Forward

The Liverpool and Manchester Railway (L&MR), the world’s first inter-city railroad designed and built between its namesake cities for the efficient, commercial transportation of passengers and freight, was designated an International Civil and Mechanical Engineering Landmark by the Institution of Civil Engineers, the Institution of Mechanical Engineers, the American Society of Civil Engineers, and the American Society of Mechanical Engineers on 14 September 2016. While this was a joint designation, only ASME’s History and Heritage Program requires a written document describing a landmark’s features and significance. Accordingly, this brochure will focus on the mechanical engineering aspects of the railway, with the most significant aspect being the locomotive trials held at Rainhill during October 1829. The Rainhill Trials are one of the earliest known examples of an engineered program to evaluate competing machines in a real-world environment.

All aspects of the Liverpool and Manchester contribute to its significance as an engineering landmark, including the company’s early decision to use only steam power to move trains. Any railway is an intimate combination of both civil and mechanical engineering, as neither the track nor the train would be of any use without the other. Significantly, this railway remains in active service. The rolling stock has changed many times since the line opened, and the modern trains are much heavier and faster than the line’s builders could have imagined, but the modern trackage is still supported by the original roadbed and most of the original bridges.
It must be regarded ... as opening the epoch of railways which has revolutionised the social and commercial intercourse of the civilized world.

—John B. Jervis

Industrial Britain before the railway

The growth of Manchester, England, during the Industrial Revolution of the late 18th and early 19th centuries, largely due to the rapid expansion of its textile production, led to a serious transportation problem. Located some 35 miles (56 km) inland to take advantage of waterpower in the hilly Lancashire Region, the growing city found itself uncomfortably distant from the closest port facilities, which were in and around Liverpool on the River Mersey to the west. As Manchester’s cotton mills expanded, efficient, economical access to Liverpool’s port was increasingly essential to receive imported cotton and to export finished cloth, along with other goods. The Lancashire Region also possessed considerable coal reserves, and the transportation problem affected it as well. Moving the coal from mine to market was slow and expensive.

For centuries the wind or animals had furnished power for transportation, with wind power primarily used for seagoing ships. Away from the coast, boats moved by animals or sails conveyed freight and passengers through natural or man-made waterways wherever practical. Competing interests improved channels in rivers and dug numerous canals across the country to handle the growing volume of traffic. These companies required charters from Parliament, and investors often tried to obtain charters that prevented the establishment of competing companies. Manchester, with its growing industry and need for access to Liverpool, was a primary target for canal companies.

The Mersey and Irwell Navigation Co. built eight locks and several channels in the rivers that connect Manchester to the Mersey Estuary at Warrington, about 15 miles (24 km) from Liverpool. It opened in 1734, but often suffered from insufficient water for navigation.

In 1759, Parliament granted Francis Egerton, 3rd Duke of Bridgewater, who owned significant coal reserves under Worsley (northwest of Manchester), permission to build and operate a canal from Worsley to Manchester. This opened in 1761, and the Duke extended it to Runcorn, on the River Mersey southeast of Liverpool, in 1776. The Bridgewater Canal drastically reduced the cost of the Duke’s coal in Manchester, and its extension to near Liverpool furnished dependable transportation that allowed the city’s industries to flourish.

With a virtual monopoly of transportation between the two cities, the canal earned its investors handsome profits that soon had Manchester businessmen suspecting those profits might be excessive. Traffic on the canal had increased to the point that transit times had become longer as well. Three men, a Liverpool corn merchant named Joseph Sandars; John Kennedy, owner of the largest spinning mill in Manchester; and a land speculator and sometime surveyor named William James, decided that a railway might well furnish effective competition to the canal. James even envisioned a network of railways throughout England, although the technology, introduced in a few collieries, was still new, and no one yet had a realistic idea of how an inter-city railway should be built and operated.

Sandars, Kennedy, and James persuaded another Liverpool corn merchant, Henry Booth, who also had some engineering experience, to join the enterprise, along with his father. These men, supported by other
Manchester and Liverpool merchants, formed the Liverpool and Manchester Railway (L&MR) on 24 May 1823, and elected Booth to lead the company as secretary and treasurer. They—primarily Booth—began preparing a bill for Parliament to authorize construction, and William James started to make a preliminary survey for the line. When presented with the bill in 1825, Parliament initially rejected it due to a faulty survey. The body ultimately passed the bill—with a correct survey—in May 1826. The world’s first common carrier railway was born. In the initial subscription, 308 shareholders purchased 4,233 shares of the company’s stock.

### Designing and building the railway

By 1826, hand- and animal-powered wagons on plank tracks had been employed in European mines for some two centuries, and a few rudimentary railways were operating at English collieries to carry coal from mine heads to docks or local users using animals, early steam locomotives, or rope systems with stationary steam engines in various combinations. Each was unique, and they worked with varying degrees of effectiveness, but there were no uniform ideas about such things as gauge, whether the wheels or the rails should be flanged, how severe curves and grades could be, or the best means of propulsion over long distances. For those building the Liverpool and Manchester, finding answers to these questions was an important preliminary to the detailed design of the track and rolling stock.

On this map from the mid-1830s, the L&MR is the heavy line between the two cities. Note that additional railways had been built that connected to it. The section drawing shows George Stephenson designed it to be as level as possible. The labeled b on the profile portion of the map above is the Rainhill Level, where the locomotive trials were held.

As the design and construction of roadbed, bridges, cuts, embankments, tunnels, and track progressed during 1826-29, several impressive structures took
shape and became prototypes for subsequent ones around the world over the next century. To minimize grades and curvature, a two-mile (3.2-km) marle-and-rock cut up to 70 feet (21.3 m) deep was required through Olive Mount east of Liverpool, and two multi-arch viaducts spanned the Sankey and Newton valleys. They measured 600 feet (182.8 m) long by 70 feet (21.3 m) high and 144 feet (43.9 m) long by 40 feet (12.2 m) high respectively, and both were approached over substantial embankments. Sixty-two additional masonry bridges—many quite impressive in their own right—conveyed roads across the railway or the railway over streams, and a cast-iron beam bridge across Water Street gave the railway access to its Manchester terminal. Equally impressive were Wapping Tunnel, a 6,750-foot (2,057-m) bore under the city of Liverpool, the first large tunnel dug under a metropolis, and a 4.75-mile (7.6-km) crossing of a soft peat bog known as Chat Moss. The entire railway was double-tracked. The original track consisted of 15-foot (4.6 m) cast-iron rails laid on stone blocks, except for the Chat Moss portion that used wooden sleepers.

**The Power Problem**

While construction of the line progressed well, one nagging question remained unanswered. Early in the process, the railroad’s directors decided to utilize steam power rather than animals, but the L&M’s engineers continued to debate the merits and demerits of fixed steam engines with rope funicular systems to pull the cars versus steam “loco-motives,” as company engineer George Stephenson first called them, that moved on the same track as the cars they pulled, with neither side demonstrating any particular advantage. The big unknown was whether a locomotive that depended solely on adhesion—the static friction between a smooth iron wheel and a smooth iron rail—could pull a useful train, even on level track, much less climb any grade.

The limitation of steel-on-steel traction was being investigated at this time by Isambard Kingdom Brunel, who began in 1840 to experiment with a fanciful system using evacuated tubes and vacuum pumps. The “Atmospheric Railway” was actually to carry passengers for a brief period beginning in 1843. The idea ultimately proved impractical and was added to Brunel’s short list of spectacular failures. The company’s directors assigned James Walker and J.U. Rastrick, both practicing engineers, to undertake a study of existing operations using both locomotives and fixed winding engines. After evaluating the advantages, disadvantages, and costs, they presented their report to the directors on 9 March 1829. The men concluded that neither had a significant financial advantage. However, the two engineers, still unsure of adhesion’s effectiveness, concluded that fixed winding engines spaced along the line would be preferable.

Stephenson had maintained all along that he strongly preferred locomotives over fixed engines, and he was not swayed by Walker and Rastrick’s report. The latter, he argued, would be cumbersome to use, slow, and prone to problems with their long ropes. They would also present problems with maintaining each train’s steady pace over the railway. Worst of all, a breakdown of any one of these engines would paralyze the entire railway. In contrast, Stephenson noted that locomotives would eliminate the starting and stopping needed to switch ropes between winding engines and offer more operating flexibility as
traffic grew. Fixed engines would have a maximum capacity that could not be easily increased, but new locomotives could easily be added as needed, and improvements would likely render newer, more powerful designs within a few years. In addition, he believed that safety would be enhanced by having an operator in direct control of each train, instead of relying on communication between the train and a remote operator of the fixed engine. Finally, should any single locomotive fail, another one could take its place, and the railway would continue to operate while the first locomotive was being repaired at a shop.

After more than a year of debate over motive power for the L&MR, the directors were no closer to a decision than when the subject was first raised. But construction of the railway continued at a pace pointing to completion by the end of 1830, and they were running out of time to make a critical choice. One of the directors, R. Harrison, had previously proposed the idea of holding a competition with a reward to stimulate innovation. Locomotives designed and built by anyone who wished to enter would be subjected to an “ordeal,” as it was first termed, to determine the best design for the L&MR. The ordeal would not be a race, per se, but rather a test of each locomotive under controlled conditions doing work as close as possible to what it would do in actual service. With no resolution in sight, the other directors finally warmed to the idea, and on 25 April 1829, the following announcement appeared in the Manchester Mercury:

The engineers realized that without direction the entrants would likely vary considerably in size and power, making selection a difficult task. Thus they developed test criteria that allowed variations in a manner that did not favor or penalize any particular design. The Stipulations and Conditions, shown below, clearly described how the tests would be conducted, the criteria to be measured, physical constraints such as gauge and maximum weight, material the company would furnish, and the nature of the winner’s reward.
Between April and October, potential contenders raised some questions that this announcement had not anticipated, and L&M officials amended the criteria as necessary to deal with the new considerations. Refinements included:

- A more useful definition of the “proportionate weight” each entrant was to pull.
- A provision for locomotives that did not require a tender for fuel and water.
- More specific information on the trial protocol, particularly details about the portion of track to be used in the trials and how each locomotive and train was to be operated to simulate a complete round trip over the entire railway.

This was a new way to evaluate competing designs of machinery, and it is the earliest known example of measured, head-to-head performance trials in a real-world environment being used to select the best of multiple options. Such evaluation programs are now common practice, notably in the procurement of military equipment, but the concept was truly innovative in the early days of the Industrial Revolution. While simple and basic by current standards, these specifications were well thought out and quite comprehensive given the limited knowledge and experience in the field at the time.

Some of the criteria presage topics that are often thought to be of only recent concern. Of particular interest is the requirement that each locomotive “effectually consume its own smoke.” Parliament evidently was concerned about air pollution even then. Equally interesting is the company’s concern over safety, seen in the requirement for two safety valves on each boiler. The stipulation that one of them had to be beyond the operator’s reach says much about engineers’ early recognition of human factors in machinery design, as well as their understanding that endeavors such as steam power and transportation involved safety risks that had to be managed, even if the people using such machines did not fully understand or appreciate those risks. The company also set a conservative limit on the maximum allowable steam pressure, fifty pounds per square inch (3.45 bar), and it reserved the right to perform hydrostatic tests on the boilers at three times the working pressure. The work of an earlier British engineer, Richard Trevithick (1771-1833), clearly influenced these stipulations. He had already built
boilers and engines using pressures of more than twice that, and he also pioneered the use of dual safety valves, fusible plugs, and mercury manometers to measure boiler pressure. In specifying a modest maximum pressure, it seems that the L&MR’s directors and engineers must have realized the importance of their undertaking and the natural apprehension on the part of people who would be exposed to any of the inherent risks as bystanders or passengers. These provisions to enhance safety, along with a number of other features designed into the railway and its operating regimen, are early evidences of the importance engineers have placed, and still place, on safety.

The trials would actually settle two questions. In the event that no participating locomotive could meet the performance requirements, the question of locomotives versus fixed winding engines would be answered in favor of the latter, and their design and installation could begin immediately. On the other hand, if, as Stephenson expected, one or more of the locomotives met or exceeded the specified requirements, the way would be clear to adopt that technology with confidence, and the railway would be equipped to support their operation. At the same time, the best of several locomotive designs would be apparent as well, giving the directors additional confidence that they had the best available technology.

The “Ordeal” at Rainhill

The L&MR’s announcement generated considerable interest throughout the industrial areas of England. As many as ten individuals or partnerships indicated interest within the first two months, but on 6 October 1829, the first day of the tests, builders brought five machines to Rainhill for evaluation:

*Cycloped*, built by Thomas Brandreth of Liverpool, was entered as a “legacy technology.” The sole non-steam entrant, the four-wheel vehicle employed two horses walking on a treadmill. *Cycloped* did not satisfy the requirement for a steam-powered machine, and it was not expected to meet the performance specifications, but it was allowed to enter as a courtesy to Brandreth, one of the company’s directors.

*Novelty*, built by John Ericsson and John Braithwaite of London, had the most innovative boiler of the entrants, and it quickly garnered the most popular support. *Novelty* featured a vertical, forced-draft firebox with a horizontal fire-tube boiler and two vertical cylinders. It rode on four wheels, two of which were powered. *Novelty* carried its fuel and water on the locomotive.

*Perseverance*, built by Timothy Burstall of Edinburgh, had a vertical boiler and two vertical cylinders. Like *Novelty*, it rode on two powered and two non-powered wheels, and it carried its fuel and water on the locomotive. *Rocket*, built by Robert Stephenson (George’s son) of around a horizontal, multi-fire-had been suggested by L&MR. Unlike the other entrants, *Rocket* that acted directly on its two drive pair of wheels supported its
Sans Pareil, built by Timothy Hackworth of Shildon, resembled locomotives that Hackworth previously had built for the Stockton and Darlington Railway (a colliery railway). It featured a large, horizontal, fire-tube boiler and two vertical cylinders driving four wheels. Sans Pareil was overweight, but the judges allowed it to compete. It used a railway-supplied tender to carry its fuel and water.

While these builders worked on their locomotives, the company made arrangements to host, conduct, and evaluate the trial program. The directors and engineers had determined that the best location for the ordeal was a level stretch of the railway, known as the Rainhill Leel, almost two miles (3.2 km) in length south of St. Helens. Allowing one-eighth mile (0.2 km) at each end for starting and stopping the train, each locomotive could run at full speed for 1½ mile (2.4 km) between markers. Ten trips, five of them pushing the train in reverse, would approximate the 35-mile (56-km) railway. After refueling, ten additional trips would complete a round trip.

To ensure impartiality, he directors asked three notable individuals not associated with the company to judge the ordeal. John Rastrick was a locomotive engineer from Stourbridge, and Nicholas Wood was a mining engineer with locomotive experience from Killingsworth. John Kennedy, a Manchester cotton spinner and proponent of the railway, completed the panel of judges.

Interest in the trials was immense, including not only engineers and builders, but also the general public. It soon became evident that the trials would be an event attended by hundreds, if not thousands, of spectators, so the company ordered a large tent to provide some shelter for the ladies. An estimated 10,000 to 15,000 people witnessed at least some portion of the trials.

The ordeal was scheduled to start on Tuesday, 6 October 1829. It would begin with some preliminary demonstration runs to show each locomotive’s general capabilities, then continue over the next several days with the measured runs. The judges anticipated that two—perhaps three—locomotives could be tested per day, an estimate that proved overly optimistic. To minimize smoke generation, the company supplied clean-burning coke to all of the steam contestants.
Several thousand spectators were on hand for the start of the ordeal. Stephenson’s Rocket was the first to perform, and it pulled its 12¾-ton train a total of 12 miles (19.2 km) at an average speed of 13½ miles per hour (21.6 kph) to suitably impress the crowd. Ericsson and Braithwaite’s Novelty was the next to run, and it ran without a train at speeds up to 24 miles per hour (38.4 kph). Brandreth’s Cycloped then ran alone for some distance, but the weight of the horses was too much for its structure, and it retired after the horses broke through the treadmill and floor. Hackworth’s Sans Pareil was exhibited late in the day, but not operated. After Novelty operated without a tender, some dispute arose about the proper weight of its train, since the tender was included in the weight of the train. The judges agreed to review the method used to compute the load for each locomotive.

When the judges arrived on 7 October, Novelty had been prepared and attached to the train already determined for it. It completed its first test run, but the bellows of its forced-air pump failed on the second run, rendering it inoperable. This had to be repaired before Novelty could continue, so her trial was postponed to another day. Sans Pareil was then called, but Hackworth had discovered a boiler defect. The judges allowed him some time to make repairs. Apparently to avoid disappointing the crowd, Stephenson steamed up Rocket and attached it to coaches that could accommodate thirty people. He then offered rides, and spent most of the day pulling the loaded coaches at speeds up to 30 miles per hour (48.1 kph) up and down the test track.

Robert Stephenson (1803-1859), the son of George Stephenson, designed and built Rocket at his works in Newcastle, the first factory built specifically to manufacture railway locomotives.
This painting by Jim Petrie shows Rocket pulling coaches under the skew bridge in Rainhill during the second day. During the measured trial runs, Rocket was the only entrant to successfully complete the entire test. The cover painting, also by Petrie, shows Novelty and Sans Pareil, with Rocket in the background.

The following day, 8 October, was Rocket’s trial day. In contrast to the earlier entries, Rocket performed flawlessly, completing the first round of tests at an average speed of 13.4 miles per hour (21.5 kph). After less than 15 minutes for servicing, Rocket began the second part of the test and finished it in slightly less time, averaging 14.2 miles per hour (22.7 kph). Stephenson’s locomotive experienced no difficulties during the ordeal, and it achieved speeds above the required minimum of 10 miles per hour (16.0 kph). The data obtained even suggested that the train had more resistance when being pushed than when being pulled, something not previously realized.
Neither *Sans Pareil* nor *Novelty* were ready to run—their repairs not yet finished—so the judges decided to postpone their trials until Monday, 12 October. (No tests were run on Sunday.) Burstall’s *Perseverance* had been dropped while being unloaded at Rainhill, and the damage was too severe for it to run when scheduled. (Burstall hoped to be ready before the tests ended.) Thus, no tests could be run on 9 October. Ericsson and Braithwaite, however, notified the judges that *Novelty* could be ready on the tenth, and the judges accepted their offer.

A suitable means of computing the proper weight train for *Novelty* had been developed by the morning of 10 October, so *Novelty* was prepared and attached to its train. Its trial began before noon, and it made its first pass without difficulty, however, the boiler feed pipe from the pump burst on its return pass, taking it out of service. It had run well, albeit for a very short time, and the judges granted *Novelty* yet another chance on 14 October. They also decided to grant Hackworth another day to affect his repairs to *Sans Pareil*, scheduling that trial for 13 October.

When *Sans Pareil* appeared for weighing on 13 October, the scale showed it to be heavier than the allowed weight for four wheels. The revised test specifications required any locomotive over 4½ tons to

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have six wheels. The judges felt it should be ineligible for the prize. Hackworth, however, argued that
the “weighing machine” was not correct. The judges finally allowed San Pareil to run, if only to see
whether it merited further consideration. The test began well, with San Pareil posting marginally better
times than Rocket, but that changed on the eighth trip when its boiler feed pump failed. The boiler’s
water level dropped to the point that a fusible lead safety plug melted, releasing the pressure and
dramatically ejecting steam and water out the chimney. Despite good running times, test records
indicated that San Pareil suffered from high fuel consumption due to excessive draft that sucked
unburned coke out the firebox and up the chimney.

The last day of the trials, Wednesday, 14 October, attracted what was probably the largest crowd of
visitors. Novelty had been repaired, but Ericsson and Braithwaite were worried that the cementitious
packing material used to seal joints in the repaired pipes had not had time to fully cure. Their worries
proved valid when a flue collapsed, causing loss of steam pressure and the train to stop. The collapse was
not likely caused by a packing failure, but the effect was the same. Ericsson and Braithwaite had no
choice but to withdraw from the competition. Hackworth wanted another opportunity for San Pareil, but
the judges refused his request.

By this time, Burstall finally had Perseverance in operating condition, and he began a demonstration run
to test the repairs. Unfortunately for him, Perseverance would not move faster than about five miles per
hour (8 kph), even without a train. At that, Burstall withdrew from the competition.

Since Rocket was the only entrant to complete the trials, and to do so without incident, it was declared the
winner of the £500 prize. In a manner that may have influenced later post-race “victory laps” after auto
races, Stephenson steamed up Rocket and ran his locomotive back and forth over the test track twice,
achieving speeds up to 35 miles per hour (56.1 kph).

**Rocket and the modern steam locomotive**

Rocket not only won the £500 prize at Rainhill and secured a contract for Robert Stephenson to build
seven similar locomotives for the L&MR, it also introduced a design that became the prototype for most
subsequent steam locomotives built over the next 160 years. Key elements of Stephenson’s design
included a horizontal, fire-tube boiler with 25 flues connecting the firebox with the chimney, as the
exhaust stack was originally known, and two cylinders directly connected to the drive wheels through a
crosshead and main rod. Steam exhausted from the cylinders through a pipe to a nozzle at the base of the
chimney to draw air through the firebox and flues to support efficient combustion. Surrounded by water,
the 25 flues provided a much greater heating surface than the two or three flues in the other competitors.
The direct cylinder-drive wheel arrangement discarded the more-complex system of cranks, rods, and
sometimes gears used by many other early locomotives, improving efficiency and simplifying
maintenance.

Stephenson did not rest on his laurels. By the time his firm finished the seventh additional locomotive,
North Star, his team had introduced several improvements in the Rocket-type design. Chief among these
were the addition of a smokebox chamber at the base of the chimney to improve gas flow through the
boiler and a relocation of the cylinders from their original 45-degree angle to nearly horizontal. Operation
quickly showed that reducing the downward force of the inclined cylinders greatly improved the tracking
qualities of the locomotive and reduced stress on the track without any sacrifice in power or tractive
effort. The railway made these modifications to the earlier locomotives, including Rocket, as well. (At
Rainhill, Rocket’s inclined cylinders had already proven to be superior in these respects to the
competitors’ vertical cylinders. San Pareil, in particular, oscillated heavily as it moved because of the
vertical forces and its high center of mass.)
For his ninth L&MR locomotive, *Planet*, Stephenson literally turned *Rocket*’s design around, placing the idler wheels and cylinders ahead of the drivers. The railway liked it and bought 19 more *Planet*-type locomotives between 1830 and 1834. While subsequent locomotives would continue to grow in size and power, all but a few would emulate this refined prototype until China’s Datong Works built the last commercial steam locomotives in 1988.

Although it is missing some key components, *Rocket* amazingly survived and is now on display at the Science Museum in South Kensington (London). Several replicas have been built, all of them in the original configuration. Interestingly, *Sans Pareil* also survived. While it did not complete the trial, the L&MR decided to purchase it anyway, but the company only ran it for a short while before leasing it to a connecting line, the Bolton and Leigh Railway, where it remained in service until 1844. *Sans Pareil* subsequently served as a collier stationary boiler until donated to the Patent Office Museum in 1864. Today, it is displayed at the National Railway Museum’s Shildon Facility, along with a replica built for the sesquicentennial of the Rainhill Trials in 1979. A replica of *Novelty* was built for the centennial in 1929. The wheels and one cylinder from the original had somehow survived, and they were used in the replica, which is now displayed in the Manchester Museum of Science and Industry.

**Significance of the Rainhill Trials**

*The trial of these Engines, indeed, may be regarded as constituting a new epoch in the progress of mechanical science, as relating to locomotion.*

— Joseph Locke

The Rainhill Trials achieved everything that the Liverpool and Manchester’s directors hoped it would. Every locomotive tested showed that the adhesion between an iron wheel and rail was sufficient to allow a self-propelled vehicle to move itself and pull a useful load of railway cars. Stephenson’s *Rocket* proved the merits of pistons acting directly on drive wheels without the need for gears and levers, and its multi-tube boiler set a precedent followed by almost all subsequent steam locomotives. The railway immediately abandoned any idea of using fixed engines to pull trains. (In the future, they would be limited to short railways with very steep inclines.) Having built the winner of the trials, Robert Stephenson received contracts from the L&MR for seven additional locomotives like *Rocket*, and he
continued to develop improved motive power for the company until 1834, producing all but seven of the L&MR’s first 33 locomotives. The early success of the railway is one indication that Stephenson’s locomotives continued to perform admirably and economically.

The initial success of the Rainhill Trials was, however, only the first chapter of a story that continues to this day. Technologies evolve by building on successes and discarding not only failures, but frequently ideas that were successful, but less than the best in their field. Rainhill did both by discarding fixed winding engines, a successful but obsolete concept for relatively level routes, and locomotive designs that were clearly inferior to Rocket. This was possible because the trial program was, itself, well designed by engineers who developed a process to generate useful knowledge by focusing on performance. They thought about what information they needed to compare similar machines, and then designed a test program that would impartially measure the appropriate parameters and use standard calculations to yield additional values. Outlined in standardized tables, these data made it simple to compare the overall performance and economy of each entrant.

Modern engineers in all disciplines use test and evaluation methods that follow directly from Rainhill. While modern computational capabilities give engineers the ability to analyze virtually anything that can be quantified, many similar objects, systems, and processes still prove challenging to compare. Whether analyzed using computers or evaluated in a physical testing facility, engineering choices frequently involve a selection between similar, competing concepts. Since Rainhill, the field of test, or experiment, design continues to develop in sophistication, but the core concept remains valid.

The Liverpool and Manchester Railway, the world’s first “common carrier” railway, remains in service, with almost all of it still on the original alignment. The Olive Mount Cutting has been enlarged to accommodate current rolling stock, and the Wapping and Crown Street tunnels are no longer in use under Liverpool, though the former still exists. Two bridges in Manchester remain in place, but not in service, and the Liverpool Road Station tracks are now isolated from the main line. Otherwise the railway still utilizes its original structures, including the major viaducts and bridges, as well as the roadbed foundation across Chat Moss, using track and trains many times heavier than the originals. In 1845, the L&MR was absorbed by the Grand Junction Railway, which became part of the London and North Western Railway in 1846. Through subsequent mergers, it ultimately became part of British Railways, now known as Network Rail, in 1948. Fittingly, when British Railways ended the use of steam locomotives on 11 August 1968, the final steam run was over the Liverpool and Manchester Railway.
Further Readings


J. Lawrence Lee, Ph.D., P.E., F.ASME
THE HISTORY AND HERITAGE PROGRAM OF ASME

Since the invention of the wheel, mechanical innovation has critically influenced the development of civilization and industry as well as public welfare, safety and comfort. Through its History and Heritage program, the American Society of Mechanical Engineers (ASME) encourages public understanding of mechanical engineering, fosters the preservation of this heritage and helps engineers become more involved in all aspects of history.

In 1971 ASME formed a History and Heritage Committee composed of mechanical engineers and historians of technology. This Committee is charged with examining, recording and acknowledging mechanical engineering achievements of particular significance. For further information, please visit http://www.asme.org

LANDMARK DESIGNATIONS

There are many aspects of ASME's History and Heritage activities, one of which is the landmarks program. Since the History and Heritage Program began, 262 artifacts have been designated throughout the world as historic mechanical engineering landmarks, heritage collections or heritage sites. Each represents a progressive step in the evolution of mechanical engineering and its significance to society in general.

The Landmarks Program illuminates our technological heritage and encourages the preservation of historically important works. It provides an annotated roster for engineers, students, educators, historians and travelers. It also provides reminders of where we have been and where we are going along the divergent paths of discovery.

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