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Applications of Operations Research in the Airline Industry

Riya Michael
Student
NMIMS
Mumbai, India

Ritwik Narula
Student
NMIMS
Mumbai, India

Rohan Kolhe
Student
NMIMS
Mumbai, India

Romika Puri
Student
NMIMS
Mumbai, India

Sarthak Kedia
Student
NMIMS
Mumbai, India

Abstract:- Operations research (OR) is a critical method of problem-solving and decision-making that is beneficial to the management of organizations. In order to make tasks trouble-free, operations research aids in breaking down problems into basic components and then solving them in defined steps, with the help of mathematical analysis. The field of operations research has contributed tremendously to today's air transportation management. Driven by enormous demand from management, airlines are turning to advanced optimization techniques to develop mission-critical decision support systems for administration and management of airline operations, in order to gain a competitive advantage in the market. This paper presents an overview of the inputs of operations research in various sectors of the air transport industry. Moreover, this paper lays emphasis on key areas of the airline industry such as air traffic control, scheduling of domestic as well as international flights, baggage management, human resource management and lastly, airport security.

Keywords:- *Operations Research; Mathematical Analysis; Advanced Optimization Techniques; Air Traffic Control; Scheduling Of Flights; Baggage Management; Human Resource Management; Airport Security.*

I. INTRODUCTION

The airline business is one that is exclusive. The airline industry offers the service of transportation, whereby passengers or cargo are conveyed by flights from several sources to the pursued terminuses. Essentially, the significant aspects to be considered while evaluating the marketability or the appeal of the product are the time, accuracy, functionality, quality, and price of the service. As recognized by passengers, the above-mentioned attributes transform into flexible schedules, on-time flights, safety, satisfactory in-flight services, air traffic control, appropriate baggage handling, and convenient ticket purchases. In order to deliver these aspects to the air transport consumers, the direct means that are desirable to develop the product include aircrafts, crew, and airport facilities such as runways and gates. Maintenance bases, fuel services, food services, and crew training facilities are additional supporting resources which are also required.

One of the most competitive industries is the airline industry. This competition not only arises from peer air carriers, but also from ground transportation modes such as buses, trains, ships, and rental cars. In addition, the rise in personally owned vehicles also poses some threat. In the United States, the airline industry particularly faces fierce competition. This is a result of the 1978 deregulation of the U.S. airline industry. Subsequently, choosing their own market segments, deciding their own routes and appointing their own airline fares in accordance with the safety and security regulations enforced by the Federal Aviation Administration (FAA), has been allowed to the airlines. The FAA performs the functions of monitoring and reporting the quality of airline services to the public.

II. METHODOLOGY

The data for this research paper has been collected using secondary research i.e. through newspaper articles, research papers, periodicals, e-books, etc. Also, this paper provides a theoretical basis for research on the functions of operations research in the airline industry (scheduling of flights, air traffic control, baggage management, human resource management and security).

III. ANALYSIS

A. Scheduling of Flights

Managing one flight might sound difficult but imagine that the airline industry manages an average of 50,000 flights where most of them are inter-connecting various places. One major key aspect of the airline industry in “scheduling these flights”. The day to day flow of commuters is dependent on this. The airline scheduling planning is a very complex matrix where every arrival time is a deliberate result of the scheduled flight times that are systematic.

For the ease of this, airplanes use something known as “hubs”. Scheduling these flights is not just a matter of sending planes to the right airport but also forming clusters in all airports. There exists another model which provides a

framework for flight schedule planning problem which considers network-level competition with other airlines. Once the airlines are provided with the desired service frequency in different city pairs for every fleet type, an operational flight timetable is produced by the framework that helps in maximizing the airline's revenue, while satisfying other critical operational requirements. Maximization of the number of efficient flight rotations to minimize the idle time is also included in these operational requirements include. This framework, also called as the GENETIC ALGORITHM (GA), integrates a randomized search technique. The GA helps to seek a near-optimal schedule and on the other hand, the competition analysis model and the resource-tracking model gauge the competency of each proposed schedule.

The second model works on the basis of optimization drawback of multi-runway approach and flight departure sorting built on genetic algorithm is discussed, the targets of runway capacity, delay losses, and robustness are made; then it presents a multi objective simulation model to solve it by using genetic algorithms. The simulation results illustrate the model and algorithm inaugurated, has led to great improvement in the flight scheduling problem. Not only has the runway capacity improved, but the delay losses have also reduced. In addition, it reduces the workload upon the controllers and increases the robustness of flights, which have high optimization efficiency. This method assists in solving scheduling problems of flight at terminal area in an effective and feasible manner. Furthermore, it aids in meeting the requirements of operation controllers in present. The optimization algorithm does not take into account the influence on the carriers initiated by flight scheduling, for example, lack of research on the impartiality of the airlines. The results derived by means of *multi-objective genetic* algorithm in this paper, have depicted a drastic development in comparison to the *FCFS algorithm.*

The last scheduling method, which is used by is “Robust Flight Scheduling”. This method is the be-all and end-all of an airline. It defines its product, its revenue potential along with its operating cost. A more robust schedule reduces the occurrence and the delay impacts, therefore reducing cost. Creating rotational buffers, implementing maintenance buffers, eliminating unnecessary rotational buffers, considering crew pairing while creating the flight schedules and intensifying communications between flight scheduling and crew management during rostering phase, are some important aspects that lead towards robust flight scheduling.

Flight scheduling is one of the most complex tasks one can come across but due to these algorithms and research, flight scheduling has become easier compared to the earlier times and the constant improvement in technology has added to the benefits for the airline industry.

B. Air Traffic Control

The United States encounters about five thousand aircrafts in the sky every single hour in the course of peak air travel times. This translates to roughly fifty thousand aircrafts operating each day. How is collision of these aircrafts prevented? How does efficient air traffic ensured while flights move in and out of an airport or across the country?

Air traffic controllers or ATCs are levied with the task of guaranteeing safe operations of commercial and private aircrafts. ATCs oversee coordination of the whereabouts of thousands of aircrafts, keeping them from colliding against each other, giving them directions during takeoff and landing from airports, guiding them around bad weather and certifying a smooth traffic flow with negligible deferrals.

Congestion problems are becoming critical in many European and American airports and air sectors. To avoid the Air Traffic Control (ATC) from overloading, a planning activity known as Air Traffic Flow Management (ATFM) is brought into the picture, in order to anticipate and prevent overload and limit resulting delays. When the traffic is expected to exceed the airport arrival and departure capacities or the air sector capacity, a delay in the flight arrival (so called congestion) occurs. The fallaciousness to be considered in this field is very extensive. In general, most references to be found in the literature written some years ago refer to the simplest models, those which do not consider air sector.

Air traffic delay has shown a significant increase over the last few years mostly as a result of challenging weather considerations. Moreover, the successive misinterpretations in air traffic and the cost-cutting in flights, will probably imply an inevitable worsening of the current situation, as it was predicted 15 years ago by Bianco (1995). To alleviate this problem, in the 1970’s, air traffic control in the USA was centralized and concentrated into one single organization with headquarters in Washington which has mitigated the impact of this surge in traffic taking into account the air traffic flow forecasting in that country.

The introduction of automated interactive planning tools is considered necessary to assist ATC managers and controllers, so that they capable of improving the safety and efficiency of future high-density terminal area ATC operations. In major terminal areas, there may exist more than one airport and probably several runways simultaneously in operation. The geometric layouts of these airports are constantly diverse, and even in one terminal area the operational procedures and traffic paths will differ over time. Developing a superior set of planning tools for every terminal area and adapting them quickly to various fluctuations in operational procedures from one year to the next, would prove to be expensive. Since operational procedures are altering dynamically as aircrafts arrive from both landings and take-offs, these planning tools must be adept enough to respond quickly while safely re-planning all operations.

The landing and take-off operations are the fundamental activities in a terminal area airspace on several runways. Aircrafts arrive from all courses, descending through the nearby airspace to move into the terminal area, and commence the merging processes which end up in an efficient spacing between all landing operations. As they ascend or travel mid-air, their climbing departure paths must be considered in order to avoid encounters or clashes with each other and with all the arrival paths. Thus, there must be a Runway Scheduling Process that sets a timing to within a few seconds for take-off and landing operations, which is vigorously changing as new traffic flow disembarks; and a Flight Path Generation Process, where in, a set of descending arrival and climbing departure flight paths in four dimensions are generated to aid the dynamic schedule. The flight paths must be conflict-free i.e. they must meet specified safe separation constraints in time and space. These two processes can be called Terminal Area Operations Planning Processes and would be utilized on a minute basis. There is also a longer-term tactical Terminal Area Planning Process which is connected to planning the outline of the runways to be used at every airport in the terminal area throughout the following hours. A Runway Configuration comprises of the set of runways at an airport and their usage for take-offs or landings by type of aircraft.

The United States airspace is segregated into 21 zones (centers), and each of these zones are divided into sectors. Also, within each zone, there are fragments of airspace, about 50 miles (80.5 km) in diameter, referred to as TRACON (Terminal Radar Approach Control) airspaces. Within each TRACON airspace are multiple airports, each of which has its individual airspace with a 5-mile (8 km) radius.

The Federal Aviation Administration (FAA) which has been designed around these airspace divisions, runs the air traffic control system.

As an aircraft journeys through a certain airspace division, it is supervised by the one or more air traffic controllers accountable for that division. This plane is monitored by the controllers, post which they provide instructions to the pilot. As the plane departs that airspace division and enters another, the air traffic controller transfers the custody to the controllers responsible for the new airspace division.

Certain pilots of small aircrafts fly by vision only (Visual Flight Rules or VFR). These pilots are not entailed by the FAA to file flight plans and are not serviced by the mainstream air traffic control system, apart from for FSS and local towers. Pilots of large commercial flights employ instruments to fly (Instrument Flight Rules or IFR), so that they are able to control the aircraft in all kinds of weather. They are required to record flight plans and are examined by the mainstream air traffic control system.

C. Baggage Management

Baggage is the personal belonging that a traveler carries with himself while he/she is traveling, and the proper handling of these belongings is an important criterion. With more than 50000 flights in a day, managing the large number of baggage is a daunting task. The baggage journey from the destination airport to the arrival airport is complex. The simplest way to explain the journey is that Once a bag is checked in, either with an agent or an automated bag drop, it must flow into a wide range of systems and processes before it is finally loaded in a container or kept on hold. And for the bags that are being transferred, the process can be even more complicated.

Through a research carried out, we got to know that a significant delay occurs during peak hours during baggage processing. Through study we found out that, it takes a longer time to process baggage from wide-bodied aircraft than narrow-bodied aircraft. The average baggage expected time in the off peak is more than that during peak hours. Further, allocation of the belt and its efficiency and labour performance during off peaks are marginally less. Considering the current situation, the delivery time of the first bag is less than 11minutes while the required target is to be lesser than 10 minutes of chocks-on, and the delivery of the last bag is less than 35 minutes during peak hour and less than 29 minutes during off-peak. Handling baggage as ULD4 s has significantly reduced the baggage processing time of wide-bodied aircraft. Results of the search reveal that Middle East flights incur the maximum number of baggage related problems, such as baggage losses and mishandled baggage and these flights normally take the maximum time to clear their baggage which is more than an hour. In Europe flights, there are more OOG (out of gauge) baggage, such as wheelchairs, baby strollers, surfing boards etc. which need more attention and care while handling.

There is another proposal which describes a perpetual baggage tagging that provides the ability to increase new information along the control points to accelerate passenger flow and ascertain more security over baggage control. Until now, there was no absolute tracking of luggage from the source to the destination is envisaged in any other prevailing system or model. This safe and uninterrupted tracing is possible in practice due to the practice of homomorphic cryptography. The proposed technology can be used to deliver more direction, efficiency, and safekeeping in the handling of luggage at airports around the world. It also denotes an answer to the high number of grievances for delays caused by luggage check-in and loss, and the system might deliver greater protection against attacks by terrorist as it indulges in an incessant and enhanced baggage control.

Well-handled baggage is one of the fundamental factors for achieving a constructive passenger experience. An enhanced, competent and highly reliable baggage handling system can signify additional business from airlines and added loyal travelers—customers prefer to connect at an airport with a dependable bag transfer

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service. It can also indicate lower irregularity numbers and related costs.

D. Human Resource Management

The human resources manager has a very important role to play in the airlines industry as he is responsible for the selection of staff in the airlines and there are many such tasks which will make a HR head take a quantitative solution to the problem. Currently India is facing a big problem – shortage of pilots. An expanding middle class and the increase in purchasing power has made contributed to making India one of the fastest growing aviation markets in the world. In the coming ten years an estimated order of 1000 planes will be scheduled which means that airlines will need around 8000 to 10000 pilots to fly those planes.

Another problem faced by the aviation industry and every other company is aging. Many industries in the future will face the effects of aging and shrinking population growth. These drifts will reduce the available workforce over the next years and even with stable workforce requirements in the coming years it will become tougher to preserve the available workforce at the required level.

Each year, even while the scope of the company remains the same, more and more people need to be recruited to fulfil the workforce demand, putting the recruitment department of human resources under a lot of pressure.

Operations research can assist the HR manager to visualize the present and imminent effect of diminishing population growth and aging. Company strategies that require changes can be analyzed as well, enabling the HR manager to set up his recruitment strategy according to the company's goals. As in any other OR project, the current situation needs to be analyzed which is the first step then identify the distribution of the current age the goals of the company in terms of size and capabilities of the required workforce. This gives insight into the current impacts of aging. Scenario analysis can be used to identify the company's growth scenarios along with the management of the company. A further understanding is given in the scope and capabilities of the required upcoming workforce with this result. The present and imminent development of the personnel of the company can be modelled using the Markov theory. When combining age, perceptions are created into the positions for which either aging will turn out to be a drawback or for which the provision of manpower will shrink. Transition probabilities characterize manpower planning models that either pull employees to the next step in their career or push them when promotions are based on years' experience or personnel motivation. A combination of Push and Pull models are used in practice. The transition prospects for these models need to be estimated from the past.

Strategies to align the available and essential workforce can be formulated and evaluated when both the development of the required and available workforce is modelled. Internal measures, the matter of the HR manager, which can be modelled as variations to the transition probabilities representing. For instance, supplementary drills, modifications in remuneration or prolonging the time people work (over 65). External measures, the field of the other board members, like incorporating contemporary technologies can be modelled as variations in the future workforce demand. With the help of this approach, the HR manager will be capable of recognizing, along with the other managers in the board, the most suitable scheme to ensure that the right expanse and class of people will always be at disposal.

E. Security

It is believed that there is a high chance that dispensing security matters to private players would prove to be detrimental to the security standards of airports and aircrafts. It must be noted in this matter that safety and security in aviation is of paramount importance. Airports and aircrafts have been pursued by terrorists' groups in the past, and it is conceivable that any loose end in security will be taken advantage of by such malicious people. Any sort of ignorance towards the issue can result in the loss of a lot of lives and substantial damage to property.

➢ *Cost Benefit Model*

We will estimate the value of the policy of security by finding the difference between the cost of not implementing the policy and the cost of implementing the policy. The per flight cost of security policy will be determined by dividing the annual cost of such policy by the number of flights and then adding the cost of a successful terrorist attack according to the risk factor associated with it.

➢ *Parameters*

CB: the annual cost of upholding any backup security that is used in lieu of the proposed policy.

PB: the effectiveness of such backup security (probability that policy will work).

C: the cost of a successful terrorist attack that might occur

Rb: the risk per flight of an attempted attack in the absence of the proposed policy.

CA: the annual cost of maintaining the policy

F: the number of domestic flights annually
PA: the effectiveness of the policy

Ra: the probability per flight of an attempted attack after the policy has been implemented.

Value of policy = (CB/F + Rb*(1- PB) *C) - (CA/F + Ra*(1- PA) *C).

This calculation justifies the selection of the proposed policy if the cost of the rear policy is higher than the cost of the chosen policy. It uses the cost of the backup policy as opportunity cost to do so. We use this technique here as we

compare the expected costs of computing each of the above security measures to the expected costs of not implementing them, as a function of the cost of a terrorist attack that would have been prevented by the policy, and the likelihood of such an attack.

IV. CONCLUSION

The air transport sector has experienced enormous growth during the past 50 years with the assistance of one of the principal contributors which is Operations Research. The advancement of paradigms and problems has been encouraged by matters and complications combatted in practice and has led, in numerous occurrences, to insights of a general nature and to prominent methodological advances in the Operations Research field at large. Airlines, airports, and ATM service providers, at this point, are constituted of OR models coupled with algorithms which are disseminated throughout the sector. In view of the multiple barriers that it faces at present, it is benign to presume an enduring central role for OR in the air transport industry.

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