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Minimising economic losses due to inefficient rescheduling

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ABSTRACT

This article sets out a procedure that enables a monetary rating of conflict-resolution scenarios for train services to be conducted by coupling simulation procedures from railway operations research with mode-choice models. Such an approach has only previously been adopted for strategic network planning. Forms of conflict resolution have hitherto had no account to the implications for end-customers.

Forming the basis for monetary ratings are the delays suffered by resolved train-running conflicts. These delays are established for given train priorities using the LUKS-S software tool and serve as input variables for mode-choice models.

Delays suffered by trains influence the mode of transport selected by the end-customer. The modal split thus computed reflects demand for the rail mode and is called upon to determine revenues. Revenues are set against variable costs to form a contribution margin per train run. Changes in the contribution margin are extrapolated by comparison with delay-free timetable conditions.

How trains are prioritised impacts on the decisions taken to resolve a conflict and hence also on the ensuing delays. Forms of conflict resolution can be rated monetarily. A conflict can thus be resolved most effectively, where the change in contribution margin is minimised.

Contents

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1. Introduction and project remit

The railway system is such as to allow a train move to be portrayed by means of a distance-time curve. Located along the curve are blocking-time segments that together form a stepped blocking-time series. This model is adopted to compute levels of track occupation on railway infrastructure. Each blocking-time segment represents occupation by a train run of an infrastructure element. Infrastructure can only be occupied by one train run at any one time, meaning that any other simultaneous train runs have to be prevented (Happel, 1959; Pachl, 2014). Duplicate track occupation may occur during timetabling, however, where there is simultaneous demand for paths. The same applies during running as a result of possible delays. The ensuing track-occupation conflicts then have to be resolved.

The present paper sets out a procedure for conducting a monetary rating of conflict-resolution scenarios in railway operations. Measures of this kind have only been rated for operational purposes hitherto. The emphasis here is on viable, smooth-running rail services as well as on a robust timetable. Priorities for train runs are frequently awarded in a conflict-resolution algorithm. They are mapped with the aid of ranking numbers that cause high-ranking trains to be given precedence over lower-ranking services (Weymann and Nieβen, 2015; Kuckelberg, 2011; Wegele, 2005). This is a course of action that can be adopted at both the scheduling and operating stages. Further approaches exist besides this ranking-based form of conflict resolution that apply different decisional criteria to the prioritisation of trains. They are summarised by (Törnquist, 2005).

In the procedure set out here, conflicts are to continue to be resolved on the basis of train priorities. Both at the scheduling and operating stages, conflict-resolution measures generally give rise to waiting times for the lower-ranking train. These waiting times can be determined with the aid of railway operations research methods and are a key variable in the dimensioning of railway infrastructure and gauging of quality. Waiting-time totals are confined to a route section or node where the application of quality benchmarks is concerned.

No account has hitherto been had to end-customers when rating the waiting times computed. This is remedied under the present approach by coupling railway operations research methods with mode-choice models. Existing approaches with this kind of coupling are only adopted in the sphere of strategic network planning for long-term planning horizons. Use is made there of analytical methods to establish waiting-time totals on the basis of macroscopic infrastructure and train data, which is applied by Deutsche Bahn, for example (totals that likewise serve as input variables for determining the modal split for rail in macroscopic mode-choice models). It is possible in this way to map long-term end-customer responses, which has been used by London Underground's network as long ago as the early 1990s. Many works with regard to the impact of delays on demand for rail transport relate mostly to the use of elasticities based on different time periods (Batley et al., 2011; Batley et al., 2007; Börjesson and Eliasson, 2011; Börjesson and Eliasson, 2008; Jevons et al., 2005).

The present approach considers a railway-operations procedure that analyses individual conflict-resolution scenarios and their impact on the end-customer. The aim continues to be to couple this with mode-choice models. In shifting the focus to individual conflict-resolution scenarios, however, use is made of a simulation procedure that functions at the microscopic level and hence delivers delay characteristics exactly determinable in space and time. There is thus no longer any direct scope for coupling with mode-choice models. Adjustments accordingly have to be made to the methods and influencing parameters adopted.

2. General procedure

The conflict-resolution algorithm continues to be based on the application of priorities. Whereas the allocation of train priorities has hitherto depended on the trains' urgency, type or travelling speed, however, the responses of end-customers are additionally to be addressed under this method. This is done by establishing contribution margins comprising the revenues and variable costs of train operating companies (TOCs). The approach subdivides into the three modules "traffic simulation", "mode-choice model" and "contribution costing" (cf. Fig. 1), which are run in several loops.

Accurate predictions of anticipated conflicts can only be made on the basis of microscopic infrastructure and train data. Assessments of end-customer flows over specific point-to-point routes in the railway network are similarly necessary. A single train run is likely to incorporate a multiplicity of such point-to-point routes. They each display distinct properties and need, therefore, to be considered separately. It is essential that this greater volume of data be readily comprehensible, clearly structured and manageable.

The repercussions of conflict-resolution measures in the form of delays to the trains involved serve as input variables for the macroscopic mode-choice model. Competing modes of transport are considered with a view to establishing the mode passengers choose on the point-to-point routes under review (cf. Section 4). The modal split thus arrived at serves as an input

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