OPEN ACCESS

International
Journal
Of Modern Engineering Research (IJMER)

# Tora Application towards an Enhanced Aviation Industriesin Nigeria

[1]Adegbola A. Adekunle,[2]Alli.O.Olutayo ,[3]Olayiwola S.Olatunji,,[4]Opakunle. J. Akinpelu, [5]Olatinwo. I.O

*[1]The Polytechnic, Ibadan, Nigeria*
*Department of Mechanical Engineering;*
*[2]Department of Civil Engineering*
*[3]Department of Electrical Engineering*
*[4]Department of Mechatronics Engineering*
*[5]The Oke-Ogun Polytechnic, Eruwa*
*Department of Civil Engineering*
*Corresponding Author: Adegbola A. Adekunle*

***ABSTRACT:*** This paper describes the enormous challenges in Civil aviation Industries viz a-viz the demand of aircrafts to a particular route. As a result, aTransportation model capable of allocating different airlines to different routes and minimizing cost of transportation was adopted. Two different airlines viz-a-vizArik Airline and Aero Contractor which have considerably different schedule demands and aircraft fleet were used as case studies. Using these already existing attributes of the system, an attempt was made to allocate aircraft in an airline's fleet to the respective routes it flies on a particular day in such a way that the total carrying cost is minimized. Fuel consumption per passenger (FCPP) is used as the basis for evaluation of costs. Aircraft availability is calculated by multiplying the number of aircraft in the fleet by a constant which represents the number of trips an aircraft can fly in a day. A standard flight capacity, defined as the number of passengers the smallest aircraft can carry, is used to create a platform for comparing the different aircraft using the fuel consumption per passenger consumed for all the routes. The aircraft were then allocated to the different routes using the transportation model (TM) functions of the TORA operation research tool.
***KEYWORDS***- *TM, TORA, FCPP, Minimizing, Transportation, Availability*

---

Date of Submission: 04-07-2018 Date of acceptance: 18-07-2018

---

## I. INTRODUCTION

The TORA attempts to achieve a high degree of scalability using a "flat", non-hierarchical routing algorithm. Hence, the application in the operations of an airline which had imposed a huge task with many variables independent of the airline's control and therefore a lot of uncertainty surrounding the performance should be accessed and assessed. An airline's task is to arrange flights in the strategic market areas of their choice to satisfy customer demands using the transportation resources (aircraft) at their disposal (Neyshabouri,2012). Thus, a lot of decisions have to be made in order to create a viable plan of operations which were further broken down into smaller tasks, and more manageable problems. Airline industries are exceptional amidst mode of transportation system globally. The aviation, as commonly tagged, more than any mode of transportation has benefitted from ceaseless flow of technology in this our own contemporary age. However, there have been numerous challenges in the industry, ranging, from demand to supply in optimization problems such as schedule design problem, fleet assignment problem, the maintenance routing problem and the crew scheduling problem.

As a result, this paper solves a simplified version of the airline fleet assignment problem generated by making a number of assumptions.In several fleet assignment models, factors such as fare class differentiation, demand variation (day to day or season to season), observed and unconstrained demand, and demand recapture are either considered in the solution or assumptions are made to mitigate their effect (Lohatepanont,2002). In this paper, for simplicity, it is assumed that all passenger seats are of the same class, and that all flights are always booked to capacity. This paper also uses an already existing schedule and assumes that this schedule is the best arrangement of flights possible.

The assignment of aircraft to routes is a factor which greatly affects an airline's turnover. It is important that an aircraft is filled for each flight because the cost of flying is relatively unaffected by the number of passengers on board whereas revenue is completely dependent on the number of passengers. It is also important that aircraft is assigned to routes on which they generate the least cost or that the sum total of the cost of all flights is lowest.

In this paper, the FAP is modelled and solved as a transportation problem – a problem of determining which suppliers send what quantity of products to which consumers so that the least total cost is incurred. A product here is a flight, the suppliers are the aircrafts which an airline has in its fleet and the routes on the airline's schedule are the customers which demand flights(Jensen,2004).

## II. AIMS AND OBJECTIVES

This work is designed to generate and OR model capable of determining the allocation of different aircrafts to diffrent routes.This could be achieved by:

(i) Considering the cost incurred for fuelling each aircraft
(ii) Putting up a constraint that is capable of ensuring the total number of flights allocated to a plane in a day must be less than its availability
(iii) Minimizing the cost of all trips

## III. METHODOLOGY

Data for the airlines under study were obtained, processed and the FAP was solved using the TORA, a software package.

**Notations**

For use in this work, let
The set of planes be I
A plane in set I be i
The passenger capacity of a plane I be $p_i$
The number of planes of a particular type be $n_i$
The set of routes be J
A particular route in the set of routes 'j' j
The plane fuel capacity $f_i$
The number of times a plane 'i' will flight a route 'j' as $x_{ij}$
The fuel consumption per kilometer per passenger for a plane I $asc_i$
The flight demand for route 'j' $d_i$
The plane availability $m_i$

**Objective Function**

The cost incurred by fuelling the aircraft for a trip is the main decision variable. This cost is calculated for each possible trip by finding the fuel consumed by a plane per kilometer, per passenger and multiplying this cost by the length of the trip being considered. The objective is to minimize the sum of the cost of all trips flown in a day by an airline.

For a plane i, the cost of fuelling all the routes is given by

$$C_{i1}x_{i1} + C_{i2}x_{i2} + C_{i3}x_{i3} + \ \dots + C_{ij}\,x_{ij} = \sum_{\forall j} C_{ij}\ x_{ij}$$

For the sum total of the cost for all the planes, we have

$$\sum_{\forall i}\sum_{\forall j} C_{ij}\ x_{ij}$$

**Demand Constraints**

The demand is the number of times an airline is required to fly in a day(Lohatepanont, 2002). This is computed from the flight schedule. Each route has a demand $d_j$, the number of times it is to be flown in a day, thus the total number of flights to that destination should be equal to its demand $d_j$.

$$x_{1j} + x_{2j} + x_{3j} \dots \dots x_{nj} \le d_j$$
$$= \sum_{\forall i} x_{ij} \le dj, forj = 1,2 \dots \dots ..$$

**Supply Constraints**

The major supply constraint is the total number of times the planes in an airline's fleet can fly in a day. This is determined by the availability of each plane which is the number of times a plane can fly in a day. The plane availability must be more than the total number of flights in an airline's schedule in order to support this schedule. But the constraint is that the total number of flights allocated to a plane in a day must be less than its availability (Neyshabouri,2012,Lohatepanont, 2002 and Jensen, 2004).

$$x_{i1} + x_{i2} + x_{i3} \ldots \ldots + x_{in} \leq m_i$$
$$= \sum_{\forall j} x_{ij} \leq m_i, fori = 1,2, \ldots \ldots \ldots .$$

Hence; the formulation becomes

$$MinZ = \sum_{\forall i} \sum_{\forall j} C_{ij}\, x_{ij}$$

s. t:

Supply constraints

$$\sum_{\forall j} xij \leq mi\ for\ i = 1,2, \ldots \ldots .$$

Demand constraints

$$\sum_{\forall i} xij \leq djforj = 1,2, \ldots \ldots \ldots .$$
$$x_{ij} \geq 0\ fori = 1, 2 \ldots \ldots ; j = 1, 2 \ldots \ldots$$

## IV. RESULTS

The two airlines chosen for this study are:
(1) Arik Airline, Nigeria
(2) Aero Contractor Airline, Nigeria

**Aircraft Fuel Consumption**

Data on the planes' passenger capacity, fuel capacity and range were collected and they were used to calculate the fuel consumption per kilometer per passenger of each plane,

$$FuelConsumption = \frac{\text{Fuel capacity}}{\text{Range} \times \text{passenger capacity}}$$

Aircraft fuel consumption for each route-plane combination is calculated by multiplying the length of each route by the fuel consumption per kilometre per passenger for each plane.

$$\boldsymbol{Costperpassengerforaroute = Fuelconsumption \times RouteDistance}$$

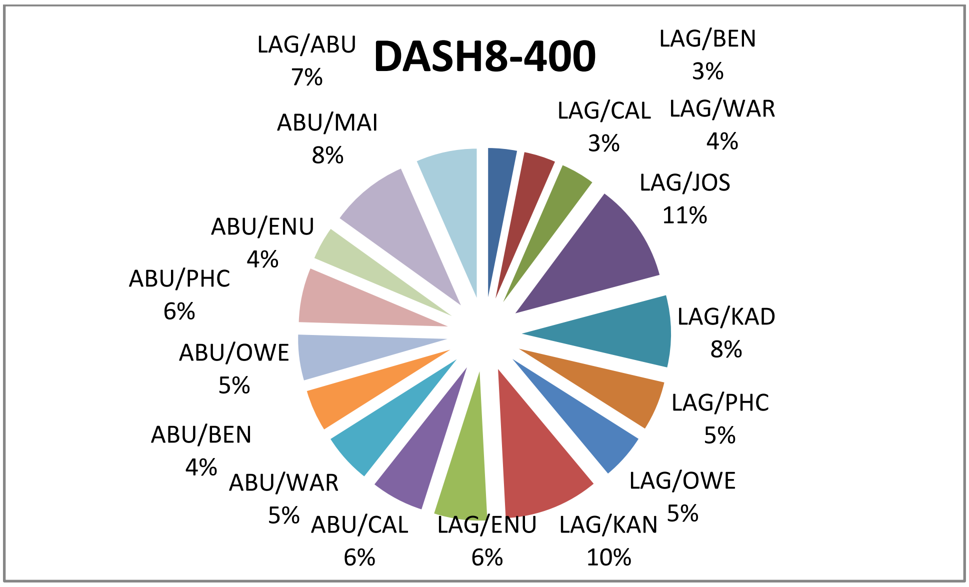


**Fig.1: Cost of FuellingAircraft per Passenger for Each Route (L/person)**

**Availability**

The availability of an aircraft for a particular airline is determined by multiplying its number by availability constant (Lohatepanot, 2002, O'Connel, 2006). This constant estimates the number of times the aircraft can fly in a day. It takes into consideration the average flight distances the airline covers, the average time for re-fuelling, and the average time for passenger loading and disembarking. The figure '6' was chosen for this constant (Morales , 2012). Thus,

$$Aircraftavailability = no.infleet \times 6$$

**Table 1:Arik airline aircraft allocation**

| **TYPE OF AIRCRAFT** | **NUMBER IN FLEET**($n_i$) | **AVAILABILITY**($n_i \times 6$) |
|---|---|---|
| DASH 8 – 400 | 2 | 12 |
| BOEING 737 - 700 | 7 | 42 |
| BOEING 737 – 800 | 4 | 24 |
| CRJ – 900ER | 4 | 24 |

**Table 2: Aero contractor airline aircraft availability**

| TYPES OF AIRCRAFT | PASSENGER CAPACITY | APPROX. RATIO OF CAPACITY | ADJUSTED AVAILABILITY ($m_i xratio$) |
|---|---|---|---|
| BOEING 737 – 400 | 144 | 3 | 72 |
| BOEING 737 – 500 | 116 | 2 | 84 |
| DASH8 – 300 | 50 | 1 | 6 |

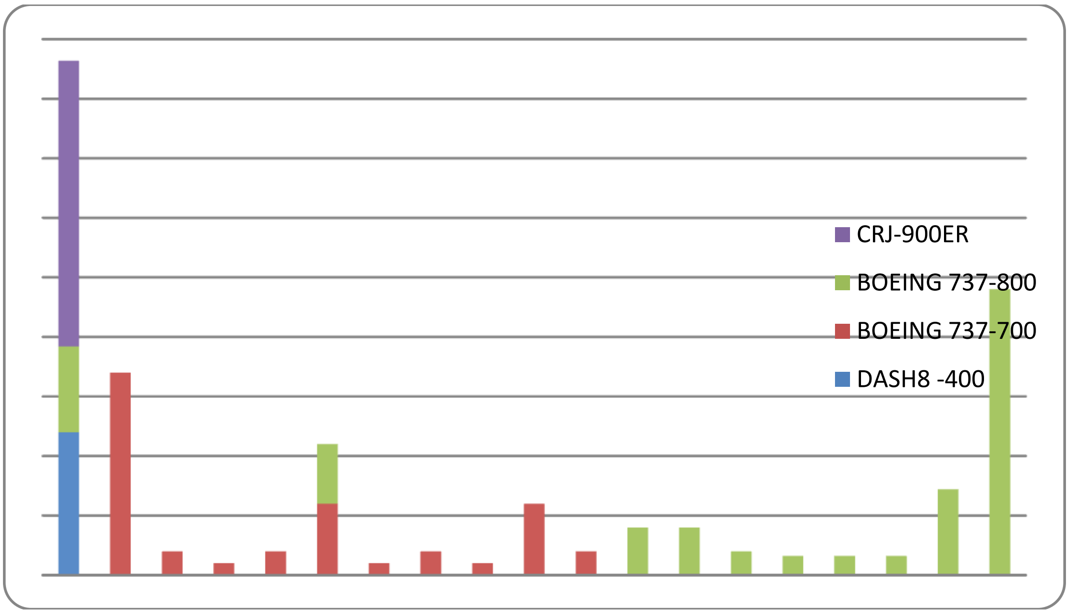


**Figure 2: Stacked graph plot of Arik aircraft allocation to routes**

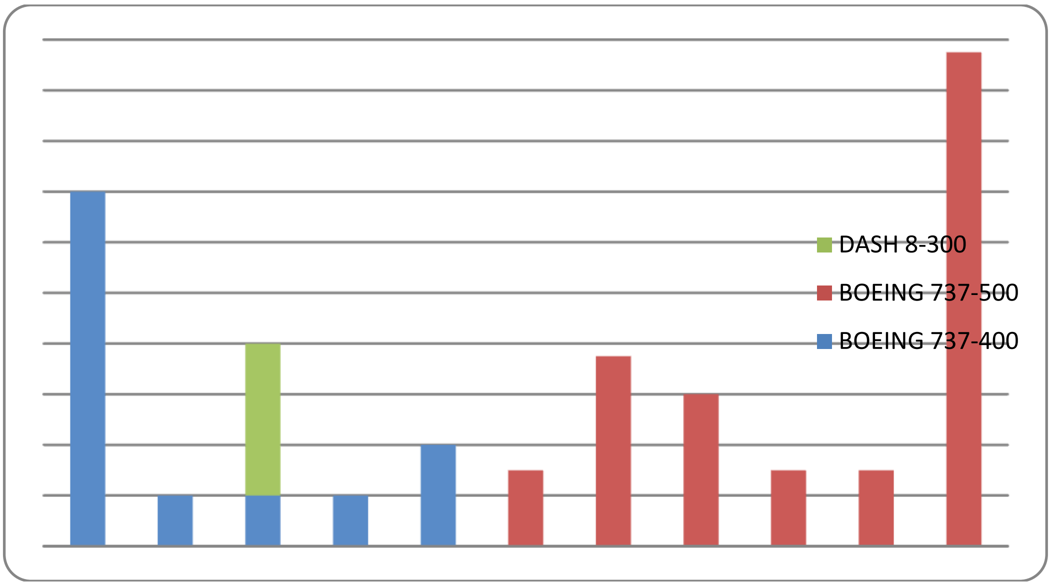


**Figure 3: Stacked graph of Aero aircraft allocation to routes**

## V. DISCUSSION AND CONCLUSION

The figures in Tables 1-3 above are in terms of a standard flight capacity defined as the number of passengers the smallest aircraft can carry. In order to interpret them as the number of flights an aircraft flies, they must be converted back to the respective plane capacities (Sherali et al, 2006). This is done by dividing by the same ratios initially used to multiply the aircraft capacities.

In Figs. 2 and 3, the values on the Y-axisrepresent the number of flights allocated to the respective route. Allocation to Dummy routes indicates excess plane availability and that the plane does not fly for that extra amount of availability. Fractional values indicate that the last flight was not filled up and thus these fractional values may be brought together and used to fill single airplanes if the flights are to fly the same route or they may be allocated to smaller planes while Fig.1 describes the percentage of passengers in a particular route with the variation in the cost of lifting.

From this result we can infer that Arik has more aircraft than is needed to meet up with their scheduled demand. The Dash 8's and CRJ 900's are all completely allocated to dummies which suggest that they are both much less efficient than either the Boeing 737-700's or the Boeing 737-800's. Both these aircraft have much smaller passenger capacities than the Boeings' which could be a reason for this result.The total cost of aircraft fuelling per kilometer, per passenger of the entire Arik airline is 1,040.16litres per kilometer per person

Similarly, we can infer that Aero contractor airlines has more aircraft than is necessary to meet up with their schedule demands.The total cost of aircraft fuelling per kilometer, per passenger of the entire Aero contractor airline is (2254.68) so as to achieve the objective of the work.

## REFERENCES


[1]. Jensen, P. A. (2004) Stochastic Programming- Aircraft Allocation to Routes, Retrieved October 4, 2012, from *Operation Research Models and Methods:*http://www.me.utexas.edu/~jensen/ORMM/computation/unit/stoch_program/aircraft.html

[2]. Kingsley, J .( 2006), Boeing's 747-8VsA380, A titanic Tussle, Flight International

[3]. Lohatepanont, M.. (2002),Airline Fleet Assignment and Schedule Design*: Integrated Models and Algorithms.*

[4]. Morales, J. (2012), The A380 Transport Project and Logistics –Assessment of alternatives, p19

[5]. Neyshabouri, S. (2012)*Airline Schedule Optimization (Fleet Assignment I). Center for Air Transportation Research, Volgenau School*, GMU.

[6]. O'Connel D.( 2006) , Fying the Airbus Giant of the Skies, The Times(UK)

[7]. Sherali, H. D., Bish, E. K., & Zhu, X. 2006. Airline Fleet Assignment Concepts, Models and Algorithms. *European Journal of Operations Research* .

[8]. Pedro Munari1(2017), Mathematical modeling in the airline industry: optimizingaircraft assignment for on-demand air transport, Proceeding Series of the Brazilian Society of Applied and Computational Mathematics, Vol. 5, N. 1, Pp.1-8.


Adegbola A. Adekunle"Tora Applicationtowards An Enhanced Aviation Industriesin Nigeria."International Journal of Modern Engineering Research (IJMER), vol. 08, no. 07, 2018, pp.01-05.