International Journal of Economics, Commerce and Management
United Kingdom Vol. VI, Issue 8, August 2018
http://ijecm.co.uk/ ISSN 2348 0386

EVALUATION OF QUEUING SYSTEM PARAMETERS IN NIGERIA: NIGERIA AIRPORT SERVICES

ALAMUTU Salimonu Adigun
Department of Management Technology, Lagos State University, Ojo, Nigeria
salimonu.alamutu@lasu.edu.ng

Abstract

The study evaluates queuing system parameters in Nigeria Airport services. Expo-facto research design was adopted for the study, where computed travelers traffic at airport were obtained via Nigeria Civil Aviation Authority (NCAA) Annual reports between 2006 to 2015 as secondary data. Data collected were analysed using TORA Optimization tools. The findings reveal that the arrival rate at both Airports are higher than the service rate with their respective probabilities at both wings of the airports. The study therefore recommended that FAAN should improve on the existing facilities installed to accommodate the influx of travelers arriving and departing the country.

Keywords: Queuing system parameter, Arrival rate, Service rate, Service pattern

INTRODUCTION

Queuing process in the airport has become very complex problem to solve manually due to the patterns in arrival, service and departure. The airports have less capacity to serve all arrivals and departures promptly in nearly all the international airports resulting into queues, rowdiness and randomness which create some waiting times (Medri, Djere & Kanmoun, 2009). In this regard, Jay and Bary (1993) and Roland (2009) put to test queuing model activities in airport services in which waiting line occurred.

Aviation practice began in Nigeria in 1920, barely seventeen years after the 'Wright brothers' (Orville & Wilbur Wright) first flight in 1903. Though it started as a purely military operation with the landing of British Royal Air Force aircraft in a polo field in Maiduguri in 1920 which marked the beginning of aviation practice (Diepriye & Onyinka, 1997). It gradually assumed the character of a civilian operation in the decades that followed (Decker, 2002). Thereafter, the Royal Air Force continued to operate in West Africa and by 1925, the British had stationed a squadron in the Sudan. The British commander sought approval from the Colonial Office in England to operate frequent cross-country flights from Khartoum to Maiduguri (Ejuka& Steve, 1987). By 1930, civil and military aircraft were carrying passengers across boundaries and touching down in places like Kano, Sokoto, Bauchi, Minna, Oshogbo and Lagos while British Imperial Airways embarked on regular passenger and mail services. Subsequently, Lagos and Accra became hubs for flights en-route to the Middle East and India. This was the beginning of aviation practice in Nigeria (Obitayo, 1998).Currently three main bodies are responsible for overseeing the affairs of the aviation industry in Nigeria's airspace. The Nigeria Airspace Management Agency (NAMA) established by Decree No 48 of 1999 responsible for formulating and implementing policies for the effective management of Nigeria's airspace. The Nigeria Civil Aviation Authority (NCAA) established by Decree 49 of 1999 is responsible for providing aviation safety and economic regulatory services that are consistent with international standards; and the Federal Airports Authority of Nigeria (FAAN) is responsible for taking care of the physical structuring within all the airspace in Nigeria. Without doubt, these organizations have contributed immensely to the development of civil aviation practice in Nigeria. However, it must be emphasized that government should not over-regulate the aviation industry through these bodies. Private airline operators should be given the opportunity to contribute their own quota to the formulation of policies for the overall delivery of prompt, safe and efficient services to passengers. Other stakeholders in the industry are Port Health Service, Nigeria Police, Custom Service of Nigeria (CSN), Nigeria Immigration Service (NIS), Nigeria Drug Law Enforcement Agency (NDLEA), Nigeria Agency for Food and Drug (NAFDAC), State Security Service (SSS), Nigerian Aviation Handling Company (NAHCO), Sky Power Aviation Handling Company (SAHCO), Independent Ticket Agencies (ITA), Standard Organization of Nigeria (SON) and Air Travelers (AT) (Sam, 2003; Idris, 1999).

Statement of problem

In Airports, Roshiand Ratnam (2015) used analogy dissection in examining the variability of aircraft passengers' movement problem with emphasis on rate of arrival and departure, in India International Airport using single queue multiple server but could not address the problem of queuing at the airport. Also, Vaddi, Shaik, Karthikeyan andNasseb (2015) applied queuing theory model for optimized service system of airline passenger's movement in India using semi-conductor two stages multiple channel with optimum server, yet the problem of queuing still persists. More also, Thiagarag and Seshaiah (2014) adopted queuing model to analyse airport capacity and delay using analytical approach and simulation. They reveal that high traffic intensity created problem of queuing at the airport. However, Ademoh and Anosike (2014) used Single Queue Multi Server approach to develop a mathematical model to solve queuing problem of air transport passengers at Nnamdi Azikwe International Airport (NAIA) Abuja. Their studies reveal that despite the development of the mathematical model, the Airport continues to experience the problems of queue due to the type of queuing system applied creating unnecessary delay and ineffective services.

Objective of the Study

The objective of this study is to examine the queuing system parameters in the Nigeria Airport Services.

Limitations of the study

The limitations of this study was getting the attention of relevant government agencies serving in the airports for getting necessary documents required for the study. Other limitation is security and government agencies flexibility to get access to the airport. The bottle necks and bureaucracy in accessing the required secondary data at the airports was also a limitation.

LITERATURE REVIEW

A queuing system is a system that follows either the arrival rate of travelers or arrival at service facilities or both which are subjected to control. Therefore, a queuing system can simply be described as travelers arriving for service, waiting for service if it is not immediate and if having waited for service, leaving the system after been served. The term "customers" is used in general term and not simply necessarily a human customer. For example, a customer could be a ball bearing waiting to be polished, an airplane waiting-in-line to take off, a computer programme waiting to be run, or a telephone call waiting to be answered (Taha, 2007; Amos, *et al* 2015) Queuing system causes inconvenience and economic loss to individuals and organizations. Hospitals, Airlines, Banks, Manufacturing Firms, Seaports and so on, which must be efficient in other to minimize the total waiting cost and the cost of providing service to their travelers. Therefore, speed of service is increasingly becoming a very important competitive parameter (Katz, Larson & Larson, 1991). Davis *et al* (2003) asserted that providing ever-faster service with the ultimate goal of having zero travelers queuing process has recently received managerial attention for several reasons. First, in the more highly developed countries, where standard of living is high, time becomes more valuable as a commodity and consequently, travelers are less willing to wait for service. Secondly, there is a growing realization by organizations that the way they treat their travelers today significantly impact on whether or not their services will encourage traveler's loyalty. Finally, advances in technology such as global telephone link, computers and internet have provided firms with ability to provide faster services. Administrators, physicians and managers are continuously finding means to deliver faster services, believing that the waiting period will affect their service evaluation negatively, (Cooper & Schindler, 2010; Jacquillat&Odoni, 2015).

Gupta & Khanna (2013) also argued that higher operational efficiency of the airport is likely to help to control the cost of airport services and consequently to provide more improved queuing system and improve their services to the timing travelers. Addressing the problem of queuing system involves a trade-off between the cost of travelers waiting time and the cost of providing faster service. Researchers have argued that service waits can be controlled by operations management technique which deals with the management of how travelers queues and servers coordinated towards the goal of rendering effective service at the least cost (Joris, *et al* 2011). Adedayo, Ojo & Obamiro (2006) stressed that many situations in life requires one to line up or queue before being attended to. The lines formed are referred to as waiting lines or queue. According to them queue occurs when the capacity of service provided falls short of the demand for the service

Fundamental of Queuing Theory

Queuing theory is a branch of operations research known as service system theory or wait in the line theory. It is used to study the objective of a service request generated by the randomness of travelers' arrivals and service rate (Trani, 2011). Queuing model in this context is used to approximate real queuing situation which are developed on the bases of queuing classified into input source and output queuing system, that is the arrival, the queue, the service mechanism and queue discipline (Event, 2013). Among the first developed model in queuing is the single queue, single-server model. Single server model is a single server with single line of travelers, a situation where travelers arrived on a single line served by a single service facility or server step by step (Dawson 2009). For any application of queuing model to any situation, the input process and output process should first be described (Blanc, 2011)

Characteristic of Queuing System

Queues are not an unfamiliar phenomenon and to define it requires specification of the characteristics or component which describes the queuing system, such as arrival pattern, queue, service channels (no of servers), queue discipline, service mechanism, system capacity and the exist. (Kendal, 1953; Adedayo, *et al*, 2006). Medhi (2003) opined that the main characteristic that determines the appropriateness of a queuing system are the arrival, the queue, service channel or number of servers, queue discipline, service mechanism, system capacity and exist. While Sharma (2012) refers to the component as calling population (or input source) queue process, queue discipline, and service process (or mechanism including exist).

Pattern of Arrival

Pattern of arrival is the arrival of the entity at a service point. This process involves a degree of uncertainty concerning the exact arrival and the number of entities arriving. And to describe this process, there are some important attributes such as the sources of the arrivals, the size of each arrival, the grouping of such arrival and the inter-arrival times (Cooper &Shindler, 2010). The time between arrivals otherwise called inter-arrival time could be probabilistic or deterministic in nature (Adedayo, *et. al,* 2006). Arrival can occur from infinite population (unlimited) or finite (limited or restricted population), (Sharma, 2012). According to Davis,Aquilano& Chase , (2003) there are four main distinct part of queue that exist which could be (controllable or uncontrollable); the size of arrival (could occur one at a time or in bulk); the distribution pattern (could be whether the time between arrival is constant or follows a particular statistical distribution such as a Poisson, exponential, Erlang and so on); and the degree of patience whether the arrival stay in line to complete the process before boarding or leave, not able to complete the process due to impatient or one problem or the other.

Queue behavior

Queue occurs when travelers wait before being attended to or before being served when the server is engaged. Queues exist when the arrival is more than the service facility which could be finite or infinite (Blanc, 2011). A queue is infinite when we have an unlimited number of travelers but it is finite when the capacity that contains it is small (Zoran &Brainslay, 2005).

Queue Discipline

Queue discipline refers to the priority rule by which travelers are served, that is the order in which items received service (Hillier & Lieberman, 2005). According to Olaniyi, (2014) and McGuire (2010) there are two main categories by which travelers are served which are pre-emptive priority: where the items in the queue are arranged so that the item with the highest priority in the system is served first and there is no displacement of items in service, while non-pre-emptive occur when the last

RESEARCH METHOD

Expost-facto research design was adopted to have access to past records of travelers' arrival and departure from the airports through the use of data from manifest, memos and publications by Federal Airport Authority of Nigeria (FAAN), Annual reports, international journals, in-house published journals of industry, particularly from National Civil Aviation Authority (NCAA), the regulatory body of the industry who is responsible for data gathering. Key information interviews were conducted with senior administrative workers and top management staff to validate the instrument used for data collected.

FINDINGS AND DISCUSSION

Travelers data obtained from National Civil Aviation Authority (NCAA) and Federal Airport Authority (FAAN) of MMIA and NAIA at the arrival and departure wing were used to analyze the arrival and departure pattern of the travelers at the airport; average arrival rate, service rate were determine including measures of probabilities. Travelers activities were used to quantify travelers flow at the airport addressing length of stay (LOS)/ delay so as to determine traffic intensity at both arrival and departure wing in the airport. These two wings were selected because of the following arguments: international travelers visit the facilities daily from time to time for their international business, personal business, tourist attraction because of their uniqueness in operational activities at both Airports for travelers arriving and departing the facilities among others. This has made it possible to analyze the two wings separately and jointly too.

Arrivals

The queuing model adopted assumes that average arrival rate daily at the airports follow a Poisson distribution and exponential service time with coefficient of variation equal 1, this is in agreement with some study which have found that arrival rate of travelers to the Departure / Arrival wing of the airport follows Poisson distribution and exponential service (Irtan, Bashir & Shakeel, 2007; Ademoh & Anosike, 2014). Available data from NCAA records shows that total number of travelers departing the Airport and arriving into the Airport for ten (10) years at MMIA Lagos is 14,133,175 (Travelers departed) and 13,854,227 (Travelers arrived). Average numbers of travelers departing from MMIA Lagos is 1,413,318 and average numbers of travelers arriving from international journey is 1,385,423 at MMIA Lagos. While the records also show that the total number of departure and arrival to and from other countries for ten years at NAIA Abuja is 4,618,257 and 4,590,059 respectively. The average numbers of travelers departing to and from international journey is 461,826 and 459,006 at NAIA Abuja. For MMIA Lagos the average number of travelers departed per day is 3,872 and travelers arriving per day is 3,796. While

1,265 travelers departed per day and 1,258 arrived per day at NAIA Abuja. Both arrival and departure wings of the chosen airports are characterized by random arrival daily. The average arrival and average service time were considered for period of 24 hrs as normal operation in our airports with peak period noticeable in the morning, evening and sometimes in the night. Average arrival and service time at both shifts were considered and invariably used for the study.

Length of Stay of Distribution

Length of stay describe the expected time in the system which is determined by expected time travelers stay in the system minus expected time spent in the queue. Average length of stay (ALOS) in relation to service pattern of a queuing model is characterized by a relatively high variability. Variability exist in both the time between arrival and duration of service time called variation between arrival and service rate. In probability theory the coefficient of variation is a measure of dispersion of a probability distribution and it is defined as the ratio of standard deviation (S.D) to the mean (X) i.e. $^{S.D}/_{X}$ (Adebayo et al 2006, Gross & Harris 2016). The coefficient of variation (cv) for each Airport is greater than 1. This implies that a delay (LOS) at the arrival and departure wing of the airport is highly variable. This conforms with the findings of Gross & Harris (2016). As described earlier, the actual (measured) LOS i.e. delay is not always the same as estimated by aviation experts. The difference between the two is that the actual LOS is caused when the system is filled. While the other required estimation

Impact in Arrival and Variation in waiting time at the Airport on Capacity Management

The study adopts an A/B/∞ using Kendall notation to analyze the fluctuation impact of arrivals and variation in waiting time (Delay) on system capacity at the arrival and departure wing of the airport. The queuing model assumes Poisson arrivals with exponential length of stay (service time) and infinite number of service provided that all requirements are met. The aim of this study is to determine how the system will accommodate all arrivals. This is necessary because one main objective of the Airport management is to provide effective service delivery for all travelers at the arrival and departure wing of the airports. Though in reality, airport management operations with variable no of servers will avoid overcrowding that might be experience.

Queuing system of the arrival and departure flow of travelers at both airports were Analyze using TORA Optimization tool (Taha, 2003). TORA Optimization tool is a Windows-Based Application for solving practical Operations research and Business management problems with the combination of several operations research techniques such as linear programming model, transportation model, queuing model, simulation, etc. As stated earlier, Poisson and exponential distribution were used to describe the queuing system arrival and service time (Length stay) respectively. The steady state analysis of arrival and Departure wing of the airport using A/B/∝ model is presented in Table 1 - 4. This show that overtime, fluctuations in arrival rate and service were not taken seriously to assume a steady state. Thus, the study therefore helps to determine the traffic intensity, efficiency and effectiveness of the two wings of the Airports.

Queuing Output Analysis

Table 1 MMIA Departure Wing Analysis

Scenario 1 – A/B/9999 (GD/infinity/infinity)

Lamda (λ) = 177.52	Mu(μ) = 173.11
L'aambdaeff = 177.52	Rholc = 0.00010
L_s = 1.02548	L_q = 0.0000
W_s = 0.00578	W_q = 0000

N	Probability P_n	Cumulative P_n
0	0.35863	0.35863
1	0.36776	0.72639
2	0.18857	0.91495
3	0.06446	0.97941
4	0.01652	0.99593
5	0.00339	0.99932
6	0.00058	0.99990
7	0.00008	0.9999
8	0.00001	1.0000

In scenario 1 of MMIA Departure wing analysis, where travelers arrive per day 177.52 (5414) travelers; average service per day 173.11(5280) with infinite servers. As asserted in the model, infinite number of servers was assumed due to the fact that airport management look forward to meet the needs of all travelers arriving the departure wing of the Airport. The system performance parameters are as follows; L_s = 1.02545 which implies that there are 1.02548(31) travelers in Departure wing of the Airport during service process W_s= 0.00578 days (8.3232 minutes) measures the average time of delay in the system (MMIA- Departure wing). That is, travelers spent 0.00578 (8.3232 minutes) in the system before departure. The time in question covers the time spent in the queue and in the system before departure after being served. As expected, L_q= W_q= 0 because of a model involving unlimited servers (infinite server was considered).

Table 2 MMIA Arrival Wing Analyses

Scenario 2 – (A/B/9999): (GD/ infinity/ infinity)

Lamda = 170.8600	Mu= 170.85
L'aambdaeff = 170.9000	Rholc = 0.00010
L_s = 1.00029	L_q = 0.0000
W_s = 0.00585	W_q = 0.0000

N	Probability P_n	Cumulative P_n
0	0.36777	0.36777
1	0.36788	0.73565
2	0.18399	0.91964
3	0.06135	0.98099
4	0.01534	0.99904
5	0.00307	0.99940
6	0.00051	0.99992
7	0.00007	0.99999

In scenario 2, the table above reveals the arrival wing analysis of the MMIA, where average arrival rate of travelers is 170.86 (5211) per day on the available data given at the arrival wing of the Airport. Average service is 170.85 (5211) per day with infinite capacity. W_s= 0.00585 (8.424 minutes) the waiting time of travelers in the system i.e.$W_s = W_q + \frac{1}{\mu}$ this include travelers being served and those departed after service. Also, the expected waiting time in the queue (W_q) and in the system (W_S) at the arrival wing is 0 because there are enough server (infinity) to accommodate and serve all travelers.

Table 3. NAIA Departure Wing Analyses

Scenario 3 NAIA departure wing (M/M/9999)

Lamda = 54.71000	Mu= 52.91000
L'aambdaeff = 54.71000	Rholc = 0.00010
L_s = 1.03402	L_q = 0.0000
W_s = 0.01890	W_q = 0.0000

N	Probability P_n	Cumulative P_n
0	0.35557	0.35557
1	0.36767	0.72325
2	0.19009	0.91334
3	0.06552	0.97885

4	0.01694	0.99579
5	0.00350	0.99929
6	0.00060	0.99990
7	0.00009	0.99991
8	0.00001	1.00000

In scenario 3**,** the table in shows NAIA Abuja departure wing analysis that Lamda (λ) = 54.71 (1,669) per day and Mu (μ) = 52.91(1,614) per day. This implies that an average of 52.91 (19,365) travelers were served and departed the Airport between Jan 2015 to December 2015. The unit performance parameters are; the system utilization is very low and the number of travelers in the system is 1.034 (32) (and time spent waiting in the system by a traveler is 0.0189 (27 minutes). The average number of travelers in the queue (L_q) and in the system (W_q) is equal to 0 due to the fact that an infinity server model was adopted for analyzing the activities at NAIA – departure wing of the Airport.

Table 4. Arrival Wing Analyses

Scenario 4 NAIA arrival wing (M/M/9999)

Lamda = 54.45000 Mu= 54.40000

L'aambdaeff = 54.45000 Rholc = 0.00010

L_s = 1.00092 L_q = 0.00000

W_s = 0.01838 W_s = 0.00000

N	Probability P_n	Cumulative P_n
0	0.36754	0.36754
1	0.36788	0.73542
2	0.18411	0.91953
3	0.06143	0.98096
4	0.01537	0.99633
5	0.00308	0.99940
6	0.00051	0.99940
7	0.00007	0.99999

In scenario 4**,** the table above gives the efficiency and effectiveness of NAIA Arrival using A/B/ $\propto$ model. Based on the data obtained from the arrival wing for 12 months, the effective arrival (λ) of urgent services is 54.45(1,661) travelers per day; average length of stay (μ) 54.40 (1,659) served per days with infinite servers. Other performance measure indexes are; L_S =

1.00092 (31) W_S = 0.018 (26 mints) where L_q and W_{q} = 0 because the model at the arrival wing has available servers for any number of incoming travelers. The probability that 0 numbers of travelers in the system is equal to 0.36754 and probability of 1-7 travelers in the system was determined.

CONCLUSION AND RECOMMENDATIONS

The queuing system parameters for the two wings of the chosen international airports shows that travelers at departure wings was more than travelers at the arrival wings and that the average spent in the system at the departure wings is higher than the average time spent at the arrival wings, and for all the wings $L_{q,}W_q$=0 with unlimited number of servers. The arrival rates of travelers in the chosen airports are higher than rate at which they are being served. This constitutes delay and queue in the system. Therefore, Federal Airport Authority of Nigeria (FAAN) should improve on the existing facilities installed to accommodate the influx of travelers arriving and departing the country. Also, for easy accessibility for the required data on queuing system parameters, the annual report from Airport authorities should be timely and well updated. Furthermore, Agents and other non-travelers should be discouraged and prevented from gaining access to the airports in other to create more enabling environment for travelers.

REFERENCES

Adedayo, O.A. Ojo, O., & Obamiro, J.K. (2006). Operations research in decision analysis and production management. Lagos: Pumark Nigeria Ltd.

Ademoh, N.A. &Anosike, N.E. (2014). Queuing modeling of air transport passengers of Nnamdi Azikwe International Airport Abuja, Nigeria, using multi server approach. Middle-East Journal of Scientific Research, 21(12), 2326-2338

Amos, N.D., Kenneth, N.K. &Onuche, P. A. (2015). Queue modeling for successful implementation of the cash-less policy in Nigeria. Journal of Applied Statistics 6(1), 95-100

Blanc, J.P. (2011). Queuing models: Analytical and numerical methods (Course 35M2C8), Department of Economics and Operations Research Tilburg University, 30-57.

Cooper, D.R. & Schindler, P.S. (2010). Business Research Methods, 10th edition. USA: McGraw-Hill.

Davis, M.M., Aquilano, J.N. & Chase, B.R. (2003). Fundamentals of operations management. 4th Ed., Boston: McGraw-Hill Irwin

Dawson, E. (2009). Introduction to research methods: A practical guide for anyone undertaking a research project, 4thEd. Oxford: How to Books LTD

Decker, J. B. (2002).Kudos to the Undaunting Eagle (2), Aviation Week and Tours Magazine (Lagos).

Diepriye, R. &Onyinka, O). Air transport in Nigeria strategies for the twenty first century in the Nigeria stock exchange bulletin, 3rd edition. New York: John Wiley & Sons Inc.

Ejuka, B. C. & Steve, M. (1987). Civil aviation in Nigeria's sky power news, and the history of the Nigeria airways and its impact on the travel mobility of Nigerians1961-1986, Unpublished M.A Dissertation Department of History University of Lagos

Event, H. (2013). M/M/1 queuing system. Retrieved online on June 15, 2016 from: http://www.modernghana.com/realtimemantra/congestioncontrol/m_m_1_queue.htm#.UQAcobnnEk

Gross, D. & Harris, C. (2016).Fundamentals of queuing theory. 7th Edition, Chichester: John Wiley.

Gupta, M.P. & Khanna, R.B. (2013). Quantitative techniques for decision making. New Delhi: Prentice Hall

Hillier, F.S. & Liberman, G. (2005). Introduction to operation research. 7th Edition, Boston: MC Graw-Hill Irwin.

Idris, W. (1999). How government policies have affected airline operations in Nigeria. A paper presented by the Managing Director of EAS Airlines at a seminar in Lagos, March 23, 1999.

Irtan, A. Bashir, A. & Shakeel, N. (2007). Performance analysis of network of queues under active queue management scheme. Simulation modeling practice and theory. 15, 416-425

Jacquillat, A. &Odoni, A. (2015). Endogenous control of arrival and departure service rates in dynamic and stochastic queuing model with application of JFK and EWR transportation research part E: Logistic and Transportation Review 73(1), 133-151

Jay, H. & Barry, R. (1993). Production and operation management strategies and tactics in business and economic. New York: Rich wolf Publishers.

Joris, W., Dieter, F., & Herwig, B. (2011). Time-dependent performance analysis of a discrete-time priority queue. Performance Evaluation, 65, 641-652.

Katz, K., Larson, K. & Larson, R. (1991). Prescription for the waiting in line blues: Entertain enlighten and engage. Sloan Management Review, 11, 44-53.

Kendall, D. G. (1953).Stochastic Processes occurring in the theory of queues and their analysis by the method of imbedded. Chain Annual Mathematics Statistics, 4(5), 67-78.

McGuire, A.M. (2010). A framework for everlasting the travelers wait experience. Journal of Service Management, 21(3):269-290.

Medri, H., Djemel, T. &Kammon, H. (2009). Solving of waiting lines models in airport using queuing theory model and linear programming: Practice case. A.I.M.H.B. Tunisia, 1,2-12

Obitayo, K. M. (1998). Aviation development in Nigeria: What role for financial sector? A paper presented at a seminar organized by the league of Airport and aviation correspondents (LAAC), Muritala Muhammed Airport Conference Center Lagos.

Olaniyi, A. (2014). Relationship between arrival rates of travelers and bank's service rates, Seminar paper series, University of Ife.

Ronald, R. G. (2009). An application of Queuing theory to airport passenger security screening. Airline Interface, 9(4), 117-123.

Roshi, A. & Ratnam, N. (2015). Analogy dissection in variability of aircraft passenger movement in India airport. International Journal of Science and Engineering Research, 6(2), 2229-5518.

Sharma, J.K. (2012). Operations research: Theory and applications, 5thedition, New Delhi India: Macmillan India Ltd.

Taha, H. A. (2003). Operations research: An introduction. 7th edition. Delhi: Peerson practice hall.

Taha, H.A. (2007). Operations research an introduction. 8th edition. USA: Pearson Education Inc.

Thiagara, H.B. &Seshaiah, C.V. (2014). A queuing model for airport capacity and delay analysis. Journal of Applied Mathematics Sciences, 8(72), 3561-3575

Trani, A.A. (2011). Introduction to transportation engineering and queuing theory, USA. Virginia Polytechnic Institute and State University, 2(9), 23-46

Vaddi, V.S., Shaik-Dawood, A. K. &Nasseb, K. (2015). Application of queuing theory model for optimized service to airline passengers. International Journal of Current Research, 7(9): 20544-20547

Zoran, R. &Brainslay, D. (2005). Optimal number and capacity of servers in queuing system. Information Management Science, 16(3), 1-16.

