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ACHILLES: the benefits and costs of increased asset information

John Armstrong and John Preston

University of Southampton, United Kingdom

Abstract

The ACHILLES research programme is providing improved understanding of earthworks' deterioration mechanisms, of earthworks' performance, with and without engineering interventions, and of the associated lifecycle cost implications. It is also developing decision support methods to inform intervention strategies and reduce whole-life costs. One of the novel aspects of ACHILLES is that it looks beyond the direct costs and benefits of the deterioration of assets and their remediation to consider the indirect costs and benefits of the various existing and potential sources of data and information on earthworks condition, on the safety, engineering and wider social implications of earthworks failures, and on the engineering and general social impacts of preventive measures to improve earthworks condition. The aim of this aspect of the work is to maximise the ratio of the benefits (safety, engineering and social) obtained from the data to the costs incurred in its collection and analysis. This aspect of ACHILLES is based upon the review of current and potentially available sources of data on earthworks condition, remediation costs and the impacts and benefits of earthworks failures and reactive/proactive interventions. The costs of obtaining and processing different data sources are compared with their potential accuracy, and their contribution to understanding and overall benefits. The work aims for generality where possible, but also takes account of the situation- and location-specific influences on failure and intervention costs.

Keywords: earthworks; data; costs; benefits.

1 Introduction

Maintaining the serviceability and safety of ageing railway earthworks is an increasing challenge in the context of climate change and increased intensity of rainfall, flooding and the effects of alternating extremes of wetting and drying. The overall aim of the ACHILLES (Assessment, Costing and enHancement of long lIfe, Long Linear assEtS) research programme [1] is to ensure that railway and other earthworks continue to operate affordably and in a consistently safe manner. This will be enabled by intelligent approaches to asset design, management and maintenance, including cost-effective remediation work as and when required, with the aim of reducing and, ideally, minimising the whole-life costs (WLCs) [2] of individual assets, routes and networks. The specific focus of the research described (element 3.2 of the ACHILLES Design and Decisions (DaD) workstream) in this abstract is the investigation of the potential benefits and likely costs of obtaining and applying additional information about earthworks asset characteristics and conditions. The objective of the research is thus to identify the means of making the most cost-effective use of currently and potentially available data, taking account of the likely benefits of the additional and improved data, as well as the costs of obtaining it, and the trade-offs between the two. These trade-offs include the potential for specification errors (arising from the omission of relevant model parameters and their data sources) compared to the potential for measurement errors as the number (and the possible 'novelty' and thus related uncertainty) of data sources is increased.

2 Methods

Network Rail is the infrastructure provider (IP) for most of Britain's heavy rail system, and, as such, owns and is responsible for maintaining and operating the railway network, including its earthworks. Network Rail's priorities and planned activities to improve the long-term safety performance of its earthworks are set out in its 2018 Earthworks Technical Strategy [3], whose information on current and potential earthworks data sources provides the starting point for this research activity. These sources of data on earthworks condition are being identified and reviewed, complemented by input from expert interviews where possible, and their costs, benefits and comparative accuracy and reliability are being assessed, including the costs associated with obtaining the required levels of accuracy and reliability through the development of statistical emulators.

The costs, benefits and net present values of improved asset data are being estimated and illustrated initially using data for earthworks cuttings on Britain's Great Western Main Line railway between London Paddington and Bristol Temple Meads. Existing approaches such as SCAnNeR (Strategic Cost Analysis for Network Rail) [4] are being extended to include (i) the social costs and impacts of line speed restrictions and line or route closures, and (ii) environmental impacts as expressed in terms of capital, operational and user carbon emissions. The research activities seek to learn lessons from and build upon work already undertaken in the highways and other infrastructure sectors [5, 6]. They also extend beyond data related solely to

infrastructure, to include data describing the effects of failures and/or remedial works on transport service punctuality and reliability, and thus on transport users [7, 8].

The economics of information are thus being assessed to identify incremental improvements in data application and to investigate optimal levels of data inclusion, beyond which the marginal costs of obtaining and processing additional data outweigh the marginal benefits.

3 Results

This research is generating a list of current and potentially available data sources on earthworks condition and remediation costs. It also provides an improved understanding of the absolute and relative costs and benefits of obtaining that additional condition and costs data, enabling the ranking of data sources in terms of costs, benefits, benefit-cost ratios and/or net benefits [9] (although these tend to vary with the circumstances and characteristics of different assets). This in turn enables the prioritisation of data sources that provide the greatest benefit-cost ratios and/or net benefits in general and in particular circumstances.

This particular aspect of ACHILLES extends the approach to cost-benefit analysis beyond the current, conventional data inputs, to consider the costs and likely benefits of the additional asset and other data that is currently and potentially available.

The work also contributes to the illustration of the wider social and environmental costs, benefits and impacts of earthworks deterioration, failures and interventions at different stages of earthworks asset, route and network lifecycles. The wider ACHILLES research programme is providing an improved, systematic approach to the measurement, assessment and monitoring of earthworks conditions, enabling the identification of timely and cost-effective interventions to reduce rates of asset deterioration and to improve their condition as necessary.

4 Conclusions and Contributions

A wide range of existing and potential condition data is available for railway and other earthworks, with varying collection and processing costs and benefits. As technology improves, the use of automated collection and processing of data from measurement trains, satellites, aerial surveys or other remote sensing becomes increasingly cost-effective, while also avoiding the need for the part or full closure of heavily-used infrastructure for manual investigation, with the associated cost and safety implications. On the other hand, remote sensing can provide only limited information on underlying ground conditions, for which purposes the additional costs of manual instrumentation and inspection are likely to be justified by the improved detail, quality and ‘richness’ of the targeted information obtained.

The work is providing an improved understanding of the costs and benefits of applying an increased range of data sources to the assessment of earthworks conditions and remediation costs and benefits at different points in the asset lifecycles. It is also taking account of the wider social and environmental costs and benefits involved. It will inform the data collection and analysis strategies of infrastructure owners, managers and operators, ultimately enabling improved earthworks performance with reduced social and environmental impacts. The work is in its early

stages, but is accepted by the wider ACHILLES team and members of the research programme's Industry Advisory Group as a potentially valuable addition to the earthworks assessment and remediation 'toolbox'. As the work progresses, its findings will be disseminated for wider implementation.

Railway earthworks are ageing across the world, having been built predominantly (in most cases) in the nineteenth century, and are subject to ongoing deterioration, with variations in deterioration mechanisms and rates across the world (the same is true of highway and other earthworks, despite having been built more recently and typically to higher engineering standards and with better documentation). Similarly, the effects of climate change are being experienced globally, manifested in different ways and to varying levels of severity in different locations. While some solutions/outcomes are likely to be location-/situation-specific, the principles and methods of cost-benefit analysis of alternative data sources, and the wider lifecycle cost analysis of earthworks assets, are generally applicable, facilitating and encouraging international collaboration in this area.

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References

1. ACHILLES (2021): *Welcome to ACHILLES* [online]. Available from https://www.achilles-grant.org.uk/ [Accessed 14 January 2022]
2. CIPFA (2022): *Whole Life Costing* [online]. Available from https://www.cipfa.org/policy-and-guidance/publications/w/whole-life-costing [Accessed 17 January 2022]
3. Network Rail (2018): *Earthworks Technical Strategy* [online]. Available from https://www.networkrail.co.uk/wp-content/uploads/2018/07/Earthworks-Technical-Strategy.pdf [Accessed 1 December 2021]
4. Power, C., Mian, J., Spink, T., Abbott, S. and Edwards, M (2016): *Development of an Evidence-based Geotechnical Asset Management Policy for Network Rail, Great Britain*, Procedia Engineering 143, pp726-733 https://doi.org/10.1016/j.proeng.2016.06.112
5. Reid, J.M. and Clark, G.T. (2000): TRL Report 430: *A whole life cost model for earthworks slopes*. Crowthorne: Transport Research Laboratory
6. TRL (2021): *The new toolkit for highways asset management* [online]. Available from https://trl.co.uk/uploads/trl/documents/A-toolkit-for-highways-asset-management.pdf [Accessed 17 January 2022]
7. Lamb, R., Garside, P., Pant, R. and Hall, J.W. (2019): *A Probabilistic Model of the Economic Risk to Britain's Railway Network from Bridge Scour During Floods*, Risk Analysis 39(11), pp2457-2478 https://doi.org/10.1111/risa.13370
8. Ilalokhoin, O., Pant, R. and Hall, J.W. (2021): *A multi-track rail model for estimating journey impacts from extreme weather events: a case study of Great*

Britain's rail network, International Journal of Rail Transportation https://doi.org/10.1080/23248378.2021.1891582

9. Department for Transport (2021): TAG UNIT A1.1: *Cost-Benefit Analysis* [online]. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1007440/tag-unit-A1.1.pdf [Accessed 17 January 2022]