A Systems Engineering Approach to Delivering High Speed 2

The cost and business benefits of a project such as HS2 are clearly influenced by how well it is designed, built and delivers what is expected. But ultimately to deliver these benefits with cost and programme certainty, it has been essential to introduce a systems engineering approach.

Systems engineering, or SE, means different things to different people. Many refer to Systems Integration, which although important is only one phase of the overall process. The International Council on Systems Engineering, INCOSE, states that 'systems engineering considers the whole problem, the whole system, and the full lifecycle from concept to disposal'.

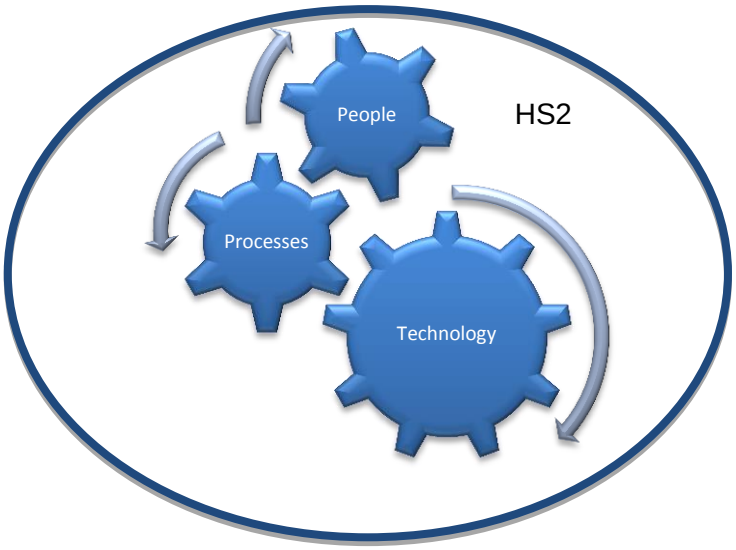
A railway is a system like any other. In the context of HS2, and embracing the entire lifecycle, the 'system' covers preliminary design through construction, testing, commissioning and operation, maintenance and ultimately, renewal. HS2 is so much more than just a construction project.

The application of SE allows project teams to 'manage complexity and reduce risk'. Research shows, generically but also for UK rail, that the application of SE techniques can reduce costs by as much as 10%-20% and deliver greater certainty in programme delivery.

Whilst the intention is to use best practice existing technology for HS2, any particular application has its own unique features and needs to be managed accordingly to deliver a successful outcome. As well as providing a holistic approach to design, SE techniques also allow for testing the potential impacts of any proposed changes against the intended outcome of the train service, and so deliver sound value engineering decisions as distinct from just cost savings.

So just what is the right system for HS2?

The HS2 project is a combination of all the civils infrastructure, track, power supply, communications, train control, stations and rolling stock. It also includes processes by which the railway will be operated and maintained, together with the people who will carry out the tasks. So it is critical to develop a plan to deliver all the elements of the system, even through to the recruitment & training.

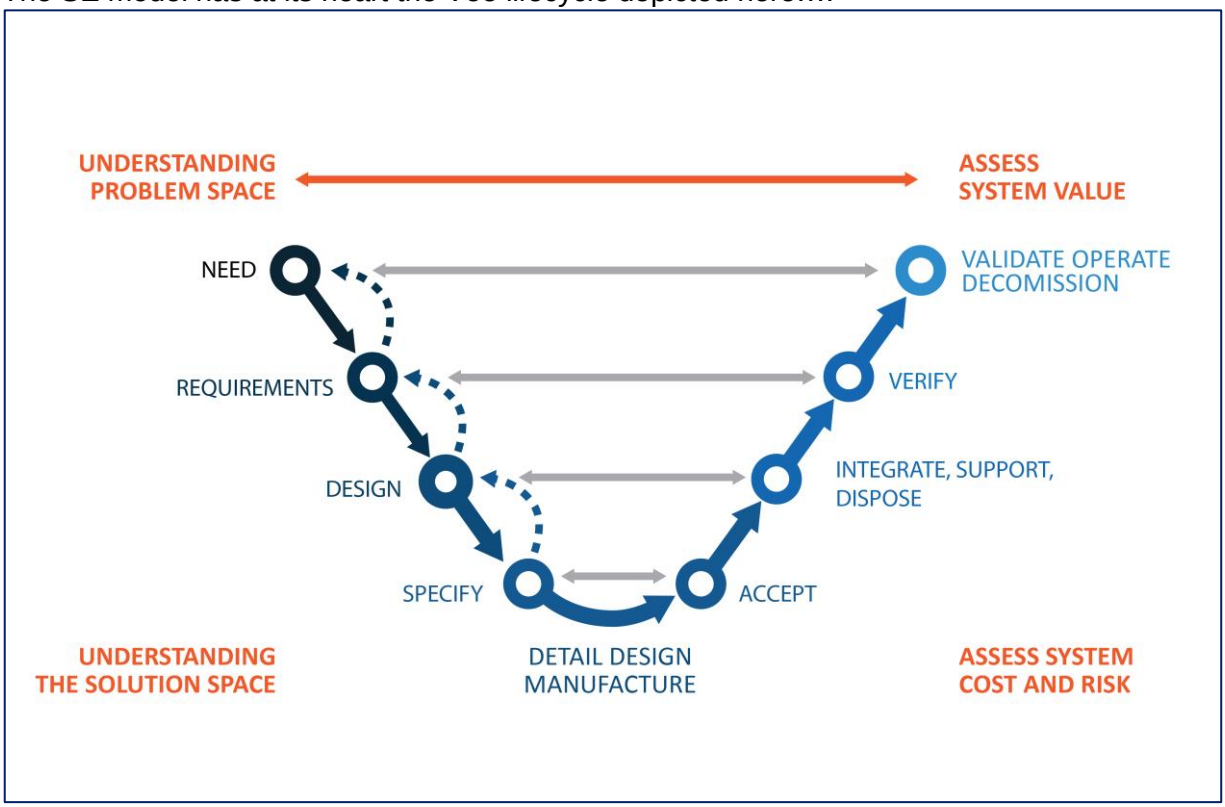


HS2 is planning to deliver a working railway system ready to take passengers "immediately", so not just built and tested, but everyone trained and practiced in what they will need to do to

deliver the high quality service. And not just any old system but one that really does deliver a step-change in passenger experience for the 21st Century.

But that is a long journey, and it would be easy for such a complex project to lose its way with respect to the original intentions unless specific steps were taken to manage the risk, and that is where the SE approach is so critical.

The SE model has at its heart the Vee lifecycle depicted here….



The first half of this is about gaining a better understanding of what needs to be achieved, setting requirements and progressively developing the detail of the design. That is followed by making and adding together all those parts to deliver the end result – the System Integration activity mentioned earlier.

HS2 is still in the top left quarter of the SE VEE life cycle moving down to the right; starting to understand the solution and still refining definition of the 'problem'. But tests are also being applied along the way to assure that at each stage the outputs do indeed deliver the required end results. By doing this in discrete stages, holding formal reviews at the completion of each stage and checking back against the same requirements, an SE approach provides the necessary discipline to keep a major project such as HS2 focussed on its required outcomes and targets for cost and programme.

Some might say that SE is just good project management, but it is more! It is a combination of project management and engineering management against the framework described above.

The railway system has to deliver against the operational concept, which in turn is developed to deliver the business case. Various sub-systems have to work together to deliver the necessary operational performance; the respective sub-system designs are based on a holistic approach to design, recognising that the overall best solution is the sum of all the parts. This frequently requires trade-offs among the sub-systems with an enhancement in one delivering a greater saving elsewhere.

For example, the use of regenerative braking reduces not only the overall power consumption but also the heat dissipation into the tunnels and so helps avoid the need for tunnel cooling. SE helps keep the emerging design focussed on delivering the business and operational imperatives.

Another key part is developing and capturing 'requirements' that describe the necessary properties or outcomes of the system. Some of the requirements, such as the target journey times and service frequency, flow directly from the business requirements. Modelling allows the project team to be confident that these can be met, and to derive more detailed parameters such as where turnouts should be placed for optimum performance.

SE uses modelling early on, to understand how the emerging design is likely to perform and test whether it will deliver the required outcomes. Partly based on the outcomes of successive modelling iterations and partly through looking at world-wide experience, the team has developed overall strategies for operations and maintenance, which have then been developed into more detailed plans. In turn these have informed the development of many requirements for the railway system that have been used as the basis of the HS2 design.

There are now around 1,500 requirements covering all aspects of the HS2 system, giving a clear definition of the project appropriate for the Hybrid Bill design. These, in turn, allow a clearer picture of the solution to be developed in the emerging detailed design, and demonstrate that the design does deliver the necessary functionality and performance.

Later, such data will be used as a basis for checking the performance of actual equipment being run in factory tests, again de-risking the outcome and avoiding nasty surprises at the time of commissioning.

This approach provides confidence that the current design, used as the basis for the Bill that was lodged with Parliament in November 2013, will deliver against the requirements and so deliver the outcomes to support the business case.

None of this is revolutionary, although some of it does push the boundaries of current world best in class. It will be another 12 years before the railway becomes operational so it would be almost negligent if the project did not look forward to what can sensibly be achieved by that time.

Each railway programme is unique in exactly how its various elements are integrated and brought together, including the people and processes to operate and maintain it and 'bring it to life' – and that is where Systems Engineering has a critical role to play in bringing High Speed 2 from a vision…. into reality.

By Andrew Shepherd, HS2 programme director and Systems Engineering specialist for Parsons Brinckerhoff