Hyperloop, the Electrification of Mobility, and the Future of Rail Travel

By Roberto Palacin

PREDICTING THE FUTURE IS much more dark art than science, and it is an undertaking that must be treated with caution. That is my disclaimer before I attempt to speculate how we will travel by rail as the 21st century advances.

Urban Mobility

We live in an urbanized world. The engine of our economy and way of life is based in the city. Transportation is the key essential facilitator of this, and it will continue to be so for the foreseeable future. Mobility, therefore, plays a fundamental role in the process of developing urban areas. This is particularly relevant in the new crop of the polycentric megapolis, where the ability to move efficiently and rapidly across each city is vital. With the advent of electromobility and driverless vehicles, it is fair to ask what role railways could play in this 21st-century mobility landscape. The answer is not easy, of course, but it lies at the railway's core advantage of mass transit and reduced land use. This should position urban railways as the backbone of the mobility chain.

Urban railways have traditionally been and will continue to be electrified. The evolution of electrification solutions will play an important part in developing transit systems that are efficient and reliable. The introduction of energy-efficiency measures, such as reversible substations, and energy storage systems are two technological developments that will underpin the advancement of electrification. There are also some urban/suburban electrification solutions that are ripe for upgrading; the third rail system is one that springs to mind. This system can still be found in large parts of London and the southern United Kingdom. As Prof. Rod Smith from Imperial College pointed out in one of his brilliant papers, a letter to *The Times* on 8 October 1904,

> … The "live rail" is itself already an obsolete device, discarded in the latest types of electric railway. In ten years time there will probably be no "live rail" left…it is an engineering blunder.

In other words, the third rail system was declared obsolete over 100 years ago, and it is still being used! There is definitely an electrification challenge there. Cost is the culprit, you might be thinking. All of this will not mean anything if the railways cannot achieve high levels of patronage that will justify the higher upfront investment cost.

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Long Distance

Long-distance rail travel in the 21st century will be dominated by speed. Stephenson's Rocket won the 1829 Rainhill competition, where it achieved the world speed record in the process—almost 58 km/h. Fast forward 135 years, and the modern era of the high-speed rail was established by the Japanese with the 1964 inauguration of the Tokaido Shinkansen commercial service, which could reach a maximum speed of 210 km/h. Since then, the pursuit of faster and reliable high-speed services has rapidly increased across the globe. Service speeds of 300 km/h are common in modern networks, e.g., Spain's AVE, the French TGV, and Germany's ICE. In the very near future, in-service speeds of 320–360 km/h will be routinely achieved. However, the technological and operational challenges that this poses are not trivial. Finding a balance between the level of safety required while maximizing capacity and optimizing energy usage is one of the biggest dilemmas faced and the cornerstone of future rail travel. The rail industry needs to resourcefully utilize its endowed energy efficiency, and it is uniquely positioned to do this. Again, electrification already

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is at the heart of the systems that make this possible, and a 25-kV ac power supply is and will continue to be the chosen approach for this.

Of course, the imagination of engineers has created many alternatives to the steel-on-steel principle that has defined the railway since its birth. Maglev and the Hyperloop are regarded as the most relevant future alternatives. Magnetic levitation (maglev) uses powerful magnets to propel the train along dedicated, as straight as possible, infrastructure. With roots in Germany and Japan, the technology is currently in service in China, linking the Shanghai airport with the city center at speeds of 430 km/h. However, maglev is intrinsically associated with Japan, the nation that established the modern era of high-speed travel and is now attempting to define the next chapter. The superconducting magnetic levitation (SCmaglev) system has been in development for decades and was recently approved to start service operation on the Tokyo–Nagoya line by 2027 and then onto Osaka. While maglev is technically viable, as demonstrated by numerous tests that have been carried out, questions remain about its suitability for commercial application, particularly with regard to the extremely high initial cost that requires dedicated infrastructure. This, in turn, also highlights its lack of connectivity and integration with existing rail networks, as well as the phenomenal energy demand (during construction and operation) that casts concerns about its true potential as an alternative to conventional high-speed technology that still has enormous development potential.

Hyperloop is an elegant idea. Traveling seamlessly at 1,220 km/h in gracefully designed pods with frequencies averaging 2 min, dropping to 30 s during peak time (no more waiting!) is very appealing. Technically, it is a challenging design, but it is proving to have captured the imaginations of entrepreneurs and engineers. However, this is not rail travel. As Elon Musk puts it, it is a fifth-transport mode. It is designed to link cities that are around 1,500 km apart. In fact, it is proposed to link Los Angeles and San Francisco, where it is possible to have uninterrupted straight-line construction without coming across any built areas of significant topographic challenges. This is not the case in many other parts of the world. Ultimately, even if the idea sees construction, given the uniqueness of its principle, it will probably be a stand-alone complementing system rather

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than one that could be seamlessly integrated with other existing modes. It is no substitute for the railway.

In practice, the vast majority of us will continue to travel on trains that are, on the surface, at least not dissimilar to what we know today. For instance, in the United Kingdom, we are about to take the delivery of 122 train sets (class 800 for those interested in this sort of thing) in the coming 18 months. These trains will be the workhorses of intercity travel for the coming decades. If the trains they are replacing are anything to go by, we will still be using the new ones in 2050.

Modern state-of-the-art railway investments around the globe are based on the steel-on-steel principle, and there is no reason to doubt this is, by and large, the rail travel of the future—as it was nearly 200 years ago. Electrification will continue to play a significant role as it always has, more so with the drive to reduce greenhouse gas emissions and the likelihood of the death of the diesel engine. This will provide a fresh opportunity to advance electrification systems around the world, which hopefully will make them more attractive financially. On other fronts, the flexibility and adaptability of the passenger's needs as part of solving the conundrum posed by the tension between capacity, energy use, and service level will be the drive for more innovation. Physical and virtual connectivity will be at the heart of how we will be traveling in the future, not just by rail.

For Further Reading

R. Smith, "Energy for railways," in *Energy, Transport, and the Environment: Addressing the Sustainable Mobility Paradigm*, O. Inderwildi and D. King, Eds. London, U.K.: Springer-Verlag, 2012, pp. 561–575.

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Biography

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