Statistical processing of arrivals and departures on Košice Airport in 2006

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This article describes the processing of records of flights from Košice airport and subsequent acquisition and processing of information contained in these data. The results of processed real data show the delays of flights in 2006.

1 INTRODUCTION

Statistical processing and evaluation of data, which are collected during creating records on individual flights to Košice airport, are important source of information regarding the operations and their parameters. This information could be used to create additional strategies, eliminating gaps respectively other decisions in the planning of other activities at the airport and its development. Partial processing of these data has been shown in work [1]. Data were provided for the processing from Kosice airport Deputy Executive Director for the operation and safety at the airport Košice Mrs. Ing. M. Horváthová. Names of airline in this article are not real. (We use other names/markers, which are described later.) The substitution of airline names is the same as in paper. The overview of the use of identical names between our article and article [2] is shown in the table (Tab. 1).

For the processing and evaluation of the data we used software Excel from Microsoft Office software package, the Matlab 7 and QOctave.

The entire procedure can be summarized in three phases. The first stage includes the preparing the data to further processed using statistical and mathematical functions, which provides the described software. In the second phase of the process we compile the adjusted data. In the third stage, the interpretation of the data was obtained in the way of the assumptions that were established in the first and second phase.

Not at last it has the meaning why we take this issue in this article. On the home page you can find various statistics of the flights to Košice airport for the years 2002 to 2009. These basic statistics can

be found there which may be obtained by simple filtration and subsequent processing of data in frequency tables without a more thorough analysis of records of flights to Kosice airport. Such procedure can not be applied to the treatment of deviations from the planned flight levels (usually delay time) because we loss the clear identification of certain data that are necessary to monitor the characteristics, if they have been processed correctly.

Airlines in 2008	Airlines in 2006
AIR-01	AIR-01
AIR-02	AIR-02
AIR-03	-
AIR-04	AIR-03
AIR-05	AIR-04
AIR-06	AIR-05
AIR-07	-
AIR-08	AIR-06
AIR-09	-
AIR-10	AIR-07
AIR-11	-
AIR-12	-
-	AIR-08
AIR-13	AIR-09
AIR-14	AIR-10
-	AIR-11
AIR-15	AIR-12
-	AIR-13
AIR-16	AIR-14
AIR-17	-
AIR-18	AIR-15
AIR-19	AIR-16
AIR-20	AIR-17

Tab. 1: An overview of the corresponding names of the airlines in this article and in article [2]

This article is also built on the article [2] in which the data of 2008 are processed. By this we create a time-series data which can be analyzed in time later or comparing the above parameters in individual years or months.

2 DATA PROCESSING AND PRESENTATION

Provided data include also the following characteristics:

DATE
- the date, when record has been made,
CARIERE
- the name of the airline, which took the listed flight
FLYGHT NUMBER
- flight number,
ARRIVAL
- Boolean value that determines if this flight was the arrival flight,
DEPARTURES
- Boolean value that specifies if this flight was the departure flight,
STM
- time of arrival, respectively departure, which is given in hours and minutes,
ATM
- the actual time of arrival, respectively departure, which is also given in hours and minutes,
DL
- delay of the aircraft (flight) in minutes.

In database over 8 000 records were checked from the time interval from 01. 01. 2006 to 31 10. 2006. The initial data processing was based on the population, which included 7 693 lines of records, each row contains 40 original data, and 6 new auxiliary data. These new data are a guide for further processing. Overall, we had more than 353 000 data.

Due to the nature of the data it was necessary to adapt these data for further processing and evaluation. Editing of input data was necessary in view of the used functions in excel and MATLAB.

The first step which we did, it was the removing ambiguities in the identification of all the data of flights. It was necessary to carry out an inspection of all records provided by the missing data, or adjust existing data to the information was not lost and that it was possible to identify all the necessary data to the flight, which we need for further calculations and processing.

The second step includes a visual adjustment of the data in order to move easily in such data. After such adjustments we could create formulas easier which are necessary for carrying out the analysis and thus also eliminates the risk of errors in creating patterns and functional dependencies.

3 DATA ANALYSIS

During analyzing the data, we focused mainly on analyzing the temporal time deviation that arose in the execution of each recorded flight to delay the planned range and arrivals at the airport Košice.

These deviations for each flight, we had to calculate firstly and enter the additional data to existing dataset for all records in that period. If it was a delay (i.e., the aircraft landed respectively took off later, as the flight was scheduled), we entered the time delay with a positive sign. If flight took off or landed earlier before its scheduled arrival (departure) time, we entered that time difference for all records with a negative sign. After the creation of additional records we had to identify the flights which have not been realized. These records had to be omitted and do not use them for further analysis.

Due to the limited space in this article we show only selected statistics, which provide a relevant image of the monitored parameters and features of flights on Kosice airport.

Here are the following results:
- The expected value of time deviation from the scheduled time of arrival respectively departure in minutes.
- The expected value of time deviation from the planned time of arrival.
- The expected value of time deviation from the planned time of departure.
- The expected value of time deviation from the scheduled time of arrival, respectively departure, with respect to flights made by individual airlines.

- The expected value of time deviation from the scheduled time of arrival for flights made by the individual airlines.
- The expected value of time deviation from the planned departure time for flights made by individual airlines.
- The expected value of time deviation from the scheduled time of arrival respectively departure in view of the day of the week.
- The expected value of time deviation from the scheduled time of arrival respectively departure in respect of the current month.
- The expected value of time deviation from the scheduled time of arrival respectively departure with respect to flights divided on scheduled flights and charter flights.
- Variances and standard deviations for the samples.

In next part we marked the airlines by symbols AIR-01 - AIR-17, when first 15 marks mean the airlines with biggest market share on Košice Airport and AIR-17 means the all other airlines with smaller market share. These airlines usually do not fly to Košice periodically. AIR-16 is special mark of realized flights in Košice international airport.

In table (Tab. 2) and graph (Graph 2) we show the number and share of each airlines on realized arrivals and departures on Košice airport.

Airlines	Nº of Arr	Nº of Dep	SUM
AIR-01	27	26	53
AIR-02	535	531	1 066
AIR-03	40	40	80
AIR-04	36	33	69
AIR-05	1 077	1 088	2 165
AIR-06	760	760	1 520
AIR-07	30	30	60
AIR-08	121	121	242
AIR-09	108	109	217
AIR-10	32	30	62
AIR-11	9	9	18
AIR-12	19	19	38
AIR-13	22	22	44
AIR-14	19	17	36
AIR-15	3	3	6
AIR-16	582	576	1 158
AIR-17	165	167	332
SUM	3 585	3 581	7 552

Tab. 2: Number of realized arrivals and departures by airlines on Košice airport
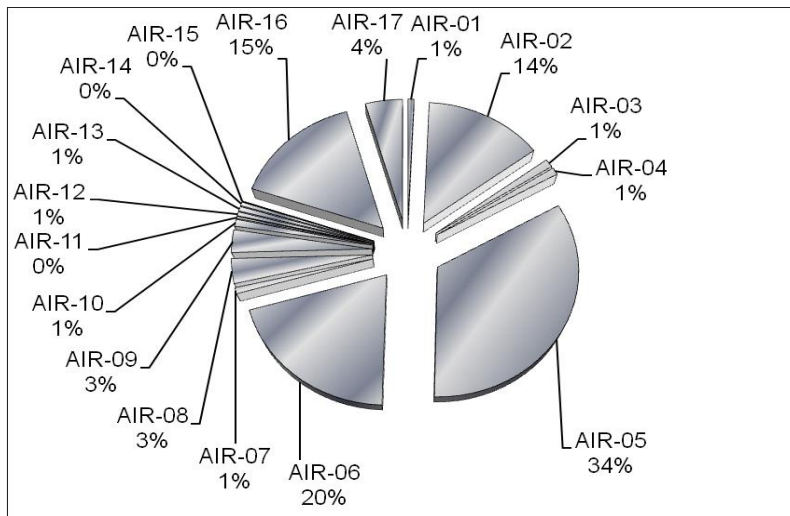
Graph 2: Average deviations with respect to weekday

We have 7 693 lines of records, but the processed table include only 7 552. The difference is 141 lines of records. These 141 data lines could not be used for processing in any studied characteristics. The tables and charts in this article were processed 7 166 data lines.

It corresponds to 3 585 arriving flights and 3 581 of departing flights. This means that 195 lines arrivals and 191 data rows of departures do not contain the necessary time information. The total number of missing values is 386.

In this table 386 records are not included, which means do not realized flights or it means

flights, for which was not checked time of arrival or departure and also planned arrival and departure

time. All these records were being excluded from next analysis and published values are adjusted from these records.

We can easily note that the largest share of air traffic and airport in Kosice airline has the AIR-05. The company had over 34% of all arrivals and departures in 2006 which were at the Kosice airport. A significant proportion has a airline AIR-06, whose share is 20% and airline AIR-02, whose share is 14%.

There are also several companies, AIR-08 and AIR-09, with 3% share. A special class AIR-16 has 15% share and here we can not analyze more, because there are several included companies which realised arrivals and departures at the airport Košice. Last group of AIR-17 contains all the other airlines that carried out arrivals and departures at the Kosice airport, but the proportion is negligible in the other described airlines as AIR-01-15.

| Airlines	Arrival	Departure	Arr + Dep
AIR-01	23,26	21,65	22,47
AIR-02	2,75	5,47	4,11
AIR-03	0,075	-2,775	-1,35
AIR-04	15,33	40,48	27,36
AIR-05	12,92	16,96	14,95
AIR-06	-5,36	17,58	6,11
AIR-07	17,97	10,00	13,98
AIR-08	0,18	8,19	4,19
AIR-09	37,85	50,69	44,29
AIR-10	212,34	137,57	176,16
AIR-11	86,44	51,89	69,17
AIR-12	71,16	26,05	48,61
AIR-13	13,86	18,77	16,32
AIR-14	20,11	26,94	23,33
AIR-15	1,33	46,67	24,00
AIR-16	39,50	24,65	32,11
AIR-17	-	-	-
TOTAL	13,88	17,77	15,82

Tab. 3: Number of realized arrivals and departures by each airlines on Košice Airport

In table (Tab. 3) and graph (Graph 3) we show the expected value of time deviation from the planned time of arrival, time of departure and time of arrival respectively departure in minutes.

Ideal expected value for flight delay is zero. This value means that flight met flight plan and aircrafts take off and land on time. We found out that average value of delay of flight for arrival or departure flights is over 15 minutes. Landing aircrafts have average delay about 14 minutes and taking off aircrafts have average delay over 17 minutes. The values of deviations from the planned time for each airline are shown in table (Tab. 3).

We can notice that in table (Tab. 3) there are only 3 negative values. That means that flights usually delay before they should land or take off earlier that is planned time.
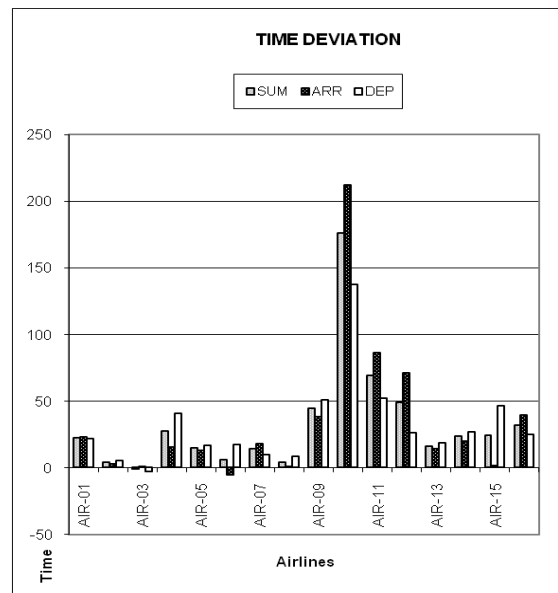
Graph 3: Time deviation

Next 2 tables and graphs show the time deviation of arrival and departure time by the day of week and month in year.

In table (Tab. 4) and subsistent graph (Graph 4) there is survey of flight delay in respect to day in week.

It is easy to see that the total values are in the table (Table 4) worse than in the table (Table 3). The reason of this situation is that in the table (Table 3) we have not include the sum of the value of companies whose share in the operation of Kosice airport is minimal.

Most arrivals and departures are on Tuesdays and Fridays and lowest on Sunday and on Saturday. The largest temporal variations are on Tuesday and Saturday, which indicates that the

total value of the delays may not only be clearly affected by traffic density in a given day.

Day	Arrival	Departure	Arr + Dep
Monday	11,87	17,87	14,79
Tuesday	24,23	17,37	20,59
Wednesday	6,88	25,71	15,78
Thursday	18,61	21,16	19,94
Friday	11,77	13,93	12,81
Saturday	28,78	11,64	18,54
Sunday	12,58	25,76	17,88
TOTAL	15,34	18,71	17,02

*Tab. 4: Average deviations regarding weekday*
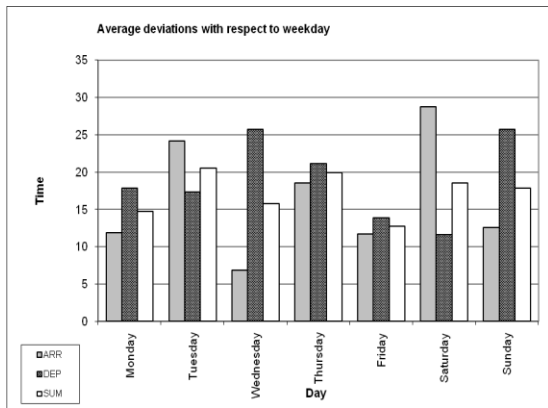
Graph 4: Average deviations with respect to weekday

In table (Tab. 5) and graph (Graph 5) we show the survey of flight delay in respect to month of year.

Months	Arrival	Departure	Arr + Dep
January	-12,18	19,63	3,66
February	20,57	19,63	20,09
March	14,09	15,93	15,01
April	12,22	13,29	12,76
May	21,63	18,48	20,05
Jun	19,83	16,93	18,38
July	26,02	19,77	22,88
August	16,98	15,55	16,27
September	25,22	28,99	27,12
October	26,41	23,72	25,07
November	-6,15	9,14	1,40
December	4,50	20,82	12,66
TOTAL	15,34	18,71	17,02

*Tab. 5: Average deviation regarding month in the year*
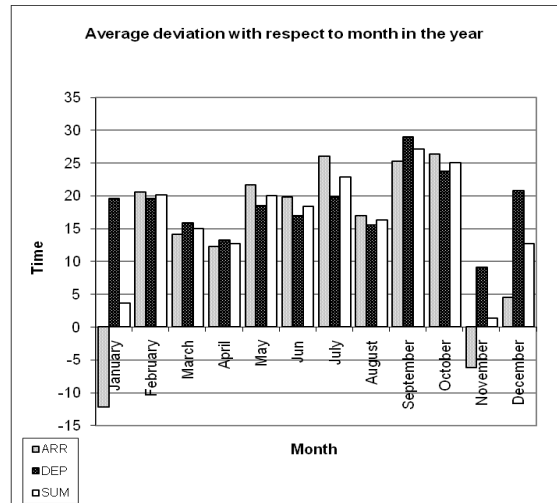
Graph 5: Average deviation with respect to month in the year

In table (Tab. 6) and graph (Graph 6) we show the time deviation in respect to schedule and non-scheduled flights and international and domestic flights.

Type of flight	Arrival	Departure	Arr + Dep
Domestic Schedule (DS)	-5,09	25,38	78,58
International Schedule (IS)	7,33	9,03	10,26
Domestic nonschedule (DN)	86,23	70,82	15,86
International nonschedule (IN)	19,49	12,23	8,18
TOTAL	15,34	18,71	17,02

Tab. 6: The time deviation in respect to Schedule and nonschedule flights and international and domestic flights

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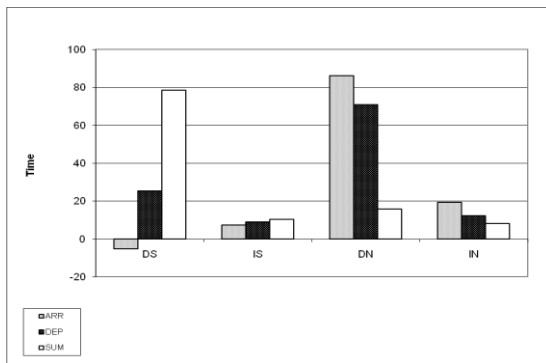
Graph 6: The time deviation in respect to Schedule and no schedule flights and international and domestic flights

4 ANALYSIS OF RESULTS

The results in the third chapter give us an initial image how the time deviations are depended on the different measured characteristics. Based on the processed data and graph we can choose the next steps of these data analysis. Some applications of results are shown in [6].

Similar analysis of data of flights we can find also for airports Chicago O Hara a Schiphol [4] [5]. These publications include similar approach for data analysis, but the results are adequate to airport size, which they describe.

In additional analysis of these data we can use the Six Sigma method and TQM, which it should be done by enclosed source [7] [8] [9]. Economic impact analysis of flights is very important in additional analysis. [10].

Similar problems of data processing as in our case had been addressed in the analysis of fractures of conveyor belts, where the issue of data processing is described in articles [11] [12].

From processed data we can see that positive deviation preponderates before negative deviation, which mean to delay and earlier arrivals and departures. The strong difference we can see in case of analysis data in respect of type of flights. The Schedule flight indicates more the negative deviations before positive deviations. This parameter could be analyzed detailly. In this paper we do not have enough places for this addition analysis.

Thus, the processed data are the basis for further analysis. One of other possibilities is the analysis of time series that was generated during data processing. A suitable method of processing this type data is described in the work [13] [14].

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