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Systems Expansion Whilst Minimising Disruption to Existing Operations

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Issue Date: July 2014

***Abstract** — This paper discusses the importance of careful planning for proposed expansion of major railway systems. Board level commitment, the appointment of a dedicated task team and selection and mobilisation of an experienced delivery entity are covered. The paper introduces systems expansion execution essentials, pre-enabling works and the controlled expansion process. The importance of risk mitigation planning, early operator engagement and regular stakeholder communications are highlighted along with learning and sharing lessons with others in the railway industry.*

***Keywords** — rail systems, systems engineering, systems integration, testing and commissioning*

INTRODUCTION

Technological advancements have shaped the development of mass transportation networks over more than a century. Railways have played an important role in safely and efficiently transporting hundreds of millions of people and freight all over the world since the invention of the first steam operated locomotive in the UK in 1811. New systems have changed and improved rail journeys steadily over the past two centuries. In particular, since the 1960s, new technology introduction has continued to increase at an accelerating pace to meet greater performance requirements and to satisfy increased customer expectations.

The global application of railways and evolution into various forms to suit operational requirements demonstrates their current and future economic benefit. Today's railways serve mainline routes between large metropolitan cities, dedicated urban light transit applications, freight networks as well as dedicated high speed lines which connect major cities across geographically distant areas.

New technologies are being introduced every year in many parts of the world to respond to growing demand for safer, more efficient, operationally flexible and higher performing railways. The added commercial pressures to shrink timescales for designing and implementing new major rail expansion projects in order to secure early revenue income, whilst minimising disruption to existing operations is resulting in a more challenging delivery environment. This added complexity now requires new management approaches to lead highly competent engineers through well planned and carefully controlled work processes.

This paper discusses the primary drivers for system expansion in railways and the means to ensure successful delivery whilst minimising disruption to existing operations.

BACKGROUND

Increasing Systems Complexity and Performance Expectations

Railway technology and systems now serve the full spectrum of functionality to allow the operators and maintainers to meet key performance and business objectives. Figure 1 shows the timeline for rail systems development and the recent trends reflecting the faster rate of change and higher levels of systems integration complexity. This Figure is adapted and updated from the diagram by Siv Bhamra and Maximilian Fieguth in the paper titled "Technology Trends in High-Speed Rail" published in the Bechtel Technology Journal in June 2011 [1].

ABBREVIATIONS AND ACRONYMS

AC	**Alternating Current**
EMU	**Electric Multiple Unit**
ERTMS	**European Rail Traffic Management System**
FAT	**Factory Acceptance Test**
HSR	**High Speed Rail**
kV	**Kilovolt**
OCC	**Operations Control Centre**
SAT	**Site Acceptance Test**
T & C	**Testing and Commissioning**
UK	**United Kingdom**

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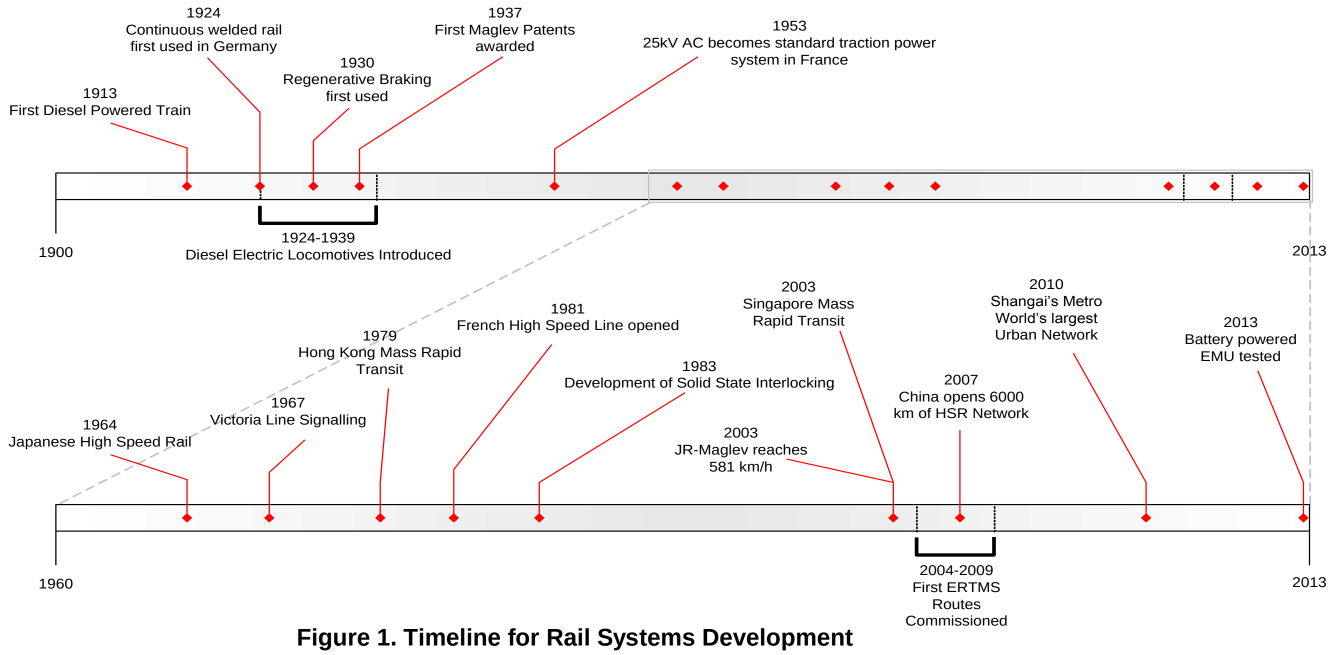

Figure 1. Timeline for Rail Systems Development

The primary business drivers for increasing specification and use of new technologies in railways can be summarised as follows:

Reduce Journey Times

- Increase train speeds
- Optimise station dwell times
- Reduce total times for full journeys

Expand Service Capacity

- Maximize customer service volume
- Expand facilities in stations and trains
- Provide passenger service 7 days a week
- Offer a wider selection of destinations
- Increase train frequency

Enhance Service Quality

- Provide greater comfort for customers
- Enhance overall journey experience
- Give regular access to information
- Maximise reliability and availability of assets
- Provide wider user accessibility

Improve Safety and Security

- Instil a 'safety first' culture throughout the life-cycle of rail projects and subsequent operations
- Compliance to new, more stringent standards
- Integrate security provisions to protect customers, staff and assets

Environment and Sustainability

- Assess and minimise environmental impact
- Ensure maximum sustainability

Technology Trends

- Build on new developments
- Avoid obsolescence

Minimise Costs

- Minimise whole-life cost to build, maintain and operate railway assets
- Ensure commercial competitiveness, value for money and affordability during implementation
- Standardise and simplify equipment to reduce construction costs and to ease future railway operations and maintenance

THE APPROACH

Executive Commitment

The decision to embark on a major system upgrade or expansion project will require commitment and support from the Board and where applicable other stakeholders like in Government, key regulatory authorities and/or funding bodies. It is necessary at this stage to articulate what success would look like and to have an aligned agreement over priorities.

From the outset it is also necessary to understand the potential level of risk to operational disruption. Ideally, it is best to assign Board Member(s) as Sponsor(s) to the change project.

The assigned member(s) should have good understanding of the project objectives and challenges.

Task Team concept

A Task Team should be initiated by the Board. This Task Team needs to be staffed by multi-disciplinary personnel, highly experienced and widely respected throughout the organisation for their knowledge and good leadership attributes.

The initial focus of the Task Team will be to cover the following activities:

- Develop high level plan for the systems expansion project
- Initiate detailed dialogue with the Railway Operations and Maintenance personnel
- Perform detailed assessment of potential disruption risks and impacts, along with possible mitigations
- Start formed consultation with the specialist supply chain. This could be dedicated internal engineering organisation and/or external companies. A formal procurement process may be necessary depending upon the governance structure of the company and expected size of the project. In this case the Task Team would help to define the scope of the procurement brief along with terms and conditions
- Development of options for the system upgrades and their analysis, ideally in a cross-functional structured workshop
- Identification of all stakeholders and start of regular briefings. These could typically include trade unions, local authorities, passengers etc.
- Detailed definition of project benefits and performance indicators towards successful delivery

The Delivery Entity will have a detailed Project execution plan, a robust schedule and competent resources.

Selection and mobilisation of Delivery Entity

The Task Team will lead selection and mobilisation of a 'Delivery Entity', which may be an internal engineering or project organisation with the right experience already resident within the enterprise, or an externally sourced organisation depending on the size and complexity of the system expansion project.

When the Delivery Entity has been mobilised the Task Team will focus on client activities relating to areas such as regular consultation / briefings within the business, regular advice and briefings to customers, on-going stakeholder liaison etc. The Task Team will pay special attention to risk identification and ensure careful monitoring of mitigation actions and associated trends.

Upon mobilisation the initial focus of the Delivery Entity will be on the following areas:

- Ensure that a highly experienced project team is in place quickly, ideally with a team of people who have worked together before on similar projects
- Selection of a system technology and products that are suitable to the railway and requiring minimal adaptation to suit specific operational and / or maintenance requirements
- Develop detailed project execution plan, supported by a robust schedule of activities and staffed with highly competent people
- Support risk management processes and develop fall back planning

Figure 2 shows the simplified roles of the Task Team and Delivery Entity.

Figure 2. The Task Team and Delivery Entity roles

System expansion delivery essentials

The work of the Delivery Entity has to cover at least the following key areas as it moves into more detailed planning and design activities for the system expansion project:

- Understanding railway operational and maintenance requirements in more detail and incorporating these into the design solutions
- Ensuring that timetables are developed and validated
- Ensuring training requirements have been identified and means for training agreed
- Securing agreement for possessions of the operational railway. Getting the right balance in ensuring adequate time for planned work to be performed and minimising disruption to existing operations
- Securing access to public roads and potentially to private land for moving of specialist plant and equipment
- Putting in place a comprehensive plan to maximise the extent of trials and testing away from the operational railway. These can typically include the following:
    - Use of dedicated simulators to test railway operating requirements such as timetables, allocation of key staff, assessment of passenger flows etc.
    - Maximise use of standard equipment and minimise use of bespoke special purpose developments – unless necessitated to satisfy the project requirements
    - Off-site building, testing and comprehensive validation assessment
    - Planned series of Factory Acceptance Tests (FATs) and Site Acceptance Tests (SATs) which will sit under the control of a dedicated Testing and Commissioning (T & C) Plan
    - Use of a dedicated test facility or test track to try to emulate a fully installed operating environment for the proposed equipment

Figure 3 shows application of test models prior to introduction of the changes on the physical operational railway.

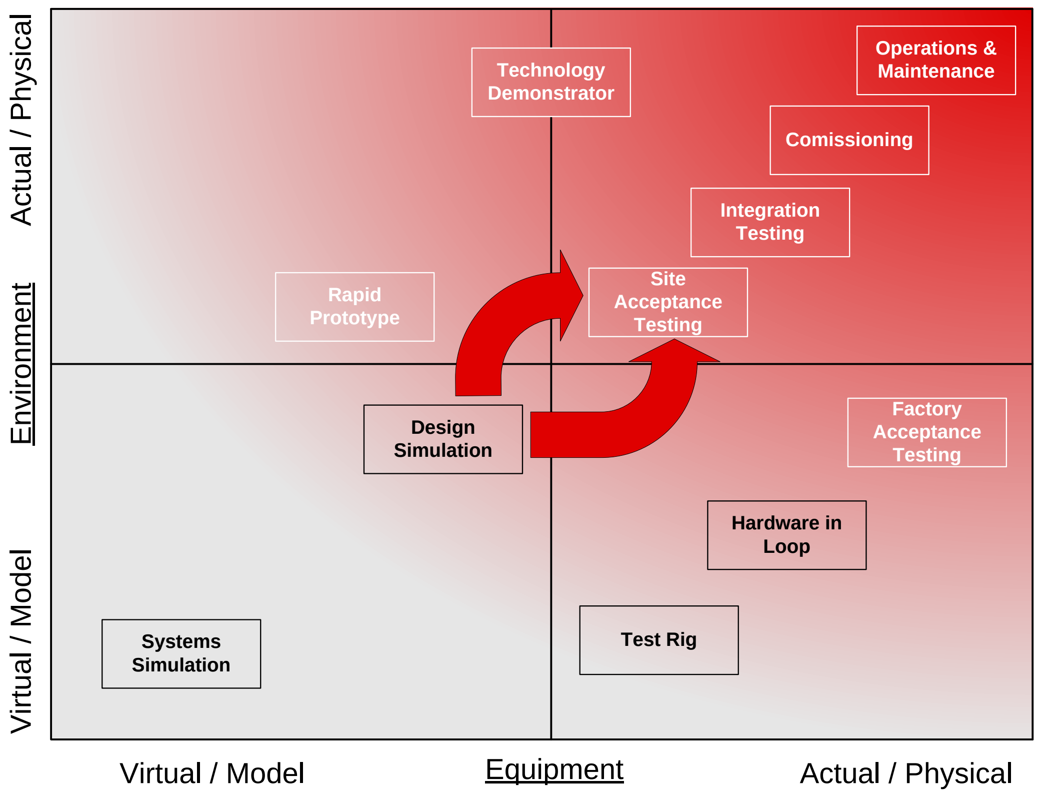

Figure 3. System development and proving

System upgrade – Enabling works

As detailed planning and design work proceeds in preparation to start the physical changes to the infrastructure the following enabling works are considered highly prudent:

- Establish Information and Process Controls
  - Understand the condition of existing assets through surveys
  - Put in place a robust configuration management process that has full vigilance of the changes to occur on the railway
  - Fully validate the test facilities and the modelling outputs
  - Brief the operators on the proposed system changes and check alignment with railway operating procedures
- Planned Installation of Enabling Equipment
  - Potentially a dedicated control desk at the Operations Control Centre (OCC)
  - Pre-enabled equipment in rolling stock. Potentially also in dedicated maintenance vehicles
  - New, pre-tested equipment installed in existing or dedicated new equipment rooms
  - 'Over-and-back' modules installed
- Intelligent Data Handling and Technical Support
  - Implement a remote diagnostics monitoring / support facility
  - Secure efficient analysis and processing of data from testing to facilitate emerging infrastructure, and potentially also related operational changes

Figure 4 shows a diagram of a typical controlled systems expansion process to minimise operational disruption. It is prudent to plan for a phased approach that introduces new functionality over defined areas of the operational railway. As operational confidence increases then additional functionality can be introduced and over a wider geographical area of the railway. Experience suggests this approach takes longer to implement through pre-defined phases, but the risk to un-planned operational disruption can be significantly less than a traditional 'big bang' approach.

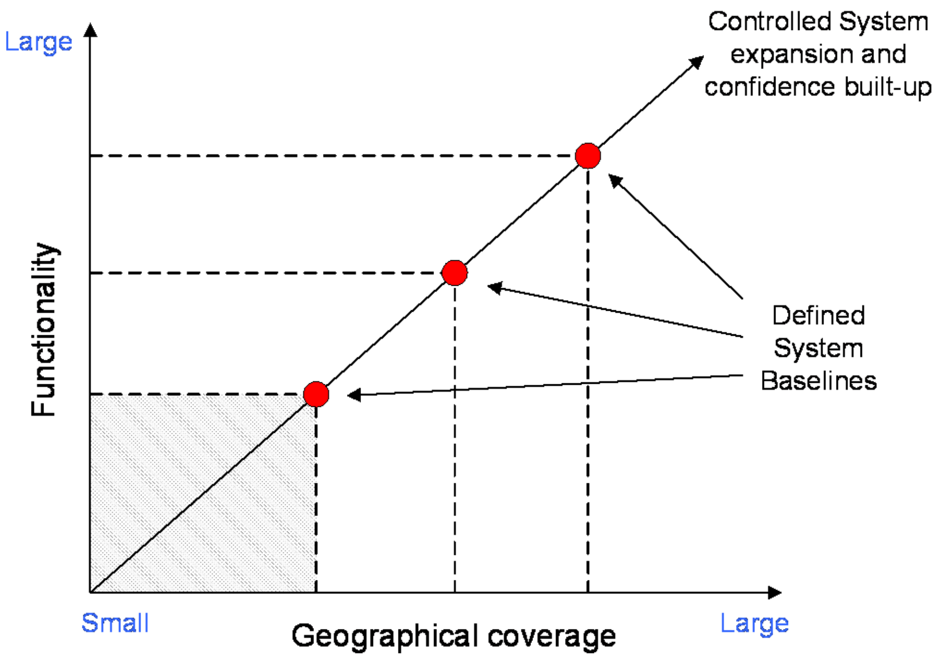

Figure 4. Phased implementation to minimise risk to operational disruption

SUMMARY

Proposals to upgrade or expand systems on an operating railway should be supported from the outset by all key parties and the whole railway company Board. Expected benefits of the system expansion and the risk of disruption to existing operations should be modelled and quantified to the greatest extent. A cross-disciplinary Task Team with people of proven leadership and interpersonal skills should be mobilised.

It is essential to secure railway operations input to the options from an early stage. Viability of different implementation and technology options can be tested on dedicated simulators. The Task Team needs to help translate the user requirement into a detailed scope of works from which a dedicated Delivery Entity can be selected and mobilised.

The Delivery Entity should be resourced with a highly experienced and motivated team of people, ideally who have worked together on other similar previous system upgrade or expansion projects. The Delivery Entity needs to offer solutions that minimise risk to operations by designing for maximum proving of systems away from the operational railway and introducing the changes to the network through a carefully controlled and phased process. The change process has to be designed and tested in situ with the operating procedures prior to any changes being proposed on the existing railway.

Communications within the project and with all stakeholders has to be planned and managed from the outset. Regular briefings will help secure consensus from those impacted by the changes.

Throughout the project a conscious effort should be put in place to capture lessons learned. These need to be documented and communicated constructively and shared with others to benefit future projects in our global and fast expanding railway industry.

REFERENCES

[1] S Bhamra and M Fieguth, “Technology Trends in High-Speed Rail”, Bechtel Technology Journal, June 2011

Siv Bhamra

Siv Bhamra is a senior executive with 30 years of experience in the project management and engineering of major rail projects. He has worked on the full spectrum of rail projects from light rail, urban metros to high-speed lines, engaging in activities ranging from conducting feasibility studies to implementing full schemes. Siv has delivered rail projects in Europe and the Far East and has performed studies for rail operators in the USA, Middle East and South Asia. His numerous achievements encompass the development of solid-state traction inverting substations to save energy, the implementation of advanced train control technologies to improve the performance of existing and future railways, and the performance of research into operational management systems.

Siv joined Bechtel in 1999 whilst on the Jubilee Line Extension Project in London. Before that, he had worked in senior roles with London Underground and a number of railway companies. Siv also served 2 years as principal transportation advisor to the European Bank for Reconstruction and Development. Currently as Director on the Crossrail Project in London, he manages railway systems and testing and commissioning functions.

Elected a Bechtel Fellow in 2004 and a Principal Vice President in 2012, Siv is a member of five professional institutions and three technical societies. He won the Enterprise Project Manager of the Year Award in 2006, the London Transport Award in 2004, a Safety Management Award in 2004, and has been accredited with further awards of excellence in 1984, 1986, 2012, 2013 and 2014.

Siv was recognised for his efforts in restoring the Piccadilly Line to passenger service following the terrorist attacks in London in 2005, commended for his work to recover operational service on the Northern Line following a derailment in 2003, and honoured for his courage during a major fire at Kennington Station in 1990.

He is a guest lecturer to several universities and is also a respected transportation specialist and advisor. He has presented at several conferences and has written numerous papers on management and technical disciplines.

Siv has a PhD in Railway Systems Engineering, an MBA in Project Management and an MSc in Engineering Design, all from Universities in the UK.

Marios Georgaras

Marios Georgaras has wide range experience in engineering and construction roles in major infrastructure projects in Europe and the Middle East.

He has designed and managed the construction of mechanical and electrical services in various types of projects spanning from university buildings, hotels, resorts, camps and hospitals to port terminals, aircraft maintenance hangars and oil refineries. Prior to that he served as Sergeant First Class in the Greek Special Forces.

The different types, sizes and locations of the projects he was involved in have helped Marios develop his abilities in services co-ordination, systems interfaces, testing and commissioning activities/planning and handover to start-up and raise his awareness on the commercial and business aspects of programme delivery.

He joined Bechtel on the Crossrail Project as a Project Engineer. His responsibilities include Systems Integration and Interfaces and he supports the development of the Testing and Commissioning Strategy.

Marios received a MEng in Mechanical Engineering from the National Technical University of Athens and has an MBA in International Business and Finance Management from Athens University of Economics and Business. He is a Chartered Engineer and Member of the Technical Chamber of Greece.