An unlikely achievement: the development of the edge railway for general freight and passengers

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1. The plateway in railway history

About 30 years after the first iron strips were nailed to wooden rails at the Coalbrookdale Ironworks in 1767, two types of rail were being manufactured in ironworks in Britain. The T-shaped edge rail, which developed into the rail used on modern railways, was designed to support vehicles with flanged wheels. The L-shaped plateway, flanged on the inside of the rail, could be used by vehicles with plain wheels.

Most historians who describe the development of the railway devote a sentence or two to the plateway, or omit it entirely, generally beginning the history of the railway with the Liverpool & Manchester Railway or its precursor, the Stockton & Darlington; it is not uncommon for historians to imply that the technology of the railway does not predate these lines.[1] When the plateway is given more consideration in railway histories it is generally portrayed as either a dead-end technology (e.g. 'a step in the wrong direction'[2]) or a precursor to the edge railway. In *The Railway Age*, for example, Michael Robbins states:

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[1]Jack Simmons, *The Railways of Britain* (London, 1986), Jack Simmons, *Railways of England and Wales, 1830-1914* (Leicester, 1978). Barrington Tatford, *The Story of British Railways* (London, 1946) traces the use of steam power back to ancient Greece, but does not describe the history of rails. The timeline in Frank Ferneyhough, *The History of Railways in Britain* (Reading, 1975) includes the Oystermouth Railway and the Surrey Iron Railway, but does not describe them as plateways; one sentence describes the Surrey Iron Railway's rail design. H. G. Lewin, *Early British Railways* (London, 1925) describes several lines laid before 1825 but does not mention that they were plateways. W. H. Boulton, *The Railways of Britain* (London, 1950) notes that the Surrey Iron Railway was a plateway, but mentions no others.
[2] C. R. Warn, *Waggonways and Early Railways of Northumberland* (Newcastle, 1976), p. 5.

> Another possibility had, however, to be tried and discarded; this was to restrain the sideways movement of vehicles by a raised lip or flange on the track itself…. But the railway was destined to develop with the edge-rail; and as iron rails designed to carry vehicles on their top sides were manufactured with increasing success, the plateway was seen to be a blind alley.[3]

W. M. Ackworth describes the natural transition from plateway to edge rail as follows:

> Originally the rails…were laid flat on the surface, and vehicles with ordinary wheels were free either to use the special track or to move at large over the whole width of the road. In the next stage of development, the rails were continuous iron plates with flanges on their outer edges to confine the wheels to the track proper. In the next stage, the rails were raised above the surface and the flange was transferred from the rails to the wheels…. Naturally, the railway forsook the public highway and was laid on land allocated to its sole use.[4]

A few historians have more carefully reviewed the history of the railway before 1830, including the development of the plateway. The plateway is mentioned in Bertram Baxter's *Stone Blocks and Iron Rails*, and in M.J.T. Lewis' *Early Wooden Railways*; the main focus of these books, however, is the wooden waggonways that preceded the development of iron rail.[5] Although Lewis describes the development of the plateway in detail, he also seems to consider its supersession technically inevitable:

> The plate rail proved a cul-de-sac in railway development. In spite of all the enthusiastic support it received from expert and amateur, it had serious defects. Its cross-section, with most of the metal thinly disposed in a flat plate and little strengthened by the vertical flange, was deplorably ill-equipped to carry heavy rolling weights. The wide running surface with its retaining flange might almost have been designed to catch and to hold the dirt kicked up by the horses' hooves, to the great increase of the friction on the wheels.[6]

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[3] Michael Robbins, *The Railway Age* (London, 1962), p. 4.
[4] W. M. Ackworth, *The Elements of Railway Economics* (Oxford, 1911), p. 5.
[5] Bertram Baxter, *Stone Blocks and Iron Rails* (Newton Abbot, 1966), M.J.T. Lewis, *Early Wooden Railways* (London, 1970).
[6] Lewis, *Early Wooden Railways*, p. 294.

A few books published within the last few years address the history of specific plateways--John van Laun's *Early Limestone Railways*, Stephen Hughes' *Brecon Valley Tramroads*, and Gordon Rattenbury and M.J.T. Lewis' *Merthyr Tydfil Tramroads and their Locomotives*.[7] These books, however, describe particular plateway systems in Wales; no historian has yet addressed the development of the system of plateways across England and Wales in the late 18th century, or examined the reasons behind the development and later abandonment of the technology.

This lack of information and lack of interest obscures three important facts about the plateway. First, between the production of the first iron plateways in 1787[8] and John Birkenshaw's patent for malleable iron edge rail in 1820[9] more than 1,500 miles of plateway were laid in Britain,[10] not only in Wales but in the Midlands, the southeast, and the southwest; in fact, by the 1820s, although some edge rail lines had been built in Devon, Cornwall, North Wales, part of Lancashire, and a few other places, plateways were the dominant form of rail technology everywhere such systems existed except in the Tyneside coal mining area.[11] Even in this region plateways were commonly used underground in coal

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[7] E.g. John van Laun, *Early Limestone Railways* (London 2001); Stephen Hughes, *The archaeology of an early railway system: the Brecon Forest tramroads* (Aberystwyth,1990); Gordon Rattenbury and M. J. T. Lewis, *Merthyr Tydfil Tramroads and their Locomotives* (Oxford, 2004); Andy Guy and Jim Rees (eds.), *Early Railways* (London, 2001); M.J.T. Lewis (ed.), *Early Railways 2*.
[8] Lewis, *Early Wooden Railways*, p. 317.
[9] Lewis, *Early Wooden Railways*, p. 294.
[10] Baxter, *Stone Blocks and Iron Rails*, p. 15.
[11] Lewis, *Early Wooden Railways*, p. 293.

mines, and a plateway was laid in 1808 at Wylam Colliery, where George Stephenson experimented with steam locomotives.[12]

By 1811 a report to the Board of Agriculture on Iron Railways in Monmouthshire could state: 'The old rail-road is exploded, except that where the rails and waggons remain undecayed, the use of them is continued; but there are no new ones made upon that plan, a decided preference being given to the modern invention of tram-plates'.[13] In 1817 John Farey could identify plateways as a more advanced form of technology than wooden 'Newcastle waggonways' with flange-wheeled vehicles: 'In the use of these wooden Rail-ways, the flanch or projecting rib for keeping the Waggon on the Railway, was on the wheel; but now the flanches of iron Rail-ways are almost universally cast on the bars, and the wheels are plain, by which they are fitted for being occasionally drawn off the Rails on common Roads.'[14]

Second, far from disappearing after the availability of malleable iron rail ushered in the 'railway age', plateways continued to be both laid and used well into the 20th century. The Gloucester & Cheltenham Tramroad, for example, remained a plateway, operating steam locomotives, until 1861;[15] Lewis and others report that some plateways continued to be used in England and Wales until the 1960s.[16]

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[12] Northumberland Record Office, 3410/Bud/15/224, John Buddle record book.
[13] Charles E. Lee, *The Evolution of Railways* (London, 1943), p. 73.
[14] C. F. Dendy Marshall, *A History of British Railways Down to the Year 1830* (London, 1938), p. 43.
[15] David Ewart Bick, *The Gloucester & Cheltenham Tramroad and the Leckhampton Quarry Lines* (Oxford, 1987), p. 39.

Finally, the conventional explanation for the abandonment of plateway technology in favour of edge rail is not substantiated by the opinions of engineers and railway builders of the period. Historians attribute the demise of the plateway to its technical inferiority to edge rail. Robbins suggests that one reason the plateway was a technological failure was the difficulty in designing points to direct vehicle wheels;[17] in general, however, the plateway is described as having two fatal technical flaws. First, the L-shaped section did not use iron efficiently, and was unable to support the weight of steam locomotives on its thin bearing surface; second, plateway surfaces collected dirt and stones which hindered the passage of vehicle wheels and increased the friction between wheels and rail.

It appears, however, that as late as the early 1820s such opinions would not have been substantiated by contemporary railway builders. During this period several prominent engineers advocated plateways over edge rails. Plateways were less expensive than edge rails, and quicker and easier to lay; they could more readily be used in place of canals, or laid to quarries or collieries that may be worked out in a few years and then moved to another location. Not only were the plates themselves lighter and therefore less expensive, vehicle wheels could be lighter, and thus vehicles could be lighter and less expensive, as well as more versatile. Barrie Trinder also theorises that Curr's presentation of plateways as a system of

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[16] See Michael Lewis and Barrie Trinder in M.J.T. Lewis (ed.), *Early Railways 2*, and David Wilmott in Andy Guy and Jim Rees (eds.), *Early Railways*. A few delegates at Early Railways 3 claimed that commercial plateways are still operating in Britain.
[17] Robbins, *The Railway Age,* p. 12.

ready-made standardised parts, easily assembled into a system, was attractive to buyers.[18]

The argument that plateways could not support heavy loads, particularly that of steam locomotives, seems less plausible when considering that several locomotives were employed on plateways during the first half of the 19th century, and that the first successful locomotive was in fact operated on a plateway. Additionally, at that time locomotives were too heavy for edge rail as well, and several colliery owners found them uneconomical to operate on edge railways due to high track maintenance costs. William Chapman, for example, mentions that '[t]his circumstance [the high cost of horses, hay and corn] was the cause of their introduction, but they have not been universally persevered in….', mentioning that Mr. Williams of Coxlodge Colliery had invested in locomotives but reverted to horses after realising that locomotive operation involved expensive track maintenance.[19] Thomas Telford mentions in a letter of 1827 that '[a]t some collieries near Newcastle, they have been laid aside, and recourse had again to horses'.[20]

It is easy to see how historians have missed evidence for the predominance and longevity of plateways. Confusion in terms in contemporary documents makes it difficult for a cursory historical study to distinguish between plateways and edge railways. Before the development of iron railways, the wooden rails that carried

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18 Barrie Trinder, 'Recent research in early Shropshire railways', in M.J.T. Lewis (ed.), *Early railways 2*, p. 17.
19 PRO, RAIL 509/22, William Chapman, *Report on the Cost and Separate Advantages of a Ship Canal and of a Railway, from Newcastle to Carlisle*, 10 May 1824, p. 12.
20 Institution of Civil Engineers, London, Thomas Telford papers, T/MT1, 1827, p. 6.

carts with flanged wheels were called waggonways in northeastern England and railways or railroads in the rest of the country; when cast iron rails began to replace wooden ones, contemporary documents referred indiscriminately to 'railways or tramroads,' making no consistent distinction based on type of rail.[21]

Baxter points out that the word tramroad (or dramroad in Wales) was sometimes used after 1790 to describe a plateway, but the word railroad was commonly used as an operational term regardless of the type of rail. John Curr used the word 'rail road' to describe his plateways.[22] Thomas Tredgold, for example, in his 1825 *Practical Treatise on Rail-roads and Carriages*, is clearly referring to plateways when he states that ‘the effect of a given power is not above half what it ought to be; and yet, the enormous increase of rail-roads in Wales, renders it evident that they receive some benefit from adopting this system of conveyance'.[23] Benjamin Outram, the most well-known and prolific designer of plateways, always referred to them as 'railways,'[24] and the Surrey Iron Railway, constructed in 1803, was a plateway. Conversely, however, the Stratford & Moreton Tramway, opened in 1826, was laid with edge rail.[25]

Later historians do not attempt to remedy this confusion; in his series of books on the canals of England, for example, Charles Hadfield uses the term 'tramroad' to

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[21] See, for example, Parliamentary acts, e.g. 1792 George IV cap. 102 p. 681, authorizing Monmouthshire Canal, also letters, e.g. PRO, RAIL 898/1 and 898/3, plans submitted to Parliament identifying 'railway or tramroad.'
[22] Charles E. Lee, 'Some railway facts and fallacies', *Transactions of the Newcomen Society* 33 (1960-1961).
[23] Tredgold, *A Practical Treatise on Rail-roads and Carriages,* p. 35.
[24] Schofield, *Benjamin Outram, 1764-1805*, p. 201.
[25] John Norris, *The Stratford & Moreton Tramway* (Guildford, 1987), p. 17.

refer to a horsedrawn railway, with no reference to the type of rail.[26] In one paragraph in *The Railway Age* Michael Robbins describes several rail lines laid with both edge rail and plate rail, confusing the words railway, tramroad and plateway, without distinguishing between the two technologies.[27] Later writers added to the confusion by adopting the word 'tramroad' to describe a system of horsedrawn (and later electrically powered) vehicles transporting passengers within cities.[28]

While the plateway itself has not yet received much historical consideration, many historians in recent years have begun to explore the area of technological choice, and technological 'failure.' In contrast to traditional railway history, this essay considers the development of plate and edge railway technologies as sociotechnical systems and views them in the context of technological choice, building on a body of work in the history of technology that explores 'failures' and alternatives to adopted technologies. Over the past several years, historians have begun to look beyond 'Whiggish' notions of an 'inevitable' evolutionary progression of technologies to path dependency and the importance of nontechnical factors in technological choices. For example, as early as 1965, Thomas Esper suggested that nontechnical factors (i.e. the composition and skill base of the English army) were more important than technical ones (i.e. the

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[26] Charles Hadfield, *Canals of the East Midlands* (2nd edn., Newton Abbot, 1970), p. 27.
[27] Robbins, *The Railway Age*, p. 12.
[28] See Lewis, *Early Wooden Railways*, pp. 135 and 256 for detailed discussions of etymology. To avoid confusion in this essay, I have used the word plateway to refer to L-shaped rail and edge rail, railway or waggonway to refer to T-shaped rail; in chapter 2 I refer to wooden rail lines as railways except in the Northeast, where I refer to them as waggonways. I have not, however, changed the wording in quotations from or references to primary or secondary sources; in these cases the word 'tramroad' generally refers to a plateway and 'railway' or 'waggonway' to edge rail, unless otherwise noted.

power, cost and effectiveness of a weapon) in the English army's decision to abandon the longbow for the musket in the 1590s.[29]

The idea of a sociotechnical system was introduced by Thomas P. Hughes in his landmark comparative study of the development of electrical power distribution, *Networks of Power*. In this book he described how personal and national style affected choices about the generation and distribution of electricity in Britain, America and Germany, resulting in different but equally technologically 'valid' solutions; using this case study Hughes demonstrated that 'technology is not necessarily a simple extrapolation of its past, or a working out of inherent technological implications'.[30] Staudenmeier defined what is now called path dependency, pointing out that in the early stages of development of a technological system individual goals and style exert great influence; with each decision, however, options narrow as decisions are to some degree based on the decisions made before.[31] Many historians have explored how this plays out in specific cases, as in, for example, the influence of the religious beliefs of steamship company directors on their technological and economic decisions and the prioritisation of capacity over safety in the choice of automatic train control systems.[32]

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[29] Thomas Esper, 'Replacement of the Longbow by Firearms in the English Army', *Technology and Culture* 6, 1965 , pp. 382-393.
[30] Thomas P. Hughes, *Networks of Power* (Baltimore, c1983), p. 286.
[31] John M. Staudenmeier, *Technology's Storytellers* (Cambridge, 1985), p. 160.
[32] Crosbie, Smith et al, 'Avoiding equally extravagance and parsimony: the moral economy of the ocean steamship', *Technology and Culture* 44 (3), July 2003, pp. 443-469; Geoffrey Channon, *Railways in Britain and the United States, 1830-1940* (Aldershot, 2001), p. 30.

Hughes, Wiebe Bijker and Trevor Pinch expanded on this idea in *The Social Construction of Technological Systems*, a collection of essays by themselves and others which address the development of several technologies including Bakelite and the safety bicycle.[33] Their model stresses the importance of understanding the people and groups whose choices establish the direction of technological development. These decisionmakers indirectly determine which technologies will be successful by choosing not only what factors they are evaluated by but also what 'problems' are significant enough to require technological 'solutions.' For example, the group that favoured bicycles with big wheels, because they prioritised speed, was ultimately less influential than the group that favoured smaller wheels because they prioritised safety; the wheel size of the safety bicycle was a result of negotiations between these and other groups rather than of technological necessity.

At some point the direction of technological development becomes 'stabilised' and the technology achieves 'closure'; after this point there is no further questioning of the nature of the problems or the correctness of the chosen solutions and the technology appears to develop autonomously. At this point a 'paradigm' has been developed--according to Constant, this is 'an accepted mode of technical operation, the usual means of accomplishing a technical task…the conventional system as defined and accepted by a relevant community of technological practitioners'.[34] The paradigm also dictates what set of formerly

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[33] Thomas P. Hughes, Trevor Pinch, and Weibe Bijker, eds. *The Social Construction of Technological Systems* (Cambridge, 1987).

[34] Edward W. Constant, 'The social locus of technological practice: Community, system, or organization?', in Thomas P. Hughes, Trevor Pinch, and Weibe Bijker, eds. *The Social Construction of Technological Systems* (Cambridge, 1987).

heterogeneous components make up the technology in question; according to Rammert these components are not only technological in nature but consist of 'people, machines and symbols'.[35] Once closure is achieved, as it appears to have been for rail shape by the early 1830s, it becomes difficult to even imagine another equally valid technological choice. In fact, after closure decisionmakers generally develop technical justifications for the chosen technology and technical explanations for the failure of the alternatives. Because Bijker et al. consider such technical justifications less explanatory than the makeup, outlook and influence of the decisionmakers that choose technologies, they consider that 'the success of an artifact is precisely what needs to be explained'.[36]

Such explorations of the mechanism of technological choice underlie recent interest in the subject of technological 'failures.' Most of these studies seem to assume that the critical decisionmaker is the consumer, and address technological failure in terms of consumer choice and product design.[37] Studies of, for example, video recorders and vehicles consider the role of cost, quality and consumer requirements and expectations in technological choice. Perhaps the most sophisticated exploration of this issue to date is Lipartito's consideration of the history of AT&T's Picturephone, introduced with great fanfare in 1964 and almost completely abandoned by 1978, in which he argues that explaining a technology's failure in terms of its inability to meet the needs of consumers is almost as tautological as explaining it in terms of technical inadequacy, implying

[35] Werner Rammert, 'New Rules of Sociological Method: Rethinking Technology Studies', *British Journal of Sociology* 48 (2), June 1997, pp. 171-191.
[36] Bijker et al., *The Social Construction of Technological Systems*, p. 24.
[37] see Kenneth Lipartito, 'Picturephone and the Information Age', *Technology and Culture* 44, January 2003, footnote 11, p. 54.

a model of 'social determinism' rather than Whiggish 'technological determinism.' He goes beyond both technical and commercial considerations to demonstrate that 'failures are not inherent in hardware but constructed by contingent social conditions'.[38]

More significantly to the structure of this essay, Lipartito goes beyond consideration of the hardware to examine the function and operation of a technological system. He highlights at several points that while the actual hardware of the Picturephone was a 'failure' it has turned out to be functionally and operationally similar to the methods of information transfer adopted over the past 20 years; in fact, the functional and operational requirements of the Picturephone system caused engineers to consider and construct the 'information infrastructure' necessary for the eventual development of the components of our current information transfer system.[39]

In the spirit of this kind of enquiry, this essay attempts to explain not the failure of the plateway but rather the success of the edge railway. In 1820 the plateway was clearly considered the most advanced form of rail transport, adopted by most experienced engineers for both new projects and renewals of existing bar and edge rail lines. The national system of railways projected by visionaries of the time was based on plateway technology. The only aboveground plateway in northeastern England, the only region in which plateways were uncommon, that of the Wylam colliery, was reportedly laid as a plateway in 1808 because the

[38] Kenneth Lipartito, 'Picturephone and the Information Age', *Technology and Culture* 44, January 2003, pp. 50-81, p. 52.

viewer, William Hedley, intended for it to be incorporated into a proposed Newcastle to Carlisle plateway, part of a projected national public railway system.[40] A decade later the construction of this national system had begun--but instead of plateways, designed and built by the designers of large transport projects across the nation, it was an edge rail system, evolved from traditional Newcastle wooden railways and designed by workers who learned their trade in Northeastern collieries. This essay attempts to explain the unlikely success of this technology and its proponents.

In this essay I suggest that technical explanations for the choice of edge over plate rail technology do not explain this choice, and look beyond them to the sociotechnical factors behind the decisions of engineers and canal and railway company directors in the 1820s. I demonstrate that the plateway was not a failure but rather a rational improvement on the traditional wooden railways for the transport of coal and general freight. However, its design and operation were based on a model of the British economy that by the turn of the 19th century had ceased to apply; the change from the operational model of the plateway and the canal system with which it was associated to that of the edge railway and the coal mining system where it originated was both a cause and effect of the changing structure of the British economy in the early 19th century.

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[39] Kenneth Lipartito, 'Picturephone and the Information Age', *Technology and Culture* 44, January 2003, footnote 11, p. 78.

[40] It appears that this line, surveyed by William Chapman in 1796, was planned as a plateway; in a letter to Sir James Graben of Kirkstall Chapman states that the railway can be used 'without any change *of the vehicle of conveyance'*, and in his *Report on the Cost and Separate Advantages of a Ship Canal and of a Railway, from Newcastle to Carlisle*, published in 1824, he describes a line 'on which, by a proper construction of the wheels, the carriages designed for that purpose, might also travel on streets, or high-roads.' (PRO RAIL 509/22; William Chapman, Newcastle, 5/10/1824, *Report on the Cost and Separate Advantages of a Ship Canal and of a Railway, from Newcastle to Carlisle*, p. 8.)

It may be that the railway historians who have considered the plateway are correct that it would eventually have been abandoned as its technical shortcomings became increasingly obvious, as rail vehicles grew heavier and faster over the course of the 19^{th} century. As indicated above, however, in the early 1820s when builders began to favour edge rail over plate rail there was no consensus among engineers on the technical merits of the two types of rail. Thus a technical explanation is not sufficient to explain builders' increasing preference of edge rail over plateway at that time. If a technical explanation of the demise of the plateway is insufficient, it is necessary to look elsewhere.

A possible explanation can be found in the difference in economic and operational arrangements between the two systems. Despite their superficial similarities, each type of rail was part of a distinct sociotechnical system. The edge railway evolved from the wooden waggonways in Northeast England that carried coal directly from collieries to staithes on the rivers Tyne and Wear. These waggonways were built and owned by individual colliers, and considered part of the equipment needed to mine and haul coal to rivers, from where it was transported by barge (keel) to seagoing vessels. They were built by colliery staff or by local 'waggonway wrights' who often contracted to maintain the lines, and were generally operated by colliery employees or contractors. Each colliery built and operated its own waggonway from its coal mines to its staithes; a single colliery owned all of the vehicles on the line and controlled its operation.

Plateways were also developed to move coal from collieries to water transport; they were generally built, however, in conjunction with canals and were often built by canal companies to increase canal traffic. A single plateway would often serve several freight generators, and might transport not only coal but also limestone, iron, and other raw materials and manufactured products. Methods of financing varied; they were built by canal companies, clients, or a combination of the two. They were often built by engineers who were also canal builders, accustomed to the design and construction of massive and complex engineering works and experienced in the management of large projects. Because these plateways served more than one client, and because they were generally built under the authority of canal acts, they were considered 'common carriers,' and anyone with the appropriate equipment who followed the byelaws was permitted free use of the line on payment of the correct toll. This connection between plateways and canals was noted by Charles E. Lee in 1943:

> Neither the canals nor their feeder railways were intended for the use of their owners' vehicles; both were looked upon as public toll highways available to all comers, and it is a fact of great significance that we find at this time our first certain records of flanged tram plates.[41]

There appear to be two reasons why the steam engine, invented and substantially developed in other parts of England, first became commercially viable on the edge rail systems of the Northeast. First, unlike plateways which were not constructed, owned and operated by a single entity, collieries already had in place a structure of labour that permitted easier adoption of locomotive technology. Workers were not only already familiar with stationary steam

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[41] Lee, *The Evolution of Railways*, p. 61.

engines, and had the skills to operate and maintain them, but also had in place job descriptions and labour hierarchies to operate and maintain them within the existing structure of the organisation. Many workers in the southwest, the Midlands and Wales were also experts in stationary steam engine technology; Trevithick himself, the inventor of the steam locomotive, picked up his skills as a mine engineer in Cornwall. However, these people were less directly associated with the operation of railways in these regions than colliery staff were with colliery waggonways.

More significantly, the highly capitalised and monopolistic transport system the Northeastern collieries had created allowed steam locomotives to be used continuously enough to make investment in them worthwhile. Locomotives were too expensive to be used intermittently by individuals, or even by one client on a multiuser plateway. Not only would a single client on a canal-based plateway not have enough goods to transport, but also the traffic on a multiuser line would not facilitate the free and continuous passage of locomotive goods trains.

The Stockton & Darlington Railway, opened in 1825, shares many physical characteristics with the Liverpool & Manchester, but it clearly bears more physical resemblance to the earlier coal lines of the Northeast. More importantly, and perhaps less recognised by historians, however, in its operations and organisational structure the Stockton & Darlington more closely resembles a canal-based plateway. The Stockton & Darlington attempted to combine the Northeastern colliery based technology of edge rail and steam locomotion promoted by its engineer, George Stephenson, and the operational characteristics of canals and plateways.

During its first few years the Stockton & Darlington Company operated the railway as if it were a canal or turnpike. It permitted access to the line by anyone with an approved vehicle, and byelaws governed behaviour on the line. Horses belonging to members of the public and to passenger and freight transport contractors were permitted on the line, as were steam locomotives that belonged to the company. Over time the system became more and more chaotic. In 1833 the company finally concluded that it was not economically viable to operate a canal-style system, and it bought out all of the private contractors and eliminated the use of horse traction. From then on all motive power was provided by the company's locomotives, and the company owned, operated and maintained all vehicles on the line.[42]

Even before the Stockton & Darlington company made this decision, the proprietors of the Liverpool & Manchester Railway had determined from the beginning to create a monopolistic system on their line. The failure of the Stockton & Darlington's attempt at running a multiuser railway, which proved incompatible with the optimal and efficient use of steam locomotives, led to the universal adoption of the monopolistic system of operation characteristic of railways in Britain and around the world for more than 100 years.

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[42] see Norman Moorsom , *The Stockton & Darlington Railway* (Middlebrough, 1975), p. 49, Kirby, *Origins of Railway Enterprise*, pp. 94-95. A few horsedrawn services were operated on branch lines until 1856.

Around the turn of the 19th century several visionaries, beginning with William Thomas of Denton Hall, Northumberland, began to propose a national system of public plateways. Thomas' idea of a national network of public plateways, starting with a line from Newcastle to Hexham, included passenger travel. Thomas, later consultant engineer at Wylam colliery, was instrumental in beginning work on the Newcastle to Carlisle railway line.[43] Dr. James Anderson, Benjamin Outram's father in law, published an essay in 1801 calling for the institution of a publically owned plateway network and including Outram's ideas on standardisation as well as containerisation.[44] Robert Lovell Edgeworth, who had first suggested the idea of building railways unconnected with canals in the 1760s, called in 1802 for the laying of plateways along turnpikes and the provision of stationary engines for traction; he also suggested the transport of coaches on carts on the railways.[45] In 1808 William James proposed a 'General Railway Company'.[46]

Those who envisioned a national public railway system expected this system to be a plateway. Dr. Anderson advised that the national railway system be operated like a turnpike, although he did suggest that trains could be made up of several individual shippers' wagons.[47] Anderson suggested that farmers would create their own road to the public plateway. The plate that illustrates Nicholas Wood's 1825 *Practical treatise on rail-roads* shows an eight-wheeled locomotive

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[43]Warn, *Waggonways and Early Railways of Northumberland*, p. 20; Dendy Marshall, *A history of British railways down to the year 1830*, p. 175; Philip R. B. Brooks, *Wylam and its Railway Pioneers* (Wylam 1975), p. 20.
[44] Dendy Marshall, *A history of British railways down to the year 1830*, p. 175.
[45] Lewis, *Early Wooden Railways*, p. 297; Baxter, *Stone Blocks and Iron Rails*, p. 18; Dendy Marshall, *A history of British railways down to the year 1830*, p. 180.
[46] Philip John Greer Ransom, *The Victorian railway and how it evolved* (London, 1990), p. 36.

on a plateway. Thomas Gray's *Observations on a general iron rail-way*, in its fifth edition in 1825, implies that plateways might be as worthwhile as edge rail; he suggests that farmers would use their own carts to move produce to and along branches on their own estates, which implies the use of plateways rather than edge rail.[48]

As has been previously mentioned, few secondary sources exist on the prehistory of railways. In the 35 years since the publication of M. J. T. Lewis' *Early Wooden Railways* little research or writing has appeared to add to this important work. In the past few years John van Laun, Stephen Hughes and others have investigated the industrial archaeology of plateways in Wales and other parts of Britain.[49] These books contain a great deal of technical information about the form and construction of these lines, drawn from company records and physical investigation of sites and artefacts. They often contain some details about the operation of the lines.

This research has largely been industrial archaeology rather than history, however, and the authors have drawn few or no conclusions about how or why particular technologies developed, or the connection between railways and the corporate entities for which they were built and operated. A great deal of secondary material is available about early iron edge railways in the Northeast,

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[47] Neil Cossons, ed., *Rees's Manufacturing Industry, a selection from the Cyclopedia*, (Trowbridge, 1972), p. 327.
[48] Thomas Gray, *Observations on a General Iron Railway* (London, 1825), p. 38.
[49] Lewis, *Early Wooden Railways*; John van Laun, *Early Limestone Railways* (London, 2001); Hughes, *The archaeology of an early railway system: the Brecon Forest tramroads.*

much of it published by specialty presses and local historical societies. A few such sources also exist for plateways and railways in other parts of Britain.

The history of the Stockton & Darlington Railway is well narrated by several authors, particularly Maurice Kirby in *The Origins of Railway Enterprise*, which addresses economic issues and draws conclusions about the Stockton & Darlington Company's development. Kirby, however, does not compare the Stockton & Darlington to predecessor and contemporary railways, and thus does not set the development of the railway into the engineering design context of the time.

A great deal of secondary material exists on early iron edge railways in the Northeast, much of it published by small presses and local historical societies. A few such sources exist for plateways and railways in other parts of the country, but evidence required to substantiate the hypotheses presented in this essay came mostly from contemporary sources. These include documents prepared to raise money or gain support for the construction of transport improvements, e.g. prospectuses, handbills, newspaper articles and printed debates. Others were prepared for the proprietors and directors of companies constructing these improvements; these include traffic forecasts, surveys and engineers' reports and recommendations. Archives also include letters written by those involved in making decisions about these issues.

In addition to sources that pertain to specific railways and canals, and to specific people, other contemporary materials that can provide evidence of the thinking of the time about the design of railways include encyclopedias, gazetteers, journals and books by contemporary experts in both engineering and economics. These works contain the thoughts of experts about the theory and practice of transport improvements including canals, plateways and railways.

The National Archives holds the records of British Rail, which was heir to the canal companies after their purchase by railway companies. Similar documents, as well as the writings and debates of engineers and other experts, can be found in the archives of the Institution of Civil Engineers. The Newcastle City Library, to which I was directed by John van Laun, has a collection of printed documents relating to early railways, and also holds many revealing letters to and from Edward Pease, the principal decisionmaker of the Stockton & Darlington Company, and George Overton, the engineer of the line before his replacement by George Stephenson in 1826. The Northumberland Records Office holds contemporary records and descriptions of coal mining railways in the Northeast, particularly the record books of John Buddle and other coal viewers.

The remainder of this essay will outline the early history of the railway in Britain (chapter 2), trace in more detail the sociotechnical development of the plateway and edge rail systems (chapters 3 and 4), outline the technical issues related to the use of locomotives on plateways (chapter 5), and describe the working-out of the clash between these two systems on the Stockton & Darlington Railway, explaining how the necessity for the optimal use of the Stockton & Darlington Company's significant investment in steam locomotion decided the issue in favour of edge rail (chapter 6).

2. The origins of the railway in Britain

A map indicating land more than 15 miles from the sea or navigable rivers shows the principal areas in England, not served by water transport, where railways could be usefully employed by industry.[50] In these areas--Shropshire, the Midlands, Wales, and the Northeast--coal miners invested in railways to transport coal to rivers, river navigations, and later canals. Before the late 18th century such railways were made of wood; both the plateway described in Chapter 3 and the edge railway described in Chapter 4 developed from these wooden and later 'bar iron' railways. Both the plateway and the edge railway developed from this vernacular technology, and the physical and operational characteristics were set by it, only to diverge in the late 18th century with the invention of plate rail and the development of specialised coal mining equipment and practice in the Northeast.[51]

Like the steam engine, first used systematically to drain mines, the railway was developed to facilitate the extraction of minerals. While Lewis mentions that dedicated tracks with rudimentary guidance systems were known in Britain and Germany since Neolithic times,[52] miners in the German speaking parts of central Europe in the 15th century began to use railways rather than wheelbarrows to transport silver, gold, copper, tin, lead, mercury and iron ores out of shaft mines.

[50] A.W. Skempton, *Civil Engineers and Engineering in Britain, 1600-1830* (Aldershot, 1996) p. 30.
[51] Information in this chapter comes almost entirely from M.J.T. Lewis' *Early Wooden Railways*, published in 1970; researchers since the publication of this book have provided additional data, but little of historical or archaeological significance about railways in this time period has been published since then.
[52] Lewis, *Early Wooden Railways*, p. 2.

By the early 16th century this technology had spread throughout Europe, where it remained largely unchanged until the early 17th century.[53]

These railways generally consisted of two horizontal planks along which miners pushed carts with unflanged wheels beneath their bodies, known as Hunds. The Hund was kept on the planks by a guide pin that fitted in a groove between them; this pin originally extended below the wheels, making Hunds unable to leave the track, though it appears that later versions had pins that could be retracted above the wheels.[54] Like the owners of coalfields in 18th and 19th century Britain, landowners contracted out the actual mining to specialists; Hunds were generally constructed by mine carpenters and smiths, or by special Hund makers, and railways were generally laid by specialist craft workers.[55]

Aside from mining, railways were used for two other purposes during this period. Channeled or U-shaped rail was used in the construction of fortresses, as can be seen in a Bohemian drawing circa 1430,[56] and channeled rail was also used to transport boats up and down canal inclines such as the one at Fusina near Venice in 1437.[57] This sort of rail, similar to the later plateway, was only found in a few mines, particularly coal mines, and Lewis is not familiar with evidence for any type of flanged rail between 1550 and 1698.[58] Builders of the period appear to have considered this type of rail particularly suitable for mechanical traction,

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53 Lewis, *Early Wooden Railways*, p. 7.
54 Lewis, *Early Wooden Railways*, p. 11, and see drawing p. 27.
55 Lewis, *Early Wooden Railways*, pp. 3, 28.
56 Lewis, *Early Wooden Railways*, p. 42.
57 Lewis, *Early Wooden Railways*, p. 44; also see William Chapman, *Observations on the various systems of canal navigation* (London, 1797).
58 Lewis, *Early Wooden Railways*, p. 52.

such as self-powered or water powered inclines.[59] It is generally difficult to tell from contemporary graphical evidence whether the rail in a drawing is flanged or flat; Lewis believes, however, that carts used on flanged rail generally had wheels outside the body, while Hunds had wheels beneath the body, and determines the type of rail depicted in an image accordingly.[60]

The first railways in Britain are generally said to have been constructed by Austrian metal miners working in the Lake District in the 16th century. In 1564 Elizabeth I authorised a partnership between British investors and Austrian miners to mine gold, silver, graphite, copper and mercury ores in eight northern and western counties and in Wales and to employ foreign technology and workers. The venture was not financially successful, and was largely abandoned by the 1580s, though the mines themselves stayed open until the Civil War.[61]

Railways were first introduced on a large scale in Britain, however, to carry not metals but coal, a use to which they had not commonly been put on the Continent. Collieries experienced a huge increase in demand in the late 17th century, for both domestic and commercial use; a horse pulling a wagon full of coal on a wooden railway could replace 24 packhorses or two or three four-horse wains, and colliery owners soon found that investing in railways provided an efficient way to increase production volume.[62] The technology was first employed in Shropshire, but soon spread to coalfields along the rivers Tyne and Wear in Northeast England.

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[59] Lewis, *Early Wooden Railways*, p. 45.
[60] Lewis, *Early Wooden Railways*, p. 45.
[61] Lewis, *Early Wooden Railways*, p. 16.

Huntington Beaumont is traditionally given the credit for introducing the wooden railway to England, first at Wollaton near Nottingham in 1603-1604 and a few years later to the collieries of the Northeast, building three lines to the river Blythe; these lines were not successful, and had been closed by 1618.[63] The technology spread quickly in both regions, and by the mid-17th century Lewis has identified evidence for five waggonways in the Northeast and up to eight along the Severn.[64]

By 1660, according to Lewis, two types of wooden railway had developed in England, the Newcastle road and the Shropshire road. Both types consisted of square-section wooden rails held in place by transverse sleepers, on which carts with wooden and cast iron flanged wheels traveled, and both differed from the mining railways of Europe in two important respects.

First, the guidance technology had of necessity to be different. European Hunds had been designed to transport dense heavy ore, and were not considered practical for carrying such a light, bulky commodity as coal. Wheels for carts that carried larger and lighter loads needed to be wider apart to balance the load, and the guiding pins of the Hunds were not as effective with such a design, so English miners developed other ways of keeping vehicles on the track. Lewis hypothesizes that the earliest railways in England used flanged wheels, because their rails were reversible and therefore not flanged; it is certain that the flanged

[62] Lewis, *Early Wooden Railways*, p. 86, 87, 299.
[63] Lewis, *Early Wooden Railways*, p. 42.77,91, also see Warn, *Waggonways and Early Railways of Northumberland*, p. 8.

wheel was known in England by the 17th century, as a flanged wheel dating from that period was found in Broseley around 1900.[65]

Second, European railways ran only inside the mines themselves, while both Tyneside and Shropshire railways ran from the mines to the nearest available water transport; while Tyneside waggonways began at the pit heads of shaft mines, Shropshire railways went directly into drift or adit mines.[66]

By the late 17th century colliers had developed a network of wooden railways to transport coal from the coalfields of east Shropshire to the river Severn.[67] Other networks appeared in this region in Flintshire, along the River Dee in the Stour Valley to the rivers Severn and Stour, in Denbighshire, in St. Helens (feeding into the Sankey Canal constructed in 1757), in Barton, Wollaton, Griff and Bedworth, and near Bath.[68] Railway technology spread from this area to South Wales when in 1697 Sir Humphry Mackworth of Shrewsbury, who had married the daughter of a South Wales collier, introduced railways to his new enterprises there. The technology quickly spread to other ironworks and coal mines in the region, and soon carried coal to the rivers Tawe, Neath, Cwm Avon and others.[69]

Unlike the lines developing along the river Tyne, vehicles on these lines did not carry coal exclusively. Some carried building stone, and others were built by

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[64] Lewis, *Early Wooden Railways*, p. 95, 99-104.
[65] Lewis, *Early Wooden Railways*, p. 77, 105.
[66] Lewis, *Early Wooden Railways*, p. 7.
[67] Lewis, *Early Wooden Railways*, p. 243.
[68] Lewis, *Early Wooden Railways*, p. 254.
[69] Lewis, *Early Wooden Railways*, p. 247; A.H. Dodd, *The industrial revolution in North Wales* (Cardiff 1951), p. 110; van Laun, *Early Limestone Railways*, p. 16.

ironmasters to carry coal, ore and limestone for their ironworks as well as finished products to river transport.[70] Because these lines often carried heavy and dense loads as well as coal, and because they often led directly into the level drift mines of the region where clearances were much more restricted, vehicles were smaller and ran on narrower gauge track than their Tyneside counterparts.

There appears to be little evidence of substantial engineering works on these lines, and they were often laid on steep gradients. John van Laun states that 'there are some surprisingly steep tramroads'; his research indicates that gradients on these lines ranged from about 1:300 to about 1:50.[71] For the most part major engineering works were not found on these lines; significant viaducts, however, were constructed across the Taff River for the Penydarren tramroad, and across the Risca for the Sirhowy tramroad. In addition, the first railway tunnel (constructed near Swansea in 1762) as well as the first significant railway tunnel (constructed on the Bullo Pill line in the Forest of Dean in 1809) were built on railways in this region.[72]

Unlike horsedrawn Tyneside waggons, but like their European predecessors, Shropshire waggons were generally moved by human power, by gravity, or mechanically.[73] A counterbalanced inclined plane was in use in Ironbridge Gorge by 1746; the first self-acting incline, for which a patent was granted in 1750, was

[70] Lewis, *Early Wooden Railways*, p. 274.
[71] van Laun, *Early Limestone Railways*, p. 29.
[72] van Laun, *Early Limestone Railways*, p. 29.
[73] Lewis, *Early Wooden Railways*, p. 62, 232.

constructed in Shropshire.[74] These types of machines did not appear in the Tyneside area until 1784, but became common there in the 19th century.[75]

Like their Tyneside counterparts, the land on which to construct many of the lines in these regions was obtained by wayleaves, or permissions from owners over whose land lines were laid. Railway owners paid the granters of wayleaves an annual rental fee, generally based on the amount of freight or traffic on a line.[76] This legal mechanism dates back to at least 1245, and was commonly used for roads before being adopted by railway builders.[77]

Railway builders in these regions, however, developed a new legal process to permit the construction of railways--government authorisation. The first railways authorised by an act of Parliament were the Stourbridge railways of Staffordshire, included in a bill for the Stour River Navigation given the Royal Assent in 1662. These railways, designed to carry coal, were built and operated by the navigation's proprietors, who were granted sole use of barges on the navigation and of vehicles on the railway. The line was operated unsuccessfully until about 1680.[78] The engineer of both the navigation and the railway was Andrew Yarranton, an ironmaster and experienced constructor of navigations.

At the same time another type of railway, referred to in the region as a waggonway, was being developed in the coalfields of Cumbria and

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[74] Barrie Trinder, 'Recent Research in Early Shropshire Railways,' in M.J.T. Lewis, ed. *Early Railways 2*. p. 12.
[75] Lewis, *Early Wooden Railways*, p. 147.
[76] Ernest Manns, *Carrying Coals to Dunston* (Usk, 2000), p. 14.
[77] Lewis, *Early Wooden Railways*, p. 88.

Northumberland, and was being used to open up the rich inland coalfields of Durham. The 'sea coal' trade between this region and London was substantial by the end of the 17th century; by that time London was consuming 500,000 tons of coal per year.[79] Before the development of the wooden railway, this coal was carried to rivers with packhorses or oxcarts. Although at least one author believes that the improvement of transport brought about by the waggonway was not a significant factor in increasing production at the collieries, it may be that increased efficiency in transport helped reduce colliers' expences for both transport and wayleave rent, which had become substantial by the end of the 17th century.[80]

Although they occasionally carried ballast, fodder, and timber for mine construction back up to the coal mines,[81] these waggonways were designed and built by colliery owners to carry coal from a single colliery's mines to its staithes, where it was loaded, often mechanically, into keels, or small boats, that travelled down the Tyne to ports at Shields or Sunderland.[82] Here the coal was loaded onto large ships that transported it to London.

It was understood that the waggonways were an extension of a colliery's mining equipment; '[t]here is little, if any, indication in the eighteenth century that waggonways were perceived as anything other than an industry-specific form of

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[78] Lewis, *Early Wooden Railways*, p. 244, 247.
[79] Robert Galloway, *The History of Coal Mining in Great Britain* (New York, 1969), p. 64.
[80] Galloway, *The History of Coal Mining in Great Britain*, p. 64.
[81] Manns, *Carrying Coals to Dunston*, p. 39.
[82] Lewis, *Early Wooden Railways*, p. 104, 147, 259.

transport--in effect part of the essential infrastructure of the coal trade'.[83] In this region, at least, '[c]oal and the railway…were in fact, one and the same industry until 1825'.[84] By the end of the 18th century the colliery, waggonway, staith, and water transport had developed into an efficient integrated system.

As these waggons carried coal almost exclusively and did not enter the vertical shaft mines of the region, they tended to be larger, wider and higher than their Shropshire counterparts. From their inception these lines were generally operated by gravity down to the coal staiths; empty waggons were drawn by horses back uphill to the colliery.[85] The rule on these lines was 'one horse, one man, one waggon'; one horse pulling more than one waggon was unusual until iron railways began to be constructed around the turn of the 19th century.

These lines were generally designed and laid out by the colliers themselves, who determined on routes and made agreements with appropriate landowners for wayleaves.[86] Once the lines were designed, colliers either constructed them with colliery labour or employed specialist waggonway wrights to oversee the work. Many of these wrights worked for a single coal owner on many collieries and pits, but also often offered expertise or service to other colliers.[87] Waggonway wright William Brown of Throckley, for example, was hired to design and build waggonways for several collieries and wrote letters to other colliers suggesting

[83] Kirby, *The Origins of Railway Enterprise*, p. 36.
[84] Manns, *Carrying Coals to Dunston*, p. 32.
[85] Lewis, *Early Wooden Railways*, p. 216.
[86] Lewis, *Early Wooden Railways*, p. 145.
[87] Lewis, *Early Wooden Railways*, p. 142.

standards and solving specific problems.[88] Albany Baker and Ralph Fetherston worked for Wortley and Liddell on the Tanfield Railway, and constructed significant engineering works on this line.[89] Aside from engineering works, the construction of wooden waggonways required a significant investment of craft labour; since the mechanical sawmill was not widely used until after 1810, each 4" by 4" rail had to be accurately hand-sawn and 'planed smooth and round'.[90]

Initially track and waggons were generally maintained by coal owners.[91] By the late 18th century, however, colliers often entered into contracts for the construction or maintenance of waggonways; in these arrangements the coal owner generally supplied materials, and a contractor agreed to provide labor at a price per yard of track (with costs for additional facilities) or a single fixed fee for a specific line.[92]

Both contemporary and later evidence indicates that the builders of early wooden waggonway lines devoted more cost and effort than their Shropshire counterparts to the efficient use of energy; more thought and work went into making lines level, and more expensive and elaborate engineering works were constructed.[93] Although no tunnels were built on waggonways, builders made extensive use of

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[88] Lewis, *Early Wooden Railways*, p. 145.
[89] Lewis, *Early Wooden Railways*, p. 150.
[90] Abraham Rees, *Rees's Manufacturing Industry (1819-1820)*, vol. 1 (Trowbridge, 1972), p. 323, and coincidentally enough remarks by Jim Rees at Early Railways 3.
[91] Lewis, *Early Wooden Railways*, p. 216.
[92] Lewis, *Early Wooden Railways*, p. 143, and see example in Buddle collection, Newcastle.
[93] Jars in Galloway, *The History of Coal Mining in Great Britain*; Manns, *Carrying Coals to Dunston*, p. 36.

earthworks and bridges (although aside from the magnificent Causey Arch on the Tanfield Railway most bridges were small and made of timber).[94]

More information appears to be available on the operation of early Tyneside waggonways than on the operation of their Shropshire counterparts. Waggonway men were generally employed by the colliery, and horses were supplied by the coal owners themselves, their tenants, the waggonmen, or outside contractors. Aside from the Tanfield railway, which seems to have carried waggons at intervals of less than a minute apart during some periods of its operation, most Tyneside waggonways carried fewer than 100 waggons, or about 250 metric tons, of coal per day.[95]

Tyneside waggonway technology spread through various means to coalfields elsewhere in England. The first known example of this technology transfer was to Sheffield, where a line was said to have been built in 1722-3.[96] This line, built for the Duke of Norfolk's collieries, is said to have carried coal into town until the 1760s. The line constructed by Ralph Allen in 1731 to carry Bath stone from quarries to the River Avon was also inspired by Tyneside rather than Shropshire practice.[97]

The development of the all-iron rail progressed through several stages over the course of the 18th century. On Tyneside waggonways wrought iron plates were attached to the wearing areas of heavily-used sections of rail possibly as early as

[94] Lewis, *Early Wooden Railways*, p. 148-149, 158.
[95] Lewis, *Early Wooden Railways*, p. 205.
[96] Lewis, *Early Wooden Railways*, p. 125.

the turn of the 18th century.[98] By about 1780 a large part of the Tyneside network had been plated with iron.[99] Although Warn states that the first cast iron strips appeared on rails in 1716, it is more generally stated that the first iron rails, 'upper bars of cast Iron' attached to wooden rails using pins through projecting mountings cast in the rail, were cast in Coalbrookdale in 1767.[100] By 1785 the Coalbrookdale Ironworks had spent about £800 to lay nearly 20 miles of this type of rail to transport materials within the works.[101]

The first all-iron bar rails were cast at the Dowlais ironworks in South Wales in 1787; between that time and the turn of the 19th century bar iron rails became popular on railways built by ironworks in the region.[102] This innovation was promoted by John Guest, a partner in the Dowlais ironworks and formerly ironmaster at Broseley in Shropshire, and by Francis Homfray, involved in the Cyrfarthfa Ironworks and also formerly of Broseley.[103] As late as 1800, however, bar iron rail had been adopted in only a few places in Wales, Yorkshire, Lancashire, and the East Midlands, apparently 'for want of a proper system in the forming and laying of such roads,' according to a communication to the Board of Agriculture that year.[104] It seems that outside the Northeast bar iron rail was not

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[97] Lewis, *Early Wooden Railways*, p. 126.
[98] Warn, *Waggonways and Early Railways of Northumberland*, p. 5.
[99] Lewis, *Early Wooden Railways*, p. 168, 264.
[100] Warn, *Waggonways and Early Railways of Northumberland*, p. 5; Lewis, *Early Wooden Railways*, p. 170; Barrie Trinder, 'Recent Research in Early Shropshire Railways,' in MJT Lewis, ed. *Early Railways 2,* p. 13.
[101] Barrie Trinder, 'Recent Research in Early Shropshire Railways,' in MJT Lewis, ed. *Early Railways 2*, p. 13.
[102] M.J.T. Lewis, 'From bar to fish-belly: the evolution of the cast-iron edge rail,' in MJT Lewis, ed. *Early Railways 2*, p. 113.
[103] John van Laun, 'In search of the first all-iron edge rail,' in MJT Lewis, ed. *Early Railways 2*, p. 95.
[104] Lewis, *Early Wooden Railways*, p. 265; John Willis, 'Communications to the Board of Agriculture', ii (London 1800) p. 477, in Lewis, *Early Wooden Railways*, p. 266.

generally adopted until it began to be used by canal builders in the region in the late 18th century.

All-iron rail appears to have been adopted in the Tyneside area later, but without the intermediate stage of iron rail on longitudinal wooden supports or of bar iron rail. The first known conversion of a Tyneside waggonway from wood to iron was at the Lawson Main colliery in 1797, where the line was laid with cast iron fishbelly edge rail;[105] however, wooden rail continued to be used in the Tyneside area through the 1840s.[106]

Even before the introduction of iron rail, and the expansion of the railway system in Britain, a distinction can be identified between railways in the coal-producing regions of northeastern England and railways in the rest of the country. The latter carried many types of freight, were associated even early on with navigations and later with canals, and were often built by waterways engineers rather than railway specialists. They often used several modes of traction, including human power and both powered and gravity inclines, were generally funded by speculation and by investors interested in transport, and occasionally obtained the authorisation of the government. Railways in the Tyne and Wear area, however, were generally built by colliers for the exclusive transport of coal using horsedrawn waggons. Additionally, development of the railway happened later in the north; the longer history of railways in the south, as well as the

[105] Lewis, *Early Wooden Railways*, p. 231, 294.
[106] Lewis, *Early Wooden Railways*, p. 231.

presence of ironworks in areas where railways were used, led to the introduction of bar iron rail and later of the cast iron plateway.

3. The origins of the plateway in canal building

As we saw in Chapter 2, the plateway, like the edge railway, developed from the wooden railways that carried vehicles in coal mines in Britain. Cast iron plate rail was first manufactured shortly after edge rail, and like edge rail was first used in coal mines underground. The cast iron tramplate was invented by John Curr, a native of Durham, who laid two miles of plateway aboveground at the Duke of Norfolk's collieries in Sheffield in 1778.[107] In a letter to the Duke in 1801 he wrote that 'about 16 collieries out of 20 have introduced this mode of carrying coals' in Yorkshire, Lancashire, Salop, Derby, Stafford, Warwick, Wales, near London, and in the neighbourhood of Newcastle upon Tyne.[108] Riden theorises that the technology became known to Benjamin Outram, its most prolific proponent, through Joseph Butler.[109]

While plateways may, like edge rail, have had their origins in coal mines, they soon became an essential component of the network of canals constructed in England and Wales between about 1760 and about 1800. An increase in international trade, particularly with Britain's colonies, in the early 18th century spurred a significant increase in domestic production. By 1794 non-European colonial trade made up 55% of total British trade, and 2/3 of total exports.[110] The capital amassed from this trade was invested in infrastructure to facilitate the

[107] John Curr, *The coal viewer and engine builder's practical companion* (2nd edn., New York, 1970), p. 2. Curr had probably been using plateways underground since 1776; see Charles E. Lee, 'Some railway facts and fallacies', *Transactions of the Newcomen Society*, 33 (1960-1961).
[108] Curr, *The coal viewer and engine builder's practical companion*, p. 3.
[109] Philip Riden, *The Butterley Company*, p. 23. Outram has often been credited with inventing the plateway, and his name erroneously cited as the origin of the word 'tramroad,'.

transport of raw materials to factories producing goods for export and of finished goods to ports for shipment overseas. By the late 18th century cotton (both raw cotton and finished cloth) was the largest of these markets, but the increase in production and trade also affected mining and other industries.[111]

Parliamentary acts permitting the first systematic investment in transport in Britain, the turnpike system, began to appear in the late 17th century. The most heavily travelled roads, those connecting London with provincial cities first in the west, then in the Midlands and the industrial and coal-producing areas of the north, were the first to be improved. Though relatively rare in the northern part of the country, perhaps because north-south trade was more effectively served by coastal shipping, by the 1770s turnpikes were common in the northwest, the south, and particularly the Midlands. The largest growth in turnpiking occurred in the third quarter of the 18th century, during which more than double the number of turnpike acts were passed as were passed between 1700 and 1750. By the 1830s more than 100 turnpike trusts had been authorised and 20,000 miles of road had been turnpiked.[112]

Turnpike trusts were local organisations, typically controlling stretches of road about 20 miles long; as they were created for the betterment of local trade rather than to produce investor dividends, they were in theory nonprofit entities, offering relatively low interest rates of about 5%. Because of the restrictions on the

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[110] John Langton and R. J. Morris, eds., *Atlas of industrializing Britain 1780-1914* (London, 1986), p. 94.
[111] Clive Howard Lee, *The British economy since 1700* (Cambridge, 1986), p. 110.
[112] Langton and Morris, eds., *Atlas of industrializing Britain*, pp. 80-81; W. T. Jackman, *Development of transportation in modern England* ([London], 1962), p. 234.

raising of money from shares imposed by the Bubble Act of 1720, turnpike companies borrowed money directly, largely from the local landowners and industrialists who administered the trusts. The trusts were not accountable to a higher authority, and abuse and mismanagement of funds was common; trusts found it difficult to pay for the substantial improvements they commissioned through tolls alone, and frequently went into debt.[113]

By the early 19th century in response to increased demand for transport turnpike trusts had begun to invest in significant engineering improvements, including realignment to shorten roads and improve gradients, and many engineers were employed to survey and design road improvements.[114] The best known of these was John Loudon Macadam, who in addition to inventing a road surfacing method that bears his name advocated commercial and rational road administration. His work led to the reform of turnpike trust management after 1820, particularly in the areas around London.[115]

In addition to improvement in road design, several associated developments made road transport more efficient and reliable. Improved suspension for carriages made heavier loads easier to pull, and systematic breeding created large, hard-boned draught horses which by 1800 were pulling twice the load and eating three quarters of the food of previous generations of horses.[116] In the early 19th century even steam power was being tried on the improved roads. A steam carriage drove from London to Melksham, near Bath, in 1829 at a rate of

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113 Jackman, *Development of transportation in modern England*, p. 240ff.
114 Dorian Gerhold, *Road transport before the railways* (Cambridge, 1993), p. 140.
115 Jackman, *Development of transportation in modern England*, p. 276ff.

12 miles per hour; this carriage could apparently reach a speed of 20 miles per hour on a good road. Entrepreneurs provided regular steam road vehicle passenger service between Gloucester and Cheltenham, and between London and Southampton; these services were both faster and less expensive than stagecoaches.[117] Even with the imposition of turnpike tolls and taxes on coaches and horses for hrie, and even without steam powered vehicles, the cost of transport dropped and speeds increased; it is argued that improvements in road technology cut travel times between some destinations in the 1830s to as low as 20% of what they were in the 1750s.[118]

While the turnpike system was centred on transport into and out of London, the canal system begun in the mid-18th century connected provincial centres in the Midlands and west coast ports which exported goods directly to Britain's colonies and trade partners. Canals offered higher capacity for lower cost than turnpikes; a horse could pull ten times as much weight on a canal as on a road, and 'a mile of canal is often made at less expence than the mile of turnpike'.[119] The first canal given the Royal Assent was the Sankey Canal Navigation in 1755; the first financially successful canal was the Bridgewater Canal, begun in 1759 and opened in 1763, which earned more than £2.2 million in toll revenues.[120] Between 1750 and 1830, 2500 miles of canal were built in Britain.[121] The 'canal age' is generally considered to have ended with the development of the mainline

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116 Gerhold, *Road transport before the railways*, p. 31, 193-194.
117 Jackman, *Development of transportation in modern England*, pp. 327-335.
118 Jackman, *Development of transportation in modern England*, p. 56.
119 John Philips, *General History of Inland Navigation*, in Abraham Rees, *Rees's Manufacturing Industry (1819-1820)* (Newton Abbot, 1972), p. 272.
120 Lee, *The British Economy since 1700*, p. 38.
121 Langton and Morris, eds., *Atlas of industrializing Britain*, p. 86.

railway, but as late as 1894 the 35.5 mile Manchester Ship Canal was constructed as a response to high railway freight costs.[122]

Until the 'canal mania' of the 1790s, investors in canals, like investors in turnpike trusts, were local landowners and industrialists who were more interested in the improvement of their property and businesses than in obtaining dividends.[123] Although canal companies had little control over the tolls they charged, which were legislated in their enabling acts, by the early 19th century a few canal investments were paying well. The *Quarterly Review* in 1825 suggested that the ten most highly paying canals averaged dividends of 27.6%, but that 70 others paid out less than 4% annually; the average return on investment for the canal system as a whole was estimated to be about 5.75%.[124]

Associated with canal and turnpike improvements was a shift that began in the mid 18th century from private transport to use of hired carriers.[125] Firms such as Pickfords developed a nationwide integrated service, using a variety of modes and transferring goods from horse carts to barge trains. Other contractors carried passengers on stagecoaches on the turnpike roads and passenger boats on the canals (passenger service had been available on the Bridgewater Canal since 1767[126]). While a few canal companies did handle carriage as well as supplying the infrastructure,[127] because of the potential for monopoly (canal companies could compete unfairly because they would not be obligated to pay tolls) until

[122] Harold Glenn Moulton, *Waterways versus railways* (Boston, 1912), p. 146-162.
[123] Jackman, *Development of transportation in modern England*, p. 104.
[124] Jackman, *Development of transportation in modern England*, p. 123.
[125] Rick Szostak, *The role of transportation in the Industrial Revolution* (Montreal, c1991), p. 167.
[126] Ransom, *The Victorian railway and how it evolved*, p. 32.

1845 they were permitted by law only to provide the use of their infrastructure to anyone who obeyed the byelaws and paid the appropriate toll. Canals and turnpikes thus served individual travellers, firms that transported their own raw materials and finished products, and the developing specialised transport sector.

Although Sweezy states that the canal system was not significant in the coal trade,[128] he is probably referring to the coal trade specifically from the Tyne and Wear area to London, which did not depend on canals; it seems clear that the motivation for the construction of most canals, including the Bridgewater Canal built to transport coal from the Duke of Bridgewater's collieries at Worsley to Manchester, was the transport of coal.[129] It is estimated that more than half of the canal acts passed between 1750 and 1800 were for coal transport.[130] Even on improved roads the transport cost of coal was high as a proportion of its value; its cost doubled if transported ten miles over land, while the same transport cost could take the same amount of coal twenty times farther on a canal or navigation.[131] Between 1815 and 1816 more than 10 million tons of coal were carried by canals.[132] Although 'the powerful opposition of the North-east's coalmasters saw to it that legal and other obstacles were placed in the way of the canal carriage of inland coal into the greater London area',[133] coal transported by canal was instrumental in the growth of regional economies, permitting, for

[127] Jackman, *Development of transportation in modern England*, p. 124.
[128] Paul Marlor Sweezy, *Monopoly and competition in the English coal trade, 1550-1850* (Westport, Conn., 1972), p. 140.
[129] Moulton, *Waterways versus railways*, p. 100, Jackman, *Development of transportation in modern England*, p. 130.
[130] Szostak, *The role of transport in the Industrial Revolution*, p. 118.
[131] Szostak, *The role of transport in the Industrial Revolution*, p. 118.
[132] Jackman, *Development of transportation in modern England*, p. 129.
[133] Jackman, *Development of transportation in modern England*, p. 131.

example, the foundation of ironworks in the Midlands and Wales.[134] Coal was also used to power steam engines used in textile manufacture, particularly in the cotton industry.[135]

Coal, as well as limestone and other materials, was often transported to canals via plateways constructed by the canal companies or by private clients. The relationship between railways and canals was so close that Rees's Cyclopedia included railways in its entry under Canals.[136] Authorisation to construct railways to a canal was often included in a canal's enabling act. Lewis identifies the Staffordshire Stour Navigation, given the Royal Assent in 1662, as the first transport improvement company granted the legal right to build railways;[137] the first railway authorised in a canal act, however, is generally said to be the Caldon Low Tramroad (also known as the Froghall Railway), built to carry limestone to the Trent & Mersey Canal, authorised in the canal's enabling act of 1776 and opened in 1778. Under the provisions of an additional authorising act in 1802, this iron-plated wooden waggonway was relaid as a plateway under the direction of John Rennie, and continued to be used as a plateway until 1849 when it was relaid as an edge railway.[138]

The Acts of Parliament that authorised the construction of canals typically permitted coal and ironworks owners within a certain distance of a canal's right of way to build 'rail or tram roads' from their sites to the canal, and gave both canal

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[134] Jackman, *Development of transportation in modern England*, p. 129.
[135] Szostak, *The role of transportation in the Industrial Revolution*, p. 171-172.
[136] Cossons, ed., *Rees's Manufacturing Industry, a selection from the Cyclopedia*, p. 280.
[137] M.J.T. Lewis, *Early Wooden Railways* (London, 1970), p. 141.
[138] Dendy Marshall, *A history of British railways down to the year 1830*, p. 46.

companies and clients constructing railways the power of compulsory purchase of intervening lands. The 'quid pro quo' for this legal right was the setting of maximum tolls and the requirement that the railway be available for use by the public. The acts for the Stourbridge Navigation (1776), the Dudley Canal (1776), and the Birmingham and Fazeley Canal (1783) permitted the construction of railways within 1000 yards of the right of way of the canal;[139] by 1790 distance restrictions rarely appeared in acts that authorised canals to build railways.[140] Railways (both plateway and edge rail) were built by canal engineers including John Rennie and William Jessop Sr., 'the greatest canal engineer in the country';[141] the best known of these engineers was Benjamin Outram, who designed canals but was better known as a consultant to several canals on the improvement of railways.[142]

The Ashby de la Zouch Canal was built to carry coal from the collieries of the Ashby Wolds in Leicester and the lime quarries north of Ashby de la Zouch. Its enabling act included the provision of non-water transport, and Robert Whitworth, the engineer responsible for constructing the project after William Jessop's design, proposed two railways to replace stretches of canal to save money, from Ticknall to the Trent at Ingleby and from Breedon Hill to the Trent. Thomas Newbold, who replaced Whitworth as engineer, requested the services of Benjamin Outram as consultant on these railways. Outram increased the

[139] Lewis, *Early Wooden Railways*, p. 281.
[140] Power to make railways without distance restriction is given in the following Parliamentary Acts: 1790 Geo IV cap. 60 p. 125, 1790 Geo IV cap. 82 p. 142, 1791 Geo IV cap. 65 p. 401, 1791 Geo IV cap. 70 p. 408, 1791 Geo IV cap. 89 p. 424, 1794 Geo IV cap. 39 p. 522, 1794 Geo IV cap. 93 p. 712, 1794 Geo IV cap. 94.
[141] ChHadfield, *Canals of the East Midlands* , p. 56.

proposed gauge of these two lines from 3'6" to 4'2" in order to facilitate carrying general merchandise, suggesting the latter measurement as a standard gauge. Thirteen miles of plateway were eventually built in connection with this canal, including major earthworks--bridges, tunnels, cuttings and embankments. The Ticknall line was opened in 1799, and operated as a plateway until 1914.[143]

Working as a consultant to William Jessop, Outram also designed and provided plates for several railways for the Cromford Canal. This canal served the Butterley Ironworks, in which Jessop and Outram were partners. Many of the plateways for this canal were designed, financed and built by private owners who purchased plates from Butterley. In 1793, for example, a brick quarry owner surveyed a line from the canal to limestone quarries owned by the Butterley Company. Benjamin Outram's brother Joseph Outram Jr. insisted on a better alignment and performed a new survey unasked. Benjamin Outram at first refused to sell plates to the quarry owner, as he thought the alignment was poor, but later agreed, though he put restrictions on his usual three year warranty.[144] In 1796 Mrs. Helen Morewood, owner of the Hermitage Colliery, requested a plateway from the canal; when the directors replied that they did not build railways, the colliery built a railway with its own labour and plates from the Butterley Company.[145] The Butterley Company also supplied plates for the Beggarlee Colliery railway, built in 1797 by the colliery owner, who had

[142] Outram's career is less well known than it should be given his significance in the history of British engineering; the only biography of Outram is R. B. Schofield, *Benjamin Outram, 1764-1805* (Whitchurch, 2000).
[143] Dendy Marshall, *A history of British railways down to the year 1830* (London, 1938), p. 50.
[144] Schofield, *Benjamin Outram, 1764-1805* , p. 212ff.
[145] Schofield, *Benjamin Outram, 1764-1805*, p. 267-268.

negotiated with the Cromford rather than the Nottingham or Erewash Canals to build a plateway to the canal in exchange for a reduction in their canal tolls.[146]

Representatives of the town of Mansfield asked the proprietors of the Cromford Canal Company to construct a link between it and the Pinxton colliery sited on the canal; the company replied that they had no objection to such a line but would not assist in its construction. The Mansfield representatives then tried unsuccessfully to negotiate rate reductions with the canal in exchange for increasing its freight revenues; they eventually decided that the plateway was worthwhile with or without the assistance of the canal company, and obtained an Act of Parliament to construct it in 1816.

The Somerset Coal Canal Company received its first act, which included authorisation to build railways, in 1794; two years later William Jessop assisted in preparing an additional act in 1796. This canal connected to the Kennet & Avon Canal, and John Rennie served as engineer for both. In 1799 Outram advised the company to improve the grades of existing railways and to systematise coal transport on the colliery railways. An additional canal act was passed in 1802. In addition to links to collieries, the canal company built the eight mile Radstock Railway instead of a canal to save money.[147] In 1800 for the Grand Junction Canal, on which William Jessop was chief engineer, Outram constructed a temporary plateway to carry canal traffic over Blisworth Hill, which permitted the canal to open in 1800. This plateway was used until the Blisworth Tunnel was

[146] Schofield, *Benjamin Outram, 1764-1805*, p. 210.
[147] Dendy Marshall, *A history of British railways down to the year 1830*, p. 68.

completed in 1805; afterward the plates were removed and reused on a branch line to Northampton which operated between 1805 and 1815.[148]

The act for the Lancaster Canal, incorporated in 1792 to carry coal north and limestone south, did not originally authorise the construction of railways; subsequent acts in 1800 and 1807 authorised and permitted funding for their construction. In March 1801 John Rennie and William Jessop prepared a report proposing the construction of temporary plateways; later, a 4.75 mile long plateway was constructed that included two self-acting inclines and one steam-powered incline.[149]

Plateways were popular in most of England, but the densest and longest networks in Britain were in the Brecon Valley and the Heads of the Valleys in South Wales. The Glamorganshire Canal, authorised in 1790 and opened in 1794, served four ironworks, Cyfarthfa, Merthyr Tydfil, Penydarren, and Dowlais, all of which were connected to water transport by plateways. The line had no formal engineer, but was built by Thomas Dadford Sr. and Jr. and Thomas Sheasby. The Penydarren Tramroad, on which Richard Trevithick operated the first successful locomotive, was built under the provisions of the Glamorganshire Canal act, although it terminated at the Abercynon Navigation; the owners of the Penydarren Ironworks argued that as the ironworks was within four miles of the

[148] Hadfield, *Canals of the East Midlands*, p. 114, 144.
[149] Gordon Biddle, 'The Lancaster Canal Tramroad,', *Journal of the Railway and Canal Historical Society*, 9 (1963), p. 88, 93.

Glamorganshire Canal the ironworks were authorised to build a railway even if it did not terminate at the canal.[150]

The authorising acts for the Monmouthshire Canal (1792) and its extension, the Brecknock and Abergavenny Canal, permitted the construction of railways within eight miles of the canals' alignments. Under the provisions of its authorising act, the Monmouthshire Canal Company decided to build feeder lines if clients contributed 7.5% of their capital costs and all of their maintenance costs.[151] The Monmouthshire Canal Company built and owned 14 miles of railway, which connected to additional line built and maintained by private entities. The 24 mile long Sirhowy Tramroad, which connected the canal to several clients including the Tredegar and Sirhowy Ironworks, was initially to have been paid for by the canal company; this agreement was later renegotiated so that part of the line's construction was paid for by the company and the rest by the Sirhowy Tramroad Company, created by a separate Act of Parliament in 1802. The canal company took responsibility for its maintenance.

In 1799 Benjamin Outram was hired as railway consultant to these canals, recommending 'lighter Waggons with smaller Wheels, turning on the axles; but if instead of the present Railroads, others were substituted on the System I have introduced, the Expence of Conveyance might be reduced three fourths, and the Expence of Repairs in Proportion'.[152] Plateways of his design were also built to

[150] Charles E. Lee, *The evolution of railways* (London, 1943), p. 69.
[151] Schofield, *Benjamin Outram, 1764-1805*, also see PRO RAIL 500/5, Monmouthshire Canal Company committee meeting minutes, 1792-1812.
[152] Schofield, *Benjamin Outram, 1764-1805*, p. 259.

Trefil, Beaufort (Ebbw Vale ironworks), Aberbeeg (Nantyglo ironworks), Trosnant, Blaenavon, and Clydach.[153]

In addition to connecting clients to canals, plateways were built in association with them for several reasons. They were often built as temporary (occasionally, due to lack of continued financing, permanent) extensions of canals, or connections between one permanent transport facility and another. For example, when in 1798 Benjamin Outram suggested constructing the route between Ashby and Ticknall Limeworks on the Ashby de la Zouch Canal as a plateway, he pointed out that the plateway would be half the length of a canal, cost 1/4 the amount to build, and half the amount to operate (his report did not state how much less traffic the plateway would carry), but would 'bring the limeworks six miles nearer to market' at a time when the canal company was desperate to begin generating revenue.[154] Plateways were built where canals were deemed too expensive, or impractical due to steep grades or lack of water. The Surrey Iron Railway, for example, was originally projected as a canal, but William Jessop's initial survey indicated that water for a canal would need to be either pumped or diverted from existing mills on nearby rivers.[155]

These examples show some of the variety of purposes plateways served in the canal system, and the variety of origins, construction, financing and maintenance schemes and freight types that could be found on the system at that time. In

[153] Schofield, *Benjamin Outram, 1764-1805*, p. 250.
[154] PRO, RAIL 803/15, *Benjamin Outram vs Ashby Canal Company*, 1802, p. 5.
[155] Charles Hadfield and A. W. Skempton, *William Jessop, Engineer* (Newton Abbot, 1979), p. 175.

addition, it shows how typical collaboration was, among engineers and between engineers and clients, in the development of these lines.

Despite the example of the citizens of Mansfield, canal companies generally had a strong incentive to construct or encourage the construction of plateways to increase the amount of canal traffic and revenue. Once a plateway was determined on, the canal company had a strong incentive to maximise traffic on it in order to increase revenues both on the plateway and on the canal. Because of this, and to share costs, plateways were often laid out to serve several clients; the shipping of many types of freight and the use of plateways by as many clients as possible was both encouraged and typical.

Legally part of the canal system, plateways were operated in the same way as canals (and turnpike roads). Proprietors built a transport facility and then opened it to anyone who paid the statutory toll and followed the byelaws. As with canals and turnpikes, plateways were used not only by private and commercial clients transporting their own freight but by transport contractors transporting the freight of ratepaying customers (and, in some cases, operating scheduled passenger service). These contractors could often rent vehicles and facilities from the canal company or plateway company. Often, as on the Mansfield and Pinxton Railway, carriers provided service on both the plateway and the canal.[156] In some cases all coal carriage was leased to a contractor who supplied equipment, horses and operators for a yearly sum. Vanags points out that such an arrangement would have been more difficult on an edge rail system; yearly leases would have provided less incentive for contractors to invest in the specialised equipment required to operate on an edge rail system. Maintenance of the plateway was also subject to various types of agreements; it could be the responsibility of the canal company or of the client, and was often leased out to a maintenance contractor for a fixed sum paid by either or both parties.

Because plateways were open to the public, proprietors quickly found that they had to devise byelaws to prevent abuse of the facilities. These byelaws controlled vehicle weights, widths and types of wheels, speed limits (generally a 'walking pace' of four to five miles per hour, though the Stratford and Moreton Tramway permitted operators to purchase a licence that allowed them to travel up to eight miles per hour and overtake vehicles without such a licence), hours of operation (usually daylight; often no traffic was permitted on Sundays and some holidays), rules of precedence (first past a marker, full rather than empty, down-travelling waggons rather than up-travelling ones), types of cargo permitted and not permitted (e.g. alcohol), and other issues. The byelaws of plateways connected to the Brecknock & Abergavenny Canal, for example, required operators of waggons that ran off the rails to unload them before attempting to rerail. Responsibility for heeding these byelaws, and penalties for breaking them, were allocated differently on different lines among freight owners, drivers and operators.

Aside from the necessity of byelaws, the fact that plateways permitted all traffic raised several operational questions. Benjamin Outram's 1798 report to the

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[156] John Vanags, *Mansfield and Pinxton Railway 1819-1848* (Mansfield, 2001), p. 26.

Ashby Canal Company discussed the issues that arise from 'different trades' using the same plateway, and made recommendations for how to handle these problems. He suggested, for example, that toll collectors might regulate start times for fast and slow vehicles, and that different types and speeds of vehicles would be permitted to use the line only at specified times.[157]

The Butterley Ironworks provided a variety of services for clients, from the provision and delivery of cast iron tramplates, through the provision of surveying services and alignment plans, through the provision of sleepers and other components and contract labour (as on the Cromford and High Peak Railway).[158] Outram was concerned not only with the materials for plateways but also with their method of design and construction, which he preferred to supervise 'as much depends on the manner in which the work is executed.'[159]

Outram claimed that a horse could pull four times as much weight on a plateway of his design than it could on an edge railway;[160] this may have been true, but may have had more to do with the quality of Outram's work than the type of rail he used. Outram systematised his design and construction processes, preparing standard estimates for standard work. His work was of very high quality, his grades were carefully surveyed and laid (he was willing to design, and capable of designing, significant engineering work where required to create grades that

157 PRO RAIL 803/15, *Outram vs Ashby Canal Company*, 1802.

158 Philip J. Riden, 'The Butterley Company and railway construction, 1790-1830', in Mike Chrimes, ed., *The civil engineering of canals and railways before 1850* (Aldershot, 1997), p. 272.

159 Riden, *The Butterley Company*, p. 45.

160 Schofield, *Benjamin Outram, 1764-1805*, p. 260.

would optimise economical operation), and he guaranteed his lines with a one year or three year warranty, replacing any plates that failed during this period.[161]

During the period that Outram was building plateways, and after his death in 1805, other engineers adopted the plateway for their own works. John Hodgkinson, Benjamin Outram's cousin[162] assisted Outram on several projects; after Outram's death he continued to use Outram's system on the Monmouthshire Canal Company's railways (including the Sirhowy Tramroad), the Hay and Kington line, the Llanfangel-Grosmont-Hereford lines, and the Gloucester & Cheltenham Tramroad.[163]

George Overton, the engineer in charge of railways at Dowlais Ironworks, also learned from Outram, and advocated the plateway, claiming that resistance to friction was less on plateways than on edge railways.[164] Overton laid a plateway at Dowlais in 1800[165] and built several plateways including the Penydarren (Merthyr Tydfil) Tramroad, the Croft Waggonway, and the Hirwaun Tramroad. Locomotives were operated on all of these plateways at least through the 1830s.[166] Overton served as the first engineer of the Stockton & Darlington

[161] Philip J. Riden, 'The Butterley Company and railway construction, 1790-1830', in Mike Chrimes, ed., *The civil engineering of canals and railways before 1850* (Aldershot, 1997), p. 269. Riden suggests that other foundries offered similar warranties.
[162] John Van Laun, 'Pre-1840 Trackways in South Wales,' in Andy Guy and Jim Rees (eds.), *Early railways* (London, 2001), p.43.
[163] Derek A. Bayliss, *Retracing the first public railway* (Croydon, 1981), p. 4.
[164] George Overton, *A Description of the faults or dykes of the mineral basin of South Wales, part 1* (London 1825), p. 38. Henry Robinson Palmer, in his *Description of a railway on a new principle* (London, 1823), p. 32, seemed to indicate that edge railways had less resistance than plateways (marginally less than the Cheltenham & Glouchester; substantially less than the Surrey Iron Railway).
[165] John Van Laun, 'Pre-1840 Trackways in South Wales,' in Andy Guy and Jim Rees (eds.), *Early railways* (London, 2001), p. 32.
[166] see Baxter, *Stone blocks and iron rails*, p. 3, and Chapter 5 of this essay.

Railway, which under his administration had been projected as a plateway; it became an edge railway after Overton's replacement by George Stephenson in 1821.[167]

Outram saw plateways and canals as a single system, and believed in the eventual nationwide integration of this system; in a 1799 letter to the committee of the Ashby Canal Company he stated that ‘it is exceedingly probable that Railways will soon become general for the transport of Merchandize thro the commercial parts of this Kingdom’.[168] Around 1800 Outram prepared a document entitled 'Minutes on the Construction of Railways', which included specifications for the design and construction of plateways, including requirements for stone sleepers, rail lengths and weights, acceptable gradients, and designs for superelevation and points; this document had originally been written to supply to clients of the Butterley Ironworks for whom Outram had not surveyed and planned a plateway, or contractors who undertook to lay Butterley plates, but was incorporated into an essay published in 1803 by Dr. James Anderson, Outram's father in law, entitled 'Recreations in Agriculture, Natural History, Arts and Miscellaneous Literature'.[169] This document included Outram's choice of a standard gauge of 4'2", which he considered appropriate for all types of vehicles and advocated as a standard for the national public network of linked plateways envisioned by Anderson and others as described in Chapter 1. Outram also prepared specifications for wagons and axles, which he provided to clients.

4. The origins of edge rail in coal mining

[167] PRO RAIL 667/867, letter from Richard Miles to George Overton, 13 December 1818.
[168] PRO, RAIL 803/15, *Benjamin Outram vs Ashby Canal Company*, 1802, p. 18.
[169] Schofield, *Benjamin Outram, 1764-1805*, p. 202-204.

The development of the iron edge railway in the coalfields of the Northeast is much more extensively documented than that of the plateway in the Midlands, Shropshire and Wales.[170] Unlike the plateway, the edge railway is the direct descendant of the wooden waggonway of the 17th and 18th centuries; it did not develop in conjunction with the common carrier canal system found in other parts of Britain but rather evolved as one component of a sophisticated single-commodity bulk transport system.

The economic situation in Northumbria and Durham was different from that of the areas in which plateways were built. In the Northeast, the use of canals to transport bulk commodities was not economically feasible because of hilly terrain and lack of available water; several canals, including one from Stockton to Darlington, were projected in this area but ultimately abandoned as unworkable.[171] Instead, colliery owners used first packhorses, then wains, then waggonways to carry coal directly from pit heads to the rivers Tyne and Wear, from where it was transported to markets primarily for house coal in the Southeast and particularly to London.[172]

Coal had been mined in this region since the 12th century, and coal for commercial purposes (including public bakeries and ovens) was being shipped by boat to London by the 13th century.[173] In the late 16th century it began to replace wood as the most popular domestic fuel, first as a source of heat and

[170] See e.g. Ernest Manns, *Carrying Coals to Dunston* (Usk, 2000), Ken Smith, *Stephenson Power* (Newcastle, 2003), Warn, *Waggonways and Early Railways of Northumberland*, Brooks, *Wylam and its Railway Pioneers*.
[171] Kirby, *The Origins of Railway Enterprise*, p. 21.
[172] Flinn, *The History of the British Coal Industry*, p. 216.

later, after the early 18th century, as a source of power for steam engines. Coal consumption grew rapidly over the course of the 18th century. By the end of the 17th century London was using about 500,000 tons of coal per year;[174] in 1818, 1,535,000 tons of coal were coming into London from the rivers Tyne and Wear via this coastal route and about 40% of Britain's coastal shipping capacity was dedicated to coal.[175] According to Jackman the amount of coal shipped coastally had risen to 5.5 million tons per year by 1829.[176] This rise in consumption was met by the opening of new collieries. By 1800 33 collieries were operating along the Tyne, and 17 on the Wear.[177] The first of these were close to the river, but newer ones, tapping into richer coal seams, were at some distance from water transport. The large profits from this enterprise, however, allowed coal owners to invest in a substantial and highly capitalised mechanised bulk transport system designed for this specific purpose.[178]

By the 1820s the standard method of mining coal in the Northeast was the bord and pillar system, in which coal was removed from bords, or stalls, leaving about half of the seam to remain as pillars supporting the mine. Coal was removed from stalls by hewers, who loaded it into corves that held up to 6 hundredweight (672 pounds) of coal; by the 1820s the traditional wicker baskets had largely

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173 Manns, *Carrying Coals to Dunston*, p. 9.
174 Galloway, *History of Coal Mining in Great Britain*, p. 64.
175 Szostak, *The Role of Transportation in the Industrial Revolution*, p. 154.
176 Jackman, *Development of Transportation in Modern England*, p. 169. Coal shipping was still primarily along the east coast, but this figure may also include coal shipped from Wales along the south coast.
177 Szostak, *The Role of Transportation in the Industrial Revolution*, p. 57.
178 It is difficult to determine the profits from coal mining during this period, and colliery profitability varied widely, but it is clear that many collieries were extremely profitable, making owners often 30% and as much as 50%, and that these profits were ploughed back into investment in colliery equipment. See Michael W. Flinn, *The History of the British Coal Industry*, v. 2 (Oxford, 1984), pp. 311-328.

been replaced by wooden-sided boxes.[179] Corves were loaded onto wheeled sledges (rolleys) and moved as far as a mile and a half on the 'levels' of the mines along 'rolley-ways' by boys (putters) or pit ponies to reach vertical shafts where winding engines could lift the corves to the surface.[180] Horses were first used in the mines in the early 18th century, and had come into more regular use by the early 19th century.[181] Levels were dug to minimise their cross-section as much as possible; where putters were used instead of horses heights could be as low as 40 inches;[182] Sheila Bye, archivist of the Middleton Colliery, suggests that replacing wooden rails with cast iron plates not only decreased the friction on the rolleys but also provided a few extra inches of clearance for the use of horses.[183] By the 1820s wooden rolley-ways had been replaced by John Curr's cast iron plateways.[184] Plateways were considered a great boon to miners:

> God bless the man wi' peace and plenty
> That furst invented metal plates,
> Draw out his years to five times twenty
> Then slide him through the heevenly gates.[185]

One horse on an iron railway could move up to 10 corves of coal; an observer in 1796 noted that a horse could move up to 14 corves on iron compared to only two on wood.[186]

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179 Flinn, *The History of the British Coal Industry*, p. 94.
180 Flinn, *The History of the British Coal Industry*, p. 81.
181 Lewis, *Early Wooden Railways*, p. 310, Flinn, *The History of the British Coal Industry*, p. 97.
182 Flinn, *The History of the British Coal Industry*, p. 82.
183 Email to the author, 6 June 2005.
184 Several primary sources relating to Northeastern collieries mention the use of tramplates, e.g. Northumberland Record Office, 3410/Bud/15/224, John Buddle's copybook notes on purchasing tramplates for various collieries.
185 'The Pitman's Pay', quoted in Flinn, *The History of the British Coal Industry*, p. 95.
186 Flinn, *The History of the British Coal Industry*, p. 96.

At the winding pit corves were hooked to ropes and hauled to the surface by horse powered or steam powered (occasionally water powered) winding engines. Although some isolated examples appear to have existed earlier, steam power was not widely used for this purpose until after the 1780s, when means to convert reciprocal to rotary motion became readily available.[187] Corves were generally attached to hemp rope, but John Curr's flat rope, introduced in 1798, stopped the corves from spinning as they were pulled up the shaft. Curr also introduced the use of vertical guard rails, set vertically into the shafts to direct the waggons.[188]

Once on the surface, coal was handled in various ways. Generally corves were emptied through sifting screens into waggons which generally carried 53 hundredweight (one Newcastle chauldron) of coal. Each waggon was pulled by one horse, and controlled by one driver; as these waggons were large and heavy, trains of waggons were not commonly used in this region. Waggonways were designed such that loaded waggons could travel downhill by gravity; waggonmen controlled their speed with lever brakes. Once the coal was discharged, horses pulled the waggons back uphill to the mines.[189]

At the river's edge waggons generally rolled onto staiths, platforms elevated over the river, which served both to protect stockpiled coal from flooding and to facilitate loading into riverboats (keels) or, as coal mining moved closer to the mouth of the river and railways were laid closer to areas where colliers could

[187] Flinn, *The History of the British Coal Industry*, p. 102.
[188] Flinn, *The History of the British Coal Industry*, p. 104.
[189] See Lewis, *Early Wooden Railways*, pp. 212-214.

reach, directly into coastal ships.[190] The first temporary staiths had appeared in the Northeast as early as the 14th century, and accommodated wains on roads,[191] but the more fixed and capital-intensive waggonway system required more permanent structures with piles in the river. By the early 18th century the loading of coal had started to become automated. On the Tyne staiths accommodated waggons with hatches on the bottoms dropping coal directly into ships.[192] Later systems used waggons with bottom or side panels to drop coal into chutes or spouts. In the late 17th century at Whitehaven coal was loaded into sacks, which were transhipped into boats.[193] Some staiths had cranes which loaded containerised coal in tubs, or the waggons themselves, directly into ships. In the 1820s John Buddle's collieries were using a system in which cranes lifted waggons directly onto colliers.[194] The volume of output of large collieries often required the construction of several staiths with turntables at the ends of the waggonways to direct waggons onto the appropriate lines; flanged wheels permitted more precise automatic guidance.[195] Although a staith was built in Swansea before 1803, this type of system was rarely seen elsewhere, as no other area mined coal on the scale found in the Northeast; mechanisation did not come to other coal mining areas in Britain until after the edge railway system had been established nationally.[196]

[190] Flinn, *The History of the British Coal Industry*, p. 169.
[191] Terry Powell, *Staith to Conveyor* (Chilton Ironworks, 2000), p. 7.
[192] Powell, *Staith to Conveyor*, p. 10.
[193] Powell, *Staith to Conveyor*, p. 10.
[194] Flinn, *The History of the British Coal Industry*, p. 170.
[195] Powell, *Staith to Conveyor*, p. 11.
[196] Powell, *Staith to Conveyor*, p. 43.

Until the end of the 18th century most coal was loaded onto keelboats and transported downriver to the furthest point inland that coastal ships could reach. Keelboats were generally rated to carry eight Newcastle chauldrons, or about 21 tons, though they were frequently overloaded. Estimates suggest that at their peak there were 400 keelboats transporting coal on the Tyne.[197] At the mouths of the Tyne and Wear keelmen loaded their cargo into coast lighters for shipment to London. These colliers, as the cargo ships were known, were not specialised coal-carrying vessels but were of all types, and generally not dedicated to carrying coal only.[198] By 1800 they were generally transporting coal in lots of 200 to 300 tons. At their peak in the 1820s it is estimated that about 1750 ships were engaged in the month long round trip between the Northeast and London.[199] As the Tyne was dredged and otherwise improved, and as mining began to spread downriver toward Newcastle, the use of keels declined as they were superseded by transshipment directly into colliers.

By the end of the 18th century the edge railway network associated with Northeastern collieries were part of an integrated mechanical system, along with mechanical loaders, dumpers, winding engines, staiths, water transport and other equipment. Lewis described the wooden railways of this region as 'part and parcel of a colliery's equipment'.[200] These edge railways can be considered part of the first large scale bulk transport system; unlike the plateways associated with local transport of goods to canals, they were a component of an integrated interregional system designed to convey bulk freight efficiently from the Northeast

[197] Flinn, *The History of the British Coal Industry*, p. 147-148.
[198] Flinn, *The History of the British Coal Industry*, p. 171.
[199] Flinn, *The History of the British Coal Industry*, p. 176-177.

to London. Also, unlike the canal-plateway system, the land-based part of this system was under exclusive individual private control.

It appears that the bar iron rail found in Wales and other regions was never used in the Northeast; wooden railways first began to be relaid with cast iron edge rail in the late 18th century. Although at least one author gives William James the credit for originating edge rail,[201] it is more generally stated that William Jessop created the first design, possibly at the suggestion of John Smeaton, for the Leicester Navigation's Forest Line in 1792.[202] Jessop's design of a fishbellied edge rail was described at the time, by someone familiar with the more sophisticated design of the plateway, as 'a reversion to the form of the original wooden railway'.[203] Although iron edge rail may have appeared in Wales by 1787, others claim that the first T-shaped rails were produced in 1794, and by 1798 were employed at several collieries in Newcastle, including the Walker Colliery, although Lewis disputes this, stating that the first conversion of a wooden railway to iron in that region took place in 1797 at the Lawson Main Colliery on the Heaton line at Benwell.[204] The wooden Tindale Fell waggonway was relaid with bulbous-topped fishbelly rail in 1808, but the first true T-shaped

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[200] Lewis, *Early Wooden Railways*, p. 141.
[201] Baxter, *Stone Blocks and Iron Rails*, p. 44.
[202] Lewis, *Early Wooden Railways*, p. 293. Although some have argued that the first use of edge rail was on a railway Jessop built from Nanpantan to the Loughborough Canal, this rail actually appears to have been three-foot bar iron rail (see John van Laun, 'In Search of the First All-Iron Edge Rail', in M.J.T. Lewis (ed.), *Early Railways 2*, p. 99).
[203] Dendy Marshall, *A History of British Railways Down to the Year 1830*, p. 146.
[204] Mike Chrimes (ed.), *The civil engineering of canals and railways before 1850* (Aldershot, 1997), p. 119, van Laun, *Early Limestone Railways,* p. 17, M. J. T. Lewis, 'From Bar to Fish-Belly: The Evolution of the Cast-Iron Edge Rail', in Lewis (ed.), *Early Railways 2* p. 103; cf Lewis, *Early Wooden Railways*, p. 231, 294.

rail was laid at Belvoir Castle in 1813.[205] What is considered the ultimate development of the cast iron rail, Losh and Stephenson's design, was patented in 1816; this rail was cast with a bottom flange, and it had lap rather than butt joints at each end to ensure smoother connections.[206] The process of conversion from wood to iron was never complete; wooden rail was still laid into the 1840s and is still identified as being used in 1965.[207]

The shift to iron rail was considered a worthwhile investment in improving waggonway efficiency and reducing maintenance costs. As early as the 1760s John Buddle had remarked that a horse could 'do more work by 30 per cent on an iron way than on a wooden way; but frequently he will do 50 or even 100 per cent more';[208] it took another 30 years, however, for the cost of cast iron rail to drop enough to make wide scale replacement of wooden rails economically feasible.

While the material was new, the construction and operation of iron railways was essentially the same as that described for the Newcastle wooden railways in Chapter 2. Cast iron rail was generally laid along the routes of existing wooden railways. As with wooden waggonways, coal viewers generally built the lines themselves though they sometimes requested proposals from waggonway wrights, like William Brown of Throckley, who laid lines to several collieries.[209]

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[205] M. J. T. Lewis, 'From Bar to Fish-Belly: The Evolution of the Cast-Iron Edge Rail', in Lewis (ed.), *Early Railways 2*, p. 100.
[206] M. J. T. Lewis, 'From Bar to Fish-Belly: The Evolution of the Cast-Iron Edge Rail', in Lewis (ed.), *Early Railways 2*, p. 105.
[207] Lewis, *Early Wooden Railways*, p. 296 , M. J. T. Lewis, 'From Bar to Fish-Belly: The Evolution of the Cast-Iron Edge Rail', in Lewis (ed.), *Early Railways 2*, p. 104.
[208] Flinn, *The History of the British Coal Industry*, p. 151.
[209] Lewis, *Early Wooden Railways*, p. 143.

Since these lines were built for private use, it was unnecessary for them to obtain Parliamentary approval; instead, colliers negotiated wayleaves. If the intervening property owners were competing collieries, they had an incentive to either deny other collieries permission, or to charge high tolls for the operation of waggonways, though it was possible to petition the Privy Council for the granting of compulsory wayleaves.[210] It is possible that the expence of the wayleave system, and the original custom of paying by the waggonload, was an incentive to invest in more efficient forms of coal transport using waggons with higher capacity than wains. Unlike the permanent nature of the Parliamentary system used to grant rights of way for canals and plateways, the flexibility of the wayleave system permitted colliers to abandon waggonways as coal seams were mined out.

Unlike their counterparts in other regions, where companies were formed to construct transport facilities and then profit by charging tolls for their use, Northeastern waggonways were constructed for the exclusive use of the collieries that built them. Kirby points out, for example, that '…the great majority of colliery proprietors were intent on reserving waggonways for their own exclusive use, either individually or collectively'.[211] Due to the shortage of routes to rivers, and to the difficulty of obtaining wayleaves, newer collieries did occasionally pay established collieries to use their waggonways, as Murton colliery paid Flatworth a fee per ton mile in 1804,[212] but the common and ideal situation was for

[210] Flinn, *The History of the British Coal Industry*, p. 162; Lewis, *Early Wooden Railways*, p. 88.
[211] Kirby, *The Origins of Railway Enterprise*, p. 13.
[212] Flinn, *The History of the British Coal Industry*, p. 156.

collieries to construct and own their own waggonways, contracting out maintenance and operation to local labour. Colliery managers had control over the vehicles and traffic on the line, and all operators of vehicles were employed by the colliery either directly or by contract.

5. The origins of steam power on plateways and edge rail

As we have seen, although railways were in widespread use in Wales, Shropshire and the Midlands, and the Northeast by 1800, these lines were primarily built and employed to carry coal from mines to water transport. Railway technology did not come into widespread use for general goods and passenger transport until the introduction of the steam locomotive beginning in the 1820s. Thomas Gray, the most widely-published proponent of a national system of public railways, was adamant that the system would only be effective with steam power:

> …in consequence of the great improvement in steam-engines, the necessity of horses on the rail-way may be superseded, for the public benefit would soon be so evident to every common observer, as to admit of no comparison between horse and mechanic-power….[213]

An observer sceptical of the enthusiasm for railways at that time pointed out that '[t]he whole arcana of the business must be sought for in the Locomotive Engine'.[214] When the Act authorising the Newcastle & Carlisle Railway passed without including permission to use locomotives, it was declared that 'no Railway can be enjoyed beneficially by the Public without the Use of the Locomotive Steam Engine'.[215] Although steam power was also being developed for use on canals and rivers, it did not provide as much advantage to water transport; 'the rapidly increasing resistance of water as velocity is increased, proves just as fatal to canals, as the rapidly diminishing force of animal power is to turnpike-roads'.[216]

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[213] Gray, *Observations on a General Iron Railway*, p. 17.
[214] Frederick Page, *The Fingerpost* (unknown, 1825), p. 15.
[215] Brooks, *Wylam and its Railway Pioneers*, p. 22.
[216] Page, *The Fingerpost*, p. 41.

As stated in Chapter 1, historians of early railways typically ascribe the decline of the plateway to its incompatibility with steam locomotion, suggesting that the thin section of a tramplate cannot support the weight of a locomotive the way edge rail can. This chapter addresses this argument in three ways. First, the development of the locomotive began on plateways, the first successful steam locomotive was operated on a plateway, and several were employed on plateways during the first three decades of the 19^{th} century and continued to be used on plateways through the 20^{th} century. Second, during the period when edge rail came to predominate, inventors were developing ways to make plate rail and steam locomotives more compatible. Third, several operators initially dismissed steam locomotion as 'uneconomical' on plateways not because of the technical difficulty of operating locomotives on plate rails but rather the impracticality of investing in a highly-capitalised machine that could not be used efficiently. Locomotives were also often seen as uneconomical on edge railways as well; it was understood that they could provide an economical alternative to horses only where a railway company owned and operated all vehicles and motive power exclusively.

Richard Trevithick of Cornwall is credited with developing the first successful steam locomotive. The son of a mining engineer, Trevithick grew up around and was familiar with the engines used to pump water out of the copper and tin mines of the region, and began his career as a mining engineer. He became interested in 'strong,' or high pressure rather than atmospheric, steam engines, in order to circumvent Watt's atmospheric steam engine patents; as well as not being covered under these patents, these engines were also simpler in design, easier to build, and less expensive to run.[217] Over the course of his career Trevithick built both stationary and locomotive engines that operated on this principle; his 1798 stationary prototype was so successful that more than a dozen had been deployed in Cornish mines by 1802.[218]

His first experiment with a travelling engine, said to have been inspired by seeing horses haul a stationary engine to its site, was his road locomotive of 1801, which he drove around Camborne and which was destroyed within a week due to his carelessness.[219] Trevithick built one more road locomotive after his first experiment, but began to focus instead on vehicles that operated on rails. The history and provenance of all of Trevithick's engines is unknown, and it seems likely that he actually built more engines than those for which documentation now exists.[220]

Although locomotives were soon adopted and eventually improved by men working in Northeastern coal mines, these earliest engines were built for and used by the ironmasters of Shropshire and southern Wales. Trevithick apparently constructed his first railway engine in 1802-1803 for ironmaster John Guest of Coalbrookdale, to transport iron on Coalbrookdale's plateway from the ironworks to the Severn; historians are familiar with references to this locomotive, but M.J.T. Lewis knows of no substantiating evidence for it.[221] The first

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[217] Richard L. Hills, *Power from Steam* (Cambridge, 1989), p. 102.
[218] Michael Bailey, 'Beaumont and Trevithick on Track: 400 Years of Wheel/Rail Interface', Smeaton lecture at Institution of Civil Engineers, 20 July 2004.
[219] Anthony Burton, *Richard Trevithick: Giant of Steam* (London, 2000), p. 60.
[220] Michael Bailey, 'Beaumont and Trevithick on Track: 400 Years of Wheel/Rail Interface', Smeaton lecture at Institution of Civil Engineers, 20 July 2004.
[221] Rattenbury and Lewis, *Merthyr Tydfil Tramroads and their Locomotives*, p. 51.

locomotive for which documentation exists was built in 1804 for Samuel Homfray of Penydarren, for whom Trevithick had built several stationary engines, for use on the Penydarren (or Merthyr Tydfil) Tramroad. This tramroad served three ironworks in south Wales, Penydarren, Plymouth, and Dowlais, as well as the Pentreback Forge and Dyffryn Furnaces. Like others in the area, this tramroad transported not only coal but also limestone, ore, and manufactured goods to and from these clients and the Glamorganshire Canal.

Homfray wagered 500 guineas with Richard Crawshay of Cyfarthfa that Trevithick's machine could pull ten tons of iron on the tramroad nine miles from Penydarren to Abercynon, the dock on the Glamorganshire Canal, and pull the empty waggons back to the ironworks. Although Trevithick's engine accomplished this task with ease, as well as carrying 70 men on the journey, it is said that Crawshay never honoured the wager because the engine misaligned some plates which later had to be reset.[222] Homfray and other observers considered the locomotive, which made the trip at an average speed of four miles an hour, an astounding success. They were struck by the ease with which the operator could control its speed and direction;[223] such comparisons with presumably intractable horses were the first of many similar observations over the course of early locomotive history.

The engine made several more journeys, but was eventually converted to a stationary engine. The reason for the machine's relatively short active life is not entirely clear. It was intended as an experimental multipurpose engine, though

[222] Rattenbury and Lewis, *Merthyr Tydfil Tramroads and their Locomotives*, p. 52.

its success as a locomotive was never pursued; it is assumed that its five tons broke too many plates, though it was not unknown for horsedrawn carts weighing as much as three tons each to break plates as well.[224] Trevithick continued to construct locomotives, in 1808 building *Catch-me-who-can* to 'run against any mare, horse or gelding that may be produced at the next October Meeting at Newmarket'; the engine never fulfilled this boast, but operated for a time as a novelty attraction on a circular plateway near what is now Euston Station.[225]

The plateway network associated with the Monmouthshire Canal Company, the most extensive in the country, had a history of experimentation with steam locomotives. Neath Abbey Iron Company, founded in 1792, built several locomotives for use on these and other plateways, and continued to produce plateway locomotives through the 19th century; the last plateway locomotive built at the Abbey was constructed for the Gurnos Tramroad in 1871, and presumably operated there until the Cyfarthfa Ironworks closed in 1908.[226] Other engines operating on this network were built by the Cyfarthfa Ironworks and Robert Stephenson & Co. In 1816 William Stewart of Newport offered a locomotive, apparently set up to travel on both railways and roads, to the proprietors of the Sirhowy Tramroad, though there is no evidence that the company considered his offer. Two years before, Stewart had built a locomotive for the Parkend Colliery in the Forest of Dean, where he was the colliery's engineer. It was to have run on a plateway between the Lydney Canal and Lynbrook, and Stewart was to

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223 Rattenbury and Lewis, *Merthyr Tydfil Tramroads and their Locomotives*, p. 52.
224 Rattenbury and Lewis, *Merthyr Tydfil Tramroads and their Locomotives*, p. 55.
225 C.F. Dendy Marshall, *Early British Locomotives* (London, 1939), p. 16-17, quoting an article in the *Times*, 8 July 1808.
226 Rattenbury and Lewis, *Merthyr Tydfil Tramroads and their Locomotives* , p. 62.

have kept the difference in cost between what he could operate his service for and what hauliers were charging the colliery. The hauliers promptly lowered their charges, leaving Stewart without a profit on the enterprise, and he soon abandoned the engine to the company.[227]

Locomotives were also being used on other plateway systems in Wales. An engine built by George Stephenson was employed at Llansamlet in 1819, and a Blenkinsop rack locomotive was used on the Nantyglo colliery line.[228] This engine may have been used on the Llangattock quarry tramroad, laid specifically to accommodate heavy locomotives. It appears a second engine, weighing 4.5 tons full and 'working upon 4 wheels & Springs' was supplied later.[229] The Tredegar tramroad began using the Robert Stephenson & Co. locomotive Britannia; eleven more locomotives for this line were built locally between 1832 and 1854, and locomotives continued to be used on this line until the quarry closed in 1920.[230] A note describing a locomotive trial on the Hirwaun tramroad in 1830 implies that locomotives were in regular use in the area at that time.[231]

At the same time the steam locomotive was also being developed in Derbyshire and Yorkshire as well as the Northeast. The first commercially successful locomotive, a rack-traction engine commissioned by viewer John Blenkinsop for the Middleton Colliery near Leeds, and constructed by Matthew Murray of

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[227] PRO RAIL 1014/4, item 28, letter from William Stewart of Newport to Chairman of Monmouthshire Canal Company, 8 January 1816, and associated information. van Laun, *Early Limestone Railways*, p. 39, and Schofield, *Benjamin Outram*, suggest that Stewart's locomotive did run on Monmouthshire Canal Company tramroads (or the Sirhowy Tramroad).
[228] van Laun, *Early Limestone Railways*, p. 39.
[229] van Laun, *Early Limestone Railways*, p. 111.
[230] van Laun, *Early Limestone Railways*, p. 144-145.

Murray, Fenton and Wood, began operation in 1812. Because the locomotive, at four tons, was designed to be light enough not to damage the rails on which it ran, it included a cogwheel intended to provide traction by engaging with a rack laid alongside the rails. Four locomotives of similar design, built in 1812 and 1813, worked this line until the last exploded in 1834.[232]

Although the locomotive was invented and first tested in Wales, and first used commercially in Yorkshire, the most fertile area for locomotive development during the first 30 years of the 19th century was the collieries of the Northeast. In 1812 William Chapman and his brother Edward Walton Chapman patented an engine designed to move by pulling itself along a chain. This engine was constructed at the Butterley Ironworks in Derbyshire in 1813, and sent to Heaton Colliery, where Chapman and viewer John Buddle experimented with it until 1815, when a flood closed the colliery and the engine was converted to stationary operation. Another Chapman engine originally commissioned by Buddle for Lambton Colliery was eventually transferred to Heaton. Buddle and Chapman continued to build engines, the next for the Wallsend Colliery (the *Steam Elephant*, a replica of which now operates at Beamish); it originally ran on a wooden railway at Wallsend, then at Washington, and was successful on neither until the Wallsend line was relaid with Stephenson and Losh cast iron edge rails. They built another engine for Whitehaven Colliery in 1816; it was converted to a stationary engine in 1818.[233]

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[231] van Laun, *Early Limestone Railways*, p. 197.

[232] Dendy Marshall, *Early British Locomotives*, p. 33; C. F. Dendy Marshall, *Two Essays in Locomotive History* (London, 1928), p. 12.

Steam locomotives were also operated on northeastern England's only plateway, at Wylam. In 1804 Christopher Blackett, Wylam's manager, ordered a locomotive from John Whinfield of Gateshead, Trevithick's northern agent; he decided, however, that at 4.5 tons the engine would crush the colliery line's wooden rails and employed it as a stationary engine instead.[234] In 1805 Blackett appointed William Hedley, then working at Walbottle, as his coal viewer. In 1808 they decided to relay the Wylam line with plate rail. Blackett may have chosen plate rail for two reasons. First, it may be that at the time the only builder of locomotives was Trevithick, whose engines operated on plateways. Second, in accordance with the expectation at the time that a national rail network would be a plateway network, Blackett might have planned for his line to be a part of that network.

Once the line was relaid Blackett attempted to obtain another locomotive; this time Trevithick declined to supply him with one, so he and Hedley built their own. In 1812 Hedley performed several experiments with carts designed to determine whether it was possible for a locomotive to pull a useful weight without a chain or rack, i.e. by adhesion alone. These experiments were successful, and between 1813 and 1815 Hedley and Timothy Hackworth, the foreman smith at Wylam, constructed four locomotives, the first modified from Hedley's experimental cart. These engines weighed 8 tons each, with the addition of 4 ton tenders.[235]

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233 <http://www.locos-in-profile.co.uk/Articles/Early_Locos/early4.html> (August 16 2005).
234 Dendy Marshall, *Early British Locomotives,* p. 15.
235 Bayliss, *Retracing the First Public Railway*, p. 14.

The best known of the locomotive designers in this area was of course George Stephenson, who in 1814 received permission and funding from Lord Ravensworth to build his first locomotive, modeled on a Blenkinsop engine. This first design was not successful, and Stephenson and collaborators continued to improve it.[236]

Although these locomotives may have been heavier than the vehicles usually used on the lines on which they were operated, they were not excessively so. Early locomotives weighed between four and eight tons; a typical Northeastern coal waggon at the time weighed only somewhat less, about 3.5 tons.[237] Welsh plateway trams could weigh as much as three tons, though two was more typical; in 1813 the Monmouthshire Canal Company passed a resolution limiting the maximum weight of coal trams on its lines to 2.5 tons.[238] Nevertheless, locomotives often broke both tramplates and edge rails. In 1812 a locomotive built by Taylor Swainson broke rails on the Whitehaven Colliery line; a letter written by the grandson of the inventor ascribes this to the fact that the rails were made of cast iron. The colliery gave up on the locomotive in 1816 rather than relaying the line. John Buddle reported the same problem with breakage on the Howgill railways in 1816; again, an 1877 article ascribes this to the use of cast iron rail.[239] George Stephenson's second engine broke the rails it rode on, leading Stephenson and William Losh of Walker Ironworks to invent and patent

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[236] See e.g. Brooks, *Wylam and its Railway Pioneers*, and any history of the steam locomotive.
[237] E.g. Dendy Marshall, *Early British Locomotives*, pp. 15, 19
[238] van Laun, *Early Limestone Railways*, p. 32.
[239] Galloway, *A History of Coal Mining in Great Britain*, p. 192; Dendy Marshall, *Early British Locomotives,* p. 37. The Whitehaven engine may have been the first referred to as an 'iron horse.'

an improved rail design in 1816.[240] In 1821 William Losh wrote to Edward Pease recommending this design; in his letter he mentions the commonness of breakage on edge railways in the Northeast:

> [At Heaton] the large Travelling Engine broke all others very fast, but none of the Patent Rails although the others were…heavier & now that they have put springs to the Engine the common rails still occasionally break but never one of our Patent ones….[241]

In his *Remarks on the comparative merits of cast metal and malleable iron rail-ways* Michael Longridge stated that in 1819 at Tindale Fell cast iron rails must be replaced every day.[242] As late as 1831 Nicholas Wood mentioned that cast iron rail was likely to break, particularly at the joints; 'the reaction of those shocks was often liable to break the rails in return'.[243]

While both plates and rails were known to break under the weight of heavy coal waggons, the problem was exacerbated by the use of locomotives, and many railway engineers at the time were engaged in devising ways to strengthen cast iron plates and edge rails as well as to lighten the loads they were required to carry. Benjamin Outram devised a weight rating system for tramplates cast by the Butterley Company. In a letter of 1795 he describes five grades of tramplate, from 18 to 40 pounds per yard; the heaviest was rated for 50 to 70 cwt (2.5 to 3.5 tons) and guaranteed to carry the specified weight for three years if 'properly laid down on a bed of Stone'. Such rails could easily have supported a

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[240] Christopher Stead, *The Birth of the Steam Locomotive* (Haddenham, 2002), p. 39.
[241] Dendy Marshall, *Early British Locomotives,* p. 68.

[242] Michael Longridge, *Remarks on the Comparative Merits of Cast Metal and Malleable Iron Rail-ways* (Newcastle, 1827), p. 7.

locomotive whose weight was spread over four plates. A specification prepared for the Marple Railway probably in late 1797 proposed 75 pound tramplates rated for up to five tons each, though two ton loads were expected on this line.[244]

While in general the heavier the plate the heavier the load it could support, in order to hold down the expence of materials and handling founders and designers created several improvements to increase their bearing capacity without proportionally increasing their weight. One such technique was 'hogging,' or increasing the height of the centre of the plate (presumably so that it looks like a hog's back), adding strength at the point where the bending moment is highest.[245] Another was the addition of a supporting rib on the underside of the plate. In a letter of 4 June 1816, William Jessop requested Butterley Company staff to prepare a model rail 'similar to the Croydon [i.e. Surrey Iron Railway] rail but nearly twice the thickness,' and with the addition of such a rib, for John Rennie's Southwark Bridge Railway. Rennie specified plates rated to carry the castings for the bridge, up to 10 tons each; Jessop sketched a sample rail with the statement, 'therefore I give my own Ideas, except Mr. Rennie's wishes to have the under rib and to be 72 to each'. A shorter and thicker rib also appears in a section drawing of the Wylam colliery plate rail. Many of the plates shown in John van Laun's book *Early Limestone Railways* show ribbing, hogging or both.[246]

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[243] Nicholas Wood, *A Practical Treatise on Rail-Roads* (London, 1825), p. 31; he suggests that this is due not to an inherent design flaw but because cast iron rail was cast too light to support required loads in order to make it cost competitive with wooden rails (p. 156).
[244] Derbyshire Record Office, D503/12/1.
[245] van Laun, *Early Limestone Railways*, p. 142-144, and illustration p. 57.
[246] Derbyshire Record Office, D503/12/2, letter 4 June 1816; Permanent Way Institution, *British Railway Track* (London, 2004), p. 16; van Laun, *Early Limestone Railways,* e. g. p. 57.

Locomotive builders also considered ways to reduce the incidence of rail cracking. The most obvious such improvement was to spread the weight of the locomotive over more wheels, and thus over more plates or rails. The Chapman locomotive of 1812 was the first to incorporate a bogie which spread the weight of the machine over more wheels, bringing the load on each rail down to that of a horsedrawn waggon; this design was so successful that William Hedley converted the locomotives he had constructed at Wylam from four wheels to eight.[247] This principle also affected rail length; both edge rails and plates could be cast as long as six feet, but manufacturers generally made them shorter both for increased ease of installation and reduced expence of replacement if they broke, as well as to permit each wheel of a waggon or locomotive to be supported by a separate plate.

Weight alone was not the only reason locomotives damaged rail lines. The dynamic loads caused by the movement of the pistons also caused rails to crack, particularly at the joins between them. Nicholas Wood suggested that such dynamic loads should be calculated as three times the weight of the locomotive itself.[248] In addition to increasing the bearing capacity of rails and plates, engineers addressed this issue by improving the design of locomotives. One way to reduce jarring shocks to the rail was to incline the cylinders. While Trevithick's first locomotives operated with horizontal cylinders, his *Catch me who can* and

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[247] W. Skempton, 'William Chapman (1749-1832), Civil Engineer', *Transactions of the Newcomen Society* 46 (1973-1974), p. 45-71, p. 69.
[248] Wood, *A Practical Treatise on Rail-Roads,* p. 163.

other early locomotives employed vertical cylinders.[249] The idea to use inclined or horizontal cylinders seems to have originated with Robert Stephenson, as after his return from South America in November 1827 George Stephenson's engines began to feature inclined cylinders. The *Experiment*, built in 1828, originally used horizontal cylinders, though these were later altered; the *Lancashire Witch* of the same year, and other engines of similar design, used inclined cylinders, as did Robert Stephenson's *Rocket*.[250] Most locomotives built after these used inclined cylinders, although those designed by Timothy Hackworth, including the *Sans Pareil* which competed with *Rocket* at the Liverpool & Manchester Railway's Rainhill trials in 1829, continued to use vertical cylinders.[251]

Locomotive designers also began to incorporate improvements in suspension. Although Robert Lovell Edgeworth installed springs in a carriage in 1768, the technology did not become generally employed until the 19th century, after Obadiah Elliott patented the elliptical spring for road carriages in 1805.[252] George Stephenson's third locomotive, built in 1816, employed steam springs, although on consideration such springs and vertical pistons cannot have worked well together as the springs would be likely to amplify the vertical motion rather than damp it. His fourth engine, built in 1823, originally worked with steam springs, though plate springs were later installed. The *Lancashire Witch* was the first to initially include metal springs; such springs were retrofitted into other

[249] See e.g. . Dendy Marshall, *Two Essays in Locomotive History,* p. 14.
[250] Dendy Marshall, *Two Essays in Locomotive History,* p. 47; Dendy Marshall, *Early British Locomotives,* p. 75; also see Michael R Bailey and John P Glithero, *The Engineering and History of Rocket* (London, 2000), pp. 5-10.
[251] Dendy Marshall, *Two Essays in Locomotive History,* p. 59.
[252] Dendy Marshall, *Early British Locomotives,* p. 65.

locomotives later.[253] By 1830 the technology was so widely used that the Monmouthshire Canal Company could state that no locomotive would be permitted to operate on its tramroads that was not suspended on proper springs.[254]

While it seems that reducing the weight of locomotives and waggons would have been a profitable tactic to pursue, designers after Blenkinsop did not generally appear to approach this problem with any significant effort. The problem of excessive weight on rails may have been less significant on plateways, where the loads, individual shipments of general merchandise, were smaller and thus lighter; because each individual transported his own load, there was not a great incentive to increase the load-carrying capacity of the railway itself.

Despite all of these efforts, the problem of rail breakage was only satisfactorily overcome with the introduction of wrought iron, or malleable iron, rail in the 1820s. Wood indicates that the first bar-shaped malleable iron rails were laid at Walbottle in 1805[255] and at Tindale Fell at about the same time.[256] Robert Stevenson's favourable opinion of the new material, expressed in a report written in 1818, impressed Michael Longridge, manager of Bedlington Ironworks near Newcastle, who decided to make malleable iron rails for a line about two miles long between a colliery near Willowbridge and the River Dene. In 1819 John

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[253] Dendy Marshall, *Two Essays in Locomotive History,* p. 39; Dendy Marshall, *Early British Locomotives,* p. 65.
[254] PRO RAIL 1014/4 , item 27, Monmouthshire Canal Company, minutes of meeting 24-25 August 1830.
[255] Wood, *A Practical Treatise on Rail-Roads,* p. 39; Warn, *Waggonways and Early Railways of Northumberland*, p. 14 identifies the first wrought iron rail at Walbottle in 1794.
[256] Lewis, *Early Wooden Railways*, p. 294.

Birkenshaw, principal agent at Bedlington, wrote to Lord Carlisle's agent at Tindale Fell; while there was and continued to be concern that the new material was 'more subject to waste, by *rust* or *oxidation*, than Metal Rails', the agent informed him that while cast iron rails broke every day, the malleable iron rails they had laid eight years ago had not been replaced.[257] Peter Northover states that wrought iron rail would in fact have been subject to delaminating, because of the high proportion of slag (as much as 5%) in the wrought iron mixture. He adds that despite the existence of several contemporary references to wrought iron 'oxidizing,' he is not sure what this refers to; it may relate to some kind of corrosion specific to certain regions or soil types.[258]

In 1820 Birkinshaw patented a wedge-shaped rail section that conserved material without sacrificing load-bearing capacity. These rails could be rolled by power machinery, thus reducing their cost and increasing the potential supply.[259] These rails could also be significantly longer than cast iron rails; by the early 1820s Bedlington Ironworks was rolling 15 foot long wrought iron rails.[260] Wood describes some of the advantages of wrought iron: longer rails deflect rather than crack or break, and the fact that rails can be rolled longer means lines have fewer joints, thus the ride is smoother and the risk of damage to vehicles and contents is less.[261] Because it was easier to produce, and because it could support loads similar to cast iron rail using less material, wrought iron rail soon

[257] John Birkenshaw, *Patent, for an improvement in the construction of Malleable Iron rails, to be used in Rail Roads; with remarks on the comparative merits of Cast Metal and Malleable Iron Rail-ways* (Newcastle, 1822), p. 8, 9. Also see Longridge, *Remarks on the Comparative Merits of Cast Metal and Malleable Iron Rail-ways*, for reference to the debate over the use of malleable iron rails.
[258] Conversation with the author. One of his MA students is investigating the issue.
[259] Evan Martin, *Bedlington Iron and Engine Works* (Newcastle, 1974), p. 11.

proved less expensive than cast iron. Although he and William Losh had recently patented a design for a cast iron rail, George Stephenson recommended the use of the new malleable iron rails for the Stockton & Darlington Railway; these rails were supplied by Longridge, a friend of Stephenson's. The committee initially requested that 2/3 of the line be laid with malleable iron and 1/3 with cast iron, but the tenders for the project showed that malleable iron was cheaper so the line was ultimately laid with malleable iron.[262]

Wood mentions that wrought iron plates were being produced as early as 1824.[263] Blocks designed to hold wrought iron plates and a sill for a wrought iron plate with a rib were found at the Llangattock quarry tramroad; wrought iron plates, and chairs to fix them, have also been found on several other plateways in Wales. Peter Northover believes that wrought iron tramplates were more complex and difficult to manufacture than rolled wrought iron rail; however, as at least one Welsh tramroad used edge rail turned on its side as a substitute for plate rail it is difficult to understand how this could have affected the choice to manufacture wrought iron plate rail.[264]

It appears that the locomotives built between 1802 and 1825, and operated on both plateways and iron edge rail, were in general technically satisfactory, but almost all were given up by their owners and converted to stationary engines because they were 'not economical', although many reports of their economic

[260] Warn, *Waggonways and Early Railways of Northumberland*, p. 5.
[261] Wood, *A Practical Treatise on Rail-Roads,* p. 165ff.
[262] PRO RAIL 1148/1, minutes of the Stockton & Darlington Subcommittee, 29 December 1821, et al.
[263] Wood, *A Practical Treatise on Rail-Roads,* p. 24
[264] See van Laun, *Early Limestone Railways*, p. 106, 143, 163.

efficiency were favourable. George Stephenson reported from Killingworth in 1814 that the cost of a steam locomotive was half that of horse traction and in a letter of 1814 John Blenkinsop stated that his engines are operating at a sixth the cost of horses.[265] Thomas Gray's cost comparisons for horse and steam traction, though erroneous, predicted that over the course of 12 years locomotives could perform the same work at 20% of the cost of horses.[266] Despite claims that the Stockton & Darlington saved up to 30% of operating costs by using steam locomotives, the directors continued to debate abandoning them altogether throughout the first two years of the line's operation.[267]

The use of locomotives may have been uneconomical on the plateways of Wales and other parts of England for reasons other than that generally stated by historians. First, railway builders had to consider that laying a line to be used by locomotives increased the initial capital cost. John Greaves suggested that rail must be twice as heavy for locomotive as for horse power, and that other works must be built for double the strength of a horse line.[268] The 1824 estimate for a proposed Stroud & Severn line, based on the cost of similar lines, was £1895 per mile for a locomotive line and £1400 per mile for a horsedrawn line.[269] It was also understood that the initial capital cost of setting up a steam line was much higher than that for a horsedrawn line. A document outlining the proposed

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[265] Andy Guy, 'North eastern locomotive pioneers 1805 to 1827; a reassessment', in Early Railways, pp. 117-143, p. 128; Galloway, *A History of Coal Mining in Great Britain*, p. 191.
[266] Gray, *Observations on a General Iron Railway,* p. 80.
[267] Kirby, *The Origins of Railway Enterprise*, pp. 61-63.
[268] Institution of Civil Engineers, London, T/MT 1, report on Yorkshire, Durham and Northumberland railroad.
[269] PRO RAIL 1019/3, item 25, J. Hinde Perry, Stroud & Severn Rail-road, Report of the Committee, 1824, p. 3.

traction options for the Canterbury & Whitstable Railway pointed out that 'there are many persons frightened at the expence of Steam Power'.[270]

Second, locomotives were costly investments, too expensive to be purchased and used intermittently by individuals, or even by one client on a multiuser plateway. Not only would a single client on a canal-based plateway not have enough goods to transport, but also a multiuser line would not facilitate the free and continuous passage of locomotive trains. Although not specifically stated as a reason for choosing or abandoning locomotive haulage on specific lines, the connection between the quantity, regularity and consistency of freight on a given line, and between speed, economy, and access, were clearly considered by both engineers and investors. Although promoters of locomotives claimed that locomotive haulage was cheaper than horse haulage, it is clear that both engineers and investors understood that this was only true under certain conditions. Locomotives theoretically cost less because they did not need to be fed if they were not working; on the other hand, once they were fired up they needed to be kept in continuous use to realise any cost economy from them.

A 31 July 1829 article in the *Leeds Mercury*, for example, reports the opinion of J. Walker Esq., Engineer, on the choice of motive power for a proposed Leeds & Selby Railway:

> On the whole Mr. Walker prefers the horse power to either the locomotive or the stationary engine power, for this road. Amongst a number of other considerations, Mr. Walker says, the most powerful motive for using the ‘uniform system’ or horse power, is its general

[270] Reginald B. Fellows, *History of the Canterbury and Whitstable Railway* (Canterbury, 1930), p. 88.

> utility to the public, and greater simplicity and certainty, which puts in the power of the manufacturer, coal owner, or farmer upon the line to convey his goods at his own time and in his own way, simply on paying his toll, which, in a mixed trade, such as this is likely to be, will be a great object [. A handwritten note in the margin states, almost certainly erroneously, 'On this point, Mr. Stephenson, it appears, now concurs with Mr. Walker.']
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> …The expense of conveying goods upon the Darlington road by horses, (and a similar expense would attend this road,) is about a half-penny per ton per mile on the coals conveyed to Stockton, and, all things considered, the locomotive engine does not convey them for less; but at the rate of eight or ten miles an hour steam power would be very much cheaper, if there be weight requiring this high speed sufficient to form a load for the engines.[271]

In a manuscript of 1827, Thomas Telford did not recommend the use of steam locomotives, considering them dangerous and expensive compared to horse traction. He noted that when considering the employment of locomotives cost calculations should take into account the number of days an engine is out of service, and the time it takes to fire the engine, get its steam up, and take in water. He suggested, however, that steam locomotion could be usefully employed on a railway under three conditions: if the line were already level (e.g. did not require a great deal of additional expence to alter its grades), if coal was inexpensive in comparison to fodder, and if the locomotive could be fully employed.[272]

This logic also seems to have been clear to William Chapman, who in *Observations on a proposed railway from Newcastle to Carlisle* suggested that as the grades were not projected to be too challenging the line could operate

[271] PRO RAIL 667/1002.

[272] Institution of Civil Engineers. London, T/MT1. Telford did not mention in this document that the full employment of such equipment depended at least in part on the operating conditions of the railway.

locomotives '*if the amount of carriage be sufficient*—because of their greater speed, in which chiefly they are more eligible'; otherwise, 'in point of economy [locomotives are] not preferable [to horses] but even inferior to horses in *short distances*'.[273] His analysis of operating expences indicated that locomotives would be a penny per ton mile less expensive than horse traction (although more expensive than stationary engines or self-acting inclines) under the same conditions given by Telford; if the line were level and in a coal district, and if the locomotive were 'fully employed'. Chapman also saw the connection between locomotives and a single user system, suggesting that 'horses may be used, which are most consonant to a public Rail-way' and pointing out that '[u]pon that portion of the way which may require machinery, *the public company* who may execute it, *must necessarily become carriers at some given rate*'.[274] Thomas Tredgold's textbook on railway design also points out that, among his other objections to locomotives, their much-touted economy disappears when it is borne in mind that they can only be as fast as the slowest vehicle on the line.[275]

Through the 1820s, in terms of cost efficiency, or amount of work obtained for a given expenditure, the jury on locomotive traction was generally out, although it seems most writers on the subject considered horse traction or stationary steam engines more cost and energy efficient than steam locomotives. As we shall see in the next chapter, however, the locomotive began to look more efficient when

[273] PRO RAIL 1014/17, item 15, William Chapman, *Report on the Cost and Separate Advantages of a Ship Canal and of a Rail-way from Newcastle to Carlisle,* (Newcastle 1824), p. 11, 12. (italics in original).
[274] PRO RAIL 1014/17 item 15, William Chapman, *Report on the Cost and Separate Advantages of a Ship Canal and of a Rail-way from Newcastle to Carlisle,* (Newcastle 1824), p. 15, 16, (italics in original).
[275] Thomas Tredgold, *A Practical Treatise on Rail-Roads and Carriages* (London, 1825), p. 88.

speed began to be taken into account. Once locomotives were clearly shown to be superior in this respect, other measures of efficiency became less important; of the competitors at the 1829 Rainhill trials, for example, Robert Stephenson's Rocket, unanimously declared the victor, was not the most efficient user of fuel or water.[276]

6. The Stockton & Darlington Railway--an experiment with edge rail technology and plateway operation

The Stockton & Darlington Railway, which opened in 1825, is generally considered the precursor to the first 'modern' railway, the Liverpool & Manchester, which opened in 1830.[277] Unlike the Liverpool & Manchester, the Stockton & Darlington line initially attempted to combine the Northeastern coal mining technology of edge rail and steam locomotion promoted by its engineer, George Stephenson, and the operational system of canals and their associated plateways. The resulting failure of this system, which proved incompatible with the optimal and efficient use of steam locomotives, led (despite Parliament's initial unwillingness to acknowledge it) to widespread adoption of the monopolistic single-operator system employed by railways in Britain and around the world for more than 100 years.

James Brindley was commissioned to survey a canal route between the port of Stockton on Tees and the Shildon coalfields of Durham in 1767, but the project did not progress any further due to lack of funding.[278] In 1800 another route was

[276] Robert Stephenson and Joseph Locke, *Observations on the Comparative Merits of Locomotive & Fixed Engines, as Applied to Railways* (Liverpool, 1830), p. 79, 82.
[277] See e.g. Michael Robbins, *The Railway Age* (Middlesex, 1962) p.20-21.
[278] Kirby, *The Origins of Railway Enterprise*, p. 21.

surveyed by George Atkins.[279] In 1810 a committee was formed to research the possibility of the construction of a railway or canal on this route; the line was projected primarily to carry coal, but was also expected to convey lead and other goods as well as a small number of passengers. They commissioned John Rennie to resurvey the route in 1813, confirming Brindley's original survey;[280] a subsequent survey performed in 1818 by George Leather, who had worked with William Jessop on the Surrey Iron Railway, confirmed the viability of a railway.[281]

That year the committee hired George Overton, described as 'a skillful engineer from South Wales',[282] to design the line. He appeared as a witness before the House of Commons Committee, and helped the Act, permitting a railway or tramroad open to all users, to receive the Royal Assent in March 1821.[283] It appears that in addition to his engineering knowledge and experience he was able to use his influence to persuade powerful people to support the railway; a Welsh colleague stated in a letter to one of the directors that he 'will write to all my friends and request them to use their influence in favor of the Stockton Railway'.[284]

At that time the plateway was clearly preferred by most railway designers. The opinion of Robert Marshall, writing in 1803, was typical:

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[279] Kirby, *The Origins of Railway Enterprise,* p. 24.
[280] Kirby, *The Origins of Railway Enterprise,* p. 27.
[281] Kirby, *The Origins of Railway Enterprise,* p. 29.
[282] Committee appointed to consider opening a line of communication between Stockton and the collieries, *A Report relative to the opening a communication by a canal or a rail or tram way, from Stockton, by Darlington, to the collieries* (Stockton, 1818), p. 3.
[283] Kirby, *The Origins of Railway Enterprise,* p. 31, 37.
[284] PRO RAIL 667/896, letter dated 6 March 1821.

> Waggons are now constructed to work as well on the road, as on the Railway. A merchant, tradesman or farmer may, therefore, load his goods, though at a distance from the Railway, in his own waggon and send them under the care of his own servant, to the places of destination. Goods will not be mixed and there will, consequently, be less chance of damage or plundering.[285]

In 1821 Thomas Telford pointed out that plateways are good for diverting heavy traffic from turnpikes, and permit roads to be used as feeders;[286] William Jessop stated in the same year that '[t]he flanged Rail Way or Tram Road is in common use in this Neighbourhood, and is universal among the Collieries in this Country'.[287]

Edward Pease, a woollen merchant and banker from Darlington, was on the Stockton & Darlington committee, and a strong supporter of the railway; not only was he himself a principal financial backer of the project, he also persuaded relations and colleagues to invest in it. Between 1818 and 1821 he systematically solicited opinions from several experts to inform the decision on whether the line should be built as an edge railway or a plateway. Several who responded to his queries recommended the plateway unreservedly. Mr. Lovesey, for example, in an enclosure in a letter of February 26, 1819, stated that were he to do anything differently he would have replaced his current waggon design 'by a form much more adapted to the Street or side road & equally as well for the use

285 Robert Marshall, *Examination into the respective merits of the proposed canal and iron railway from London to Portsmouth* (London, 1803), p. 18.
286 Institution of Civil Engineers, London, Thomas Telford papers, T/MT2, *Further Report on the Stockton & Darlington Railway.*
287 Philip James Riden, *The Butterley Company* (Chesterfield, 1973), p. 45.

of the Colliery'.[288] C. N. Dawson of Low Moor recommended that Pease build a line

> constructed so to allow the common cast of Waggons of the country to travel where and for any distance they pleased and at any velocity they pleased [because] [o]ur great aim in a Good road in such a country as yours, would be to accommodate all descriptions of carriages whether carrying Heavy or light goods and whether travelling quickly or slowly and this in my opinion would be most effectually accomplished by such a Road as I mentioned.[289]

Others recommended the plateway under certain circumstances. Fenton and Murray of Leeds suggested in a letter in 1821 that

> the tram-way is the cheapest in the first cost, & will answer for conveying Lime, Coals & other Minerals that can be distributed upon a larger surface of the way, & in small quantities; but not so well adapted for the conveyance of general Merchandise, such as Hogsheads of Sugar; Timber in the Balk; heavy cast Iron articles; Mill Stones &c, & such goods as require to be conveyed in Manufacturing Countries. For the latter purposes a Rail-way is certainly preferable & those used about Newcastle are as good as any….[290]

And in 1818 Joseph Price of Neath Abbey Ironworks wrote the following:

> Experience is the best guide as to which, Tram or rail roads, are eligible--The experience of Wales where there is perhaps 300 Miles of *Tram* road in use is decidedly in *their* favour, and the opinion of I suppose 9/10ths of the intelligent men in Wales would be in *their* favour in preference to *Rail* roads. The opinion I hold accords with this--At the same time It is fair to admit that in the face of this experience, there is at this time a line of *Rail* Road making within 4 Miles of this place by a person who, as surveyor &c., has had a great deal to do with tram roads--he is, however, doing it by direction of his Principal and his decided judgment in favour of either remains to be governed by the *experience* he may yet have--meantime, the degree of favourable influence he has rec'd is p'suing the improved *Rail* Roads in use in the North, where Steam Engines are employed as the running Power--I confess that altho: I express my opinion in fav'r of tramroads--had I to project an

[288] Newcastle City Library, railways collection, book 1, page 11.
[289] Newcastle City Library, railways collection, book 1, page 55.
[290] Newcastle City Library, railways collection, book 1, page 54.

extensive road I should investigate the *facts* w'ch can be adduced to exhibit their comparative merits, before I *decided*.

Upon a well-made *Tram* road in Wales four middle sized draught horses valued abt £20 each draw regularly 24 tons 8 miles & back 8 Miles empty on a declivity of about 1/3rd of an inch on a progressive yard--on waggons *carrying*, 2 1/4 to 2 1/2 tons, each,. assume that as one fact and permit me to be acquainted with a paralel fact with respect to a rail road if thy researches discover one; I think Christ'r Dawson of Low Moor nr Bradford could state the experience of that neighbourhood, with respect to *Rail* Roads. Possibly our frd Jno Hustler might--altho: I believe his experiences more connected with canals. -- permit me to caution thee against receiving the duty performed by a Steam Engine as paralel with that performed by horses--such cases are not paralel--altho such information may be valuable. In Wales there are no locomotive Engines employed at present.[291]

Two responses, however, recommended edge rail; in a letter dated 6 June 1821 William James, a supporter of George Stephenson, wrote:

as to the form; the plate top, (without flange) is infinitely preferable to the Flange Rail work, without Reference to the Difference of friction from the impossibility of being clogged or impeded by small stones, cobbles ice in front--the latter obstructed one at all practically acquainted with Rail Roads must know it is very great and attended with undesirable expense in Most Winters....[292]

In this letter James mentioned that he favours malleable iron rail, which had only recently become generally available. William Jessop Jr. wrote to the Stockton & Darlington committee:

we have seen, indeed made the Rails for so many in the Neighbourhood of Newcastle, & we can pronounce without any hesitation or doubt, that the edge Rail Ways are very superior to the Tram Roads of this County & Wales, and we should very gladly alter all our own roads to that plan [if it] were not attend'd with so great an expence. The expences of Repairs are less, & they a[llow] of greater Weights being carried on them than Rails [of] the same Weight on the Tram plate & Trams will also do considerably more work. The advantages are so many as not to leave a doubt on the

[291] Newcastle City Library, railways collection, book 1, page 5.
[292] Newcastle City Library, railways collection, book 1, page 55.

> subject and all those who have experienced both will agree in that opinion.[293]

It is clear that the proprietors of the Stockton & Darlington Company were designing a multiuser system, which would lower the initial cost of opening new pits in previously unexploited areas by providing transport to the river Tees rather than forcing collieries to invest in their own. The Stockton & Darlington directors succeeded in this objective; between 1826 and 1834 eight new collieries opened in the area served by the railway.[294]

In April 1821 George Stephenson, accompanied by Nicholas Wood, the coal viewer at Killingworth, travelled from Killingworth to Darlington to meet with Edward Pease.[295] Shortly thereafter the committee fired Overton and on Pease's recommendation replaced him with Stephenson. Despite Mr. Peacock's statement in a letter of 25 September, 1821, that '[i]t appears to have become now necessary to be explicit in regard to Overton & Stephenson', the reason for Overton's ouster is not made entirely clear. It appears the committee believed that Overton was not devoting the attention to their project that they would have liked him to, and that while they had already paid him a significant sum they had not yet received sufficient contract documents to proceed with their plans. Mr. Peacock was of the opinion that '[the committee] have not sufficient confidence in him as a civil engineer' (the phrase 'at least in the execution of edge railways' had been crossed out). '[I]n fixing upon Mr. Stephenson,' the committee were

[293] Philip J. Riden, 'The Butterley Company and railway construction, 1790-1830', in Mike Chrimes, ed., *The Civil Engineering of Canals and Railways before 1850* (Aldershot, 1997), p. 265.
[294] Kirby, *The Origins of Railway Enterprise,* p. 86

'influenced solely by the high character they have received of him from various quarters as an intelligent active & experienced practical man, [unintelligible] in his attention to what he undertakes & moderate in his charges'; this last point being perhaps particularly significant.[296] The committee authorised Stephenson to perform a new survey, which he completed in January 1822.[297]

Railway historians have described how Stephenson, at the time an enginewright at Killingworth Colliery, influenced Edward Pease to hire him and to build the railway according to Stephenson's designs.[298] Although Stephenson had by that time laid several colliery railways and had constructed several stationary and locomotive engines, he had no reputation outside the Northeast, nor had he done any significant civil engineering work. Heavisides[299] recounts that the committee's offer letter, addressed to George Stephenson, Engineer, nearly went undelivered by colleagues who did not recognise in that title the mechanic they'd worked with for years.

Stephenson advocated edge rail, and in fact had patented a design for cast iron edge rail with William Losh, although he chose wrought iron rail from the Bedlington Ironworks for the Stockton & Darlington Railway. More importantly, Stephenson advocated mechanical rather than horse traction, a plan which Edward Pease agreed to after an exciting visit to Killingworth in the summer of

[295] J.S. Jeans, *Jubilee Memorial of the Railway System. A History of the Stockton and Darlington Railway and a record of its results* (London 1875), p. 37.
[296] Newcastle City Library, railways collection, book 1, page 57.
[297] Kirby, *The Origins of Railway Enterprise,* p. 40.
[298] Kirby, *The Origins of Railway Enterprise,* also Michael Heavisides, *The History of the First Public Railway* (Stockton-on-Tees, 1912).
[299] Heavisides, *The History of the First Public Railway,* p. 34.

1822.[300] The Stockton & Darlington's Act was amended in 1823 to permit construction of one stationary steam engine, use of locomotives, and the carriage of passengers.

Although it was laid with edge rail and employed locomotives, during its first few years the Stockton & Darlington Railway was operated like a canal-based plateway. The company ran the line as if it were a canal, permitting access by anyone with an approved vehicle who paid the appropriate toll and followed the byelaws. The original Act included ten byelaws controlling bills of lading, vehicle construction, identification and registration, damage to company property and obstruction of the line;[301] these byelaws, like those of plateways associated with canals, were analogous to those of canals. In 1827 the company imposed 31 additional byelaws, eight of which governed passing precedence.[302] These laws imposed fines on transgressors; the heaviest, £5, were for conflicts of interest (e.g. toll takers dealing in freight) and for taking waggons off at unauthorised places.[303] The byelaws demonstrate that, like the users of canals and plateways, vehicle operators were considered responsible for their own equipment and cargo, and were expected to do their part to maintain the line by such behaviours as resetting switches once they had passed them and reporting broken or misaligned rail.

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[300]Jackman, *Development of Transportation in Modern England*. p. 480, Peter John Holmes, *The Stockton and Darlington Railway* (Ayr, 1975?), p. 8.
[301] Norman Moorsom, ed., *The Stockton & Darlington Railway* (Middlesbrough, 1975), p. 43.
[302] Until 1831, when the directors doubled the line between Brusselton and Stockton, the line was a single track with sidings every quarter mile to permit passing. Posts were set halfway between each siding, and the original byelaws stated that when vehicles travelling in opposite directions met, the one that passed its respective post first had the right of way. Charlie Emmet, *The Stockton & Darlington Railway: 175 Years* (Stroud, 2000), p. 21; Heavisides, *The History of the First Public Railway,* p. 75.
[303] Moorsom, *The Stockton & Darlington Railway,* p. 44.

Freight traffic, mostly coal to Tees ports, rose slowly but steadily.[304] Contrary to expectations, however, until at least 1833 the revenue from freight transport was always less than that from passenger travel.[305] Kirby seems to indicate that the company initially operated its own passenger service,[306] but more typically the company granted yearly licences to coaching contractors for the right to provide passenger service. The first of these was to Thomas Close, who also received an advance to purchase a horse and harness. About a month after the line opened the company granted Richard Pickersgill a licence; at first he ran his own vehicle, but later leased the company's passenger coach, named the Experiment, to operate one trip in each direction every day.[307] Additional passenger vehicles, often simply stagecoaches mounted on flanged wheels, were procured by the company and by private contractors.[308] Operators ran unregulated passenger services until 1830, when the company set up regulations and a timetable. By 1831 six contractors operating one-horse coaches offered services on the line, carrying a total of 324 passengers on 36 journeys per week; by 1832 they were carrying about 520 passengers per week.[309]

Although the Experiment was pulled by a locomotive at the Stockton & Darlington's opening ceremony, when the line began operating mechanical traction was not permitted to provide passenger service (although passengers

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[304] Jeans, *Jubilee Memorial*, p. 80, 124.
[305] Jeans, *Jubilee Memorial*, p. 123.
[306] Kirby, *The Origins of Railway Enterprise,* p. 90.
[307] Jeans, *Jubilee Memorial*, p. 82.
[308] Emmet, *The Stockton & Darlington Railway: 175 Years*, p. 21.
[309] Jeans, *Jubilee Memorial*, p. 85, Kirby, *The Origins of Railway Enterprise,* p. 89.

are said to have ridden unofficially on steam-hauled freight trains).[310] The company operated locomotives on the line, but did not permit private parties to operate their own locomotives.[311] The company owned only two locomotives when it opened, but by 1832 owned and operated 19 locomotives, 12 of which had been purchased in the past year.[312] In addition to the tonnage fee charged for access to the line the company charged a haulage fee for the provision of locomotive traction. Horses belonging to members of the public and to passenger and freight transport contractors were permitted on the line.[313]

Despite elaborate byelaws and locomotive speed restrictions, over time the system became more and more chaotic, and fights broke out between drivers unwilling to give up the right of way or attempting to pass slower moving vehicles. Contemporary accounts blame the availability of drink at nearby taverns for exacerbating this problem.[314] Kirby quotes Tomlinson's description of a contemporary source describing the situation on the line before consolidation:

> Two of the [horse leaders] who left Shildon on the 1st March 1832, drunk, after driving recklessly along for some miles and committing several breaches of the bye-laws, met the *William IV* engine ascending the line. They refused to go into the siding and not only laid a rail and chair before the engine with the object of throwing it off the line, but got onto the footplate and collared the enginemen. Several others on the 23rd April 1832 made the *Rocket* engine follow them from Redhall to Darlington, a distance of over two miles, before they would allow the engine to pass. The horse-leaders were constantly leaving the switches wrong, travelling by night without lights, driving furiously across the roads and lanes (which were unprotected by gates at this time), going down the *runs* at headlong speed, numerous horses being killed and lamed and locomotive engines damaged by the breaches of the bye-laws. Not

310 Jeans, *Jubilee Memorial*, p. 83
311 Moorsom, *The Stockton & Darlington Railway,* p. 49.
312 Kirby, *The Origins of Railway Enterprise,* p. 94.
313 Moorsom, *The Stockton & Darlington Railway,* p. 49.
314 Kirby, *The Origins of Railway Enterprise,* p. 94.

> infrequently they left their horses and waggons standing on the line for a considerable time…while they were drinking in a public house adjoining the line. On one of these occasions, the *Globe* engine ran into the waggons which were standing without a light at Aycliffe Lane; …Two of the leaders on the 30th June 1832 stood their horses and waggons at the top of Darlington Run and went into the lane to fight.[315]

In August 1833 the company finally decided that it was no longer economically viable to operate a canal-style system; by October it had bought out all of the contractors and eliminated the use of horse traction, ostensibly because operators were cheating on tolls,[316] though Kirby states that the decision was a 'direct consequence of operational and traffic considerations'.[317] Although in testimony before the Select Committee on Railways in 1839 Joseph Pease, Edward Pease's son and at the time treasurer of the Stockton & Darlington Company, stated that 'every party has the power of putting on horses',[318] from that time on for all intents and purposes all motive power was provided by company-owned locomotives, and the company owned, operated and maintained all vehicles on the line.

Even before the Stockton & Darlington's directors made this decision, the directors of the Liverpool & Manchester Railway, which had opened in 1830, had determined from the beginning to operate a monopolistic locomotive-based system on their line. Although their Act was similar to those of previous railways in that it permitted other traffic on the line, and expected the company to collect tolls rather than charge fares, and although in 1831 the line was open to

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[315] Kirby, *The Origins of Railway Enterprise,* p. 94 (italics in original).
[316] Kirby, *The Origins of Railway Enterprise,* p. 94, Jeans, *Jubilee Memorial*, p. 88.
[317] Kirby, *The Origins of Railway Enterprise,* p. 95.
[318] Moorsom, *The Stockton & Darlington Railway,* p. 49.

tollpayers (and at least one coal dealer ran its own trains up until at least the mid-1840s), the company prepared to operate its own freight transport service by setting up a carrying department, erecting warehouses, and purchasing goods wagons.[319]

The success of the monopolistic 'coal mining model' rather than the multiuser 'canal model' on the Liverpool & Manchester Railway and later on the Stockton & Darlington and other lines is the result of the changes in the British economy over the course of the 18th century. The growth in export markets mentioned in Chapter 3, the growth in the regional credit network, and the resulting investment in road and canal transport, had helped to shape a regionalised economy in Britain by the end of the 18th century. The road network tied London to the provinces, and the canal network bound regions together and helped move products from region to region.[320] Various parts of the country specialised in the production of agricultural products and manufactured goods which were transported all over the country; many of these areas (e.g. Sheffield steel, Kidderminster carpets, Staffordshire pottery) are still familiar today. Most goods were produced in shops and private houses; in the 'putting out' system a capitalist often provided several small producers with raw materials, paid them piecework rates for their labour, and collected and sold the finished products. [321] Such decentralised production and trade required a dense and diffuse transport network providing easy access to multiple origins and destinations. Until the

[319] Philip John Greer Ransom, *The Victorian Railway and How It Evolved* (London, 1990), p. 247.
[320] See e.g. Hudson, Pat, ed. *Regions and Industries: a perspective on the industrial revolution in Britain* (Cambridge, 1989), p. 70.

early 19th century the road and canal system was the most effective structure to support this complex interrelated economy. However, during this period two major changes began to reorganise this economy. First, imports and exports of raw materials and manufactured products, particularly between Britain and its colonies in the Western Hemisphere, grew substantially. By 1795 55% of Britain's imports and 2/3 of its exports were with Britain's Western colonies.[322] Re-exports put Britain at the centre of trade between North America, Asia and Europe. This trade was channeled through London and a few major port cities on the west coast, the biggest being Liverpool and Carlisle, which helped increase the economic power and prominence of the northwest as well as shape the requirements for transport in the region.

A significant part of this import and export trade was in raw cotton, cotton yarn, and finished cotton fabric. Until the 1780s, most of the cotton used in textile production in England came from Turkey and Spanish colonies in the West Indies, and was distributed to small cotton producers around the country by road from London. By the early 19th century, automated mills' enormous demand for raw cotton was being met by imports from the American south shipped through Liverpool. In 1792, 503 bags of cotton came through this port; by 1823 more than 412,000 tons came through Liverpool from the United States alone.[323]

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[321] See e.g. Roderick Floud and Donald McCloskey, *The Economic History of Britain since 1700* (vol. 1) (Cambridge, 1994), pp. 127-143; Pat Hudson, *The Industrial Revolution* (London, 1992), p. 116.
[322] Langton and Morris, eds., *Atlas of Industrializing Britain 1780-1914*, p. 94.
[323] Robert Eugene Carlson, *The Liverpool & Manchester Railway Project, 1821-1831* (Newton Abbot, 1969), p. 20.

This increase in bulk production for export, and the increasing automation of several manufacturing processes and particularly cotton textile production, hastened the existing trend toward centralisation of production in factories.[324] This trend was particularly strong in Lancashire, where water and coal power were readily available; with the impetus of the availability of powered machinery, over the course of the 18th century cotton textile processing became centralised into a few areas, particularly around Manchester.[325]

Such an economy, in which a few centralised production points accept raw material from and ship finished products to a few ports, is better served by fixed high-capacity links between specific origins and destinations than by a dense transport network designed for easy access and multiple users. This was probably already understood by the 1820s, as companies were being formed to connect city pairs even before the Stockton & Darlington's success demonstrated their feasibility. By 1821 the export economy was concentrated in the northwest, Birmingham and Bristol, all areas where the first mainline railways were built[326]; mainline railways were constructed later in areas like the southeast, Cheshire, and the west, where small producers continued to grow or manufacture goods primarily for internal consumption.

[324] Lee, *The British Economy since 1700*, p. 110; Szostak, *The Role of Transportation in the Industrial Revolution*, p. 178.
[325] Langton and Morris, eds., *Atlas of Industrializing Britain 1780-1914*, p. 109. Although the availability of steam power sources facilitated this centralisation, it did not play a major role in this process until the 1790s; in 1787 the first steam engine was installed in a spinning mill in Warrington; by 1789 steam power had been introduced into mills in Manchester.
[326] Dendy Marshall, *Two Essays in Locomotive History,* p. 39; Dendy Marshall, *Early British Locomotives,* p. 65.

Neither secondary sources nor many primary sources indicate what freight the Liverpool & Manchester line carried, except coal, which appears to be a small part of the total. Inferences can, however, be drawn from several pieces of available information. For example, 'practically every man on this list [of directors] was connected in some way or other with the cotton industry in [Manchester]'.[327] Several witnesses supporting the railway in Parliament testified that it was needed because delayed shipments of cotton to Manchester resulted in spinners being put out of work for lack of raw material; canals were unable to keep up with the demand, and shippers were not able to obtain boats to transport cotton.[328] Cotton is mentioned in nearly every instance where freight is described on the line. The second prospectus for the company mentioned the benefit of 'rapid transit of Cotton and Woollen Goods in different stages of their manufacture'.[329] The first goods shipment on the line, which left Liverpool on 4 December 1830, carried 135 bags and bales of American cotton as well as foodstuffs;[330] cotton was mentioned as a fire risk, as the freight hauled by a record-breaking locomotive, and as the subject of a fraud case.[331] By February 1831 nearly 5000 tons of cotton had been shipped on the line.[332] In early January 1831 the Bridgewater Canal reduced its toll for shipping cotton from 15s to 10s per ton, provoking a price war which continued until prices were fixed in 1842.[333]

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[327] Carlson, *The Liverpool & Manchester Railway Project, 1821-1831*, p. 50.
[328] Carlson, *The Liverpool & Manchester Railway Project, 1821-1831*, p. 114.
[329] Carlson, *The Liverpool & Manchester Railway Project, 1821-1831*, p. 273.
[330] Carlson, *The Liverpool & Manchester Railway Project, 1821-1831*, p. 239.
[331] R.H.G. Thomas, *The Liverpool & Manchester Railway* (London, 1980), pp. 205-207
[332] Carlson, *The Liverpool & Manchester Railway Project, 1821-1831*, p. 240.

The difference in transport requirements between decentralised small loads and large bulk loads is evident in the logic behind a letter Robert Stephenson wrote to William James in 1822. Stephenson had discussed railways with the Scottish engineer Robert Stevenson, arguing in favour of heavy, capital-intensive construction:

> …when small waggons are employed the friction is considerably augmented from the greater number of axletrees; likewise a greater number of wheels are employed hence the wear and tear will be much more--when all these circumstances are candidly considered more especially on a Public Railroad where an immense quantity of heavy goods are passing over: they cannot fail (in my opinion) in making every Engineer a convert to a strong Railroad.[334]

While this argument initially appears sensible from a purely engineering point of view, it only makes sense within a particular economy and a particular organisational structure. It is only true for a system designed to transport large bulk loads from single origins to single destinations, rather than a system serving small producers transporting small loads to a variety of destinations. It also assumes the existence of a single carrier organisationally complex enough to consolidate loads, rather than many small independent carriers.

Yet it was not solely the need for high capacity fixed links that led to the adoption of the monopolistic edge railway--canals already provided such links--but also the issue of speed. Until the late 1820s, although it was occasionally mentioned in passing, speed was not considered a requirement or desirable property of railways. In 1823 Henry R. Palmer wrote in *Description of a Railway on a New Principle* that although 'expedition' may be necessary 'in some instances', '[t]he

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[333] Thomas J. Donaghy, *Liverpool & Manchester Railway Operations, 1831-1845* (Newton Abbot,

leading problem in our present subject is, to convey any given quantity of weight between two points at the least possible expense'.[335]

Initial consideration of the Stockton & Darlington and Liverpool & Manchester lines specifically excluded speed as a design consideration; Nicholas Wood stated '[h]igh rate of speed was no element for the consideration of either directors or engineers'.[336] When the Liverpool & Manchester Railway committee instructed James Walker and John Urpeth Rastrick to inspect several lines in the Northeast in 1829 to gather information to help them choose the appropriate source of motive power for the railway, they were instructed to evaluate them according to several criteria including power of engines, cost, reliability, and state and condition of the rails and rolling stock; speed was not mentioned as a criterion.[337] This is more significant in light of the fact that of the lines they inspected the one using stationary engines developed the most speed (12 mph compared to 10 mph for locomotive-drawn lines). It was, however, noted in Walker and Rastrick's report that if the Liverpool & Manchester line ran at less than 10 mph it would be considered a failure 'as the public would be most grievously and bitterly disappointed';[338] 'nothing less would be satisfactory to passengers' and 'you ought not to disappoint the public'.[339]

1972), p. 79; Carlson, *The Liverpool & Manchester Railway Project, 1821-1831*, p. 242.
[334] Michael Bailey, *Robert Stephenson--the Eminent Engineer* (Aldershot, 2003), p. 10.
[335] Henry Robinson Palmer, *Description of a railway on a new principle* (London, 1823), p. 33.
[336] Jeans, *Jubilee Memorial*, p. 53.
[337] James Walker*, Liverpool and Manchester Railway: report to the directors on the comparative merits of loco-motive & fixed engines, as a moving power* (London, 1829).
[338] Walker*, Liverpool and Manchester Railway: report to the directors on the comparative merits of loco-motive & fixed engines, as a moving power*, p. 15.
[339] Walker*, Liverpool and Manchester Railway: report to the directors on the comparative merits of loco-motive & fixed engines, as a moving power,* p. 17.

Yet after the mid-1820s speed started to be considered worthy of comment. Up until then the benefit of railways was represented as energy efficiency and cost savings, but starting at about that time descriptions of the benefits of railways started to include speed. For example, in a letter about the Liverpool & Manchester Railway written in 1824, Joseph Sandars mentions the benefits of 'speed, certainty, and economy'.[340] Thomas Gray, writing in the 1820s (the fifth edition of his book was published in 1825), refers to 'safety, speed and economy' several times.[341] Henry Booth, treasurer of the Liverpool & Manchester Company, referred to the line's benefits as 'safety, economy and despatch'.[342] Thomas Tredgold's textbook on railway design, published in 1825, describes their benefits as 'economy, speed, certainty, convenience and safety'.[343]

The issue of speed was more complex than simply a matter of moving faster. On the one hand, it was tied into ideas of economy and time efficiency. In his *Elements of Natural Philosophy*, for example, Dr. Arnott states that 'at the expence of as little time and money as he now spends to go a short distance, he might go a long one'.[344] Sandars uses the expression 'economy in time and expense,' implying that the 'savings' from such efficiency could be used for such beneficial purposes as feeding the poor and paying the national debt.[345]

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[340] Joseph Sandars, *A letter on the subject of the projected rail road, between Liverpool and Manchester* (Liverpool, 1824), p. 29.
[341] Gray, *Observations on a General Iron Rail-way*.
[342] Henry Booth, *An Account of the Liverpool & Manchester Railway* (Liverpool, 1831), p. 10.
[343] Thomas Tredgold, *A Practical Treatise on Rail-Roads and Carriages* (London, 1825), p. 9.
[344] Quoted in Michael Longridge, *Remarks on the Comparative Merits of Cast Metal and Malleable Iron Rail-ways* (Newcastle 1827), p. v.
[345] Sandars, *A letter on the subject of the projected rail road, between Liverpool and Manchester,* p. 27; also see Carlson, *The Liverpool & Manchester Railway Project, 1821-1831*, p. 79.

On the other hand, speed was associated with ideas of fuel and power efficiency. Over the course of the 1820s it became clear to experimenters and observers that while at similar speeds the horse was less expensive than the locomotive as a source of motive power, at increased speeds the locomotive became more cost effective in terms of amount of work that could be performed.[346] Rev. James Adamson suggests, for example, that 'a rate of speed may be found at which conveyance by [locomotives] will be cheaper than by horses moving at the velocity most favourable for their action. But the great advantage of steam-power lies in the economy with which quickness of motion may be produced'.[347]

The speed of a means of transport is not dependent only on the type of technology employed, but also on the operational constraints of the system. Manufacturers now produce cars capable of moving two to three times faster than speed laws permit, but on a multiuser road system such speeds would be both impractical and dangerous. During the first three decades of the 19th century, locomotives were built and used successfully on multiuser lines, but operational constraints did not permit their owners to use these highly capitalised machines at the speeds at which they became more efficient than horses.

Thus the edge rail/locomotive system, originally a vernacular technology designed to facilitate the transport of coal from pits to staiths, proved to be more suited to the new economy of centralised production for export than the more modern plateway system. The monopolistic system sacrificed the freedom of

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346 See for example Rev. James Adamson, 'Sketches of information as to rail-roads,' in Longridge, *Remarks on the Comparative Merits of Cast Metal and Malleable Iron Rail-ways,* p. 25.

347 Rev. James Adamson, 'Sketches of information as to rail-roads,' in Longridge, *Remarks on the Comparative Merits of Cast Metal and Malleable Iron Rail-ways,* p. 26.

individual operators to pack, carry and supervise their own loads, use their own equipment, enter and exit at will, and travel at speeds and times of their own choosing, but gained speed, reliability and efficiency in the transport of bulk cargo (and, unexpectedly, passengers) between two fixed points.

The change in the operational requirements of transport led to the decline in popularity of plateway technology. By 1824, T. G. Cumming, who describes himself as a 'surveyor &c.', wrote that although 'highly respectable and experienced men in this part of the country' would say plateways were best, 'some of the most eminent practical engineers in the kingdom' would choose edge rail and 'in many districts the tram plate has been entirely exploded'.[348] In his inspection tour of British railways in 1827 Carl Oeynhausen drew the conclusion that although '[i]n a large part of England, in the south and midlands, tramroads predominate; only in the north of England do railways predominate';[349] because malleable iron had already shown its superiority to cast iron, and because tramroads are made only of cast iron (although this observation was not accurate), 'the German railways [plateways] are considered generally inferior to the English Railways'.[350] By 1831 Henry Booth could write in his *Account of the Liverpool and Manchester Railway* that 'it was not till the adoption of the edge-rail, raised above the ground, that Railways attained those advantages over common roads which they are now acknowledged to possess'.[351]

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[348] T. G. Cumming, *Illustrations of the Origin and Progress of Rail and Tram Roads, and Steam Carriages, or Loco-motive Engines* (Denbigh, 1824), p. 26.
[349] Carl Oeynhausen, *Railways in England, 1826 and 1827* (Cambridge, 1971), p. 78.
[350] Oeynhausen, *Railways in England, 1826 and 1827*, p. 63.
[351] Booth, *An Account of the Liverpool & Manchester Railway*, p. 4.

In the early years of the 19th century, the plateway, a new and systematically designed multipurpose, multiuser transport system adopted by the engineering community across the country, appeared to be the most advanced form of rail transport. Rees's *Cyclopedia* describes Outram's rail design as the peak of rail development.[352] While at the time it was considered an advance over the edge railway, which evolved from the traditional wooden coal pit railway, in operational terms it was a simply a new form of the soon to be outmoded multiuser canal system. It was in fact the edge railway, evolved from the traditional transport system of the coal mines, that proved to be best adapted to the needs of the new manufacturing and export economy.

7. Further research

This paper only begins to address several issues in this area of the history of early railways; many more remain to be considered. For example, several practical questions about plateways have been raised over the course of this research. The most significant of these is the question of whether plateway vehicles were ever used on public roads. While several sources both secondary and contemporary suggest that they were, there appears to be almost no actual evidence of operations of this sort. In addition several researchers and reviewers have suggested that mechanical analysis of tramplates and locomotives might provide information to substantiate or refute the claims of contemporary engineers.

[352] Rees, *Rees's Manufacturing Industry (1819-1820)*, p. 280.

Further investigation of the legal and economic questions surrounding the construction and operation of plateways would also be useful. It is still unknown, for example, why early canal acts specified the construction of feeder railways only within specific distances of the canal, and why these distances varied and were eventually abandoned. It seems clear that various legal and economic constraints, such as the cost and nature of wayleaves and other methods of obtaining land, turnpike tolls, and taxes on coaches and horses for hire, had an effect on the choice of transport technology. Finally, although tangentially, the question of deodands may be relevant to the speed and pattern of the adoption of steam locomotion on railways. The legal requirement to confiscate an object that caused a death appears to have been abolished by 1846; it is likely that the increased use of steam locomotives contributed to this change in British law.

Additionally, it may be possible to gain a better understanding of the noneconomic motivations and considerations of decisionmakers during this time, and of what noneconomic factors contributed to their choice of plateways or edge railways, and of horsepower, stationary steam engines or locomotives. It has been suggested, for example, that religious beliefs are relevant to understanding these choices. Prosopographical analysis is likely to contribute further to answering these questions by highlighting the backgrounds of and influences on these decisionmakers. Prosopography may also assist in tracing the dissemination of both technical information and the change in the perception of railways from public carriers to private businesses to public utilities.

Three issues mentioned in this essay also deserve further research and consideration; additional information relating to them should increase our understanding of why particular technical choices were made. One influence on these choices was the development of the idea of a national plateway network; Outram's choice of gauge, for example, appears to be related to the types of freight he expected such a national network to carry. A second influence was the increasing importance of speed, and its relationship to the idea of 'saving time' as well as, or even in some cases instead of, saving cost. Finally, it is clear that technological choice is affected by regional factors; as we have seen, the Northeast developed railways differently from the rest of the country, and plateways were particularly popular in Wales. What, if any, noneconomic factors influenced these regional choices?

Finally, although this research is outside the period currently under consideration, M. J. T. Lewis suggests that it might be revealing of motivations to investigate the gradual abandonment of the plateway in Wales beginning in the mid 19th century. Records of conversions to edge rail might reveal the motivation for building plateways, and for retaining them even after edge rail became the national standard.