THE DEVELOPMENT OF RAILWAY SAFETY IN FINLAND

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ABSTRACT

This study reviewed the development of railway safety in Finland from 1959 to 2008. The data for national analysis were mainly collected from the statistics of the Finnish railway operator (VR Group Ltd.), the Finnish Rail Administration, (RHK) and, for the international comparison, from the Eurostat database and the European Railway Agency's Public database of safety documents. The results showed that the level of safety has greatly improved over the past five decades. This positive development was owed to the use of new technology and the new procedures to protect railway employees working on the tracks. Furthermore, the number of road users killed at level crossings has diminished due to the installation of barriers and the construction of overpasses and underpasses at the crossings with dense traffic, the removal of the level crossings and an improvement of conditions such as visibility at the crossings. However, the number of trespasser fatalities has not seen a similar reduction. At the European scale, the level of railway safety in Finland is around the average based on the number of accidents per million train-km. The main plans for the future include the removal of 1,500 level crossings by 2025 and involving communities in the safety work related to railway trespassers to decrease the large amount of trespassing accidents.

Keywords: Railways, safety

INTRODUCTION

Rail transportation has been considered one of the safest and most efficient modes of transport for some time. Risk comparisons for the EU Member States show that rail together with air travel are the safest modes of transport per travelled passenger-km. Specifically, for the years 2001 and 2002, the fatality risk (fatalities per 100 million passenger-km) for air (civil aviation) and rail travel was 0.035 and 0.95 for road transport (ETSC 2003). In addition, train together with bus travel has the lowest passenger fatality risk per time spent travelling, with two fatalities per 100 million person travel hours. The risk is more than 12 times less than for normal car travel (ETSC 2003). Moreover, rail transport is one of the safest forms of land transport when comparing the yearly number of fatalities per mode. In 2005, nearly 43,000 lives were lost in traffic accidents on EU region, while road accidents were responsible for 96% and rail accidents 3.4% of the fatal accidents (EC 2007). The number of persons killed in railway accidents per million inhabitants is about one-tenth of the corresponding number for road accidents in Europe (Peltola and Aittoniemi 2008).

In spite of the positive safety image of rail transport, fatalities caused by rail accidents do occur and the number of yearly fatalities caused by railway accidents (excluding suicides) in Finland was around 20 during the 21st century (the Finnish Rail Administration, 2000–2009). Consequently, there is still work to be done to improve the safety of Finnish railways.

This study examined the development of railway safety in Finland from 1959 to 2008. Due to the small number of accidents per year, the long time span is important to increase the reliability of the results of the analysis. Comprehensive accident data enables risks to be quantified and to some extent, compared (ETSC 2000). The analysis of the historical accident data provides useful background information when evaluating previous safety work and when planning future safety strategies. For example, in Great Britain Evans has analysed fatal transport accidents (Evans 2003a, 2003b), railway risks and valuation and the costs of preventing rail fatalities (Evans 2005), along with fatal train accidents on Britain's main line railways (Evans 2009, 2008, 2007 and 2006).

This study consisted of two parts. The first part included an analysis of the development of railway safety in Finland. In the second part, the international statistics were used to compare railway safety in Finland to that in other EU Member States.

METHOD

The data for national analysis were mainly collected from the statistics of the Finnish railway operator (VR Group Ltd.) and the statistics of the Finnish Rail Administration (RHK, part of the Finnish Transport Agency since the beginning of 2010). The data for international comparison were collected from the Eurostat database including most of the Member States and the candidate countries and from public database of safety documents maintained by the European Railway Agency. The databases are introduced in the following section.

National accident statistics

The Finnish railway operator (VR Group Ltd., State Railways until 1995)

Finnish State Railways started to publish yearly railway accident and damage statistics in 1959 (State Railways 1960). The aim of these statistics was to guide railway safety work and education. Based on the statistics, it was possible to recognise the circumstances in which railway accidents and damages most often occur as well as the mistakes, failures or shortages that led to most accidents. This information was used to tackle the faults and plan measures to remedy them. Furthermore, the information from the statistics was used to check the current state of safety regulation and to plan new safety devices.

Over the years, the accident and damage statistics for railways have undergone some changes (State Railways 1994). The first important change came in 1985, when the railway administrations in the Nordic countries agreed to harmonise their statistics to improve comparability. According to the Nordic guidelines, only accidents involving fatalities or seriously injuries, or accidents causing damage of more than 5,000 UIC-francs (a virtual currency unit used by the International Union of Railways) need to be reported. (State Railways 1986). The second substantial change came in 1993, when the limit for reported damage was increased to 10,000 ECU (1 ECU = 1 €, corresponding to about 72,000 FIM). Therefore, starting in 1993, the statistics include parts that make them incompatible with those of previous years for the purposes of comparison.

In addition, there have been some minor changes over the years, such as new explanations for the concepts used, new statistics and minor changes in the classification or table contents. These changes do not, however, have a major impact on the comparability of year-to-year statistics.

The Finnish Rail Administration

The Finnish Rail Administration has released yearly railway statistics since its foundation in 1995. These railway statistics include safety statistics such as the yearly number of accidents, fatalities and seriously injured persons. Moreover, it includes some ratios such as accidents per million train-km and the number of passengers killed per million trips.

International accident statistics

The International Union of Railways

The International Union of Railways (UIC) collects international railway statistics on railway accidents reported yearly by their member organisations. UIC's railway statistics have been collected over the decades and they are globally quite comprehensive, since the UIC has members from more than 100 countries from all five continents (the International Union of Railways 2007a). Both the Finnish Rail Administration and VR Group Ltd. (the Finnish rail operator) are members of the UIC. Regardless of the broad international coverage of the statistics, there are some problems. In practice, there are differences between the definitions of accident categories and the reported information among different countries. In addition, the UIC's statistics are non-official and contributed only by UIC's members. These members typically represent the main national railway system of each country, and casualties on other railways are not included in the data. Therefore, the UIC statistics do not give a fully accurate image of the differences in safety levels between countries. (ETSC 1999.) However, due to the lack of more reliable data, the statistics of UIC have been the only source available for international comparisons on railway safety in different countries until recent years. This study focused on European countries and therefore, the European level databases introduced in the following section are the main sources for the data.

Eurostat

The European database Eurostat (http://ec.europa.eu/eurostat/) was started as the result of Regulation (EC) No. 91/2003 of the European Parliament and of the Council on rail transport statistics, which stipulates that the information concerning rail accidents in the Member States has to be collected in a single database. The Eurostat database includes statistics concerning rail safety in different Member States starting from the year 2004. Further details concerning the required information for Eurostat rail transport database (e.g. the classification of accidents) have been defined in Commission Regulation (EC) No. 1192/2003 of the European Parliament and of the Council on rail transport statistics. The Member States are obligated to report all accidents causing fatalities or serious injuries or if the damages of the accident amount to 150,000 € or more. Under Regulation (EC) No. 91/2003, *fatalities* means any person killed immediately or within 30 days after an accident (excluding suicides) while *seriously injured persons* refers to any person injured who is hospitalised for more than 24 hours as a result of an accident (excluding attempted suicides).

Eurostat statistics concerning rail safety include the following information: (a) the number of significant accidents and the number of serious injury accidents (optional), by type of accident, (b) the number of accidents involving the transport of dangerous goods, and (c) the number of persons killed and seriously injured, by type of accident and by category of person. In Finland, the Finnish Railway Administration reports these statistics to Eurostat.

Public database of safety documents

As instructed in the Railway Safety Directive (2004/49/EC), the European Railway Agency has collected information about railway accidents for its public database of safety documents since 2006. The national rail agencies are responsible for delivering the required information on the number of accidents, fatalities and serious injuries as well as safety-related indicators. In Finland, the Finnish Rail Agency (part of the Finnish Transport Safety Agency since the beginning of 2010) collects the necessary information from the railway actors, which are currently VR Group Ltd. and the Finnish Rail Administration. In addition, starting in 2010, the new directive (2009/149/EC) requires that national rail agencies report the indicators used to calculate the economic impact of accidents, including the economic impact on society of all accidents, regardless of the significance of the impact.

Data analysis

The development of railway safety in Finland was evaluated based on fatalities alone due to the large number of changes in the criteria used to calculate the yearly number of railway accidents. The latest changes occurred in the 21st century due to European regulation (No. 1192/2003) and the Railway Safety Directive (2004/49/EC). Therefore, it was concluded that reliable conclusions could not be reached on the development of safety based on the yearly number of all reported railway accidents, or reported accidents resulting in personal injury, for example.

In a way, the analysis of fatalities is solid, since the definition of the term is clear and practically all fatal accidents have been included in the statistics. In contrast, the definitions for slight and serious injuries have changed considerably over the years and hence the number of injured people may more accurately reflect the changes in criteria than the changes in the level of safety. The number of fatalities is also a suitable measure in the sense that when improving the level of safety, the most important aim is to reduce the number of fatalities (and serious injuries). On the other hand, it is important to note that in particular, the yearly number of passengers or railway employees killed is so small that the changes in the level of safety can easily be masked by random variation. For example, if the long-term average of the annual number of fatalities is 9, the approximate 95% confidence interval of the observed number of fatalities in any year is $9 \pm 2 \cdot \sqrt{9}$. Therefore, the observed annual number of fatalities can vary between 3 and 15 even when there are no significant changes in safety.

It must be noted that suicides were not included in this study since they have not been included in the accident and damage statistics of the Finnish rail operator since 1985. This information is also not available in the Eurostat statistics. However, the Railway Safety Directive (2004/49/EC) has changed the situation. At the moment, the Member States are required to report this information and it is publicly available in the European Railway Agency’s public database of safety documents. In Finland, the share of railway suicides of all suicides is small (about 4% in 2006) (Peltola and Aittoniemi 2008). However, suicides represent a significant share of all railway fatalities, since in Finland about two-thirds of railway fatalities are suicides. In general, around 60 railway fatalities that can be classified as suicides occur in Finland each year.

RESULTS

The development of railway safety in Finland

Figure 1 shows the average number of passengers and railway employees killed in railway accidents in five year periods from 1959–2008. This figure refers to the internal safety of railways, which is measured by the number of killed passengers and railway employees. The people who are entering or exiting the train are also considered passengers, while staff members who are working at the tracks are considered employees. The number of passengers and railway employees killed has decreased during the last forty years and at the moment, it is clearly less than one-fifth of that recorded at the beginning of 1960s. However, with such relatively small numbers, a single major accident can seriously influence statistical trends. This occurred, for example, in 1998 when ten passengers were killed in a single accident.

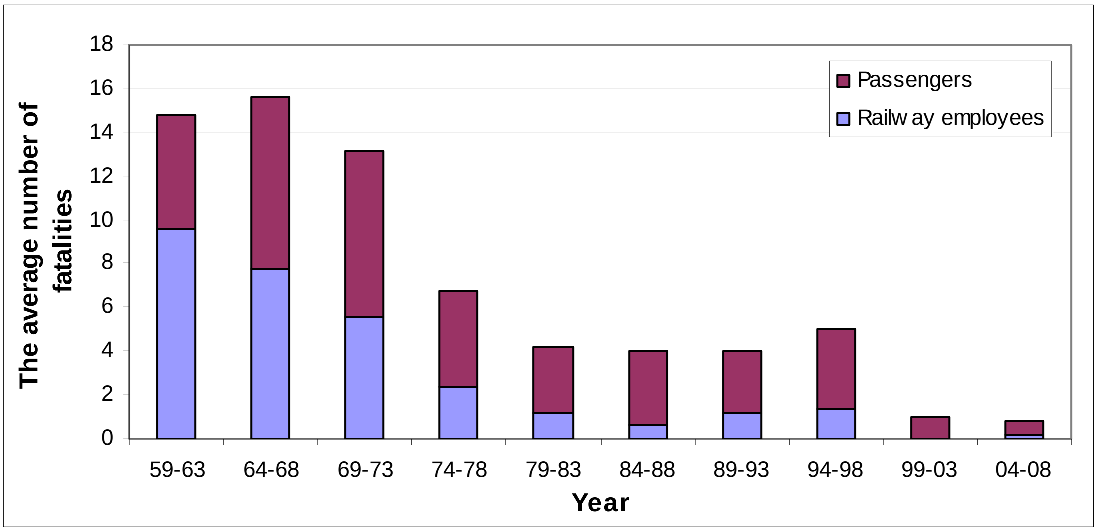

Figure 1. The average number of killed passengers and railway employees in railway accidents (State Railways 1960–2006, the Finnish Rail Administration 2007–2009).

The development of safety has been nearly similar if all the accidents - including those caused by rolling stock in motion - are taken into consideration (Figure 2). However, the total number of accidents is higher than in Figure 2, since in addition to passengers and employees, the people killed in level crossing accidents and railway trespassers are included.

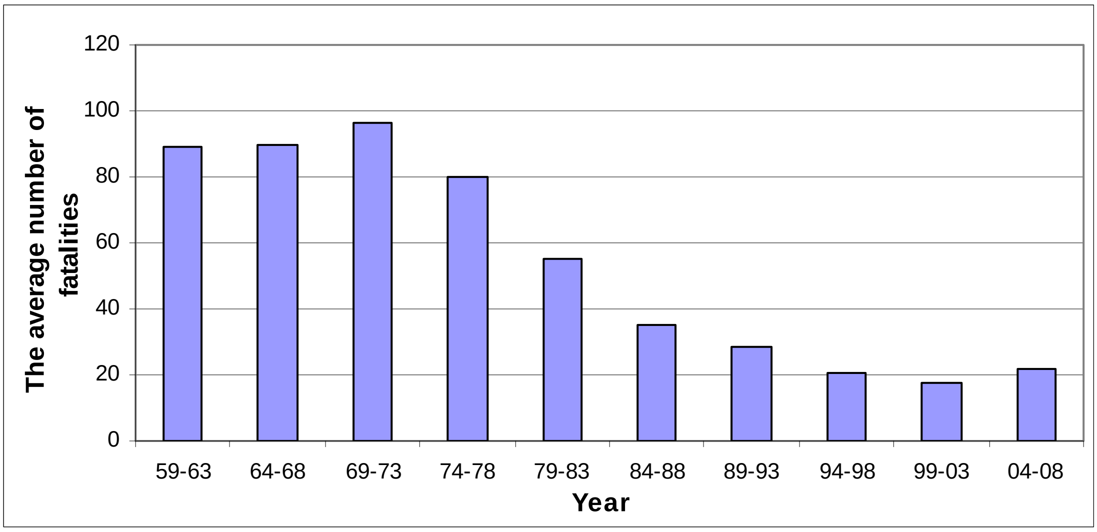

Figure 2. The average number of fatal train accidents 1959–2008 in Finnish railways (State Railways 1960–2006, the Finnish Rail Administration 2007–2009).

The increase in railway traffic during the study period has been relatively small (23%), from 42.5 to 52.3 million train-km. Therefore, the general picture of the development of railway safety has not changed much if the number of fatalities is calculated per million train-km (Figure 3).

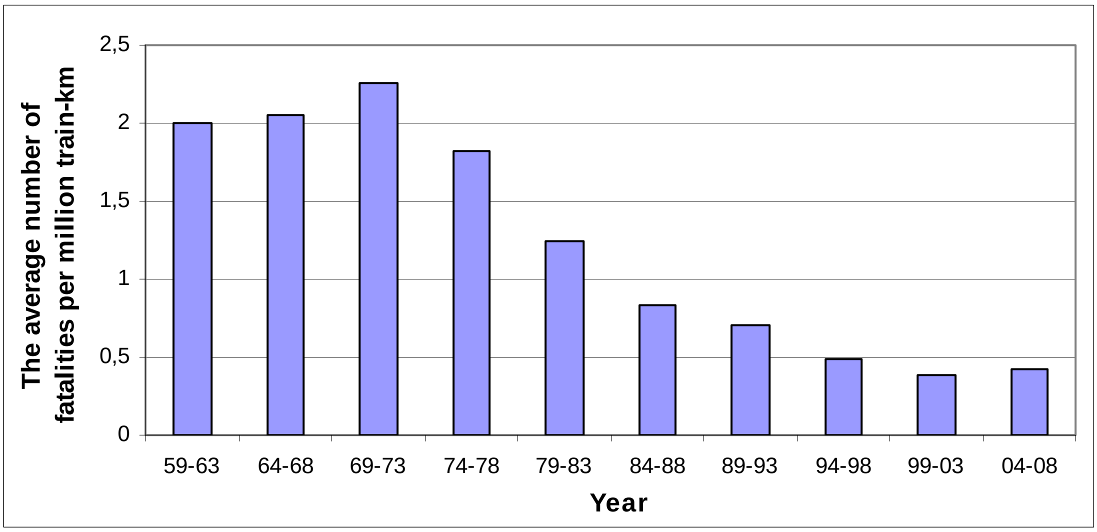

Figure 3. The average number of railway fatalities (excluding suicides) per million train-km 1959–2008 . Train-km information for 1959 and 1960 (State Railways 1962), for 1970–2005 from the UIC's Railisa database (the International Union of Railways 2007b) and for the years 2006–2008 from the Finnish Rail Administration's statistics (the Finnish Rail Administration 2007–2009). There was no information available about train-km from 1961–1969 and therefore the numbers have been interpolated from the information from 1960 and 1970.

Figure 4 presents the trend in passenger fatalities per passenger-km, which can be regarded as a measure of passenger risk. This risk fell by about a factor of 5 from the beginning of the 1960s to year 2008. However, if the numbers from each year are evaluated separately, the real changes in the safety level are not visible due to the small annual number of fatalities which causes significant random variation. Specifically, the development is clear when comparing the first and the last ten years of the period considered. In the 21st century, approximately one passenger has been killed per 300 million passenger-km. Over the years, the amount of passenger-km has increased from 2272 million to 4052 million per year.

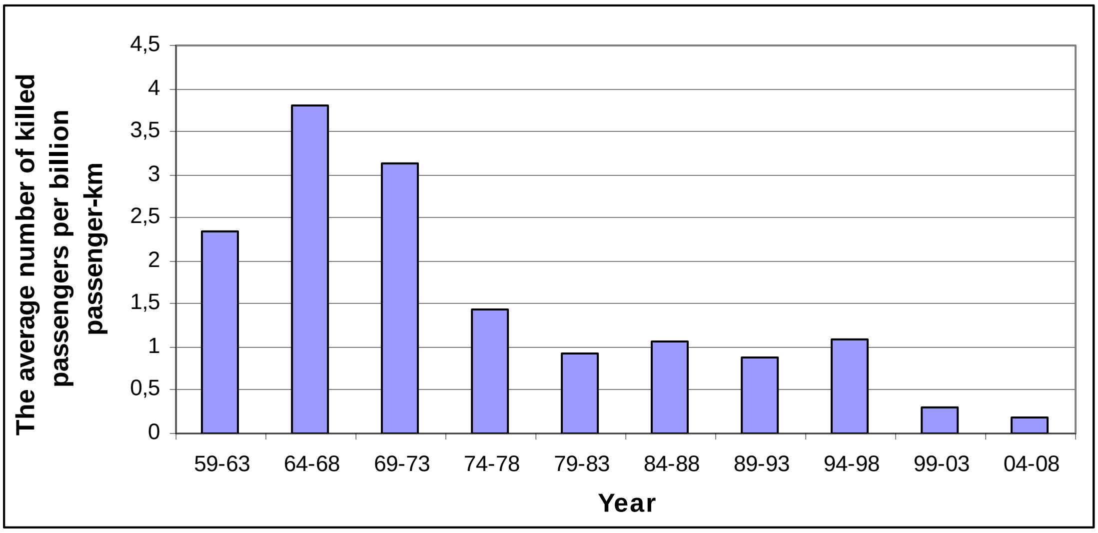

Figure 4. The average number of railway passenger fatalities per billion passenger-km 1959–2008 (State Railways 1960–2006, the Finnish Rail Administration 2007–2009).

Furthermore, the development of safety has been favourable for railway employees: while in the 1960s, 1 out of 5000 employees was killed, during the years 2000–2006, no staff member was killed even thought the number of staff totalled 10,000–13,000 (Figure 5). These numbers include all accidents caused by rolling stock in motion. Therefore, fatalities that occurred during i.e. track works where no train or construction machine is moving are excluded. Instead, these are included in occupational accident statistics.

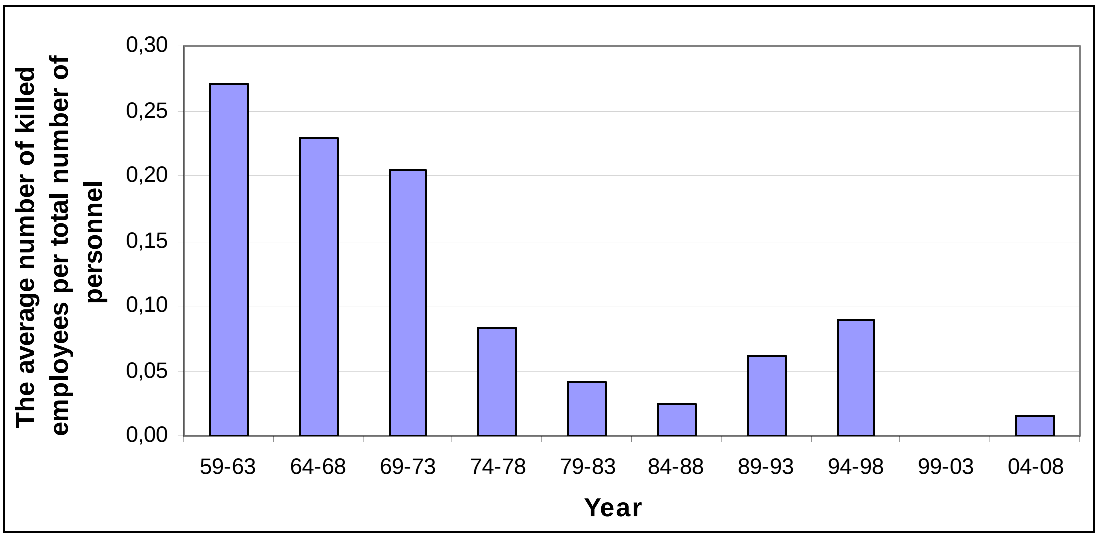

Figure 5. The average number of railway employee fatalities per number of staff members 1959–2008 (State Railways 1960–2006, the Finnish Rail Administration 2007–2009).

The largest decrease in the number of fatalities concerns road users in level crossing accidents (Figure 6). At the end of the 1960s and the beginning of the 1970s, the yearly number of people killed at level crossings was about 50. The corresponding number at the beginning of the 21st century has been around 10. In addition, the number of passengers and employees killed has decreased significantly during the study period. During the 1960s and 1970s, it was typical for 5–10 passengers and railway employees to be killed yearly. During the 1980s and 1990s, the corresponding number was one railway employee per year. During the years 1999–2006, no railway employees were killed in accidents. Unfortunately, seven passengers were killed during the 21st century. Over the last years, the majority of railway fatalities have been railway trespassers (group *others* in Figure 6).

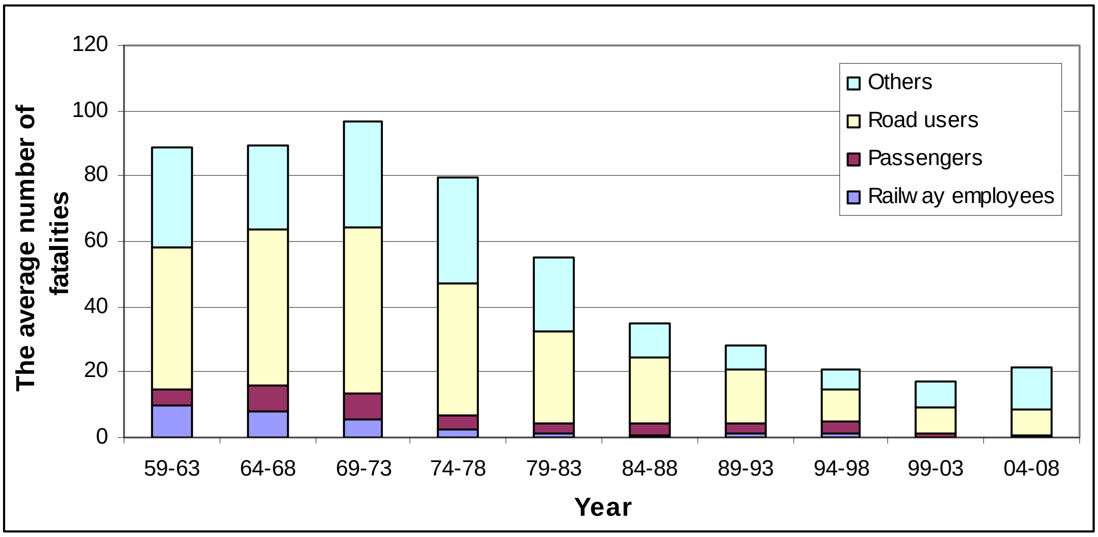

Figure 6. The average number of railway fatalities (excluding suicides) subdivided into passengers, railway staff, road users and others 1959–2008. The group "others" mainly includes persons killed by rolling stock in motion outside level crossing areas. (State Railways 1960–2006, the Finnish Rail Administration 2007–2009).

The number of level crossing accidents decreased quite steadily from the 1960s until the middle of the 1990s (Figure 7). The level crossing accidents mostly occur at passive level crossings, which mean level crossings with no active warning device such as automatic barriers or light and sound warning devices. VR Group Ltd. assumes that the high number of accidents at the end of the 1950s and in the 1960s is owed to the substantial increase in motorised road traffic (State Railways 1987). The number of level crossings (excluding private tracks) has decreased over the years from 7,570 level crossings in 1959 to 4,218 level crossings in 2008. Specifically, at the beginning, the number of level crossings remained quite steady and even increased a little bit during the years. However, the effective removal of level crossings began in the middle of the 1970s when the danger of such crossings was recognised. At the same time, the increasing number of remaining level crossings was installed with active warning devices. In 1959, 2.7% of the level crossings were equipped with active warning devices while the corresponding number in 2008 was 20.1%.

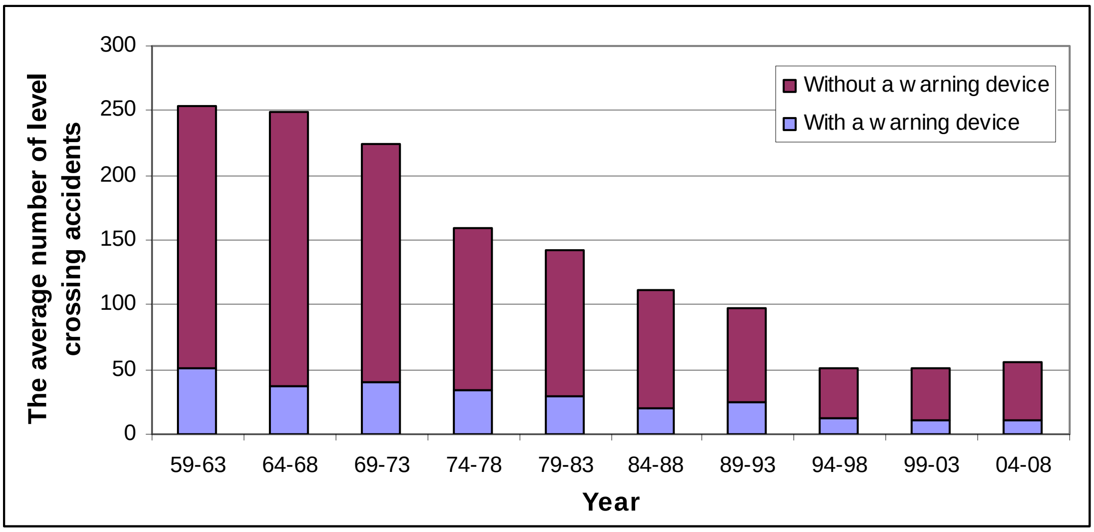

Figure 7. The average number of level crossing accidents by level of warning in Finnish railway network (State Railways 1960–2006, the Finnish Rail Administration 2007–2009).

Finnish railway safety in the European context

In the European comparison, railway safety in Finland is considered average based on the yearly median of railway fatalities (excluding suicides) per million train-km (Figure 8). As in most European countries, the largest share of fatalities in Finland also involves road users at level crossings and trespassers, which means persons killed by rolling stock in motion outside the level crossing areas (others than passengers or railway employees).

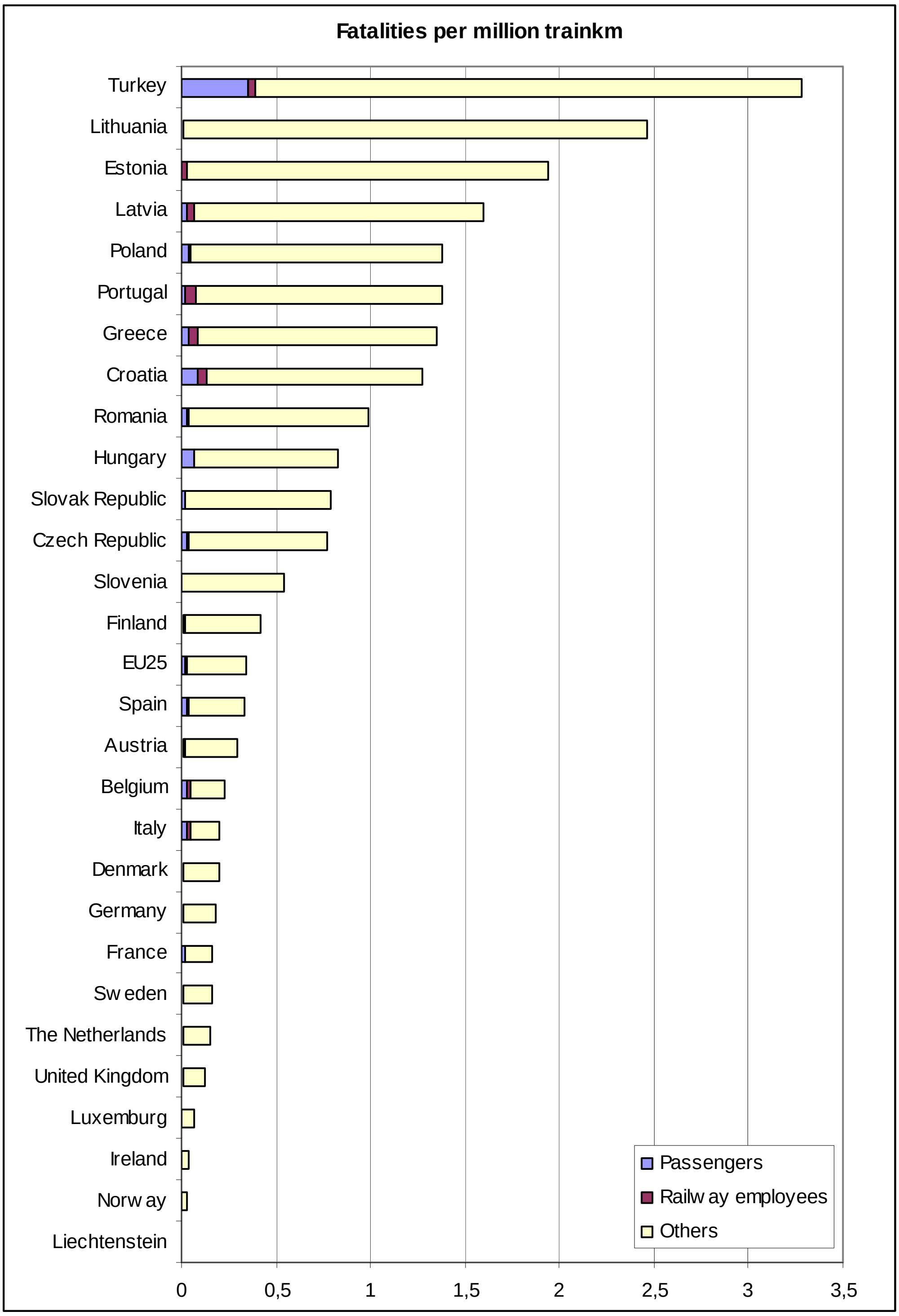

Figure 8. The average yearly number of fatalities per person group and million train-km in different European countries during 2004–2008. (Eurostat 2007, Eurostat 2010). The information for Croatia, Turkey, Luxemburg and Liechtenstein only covers the years 2004–2007.

The yearly average number of killed passengers and railway employees per train-km in Finland is lower than the EU-25 average (Figure 9).

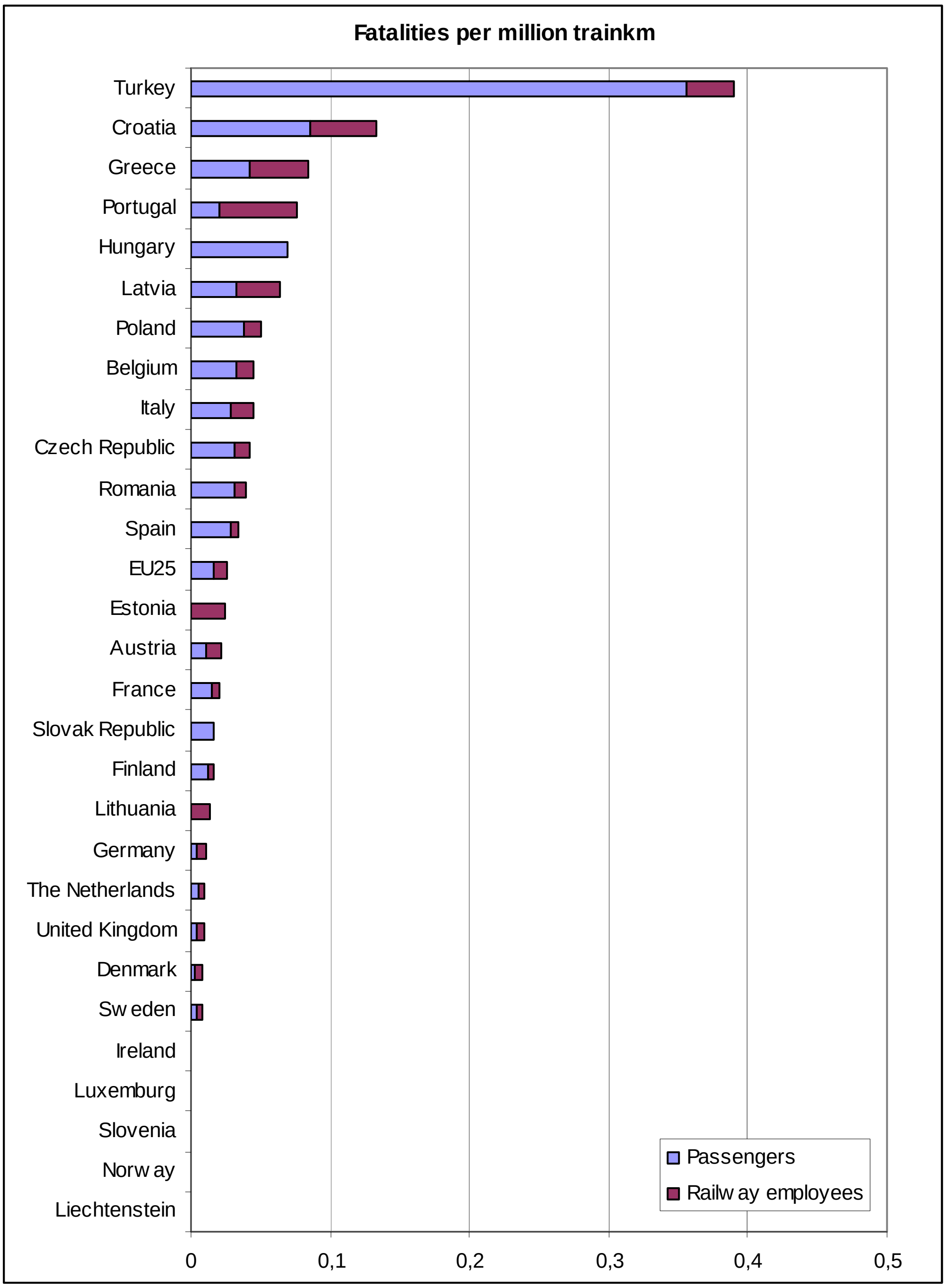

Figure 9. The average yearly number of accidents per person group and million train-km in different European countries during 2004–2008 (only including passengers and railway employees). (Eurostat 2007, Eurostat 2010). The information for Croatia, Turkey, Luxemburg and Liechtenstein only covers the years 2004–2007.

Moreover, the average yearly number of accidents per accident type and million train-km shows that Finland is around the EU-25 average (Figure 10).

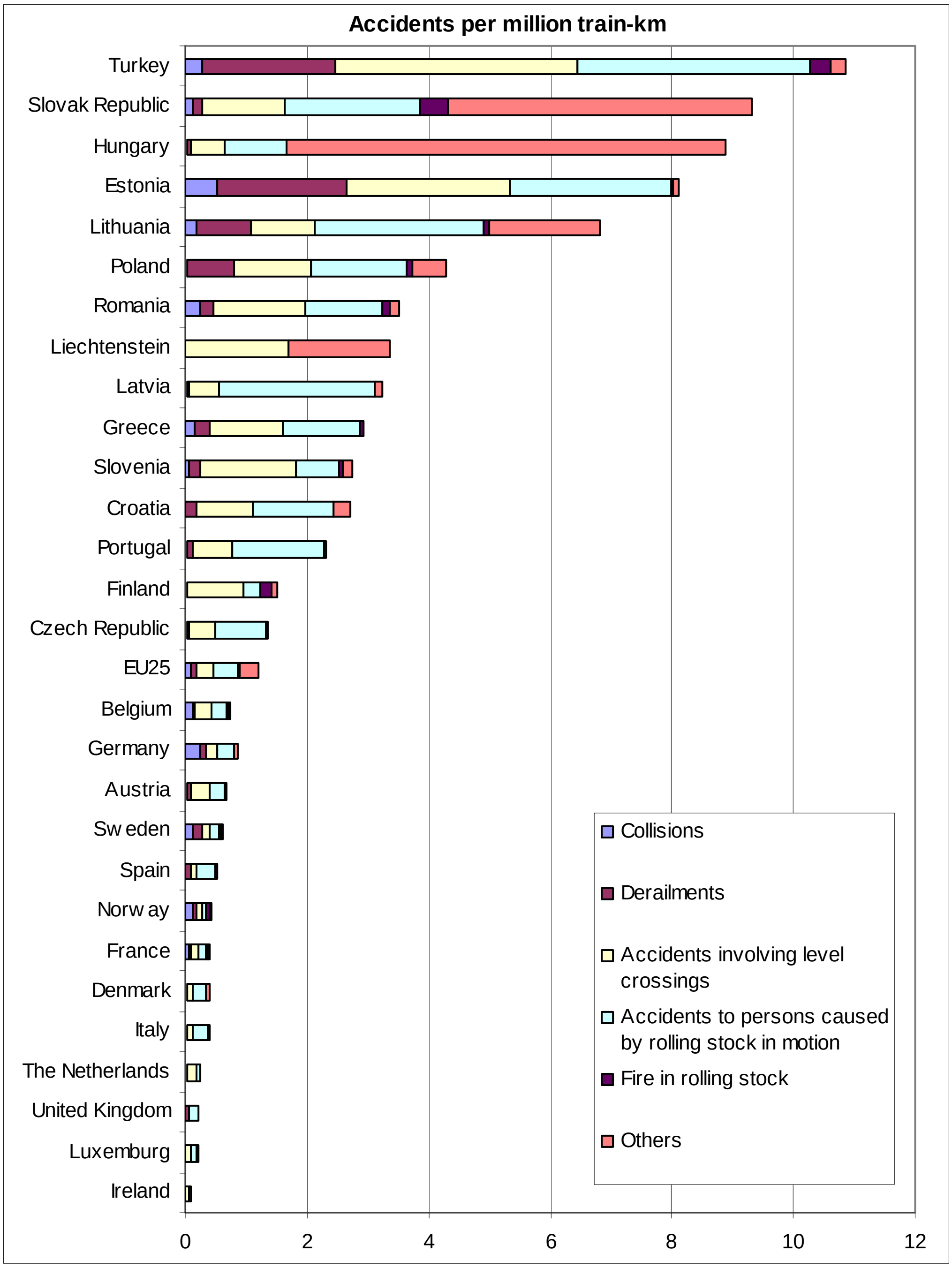

Figure 10. The average yearly number of accidents per accident type and million train-km in different European countries during 2004–2008 (Eurostat 2010). The information for Croatia, Turkey, Luxemburg and Liechtenstein only covers the years 2004–2007.

Furthermore, the situation looks even better for Finland if level crossing accidents are excluded from the statistics (Figure 11). In Finland, a greater share of all railway accidents occurs at level crossings than in most other countries.

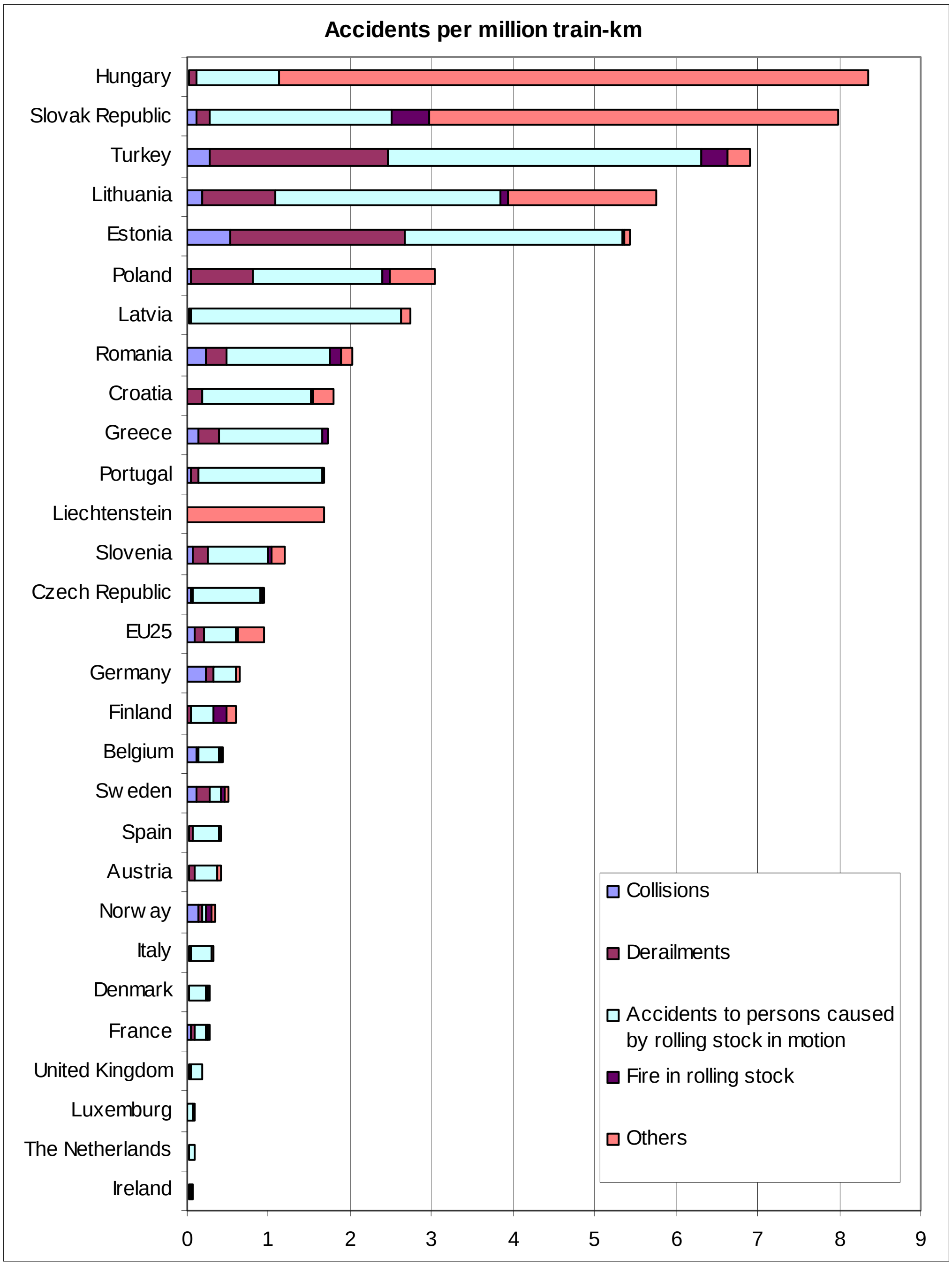

Figure 11. The average yearly number of accidents per accident type and million train-km (excluding accidents involving level crossings) in different European countries during 2004–2008 (Eurostat 2010). The information for Croatia, Turkey, Luxemburg and Liechtenstein only covers the years 2004–2007.

DISCUSSION

The main results showed that the level of safety in Finland has greatly improved over the past five decades. This concerns both passengers and railway employees. The risk of fatal accident for passengers and railway employees fell by a factor of about five between 1959 and 2008. During the last years, there have been no more than two fatalities among passengers and railway employees per year. This positive development was owed to several factors like the use of new technology such as automatic train protection (ATP) which has reduced the possibility of serious human errors. In addition, new guidelines and procedures to protect the railway employees working on the tracks have been introduced.

The number of road users killed at level crossings has diminished as well. This is especially due to the installation of barriers and the construction of overpasses or underpasses at the crossings with dense traffic, the removal of the level crossings and the improvement of conditions such as visibility at the crossings (e.g. by clearing of vegetation and other obstacles from the sight lines). The removal of level crossings and the construction of overpasses or underpasses are concentrated on railway sections where maximum speed is increased beyond 140 km/h and railway sections where dangerous goods are transported frequently. According to the Finnish Railway Agency's guidelines level crossings are not allowed on track sections where train speed is over 140 km/h. The improvement of conditions is important for safety especially at level crossings situated on minor gravel roads (like most level crossings in Finland), where traffic volumes are often less than 10 vehicles per day and the crossings have no active warning devices. These are the level crossings where most accidents happen. However, improvement of visibility at the crossings to achieve adequate sight conditions is not always possible and in these cases the safety can be improved, for example, by setting a driving ban for long and slow vehicles or reduced spot speed limits for trains (Kallberg 2008). The improvement of safety of passive level crossings is challenging since it is not feasible to provide any significant number of them with automatic barriers or flashing lights and bells. In addition to the earlier mentioned measures, the safety of level crossings on minor roads can be improved, for example, by reducing the speeds of road vehicles so that drivers have more time to stop before the railway if needed (e.g. by installing stop signs or speed bumps), improving of vertical alignment of road or using different technical solutions to help drivers to observe the approaching train (e.g. in-vehicle devices in cars to inform about the approaching train). However, despite all the efforts to improve the safety of level crossings, the positive development seems to level off at about 50 yearly accidents, resulting in approximately 10 yearly fatalities.

Over the past ten years, most railway fatalities consist of railway trespassers. These are people who cross the railway lines at places which are not marked for that purpose or people who are walking along the tracks illegally or loitering in the railway area. In the 21st century in Finland, more than half of all railway fatalities (excluding suicides) can be assigned to trespassers. The number of trespasser fatalities has not decreased in a similar way as the other fatalities. The yearly number of trespassers killed has been between 6 and 17 during the 21st century.

The prevention of trespassing is challenging, because nearly everyone is a potential trespasser and the railway lines in Finland, unlike in some other countries, are usually not isolated from the surrounding areas by fences. The problem with trespassing occurs especially in cities, which are divided by the railway lines (Silla and Luoma 2008). Railway lines have always divided communities and in some cases, this separation has become even more marked over the years. This means that new developments within the city such as living areas, shopping areas and schools are often located on both sides of the railway lines, increasing people's need to cross the tracks. However, the actors in the railways have only limited possibilities to improve this situation. The railway authorities can reduce trespassing by restricting the access to railway lines (e.g. by building fences or landscaping) at locations where trespassing is frequent, but due to the great number of such locations, it is important that the other actors of society (e.g. policy makers, urban planners and school teachers) also participate in prevention. In spite of this shared responsibility, these fatalities affect the image of railways and its safety level as experienced by the general public.

At the European scale, the level of railway safety in Finland is around average based on the number of accidents per million train-km. However, the number of level crossing accidents is quite high in Finland.

Consequently, there is still work to be done to improve the safety of Finnish railways. The implementation of safety management systems has made safety work more organised and enhanced preventive safety work in order to recognise safety risks before they lead to accidents. One of the main strategies for the future includes the removal of 1,500 level crossings by the year 2025; according to estimates, this will reduce the number of level crossing fatalities by 50% (Finnish Rail Administration 2006b). Furthermore, more research is needed to find solutions to increase the safety of passive level crossings. Another goal is to involve communities in the safety work related to railway trespassers to decrease the large amount of trespassing accidents.

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