# Finding the Optimal Path of Airline Flight Plans using Simulation

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# Abstract

Nowadays, airline transportation takes the first place. It seems that competition has recently increased with the establishment of many new airline companies and the enrichment of existing airline fleets. That includes the number of pilots, the number of flight crew, the number of ground personnel, and so on, and consequently increases the costs. Redesigning and scheduling of aircraft fleet networks by firms is considered as a solution to reduce costs. Simulation studies are carried out by using advanced computer aided programs. As a result, flight scheduling problem which is also called flight punctuation problem, constitutes the most important basic problem to be solved. Route planning optimizes the most cost-effective route. In this study, fleet scheduling and crew scheduling concepts of the transit flight route of the airline company were examined with the help of simulation and the studies were focused on.

# Keywords

airplane routing, scheduling, simulation

# 1. Introduction

Route planning is a problem of finding the best route between two flight points on a map. Eligibility criteria are the length and time that affect cost. The weather conditions and the returning position of the world affect the time and distance between the two cities. Air traffic is also affects the flight route and its duration in a negative way. Most airlines have monthly flight schedules. Seasonal changes are taken into account in changing market requirements and flight schedule design, fleet designation, flight order selection, crew mapping, and ground personnel scheduling flight schedules. In large airline companies, this process is complicated. In order to facilitate this process, it is usually practiced to divide into several sub plans. The main purpose of flight scheduling is to reduce operating costs to the lowest under specific constraints. For this purpose, simulation methods (such as the Arena program) can be used. In this study, the flights of the airline company examined from İzmir to Antalya (connected via İstanbul) were examined. Simulation studies have been done for low (50 %) and high (75 %) capacity flights. The distance between the flight legs of the fleet and the flight module will perform with the process module is selected as Triangular in the Delay Type section. The minimum time of 45 minutes, the average time of 60 minutes and the maximum time of 75 minutes are determined as the time of departure from İzmir.

#### **1.1 Flight Scheduling**

Flight schedules are examined in two parts, fleet assignment and aircraft flight. Each step in flight networks is assigned the lowest cost plane and a route is determined accordingly. This increases the profitability of the operation. When flight schedules are made, flight routes and company facilities of competing airlines are considered as external factors. When flight schedules are made, factors such as variable demand in the sector, constraints arising from competitors, market forecasts are taken into account. A flight schedule includes; flight number, departure and arrival location, departure and arrival time, days and fleet type.

#### **1.2 Formation Routing**

The capacity of the aircraft at fleet landing is crucial for flight cost and income to be earned. If the operating costs of the flight route fail to meet the demand in the required circumstances, the lost should be minimized.

In fleet assignment problems, flights of the same property are treated as a group. Maintenance of aircraft at certain intervals also creates a constraint on fleet assignment. The time and space required for aircraft maintenance is important. It may not be the same when you get this look for each plane.

In the fleet assignment problem, a flight time is considered as the time from the closing of the aircraft doors to the reopening of the doors at the point of arrival. The assumption is that there is no setback in the calculation of this employee. The intensity of the airports, the weather conditions can cause the extension of this employee.

The most important consideration to avoid increasing flight costs is that the operator can actively use the full flight at full capacity. Thus, the costs do not rise and the desired profit can be obtained.

#### **1.3 Flight Routing**

The number of flights that each flight will perform is determined by airplane punctuation. When this determination is made, it is also taken into consideration that the aircraft will look at the points as it is in the fleet assignment process. In the air route, the arrival point of a flight is taken as the starting point of the next flight.

# 2. Literature

In flight scheduling, flight route planning is established taking into account maintenance constraints for the aircraft after assignment of the flights to the flight routes. Feo and Bard (1989) presented a flight program development model that can be used both for maintenance centers and for better control of type A control requirements. Subramainan (1994) solved the fleet assignment problem for Delta Airlines, saving the operator \$100 million annually. Rushmeier and Kontogiorgis (1997) presented an advanced model for solving and formulation of largescale fleet assignment problem in airline schedules. Clarke (1997) modeled the problem of aircraft locomotion as the Eulerian tour problem, which provides maintenance constraints and maximizes the uninterrupted flight value of the connected flights. Desaulniers (1997) examined the problem of daily airplane positioning and scheduling which is the most profitable from heterogeneous aircraft fleet, and presented two models. By using the first model linear relaxation column derivation technique, the second model linear relaxation is solved by using the Dantzig-Wolfe decomposition approach. Barnhart (1998) solved the problem of integrated fleet assignment and airplane positioning by using the branch - based approach, modeling the sequence base. The disadvantage of this model is that the flight program with hundreds of flights has millions of lanes. Cordeau (2001) modeled the problem of aircraft positioning and team scheduling simultaneously and used the Bender decomposition approach for the solution. Sriram ve Haghani (2003) examined maintenance scheduling and reassignment of aircraft. Both A and B type control have considered models. Sarac (2006) solved the problem by modeling the available man-hour operational aircraft maintenance locating problem from maintenance slots and maintenance stations.

# **3. Application**

A simulation was performed by adapting the data received from the company according to the Arena program. Izmir and Antalya (Istanbul transfer point) cities were considered as points in the project. The company's fleet capacity consists of 19 flights.

The data used in this model has been obtained from the application company and is given in Table 1.

Departure Time of Time Arrival		<b>Boarding Point</b>	Destination		
07:40	08:40	Adnan Menderes Airport	İstanbul Atatürk Airport		
10:50	12:00	İstanbul Atatürk Airport	Antalya Airport		
07:40	08:40	Adnan Menderes Airport İstanbul Atatürk Airp			
16:40	17:50	İstanbul Atatürk Airport Antalya Airport			
07:40	08:40	Adnan Menderes Airport	İstanbul Atatürk Airport		
20:30	21:10	İstanbul Atatürk Airport	Antalya Airport		
Departure Time of		<b>Boording Doint</b>	Destination		
Time	Arrival	Doar unig 1 onit	Destination		
10.00					
19:00	20:10	Antalya Airport	İstanbul Atatürk Airport		
19:00 21:20	20:10 22:20	Antalya Airport İstanbul Atatürk Airport	İstanbul Atatürk Airport Adnan Menderes Airport		
19:00 21:20 07:50	20:10 22:20 09:00	Antalya Airport İstanbul Atatürk Airport Antalya Airport	İstanbul Atatürk Airport Adnan Menderes Airport İstanbul Atatürk Airport		
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19:00 21:20 07:50 11:25 12:00	20:10 22:20 09:00 12:25 13:10	Antalya Airport İstanbul Atatürk Airport Antalya Airport İstanbul Atatürk Airport Antalya Airport	İstanbul Atatürk Airport Adnan Menderes Airport İstanbul Atatürk Airport Adnan Menderes Airport İstanbul Atatürk Airport		

Table 1. İzmir – Antalya Hour of Flight

#### 4. Simulation

In the simulation study, the Arena program was used. In the Arena program, Siman commands are used for the model.

In this study, create, process, decide, seize delay release and dispose processes are used in Arena Program. Flight names are specified in the Create process. The time between arrivals of the fleets was chosen in an infinite number of times. With the Process module, fleet flotation was performed. Delay type was selected as triangular, minimum time 45 minutes, average time 60 minutes and maximum time 75 minutes. The source for the fleet is added under the pilot name Seize Delay Release. The number of passengers in the Decide process was considered as a constraint, 75% for high-capacity filaments and 50% for low-capacity filaments. Flight terminated with Dispose module.

# 4.1 İzmir – Antalya (İstanbul Connected) Simulation

The arena model of İzmir-Antalya flight is prepared and the create module can be seen in Figure 1.



Figure 1. İzmir – Antalya Create Module

Transfer flight is between these two specified points. For this reason, for the first flight, the create module was started as the Izmir point where the transfer flight would take place and the time between two fleets was considered as 1 hour in the Random type, and this can be seen in the process module as in Figure 2.



Figure 2. İzmir - Antalya Process Module

The distance between the flight legs of the fleet and the flight module will perform with the process module is selected as Triangular in the Delay Type section. The minimum time of 45 minutes, the average time of 60 minutes and the maximum time of 75 minutes are determined as the time of departure from İzmir. The resource assignment Seize Delay Release has been performed. The decide module can be seen in Figure 3.



Figure 3. İzmir – Antalya Decide Module

The number of passengers in the fleet that will be flying from Izmir point is defined by the decision module. The first stop of the transit flight is Istanbul. If the fleet's number of passengers is less than 75% of the capacity, the restriction that flights can be made is determined by decision. Different capacities can be seen in Figures 4 and 5.



Figure 4. İzmir – Antalya Process Module

If the number of passengers of a high-capacity fleet is not sufficient, a process module is used to realize a low-capacity fleet assignment. The time for the low-capacity fleet to fly is triangularly and derived from 45, 60 and 75 minutes. The source is Seize Delay Release.



Figure 5. İzmir – Antalya Decide Module

The low-capacity fleet also has a certain capacity and this capacity is built with the decision module as a constraint. The 50% of the capacitor is filled and the Decide module is selected for the steps to take when the capacitor is not full.



Figure 6. İzmir – Antalya Dispose Module

If the number of passengers in a low-capacity fleet is less than 50%, the Dispose module has been tried to be implemented as the last point that flight cannot be realized (see Figure 6).



Figure 7. İzmir – Antalya Process Module

If the number of passengers with high capacity and low capacity will be limited due to the fact that it will take place in Istanbul at the point of flight transit, a flight from Istanbul to Istanbul will be realized. The true parts of the Decide modules are linked to the flight to Istanbul. For Istanbul flight, high capacity fleet assignment was provided

by using the process module. The source is Seize Delay Release. The duration of the flight is triangular at 45, 60 and 75 minutes, see Figure 7.



Figure 8. İzmir – Antalya Decide Module

The Decide module was used (Figure 8) for the decision when the number of passengers for the flight to be realized from Istanbul to Antalya would be 75% or less of the capacity.



Figure 9. İzmir – Antalya Dispose Module

The final point to be established as a result of the specified number of passengers being restricted is determined as the completion of the flight with the dispose module as seen in Figure 9.

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Figure 10. İzmir - Antalya Process Module

If the number of passengers of high-capacity fleet to fly from Istanbul to Antalya is expected to be lower than expected, a low-capacity fleet assignment is made. Low-capacity filing is done with the process module. Seize Delay has been assigned as a resource and triangular times have been determined (see Figure 10 and 11).



Figure 11. İzmir – Antalya Decide Module

The limit is determined by the decide module if the flight of the low-capacity fleet is 50% of the capacity of the passengers.



Figure 12. İzmir - Antalya Dispose Module

If the number of passengers is below the capacity, the flight will not take place as the last point command was created with the dispose module as seen in Figure 12. After these considerations the model is run as seen in Figure 13.



Figure 13. İzmir - Antalya Arena Run

In this section, it was tried to obtain the data by repeating the flight and repeating the times during the day.

# 5. Results of Arena Simulation

The simulations that prepared in the previous section, were run and the results were obtained as follows.

Istanbul-İzmir result summaries can be seen in Figures 14 - 18.

	Values Across All Replications	
Replications: 8 Tr	me Units : Hours	
	Key Performance Indicators	
System	Average	
Number Out	6	

Figure 14. Number of replications for İzmir-Antalya Flight per a day

0:28:57	Catego	ory Overv	view			
	Value	e Across All Replic	ationa			
Replications: 8	Time Units : Hours					
intity						
Time						
VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maxim. Val
airplane	1.0108	0,24	0.6215	1.3581	0.00	2.24
NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximu
airplane	0.00	0,00	0.00	0.00	0.00	0.0
Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximu
airplane	1.4281	0,68	0.6137	3.0947	0.00	5.519
Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximu Val
airplane	0.00	0,00	0.00	0.00	0.00	0.0
Other Time	Average Group #4 Name (String)	Half Width	Minimum Average	Maximum Average	Minimum Value	Maxim. Val
aimlana	Group #4 Name (String)	0.00	0.00	0.00	0.00	0.0

Figure 15. Average Time Spent on System for Izmir-Antalya Flight

Queue						
Time						
Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximun Value
Low Consoit: Elight Ours	1.1394	0,85	0.00	2.3867	0.00	2.3867
Low Capacity Flighto Queue	0.6358	1,50	0.00	5.0865	0.00	5.0865
Flight A320.Oueue	1.5420	0,49	0.6023	2.1328	0.00	4.4792
İstanbul Queue	2.0480	0,67	0.8358	3.0996	0.00	4.2140
Other						
Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Low Conneity Flight Queue	0.1895	0,10	0.00	0.4038	0.00	1.0000
Low Canacity Flighto Queue	0.06358064	0,15	0.00	0.5086	0.00	1.0000
Flight A320.Queue	1.4609	0,65	0.1807	2.5562	0.00	6.0000
İstanbul Queue	1.1587	0,35	0.4179	1.7702	0.00	4.0000

Figure 16. Waiting Times for the Izmir-Antalya Flight

Usage						
Instantaneous Utilization	A	11-16 VAVLAN	Minimum	Maximum	Minimum	Maximur
	Average	Hair Width	Average	Average	Value	Valu
Pilot	0.9288	0,07	0.7652	1.0000	0.00	1.000
Number Busy			Minimum	Maximum	Minimum	Maximu
	Average	Half Width	Average	Average	Value	Valu
Pilot	0.9288	0,07	0.7652	1.0000	0.00	1.000
Number Scheduled			Minimum	Maximum	Minimum	Maximu
	Average	Half Width	Average	Average	Value	Valu
Pilot	1.0000	0,00	1.0000	1.0000	1.0000	1.000
Scheduled Utilization			Minimum	Maximum		
	Average	Half Width	Average	Average		
Pilot	0.9288	0,07	0.7652	1.0000		
Total Number Seized			Minimum	Maximum		
	Average	Half Width	Average	Average		
Pilot	9.6250	0.62	8 0000	10 0000		

Figure 17. Utilization for the Izmir-Antalya Flight

ccum VA Time	Average	Half Width	Minimum Average	Average	
our Conscity, Flight Quana	0.5392	0,67	0.00	2.0869	
ow Canacity, Flighto Queue	0.00	0,00	0.00	0.00	
light A320.Oueue	5.0783	0,77	3.2617	6.2259	
stanbul.Queue	3.0657	0,76	1.6471	4.0439	
6,000					
5,000					
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3,000					Low Consents Elight
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0,000					

Figure 18. Accumulated Time for Izmir-Antalya Flight

As can be seen from these results, serious waiting and losses exist on the route. Various attempts can be made in the simulation model to reduce lost and increase the number of flights with improvement studies to be made.

# 6. Conclusions

The data obtained from the iron was evaluated in the Arena program. It has been accepted that the flights are carried out with a transfer from İstanbul. Thus, the number of flights realized during the day was increased after the preliminary determination was made. With the increase in the number of flights, the profit will be increased in the right proportion and the airline company will be profitable. As a continuation of the study, it is aimed that the problem of locating is solved for more routes by using optimization methods by accepting certain constraints.

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