The Journal of ARSYM

A Publication of Students' Research of the Annual Research Symposium in Management

Volume: 3 Issue: II - December 2023

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National Library of Sri Lanka - Cataloging in Publication Data
Journal of ARSYM (JARSYM)
ISSN No: 2756-9373
Bar Code: 9772756 937008

Published by:
Faculty of Business Studies and Finance
Wayamba University of Sri Lanka
Kuliyapitiya, Sri Lanka
Tel: +94 37 228 4216
Web: http://bsf.wyb.ac.lk

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- Banking
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- Operations management
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- Strategic management

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The Simulation on Toll Ticketing Performance: A Case Study of The Highway Ticketing Counter at Kadawatha Interchange

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ABSTRACT

The transportation sector in Sri Lanka plays a crucial role in nourishing the local economy. Apart from numerous other transportation aspects, the expressways, which are also referred to as highways, serve a vital portion of the transportation revenue. This study focuses on analyzing the queuing system at the Expressway Ticketing Counter at the Kadawatha Interchange. Both the existing and proposed systems were modeled using the ARENA simulation tool. Direct observation was the method utilized to collect data, which was then analyzed and simulated using ARENA software. Some modifications were deduced for the existing system to achieve the optimum output, and three models were developed: (1) Model with automated barrier arm: M1, (2) Model with E-tag system installation: M2, (3) Model with Open Road Tolling system installation: M3. Among these three models, M3 gives the best performance, but with its practical implementation, it is not feasible to implement. Therefore, the model M2 was recommended for the implementation procedure according to the Sri Lankan context.

Keywords: *ARENA Simulation, Input Analyzer, Multi Server Queuing System, Open Road Tolling, Toll Plaza*

1. INTRODUCTION

Sri Lanka's extensive network of roads and highways is assisting in driving the economy and moving people and goods more quickly. This allows the country to become an integrated hub for trade and commerce in Asia. The national government has laid special emphasis on improving road networks to meet traffic demands. Today, it is a modern highway with steady traffic, including an increasing number of tourists traveling to Sri Lanka's historic sites. The road was upgraded as part of the ADB-supported National Highways Sector Project and is part of a vast network of roads and highways built or improved over the last decade. The section of the E03 expressway under our observation spans from Kerawalapitiya to Kadawatha. Specifically, the toll plaza placed at the Kadawatha exit has three toll counters, which are all Manual counters. A vehicle that arrives at the counter pays the relevant toll charge. As soon as the payment is settled, the billing officer lifts the barrier arm. Immediately, once the vehicle leaves the toll counter, the barrier arm is dropped.

1.1 Problem Identification

With increased traffic in the future, the possibility of traffic queues forming at entry or exit points during congested periods can cause significant time delays and may result in reduced highway performance. At the moment, since manually operated toll gates have been installed and traffic has increased, it is intended to see if their efficiency is sufficient to handle higher vehicle volumes. A queue's waiting time is determined by the performance of the vehicles in the queue as well as the server's performance. The reason for the time choice is that Friday afternoons, particularly from 3 p. m. to 4 p. m., the Kadawatha highway interchange is extremely busy with vehicles rushing to leave Colombo for the weekend.

1.2 Significance

In addition to recent expressway developments on the island, Kadawatha has been chosen as a major Colombo Expressway interchange connecting the Southern, Airport, and Central expressways. The recently constructed Kadawatha city bypass has greatly aided motorists.

1.3 Objectives

The goal of this study is to determine the impact of toll gate efficiency on the capacity of the Highway Kadawatha Interchange by measuring queue waiting time. It entails investigating the current state of affairs in interchanges and developing recommendations for future implementation. These objectives entail the following:

- To find any inefficiencies at toll gates that are manually operated.
- To suggest solutions (new systems) to minimise the queue at the toll gates.
- To check the feasibility of the designed systems for the implementation of the Sri Lankan context.

1.4 Nature of Arrival

The day chosen was a fairly busy day, and a particularly busy time, vehicles arrived in droves. Because there were heavy vehicles in the queue at times, many vehicles chose the other counter when this scenario occurred. The queues chosen were larger than three vehicles, so when the vehicle arrived, it had to wait for a while.

1.5 Nature of the Service

A toll booth is a small structure on some highways and bridges that collects fees from drivers who use them. Two toll booths have been selected for the study. At the toll, there is a person who collects the money and issues the ticket. In addition, the person opens and closes the barrier for each vehicle one by one. The majority of the delays occurred during the service.

1.6 Queue discipline

Below are some disciplines that the users have to maintain.

- Maintain a safe distance from the vehicle in front.
- The maximum speed on the Expressway's entry/exit ramps is 60 kilometres per hour.

– Make sure to have enough money to pay the "user fee." Change will help to avoid delays at toll gates.

2. LITERATURE REVIEW

Among the various types of transportation options available in Sri Lanka, road transportation is one of the most highlighted areas of modern development plans. Road transportation covers more than 90% of the land transport in the country. Therefore, with the intention of developing and upgrading road transportation, the government has planned to construct expressways for its road network (Rodrigo & Edirisinghe, 2015).

According to the study conducted by Vidanapathirana and Pasindu (2017), Sri Lanka's current manual toll collection system is predicted to be unable to meet forecasted traffic demand at most interchanges. High wait times at manual toll booths would have a direct impact on expressway user delays and service levels.

No one has undertaken a proper and meaningful study to analyze the present toll collection system and determine its impact on traffic congestion. The conventional method of collecting tolls by road barriers located at the entrance and exit locations of expressways is used in the road toll system. Although the toll is collected directly from the drivers under this system, the presence of barriers increases travel time, fuel consumption, and, as a result, pollution in the road environment (Kumara, 2018).

Highways are mostly used to save time by avoiding traffic bottlenecks. When it comes to Sri Lanka, people waste their time at expressway counters due to huge lines, especially during peak hours. Currently, most of the counters are operated manually (MTC); however, the manual process is expensive due to its labor-intensive processes (Sandaruwan, 2020).

A study has been done to evaluate the operational improvements of using electronic toll collection, incorporating the traffic characteristics of expressways in Sri Lanka (Vidanapathirana & Pasindu, 2017; Kumara, 2018). At present, Electronic Toll Collection System is used only in some of the Sri Lankan expressway lanes to improve its performance.

Electronic tags affixed inside vehicles are read by overhead or roadside antennae, and tolls are automatically deducted from motorists' accounts by a computer system. Meanwhile, above-ground cameras capture the license plate numbers of unregistered vehicles, and those who do not pay the toll receive a bill (Persad et al., 2007).

Open Road Tolling is also one of the most popular tolling systems in the world. Instead of toll plazas, gantries will be used to calculate the toll. It allows drivers to pay without having to slow down at highway speeds. According to the research findings, U.S. toll operators identified that open-road tolls were almost entirely free of accidents (Siegel, 2004). In the open road tolling system, vehicles are identified by using an RFID tag and/or ANPR technology. This system enables dynamic pricing and manages vehicle lane traffic. However, this method is costly for users (Sandaruwan, 2020).

In a study conducted using the simulation approach and the analytical approach, the researcher concluded that both methods provide coinciding results. That study was based on the traffic delay at a toll plaza, and the researcher investigated the performance measures for a single server queue with four types of vehicle categories. Each vehicle category was simulated, and performance measures for each were obtained accordingly (Punitha, 2018).

Sihotang et al. examined the performance measures of a toll plaza queuing system under the assumption that arrivals and service times were normally distributed. The total number of vehicles that arrived and the total number of vehicles served for five weekdays at the toll gate Mukti Harjo were the data collected for this study. They estimated the arrival rate and service rate using the data and determined the distribution of arrivals using the Kolmogorov-Smirnov test and the Chi-Square test. The researcher found that the number of servers at the toll plaza is ideal and does not need to be adjusted after using Arena Software to simulate the system with varied numbers of servers (Sihotang et al., 2020).

3. METHODOLOGY

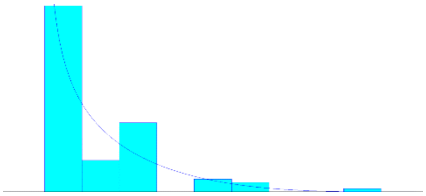
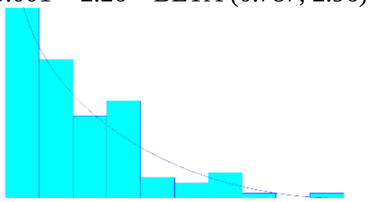
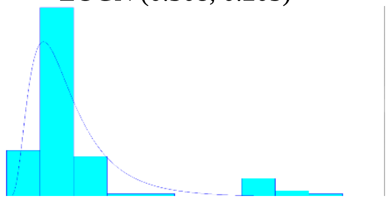
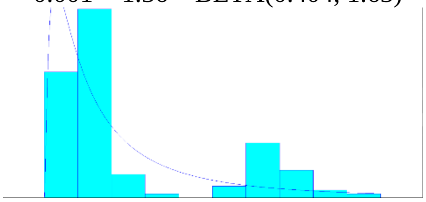
3.1 Data Collection

The time interval of one hour spanning from 3.00 pm to 4.00 pm was taken into account for Inter arrival times' and Service times' data collection. The method used for data collection was direct observation. The vehicles leaving the Kerawalapitiya - Kadawatha expressway from the Kadawatha toll plaza were the target population of the study. The primary data sample adjoined a total of 214 vehicles to the system using seconds of two separate toll counters allocated for two lanes. The service times of vehicles were gathered using digital stopwatches.

3.2 Data Analysis

For the resolution of many real-world issues, simulation is a crucial approach of problem-solving. When describing and analyzing a system's behavior, posing hypothetical "what-if" scenarios, and helping with the design of actual systems, simulation is employed. Simulation can be used to model both actual and hypothetical systems. To simulate a process, random interarrival and service times need to be generated. Inter arrival times were computed using Excel by using a formula to obtain the differences between two adjacent consecutive arrivals. Inter arrival times and service times were then entered into notepad files and imported into the Input Analyzer to fit the statistical distributions. The latest square error was used to deduce the best fitted distribution for the data set.

Table 1: Distributions obtained from input analyzer

	Distribution	Equation
Inter arrival times in lane 01 (counter 01)	Beta	3.56 * BETA (0.616, 3.56) 
Inter arrival times in lane 02 (counter 02)	Beta	-0.001 + 2.26 * BETA (0.787, 2.96) 
Service times for counter 01	Log Normal	LOGN (0.308, 0.205) 
Service times for counter 02	Log Normal	-0.001 + 1.36 * BETA(0.404, 1.63) 

3.3 Model Development

The two queues of the existing system were modelled using the 14.00.00000 version of the Arena software. The vehicles arriving at the selected tolling counters are the vehicles leaving the Kerawalapitiya - Kadawatha expressway. The vehicles shift to the counter allocated for their respective lanes. The conceptual model for the selected Toll plaza is shown in Figure 1.

 ISSN: 2756-9373

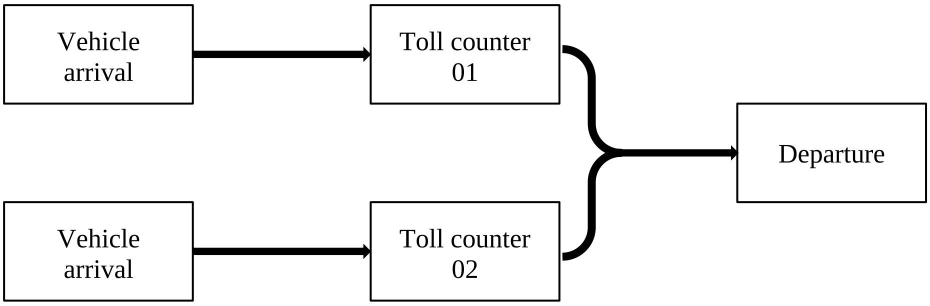


Figure 1: A conceptual model for the selected toll plaza

3.4 Existing System Model

The ARENA modelling simulation was used to develop the existing system taking the above conceptual model (Figure 1) into account. The vehicles had two tolling counters to pay and exit the expressway from with each tolling counter equipped with one billing officer who took care of both the barrier arm and billing all by himself. Therefore, resources were equally distributed as one for each tolling counter. As illustrated in Table 1, the distributions of arrivals and services were identified using the input analyzer of the ARENA software. The model was developed in the ARENA software under the following assumptions,

- Vehicles arrive at the toll plaza in a random sequence.
- A continuous service was offered to the vehicles in a First In First Served method (FIFO).
- A vehicle arrives at that toll plaza once and only once on the given day.
- Vehicle arrivals are independent of each other.
- A vehicle joins the queue isolatedly, without any company.

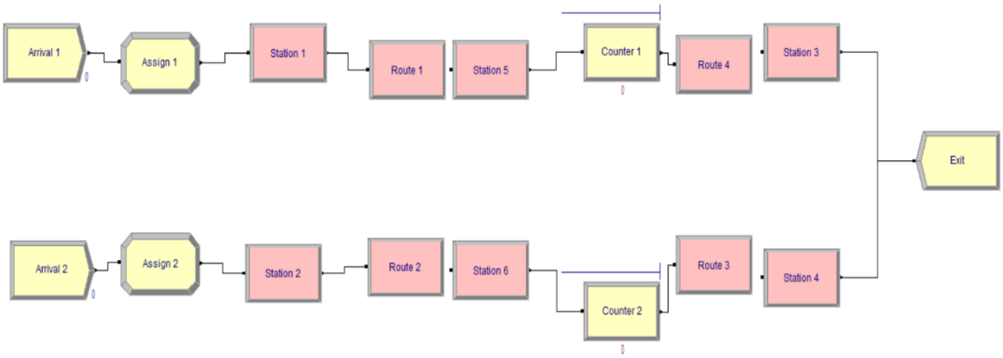


Figure 2: The existing system model

3.4.1 Existing System Model Results

There still are inefficiencies concerning the toll counters at the Kadawatha expressway interchange in the context of Expressway exit toll plazas. The model was run for 10 straight hours considering the toll counters being active 24 hours a day. The existing model was run for ten replications. The model made using ARENA software, for the existing system, used two Create modules for the counters, process modules and a Dispose module extracted from the "Basic Process" panel and Stations and Routes extracted from the "Advanced Transfer panel". Figure 2 illustrates the model for the existing system of the toll plaza.

Table 2: The existing system model results

Parameters	Existing model
Number in	5815
Number out	5813
Average waiting time - tolling counter 01	0.3921 minutes (23.526 seconds)
Average waiting time - tolling counter 02	0.3615 minutes (21.690 seconds)
Number waiting at tolling counter 01	0.7549
Number waiting at tolling counter 02	0.7665

3.5 Proposed Model Development

There is a relatively high waiting time in the existing model. To overcome this, three unique approaches have been considered to choose the best and feasible option to implement as the optimal condition. First, the existing model was replaced with an automated barrier arm. The second approach replaced the existing model with an E-tag implementation. The third approach was the use of Open Road Tolling systems. Therefore, the suggested models were follows:

- Model with automated barrier arm (Model 01)
- Model with E-tag system installation (Model 02)
- Model with Open Road Tolling system installation (Model 03)

3.5.1 Model with automated barrier arm (M1)

A solitary approach of adding an automated barrier arm while retaining the billing officer solely for billing is considered here. It was observed on site that the billing officer took an average of 3 seconds to go for the barrier arm button back and forth. This model eliminated that 3-seconds time period from the billing officer's service time. The results however, indicate that the proposed model is not upto expected values when compared with the existing system.

Toll Counter 1: LOGN (0.256, 0.209)
Toll Counter 2: -0.001 + WEIB (0.139, 0.539)

Table 3: Model with automated barrier arm

Parameters	Model values
Number in	5823
Number out	5822
Average waiting time toll counter 01	0.2750 minutes (16.5 seconds)
Average waiting time toll counter 02	0.2518 minutes (15.108 seconds)
Number of vehicles waiting at toll counter 01	0.5310 (1 vehicle)
Number of vehicles waiting at toll counter 02	0.5328 (1 vehicle)

The above model has lowered the existing model's average waiting time for the Counter 01 and Counter 02 by a considerable amount. Considering the number of vehicles in and out, the service rate indicates a higher rate than the existing model. The figure 3 illustrates the automated barrier arm adding approach model.

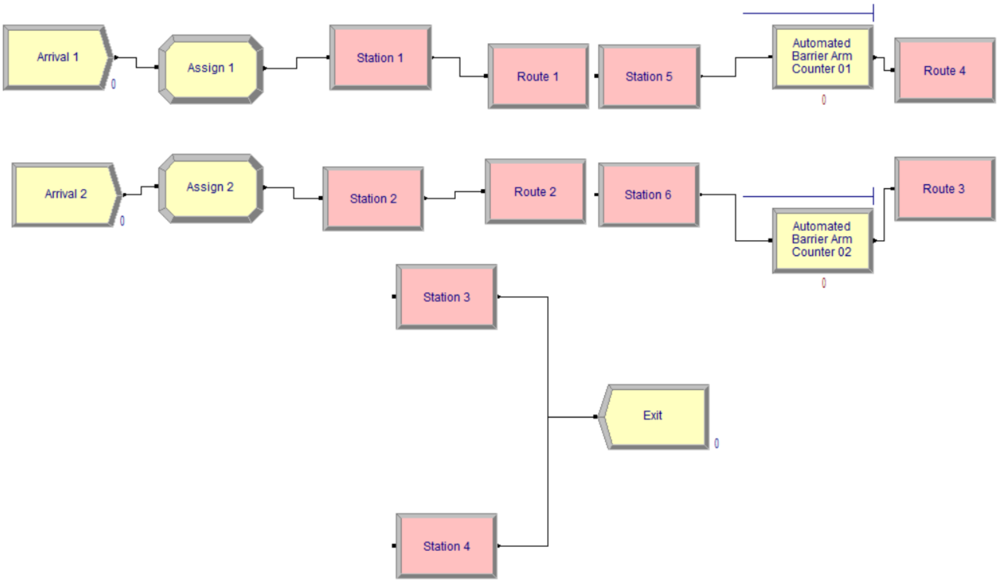


Figure 3: The proposed model for automated barrier arm approach

3.5.2 Model with E-tag system installation (M2)

This model considers the installation of an E-tag system at the tolling counter eliminating the billing officer and the associated manual process entirely but leaving the barrier arm. The barrier arm is an automated system. Shifting from a manual tolling process to an E-Tag tolling process is found to increase the Toll Plaza capacities from 350 vehicles to 1200 vehicles which implies a drop in the mean service time by 70.83%. The percentage was associated with the original data set to obtain a new set of service times which was then fed into the input analyzer for a brand new distribution.

Toll Counter 1: LOGN(0.0899, 0.0597)
Toll Counter 2: -0.001 + 0.401 * BETA(0.416, 1.67)

Table 4: Model with E-tag system installation

Parameters	**Model values**
Number in	5805
Number out	5804
Average waiting time toll counter 01	0.0198 minutes (1.1873 seconds)
Average waiting time toll counter 02	0.0183 minutes (1.0993 seconds)
Number of vehicles waiting at toll counter 01	0.0378 (0 vehicles)
Number of vehicles waiting at toll counter 02	0.0389 (0 vehicles)

The above model has lowered the existing model's average waiting time for the Counter 01 and Counter 02 by a considerable amount. Considering the number of vehicles in and out, the service rate indicates a higher rate than the existing model. The figure 4 illustrates the model with E-tag system installation.

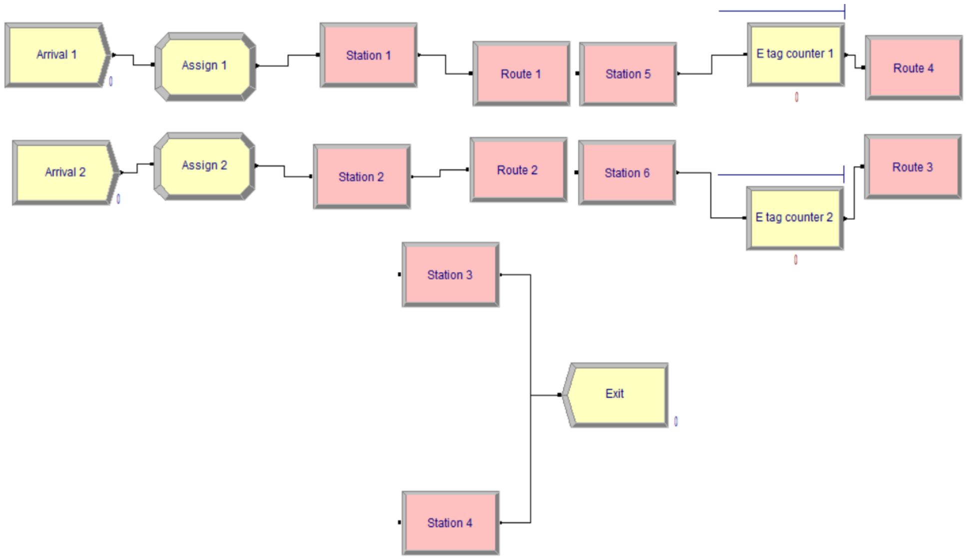


Figure 4: The proposed model for E-tag system installation

3.5.3 Model with Open Road Tolling system installation (M3)

This model considers the installation of an Open Road system at the tolling counter eliminating the billing officer and the associated manual process entirely. In this case there is no need for a barrier arm because the ORT system allows the vehicle to continuously move at highway speeds while the system takes care of the tolling process. Shifting from a manual tolling process to an ORT tolling process is found to increase the Toll Plaza capacities from 350 vehicles to 1800 vehicles which implies a drop in the mean service time by 80.56%. The percentage was associated with the original data set to obtain a new set of service times which was then fed into the input analyzer for a brand new distribution.

Toll Counter 1: LOGN(0.054, 0.0358)
Toll Counter 2: -0.001 + LOGN(0.0524, 0.0957)

Table 5: Model with ORT system installation

Parameters	**Model values**
Number in	5793
Number out	5793
Average waiting time toll counter 01	0.0087 minutes (0.5209 seconds)
Average waiting time toll counter 02	0.0081 minutes (0.4867 seconds)
Number of vehicles waiting at toll counter 01	0.0166 (0 vehicles)
Number of vehicles waiting at toll counter 02	0.0172 (0 vehicles)

The above model has lowered the existing model's average waiting time for the Counter 01 and Counter 02 by a large amount. Considering the number of vehicles in and out, the service rate indicates a 100% efficiency. The figure 5 illustrates the Open Road Tolling system installation model.

 ISSN: 2756-9373

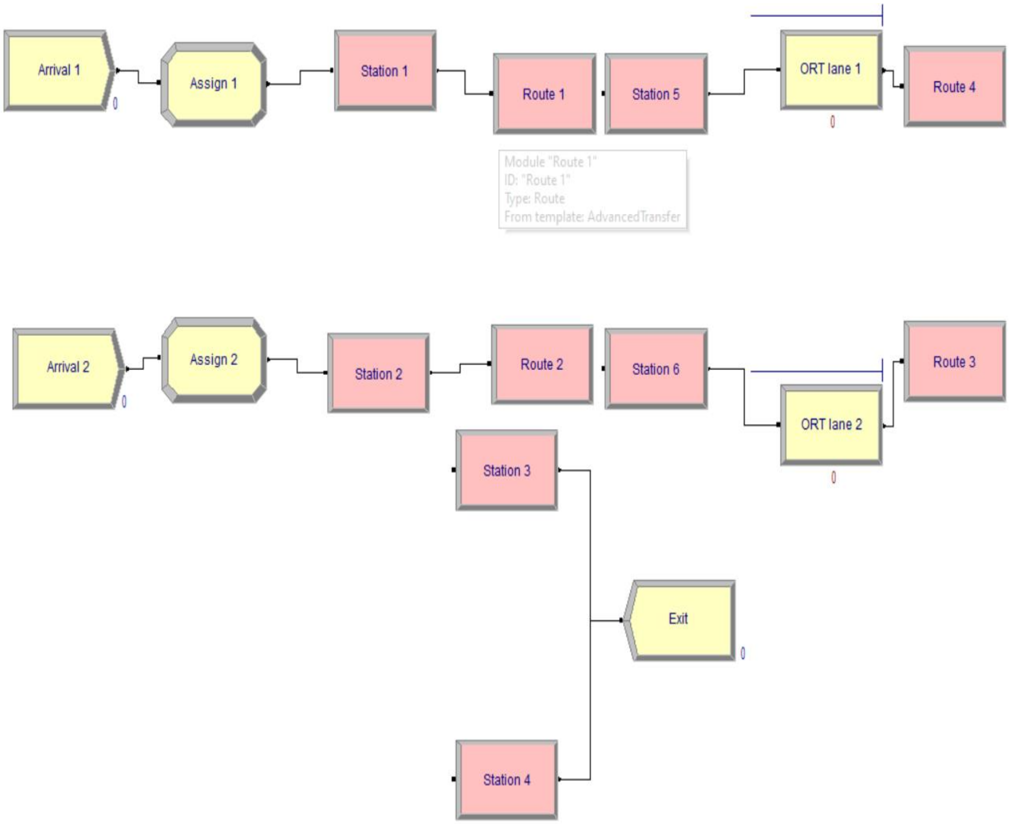


Figure 5: The proposed model for ORT system installation

4. RESULTS AND DISCUSSION

The parameters of the models that have been developed show a significant difference from the existing model parameters. In the context of number of vehicles in and number of vehicles out, the model with an automated barrier arm installation (M1) and the model with the E-tag system installation (M2) were one vehicle short in the number of vehicles sent out, which is significant compared to the model with the Open Road System installation (M3), in which all the vehicles entered the system are exiting the system successfully.

In terms of the average waiting times at the two toll counters, the model with an E-tag system installation (M2) and the model with the Open Road System installation (M3) have recorded significantly lower waiting times for the vehicles in the queue when compared to the waiting times for the vehicles in the queues formed at the model with an automated barrier arm installation (M1).

In the context of the number of vehicles waiting at the respective toll counter queues, the model with an E-tag system installation (M2) and the model with the Open Road System installation (M3) in particular have recorded absolutely no vehicles waiting at the queues, in contrast to 1 vehicle waiting at each of the queues formed at the two counters in the model with an automated barrier arm installation (M1).

Although the model with an automated barrier arm installation (M1) has shown a significant improvement in all three parameters when compared to the existing system, it still has minor inefficiencies when compared to the model with an E-tag system installation (M2) and the model with the Open Road System installation (M3). The most obvious inefficiencies in the model with an automated barrier arm installation (M1) as per the results are that the average waiting times at the two toll counters are still high and there is one vehicle at each counter waiting to be served. This prevents the model with an automated barrier arm installation (M1) from being implemented.

Considering the model with an E-tag system installation (M2) and the model with the Open Road System installation (M3), the results of the parameters show that the model with the Open Road System installation (M3) is the best implementation. However, when considering the financial, environmental, and operational feasibility, Sri Lanka, being a developing country, may face drastic challenges during the implementation of the model with the Open Road System installation (M3) since such an installation needs to undergo an entire structural modification.

Therefore, considering the financial and operational feasibilities, the model with an E-tag system installation (M2) is the optimal implementation. Hence, the manual toll counters Counter 1 and Counter 2 need to be replaced with E-tag-identifying counters.

Table 6: Comparison between best choices of toll counter alterations

Parameters	**M2**	**M3**
Number in	5805	5793
Number out	5804	5793
Average waiting time toll counter 01	0.0198 minutes	0.0087 minutes
Average waiting time toll counter 02	0.0183 minutes	0.0081 minutes
Number of vehicles waiting at toll counter 01	0.0378	0.0166
Number of vehicles waiting at toll counter 02	0.0389	0.0172

5. CONCLUSION

This study assessed the existing queueing system at the Exit toll plaza of the Kadawatha highway interchange and identified minor yet adversely significant inefficiencies due to slow work rates. The ARENA simulation was employed to simulate the existing model and understand the ongoing situation. It was observed that the average waiting time at toll counter 01 was greater than that at toll counter 02. This may be due to different reasons. Since the vehicles that join the toll plaza arrive from two different lanes, one lane may be more convenient to drive in than the other, and there can even be a cognitive factor affecting the driver's choice of lanes.

There are three toll counters for vehicles to exit the Kerawalapitiya-Kadawatha expressway from, and the two counters placed under observation had a maximum of six vehicles on average at each toll counter at a given time, with each vehicle spending an average of 20 seconds in the system. As per the Ministry of Transport in Sri Lanka (Ministry of Transport, 2021), the number of vehicles in the country is set to increase in the future. In addition, the number of users who use the expressway every day will increase with the expansion of expressways. Therefore, it is important that steps are taken to increase the service efficiency of the toll plaza.

Derived from the results of the three proposed alternatives for the existing system, the recommendations are placed in Table 6 for the RDA and other relevant officials to utilize when making future decisions for the improvement of the current prevailing system.

One of the objectives of this study was to find any inefficiencies at toll gates that are manually operated. Therefore, we identified delays in operating the barrier arm and inefficiencies in collecting the fee in a manual system. These problems can be reduced by an automated system, such as an automated barrier arm or an E-tag system, to collect the fee automatically. The next objective was to suggest new solutions to reduce the queue length (Number of vehicles waiting in the queue) at toll gates. As solutions, three unique approaches have been introduced. First, the existing model was replaced with an automated barrier arm (Model M1). The second approach replaced the existing model with an E-tag implementation (Model M2). The third approach was the use of Open Road Tolling systems (Model M3).

The third objective of this study was to check the feasibility of the suggested solutions. Therefore, we conducted a feasibility test to decide the best option among three models. Implementing Model M1 and Model M2 is feasible in terms of cost. But when considering the Model M3, it takes a high initial cost to implement an Open Road Tolling system.

According to the time factor (waiting times or efficiency of the system), the model with an E-tag system installation (M2) and the model with the Open Road System installation (M3) have recorded significantly lower waiting times for the vehicles in the queue when compared to the waiting times for the vehicles in the queues formed at the model with an automated barrier arm installation (M1). Therefore, Model M1 is not feasible according to the time factor.

By analyzing those two factors—cost and time—the Model M2 (Model with E-tag system installation) can be suggested as the best method according to the Sri Lankan context. In summary, this study performs a simulation-based analysis of the performance level at the Kadawatha highway toll booth. Recommendations are made based on the results of the simulated setups and their performance measurements.

REFERENCES

Grabau, S., & Hewapathirana, I. (2021, September). Simulation analysis of an expressway toll plaza. In 2021 International Research Conference on Smart Computing and Systems Engineering (SCSE) (Vol. 4, pp. 223-229). IEEE.

Kumara, H. B. N. S. (2018). Evaluation and improvement of toll collection system in Sri Lankan expressways: case study for Colombo-Katunayake expressway (Doctoral dissertation).

Ministry of Transport. (2021). Vehicle population. https://www.transport.gov.lk/web/index.php?option=com_content

Persad, K., Walton, C. M., & Hussain, S. (2007). Toll collection technology and best practices (No. Product 0-5217-P1).

Punitha, S. (2018, December). Design and evaluation of traffic delays in toll plaza using combination of queueing and simulation. In Journal of Physics: Conference Series (Vol. 1139, No. 1, p. 012080). IOP Publishing.

Rodrigo, A., & Edirisinghe, L. (2015, May). A Study on electronic toll collection systems in expressways in Sri Lanka. In Proceedings of 8th International Research Conference, KDU, Published November.

Sandaruwan, L. A. C. A. (2020). A Study on Subscription Based Toll Collection Scheme for Sri Lankan Expressways.

Siegel, J., Orcutt, J., & Slevin, K. (2004). The Open Road: The Region's Coming Toll Collection Revolution. Report, Tri-State Transportation Campaign.

Sihotang, E., Ispriyanti, D., Prahutama, A., & Rachman, A. (2020, April). Analysis of queue and performance of automatic toll booths with a normal distribution (case study: automatic booths toll gate muktiharjo). In Journal of Physics: Conference Series (Vol. 1524, No. 1, p. 012093). IOP Publishing.

Vidanapathirana, C., & Pasindu, H. (2017, May). Analysis of toll station operations in Sri Lanka using a micro-simulation technique. In 2017 Moratuwa Engineering Research Conference (MERCon) (pp. 321-324). IEEE.