Accidents in railway transportation: Lessons learned from Thailand and France

Kanokporn Sripathomswat[1*], *Lattapon* Promkamol[1], *Worachon* Romruen[1], *Quentin* Arthaud[2] and *Alban* Drouin[3]

[1]Department of Industrial Engineering Technology, College of Industrial Technology, KMUTNB, Thailand
[2]General Engineering School, CESI Nancy, France
[3]General Engineering School, CESI Dijon, France

Abstract. Thailand's railway network spans over 4,000 kilometres, comprising five lines that extend across all regions of the country. This research focuses on applying hazard management techniques, particularly in establishing accident frequency and severity indices to evaluate accident data at railway crossings in Thailand. Utilizing accident data from the Department of Rail Transport's open database (2017-2022), the study aims to identify the most dangerous railway locations in Thailand. To enhance the analysis, geographic information system (GIS) methodologies are employed to visualize accessibility data and identify disparities across different train lines. In a complementary part of the study, French railway incident data are analysed. Security incidents, sourced from the open data of SNCF France and provided by the Établissement Public de Sécurité Ferroviaire (EPSF), are visualized. The research highlights differences in incident severity between the two countries. By comparing these two contexts, the study offers insights into how to restore public confidence in the railway transportation system, emphasizing the importance of tailored hazard management approaches.

1 Introduction

Railway crossing accidents in Thailand have become a major issue in managing rail transportation safety. These accidents result in significant economic losses and undermine the reliability of the national transportation system. According to the State Railway of Thailand (SRT), Thailand's railway network spans over 4,000 kilometres, divided into five main lines: Northern, Northeastern, Eastern, Southern, and Maeklong lines. Within this network, there are 2,657 railway crossings, of which 676 are unauthorized crossings known as "informal crossings". These unauthorized crossings contribute to a high rate of accidents, leading to train delays and substantial losses of life and property [1]. The frequency of accidents at these crossings affects the overall public trust in Thailand's railway system at a macroeconomic level.

To effectively analyse railway accidents, it is essential to study and evaluate the severity and frequency of these incidents. The development of tools that can geographically analyse accident locations along the railway network, showing the frequency and severity of accidents, is crucial [2]. Such tools can help identify accident-prone areas, which are necessary for further investigations into root causes and to propose effective safety solutions.

This research aims to apply risk management techniques to establish standard indices for evaluating accident frequency and severity at railway crossings in Thailand. The study utilizes accident data from the open database of the Department of Rail Transport of Thailand, covering the years 2017 to 2022, along with geographic information system (GIS) methodologies [3]. The accident database is analysed using QGIS (Quantum Geographic Information System), a free, open-source software that allows users to create, edit, visualize, analyse, and publish geospatial data. The study then extends the comparison to include French railway data from Société Nationale des Chemins de Fer Français (SNCF) and Établissement Public de Sécurité Ferroviaire (EPSF), providing insights into similar issues in France. By contrasting these two contexts, the research offers recommendations to restore public trust in Thailand's railway system, emphasizing the importance of risk management tailored to local conditions.

2 Study background and scope

The development of railway systems in France and Thailand has taken very different paths, making direct comparisons impossible based on available open data. According to SNCF, France began constructing its railway network in 1842, quickly developing it into one of the most advanced systems in the world. The country became a benchmark in railway technology, especially with the introduction of the TGV (Train à Grande Vitesse), which has set multiple speed records, including the highest at 574.8 km/h in 2007. France's commitment to high-speed rail has established it as a

* Corresponding author: kanokporn.s@cit.kmutnb.ac.th

leader in railway transportation. On the other hand, Thailand initiated its railway development in 1897 but has progressed at a slower pace. Although Thailand is making efforts to modernize its system, it remains significantly less developed compared to France.

The French railway network, managed by SNCF, spans approximately 27,500 kilometres, with 24,000 kilometres dedicated to passenger and freight trains, and 2,800 kilometres reserved for high-speed trains (TGV). The SNCF facilitates nearly 4 million train journeys annually, transporting approximately 1.4 billion passengers. This study focuses on the 24,000 kilometres of track that accommodate passenger services. The data examined includes operational performance and incident records from 2019 to 2023, a period chosen to ensure the availability of current and relevant information.

Thailand's railway system is managed by SRT, which is a state-owned enterprise. SRT's fares are comparatively lower than other types of transportation because the government considers those as public services. In 2022, around 35 million passengers travelled across 100,000 train routes operated by SRT. Like the study of France, the period from 2019 to 2023 is selected for data collection and comparison. However, Thailand's railway system faces distinct challenges, particularly related to safety at railway crossings. The data analysed includes detailed records of accidents at railway crossings, focusing on variables such as the number of incidents, year of occurrence, GIS coordinates for spatial analysis, type of railway line, proximity to nearby stations, and the train numbers involved in the accidents.

While this study utilizes data from both France and Thailand, a direct comparison between the two countries is challenging. The nature of the data and the context of each railway system differ significantly. For instance, the scale and modernization of the French railway system, with its emphasis on high-speed rail, contrasts with Thailand's more limited infrastructure, which still heavily relies on traditional rail services. Furthermore, the accident data from the two countries are not directly comparable, as the causes, locations, and types of accidents vary based on each country's unique operating environment.

Despite these differences, this study aims to provide a general overview of accident trends in both countries, focusing on railway crossings, which are common points of danger. In Thailand, the large number of unauthorized crossings (often referred to as "dangerous shortcuts") presents a significant safety risk. The study emphasizes the need for enhanced safety measures at these crossings, such as the installation of barriers and warning systems, which have proven effective in France.

3 Methodology

The methodology of this research consists of 4 steps: data collection, database management, hazardous location analysis [4] calculated in Excel, and locating the results in QGIS for Thai railway data. Both Thai and French results and findings are visualized in Power BI. Fig. 1 shows these steps.

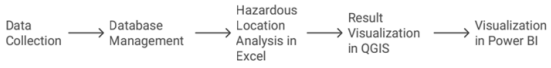


Fig. 1. Research Methodology.

3.1 Data collection

This study utilizes open data sources from both SNCF and SRT. The primary data sources include annual reports, which were supplemented and verified through on-site surveys and actual travel experiences in both countries. These open datasets encompass a wide range of information, including delays, incidents, accidents, causes, number of journeys, and station details. The data formats vary, including structured data (xlsx, csv) readable by Excel, and geospatial and vector data (shapefile, JSON) compatible with Power BI and QGIS. For the Thai railway system, the research relies heavily on data published by the Department of Rail Transport, accessible through the official Thai government open data portal (data.go.th). This dataset, available in Microsoft Excel format, provides a comprehensive six-year historical record of railway incidents. For the French railway system, open data from SNCF (data.sncf.com) is used. The study utilizes both numerical data and spatial data, such as shapefiles and JSON files, which are instrumental in creating interactive maps using Power BI. These diverse data types support a thorough analysis of railway hazards and accidents, enabling a multifaceted approach to safety assessment and visualization.

3.2 Data analysis

Firstly, the data analysis for the Thai dataset was performed using the hazard location analysis method [4]. To assess the severity of railway traffic accidents, two key factors must be considered: the likelihood of occurrence (Hazard Likelihood) and the severity of the accidents (Hazard Severity. For evaluating the likelihood of accidents, the Accident Rate Method) [4-5] was applied. This method incorporates traffic volume and the length of railway tracks to calculate the frequency of accidents.

Next, the severity of accidents was determined by evaluating predefined criteria. The severity scores were calculated by dividing the data into equal intervals based on a normal distribution. The accidents with the highest severity were assigned the highest scores, while those with the lowest severity were assigned the lowest scores. Accordingly, the Thai dataset was visualized using QGIS to rank and display hazardous railway crossings. The visualization method relied on two key factors: accident frequency and severity rate. These were calculated using data extracted from a prepared database. Accident frequency was determined by assessing the likelihood of accidents occurring at different railway crossings, while the severity rate was based on how severe the accidents were. These metrics

were then used to create a matrix-based risk assessment for the railway crossings.

Secondly, for the French dataset, we decided to use Power BI for formatting and visualization. Power BI allows for the creation of interactive reports to visualize various types of data, whether for general analysis or specific locations. The visualizations are based on maps of French and Thai provinces. Since Power BI does not include an interactive map of Thailand, we conducted additional research to locate a Shapefile format, which was then converted into JSON for use within the software. Using this data, we were able to calculate the number of incidents for both countries. However, since France handles more passengers, it is more susceptible to incidents. To compare the two countries on equal terms, we calculated the incident-per-passenger ratio *(IPR)*, as shown in (1):

$$IPR = Annual\ incident\ avg. / Annual\ passenger \quad (1)$$

Additionally, it is essential to consider the scale of each country's rail network [6]. Therefore, we also calculated the incident-per-kilometre ratio *(IPK)*, as shown in (2):

$$IPK = Total\ crashes / Kilometer\ of\ rail\ track \quad (2)$$

In the next section, we will briefly present the results.

4 Results

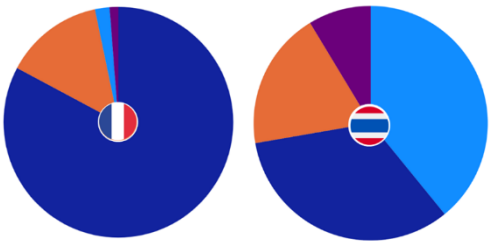
The results of the first part of this research, for the Thai dataset, were displayed on a 2D map of Thailand, showing railway routes and the locations of railway crossings (informal crossings). Each crossing was represented by a point on the map, with the points color-coded based on the calculated level of hazard. Crossings with higher accident frequency and severity scores were shown in more intense colours, indicating a higher level of risk. This clear visualization, shown in Fig. 2, enables a comprehensive analysis of dangerous railway crossings and provides essential guidance for future planning and improvement efforts. Additionally, the QGIS results can be further integrated into Google Maps for hybrid visualization to support decision-making.

Fig. 2. QGIS results of Thai railway accident data.

The French dataset in this research is limited because the available open data does not include precise accident locations on the map (hazardous locations, meaning specific points where accidents occur frequently), unlike the open data for Thailand, which provides this information. As a result, in the second part of this research, we used the equations mentioned earlier to calculate IPR (the number of incidents per passenger) and the IPK (the number of incidents per kilometre of railway track) to compare the railway accident data between France and Thailand.

For IPR, in France, there is an average of 183 incidents per year with 1.4×10^{9} passengers, resulting in 13×10^{-8} incidents per passenger. In Thailand, there is an average of 101 incidents per year, resulting in 29×10^{-7} incidents per passenger.

In France (Fig.3), 15% of railway incidents resulted in serious or significant consequences, including minor injuries, serious injuries, or fatalities. The higher percentage of serious outcomes in France suggests that while the overall number of incidents might be controlled, a larger proportion lead to injuries or fatalities. This could be due to factors like higher passenger volumes or faster train speeds, especially considering France's extensive high-speed rail network (such as the TGV). In contrast, Thailand recorded that 52% of railway incidents resulted in serious or significant consequences. Although the percentage of serious incidents is lower than in France, the overall safety of Thailand's railway system remains a concern, particularly regarding the frequency of accidents. The lower severity rate may be due to slower train speeds or different types of incidents, such as those occurring at informal crossings (unprotected places where people cross the tracks), which may result in fewer severe injuries but more frequent accidents.



1: Minor safety event that could have minor injuries or material consequences
2: Event that could have human consequences
3: Accident with significant consequences
4: Accident with serious consequences

Fig. 3. Distribution of incidents by severity (France vs Thailand).

In comparing the two, while France experiences a higher proportion of severe incidents, Thailand faces a greater challenge in accident prevention, particularly at unprotected crossings. This highlights different safety challenges between the two countries, with France needing to address the severity of incidents and Thailand focusing on reducing accident frequency.

5 Conclusion

In this study, a hazard assessment was applied to rank the accidents at the railway crossing of the Thai railway system, using criteria based on accident frequency and severity through QGIS mapping. Then, data were compared between security incidents from the open data provided by SRT (Thailand) and SNCF (France). The data were visualized, and compared to highlight key differences. The research underlines the variation in incident severity between the two countries. The findings from this comparative analysis suggest future directions for Thailand, where adopting certain safety measures used in France, particularly at railway crossings, could be beneficial. By investing in infrastructure improvements, such as reducing the number of dangerous crossings and modernizing older parts of the network, Thailand could significantly lower the frequency of accidents that will enhance railway safety.

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