Explainer: The engineering challenges of HS2

November 19 2013, by Felix Schmid

Faster, safer, shinier. Credit: PA

Next year, high-speed rail travel will celebrate its 50th birthday. In 1964, Japan put into service the first Shinkansen line, from Tokyo to Osaka. Its trains initially operated at speeds of up to 210 km/h, much slower than the 331 km/h speed record established by SNCF in France in 1955, but much higher than the 160 km/h achieved by service trains in Europe.

The real achievement of the designers and builders of Japan's new railway was not the speed of the trains. It was that the railway had been designed from the beginning as a system, an integrated whole. The structures, the tracks, the station layouts, the signalling equipment and the trains were all optimised together to achieve the expected standard of performance.

Today, High Speed 2 (HS2) is at the top of Britain's political agenda, and its construction will be the UK's largest infrastructure project in decades. Given the enormity of the task it presents, what can its engineers and designers learn from the examples of other high-speed lines?

Lessons from HS1

The only domestic comparison for HS2 is High Speed 1 (HS1), Britain's first high-speed capable railway. HS1 is modelled on the French Lignes à Grande Vitesse (LGV). This means HS1 has inherited many of its parents' successful features – and some of their flaws as well.

On the one hand, HS1 supports reliable train operations with a high level of comfort and safety, since the trains and the tracks are well matched. If alignment faults are detected, the ballasted track can be adjusted easily and economically.

On the other hand, frequent maintenance is required to ensure the expected level of performance. Also, while the trains have a high standard of built-in safety, their design slows down both boarding and alighting, and thus results in slower turnaround times and longer "dwells" at stations. The automatic train protection subsystem employed on HS1 is tried and tested, but it compares poorly with newer equipment.

Largely thanks to the experience of running HS1, the engineers designing HS2 are aware of the state of the art in high-speed rail design. To ensure that the systems chosen for HS2 will satisfy the exacting capacity and performance requirements, HS2's engineering teams are carefully reviewing lessons from France, Germany, Japan, Korea, Spain and Taiwan.

Challenges for HS2

- The most obvious challenge is to ensure HS2's full compliance with the Technical Specifications for Interoperability (TSIs), the standards that will allow high-speed trains from the continent to reach London, Birmingham, Manchester and Leeds.
- HS2 must have an operational concept supported by systems engineering of the same quality as that of the Shinkansen network, in terms of train design and infrastructure. The latest Shinkansen trains, the 700A series, are able to decelerate very rapidly, returning energy to the supply line as they do so. Thanks to this level of performance, the infrastructure of the stations and the arrangements between stations can be kept simple and it is possible to exchange a complete junction in one night.
- The engineers must choose a type of track that supports the trains' high level of performance optimally, while offering both low maintenance and very good aerodynamic performance. Most likely, this will be an advanced form of slab-track (a track form that is not supported by ballast but is constructed on a concrete slab). This will have to be complemented by a well-designed formation – that is: cuttings, embankments and tunnel inverts that are strong and stable. Germany has experienced significant problems with recently built sections of high-speed railway slab track because of inadequate compaction of the ground and insufficient drainage.
- Development of modern railway control systems that offer a high level of accuracy and service resilience, combined with a high level of safety. This will allow the operator to make best possible use of the expensive infrastructure.
- The many tunnels on HS2 will have to be of a low noise design to provide a comfortable environment inside the trains and to create minimal impact on the neighbours. At the same time, the tunnels must be large enough to limit the resistance to motion of the

trains operating at speeds greater than 300 km/h. This presents aerodynamic challenges for both the designers of the trains and the civil engineers.
- Segregation of the railway from its environment to minimise external influences on its performance, for instance, by providing platform screen doors in all the stations and aesthetically pleasing security and noise barriers that still allow the passenger a view of the countryside.

In addition to these problems of high-grade engineering, HS2 poses challenges to all local authorities that will be served by new stations. The local transport systems in the regions are generally not of the standard needed to convey the maximum benefit of the high-speed line. The proposed HS2 Manchester Airport station, for example, risks being too far from the heart of the airport and will thus have to be served by an extended tramway. The new East Midlands Hub must offer very good connectivity in all directions – a major challenge for the existing rail network as well as for trams and buses.

Speed is not everything

It is important to correct two misconceptions about HS2. First, trains may not run at 400 km/h as soon as the railway opens. Second, thanks to good design, noise and vibration associated with the new line will not make life in its vicinity unbearable.

It is true that the alignment has been designed for a maximum speed of 400 km/h, necessitating turning radius that is more than 7 km. However, the proposed journey times can be achieved by operating at less than 320 km/h. Essentially, the designers of HS2 have planned the line's alignment in a similar manner to that adopted by Brunel for his Great Western Railway.

Brunel's trains barely achieved 100 km/h, but he designed his railway for speeds of more than 160 km/h, clearly expecting that one day it would be both possible and necessary to run trains at much higher speeds. So, while operating HS2 at up to 320 km/h will create a quiet high-speed railway with an acceptable carbon footprint, the capacity for an even faster service will have been built in from the start.

More and detailed design work will have to be carried out. Links to the existing network will have to be studied and modelling of the operation of HS2 will have to be undertaken and the impact of services joining HS2 from the classical network will have to be assessed. But it is likely that the result will be an even better railway with a lower environmental impact throughout its route.

This story is published courtesy of The Conversation *(under Creative Commons-Attribution/No derivatives).*

Source: The Conversation

Citation: Explainer: The engineering challenges of HS2 (2013, November 19) retrieved 19 April 2024 from https://phys.org/news/2013-11-hs2.html