Systems Engineering Case Study #8 Jubilee Line Extension

Keywords: Stakeholder Requirements Definition; Requirements Analysis; Interface Management

Background to the Project

The Jubilee Line forms part of the London Underground network. In 1979, when it opened, it ran from North West London into the center of the city. However, in 1993, the Jubilee Line Extension Project (JLEP) was started with the objective of extending the line by 16km to reach east London via two busy mainline termini. The route ran through disused dockland areas which were in the early stages of regeneration when the project started, but have now been transformed. The regenerated areas include Canary Wharf, which has become a major financial center to rival the City of London. An evaluation after the project had finished[4] found that the project had delivered an estimated benefit cost ratio of 1.75. The project has left London with some handsome stations which have won several awards. The extension was completed without a single loss of life.

However, these achievements are tempered by significant cost and time overruns. The project started in October 1993 with a planned timescale of 53 months and an approved budget of £2.1 billion. When it was completed in December 1999, it had taken 74 months and had cost £3.5 billion, despite the fact that some signaling capability had been removed from the scope.

The project has been well documented. This case study is drawn from a report into the project published by Arup[5], which had acted as agent for the UK government during part of the project, and a book about the project written by Bob Mitchell[6].

The project overruns could not have been eliminated by better SE alone. The sources cited above include criticisms of some aspects of project management. The project was also victim to external events beyond its control including the financial collapse of a developer investing in the project, which delayed the start of construction, as well as the physical collapse of a tunnel being bored by another project using the same methods as the JLEP, which caused a pause in tunneling on the JLEP. This case study presents evidence from these sources that the project's performance against schedule and budget could have been significantly improved by taking a whole-system view from the outset, by improved treatment of operational factors and by improved interface management.

[4] "Project Profile: UK Jubilee Line Extension", The Omega Centre at University College London, 2009, downloaded from www.omegacentre.bartlett.ucl.ac.uk

[5] "The Jubilee Line Extension: End-of-Commission Report by the Secretary of State's Agent; Summary Statement", Ove Arup Partnership Ltd, 2000)

[6] "Jubilee Line Extension: From Concept to Completion", Bob Mitchell, 2003, Thomas Telford Publishing, ISBN 978-0727730282

A Whole Systems View

Mitchell notes that, *"Very little provision had been made in the original Project cost and programme estimates for any works on the basis that the extension was really a 'bolt-on' to the existing railway. A figure of £15 million was included for some works at Green Park station to cope with increased passenger flows and some upgrading to the signalling."* He goes on to record that, in Spring 1991*, "The extent of work needed on the existing Jubilee line between Charing Cross and Stanmore began to be realised".* In the final reckoning, the works on the existing line cost well over £100 million.

The primary reason for this appears to be framing the problem incorrectly and regarding the project's deliverable as "a 'bolt-on' to the existing railway". Mitchell comments on this point later in his book:

> *"If the scope of the Project had been considered as the Extended Jubilee Line from the start as opposed to the Jubilee Line Extension, it would have brought about a more holistic approach to planning and design and a more realistic assessment of the costs and risks involved. As it was, the Project team initially took an entrenched view (understandably) that the existing line was nothing to do with them."*

Mitchell may find the project team's view understandable given the objectives given to them but with hindsight, it is clear that these objectives were not fully aligned with the objectives of the business. Arup expands on this:

> *"The fundamental objective that LUL [London Underground Limited] set out to achieve in 1989 was building, equipping, commissioning and opening a new Railway. To achieve this objective, LUL needed to decide not only on the strategy and management structure of the new construction (that is the Project) but, equally important, the strategy and management structure for the delivery of the Railway. The two are not the same. The latter appears to have not been given sufficient consideration when the arrangements were first set up."*

The adoption of SE good practice in the area of managing requirements and specifying the system forces consideration of the system to be built, the systems with which the new system must interface and the desired outcomes of running the new system in its environment. The evidence cited above suggests that adopting good SE practice in these areas would have revealed the oversights and allowed a more realistic scoping of the works on the existing line.

Operational factors

Mitchell quotes the General Manager of the Jubilee and East London Lines business unit as saying that it was not until the latter stages of the project that the project team "*involved the line management much more in project matters and viewed [him] as the 'ultimate client' - the person who would ultimately have to weld the people, assets and systems into an operational business".* Arup makes a similar point, *"[London Underground Limited] lacked the strategy and the structure and continuity of management that would ensure the delivery of a working Railway and not just the construction Project*." An Operating Plan for the extended line was not put together until January 1991; more than a year after the project had started.

There were a number of significant changes to the project that were made after the initial project had been defined in order to meet operational requirements:

- A radical change to the service reversing facilities was agreed in February 1991, which included the introduction of a third platform at two stations.

- A decision was made to start operations in a phased manner in late 1998; two years after the business unit had proposed such an approach.

The evidence cited above suggests that, had the project followed good SE practice in the elicitation and formulation of operational requirements, it would have been possible to have brought these decisions forward significantly.

Interface Management and Co-ordination

Mitchell is critical of the arrangements for co-ordination of contract and management of interfaces when he writes:

> *"The Contractor was required to co-ordinate his own work with that of all the Designated Contractors. The Contractor was also required to provide attendance (all reasonable facilities and opportunities for carrying out their work) on the Designated Contractors and any other contractors and workmen of the Employer. The inclusion of this contractual obligation still left the Project team with the sizeable task of managing the interfaces directly and ensuring co-ordination of all the contractors with the overall master programme for the Project. Managing the interfaces was a key factor in the increased costs incurred by the Project as will be seen later."*

Arup corroborates this criticism and provides evidence that it was a source of delay:

> *"Works contractors were also procured individually, and management of interfaces between them was not defined. This was particularly relevant to the Railway controls contractors, where absence of early interface management delayed this package by many months"*

The evidence cited above suggests that, had good SE practice in interface management been adopted from the start, the project might have enjoyed significant time and cost savings.

Time is Money

Mitchell reminds us that "*time is money"* and goes on to conclude that "*it is estimated that something like £600 million of the £1.36 billion [overspend] is attributable to time-related causes, be it claims for delay and disruption, acceleration measures instructed by the Client or extensions of time awarded by the Engineer along with the prolonged resourcing of the Project team*".

Conclusions

The JLEP was ultimately a successful project that delivered improvements to London's transport infrastructure that justified the considerable investment made in them. The evidence from authoritative accounts of the project suggests that, had the JLEP adopted good SE practice from the start, the project could have avoided some of the problems listed above on the way to delivery. It also suggests that adopting good SE progress could have avoided a number of late changes and delivered savings in both project timescales and budget.