UNIT 23: STRATEGIC PLANNING FOR AIR TRANSPORT

TOPIC

Evaluate the techniques involved in airline planning to optimise fleet assignments and maximise capabilities

ESSENTIAL CONTENT

- Fleet planning to meet demand levels and operating costs

FLEET PLANNING

A THOROUGH UNDERSTANDING OF AIRCRAFT PERFORMANCE, AIRCRAFT ECONOMICS AND THE LEASE/FINANCE SECTOR THAT IS ESSENTIAL TO THE FLEET PLANNING DECISION.

THE CORE REVENUE/PROFIT CONTRIBUTOR FOR ANY AIRLINE IS DELIVERED BY OPERATING ITS AIRCRAFT FLEET. THEREFORE, EVALUATING, SELECTING AND MANAGING THE OPTIMUM FLEET, MATCHING CAPACITY TO DEMAND AND MAKING SMART PURCHASE/LEASE DECISIONS ARE CENTRAL TO AN AIRLINE'S SUCCESS.

(AVIA SOLUTIONS, 2006)

FLEET PLANNING

FLEET PLANNING IS CARRIED OUT BY AIRLINES TO DETERMINE THE QUANTITY AND TYPE OF AIRCRAFT TO BE PURCHASED OR LEASED IN ORDER TO PROVIDE A PROFITABLE SERVICE THROUGHOUT THE LONG-TERM PLANNING HORIZON.

A STRATEGIC FLEET PLANNING IS VITAL AS IT HAS A GREAT IMPACT ON THE ECONOMIC EFFICIENCY OF AIRLINES.

(TEOH AND KHOO, 2016)

Fleet Planning

Travel demand and service frequency are found to be two influential factors in fleet planning. In other words, there is a close relationship between the type of aircraft, aircraft quantity, travel demand of passengers, and the service frequency in fleet planning.

Past research had shown that if travel demand is estimated stochastically to account for uncertainty, the optimal solutions are more accurate and reliable.

(Teoh and Khoo, 2016)

OPERATORS MUST CONSIDER MANY FACTORS WHEN SELECTING A NEW OR REPLACEMENT FLEET:

Match capacity to demand

Optimum number of fleet types

Fleet commonality

Aircraft payload range capability

Aircraft take-off performance

Relative fuel consumption

Relative revenue driven by seat count

Maintenance cost and support capability

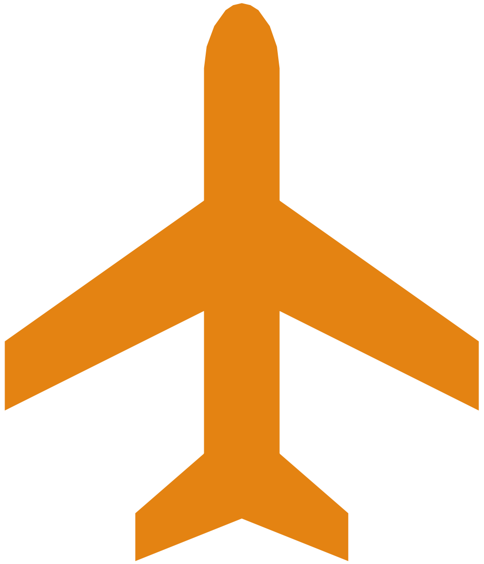
The value of passenger comfort

Cargo capacity

Old versus new trade-offs

Aircraft pricing/lease rates

Aircraft buy versus lease trade-offs



FLEET PLANNING; RESEARCH

It is suggested that the factors that have an influence on airline flight frequencies and aircraft size for US airline routes by taking into consideration market demographics, and the airport, airline and route characteristics.

Using the regression analysis, it is found find that route characteristics, such as distance, level of demand and competition, strongly influence the selection of aircraft size, while airport characteristics do not influence aircraft selection.

(Dožić and Kalić, 2015)

FLEET PLANNING; RESEARCH

One study developed a nested logit model to investigate the influence of aircraft size, frequencies, seat availability and airfare on demand for air travel and airline market share in duopoly markets.

They demonstrate that an airline achieves greater market share by increasing frequencies rather than increasing seat availability per flight.

(Dožić and Kalić, 2015)

FLEET PLANNING; RESEARCH

A STUDY COMPARED THE ENVIRONMENTAL IMPACTS OF OPERATING LARGE VERSUS SMALL AIRCRAFT ON SHORT HAUL ROUTES.

THEY POINT OUT THE IMPORTANCE OF FREQUENCY FOR PRESERVING THE AIRLINE POSITION ON THE MARKET AND THE FACT THAT AIRLINES PREFER INCREASING FREQUENCY TO INCREASING AIRCRAFT SIZE, ESPECIALLY ON SHORT ROUTES.

(DOŽIĆ AND KALIĆ, 2015)

FLEET PLANNING; RESEARCH

A STUDY FOCUS ON THE EFFECTS OF AIRCRAFT LEASING ON AIRLINE OPERATION RATHER THAN ON THE FINANCIAL IMPLICATIONS.

THEY INDICATE THAT AN AIRLINE WHICH NEEDS ADDITIONAL CAPACITY IN SHORT TIME PERIODS MAY NOT REACH ADVANTAGEOUS AGREEMENTS WITH MANUFACTURERS, WHILE LARGE LEASING COMPANY CAN PROVIDE AIRCRAFT IN SHORT TIME PERIODS AND AT LOWER PRICES.

(DOŽIĆ AND KALIĆ, 2015)


Stage one - Approximate fleet mix
Stage two - Fleet sizing
Stage three - Aircraft type selection

STOCHASTIC DEMAND

GLOBALLY, THE AIRLINES FORECAST THE FUTURE GROWTH OF TRAVELERS ANNUALLY TO OBTAIN THE LATEST TREND IN TRAVEL DEMAND. TYPICALLY, THE FORECASTING OF THE GROWTH OF DEMAND IS FOUND TO BE POSITIVE IN ACCORDANCE WITH THE INCREASE IN POPULATION SIZE AND INCOME LEVEL.

HOWEVER, WHEN THERE IS AN OCCURRENCE OF AN UNPREDICTED EVENT THAT COULD AFFECT THE TRAVELER'S DECISION, THERE WOULD BE A REDUCTION IN DEMAND DURING THE PERIOD. THIS IS REFERRED TO AS A NEGATIVE EFFECT.

(TEOH AND KHOO, 2013)

STOCHASTIC DEMAND; STEPS

1. Determine the possible event's occurrence
2. Determine the probability of the event's occurrence (negative effect)
3. Determine the possible increment of the forecasted demand $D_{f(inc)}$
4. Determine the probability of the increment of the forecasted demand $D_{f(inc)}$
5. Determine the value of SDI for each operating period

(Teoh and Khoo, 2013)

Fleet Management

Fleet management determines the optimal number of aircraft needed by an airline to maintain a targeted level of service while maximizing its profit.

Two major decisions are to be made, that is, to determine the number of aircraft to be purchased and leased at any point in time to meet the demand.

Proper fleet management is important as it would affect the economical efficiency of the airline and it has an influential impact on customer satisfaction.

(Teoh and Khoo, 2013)

FLEET MANAGEMENT OPTIMIZATION MODEL

THE FLEET MANAGEMENT DECISION MODEL IS FORMULATED AS A PROBABILISTIC DYNAMIC PROGRAMMING MODEL.

FOR A SET OF THE ORIGIN–DESTINATION PAIRS, ASSUME THAT THERE IS A SELECTION OF N TYPES OF AIRCRAFT THAT COULD BE PURCHASED OR LEASED. THE DECISION VARIABLES OF THE MODEL ARE THE NUMBER AND TYPES OF AIRCRAFT TO BE PURCHASED OR LEASED TO MAXIMIZE THE OPERATIONAL PROFIT OF THE AIRLINES.

(TEOH AND KHOO, 2013)

FLEET MANAGEMENT OPTIMIZATION MODEL

THE STAGE OF THE MODEL IS THE PLANNING HORIZON OF THE FLEET MANAGEMENT DECISION MODEL. THE OPERATING PERIOD, T, IN TERMS OF YEARS IS THE STAGE VARIABLE OF THE MODEL.

THE STATE VARIABLE AT EACH STAGE T CONSISTS OF VARIOUS INTERCORRELATED VARIABLES, NAMELY THE NUMBER OF AIRCRAFT TO BE PURCHASED OR LEASED, TOTAL OPERATED AIRCRAFT, NUMBER OF AIRCRAFT TO BE SOLD, NUMBER OF AIRCRAFT TO BE ORDERED, AND NUMBER OF AIRCRAFT TO BE RELEASED FOR SALES.

(TEOH AND KHOO, 2013)

FLEET MANAGEMENT OPTIMIZATION MODEL; CONSTRAINTS

THE PRACTICAL CONSTRAINTS CONSIDERED FOR THE FLEET MANAGEMENT DECISION MODEL ARE AS FOLLOWS:

- BUDGET CONSTRAINT
- DEMAND CONSTRAINT
- PARKING CONSTRAINT
- SALES OF AIRCRAFT CONSTRAINT
- ORDER DELIVERY CONSTRAINT
- LEAD TIME CONSTRAINT
- SELLING TIME CONSTRAINT

(TEOH AND KHOO, 2013)

FLEET MANAGEMENT OPTIMIZATION MODEL; CONSTRAINTS

BUDGET CONSTRAINT:

THE BUDGET CONSTRAINT ASCERTAINS WHETHER OR NOT THE SOLUTION IS FINANCIALLY FEASIBLE FOR THE AIRLINES. FOR THIS CONSTRAINT, THE SUM OF THE PURCHASE AND LEASE COST OF THE AIRCRAFT SHOULD NOT BE MORE THAN THE ALLOCATED BUDGET, WHICH COULD BE EXPRESSED AS FOLLOWS:

$$\sum_{i=1}^{n} purc_{ti} X_{ti}^{P} + \sum_{i=1}^{n} lease_{ti} X_{ti}^{L} \leq MAX_{budget\,(t)}$$

$$for\ t = 1, 2, \dots, T$$

(TEOH AND KHOO, 2013)

FLEET MANAGEMENT OPTIMIZATION MODEL; CONSTRAINTS

DEMAND CONSTRAINT:

THE STOCHASTIC DEMAND IS USED TO FORM THE DEMAND CONSTRAINT. TO ENSURE THAT TRAVELERS' DEMAND COULD BE MET SATISFACTORILY, THE DEMAND CONSTRAINT COULD BE EXPRESSED AS:

$$\sum_{i=1}^{n} (SEATi) \left(f\left(D_t^s, A_t^i\right)\right) \geq (1-\alpha) D_t^S$$

$$for\ t + 1,2, \ldots, T, S = S_1, S_2, \ldots, S_k$$

WHERE 1 - A IS THE CONFIDENCE LEVEL (SERVICE LEVEL) TO MEET THE STOCHASTIC DEMAND.

(TEOH AND KHOO, 2013)

FLEET MANAGEMENT OPTIMIZATION MODEL; CONSTRAINTS

Parking constraint:

When an aircraft is not in operation, it has to be parked at the hangar at the airport. In such a case, the choice of aircraft would sometimes be constrained by the geometry layout of the hangar at the airport. As such, the parking constraint is ought to be considered feasibly. This constraint is shown as follows:

$$\sum_{i=1}^{n} \sum_{y=0}^{n} \left(In_{tiy}^{P} + In_{tiy}^{L} + X_{ti}^{P} + X_{ti}^{L}\right)(SIZE_i) \leq PARK_t$$

$$for\ t = 1, 2, \ldots, T$$

(Teoh and Khoo, 2013)

Fleet Management Optimization Model; Constraints

Sales of aircraft constraint:

For some airlines, the aging aircraft, which is less cost-effective, might be sold at the beginning of a certain operating period when the airlines make the decision to purchase a new aircraft. However, the number of aircraft sold should not be more than the aircraft owned by the airlines. It is expressed as follows:

$$Sold_{tiy} \leq In^{P}_{(t-1)i(y-1)}$$

$$for\ t = 1, 2, \ldots, T, i = 1, 2, \ldots, n, y = 1, 2, \ldots, m$$

(Teoh and Khoo, 2013)

FLEET MANAGEMENT OPTIMIZATION MODEL; CONSTRAINTS

LEAD TIME CONSTRAINT:

IN PRACTICE, THE AIRLINES WOULD GET AN AGREEABLE LEAD TIME (THE PERIOD BETWEEN PLACING AND RECEIVING AN ORDER) FROM THE AIRCRAFT MANUFACTURER WHEN THEY PLACE AN ORDER FOR NEW AIRCRAFT. THIS CONSTRAINT SHOULD BE CONSIDERED AS IT INDICATES WHEN THE AIRLINES ARE SUPPOSED TO ORDER NEW AIRCRAFT. FOR N TYPES OF AIRCRAFT, THIS CONSTRAINT CAN BE EXPRESSED AS FOLLOWS:

$$P(RTL_{ti} \leq DLT_{ti}) \leq \beta$$
$$for\ t = 1, 2, \dots, T, i = 1, 2, \dots, n,$$

(TEOH AND KHOO, 2013)

Fleet Management Optimization Model; Constraints

Lead time constraint:

Because in real life, there are chances that the targeted lead time would change (say, because of the technical problems of the manufacturer), the lead time should be a random value that could be represented by a certain distribution. In this study, the lead time is assumed to be normally distributed with mean μ_{LT} and standard deviation σ_{LT} The constraint could be stated by:

$$DLT_{ti} \geq F^{-1}(1-\beta)\sigma_{LT} + \mu_{LT}$$
$$for\ t = 1, 2, \ldots, T, i = 1, 2, \ldots, n,$$

where $F^{-1}(1-\beta)$ is the inverse cumulative probability of 1-β.

(Teoh and Khoo, 2013)

FLEET MANAGEMENT OPTIMIZATION MODEL; CONSTRAINTS

SELLING TIME CONSTRAINT:

AN AGING AIRCRAFT, WHICH IS CONSIDERED AS LESS ECONOMICAL, MIGHT BE SOLD BY THE AIRLINES AT A CERTAIN OPERATING PERIOD. IN SUCH A CASE, THE AIRLINES NEED TO KNOW THE MOST SUITABLE TIME TO RELEASE THEIR AGING AIRCRAFT FOR SALES PARTICULARLY TO LOOK FOR PROSPECTIVE BUYERS IN ADVANCE. IN REAL PRACTICE, THE REAL SELLING TIME MIGHT BE LONGER THAN THE DESIRED SELLING TIME. THEREFORE, THIS CONSTRAINT IS FORMED WITH THE AIM TO REDUCE THE POSSIBILITY OF THIS INCIDENT AS MUCH AS POSSIBLE. THIS CONSTRAINT COULD BE DEFINED AS FOLLOWS::

$$P(RST_{ti} \geq DST_{ti}) \leq y$$
$$for\ t = 1, 2, \dots, T, i = 1, 2, \dots, n,$$

(TEOH AND KHOO, 2013)

FLEET MANAGEMENT OPTIMIZATION MODEL; CONSTRAINTS

SELLING TIME CONSTRAINT:

IT IS ASSUMED THAT THE SELLING TIME HAS A NORMAL DISTRIBUTION WITH MEAN μ_{ST} AND STANDARD DEVIATION σ_{ST}:

$$DST_{ti} \geq F^{-1}(1-y)\mu_{ST} + \sigma_{ST}$$
$$for\ t = 1, 2, \ldots, T, i = 1, 2, \ldots, n,$$

WHERE $F^{-1}(1-y)$ IMPLIES THE INVERSE CUMULATIVE PROBABILITY OF 1-Y

(TEOH AND KHOO, 2013)

For $t = 1, 2, \ldots, T$

$$P\left(I_t^P + I_t^L\right) = \max_{X_t} \left(1 + r_t\right)^{-t} \left\{ \begin{array}{l} p_{s_1} \left(\begin{array}{l} E(fare_t^{s_1}) D_t^{s_1} + \sum_{i=1}^{n} \sum_{y=1}^{m} sold_{tiy} resale_{tiy} - E\left(\cos t_t^{s_1}\right) D_t^{s_1} - \\ \sum_{i=1}^{n} u_{ti} + (purc_{ti})(x_{ti}^P) - \sum_{i=1}^{n} lease_{ti}\left(x_{ti}^L\right) - \sum_{i=1}^{n} hgf(D_t^S, A_t^i) - \\ \sum_{i=1}^{n} \sum_{y=1}^{m} \left(In_{tiy}^P\right)\left(dep_{tiy}^P\right) - \sum_{i=1}^{n} \left(In_{ti}^L\right)\left(dep_{ti}^L\right) - \sum_{i=1}^{n} dp_{ti}\left(x_{ti}^P\right) - \\ \sum_{i=1}^{n} dl_{ti}\left(x_{ti}^L\right) - \sum_{i=1}^{n} C(fuel_{ti}) \end{array} \right) + \ldots + \\ p_{s_k} \left(\begin{array}{l} E(fare_t^{s_k}) D_t^{s_k} + \sum_{i=1}^{n} \sum_{y=1}^{m} sold_{tiy} resale_{tiy} - E\left(\cos t_t^{s_k}\right) D_t^{s_k} - \\ \sum_{i=1}^{n} u_{ti} + (purc_{ti})(x_{ti}^P) - \sum_{i=1}^{n} lease_{ti}\left(x_{ti}^L\right) - \sum_{i=1}^{n} hgf(D_t^S, A_t^i) - \\ \sum_{i=1}^{n} \sum_{y=1}^{m} \left(In_{tiy}^P\right)\left(dep_{tiy}^P\right) - \sum_{i=1}^{n} \left(In_{ti}^L\right)\left(dep_{ti}^L\right) - \sum_{i=1}^{n} dp_{ti}\left(x_{ti}^P\right) - \\ \sum_{i=1}^{n} dl_{ti}\left(x_{ti}^L\right) - \sum_{i=1}^{n} C(fuel_{ti}) \end{array} \right) + P_{t+1}\left(I_t^P + I_t^L\right) \end{array} \right\}$$

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