Traffic engineering and control before the motor vehicle

Fig 1. Islington Turnpike in 1819.

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One of the earliest enactments for traffic control was a proclamation of Charles I in 1635 prohibiting the use of hackney coaches in London and its vicinity, unless the passenger was travelling at least three miles out of town. The owner of a coach was also required to maintain four good horses for the King's use. In the two years preceding this edict, there had been so great an increase in the number of hackneys that the streets were 'pestered' with them and the pavements broken up. One contemporary account suggests that the proclamation had the effect of reducing their numbers from 6 000 to 60, although in the following year their numbers appear to have increased to 600.

In 1722, a determined effort was made to control traffic on London Bridge. The order of the Lord Mayor's Court read:

> This Court being very sensible of the great inconveniences and mischiefs which happen by the disorderly leading and driving of cars, carts, coaches and other carriages over London Bridge, whereby the common passage there is much obstructed, doth straightly order and enjoin that three sufficient and able persons be appointed and constantly maintained; one by the Governors of Christ's Hospital, one by the inhabitants of the Ward of the Bridge within, and the other by the Bridge Masters; which three persons are to give their diligent and daily attendance at each end of the bridge, and by all good means to hinder and prevent the said inconveniences, and for that purpose to direct and take care that all carts, coaches and other carriages coming out of Southwark into the City, do all keep along the west side of the bridge, and all carts, coaches and other carriages going out of this city do all keep along the east side of the said bridge, and that no carman be suffered to stand across the bridge to load or unload, and that they shall apprehend all such who shall be refractory or offend therein and carry them before some of His Majesty's Justices of the Peace . . . to be dealt with according to Law. And further . . . that the Toll Collector . . . shall take care that duties be collected without making a stay of the carts for which the same shall be paid.

At this early date it is interesting to note the appointment of traffic controllers and the direction of traffic to the left. A car was 'a small carriage of burden, usually drawn by one horse or two'. There were few general traffic regulations. Weights of loaded carts and waggons were controlled to some extent by a limit on the number of horses drawing and, in London, by a wheel width restriction as well. General driving controls were introduced as traffic increased and by 1772 a driver was required to have physical control over his horses and to keep to the left when making way for another vehicle. From 1822 onwards, children under 13 years of age were prohibited from driving.

Towards the end of the 18th century the national main-road network of 'turnpikes' was, by and large, in a ruinous and dangerous state. Efforts were made to preserve and improve the roads by regulating the weight, tyre breadth and draught of vehicles. Broad wheels were encouraged by means of toll concessions; narrow wheels were penalised. Weighing-engines were erected and heavy penalties charged for overweight vehicles. The extent to which these measures were effectual can be assessed from a contemporary description of roads. R. L. Edgeworth wrote in 1813[1]:

> I have visited England, and have found, on a journey of many hundred miles, scarcely twenty of well-made road. In many parts of the country, and especially near London, the roads are in a shameful condition; and the pavement of London is utterly unworthy of a great metropolis.

Table I shows details of the various categories of traffic by wheel-breadth in 1809. The coach wheel was exempt from the turnpike weight regulations and transmitted damaging pressures to the road. By 1822, the few cumbersome vehicles built with 16-in. broad wheels had disappeared from the road.

Turnpike Trusts were empowered to erect direction posts and stones, town name signs, graduated stones alongside roads liable to flooding and milestones. Waggons and coaches used for hire were required to have the Christian name and surname of the owner painted on 'in large legible letters' for 'the better discovery of offenders'. At toll-gates the collector was required to exhibit his name and a list of tolls.

The view of Islington Turnpike[2] (Fig 1) depicts a fairly typical London turnpike scene in 1819. This establishment with its well-positioned octagonal toll-houses and a weighing-machine was built about 1808 for £700. It was situated on the Great North Road near the junction of Liverpool Road and Upper Street and considered to form 'a very handsome entrance into the village'. The gates were almost certainly painted white and were well illuminated at night by the central lamps. The traffic consisted of a stage-coach, possibly a short-stage precursor of the omnibus; a horse-back rider, presumably paying toll; a two-horse carriage and cattle heading for Smithfield Market. Many cattle passed through this gate. In 1757, the annual cattle-traffic volume was 30 952 oxen and 200 180 sheep.

Cattle featured prominently on the roads before the development of railways and the saving in cattle driving time was used as an economic justification for road proposals.

TABLE I. *Weight, horse-power and wheels of vehicles on common roads, 1809*[3]

Breadth of wheel	*Gross weight*	*Number of horses*	*Draught of each horse*	*Weight on the road per wheel*	*Pressure per inch of width*
inches	tons		cwt. lb.	cwt.	lb.
16	8	10	16 0	40	280
9, rolling 16	6·5	8	16 42	32·5	404
9	6	8	15 0	30	373
6, rolling 11	5·5	6	18 37	27·5	513
6	4·5	6	16 0	22·5	420
3	3·5	4	17 56	17·5	653
2 stage coach	4	4	20 0	20	1 120

Engineering for traffic

The engineer Thomas Telford was one of the pioneers of 'engineering' for traffic as distinct from the carriageway improvements of Macadam and others. From about 1815 onwards, the lines, levels and construction of Telford's roads were specifically designed to reduce the tractive effort required for drawing vehicles, combined with a

Fig 2. Telford's proposed Birmingham Improvement of 1820.

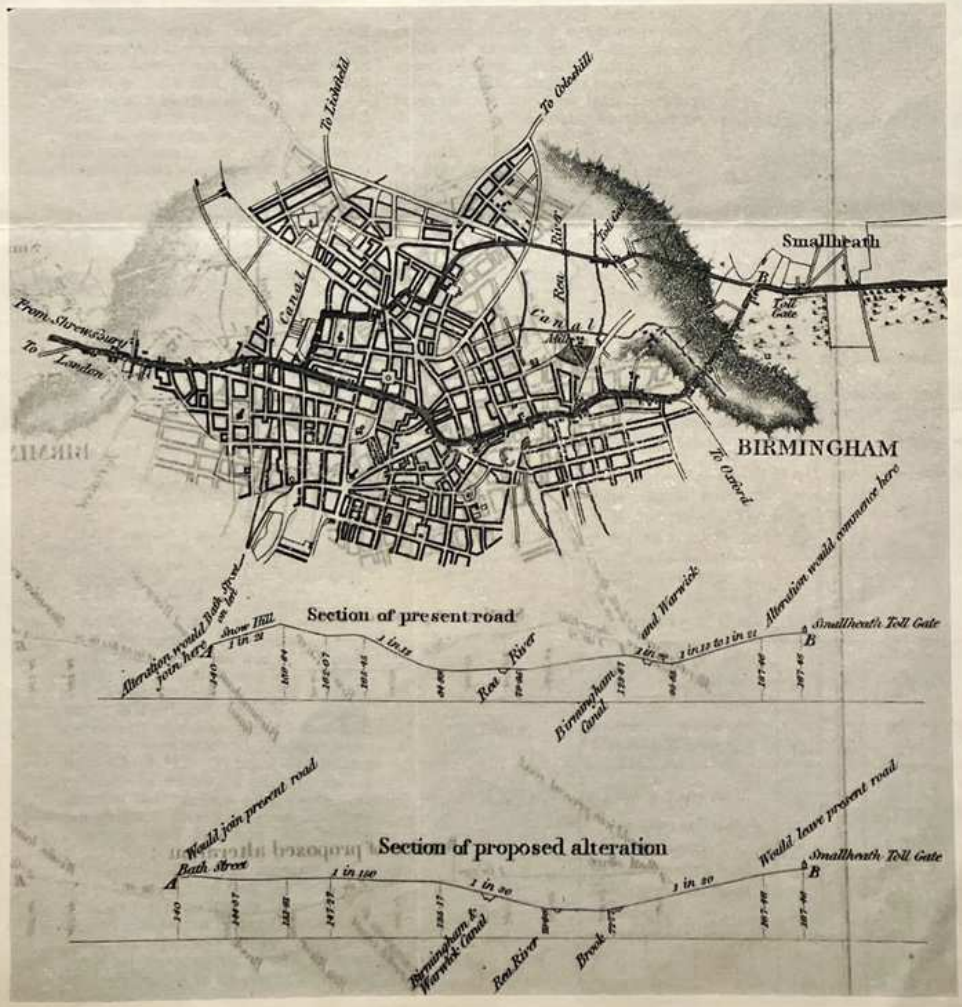

TABLE II. *Macneill's dynamometer/expense table*[5]

Length	*Rates of inclination*	*Expense*
feet		pence
130	Horizontal	0·5360
300 rise	1 in 78	1·3950
200 rise	1 in 78	0·9300
300 fall	1 in 42	0·9255
	Expense of one ton	78·4023
	Expense of one ton in the contrary direction	85·7272
	Mean expense of one ton	82·0647

TABLE III. *Cost/benefit abstract of Stowe Hill Valley Improvement proposals*[5]

No. of Plan	*Estimate*	*Saving in horse labour*	*Saving to the public*	*Loss to the public*
1	£23 757 10s	£30 310 10s	£6 553 0s	—
2	£28 890 0s	£16 394 0s	—	£12 496 0s
3	£20 144 0s	£18 483 0s	—	£1 661 0s
4	£14 171 0s	£11 420 0s	—	£2 751 0s
5	£19 607 0s	£25 815 0s	£5 208 0s	—

shortening of the route wherever practicable.

Figure 2[3] shows Telford's proposed Birmingham Improvement of 1820. The existing line of road had gradients of 1 in 21 at Snow Hill, 1 in 13 at the Bull Ring and 1 in 18 elsewhere. The proposed line A-B to the north re-routed traffic along Belmont Street and via a new road across the fields to Small Heath toll-bar with a maximum gradient of 1 in 30.

In the following decades, the reduction of the tractive effort required to draw vehicles, by decreasing gradients and road friction to a minimum practicable level, was a principal design consideration for engineers. On a good, level turnpike road, a horse with a force of traction of 100 lb could draw about 1 800 lb at 2·5 mile/h for 11·5 hours a day. For anatomical reasons the power of a horse decreases disproportionately with increase in gradient. On a gradient of 1 in 44 a horse can only draw three-quarters as much as on the level, on a slope of 1 in 24, half as much and on a slope of 1 in 10, only one-quarter as much. The American engineer W. M. Gillespie wrote in 1847[4]:

> As a general rule the horizontal length of a road may be advantageously increased, to avoid an ascent, by at least 20 times the perpendicular height which is to be thus saved.

Road/vehicle friction was measured by a dynamometer attached to carriage shafts. John Macneill, one of Telford's engineers on the Holyhead Road, improved this device to give steadier readings and used it to provide data for economic assessment on the proposed Stowe Hill Valley Improvement in Northamptonshire about 1830. From dynamometer readings he calculated the expense of drawing one ton by a stage-coach over the existing four-mile route in both directions and tabulated his results in the form of Table II.

Using a daily traffic tonnage and a five per cent interest rate, Macneill then calculated his saving in horse labour for five competing proposals and compared the results with his estimates. Table III showing his general abstract indicates Plan 1 to be the most economic proposition.

Work on road/vehicle friction continued and in 1843 A. J. Morin published the results of a comprehensive series of experiments. Some of his more important results are given in Table IV. The fractions represent the proportion of the total load necessary as a force of draught to overcome friction.

These results emphasise the scope for improving roads, the importance of maintenance and the considerable influence of vehicle type on the degree of friction. These and similar figures were used in feasibility studies about 1850. Annual tonnages were calculated from classified traffic counts taken at times of 'average activity'. The work required to overcome friction and gravity expressed in horse/days per annum was calculated for alternative schemes and quantified in monetary terms. A scheme was considered viable if the annual saving was greater than the current borrowing rate percentage of the capital cost.

Traffic in towns

The first omnibuses replaced short-stage coaches in the London streets in the late 1820s and grew rapidly in popularity. In the following decades the railways superseded the turnpike roads and generated more traffic in towns.

By 1856 the amount of traffic in town streets, particularly in London, had increased tremendously. The number of vehicles passing through the Islington Gate in 24 hours on June 26 was 2 792. The traffic composition for this count is shown in Fig 3.

Fig 3. Composition of a 2 792-vehicle traffic count made in Islington Gate in June 1856.

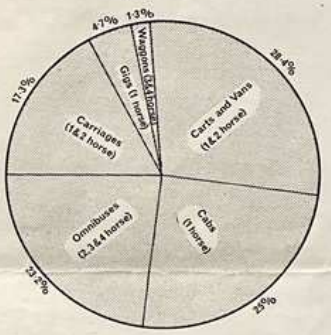

TABLE IV. *Morin's road/vehicle friction constants*[4]

CHARACTER OF THE ROAD.	CHARACTER OF THE VEHICLE. Carts.	Trucks (of 3½ tons.)	Diligences (of five tons.)		Carriages with seats hung on springs.	
New road, covered with gravel five inches thick,	1/13	1/9	1/4		1/8	
Solid causeway of earth, covered with gravel 1½ in. thick,	1/18	1/11	1/18		1/18	
Causeway of earth in very good condition,	1/11	1/16	1/30		1/30	
Oaken platform,	1/18	1/18	1/11		1/13	
Broken-stone road.			Walk.	Trot.	Walk.	Trot.
Very dry and smooth,	1/13	1/14	1/18	1/11	1/18	1/13
Moist or dusty,	1/13	1/13	1/14	1/11	1/13	1/11
With ruts and mud,	1/13	1/14	1/11	1/18	1/13	1/18
Deep ruts and thick mud,	1/18	1/14	1/13	1/18	1/13	1/18
Pavement, dry,	1/18	1/13	1/11	1/16	1/18	1/30
Pavement, muddy,	1/18	1/16	1/14	1/13	1/14	1/24

The proportions of the various types of vehicle can be considered as fairly typical for London traffic. Horse-drawn omnibuses and cabs accounted for about half the traffic and commercial vehicles for a further 30 per cent. A few years later, the City Surveyor conducted 12-hour traffic surveys in 24 of the main London streets, recording the type of conveyance and number of horses. From his findings two tides were quantified, one at 11 a.m. when there were very nearly twice as many vehicles as at 9 a.m., and the other at 5 p.m. when the flow was slightly in excess of that at 11 a.m. The 12-hour daily flow was in excess of 125 000 vehicles for the 24 streets. Allowing for the fact that many of these vehicles were counted more than once, a contemporary estimate put the total amount of city traffic at about 60 000 vehicles. The locations of the survey stations and number of vehicles passing are given in Table V.

In the 1860s, as horse trams were added to the crowded city streets, neglected inter-town turnpikes were taken over by Local Authorities. It is rather ironic that in 1895, the year in which the last turnpike came to an end, the first motor cars appeared on British roads, marking the beginning of an era which required the resurrection of many of the former turnpike roads as the basis of the modern trunk road system.

TABLE V. *Return showing the total number of vehicles passing through the principal London streets between 9.00 a.m. and 9.00 p.m. (c. 1860)*

Lower Thames Street, by Botolph Lane	1 380	Bishopgate Street Within, by Great St Helen's	4 842
Threadneedle Street	2 150	Cornhill, by the Royal Exchange	4 916
Lombard Street, by Birchin Lane	2 228	Blackfriars Bridge	5 262
Upper Thames Street in rear of Queen Street	2 331	Leadenhall Street, in rear of the East India House	5 930
Aldersgate Street, by Fann Street	2 590	Newgate Street, by Old Bailey	6 375
Tower Street, by Mark Lane	2 890	Ludgate Hill, by Pilgrim Street	6 829
Smithfield Bars	3 108	Holborn Hill, by St Andrew's Church	6 906
Fenchurch Street	3 642	Temple Bar gate	7 741
Eastcheap, by Philpot Lane	4 102	Poultry, by the Mansion House	10 274
Bishopgate Street Without, by City Boundary	4 110	Cheapside, by Foster Lane	11 053
Finsbury Pavement, by South Place	4 460	London Bridge	13 099
Aldgate High Street, by City Boundary	4 754	TOTAL	125 859

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[2]PUGIN, A. WELBY. Select views in Islington, 1819.

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