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DESIGN PLANNING OF A RAILWAY NETWORK SYSTEM: USING A SIMULATION MODEL

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Graphical abstract

Abstract

Railways are one of the most popular means of mass transportation systems. The proposed approach has a universal characteristic that can be applied by cities or authorities to design a strategic plan of urban transportation systems that can solve advanced transportation problems. This study focused on designing a new railway network between two big cities in Malaysia—Kuala Lumpur and Kuantan. The simulation model applied for planning the new railway design and analysis is an important factor. The overall objective of this approach is to increase the advantages of passenger service and public transportation systems as well as to make available other transportation means between these two cities. In addition, the model will also choose the best railway network that can accommodate more passengers along the routes between these two cities.

Keywords: Transportation system, railway design, simulation model, neural network

Abstrak

Kereta api merupakan salah satu sistem pengangkutan massa yang popular. Pendekatan universal telah dicadangkan dan ia boleh digunapakai di bandar dan oleh pihak berkuasa untuk mereka bentuk pelan strategik sistem pengangkutan bandar bagi menyelesaikan masalah pengangkutan maju. Kajian ini memberi tumpuan kepada mereka bentuk rangkaian kereta api baru antara dua bandar-bandar besar di Malaysia iaitu Kuala Lumpur dan Kuantan. Model simulasi digunakan untuk merancang reka bentuk kereta api baru dan analisis faktor-faktor penting. Objektif keseluruhan pendekatan ini adalah untuk meningkatkan perkhidmatan penumpang dan sistem pengangkutan awam dan juga untuk menyediakan kategori pengangkutan lain yang sedia ada di antara bandar-bandar. Di samping itu, model rangkaian kereta api terbaik akan berupaya untuk menambah lebih banyak penumpang antara kedua-dua bandar.

Kata kunci: Sistem pengangkutan, rekabentuk landasan, model simulasi, rangkaian neural

1.0 INTRODUCTION

The main problem of transportation systems in Malaysia is that it does not generally achieve a satisfactory level of feedback by many of its customers. This is due to the inability of the transportation system itself to connect customers to many different places. The railway network is one aspect of transportation system's operations, which is a requisite in creating new train lines that interconnect cities to enhance the transportation system and fulfil customer satisfaction [1, 12].

In Malaysia, the railway system is state-run and covers a total of 1,849 km. Popular within the cities is the Light Rail Transit, which reduces traffic load on

other transportation systems and is considered safe, comfortable and reliable.

In this study, a new railway line is proposed between two big cities, which are Kuala Lumpur—the capital city of Malaysia—and Kuantan, Pahang. A new railway is pertinent because it connects between two very essential cities, whereby it involves more active passenger transportation due several important tourism spots between the two cities with the potential to increase the passenger ratio of this railway. Currently these two cities are only connected by a highway federal roads in which facilitate road transportations such as cars and busses.

This study proposes a simulation approach for the planning and design of a railway transportation system. The base of the simulation is intended to seek a new railway design by incorporating transportation planning and operational strategies [4, 8, 9]. The objective of this model is to advance a new active transportation option among the spots located between the two main cities in Malaysia as this model will apt to increase customer satisfaction and therefore contribute to profit gain its operation [2,3,5].

The contributions of this study are from the application of the simulation model to achieve three objectives: First, to analyze the data collection for the design of a new railway. Second, to develop a model that enhances the efficiency of transportation systems—by offering a new transportation option for passengers between these two cities. Thirdly, to increase the profitability of the transportation system.

1.1 Literature Review

Railway systems in Malaysia have been state-run since 1885 and cover a total of 1,849 kilometres (1,149 mi). 1,792 kilometres (1,113 mi) are of narrow gauges, while 57 kilometres (35 mi) are standard gauges. 438 kilometres (272 mi) of the narrow gauge and standard gauge tracks are electrified. Railways in Malaysia began because of the need to transport tin from mines in the hinterlands of the West Coast states of Peninsular Malaysia to the coastal ports. The first railway line, which was opened on 1 June 1885, was about 13 km long and ran between Port Weld and Taiping, the heart of the tin-rich Larut Valley in Perak. The latest railway is the Klang Valley MRT—a proposed three-line Mass Rapid Transit system by Gamuda Berhad-MMC Corporation Berhad, stretching 150 km, in Klang Valley. The system envisages a "Wheel and Spoke" concept comprising of two northeast-southwest radial lines and one circular line looping the city of Kuala Lumpur.

The intercity railway network in Peninsular Malaysia consists of two main lines: The West Coast Line between Singapore and Padang Besar, Perlis—the Malaysian-Thailand border—and the East Coast Line between Gemas in Negeri Sembilan and Tumpat in Kelantan. Figure 1 shows the train line map in Malaysia. There are also several branch lines between Kuala Lumpur and Port Klang, Batu Junction, Batu Caves, etc. The entire 1,699 km network uses the 1,000 mm (3 ft 3 3⁄8 in) gauge track. The network is linked with the Thailand railway network at Padang Besar and Rantau Panjang [3]. However, the train transportation in Malaysia still doesn't cover all states and this impacts the effectiveness of transportation systems in Malaysia.

Figure 1 Train line map in Malaysia

Figure 2 A new plan for railway system

Table 1 Population for each city

No. City	City	Population
1.	Kuala lumpur	1,627,172
2.	Genting	15,000
3.	Karak	249,100
4.	Tenerloh	149,000
5.	Maran	67,000
6.	Gambang	88,000
7.	Kuantan	807,778

Table 2 Annual passenger number

Bus Category	Gambang	Maran	Tenerloh	Karak	Genting	KL Sentral
Kuantan	85143	7098	9523	12133	8007	951537
	Gambang	2067	4598	1398	1120	5490
		Maran	3660	2928	1196	4026
			Tenerloh	3294	3660	7686
				Karak	5124	5124
					Genting	1830
						KL Sentral

Table 3 Bus distance time between stations (minutes)

Bus Category	Gambang	Maran	Tenerloh	Karak	Genting	KL Sentral
Kuantan	20	55	98	142	172	188
	Gambang	35	76	119	134	150
		Maran	44	104	160	175
			Tenerloh	46	101	137
				Karak	61	67
					Genting	35
						KL Sentral

2.0 DESIGNING THE NEW RAILWAY NETWORK SYSTEM

2.1 Case Study

This study focuses on designing a new railway line connecting between Kuala Lumpur and Kuantan. This railway will be interconnecting many tourist attractions and popular spots such as Beta Cave, Genting, France village, Gambang Resort Park and other tourist destinations in Kuantan including government and public sites such as International Islamic University Malaysia (IIUM), Maran University, University Malaysia Pahang (UMP), and other colleges. Therefore, the new railway system is very important as it covers many tourists and government/public areas. Figure 2 shows the new railway network system that is recommended by the simulation model, relying on the data collection between the two cities.

Figure 2 shows the new railway design that passes through 7 stations. This line starts in KL Sentral and ends at the Bus Terminal in Kuantan. It passes another 5 stations between these two cities, which are Terowong Genting, Karak, Temerloh, Maran and Gambang. The total distance is 301 KM. Currently, there is only one federal road connecting between these cities. This single lane road was established more than 50 years ago.

2.2 Data Description

There is a substantial collection of data related to this study that may affect the new railway design [6]. These data will be described in this section. Table 1 shows the population for each city's train station. The population factor is very important in the planning of a new design [10]. The new railway design is established by using a simulation model. The model relies on population as one of the primary factors for designing the railway.

Table 2 presents an annual passenger number between the train stations. This data was collected from the bus transportation system. Table 3 presents the distance in time between the train stations. This data was also collected from the bus transportation system.

2.3 Simulation Model

A computer simulated model is the only viable means for the evaluation and analysis of the transportation system [7, 11]. This model can create and improve the new railway design depending on actual data of this railway line, which consists of the number of urban population for each city of this line. Thus, the model will point towards the best railway line. Figure 3 shows the simulation model flowchart.

The model achieved the three objectives which are (1) To design a new railway that covers all major urbanizations between Kuala Lumpur and Kuantan. (2) To minimize the distance time among the train stations. (3) To minimize the transportation costs between the train stations besides enhancing customer satisfaction. Thus, the model followed Equation (1) and (2) to achieve these objectives. Equation 1 was used to maximize the efficiency of the new train line by choosing the best line that connects/links more popular cities as well as tourism and government/public cities.

$$\text{Max}\ (P, A) = \sum_{i=1}^{n} \sum_{j=1}^{m} (p, a)_{ij} * X_{ij} \quad (1)$$

Where:
P: population in each city;
A: Annual passengers

Equation 2 is to minimize the distance time and transportation cost among the cities.

$$\text{Min}\ (D, C) = \sum_{i=1}^{n} \sum_{j=1}^{m} (d, c)_{ij} * X_{ij} \quad (2)$$

Where:
D: distance time;
C: transportation cost

3.0 RESULTS AND DISCUSSION

3.1 Distance Time

After applying the model to the distance time between the cities, a reduction of around 50% was obtained. For example, the distance time between KL to Genting, which appeared as 35 minutes using public transport such as buses, will be reduced to only 18 minutes when using the trains. Table 4 shows the distance time between the train stations.

3.2 Transportation Cost

The model also estimated ticket pricing between the train stations. The transportation cost has been reduced by 10% when using the train. Table 5 shows the ticket pricing between the train stations.

4.0 CONCLUSION

This study focused on two major objectives which are: First, to fulfill customer satisfaction and second, to increase the profitability. These achievements were realized by the following terms:

1. Developing a simulation model that is used to design the new railway between Kuala Lumpur and Kuantan, which is more effective and efficient.
2. Improving the customer satisfaction level by reducing the transportation costs by approximately10%.

3. Increasing the volume of the customers that will eventually generate more profits.
4. Reducing the distance time between the cities by approximately 50%.

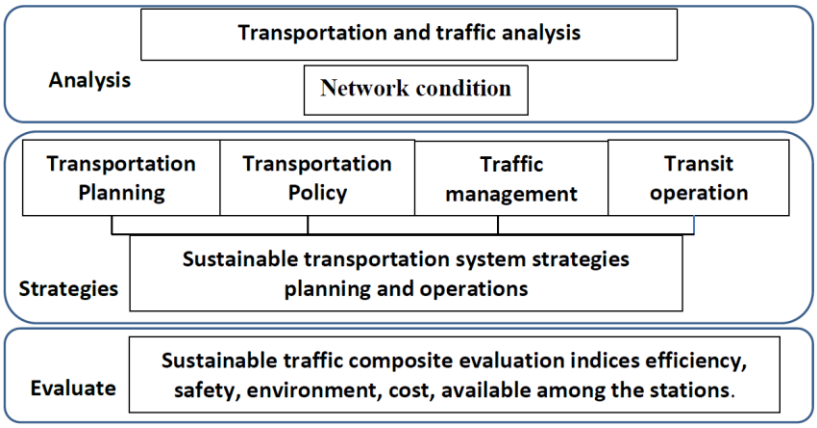

Figure 3 Simulation model flowchart

Table 4 Bus duration time between the stations (minutes)

Train system	Gambang	Maran	Tenerloh	Karak	Genting	KL Sentral
Kuantan	10	30	49	73	92	110
	Gambang	20	42	70	85	100
		Maran	23	60	90	92
			Tenerloh	24	60	85
				Karak	20	35
					Genting	18
						KL Sentral

Table 5 Train ticket pricing between the stations (MRM)

Train Station	Gambang	Maran	Tenerloh	Karak	Genting	KL Santral
Kuantan	4	8	12	16	18	20
	Gambang	6	10	12	16	18
		Maran	6	10	12	16
			Tenerloh	6	10	14
				Karak	6	12
					Genting	10
						KL Santral

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