Rail Passenger Service Delays: An Overview

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***Abstract*- This paper draws an overview of rail passenger service disruptions which lead to service delays. Some findings on the train service delays in some parts of Asia and Western Europe are presented. The types and causes of service disruptions are analyzed across some rail network operators. The equivalent cost measures of delays done by past studies are also discussed. These costs are expressed in terms of monetary and time value. Finally, the benefits obtained from some improvement projects, are briefly addressed. In total, this review suggests that there is an urgent need to minimize service delays for passenger trains, which solution approaches may be obtained from a mathematical model.**

Keywords- service delays; rail passenger; delay causes; delay cost.

I. INTRODUCTION

Rail transportation plays an important role in the development of a country. The rail transport network is considered as one of the important modes of public transportation to meet the diverse expectations of urban economic activities due to the fast growing population growth of the nation. For most countries, it is a major service provider for both passenger and freight transportation. As demand for rail services increases, the service performances of the urban railway system which are dissatisfactory to the public are often discussed in public forum and media.

Occasionally, there occur unexpected events which lead to the inability of the train to run within their scheduled timetable. Such event is termed as disruptions. Disruption is defined as an event or a series of events that renders the planned schedules for aircraft, crew or other timetable to be infeasible [1]. Service disruptions in most cases often lead to non-adherence to scheduled timetable and thereon leading to service delays. Rail service disruptions do not only occur in less developed countries, but also in highly developed countries where the services are advanced and equipped with sophisticated technology and infrastructures.

Kroes *et al.* [2] found that for the Paris suburban rail network services in 2004, there was a 5% to 16% cases of delayed services during its peak hours. In the United Kingdom, a total of 800,000 cases of delays were recorded on the national rail network in 2006-2007, which was equivalent to 14 million minutes of delay [3]. In addition to this, the railway network of Netherlands approximate 17 daily disruption infrastructure-related events, with a daily period of 1.8 hours [4]. The national railway service is always being the subject of criticisms due to the frequent service cancellations, combined with unclear and inconsistent travel information.

In Malaysia, a 40-minute delay or more is quite common with its urban commuter rail system, KTM Komuter, during morning and evening weekday peak hours [5]. As a result of prolonged waiting time, the rail cars become overcrowded, creating a chaotic situation along the journey. In addition to this, in a survey done to evaluate the customers' perception towards the commuter rail, 67% of the respondents stated that the trains are always delayed [6]. In the case of Indonesia, a study has revealed that a total of 74% of the total passenger train services in 2007 arrived later than the scheduled time [7]. This relatively high percentage implies that majority of the journeys made on trains would end up arriving late. The effects of these findings would indicate that people may be deterred from taking trains as their mode of transportation.

Table I Section A summarizes some related findings on issue of train delays in some parts of Asia and Western Europe. When people choose to commute by train, they expect to arrive at their destination at the scheduled time. However, when service trips do not adhere to schedules, travelers arrive to the destinations later than expected, causing much frustration and discomfort. The service disruptions would force passengers to wait thereby leading to loss of economic productive man-hours that they could have instead spent at their office. If this unpleasant situation continues, then people would leave the public transport for their private vehicles. The road congestion and carbon dioxide emissions from vehicles will continuously be the environmental issues being debated everywhere. Sustainable mobility could not be achieved when the public transport is only theoretically be regarded as a green mode of transportation. Therefore, there is a need for the public to understand the underlying problems in rail service disruptions. To educate them, related facts supporting the rail disruptions need to be highlighted.

This paper describes the overview of railway service disruptions or service delays, focusing only on passenger rail transport system. Section II describes the general types and causes of delays which frequently affect rail services. Section III presents the equivalent cost of service disruption borne by the service providers and the passenger. Section IV, on the other hand, highlights the benefits realized from improvement projects carried out in dealing with service disruptions, while Section V presents the final remark and conclusion.

II. CAUSES OF RAIL SERVICE DELAYS

Train service is highly affected by unavoidable disruptions representing the operational difficulties, such as traffic, load, accidents, maintenance problems or other operational difficulties. These factors are regarded as the common drivers affecting the punctuality of the service rendered. When disruptions occur, trains become oversaturated, bottlenecks are created, travel times are extended thereby causing annoyance among the passengers.

One of the early studies on the causes of railway service delay was done by Higgins *et al.* [8], who grouped them into three types of delay. The first category is track related delays, which involve train slowing down or stop due to track problems. The second category is train dependent delays, which are caused by train car malfunctions. The final category is called terminal/schedule stop delays, which take place at the railway station or terminals. This is a simple categorization of service delay causes, and yet it is very practical and truely represent the related underlying causes.

More recent literatures categorize the reasons of delay according to the nature of delay itself. Nelson and O'Neil [9] grouped the causes of delays as engineering and mechanical malfunctions, programmed track work, transportation crew failures, passenger-related issues, weather and cascades. The hierarchy of causes has recorded engineering failures as the most common incident whereby it recorded 25% of all reported delay minutes. It is followed by cascade delays that accounted 20% of the entire delay minutes. Cascades were usually coded as transportation delays instead of their root cause. This type of delay which resulted from earlier delays of other trains, however does not depict the true situation of the problem. This will unintentionally leave the real root of delay causes left unnoticeable. Some literatures called this phenomenon as *knock-on effect*. Passenger-related delays, which contributed 13% of the total delay minutes, include delays due to passengers with special needs such as the elderly, handicapped, sick or heavy baggage passengers. Some rail operators might be affected by this type of delay while there are many operators which do not give any special attention to these group of passengers. Hence, many service delays recorded by some rail operators do not include this as one of the delay causes.

A report on research in UK during the year 1999-2000 revealed that train delay caused by rail operator contributes 50% of all delay minutes [10]. This category of delay includes the train faults, crews as well as operation and station delays, among others. Poor rolling stocks are the main cause of the train faults which are mainly due to frequent breakdowns and low train speed. The other category of delays which comprised 35% of the delay minutes is due to the network or railway infrastructure causes. Besides the network operations, this category also include the track and signaling faults. The final category of delays of 15% includes all external causes which are beyond the control of the railway operators. These include unexpected events like vandalism, extreme weather, accidents and others. During the year 2006-2007, a parallel work undertaken by the National Audit Office of London found that the percentage of delay caused by rail operator has dropped to 38% while the delay caused by rail track has risen to 42% and those caused by external causes has also increased to 20 percent. The findings indicate that the railway operators have undoubtedly taken significant measures in improving their operational performance and bringing the percentage delay down. The maintenance agencies, on the other hand, should be responsive for the increasing number of railtrack breakdowns. Even though the external causes are beyond the control of the rail operator, there should be an efficient information link with the emergencies services so that the impact of the unexpected delay events can be effectively minimized.

Groth *et al*. [4] highlighted that the common disruptions of the Dutch railway are mainly due to infrastucture and operators problems. Infrastructure reasons include the technical failures and external problems caused by third party. On the other hand, the operators problems recorded 45% of total passenger-related delays, 30% of rolling stock problems and 15% of delays are caused by the crews. This paper highlighted the two officials mainly responsible in the problem of service delays were the infrastructure managers and the railway operators. It presents a clear view of how the major responsibilities for the different sections are shared among the officials. Not many research works address the two parties distinctively when finding the solution approach. The different tasks carried out by each party are often neglected in railway disruption studies.

In Malaysia, the urban commuter trains are jammed by about 100,000 commuters daily during weekdays. Theoretically, in order to provide a service on 15-minute schedule, it requires at least 36 electric multiple units or EMUs. However due to maintenance problems, the availability of EMU has been down to 21 units and even as low as 15 units on some unfortunate days [5]. The situation has also deteriorated when the Komuter service are extended to more stations but without additional EMUs.

Table I Section B summarizes some of the causes of passenger train delays which are being discussed in this paper. The engineering or mechanical malfunctions are the most common reasons for train delay. This undoubtedly refers to the poor maintenance of the rail cars. With regard to the spare parts, they are usually imported, very limited and expensive, while their maintenance cost are relatively very high. For some rail companies, lack of fund and financial support also prevented the coaches from undergoing regular preventive and corrective maintenance. These are among the reasons as to why train cars frequently breakdown or left unrepaired.

External reasons are one of the causes contributing to the disruption of passenger train schedule. The service delays caused by external factors usually involve events which are

TABLE I
OVERVIEW OF RAIL SERVICE DELAYS

A. Findings of past studies on passenger train delays

Rail Operator	Year of study	Proportion of delayed rail service
Malaysia KTM Komuter [6]	2010	67% of a survey respondent categorized the train service as always delayed.
Dutch Railway Network [4]	2009	On average, the railway network has 17 daily disruptions or equivalently 1.8 hours of delays.
PT.KAI Kereta Api Indonesia [7]	2007	74% of the commuter trains arrived late.
Great Britain National Rail Network [3]	2006/07	800,000 number of delays or 14 million minutes of delay were recorded.
French National Railway Network [2]	2004	5%-16% of the rail services were delayed.

B. Possible causes of passenger train delays

Rail Operators	Engineering	Passengers	Rail tracks	Cascades	Rolling stock	Drivers	External
	Mechanical						
Anonymous commuter rail [9]	•	•		•			
Great Britain National Rail Network [10]	•		•		•	•	•
Dutch Railway Network [4]	•	•			•	•	•
Malaysia KTM Komuter [5]	•				•		

C. Recent delay events due to external causes

Rail Operators	Year of events	External causes of delay	Disruption on services
Network Rail of Britain [11]	2011	Copper cables theft.	1,969 train services were cancelled .
East Japan Railway [12]	2011	Wiring malfunction and computer control system.	Bullet train service was interrupted for hours in January.
Beijing Railway [13]	2011	Power outages.	Train arrived 2.5 hours late on July 13.
India Kanchankanya Express [14]	2011	Derailment and fire on diesel tankers.	Train delayed for 16 hours on Sept 30.

D. Cost measures of rail service delays

Rail Operator	Year of cost measurement	Cost Valuation
Swedish Railway [18]	2010/11	Cost the society about 2.4 billion kronor ($372 million) due to lost working hours.
US Class 1 Railroad [16], [17]	2007 2011	The average total train delay cost was estimated at $213 per train-hour. This value has increased to $232 per train-hour in a recent study.
Great Britain National Rail Network [10]	2007	Long distance business travelers valued the price of delay time as 54.83 pence per minute. Other-purpose short distance travelers valued the price of delay time as 21.23 pence per minute.
British Rail Intercity [15]	1984	1 minute of average train lateness is equivalent to 2.5 minutes of scheduled journey time.

E. Improvement projects benefit

Country	Benefits from projects done
Netherlands [20]	Train punctuality has increased from 84.8% to 87%. Projected profit of 10 millions Euro for 2007 and 20 millions Euro for 2009.
France [2]	Expected to reduce train delays of 5 to 15 minutes from 10.8% to 7.9%. Equivalent time savings per trip was estimated as 2 minutes and 50 seconds. Total punctuality benefits are 9.9 million Euro per year.
Hypothetical route model [21]	The optimal time point schedule expects a benefit of 4.5 minutes of riding time per passenger.

beyond the expectation of the rail operators, which may be due to third party or extraordinary events which rarely occured. Some of these events which took place in the year 2011, are highlighted in Table I Section C.

Britain's railway was hit by 1,602 incidents of copper cables theft from April to October 2011[11]. The price hikes of copper which has tripled to about 5,000 Euro a tonne has lead to service disruptions. A cable theft incident had caused 1,969 cancellations of scheduled trains and 8.5 million Euro lost in revenue. Not only the rail operators has to spend millions of pounds to repair and replace the stolen cables, but also to pay out compensation to train companies for the system delays.

There is no exception on the prestigious Japan bullet train system from suffering the service disruptions due to external causes. In January, a wiring malfunction interrupted three lines for four hours, followed by an overloaded computer control system a few days later, that brought five lines of the bullet train service down for an hour [12]. These events are considered as external delays because Japan's high technology train system is widely recognised for its punctual rail service and delays problems are very rare.

Unexpected delays recently occur at Beijing-Shanghai new high-speed line. Power outages disrupted the services and brought the train arrival two and a half hours behind schedule [13]. The rail operator was criticized by the public in media reports, internet blogs and online forums. In India, fire spotted on diesel tankers has lead the tanker to steered towards Chanabana to avoid the crowded locality of Magurjan [14]. Unfortunately, it was accidentally derailed and fire has caused a 500 stretch of tracks melted. As a result of the railtrack damage, passengers of Kanchankanya Express have suffered 16 hours of service delay. Even when the train run late, it stopped for another hour in the journey. This has caused the passengers to initiate chaos, ransacked the station master's office and broke the train windows. These are some of the unexpected events of train delays which rarely occur, but yet have caused a significant impact to not only the train operators, but also the passengers.

III. COST OF RAIL SERVICE DELAYS

There are many literatures that have attempted to associate the train delays with its subsequent cost. These costs may be established in terms of financial values or equivalent delay minutes. One early study on valuing delay was done by Benwall and Black [15] on British Rail which stated that 1 minute of average train lateness is equivalent to 2.5 minutes of scheduled journey time. The respondents who were the train passengers gave a different perception on the aim to minimize the maximum lateness of train and the minimize the total number of late train.

A hypothetical stated preference study was carried out in 2007 which examined the financial value of delays on passenger train services. The experiment used segmentation technique whereby it separated data by distance and journey purpose [10]. Distance aspect was categorized as short and long whereas journey purpose was categorized as business, commuting and other purposes. The findings showed that the highest price of delay time of 54.83 pence per minute was valued by the long distance business travelers whereas the short distance travelers with other journey purposes valued the least price of delay time of 21.23 pence per minute. The findings obtained in this study may not represent the accurate value of time delay, due to the limited segmentation of distance (long and short) and journey purposes (business, commuting and others). There should however be more segmentations made so as to reflect the various distance intervals and travel intentions.

Besides passenger trains, research were also undertaken to comprehend the delay cost incurred by freight railroad transporter. Schafer [16] studied the broken derailments and service disruptions of US freight traffic and developed a train delay cost calculator to value train delay. The average total train delay cost US Class I railroads was then estimated at $213 per train-hour. This delay cost has increased to $232 per train-hour in a recent study done by Schlake [17] which did not incorporate the lost revenue due to lading delay. The increasing delay cost would definitely continues with time. As time goes on, it is not impossible that in few years time, another research work will record a sharp rise on the delay cost.

Train delays are also attributed to weather conditions, as in the case of Swedish Railway. The railways recently experienced train delays due to extra-ordinary bad weather. The heavy snowfalls and cold record during the winter in 2010-2011 has wiped out major Swedish railways and the downed power supply has prompted train service delays [18]. Even though the traffic woes are expected in yearly winter, this time it has cost the society about 2.4 billion kronor ($372 million) due to lost working hours. A total of 22 million tonne-hours worth of delays has affected the cargo traffic while the cost of cancelled freight trains was valued as 200 million kronor. Even though the administration has budgeted the costs for the recovery works, the amount that need to be spent is extremely huge. This natural disaster, however, does not stop the public to criticize the Swedish rail service for its late information about service delays and cancellations.

These cost measures of rail service delays is outlined in Table I Section D.

IV. IMPROVEMENT PROJECTS BENEFITS

As punctuality and reliability of train affect the regularity measure of the rail services, various projects and studies are undertaken to analyze the benefit that could be realized if the service regularity is to be improved. Even though some improvement projects were successfully implemented by the rail companies, there are also projects which are only carried out hypothetically and or still undergoing testing phases. Table I Section E addressed some of the improvement projects benefit carried out.

A case study on the railway network linking Paris to its suburban rail services was done in 2005. Among the main objectives of the study is to improve the service quality including passenger train punctuality [2]. New service measures were proposed in terms of the installation of additional railway tracks and increasing the frequency of trains per hour. The 324 million Euro project was expected to reduce train delays of 5 to 15 minutes from 10.8% to 7.9 percent. The equivalent punctuality time savings per trip was estimated as 2 minutes and 50 seconds, while the total punctuality benefits for existing passengers are 9.9 million Euro per year. As a whole, 41 million Euro will be realized on the total benefits with regards to travel time plus punctuality improvements. The project has demonstrated a comprehensive mix of qualitative and quantitative approach to quantifying the monetary benefits of punctuality improvements. The method can be applied on other similar rail services or extended to other modes of public transportation elsewhere. The details on the project implementation are disclosed in Kroes *et al.* [19].

In 2006, when the Netherlands Railway implemented a new timetable to support its planning processes, significant investments were made to replace its 1970s timetable with a more robust ones to improve its train delays [20] . The investments use innovative operation research (OR) techniques in scheduling its rolling-stock and crew costs. As a result of the new planning, train punctuality has increased from 84.8% in 2005 and 2006, to 87% in 2007. With a predicted steady punctuality rise of 1.5% per year, the company anticipated an additional profit of 10 million Euro for the year 2007 and 20 million Euro for the year 2009. The new timetable will not only facilitate the growing demand of the Dutch society, but it also estimates that the Dutch economy will benefits 8 million Euro per year for every percentage-point increase in punctuality.

Furth and Muller [21] presented a new approach in quantifying the user costs associated with service unreliability. The theory of the experimant is to look into the impact of scheduling with different numbers of time points and different levels of running time and cycle time supplements. Using a simple hypothetical route operation model, the expected benefits from the optimal time point schedule is 4.5 minutes of riding time per passenger. Taking more stops as the time points will consequently increase the benefits. This method of measuring the user costs is very practical and it is not only applicable to rail services but also other modes of transportation.

V. CONCLUSION

The many cases of passenger train delays and its clear impact on the users, regulators as well as the operators at both domestic and international levels have been the motivation behind this review paper. The many criticisms on railway companies for these service delays and its impact have led to many research works being undertaken and discussed in great length. This paper has discussed the types and causes of rail service delays and the cost incurred in terms of monetary and time value. It eventually highlighted the benefits obtained from the improvement projects being carried out.

Train punctuality is a very important attribute of the public transport system. The perceived utility of the system will definitely decrease if trains are late or cancelled very often. Even though rail operators strive hard to increase its market share in the mobility market, it will not be able to achieve its target if the the people expectations on service punctuality are not met. Therefore, it is a major challenge for railway operators to cope with the problems and look for new solutions and approaches which are both practical and economical in improving the service punctuality.

This paper is part of a study that will be conducted on the passenger rail service delays within the Malaysia commuter rail system. The review justifies the need to minimize service delays for the passenger trains. Thus, solution approaches in the form of mathematical model which minimizes service delay due to disruptions are to be developed and proposed to the railway operators. These solution approaches will be presented in next papers of our study in the near future.

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