 4 routes that connect Zurich to Winterthur and beyond. Flexibility can be enhanced when these train drivers can be optimally shared and jointly assigned to these routes, disregarding the depot they belong to (See figure 10).

Depot	S-Bahn [#Line/d]	S-Bahn	Long Distance [#Line/d]	Long Distance [#Pers/d]	Sum Required personnel
Winterthur	13	1.95 d Arbeit /d → 2 Pers	5	2.25 d Arbeit /d → 3 Pers	5
Zürich	22	3.3 d Arbeit /d → 4 Pers	14	6.3 d Arbeit /d → 7 Pers	11
Cluster W + Z	35	5.25 d Arbeit /d → 6 Pers	19	8.55 d Arbeit /d → 9 Pers	15

Figure 10. Example of depot cluster concept applied to Winterthur and Zurich. Redution of personnel requirements is highlighted.

The depot group concept should transfer the focus from single depot considerations to a group of depots. Well-defined cluster criteria have to be found though. Some criteria could be: number of routes in common, rolling stock types in common, travel time between two depots, geographically nearness, language, etc.

Productivity. With more flexibility there is potential for a better planning and assignment, thus for an increase of the overall driving time share, i.e. a more efficient use of resources (see figure 11). Nevertheless, individual driving time shares could decrease as well. A productivity index for a single train driver is not recommended anymore; it has to be replaced by a depot group productivity index.

Depots	Planned tasks		Required personnel		
	S-Bahn	Long distance	S-Bahn	Long distance	Sum
Winterthur	13	5	2	3	5
- Efficiency			97.5%	75%	84%
Zürich	22	14	4	7	11
- Efficiency			82.5%	90%	87%
Cluster W + Z	35	19	6	9	15
- Efficiency			87.5%	95%	92%

Figure 11. Example of depot cluster concept applied to Winterthur and Zurich. Highlight on a more efficient use of resources.

Robustness. With the depot group concept, delays and cancellations result from the sum of the cases of each depot. On the other hand, there are more resources available and therefore more flexibility to reschedule tasks among train drivers on short notice, and there is potential for faster interventions when a disruption occurs on the tactical level. At the same time it must be taken into account that, referring to the example above, the substitute driver in Zurich may come from Winterthur. While robustness increases on a tactical level, special attention must be paid on robustness issues at the strategic level. Time buffers to alleviate treatments of everyday delays are placed inside tours – either intentionally or by chance . If those time buffers are reduced as well, then it is assumed that robustness on the tactical level will decrease, as the increased flexibility doesn't outweigh the potential risks of not being able to cope with certain delays. It is therefore strongly recommended, that placing and usage of buffer times is both intentionally planned and reasonably managed.

Satisfaction. With the depot group concept, the satisfaction increases since there is more variability in the assigned tasks. There might be increasing costs for completing the shared knowledge of routes and trains (i.e., a part of the track, on which some drivers of a given depot do not usually drive). This might interest only some train drivers ‘groups and some selected routes served with specific train types.

4.1.2 Individualized tours

The current planning steps consider the timetable definition, the rolling stock assignment, and the crew management as three consecutive activities, positioned in this sequence. Starting from the survey’s outcome that train drivers don’t like repeatedly, monotonous shifts, a natural question on individualization possibilities arises. Is it possible to state some individual preferences, so that at the strategic level shift planning can be individualized? This question is highly motivated by the survey’s outcome, that 2/3 of the train drivers prefer attractive tours to higher salaries.

Behind this question are two relaxations that have to be made: First, the shift planning process has to be changed slightly, as tours have to be directly assigned to individual crew members and not to crews. Given the necessary computer support for automating roster decisions, this process adaption seems feasible, yet has to be well analysed in detail. Moreover, a system to hand in individual preferences has to be built. Second, in SOPRE or similar systems an adaption in tour composition has to be made. It is of crucial interest to compose interesting tours, i.e., mathematically expressed, an evaluation function has to be developed. This evaluation function assesses a tour in terms of variability. The more variable a tour is, the more attractive this tour is for the train drivers. The task in rostering and a task in strategic as well as in tactical planning is then to assign a balance of attractive and less attractive tours to all train drivers.

One main reason for delayed or cancelled trains due to train driver errors is the “missed or delayed transfer”. If the number of transfers for train drivers can be reduced, then realized robustness will increase and hence realized productivity will increase as well. Reducing the number of transfers is however running counter to increasing the attractiveness of tours. Hence, it has to be examined how a reduction of the number of transfers affects the attractiveness of a tour.

It has to be noted that this system of individual preferences is an opt-in system. Train drivers are able to set individual preferences, yet they are not allowed to deselect certain preferences. If the latter would be allowed, then feasibility isn’t ensured anymore as the set of constraints is getting smaller. Hence the opt-in preference set ensures first feasibility of the solution and then among all possible solution a most preferable solution for the train drivers is selected.

Individualizing tour preferences can be implemented in two steps: (i) an attractiveness function has to be invented, so that attractive and unattractive tours can be recognized. (ii) individual preferences are then set by weights (factors) of this attractiveness function.

Productivity: Neither the flexibility nor the number of train rides is affected with this preference system. Hence, both planned and realized productivity are expected to remain the same as without any preference system. If the number of transfers is reduced, then it is expected that both the planned and realized productivity increases.

Robustness: At first sight, robustness isn’t affected by this preference system. On a strategic level, time buffers are not affected and hence it is expected that robustness isn’t decreasing while planning. For coping with everyday delays, it is important that robustness isn’t getting affected due to dissatisfaction of train drivers. Hence communication of tasks and transparency in decisions is important (see below).

Job satisfaction: The measure implements preferences which is a benefit in comparison to today’s system. Hence an increase in satisfaction is expected. However, communication of those preferences is crucial: It is not a system, where each train driver has an attractive tour every day – it is a social optimization. Another point to keep in mind is the robustness link: If a train driver has planned attractive tours but has been assigned to unattractive tours after rescheduling and re-rostering during tactical phases, then a dissatisfaction might happen. Therefore, it is important how both planned and realized tours are communicated and how the decision has been supported. If the number of transfers is slightly reduced as well, then it is expected that job satisfaction will remain the same or will even increase (less stress while executing the transfer). However, if the number of transfers is so low, that a train driver seldomly or never changes the rolling stock during his/her shift, then job satisfaction will decrease significantly.

4.1.3 Individualizing non-driving times

Previously, productivity has been expressed as the quotient between outputs and inputs. As the output is assumed to be fixed by the timetable, the inputs have to be lowered in order to increase productivity. Instead of introducing more flexibility among crews (see 4.1.1.) the individual non-driving times have to be adjusted. If the duration of those tasks can be shrunk, then productivity automatically increases. From the survey's outcome it is unclear whether or not non-driving times are set correctly or if the duration is too long or too short. However, there might be a potential to individualize those times so that productivity can be increased.

From a computational point of view, individualizing task times is very hard to introduce. The duration is not a fixed value anymore, but dependent on the individual train driver that executes the task. The mathematical program is therefore more complex and computer support is expected to be (much) slower and the quality of the support could be reduced as well.

Productivity: Shortening of task duration will automatically increase and widening of task duration will automatically decrease the productivity. As the durations can be set by the train drivers themselves, planned productivity is individualized as well. It is assumed that planned productivity will decrease, as most train drivers would increase their task duration. However, realized productivity is assumed to increase, as delays caused by train drivers are assumed to decrease. Late trains or train cancellations are therefore reduced. In a later project is has to be proved that this measure brings planned and realized productivity together.

Robustness: Shortening non-driving times on the first hand comes with the risk of delay propagation: If some tasks are shortened, then buffer times are shortened as well, increasing the risk of delayed trains or even missed trains. Hence, robustness is affected on both the strategic and the tactical level. On the other hand, non-driving times could also be increased (slightly). It has been reported that train drivers do this already "for free" if they think their individual plan is too tight. In that case, robustness is increased as variable execution times of different tasks can be better absorbed.

Job satisfaction: At first sight the job satisfaction is not directly affected, as non-driving times usually do not correlate to tour attractiveness. However, too short task duration at a strategic planning phase might cause stress during the execution. For work-life-balance of the train drivers it is most important that the stress level is lowered. The survey clearly showed, that many train drivers think about reducing their workload due to stress. The most listed subject for experiencing stress was "planned duration too tight". Again, communication plays an important role here: If it is expected from the management that durations of non-driving tasks are reduced, then job satisfaction will decrease. If, however, the individualizing step is a true individualization for increasing job satisfaction and work-life-balance of the train drivers, then this measure might increase the satisfaction level.

4.2 New tour planning and assignment – tactical level

On a tactical level, the plan must be realized. However, due to some events outside and inside the system, trains get delayed. This causes problems in the daily disposition of train drivers. Hence the minimization of the differences between planned and realized productivity (tactical level) must be pursued.

The tour planning and assignment process is a two steps process that sequentially generates: (1) tour scheduling, and (2) roster planning. A tour starts and ends in a crew depot and describes the consecutive tasks for a generic train driver. For each day, a set of anonymous tours is generated. Rosters prescribe how to assign the anonymous tours to train drivers on consecutive days.

Tour planning and assignment affects the performance characteristics in the following theoretical way:

- **Productivity** targets are normally defined through duty schedules. Therefore, a duty schedule is theoretically more efficient when fewer duties are scheduled to operate all tasks. This however does not return the expected results in practice. More tasks to be done means also more transfer times and more probability that something goes wrong in the execution of the planned services.
- **Robustness** of train drivers' duties, i.e., preventing the propagation of delays via the duty schedules, depends on several elements, which are normally referred to additional resources, i.e. time, personnel, etc., and transfers, which are directly connected to the number of tasks within a tour. Robustness is often addressed in the crew duty scheduling problem by using constraints. It is hard to define a value to robustness, which can be optimized, it is however clear that either buffer time between tasks/ spare duties or fewer but longer tasks will limit propagation of delays (but, at least in the first case, the time productivity decreases).
- The **job satisfaction** for the tour planning pertains the qualitative aspects of the scheduled duties perceived by the crew members. This is addressed via labor rules and company agreements, like the amount of variation in the duties. In the roster planning the quality of work can be measured by computing the number of preferred and non-preferred patterns of consecutive days of work.

Given the afore-mentioned assumptions, the analyzed data show that the performance characteristics are affected by the following:

Productivity targets are largely affected by the number of cancelled trains and, in second place, by delayed trains. From the data analysis, the events might be not directly related to the timetable construction.

Robustness measures, i.e. reserve times, buffer times, etc. can be effective for the delays they are planned for. This means that large delays are managed differently, i.e. with rescheduling and re-rostering for the affected tasks/duties. It is therefore to consider the number of reserve times or buffer times dedicated to each task, i.e., the number of tasks, as possible variable for increasing/decreasing robustness. The less the tasks, the more the robustness and vice versa.

Job satisfaction is mostly affected by the variability of tour sequences and of tasks within a tour. This has been also highlighted in the free text answers, where 42% of the answers correlated to requests of more variation in train types and routes (ca. 40% of the total answers received) asked explicitly less S-Bahn services and more long-distance tours, or even a good mix between the two.

Based on the theoretical assumptions and the analyses of real data, productivity results can be improved if the robustness of the tour planning and assignment is also improved (see strategic level, last section). Tour schedules and rosters, which allow for quick recovers, may have a positive effect to productivity.

This bring to the following points, which are worth investigating.

1. Longer tasks may lead to more stable operation and better results. This might also consider less planned time used for train preparation (AVOR1). With less but longer tasks within a tour, also the amount of information exchanged between the planner and the driver is reduced. This impact positively on the number of delays generated by wrong/missing information, which is one of the main motivations reported on EFA.
2. Through a weighted function in the tour planning, the tour can be therefore composed so that a good balance between S-Bahn and Long-distance train is achieved.

This might be a tactical solution that would allow enhancing directly robustness and job satisfaction, and indirectly productivity KPIs, through the minimization of the distance between planned and realized performances.

Together with the previous consideration on the analyzed data, other points that go in this direction are worth mentioning. Specifically, from the job satisfaction survey it results that:

1. 36% of the answers indicates that Locomotive personnel would prefer to work in consistent tour patterns. That means, for example, only early tours or only late tours. This wish could have an influence on productivity. On the one hand, better planning could be possible, since less attention would have to be paid to changing tours from, for example, late to early. On the other hand, productivity could be increased by fewer errors and thus delays / cancellations caused by locomotive personnel, since they always work at a certain time of day.

2. In general, locomotive crews would like to be assigned to tours as early as possible. The survey shows that for the right price, it is quite possible to communicate the scheduling later. This could have a positive impact on robustness, in terms increased flexibility, as better replanning becomes possible.

For this solution, an in-depth analysis with simulation of tours and tour sequences is foreseen, to eventually confirm the conclusion here reported.

4.2.1 SOPRE – New model for tour planning.

In the tactical level, a new tour planning model which includes a weighted function for the train types within a tour and new time redistribution where time is more needed is suggested.

The main direct benefits are identified in a more robust tour plan and in higher satisfaction of train driver. The first aspect, according to the data analysis should positively affect the productivity of train driver, because KPIs values mostly decrease when delays and cancellation occurs.

Cancellation and delays are not necessarily linked with train drivers' activities, but these affect their performances. For the planning side, the only action one can take is to make the crew management process more robust. In other words, to make an example, the optimization of the duties for increasing the driving times may affect less than ensuring that the currently planned driving times are executed.

The costs related to the implementation of this measure can be limited to the planning team. The additional time eventually to be planned within the tour planning, must be evaluated through an in-depth analysis and/or through tour simulation.

4.2.2 Best practices in Switzerland

Within the activities of data analysis regarding the survey on job satisfaction, a different behaviour in the answers between different depots can be found. An example is given by analyzing the groups Aarau, Basel, Olten (AA-BS-OL) and the group Lucerne, Arth Goldau, Zug (LZ-GD-ZG).

The indicators considered show a different behaviour between the two groups. In particular, the group AA-BS-OL adheres more to the general statistics. The group LZ-GD-ZG tends to be more satisfied with the current tour and deployment planning (see Figure 12).

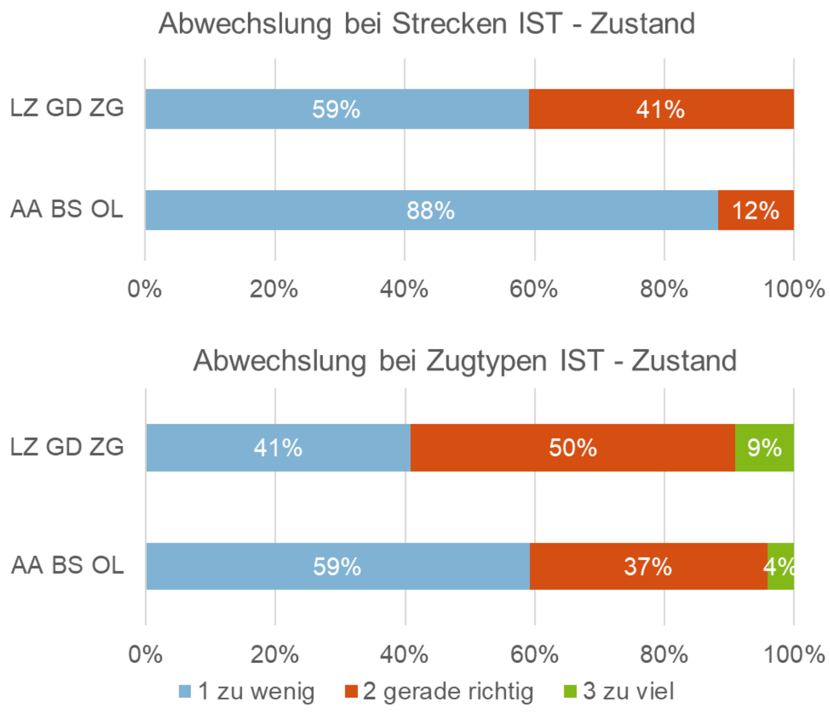


Figure 12. Train drivers evaluation about current variability of routes and train types

Possible reasons for this different behavior are that:

- The services offered in the region are differently attractive.
- The communication between the locomotive staff and the manager in the depots is different.
- The locomotive staff in the depot cluster LZ GD ZG is used on variable routes and trains while in the depot cluster AA BS OL they are used on uniform routes and trains.

These differences suggest that further investigations to identify the key aspects, which allow enhancing the productivity indicator together with the robustness and the satisfaction of train drivers, are needed. Through a deep analysis of depots groups indicators coupled with results from the train drivers' job satisfaction survey, it is possible to identify and isolate the best results and main reasons that allow these results. In this way it can be possible to define the key aspects for tour planning and rostering that can bring to productivity enhancements without negatively affecting robustness of the services and job satisfaction.

5 Conclusion

In this project report the identification and evaluation of optimization potentials for train drivers productivity by including train driver and customer perspectives, such as job satisfaction and punctuality into productivity objectives has been presented

The identification of potential leverages that positively impact on the three dimensions have been deduced from the gap analysis between the current state and the desired state, which allowed identifying which aspects may contribute to the system improvements and to which extent. We started from the assumption that the simple interactions between two of the three dimensions may not give information about e.g., the train drivers' satisfaction related to the scheduled tasks, the expected service quality related to the timetable, or the efficient/inefficient use of human resources.

Operators' perspective is here considered through the main concepts that the total train drivers' costs must be as small as possible. These costs directly relate to the number of train drivers needed to operate the schedules. In this aspect, a tour sequence is more efficient when fewer tours are scheduled to operate all tasks. Next to the number of tours per day, an indicator for the efficiency is the average driving time within a duty. At SBB, this is about 50%. The remaining time is spent on other tasks, which can be directly or indirectly related to the driving activity, or be unproductive (e.g. holidays). Because the amount of work is given by the timetable, a higher percentage of driving time means that fewer tours are scheduled.

Customers' perspective is seen as the perception of customers about the good or bad operation of the train services. The main aspect to take into consideration is that customers do not know whether the delay/cancellation of a train is due to crew management problems or to other problems related to other processes, e.g. traffic management, rolling stock failures, etc. Since the evaluation of robustness in general terms is out of scope for this project, only the robustness of the train drivers' duties is considered. The robustness of the train drivers' duties, i.e., preventing the propagation of delays via schedules, depends on several elements, including the transfer times of the crew when transferring from one train to another. Robustness is often addressed in the crew duty scheduling problem by using constraints. It is hard to define a value to robustness, which can then be optimized, but it is clear that buffer time between tasks on two different trains will limit propagation of delays.

Train drivers' perspective is here evaluated as the satisfaction perceived by the train drivers regarding their job. This is addressed via labor rules and company agreements, for example, on the amount of variation in the tours and in the tour sequences. In this section, some examples of indicators, used to determine the level of satisfaction within the train drivers are also presented.

From these assumptions a set of measures have been proposed, both at strategic and at tactical level. Specifically:

1) Increase of productivity within the planning phase (strategic level), i.e., increase the share of planned driving time with respect to the overall available time,

2) Minimization of the differences between planned and realized productivity (tactical level), i.e. increase the driving time during operation to meet the expected (as planned) performances.

It has been also shown that the difference between planned and realized productivity is mostly due to the disruptions that occur during operation (heavily delayed train, cancelled trains), which lower the driving time value and let the AVOR 2 value grow due to train drivers transfers. The reasons behind disruptions may vary and may not depend on train drivers' activities. Increasing the robustness therefore means, that large train delays and train cancellations have to be avoided as far as possible in order to prevent reschedulings and re-rosterings. However, if an incident happens, then reschedulability and re-rosterability should be high, meaning that resources are geographically and timely flexible. From a management perspective, the train drivers' shift plans and tours have to be designed in such a way that time buffers and flexibilities are manageable and useable if needed.

The robustness has thus been evaluated through the MTBF (mean time between failures) – a well-known and widely used value in manufacturing and service operations management. In the context of train rides the MTBF is a measure indicating the time between two rescheduling/re-rostering events either inside a depot (crew view) or of a single tour (tour view). A low MTBF value shows, that either in a depot (crew view) or on a specific tour (tour view) a disposition decision has to be made. In the context of tours, "risky" tours can be identified, if the MTBF value is low. In the context of crew views, the needed flexibility of the crew is measured; again, a low MTBF showing a high required flexibility for crew members on duty. It goes without saying that frequent rescheduling means that more crew resources have to be kept available. If a higher number of resources is not available then only two general measures can be taken into account to increase robustness: (i) the flexibility of the train drivers must increase so that a single incident can be dealt with by many different means – adapted to the situation These measures are on a strategic level. (ii). the variability of failures must decrease, i.e. the number and amount of rescheduling processes, which are directly connected to the number of tasks to be performed during a duty This view is on a tactical level.

The job satisfaction KPIs show a partially satisfying working condition, which can be enhanced through specific leverages in each component (i.e. macro topic). According to what has been already identified through the survey on job satisfaction, two main areas for enhancement are therefore considered. The first regards the variability in the tasks that compose the tour (on a strategic level), which is a priority to train drivers, and the second refers to the aspects related to communication of tasks (i.e., punctuality, correctness, detail level, etc.), within the Disposition topic and thus on a tactical level. Dealing with those communication issues shall reduce some of the aspects like stress and time pressure and therefore enhance job satisfaction of train drivers. Moreover, the robustness in terms of flexible task assignment is addressed as well. It must be mentioned that the technological component plays an important role, i.e. modifications on the planning and rostering on a strategic level may not bring relevant enhancements, if on a tactical level the measures are not realizable

6 Bibliography

1. Abbink, E., Albino, L., Dollevoet, T., Huisman, D., Roussado, J., Saldanha, R. (2011). Solving large scale crew scheduling problems in practice. Public Transport, 3:149–164. ISSN 1866-749X. 10.1007/s12469-011-0045-x.

2. Abbink, E., Mobach, D., Fioole, P., Kroon, L., Heijden, E. van der, Wijngaards, N. (2009). Actor-agent application for train driver rescheduling. In Proceedings of the Eighth International Conference on Autonomous Agents and Multiagent Systems, pages 513–520. International Foundation for Autonomous Agents and Multiagent Systems.

3. Abbink, E.J.W, van den Berg, B.W.V., Kroon, L.G., Salomon, M. (2004). Allocation of Railway Rolling Stock for Passenger Trains. Transportation Science, 38(1):33–42.

4. Barnhart, C., Johnson, E.L., Nemhauser, G.L., Savelsbergh, M.W.P., Vance, P.H. (1998). Branch-and-Price: Column Generation for Solving Huge Integer Programs. Operations Research, 46:316–329.

5. Caprara, A., Fischetti, M., Toth, P., Vigo, D. (1998). Modeling and Solving the Crew Rostering Problem. Operations Research, 46:820–830.

6. Caprara, A., Fischetti, M., Toth, P., Vigo, D., Guida, P.L. (1997). Algorithms for railway crew management. Mathematical Programming, 79(1–3):125–141.

7. Castro, A. JM, Oliveira, E. (2011). Airline operations control: A new concept for operations recovery. Airline Industry: Strategies, Operations and Safety.

8. Cawsey, T.F., Ingols, C., Cawsey, T.F., Deszca, G. (2011). Organizational Change: An Action-Oriented Toolkit. SAGE Publications. ISBN 9781412982856.

9. Dollevoet, T. (2013). Delay Management and Dispatching in Railways. Ph.D. thesis, Erasmus Research Institute of Management.

10. Fioole, P.J., Kroon, L., Maroti, G., Schrijver, A. (2006). A Rolling Stock Circulation Model for Combining and Splitting of Passenger Trains. European Journal of Operational Research, 174:1281–1297.

11. Fores, S., Proll, L., Wren, A. (2001). Experiences with a Flexible Driver Scheduler. In Voß, S., Daduna, J.R. (editors), Computer-Aided Scheduling of Public Transport, pages 137–152. Springer, Berlin, Germany.

12. Gambacorta, R., Iannario, M., (2012). Statistical models for measuring job satisfaction. Bank of Italy Temi di Discussione Working Paper No. 852, Available at SSRN: https://ssrn.com/abstract=2030802 or http://dx.doi.org/10.2139/ssrn.2030802.

13. Hartog, A., Huisman, D., Kroon, L. (2009). Decision support for crew rostering at ns. Public Transport, 1:121–133. ISSN 1866-749X. 10.1007/s12469-009-0009-6.

14. Hohmann, D., (2017). Fragebogen: Erstellung -Durchführung – Auswertung. Methodenseminar ZHAW, MSE.

15. Huisman, D. (2004). Integrated and dynamic vehicle and crew scheduling. Ph.D. thesis, Tinbergen Institute, Erasmus University Rotterdam.

16. Huisman, D. (2007). A Column Generation Approach for the Rail Crew Rescheduling Problem. European Journal of Operational Research, 180(1):163–173.

17. Kohl, N., Karish, S.E. (2004). Airline Crew Rostering: Problem Types, Modeling and Optimization. Annals of Operations Research, 127:223–257.

18. Kroon, L., Huisman, D., Abbink, E., Fioole, P., Fischetti, M., Maroti, G., Schrijver, A., Steenbeek, A., Ybema, R. (2009). The New Dutch Timetable: The OR Revolution. Interfaces, 39(1):6–17. 10.1287/inte.1080.0409.

19. Kroon, L.G., Fischetti, M. (2001). Crew Scheduling for Netherlands Railways "Destination: Customer". In Voß, S., Daduna, J.R. (editors), Computer-Aided Scheduling of Public Transport, pages 181–201. Springer, Berlin, Germany.

20. Lepold, A., Tanzer, N., Bregenzer A., Jiménez, P. (2018). The Efficient Measurement of Job Satisfaction: Facet-Items versus Facet Scales. International Journal of Environmental Research and Public Health, 15, 1362; doi:10.3390/ijerph15071362.

21. Potthoff, D., Huisman, D., Desaulniers, G. (2010). Column generation with dynamic duty selection for railway crew rescheduling. Transportation Science, 44(4):493–505.

22. Rezanova, N. J., Ryan, D. M. (2010). The train driver recovery problem – A set partitioning based model. Computers & Operations Research, 37:845–856.

23. Shibghatullah, A.S., Eldabi, T., Rzevski, G. (2006). A Framework for Crew Scheduling Management System Using Multi-Agents System. In 28th Int. Conf. on Information Technology Interfaces (ITI 2006).

24. Schnieder, L. (2018). "Betriebsplanung im öffentlichen Personennahverkehr", Springer, 136-148.

25. Sodhi, M., Norris, S. (2004). A Flexible, Fast, and Optimal Modeling Approach Applied to Crew Rostering at London Underground. Annals of Operations Research, 127:259–281.

7 Attachment A - Communication of the SBB survey's main results

(The original communication is here reported in German, it is available in French and Italian upon request)

1. Ausgangslage

Die SBB führt gemeinsam mit der ZHAW eine Studie durch, wie sich die Produktivität des Lokpersonals mit dessen Arbeitszufriedenheit und der Qualität der erbrachten Dienstleistungen in Verbindung bringen lässt. Während sich die Produktivität und teilweise auch die Qualität der erbrachten Leistungen einfach messen lassen (erbrachte Zugfahrten), ist der Zusammenhang zwischen Arbeitszufriedenheit und Produktivität bzw. Qualität der erbrachten Leistungen deutlich schwerer messbar. Um die Personalbedürfnisse bewusst in die Studie zu integrieren, wurde die Touren- und Einsatzplanung der Lokführer als zentrale, messbare Grösse identifiziert. Um herauszufinden, welche Faktoren dieser Touren- und Einsatzplanung für die Lokführer besonders wichtig sind, fand vom 22. April bis 09. Mai 2022 eine Onlineumfrage statt.

Das vorliegende Dokument fasst wichtige Erkenntnisse zusammen und zeigt optional mögliche Stossrichtungen auf, wie die Touren- und Einsatzplanung in Zukunft optimiert werden kann, so dass das Zusammenspiel zwischen Produktivität, Arbeitszufriedenheit und Qualität der erbrachten Leistungen verbessert werden kann.

2. Überblick Fragebogen

Der Fragebogen wurde in 4 thematische Aspekte unterteilt: Tourenabfolge, Tourenaufbau, Einteilung und Arbeitsumfeld. Zu all diesen Themen wurden gezielte Fragen entworfen, um die Bedürfnisse den Ergebnissen und Auswertungen bzgl. Produktivität und Qualität der erbrachten Leistungen gegenüberzustellen.

Gesamthaft gingen 480 Antworten ein. An dieser Stelle ein grosses Dankeschön an alle, welche an, dieser Umfrage teilgenommen haben! Dies zeigt wie wichtig das Thema Arbeitszufriedenheit ist und bei so vielen Antworten (ca. 20% der Lokführer:innen haben geantwortet) kann von einem repräsentativen Ergebnis ausgegangen werden.

- Facts

- 73% in Deutsch ausgefüllt, 27% in Französisch und weniger als 1% in Italienisch
- Durchschnittsalter: 44 Jahre
- 88% von Männern ausgefüllt, 5% von Frauen, 6% ohne Angaben und knapp 1% haben Divers angegeben
- 61% haben keine schul- oder betreuungspflichtigen Kinder, 36% mindestens ein schul- oder betreuungspflichtiges Kind und 3% haben keine Angaben gemacht
- Insgesamt kamen Antworten aus 35 verschiedenen Depots, 46,6% der Antworten kamen aus den Depots Zürich, Genf und Bern
- 85.5% der Teilnehmenden arbeitet 80-100%, 14.5% arbeitet weniger als 80%

3. Welche sind die wichtigsten Umfrageergebnisse in Bezug auf die Touren- und Einsatzplanung?

Vor dem Hintergrund einer möglichen Flexibilisierung der Tourenplanung wurden gezielt Fragen bzgl. Tourenabfolge, Tourenaufbau und Einteilung auf die Touren gestellt. Mit Hilfe der Umfrageergebnisse können nun Indikatoren gezeigt werden, die bei einer allfälligen Umsetzung von Strategien für eine flexible Tourenplanung berücksichtigt werden müssen.

- Tourenabfolge

Etwas mehr als ein Drittel der Befragten geben an, dass sie lieber in einem einheitlichen Muster arbeiten möchten (z. B. nur Spättouren oder nur Frühtouren) anstelle einer ausgeglichenen Tourenmischung (vgl. Abbildung 1). Die Mehrheit (57%) bevorzugt jedoch einen Mix aus aufeinander folgenden Schichten.

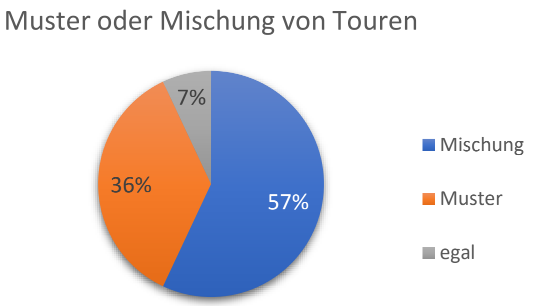
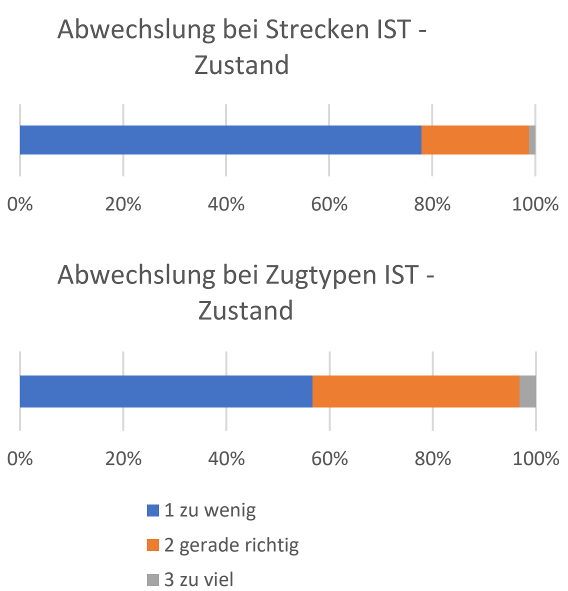


Abbildung 1: Antworten ob lieber in einheitlichen Mustern oder ausgeglichenen Mischungen gearbeitet werden möchte

- Tourenaufbau

Die Umfrageergebnisse zeigen eindrücklich, dass der Tourenaufbau, also die Zusammensetzung von Fahrten in einer Schicht, der wichtigste Aspekt bzgl. Arbeitszufriedenheit des Lokpersonals darstellt.



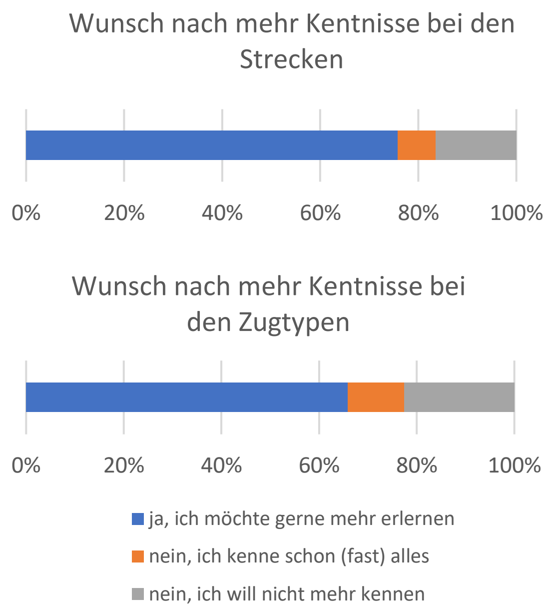


Abbildung 2: % Anteil Antworten Aktueller (links) und idealer (rechts) Zustand für den Punkt «Abwechslung Strecken/Zugtypen»

Die Vielfalt der Strecken und Zugtypen innerhalb einer Schicht ist für die Lokführer der wichtigste Aspekt: 78% gaben dabei an, dass es für sie zu wenig Abwechslung bei den Strecken gibt. 57% gaben an, dass es für sie zu wenig Abwechslung bei den Zugtypen gibt. Dies zeigt auch der deutliche Wunsch nach neuen Kenntnissen bei den Strecken und Zugtypen. Da gaben 76% respektive 66% an, dass sie gerne mehr erlernen möchten (vgl. Abbildung 2). Die Auswertung der Freitexte verdeutlicht diesen Aspekt: Eine Schicht, die beispielsweise nur aus S-Bahn-Fahrten zwischen A und B besteht, ist eine unglücklich zusammengestellte Tour.

- Einteilung

Die Umfrage zeigt, dass die detaillierte Kommunikation von Touren und die Änderungen der zugewiesenen Touren (sowohl bezüglich des Tourenaufbaus als auch der Tourenabfolge) auf den ersten drei Positionen der Wichtigkeit liegen: vor allem sind 68% des Fahrpersonals der Meinung, dass Änderungen der Fahrten (zu) kurzfristig mitgeteilt werden (vgl. Abbildung 3). Die Kommunikation der Dienstpläne (Zeitpunkt, sowie Art und Weise) ist ein zentrales Thema, wenn die Arbeitszufriedenheit gesteigert werden soll.

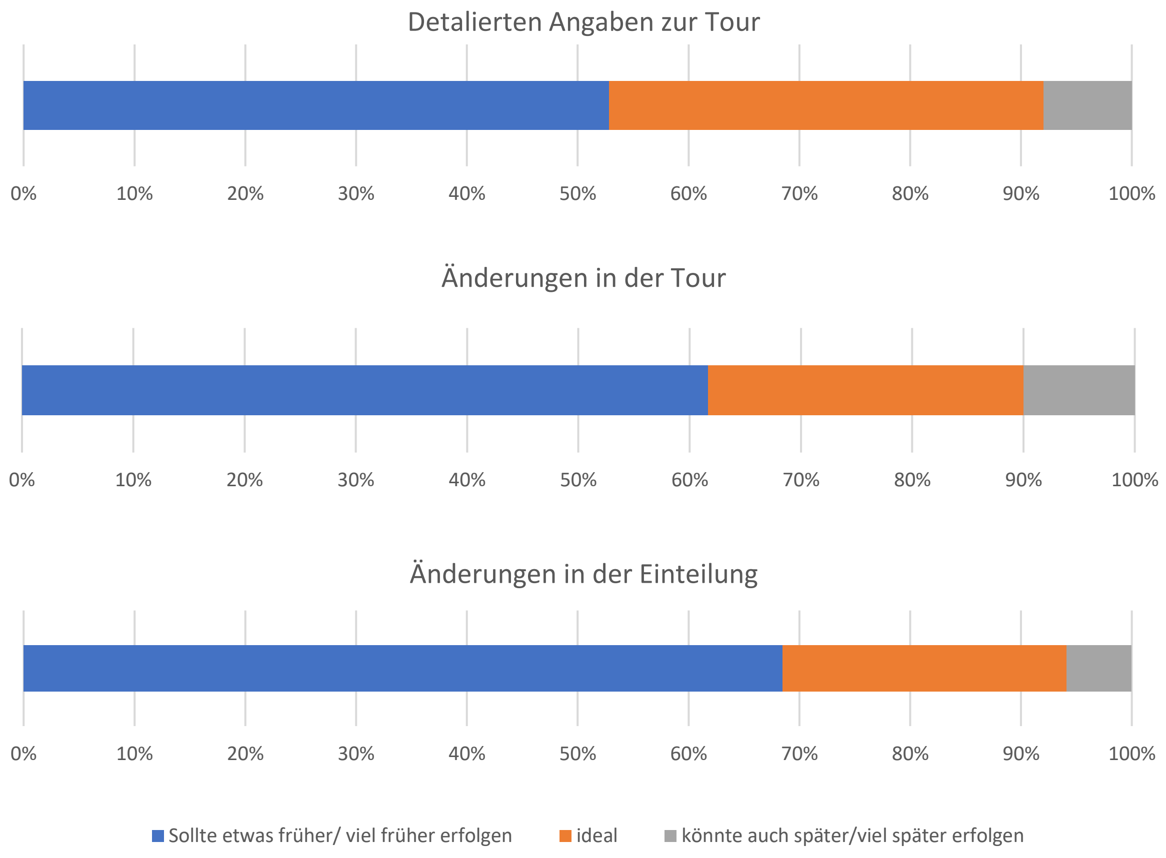


Abbildung 3: % Anteil Antworten Bewertung der Dienstplänekommunikation

4. Gibt es altersbedingte Unterschiede?

Eine vertiefte Analyse der Umfrage ermöglicht es Stossrichtungen bzgl. Flexibilisierung der Arbeiten und Einsätze des Lokpersonals anzugeben, ohne die Arbeitszufriedenheit, Produktivität oder die Qualität der erbrachten Leistungen zu schmälern.

- Beobachtungen bzgl. Altersgruppen

Auf der Grundlage der Umfrageergebnisse ist es möglich, eine Gruppierung der Funktionsprofile nach Alter vorzuschlagen.

Im Hinblick auf die Einteilung und insbesondere die Zuordnung der Züge wurde eine Clusterung der Befragten nach dem Alter vorgenommen. In Abbildung 4 ist die Verteilung der Grundgesamtheit in Clustern nach Alter dargestellt. Die Verteilung ist nach der Anzahl der statistischen Grundgesamtheit sortiert, um bei den folgenden Vergleichen die Unterschiede besser hervorzuheben.

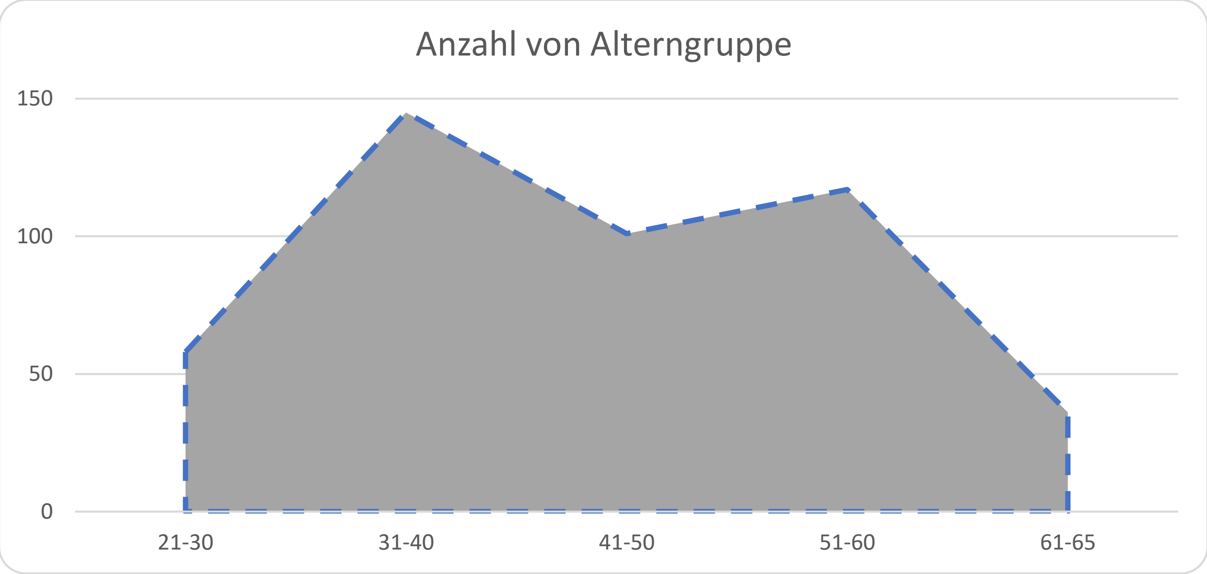


Abbildung 4: altersabhängige Clustern

Man kann in den Umfrageergebnissen einen Trend hin zu der Aussage sehen, dass mit dem Alter einerseits die Belastbarkeit abnimmt, andererseits aber die nutzbare Erfahrung zunimmt. Während der letzte Punkt eine natürliche Annahme ist, kann der Aspekt der Belastbarkeit in Bezug auf die folgenden drei Kriterien erkennt werden: Verfügbare Zeit für die Arbeitsvorbereitung, Toleranz gegenüber kurzfristigen Änderungen der Toureneinteilung und häufig Erschöpfungs- oder Stresszustände.

Verfügbare Zeit für die Arbeitsvorbereitung

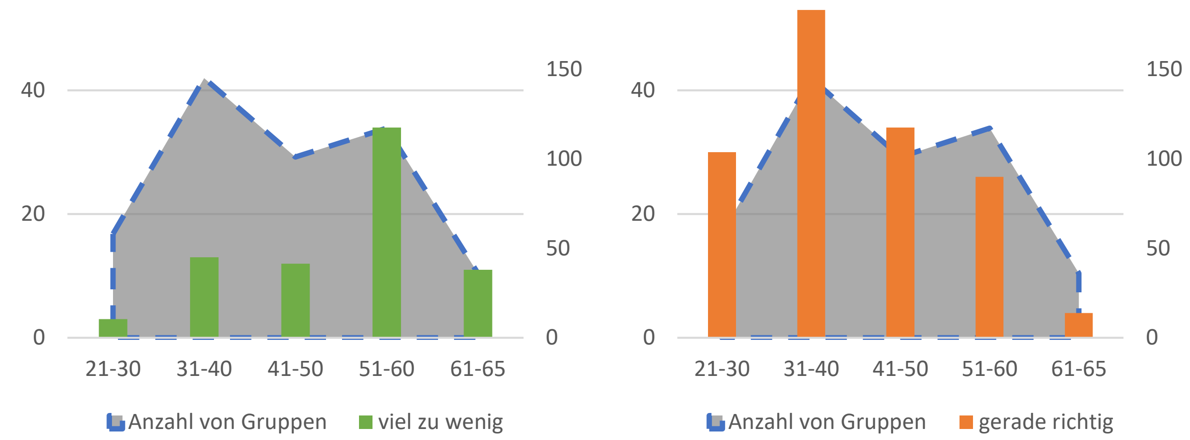


Abbildung 5: AVOR Zeiten. Bewertung nach Alterclustern spezifiziert

Abbildung 5 zeigt den Vergleich zwischen der Verteilung der Altersgruppen (graue Verteilung), die der Einfachheit halber skaliert ist, und der Verteilung der Bewertungen für die geplante Zeit für AVOR-Aktivitäten (blaue Säulen). Die Grafik lässt sich folgendermassen lesen: Da die Verteilung der Antworten tendenziell von der Verteilung der Grundgesamtheit der Cluster abweicht (grosse Differenz zwischen blauem und grauem Balken), können Abhängigkeiten zwischen den Aussagen bestehen: Hier zeigt sich, dass vor allem jüngere Lokführer:innen die AVOR-Zeitdimensionierung als richtig dimensioniert empfinden. Ältere Lokführer:innen hingegen empfinden sie meist als unzureichend.

Toleranz gegenüber kurzfristigen Änderungen der Toureneinteilung (Kommunikation)

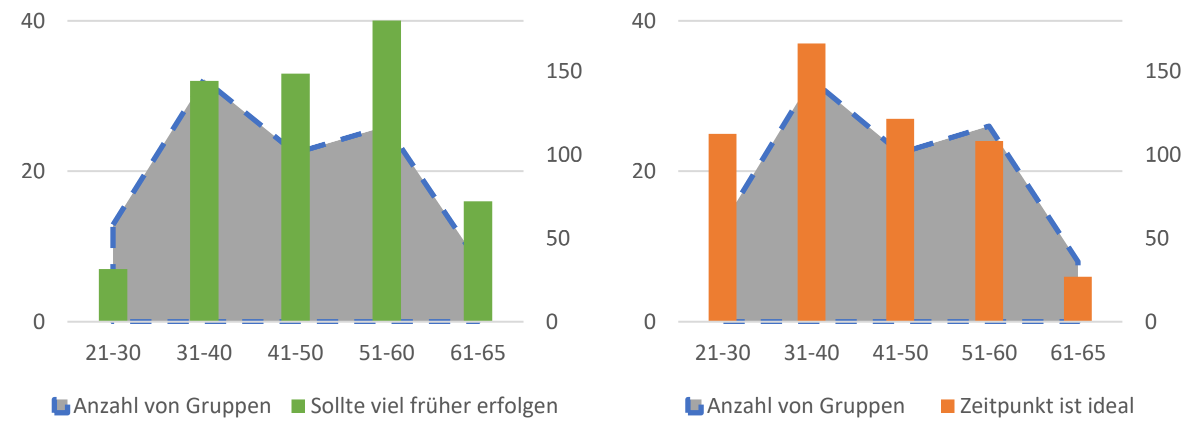


Abbildung 6: Toureneinteilung. Bewertung nach Alterclustern spezifiziert

Abbildung 6 zeigt, ähnlich wie Abbildung 5, die Unterschiede im Verhalten bei der Bewertung der Toureneinteilung. Auch hier zeigt sich eine grössere Akzeptanz der jüngeren Lokführer:innen gegenüber der kurzfristigeren Kommunikation von Änderungen als bei den älteren Lokführer:innen.

Häufige Erschöpfung / Stress

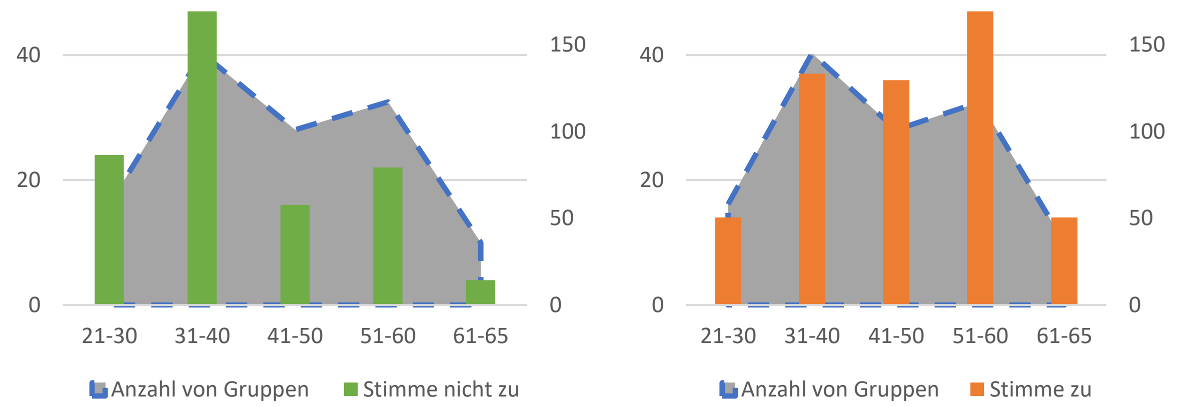


Abbildung 7: Häufige Erschöpfung. Bewertung nach Alterclustern spezifiziert

Abbildung 7 zeigt, ähnlich wie die beiden vorherigen Abbildungen, die unterschiedlichen Empfindungen der Altersgruppen in Bezug auf die Arbeitsintensität in Form von Stress. Auch hier empfanden die jüngeren Lokführer:innen weniger Erschöpfung oder arbeitsbedingten Stress als ihre älteren Kolleg:innen.

5. Mögliche Massnahmen

Zusammenfassend kann festgehalten werden: Eine Steigerung der Arbeitszufriedenheit bzw. die Vermeidung eines Arbeitszufriedenheitsrückgangs bei gleichzeitiger Flexibilisierung der Arbeiten kann mit Hilfe folgender Punkte bei der Neugestaltung von Touren unterstützt werden:

- Mitgliedern des jüngeren Clusters werden abwechslungsreiche Touren und in der Tourenabfolge wechselnde Schichtlagen zugeteilt. Die bestehende Zeit für die Arbeitsvorbereitung bleibt bestehen.
- Mitgliedern des älteren Clusters werden teilweise abwechslungsreiche Touren zugeordnet und andererseits Touren mit weniger kräftezehrenden Aufgaben und Schulungsfunktion (z.B. Vermittlung von neuen Strecken-, und Zugs-Kenntnissen an jüngere Lokführer:innen und Einsteiger:innen). Zudem wird beim Tourenaufbau für diese Gruppe mehr Zeit für die Arbeitsvorbereitung vorgesehen.

Abbildung 8 zeigt ein Beispiel für die Unterschiede zwischen einer Tourenabfolge, die sich tendenziell an junge Lokführer:innen richtet (links), und einer Tourenabfolge, die sich an ältere Lokführer:innen richtet (rechts).

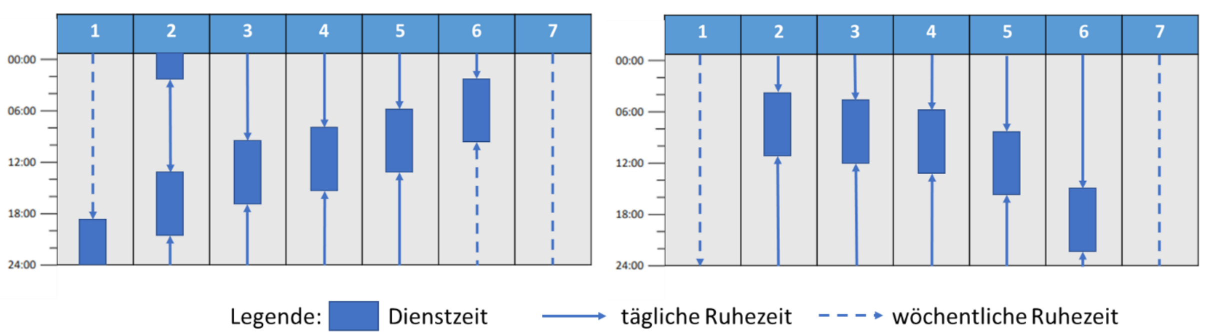


Abbildung 8: Vergleich von Beispielen intensiver Tourenabfolgen (links), die sich an jüngere Lokführer richten, und teilweise fester Tourenabfolgen (rechts), die sich an ältere Kategorien richten.

Diese altersgruppenbezogene Strategie würde zwei wesentliche Vorteile mit sich bringen:

1. Berücksichtigung des Alters und der Dienstjahre älterer Lokführer:innen (Lokführer:in ist ein kräftezehrender Beruf) bei der Gestaltung der Touren.
2. Erhöhung der Anzahl der Lokführer:innen pro Zug- und Streckentyp. Hierdurch wird die Flexibilität, Lokführer:innen bei Bedarf zu ersetzen, effektiv erhöht.

Diese Planungskriterien würden es einerseits ermöglichen, die Flexibilität bei der Planung und im Dispositionsfall zu erhöhen, und andererseits die Erfahrung der ältesten Mitarbeiter:innen zu nutzen und die der jüngsten zu erweitern, so dass das Lokpersonal die Möglichkeit hätte, einen Arbeitsplatz zu haben, der den Karrierestufen "folgt".

6. Fazit

Die vorgeschlagenen Planungsstrategien ermöglichen mit absehbarem Zusatzaufwand Verbesserungen hinsichtlich der Arbeitszufriedenheit zu erzielen. Mehr noch: dadurch, dass spezifisch auf einzelne Personengruppen individuell eingegangen werden kann, wird auch eine Flexibilisierung der Arbeiten ermöglicht. Wenn es aber gelingt, auf die spezifischen Präferenzen der einzelnen Gruppen positiv einzugehen und ihre Stärken zu nutzen, erreicht man ein Zusammenrücken der realisierten und geplanten **Produktivität**. Eine breitere Strecken- und Zugkenntnis des Personals würde einfachere und pünktlichere Austausche sowie die Entwicklung neuer Umplanungsstrategien (Dispositionsfall) während des Zugbetriebs ermöglichen. Auf diese Weise werden die negativen Auswirkungen, die die Abweichungen im Zugbetrieb auf die Produktivität des Lokpersonal haben, gemildert und die Produktivität erhöht. Dies würde sich auch positiv auf die **Qualität** des angebotenen Dienstes auswirken, da es weniger Verspätungen gäbe, weil man auf den für den jeweiligen Zug/die jeweilige Strecke qualifizierten Lokführer:innen warten müsste. Vorausgesetzt im Dispositionsfall können kurzfristig entstandene Lücken im Personaleinsatz ebenso flexibel gefüllt werden wie heute, kann somit auch in Zukunft die geforderte Leistung qualitativ höher und mit höherer Arbeitszufriedenheit erbracht werden.

Die **Zufriedenheit** des Lokpersonals würde steigen. Die Umfrageergebnisse zeigen deutlich: Diejenigen, die den Beruf der/des Lokführers/Lokführerin wählen, tun dies, weil sie gerne reisen und verschiedene Züge fahren. Mehr noch: älteres Lokpersonal bittet das Unternehmen um Anerkennung für seine langjährige Betriebszugehörigkeit und sein Engagement in einem Beruf, der oft als kräftezehrend beschrieben wird. Das sich daraus ergebende Gleichgewicht, das den jüngeren Arbeitnehmern mehr Abwechslung und den älteren Arbeitnehmern "komfortablere" Arbeitsbedingungen bietet, mit der zusätzlichen Aufgabe, die jüngeren Arbeitnehmer auf neuen Strecken/Zügen zu schulen, könnte zu einer Win-Win-Situation im Bereich der Arbeitszufriedenheit und zu einer Win-Win-Situation zugunsten der Erreichung der Ziele der Produktivität und der Qualität des Eisenbahndienstes führen. Weitere Alternativen und Massnahmen für die Planung, Zuteilung und Durchführung von Touren sind auf Grund der Umfrageergebnisse ebenfalls möglich, bedürfen aber einer eingehenden Machbarkeitsanalyse. Verhältnismässigkeit und Zweckmässigkeit der Planungs- und Massnahmenalternativen vorausgesetzt, können absehbare Ziele der Flexibilisierung seitens Arbeitgeber erreicht werden, ohne die Arbeitszufriedenheit seitens Arbeitnehmer zu verringern. Die Produktivität ist eng verknüpft mit der Fahrplangestaltung und den Dienst- und Sicherheitsvorschriften; sie ist somit intrinsisch nur schwer veränderbar. Klar scheint indessen, dass die Qualität der erbrachten Leistungen nicht erhöht werden kann, wenn innerhalb desselben Zeitfensters mehr und/oder neue Aktivitäten für die Lokführer:innen anfallen.

8 Attachment B – Integration of the communication document (attachment A) with a specific analysis on 2 depot groups.

(available in German only)

1. Ausgangslage

Dieses Dokument erläutert den Inhalt des Kommunikationsdokuments, insbesondere für die folgenden Depotgruppen:

1. Aarau (AA), Basel (BS), Olten (OL)
2. Goldau (GD), Luzern (LZ), Zug (ZG

Die berücksichtigten Indikatoren zeigen ein unterschiedliches Verhalten zwischen den beiden verbleibenden Gruppen. Insbesondere die Gruppe AA-BS-OL hält sich mehr an die allgemeinen Statistiken. Die Gruppe LZ-GD-ZG ist tendenziell zufriedener mit der aktuellen Touren- und Einsatzplanung. Diese Ergebnisse sind interessant, da sie unterschiedliche Bewertungstrends zwischen den betrachteten Gruppen zeigen.

- Mögliche Gründe für dieses unterschiedliche Verhalten :
- Die in der Region angebotenen Dienstleistungen sind unterschiedlich attraktiv.
- Die Kommunikation zwischen dem Lokpersonal und Führungskraft in den Depots ist unterschiedlich.
- Das Lokpersonal in dem Depotcluster LZ GD ZG wird auf variablen Strecken und Zügen eingesetzt während es im Depotcluster AA BS OL auf einheitlichen Strecken und Zügen eingesetzt wird.

Dieser Unterschied muss unbedingt weiter untersucht werden, ebenso wie die Möglichkeit, ein Modell aus Best-Practices in der Schweiz zu erstellen.

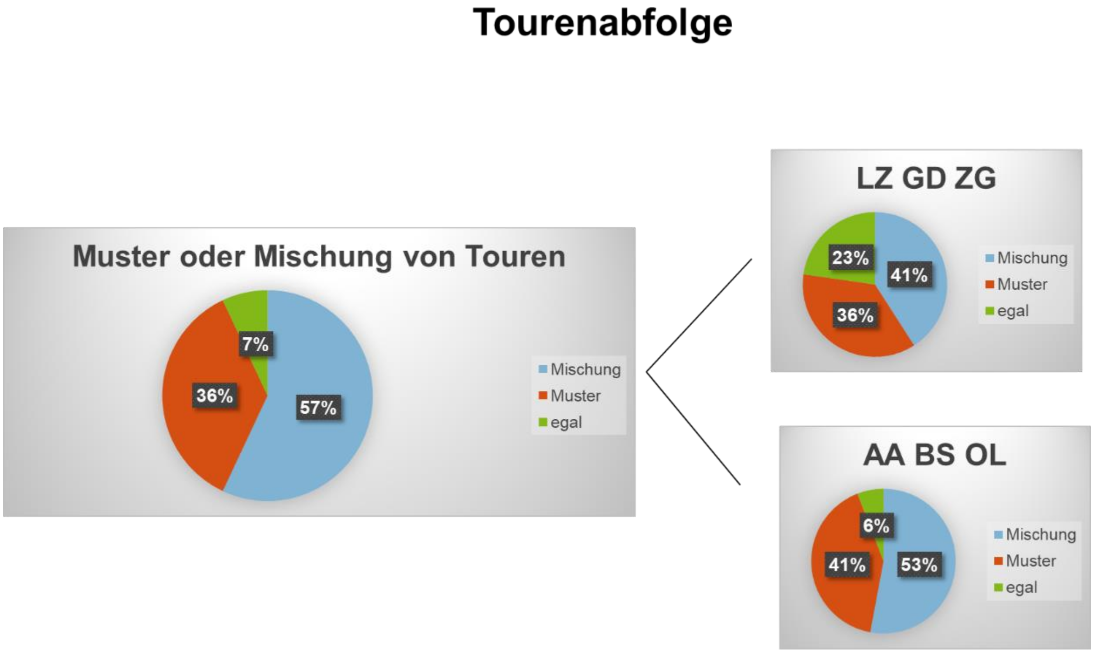


Abbildung 1: Vergleich der Ergebnisse für die beiden Depotgruppen hinsichtlich der Tourenabfolge.

Tourenaufbau

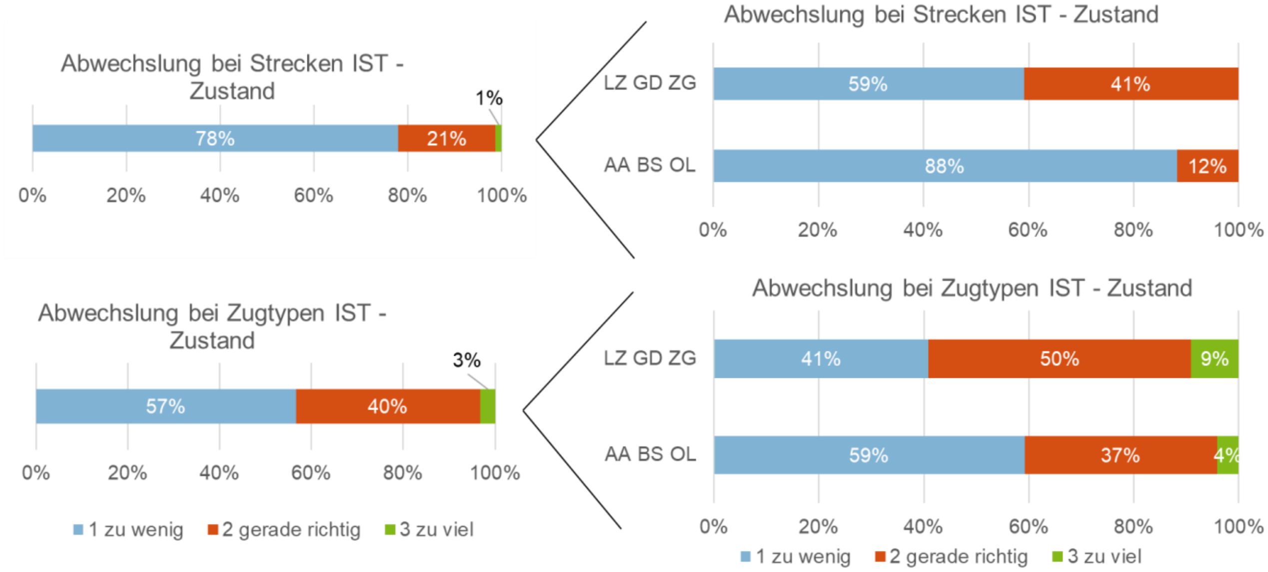


Abbildung 2: Vergleich der Ergebnisse für die beiden Depotgruppen hinsichtlich der Tourenaufbau.

Einteilung

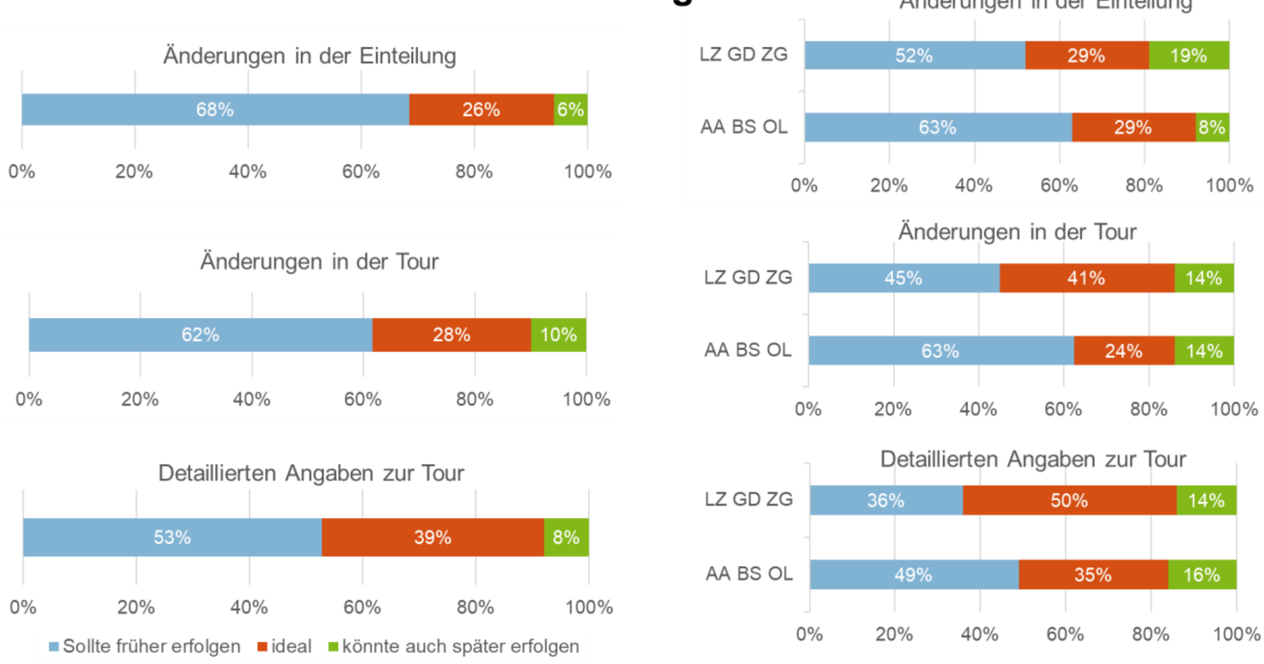


Abbildung 3: Vergleich der Ergebnisse für die beiden Depotgruppen hinsichtlich der Einteilung der touren.