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The philosophy and practice of *Taktfahrplan*: a case-study of the East Coast Main Line

Jonathan Tyler

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Executive Summary

This Working Paper has three purposes, represented by three Parts:

A to explain the principles of the *Taktfahrplan* approach to railway timetabling;

A to summarise the implications of the background research on the structure of the network; and

A to describe the exercise of constructing a *Taktfahrplan* for the East Coast Main Line that formed the case-study of the potential benefits of such a scheme compared with the existing timetable.

In Part 1 the broad principles and objectives are first outlined, and the advantages and disadvantages discussed [§1.1,1.2]. A *Taktfahrplan* is based on standard hours and the careful, network-wide coordination of services. It is recognised that ultimately the choice between this and conventional timetabling methods must depend on an evaluation of the loss of present flexibility to adjust to time-specific market demands against the gains from enhanced connectivity and from the fact of regularity. Issues concerning resources and the management of peak periods are also explained.

Terminology is then dealt with because words and phrases are being used with imprecise and various meanings [§1.3]. There follows a detailed account of the arithmetic rules through which the ideal relationships between train (and bus) services can be attained, together with an explanation of the measures that can be taken to make the best compromises in the face of the characteristics of the real network – or to adjust it over time [§1.4].

In Part 2 the research to highlight features of the underlying demand for travel is described. This is not a necessary component of strategic timetable planning, but it is argued that it is desirable in order both to break free from the historical baggage and to seize the business, environmental and social-policy opportunities that a 'clean-sheet' timetable would present [§2.1]. The provisional findings from this work (it was left incomplete for reasons that are explained) are then deployed to form the skeleton of a national network connecting 100 important centres with 158 links.

This is followed by an analysis of the very variable standards of the rail timetable on those links and of the road competition and by an account of some first thoughts as to how a full-scale *Taktfahrplan* might start to be developed on this network [§2.2]. This emphasises the inter-relationships between services and the inescapable consequences for pathing trains, once it is accepted that sensible spacing of services and striving for good connectivity are more important than optimising routes on a self-contained basis. It was thought appropriate to include a summary of the findings regarding the low-density end of the current rail system in order to indicate the issues that *Taktfahrplan* might raise in this respect [§2.3].

The East Coast case-study is presented in Part 3. Some technical matters are explained first, including the key point that the exercise used the *Viriato* timetabling software employed by the Swiss Federal Railways (and many other systems) to construct *Taktfahrpläne* [§3.1]. Successive sub-parts then describe groups of services: long-distance [§3.2], services within Scotland [§3.3], services in North East England [§3.4], the trans-Pennine network [§3.5] and some of the Yorkshire services [§3.6].

This Project would not have been possible without the interest and support of various colleagues in the railway industry, but if a dedication is appropriate it must be to the staff of SMA, the developers of Viriato*, whose knowledge of and commitment to good timetables for public transport have been an inspiration.*

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Contents

1. THE PRINCIPLES OF A *TAKTFAHRPLAN*

1.1 Background

1.1.1 The timetable is the prime and essential feature of the service offered to potential travellers by public transport. The importance of the reasoning underpinning the *Taktfahrplan* approach to timetabling itself rests on this fact. Other features – the design of vehicles, the ambience of terminals, the welcome by staff, the price – are all significant, but without a timetable whose characteristics make choosing the train or bus an option competitively relevant to sufficient customers the service will fail. A theme of the research was that, since this apparently self-evident point has been neglected for many years, and particularly in the model of privatisation[1], it was desirable to study the implications of restoring its status. This Working Paper describes the principles that were followed [in this Part], some theoretical considerations about the network and its timetabling [in Part 2] and a case-study [in Part 3].

1.1.2 Every timetable offered by any public mode of transport is planned in one of three ways:

- each element of the service (a vehicle-movement from A to B, variously (and confusingly) described as a plane or flight (air), a train (rail) or a bus or journey (bus)) can be organised individually to match the planner's judgment of specified market demands and in accordance with any resource or operational constraints; or
- a repeating pattern that provides in broad terms for the demand can be determined and strictly maintained throughout the operating day; or
- a pattern can simply be a starting-point, with the detail varied as may be required.

1.1.3 It is vital that the design of the timetable be appropriate for each set of circumstances. Traditionally, most railway timetables were produced on a painstaking train-by-train basis, although the idea of patterned services is almost as old as railways and many networks have enjoyed complete or partial provision of trains running at regular intervals in some periods of their history. Development of a system-wide coordinated timetable based on clear rules, repetition and consistency is largely the product of discussions among visionary staff of the Swiss Federal Railways [SBB] in the late 1970s, with the first implementation in 1982. The name they used then, *Takt-fahr-plan* ['rhythm-journey-plan'], has become established in German and is used in this paper and elsewhere in the absence of a satisfactory phrase in English.

1.2 Structure, advantages and disadvantages

1.2.1 As argued by its proponents, the advantages of a *Taktfahrplan* over a conventional timetable[2] derive from six characteristics:

A that the methodology delivers a logical and coherent timetable across a network;

A that it articulates a well-defined hierarchy of services;

A that connectivity between services, and thus for a journey on any relation (place-pair), is optimised;

[1] There is only one, minimalist reference to timetables in the Railways Act 1993 [¶ 82 (3) (g,h)]: it concerns their function in "the exercise of day to day control over train movements over or along any track".

[2] For a critique of the National Rail Timetable [NRT] see: Railway Reform Group (2000).

- A that systematic planning and regularity together make the best use of capacity;
- A that a repeating pattern is simple to market and memorable for customers; and
- A that the service in one direction is the mirror-image of that in the reverse direction.

1.2.2 The first three of these provide the structural framework. Its merits need to be measured on two levels:

- for any group of services or any (sub-)network does the timetable offer more attractive journey opportunities to potential customers than the alternative(s), and thus grow revenue overall, net of any extra costs ?; and
- does a timetable designed under this policy afford the community at large the best possible benefit from its railway (and associated modes) ?

The latter question is important, because a region or country may, for example, choose to forgo improvements and increased use on a particular line for the sake of enhanced connectivity and hence environmental gains in a wider area. For the purpose of this paper the three structural characteristics of a *Taktfahrplan* are assumed to be desirable: they are evaluated elsewhere.

1.2.3 A railway is a system comprising the track, the trains and the control mechanisms. The number of trains that can pass along each section of track is determined by the interactions between features of its specific infrastructure, vehicles and controls. For a given set of features the maximum throughput can be achieved if every train is operationally identical and runs at the same, optimal speed. In practice, only dedicated mineral lines and some urban metros are worked on that basis, and the latter have to allow ample margins for daily perturbations.

1.2.4 On multi-purpose, multi-route railways trade-offs are unavoidable between, on the one hand, the commercial requirements for different types of service, with various acceleration-curves, running speeds, stopping patterns, junction movements and inter-relationships, and on the other, the obligation to obtain the best practicable return on the high cost of the infrastructure, or to properly justify an enhancement. For a network the equations are complicated, not least because it is not obvious what the objective function should be and how it should be measured.

1.2.5 Rather than search for a theoretical 'best' solution it is usually therefore more sensible to test a relatively small number of feasible and acceptable solutions to match the market, and if, as is typically the case, the pattern of demand is fairly stable through the day, to select one pattern and to treat it as a 'standard hour'. In other words, that pattern is replicated every hour from the start to the end of the service, with a greater or lesser degree of adjustment to cater for peak-hour traffic[3].

1.2.6 This approach is reinforced by the fact that in a network of any complexity even a small deviation from a desirable standard pattern can spread consequential changes very extensively. It follows that, once a standard-hour policy is adopted, it may be wise to state a presumption against adjustments to meet particular requirements. However, although few would now suggest that timetabling each train individually can possibly make effective use of resources (and many exercises in regularisation have been justified by savings or by running more train-kilometres with the same equipment), some argue strongly that, since it is necessary to fit the offer to the needs of certain time-sensitive markets or groups of customers, absolute regularity may impose unacceptable rigidity and at worst a loss of business.

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[3] Calculation of an index of capacity is highly dependent on assumptions about the mix of services, whereas what matters is the *structure* of what is to be delivered, ie. the timetable, including relationships between services.

1.2.7 There can be no dogmatic answer to this problem. What is nonetheless clear is that the ripple-effects of a change on other timings and on rolling-stock diagrams are often difficult to trace, especially when variations have accrued over some years[4], that the tools to measure the worth of adjusting an irregular timetable are not well developed, that the record of acceding to pleas from interest-groups is debatable, and that there is no self-defining limit to adjustment. If by contrast there is an explicit presumption of regularity the price of a deviation is more transparent and it can be balanced against any benefits. The 'clean sheet' exercise described in this paper therefore proposes wholly regular patterns and has not reached the point in its development where adjustments may come under review.

1.2.8 The fifth characteristic concerns (potential) customers' reading of the timetable. It is self-evident that a service with a day-long repeating pattern can be presented more simply in every medium than a service with haphazard timings, and that by the same token it is more memorable (eg. "10 and 40 minutes past every hour" compared with recourse to an information source because every hour differs from the next). Even so, that does not of itself justify operating a timetable on a rigorously regular basis. Three factors have to be considered.

1.2.9 First, any public transport service will, by definition, be unsuitable for some travellers with very time-specific needs: preferred and offered timings are most unlikely to coincide for everyone. This was recognised from the start of demand-modelling [Tyler (1973)], and an equivalent time-value for the negative impact of the necessary adjustment, which of course varies substantially by journey-circumstances, has been measured and incorporated in railway forecasting procedures [ATOC (2002)]. In that respect all timetabled services are similar in their nature, as compared with the private alternatives. However, as already noted, a commitment to regularity must mean less scope for modifying the timings, and in a *Taktfahrplan*, where network interconnections are strong determinants, this drawback may be especially acute and difficult to resolve.

1.2.10 Second, by way of counter-argument, a standard pattern with high connectivity may create such a sense of the *convenience* of moving about an area by rail, and by public transport collectively, that most travellers are content to adjust their lives to what is offered (give or take some grumbling on the rare occasions when the pattern has to change). This positive perception may be strengthened by the impression of clear purpose conveyed by an organisation that offers structure and regularity. And third, simplicity and memorability may of themselves generate use of a system. Seeking to understand these factors is not easy[5], but it does seem that the second and third may help offset the first [Wardman et al. (2003)]. It should also be remembered that one variation, however minor, will have disproportionate effect, since it disrupts the straightforward presentation of timings and also leaves users uncertain – and at worst cross at being misled[6].

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[4] Some railway managers in Britain have been highly successful in maximising the use of rolling stock by tweaking timetables, and each step will have been legitimised by net revenue benefits. However, incremental progression toward a disjointed timetable, albeit unintended, may have had damaging intangible effects on public perception, and it is not certain that the sum of separate decisions over time yields the most efficient outcome.

[5] *Conviction* regarding their importance is notable in much of mainland Europe. The Swiss railways have jointly established 'Takt' as the central, popular concept of the passenger service, and the idea is now beginning to be found even in France, which has traditionally been reluctant to accept regularity: the slogan "Facile à retenir ... Toutes les heures à 55 au départ" was noted advertising an Alsace regional service in Strasbourg in October 2003.

[6] In our consultations some have argued that marketing problems with irregular patterns will diminish as recourse to electronic information sources grows. To a degree that may be so, but quite apart from the capacity-utilisation and connectivity justifications of regularity being sufficient in themselves, the argument has five weaknesses: (1) it is premature until most of the population has ready access to electronic devices; (2) their use depends on a predilection for public transport, which may be weak unless the full scope of the service is promulgated through media with a more expansive format than internet channels; (3) these channels themselves cannot act as marketing tools if the information they purvey is needlessly complicated; (4) not all journeys fit into the prescriptive framework of call-centre guidelines or screen layouts (which irritates some users); and (5) many journeys should not *need* an enquiry.

1.2.11 On these grounds too then, the presumption of repeating patterns for the present exercise seems justified. The last characteristic is the design of the two directions as mirror-images, the one of the other. This is both a consequence and a reinforcement of the other characteristics. It is intrinsic to the idea of structure, it is necessary arithmetically to good connectivity [as explained in §1.4], it complements regularity in planning (and simplifies the process) by ensuring that what works in one direction will work in the same way in the opposite, and it aids memorability. A failure to follow the mirror-image rule can significantly erode the advantages of a *Taktfahrplan* and it has therefore been applied meticulously.

1.3 Terminology

1.3.1 This subject is bedevilled by poorly-defined terminology. The essential points in terms of the coherence of the timetable, of capacity-planning and of the offer perceived by customers are that the 'standard hour' pattern should repeat itself every hour and that services should connect with each other. (There is a debate about whether to manage the peak by superimposing additional trains on the off-peak base or whether to use a different pattern altogether, but that is a distinct issue not addressed in detail here.) The phrase often used to describe the outcome is a 'regular-interval' timetable, but its exact meaning and its limitation must be emphasised.

1.3.2 'Regular-interval' is an adequate phrase for describing the 'standard-hour' approach to planning the timetables of a network, but there must not be any suggestion that 'regular' connotes 'even'. Quite often two or more separate services may combine to cover the requirements of a common section, and it is rare, for all manner of operational reasons, to be able to path them at exactly even intervals over the shared route (eg. departures may be at xx.10 and xx.38). Evenness may be the ideal, but it is not the highest priority[7].

1.3.3 More importantly, a collection of services independently timed at regular intervals only qualifies as a *Taktfahrplan* if the rules outlined below [§1.4] are followed, and in particular if the emphasis is on optimising connectivity and if the mirror-image is exact. Mere regular operation would yield some benefits (which is why it is being increasingly stressed in announcements from the Strategic Rail Authority [SRA] and franchisees), but it is unlikely to have the impact of a comprehensive plan. Indeed, if regularisation is not performed under *Taktfahrplan* rules it runs the risk of creating poor spacing every hour, which could jeopardise frequency benefits, or poor connections every hour, which could prove worse than random meets.

1.3.4 The matter is further confused in that some Train Operating Companies [TOCs] believe that offering departures from principal stations at round-number times (eg. xx.00, xx.30) is commercially desirable. There is tentative evidence to support this [Wardman et al. (2003)], but since it can only be achieved at a few stations and since doing it at X in one direction and Y in the other usually precludes a mirror-image timetable for X ↔ Y, it was not an objective in the present exercise[8]. Moreover, 'round-numbered-ness' is arithmetically incompatible with the 'zero-minute'

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7 Of the three features of a timetable that were evaluated it has the weakest percentage effect on demand.

8 If a service is timed, say, to leave Edinburgh Waverley at xx.00 and to arrive in London Kings Cross at xx.19, then by the mirror-image rule the northbound service must leave London at xx.41. Suppose the train calls at York southbound at xx.28 and northbound at xx.32. A connecting service may be timed to arrive at xx.23 and to depart at xx.37. If for the sake of 'round-numbered-ness' the northbound train is retimed to leave at xx.00 it will call at York at xx.51 and thus not offer the connection – unless that too is adjusted, and so on rippling across the network. The National Rail Timetable contains numerous examples of connectional patterns, and often journey times, differing by direction as a result of not applying the mirror-image rule. Since most travellers are likely to judge a timetable by what they are offered in the two directions taken together (or even by the slower), this phenomenon could be losing more business on the many relations affected than is gained by the "0 and 30" benefit on a few principal relations. Round-number departure times, even in units of 5 minutes, are difficult to find in the Swiss timetable.

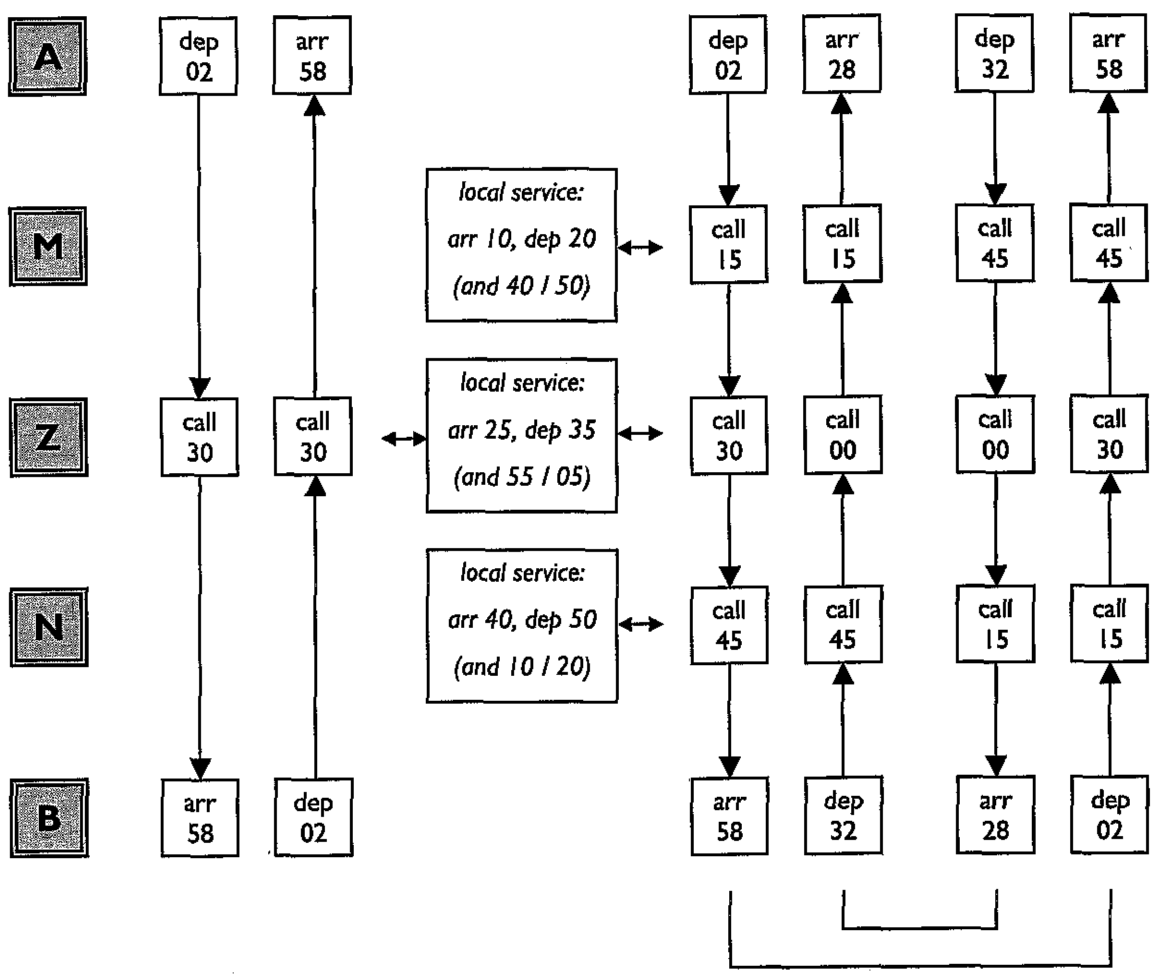
rule [see ¶1.4.3]. A final complication is that the adjective 'clockface' appears to be used both as a synonym for regular-interval and more specifically to describe round-number timings. Since it is also not understood in common speech it is best avoided.

1.4 Seeking perfection: goals and rules

1.4.1 The ideas outlined above are realised through a number of goals and rules. Their aim is the perfect timetable, but it has to be accepted that all manner of constraints intrude. If a train leaves A at xx.02 and arrives at B at xx.58 and the service in the opposite direction leaves B at xx.02 and arrives at A at xx.58 they will pass at xx.30 (where xx stands for any hour of the operating day). If a station, Z, is located where they pass and it is decided that the A ↔ B train should stop at that station (the symbol ↔ means the service in both directions), then a local train or a bus that arrives at Z at xx.25 and departs at xx.35 will have an optimal outward and return connection with both A and B. Stations A and B may have similar connecting services timed around the hour.

1.4.2 In the perfect network and where the typical frequency is hourly trains will cross every 30 minutes and the centres they serve should therefore lie 26 or 56 minutes apart from each other (assuming 4-minute dwell-times for arithmetic neatness). In this way connectivity is maximised. If the services on a network are predominantly at a half-hourly frequency then centres with their own half-hourly frequencies of secondary routes can lie at the quarter-hour crossings. These possibilities are illustrated in Figure 1.

Figure 1. Standard patterns for perfectly-arranged nodes



1.4.3 It will be noted that 2 + 58 and 30 + 30 (actually, say, arrive 29 + depart 31) both sum to 60. This arises from a combination of arranging the timings around the 'zero-minute' and insisting on strict mirror-image working. If the first is taken as given and the second rigorously followed then *every* pair of departure times to another station and arrival times from it at *every* station will sum to 60 (in real timetables slight variations may arise from differential running times [for the question of performance margins see ¶3.1.6-9]). The base does not have to be zero. It can be any value, for instance, if it were 26 then arrivals might be at 24 and departures at 28, summing to 52 (twice 26). The convention is to make it 0, with times summing to 60, for the sake of simplicity, although if it were 58 it would give round-number departures at xx.00 and xx.30 at some stations for some trains (the times would sum to 56 + 0 or 26 + 30, = 56 = ((2x58)-60)).

1.4.4 This feature (which could have a useful supporting role in the public presentation of the memorability of a *Taktfahrplan*) also helps to highlight another important detail in Figure 1. It is assumed in the right-hand display that the principal services at xx.02 and xx.32 have identical stopping patterns throughout their journeys and that each pair of connecting local services is also half-hourly and identical. Strictly speaking, the outer two and the inner two of the principal service are pairs, with times summing to 60, and the local pairs are 10 + 50, 25 + 35 and 40 + 20, but if the conditions hold then it is largely academic whether one sums to 60 or to 30.

1.4.5 Suppose, however, that the 02/58 principal pair of trains serves station X 'south' of B and that the 32/28 pair serves Y on a different route, while the local services can only sensibly run hourly. It then becomes more necessary to correctly pair the trains. For example, passengers arriving at M at xx.10 catch the xx.15 to X and arrive back at xx.45 expecting the local at xx.50. That may be possible, but it could be ruled out as involving too lengthy a turnround and it may have to run at xx.20. In that event the decision may be to accept the non-mirror 02/28 pairing of services on the common section of the main line so far as branch connections are concerned. These would remain good for links with A, Z, N and B, but the return service from X, and that outward to Y, is decidedly poor. The problem may also arise when a service is reduced to half the normal frequency in the evenings. The risk of damaging accumulative (and unintended) effects across the network from such derogations from the normal rule must also be borne in mind.

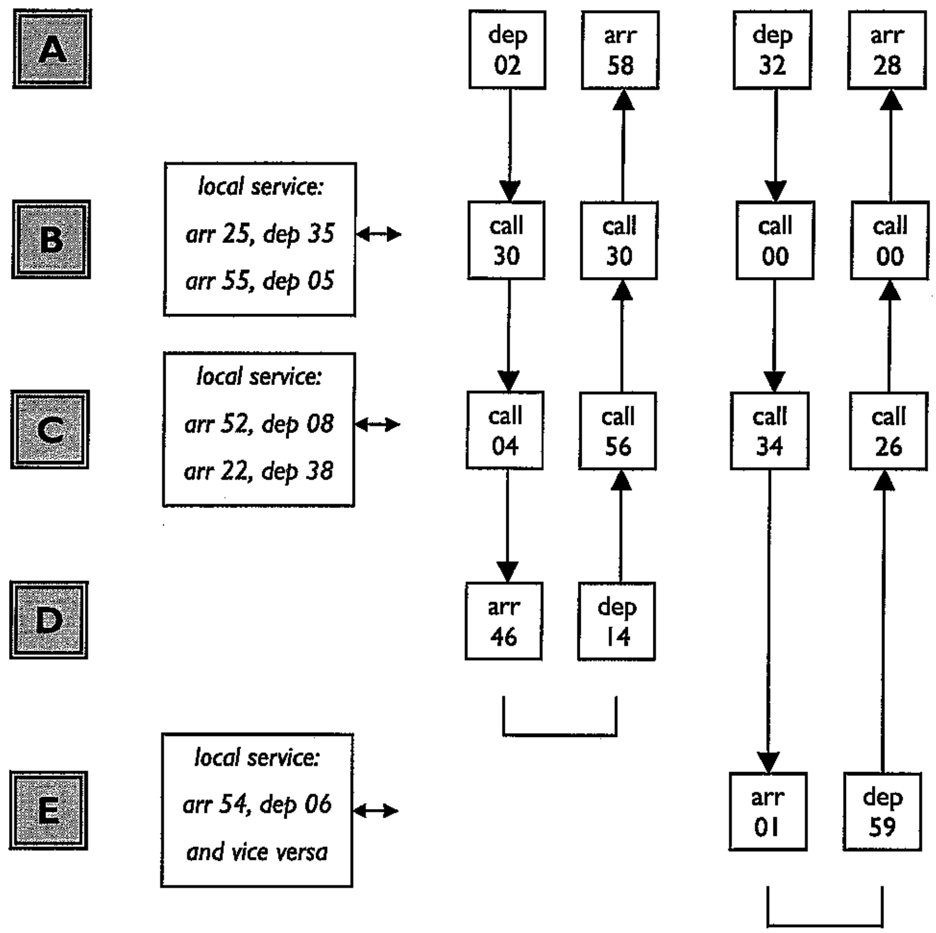
1.4.6 Compromises are the stuff of timetabling, but the National Rail Timetable contains rather too many cases where the extended effects appear not to have been realised. In a *Taktfahrplan* deviating from the rules incurs notably transparent effects and a corresponding presumption against it maintains the integrity of the network timetable. That approach was adopted in the case-study (one particular deviation was felt to be justified, for the reasons explained [¶3.4.8-10]), but in more detailed analysis it would be necessary to evaluate the cost in resources of maintaining the rules against the extra revenue and other benefits from so doing.

1.4.7 In order to illustrate the concepts the discussion so far has taken a hypothetical perfect network. In reality of course networks are not like that, and in particular, places do not typically lie a neat 26 or 56 minutes apart from each other. Before reviewing the possible strategies for addressing this problem it is helpful to look at the implications of a less-than-ideal disposition, as shown in Figure 2. Suppose two hourly services, respectively between A and D and A and E that are arranged to operate at even intervals over the common section between A and C.

1.4.8 The timings at A and B permit the ideal arrangement of related services around them, and there would be no network benefit in reducing the running time below the current 27 minutes (assume the dwell at B is 2 min). At C, the local route could be timed at, say, arrive xx.57 – depart xx.03 (or even xx.59 / xx.01 if running through), with equivalent times at the half hour if required. There would then be a good connection to and from D (and/or E), but to/from A and B the connection requires a lengthy wait, although it is quite possible that that is of limited consequence, given the particular geography and relative sizes of flows.

1.4.9 If on the other hand an all-ways interchange at C is desirable two tactics are possible. With the existing mainline timings the local route would have to be timed at xx.52 – xx.08. That may happen to work better in terms of paths elsewhere or of more robust turnrounds, but it means a relatively poor interchange toward D (arrive xx.52, depart xx.05, with 55,08 in the reverse direction). The alternative approach is to reduce the B ↔ C running time by 4 minutes. Assuming that the track layout allowed the local and mainline trains to arrive within 3 minutes of each other, this would give a xx.56 / xx.01 interchange (59/04), thus saving 'local' ↔ D passengers 8 minutes and bringing the margin down to the minimum previously only offered for 'A' trips.

Figure 2. Standard patterns for imperfectly-arranged nodes



1.4.10 The C ↔ E running time is currently the ideal 26 minutes but the sub-optimal B ↔ C time could result in another type of problem at E. As shown, a local service, in this case assumed to be on a through route, is timed to give the minimum interchange of 5 minutes, but at the expense of a 12-minute dwell-time. That might be acceptable if the great majority of passengers are changing to/from mainline trains, but it is unsatisfactory for through passengers and undesirable in respect of poor resource utilisation from idle train sets and extended platform occupation. To time the secondary service at xx.59 / xx.01 in both directions would destroy all connections. To time it at 54/56 and 04/06 in the reverse would secure connections from/to one arm of the route but not the other. To cut 4 minutes off the mainline schedule would give an xx.57 arrival / xx.03 departure pattern, enabling the local (assuming no conflicts) to call at xx.58 / xx.02 in both directions, with its dwell shortened by 8 minutes.

1.4.11 Finally, at D no significant connection is assumed and the timings are acceptable because 28 minutes is perhaps not much more than the stipulated turnround allowance. The 4-minute acceleration would increase this to 36 minutes, which may be tolerable within the broader picture. Of course, if there exists a local bus passing the station at xx.15 and xx.45 then the revised timing would yield better modal integration, and it might be worth seeking to shorten the C ↔ D timing by a few minutes to secure a more robust margin.

1.4.12 The distinguishing tenor of this description of a typical set of circumstances and options is concern for the *connectivity of the network* – it expresses an instinctive view that that is what public transport should be about. The perfectly legitimate contrary view is that the significance of connections should not be exaggerated. One should proceed instead to plan each service independently, either maximising income or minimising resources or more likely seeking the best net return. There may still be scope for some attention to connections, but it will be selective and usually secondary. This is what sometimes happened under British Rail, and encouraging each Train Operating Company to pursue its own interests (within a weak *National Rail* brand) appears to have given that approach greater acceptability.

1.4.13 Nonetheless, it may be that neglect of the network concept harms the interests of Britain, or of the industry collectively or even of individual companies. It is certainly not in keeping with apparent public attitudes or with the fact that, in the nature of things, large numbers of journeys depend on the combined services of more than one operator. And poor planning of connections continues to draw widespread criticism. The Swiss philosophy is entirely different. There, the objective is to bind the whole country together in a tightly-coordinated web of routes such that any I ↔ J journey can be made straightforwardly with the best possible connectional arrangements – and on a repetitive basis every hour throughout the day and on every day. The outcome seems to be a more positive perception of public transport than exists in Britain.

1.4.14 For any network or part of a network only an evaluation of every aspect of the two approaches can lead to any definitive conclusion about their respective merits. This, experimentally, was the reason for preparing a draft *Taktfahrplan* for the East Coast Main Line, and the draft therefore quite rigorously follows the Swiss model [see Shires et al. (2003) for a description of the appraisal findings]. It will be seen to include a number of examples of dwell-times and train-set turnrounds that would in themselves probably be considered poor practice but which may be justified by their contribution to the wider picture. In assessing such circumstances it should also be recognised that in some cases of diagram-driven timetables, particularly where frequency is entirely determined by the number of sets allocated to a line, it is arguable whether the outcome is so mediocre as to be unsustainable. Forging routes that fit within the temporal framework prescribed by the concept of key nodes may be a sounder strategy.

1.4.15 Finally there is the question of how something approximating the optimal pattern can be achieved. There is a certain mystery about this, as though Switzerland, the arch-exponent of the principles, was somehow blessed with a disposition of nodes that especially favoured *Taktfahrplan*. It would be an interesting exercise to test that unlikely proposition, but the real point is that it is possible, over time, to adjust the network so that the arrangement of sectional running times [SRTs] is as close as possible to the ideal. The procedure in the Swiss *Bahn 2000* project was to devise a timetable vision, to test what could be done by some combination of infrastructure enhancements and new rolling stock, to iterate solutions and then to commit to a programme of works that would deliver the best practicable timetable. This is due to start in a 'big bang' revision in December 2004 (90% of the timetable will change), and further schemes are envisaged, culminating in the opening of the two new Alpine Tunnels.

1.4.16 What was planned for the Zürich ... Lausanne (... Genève) axis epitomises the reasoning. There are two routes, one via Neuchâtel and the other via Bern. The end-to-end running times were 163 minutes and 141 minutes at the time of the planning. The chosen objective is to reduce them to 131 and 128. It would presumably have been possible to achieve sub-2-hour schedules, but only at prohibitive cost. Instead, the two critical points are that the timings will be made almost identical, which will allow the hourly service by each route to afford travellers a combined opportunity to travel every half-hour, and that the new timings will facilitate a grouping of secondary and local services at Lausanne at the quarters and three-quarters.

1.4.17 The acceleration is being realised by a mix of infrastructure works and new trains. Of the former the major task also serves another prime objective of the master-plan, namely reduction of the running times between Zürich and Bern and Basel and Bern from about 68 minutes to just less than one hour. This will be delivered largely by construction of a new line between Rothrist and Mattstetten to replace part of the route (with capacity benefits too). The aim is to establish Bern as the second principal 'zero-minute' hub after Zürich. These schemes were chosen as being superior in net national benefit to more dramatic high-speed improvements for selected corridors, and they nicely illustrate the Swiss dictum "as fast as necessary, not as fast as possible"[9] – in other words, use speed to obtain a good nodal interchange pattern rather than pursue it to its maximum for its own sake.

1.4.18 Figure 3 [next page] sums up the fundamental principles of a *Taktfahrplan.* At a *zero-minute* node a principal service calls in both directions at xx.58 – xx.02 (note the 4-minute dwell-time to aid smart timekeeping). A secondary service which it is desired shall connect in all four combinations with the principal service is timed at xx.56 – xx.04, assuming that the layout and signalling permit arrival only 2 minutes ahead of and departure 2 minutes behind the primary train in both directions and that the platform layout requires 6 minutes for comfortable interchange by passengers, including a margin for small delays[10]. The tertiary service arrives at xx.54 and departs at xx.06, on the basis of a slightly longer walk and of securing all-ways exchange with the primary and secondary trains. In this manner each order of the hierarchy is tied in with the others. The pattern is akin to the airline 'hub and spoke' concept but with rather more through services.

1.4.19 Four important items need reiteration. One is that the times are a function of the infrastructure. Where it is ideally laid out, for example with cross-platform interchange, the timings could be tighter, and a key factor in mainland European practice has been works specifically directed to achieving this. Second, on-time operation is obviously and absolutely vital, and it is also essential to have firm rules about the holding, or not, of connections[11]. Third, if it is argued that the 8-minute dwell-time of the secondary service or the 12-minute turnround of the local (or bus) are excessive, then the evidence must be strong that the advantage to through passengers of removing the lengthy stop or the saving in resources from a tighter turnround outweigh the potentially large, extensive and ultimately perhaps psychological benefit of locking these routes into the wider network. The effect after all of not so timing them is that they may continue to be seen as self-contained, not very relevant to most people's lives and thus vulnerable.

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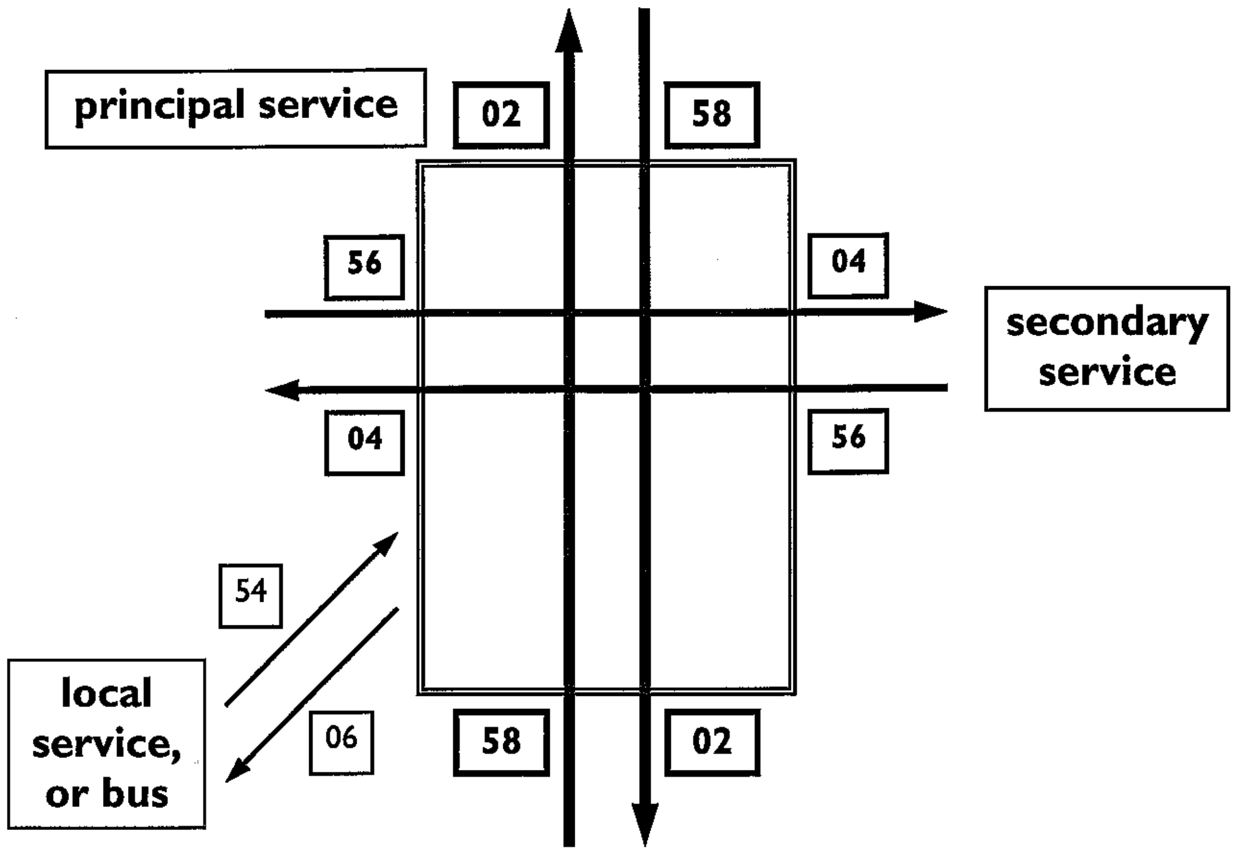
[9] In German *so rasch wie nötig, nicht so schnell wie möglich !*

[10] Note that the minimum physical time is the determinant, and hence that nothing is gained by reducing the headway between the arrival times of the pair of trains beyond a certain point: if h is the headway, d the dwell of the principal train and p the interchange time plus the margin, then ideally $(h + d) = p$.

[11] The prerequisites are reliable infrastructure, signalling equipment and rolling stock, a minimisation of external factors intruding on railway working, and the ability to respond flexibly to problems without being hampered by obsessive safety regulation. Realistic margins and dwell-times are also necessary (and preferred by travellers to random late running). In addition, experienced operators believe that by promoting disciplined working a repetitive pattern aids good timekeeping. (In Switzerland the target is 75% of trains arriving within 1 minute of scheduled time and 95% within 4 minutes: these are being exceeded [see < www.sbb.ch/bf/kennr_e.htm >], and departure boards are almost always free of delays [< www.sbb.ch/prosurf/index_e.html >]). Regularity supports a clear policy regarding the holding of connections because it is easier to write guidelines for standardised situations than for those where the considerations differ for each train. The prevailing practice whereby TOCs, under perverse performance incentives, disregard connections in order to ensure the punctuality of 'their' trains has no place in a *Taktfahrplan* railway.

Figure 3. The ideal pattern of services at a 'zero-minute' node



1.4.20 The final point concerns the procedure for building a *Taktfahrplan*. The ideal is that all major interchanges shall be located, as it were, at the zero-minute and all significant interchanges at the hour, quarter, half or three-quarter positions. In reality, some will fall serendipitously in the right place, some can be adjusted through greater or lesser projects to fall where it is desirable they should, and some may present intractable difficulties. The challenge (and the fun) is to get the balance right between the ideal, the achievable, the cost, the benefits and the impossible (for now). And it does need to be right, because although the demography and the demand are stable enough to support long-term commitments, the cost of misjudgment may be high.

2. AN OUTLINE OF AN INTER-URBAN NETWORK

2.1 Methodology

2.1.1 A *Taktfahrplan* could be designed on the basis of manipulating into a regularised framework the set of services bestowed by the long, complicated and often muddled history of Britain's railway. That would not however do the principles justice, for their radical nature predicates a clean sheet, and that in turn opens the opportunity to rethink the structure of the timetable, and by extension to investigate the underlying demand. It can be argued too that at a time of serious institutional and financial problems, and indeed anxiety about the very future of the railway, it is incumbent on any analyst to ask fundamental questions. These tasks were written into the specification of the research project.

2.1.2 The methodology was based on the premiss that in an urbanised country such as Britain demand is focussed on relatively few *nodes* and that these can be connected by some optimal arrangement of *links* to form a strong inter-urban *network*. The best location for a node was taken to be at the centre of a concentration of population and of economic activity: this normally maximises ease of access for outward journeys, ensures short egress journeys for the majority of inward journeys and exploits the railway's virtue of moving large numbers of people in and out of urban cores with great efficiency in respect of land and energy inputs. It also fits well with the new vibrancy of city centres, as noted by the Strategic Rail Authority [SRA (2003), pp.17-20][12].

2.1.3 The procedure for identifying nodes, independently of any preconceptions about the existing transport infrastructure, was based on several complementary analyses: these included systematic aggregation of population 'nodules', ie. unit postcodes, into 'nodes' (with associated demographic data from Census sources); taking a wide range of measures of the relative status of places to form an Urban Hierarchy (an established idea in geography); and a technique known as 'simulated annealing' which searches for the best distribution of N nodes, given knowledge about the effects on demand of access to stations [these are described in more detail in Tyler (2003b)].

2.1.4 Nodes were defined at two levels that influenced thinking about the design of the case-study timetable, though all of this work is provisional and needs refinement[13]. The lower level located about 2560 centres with a minimum catchment population of 2230. This is well below the number presently needed to support an hourly bus unless a settlement happens to be on a route between larger places. If that is taken as the basic qualification for inclusion in a national timetable plan (less frequent services would be complementary to it, whenever appropriate), the final set is likely to comprise somewhat fewer than 2000 centres. The upper level is represented by the output from the urban-hierarchy exercise: this listed 176 principal centres in Orders 1 (the two capitals), 2 (23 dominant provincial centres) and 3 (151 sub-regional centres), all but one of which now have a railway station, and a supporting set of about 700 Order 4 centres.

2.1.5 Several methods can be employed to devise the links connecting nodes. The more links there are the more direct any journey will be, but the more links the more expensive the infrastructure and the smaller the number of users on each link, even after taking into account the loss of users as deviation slows services and thus diminishes their attractiveness. One can search for the best balance by assuming a direct link between every pair of places in a matrix and progressively removing the least-viable link until one reaches some sort of equilibrium; or one can draw a network using common sense and then add or remove one link at a time (the number of links necessary for a worthwhile network is a small fraction of the nominal maximum), testing each modification in turn; or one can use various (semi-)automated heuristic techniques.

2.1.6 In the current work experiments with the first two of these methods were pursued, each supported by a specially-written program that implements Floyd's Algorithm for finding the shortest route between two points through a sequence of links[14]. Like the work on nodes it was

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[12] In the last 30 years sites have often been proposed for ex-urban stations at points on the rail network that have high accessibility by road. Some, starting with Bristol Parkway in 1972, have been built, many others have not been justified. Since there is no credible *general* case for numerous stations of this kind (it has been propounded, but it would be inconsistent with the factors outlined and would imply a commitment to car-dependency wholly out of keeping with Government policy and with the sustainability objectives of this research) we did not use any technique solely based on drive-times for locating ideal nodes. That does not rule out some such stations in suitable circumstances. Similarly, in this Project we did not enter the controversy about the future demand for rail access to airports and indeed aviation growth in general, although both raise big questions about the role of railways in Britain.

[13] It was not brought to conclusions partly because the timetabling had to be progressed, partly because some technical problems have yet to be resolved and partly because it merits wider discussion before being made firm.

[14] At this stage straight-line distances were used, except for a device to ensure that links crossed estuaries only at or above the existing lowest line of crossing.

not possible to bring this to full fruition, but the experience raised a number of issues for more detailed examination and informed the tentative exercise outlined in the next sub-part. These studies assumed that demand between any pair of places is entirely a function of their respective populations and inversely of the distance (the classic Newtonian gravity model): this adequately explains the general magnitudes, but further work must take into account the historical, cultural and socio-economic factors that modify the size of each flow.

2.1.7 The results of the nodes-and-links work highlighted features of contemporary geography that are often obscured by the actual distribution of the railway's terminals and routes:

- a large proportion of the population resides within a short distance of a relatively small number of nodes;
- a significant number of stations have very small catchment populations;
- large numbers of people live in suburbs further away from the central station than access-decay models indicate is desirable in terms of realising the demand, and even where there is a suburban station it may well not offer good connections with the national network in directions opposed to that of the local line;
- there are noteworthy gaps in the current set of links;
- many existing links are not to be found in models of a network designed to define priorities systematically;
- even where the links exist services are often poorly matched to the indications of potential demand.

How this work was summarised in an illustrative (it is no more than that) outline of a core network is explained next.

2.2 "Inter-city-plus" – an illustrative network

2.2.1 Any credible national network will certainly include all the centres in Orders 1, 2 and 3 of the urban hierarchy, but logically its general shape will be determined by a sub-set of the larger and more important centres and then adjusted to incorporate the remaining places (and lower-order places). Somewhat arbitrarily, we chose to select 100 centres. Four measures were used, the urban ranking and three catchment-population counts, each using a different access-decay weighting, in order to achieve reasonably comprehensive cover of the country for this demonstration. The overall population distribution shown as background on the map was also taken into account. One cannot specify a sharply-defined set[15], and it is not really necessary to do so. There can therefore be argument at the margin, but it is unlikely that many centres would transfer in or out of the set in the course of more detailed work[16].

2.2.2 Three types of special case did however occur, and each raises a matter of interest. First, two centres of less than third-order status are included because they provide natural interchanges between routes that cross there – Ely, and Westbury in Wiltshire. Others are likely to emerge

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[15] Even in this age of 'the hundred best / favourite / most ...' !

[16] It could be illuminating in future research to conduct the following exercise: (1) run the simulated annealing program to locate just 2 'ideal' nodes; (2) timetable a service and forecast the demand on that link, taking account of access-decay effects; (3) repeat for N = 3 nodes, add a link or links, recast the outline timetable and re-estimate demand; (4) go on repeating the exercise for N +1 nodes, adjusting the network and timetable each time until the extra increment of traffic no longer justifies the extra infrastructure or train service.

later, for instance, Newark-on-Trent[17]. For its junction status in the network, as well as its local purpose, Bristol Parkway was also included. Second, for geographic and historic reasons a few centres of some substance have been left aside from the railway network or never been treated with due attention, and even the boldest strategic plan is unlikely to be able to change their standing. Explicitly left out of the set on these grounds were Oldham, St. Helens and Dudley[18].

2.2.3 Third, we have set aside for the present the vexed issue of how best to serve certain suburban centres that are significant in both population-size and, most importantly, in having a range of upper-order urban functions that are likely to attract inward journeys. These are mostly in Greater London but also include Bury and Altrincham in Manchester and Sutton Coldfield and Solihull in Birmingham. The latter, and all the London centres, have good local services, and the Manchester centres lie at each end of the first *Metrolink* tram route, though that makes journeys rather slow for the distances concerned. What raises disquiet is that often other provision is poor. For example, people in Bury have no conventional rail service at all, while Sutton Coldfield has no rail link to/from the north or east, other than by a detour via Birmingham New Street – and little is known about the impact this has on attitudes toward the use of rail, including through alternative railheads[19]. Similarly, some London suburban centres rely on unsatisfactory routes across Central London for their links with much of the national network[20].

2.2.4 For all these reasons the set of 100 nodes should be treated as 'work in progress'. Next came the drawing of links between them. To be realistic, this was conditioned by existing rail geography where there was no great cause to raise queries – but not automatically so. Thus the Cambridge ... Bedford ... Milton Keynes ... Oxford ... Swindon corridor appears (the symbol '...' indicates a route, as distinct from a train service shown with '↔'), since without it the network would plainly be imperfectly articulated (the *Virgin*-promoted and *Stagecoach*-operated coaches along the route are welcome, pending resolution of the debate about rebuilding the railway). The sharp-eyed will notice a few other 'new' links, notably Leicester ... Northampton, and the Leeds ... Nottingham routeing via Barnsley and Mansfield. The links are of course highly variable in substance: Inverness ... Aberdeen, Ayr ... Carlisle and Exeter ... Salisbury are not in the same league as Crewe ... Stafford or Reading ... London, but they appear in order to give the centres concerned a rounded package of access to adjacent centres and the national network, and to provoke discussion, but the best way of covering such routes would need careful appraisal.

2.2.5 Figure 4 displays the network; the thematic graduation is related to speed. The number of links is 158, for 100 centres and 4950 bi-directional cells in the origin/destination matrix.

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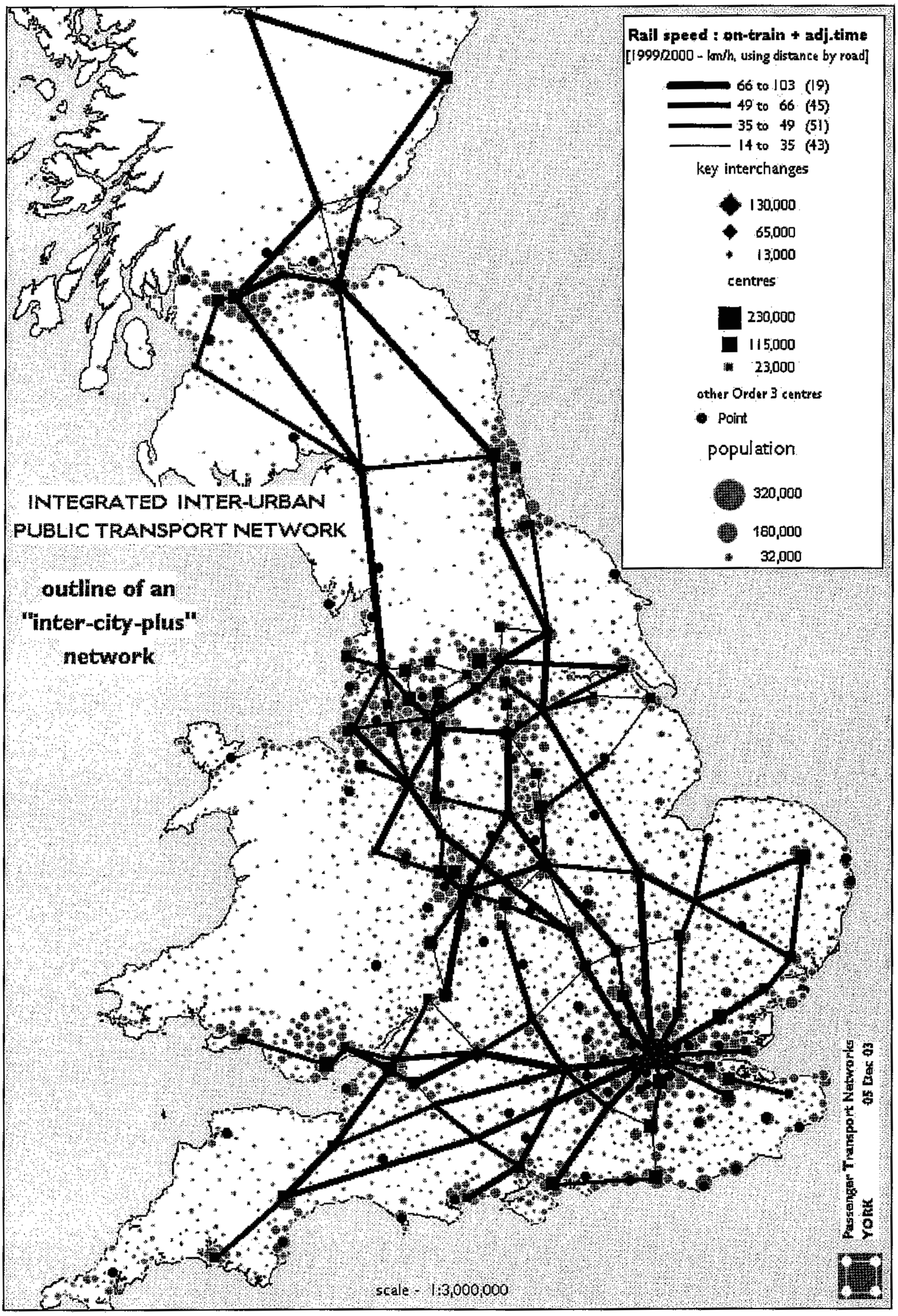
[17] Ely is in order 4A. Westbury is only a fifth-order centre but acts as a railhead or interchange for three nearby fourth-order places. Newark is also 4A but on the margin with 3C.

[18] Oldham has long been poorly served by conventional rail and is now getting a new deal in the form of a *Metrolink* extension through the town centre, making Rochdale and Manchester its connecting points with the national network. Central station in St Helens is served by a local line from Wigan to Liverpool, but for eastward journeys the junction station lies south of the town, and there is no adequate provision for journeys to/from the south. Various solutions can be conceived, but none are obviously sound. Dudley is on a hill and the main railway runs in the valley. Sandwell & Dudley station was built at a sensible road location in an attempt to give the town better rail access, but it has suffered from involving insertion of an extra stop in an already short run (Wolverhampton ... Birmingham, 19 km) and from acute pressures on line capacity that inhibit stops. Together these (and non-mirror-image timetabling) have left it with a patchy service.

[19] In the West Midlands the difference between the Birmingham core and the peripheral centres in the number of journeys made by each resident to other regions of the country is huge, and seemingly well beyond what could be explained by non-rail access to New Street or by the use of Travelcards for the local segment of longer-distance trips.

[20] The success of *Thameslink*, and the consequential proposals for its enhancement, highlight the contrast between those areas that benefit and those do not. The Channel Tunnel Rail Link will have a similarly welcome, but also divisive, effect in Kent when the domestic services to St Pancras are introduced.

Figure 4. The selected 100 nodes converted to an outline network



Their total length is 8414 km. The 100 centres have 29% of the population of Britain living within 5 km (3.1 miles) and 44% within 8 km (5.0 miles); the latter figure would rise to 51% with the addition of 14 London suburban centres. Inspection of the map shows that many of the 'candidate' centres for addition to the base network lie close to included links or would require only modest extensions. The outliers are Scarborough and Barnstaple (note the very different quality of service those two now have [Tyler (2003a)]), Bangor in North Wales, Hereford and Truro.

2.2.6 Before describing how this network could form the basis of a national timetable plan it is worth noting some features it draws attention to.

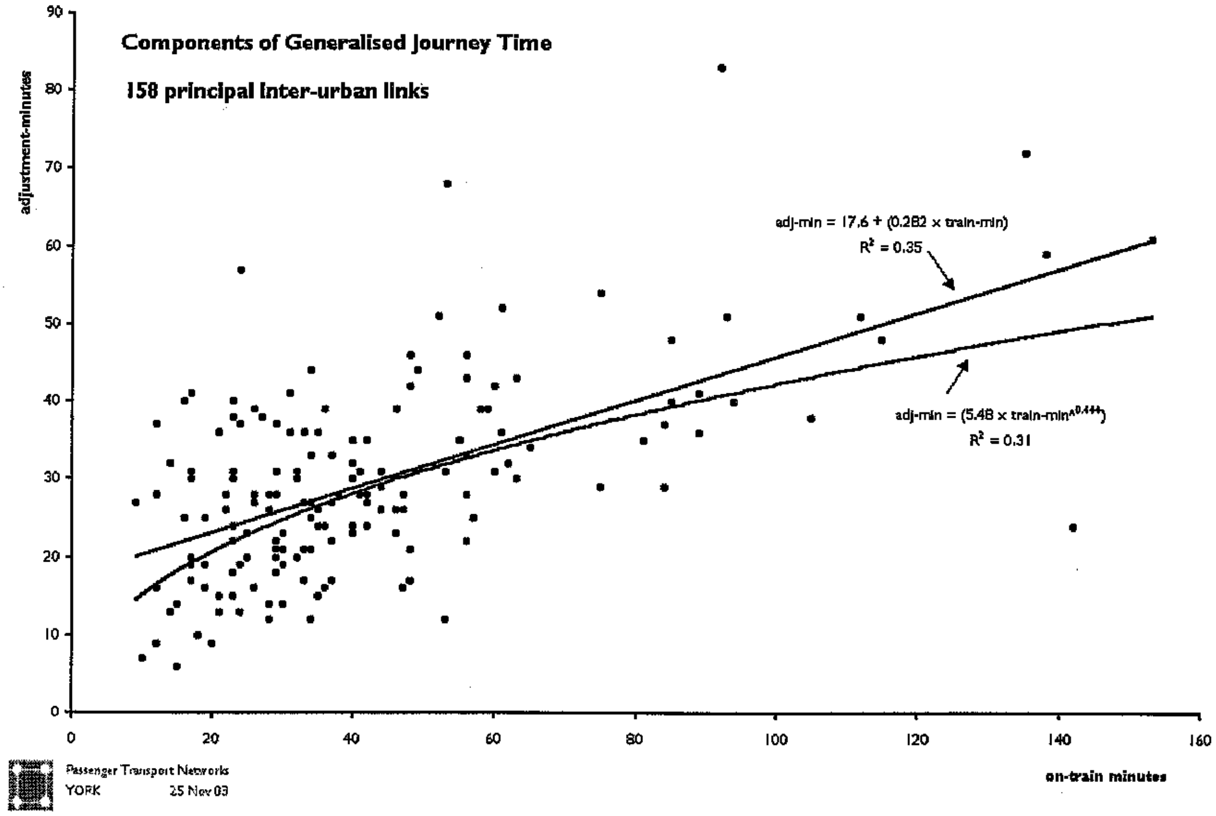
- Places that are significant enough to rank within the upper set of 100 but yet are served only by local trains are quite numerous: Harrogate (apart from the one train to London), Birkenhead (dependent for its national links on the Liverpool stations or a slow train through Chester), Mansfield (only recently reconnected to the network but by a Nottingham-centric local line), and Walsall (a longstanding case of neglect, now having a half-hearted Wolverhampton service as well as its Birmingham routes). Use of and attitudes toward rail in places like these would merit comparative analysis, and plans to give them timetables more commensurate with their status should be tested.
- The Bradford ... Halifax ... Burnley ... Blackburn ... Preston and Bradford ... Halifax ... Rochdale ... Manchester corridors may be under-rated, given the populations of the centres they link.
- The routeing of the East Coast Main Line through Peterborough is fine for movements between Scotland, North East England and Yorkshire on the one hand and London and East Anglia on the other, but there is a manifest case for examining better links between those areas and the East and South Midlands. A start would be to overcome the barriers of traditional timetable patterns and secure better connections (as the SRA has haltingly begun to do), but in the longer run new routeings and infrastructure should be examined. This may be just as important as more glamorous proposals for high-speed lines and rather more so than schemes to bring the railway back to small market towns. The infrastructure possibilities include lines between Doncaster and Mansfield and the Leicester ... Northampton re-opening, or a curve at Newark.
- Crewe ... Stoke-on-Trent ... Derby seems to be another axis whose potential may have been underestimated because the longer-distance role of the customary service is degraded by also having to cater for local functions (those within the Potteries are patently obsolete). The merely hourly frequency should also be questioned.
- The diagram spotlights the way in which Northampton, having suffered the vagaries of railway history, nevertheless makes it into the 100 (it is a 3A place though only about 65th in the population ranking) and should probably be accorded a better offer. Current plans for the West Coast do give it some inter-city trains for the first time, but the proposed worsening of its Birmingham service is strange. It deserves better.
- The Cambridge ... Swindon corridor unfortunately involves substantial infrastructure works, but another that does not is Bristol ... Bath ... Westbury ... Salisbury ... Southampton ... Portsmouth ... Brighton. Here the string of urban centres is plainly to be seen, while current timetables are disconnected and typically display uncertainty as to what markets they are directed at. By well-ordered connections at Westbury and Salisbury the route could also help overcome the handicap that there has never been a railway bridging the gap between Exeter and Weymouth.

Some other deficiencies are mentioned in Part 3 describing the case-study.

2.2.7 Only detailed modelling at a network scale can quantify the relative future importance of each link, and of superimposed links for fast services omitting intermediate stops, given the objective of a truly-integrated national public transport system. In that framework some links might best be covered by integrated coach services. We hope however to have demonstrated by looking at Britain's urban geography in this fresh way the breadth of issues that need to be addressed. As a further illustration, and as a precursor of a long-term *Taktfahrplan* for this network, we also analysed existing provision and its implications. Appendix I and Figures 5 and 6 set out the results.

2.2.8 For each of the 158 links the estimates of 1999/2000 on-train, adjustment and interchange minutes were extracted from the file of Generalised Journey Times [GJTs] prepared for the cross-sectional modelling work and expressed as the mean of the values for the two directions. The on-line AA Route Planner was used to find the length by road of each recommended route and the AA's calculation of a typical (2003) drive-time. A number of relationships were then examined. The association between road and rail distances is naturally close in general (interestingly, whereas the mean excess over the straight-line distance is 14% for rail it is 24% for road, presumably in part because the fastest route was requested), but graphing it identifies geographic exceptions[21]. Time by road is a fairly close function of distance, but again there are noteworthy outliers[22].

Figure 5. Analysis of the 1999/2000 timetable for principal inter-urban links

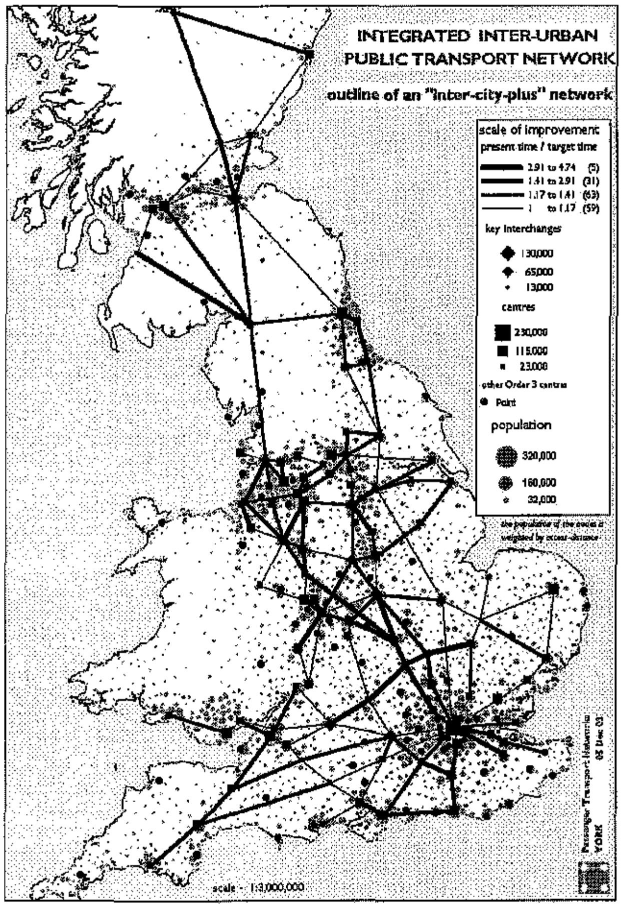


[21] The formula is: Rail-km = ((1.013 x road-km) – 4.2). The most significant rail deviations are Perth … Edinburgh – the result of a misguided Beeching-era closure – and Edinburgh … Carlisle – the result of topography and history. York … Doncaster, Stockport … Crewe and Wolverhampton … Birmingham are among a group of eight links whose distance by rail is markedly shorter than it is by road.

[22] The formula is: Road-min = (5.2 + (0.76 x road-km)); this gives mean speeds of 67 km/h at 40 km and 76 at 200 km. Most of the slower links are short urban examples or in the London area, but they include Harrogate … Leeds, Birmingham … Coventry and Bristol … Bath. The fastest links are of course the prime arteries with long stretches of motorway or dual-carriageway (and parallel fast rail lines), such as Glasgow … Carlisle … Preston, Doncaster … Peterborough … Stevenage, Stockport … Stoke-on-Trent … Stafford … Northampton, and Taunton … Bristol.

2.2.9 It is in the rail data that the correlations are weaker. In particular, in-train (or in-vehicle) time against distance has an R^2 value of only 0.62, compared with 0.93 for the road equivalent, while the distribution of adjustment time, which is largely a function of frequency and pattern (or lack thereof), relative to train time is quite extraordinarily dispersed, as Figure 5 shows. Expressed in terms of speed the range for in-train time is from 144 down to 42 km/h[23], even excluding five relations with no real pretence to a service, with a mean of 76 km/h and a coefficient of variation of 28%, which compares with a value for road speeds of 68 km/h and variation of only 17%. The range for GJT, including the adjustment and interchange penalties, is 96 down to 13 km/h (Wolverhampton ↔ Walsall), with a mean of 42 km/h and a coefficient of 35%.

Figure 6. Targeted acceleration of rail services



2.2.10 The consequence of this is that the train time varies from 0.45 x road time for the best link (Darlington ↔ York) to 1.67 for the worst (Perth ↔ Edinburgh; Southampton ↔ Portsmouth is the second worst, at 1.59) (again excluding the special cases). For GJT the best ratios (GJT/road-minutes) are Croydon ↔ London at 0.66 (the road time is notably slow) and Reading ↔ London at 0.71, with Edinburgh ↔ Newcastle the best long relation at 0.78. The worst are Burnley ↔ Blackburn at 3.63, Coventry ↔ Leamington at 3.50 and Crewe ↔ Stoke-on-Trent at 3.14. The adjustment penalty within GJT can be a modest proportional addition to on-train time either where frequency is high (eg. Chelmsford ↔ London) or where speed is low (eg. Portsmouth ↔ Brighton). At the other extreme the adjustment/in-train ratio is 3.08 for Wigan ↔ Warrington and 3.00 for Cheltenham ↔ Gloucester. Two of the fastest links, York ↔ Doncaster and Bristol Parkway ↔ Swindon, have unusually large adjustment times, that is, frequency does not match the speed (the cross-country recasting in 2002 will have ameliorated the York ↔ Doncaster situation).

2.2.11 Now it can be argued that road characteristics inevitably tend toward homogeneity because that is in the nature of a road network in an urbanised country and because that is what is popularly expected in order to satisfy many different demands, whereas a rail network is more specialised and is designed to cater selectively for segments of the market. That is a reasonable defence up to a point, but we posit that, given the homogeneity of the set of nodes, the huge variation in the characteristics and quality of the rail timetable is difficult to explain other than by history, chance, the long record of incremental change and a corresponding failure to explore strategic priorities. A review is surely justified.

[23] Six fast relations stand out: Doncaster ↔ Peterborough (144 km/h), Darlington ↔ York (142), Edinburgh ↔ Newcastle (135), Swindon ↔ Reading (132), York ↔ Doncaster (127) and Bristol Parkway ↔ Swindon (122). The slow ones are Leeds ↔ Bradford (40 km/h), Chatham ↔ Gravesend (41), Birkenhead ↔ Chester (42), Blackburn ↔ Bolton (43) and Wolverhampton ↔ Walsall (43). All speeds are via the rail route (but in Figure 4 they are by road).

2.2.12 As a taster a series of calculations was performed whose end-product is given in the last column of Appendix 1, 'Target SRT'. First, the start-to-stop time for a *Voyager* diesel unit was read off from an SRT file supplied by Virgin Trains for 93 of the links, from which a simple performance formula was estimated[24]. The fastest of the actual 1999 on-train component of GJT and the quoted *Voyager* SRT or (in its absence) the formula-time was then taken as a provisional target-time. Next, this was compared with times by road, and rail targets that were notably slow were tightened, while conversely a limit was set on the feasible scale of improvement, except in the new-infrastructure cases. Finally, a minimum threshold rail speed of 60 km/h was imposed – which is hardly demanding. The results are shown in Figure 6 [previous page], where the scaling reflects the degree of acceleration needed on each link to bring the running time down from the 1999 level to the target value. In some cases this has already been (partly) achieved through the introduction of the *Voyager* timetable on many cross-country routes in September 2002.

Table 1
Edinburgh → Plymouth

	arr	dep
Edinburgh		00.57
Newcastle uT	02.22	02.26
Darlington	02.52	02.54
York	03.20	03.23
Leeds	03.46	03.53
Wakefield	04.04	04.06
Sheffield	04.32	04.35
Derby	05.05	05.08
Birmingham	05.42	05.48
Cheltenham	06.30	06.32
Gloucester	06.41	06.45
Bristol Pkwy	07.15	07.17
Bristol TM	07.26	07.34
Taunton	08.05	08.07
Exeter SD	08.29	08.32
Plymouth	09.27	

2.2.13 Ideally this exercise needs to be reworked with demand-weighting of the links and the inclusion of longer-distance direct links, but we think it has established a *prima facie* case for examining the benefits of a strategy to narrow the variation across the inter-urban network, as compared with one focussed on further enhancement of a relatively few, already-fast inter-city relations on which market-share is high. It is of course true that building new high-speed lines would facilitate improvement of shorter-distance services remaining on the original routes, but the problem is the years the new construction may take, while rail continues to be largely irrelevant on a significant number of non-trivial inter-urban links and routes with a notably mediocre quality of timetable.

2.2.14 To move from this exercise to a strategic *Taktfahrplan* would require the link SRTs to be worked up into timings for services matched to estimates of future demand. As this progressed key nodes would be identified and the options for securing ideal inter-node timings would be examined. Nodes most likely to be selected as key include those with high numbers of radiating links: some of these are shown in Figures 4 and 6 (note that Manchester, Birmingham and London may not be critical in timing terms because of the frequency of their local services).

2.2.15 Although one cannot draw much data regarding ideal timings until patterns start to emerge it is possible to spot some promising schemes, to see the outline of a national plan and to give some examples of interacting decisions. The timings in Tables 1 to 9 are expressed in hours and minutes from a base, not in clock-times, and their starting point is the *Taktfahrplan* for the East Coast Main Line described in full in the next Part. *All* of them *must* be construed as tentative ideas to be researched, and it is naturally understood that the reverse timings are the exact mirror-image. Not all the likely station-calls are shown.

2.2.16 Suppose that the Edinburgh → Plymouth train is timed forward from Leeds as shown in Table 1. This brings it into Birmingham at the three-quarter-hour slot, ie. xx.42/48. It then takes half-hour slots at the critical interchanges at Bristol, Exeter and Plymouth, although this is linked

[24] Generally the slowest of the Class 220 or 221 (tilting) times for the two directions was taken and increased by 5% as a running allowance. The formula was: Time (in minutes) = (7.7 + (0.44 x rail-km)) [R^2 = 0.81].

Table 2 Leeds → London St Pancras		
	arr	dep
Leeds		00.57
Sheffield	01.36	01.39
Chesterfield	01.49	01.51
Nottingham	02.25	02.29
Leicester	02.57	03.00
Bedford	03.36	03.38
London StP	04.15	

Table 3 Liverpool → Norwich		
	arr	dep
Liverpool LS		00.30
Manchester P	01.13	01.17
Sheffield	02.00	02.09
Nottingham	02.55	02.58
Peterborough	03.56	03.59
Ely	04.30	04.34
Norwich	05.30	

Table 4 Newcastle → Liverpool		
	arr	dep
Newcastle uT		00.33
York	01.43	01.49
Leeds	02.15	02.19
Manchester P	03.13	03.17
Liverpool LS	04.00	

Table 5 Birmingham → Cambridge		
	arr	dep
Birmingham		00.42
Leicester	01.30	01.34
Peterborough	02.30	02.37
Cambridge	03.26	

with the controversial issue of whether or not to serve Gloucester. If this path is accepted then it is suggested [Table 2] that the Leeds → London St Pancras service should closely follow it to Sheffield. The SRA has considered spacing these trains to produce a half-hourly fast Leeds ↔ Sheffield service. The objective is undoubtedly desirable, but having an Edinburgh ↔ Plymouth train form a part of it may not be very robust and regional routes may be more appropriate. The advantage of the configuration proposed is that it secures enhanced Scotland and North East England ↔ East Midlands connections. If the Midland Main Line is to have an exact half-hourly fast service the Sheffield → Derby → London would leave Sheffield just ahead of the Plymouth and thereby provide Chesterfield's connections to the south.

2.2.17 Another proposed pairing is that between Sheffield and Nottingham, with the Liverpool ↔ Norwich half-an-hour apart from the St Pancras [Table 3]. This would interact with many other services. For example, leaving Liverpool at xx.30 it alternates with the Liverpool → Newcastle path, which is set at the hour by the considerations described in Part 3 [Table 4]. At Peterborough it is fed by the Leeds → London fast to secure some of the Yorkshire → East Anglia connections. In turn this fixes a Birmingham → Cambridge path [Table 5], which needs if possible to be at the opposite half-hour, on the assumption that other services will be timed at Ely to give forward connections to Norwich, or to Cambridge out of the Norwich. This may be realised by skilful timing of the recently-introduced Norwich ↔ Ely ↔ Cambridge trains.

2.2.18 A highly-desirable goal is a half-hourly (near-)even interval service between Sheffield and Birmingham (and on the other Birmingham radials, but those are not addressed here). In the present arrangement the standard paths are 28 minutes apart at Sheffield southbound but at 39/21-minute intervals into New Street, while the northbound departures are at xx.03 and xx.30, into Sheffield at xx.18 and xx.50. That is better than many features of a cross-country timetable that suffered from an institutional failure to adopt a clean-sheet approach (and from subsequent brusque amendment), but in a *Taktfahrplan* it should be fully regularised. Every effort would also be made to organise a cross-platform exchange at Birmingham between trains on the different routes to replace the sequential scheme that so extends journey-times (another draft exercise demonstrated that this is feasible, with the use of the Kings Heath rather than the Selly Oak route).

2.2.19 A York → Bournemouth service is therefore shown [Table 6] on the exact opposite half-hour from Sheffield to the Edinburgh → Plymouth. It would be fed at York by the Edinburgh → London to give the Scotland and North East link with the South Coast (which is deemed less important than that with the South West for the through train, because proportionately more

Table 6 York → Bournemouth		
	arr	dep
York		00.15
Doncaster	00.38	00.41
Sheffield	01.02	01.05
Derby	01.35	01.38
Birmingham	02.12	02.18
Coventry	02.38	02.40
Oxford	03.30	03.34
Reading	03.56	04.01
Southampton	04.53	04.56
Bournemouth	05.26	

Table 9 South Wales / Bristol → London Paddington					
Swansea	d	00.31			
Cardiff	a	01.22			
	d	01.26		01.56	
Bristol Pkwy	a	02.00		02.30	
	d	02.02		02.32	
Bristol TM	d		02.04		02.34
Swindon	a	02.29	02.44	02.59	03.01
	d	02.32	02.47	03.02	03.17
Reading	a	03.00	03.15	03.30	03.45
	d	03.03	03.18	03.33	03.48
London Paddn	a	03.28	03.43	03.58	04.13

passengers will opt to travel via London). Note that it is judged that only one cross-country route will normally run north of York, and that the Burton-on-Trent and Tamworth stops are assumed transferred to regional services.

2.2.20 Another case of desirable pairing is that of the London and cross-country services in the West of England in order to secure a clear pattern for the principal regional flows between Plymouth, Newton Abbot, Exeter and Taunton, and by extension for related regional services that will bring Cornwall, Totnes and Tiverton Parkway into the network. The London-bound train from Plymouth is therefore shown at an exact spacing with the mirror-image of the train from Edinburgh [Table 7]. That in turn shapes the preferred path for the Cardiff → Portsmouth train [Table 8], since it should have an all-ways interchange at Westbury to give good South West ↔ South Coast connections, as well as to serve specific flows such as Trowbridge and Warminster ↔ London (whose existing timetable is characteristically disjointed).

Table 7 Plymouth → London Paddn		
	arr	dep
Plymouth		00.03
Exeter SD	00.58	01.01
Taunton	01.24	01.26
Westbury	02.04	02.06
Reading	02.57	03.00
London Paddn	03.25	

Table 8 Cardiff → Portsmouth		
	arr	dep
Cardiff		00.31
Bristol TM	01.20	01.24
Westbury	02.02	02.08
Southampton	03.06	03.09
Portsmouth	03.39	

2.2.21 Finally, the Edinburgh ↔ Plymouth path will probably influence the Bristol ↔ London, and hence the South Wales ↔ London schemes, partly because the optimal pattern of regional and local services at Bristol requires trains on the two major routes to come together on the hour and half-hour, partly because that is the best way to arrange for flows between the West of England and Bath and Swindon. The outline plan [Table 9] assumes a scheme similar to that now operated by First Great Western, including the critical evenness of intervals between Swindon, Reading and London. The Swansea → London would nicely feed the Cardiff → Portsmouth, but deliberately left unresolved as an instance of a clash is the fact that the York → Bournemouth cannot approach Reading simultaneously with the Penzance → London if it is to use the bay platform for reversal. The plan does however achieve a robust and important connection from the Birmingham direction toward South Wales at Bristol Parkway: arrive xx.15 [Table 1], depart xx.30 [Table 9], and probably a similar pattern at the other half-hour.

2.2.22 It is hoped that this discussion will serve to deepen understanding of how a *Taktfahrplan* is built up and to illustrate the potential attractions of a coherence of structure that cannot be realised through piecemeal planning. Organising relationships – for sensible spacing over shared sections of route or those arising from connectional inter-dependency – inexorably spreads the basic concepts across the network in such a manner as to embrace virtually every service, though not always with the ideal pattern. It would be advantageous if the process could be informed by a better understanding of the matrix of rail-capturable flows throughout Britain than is presently available and by a methodology to test the merits of different solutions in an iterative cycle.

2.3 Outside the inter-urban network

2.3.1 The counterpart of a study that explicitly concentrates on urban centres and inter-urban networks is the attention it draws toward those parts of the existing system that do not figure in the new lists and maps. There can be little doubt that the rail passenger business is still as skewed in distribution between strong and weak elements as it was at the time of the Reshaping Plan in 1963. It is ultimately a matter for national policy whether it is wise to perpetuate this, either in terms of the benefit/cost ratios for the public expenditure required to support the weaker elements or with regard to the damage that neglected and little-used services may inflict on the image and pertinence to modern life of the sounder parts of the railway. Nonetheless the issue cannot be excluded from the timetable debate, for two reasons.

2.3.2 First, any timetable planning is about priorities. In that context it is necessary to take a sharp view of any station whose contribution is markedly poorer than that of others on a route, or of a complete service that is not generating much traffic, in order to enforce a decision as to its value and the extent to which it should influence patterns. It may be, for example, that the benefit of a stop is outweighed by the slower timing experienced by through passengers (this criterion is after all applied in evaluations of additional stops or proposed new stations) and that downgrading a station to provision at a different level in the hierarchy would be appropriate, or in extreme cases, closure. Similarly, planning of the best possible connectional scheme will in reality require compromises to be made, and decision-makers are necessarily cognisant of relative use and potential. Sometimes, too, it may reasonably be argued that a path would be better employed for a freight train than for a train carrying few people.

2.3.3 Second, *Taktfahrplan* is particularly demanding. Its emphasis on connectivity (every hour) means that there may be pressure to reduce running times in order to secure a proper arrangement of trains at an interchange. In that event closure of a thinly-performing intermediate station may legitimately be considered alongside infrastructure enhancements or faster rolling-stock by assessing the gain from the good connections against the loss of traffic. The same point may also arise if a closure would facilitate diagramming, either by ensuring more robust operation or by saving a unit.

2.3.4 The proposition is that this analytical approach is sounder than what has happened in recent years, where mainline services have had irregular timings, many branch timetables have been entirely determined by unit diagrams, and inordinate effort has gone into patching connections train-by-train at junctions, often with poor outcomes. In standard-hour timetables there is also no place for stations that are served occasionally: the usage data can only lead to scepticism of the value of provision that is so mean or exiguous as to insult the very people it is supposed to be assisting. Such stations should either be upgraded or declared obsolete.

2.3.5 Specific cases are discussed when each service is reviewed in the next Part, but it may be helpful to set the general scene here by summarising the results of an exercise that looked at 166 stations in Northumberland, Durham and North, East and West Yorkshire. Four measures were considered:

- the whole territory was divided into station-catchments, each with a population count: exclusive boundaries were drawn (except for four whose usage is tiny) on the basis of road geography, our current understanding of access behaviour and an assumption of equal attractiveness, and then Census data was summed by means of Geographic Information System tools – plainly this oversimplifies, but it has the virtue of consistency, it seems precise for a surprising number of stations and it provides useful pointers to relative importance pending more sophisticated modelling;
- the number of trip-ends (or single journeys) in the CAPRI ticket-sales database was summed for each station and halved to roughly represent the number of users (most rail trips are two-way): this is broadly reliable outside the PTE areas, except that some contract flows of schoolchildren may be omitted, but within those areas there is an abiding problem (which was allowed for) that the use of multi-journey tickets is not converted, even on an estimated basis, into station-to-station counts;
- this absolute figure was also employed in two derivatives, namely return-journeys / person in the catchment (excluding short-distance trips), and trip-ends / timetabled stop of a train, ie. the number of people joining and alighting at each call, the number of which was estimated by close inspection of timetables.

2.3.6 The 166 stations were successively ranked on each of these four measures and those that fell below selected thresholds, usually taken at natural breaks in the tabulation, were marked as either poor performers (2 points) or marginal (1 point). The thresholds were:

- catchment-population: < 2500 people (25 stations); ≥ 2500 < 3800 (13); special cases (4);
- return journeys (≈ number of users): < 25/day (38 stations); ≥ 25 < 50 (19);
- return journeys / person (excluding short trips): < 0.25/year (27 stations); ≥ 0.25 < 0.45 (13); special cases (4);
- join+alight / station-call: < 0.45 (16 stations); ≥ 0.45 < 1.00 (24).

The number of points was then summed for each station. Twelve stations scored 8 or 7, sixteen 6 or 5, and twenty 4 or 3. In other words, there must be some doubt about the value of 29% of this set of stations, and serious doubt about perhaps 17% of them. The 28 weakest account for 0.2% of all trip-ends and about 150 people/day would be affected by their closure. The 57 stations used by fewer than 50 people each day account for 1.2% of trip-ends.

3. THE EAST COAST MAIN LINE

3.1 The route, its current services and the case-study

3.1.1 The East Coast Main Line [ECML] is the principal rail artery on the east side of Britain, running from Edinburgh, through Newcastle upon Tyne, York and Peterborough, to London. Its electrification was completed in 1991. A line from Leeds, also electrified, joins the route at Doncaster, and the services between Edinburgh and London and Leeds and London form the core of the timetable on the route. Some of these are extended to serve Aberdeen, Inverness and Glasgow in Scotland, and Hull, Harrogate, Skipton and Bradford in Yorkshire.

3.1.2 North of York the route also serves as the northern end of two corridors connecting major provincial cities: across the Pennines to link with Manchester and Liverpool, and southwest toward Sheffield, Birmingham and Bristol. Apart from a limited number of through London trains and some cross-country trains via Birmingham none of the extensive network of Scottish services runs beyond Edinburgh. In North East England regional and local routes serve Tyneside (Newcastle), Wearside (Sunderland) and Teesside (Middlesbrough), and a similar network serves East, West and South Yorkshire. Peterborough is an important junction with services to/from East Anglia, and south of Peterborough the line also carries outer- and inner-suburban traffic.

3.1.3 Services are at present operated by

- Great North Eastern Railway [GNER] – all trains to and from London;
- Virgin CrossCountry [VXC] – all the through trains on the Birmingham route;
- Arriva Trains Northern [ATN] – all other services in the North East and Yorkshire;
- West Anglia Great Northern [WAGN] – the suburban services in the London area.

The rest of this Working Paper will not however refer to services by operator. This expresses a deliberate principle of the Project that long-term planning should not in any way be influenced by the private interests of incumbents or by the institutional structures of franchising. It is essential to plan the best possible timetable first and then to decide the best means of delivering it, as a critical but nonetheless secondary matter.

3.1.4 What follows is not a definitive plan. It expresses judgments based on the evidence available at the time of the work, both from ticket sales[25] and from the work on the underlying demand implicit in the 'ideal network' studies, and on an understanding of then-current thinking in the industry. The draft assumes some slight adjustments to the existing infrastructure and some redistribution of the rolling-stock fleet but otherwise reflects the broad outline of the 1999/2000 timetable that acted as the comparator for the evaluation. Full iteration in the light of experience was not possible at this stage but is clearly desirable. The description is put forward in order to illustrate the principles and as a starting-point for discussion. In no way does it represent a formal position adopted by any party to the research.

3.1.5 The timetable encapsulating the objectives and aspirations was designed with the aid of the Swiss *Viriato* software that was conceived and developed for this type of strategic overview. Its essential components are a database describing the infrastructure, a file containing the running details of each path (including traction, and tracks used) and displays of the timetable both as conventional time x distance graphs for sections of route (an example appears as Appendix 2) and in 'netgraphs'. Two of these for the ECML *Taktfahrplan* form Appendix 3. This form of presentation is the distinctive feature of an absolutely-regular, truly mirror-image timetable (and hence of its supporting software), since those characteristics make it possible to display the essentials of the offer over an entire network in this elegantly simple manner[26]. The rules for reading a netgraph are (a) that the times shown adjacent to the line for each service (ie. the repeating series of trains) are on the same side as the running-line convention for the country and (b) that arrival times are adjacent to the station-box and departure times are set further from it.

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[25] As part of the railway industry's support for the Project we were provided with a complete database, drawn from the CAPRI accounting system, of station x station ticket sales for the year 1999/2000, disaggregated by ticket-type and route. Access to the industry-standard forecasting model MOIRA and its built-in ticket data was also arranged. We are extremely grateful to the Passenger Demand Forecasting Council for facilitating these arrangements.

[26] The full Swiss inter-urban timetable and an outline of local services including the Zürich *S-Bahn* are published *on a single B2 [500mm x 700mm] sheet*. It is difficult to overestimate the marketing potential of such a diagram in an age when the shape of the primary road network is much more familiar than the structure of rail services – or its contrast with the bulk, impenetrable complexity and unrestrained tendency to variation of Britain's National Rail Timetable.

3.1.6 This exercise would not have been valid if it had relied on amateur knowledge and guesswork, and it was agreed in establishing the Project that real railway data would be used. Railtrack therefore provided a copy of the Rules of the Plan, which sets out the practical arrangements for operating the railway safely and robustly, and a database of Sectional Running Times, which lists the standard times to be applied between any pair of timing points for each direction and all relevant types of train. Information on track layouts is available in the 'Quail' maps that are privately published but with the assistance of Railtrack, now Network Rail. Every effort was made to apply this data rigorously, although in a few cases where errors are apparent it was supplemented by personal observations of train performance[27].

3.1.7 In one respect, however, the ECML *Taktfahrplan* does differ from conventional timing practice (as do the other case-studies that have been worked up). On most, but not all, of the British network the extra time needed in the event of temporary speed restrictions caused by engineering work is provided by inserting a stipulated number of minutes into the standard schedule over sections approaching key junctions, major stations and the terminal station of a train. This usually has the effect of unbalancing intermediate times in a mirror-image scheme and is thus undesirable in a *Taktfahrplan.*

3.1.8 Three other allowances appear at specific locations in Working Timetables: "extra time for pathing requirements", a "performance allowance", and adjustments from working to advertised times. The first is almost always the result of paths simply not being compatible in an environment of train-by-train planning and should not be necessary in a clean-sheet, regularised timetable. The second has been introduced as a means of enhancing the performance statistics (and is concentrated at the end of a train's journey), and the third has become more generous for the same reason, having previously been limited to rounding half-minutes and very occasionally adding further minutes to deal with particular operational circumstances. Vastly better reliability is a *sine qua non* of *Taktfahrplan*, and it is also assumed that were it to be implemented it would be in a context where a discredited performance regime had been superseded.

3.1.9 Behind these practices there is however a genuine issue in that it is impossible to operate a railway with precise accuracy for every train every day. Slight variations in the behaviour of apparently identical trains and in driving technique, minor equipment failures, the ordinary range of weather and other environmental factors, fluctuating numbers of passengers, small incidents at stations as people board and alight, and the consequential interactions where paths conflict, all mean that minor perturbations are inevitable. It is therefore desirable and proper to allow for this in timetable planning, at some level that distinguishes between the everyday variation and the more random, larger disruptions which cannot be predicted and for which quite different planning procedures are required.

3.1.10 It is generally agreed within the industry that the allowances are not only unsatisfactory in structure but also fail to accord with experience, even if normal performance were to be improved. Moreover, inherited dwell-times are often shorter than are commonly now achieved, partly maybe because of less-than-smart operating but also because of technical changes, such as more complex door designs and greater volumes of luggage. We therefore decided to replace the allowance system with a percentage addition to all SRTs – typically 4-5% – and slightly longer dwells. The percentage method is found on the former Southern Region (in lieu of engineering margins) and on some mainland European railways. It should have the effect of promoting more reliable timekeeping where minor delays are fairly evenly distributed along a train's path, although statistically it would occasionally result in a train having time to spare earlier in its journey and arriving later than under the present regime at its destination because of delays in the final stages.

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[27] We are equally grateful to the Operations Planning staff of Network Rail for their assistance with this material.

3.1.11 Although a well-differentiated hierarchy of services is not a necessary requirement of a *Taktfahrplan* it tends to follow from the clarity of thinking about the form of provision for each type of station and each component of the market. On the basis of the research it was concluded that the long-term aim should be to establish the following categories of service:

- long-distance inter-urban – fast and normally calling only at principal stations;
- regional inter-urban – not as fast as the long-distance trains but brisk over shorter inter-station distances and not calling at minor stations, probably differentiated between routes connecting major cities and the generality of routes;
- outer-suburban – the longer routes providing fast links between local centres and London and in some provincial territories;
- suburban – stopping trains entirely within a conurbation; and
- local and rural – branches, and the social lines in sparsely-populated areas.

3.1.12 Unsurprisingly, the broad classification is not markedly at variance with what has evolved over the years, but some detail is materially different, notably the emphasis on avoiding multiple-function trains whenever possible. By implication too it prefers branding by purpose to branding by franchisee. The scheme could not be achieved all at once, but defining distinctive brands in this way could be beneficial in terms of establishing standards of exactly what customers can expect[28]. Compromises would nevertheless be likely in certain circumstances, where for instance a service has to be provided at a higher or lower order in the hierarchy than is strictly appropriate because of geographic or operational constraints. Nor are the distinctions always firm: whether a non-stop train from Cambridge to London is a 'regional' or an 'outer-suburban' service maybe does not matter greatly and can be handled pragmatically. It is the greater overall systemisation compared with what prevails now that matters – and stability over transience.

3.1.13 In paper-and-pencil days planning the utilisation of resources (which is usually referred to as *diagramming* in the railway industry) was typically undertaken as a separate exercise after the timetabling was complete, though a competent timetabler would have borne the need for good diagrams in mind. With the advent of computer-based methods and pressure for maximising the output of expensive equipment two schools of thought have emerged, one being to apply optimisation algorithms to pre-specified timetables and the other to bring the two tasks together so that the one influences the other from the outset. The bus industry has tended to pursue the first course in respect both of vehicles and staff, the railways – and this exercise – the second.

3.1.14 A *Taktfahrplan* makes combined analysis easier because of its repetitive scheme through the day, but its rules normally take precedence over the minimisation of resources. This can lead to a requirement for additional resources, but it is quite wrong to suggest that this automatically follows or that it undermines the principle (and it has nothing to do with the argument for operating at higher frequencies over a longer day – that is a distinct policy issue). It has been found in this case-study that a good pattern may deliver a bundle of diagrams with no significant extra call on resources compared with an irregular timetable (only train-sets were actually planned, but the point can be assumed to be similar for staff). Some will have brisk turnrounds, some will be longer than ideal, and some may justifiably be manipulated to work well. This is partly conditioned by the arithmetic fact that the target of relating key timings to the (half-)hour tends to create turnrounds that are just right for shorter-distance services (in the 5 to 15 minute range) but longer than necessary (c. 65 minutes) for mainline trains (unless sets can interwork).

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[28] An example of present confusion is that '*transpennine*', surely the premier regional brand, is not mentioned in the National Rail Timetable while '*Alphaline*' is. The latter is offered by two separate TOCs and curiously defined as "long distance trains joining together large centres of population" – but yet they also function as very local services. Anecdotal evidence also shows the widespread failure of travellers to understand the many franchise brands.

3.2 The *Taktfahrplan* : long-distance services

3.2.1 The natural heart of the plan is the service between Edinburgh Waverley and London Kings Cross. The current competitive circumstances are such that it cannot hope to attract those for whom speed is paramount between Edinburgh and London, and even though GNER offer discounted fares it is difficult to match the allure of cheap flights. There is, though, a strong market for travellers wanting a reasonably fast facility with a quality of journey-experience rarely obtained by flying. Moreover, the route also serves important relations between major provincial centres and London where air competition is more limited (Newcastle) or barely existent because of access-distances (Darlington, York). In the case of York rail has a virtual monopoly of the public modes, since road geography (and perhaps the traditional strength of the rail service) has also kept coach competition minimal. Many non-London flows are significant too.

3.2.2 The Edinburgh ↔ London trains should therefore stop sufficiently often to secure good frequencies and speeds to capture the intermediate business but not so often as to degrade the end-to-end journey, either in terms of overall time or of the psychological effect that frequent stops appear to give passengers the feeling that the train is slower than it actually is. The two indubitable calls are at Newcastle upon Tyne and York. The next three were considered to be Darlington, Doncaster and Peterborough, all significant urban centres in their own right but also important junctions for connectional purposes, as described elsewhere [§2.2 and below]. The reason for adding Berwick-upon-Tweed is given in a wider context [¶3.2.9], and Durham was judged best served by alternating this direct service with a connection [¶3.2.12, ¶3.4.4].

3.2.3 With that stopping pattern the procedure next required decisions on the 'zero-minute' node and the performance characteristics of the trains on which the timings were to be based. York was chosen to be the key node. To some extent this was arbitrary (or biased), but it can be justified on the grounds that at larger centres local routes tend to run frequently and therefore connections need relatively less attention, and that at centres with only modest interchange roles poor(ish) connections may have to be tolerated. York, on the other hand, is one of the busiest interchanges on the system, and while a number of its services carry important flows they only run hourly and thus necessitate careful organisation. Increased frequencies on these routes may however be desirable and are being contemplated.

3.2.4 Subject to the reservations expressed below [¶3.2.13-15] it was assumed that some trains would run through Edinburgh to serve other Scottish centres. Those for Aberdeen and Inverness involve non-electrified routes and must use diesel trains. This in turn means either that the standard electric timing would have to be altered for these services or that the standard timing should be set by the diesels. As it happens, British Rail's High Speed Trains [HSTs] are still, 27 years after they first began working, extremely effective vehicles at sustained speed over long inter-station distances, and their running time between Edinburgh and London, with the intended stops, is only about 6 minutes greater than for a 1991-built electric set. Given the *Taktfahrplan* emphasis on consistency the choice of a diesel base for the timings almost made itself[29].

3.2.5 This all gave an end-to-end time of 4 hours 38 minutes, 6 minutes slower than the 1999 mean time, which was deemed satisfactory within the broader picture and apparently vindicated by the later evaluation. The southbound and northbound trains are planned to call at York simultaneously at xx.58½ – xx.01½, or xx.59 – xx.01 in the public timetable. Departure from Edinburgh is at xx.26 and hence arrival at xx.34, not quite perfect but a good approximation. Intermediate (up/down) times are 08/52 at Berwick (to simplify the description a single mid-dwell time is quoted rather than separate arrival and departure times), 56/04 at Newcastle, 11/49 at

[29] GNER has come to the same conclusion. Following refurbishment the sets also offer a better-than-acceptable ambience to passengers.

Durham and 30/29 at Darlington. These are close to the ideal, and if 4 minutes could be saved between Newcastle and Darlington there would be perfect meets at Edinburgh, Newcastle, Darlington and York (and near-quarter-hour meets at Berwick and Durham).

3.2.6 South of York the running times are not so conducive to ideal patterns. The station times are 24½/35½ at Doncaster and 15/44½ at Peterborough. Since 15 minutes cannot be cut from the York ↔ Peterborough SRTs it is probably best to accept the connectional outcome at Doncaster and to leave Peterborough on the quarter-hour. Arrival in London is at xx.04 and departure at xx.56. Whether achieving 00/00 timings there to gain the benefit of round-numbered-ness could justify what would be needed to save 4 minutes has not yet been tested.

3.2.7 It will be noted that the two directions (up/down, south-/north-bound) have been described as an entity, because of the strict application of the mirror-image rule. Since that applies throughout, the rest of the text has been further simplified by discussing only the one, specified direction. It can be taken as given that what applies in that direction, whether of timings or of connections, will work in the opposite case, give or take some minor variation (which has itself been minimised by manipulation of the percentage performance margin where appropriate).

3.2.8 Between Edinburgh and London the basic service will be hourly. As far as York it shares the ECML with the cross-country route, which also has a strong case to operate hourly. The questions are thus inter-related as to their disposition around the hour and as to provision for the intermediate stations. There have been suggestions that between Edinburgh and Newcastle the two services should be 'flighted', that is, operated in close succession so that the track is left clear for a long period for slower freight trains. That was rejected on the grounds that it would reduce an important inter-city link effectively to one train/hour, which is not competitively attractive, albeit for historic reasons this particular link may not generate as much business as similar links elsewhere might, and by extension limit provision between all of Scotland and the eastern side of England to an unappealing and inflexible hourly pattern[30].

3.2.9 The better choice is to arrange the two paths as nearly as possible at even intervals. Whereas the London leaves Edinburgh at xx.26 and arrives at Newcastle at xx.54 the cross-country is timed at xx.57, arrive xx.22 (the reason for exploiting its speed advantage of 3 min is explained later [¶3.2.12]). Both timings depend on the decision about intermediate stations. The ECML passes through sparsely populated territory north of Newcastle upon Tyne. Even Berwick-upon-Tweed does not register strongly in the analysis of population and urban hierarchy, although plainly it serves as a railhead for a huge area. Dunbar and Alnmouth qualify as minor centres, large enough not to be ignored but too small to justify inclusion in the upper-tier network unless that is the only means of serving them. The present compromise of rather random calls is inherently

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[30] Freight paths have not so far been considered. This is recognised as a limitation but also reflects a certain unresolved ambivalence. Strategically railfreight is regarded as very important by the SRA, the railway lobby-groups campaign fervently for it to grow, and a study at the Institute for Transport Studies [Sansom et al. (2001)] has conclusively demonstrated its social and environmental benefits, especially over against some of the least well-loaded passenger trains. On the other hand, quite apart from some profound sustainability questions that must be asked of certain commodity movements (eg. long-haul power-station coal, those involving excessive food-miles, maritime containers stuffed with throw-away products), the present standing of railfreight in Britain creates problems for regular passenger timetables. On most routes it is nowhere near strong enough to obviously require a standard path or paths every hour (unlike Switzerland), and many flows have (or are said to have) a requirement at the behest of customers for day-to-day, or even hour-to-hour, flexibility that is extremely difficult to reconcile with the imperative of stability for a passenger railway. The issue needs debate beyond the assertions that railfreight is 'a good thing' – and a challenging search for innovative solutions. We would need much persuading that regularity should *ever* be compromised to accommodate a one-off freight path, but it is conceded that the passenger timetable may need to be adjusted to allow for reasonably frequent and predictable freight flows. In the meantime it is accepted that the evaluation of this ECML timetable may have over-estimated the benefits by not discounting possible freight disbenefits.

unattractive and certainly out of keeping with the *Taktfahrplan* concept of at least an hourly offer to generate a sense of convenience and confidence in the public transport system[31].

3.2.10 Immediately north of Newcastle a sizeable population in the Morpeth / Ashington / Blyth area has been poorly served for many years. Morpeth has very occasional stops in ECML trains and otherwise an erratic local service. The area is well served by buses, but little effort is made to integrate them with trains, compared with the work that has gone, for example, into advertising links between York and smaller places such as Whitby and Pickering. Between Morpeth and Newcastle Cramlington is served only by the local trains. The chosen solution (which the evaluation appears to support) is to operate a 'regional' service between Edinburgh, Drem (for connections with the North Berwick trains), Dunbar, Berwick, Alnmouth, Pegswood, Morpeth, Cramlington and Newcastle. This would employ 160 km/h units of some quality, and by leaving Edinburgh after the London and preceding the cross-country into Newcastle it would secure for these intermediate towns extensive connections every hour – but with the loss of direct services[32].

3.2.11 For the purposes of this case-study the cross-country trains serve Edinburgh, Berwick, Newcastle, Darlington, York and Leeds. It is assumed that they will continue to Sheffield, Derby, Birmingham, Cheltenham, Bristol, Taunton, Exeter, Newton Abbot and Plymouth, and provisional timings [see Table 1] suggest that the SRTs and this calling pattern will fit quite closely into the ideal *Takt* scheme. Several points are important. Within the hierarchy of services it is desirable to remove arguably marginal intermediate stops from these trains, hence none stop at Alnmouth or Durham (most arguably, but compensated by a good connection at Darlington), or, south of Leeds, at places such as Burton-upon-Trent, Tamworth, Tiverton Parkway and Totnes. The train is routed via Leeds in order to cover two prime requirements, the Scotland ↔ West Yorkshire market and the West Yorkshire ↔ Birmingham ↔ interchange / West of England market.

3.2.12 To complement the Edinburgh ↔ London service trains run hourly between Newcastle upon Tyne and London. These are timed to depart at xx.30, thereby affording a connection out of the Edinburgh → Plymouth (arrive xx.22) and thus a half-hourly pattern between Edinburgh and principal ECML stations, alternately through and by changing (this is a common arrangement in a *Taktfahrplan*). The two are flighted to Darlington, not calling at Durham, but the London then calls at Northallerton. Stops here by ECML trains have increased in recent years, and the data suggests that an hourly service might be justified. The trains are booked away from York at xx.33, not quite evenly with the Edinburgh → London trains at the other half-hour, and then call, like them, at Doncaster and Peterborough. They are timed for standard ECML electric sets. In hours when two London trains from Scotland may be justified, especially during the summer, this route could easily be extended back to Edinburgh (running non-stop and closely flighted behind the Plymouth).

3.2.13 Services within Scotland were not included in this study, except in the sense that their probable future shape was borne in mind in planning operations at Edinburgh Waverley. Some consideration was given to the through workings. These present problems that could not be properly settled without further debate. The issues are these:

- through trains are valued by travellers for their obvious convenience; and

[31] The Passenger Service Requirements [PSRs] are partly to blame for the capriciousness of the timetable. Conceived as a political necessity at the time of privatisation they not only tended to ossify the 1994 timetable but also, as a result of being written by lawyers, specified the number of trains to call at a station without much regard for whether the pattern was sensible or whether connections down the line offered customers good journeys.

[32] Closure of the relict stations of Chathill, Acklington and Widdrington is assumed. They serve small villages, and have few users and effectively only one train/day in each direction. Pegswood is in the same category, but its fortunes might change with an hourly service and integrated buses linking it with Ashington. In the long run one might hope for the proposed rail bypass of Morpeth that would leave the regional service on the old route while enabling expresses to avoid the speed restriction around the very sharp curve south of the station.

- the poor quality of certain local trains, mediocre timetabling at interchanges and on some lines, unreliability, the policy of not generally holding connections (the result partly of operational common sense, partly of the performance regime) and the unsatisfactory physical arrangements at many stations have together, it is suspected, generated a stronger resistance to changing trains in Britain than elsewhere in Europe[33];

but

- through workings can disrupt timetable patterns, even in conventional systems where capacity utilisation deteriorates and certainly in a *Taktfahrplan*, unless care is exercised;
- occasional through trains may upset neat rolling-stock diagrams and hence call for disproportionate resources;
- the train sets concerned may be highly suitable on their main route but not so when services are extended onto other routes;
- the number of passengers remaining on through trains at a place like Edinburgh may be small compared with the numbers leaving and joining;
- prolongations may duplicate other services; and
- well-ordered interchange might, over time, reduce the reluctance people now show, as it seems to have done in Switzerland and The Netherlands.

Each case requires to be weighed carefully, especially since there is some evidence of past inertia and of circumstances having changed. It is also true that it is not always logical to defend certain through workings when other, equally credible services are not operated for no better reason than the chance of history.

3.2.14 Typical issues in Scotland are these. The HSTs on the Aberdeen ↔ London service cannot use their full power until south of Edinburgh, are slower than the trains now covering the internal service between Aberdeen and Edinburgh and have more seats than the normal demand. Moreover, these trains have lost most long-distance passengers since the advent of cheap air travel, and they unbalance stock diagrams. The daily, daytime Inverness ↔ London train is a splendid institution that may be justified by tourist traffic, but it suffers the same drawbacks. Extension of the ECML electrification to Glasgow Central via Carstairs facilitated a regular through service for the first time between Glasgow, Motherwell and North East England. It has built up significant usage, but not enough to support more than a two-hourly frequency (as against 4 trains/hour on the faster *ScotRail* route between Glasgow Queen Street and Edinburgh), while the big ECML electric trains are not obviously the most fit for purpose. And the extension of cross-country services north of Edinburgh may have added more trains to the route than are really needed.

3.2.15 The *Taktfahrplan* has provided for these services to continue if so decided, but equally, they could be withdrawn while still leaving a pattern of good connections. In the case of Glasgow one possibility would be to replace the London train by extension of the Edinburgh ↔ Newcastle regional back to Central. This would permit the use of a more appropriate type of train and better provision, through an hourly link and an extra stop, for the Clyde Valley southeast of Glasgow, but it would certainly depend on a high-quality train and might be deemed inadequate for

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[33] For the development of the measures of regularity (or otherwise) the listing of the Opportunities to Travel [OTTs] generated within MOIRA was analysed, ie. the timetable offered through the day for each I → J relation and the proportion of travellers allocated to each OTT. This was a strong reminder of the weights attached to interchanging in the calculation of Generalised Journey Time, but some curious preferences output by the algorithm did lead to reservations about whether the effect is being exaggerated. Worryingly, this may affect the distribution of revenue through ORCATS, and that in turn has become so sensitive that it is not easy to reconfigure the OTT rules.

journeys to/from places south of Newcastle. Another option might be to extend the Plymouth service to Glasgow, given the greater flexibility of the *Voyager* units (and the maintenance facilities that are already available in Glasgow for the sets running via Carlisle).

3.2.16 Edinburgh and Newcastle trains represent one part of the ECML offer, the other, equally important, is the Leeds ↔ London service. This was increased to close to a day-long half-hourly frequency during the course of the study, and that longstanding aspiration of GNER is clearly in line with the nature of the market. A sharper differentiation than GNER apply between the alternating trains was however adopted. One hourly service calls only at Wakefield and Peterborough and completes the journey in 129 minutes. The other calls also at Doncaster and Stevenage [see ¶3.2.22] and provides the main London service for the three places between Doncaster and Peterborough, namely Retford, Newark and Grantham.

3.2.17 The first stage of the reasoning behind this arrangement was as follows:

- these three centres and their wider catchments are undoubtedly important enough to be served at least hourly by a fast train to/from London;
- the flows between any pair of these three plus Doncaster and Peterborough are not large but if they are to be cultivated, as they should be in an inter-urban network, the timetable must be patterned (and preferably half-hourly [see ¶3.2.19-21]); and
- the relations between the three and West Yorkshire are numerically more important than the relations with places north of Doncaster.

The second stage is then

- that a Leeds train should call every hour, thus securing their London service and direct links with West Yorkshire;
- that this train should be timed to follow immediately behind the Edinburgh → London from Doncaster (and precede it northbound), in order to give good connections between Scotland, northern England and the three places;
- that the Leeds train should precede the Edinburgh into Doncaster, so that Leeds passengers have the (cross-platform) opportunity to transfer to the latter for a faster journey to Peterborough and London; and
- that a second intermediate service should be considered.

3.2.18 This was deemed to be a more coherent scheme than the erratic distribution of stops that now obtains (though it should be understood as a basic pattern – the question of additional stops up in the morning and down in the evening to cater for London commuters has not yet been addressed). Leeds → London customers would be offered this timetable:

Leeds	dep	00.33	00.49	00.49
Doncaster	arr		<u>01.20½</u>	*(01.20½)*
Doncaster	dep		01.26	*(01.30½)*
London KX	arr	02.42	03.04	03.27

It does not give Leeds a near-even half-hourly fast pattern for London trips (which it does not have now), but unless and until that can be justified the disposition of the slower train 16 minutes behind on departure and 15 minutes ahead into London seems a good compromise when taken with the Doncaster option. If it is possible to time the xx.49 from Leeds and the Edinburgh to run into Doncaster simultaneously from Marshgate Junction (to platforms 3 and 1 respectively, and to do the same out of 8 and 4 northbound), then the interchange could be to German standards and 2½ minutes could be cut from the Leeds timing.

3.2.19 The remaining question is 'the fifth path' on the ECML south of Doncaster. It is generally agreed that this would be available every hour with consistent patterns whereas it is not at present. It did not appear that there is a need throughout the day for a third service between either Northern England or Leeds and London. Another contender is Hull and Lincolnshire. Hull is a 2C centre in the Urban Hierarchy, though it has a reputation for generating less travel than might be expected[34]. At present it is served by one GNER and four *Hull Trains* through workings daily, and otherwise by connections at Doncaster. It has always proved difficult to justify something better than this less-than-ideal arrangement. *Hull Trains* was an attempt by an open-access company to improve the offer, but it is limited by using 160 km/h units, and by the sub-optimal paths and rather arbitrary intermediate calls that emerged from the convoluted regulatory process. 200 km/h units are however now on order.

3.2.20 A second 'stopping' path has been included in each hour, with calls at all stations from Doncaster to Peterborough, then non-stop to London. Departures from Doncaster are at xx.30 for the Leeds train and xx.08 for this service, but arrival in London is near-even in spacing (xx.27 / xx.59) because only the Leeds stops at Stevenage. The intermediate stations gain a more regular and more frequent pattern, as is desirable. It would probably make sense to run through from Hull every other hour (assuming good connections at the alternate hour and into the fast train at the other half-hours) [see ¶3.6.11]. It should be stressed that protection of specific (and irregular) *Hull Trains* paths under Track Access Agreements is incompatible with *Taktfahrplan*, and that the operator should expect to bid to run a service of a similar kind but within the pattern, if it so wishes, or to have its rights bought out by the SRA.

3.2.21 Other possibilities might be considered for this path. They include a Leeds ↔ Cambridge ↔ Stansted Airport service if the fifth path south of Peterborough is needed for peak long-distance trains and the demand were established (London passengers would change to the immediately-following Edinburgh); a through South Humberside ↔ Lincoln ↔ Newark ↔ London service alternating with the Hull working (Retford is the least important of the three intermediates for a half-hourly frequency, and Doncaster has two fast trains/hour anyway); and stopping the Doncaster train at Huntingdon, which is otherwise left only with an outer-suburban service.

3.2.22 Two other matters should be mentioned in conclusion. Regularisation excludes the acceleration of selected trains by omitting stops or running exceptionally fast under special pathing arrangements[35], but it may be possible to provide for *extra* trains. One such case, for which a path could possibly be found, is an up-morning / down-evening working calling at all the mainline stations between Edinburgh and Newcastle, plus York (the up timings appear in the netgraph). At the southern end of the ECML, where the long-distance trains share the route with a frequent and well-structured regional and local service, two acute operating problems arise, namely the conflicts at Cambridge Junction, Hitchin and the reduction from four to two tracks over Welwyn Viaduct. There is much debate about just how serious these problems are. The draft plan has merely been checked for basic operability in the area, using a spreadsheet that enables a search for the best combination of paths, given specified inter-service relationships and operating regulations. This led to the provisional decision to stop only one long-distance service at Stevenage, around which there are some interesting demand issues. The netgraph shows provisional timings for the Cambridge and outer-suburban services.

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[34] Moreover, while on a simple allocation of catchment populations to places in Order 1, 2 and 3 Hull's rank is in the upper 30s nationally, when population is weighted for access-decay effects it falls to around 94th.

[35] For which we coined the term *prima-donna trains*. The 10.30 from Kings Cross is a good example of the disruptive consequences (including a gap in the half-hourly London → Darlington series and a disreputable pathing fudge in Scotland), although GNER would claim to be capitalising on certain market-demands and evening-out loadings.

3.3 The *Taktfahrplan* : services within Scotland

3.3.1 Reference has been made above to trunk services within Scotland and their arrangement vis-à-vis Anglo-Scottish services. Beyond that no detailed timetabling of Scottish routes in general was undertaken for the case-study, although a separate exercise later did produce a first-draft scheme for the whole of Scotland that is compatible with it. So far as the lines around Edinburgh are concerned it is expected that their frequencies will fit well with the principal ECML departures at xx.26 and xx.57 (which ideally should be brought closer to the round (half-)hour; the third path is at xx.02). Two routes however did need full planning because they interact with ECML trains east of Waverley, namely the North Berwick service and the Newcraighall Park & Ride service.

3.3.2 The first has calls at five stations on the main line in the eastern suburbs of Edinburgh (two of these stations have been opened in recent years) and then diverges (at Drem) to the dormitory town and small seaside resort of North Berwick. Ticket-data and observation suggests that demand is not particularly high, outside of weekday peak hours, but neither is it trivial nor is relief of road-congestion unimportant in this area. Assuming, therefore, that the social case for the route is sound it was felt that the service should be made more convenient by operating it half-hourly – which is already done on Saturdays. The paths were planned accordingly, and three units are needed instead of two; the frequency would probably become hourly mid-evening.

3.3.3 Edinburgh City Council, which is facing huge traffic problems, sponsored the reopening to passenger trains of a freight line in 2002 in order to link two new Park & Ride sites at key locations on the road network, Newcraighall and Brunstane, with the City Centre. The frequency is half-hourly: trains from Bathgate are extended from Waverley eastbound but they return to Dunblane westbound. This is a classic case of non-mirror-image working that arises from superimposing a new service on a flawed base, although to be fair it is done more for operational convenience than because either association is significant in demand terms.

3.3.4 The real problem, though, is that 2 trains/hour is not particularly convenient to attract Park & Ride business (most bus schemes run at a minimum of 4/hour, and many more frequently), especially if delays west of Waverley cause unreliability, and the scheme did not make much impact in its early months. Yet to increase the number of trains (probably to 4/h – 3/h would still be inadequate and would be non-standard in *Taktfahrplan*) would put pressure on Portobello Junction and might well be deemed insufficiently robust. Serious development of this service, and of other ideas for the Edinburgh area, probably requires a flying junction at Portobello, which can only be an expensive long-term objective[36].

3.4 The *Taktfahrplan* : services in North East England

3.4.1 In North East England, Yorkshire and Humberside regional and local routes perform vital functions within the area as well as complementing the north ↔ south long-distance routes. The principal regional corridors in the North East are Carlisle … Newcastle via the Tyne Valley and Newcastle … Middlesbrough via the coastal route. It is convenient to serve these two by through trains in order to facilitate journeys across Newcastle. An hourly Carlisle ↔ Middlesbrough service was therefore timed, using 145 km/h Class 158 units; it calls at Haltwhistle, Hexham, MetroCentre, Newcastle, Heworth (for Metro interchange), Sunderland, Seaham, Hartlepool,

[36] On a standard double-track railway a flat junction causes the loss of a path (or two with extended signalling margins) on the line in the opposite direction to allow the crossing movement. Grade-separation removes this constraint. In a mirror-image timetable it is the blocked direction that must determine the pattern, although the effect on capacity is not significantly different between a regularised and a train-by-train timetable.

Stockton-on-Tees, Billingham and Thornaby[37]. This tidies up and enhances a presently scrappy arrangement to give both corridors a quality core service. It is timed into Newcastle from the west at xx.21 to feed neatly into Plymouth and London trains.

3.4.2 Hexham justifies a second service to Newcastle each hour, MetroCentre needs frequent trains and the intermediate stations appear to be worth serving hourly[38]. A similar logic applies on the other side of Newcastle, at least as far as Hartlepool. These considerations lead to a Hexham ↔ Hartlepool local train being timed at the other half-hour at Newcastle (connecting with the Edinburgh ↔ London). It is shown as being extended to Billingham, on the basis of using time otherwise spare in the diagram, and preferably it should run through to Middlesbrough, albeit at the cost of an extra unit. The drawback is that this is an area where *per-capita* demand seems to be exceptionally low (or very localised) and buses notably frequent.

3.4.3 In a proper attempt to keep public transport relevant for people travelling to the shops and other attractions at MetroCentre the adjacent purpose-built station has always had a frequent service, at present every 15 minutes with some variations. This practice has been replicated but with exact patterns by supplementing the Carlisle and Hexham trains with a regularisation and extension of the Morpeth ↔ Newcastle service and a MetroCentre ↔ Newcastle shuttle.

3.4.4 The Tyneside ↔ Teesside service via the Coast is currently matched at some hours by trains running via the ECML and Darlington, most of which are extended beyond Middlesbrough to Saltburn. The end-to-end benefit is however sometimes lost because trains by the two routes are timed close together and also fail to offer useful connections at Darlington[39]. It was decided that the ECML route should have a regular hourly service, carefully timed to alternate with the Coast trains. Respective departures from Newcastle are at xx.07 and xx.26, with arrivals in Middlesbrough at xx.10 and xx.39 (ie. running times are 63 min and 73 min). This scheme does several other things:

- it adds a third train to the Newcastle ↔ Durham timetable at reasonably even intervals;
- it feeds Durham passengers into the Plymouth and Newcastle → London trains at Darlington, thus enabling them to omit a Durham stop;
- it covers the need for a decent frequency of calls at Chester-le-Street, so ensuring its links with the national network;
- it forms one half of the Darlington ↔ Teesside service; and
- it provides a (slightly too long) connection at Darlington from the northbound Edinburgh train for passengers between London, intermediate stations and Teesside.

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[37] The work on nodes highlighted the seemingly-neglected case for a new station to serve Peterlee. Conversely, this plan leaves open the future of the marginal stations of Wetheral, Brampton, Bardon Mill and Haydon Bridge, all west of Hexham, and of Seaton Carew, an industrial suburb of Hartlepool.

[38] With the exceptions of Riding Mill and the barely-used inner-urban Blaydon and Dunston.

[39] For example, in the Winter 2003/04 timetable [NRT, Tables 26, 44 and 46] the 09.30 from Middlesbrough via the Coast and the 09.36 via Darlington arrive in Newcastle within 1 minute of each other. It is the second that runs through from Saltburn, so passengers from east of Middlesbrough to the Coast stations have a 43-minute wait in Middlesbrough. The 09.36 arrives at Darlington at 10.03, 7 minutes after a fast train to London has left, with the next service involving an invalid interchange at Doncaster (ie. the 5 minutes between a Virgin arrival and a GNER Leeds → London departure is excluded by the 7-minute rubric) and the next direct train not departing until 11.00. Neither Tees train arrives in Newcastle in time to connect with the 10.57 to Edinburgh, even though the 09.36 is pathed to precede it into Central. This failure of joined-up timetabling is endemic and may help to explain the conundrum that lots of trains whizzing about do not automatically impress the public. It is also the reason why it is not hard to find positive benefits simply from regularisation and why a *Taktfahrplan* does not necessarily require more train-sets.

3.4.5 Since this plan was drafted the SRA has expressed its intention to remove these trains in the course of its Route Utilisation Strategy and re-letting of the ECML and new Northern franchises. If this is the only means of securing adequate freight paths it may be unavoidable, but the evidence for that has not yet been published. The plan is to insert stops at Chester-le-Street in cross-country services. This (4B) place is significant enough for closure of the station to be contentious, but the plan is unsatisfactory: long-distance trains should not be slowed by calling at minor centres to handle largely short-distance traffic, and if the stops can only be occasional then usage will be limited and it would be more honest to propose closure. It will also be necessary to be vigilant about other side-effects of withdrawal. At present the train-mileage in the whole area is quite high but it is demonstrably not used to best advantage. Regularisation is designed to offer opportunities to travel every half-hour wherever possible, including the connections with the national network, and any other plan must achieve similar standards.

3.4.6 East of Middlesbrough there are two lines. One provides a local service for Redcar and Saltburn, the other is the Whitby branch. The former has sufficient traffic to justify two trains/hour on present assessments of social benefit, and running the ECML local through and alternating it with a Darlington ↔ Saltburn service has maintained that[40]. The timings are arranged to give good connections out of the Carlisle ↔ Middlesbrough regional and a trans-Pennine service (respectively).

3.4.7 The Whitby branch has not been timed, since on the evidence from the demographic studies and the ticket data its future must be in serious doubt. The local geography is such that it cannot compete with the direct bus for Whitby ↔ Middlesbrough traffic (it follows in an integrated system that that bus should be the one to fit into the *Taktfahrplan*), but whether its function of serving the small settlements adjacent to its route would be better covered by minibuses and taxis is outside the scope of this study. There is optimism that 'micro-franchising' might revive its fortunes. If it is desired to fit it into the broader scheme one unit could circulate every three hours, departing Middlesbrough at xx.08 after arrival of the trans-Pennine train and arriving back at (xx+2).52. About 7 minutes would need to be removed from the (painfully slow) schedule, perhaps by the small scheme to cut out reversal at Battersby, perhaps by closing four stations at which less than one person joins or alights at each train-call and which are used, on average, by one in ten of local residents for one journey annually and by the other nine not at all.

3.4.8 Finally in the North East there is the equally problematic Bishop Auckland branch. This runs for 19 km to a junction with the ECML at Darlington. It is the last remnant of a once-extensive network in County Durham west of the main line, and it has suffered the characteristic spiral of decline as attempts to economise in the face of large losses and an arguable social case have led to poorer services and very few users[41]. Geography does not help, in that while the line serves Bishop Auckland, Shildon and Newton Aycliffe well enough, it is of little relevance to other settlements to the north, such as Crook and Willington, whose residents are unlikely to be attracted by bus + train (+ train) options in an area where the buses run frequently in a dense network. Moreover, as GNER point out, most long-distance customers do not live close to the branch and much prefer driving to Darlington. And an operating problem adds to the difficulties: through working to/from Teesside means using the through platforms rather than the south-end bays at Darlington, which cannot be justified for small numbers of users.

3.4.9 In such situations the financial and operating imperative is that the product should either be radically redeveloped – or withdrawn. To perpetuate the existing thin service of 10 trains/day

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[40] The plan assumes closure of the poorly-used stations of Dinsdale, Tees-side Airport (this has been reduced to token service, and we are not aware of a case for reviving it) and Allens West (sited very close to Eaglescliffe).

[41] On average each person in the catchment population of about 120,000 uses the line about once every two years.

each way, with poor units and a decaying infrastructure, does the image of public transport no favours and is of doubtful social value. The problem is that, although a brisk new half-hourly service connecting well at Darlington (but probably not running through to Teesside) would undoubtedly increase use of the line, it would require an upgraded infrastructure to facilitate the desirable timings and smart new units – at considerable expense[42]. A road coach would almost certainly be a more economical alternative and it could serve other places outwith the branch. However, even that is arguable, since it would duplicate the bus network, except insofar as the latter does not link with the railway at all well in Darlington, for historic and street-layout reasons.

3.4.10 In the absence of a full investigation we chose to indicate a short-term compromise, pending a clearer policy regarding such lines. This is a one-unit hourly shuttle that brings a higher frequency and regularity, although it cannot be a mirror-image service and hence offers timings that differ by direction for through journeys. Even then it would need to be worked very briskly (from/to the north end of the down through platform) because the 55-minute round-trip time is tight. Closure of North Road station in Darlington, which is poorly used, might ease this.

3.5 The *Taktfahrplan* : trans-Pennine services

3.5.1 Trans-Pennine services are one of the success stories of British Rail's management of regional routes. In the early 1960s a fleet of purpose-designed diesel multiple units [DMUs] transformed a bunch of infrequent and poorly-timetabled steam-hauled services into a reasonably regular and brisk offer. The momentum of this improvement was unfortunately not maintained, but in the early 1990s another class of DMUs, the 158s, once again allowed an upgrade. On the central corridor between Leeds and Manchester via Huddersfield and Standedge Tunnel the frequency was built up to 4 trains/hour (though with some irregularities). In parallel with this the Bradford ... Halifax ... Burnley ... Preston route, which had had few trains, moved in stages toward an hourly timetable. Although passenger numbers still fall well short of securing profitability they have grown considerably, and rail is thought to hold a much higher market share on some key centre-to-centre flows than it does for non-London routes generally.

3.5.2 East of the Pennines the routes to be served are those from Newcastle upon Tyne, Middlesbrough, Scarborough and Hull. West of the Pennines the routes serve Preston, Liverpool via Manchester, and Manchester Airport. A further service runs between Sheffield and Manchester via the Hope Valley Line and Stockport, with many trains being extended along part or all of the Cleethorpes ↔ Airport or Norwich ↔ Liverpool axes. This has not been included in the present exercise, although pairing the Hope Valley Liverpool trains west of Manchester half an hour apart from the trans-Pennine trains would effectively impose timings on routes across a swathe of country [see ¶2.2.17]. The permutation of east and west places has varied from time to time, but in recent years the normal scheme has settled down to

- Newcastle ↔ York ↔ Leeds ↔ Manchester Piccadilly ↔ Liverpool
- Middlesbrough ↔ York ↔ Leeds ↔ Manchester Piccadilly ↔ Manchester Airport
- Scarborough ↔ York ↔ Leeds ↔ Bradford ↔ Preston ↔ Blackpool
- Hull ↔ Leeds ↔ Manchester Piccadilly ↔ Manchester Airport
- Leeds ↔ Manchester Piccadilly.

During the day there are some variations. Some of the supporting local services have also been included in the case-study and are described below.

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[42] It is noted however that such schemes are being implemented in Germany and parts of France, where a range of attractive diesel units highly suited to this type of line is now available. Intriguingly, elsewhere in France rural 'rail' services may now turn out to be worked by buses.

3.5.3 Although no deep analysis was undertaken this seems intuitively sound and accords with the messages from the demographic studies. For example, the Newcastle ↔ Liverpool corridor is the prime route, Manchester Airport's catchment thins out as it overlaps with that of Newcastle Airport, and the Scarborough line, having the weaker claim to through Airport trains, is conveniently linked with a through service between York and Leeds and North East Lancashire, with connections at Preston for the West Coast Main Line. A fast service between Bradford and Manchester is the big gap, but filling it depends on a grander strategy for high-quality connectivity throughout the area than was attempted for the case-study. The first step toward that is the establishment of a separate Trans-Pennine franchise (although the proposed splitting of the York ↔ Preston route to fit the new franchise geography is disappointing). The fresh operator is committed to the purchase of new 160 km/h DMUs, but this was not taken into account here.

3.5.4 The chosen scheme therefore replicates the current general pattern while regularising its detail. It has only been timetabled fully east of the Pennines, but the framework is broadly consistent with arrangements on the west side, including provision for sensible turnrounds. The Newcastle ↔ Liverpool trains serve Durham, Darlington, York and Leeds. They start back from Sunderland but stand for 12 minutes at Newcastle: the purpose of this arrangement is to offer a good connection from Sunderland into the Plymouth and Newcastle → London trains.

3.5.5 The Middlesbrough ↔ Manchester Airport trains serve Thornaby, Yarm, Northallerton, Thirsk, York and Leeds. Yarm and Thirsk are small places but this is probably a case where a longer-distance service must cover their needs in the absence of any other credible way of providing for them. Timings at York allow a feed into the Edinburgh → London in order to secure a fast connection between Teesside and London, although this decision was hard because it means a lengthy turnround at Middlesbrough, poor connections at Thornaby for the northern part of Teesside and the two services calling at Northallerton being unevenly spaced. The connection via Darlington requires departure from Middlesbrough 10 minutes earlier, although it is necessarily via Darlington at the other half-hour.

3.5.6 The Scarborough ↔ Blackpool trains call at Seamer, Malton, York, Garforth and Leeds. They too have an extended dwell, at York. It uses what would otherwise be idle time at Scarborough, where instead the turnround is brief. The steps of the argument here were

1. departure for Leeds must be at xx.36 after a feed out of the Newcastle → London [see ¶3.5.7-10 for the spacing of York ↔ Leeds trains];
2. latest arrival at York must be at about xx.25, between the Plymouth and the Newcastle, which provides the connection toward London (timing are constrained by the signalling overlap when running into platform 4);
3. if the arrival is moved back to xx.17 there can also be a feed into the Plymouth;
4. the majority of passengers using the Scarborough trains join or leave at York, although that is not to say that the flow across York toward Leeds is negligible (the ratio is about 8 to 1); and
5. passengers for Leeds have the option of a cross/along-platform change into the Plymouth.

This type of situation is not unique to *Taktfahrplan*, but under that regime, unlike a context of different permutations for every train, the issues are made clearer because by definition the pattern will be applied across the day – though that makes the right choice very important.

3.5.7 Each of these pathing decisions was made primarily with respect to connections and conflicts on the ECML and its associated lines north of York. However, equally important considerations affect the schemes between York and Leeds and west of Leeds. The section between York and Leeds carries a substantial through traffic, but in addition York ↔ Leeds is the busiest inter-urban relation of its kind outside London. Its service must therefore be frequent, and it is highly desirable that it also be of a 'Metro' style of near-even timings. Unfortunately the need also to serve the intermediate stations introduces a restriction.

3.5.8 The local service consists of an hourly train from York to Leeds calling at Church Fenton (sometimes[43]), Micklefield and three further stations to Leeds, and an hourly train from Selby to Leeds calling at South Milford, Micklefield (the junction) and the three others into Leeds. Between Micklefield and Leeds the timetable is, as it should be, regular for much of the day, and the trains are extended west of Leeds in an equally regular pattern as the all-stations service to Manchester Victoria via Bradford, Halifax, the Calder Valley and Rochdale. The problem is that faster trains from York cannot overtake before Leeds (except at Church Fenton, which is not a useful point to do it, and then only southbound). In the long term this must surely merit upgraded infrastructure if the inter-urban artery is to have a frequent, even and reliable service and the local stations due convenience (2 trains/hour is not ideal)[44]. For the present there is a severe timing dilemma.

3.5.9 A *Voyager* unit is allowed 23 minutes between York and Leeds, a Class 158 on the Newcastle and Middlesbrough services 26 and the Scarborough, with the Garforth stop, 28 minutes. The local requires 40 minutes. This has the effect that there must be about a 24-minute gap between the pair of fasts either side of the stopper and hence about 12 minutes between the other pairs. This and the ECML pattern therefore together determined the following timetable:

		MDBR	local	X-country	HULL	SCRB	local	NCLT
York	arr	54		20		17	-	43
York	dep	57	02	23		36		49
Selby	dep				34		38	
Leeds	arr	23	42	46	56	04	12	15
Leeds	dep	31		(45)	01			19
	dep		46	53		07	16	

3.5.10 We might claim this to be ingenious, given the constraints, but not that it is ideal. It will be noticed that the Hull feeds into the local at Selby and then takes the place of the Scarborough on the Standedge route as the latter heads toward Blackpool via Bradford. Similarly, a Leeds → Manchester Piccadilly service starts up at xx.45 to take the place of the Plymouth train as it turns toward Wakefield (but does not connect out of it). This secures the 4 trains/h frequency between Leeds and Manchester, and by holding the Middlesbrough for 8 minutes departures from Leeds are at nearly-even intervals. The distribution is in fact so designed (provisionally) that, taking into account differing intermediate stops, arrivals in Piccadilly form an exact 15-minute sequence and hence eastbound departures do the same.

[43] The timetable for Church Fenton would seem too infrequent, because of deficiencies in the layout and pathing constraints, to be attractive and yet, per head, it is well used. Southbound, many trains wait there to be overtaken, which slows the service from York to the local stations beyond. Ulleskelf, used by10 people/day, is assumed closed.

[44] To put one idea: reinstating the through lines at Cross Gates to enable an express to overtake a local would probably permit a pattern comprising 4 expresses/h and 4 locals/h. Electrification from Colton Junction to Neville Hill (which would be helpful anyway for operational flexibility on the ECML) would be desirable, and four-tracking between Cross Gates and Neville Hill East Junction would add further benefits.

3.6 The *Taktfahrplan* : other services in Yorkshire

3.6.1 One other service was prepared in detail, that between Scarborough and Hull. This route is typical of a number in Britain's railway network where it can be argued that a useful link between towns is not offering the service it could do because it is slowed down by calls at minor stations. Often too the timetable is an uneasy compromise between these marginal functions, a traditional infrastructure and unit-minimising stock diagrams. Little attempt seems to be made to think even tactically beyond each line in isolation, despite the pressing need to make regional services busier. Equally, it seems probable that the state of the railway's finances within the context of the Government's transport policy is such that routes like these will in the near future have to be drastically overhauled. The aim therefore, within the *Taktfahrplan* framework, was to propose a step-change in the offer on this route.

3.6.2 Two stations – Bempton and Arram – are used for a journey less than once every two years per head of the local population and generate only 27 or 5 trip-ends respectively per day. Hunmanby, though also poorly used on a per-head basis, yields more trips in total (63/day, ie. about 30 return journeys), but about 80% of its traffic is very short-distance, the village is well-served by bus and it is on a section where time must be saved to secure robust paths through a single line. These three are thus assumed closed. Several others serve small communities, but no operating benefit other than acceleration would be obtained. Their future would need to be appraised by considering the gain from faster running against the loss of business from closure.

3.6.3 It is desirable (but rarely found in the present timetable[45]) that passengers from the York direction should have a good connection at Seamer (the junction between the Scarborough ... York and Scarborough ... Hull lines, and also a useful station for the southern part of Scarborough) toward Filey and Bridlington *and* that passengers from the Leeds and Doncaster directions should be able to connect quickly at Hull for Beverley and beyond. This largely determined the paths, but it does require tight working for access to the single line between Seamer and Bridlington (the intermediate double section between Filey and Hunmanby is not used for crossing in this plan) and an extended dwell-time at Bridlington, which does not affect the majority of users but does offset the gain in end-to-end time from the station closures.

3.6.4 The present nine trains/day are replaced by an hourly service with good links with the wider network, and the evaluation suggests that this may be the best strategy. Certainly any other pattern would leave the line self-contained in timetable terms, with poor connections, and that would be detrimental to flows between its intermediate centres and everywhere beyond Scarborough and Hull. The timings are such that units could be diagrammed to run Manchester Airport ⟶ Hull ⟶ Scarborough and return: this would obviate either an un-robust or an over-long turnround for the trans-Pennine service at Hull and afford the additional benefit of through services. A dwell-time of 9 minutes would cushion the local service against most perturbations, but it might be thought extravagant to use 'regional' units on such a line. Finally, though not timed

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[45] Let this case serve as an example of the manner in which regularisation plus some (fairly easy to organise) extra train-kilometres could reap large benefits simply because connections are so often now in disarray. If one enquires of the on-line timetable one is offered an amazing set of options for a return journey between York and Bridlington. Eliminating the slow, devious and barely relevant and making a judicious selection of those that might actually appeal to a potential customer, one finds that there are about 20 services/day in the two directions together. Their median timing is 107 minutes, the best is 74 minutes. The OTT listing for the 1999/2000 timetable, this time using low logit scores (ie. those for opportunities that barely register for ORCATS revenue-allocation purposes) to exclude slow services, gives a mean time of 115 minutes (coefficient of variation = 18%) and a best of 79. By road the distance is 66 km. It takes 69 minutes by car, at any time. The occasional bus or coach takes 105 – 115 minutes. *Taktfahrplan* would offer 77 minutes, every hour for a longer operating day, with an ordered change at Seamer (coefficient of variation = 0%). Not surprisingly the evaluation predicts a more than doubling of the Bridlington ↔ York business.

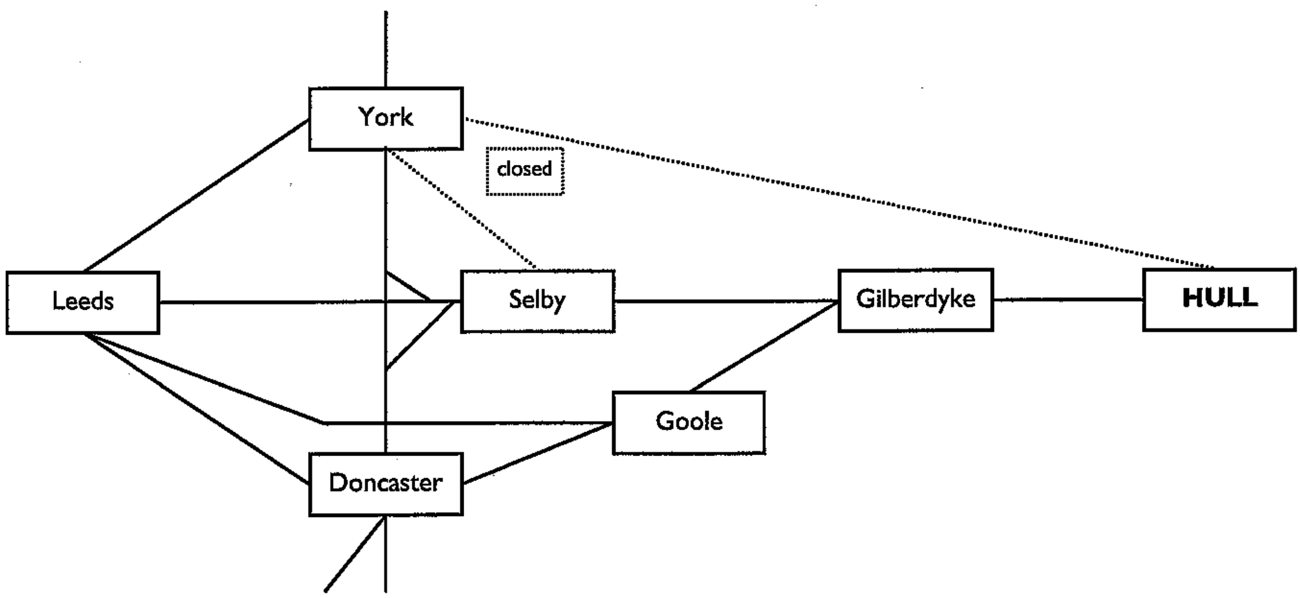
in detail, the Scarborough service will be complemented as now by a Beverley ↔ Hull shuttle at an even 30-minute interval to cater for a surprisingly strong flow.

3.6.5 That completes the description of the services which were included in the *Taktfahrplan* and thus in the evaluation. Others have been borne in mind, and many more will fall into place as the geographic coverage is extended. Of the former two should be mentioned, not least to convey a sense of the decision-processes that have to be worked through for each route or group of services and then iterated as may be necessary.

3.6.6 The York ↔ Harrogate ↔ Leeds route is important for local travel, especially between York and Poppleton and from Knaresborough towards Leeds, but it also secures the important links between Harrogate and the national network. At present the service is approximately half-hourly between Knaresborough and Leeds, but only hourly on the York section, with slow timings and some poor connections at York, particularly out of southbound GNER services and northbound Virgin services.

3.6.7 The aspiration might be to add a faster service calling only at Knaresborough, Harrogate and Horsforth (or a new park & ride station where the railway crosses the Leeds ring road ?). This would leave York at about xx.35 after arrival of the north- and south-bound Newcastle ↔ London trains and could be into Leeds at about xx.27, to connect with the xx.33 fast to London. The existing all-stations train would leave York at xx.04 (connecting both ways out of the Edinburgh ↔ London) and reach Leeds at about xx.13, thus enabling the Knaresborough starter to be timed to arrive at xx.43 to feed into both the slower London train and the Plymouth (and, for what it is worth, to be fed by the three-stop train for travel from York to the lesser stations at the alternating half-hour). This scheme would work, with some adjustment, with the single-line sections configured as they now are, but it is tight and would need careful appraisal for robustness. It also has a diagramming problem in a long layover at Knaresborough.

Figure 7. Connections between Hull and the national network



3.6.8 York ↔ Selby ↔ Hull was also left unresolved. This link is important regionally and assuredly merits a more regular pattern than it now has, and it is desirable to secure a good facility between Scotland and the North East and Hull. Plans for it are however associated with the broader question of how to serve Hull adequately without running excessive train-kilometres. The problem is geographic, as Figure 7 shows. The (not-very-direct) route between York and

Hull via Market Weighton has been closed, and it is improbable that it will ever be reopened, given that the intermediate towns are small and that the route via Selby is faster and involves only a short spur not used by other trains. York and Leeds must therefore share the route from Selby (or more exactly, Hambleton East Junction), but running 2 trains/h from each through to Hull, as aspiration might suggest, would be extravagant in view of the paucity of intermediate demand between Selby and Hull, while doing otherwise introduces a change at Selby.

3.6.9 On the southern side the Hull ↔ Goole ↔ Doncaster route clearly requires 2 trains/h to sustain the credibility of the link between Hull and Goole and the whole of central and southern England. Goole ↔ Leeds via Wakefield cannot sustain more than a token service at present, and no enhancement is foreseeable (Goole appears to have little socio-economic affinity with Leeds). Routeing of passengers between Hull and the south via York (or even Leeds) or between Hull and the north via Doncaster is now encountered, but only in the absence of more direct alternatives, and even with perfectly-ordered connections it would still be slow because the detour is significant. Finally, Selby has had a poor service to and from the south since it was bypassed by the new route of the ECML between Colton Junction and Temple Hirst Junction in 1981.

3.6.10 In the Winter 2003/04 timetable there are 8 Hull → York trains/day, 6 just from Selby to York, connecting reasonably well out of trains to Leeds, 15 *transpennine* expresses via Leeds, 6 Hull → Doncaster trains via Selby (of which one is the through GNER London service, four comprise the *Hull Trains* London service, and one is a local; there is also one Selby → Doncaster working), and 31 Hull → Doncaster trains via Goole, 18 of which continue to Sheffield. In view of the modest loadings of these services (the ticket-data suggests that west of Brough the traffic-flow is of the order of 100 journeys/(average-hour x direction)) caution is essential in arguing for any increase in these frequencies, despite present shortcomings, especially since any timetable can be made to look better by throwing trains into it.

3.6.11 The provisional *Taktfahrplan* solution is as follows:

- consolidate the Hull ↔ Leeds ↔ Manchester service and slightly extend its operating day;
- run an hourly York ↔ Hull through service, in the opposite half-hour hour from the Leeds train and connecting with the Edinburgh ↔ Plymouth and Newcastle ↔ London services at York (some acceleration would be needed to achieve a time of about 53 minutes and hence good diagrams for two units – the distance is 78 km and the car-journey takes 60 minutes);
- divert the Hull ↔ Selby ↔ Doncaster ↔ London trains via Goole and run them every two hours [see ¶3.2.19-21] as part of a regularised, half-hourly Hull ↔ Doncaster (↔ Sheffield) service; and
- run an hourly Selby ↔ Doncaster service, connecting with the Newcastle ↔ London train (in some hours this might run from/to York in connection with the Edinburgh ↔ London at York and the *transpennine* service at Selby, where it would reverse).

With some thinning in the evening this would probably mean about 64 departures/day from Hull, compared with 60 at present, plus the (York ↔) Selby ↔ Doncaster service in lieu of the London trains. York and all points north thereof would have enhanced connections with Selby and Hull, Selby would gain a good hourly connection to London (and many other places) while losing its five through trains, and Hull and Goole would gain two-hourly through trains to London, compared with five a day and none respectively now. The chief deficiency remaining is that Leeds would have only an hourly link with Hull. Running a shuttle connecting in and out of the York ↔ Hull trains at Selby could fill this gap at at least some hours.

3.6.12 These stand as first-stage ideas. The next stage is detailed pathing, and although the outline is believed to be sound, it is known that some constraints exist. In particular the *transpennine* trains and the Selby ↔ Leeds locals would have to be adjusted to make room for the York ↔ Selby ↔ Doncaster train between Hambleton East Junction and Selby, where the platform working would need to be slick. But, once again, it is easier to work on that for a standard hour than it is to have to worry about different details every hour.

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This Working Paper was written by Jonathan Tyler
of Passenger Transport Networks, York.
He is an Honorary Fellow of the Institute.

email contact: < ptn@btconnect.com >

Appendix I

158 principal inter-urban links : current road and rail distances and times, and target improvements for rail

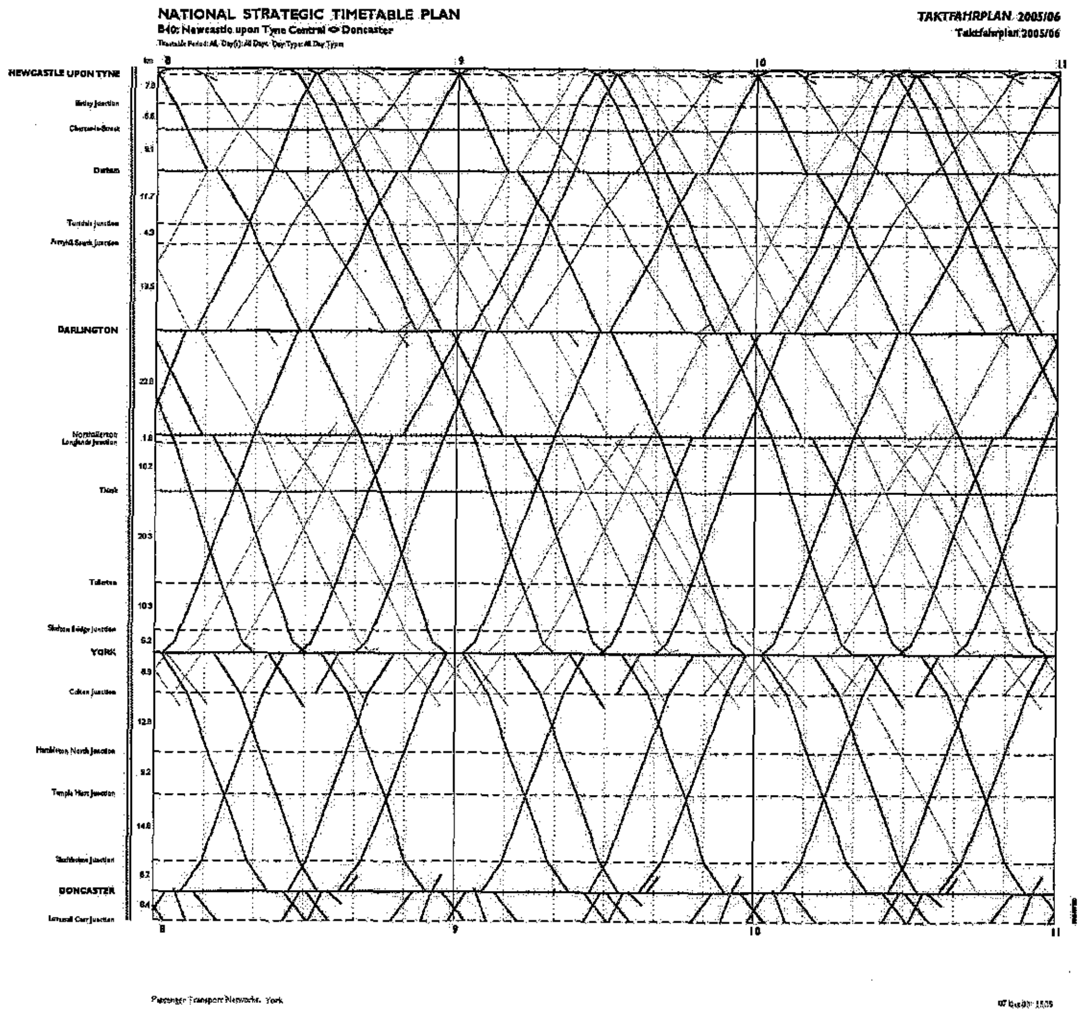
		distance	GJT minutes [1999/2000]				road link [AA RoutePlanner]		rail time relative to road time		TARGET SRT
CENTRE_O	CENTRE_D	km	in-train	wait / adjust	inter-change	T+A	km	min	in-trn	T+A	min
Aberdeen	Dundee	114	75	29	0	104	106	90			68
Ayr	Carlisle	169	153	61	29	214	166	127	slow	slow	94
Barnsley	Sheffield	26	29	22	0	51	26	23			21
Basingstoke	London	74	48	17	0	65	76	65			42
Basingstoke	Reading	24	23	22	0	45	27	29			19
Bath	Swindon	47	28	26	0	54	60	46			27
Bath	Westbury	26	26	28	0	54	26	31			23
Bedford	Luton	31	23	15	0	38	30	32			16
Bedford	Milton Keynes	23	59	39	16	98	26	26	vslow	vslow	19
Birkenhead	Chester	24	34	25	0	59	29	25	vslow	vslow	24
Birmingham	Coventry	31	24	13	0	37	29	34			21
Blackburn	Bolton	21	29	31	0	60	21	24			18
Blackburn	Preston	19	22	26	0	48	17	20			18
Blackpool	Preston	27	25	20	0	45	30	28			23
Bolton	Manchester	16	18	10	0	28	23	23		fast	16
Bournemouth	Southampton	45	34	21	0	55	53	47			30
Bradford	Halifax	13	12	16	0	28	14	19	fast		12
Brighton	Crawley	35	40	24	17	64	36	29	slow		22
Bristol	Bath	18	15	14	0	29	21	25	fast	fast	13
Bristol	Bristol Parkway	10	12	28	0	40	11	14			9
Bristol Parkway	Swindon	55	27	38	0	65	60	43			27
Burnley	Blackburn	18	17	41	0	58	19	16		slow	16
Cambridge	Bedford	42	142	24	78	166	46	44	vslow	vslow	30
Cambridge	Harlow	51	47	26	0	73	62	46			37
Canterbury	Chatham	43	44	26	1	70	47	36			32
Cardiff	Newport	18	14	13	0	27	21	22	fast	fast	14
Carlisle	Newcastle upon Tyne	98	85	40	0	125	96	84			65
Carlisle	Preston	145	84	37	0	121	144	95			67
Chatham	Gravesend	13	19	25	0	44	15	18			13
Chelmsford	London	47	34	12	0	46	57	63	fast	vfast	33
Cheltenham	Birmingham	72	44	31	0	75	83	65			42
Cheltenham	Gloucester	10	9	27	0	36	15	16	vfast		9
Chester	Crewe	34	23	30	0	53	38	36			23
Colchester	Chelmsford	34	23	18	0	41	38	28			22
Coventry	Leamington	14	16	40	0	56	15	16		slow	13
Coventry	Northampton	48	34	33	0	67	54	42			30
Crawley	Croydon	32	32	20	1	52	35	32			18
Crewe	Shrewsbury	51	37	33	0	70	58	58			32
Crewe	Stafford	39	23	24	0	47	48	32			18
Crewe	Stoke-on-Trent	24	26	39	1	65	25	21		slow	20
Croydon	London	16	15	6	0	21	17	32	vfast	vfast	15
Darlington	York	71	30	23	0	53	89	67	vfast	fast	28
Derby	Birmingham	66	46	23	0	69	68	55			34
Derby	Leicester	47	29	28	0	57	47	39			23
Doncaster	Peterborough	127	53	31	0	84	144	97			48
Doncaster	Sheffield	29	33	21	0	54	35	28			21
Dundee	Edinburgh	95	81	35	0	116	98	73			62
Dundee	Perth	34	23	38	0	61	35	28			22
Edinburgh	Carlisle	164	92	83	0	175	124	124			74

Edinburgh	Newcastle upon Tyne	200	89	36	0	125	170	160			86
Ely	Cambridge	23	16	25	0	41	25	28	fast		16
Ely	Ipswich	80	75	54	7	129	83	65		slow	55
Ely	Norwich	85	56	46	0	102	96	88			56
Exeter	Salisbury	142	112	51	4	163	150	123			85
Exeter	Taunton	48	28	28	0	56	55	43			23
Falkirk	Edinburgh	40	28	14	0	42	42	37			27
Falkirk	Glasgow	34	21	15	0	36	41	32			21
Glasgow	Carlisle	164	93	51	0	144	154	102			72
Gloucester	Bristol Parkway	50	36	39	1	75	50	39			30
Gloucester	Swindon	58	49	44	1	93	52	50			42
Gravesend	London	35	47	16	0	63	42	54			32
Grimsby	Lincoln	69	53	68	0	121	59	55		slow	43
Grimsby	Scunthorpe	40	34	44	0	78	45	34		slow	27
Guildford	Crawley	48	62	32	19	94	45	41	slow	slow	33
Guildford	London	45	37	17	0	54	48	48			31
Halifax	Burnley	34	31	41	0	72	36	38			28
Halifax	Rochdale	35	37	27	0	64	35	28			27
Harlow	London	35	35	15	0	50	44	54			32
Harrogate	Leeds	29	36	24	0	60	26	34			25
Harrogate	York	32	35	36	0	71	35	37			24
Huddersfield	Manchester	40	36	16	0	52	45	37			30
Hull	Doncaster	64	58	39	0	97	75	54			43
Hull	Leeds	82	63	43	0	106	96	69			56
Inverness	Aberdeen	174	138	59	0	197	170	159			102
Inverness	Perth	190	135	72	0	207	183	164			108
Ipswich	Colchester	27	19	19	0	38	28	23			19
King's Lynn	Ely	42	31	36	0	67	47	44			28
Leamington	Oxford	68	42	35	0	77	75	54			37
Leeds	Bradford	14	21	13	0	34	15	19			13
Leeds	Huddersfield	26	26	16	0	42	33	27			20
Leicester	Bedford	79	46	39	0	85	83	78			36
Leicester	Birmingham	64	56	28	0	84	73	56			50
Leicester	Coventry	45	48	46	4	94	43	40		slow	36
Leicester	Northampton	59	105	38	35	143	63	48	vslow	vslow	36
Leicester	Peterborough	84	60	42	0	102	70	67			51
Lincoln	Nottingham	53	55	35	0	90	63	58			41
Liverpool	Crewe	56	44	29	0	73	78	60			36
Liverpool	Manchester	50	48	21	0	69	55	45			36
Luton	London	48	30	14	0	44	56	51		fast	25
Maidstone	London	60	57	25	0	82	61	64			39
Mansfield	Nottingham	27	33	36	0	69	24	26		slow	24
Middlesbrough	Darlington	24	26	27	0	53	24	21			20
Middlesbrough	York	80	61	36	3	97	79	67			52
Milton Keynes	Oxford	59	115	48	39	163	63	58	vslow	vslow	37
Milton Keynes	Watford	51	33	17	0	50	64	43			23
Newcastle upon Tyne	Darlington	58	34	21	0	55	58	43			28
Newcastle upon Tyne	Sunderland	19	23	15	0	38	18	22			14
Newport	Bristol	42	33	27	0	60	50	41			27
Newport	Bristol Parkway	34	21	36	0	57	43	33			21
Northampton	Milton Keynes	26	17	19	0	36	32	23			11
Norwich	Ipswich	74	40	30	0	70	71	66			40
Nottingham	Derby	24	25	23	0	48	25	22			19
Nottingham	Leicester	43	30	19	0	49	42	40			28
Oxford	Reading	43	29	20	0	49	42	44			25
Oxford	Swindon	55	40	35	6	75	49	47			26
Paisley	Ayr	55	42	24	0	66	49	49			37
Paisley	Glasgow	11	12	9	0	21	14	11		fast	11
Perth	Edinburgh	64	85	48	5	133	68	51	vslow	vslow	43
Perth	Glasgow	100	65	34	0	99	103	74			56
Peterborough	Ely	48	34	27	0	61	53	55			32
Peterborough	Stevenage	77	41	28	0	69	87	60			41
Plymouth	Exeter	84	63	30	0	93	71	57			53

Portsmouth	Brighton	71	84	29	6	113	87	70	slow		53
Portsmouth	Guildford	69	56	22	0	78	74	59			47
Preston	Bolton	32	29	21	0	50	37	31			22
Preston	Liverpool	45	60	31	3	91	58	47	slow		32
Preston	Wigan	24	17	31	0	48	30	28	fast		13
Reading	Guildford	40	40	23	0	63	44	43			31
Reading	London	56	28	12	0	40	66	56	fast	vfast	25
Rochdale	Manchester	16	19	16	0	35	22	22			15
Salisbury	Basingstoke	56	40	32	0	72	64	48			36
Salisbury	Southampton	39	32	31	0	63	38	36			30
Scunthorpe	Doncaster	37	32	30	0	62	44	34			27
Sheffield	Derby	58	38	28	0	66	75	58			30
Sheffield	Mansfield	48	94	40	19	134	50	39	vslow	vslow	31
Sheffield	Stockport	58	42	27	0	69	62	58			35
Shrewsbury	Wolverhampton	47	42	28	0	70	52	44			39
Southampton	Basingstoke	50	37	22	1	59	51	38			32
Southampton	Portsmouth	29	46	26	2	72	32	29	slow	slow	29
Southend-on-Sea	London	56	53	12	0	65	69	71			42
Stafford	Northampton	113	89	41	32	130	129	89			46
Stafford	Wolverhampton	24	17	20	0	37	29	27	fast		15
Stevenage	London	43	29	18	0	47	52	48			28
Stockport	Crewe	40	35	24	0	59	55	42			24
Stockport	Manchester	8	10	7	0	17	10	13	fast	vfast	7
Stockport	Stoke-on-Trent	51	35	26	0	61	70	49			24
Stoke-on-Trent	Derby	58	48	42	0	90	58	47			42
Stoke-on-Trent	Stafford	26	23	31	0	54	28	19			15
Sunderland	Middlesbrough	55	56	43	0	99	48	39	slow	slow	37
Swansea	Cardiff	76	56	33	0	89	67	50			47
Swindon	Reading	66	30	21	0	51	67	51			27
Taunton	Bristol	71	41	31	0	72	82	57			32
Taunton	Westbury	76	52	51	6	103	82	78			38
Wakefield	Barnsley	18	17	30	0	47	21	17			16
Wakefield	Doncaster	31	22	28	0	50	33	33			22
Wakefield	Leeds	16	17	17	0	34	17	18			13
Walsall	Birmingham	18	24	19	0	43	17	19			16
Warrington	Crewe	39	23	40	0	63	45	37			18
Watford	London	27	21	13	0	34	33	36	fast	vfast	16
Westbury	Reading	95	61	52	5	113	122	91			52
Westbury	Salisbury	39	29	37	0	66	44	42			28
Wigan	Warrington	18	12	37	0	49	22	20	fast		11
Wolverhampton	Birmingham	19	20	9	0	29	28	28		vfast	17
Wolverhampton	Walsall	10	14	32	0	46	11	15			10
Worcester	Birmingham	40	47	28	0	75	52	44			33
Worcester	Cheltenham	35	24	57	0	81	40	30		slow	22
York	Doncaster	51	24	37	0	61	69	50	vfast		23
York	Leeds	40	29	18	0	47	43	41			24

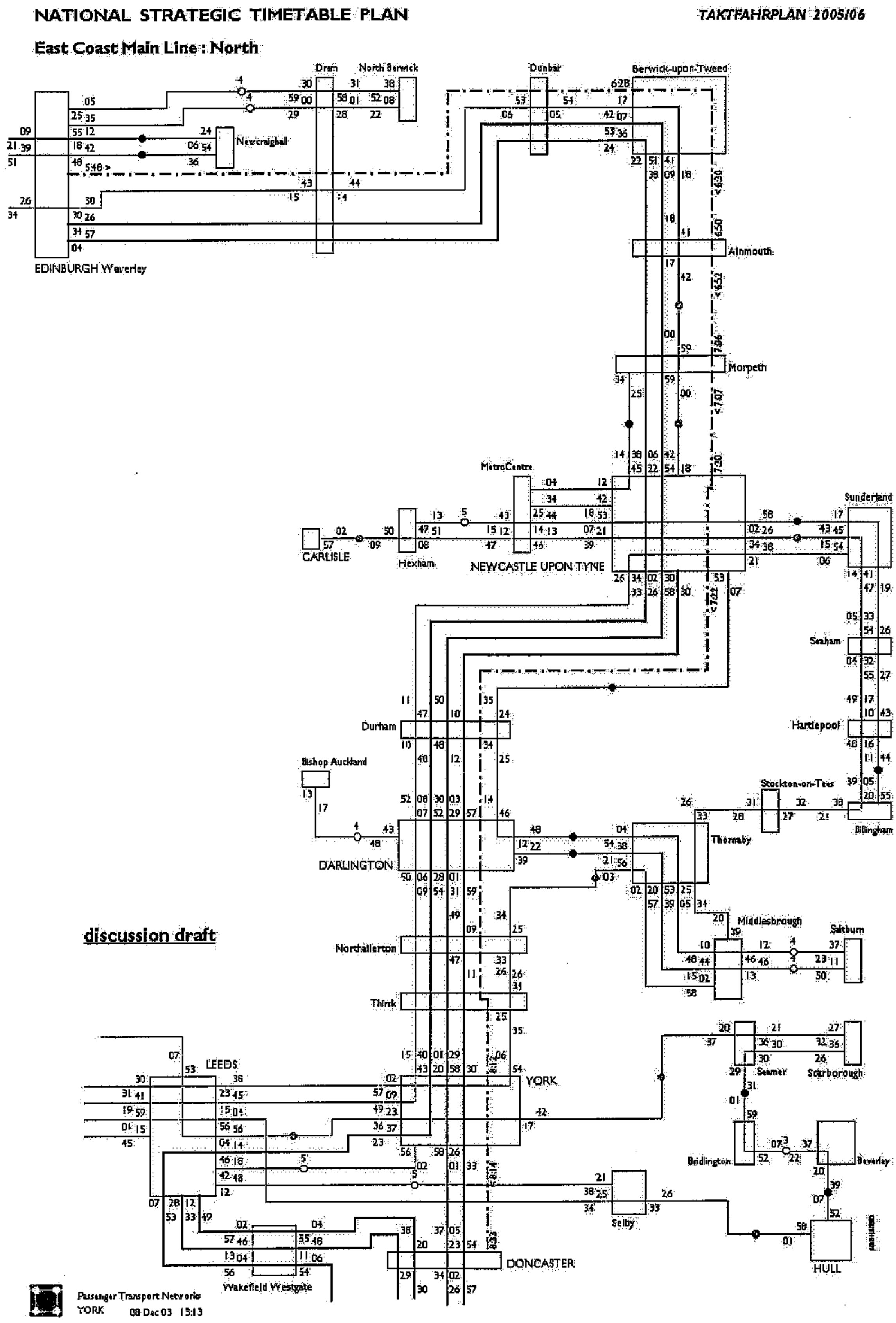
Appendix 2

Train-graph, Newcastle upon Tyne ...Loversall Carr Junction



Appendix 3

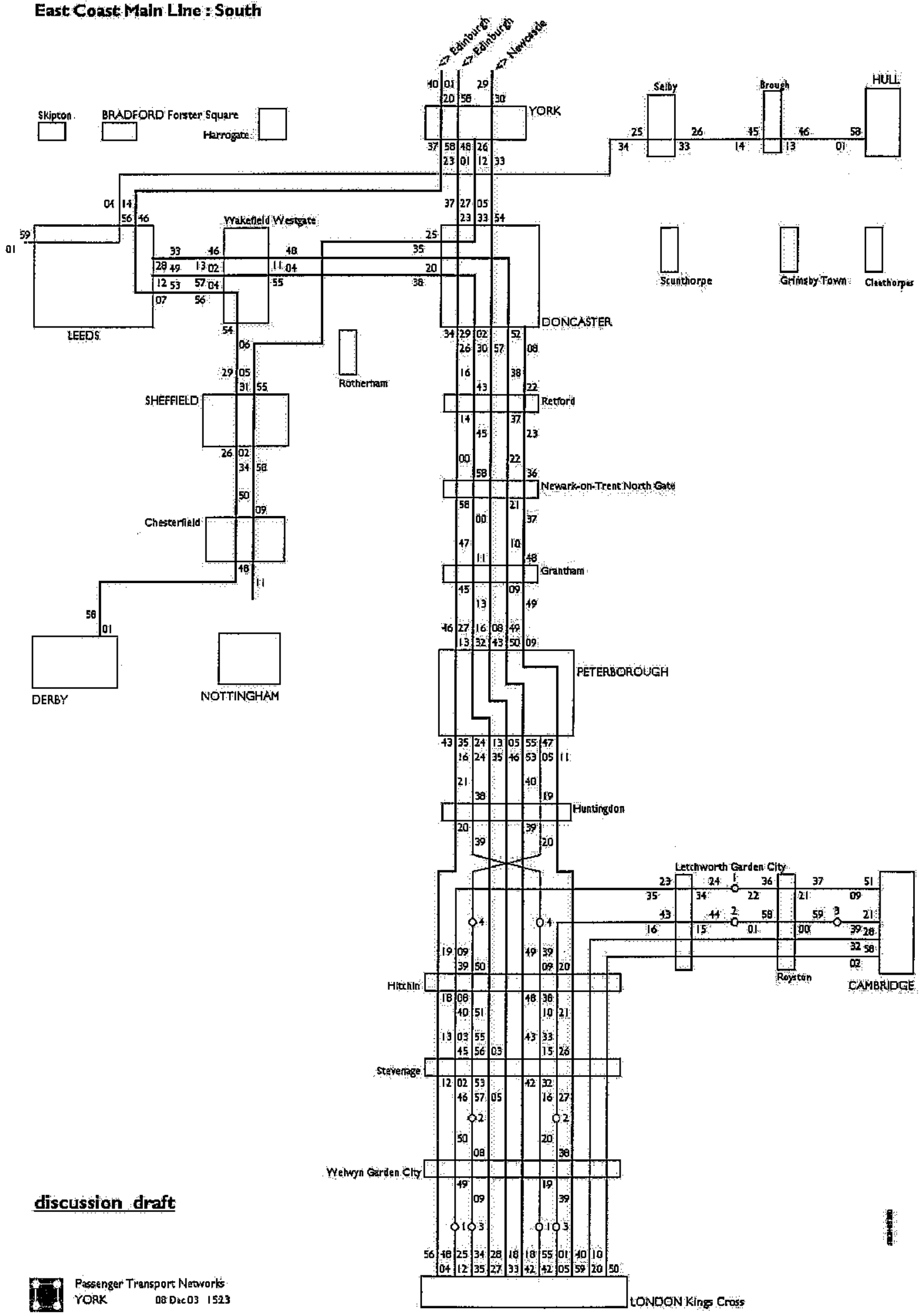
Netgraphs of the East Coast Main Line *Taktfahrplan*



NATIONAL STRATEGIC TIMETABLE PLAN

TAKTFAHRPLAN 2005/06

East Coast Main Line : South



discussion draft

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