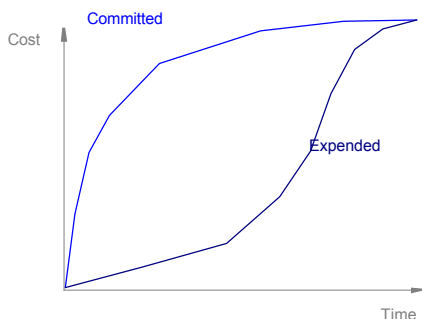


The Value Proposition for Systems Engineering in Railways and Transit

Introduction

All too often, complex rail and transit projects suffer overspends and overruns attributable to:

- Requirements which are ambiguous, contradictory, difficult to test or not really required at all
- Mismatches at interfaces
- Technical snags discovered late in the project
- Unexpected difficulties at acceptance



All projects follow the same basic approach. The initial work determines what is needed, and how it will be delivered, with later work delivering the components, integrating and commissioning them.

As the graph shows, while most of the costs are incurred in the second half of the project, they are committed in the first half. Nearly all integration, commissioning and performance problems derive from inappropriate decisions made early in the project.

To deliver the next generation of complex rail and transit projects successfully, we must get a firmer technical grip on them at the outset and maintain that grip until they are complete.

Systems Engineering (SE) is a term used for a body of techniques to:

- understand the requirements that a system must meet and then
- coordinate the different parties to ensure that those requirements are indeed met.

Good SE practice overlaps good project management practice. There is no need to choose between SE and project management: they complement each other. Some SE techniques are already in routine use on railway projects, but others are not. And where those techniques are being used, there tends to be a lack of technical rigor in the way they are applied, as well as little coordination between them.

Systems engineers use 'system' to mean any collection of equipment, people and procedures designed to accomplish a defined function. Conventionally, railway and transit engineers have reserved the term 'system' for the electrical parts of a railway infrastructure (train control, communications, and traction power), but the SE approach expands this narrow use. The SE 'system' still covers the electrical parts of the railway, but adds in the rest of the railway, including the mechanical equipment (rolling stock, points and pumps), the physical facilities (track, structures, stations, yards, and shops), the people who operate and maintain the equipment and paper components such as the set of operational procedures.

Railway and transit organizations can use SE to improve their grip on their projects and so significantly mitigate technical risk. By putting in place a comprehensive, rigorous, and integrated program of SE, they can enjoy benefits that exceed the sum of the benefits resulting from the individual activities.

The table below describes the main activities that would comprise a full SE program in a railway and transit project and describes the principal benefits that accrue from investing in each SE activity. Typically these activities would be shared between the contractual parties involved in a major project.

Activity	Summary Description	Summary of value added
Requirements Engineering	<p>Requirements Engineering is a disciplined approach to</p> <ul style="list-style-type: none"> • identifying, assessing, reconciling and defining the requirements placed on a system; • following these requirements until they have been met; • and tracking changes to them. 	<p>Heads off scope creep and prevents both doing too little to meet the requirements and too much. Mitigates the effects of risk and change by ensuring that everyone is working towards achieving the same requirements.</p>
Systems Architecture	<p>Systems Architecture is concerned with understanding the subsystems that make up a system, their behavior and the way in which these subsystems interact in order to ensure that they combine to deliver an integrated system which behaves as desired and meets the requirements placed on it.</p>	<p>Prevents expensive rework by allowing systematic checking of the integrity and balance of the system and its interfaces while the design is still on paper and rework is relatively inexpensive.</p>
Verification and Validation	<p>Verification and Validation (V&V) together describe a range of activities to confirm that the system is being built correctly and will meet its requirements and operational needs.</p>	<p>Finds flaws early, when they are cheaper to fix, leaves fewer flaws in the final system and streamlines customer acceptances of the system.</p>
Systems Modeling	<p>Systems Modeling is concerned with forecasting properties of a system as a whole, such as safety, reliability, passenger capacity, and trip times, in order to ensure that the system will meet the requirements placed on it.</p>	<p>Avoids painful surprises and allows meaningful, objective evaluation of design alternatives, which can improve decision making and reduce over-engineering. Also helps acceptance by demonstrating the compliance of attributes which are difficult to directly measure.</p>
Interface Management and Systems Integration	<p>Interface Management and Systems Integration facilitates the smooth integration of a system as a whole by identifying and defining interfaces in and around the system.</p>	<p>Awareness and careful management of all interfaces greatly eases system decomposition during the requirements and design stages and the integration after manufacture and construction thereby avoiding costly redesigns during construction or even more costly modifications and retrofits after operations begin when subsystems do not integrate optimally. Allows assurance to be provided progressively and thereby supports system safety certification and acceptance.</p>
Configuration Management	<p>Configuration Management is the process of identifying, assessing, approving and tracking changes to the system being built and all the associated documentation which must be maintained with it.</p>	<p>Through visibility and control of the system configuration it:</p> <ul style="list-style-type: none"> • Improves certainty of quality, time and cost (reduces associated risk); • Better informed decisions and clearer lessons learned; • Tighter control of changes and understanding of impact; • Improves asset management and maintenance.
Risk Management	<p>Risk Management is a disciplined effort to identify potential events that might adversely impact a project and then take action to head them off.</p>	<p>Identification of possible adverse events in advance allows them to be registered and mitigation strategies agreed hence significantly reducing the likelihood of them occurring or reducing the consequences on quality, time and cost if they do.</p>