12 Gaining accurate input data for a comprehensive assessment of the railway system

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12.1 Introduction and Aim / Background

In order to fulfil the vision of rail being the backbone of carbon free mobility in the future [1], a modernisation of the European railway system is needed. In the Shift2Rail initiative the European railway research community is taking on the task to develop innovations that enable the European railway system to be the "most sustainable, cost-efficient, high-performing, time-driven, digital and competitive customer-centred" transport mode and thus to enable a modal shift to rail [2]. Key targets of halving life-cycle-costs, doubling capacity and improving punctuality by 50% as well as increasing customer satisfaction [3] are pursued through the innovations developed in Shift2Rail. Different model structures for estimating improvements in the named key targets and finally in the resolving change of modal share has been developed by the IMPACT-2 project [4] [5] [6]. All three models are based on artificial scenarios that should reflect a railway system that theoretically might be found somewhere in Europe. To create such scenarios a tremendous amount of data is needed from railway undertakings and infrastructure managers across Europe. Within the IMPACT-2 project, researchers took on the challenge to collect such data and align them to create common scenarios to evaluate the broad range of innovations developed in Shift2Rail. Through this process, several issues were faced from identifying subsidies included in some national cost data to different definitions of indicators with the same name in different companies up to various operational practices across Europe. In this paper, some of these challenges will be addressed and described as well as how the project handled them.

12.2 Input data definition for railway assessment

To make data from different sources comparable and use it within assessment models for the railway system, several aspects have been considered in the IMPACT-2 project. Common definitions, aggregation level of data items as well as measurement techniques are vital. This provides a challenge when the data sources are within the same country and even more so when collecting railway data across Europe [7].

12.2.1 Special challenges in the European railway sector

Consequently, various challenges have to be faced to gain accurate input data for a comprehensive assessment of the railway system. Historically, systems often still end at the national borders. As can be seen in Figure 12-1, this leads to various differences between the countries in Europe.

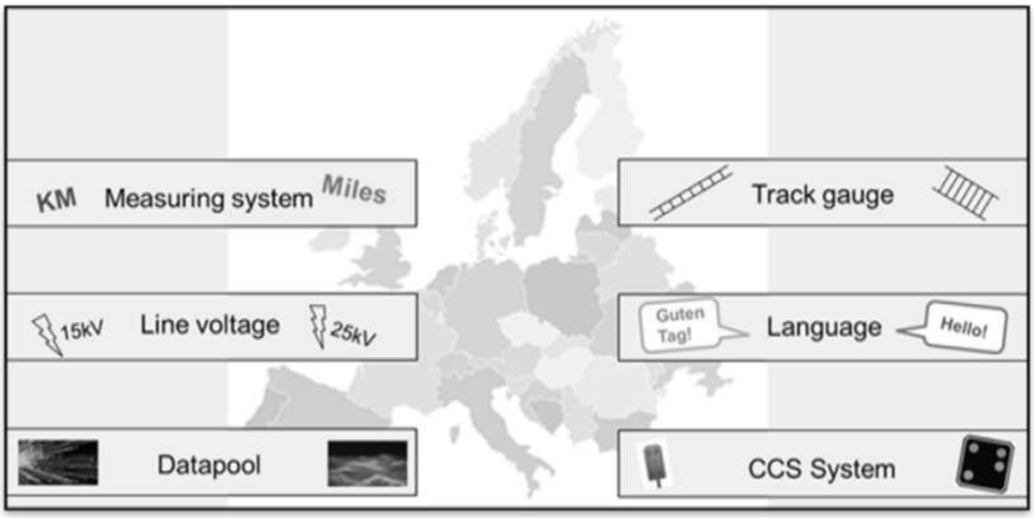

Figure 12-1: Challenges in Europe for coherent data due to different baselines [8]

Technologies and even rules of operation differ among the European countries. There are obvious differences which are easy to handle such as the different measuring systems, track gauges or the thresholds for delay. There are, however, also more hidden differences.

Data can be collected on different aggregation levels. On a high level, there is less data to collect but it is more of a black box what is included in the gained data set. On a less-aggregated level the amount of data that has to be collected increases and with this the effort and consequently the likelihood to not get everything that is needed to perform the assessment. An example for this has been subsidies. Especially infrastructure data can include partially subsidies from the state. When asking for cost data of infrastructure elements on a high level, these values can thus differ a lot. This does not, however, in all cases mean that the cost really varies between individual countries, but it might be due to the fact that they are partially subsidised and therefore reduce the direct cost for the infrastructure manager.

The definition of what a parameter entails goes even further. Operational costs can include energy costs, maintenance and personal costs. Personal costs can, however, be also already included in the maintenance costs to some extend or be a part of the overhead and thus counted towards capital expenditures rather than operational expenditures. A good communication and detailed definition of the data needed is key to be able to compare them and use them further in the model.

All of these challenges have to be met under the premise that a majority of the data, especially when it comes to cost data are highly sensitive and the source shall not be disclosed when used in projects where the end results are publicly available. When using real world scenarios, data to describe these scenarios can often be linked to the source by experts, e.g., which type of trains is described, even if the information is officially disclosed. Therefore, the definition of the scenario that the assessment is performed on is of major importance. To hide the sources of sensitive data, the scenarios that are used in IMPACT-2 are created in such a way that they could be found anywhere in Europe but are not identical with one exact railway line or train type in a specific country. Another approach to incorporate sensitive data in the model is the number of different sources for one parameter. In the IMPACT-2 project, the most valuable sources are the project partners, among them railway undertakings (RU), infrastructure managers (IM), research companies and industrial rail partners from across Europe. This multitude of sources of expertise has been used in two ways to disclose sensitive data. First, the various sources were used to get multiple values for a set of parameters which could then be averaged or weighted to gain input for the scenario.

With a higher number of independent sources, sensible data can be hidden by using an average across the source when applicable. It also increases the usability for the whole assessment as individual country specifics can be averaged out. When no data could be provided due to confidentiality, e.g., cost data for specific train parts, the sources named above were used to verify the estimated range of the values as well as using distribution rates to, e.g., gather costs of the boogie from the total cost of the train.

12.3 Examples from the IMPACT-2 project

In this chapter, two examples from the IMPACT-2 project are described in more detail. First the impact of differing values of time for modal shift calculations is explained and in the following subchapter challenges of data definition on the example of freight train data are decribed.

12.3.1 Value of time data for modal shift calculations

One of the aims of the IMPACT-2 project has been to estimate the potential of Shift2Rail innovations to shift demand to rail from other modes of transport. When it comes to passenger transport, this implies developing a modal shift model which can assess the innovations' potential to attract new travellers from, e.g., car and air to rail. Such modal shift analyses are traditionally in the transport research area conducted using so called logit models, within which each mode has a utility to the traveller which is composed by a known part (travel time, travel cost, waiting time, delays, comfort etc.) and a part unknown to the researcher (random error term). Improvements in the utility of a mode increases the probability that the traveller will choose this mode. The variables in the utility function differ in importance (weight) to the traveller, which in the model is represented by the parameter in front of the variable. The quotient between the travel time and travel cost parameter describes how much value the traveller puts on reductions in travel time in monetary terms and is therefore often called the value of time. Similar valuations can be calculated from the parameters in front of, e.g., waiting time and delay (the value of reducing waiting time/delay). In the modal shift model, these valuations are very important since they determine the effect an improvement in, e.g., waiting time will have on travelers' mode choice. In the context of the IMPACT-2 project, an example of the effect chain looks like this for waiting time: A number of Shift2Rail innovations improves Command Control and Signaling systems and technology → this will make it possible on some corridors to run more trains per hour in the future (possible percentage increase in train frequency as calculated in the KPI model) → increase in train frequency means shorter waiting times for train travellers → the shorter waiting times are included in the modal shift model together with waiting reduction valuations → estimations of increased rail demand is calculated using the modal shift model.

There was no European travel behaviour survey available to the IMPACT-2 project from which traveller valuations of time could be calculated. An available data source was, however, country-specific guidelines for value of time used in cost-benefit analyses (CBA) of infrastructure investments. A challenge was, however, that these differed significantly depending on country. To capture different conditions across Europe, we decided to compare results using valuations from different countries. Three sets of passenger valuations regarding in-vehicle time, access/egress time, waiting time and average delay were compared – a French [9], Swedish [10] and Eastern European Union (EEU) set of valuations, where we calculated the EEU valuations based on a model developed in [11], which included GDP per capita and trip distance (the GDP per capita of EEU was calculated as the population weighted average of GDP per capita of all EEU countries). The latest German value of time guideline [12] is developed according to a different methodology with no variation in value of time across different modes but on the other hand variation across distances, and was therefore difficult to compare to the other guidelines and could not be included in the analysis. The French values of time are higher than Swedish and EEU values of time. Swedish values of time are obtained from a Stated-preference survey. The Swedish value of time calculated by GDP per capita would yield 0.83 €/min for rail in-vehicle time which is much higher than the Swedish value of time according to the guideline, 0.27 €/min. This suggests that value of time calculated using different approaches may differ significantly. It can therefore be necessary to use local values of time measures in valuation of specific corridors/ use cases.

The impact of differing values of time is substantial if the possibility to attract new rail demand is not limited by available track and train capacity. In the IMPACT-2 modal shift results, this is the case for the regional rail corridor application. The results show [13] that Shift2Rail innovations have the potential to increase rail demand on this regional corridor by 118% using French valuations, 102% using Swedish valuations and 58% using EEU valuations. To a large extent these differences are explained by higher valuation of reductions in waiting time and delay in the French and Swedish guidelines.

12.3.2 Data for freight train definition

Additional to the challenges faced for the passenger scenarios, freight scenarios were developed, facing their very own challenges. For rail-bound freight transport, the whole transport chain from terminal to terminal including marshalling yards must be considered, since the processes within the terminals and yards have a huge impact on the transport time and on the number of required locomotives and wagons. Hence, reference parameters must be provided for a lot of assets like locomotives, wagons, terminal, yard, infrastructure, and operation. The parameters must be assessed for the three main freight transport categories single wagon, block, and intermodal trains, which were chosen to be included in the freight scenarios of IMPACT-2.

The most important parameters are the operational data. These are average speed, transport distance, train length, payload, yearly loco- and wagon-km, delay minutes, and loading factor. Here average values of European transports were considered taking into account the requirements mentioned above. They have been provided by Railway Operators and Infrastructure Managers. Further important operational parameters are the process times in terminals and yards. Here a bottom-up assessment was carried out by adding up the detailed process steps like loading, coupling, shunting and brake test. Additionally, times for delays due to unexpected occurrences are considered.

Some reference data is dependent on the KPI to be assessed. For the cost calculation, average data for transport across Europe is used. But for capacity assessment, data for lines with capacity limits are used, since measures for increasing capacity should increase the capacity of these lines.

One way to increase capacity is by increasing the train length through coupling of short trains on high density lines or by increasing the train length and load with automatic coupling. Another way is through an improved command control and signaling (CCS) system with moving block or virtually-coupled trains. For both measures, the considered train length respectively payload in the underlying scenario is having a high influence on the result.

To decide on train length and payload/loading factor for the three freight transport categories single wagon, block, and intermodal trains, was challenging even though average values were available. While it first needed to be clearly distinguished between the actual average train length and the allowed train length, different regulations and capabilities of infrastructure between and even within European countries led to a wide range of averages in train length and thus also average load factor. So, while European averages were available, a thorough reconsideration, if those were distorted by extremes, needed to be made and the average train length needed to be adapted accordingly.

This has been especially important as train length and load factor feed into several secondary calculations thus influencing the final results on multiple level, e.g., the energy consumption, which was finally assessed by simulating a train run using the reference freight speed profile defined in EN 50931 [14].

The average train length is a good example, that some data, even though it seems simple at first hand and there are values easily available for it, should be reflected upon. Especially, when they influence the results of an assessment significantly.

12.4 Conclusion

A comprehensive assessment approach has been developed to ensure that the results can be extrapolated for different use cases in Europe. This has been achieved by developing a multiple-steps- approach using the various industry and railway partners in the Shift2rail innovation projects for an extensive data collection. Not only has data been collected but approaches have been developed to make the large amount of individual data comparable including coherency between data, smoothing over sensitive data, disclosing of differences in wording and definition and the setting of common thresholds.

As the value of time example showed, in cases where it has been impossible to use average data from many input sources the approach explained in chapter 3.1 has been adapted. Instead of using an average, the results have been calculated for each data set individually and the results can then be compared by each stakeholder depending on their research focus. As there has been no available input data from the EEU for the KPI, it cannot be said if the difference there would be in the same magnitude.

The example of freight highlights the importance of detailed analysis of average values as they can be influenced by various individual factors. This is especially important for input data which feed into multiple secondary calculations thus influencing the final results on several level.

Good communication has in all cases been crucial so that reliable results on a European level could be ensured for the assessment.

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