## Low Waste Modelling Techniques

Every project manager knows how important it is to discover defects as early as possible. Most project costs are already committed at a very early stage and discovering a defect even in the course of building your product can be extremely costly. If a defect happens because of an unexpected interaction between different parts of the system, it might not even be discovered until the system is in use, with no recourse but to go back to the drawing board.

In rail, as the systems that run the network get more and more complicated, the potential for problems like this is getting bigger and bigger. Failing to anticipate defects early enough is an expensive source of waste, and a huge risk that damages the value your customers can derive from your work.

The original motivation for systems engineering, and still the core of its mission today, is to provide a way of thinking about projects that prevents precisely that sort of disaster. Scientific rigour in requirements and quality is a part of that story, and a major part of how that translates into value benefits is the modelling techniques that this rigour enables. Using SE techniques allows you to build models that help you understand every stage of your product's life cycle and anticipate how it will behave in the context of the network as a whole.

A formal systems engineering model is built out of black boxes, taking inputs from users and the environment and outputting stakeholder needs. Until you reach the finest levels of detail, the model is not concerned with how individual components work, but rather with the structure of a system as a whole: the inputs, outputs and interactions of system elements. It's about recognising that the structure of a system, rather than the specifications of individual parts, are what determines its behaviour as a whole.

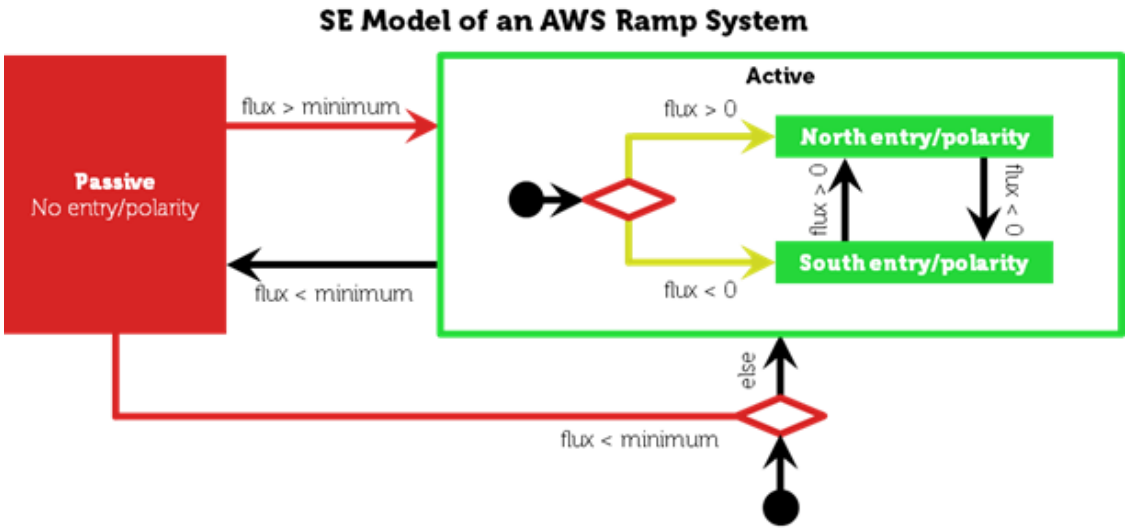
As such, the models are nearly always built from the top down, with the system as a whole taking inputs from users and the environment and outputting stakeholder needs. As requirements get clarified and detailed, the model progresses down equivalent layers of complexity, at each stage fundamentally treating subsystems and individual elements as black boxes that transform inputs into outputs.

As such, the benefits of a systems engineering model are not just confined to presenting a clear, coherent architecture to build from: it also allows the behaviour of the system as a whole to be anticipated prior to building, and sometimes even designing, anything physical.

By helping you get it right the first time, these models directly and straightforwardly help you reduce waste even when your projects have clear and relatively fixed objectives. But where they really shine is in helping you cope with change.

In rail, stakeholder needs can change at any point in the product life cycle, either during development or as the network changes around your work. 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 they will mean for your product. This allows you to reduce the waste associated with project change, and even to add lifetime value, by designing your product to be more adaptable to changes in what's happening around it.

More and more rail suppliers need to think about their work in the context of the whole, and SE modelling is a fantastic tool to bring that to your business.




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

AWS = Automated Warning System

## The SWORD Project: Modelling for Efficiency

Network Rail's 'Digital Railway' programme is a large-scale overhaul of the entire network's Control, Command and Signalling (CCS) systems, with the potential to hugely increase the safe capacity of the network while reducing cost. The programme will ultimately replace every lineside signal on the network with cab signalling systems, but in the meantime, some existing infrastructure will reach the end of its life and require immediate replacement.

The SWORD (Self-powered Wirelessly Operated Distant signal) project was the result of exploring cost-effective options for these 'temporary' signals. The idea was to remove the need for long lengths of fixed copper cable between the signal and its control point.

At the time, model-based systems engineering and simulation-based validation were relatively new approaches to Network Rail and CCS, but there was a need to verify and validate the SWORD system more quickly, cheaply and safely than would have been possible with a traditional prototype.

By building a systems engineering model of SWORD, Network Rail was able to validate the system through simulated testing, produce a better specification for stakeholders, ensure end-to-end traceability of the system, and maintain an adaptable model for any future specification changes.

*This case study was adapted from "Verification and Validation of a new type of Railway Signal using MBSE and Simulation", Stephenson, Vine & Towers, November 2018.*

## Planning for Change

Production methods like Lean, Kaizen and Six Sigma are effective at reducing waste and providing assurance throughout the construction process, but providing similar assurance before you start building anything physical requires a different set of tools.

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 is how easy it makes it to plan for change.

SE modelling requires appropriate technologies to support your team, as well as the skills to operate them, 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 Maximising Value 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.