ARTICLE IN PRESS

Transportation Research Part C xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Transportation Research Part C

journal homepage: www.elsevier.com/locate/trc

Cost effective future derailment mitigation techniques for rail freight traffic management in Europe

Dewan Md Zahurul Islam [a,*], Konstantina Laparidou [b], Arnaud Burgess [b]

[a] NewRail – Newcastle Centre for Railway Research, Newcastle University, Newcastle upon Tyne NE1 7RU, UK
[b] PANTEIA, Bredewater 26, P.O. Box 7001, 2701 AA Zoetermeer, The Netherlands

ARTICLE INFO

Article history:
Received 28 April 2014
Received in revised form 29 May 2015
Accepted 19 June 2015
Available online xxxx

Keywords:
Traffic management
Rail freight
Train derailments
Mitigation techniques
Long-term impact
CBA
Europe

ABSTRACT

Safe and reliable traffic management is vital for uninterrupted and successful operation of the European rail network, where mixed traffic (i.e. freight and passenger) services are run. Although rail freight derailment is infrequent, its consequences can be severe and may result in different forms of costs, including infrastructure; rolling stock; traffic disruptions; injuries and fatalities. The objective of this research paper is to conduct a cost benefit analysis (CBA) to identify cost effective mitigation techniques for efficient rail freight traffic management in Europe, by 2050. Reviewing previous derailments and studies, eight sets of derailment causes are analysed and, for each of them, sets of mitigation techniques are aimed at for their alleviation. The study finds that the highest cumulative costs of derailment are associated with 'wheel failure', while the lowest cumulative cost is identified for 'excessive track width'. Regarding mitigation techniques, the lowest cumulative benefits are demonstrated for 'track height' interventions, whereas 'wheel failure' alleviation demonstrates the highest benefits, in value terms (all by 2050). In most cases, the benefit to cost ratio did not exceed 2.6; in two cases ('track height' and 'rail failures') the ratio remained below 1 – a negative outcome where cost is higher than benefit. The study suggests that the most cost-efficient interventions are those applied to 'hot axle box and axle rupture' and 'spring and suspension failure'.

1. Introduction

A railway derailment causes different types of loss and damage – to infrastructures, vehicles, rail and passenger service operations, and people causing injury or death. The impact on railway traffic management and operational service quality is huge. Analysing mainline derailments on European railways, a study within the D-RAIL (2012b) project identifies three major causes, ordering the associated derailments into the following categories: *Infrastructure failures* (34%); *Rolling Stock failures* (38%); *operational failures* (22%); *weather, environment and 3rd Party causes* (2%); and unspecified (4%). While some derailments are classified as less severe, the consequences of serious rail freight derailments may result in variety of costs, including infrastructure; rolling stock; operational disruption; fatalities; litigation; third party damage; cost of attendance of emergency services; environmental costs; loss/damage/delay of cargo and loss of freight business.

The European Railway Safety Directive requires the National Safety Authorities (NSAs) of the Member States to report significant accidents (defined as accidents either causing fatalities or with total damages in excess of €150k) to the

---

* Corresponding author. Tel.: +44 (0) 191 2083972.
E-mail address: dewan.islam@newcastle.ac.uk (D.M.Z. Islam).

http://dx.doi.org/10.1016/j.trc.2015.06.017
0968-090X/© 2015 Elsevier Ltd. All rights reserved.

Please cite this article in press as: Islam, D.M.Z., et al. Cost effective future derailment mitigation techniques for rail freight traffic management in Europe. Transport. Res. Part C (2015), http://dx.doi.org/10.1016/j.trc.2015.06.017

European Railway Agency (ERA) and to EUROSTAT (for statistical information), as defined in Regulation (EC) No 2003/91 (ERA, 2010, p. 13). Data for the period 2004–2009 show approximately 600 open line freight train derailments each year, more than 50% of them severe. Subsequently ERA (2012) adjusted this estimate to 500 open line freight derailments per year for 2011. Clearly then, prevention and mitigation of derailments are vital for safe and cost effective operation of railway services (European Railway Agency, 2014).

1.1. Objective

The current research aims to conduct a monetisation of rail freight derailments and an evaluation of mitigation techniques, using cost benefit analysis (CBA) which is a quantitative tool, widely used by academics and decision makers, to determine a project's appropriateness, efficiency and effectiveness (Litman, 2003; Mishan and Quah, 2007; Priemus et al., 2008; Venables, 2007). Even a critical review of the tool (Mackie, 2010, p. 5) accepts that: 'there is a well codified history and development of practice'. It identifies costs and benefits, often converting them into monetary values, in order to show the long-term (e.g. 40 years for the current study) effects of the proposed solution(s). Thus, to contribute to the advances in rail traffic management and planning, the objective of this research paper is to conduct a CBA to find cost effective mitigation techniques for reducing, by 2050, the impact of freight train derailments in Europe.

1.2. Limitations of the analysis

Regarding the limitations of CBA, some experts (e.g. Mackie, 2010) opine that it is: 'a controversial tool, generating accusations of unacceptable principle, improper application, inadequate evidence base and bias'. Mackie and Preston (1998) identified as many as twenty-one errors and bias in the application of the CBA tool for appraisal of projects. In the area of transport these include incorrect transport inputs, errors in planning assumptions, prior political commitment, inaccurate data on the current situation, and interactions with other transport options not being taken into account.

There are four main constraints or limitations in the current CBA. First, it limits itself to rail transport, excluding other potential impacts. For example, a prevention measure could, in the future, increase rail demand by shifting traffic from road, consequently causing decongestion, decreased transport costs, lower environmental impact, etc. This study is based on the results of previous studies conducted under the D-RAIL project, such as 'Rail freight forecast to 2050' (for demand projection) (D-RAIL, 2012a); 'Future Rolling Stock Breakdown up to 2050' (for rolling stock quantity) (D-RAIL, 2013); 'Report on Derailment Economic Impact Assessment' (for definition of cost) (D-RAIL, 2012b).

Secondly, the analysis focuses only on the rail freight perspective, excluding the cost analysis of rail passenger demand. This is due to the nature of the study, which investigates derailments in the freight sector only. More specifically, even though it is certain that the implemented interventions in the railway network will have a positive impact for passenger trains (European railways are used by both freight and passenger trains), this is not accounted for in the cost and benefit results. Thirdly, the study assumes that the technology and its costs will remain the same throughout the coming 40 years. Finally, the analysis limits itself to studying derailment costs only, excluding from the model other costs for rail freight transport. This is due to the assumption that the basic transport costs (€/tonne) will remain the same for each type of intervention/mitigation technique. However, it is already mentioned (in Section 1.1) that CBA is a wide used tool for estimating economic benefits (compared to its costs) of a project and accordingly, this research has adopted this tool.

2. Methodology

The CBA applies two approaches: top-down and bottom-up. The top-down approach for cost savings intends to indicate the cumulative amount which could be spent on mitigation measures by 2050 and, consequently, to find which mitigation measures would be affordable, effective and efficient enough to achieve a derailment cost reduction of 10–20% in the EU by 2050. The bottom up approach of cost analysis employs the Benefit–Cost Ratio and the costs and benefits throughout the project duration. Based on these results, each intervention is assessed for its effectiveness. For this we need a comprehensive and balanced analysis approach, where the performance of an infrastructure or intervention/mitigation measure and its total cost accrued over the entire life-cycle are taken into account (Frangopol and Liu, 2007). Keeping this on board, this research first defines the costs per intervention; only long term mitigation measures are considered for the research, as previous study suggests that most short and medium term mitigation measures have a low effect on reducing the economic impact of derailments (European Railway Agency, 2012; D-RAIL, 2012b). For each mitigation measure, the current research defines three types of costs: the implementation (investment and reinvestment); the maintenance costs that differ per intervention; and the avoided derailment costs. These costs are identified per cause of derailment and per frequency of occurrence.

The methodology for performing the economic analysis is based on European guidelines (by the European Commission (2008)) and the guidance on the use of cost benefit analysis for investment regarding health and safety on British railways (by the Office of Rail Regulation (ORR, 2008)). The CBA tool employs the flows of real resource costs and benefits, but without taxes and subsidies. In its analysis, CBA attempts to monetise intangible costs and benefits that are directly connected to the use of the financial resources. For example, expenditure on interventions that reduce the occurrence of derailment directly decreases the environmental costs of derailment. Such costs (accidents, environmental, etc.) are therefore monetised and

Please cite this article in press as: Islam, D.M.Z., et al. Cost effective future derailment mitigation techniques for rail freight traffic management in Europe. Transport. Res. Part C (2015), http://dx.doi.org/10.1016/j.trc.2015.06.017