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Operations Research

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ABSTRACT

This paper provides an overview of several key areas of operations research applications in the air transportation industry. Specific topics covered include: the various stages of aircraft and crew schedule planning; revenue management, including overbooking and leg-based and network-based seat inventory management; and aviation infrastructure planning and operations (airports and air traffic management). In each of these cases, the paper provides both a historical perspective on OR contributions and a brief summary of cutting-edge technology. It also identifies some of the major research challenges for the future. The paper also addresses these factors by way of a Transportation Problem, Monte Carlo Simulation and a Game Theory Matrix respectively. This study considers a multitude of factors paving way for further research to consider solutions for problems of greater complexity.

Keywords: *Airline Management, Airline Scheduling, Vogel's Approximation Method, Hungarian Assignment Model, Critical Path Analysis, Aircraft Maintenance Problem.*

1. INTRODUCTION

The dramatic growth of the airline industry over the past thirty years into a highly competitive world-wide transport network has been accompanied by the extensive use of operations research and management science methodology in all areas of airline operations. Air transport has historically increased in size every 15 years, outpacing most other businesses. In 2016, aeroplanes carried around 3.8 billion people around the world, totalling 7.1 trillion revenue passenger kilometres (RPKs). Air freight carried 53 million tonnes of cargo, totalling 205 billion freight tonne kilometres (FTKs). Every day, about 10 million passengers and USD18 billion worth of cargo are transported by around 100,000 planes Operations research uses mathematical and statistical techniques to answer optimisation and simulation questions that improve decision making. Operations research has had a significant impact on airline operations. The monopoly air transportation market is highly competitive and in order to gain an edge in this industry, airlines have turned to various operational research techniques.

The airline industry has been divided under the following heads: Marketing Advertising Airline forecasting Pricing Airline Operations Under the above-mentioned heads, the problems have been solved using OR techniques

2. LITERATURE REVIEW

Aviation industry, is an industry where operations techniques are used immensely and major issues in this industry is solved by OR technique's. Since 80's there has been an tremendous increase in people using aero planes as a means of transportation which made airlines dependent on OR for planning and managing all the airline propositions. Every airlines uses different type of OR techniques in order to solve specific problem.

AIR INDIA Airline Management and Scheduling examined certain well- known problems and their solutions, as well as current research in the field and developing areas of future significance. With the massive growth in the aviation industry, reducing cost and being effective at the same time is one of the key things that has to be consider by any airline. In order to solve problems AIR

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INDIA uses OR techniques for Route selection where Vogel's appropriation method is used along with MODI method which helps to profitably operate the route while also recognizing operational restrictions. Similarly, Hungarian approach of assignment is used for crew scheduling to find a workable low-cost project such that assigns each crew to flights with the lowest possible cost and Critical path method(CPM) is used for aircraft maintenance in order to lower the cost of the maintenance and can be done in effective time period.

Game theory is a framework used by economics to understand how firms compete with each other. Some companies may have dominant strategies or strategies that give higher payouts no matter what other players choose in the game. Delta Air Lines used that concern to implement a new profitable strategy that puts it one step ahead of its previous competitors. Delta Air Lines has been offering basic economy fares for years, so it may still have a first-mover advantage in this space. American and United's basic economy offerings are more restrictive than Delta's.

Linear programming (LP) method to minimize the daily operational cost of the airline. LP is a powerful technique for dealing with resource- allocation problems. The fleet arrangement was optimized using the Linear programming method to reduce daily operational costs in. Consequently, to reduce the fleet operations operational cost for a low- cost airline. The first stage is to use the analytical hierarchy approach to choose the most appropriate aircraft type from the company's current fleet (AHP). The corporation will allocate the greatest number of that aircraft type that is currently present in its fleet once the aircraft type with the highest rating has been identified. Second, to optimize the fleet that has been allotted to its operations and reduce daily operational costs, the linear programming method is applied. This method is used by Turkish Airlines in all of its daily operations. This is done to optimize fleets and cut expenses. Turkish Airlines' data was used to create a fleet assignment model using linear integer programming. For each fleet type, operation expenses and passenger spill costs were determined. These numbers were computed using the standard deviation for flights and predicted demand, taking recapture rate into account. Utilizing optimization software ensures a simpler answer to this issue.

In the modern airline industry, customer relationship management (CRM) is essential due to globalization, escalating competition, market saturation, and quickening technological advancements. Understanding the profitability of their clients and keeping the profitable ones is the goal of CRM. Therefore, in order to keep or even grow the potential profit of customers, many businesses need to be able to calculate the value of their clients.

An international airline in the Taiwan was surveyed, who travels more than 40 destinations all over the world. In order to create a stronger CRM, VC-DRSA approach is used. VC - Dominance-based Rough Set Approach (DRSA) offers a set of guidelines for figuring out customer attitudes and loyalties, which can assist managers in creating plans to both win over new clients and keep the ones that are most valuable to them. The advantage of VC-DRSA over other strategies that disregard the background knowledge on preference orders in the characteristics domains was proved empirically using a Taiwanese airline as an example. This study used the VC-DRSA to mine data from the surveyed airline market data and aid airlines in creating a stronger CRM.

One of the most important tasks with airport authorities is Aircraft Turnaround Problem (ATP) which is flight stopovers caused by air traffic control, land services. Project Evaluation and Review Technique (PERT) approach is used to find the critical path that implies a delay on the overall system. A study by Fricke and Lufthansa City Line proposes adding a time buffer to partially absorb potential time delays. Analysis of Variance (ANOVA) test was run in order to determine different scenarios of average costs associated with each minute of delay of flights.

3. ANALYSIS AND FINDINGS

Operations research has long been used in the aviation sector.

- Uses of operations research are:

Its use is primarily intended to reduce expenses and increase revenue for airlines. Numerous issues relating to airlines, including the gate assignment problem (GAP), crew scheduling issue, airline advertising, route selection issues, aircraft sequencing issue, fleet assignment issue, aircraft turnaround issue, aircraft conflict avoidance issue, etc., have been resolved.

- Different OR technologies that are used:

linear programming, game theory, inventory control, scheduling, integer linear programming, Vogel's approximation method (VAM), modified distribution method (MODI), and mixed-integer nonlinear programming, are utilized by OR managers to handle these airline-related difficulties. In our study, integer programming was used to resolve issues with gate assignment and staff scheduling.

- Scheduling software has been used to overcome aircraft sequence issues. The problems of fleet assignment, operational costs, and aircraft turnaround were all resolved utilizing the simulation technique.
- The tendency we found in our investigation was that simulation and linear programming is the most common OR technologies utilized in the aviation industry. The LP model determines the flight frequency for each kind of aircraft on a specific route in order to reduce operational costs while taking into account any operational limitations.
- One key aspect of **linear programming** in OR is that it uses a set of mathematical relationships (such as equations, inequalities, etc.) that correspond to more realistic relationships in the outside world. A linear programming model specifically comprises of three modules: first, optimization, Models are developed to either maximize or decrease something. Second, it includes limitations that reflect actual correlations between variables. And finally, the input data, which includes costs, resource availability, technological coefficients, etc. At all stages of development, knowledge is gained through the usage of **simulation models.**
- Participants can analyze market demand by using the simulation. This information creates a significant impact on the airlines ability to turn a profit and keep low load factors in the simulation.
- Applications of Operations Research in Airline Operations:

According to the findings of a primary poll, respondents chose "waiting time in queues at various airport checkpoints" for the airport operations category's delay in a time period due to the issue they encounter when they fly. Why do issues with standing in lines occur? When a service counter must serve several clients who arrive in a specific order (or even at the same time), the situation is known as a "queuing dilemma." The majority of the time, the service delivery requires more time than the rate of client arrival, therefore the consumers must wait for their turn.
Operations research methodology known as queuing theory is utilized to develop solutions to this issue. A mathematical model called queuing theory was created to address the issue of lining up in airports. The amount of time customers must wait could be cut down using this method.

4. CONCLUSION

- Techniques from operations research can be highly beneficial for route optimization and better resource efficiency. It offers a simple and practical solution for better decision-making while saving enterprises money, time, and resources.
- For the purpose of this study, we used the Hungarian method and various methods of assignment algorithm to reroute flights in order to maximize the crew's rest time. Thus, using OR approaches to plan flight times and itineraries can significantly reduce operational costs. Critical Path Analysis was used to analyze the aircraft maintenance tasks, and the results showed that CPM is a useful technique for accelerating the airline's ability to fly more frequently and for less time overall, both of which improve revenue.

5. LIMITATIONS:

- The shortcomings of operations research are the same as those of any management system. In actuality, some of the toughest restrictions result from the benefits. For instance, fair comparison yields a statistical study that is entirely objective, but there are human aspects that cannot be quantified.
- One example of operations research's drawbacks is Higher cost: All upfront costs associated with operations research are substantial, including in-depth analysis, expert evaluation, and consultation fees. Most businesses must pay a consultant for an operations research examination because the subject is so in-depth. Utilizing technology: A computer must perform the math needed to analyze situations. The company's operations would be impacted if technology failed or documents were lost in some other way. Without taking into account the human element.
- Although math is useful and objective in evaluation, there is always a human component to business. For instance, the investor who owns the most stock in your company can insist that a certain amount of funding be used in a situation that isn't ideal.

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