Risk Management in the Rail Industry

Information Sheet

Anticipating Risk

As rail systems become more complex, the risks associated with project change become more difficult to manage. Different components in the network interact in increasingly complicated ways. Keeping sight of the big picture while the individual parts adapt to new technologies is a critical mitigation of risk, but engineering doesn't always have the tools it needs to do that. All rail products exist as part of a larger system, and successful rail engineering needs to understand not just how its product fits into that system as it stands, but how it will react as the system changes in the future.

The introduction of cab signalling shows that even rolling stock needs to be able to adapt to the changing systems of the network, to say nothing of future pressures from accessibility and decarbonisation. Network-wide systems like control, command and signalling also have a great deal of complexity and emergent behaviour in their own right and exist in a constant state of flux; never more than now.

The risks of engineering in an environment like this are huge, especially because without proper consideration of the emergent properties of the system as a whole, a defect in a new product may not emerge until after it has already been integrated into the network. The best way to mitigate these risks is, naturally, to find a way to anticipate such problems before they arise, and use a development process which is designed around seeing its output not as an isolated component but rather as a detail in a big picture. If the product itself needs to change, your understanding of the associated risks needs to change with it.

Systems Engineering (SE) is the best toolkit available to engineers for managing such risks. It draws on the science of finding patterns in organised complexity, and the analysis of the emergent properties of a whole rather than the specific behaviour of individual components. The critical shift in understanding that systems engineering brings to the table is that it is the structure of a system that generates its behaviour, more than the mechanical details.

A huge part of that is in its scientific approach to requirements engineering, which generates specific, unambiguous and testable requirements using the same method as a scientist uses to generate the hypothesis of an experiment. Taking this approach to requirements enables an approach to modelling systems as such which such can treat the parts of the system as black boxes, 'system elements', which take their inputs from their environment and produce outputs. These 'system elements' are organised into systems, and then even into a 'system of systems', which is a model for systems with very independent components and a function that firmly rests on emergent behaviour, like a railway network or a supply chain.

These models are generally built from the top down, defined first in terms of broad stakeholder needs. As requirements get clarified and detailed, the model progresses down equivalent layers of complexity, at each stage fundamentally treating subsystems and individual elements as black boxes that transform inputs into outputs. As such, using a systems engineering model allows the behaviour of the system as a whole to be anticipated prior to proceeding with development. In rail systems, where components are so heavily integrated into a network with complex behaviour, this can be a critical mitigation of risk.

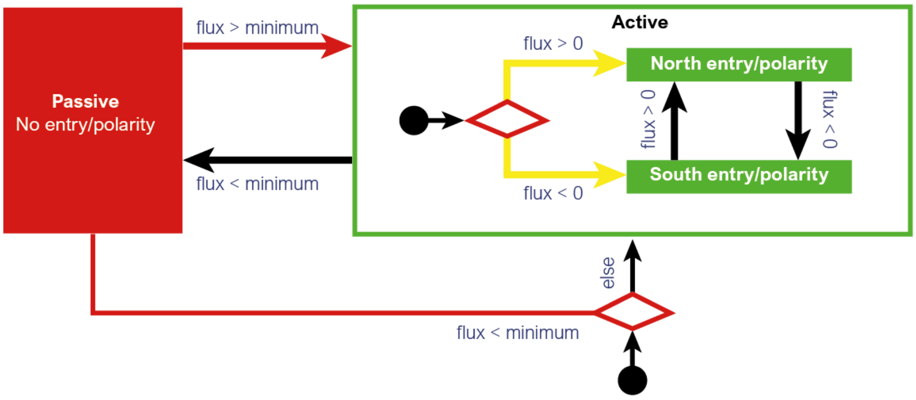
East London Rail Extension: Systems Engineering as Risk Mitigation

The 1990s saw two major eastward expansions of the London rail network: the extension of the Jubilee Line to Stratford, and the first stage of the Docklands Light Railway (DLR) extension. The projects began within a year of one another and were expected to take roughly similar amounts of time. The DLR extension was delivered within the agreed fixed price and performance requirements were fully met. But the Jubilee Line extension took 21 months longer than planned and cost around two-thirds more than the original budget.

INFORMATION SHEET

The DLR extension was delivered from the outset using an SE approach, including formalised system requirements, modelling and simulation, and a comprehensive set of integration tests.

SE Model of an AWS Ramp System



Adapted from "Verification and Validation of a new type of Railway Signal using MBSE and Simulation", Stephenson, Vine & Towers, November 2018.

By contrast, the Jubilee Line extension made little effort to maintain a whole system view, and very little provision was made for the huge extent of work necessary on the existing Jubilee line for the project to succeed. The extension was regarded as a bolt-on to the existing railway, and the integration work was not understood until a late stage. Several key decisions were not taken until much later than would be recommended by SE practice, and an SE approach to stakeholder and interface management might have resulted in significant cost and time savings. Of course, some of the differences between the projects can be attributed to the approach to management and external factors, but the evidence from authoritative accounts of the project suggests that the Jubilee Line extension could have avoided a number of late changes and delivered savings had good SE practice been adopted from the start.

This case study was adapted from those maintained by the INCOSE Transportation Working Group, available free at https://www.incose.org/incose-member-resources/working-groups/Application/transportation.

Derisking Change

A global study by the Project Management Institute (PMI) found that for every pound spent on projects and programs, 5.1 percent is wasted due to poor requirements management [1]. The techniques and processes of systems engineering, especially the ability to model complex systems early in development, can reduce this waste considerably. But the advantages don't stop there. For one thing, SE modelling and requirements management can significantly improve your relationship with your own supply chain by introducing a single source of truth, and clear specifications which can be passed down to suppliers in a traceable way. But the main benefit of an SE model in the long run how easy it makes it to plan for change.

Stakeholder needs can change at any point in the product life cycle, either during development or as part of a midlife upgrade to the system. By developing and maintaining an SE model, your organisation could have a relatively easy way to adapt to the impact of those changes, and determine quickly and cheaply what those changes will mean for the functionality of the system as a whole. SE modelling requires appropriate technologies to support engineers, but those technologies are already very mature, thanks to industries which have been using systems engineering techniques for some time. As rail continues to become a more complex environment, the rail supply industry could benefit from using SE modelling in its work.

This information sheet is an excerpt from SyntheSys Technologies White Paper about Embracing Change in Rail Supply. Read the full White Paper [here].

[1] PMI (2014). Requirements management.

About SyntheSys

SyntheSys provides defence systems, training, systems and software engineering and technical management services over a spectrum of different industry sectors. Along with distinct support and consultancy services, our innovative product range makes us first choice provider for both large and small organisations. Established in 1988, the company focus is on fusing technical expertise with intuitive software applications to solve common industry challenges.

INFORMATION SHEET

SyntheSys TECHNOLOGIES