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Capacity utilisation and performance at railway stations

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ABSTRACT

As railway traffic levels increase in Britain and elsewhere, improved understanding of the trade-offs between capacity provision/utilisation and service quality is increasingly important, as Infrastructure Managers and Railway Undertakings seek to maximise capacity provision while maintaining service reliability and punctuality. This is particularly true of the stations and junctions forming the nodes and capacity bottlenecks of railway networks, for which the relationships between capacity utilisation and performance are less well understood than for their intermediate links. Following work undertaken for the OCCASION project on the calculation of nodal Capacity Utilisation Indices, and on the application of these techniques to the recalibration of the Capacity Charge element of the Track Access Charges in Britain, one objective of the DITTO Rail Systems project is the further investigation of the relationship(s) between capacity utilisation and performance, as indicated by congestion-related reactionary delay levels at railway stations and junctions. Historic timetable and delay data for selected stations have been used to investigate these relationships, which take the expected form and tend to suggest lower maximum capacity utilisation levels for stations than for the links between them. Work is ongoing to develop these datasets and relationships further, and to identify suitable capacity utilisation upper limits.

1. Introduction

Demand for rail transport in Britain is increasing rapidly, while the railway infrastructure is expanding slowly. This requires the railway industry to make the best possible use of available capacity, typically by running additional trains on existing infrastructure, while seeking to maintain acceptable levels of performance, i.e. punctuality, and, particularly, safety. This challenge is particularly pertinent to the network nodes – junctions and stations – that tend to form the capacity bottlenecks on the system, and for which the trade-offs between capacity utilisation and performance are more complex and less well-understood than for the plain line links between them. This paper describes work being undertaken to investigate the relationships between capacity utilisation and performance at nodes, as part of the research project 'Developing Integrated Tools To Optimise Rail Systems' (DITTO Rail Systems), funded by Britain's Rail Safety and Standards Board (RSSB).

Following this introduction, the background to the work is summarised, followed by a review of the underlying issues and previous work in this area. Next, the methodology adopted and the data used are described, the results and findings of the

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work to date are presented, and ongoing and planned further work is outlined. Finally, some conclusions are drawn, followed by a list of references.

2. Background: problem statement and objectives

Passenger and freight rail traffic growth in Britain in recent decades has not been matched by an equivalent increase in network capacity, with the result that maintaining system performance is an increasing challenge. Train operators' desire to run additional services to meet growing demand can conflict with the Infrastructure Manager's (and the operators') objectives of maintaining service punctuality and reliability. Punctuality in Britain is monitored by means of the Public Performance Measure (PPM), a measure of the percentage of services arriving on time at their destinations (for the purposes of PPM, on-time arrivals are those within 10 min of the scheduled arrival time for long-distance train services, and those within 5 min for other services). Furthermore, under Schedule 8 of their Track Access Agreements, Network Rail (the Infrastructure Manager (IM) of Britain's railways) and the Train Operating Companies (TOCs) are liable to pay one another compensation for delays for which they are responsible. Since the IM and the TOCs are completely separate organisations, potentially liable to net performance-related costs, there is an overall tendency towards conservatism, and a reluctance to operate additional services whose performance disbenefits might outweigh any service provision and capacity benefits.

This conservatism, and uncertainty surrounding reliable capacity utilisation limits, means that potentially valuable and beneficial train paths are not being used. The issue is particularly acute at railway stations and junctions, since they tend to form the capacity bottlenecks on a network, and, in contrast to their intermediate plain line links, no standard capacity utilisation upper limit values are available for them. Established methods of timetable stability analysis, such as the use of max-plus algebra (Goverde, 2015), have not yet been applied in Britain, for various reasons. Instead, continuing reliance has been placed upon simulation, and on empirical investigation of relationships between performance and various timetable and infrastructure characteristics. There is thus a need for a more generalised understanding of the relationships between capacity utilisation and performance at junctions and stations, if reliable capacity is to be maximised without repeated recourse to scenario-specific simulation; the work described in this paper seeks to address this need.

3. Review

The increasing demand for rail transport in Britain is reflected by the fact that annual passenger numbers recently exceeded the previous record number seen in the late 1940s (OECD, 2013), but on a much smaller network, comprising approximately half the 1948 route mileage (Capgemini, 2013). Although train performance and signalling and control technologies have improved significantly in the intervening period, the inevitable consequence is that the network is being used more intensively. There is no sign of these increases in demand abating, as confirmed by the Department for Transport (DfT, 2012):

> Demand for rail travel is forecast to continue growing steadily for the next 20–30 years and many services will be full by the mid-2020s if we do not act now … to provide much-needed additional rail capacity.

Additional capacity is being provided or planned for various sections of the network, in the form of new or upgraded infrastructure, including High Speed 2, the high-speed railway that will link London with the midlands and north of England, and beyond. It is nonetheless crucial to make the best possible use of existing (and new) infrastructure, thus maximising the beneficial exploitation of the potential capacity that is available.

Even defining capacity, however, is not necessarily straightforward. As noted by the International Union of Railways (UIC, 2004), it is difficult, if not impossible, to define a specific capacity value for any given section of railway:

> capacity as such does not exist [and] railway infrastructure capacity depends on the way it is utilised.

Achievable capacity therefore depends not only upon infrastructure characteristics, including signalling systems, but also upon the performance characteristics and mix of trains using the route, the timetable in operation, and the target levels of reliability and punctuality to be achieved by the timetabled services. Capacity utilisation, or capacity consumption, measures (Pachl, 2015) provide an indication of the extent to which maximum theoretical capacity (for a given operating scenario) is being used.

As indicated above, on busy railway systems, two important capacity-related objectives are: (1) to maximise the number of trains that can be operated, subject to constraints imposed by service mix, stopping patterns, etc., while (2) maintaining acceptable levels of punctuality and reliability. As capacity utilisation levels increase, so, typically, does the capacity provided (although, as indicated above by UIC, capacity may be utilised in many different ways, with correspondingly varying levels of capacity provision).

However, as noted by Pachl (2009) and Martin (2015), as railway traffic flow increases, there is “increasing mutual hindrance of trains”, with associated increases in waiting times, both scheduled (i.e. allowances, etc.) and unscheduled (i.e. delays). This decline in service quality is particularly pronounced when capacity utilisation exceeds recognised limits (UIC, 2004, 2013).

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