LIME
Model for capacity utilisation and profitability of a railway line

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Summary

In many countries marked attention is now paid to the railway. The reason to this has an historical background. The market share for railway has been on decline for both passenger and freight traffic over the last decades. The situation is somewhat the same in most of the industrialised countries. The railway has of many reasons been pushed into the background in favour of car and air traffic. This situation is now altering. Due to the increasing traffic problems and the growing environmental concern in combination with improved capacity and comfort of train services, traffic planners and politicians are now focusing on the railway.

General Problem Description

The demand for train journeys varies during the day, along the line and between days of the week and different seasons. The total effect of these variations might result in a maximal seat occupation for a specific train on a link of 3-10 times greater than the average seat occupation of the line. If the train supply is rigid, i.e. when the number of coaches in each train is fixed, this will result in a rather low load factor of 20-30%.

As a responsible planning authority or train operator, you are of course interested in increasing the occupancy in order to attain improved profitability. The load factor can be raised by varying the number of wagons in the trains, by allowing standing passengers in occasional departures, by adjusting the time-table to demand or by differentiating the tariffs. These are all principles that more or less are utilised by the train operators. One of the principal ideas behind the project is to study these and other possibilities to increase the utilisation of the train capacity in terms of seat occupation in a systematic way.

The main objective is to find ways to reduce costs or increase revenues in order to improve both net surplus and socio-economic benefits of train operations.

The model has been called LIME, which stands for LIne Model for Efficient train operations with special regard to demand effects. The model describes how different operating principles (timetable factors such as departure times, interior comfort and service on board) have influence on the demand for rail travel and the profitability of a rail line. The object of the model is to be a tool for planners and operators when evaluating different operating princ-
ples and extended train services. It is expected to be useful both for planning future train operations connected with renewal of the rolling stock or extending the rail infrastructure (strategic planning) and for adaptation of the existing train service in the next timetable (tactical planning).

The Overall Model Structure

The starting point will be the total demand for travel on the current market consisting of car, bus, train and air trips. Depending on the quality of the supply, which includes the timetable (travel times, departure times), the fare system and the train characteristics, that is offered, some of the potential passengers will choose to go by train. The model consequently starts with a mode choice stage where shifts in mode choice can be studied.

The calculation in LIME is mainly divided into three phases. In the first phase the demand is calculated on basis of the specified supply. The demand is distributed between the offered departures.
In the second phase the seat capacity and vehicle requirement is dimensioned from different criteria and finally in the third phase the benefits and costs are calculated.

The first phase consists of five sub models; the mode choice model, the train choice model, the journey time model, the fare model and the comfort and service model. The second phase consists of the capacity design model. The third phase consists currently of two sub models; a cost model and an economics model. It is intended to include also an optimisation model, where the best mix of the different influencing factors can be chosen. At the present time, however, only by the operator predefined solutions can be analysed.

The travellers is distributed between the different modes with help from a mode choice model which takes into account how well the modes correspond with the travellers desires. The mode choice model in LIME is based on the forecast model of logit type, the Intercity Model, which is currently used by the Rail Administration and the Swedish Institute for Communications Analysis. The model considers fare, travel time, waiting time and access and egress distances. Input to the mode choice model is a fix trip matrix describing the total demand between the existing origin-destination relations influenced by the studied line. Car, bus and air are described in LIME according to the Intercity model and the passengers is distributed between the modes according to their resulting attractiveness.

The choice between different train alternatives is included in the train choice model which is located one level below the mode choice model in the logit tree structure. How the travellers in practice will be distributed between the various train alternatives is, beside train characteristics, also depending on their desired departure and arrival times. In turn, this is dependent on their trip purposes and what time restrictions they may have at the start or at the destination. Preferred departure times is an important entry into LIME and has currently been obtained from a national travel survey. To find out about the willingness to pay for better adapted departure times a Stated Preferences study has been undertaken as a part of the LIME project.

An interesting question is how improved vehicle characteristics, which reduces travel time and improves passenger comfort, influences the economy of passenger trains. Vehicle characteristics and train interiors have been studied in other projects within the Railway Group. Comfort and service can in LIME be chosen freely within a train type. A single vehicle (of the above mentioned) can be furnished and designed in different ways for fast- and
regional operations. How the quality of the supply influences the demand is calculated in the comfort and service model. At present it is possible to choose from three different comfort levels and three different service levels; low, medium, high. The choice of a certain level influences the passengers’ valuation of the attractiveness of the service in the train choice model, but also operational costs in the cost model. When the comfort levels low and high are chosen, the seating capacity also changes which effects the capacity design model.

Input to the dimensioning model is the potential demand for each subsection and train, which has been calculated in the train choice model. Different principles to estimate the need for seats and requirement of vehicles can be tested to correct the potential demand in the capacity design model. Choice of dimension principle influences the cost and economy model. If, for example, a substantial lack of capacity is tested as a means to get a uniform and high load factor, the costs of vehicles and operation will decrease in the cost model. At the same time, however, the train will not hold all travellers and potential passengers will be left behind at the stations. In this case, the ‘lost’ passengers also decreases the revenues in the economy model.

One important factor to consider in the capacity design model is the risk to be left behind or not finding a seat as the first train arrives, when demand variations compared to average demand are high. These probability calculations constitutes the most important part of the capacity design model. Variations between days and weeks will also be regarded.

In the cost model the costs for operating trains, which includes staff, vehicles and maintenance are calculated. The outcome is used in the economy model, which also includes calculation of changes in consumers’ surplus and consideration of external effects. The economy model makes it possible to calculate both operational and socio-economic costs. The optimisation model, finally, is used to analyse different changes in the supply easier. It will also optimise supply with regard to given economic objectives. At present solutions can be tested, but no optimisation is taking place.