TACTICAL TOOLS FOR INTEGRATED RAIL SERVICE PLANNING

Achieving integrated control of train loads, and other rail service planning issues, through the use of computer models

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OVERVIEW

This paper uses case studies on load management to illustrate how computer models can help integrate planning and control at the operational and strategic levels.

Load management is the process of planning rail services to ensure the optimal provision of rolling stock for each service. Load management occurs in all planning timeframes:

- long-term, ensuring provision of sufficient rolling stock for the future
- medium-term, making best use of the existing rolling stock,
- short-term, responding to operational incidents.

As rail markets expand, load management is becoming an increasingly important part of the planning and control process. This paper shows through a number of load management case studies how computer models have a key role in load management.

The paper also demonstrates that the existence of such computer models in a ‘tactical’ role reaps benefits for strategic and operational planning. Through the use of computer models, and the processes they facilitate, the different levels of planning and control can become better integrated.

PLANNING RAIL SERVICES

The aim of rail service planning is to produce plans for rail services which are optimal, in terms of both financial targets and service to the public (the relative importance of these two factors of course depends upon stakeholder emphasis).

To do this we must understand the interactions between many different factors (see Fig. 1).
Fig. 1 Issues in rail service planning are heavily linked. Taking account of these links when planning is vital.

The key interactions this paper will concentrate on are:

- The effect of the timetable on demand and revenue. It is well known that demand for rail travel is strongly affected by the frequency of service and time of travel.
- The effect of the provision of resources (in this example, rolling stock) on demand and level of service. High levels of crowding or poor quality rolling stock can restrict demand growth and hence revenue.
- The balance between the cost of investment in extra capacity and the benefits of the growth in demand which is stimulated by such investment.

LOAD MANAGEMENT

Load management is the process of monitoring train loadings and taking action to prevent crowding becoming (or remaining) excessive in the future. In a rapidly expanding rail market, with limited resources, load management is a key part of service planning. This is increasingly so in urban areas, and on many long distance routes. Crowding affects train operators, and in some cases infrastructure operators, through:

- customer dissatisfaction, which depresses demand and hence revenue,
- delays caused by excessive platform crowding, impacting on performance and safety,
- breaches to regulatory guidelines, which can result in fines (and, in extreme cases in the UK, loss of franchise).
Analysing historic data shows where crowding occurs, but cannot help predict the benefits of proposed solutions. These solutions might include new rolling stock, which is a costly investment, requiring a great degree of certainty. Alternatively, timetable changes can contribute significantly to relief of overcrowding. A major benefit of load management is that it allows train operators to identify simple, low-cost solutions to overcrowding, or, if no such solutions exist, establish with a high degree of certainty how much extra capacity is required.

Examples of load management
Figs 2 and 3 below show simplified examples of load management problems. In each case, five consecutive services between two points are represented. The departure time and travel time of each service will affect its load (represented by the red bar), as will its capacity (blue bar).

Fig. 2 Example of a successful solution where crowding is spread evenly across 3 trains.

In Fig 2, the three middle trains each have some crowding. To alleviate this, extra capacity might be needed on each train. Alternatively (as illustrated here), increasing capacity of just one train might be sufficient, since the demand will migrate to fill the extra space, eliminating crowding completely.
Fig. 3 Where one train is more popular than all the others (perhaps the only express train) an identical solution cannot be used as extra capacity will merely attract more passengers.

In the second case (Fig 3), the middle service is clearly more popular, and following a similar strategy does little to alleviate crowding: the middle train is so popular that passengers will happily stand rather than sit on the other trains. In this situation, a more detailed analysis of why one train is more popular is recommended. Such an analysis can help introduce targeted measures to spread the load more evenly between trains.

In a timetable with dozens of trains, all with different stopping patterns, it is easy to see why load management is an extremely complex and important problem. This complexity has driven the development in the UK of a specialist load management model.

THE LOAD MANAGEMENT MODEL

In the UK, train operators serving the London commuter market use a computer model, known as PLATO, to predict train loadings and find solutions to overcrowding. The model allows planners to predict how passengers will respond to changes in the service, so that possible solutions can be explored. It is essentially a simulation model which takes into account a wide range of factors, including:

- the total demand for travel between each possible origin and destination point,
- customer’s preferred time of travel,
- interchanges, either rail or other travel mode (foot, bus, underground),
- customer responses to journey time, types of rolling stock and, most importantly, crowding.
The initial driver for the development of the model was regulatory pressure to control overcrowding. All operators of London commuter train are required to demonstrate plans to alleviate any unacceptable crowding. The accuracy of the model has been proven through 10 years of continuous use in London, and the Strategic Rail Authority approve its use as a means of guaranteeing the effectiveness of plans to alleviate crowding. The model is used both in-house by train operators and by consultants for project work.

However, in addition to the direct regulatory requirements, the model has reaped benefits for train operators at other stages of the planning process. In the following sections, we will consider how the existence of the model impacted on three areas of planning:

- Operational control
- Identifying future requirements
- Testing development options

**BENEFITS FOR OPERATIONAL CONTROL**

Two specific examples of the use of the load management model for operational control are worth considering:

1. **Re-planning the timetable during engineering work**
   During major engineering work at Euston station in Summer 2000, it was necessary to restructure the timetable entirely. This presented the train operator with a completely unknown situation – it would be impossible to know which trains would be most heavily loaded, and hence where to utilise rolling stock, and it would not be desirable to re-plan during the summer. The load management model was used to establish a satisfactory plan, which provided a workable solution.

2. **Setting operational priorities**
   No matter how well planned the service is, there will inevitably be days when incidents occur which cause delays, cancellations or shortages of rolling stock. Operational managers will then need to quickly make decisions about how best to run the day’s services to both minimise further delays and maximise the level of service. The load management model can help set priorities, showing the impact of altering the times or capacities of certain trains dynamically. This ensures that problems are not further compounded by the course of action chosen, and that overall strategy is maintained.
IDENTIFYING FUTURE CAPACITY REQUIREMENTS

Requirements for the development of rail services might be driven by many issues. The key issues will depend on the type of services operated, for example:

- On long distance lines, reducing journey times may be the key to securing future revenue.
- For regional operators, it is important to identify sites where economic development will stimulate future demand for rail travel.

In both cases knowledge of the required capacity will be essential, as lack of capacity will certainly constrain demand. For train operators with a high level of commuter services, capacity is the key driver for development. Users of the load management model follow a simple but high effective process for identifying requirements for extra capacity:

- Future demand is forecast using econometric techniques
  - The forecast is fed into the load management model to assess the effect on crowding.
  - The model results indicate the extent of crowding and the areas which will be most heavily affected.
  - This allows requirements for extra capacity to be specified.

This method is commonly used by London commuter train operators for identifying requirements in the near future. The model is vital for highlighting problems in the next 1-2 years.

However, looking further ahead, data on the precise timetable and infrastructure are often not available, so it is difficult to apply a precise model. Also, it is essential to be able to assess investments on a cost/benefit basis. What is really needed is a simple relationship for judging the balance between investment in capacity and future revenue. This is made difficult by the fact that crowding on trains, which constrains revenue, has a complex relationship with demand.

Fig 4 illustrates how the model can reveal the required relationship. The cost-benefit curves shown can be quantified and projected for any given train operator, allowing decisions to be made without recourse to detailed modelling of every scenario. Thus, having a model facilitates flexible high-level decision-making. This is of very high value in the case of rolling stock investment, where a small percentage change in requirements can save millions of pounds per year in rolling stock payments.
Fig. 4 Computer modelling can reveal relationships which help develop simple forecasting techniques. In this case, the load management model has revealed the general trend in crowding as demand increases over time. The effect of adding extra rolling stock can also be gauged. The resulting forecasts show revenue would effectively be capped by crowding if extra capacity were not available.

TESTING DEVELOPMENT OPTIONS

By necessity, strategic plans are often formed based on a generic understanding of operations. As we have seen, having a clear understanding of requirements can ensure that the plans developed are as relevant as possible. However, it is also vital to test the strategy, to ensure that it is workable.

In a recent bid for a train operating franchise in the UK, a load management model was used to test the plan developed. A demand forecast and timetable had been developed, based on provision of sufficient rolling stock to minimise crowding. However, this would mean longer trains, and there could be problems associated with platform lengths, requiring further capital investment.

The load management model was used to assess what train lengths would be required, year by year throughout the plan. This immediately revealed where and when platform lengthening would be required. The existence of the model also meant that slight changes to the timetable could be tested ‘live’, so the franchise bid team could be part of the exercise. The bid was successful, and the increased understanding of loads has subsequently helped with detailed timetable planning.
THE PLANNING PROCESS

The case studies have been grouped into 3 separate groups because each of these illustrates areas of planning and control where computer models and related techniques can be of particular help. The 3 areas are:

- **Operational control.** It is frequently necessary to take short or medium term control actions. These must be practical, swiftly implemented and in line with the overall strategy.

- **Identifying development requirements.** The task of identifying requirements for investment is not a simple one, and relies on a detailed knowledge of the interactions between the level of demand, the infrastructure, the resources and the timetable.

- **Testing development options.** Strategic planning normally involves developing a number of options, the practicality and benefits of which need to be tested. Again, the capability to consider interactions between demand, timetable, resources and infrastructure is vital for a realistic assessment. It is advantageous if options can be assessed and amended quickly.

Fig. 5 The 3 types of planning activity discussed in the case studies each help support strategic and/or operational planning and control.
Fig 5 gives a view of how these areas link to other planning and control activities. The common thread of these activities is that they are not entirely within the traditional ‘strategic’ and ‘operational’ planning arenas. They are more concerned with linking the two together, and can therefore be usefully considered as ‘tactical’ planning activities.

TACTICAL PLANNING

Tactical planning helps ensure operational knowledge is interpreted and fed into strategic planning. It also helps to apply strategic control to operational planning. To do this, tactical planning must have:

- a detailed knowledge of, and ability to reason about, operations,
- an understanding of the key strategic drivers (i.e. investment criteria, regulatory policies),
- good communication with operational and strategic levels.

The case studies above show that a computer model can bring extra benefits by facilitating the development of all these attributes.

Fig. 6 Activities which help link Strategic and Operational planning and control can be thought of as ‘Tactical Planning’. Computer models and related techniques can help facilitate these links.
TOOLS FOR TACTICAL PLANNING AND CONTROL

Over the last 10 years in the UK, there have been many examples of computer models developed to assist with tactical problems. Some examples of these are:

- Revenue prediction. It is possible to directly predict the revenue benefits expected from changes to rail services, based on interactions with competitors and econometric trends. A model is available for consultancy and in-house use which is based on the system used for revenue allocation in the UK. 21 UK train operators use this system, as well as the Strategic Rail Authority.

- Yield management. Where different ticket offerings and quotas for advanced purchase tickets exist, it is possible to analyse interactions between price, ticket type and timetable design in order to maximise overall revenue. A model has been developed to help understand these interactions, and reveal the benefits of certain changes.

- Load Management. With rail capacity limited in many countries, and more and more growth expected, load management is becoming a key issue. The London commuter model described in this paper, PLATO, is one of two models available in the UK, the other being focused more on long distance operators.

- Performance modelling. One of the most important aspects of a rail service is the level of performance achievable (punctuality of trains). In the UK, models have been developed for Railtrack which simulate the movement of trains and occurrence of different types of delay. The results summarise the delays experienced, and the costs incurred, as well as illustrating the causes of delays. These results help guide timetable and infrastructure design at high or low levels.

In planning rail services, it will usually be necessary to consider all of these factors, and perhaps many more. Hence the next challenge is to integrate the different models, so that these factors can be considered simultaneously.

CONCLUSION

As we have seen, the planning of rail services involves linking knowledge and ideas from many areas. It is vital to ensure operational knowledge is properly utilised for strategic planning, and that strategic control is available during operations. Computer models used in the tactical role described here are powerful tools which provide:

- appropriate input to operational control, using operational knowledge and knowledge of customer behaviour in order to apply strategy,
• a clear assessment of future development requirements, clarifying what the key drivers are (e.g. capacity, travel time or local economies) and ensuring the balance of cost and benefit is properly understood,

• the ability to rapidly test options against reality, to see their real effects and modify the options to make them more suitable.

Perhaps the most significant point is that investment in one computer model can often unleash a whole range of benefits in different parts of the planning process by:

• promoting discussion about the interactions occurring,

• allowing the development of easy to use techniques based on the relationships revealed,

• facilitating communication between planners at all levels and external consultants, using a common language and medium.

In the future the models discussed here will be linked more and more, to allow demand forecasts, infrastructure, timetables and rolling stock to be shared. This will mean tactical planning will be fully integrated, both vertically and horizontally with all other planning processes.

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