EVALUATION AND SELECTION OF A FLEET OF AIRCRAFT LOCATED IN MADNIAH, SAUDI ARABIA

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ABSTRACT

The present work simulates the evaluation and selection of a fleet of aircraft for a proposed airline located in Madniah, Saudi Arabia, to operate across an assumed network that includes both local and international destinations. This simulation is conducted through a series of phases and subsequent deeper and meticulous levels of analysis. At the end of these phases some recommendations are given for selecting the suitable fleet. The phases are simulated using MS Excel and the output of the study predicts both the aircraft efficiency and its contribution to the net profit of the airline. Considering the destination ranges covered within the network and such other important criteria as the respective payloads, a number of candidate aircraft were chosen for the study. Finally, it was found from the study that 5 of the EMB170 aircraft would be the best choice for the proposed airline.

Keywords: Fleet Planning, Operating Cost, Fleet Selection

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1. INTRODUCTION

Aircraft fleet planning is perhaps the starting point for a new airline proposed to serve a given flight network in a prescribed region of the world. This paper addresses this precise need for a proposed start-up airline based in Madinah, Saudi Arabia to serve both national and international flight destinations. It is proposed that in its initial evolutionary stages, the airline will target Umra and Hajj travelers. The airline will offer an economy class service at affordable prices to all its customers. The airline will pointedly operate where there are strong potential links, the airline has a mission vision and objective.

Between the proposed city pairs within and outside of Saudi Arabia it is strongly anticipated that the level and the type of service offered together with the affordability will promote a growth in traffic generation between the city pairs.

Mission:

- To provide a safe, reliable and value added air travel service in Saudi Arabia.

Vision:

- The airline will be established as one of the leading regional and domestic airline, offering an economy service to passengers.
- The airline will create an environment in which the competent staff will be highly motivated and will drive customer satisfaction
- The airline will create an environment in which dedicated employees and effective management team will make every effort to improve efficiency and productivity whilst minimizing cost.
- The airline will achieve a steady growth
- The airline will fill a very important gap in the airline industry where the increased demand for Umra and Hajj is necessarily picked up by adjustment to operating schedules of other carriers.

Objective:

- To consistently deliver a high level punctuality
- To offer a reliable and convenient schedule of air service in the region

- To generate a high level of demand for the airline
- To offer customers a competitive product at an affordable price
- To generate a satisfactory rate of return.

General Airline Operational Procedures

Most airlines operate under a well designed, well organized and established structure. Understanding the airline operation and structure is an important step for better understanding of the airline world. Airlines have generally evolved sound and very technical procedures in handling different aircraft designs. They operate under tried and tested strategies, on when to buy, sell, or rent an aircraft. Important information is available a priori on aircraft performance details and parent aircraft industry to investigate the suitability of a given aircraft for a given airline. Other such information as the capacity and number of hangars and their individual dimensions would be required for accommodating types and number of aircraft. If there is an industrial urgency to outsource some of their maintenance services other tasks and services, or even a number of employees and their salaries, the airline must plan for that. It is a well known fact that a given aircraft would be suitable for a large carrier but not suitable for a small carrier.

For a proposed burgeoning airline, the base maintenance would include all major checks that need to be carried out in a hanger usually in the base. Other line maintenance tasks are conducted every flight or day for the aircraft. Ground time or turn round time is an important issue to the airline industry. It is where aircraft, airline, airport, and air traffic control clearly interact. Ground time is important for the airline industry because the lower the ground time the higher the utilization of the aircraft and this would lower the direct operating costs. Ground time is also important for the airports. Lower ground time reduces congestion at the airport. The airports would then handle more travellers.

To make a successful plan, a fleet planner must incorporate ground time, flight times and other maintenance times into consideration quite early in the planning stage. Therefore, ground time is necessarily accounted for while building the airline fleet plan model. In real life each aircraft has its ground time, which depends on a number of elements such as range of flight, whether the flight is domestic or international, is the aircraft at the base or not, the capacity of the flight, the design of the aircraft, and other factors.

2. FLEET PLANNING

Fleet planning is very important for any airline. Fleet planning determines what type and what number of aircraft the airline should buy, in order to achieve the airline goals. Fleet planners also get involved in the negotiation deals with aircraft and engine manufactures. Most decisions are arrived at after due considerations of the pertinent flight missions. So by understanding basic elements of fleet planning, one would essentially understand the airline needs and operation parameters.

It should be noted that there are other factors that influence the new aircraft purchase that do not depend on fleet planning. These would include such deliberations as alliance with other operators, people factors and communality (Clark, 2001).

For example The Airbus, when marketing their Aircraft emphasize upon communality amongst their aircraft and point to the advantage of having a fleet of different type and size of aircraft from Airbus inventory. These advantages address such issues as:

- Expediency of time needed in training pilots on aircraft from their inventory.
- Efficiency in time in training maintenance manpower on aircraft from the same source industry.
- Since the systems are similar and properly use the same tools and procedures for maintenance or even operational such as refuelling, or baggage handing, that would have a big effect on the operational cost.

The only real disadvantage is that having similar aircraft from the same manufacturer would make negotiations for new purchases from a new vendor somewhat difficult as there would be little or no residential familiarity for other aircraft. A mixed inventory would provide better leverage in new transactions.

It is important to note that fleet planning is not just aircraft evaluation, aircraft comparison, route analysis, aircraft acquisition, or matching supply to demand in isolation but includes all these elements simultaneously (Clark, 2001).

A better understanding of fleet planning procedures and the evaluation of aircraft deployments in an airline would help construct the overall flight operational model. One of the most difficult decisions in an airline is whether to buy a new or a used aircraft. Decide upon what type of aircraft would be required for purchase or lease or go for renewing the existing aircraft.

The dilemmas of fleet planning of an airline is that

- Fleet Complexity
- Decisions must be long term
- Market volatility
- Heterogeneity of Networks

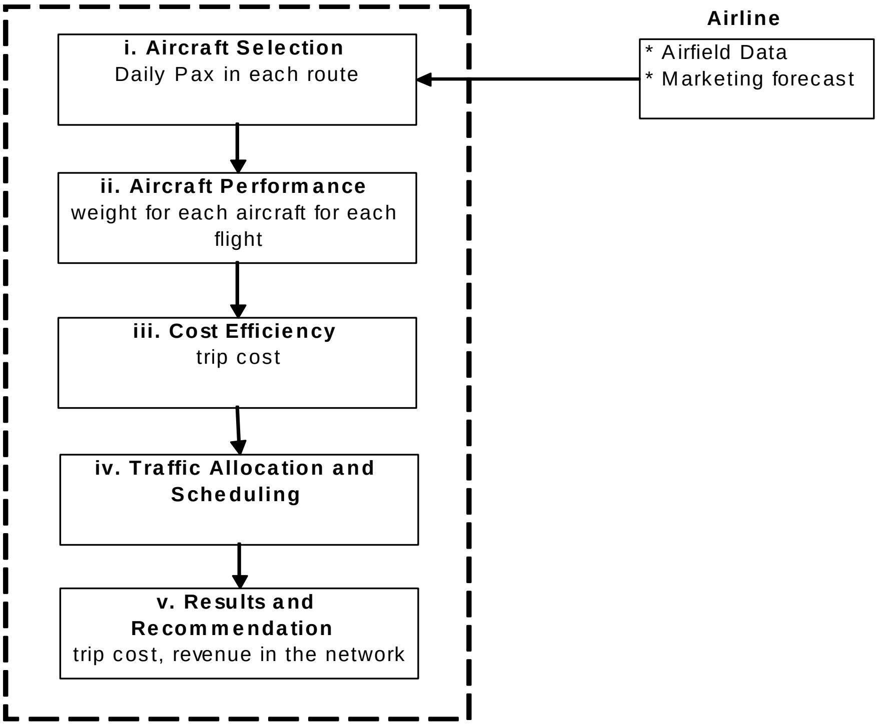
In fact the fleet planning is a compromise amongst a large number of competing imperatives. Each airline has a different approach towards the replacement of its aircraft. There are *large airlines which are government supported*, *small airlines*, or *capital rich airlines,* all would have a different aircraft average age, but they all follow the simpler principle of fleet planning.

Fleet planning is an on going process over the life cycle from the evaluation through disposal and data collection. More details are available in Clark (2001).

3. APPROACH

The emphasis will be on the interaction and competing interests amongst all of the above mentioned elements. Establishing a model which addresses the complexity of above issues in combination would help in the decision making of the fleet planning. Modelling remains an important step to gain an understanding of how the air transport world acts and interacts. It represents the most challenging task in constructing a unified strategy from a large number of disciplines that need to be covered and their mutual interaction in building up the functional flight model. Typically fleet planning evaluation and selection in the airline for a number of aircraft can be broken down into five main steps as shown in Figure 1 (Roskam, 1990a).

Figure 1 - Typical Practical Steps in Fleet Planning



Source: Roskam (1990a)

These steps are:

1. *The Process of Aircraft Selection*. The first set of input data for this step would be from the airline in the process of selecting an aircraft, the input data would be a*irfield data* which includes (elevation, temperature, runway length and surfaces, etc). The selection is based on the operation of regional jets from Madniah to selected destinations in a network that includes local destinations such as Riyadh, and Dammam, and International destinations such as Beirut, Dubai, Cairo and Istanbul. Table 1, Shows the airfield data for the mentioned cities. Table 2 shows the aircraft that have been selected for the study, their engine type and the associated weights. The second source of information would be the *Market Forecast,* Table 3, which includes assumed data such as growth rates, frequency, saturation load, etc. The last set of information needed in this process is domestic, regional, and international network distances. After making an analysis, the output of this step would be the daily passenger profile for each sector in the long and short term and a payload range plot. The aircraft candidates would then be determined in this step.

Table 1 - Airfield Data

Airfield	Eleva.	Temp	Runway Length
City (+IATA Code)	ft	C	ft
Madinah (MED)	2151	23	12657
Jeddah (JED)	48	25	12491
Riyadh (RUH)	2049	22	13829
Dammam (DMM)	72	26	13165
Cairo (CAI)	382	21	13127
Istanbul (IST)	163	17	9813
Dubai (DXB)	34	26	13143

Source: Roskam (1990b)

Table 2 - Aircraft Type

Aircraft	Engine	OWM	MFW	MTOW	MPLW
Type	Type	lb	lb	lb	lb
EMB170	CF34-8E	46165	20887	79344	12292
B717-200	BR715-30	68500	29500	121000	23000
A318-200	CFM56-5	84600	42080	145500	18820

Note: All has an Aux. Power Unite
OWM: Operating Weight Empty
MFW: Max. Fuel Weight
MTOW: Max. Takeoff Weight

Source: Snow (2004)

Table 3 - Market Forecast

Sectors	Ann. Pax	Growth	Frequency	Staturation	Yield
From To	Each way	p.a.		Load %	$/nm
MED - JED	24000	5	2D	85	0.25
MED - RUH	16000	5	3D	85	0.25
MED - DMM	8000	10	D	85	0.25
MED - CAI	42000	10	D	85	0.25
MED - IST	28000	10	2D	85	0.25
MED - DXB	16000	10	3D	85	0.25

Ann. Pax: Number of passengers yearly each way
p.a: per annum
D: Daily flights

2. *Detailed Aircraft Performance*. In the previous step the candidate aircraft has been identified. Therefore, the performance of each aircraft can be known, the airfield and en-route capabilities of these aircraft will be examined. After setting up some ground rules such

as time for taxi-in, time for taxi-out, time for start-up, the reserve fuel, the assumed alternative airport etc all for domestic and international routes, the output would be a weight breakdown and passenger payload in the network for each nominee aircraft and that by using Roskam (1990a, 1990b). That would give an indication of how many passengers a given aircraft can take.

3. *Cost Efficiency.* This step will indicate the economic suitability for each aircraft on a typical stage length or cost per trip. In this step some assumptions must be made to progress the economic analysis. Example of these assumptions would be fuel cost, cost of maintenance, annual insurance rate, annual salaries paid, etc, as shown in Table 4. The specific fuel consumption was given as specified by the manufacturers. The dollar year was assumed to be 2013. The engine maintenance labour rate used is $12 per man hours, and the fuel price is assumed to be $ 2.9 per US Gallon. Direct Operating Cost or (DOC) calculations were based on methods mentioned in World Airport Code (2013). DOC is an area where it is very tricky to get a third party reliability data source and airlines are very reluctant to provide data on their cost per stage length.

Table 4 - Assumed Parameters

Parameter		**Value**
Annual salary paid for one pilot	[$/year]	100000
Annual salary paid for one co-pilot	[$/year]	80000
Cost of maintenance materials for airplane	[$/n.m]	404
Cost of maintenance materials for engine	[$/n.m]	217
Annual hull insurance rate	[$/$/year]	0.015
Maintenance man-hours per flight hours	[hrs/hr]	5.86
Number of flight hours/year		750
Fuel density FD	[lbs/gallons]	8
Fuel price FP	[$/gallons]	2.9
L/D		15
Engine maintenance labor rate	[$/hr]	12

The output would be a cost per trip per aircraft on the given network.

$$DOC = DOCfly + DOCmaint + DOCdepr + DOClnr + DOCfin \quad (1)$$

Where:

DOCfly is the direct operating cost of flying in $/n.m.

DOCmaint is the direct operating cost of maintenance in $/n.m.

DOCdepr is the dirct operating cost of depreciation in \$/n.m.

DOClnr is the direct operating cost of landing fees, navigation fees and taxes in \$/n.m.

DOCfin is the direct operating cost of finance in \$/n.m.

n.m. nautical miles

The DOCfly is given by

$$DOCfly = Ccrew + Cpol + Cins \quad (2)$$

Where:

Ccrew is crew cost given by

$$Ccrew = SUM\ [\ (n_{cj})\ \{\ (1 + K_j)\ /\ V_{bl}\ \}\ (SAL_j\ /\ AH_j) + (TEF_j\ /\ V_{bl})\ ] \quad (3)$$

nc_j is the number of crew member of each type (i.e. captain, and co-pilot)

V_{bl} is the airplane block speed in n.m/hr.

SAL_j is the annual salary paid to crew members of each type

AH_j is the number of flight hours per year of each type

TEF_j is the travel expense factor

K_j factor which accounts for items such as vacation pay, cost of training

Cpol is the fuel and oil cost per nautical mile given by

$$Cpol = 1.05\ (Wf\ /\ R)\ (FP\ /\ FD) \quad (4)$$

Wf is the fuel weight in lb

R range in n.m

FP is the price of fuel in \$ / gallon

FD is the fuel density in lbs / gallon

Cins is the airframe insurance cost in \$/n.m given by

$$Cins = (fins)\ (AMP)\ /\ \{\ (Uann)\ (V_{bl})\ \} \quad (5)$$

fins is the annual hull insurance rate in \$/\$/year

AMP is the airplane market price

Uann is the annual hour utilization

The DOCmaint is given by

$$DOCmaint = Clab/ap + Clap/eng + Cmat/ap + Cmat/eng + Camb \quad (6)$$

Where

Clab/ap is the labor cost of airframe and systems in $/n.m

$$Clab/ap = 1.03 (MHRa) (R / V_{bl}) \quad (7)$$

MHRa is number of airframe and systems maintenance hours needed per block hours

Clap/eng is the labor cost of engines in $/n.m

$$Clap/eng = 1.03 (1.3) Ne (MHRe) (R / V_{bl}) \quad (8)$$

Ne number of engines

MHRe is the number of engines maintenance hours needed per block hours

Cmat/ap is the cost of maintenance materials for the airframe and systems $/n.m

Cmat/eng is the cost of maintenance materials for the engines $/n.m

Camb is the applied maintenance burden in $/n.m.

The DOCdepr is given by

$$DOCdepr = Cdap + Cdeng + Cdav + Cdapsp + Cdengsp \quad (9)$$

Where

Cdap is the cost of airplane depreciation without engines in $/n.m

Cdeng is the cost of engine depreciation in $/n.m

Cdav is the cost of depreciation of avionics systems in $/n.m

Cdapsp is the cost of the depreciation of airplane spare part in $/n.m

Cdengsp is the cost of the depreciation of engine spare part in $/n.m

The DOClnr is given by

$$DOClnr = Clf + C nf + Crf \quad (10)$$

Where

Clf the direct operating cost due to landing fees in ($/n.m) are calculated by

$$Clf = (Caplf) / \{ (V_{bl}) (t) \} \quad (11)$$

Where

Caplf is the landing fees per landing given by

$$CapIf = 0.002 Wto \ \$/lbs \quad (12)$$

Wto is the airplane takeoff weight in lbs

Cnf the navigation fees in $/n.m

$$Cnf = (Capnf) / \{ (V_{bl}) (t) \} \quad (13)$$

Where

Capnf is the navigation fees charged per airplane per flight

Crt is the direct cost of registry taxies in ($/n.m) are calculated by

$$Crt = (frt) DOC \quad (14)$$

Where frt is a factor suggested from Ref[6]

$$Frt = 0.001 + (10^{-8}) Wto \quad (15)$$

Where

Wto takeoff weight in lbs

The DOCfin is given by

$$DOCfin = 0.07 \ DOC \quad (16)$$

In order to calculate the cost per aircraft per trip and the cost per seat mile, it is calculated as follows

Cost per aircraft per trip = DOC [$/n.m] × Distance [n.m] (17)

Cost per seat mile = DOC [$/n.m] ÷ Number of seats (18)

More details are available in Taylor (2005).

4. *Traffic Allocation and Scheduling.* This step will identify the quantity of each aircraft required and schedule the flights. This would require some information such as ground time for each aircraft, refuelling time and other information or rules supplied by the commercial management department, such as, daily frequencies for a given aircraft on each route, international flight linked to domestic flights, and other ground rules such as aircraft limited to operating between 06:00 and 23:00 or frequency for international routes should be either 3 times a week or once a day. The output of this step is a flight schedule.

5. *Results and Recommendation.* Which should identify the preferred fleet choice by comparing trip cost, revenue, operating cost, results or total, number of passengers, … etc with time.

4. ASSUMPTIONS

In order to get the cost information about the airline, some relevant economic and operational data were either assumed or collected with the help of Saudi Arabian Airline.

In creating the model, some ground rules are assumed:

1. All maintenance checks are performed at the base airport.
2. There is at all times, at least one aircraft at stand-by for emergency circumstances
3. Each aircraft should undertake an inspection after each flight.
4. General ground rules have been assumed for various time slots. This includes time slot passengers embark, refuelling, passengers disembark, repair, inspection …etc.

5. RESULTS

An Excel programme created by the author was used to generate data for each aircraft type, by running the programme for 1, and 5 years, generating DOC (Direct Operating Costs), net contribution to profit share for each sector, and total contribution to profit for the entire fleet after 5 years. This provides a assessment of the impact of each aircraft type. The output information can be used by a Project Manager, or a Fleet Planner, to decided upn which aircraft would provide the best benefits or best results during flight operations. These results would be automatically processed to the fleet planner.

The study also shows that for the given annual passenger traffic and the growth rate, the airline would need 5 aircraft from the EMB170, or 3 aircraft from the B717, or 3 from the A318 aircraft.

Figure 2 shows the efficiency of each aircraft for a given sector. Different aircraft types are not only compared with their trip cost but also with their seat mile costs. When assessing such results it should be understood that, lower the two parameters for the given aircraft the better, the aircraft is said to be for more efficient if both parameters are low.

Figure 2 - Aircraft Efficiency

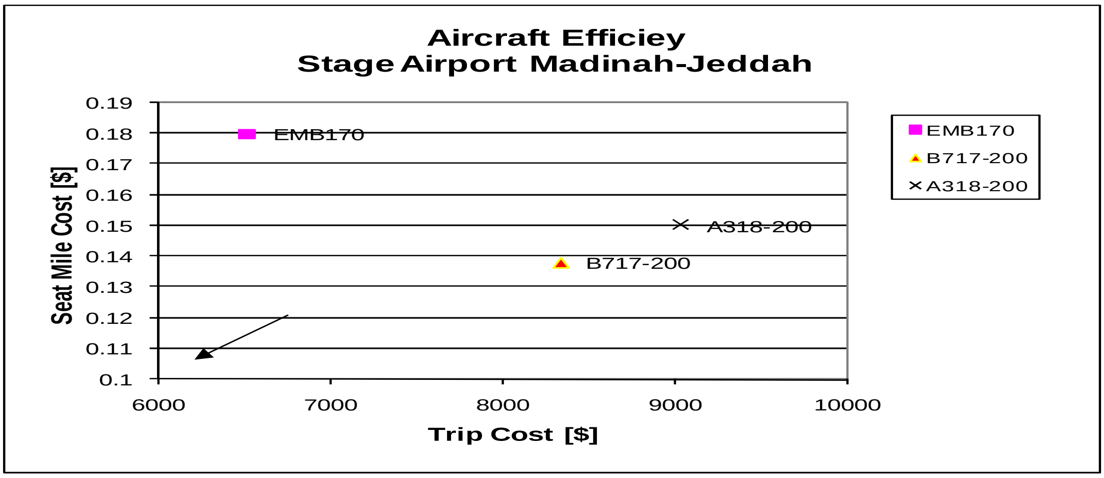
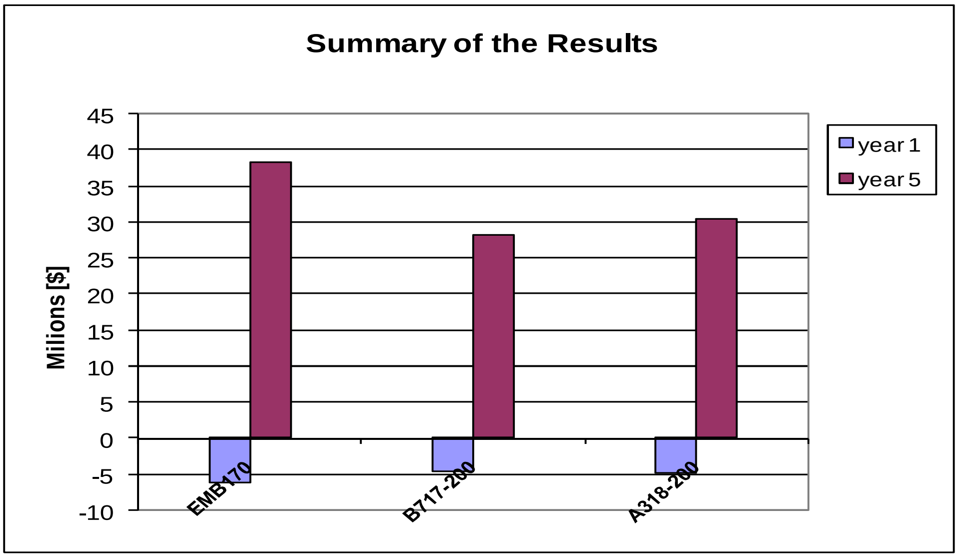


Figure 3 summarizes the study made for the 5 year time line for each aircraft operation under the assumed network. It shows that the first year would demonstrate a loss for all the aircraft types. This is to be expected as the cost is high when a new aircraft is introduced to an airline for the first year, but then the costs would come down and stabilize at a given rate. , After 15 to 20 years, the cost would go up due to aging and increasing maintenance.

After 5 years, the model shows a decrease in cost and an increase in profit, and therefore revenue is generated.

Figure 3 - Study Results



6. CONCLUSION

Aircraft efficiencies and contribution to profile share have been duly identified. It was learnt from observations in Figure 2 that Embarer Aircraft EMB 170 provides the highest cost per seat mile and the lower individual trip cost. The B717 aircraft on the other hand has the lowest seat/mile cost. The Airbus A318-200 was found to have the highest trip cost but a low seat/mile liability.

Further deeper analysis in Figure 3 have confirmed that the best choice for a given flight operational network the highest profit would be recovered from at least 5 EMB 170 aircraft. This fleet of 5EMB 170 aircraft are also provide the best flexibility. B717 aircraft appear to show the least profit.

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