Brunel's Dream

Achieving Comfortable Mobility

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Renowned Engineer Isambard Kingdom Brunel

The resigned sigh that passed my lips on arriving at Heathrow Airport was prompted by the long queues at immigration. Being the gateway to London, a city known as a melting pot of races, the arrivals processing area was jammed with travelers from all corners of the world; from Europe of course, but also from the Middle East, Africa, Asia, and North and South America. What is normally a one-hour wait can stretch to two or more hours if you are unfortunate enough to catch a busy time of overlapping flight arrivals. While this only adds to the weariness of a long journey, the prospect of comfort awaits you on the other side. The Heathrow Express between airport and city center runs frequently and delivers you to Paddington, one of London's major railway stations, in a mere 15 minutes.

A series of railway lines are laid out beneath the three vast spans of vaulted roof that enclose the station building. The top-most section of the roof arch is filled with glass through which sunlight brightens the interior. The Great Western Railway that runs between Paddington and Maidenhead, a town not far from the British Royal Family's Windsor Castle where Queen Elizabeth II spends her weekends, first opened in 1838. Construction of the railway was overseen by Isambard Kingdom Brunel [1]. Although few are familiar with him, Brunel still enjoys great popularity. In a 2002 poll organized by the BBC to choose the 100 greatest Britons, Brunel came in second only to Churchill. Similarly, the opening ceremony of the 2012 London Olympics included a scene portraying the beginnings of the Industrial Revolution in which the actor playing Brunel gave a soliloquy from Shakespeare's *The Tempest*. He remains one of the most notable engineers in British industrial history and also gave his name to the Brunel Awards International Railway Design Competition.

While the initial section of the Great Western Railway between Paddington and Maidenhead was opened in 1838, as noted above, Paddington Station remained a temporary wooden building for many years. It was not until 1854 that the station acquired the vaulted glass roof that it has today. This structure, too, was designed by Brunel. For a railway engineer like Brunel to take on the design of the station building was a ground-breaking move given at a time when accepted wisdom said the job should go to an architect.

The design of Paddington Station's glass roof was influenced by the Crystal Palace building erected as the venue for London's first Great Exhibition held in 1851. Brunel was also involved in the planning for Crystal Palace, serving on the building committee of the Great Exhibition, and acclaimed the resulting structure of glass and iron.

Rather than pursuing efficiency in isolation, Brunel's approach to constructing the Great Western Railway was to make the railway lines as flat as possible so that passengers could enjoy a pleasant journey while taking in Britain's wonderful rural scenery. He employed a variety of techniques to overcome the constraints of the terrain, constructing bridges, cuttings, and tunnels to achieve this purpose.

Rain, Steam and Speed – The Great Western Railway, a famous work of Turner, the renowned English Romantic painter, shows a Great Western Railway train travelling at speed over the Maidenhead Railway Bridge designed by Brunel [2].

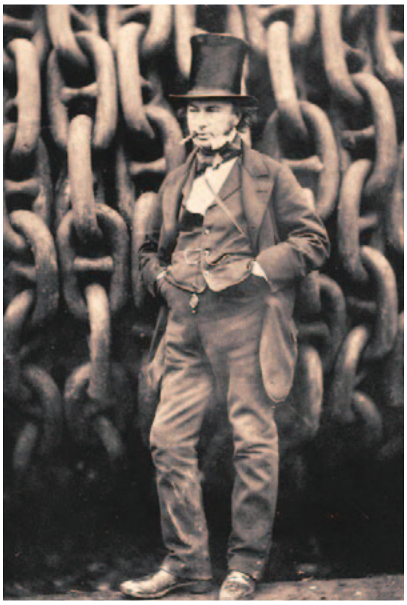
Brunel's work extended beyond railways to also include the design of large steam ships that sailed the Atlantic Ocean, including the SS Great Western, the SS Great Britain, and the SS Great Eastern. Passengers departing from New York could look forward to a comfortable and seamless journey that would include reaching London aboard the Great Western Railway that ran to the port city of Bristol on England's west coast. Incidentally, the SS Great Eastern would later be used to lay a transatlantic undersea telegraph cable.

We can feel nothing but reverence for this great forebear who took a broad view of society as a whole during the Second Industrial Revolution and who had a vision for utilizing human-centric technologies that he subsequently put into practice.

Exploring Frontiers

The ongoing Industrial Revolution meant that the 1830s, when the first railway lines were being built, were a time of growing urbanization in Europe, with the result that the reclamation of old town centers and the ease of travel to and from surrounding areas became an issue. Cities like London and Paris lacked what might be considered a central station. This was due to a failure to get the support of local residents, a phenomenon that remains common with the construction of new lines today. In particular, a lack of appreciation at that time for the convenience of train travel meant that opposition by residents

[1] Isambard Kingdom Brunel



[2] *Rain, Steam and Speed – The Great Western Railway* by J.M.W. Turner

Source: The National Gallery

was deeply rooted. In contrast to Britain, where the private sector took the lead, the laying of railway tracks in France was largely accomplished through royal authority. This was during the restoration of the monarchy after the Napoleonic regime — a time when royal authority was dwindling — that residents of central Paris could not be forcibly evicted to allow for the construction of railway lines.

Paris in the form we know it today took shape in the years following 1853 when Georges-Eugène Haussmann, the Prefect of Seine appointed by Napoleon III, embarked on a major urban renewal program. Along with installing water supplies and sewers, establishing parks, and clearing slums, Haussmann also undertook a comprehensive program of work to build a transportation network in which roads were joined up with the railway lines that terminated on the outskirts of Paris. Obviously, the horse-drawn carriage was the main form of mobility in Paris in those days, as used by the Enterprise des Omnibus that commenced operation in 1828. "*Omnibus*" is a Latin word meaning "for all." In Britain, meanwhile, an omnibus service was likewise established between Paddington and Bank in the city center. It is from this that we get the modern word "*bus*." Haussmann differed in age from Brunel by only three years, and like Brunel he took a broad view of society as a whole and shared the dream of building a comprehensive public transportation system.

The heart of public transportation in London was the underground. The Metropolitan Railway was the world's first underground railway service and ran between the major railway stations of London, including Paddington, Euston, Kings Cross, and Farringdon on the City Line (City of London). Although it came after the death of Brunel, the Great Western Railway invested in the Metropolitan Railway with a view to running its services from Paddington to the City. While this plan never came to fruition, the intention was to provide users with seamless mobility. The Metropolitan Railway subsequently grew in size to become the underground network that serves as a primary means of travel in the city, in the process influencing countries around the world in a variety of ways. It is how we come to use the word "*metro*" to mean an underground railway system.

On the other side of the Atlantic in the USA, the opening up of the west was largely over by around 1890, bringing the era of the frontier to an end. After this, the USA's new frontier was to be found in the sky, or rather in the construction of ever taller buildings. In the USA, the construction of high-rise buildings first got underway in Chicago in the 1880s, and subsequently in New York in the 1890s. It was around this time, in the 1890s, that the term skyscraper was coined. What made these high-rise buildings possible were steel framing, glass, and elevators. Whereas past structures built using materials like stone or brick were restricted in terms of how high they could be stacked by the weight of the building material itself, steel framing and glass overcame this limitation. The average building height in 19th-century London and Paris was in the range of five or six stories. This was the limit of how high people were prepared to climb up and down stairs.

Elisha Graves Otis, who differed in age from Brunel by only five years, conducted a public test of an elevator at the 1853 World's Fair in New York. While lifting apparatuses similar to elevators had existed before this, they had a poor safety record, being prone to frequent falling accidents. Their use was limited to things like moving goods at factories or transporting ore at mines, while the transportation of people was prohibited. At the World's Fair, Otis put on a performance in which he deliberately cut the rope suspending an elevator on which he was standing. The test was a success as the elevator car was prevented from falling by its two guide rails. Having demonstrated its safety, the elevator was at last ready to enter widespread use. When Otis went on to release an electrically powered elevator in 1889, it led to a forest of high-rise buildings of 100 m or more sprouting across Chicago and New York.

It may be no exaggeration, then, to say that the elevator was responsible for opening up the frontier of the sky. Between them, the three contemporaries of Brunel, Haussmann, and Otis each in their own way sought to provide people with comfortable mobility.

Moonshot!

Since then, humanity's exploration of frontiers has spread beyond the planet. On July 21, 1969, Neil Armstrong, commander of the Apollo 11 spacecraft, landed on the surface of the moon. This was the moonshot moment. This word, "*moonshot*," derives from the Apollo program and has come to mean a vision for the future involving a grand challenge or objective that, while it may require overcoming great hurdles to achieve, it will have a major impact if successful.

Despite the existence of a variety of challenges at a global level, the 1960s were also a time when there was a great spirit of innovation in the air, as exemplified by the Apollo program. On August 21, exactly one month after Commander Neil Armstrong took his great leap for mankind, Hitachi too took a new step forward. This was the day when Omika Plant (now Omika Works) commenced operation, merging departments that had dealt with products like electrical switchboards, control equipment, and computer control systems at Hitachi Works, Kokubu Factory, and other such locations into a new site dedicated to the control systems business [3].

While the history of Hitachi's involvement with control systems goes back to its founding in 1911, the field went through a major turning point in the 1960s, from the classical control theory that had held sway since the Industrial Revolution, to the modern control theory of Professor Rudolf Kalman. A mathematical algorithm he devised called the Kalman filter was used by the Apollo program in the spacecraft guidance system and contributed to its success.

The invigorated spirit of the times was also reflected at Omika Plant, which formulated its Greater Omika (GO) Pledge that was underpinned by Hitachi's mission of "contributing to society through the development of superior, original technology and products" and imbued with "Pioneering Spirit," one of the Hitachi Founding Spirits [4].

[3] **Omika Plant**

Source: 20 Years of Hitachi's Omika Plant Seeking to Become Integrated System Factory

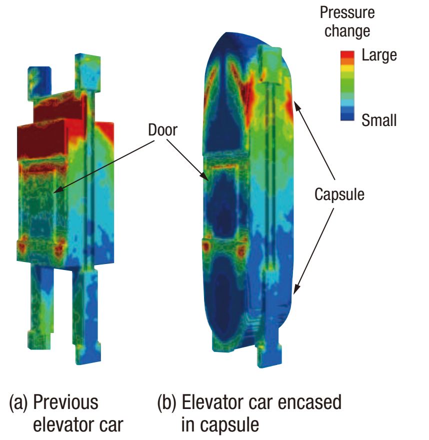
[4] **GO Pledge**

GO Pledge

Along with seeking to be better members of society, we pledge to go forward as one with a strong commitment to fulfilling our mission, taking pride and responsibility as staff of Omika Plant with its role as an agent of social progress

1. To acquire more advanced skills
2. To work in ways that merit trust
3. To think and act in ways that are considerate of others
4. To build a workplace that is invigorated and vibrant
5. To be self-disciplined and feel gratitude

[5] Use of Computational Fluid Dynamics to Determine Changes in Elevator Car Surface Pressure



Source: Development of Ultra-High-Speed Elevator that Achieved the World's Fastest Elevator with a Speed of 1,200 m/min

Incidentally, Hiroaki Nakanishi, now Executive Chairman and Executive Officer of Hitachi, Ltd., joined the company in April 1970 as part of that year's new intake at Omika Plant.

Omika went on to develop a variety of control systems under the auspices of this GO Pledge. These included the COMTRAC, COSMOS, and other traffic management systems for the Shinkansen. The COMTRAC traffic management system for the Tokaido-Sanyo Shinkansen commenced operation in 1972, coinciding with the opening of Sanyo Shinkansen services to Okayama. It underwent further enhancements, including a functional upgrade to enable the sharing of track with the Kyushu Shinkansen.

The new COSMOS Shinkansen traffic management system is a large-scale and wide-area distributed system, providing integrated management of Shinkansen operations across lines such as the Tohoku and Joetsu Shinkansens, including train scheduling and other planning tasks, rolling stock operation, and the monitoring, control, and maintenance of equipment.

Highly reliable real-time control systems are aligned with Brunel's dream from long ago of enabling people to travel in comfort (mobility), and also underpin the high-speed, high-density, punctual, and safe running of the Shinkansen. These include the real-time automatic control of signals and other infrastructure and systems that use predicted train schedules to assist with operational coordination.

Japan too began to look to the skies in the 1960s, marking the beginning of the era of ultra-high-rise buildings. The construction code was revised in 1963, abolishing the limit of 31 m that had been placed on building heights.

The first of many ultra-high-rise buildings that would follow was the Kasumigaseki Building completed in 1968. As noted earlier, the development of elevators had been a prerequisite for the construction of taller buildings. Hitachi supplied the Kasumigaseki Building with elevators that, at 300 m/min, were the fastest in Japan at the time. The company went on to release a series of further elevators that in their time were the fastest in the world, achieving speeds of 540 m/min in 1974, 810 m/min in 1993, and 1,200 m/min in 2016.

This opening up of vertical space went global in the 2000s with the construction of ultra-high-rise buildings getting underway in the Middle East and Asia, especially in China. In 2019, Hitachi elevators supplied to the Guangzhou CTF Finance Centre in Guangzhou, China commenced operation with a speed of 1,260 m/min. While setting a target of being the fastest in the world constituted a moonshot, the objective was to use elevators as a means of contributing to society, which is to say, to provide people with the means to travel up and down in comfort. 1,260 m/min equates to 75.6 km/h, a speed at which air movements or small bumps or curvatures in the rails have a major influence on the level of noise and vibration. Another issue for users is the ear discomfort people experience due to sudden changes in air pressure. To address these, Hitachi works on ways of improving comfort and safety as well as on the drive and control technologies used to achieve maximum speed. To reduce sources of vibration, Hitachi utilized techniques from computational fluid dynamics acquired in its work on high-speed trains to develop an elevator car with a capsule design [5]. Other developments included an air pressure control mechanism to reduce ear discomfort.

Carrying on Brunel's Dream

Hitachi launched the European operations of its railway business in 1999. The inaugural president of Hitachi Europe, headquartered in Maidenhead, was none other than Hiroaki Nakanishi, who had transferred from his role as deputy manager of Omika Plant. A person was subsequently appointed to handle the railway business at Hitachi Europe in 2000. That Hitachi's railway business in Europe made its start in Maidenhead where Brunel first commenced operations of his Great Western Railway cannot help but leave one feeling a sense of continuity with this great man who came before us.

[6] **Great Western Main Line Served by Hitachi Class 800 Trains**

[7] **Hitachi Class 802 Train at Paddington Station**

A June 2019 order for rolling stock for the new Caravaggio double-deck commuter trains from Italian railway operator Trenitalia was intended to meet the high level of demand in Italy for commuter and regional trains linking major cities and their surrounding areas, utilizing advanced technologies honed by Hitachi in Europe and Japan. The automatic train protection/automatic train control (ATP/ATC) system for maintaining safety is built on a "double-standard" platform that integrates existing Italian systems with train control based on Europe's Technical Specifications for Interoperability (TSI).

Similarly, the Dynamic Headway solution that Hitachi is trialing at the Copenhagen Metro in Denmark is a driverless signal and rail service management system that adjusts transportation capacity in real time in response to changing demand, and it too utilizes technologies honed in Europe and Japan.

Meanwhile, Hitachi Class 800 rolling stock are currently operating on the Great Western Railway that forms part of Brunel's legacy [6], [7]. It is as if they are carrying on his dream. Indeed, I believe that Hitachi's Pioneering Spirit represents the continuation of Brunel's dream.

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