SYSTEMS INTERGRATION IN A FRAGMENTED RAIL INDUSTRY

The SI:D³ methodology helps manage complex railway programmes in the context of a fragmented rail industry.

The Structure of the UK Rail Industry

Privatisation of Great Britain's (GB's) heavy rail network in 1993 divided British Rail into three main parts: rail infrastructure management (Network Rail [NR], formerly Railtrack); Train/Freight Operating Companies (TOCs/FOCs); and rolling stock leasing companies (known as ROSCOs). This provided compliance with the European Union directive that required member states to grant rail companies independence from the government and to separate the management of infrastructure from transport management.[1]

In addition to the three main parties, the GB rail industry is governed by the Department for Transport (DfT) and regulated by the Office of Rail and Road (ORR) (see Figure 1). The DfT is responsible for: determining the rail budget, setting the strategic direction, and specifying and awarding contracts to run the passenger rail franchises.[2] The ORR's role is to regulate the industry and to hold the appropriate parties accountable for safety, economic issues, performance, track access, and project delivery.

The GB rail industry, therefore, is a complex and highly fragmented one. Adding to this complexity are the misaligned timescales for the strategic and financial planning of the infrastructure and the train operating companies (TOC) franchise timescales, durations, and contracting approaches.

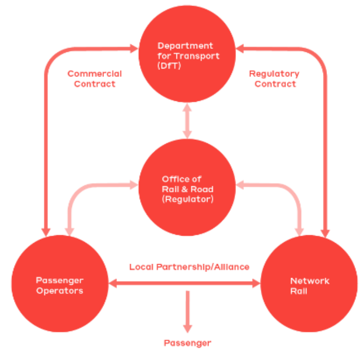

Figure 1 – Great Britain Rail Industry Structure
Source: House of Commons Library, Quick guide to the railways, July 2012

In May 2011, Sir Roy McNulty published his findings and recommendations for improved efficiency and value for money in the GB rail market. Known as 'The McNulty Report',[3] it concluded that the cost of rail in GB was 40 percent more expensive than in other countries. The report identified a number of barriers to efficiency including the fragmentation of industry structures and interfaces, and the relationships and culture within the industry. The report also recognised that the industry partners needed to work more closely together to implement a 'whole-system' approach to planning of timetables, infrastructure, and rolling stock, so as to improve the efficiency of the rail system as a whole.

Between 2014 and 2019 (Control Period 5), an unprecedented £37.5 billion was invested in the heavy rail network and Network Rail is forecast to invest £35 billion between 2019 and 2024 (CP6).[4] A significant risk to delivering this mega-

[1] EU Directive 91/440/EEC, 29 July 1991
[2] Except in Scotland for which transport matters are devolved to Transport Scotland.
[3] Department for Transport, Realising the Potential of GB Rail, May 2011.
[4] This is exclusive of DfT procured rolling stock, HS2, Crossrail, London Underground and funds devolved to passenger transport executives for light rail transport schemes.

programme of capital investment successfully is the integration of the enhancements, new/cascaded rolling stock, timetable, operations, and maintenance, within a fragmented industry structure.

Applying System Engineering (SE) and Project Management (PM) Expertise to Establish an Industry-Level Systems Integration Approach

One scheme included within Control Period 5 investment was the Thameslink Programme (TLP) which transformed north-south travel through London and increased passenger services from 12 to 24 trains per hour (tph). This was achieved through infrastructure enhancements, new rolling stock, and advanced rail technology, including in-cab signalling, automatic train operation (ATO), traffic management, and driver advisory systems (DAS).

Network Rail (NR) identified an issue with the highly ambitious programme, recognising the need to improve integration between the four main industry parties: the DfT, the train manufacturer, NR, and the TOC. To manage the integration risk, NR and the DfT instigated a stream of activity, managed by a new model of 'industry-level' systems integration team (see Figure 2). The programme established a multi-discipline, multi-stakeholder systems integrator (SI) responsible for ensuring that the system design reliably delivers the transport benefits that its funders expect. The team, which included WSP as a key partner alongside the industry partners, was engaged to develop an integrated solution that would allow the effective management of the programme complexity as it was delivered. This approach was featured in the WSP publication, 'Exploring Innovation' April 2012).

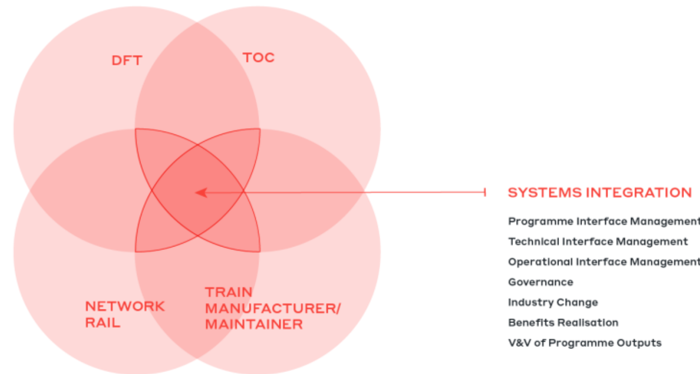

Figure 2 – Model of multi-organisational 'industry-level' systems integration

The Thameslink Programme industry-level system integration approach was recognised in the McNulty Report as having *"delivered significant benefits…identified and designed-out non-value adding requirements, and mitigated many problems"*.

Following the McNulty Report, and at the DfT's requirement, other major rail programmes established similar models of systems integration. In response to this market demand, WSP codified our experience into a scalable framework based on integrating operations, technology, schedule, and contracts to ensure the required system capability is being delivered (Figure 3).

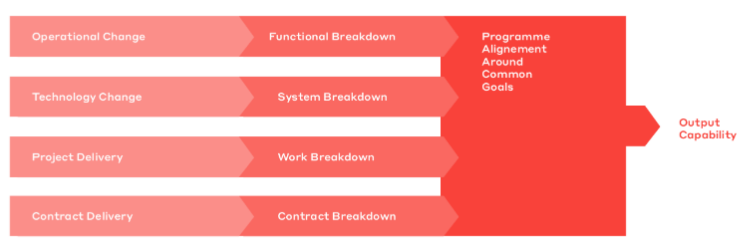

Figure 3 – Principles of systems integration management used to the develop SI:D³ framework

The framework is known as Systems Integration: Define, Develop, Deliver (SI:D³). SI:D³ employs best practice elements of System Engineering

(INCOSE System Engineering Handbook)[5] and Project Management (PMI PMBOK)[6]. SI:D^3 is a compendium of processes, techniques, and proprietary software tools that we have created, and used to good effect, to help our clients better understand and manage their complex programmes. (See Figure 4.) SI:D^3 has been applied on programmes as diverse as the Northern Hub, Deep Tube Upgrade Programme, and the Great Western Route Modernisation.

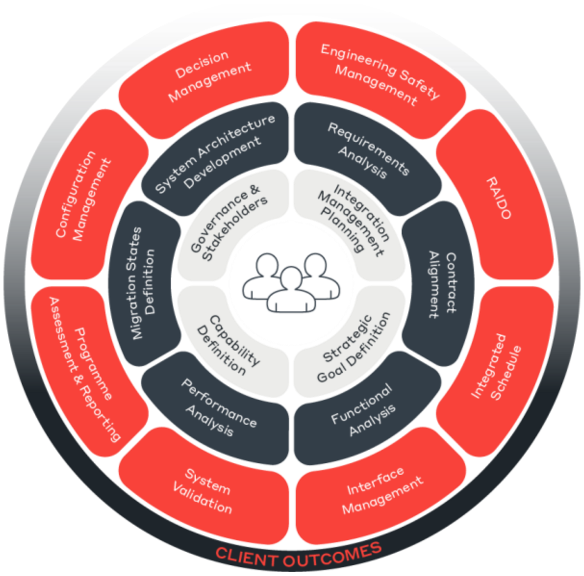

Figure 4 – SI:D^3 model for systems integration

A Complementary Suite of Software Tools

Supporting the SI:D^3 process framework are a suite of bespoke tools that produce visual representations, or models, of the system; these representations are referred to as 'system architectures'. The process of system architecting typically involves examining a system from a number of different contextual viewpoints, breaking the system down to its fundamental structure and then building a model of these 'building blocks' and their interconnections.

These contextual viewpoints can include:

Temporal views: A major challenge to the railway is managing the changing configurations of the infrastructure, rolling stock, and operations, over time. WSP has developed a 'migration plan' (or roadmap for success) architecture view to aid the planning of major migration phases whilst ensuring the final operation delivers the required performance.

Geographic views: The railway network is a system in which technologies, operations, and maintenance can be widely geographically distributed. To develop an architecture view of the whole railway requires an approach that falls somewhere between classic model-based systems engineering (MBSE) and geographic information systems (GIS). We have implemented a data-driven approach where the geographic network is represented as a schematic map upon which various aspects of the system can be overlaid. For instance, we have been able to produce a 'heatmap' visualisation of performance along the Great Western route, based on Network Rail's recorded data. This has provided important insight into where system delays were occurring and allowed mitigation measures to be established to achieve specified performance targets.

Physical views: Commonly rail projects are incremental upgrades of existing infrastructure. Therefore it is necessary to model the physical system architecture to understand technical and operational interfaces at the current 'as is' state, end state, and at any interim configuration milestones as defined on the migration plan. Simple 'rich picture' approaches to physical systems architecture (Figure 5, next page) have been developed; these show the interfaces between various sub-systems of the railway. These are also data-driven, allowing coloured

[5] INCOSE, Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities, Version 4.0 2015

[6] PMI, A Guide to the Project Management Body of Knowledge (PMBOK), 2000

highlighting to show system changes at different configuration states. This has helped clients such as London Underground get a clear understanding of how changes will occur across their system as programmes progress and ensures that work package scopes are complete and consistent.

SI:D^3: The Blueprint of Our Industry-Level Systems Integration Approach

SI:D^3 is a tailorable and repeatable set of processes supported by a complementary set of tools which has been proven on a number of major UK rail programmes. Increasingly the framework is being applied globally, for example, on the Melbourne Metro Project in Australia, and as a structure to peer review the systems integration approach on the Noord-Zuidlijn line project in Amsterdam.

SI:D^3 is subject to continuous improvement reviews – where lessons learned from each application are assessed and fed back into future iterations. It also forms a framework for measuring and monitoring our individual and team's capability against perceived market need.

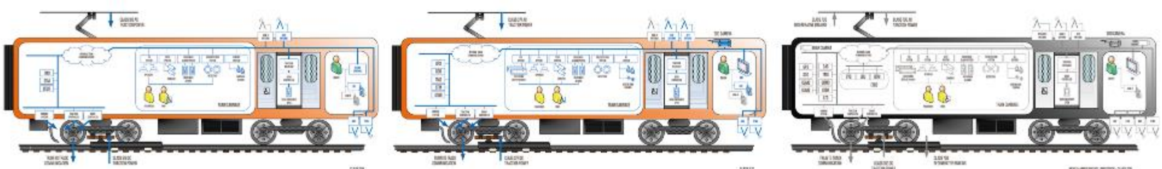

Figure 5 – Example of a physical system architecture view

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