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Product-Service Systems across Life Cycle

Development of a Whole Life Cycle cost model for electrification options on the UK rail system

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Abstract

Projects to deliver Overhead Line Equipment (OLE) electrification on the UK rail infrastructure system presents technical challenges which the rail industry in Britain have not traditionally had to consider. Whole Life Cycle assessment provides decision makers with cost estimates for the installation phase and over the entire service life of the system, including disposal. The OLE projects face a particular problem when analysing the best option for overbridges. Much of the rail infrastructure has not traditionally had to consider overhead clearances and therefore many of the bridges are only a little taller than the rolling stock. In addition to the difficulties in assessing the Life-Cycle costs of assets that have historically been used in very limited scales, the Whole Life Cycle assessment must consider the various engineering options that are available for projects. The three competing options (bridge rebuild, track lowering, reduced clearance) are all going to have very different capital expenditure (CAPEX) and operating expenditure (OPEX) costs. This work presents a model created to predict these costs over the anticipated assessment period. The developed model predicts capital expenditures, maintenance and service disruption costs and links them to the three major assets options involved in OLE underbridges.

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Keywords: whole life cycle; rail maintenance; OLE; cost

1. Introduction

Network Rail are facing challenges with the extension of the electrification system to the network, because electrified routes provide not only ‘faster, quieter and more reliable journeys’ for passengers and freight transportation, but also a reduction of up to 35% in carbon emissions [1]. The Overhead Line Equipment (OLE), supplies electrical power to trains by means of contact wires suspended over the track. The electrification project includes considerable civil engineering modifications to railway assets. These are expected to be particularly challenging at particular features on the network, particularly in proximity of overbridges. Network Rail define Overbridges as “to carry another service (such as roadways, footways and public utilities) over the railway”.

A product breakdown structure of an OLE would include the following [2]; Contact wires, Messenger wires, Droppers (which link messenger wires to contact wires) and Steady arms (maintaining a zigzag shape of contact wires to prevent uneven wear).

For many railway overbridges, the expected gap between power cables and the ceiling are inadequate to comply with the European standards for electrical clearances. Major alterations are required on the railway infrastructure. Three options are relevant: Bridge reconstruction, Track lowering and Reduced clearances.

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Bridge reconstruction: Where the bridge is demolished and replaced with a newer bridge capable of accommodating the required clearance of electrical equipment. Capital expenditures are expected to be mostly related to demolition, reconstruction of the overbridge and OLE installation costs [3]. This option is expected to be favourable for maintenance expenditure, due to the OLE clearance minimising problems and the condition of the reconstructed bridge being excellent.

Track lowering: Existing rails and ballast are first removed to allow for digging the soil on the approaches to the overbridge. A new drainage system installed, together with new ballast and new rails. This solution involves considerable denial of service costs during initial engineering works and can lead to greater maintenance expenditure for tracks, because rails, ballast and drainage are affected by stagnating water during rainy periods [3]. Lowering the track to increase the clearance between the OLE and rolling stock is an option likely to alleviate the OLE problems but could introduce significant issues with water ingress onto the track and subsequent damage to the track, ballast and sleepers.

Reduced clearances: It is possible to install OLE that gives much less room between the live wire and the rest of the support structure. This reduced clearance results in slower speed limits through that section of the track, making it unsuitable on very busy lines. However, required alterations are less substantial and solution presents the lowest capital investment of the three options. Reduced clearance OLE is suspected to be particularly prone to electrical trips.

In addition, the height of the cables under the overbridge is lower than on open routes so that a gradient is present while approaching the bridge which generates increased amounts of wear on contact wires as a consequence of the greater forces acting between cables and pantographs. Reduced clearances raise specific concerns regarding increased fault occurrences, possession times and negative impacts on the organisations reputation. The difficulty with accepting a lower clearance is that the maintenance costs are anticipated to be much higher; over the 60 year assessment period this may well prove to be disastrous to cost. Maintenance problems can also cause issues with asset availability, and the decision making process is very sensitive to denial of service of the infrastructure system.

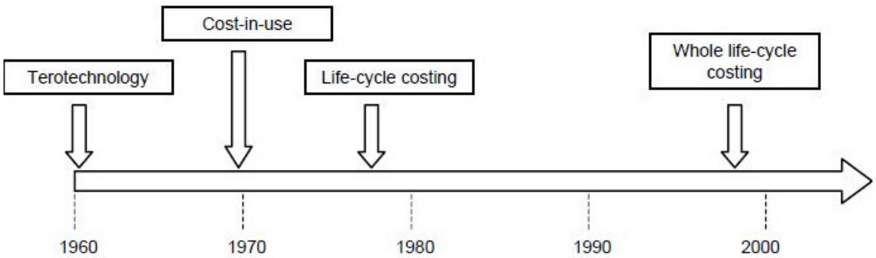

Figure 1: The evolution timeline of WLC costing model [4]

The installation of the electrical system to overbridges is a requisite for the complete electrification of rail routes. However, the decision-making process will be looking for the best compromise between capital investments and maintenance costs occurring over a defined period of time. A final complication with adjusting overbridges is that many of them are considered part of the UK's historical and architectural heritage (particularly those that are from the Victorian era) and are protected by Government legislation. The industry is therefore interested in assessing other options beyond bridge demolition and reconstruction.

1.1 The AUTONOM project

The AUTONOM project at Cranfield is seeking to develop cross-industry approaches to the difficulty with integrating condition monitoring to automated planning/scheduling and cost estimation. Cost of a maintenance activity prompted from an alerted change in condition, will be optimised as much as possible (through scheduling at cost effective times). The project is also seeking to model the whole-life costs arising from maintenance interventions, so that cost savings can be realised by the integrated approach.

1.2 Whole Life Cycle cost modelling

Whole Life Cycle costing is a structured methodology that helps decision-makers in selecting the option that minimises the sum of all relevant costs occurring over the whole service life of a product, system or service [4].

The concept was gradually developed during the last sixty years, as figure 1 shows. Before the 1960s, capital investment decisions were drawn basically on the basis of capital costs, because the general belief was that, along with increasing initial investments, decreasing long-term expenditures would be consequently experienced (Terotechnology). The concept then evolved to 'cost-in-use' with a consideration of the costs associated with also the operations of an asset, [4].In the late 1970s, analysts and accounting managers began introducing forecasting techniques for the evaluation of future costs (Life Cycle Costing) but the method was adopted only for projects with large capital investments.

Towards the end of the last century, the technique evolved to 'Whole Life-cycle Costing', which differs from LCC by considering costs occurred over not only the economic life (the period of commercial interest) but rather over the entire life of a product or service (i.e. disposal costs are considered).

1.3 Application of WLC to the railway industry

The railway industry has challenges when applying WLC methods. In particular, assets have extended life spans and capital investments are considerable. Decisions about maintenance strategies need to be considered from a whole