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Aircraft Routing and Scheduling: a Case Study in an Airline Company

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Abstract. A major problem faced by every airline company is to construct a daily schedule for a heterogeneous aircraft fleet. In the present paper implementation of aircraft routing and scheduling for cargo transportation, known as one of the scheduling problem in transportation, in an airline company is presented. First, problems faced by the company are defined and then implementation steps and expected improvements that will result from carrying out the solution of mathematical model of the problem are given in detail. The purpose of this paper is to describe, analyze and evaluate a case study of how aircraft scheduling was managed in an airline company.

Keywords: Aircraft Scheduling, Aircraft Routing, Optimization

AMS subject classifications: 90B35, 90C10

Abbreviations and notation

The abbreviations and notations used in this paper are as follows:

- L Set of flight legs
- T Number of different aircraft types
- m_i Number of available aircraft of type i where i=1,2,..,T
- L_i Set of flight legs that can be flown by an aircraft of type i
- S_i Set of feasible schedules for an aircraft of type i
- (0) Empty schedule (an aircraft assigned to this schedule is simply not being used)
- π_{ij} Profit generated by covering flight leg j with an aircraft of type i.
- l All schedules at S_i
- P Set of Airports
- P_i Subset of airports that facilities to accommodate aircraft of type i.
- o_{ip}^{l} Origin of schedule l
- a_{ij}^{l} is equal to 1 if schedule l covers leg j and 0 otherwise
- d_{ip}^{l} Final destination of schedule l
- τ_{ij} Duration of leg j
- X_i^l Binary decision variable

1. Introduction

Much research by the air industry as well as academics has already been devoted to fleet routing and flight scheduling problems. Researches on flight scheduling have mainly focused on passenger transportation, which is fundamentally different from cargo transportation. In particular, the selection of airports in a passenger service network usually involves long-term planning, but in cargo transport, this is not the case [1]. To respond to significant rapid fluctuations in demand, carriers must perform their airport selection, fleet routing and timetable setting to formulate short-term plans, while still considering demand and profit. Moreover, passengers are more time sensitive than cargos. Too many transfers in a passenger service may result in a significant loss of customers, but cargos are not lost, provided they can be delivered on time [1]. Research on freight transportation and fleet routing has been performed by few researchers. The earlier studies commonly focused on pure hub-and-spoke network for air express carriers, hierarchical network design problems, hub location and routing problems. Also meta-heuristics (genetic algorithm (GA), tabu search (TS), threshold

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accepting (TA), and simulated annealing (SA) methods) have been employed to solve network flow problems, optimal communication spanning tree problem, probabilistic minimum spanning tree problem, bipartite transportation network problems; concave cost transshipment problems. When the recent studies on freight transportation and fleet routing are inspected, it is observed that the following studies are remarkable.

Yan, Lai and Chen (2005) developed a short-term flight scheduling model for air express carriers to determine suitable routes and flight schedules with the objective of minimizing operating costs, subject to related operating constraints. The model is formulated as an integer multiple commodity network flow problem solved using mathematical programming [2]. Belanger et al. (2006) proposed a model for the periodic fleet assignment problem with time windows in which departure times are also determined [3]. They proposed a non-linear integer multi-commodity network flow formulation and developed new branch-and-bound strategies which are embedded in their branch-and-price solution strategy. Sherali, Bish and Zhu (2006) presented a tutorial on the basic and enhanced models and approaches that have been developed for the fleet assignment problem (FAP) [4]. Yan, Chen and Chen (2006) studied on air cargo fleet routing and timetable setting with multiple on-time demands [1]. In their research, they combined airport selection, fleet routing and timetable setting to develop an integrated scheduling model. The model is formulated as a mixed integer program that is characterized as NP-hard. Yan, Tang and Lee (2007) developed a short-term flight scheduling model with variable market shares in order to help an airline to solve for better fleet routes and flight schedules in today's competitive markets [5]. The model was formulated as a non-linear mixed integer program, characterized as an NP-hard problem, which is more difficult to solve than the traditional fixed market share flight scheduling problems, often formulated as integer/mixed integer linear programs. They developed a heuristic method to efficiently solve the model. Tang, Yan and Chen (2008) develop an integrated scheduling model that combines passenger, cargo and combi flight scheduling [6]. They employ network flow techniques to construct the model which is formulated as an integer multiple commodity network flow problem that is characterized as NP-hard. They developed a family of heuristics, based on Lagrangian relaxation, a sub-gradient method, heuristics for the upper bound solution, and a flow decomposition algorithm, to solve the model. Yan and Chen (2007, 2008) employed network flow techniques to construct coordinated scheduling models for passenger and cargo transportation, respectively [7, 8]. These models are formulated as mixed integer multiple commodity network flow problems with side constraints (NFPWS) that are characterized as NP-hard. Problem sizes are expected to be huge making the model more difficult to solve than traditional passenger/cargo flight scheduling problems. Therefore, Chen, Yan and Chen (2010) developed a family of Lagrangian based algorithm to solve the coordinated fleet routing and flight scheduling problems [9].

The fleet assignment problem (FAP) deals with assigning aircraft types, each having a different capacity, to the scheduled flights, based on equipment capabilities and availabilities, operational costs, and potential revenues. An airline's fleeting decision highly impacts its revenues, and thus, constitutes an essential component of its overall scheduling process. However, due to the large number of flights scheduled each day, and the dependency of the FAP on other airline processes, solving the FAP has always been a challenging task for the airlines [4]. In this paper, we present a case study on FAP for cargo carrying at an airline. First, problems faced by the company are defined and then implementation steps and expected improvements that will result from carrying out the solution of mathematical model of the problem are given in detail. The purpose of this paper is to describe, analyze and evaluate a case study of how an aircraft scheduling was managed in an airline company.

Rest of the paper is organized as follows. Next section describes the mathematical model used for Aircraft Routing and Scheduling. In Section 3, the case study with an illustrative example is presented and the conclusions are pointed out in Section 4.

2. The Process Model

A major problem faced by every airline is to construct a daily schedule for a heterogeneous aircraft fleet. A plane schedule consists of a sequence of flight legs that have to be flown by a plane with exact times at which the legs must start and finish at the respective airports. The first part of the problem (determining the exact times) is a scheduling problem. The fleet schedule is important since the total revenue of the airline can be estimated if the demand function of each is known. Moreover, the fleet schedule also determines the total cost incurred by the airline, including the cost of fuel and the salaries of the crews. The daily aircraft routing and scheduling problem can now be formulated as follows; given a heterogeneous aircraft fleet, a collection of flight legs that have to be flown in a one-day period with departure time windows, durations, and cost/revenues corresponding to the aircraft type for each leg, a fleet schedule has to be generated that maximizes the airline's profits [10].

Some of the additional constraints that often have to be taken into account in an aircraft routing and scheduling problem are the number of available planes of each type, the restrictions on certain aircraft types at certain times and at certain airports, the required connections between flight legs imposed by the airline and the limits on the daily service at certain airports. Also, the connection of flight legs may have to be balanced, i.e., at each airport there must be, for each aircraft type, as many arrivals as departures. One must further impose at each airport the availability of an equal number of aircraft of each type at the beginning and at the end of the day. In the formulation of the problem, total number of available aircraft is calculated by $\sum_{i=1}^{T} m_i$ where T denotes the number of different aircraft types and m_i denotes the number of available aircraft type i, $i=1,\ldots,T$. Some flight legs may be flown by more than one type of aircraft. In this case the total anticipated profit is $\pi^l_i = \sum_{j \in L_i} \pi_{ij} a^l_{ij}$, where π_{ij} denote the profit generated by covering flight leg j with an aircraft of type i and a^l_{ij} is 1 if schedule l covers leg j and 0 otherwise. If an aircraft has been assigned to an empty schedule, then the profit is π^0_i. The profit π^0_i may be either negative or positive. Let P denote the set of airports, and P_i be the subset of airports that have facilities to accommodate aircraft of type i. Let o^l_{ip} be equal to 1 if the origin of schedule l, $l \in S_i$, is airport p, and 0 otherwise; let d^l_{ip} be equal to 1 if the final destination of schedule l is airport p, and 0 otherwise. The daily aircraft routing and scheduling problem can now be formulated as follows [10]:

$$\text{maximize} \quad \sum_{i=1}^{T} \sum_{l \in S_i} \pi^l_i X^l_i \qquad (1)$$

subject to

$$\sum_{i=1}^{T} \sum_{l \in S_i} a^l_{ij} X^l_i = 1 \qquad j \in L \qquad (2)$$

$$\sum_{l \in S_i} X^l_i = m_i \qquad i = 1,\ldots,T \qquad (3)$$

$$\sum_{l \in S_i} \left(d^l_{ip} - o^l_{ip} \right) X^l_i = 0 \quad i = 1,\ldots,T,\ p \in P_i \qquad (4)$$

$$X^l_i \in \{0,1\} \qquad i = 1,\ldots,T,\ l \in S_i \qquad (5)$$

The objective function specifies that the total anticipated profit has to be maximized. The first set of constraints implies that each flight leg has to be covered exactly once. The second set of constraints specifies the maximum number of aircraft to each type that can be used. The third set of constraints corresponds to the flow conservation constraints at the beginning and at the end of the day at each airport for each aircraft type. The remaining constraints imply that all decision variables have to be binary 0-1 [10].

3. Case Study

Our company is involved in domestic cargo transportation operations and based in Istanbul. With charts we developed it is aimed at gaining the maximum profit from the flights on April 2nd, provided that all the specified flights will be conducted using all the aircrafts in the fleet and all the aircrafts will return to Istanbul at the end of the day. Flight data are given in Table 1 and the airport features are presented in Table 2. These eleven flights must be conducted across four airports. The Table 1 provides city names and departure times of the aircrafts for each flight and flight times for each route.

Runway dimensions and wingspan are of importance during landing of the aircrafts on the specified airports. Features of the airports are given in Table 2. The airports are:

p = 1: Istanbul Ataturk Airport
p = 2: Ankara Esenboga Airport
p = 3: Izmir Adnan Menderes Airport
p = 4: Adana Airport

Table 1 Flight Information

Route j	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Cities	1-2	2-1	1-2	1-4	1-3	2-1	1-2	3-1	4-1	2-3	3-1
τ_{ij}	1 hour	1 hour	1 hour	1 hour 35 minutes	1 hour	1 hour	1 hour	1 hour	1 hour 35 minutes	1 hour	1 hour
Departure Time	08:00	10:30	12:30	13:00	15:00	16:00	17:00	18:00	19:00	20:00	22:30

Table 2 Airport Features

Airport Number	**1**	**2**	**3**	**4**
Airport	Istanbul	Ankara	Izmir	Adana
Runway Dimensions	3000 x 45 3000 x 45 2300 x 60	3750 x 45 3750 x 60	3240 x 45 3240 x 45	2750 x 45

There are four aircrafts available to conduct the flights specified in Table 1. There are three aircrafts of type one and one aircraft of type two. As can be seen in the Tables, Airbus 330 can conduct only Istanbul to Ankara flight. Features of the aircrafts are given in Table 3 (T= 4, m_1=3 (Airbus 310), m_2=1 (Airbus 330)).

Table 3 Aircraft Features

Aircraft	**1**	**2**	**3**	**4**
Name of Aircraft	**AIRBUS 310**	**AIRBUS 330**	**AIRBUS 310**	**AIRBUS 310**
Aircraft Capacity	7000 kg / 30 m³	10000 kg / 50 m³	7000 kg / 30 m³	7000 kg / 30 m³
Loading Modes	The lower fuselage compartments are suitable for batch and palette loadings.	The lower fuselage compartments are suitable for palette and container loadings and the bulk compartments is suitable for batch loading.	The lower fuselage compartments are suitable for batch and palette loadings.	The lower fuselage compartments are suitable for batch and palette loadings.
Cooling and Ventilation	The front and rear cargo compartments are heated, pressurized and ventilated.	The cargo compartments are heated, pressurized and ventilated.	The front and rear cargo compartments are heated, pressurized and ventilated.	The front and rear cargo compartments are heated, pressurized and ventilated.
Length of Aircraft	46.66 m	58.8 m	46.66 m	46.66 m
Weight of Aircraft	150 ton	230 ton	150 ton	150 ton
Cabin Width	5.28 m	5.28 m	5.28 m	5.28 m
Cabin Height	2.54 m	2.54 m	2.54 m	2.54 m
Cabin Length	33.25 m	45 m	33.25 m	33.25 m
Max Fuel Capacity	61070 lt	139100 lt	61070 lt	61070 lt
Wingspan	43.90 m	60.30 m	43.90 m	43.90 m
Speed	850km/h	1030km/h	850km/h	850km/h
Position	ISTANBUL	ISTANBUL	ISTANBUL	ISTANBUL

Different charts were developed for two types of aircrafts. During development of the charts, it was taken into consideration that all criteria will be ensured. Our criteria are as follows:

- Realization of each flight,
- Utilization of all aircrafts,
- Return of the aircrafts to the airport at the end of the day where they took off.

It is not deemed necessary to develop individual charts for the aircrafts of the same type. Thus, for three Airbus 310 aircrafts, it also applies the charts given in Table 4. Subsequently, charts for Airbus 330 are presented in Table 5.

Table 4 Charts for AIRBUS 310 (i=1, 3, 4)

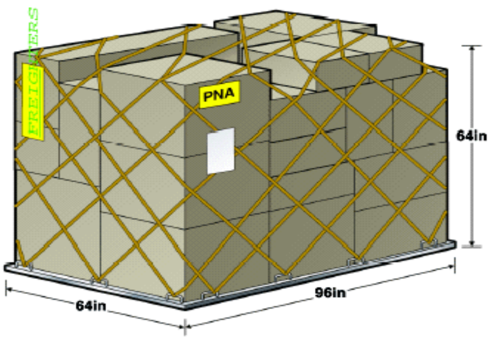
Flight No / **Schedule**	**Flight 1**	**Flight 2**	**Flight 3**	**Flight 4**	**Flight 5**	**Flight 6**	**Flight 7**	**Flight 8**	**Flight 9**	**Flight 10**	**Flight 11**
a^{1}_{1j}	1	1	1	0	0	1	0	0	0	0	0
a^{2}_{1j}	1	1	0	1	0	0	0	0	1	0	0
a^{3}_{1j}	1	1	0	0	1	0	0	1	0	0	0
a^{4}_{1j}	1	1	0	0	1	0	0	0	0	0	1
a^{5}_{1j}	1	1	0	0	0	0	1	0	0	1	1
a^{6}_{1j}	1	0	0	0	0	1	0	0	0	0	0
a^{7}_{1j}	1	0	0	0	0	0	0	0	0	1	1
a^{8}_{1j}	1	1	1	0	0	0	0	0	0	1	1
a^{9}_{1j}	0	0	1	0	0	1	0	0	0	0	0
a^{10}_{1j}	0	0	1	0	0	0	0	0	0	1	1
a^{11}_{1j}	0	0	0	0	0	0	1	0	0	1	1
a^{12}_{1j}	0	0	0	0	1	0	0	1	0	0	0
a^{13}_{1j}	0	0	0	0	1	0	0	0	0	0	1
a^{14}_{1j}	0	0	0	1	0	0	0	0	1	0	0

Table 5 Charts for AIRBUS 330

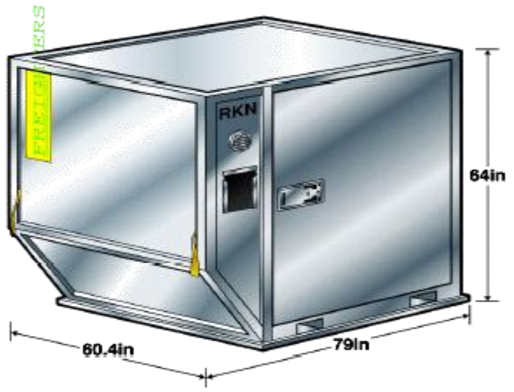
Flight No / **Schedule**	**Flight 1**	**Flight 2**	**Flight 3**	**Flight 4**	**Flight 5**	**Flight 6**	**Flight 7**	**Flight 8**	**Flight 9**	**Flight 10**	**Flight 11**
a^{1}_{2j}	1	1	1	0	0	1	0	0	0	0	0
a^{2}_{2j}	1	1	0	1	0	0	0	0	1	0	0

While developing the charts, the airport and the aircraft features were taken into account. Another important step is to calculate the costs. When calculating the costs various assumptions were made. Cargo types are identified based on the cargo types that the airline cargo considered when setting the prices. For this practice, the cargo types are textile products, marine products, meat products, computers, general cargo, hazardous materials, and chemicals.

Loads are arranged in the cargo department of the aircraft through various loading tools (ULD: Unit Load Device) by taking the cargo capacity and the cargo type into consideration. The used ULD types are igloo and palette.



a) Palette



b) igloo

Figure 1 Palette and igloo

Packaged products are first placed on palettes and then arrange in the aircraft by means of a forklift after they are covered with a net. Marine and meat products are shipped by using special coolers called igloo. Table 6 presents the ULD dimensions used for those products with different sizes. The maximum payload is 2449 kg for palette and 1588 kg for igloo. Textile products are loaded in the aircraft after they were placed on the palettes within $0.60m\times0.50m\times0.50m$ sized packages. Computers were stacked in the aircraft as a batch being within $0.80m\times0.75m\times0.75m$ sized packages. General cargoes were placed on the palettes in a manner that they will not exceed the maximum palette capacity since they were composed of boxes in different dimensions, and then loaded in the aircraft. Meat products were arranged in the igloos by means of hangers, and then loaded in the aircraft. Hazardous materials and chemicals were placed on the palettes being within $0.235m \times 0.235m \times 0.35m$ sized tins, and then stacked in the aircraft. Marine products were put on the igloos being within $0.60m \times 0.40m \times 0.14m$ sized crates, and then loaded in the aircraft.

If the weight per 6000 cm^3 is lower than 1 kg, these cargoes are classified as low density cargoes. When calculating the price, bulk density is considered. As it can be understood from the explanation above, a freight price is charged for each kg exceeding the bulk weight. Table 6 presents the quantities of cargoes exceeding the bulk weight. It is assumed that it takes five minutes to take a ULD from the warehouse and load in the aircraft by means of a forklift. Besides, the computer packages are transported and loaded in the aircraft as a batch via a trailer with hydraulic damper. All of these assumptions also apply to the unloading of the cargoes from the aircraft.

The amount of fuel consumed during a flight comprises another cost item. Since the consumption amounts are similar, values are provided for only one route. For each flight, amounts of the fuel consumption are as follows in Table 7. The costs in Table 8 were calculated by using 2007 tariffs of the General Directorate of State Airports Authority of Turkey.

Table 6 Cargo Features

Cargo	Cargo Type	Cubage											Airport of Departure	Airport of Arrival	Loading Time (minute)	Unloading Time (minute)
		Weight (kg)	Lenght (m)	Width (m)	Height (m)	Number of parcels	Volume (m^3)	Freight Weight	ULD Type and Dimensions (m)	Number of ULD	Area (m^2)	Volume (m^3)				
1	**Textile Products 1**	3960	0.600	0.500	0.500	180	5170	0	Palette (1.63x1.56x2.44)	5	3.8 x 5	28.54	Istanbul	Ankara	25	25
2	**Marine Products 3**	2700	0.600	0.400	0.140	180	1671	1029	Igloo (1.63x1.53x2.01)	2	3 x 2	10	Istanbul	Ankara	10	10
3	**Textile Products 2**	2367	0.600	0.500	0.500	108	3102	0	Palette (1.63x1.56x2.44)	3	3.8 x 3	17.12	Istanbul	Adana	15	15
4	**Hazardous Materials**	1344	0.235	0.235	0.350	384	1237	107	Palette (0.94x0.94x1.05)	8	1 x 8	7.36	Istanbul	Adana	40	40
5	**Computers**	120	0.800	0.750	0.750	6	450	0	Aggregated Cargo		0.6 x 3	2.7	Istanbul	Izmir	12	12
6	**Meat Products 2**	2560					3342	0	Igloo (1.63x1.53x2.01)	4	3 x 4	20	Adana	Istanbul	20	20
7	**General Cargo 1**	575	2.440	1.560	1.630	1	1034	0	Palette (1.63x1.56x2.44)	1	3.8 x 1	6.2	Ankara	Istanbul	5	5
8	**Marine Products 2**	5400	0.600	0.400	0.140	450	4177	1223	Igloo (1.63x1.53x2.01)	5	3 x 5	25	Istanbul	Ankara	25	25
9	**General Cargo 2**	875	2.440	1.560	1.630	1	1034	0	Palette (1.63x1.56x2.44)	1	3.8 x 1	6.2	Ankara	Izmir	5	5
10	**Meat Products 1**	3400					3342	58	Igloo (1.63x1.53x2.01)	4	3 x 4	20	Izmir	Istanbul	20	20
11	**Marine Products 1**	4680	0.600	0.400	0.140	360	3342	1338	Igloo (1.63x1.53x2.01)	4	3 x 4	20	Istanbul	Ankara	20	20
12	**Chemicals**	2400	0.235	0.235	0.350	480	1546	854	Palette (0.94x0.94x1.05)	10	1 x 10	9.2	Izmir	Istanbul	50	50

Table 7 Table for fuel costs

		Fuel Consumption		Cost of Fuel Consumed	
Flight Route	τ_{ij}	A310 (6227lt/hr)	A330 (6227lt/hr)	A310 (0.8029 TL/lt)	A330 (0.8029 TL/lt)
1-2	1 hour	6227	6227	5000	5000
1-4	1 hour 35 minutes	9860	9860	7917	7917
1-3	1 hour	6227	6227	5000	5000
2-3	1 hour	6227	6227	5000	5000

Table 8 Costs for aircraft take-offs and landings

	Landing		Accommodation		Lighting
Flight Route	A310	A330	A310	A330	
1-2	90 TL	138 TL	60 TL	92 TL	25 TL
1-4	90 TL	138 TL	60 TL	92 TL	25 TL
1-3	90 TL	138 TL	60 TL	92 TL	25 TL
2-3	90 TL	138 TL	60 TL	92 TL	25 TL

Costs for forklift rental, forklift operator, trailer with hydraulic damper and storage included in Table 9 are calculated using 2007 tariffs of the General Directorate of State airports Authority (DHMI). Pilot rate is estimated and is assumed to be 200 TL for a flight of one hour. It is deemed that there would be general expenses such as maintenance, checks, etc. for each flight and these expenses are determined to be 300 TL/Flight. By considering the calculation system of domestic cargo rates applicable in the airline cargo, a freight cost of 2.2 TL is estimated to be charged for each kg surpassing the bulk weight.

Table 9 Other costs

General Expenses	300 TL/Flight
Pilot	200 TL/Hour
Forklift Rental	129TL/Hour
Forklift Operator	37 TL/Hour
Trailer with Hydraulic Damper	90 TL/Hour
Storage	0.37 (m^2/Day/TL)
Freight Cost	2.2 TL Per Each Kg Exceeding the Bulk Density

At the final stage, costs regarding the charts developed for each aircraft type are calculated and presented in Table 10 and Table 11 (given in Appendix). Each flight involves passenger transportation as well as cargo transportation. By considering this fact, it is assumed that the flight costs are covered by passenger revenues up to 70% and by cargo revenues up to 30%. The warehouse rental is calculated by assuming that cold storage rooms are ten times more expensive than normal warehouses. Each income item related to cargo transportation operations is obtained from the calculation system of domestic cargo rates applicable in the airline Cargo.

There may be more than one cargo type that has to be transported on the same route.

However, it is unlikely to convey all the cargoes simultaneously since aircrafts have limited cargo transport capacities. In this case, it is assumed that some criteria must be considered when selecting cargoes to be shipped. In this context, marine and meat products are of utmost importance. These products have higher storage and insurance costs compared to other products and must primarily be transported. If a choice is required to be made between them the heavier one has the priority. By taking all the data into consideration, a model was created as follows:

Objective function:

$$\begin{aligned}\mathrm{MaxP} = {} & 4504.07X_1^1 + 4744.49X_1^2 + 6428.25X_1^3 + \\ & 6403.82X_1^4 + 9794.88X_1^5 + 3099.96X_1^6 + 8474.81X_1^7 + \\ & 9794.88X_1^8 + 3124.39X_1^9 + 8474.81X_1^{10} + 8501.36X_1^{11} + \\ & 3301.74X_1^{12} + 3277.31X_1^{13} + 1593.56X_1^{14} + 9379.23X_2^1 + \\ & 8555.17X_2^2 4504.07X_3^1 + 4744.49X_3^2 + 6428.25X_3^3 + \\ & 6403.82X_3^4 + 9794.88X_3^5 + 3099.96X_3^6 + 8474.81X_3^7 + \\ & 9794.88X_3^8 + 3124.39X_3^9 + 8474.81X_3^{10} + 8501.36X_3^{11} + \\ & 3301.74X_3^{12} + 3277.31X_3^{13} + 1593.56X_3^{14} + 4504.07X_4^1 + \\ & 4744.49X_4^2 + 6428.25X_4^3 + 6403.82X_4^4 + 9794.88X_4^5 + \\ & 3099.96X_4^6 + 8474.81X_4^7 + 9794.88X_4^8 + 3124.39X_4^9 + \\ & 8474.81X_4^{10} + 8501.36X_4^{11} + 3301.74X_4^{12} + 3277.31X_4^{13} \\ & + 1593.56X_4^{14}\end{aligned} \tag{6}$$

Eq. (2-5) are used to construct the constraints, where j = 1,....,11; S_i: for i = 1,3,4 then use Table 4, for i = 2 then use Table 5; m_i = 1; p = 1,...,4.

Constraints:

Constraints related to the flights :

Constraints related to the flight 1:

$$\begin{aligned}& X_1^1 + X_1^2 + X_1^3 + X_1^4 + X_1^5 + X_1^6 + X_1^7 + X_1^8 + X_2^1 + X_2^2 + \\ & X_3^1 + X_3^2 + X_3^3 + X_3^4 + X_3^5 + X_3^6 + X_3^7 + X_3^8 + X_4^1 + X_4^2 + \\ & X_4^3 + X_4^4 + X_4^5 + X_4^6 + X_4^7 + X_4^8 = 1\end{aligned} \tag{7}$$

Constraints related to the flight 2:

$$\begin{aligned}& X_1^1 + X_1^2 + X_1^3 + X_1^4 + X_1^5 + X_1^8 + X_2^1 + X_2^2 + X_3^1 + X_3^2 \\ & + X_3^3 + X_3^4 + X_3^5 + X_3^8 + X_4^1 + X_4^2 + X_4^3 + X_4^4 + X_4^5 + \\ & X_4^8 = 1\end{aligned} \tag{8}$$

Constraints related to the flight 3:

$$\begin{aligned}& X_1^1 + X_1^8 + X_1^9 + X_1^{10} + X_2^1 + X_3^1 + X_3^8 + X_3^9 + X_3^{10} + X_4^1 + \\ & X_4^8 + X_4^9 + X_4^{10} = 1\end{aligned} \tag{9}$$

Constraints related to the flight 4:

$$X_1^2 + X_1^{14} + X_2^2 + X_3^2 + X_3^{14} + X_4^2 + X_4^{14} = 1 \tag{10}$$

Constraints related to the flight 5:

$$\begin{aligned}& X_1^3 + X_1^4 + X_1^{12} + X_1^{13} + X_3^3 + X_3^4 + X_3^{12} + X_3^{13} + X_4^3 \\ & + X_4^4 + X_4^{12} + X_4^{13} = 1\end{aligned} \tag{11}$$

Constraints related to the flight 6:

$$\begin{aligned}& X_1^1 + X_1^6 + X_1^9 + X_2^1 + X_3^1 + X_3^6 + X_3^9 + X_4^1 + X_4^6 + \\ & X_4^9 = 1\end{aligned} \tag{12}$$

Constraints related to the flight 7:

$$X_1^5 + X_1^{11} + X_3^5 + X_3^{11} + X_4^5 + X_4^{11} = 1 \tag{13}$$

Constraints related to the flight 8:

$$X_1^3 + X_1^{12} + X_3^3 + X_3^{12} + X_4^3 + X_4^{12} = 1 \tag{14}$$

Constraints related to the flight 9:

$$X_1^2 + X_1^{14} + X_2^2 + X_3^2 + X_3^{14} + X_4^2 + X_4^{14} = 1 \tag{15}$$

Constraints related to the flight 10:

$$\begin{aligned}& X_1^5 + X_1^7 + X_1^8 + X_1^{10} + X_1^{11} + X_3^5 + X_3^7 + X_3^8 + X_3^{10} \\ & + X_3^{11} + X_4^5 + X_4^7 + X_4^8 + X_4^{10} + X_4^{11} = 1\end{aligned} \tag{16}$$

Constraints related to the flight 11:

$$\begin{aligned}& X_1^4 + X_1^5 + X_1^7 + X_1^8 + X_1^{10} + X_1^{11} + X_1^{13} + X_3^4 + X_3^5 + \\ & X_3^7 + X_3^8 + X_3^{10} + X_3^{11} + X_3^{13} + X_4^4 + X_4^5 + X_4^7 + \\ & X_4^8 + X_4^{10} + X_4^{11} + X_4^{13} = 1\end{aligned} \tag{17}$$

Constraints related to the Aircrafts:

Constraints related to the Aircraft 1:

$$\begin{aligned}& X_1^1 + X_1^2 + X_1^3 + X_1^4 + X_1^5 + X_1^6 + X_1^7 + X_1^8 + X_1^9 \\ & + X_1^{10} + X_1^{11} + X_1^{12} + X_1^{13} + X_1^{14} = 1\end{aligned} \tag{18}$$

Constraints related to the Aircraft 2:

$$X_2^1 + X_2^2 = 1 \tag{19}$$

Constraints related to the Aircraft 3:

$$\begin{aligned}& X_3^1 + X_3^2 + X_3^3 + X_3^4 + X_3^5 + X_3^6 + X_3^7 + X_3^8 + X_3^9 \\ & + X_3^{10} + X_3^{11} + X_3^{12} + X_3^{13} + X_3^{14} = 1\end{aligned} \tag{20}$$

Constraints related to the Aircraft 4:

$$\begin{aligned}& X_4^1 + X_4^2 + X_4^3 + X_4^4 + X_4^5 + X_4^6 + X_4^7 + X_4^8 + X_4^9 \\ & + X_4^{10} + X_4^{11} + X_4^{12} + X_4^{13} + X_4^{14} = 1\end{aligned} \tag{21}$$

Constraints correspond to the flow conservation constraints at the beginning and at the end of the day at each airport for each aircraft type:

$$\sum_{l \in S_i} \left(d_{ip}^l - o_{ip}^l\right) x_i^l = 0,\ \forall\left(d_{ip}^l - o_{ip}^l\right) = 0 \tag{22}$$

where $i = 1,...,4,\ p \in P_i;\ l = 1,...,14$ for $i = 1,3,4$ and $l = 1,2$ for $i = 2$

All decision variables have to be binary 0-1

$\forall(X_i^l) = 0,1 \quad i = 1,...,4;\ l \in S_i$

The mathematical model given in section 3 is solved by LINDO package program and results show that each aircraft is assigned to a schedule and flights are performed. According to the solution of LINDO, 1., 2., 3., and 4. aircrafts are assigned to the 12., 1., 11., and 14. schedules respectively and 22775.8906 TL profit is provided. The calculation was completed in 0.54s (less than 1s) of CPU time on a personal computer (AMD turion, 1.79 GHZ, 2.87 GB Ram). In the present study the minimum transportation cost and optimal assignment of the flights to the schedules were aimed to determine. By the assignments calculated from the mathematical model by LINDO, the minimum transportation cost is reached and the optimal aircraft assignments to the schedules are determined.

4. Conclusions

The scope of this research is confined to cargo fleet routing and flight scheduling. The purpose of this paper is to describe, analyze and evaluate a case study of how aircraft scheduling was managed in an airline company step by step by using real world data provided from an airline company which has operations in Turkey. The contributions of the paper to the literature is to provide the real application of cargo fleet routing and flight scheduling step by step in detail. During the scheduling phase in practice, aircraft maintenance and crew scheduling processes must be considered. In the present paper, these constraints are excluded in the modeling to reduce problem complexity. There are no limitations that hinder company to adopt the results. The potential contribution of the present paper to the aircraft company is to provide an efficient mathematical modeling technique for its scheduling facilities. Future research may extend to the models those include constraints related to aircraft maintenance and crew scheduling.

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APPENDIX

Table 10 Distribution of the cost items in accordance with the charts and total costs for the charts in relation with Airbus 310

Schedule 1			Frklft	Warehouse	Cooling	Freight	Landing	Accommodation	Enlightening	Fuel	Pilot	General	15% Insurance	Additional Insurance	18% value added tax (VAT)	Cost	Income	Profit
1-2	**08:00**	**Sea 2**	166.20	11.10	111.00	2690.6	27.00	0.00	0.00	1500	60	90	698.39	465.59	1047.58	6867.45	11773.00	4905.55
2-1	**10:30**	**General 1**	33.24	2.81	0.00	0.0	27.00	0.00	0.00	1500	60	90	256.96	0.00	354.60	2324.61	570.00	-1754.61
1-2	**12:30**	**Sea 1**	132.96	8.88	88.00	2943.6	27.00	18.00	0.00	1500	60	90	730.27	465.59	1091.57	7155.87	10204.00	3048.13
2-1	**16:00**	**Empty**	0.00	0.00	0.00	0.0	27.00	18.00	0.00	1500	60	90	0.00	0.00	0.00	1695.00	0.00	-1695.00
General Total			332.40	22.79	199.00	5634.2	108.00	36.00	0.00	6000	240	360	1685.61	931.18	2493.75	18042.93	22547.00	4504.07
Schedule 2			**Frklft**	**Warehouse**	**Cooling**	**Freight**	**Landing**	**Accommodation**	**Enlightening**	**Fuel**	**Pilot**	**General**	**15% Insurance**	**Additional Insurance**	**18% VAT**	**Cost**	**Income**	**Profit**
1-2	**08:00**	**Sea 2**	166.20	11.10	111.00	2690.6	27.00	0.00	0.00	1500	60	90	698.39	465.59	1047.58	6867.45	11773.00	4905.55
2-1	**10:30**	**General 1**	33.24	2.81	0.00	0.0	27.00	0.00	0.00	1500	60	90	256.96	0.00	354.60	2324.61	570.00	-1754.61
							For this shipment, the Cargo Costs comprises by Textile2 up to 63.78% and by Hazardous Materials up to 36.22%.											
		Hazardous Material	265.92	5.92	0.00	235.4	9.78	6.52	0.00	860	33	33	217.35	0.00	299.94	1966.29	2421.00	454.71
1-4	**13:00**	**Textiles 2**	166.20	14.02	0.00	0.0	17.22	11.48	0.00	1515	57	57	275.78	0.00	380.58	2494.93	1648.00	-846.93
4-1	**19:00**	**Meat 2**	132.96	8.88	88.00	0.0	27.00	18.00	7.50	2375	90	90	425.62	283.74	638.42	4185.22	6171.00	1985.78
General Total			764.52	42.73	199.00	2926.0	108.00	36.00	7.50	7750	300	360	1874.09	749.33	2721.13	17838.51	22583.00	4744.49
Schedule 3			**Frklft**	**Warehouse**	**Cooling**	**Freight**	**Landing**	**Accommodation**	**Enlightening**	**Fuel**	**Pilot**	**General**	**15% Insurance**	**Additional Insurance**	**18% VAT**	**Cost**	**Income**	**Profit**
1-2	**08:00**	**Sea 2**	166.20	11.10	111.00	2690.6	27.00	0.00	0.00	1500	60	90	698.39	465.59	1047.58	6867.45	11773.00	4905.55
2-1	**10:30**	**General 1**	33.24	2.81	0.00	0.0	27.00	18.00	0.00	1500	60	90	259.66	0.00	358.33	2349.04	570.00	-1779.04
1-3	**15:00**	**Computer**	60.77	3.60	0.00	0.0	27.00	0.00	0.00	1500	60	90	261.21	0.00	360.46	2363.04	294.00	-2069.04
							For this shipment, the Cargo Costs comprises by Meat1 up to 58.62% and by chemicals up to 41.38%.											
		Meat 1	132.96	8.88	88.00	127.6	15.83	10.55	0.00	879	35	53	202.66	135.10	303.99	1992.80	7413.00	5420.20
3-1	**18:00**	**Chemical**	332.40	7.40	0.00	1878.8	11.17	7.45	0.00	621	25	37	438.00	0.00	604.44	3962.43	3913.00	-49.43
General Total			725.57	33.79	199.00	4697.0	108.00	36.00	0.00	6000	240	360	1859.90	600.69	2674.79	17534.75	23963.00	6428.25

Table 10 Distribution of the cost items in accordance with the charts and total costs for the charts in relation with Airbus 310 (continue)

Schedule 4			Frklft	Warehouse	Cooling	Freight	Landing	Accommodation	Enlightening	Fuel	Pilot	General	15% Insurance	Additional Insurance	18% VAT	Cost	Income	Profit
1-2	**08:00**	**Sea 2**	166.20	11.10	111.00	2690.6	27.00	0.00	0.00	1500	60	90	698.39	465.59	1047.58	6867.45	11773.00	4905.55
2-1	**10:30**	**General 1**	33.24	2.81	0.00	0.0	27.00	18.00	0.00	1500	60	90	259.66	0.00	358.33	2349.04	570.00	-1779.04
1-3	**15:00**	**Computer**	60.77	3.60	0.00	0.0	27.00	18.00	0.00	1500	60	90	263.91	0.00	364.19	2387.46	294.00	-2093.46
							For this shipment, the Cargo Costs comprises by Meat1 up to 58.62% and by chemicals up to 41.38%.											
		Meat 1	132.96	8.88	88.00	127.6	15.83	10.55	8.79	879	35	53	202.66	135.10	303.99	1992.80	7413.00	5420.20
3-1	**22:30**	**Chemical**	332.40	7.40	0.00	1878.8	11.17	7.45	6.21	621	25	37	438.00	0.00	604.44	3962.43	3913.00	-49.43
General Total			725.57	33.79	199.00	4697.0	108.00	54.00	15.00	6000	240	360	1862.60	600.69	2678.52	17559.18	23963.00	6403.82

Schedule 5			Frklft	Warehouse	Cooling	Freight	Landing	Accommodation	Enlightening	Fuel	Pilot	General	15% Insurance	Additional Insurance	18% VAT	Cost	Income	Profit
1-2	**08:00**	**Sea 2**	166.20	11.10	111.00	2690.6	27.00	0.00	0.00	1500	60	90	698.39	465.59	1047.58	6867.45	11773.00	4905.55
2-1	**10:30**	**General 1**	33.24	2.81	0.00	0.0	27.00	18.00	0.00	1500	60	90	259.66	0.00	358.33	2349.04	570.00	-1779.04
1-2	**17:00**	**Sea 1**	132.96	8.88	88.00	2943.6	27.00	0.00	0.00	1500	60	90	727.57	465.59	1087.85	7131.44	10204.00	3072.56
2-3	**20:00**	**General 2**	33.24	2.81	0.00	0.0	27.00	0.00	15.00	1500	60	90	259.21	0.00	357.71	2344.97	570.00	-1774.97
							For this shipment, the Cargo Costs comprises by Meat1 up to 58.62% and by chemicals up to 41.38%.											
		Meat 1	132.96	8.88	88.00	127.6	15.83	10.55	8.79	879	35	53	202.66	135.10	303.99	1992.80	7413.00	5420.20
3-1	**22:30**	**Chemical**	332.40	7.40	0.00	1878.8	11.17	7.45	6.21	621	25	37	438.00	0.00	604.44	3962.43	3913.00	-49.43
General Total			831.00	41.88	287.00	7640.6	135.00	36.00	30.00	7500	300	450	2585.47	1066.28	3759.88	24648.12	34443.00	9794.88

Schedule 6			Frklft	Warehouse	Cooling	Freight	Landing	Accommodation	Enlighteni ng	Fuel	Pilot	General	15% Insurance	Additional Insurance	18% VAT	Cost	Income	Profit
1-2	**08:00**	**Sea 2**	166.20	11.10	111.00	2690.6	27.00	18.00	0.00	1500	60	90	701.09	467.39	1051.63	6894.00	11773.00	4879.00
2-1	**16:00**	**General 1**	33.24	2.81	0.00	0.0	27.00	18.00	0.00	1500	60	90	259.66	0.00	358.33	2349.04	570.00	-1779.04
General Total			199.44	13.91	111.00	2690.6	54.00	36.00	0.00	3000	120	180	960.74	467.39	1409.96	9243.04	12343.00	3099.96

Table 10 Distribution of the cost items in accordance with the charts and total costs for the charts in relation with Airbus 310 (continue)

Schedule 7			Frklft	Warehouse	Cooling	Freight	Landing	Accommodation	Enlightening	Fuel	Pilot	General	15% Insurance	Additional Insurance	18% VAT	Cost	Income	Profit
1-2	08:00	Sea 2	166.20	11.10	111.00	2690.6	27.00	18.00	0.00	1500	60	90	701.09	467.39	1051.63	6894.00	11773.00	4879.00
2-3	20:00	General 2	33.24	2.81	0.00	0.0	27.00	0.00	15.00	1500	60	90	259.21	0.00	357.71	2344.97	570.00	-1774.97
							For this shipment, the Cargo Costs comprises by Meat1 up to 58.62% and by chemicals up to 41.38%.											
3-1	22:30	Meat 1	132.96	8.88	88.00	127.6	15.83	10.55	8.79	879	35	53	202.66	135.10	303.99	1992.80	7413.00	5420.20
		Chemical	332.40	7.40	0.00	1878.8	11.17	7.45	6.21	621	25	37	438.00	0.00	604.44	3962.43	3913.00	-49.43
General Total			664.80	30.19	199.00	4697.0	81.00	36.00	30.00	4500	180	270	1600.95	602.49	2317.76	15194.19	23669.00	8474.81
Schedule 8			Frklft	Warehouse	Cooling	Freight	Landing	Accommodation	Enlightening	Fuel	Pilot	General	15% Insurance	Additional Insurance	18% VAT	Cost	Income	Profit
1-2	08:00	Sea 2	166.20	11.10	111.00	2690.6	27.00	0.00	0.00	1500	60	90	698.39	465.59	1047.58	6867.45	11773.00	4905.55
2-1	10:30	General 1	33.24	2.81	0.00	0.0	27.00	0.00	0.00	1500	60	90	256.96	0.00	354.60	2324.61	570.00	-1754.61
1-2	12:30	Sea 1	132.96	8.88	88.00	2943.6	27.00	18.00	0.00	1500	60	90	730.27	465.59	1091.57	7155.87	10204.00	3048.13
2-3	20:00	General 2	33.24	2.81	0.00	0.0	27.00	0.00	15.00	1500	60	90	259.21	0.00	357.71	2344.97	570.00	-1774.97
							For this shipment, the Cargo Costs comprises by Meat1 up to 58.62% and by chemicals up to 41.38%.											
3-1	22:30	Meat 1	132.96	8.88	88.00	127.6	15.83	10.55	8.79	879	35	53	202.66	135.10	303.99	1992.80	7413.00	5420.20
		Chemical	332.40	7.40	0.00	1878.8	11.17	7.45	6.21	621	25	37	438.00	0.00	604.44	3962.43	3913.00	-49.43
General Total			831.00	41.88	287.00	7640.6	135.00	36.00	30.00	7500	300	450	2585.47	1066.28	3759.88	24648.12	34443.00	9794.88
Schedule 9			Frklft	Warehouse	Cooling	Freight	Landing	Accommodation	Enlightening	Fuel	Pilot	General	15% Insurance	Additional Insurance	18% VAT	Cost	Income	Profit
1-2	12:30	Sea 2	166.20	11.10	111.00	2690.6	27.00	18.00	0.00	1500	60	90	701.09	467.39	1051.63	6894.00	11773.00	4879.00
2-1	16:00	General 1	33.24	2.81	0.00	0.0	27.00	18.00	0.00	1500	60	90	256.96	0.00	354.60	2324.61	570.00	-1754.61
General Total			199.44	13.91	111.00	2690.6	54.00	36.00	0.00	3000	120	180	958.04	467.39	1406.23	9218.61	12343.00	3124.39

Table 10 Distribution of the cost items in accordance with the charts and total costs for the charts in relation with Airbus 310 (continue)

Schedule 10			Frklft	Warehouse	Cooling	Freight	Landing	Accommodation	Enlightening	Fuel	Pilot	General	15% Insurance	Additional Insurance	18% VAT	Cost	Income	Profit
1-2	12:30	Sea 2	166.20	11.10	111.00	2690.6	27.00	18.00	0.00	1500	60	90	701.09	467.39	1051.63	6894.00	11773.00	4879.00
2-3	20:00	General 2	33.24	2.81	0.00	0.0	27.00	0.00	15.00	1500	60	90	259.21	0.00	357.71	2344.97	570.00	-1774.97
							For this shipment, the Cargo Costs comprises by Meat1 up to 58.62% and by chemicals up to 41.38%.											
3-1	22:30	Meat 1	132.96	8.88	88.00	127.6	15.83	10.55	8.79	879	35	53	202.66	135.10	303.99	1992.80	7413.00	5420.20
		Chemical	332.40	7.40	0.00	1878.8	11.17	7.45	6.21	621	25	37	438.00	0.00	604.44	3962.43	3913.00	-49.43
General Total			664.80	30.19	199.00	4697.0	81.00	36.00	30.00	4500	180	270	1600.95	602.49	2317.76	15194.19	23669.00	8474.81
Schedule 11			Frklft	Warehouse	Cooling	Freight	Landing	Accommodation	Enlightening	Fuel	Pilot	General	15% Insurance	Additional Insurance	18% VAT	Cost	Income	Profit
1-2	17:00	Sea 2	166.20	11.10	111.00	2690.6	27.00	0.00	0.00	1500	60	90	698.39	465.59	1047.58	6867.45	11773.00	4905.55
2-3	20:00	General 2	33.24	2.81	0.00	0.0	27.00	0.00	15.00	1500	60	90	259.21	0.00	357.71	2344.97	570.00	-1774.97
							For this shipment, the Cargo Costs comprises by Meat1 up to 58.62% and by hazardous Materials up to 41.38%.											
3-1	22:30	Meat 1	132.96	8.88	88.00	127.6	15.83	10.55	8.79	879	35	53	202.66	135.10	303.99	1992.80	7413.00	5420.20
		Chemical	332.40	7.40	0.00	1878.8	11.17	7.45	6.21	621	25	37	438.00	0.00	604.44	3962.43	3913.00	-49.43
General Total			664.80	30.19	199.00	4697.0	81.00	18.00	30.00	4500	180	270	1598.25	600.69	2313.71	15167.64	23669.00	8501.36
Schedule 12			Frklft	Warehouse	Cooling	Freight	Landing	Accommodation	Enlightening	Fuel	Pilot	General	15% Insurance	Additional Insurance	18% VAT	Cost	Income	Profit
1-3	15:00	Computer	60.77	3.60	0.00	0.0	27.00	0.00	0.00	1500	60	90	261.21	0.00	360.46	2363.04	294.00	-2069.04
							For this shipment, the Cargo Costs comprises by Meat1 up to 58.62% and by chemicals up to 41.38%.											
3-1	18:00	Meat 1	132.96	8.88	88.00	127.6	15.83	10.55	0.00	879	35	53	202.66	135.10	303.99	1992.80	7413.00	5420.20
		Chemical	332.40	7.40	0.00	1878.8	11.17	7.45	0.00	621	25	37	438.00	0.00	604.44	3962.43	3913.00	-49.43
General Total			526.13	19.88	88.00	2006.4	54.00	18.00	0.00	3000	120	180	901.86	135.10	1268.89	8318.26	11620.00	3301.74

Table 10 Distribution of the cost items in accordance with the charts and total costs for the charts in relation with Airbus 310 (continue)

Schedule 13			Frklft	Warehouse	Cooling	Freight	Landing	Accommodation	Enlightening	Fuel	Pilot	General	15% Insurance	Additional Insurance	18% VAT	Cost	Income	Profit
1-3	15:00	Computer	60.77	3.60	0.00	0.0	27.00	18.00	0.00	1500	60	90	263.91	0.00	364.19	2387.46	294.00	-2093.46
							For this shipment, the Cargo Costs comprises by Meat1 up to 58.62% and by chemicals up to 41.38%.											
3-1	22:30	Meat 1	132.96	8.88	88.00	127.6	15.83	10.55	8.79	879	35	53	202.66	135.10	303.99	1992.80	7413.00	5420.20
		Chemical	332.40	7.40	0.00	1878.8	11.17	7.45	6.21	621	25	37	438.00	0.00	604.44	3962.43	3913.00	-49.43
General Total			526.13	19.88	88.00	2006.4	54.00	36.00	15.00	3000	120	180	904.56	135.10	1272.61	8342.69	11620.00	3277.31
Schedule 14			**Frklft**	**Warehouse**	**Cooling**	**Freight**	**Landing**	**Accommodation**	**Enlightening**	**Fuel**	**Pilot**	**General**	**15% Insurance**	**Additional Insurance**	**18% VAT**	**Cost**	**Income**	**Profit**
							For this shipment, the Cargo Costs comprises by Textile2 up to 63.78% and by Hazardous Materials up to 36.22%.											
1-4	13:00	Hazardous Material	265.92	5.92	0.00	235.4	9.78	6.52	0.00	860	33	33	217.35	0.00	299.94	1966.29	2421.00	454.71
		Textiles 2	166.20	14.02	0.00	0.0	17.22	11.48	0.00	1515	57	57	275.78	0.00	380.58	2494.93	1648.00	-846.93
4-1	19:00	Meat 2	132.96	8.88	88.00	0.0	27.00	18.00	7.50	2375	90	90	425.62	283.74	638.42	4185.22	6171.00	1985.78
General Total			565.08	28.82	88.00	235.4	54.00	36.00	7.50	4750	180	180	918.75	283.74	1318.95	8646.44	10240.00	1593.56

Table 11 Distribution of the cost items in accordance with the charts and total costs for the charts in relation with Airbus 330

Schedule 1			Frklft	Warehouse	Cooling	Freight	Landing	Accommodation	Enlightening	Fuel	Pilot	General	15% Insurance	Additional Insurance	18% VAT	Cost	Income	Profit
							For this shipment, the Cargo Costs comprises by Sea2 up to 53.57% and by Sea1 to 46.43%.											
		Sea 2	166.20	11.10	111.00	2690.6	22.18	0.00	0.00	804	32	48	582.75	388.50	874.12	5730.35	11773	6042.65
1-2	08:00	Sea 1	132.96	8.88	88.00	2943.6	19.22	0.00	0.00	696	28	42	593.81	395.88	890.72	5839.17	10204	4364.83
2-1	10:30	General 1	33.24	2.81	0.00	0.0	41.40	0.00	0.00	1500	60	90	259.12	0.00	357.58	2344.15	570	-1774.15
							For this shipment, the Cargo Costs comprises by Textile1 up to 59.45% and by sea 3 up to 40.55%.											
		Sea 3	66.48	4.44	44.00	2263.8	16.7877	11.1918	0.00	608	24	36	461.37	307.58	692.05	4536.77	5887	1350.23
1-2	12:30	Textiles 1	166.20	14.02	0.00	0.0	24.6123	16.4082	0.00	892	36	54	180.32	0.00	248.85	1631.34	2746	1114.66
2-1	16:00	Empty	0.00	0.00	0.00	0.0	41.40	27.60	0.00	1500	60	90	0.00	0.00	0.00	1719.00	0	-1719.00
General Total			565.08	41.25	243.00	7898.0	165.60	55.20	0.00	6000	240	360	2077.37	1091.95	3063.32	21800.77	31180	9379.23
Schedule 2			Frklft	Warehouse	Cooling	Freight	Landing	Accommodation	Enlightening	Fuel	Pilot	General	15% Insurance	Additional Insurance	18% VAT	Cost	Income	Profit
							For this shipment, the Cargo Costs comprises by sea 2 up to 53.57% and by sea1 to 46.43%.											
		Sea 2	166.20	11.10	111.00	2690.6	22.18	14.7853	0.00	804	32	48	584.97	389.98	877.45	5752.16	11773	6020.84
1-2	08:00	Sea 1	132.96	8.88	88.00	2943.6	19.22	12.8147	0.00	696	28	42	595.74	397.16	893.60	5858.07	10204	4345.93
2-1	16:00	General 1	33.24	2.81	0.00	0.0	41.40	27.60	0.00	1500	60	90	263.26	0.00	363.30	2381.61	570	-1811.61
General Total			332.40	22.79	199.00	5634.2	82.80	55.20	0.00	3000	120	180	1443.96	787.13	2134.35	13991.83	22547	8555.17