A Comparison of Highway-rail Crossing Accidents in the United States and United Kingdom

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INTRODUCTION

In November 2004, all eight cars of the 1735 First Great Western derailed near Ufton Nervet, Berkshire, UK after striking a motor vehicle parked across the track. The accident resulted in sixty-one injuries and six deaths. It was the worst rail crossing accident since the June 2003 crash between a minibus and another First Great Western train that resulted in three deaths. Her Majesty's Railway Inspectorate has called level crossings the "greatest potential rail risk" and reaffirmed the government's plans to continue removal of the nation's remaining crossings (BBC News, 2004). The United States experienced an accident similar to the Berkshire crash in January 2005 when a commuter train derailed after a chain reaction that began with the train hitting a motor vehicle on the crossing, before clipping a freight train on a sidetrack, and a northbound train. This accident resulted in 11 deaths and over 180 injuries. While there have been no calls to close US rail crossings, a number of communities and transportation authorities are looking into ways to reduce the risk of these types of accidents (Chavez, 2005; Warburton, 2005).

Given the recent attention to rail crossing safety, this paper examines the rail industry in the United States and the United Kingdom, particularly focusing on factors that account for the substantial variation in crossing accidents and the differing reactions to crossing safety.

RAILWAY SYSTEM DEVELOPMENT

The railway traces its origins to Britain where it evolved from industrial tramways connecting quarries and collieries (coal mines) to other modes of transportation into its own vital, distinctive mode of transportation. The Surrey Iron Railway Company, founded in 1804, was the world's first public railway company. Surrey offered a horse-drawn service connecting the Wandsworth Wharf on the Thames River in London to Corydon in Surrey (Garratt and Wade-Mathews, 2003). The invention of the stream engine and its application to locomotives, however, insured the railways place in the industrial revolution. In 1821, the British Parliament authorized the Stockton & Darlington Railway which became the first public steam-powered company in the world. By the late 1820s, US railway companies were being formed using technology and equipment imported from British firms.

Diverging Paths

A number of factors led to the very early divergence in railway growth and development between the United Kingdom and the United States. The first factor is topographical. By comparison to the US, British geography was relatively compact with a number of well-established, densely populated urban and industrial centers connected by a reasonably well-maintained network of roads and canals. These conditions gave British rail systems a healthy traffic base to begin operations. While some parts of the US East Coast shared some of these factors with their British counterparts, US railways for the most part were faced with challenging geographical obstacles (mountains, rivers, etc) that traversed long stretches of unpopulated land; US railways eventually helped 'create' population centers rather than connecting existing centers of population. This relates to the second major difference between the U.S. and British system, namely the transport requirements. US railways played a key role in the settlement of the American West, transporting not only the settlers themselves but the goods needed to support them in distant, often isolated locations (Boyd, 2001). Third, the attitude of the people of the United States toward legal issues, business practices, technology, and individual responsibility meant that US railways did not receive direct governmental funding (or operate under government ownership) but were expected to raise funds from private markets, build and maintain their own tracks, and operate with open right-of-ways (Boyd, 2001; Solomon, 2003).

The combination of these factors resulted in a US system where railways often struggled in their early years for funding and tended to be lightly engineered with track that followed the least-cost path from A to B and might face "prolonged and sometimes steep gradients, frequent level highway crossings and railway crossings, and generally did not fence their right-of-ways" (Solomon, 2003: 11). Signaling throughout the 1800s was relatively primitive in the U.S., virtually nonexistent in sparsely populated area. By the beginning of the 1900s, technological innovations were increasingly adopted by US railways, although each railway often maintained its own standards creating a complex and sometimes confusing system. US transportation needs led to operating practices whereby US railways tended to run fewer but longer and heavier trains over their rails. Train lengths in the US meant that passing sidings had to be longer and locomotive size and power greater (Boyd, 2001; Solomon, 2003). Challenging terrains meant that these locomotives carried two tonnage ratings: a drag rating that indicated the most the engine could haul without stalling over the ruling (most severe) grade and a time-freight rating which indicated the load the engine can move over a fast (speed of travel) schedule (Armstrong, 1979).

Meanwhile, British railways tended to start life well-financed and highly engineered. Efforts were made to build railways with gentle gradients and avoid grade (or level as it is called in Britain) crossings with highways and other rail lines. Right-of-ways were normally fenced off rather than open. Restrictive loading gauge regulations, established in the early years of development, coupled with the numerous tunnels and over-bridges necessary to reduce gradient and avoid level crossing made changes to the system prohibitive (Solomon, 2003; Strohl, 1993). Government rather than railway companies were responsible for the development and maintenance of tracks. In part, these differences eventually result in significant variation in the make-up of trains between the US and UK. In the late 1980s, Britain closed the last of its classification yards as railways moved to shorter unit trains and intermodal transportation services. A unit train consists of an entire trainload of goods originating at one point and delivered to a single destination without any intermediate switching or handling (Boyd, 2001). In the United States, freight accounts for approximately 90 percent of the railway traffic and classifications yards play a vital role in creating the long, mixed freight trains common on US railways. A freight yard or a larger classification yard consists of a series of parallel where freight cars are sorted by distance to be traveled and time sensitive nature and then assembled into outbound trains (Boyd, 2001; Rhodes, 2003).

Railroad passenger travel began to decline in the 1920s with the introduction of the automobile. This trend accelerated with the 1958 introduction of the first jet aircraft, the Boeing 707 (Vranich, 2004). As railroads in both countries continued to falter, many outside observers searched for answers. Outside observers suggested that internal managerial reform, new organizational structures, and new processes in accounting and information technology would improve efficiency and reduce costs. Inside observers tended to blame excess trackage and call for consolidation (Salsbury, 1982). In any event, financial difficulties resulting from the decline in passenger traffic was a key factor in the British decision to nationalize four railway companies into British Rail in 1948. The US would not nationalize its passenger rail system until the Rail Passenger Service Act of 1970 created what is today called Amtrak. This same year witnessed the largest US bankruptcy to date, Penn Central Railway, a merged northeast carrier that derived a higher percentage of its revenues from passenger traffic than its western cousins (Salsbury, 1982).

Government ownership did not halt the decline in passenger traffic in either country. In fact, declining service and continuing declines in passenger traffic created worsening financial losses that prompted Great Britain to privatize their rail system, creating sixty separate businesses of which twenty-five are train operating companies. The British railway system has since posted its highest ridership since 1947 and is expected to have one of the newest fleets in Europe by 2005. Meanwhile, Amtrak continues to lose money on 38 of its 40 existing routes with the result that the U.S. Federal government has been forced to spend US$27 billion to cover operating costs and infrastructure upgrade (Vranich, 2004). The new budget proposed by US President George Bush provides no operating subsidy for Amtrak, but does include funding to help regional commuter lines operate in the event of an Amtrak shutdown (Brancatelli, 2005)

Railway Crossing and Signaling

As previously mentioned, the British railway system was designed from the beginning to reduce the interaction of highways and railways (grade or level crossings) while the US system tended to feature more open access. Whenever two major modes of transportation meet, the results can be both expensive and at times catastrophic. In 2004, the intersection of railroads and highways crossings, also known as grade crossings in the United States, and level crossings in the United Kingdom, accounted for 17 fatalities in the U.K. and 377 deaths in the U.S (HSE, 2005B and FRA, 2005). By definition, a grade or level crossing is “a location where a public highway, road, street, or private roadway, including associated sidewalks and pathways, crosses one or more railroad tracks at grade” (FRA, 2005). These intersections of road and rail have been the source of controversy in recent years due to high-profile accidents as well as the resulting closings or redesign.

The U.S. has over 250,000 grade crossings, of which approximately 155,000 cross public roadways with a resultant 3,133 accidents in 2004 (FRA, 2005). Similar numbers for the U.K. include 9,000 total crossings, 8,300 on the public network with 28 accidents during a reporting period of 2003-2004 (HSE, 2005A). Table 1 below shows 10-year statistics for both the U.S. and U.K.

Table 1 Total Grade Crossing Accidents, Fatalities and Injuries between 1993 and 2004

	Accidents	Fatalities	Injuries
U.K.	449	130	336
U.S.	45,334	5,505	16,991

Source: HSE, 2005A and FRA, 2005.

Relative to the individual countries, fatalities in the U.S. are at a 10-year low while the 18 deaths last year in the U.K. are the highest since 1991—1992. The result of these statistics has been a call for increased safety, especially a move to close crossings in general. Rail traffic is closely regulated in that the location, speed, and direction of a train can be closely tracked though either signaling systems within the track or using modern Global Positioning Satellite (GPS) systems. Highway traffic on the other hand is very loosely regulated with the only parameter being the location where the roads cross the rails (Solomon, 2003). Exact location and volume of traffic in the proximity of a crossing is essentially an unknown, although the use of video monitoring and roadway sensors are developing practices. Due to an inability to swerve or stop effectively, trains have the right-of-way at crossings. It is essentially up to motorists to have the necessary information and then to take appropriate action. Various types of warning systems exist to alert motorists to the presence of oncoming trains with some variation existing across regions and national borders.

Rail Crossings in the UK

The United Kingdom has a large number of different types of level crossing warning systems that range from manually controlled barriers and gates to automatically, remotely monitored and even user-worked crossings. The two basic categories of crossings are *controlled* and *open* (U.K. Highway Code, 2005). Table 2 describes the various types of crossings used within the U.K.

Table 2 Types of Level Crossing in the United Kingdom

Type of Warning/Safety Device	Number	Percent
Manually Controlled Barriers	242	2.90
Manually Controlled Gates	264	3.16
Manually Controlled Barriers with Closed Circuit TV	358	4.29
Automatic Half Barrier	470	5.63
Automatic Half Barrier Locally Monitored	45	.54
Automatic Open Locally Monitored	140	1.68
Automatic Open Remotely Monitored	1	.01
User-worked with Miniature Warning Lights	155	1.86
User-worked with Telephone	1617	19.37
User-worked	2290	27.43
Footpath and Bridleways	2546	30.50
Open	60	.71
Station Footpath	160	1.92
Totals	8,348	100.00

Source: RSSB, 2004: 4, 15

Controlled crossings include signs, lights, alarms, and either full, half or no barriers. There are telephone-controlled crossings where the user contacts railway personnel and makes them aware they are about to use the crossing. This is especially necessary when a convoy of vehicles or a herd of animals must cross. An "all clear" call is made once the crossing is complete. Crossings with gates and no lights require increased diligence on the part of the motorist as the gates may lower unexpectedly. Line-of-sight is important with these types of crossings and constant maintenance and monitoring is required to prevent vegetation or construction from affecting the view. Under inclement weather conditions, listening for an oncoming train can be as important as seeing it. User-operated barriers are typically closed to highway traffic in both directions and require the motorist to manually open the barriers on either side of the crossing and close them after driving across. Lights are typically used at these crossings with green (proceed) and red (stop) being the most common colors. Open or uncontrolled crossings will typically have no warning devices other than a "Give Way" sign.

Rail Crossing in the US

Grade crossing protection in the U.S. was not standardized until the 1920's with a variety of methods used. Both passive and active devices are used today. Passive devices may include warning signs, roadway markings, and "rumble strips". Active devices include flashing lights, gates, bells, and wigwags. It is the responsibility of the railroad owning the track to install warning devices, maintain signals in working order, and take alternative measures when signals fail. Railroads are required to make monthly inspections of all crossings. Table 3 below shows the number of warning devices by type.

It should be noted that this data comes from 1986, the last date that a complete breakdown by warning devises is available for the US system. Since 1986, the US has closed approximately 50,000 public crossings as part of the Department of Transportation's Action Plan which set a goal of eliminating 25% of the redundant or unnecessary grade crossing in the US (FRA 1994). It is actually the Federal Highway Administration (FHWA) that is responsible for public grade crossing issues related to safety. The FHWA provides guidelines and standards for design, safety, and assessment. They also administer the so-called Section 130 funds that have been authorized to pay for crossing elimination or upgraded warning systems. States actually determine which crossings present a hazard to public safety according to the FHWA guidelines, recommend action, and apply for funding assistance (US Department of Transportation, 1999). In the State of California, for example, the California Public Utilities Commission (CPUC) maintains regulatory and safety oversight for railroads and rail transit systems. In addition, many local governments exercise oversight in coordination with the CPUC and the FRA. The

Los Angeles County Metropolitan Transit Authority (LACMTA) is the responsible organization for that county and has taken independent action to increase crossing safety by installing video surveillance cameras at crossings and instituting a public education campaign. As a result of their campaign and video enforcement of violations at rail crossings, there has been a 92 percent reduction in such incidences (CPUC, 2004).

Table 3 Types of Public Crossings in the U.S

Type of Warning/Safety Device	Number	Percent
Gates	19,473	9.48
Flashing Lights	34,120	16.62
Signals, Wigwags or Bells	2,618	3.50
Flagged by Train Crew or Other Method	7,181	3.50
Crossbucks	126,963	61.83
Stop Signs	1,374	0.67
Other Signs	889	0.43
No Signs or Signals	12,721	6.20
Total	205,226	100.00

Source: Federal Railway Administration, 1986

The most common warning sign is the *crossbuck*, consisting of two white slats in an "X" pattern containing the words "RAILROAD" and "CROSSING" painted in black. The majority of U.S. crossings employ the crossbucks in addition to other features. When a crossing has more than one track, an auxiliary sign denoting the number of tracks to be crossed is attached directly below the crossbuck. Figure 1 below shows a typical crossbuck and accompanying auxiliary sign.

Figure 1 Crossbuck.

The original "active" railroad warning device in the U.S. was a railroad flagman that would stop traffic by swinging a red flag during the day or red lantern at night as the train approached. As wages rose and the number of crossings increased, there was a move toward automated (train activated) signals. The wigwag flagman was a device consisting of swinging pendulum with visible markings and later versions contained a light and bell. Colors of the pendulum "target" varied from red to white with black accents.

Use of the wigwag became obsolete in the 1940s, though some are still in use today (Wikipedia, 2005). Modern active crossing devices warn motorists of an approaching train through either lights, lowered gates, warning bells. When flashing lights are used, two red bulbs flash at the rate of approximately once per second and is designed to simulate a watchman swinging a lantern. In the U.S. warning gates typically only protect the crossing from the approaching traffic side with an example shown in Figure 2. This allows vehicles that enter the crossing after the gate is lowered to continue. Unfortunately, it allows motorists the ability to circumvent the gates with such behavior being the cause of a number of grade crossing accidents each year. Lights and gates are typically accompanied by warning bells (FRA, 1986: 104, 108).

Figure 2 Automatic Gate with Warning Lights.

Advanced warning signs are also used in the U.S. and consist of round black and yellow sign placed a specific distance before the crossing depending on the speed limit of the roadway. These signs are required in advance of all crossings except on low volume roadways, in large business districts where other (active) devices are used, and where conditions make their use ineffective. Standard road signs used at railroad crossings include an advisory Speed Plate, Stop

Ahead, Turn Prohibition, No Passing Zone, and the octagonal-shaped Stop sign. All of these signs are used when engineering studies or conditions warrant. In addition, Do Not Stop on Tracks is used when studies show a propensity for drivers to slow or stop due to traffic congestions or signal lights. Exempt signs are used at crossings to notify drivers that are normally required to stop at crossings that a stop is not required unless railroad equipment is approaching or in the crossing. In addition to signage, another common type of passive warning device is pavement markings. The roadway is typically marked in contrasting colored markings that may include "RR", "X", and horizontal *stop lines*. Both paint and adhesive-backed plastic markings may be used. Reflective materials that include glass beads are commonly in the markings. Some crossings may be "enhanced" with rumble strips, which are raised or indented portions of the pavement designed to get the driver's attention by creating a mild vibration or rumble within the vehicle. The use of Rumble strips is typically based upon the discretion or policies of local or state governments.

A comparison of Tables 2 and 3 reveals that a significant percentage of US crossings do not contain either manual or automatic gate barriers to track crossing, but rely on the presence of warning lights and signs (and driver judgment) to prevent accidents. Even with recent efforts to improve crossing safety, the FRA estimates that only approximately 38% of all crossings contain both flashing lights and gates that are automatically activated by approaching trains (FRA, 2002).

METHOD AND RESULTS

In order to compare the US and UK systems of grade crossing, data was collected primarily from two sources. Information on the US rail system, including safety data was gathered from the Federal Railway Administration (FRA). The FRA was created with the Department of Transportation Act of 1966 to promulgate and enforce rail safety and conduct research and development into safety and rail transportation policy. Safety and other rail system data are available directly from the FRA website (www.fra.dot.gov). Data for the UK system was obtained from the Health and Safety Executive, an agency of the UK Health and Safety Commission (www.hse.gov.uk). Table 4 provides general descriptive data on the US and UK system for 2004 as well as calculations on crossing density and fatalities per crossing. As shown, crossing density is higher in the US but the fatalities per crossing are lower.

Table 4 US/UK Rail System

	US	UK
Total Track Miles	141,960	10,678
Total Grade Crossings	247,443	7,937
Total Incidents	2,718	28
Total Fatalities	339	17
Crossings per Track Mile	1.73	.74
Fatalities per Crossing	0.0014	0.0021

Source: Federal Railway Administration and Health and Safety Executive

DISCUSSION

An examination of the development of the rail system in the United States and United Kingdom reveals that the two systems began to diverge relatively early in their history due to market and geographical differences in the two countries. While the US possesses a substantially larger rail system that has a higher density of crossings per track mile and a lower overall percentage of barrier-protected crossings, the likelihood of a fatality occurring at a rail crossing is higher in the UK than in the US. In part, this can be explained by the different nature of the rail traffic on the two systems. As noted earlier, 90 percent of the rail traffic in the US system is freight rather than passenger. The locomotives in use in the Unites States have been designed to withstand crashes with highway vehicles. The North American Safety Cab is an armored locomotive designed with the safety of the railroad crew in mind. This safety design and the greater size and mass of the train itself generally mean that any fatalities likely to occur would be in the passenger vehicle and, therefore limited to the carrying capacity of that vehicle (Solomon, 2003: 155). On the other hand, the UK has a much higher percentage of passenger traffic. Such trains are not only travelling at higher speeds than the typical US freight train but they are carrying much more potential causality.

There are a number of consumer groups in the US who have called for increased funding to close grade crossings and "transportation officials contend that literally thousands of redundant at-grade crossings could be consolidated without significantly affecting travel time or public convenience (FRA, 1994: 3), but "such costs have been deemed prohibitive and the operations impractical". Even the additional integration of block signals to govern train movements into grade-crossing signals has often been considered too costly and complex since US trains are longer and heavier than their UK counterparts (Solomon, 2003: 155). Another approach to grade crossing safety might be through the implementation of positive train control (PTC). PTC can track the speed and location of trains and could be combined with increased use of video observation and/or integrated block signals at crossings to provide sufficient advance warning to train operators of track blockage, however, it is not clear whether this system would be less expensive or as effective as grade closure. In any event, rail operators are likely to fund PTC only if they perceive value from increased operational efficiency. The US Federal Government might consider additional funding for reasons of security in the wake of the London rail bombings, although the US Senate recently rejected proposals to increase mass transit and rail funding for Homeland Security. Since September 11th, the Department of Homeland Security has allocated US$250 for transit security and approximately US$15 billion for the aviation system. Michael Chertoff, Secretary of Homeland Security, has stated that "the truth of the matter is, a fully loaded airplane with jet fuel, has the capacity to kill 3,000 people. A bomb in a subway car may kill 30 people" (Lipton, 2005). In essence, the cost/benefit analysis of reducing crossing fatalities in the US does not warrant additional action. Meanwhile, the UK continues to pursue a policy of level crossing closure that is likely to increase as the government there reviews safety and security following the July 7th attacks.

The World Bank (2002) defined sustainable development in their *World Development Report 2003* as the ability to meet the needs of the present without undermining the ability to meet future needs. From a rail system/crossing perspective, this is neither enlightening nor directive. US citizens have made a collective decision that it "is cheaper and perhaps more practical to place the burden of responsibility on highway users and afford them the freedom of decision rather than provide absolute protection" (Solomon, 2003: 155). Whether this attitude would change with an increase in passenger rail traffic or the presence of greater potential threats is not known at this time. Currently grade crossing closure is more likely to occur 1) to reduce the noise that results from Federal regulations requiring trains to sound their horn when approaching a crossing, 2) to reduce highway traffic congestion caused by train crossing activity, or 3) to facilitate more rapid movement of trains from port facilities to switching stations as occurred with the construction of the Alemeda Corridor in California. The current death toll is deemed to be acceptable given the alternative of closure. As long as this attitude prevails in the US, the existing system is clearly capable of meeting current and future needs of US passengers and freight cargo shippers. A different calculus has and is being applied in the UK that makes crossing closure and rail passenger/motorist safety an issue for the sustainability of their system. Given the original design of the UK system and its size and scope, it is certainly possible with moderate levels of spending to reduce the fatality rate in the UK.

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