Fire Safety Journal 79 (2016) 100–110

Contents lists available at ScienceDirect

Fire Safety Journal

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

First responders' response area and response time analysis with/without grade crossing monitoring system

Peter Y. Park [a,*], Wook Rak Jung [b], Godfred Yeboah [c], Garreth Rempel [d], Dan Paulsen [e], Dave Rumpel [e]

[a] Department of Civil Engineering, York University, 4700 Keele Street, Toronto, ON, Canada M3J 1P3
[b] Department of Geography and Planning, University of Saskatchewan, Canada
[c] Department of Civil and Geological Engineering, University of Saskatchewan, Canada
[d] MORR Transportation Consulting, 202–1465 Buffalo Place, Winnipeg, MB, Canada R3T 1L8
[e] Saskatoon Fire Department, 125 Idylwyld Drive South, Saskatoon, SK, Canada S7M 1L4

ARTICLE INFO

Article history:
Received 7 October 2014
Received in revised form
25 October 2015
Accepted 29 November 2015
Available online 9 December 2015

Keywords:
First responders
Emergency response
Grade crossing monitoring system
GIS

ABSTRACT

In North America, highway–railway grade crossings can lead to significant travel delays for emergency responders trying to reach an incident. Grade separation cannot be justified for most grade crossings, but a grade crossing monitoring system (GCMS) can detect a blockage and communicate the information to local emergency dispatchers in real-time. As every minute can be critical in emergency work, the potential for such systems clearly needs investigation. Saskatoon, Saskatchewan has numerous grade crossings and blockages caused by long slow moving or stationary freight trains. This study uses two Geographic Information System based analyses: service area analysis to show how the fire responders' service area changes with and without a grade crossing blockage; and network analysis to estimate the impact of GCMS on fire responders' response times both with and without a blockage. Both analyses are quantitative and both can present the results visually. The results from our examples in Saskatoon show significant savings in response times by, for example, avoiding detours made on the assumption that a road is blocked, avoiding taking a route found to be blocked and then having to take a detour, and choosing to wait at a crossing for a blockage to clear when the GCMS indicates that this is more efficient than taking a detour route. Although all cities and road networks are different, this study demonstrates that a GCMS can benefit certain jurisdictions by improving their emergency services and saving lives and property.

1. Introduction

1.1. Problem statement

In North America, there are approximately 261,000 at-grade public rail crossings, approximately 33,000 of which are in Canada. (A public grade crossing refers to a grade crossing which is designed for public use and opened or maintained by a road authority) When trains block these crossings, what are the consequences for emergency first responders? Delays at blocked grade crossings can clearly have significant consequences for emergency responders as the success of an emergency response is often measured in minutes or even seconds.

The US Federal Railroad Administration (FRA) does not set a maximum time that slow moving or stationary trains can block traffic at grade crossings [1], but many states have their own legislation and/or administration code. In the state of Washington, for instance, the Washington Administration Code (WAC) 480-62-220 states that "…*railroad companies must not block a grade crossing for more than ten consecutive minutes*…" A ten-minute limit is also applied in a number of other states, including Texas [2] and Nebraska [3]. No state currently allows trains to block a grade crossing for more than 20 min [1].

In Canada, permitted blockage times are shorter. The Canadian Rail Operating Rule (CROR) 103 (d) governs the time that a train may block a railway crossing: "…*no part of a movement may be allowed to stand on any part of a public crossing at grade, for a longer period than five minutes, when vehicular or pedestrian traffic requires passage. Switching operations at such crossing must not obstruct vehicular or pedestrian traffic for a longer period than five minutes at a time*…" [4] In practice, however, Canadian provincial railway

* Corresponding author.
E-mail addresses: peter.park@lassonde.yorku.ca (P.Y. Park), wook.jung@usask.ca (W.R. Jung), godfred.yeboah@usask.ca (G. Yeboah), garreth.rempel@morrconsulting.com (G. Rempel), dan.paulsen@saskatoon.ca (D. Paulsen), dave.rumpel@saskatoon.ca (D. Rumpel).

http://dx.doi.org/10.1016/j.firesaf.2015.11.003
0379-7112/

representatives are aware that it is not rare for vehicles to have to wait 20 minutes and more at grade crossings in Canadian cities, despite the CROR's five-minute limit [5].

The City of Saskatoon in Saskatchewan, for example, commonly experiences long delays some of which far exceed five minutes, especially on spur lines used mainly for loading, unloading or marshalling trains [6,7]. Delays are longest for trains (usually freight trains) longer than 9500 ft (2.8 km). Such trains can block more than one grade crossing simultaneously forcing first responders and busy and/or impatient drivers to take long detours.

The Saskatoon Fire Department aims to respond to an incident within six minutes as small delays in responding to a fire can be catastrophic or even fatal. The six minutes includes one minute for emergency call handling time plus one minute of fire fighters' preparation time so the target for the journey time is only four minutes. This is the standard target response time recommended by the International Association of Fire Fighters for most jurisdictions in North America and many other countries, such as Australia, New Zealand, and United Kingdom. The specific standard (NFPA 1710) reads "…*the fire department shall establish a time objective of four minutes (240 s) or less for the arrival of the first arriving engine company at a fire suppression incident*…" [8].

There may be a tendency to assume that delays at grade crossings occur in only a small percentage of emergency calls, but in Saskatoon and many other North American cities, (and possibly in many cities on other continents as well), research and anecdotal evidence from dispatchers indicate that trains delay emergency vehicles on a weekly and sometimes almost daily basis [9]. Delays can have major consequences. For example, Tank [7] reported a very serious outcome when first responders were held up at a blocked crossing in Sutherland, Saskatoon. The delay resulted in very extensive and expensive property damage at a fire at a tire warehouse in February 2014. After the delayed response, the fire required 15 consecutive hours of fire fighting from numerous fire fighters and 32 equivalent fire engines. Similar delays may well occur at grade crossings in many cities on other continents as well, but this investigation was, unfortunately, beyond our resources.

The most powerful solution to delays at grade crossings is probably grade separation, but this solution requires large scale construction, traffic delays during the construction period, and very considerable expenditure. At locations where the problem of delays is acute, where change is demanded by the public, and where funds are available, grade separation permanently resolves the issue, but grade separation cannot be justified as the most cost-effective or affordable solution at many at-grade crossings in North America [10].

In some locations, grade separation may not be feasible. Apart from cost issues, factors that may prohibit grade separation include: locations where large scale earthworks are prohibited due to the presence of an underground high-pressure gas pipe line network; locations with high-density commercial or residential development and strong public and/or council resistance to construction work due to the noise, dust, and traffic delays that are inevitable during the construction period; and locations where no alternative rail route is readily available for use during the construction period. An alternative approach to grade separation is then required.

One alternative approach is a monitoring system that provides real-time blockage information to emergency dispatchers so they can plan an alternative route that avoids the blocked crossing. Several technologies are available to track the real-time positioning of locomotives that uses Global Navigation Satellite Systems (GNSS) (e.g., Global Positioning Systems (GPS)). In North America, some railway companies (e.g., Canadian Pacific Railway Limited (CPR) and Canadian National Railway Company (CNR)) already monitor the position of their locomotives on a real-time basis using a built-in GPS device. Ideally, railway companies would simply release their real-time train positioning data to local emergency dispatchers who would then plan their routes accordingly. Unfortunately, security (e.g., terrorism) is a major issue and makes railway companies extremely hesitant to share real-time train positioning data with possibly thousands of emergency dispatchers across North America. Furthermore, not all rail crossing blockages are due to a train. (Blockages may also be caused by, for example, regular/irregular grade crossing maintenance.) An alternative approach to solving the problem of grade crossing delays is needed.

Another possibility is the development of grade crossing monitoring systems (GCMS) that do not require sensitive real-time positioning data on individual locomotives. These systems include prototypes developed by the Texas Transportation Institute and a conceptual framework outlined by Cisco (www.cisco.com) [11–13]. The systems attempt to collect train traffic location and other information (e.g., speed, train travel direction, and train length) using external train detection technology such as radar detection coupled with CCTV. It is reasonable to expect that the cost of installing and maintaining a grade crossing monitoring system (GCMS) would be considerably less than grade separation for almost all locations. Nonetheless, any decision on the use of grade separation or an alternative approach at a particular level crossings requires an analysis of the option's cost-effectiveness. A detailed and thorough benefit-cost (BC) analysis that takes into account capital investment and life span maintenance costs should be conducted to justify any decision regarding a grade crossing.

In this study, we investigate and analyze the effects of GCMS installation on first responders' response areas and response times. While the conceptual and theoretical merits of GCMS appear self-evident, the actual potential benefits of installing GCMS to reduce emergency response times have not been adequately assessed. Goolsby et al. [12] and FRA [9] investigated the impact of grade crossing blockages on first responders and suggested that GCMS would be beneficial, but both studies relied mainly on surveys of first responders and neither undertook any rigorous analysis of the issues. The magnitude of possible reductions in emergency response time remains unknown. Jurisdictions may be hesitant to commit significant funding to GCMS until scientific analysis provides a clear understanding of the expected reduction in response times and the implications of alternative routes for emergency responders. For example, the size of the service area is likely to vary when GCMS information changes the routes taken by emergency responders. Without this information, it is impossible to assess the benefits and costs of GCMS.

1.2. Study objectives

This study provides a rigorous analysis of the issues involved in adopting the GCMS approach to the problem of reaching an incident when there is a grade crossing blockage. The study focuses on fire responders, but the approach can be transferred to Emergency Medical Services and Police first responders. The study area is the road network in the vicinity of selected grade crossings in two areas of Saskatoon (Montgomery and downtown Saskatoon), Saskatchewan.

There are two objectives. The first objective is to investigate how the size of the service area of target fire stations varies with/without a grade crossing blockage. This analysis provides a foundation for understanding the dynamic nature of the service area. The second objective is to establish how the grade crossing blockage information available from a GCMS changes first responders' response times. The study estimates and compares response times without GCMS and with GCMS. The study's outcomes are expected to help decision makers in cities and