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Investigation of the Effect of the Instrument Landing System on Flights to Konya Airport between 2019-2022 Years

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Abstract

The Instrument Landing System (ILS) is the most widely used navigation aid system among the precision approach types, which enables the pilots to approach the runway in the appropriate direction and glide slope, especially in foggy and snowy weather when the visibility is very low. This study investigated the relationship between flight disruptions and ILS in Konya Airport. In this context, meteorological events such as snow, ice, fog, and cancellation, divert and delay events caused by humans (company policy) at Konya Airport in the period of 2019-2022 were revealed with numerical data. In light of these data, it has been revealed that ILS not only provides safe flights but also prevents possible passenger complaints and financial losses by reducing the number of diverts, and therefore ILS is also of great importance in terms of customer satisfaction.

1. Introduction

The instrument landing system (ILS) is the most widely used navigation aid system among precision approach types, guiding the aircraft in horizontal and vertical directions to ensure the safe landing of the aircraft on the runway. It allows aircraft to land safely even in bad weather conditions where visibility is very low, such as foggy and snowy weather. The antennas and markers, which are the components of the ILS, which enable the aircraft to land despite all these adverse conditions, and their positions relative to the runway, are shown in Figure 1.

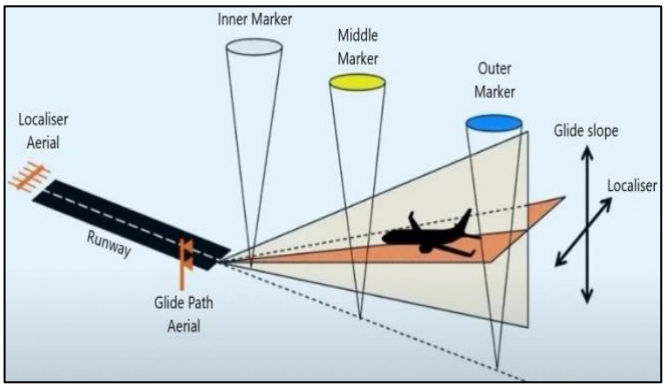

Figure 1. All components of ILS and their placement.

ILS is available at airports with good infrastructure and environmental conditions. Although the airplanes have the necessary equipment related to ILS, the fact that the airport has a very low density, the structure of the airport, and seasonal conditions can be counted as the reasons why this system is not available at some airports. Accordingly, the ILS infrastructures of airports differ in terms of operational categories.

Some of the academic studies on ILS and approach systems, which have such important benefits in terms of flight safety, are summarized below.

Elaboration of ILS and its components (Öktemer & Gültekin, 2021), the use of ILS and the additional costs arising from flight delays (Kaba & Ürgün, 2019), advanced technologies used in approach systems (Ataş et al., 2014), comparing and analyzing the operational category efficiencies of the busiest airports in Europe, Asia, and North America (Güner, Ergüzel, & Cebeci, 2019), mathematical modeling that will reduce the effect of irregular surfaces in order to prevent the negative effects such as the hangar and terminal buildings reflecting the localizer signals to the route region (Odunaiya & McFarland, 1996), airplanes in the taxiway disrupting the ILS signals and comparing this situation for various airplane types (Geise et al., 2010), suggestions for improving localizer antenna arrays (Peterson, 1976), simulating the accuracy of ILS in conditions such as fog, rain, snow, etc. (Merkisz, Galant, & Bieda, 2017), classifying the fogs that occurred at Istanbul Atatürk Airport between 2008-

2012 in the ILS category and determining the CAT categories in the foggy hours (Özdemir, Sezen, Deniz, & Menteş, 2014), inferences obtained from tests performed by performing front course and back course approaches in the ILS (Hunting, 1972), development of an electromagnetic scattering model to predict localizer and glide slope performance (Chin, Jordan, Kahn, & Morin, 1975), flight measurement and testing of the ILS by flying laboratory aircraft at the University of Žilina (Novák, Havel, & Janovec, 2017), examination of ILS interference caused by Airbus A380 and Boeing B747 aircraft, via analyzes using scaled localizers (Geise, Enders, Vahle, & Spieker, 2008), advices about possible variants of ILS control process improvement (Zuiev, 2017), airborne measurement of ILS Signals using an unmanned air vehicle (Jantz, West, Mitchell, Johnson, & Ambrose, 2019), receiving the signals reflected from the aircraft and measuring the signal deviations that occur on the glide path (Yungaitis, Zhdanov, Zotov, & Voytovich, 2020), simulating the approach track of the aircraft in Matlab and thus investigating the safe landing in bad flight conditions (Geng & Ping, 2015), analysis of electromagnetic disturbances caused by buildings and obstacles around the airport (Wang, Shen, Cheng, & Wang, 2019), improvements that can be made in the localizer and glide path designs of ILS (Metz, 1959), elaborating of the inadequacies of ILS's existing before 1973 (Sanders & Fritch, 1973), controller design and experimental evaluation for ILS (Jain, Shetty, & Shenoy, 2014), experimental based learning and teaching management for localizer (Tangthong & Aktimagool, 2020), performing flight inspections and analyses of the ILS (Novák & Pitor, 2011), analyses and differences of microwave landing system and ILS (Neville & Matolak, 2004), ILS's analysis based on adaptive beamforming technology (Li et al., 2006), presenting advanced models to solve the problems that occur in the aircraft receiver due to the obstacles around the runway disrupting the signals (Noshiravani & Rezaee, 2010), analyzing the signal quality of the ILS (Zhao, Zhao, He, & Dong, 2019).

The most striking study that can be thought of as similar to our study is the study presented in (Kaba & Ürgün, 2019). In the study conducted by Kaba and Ürgün (2019), the daily average number of flights and low visibility rates for January, February, March, and April at Odessa, Bishkek, Pristina, and Rostov airports between 2014-2019 are shared in tables. However, numerical data that would clearly reveal the effect of ILS such as annual total flight information and the number of divert at the relevant airports are not included.

In this study, first of all, information about the usage status and ILS categories of some airports in our country is given. Then, official meteorological data of Konya Airport were shared. Finally, the relationship between meteorology and company-related disruptions and ILS was researched specifically for Konya Airport, covering a period of 4 years starting from 2019, and the numerical data obtained were shared.

2. ILS and Operational Categories

Precision approach is a type of instrumental approach that the aircraft performs by collecting information in lateral and vertical directions within the scope of operational categories. Operational categories vary according to airport approach procedures and are actually segmented by cloud ceiling and visibility. According to their performance, there are three types of ILS categories: Category-1 (CAT-I), Category-2 (CAT-II) and Category-3 (CAT-III). These categories are expressed in terms of decision height (DH) and runway visual range (RVR). Airports are also separated into these categories.

The values of the decision heights and runway visual ranges that should be applied in the current operational categories are given in Table 1. The categories in Table 1 are used for runways with ILS and are determined according to their visual ranges. When Table 1 is examined, it will be seen that CAT-IIIC is the most sensitive approach where landing takes place even at zero visibility. However, it should not be forgotten that the presence of the components of the ILS at airports and aircraft is not sufficient alone and that the pilots who will land with the ILS must have received training on the relevant CAT.

3. Use of ILS at the Airports of Our Country

There are 59 civil airports in use in our country. 37 of them operate international flights. 18 of the existing airports are used together with the Turkish Armed Forces for military purposes. The number of airports used only for military purposes in our country is 18. Information on some airports in Turkey and their ILS categories is presented in Table 2. The locations of the airports, their abbreviations according to the International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA), their names, and their usage purposes are also shared in the table.

4. Konya Airport, Meteorological Data, and ILS

4.1. Konya Airport

Konya Airport is an airport located within the borders of the Selçuklu district of Konya and used for civil and military purposes. This airport, which was previously used only for military purposes, was opened to civil air traffic in the 2000 year. Konya Airport, which is used under the joint management of the State Airports Authority and the Turkish Air Force, was established on an area of approximately 141,000 square meters.

ILS started to be used at Konya Airport in 2008 and its infrastructure was created according to CAT-I. In order to increase the operational category, technical studies were last carried out in 2018 and presented to the relevant institution. However, considering both the joint use of the airport runway with the Turkish Air Force and the obstacle criteria, operating conditions, and costs, it was evaluated that it was appropriate for the airport to remain in the CAT-I category.

Konya Airport has two runways for the landing and take-off of airplanes. These runways are named East and West. The ILS is only used on the West runway. Located at the northern beginning of the runway, ILS broadcasts towards the south. The biggest factor in the placement of the system in this direction (from north to south) is the winds. The winds blowing in Konya generally blow from the north. Considering the necessity of always taking the wind from the front during the landing and take-off of the aircraft, it will be understood that the landings made using the ILS should take place from the south to the north.

The fact that there is a one-way ILS at the airports causes air traffic during landings. The first thing that comes to mind to eliminate such situations is the back-course approach. However, the ILS systems used in our country only have front course approaches.

Table 1. Operational Categories (Kazan & Öktemer, 2023)

Category of Operation	Decision Height (DH)	Runway Visual Range (RVR)	
CAT-I	DH > 200 ft	RVR > 550 m	Min. 800 m
CAT-II	100 ft < DH < 200 ft	RVR > 300 m	-
CAT-IIIA	DH < 100 ft or no DH	RVR > 200 m	-
CAT-IIIB	DH < 50 ft or no DH	50 m < RVR < 200 m	-
CAT-IIIC	no DH	no RVR limitation	-

4.1 Meteorological Data of Konya Airport

Undoubtedly, the meteorological conditions in the airport area are of great importance in the number of landings and take-offs at airports. For this reason, sharing data on meteorological events at Konya Airport in this four-year period covering the years 2019-2022 will provide a better understanding of the impact of ILS in this process. The number of snowy days at Konya Airport during this period covering the years 2019-2022 is given in Table 3 as monthly data. The number of days when the airport is covered with snow after these precipitations are given in Table 4 and the manually measured maximum snow thicknesses in cm are given in Table 5.

Table 2. Information about some airports in our country

Location	ICAO	IATA	The Name of the Airport	Purpose of Usage	ILS Category
Adana	LTAF	ADA	Şakirpaşa Airport	Civil	CAT-I
Amasya	LTAB	MZH	Amasya-Merzifon Airport	Civil/Military	CAT-I
Ankara	LTAD	-	Etimesgut Airport	Military	CAT-I
Ankara	LTAE	-	Mürted Hava Üssü	Military	CAT-I
Ankara	LTAC	ESB	Ankara Esenboğa Airport	Civil	CAT-I/II/III
Antalya	LTAI	AYT	Antalya Airport	Civil/Military	CAT-I/II
Balıkesir	LTFD	EDO	Balıkesir Koca Seyit Airport	Civil	CAT-I
Erzurum	LTCE	ERZ	Erzurum Airport	Civil	CAT-II/III
Gaziantep	LTAJ	GZT	Gaziantep Airport	Civil	CAT-II
İstanbul	LTFJ	SAW	Sabiha Gökçen Airport	Civil	CAT-I
İstanbul	LTFM	IST	İstanbul Airport	Civil	CAT-I/II
İzmir	LTJB	ADB	Adnan Menderes Airport	Civil	CAT-I/II
Konya	LTAN	KYA	Konya Airport	Civil/Military	CAT-I
Kastamonu	LTAL	KFS	Kastamonu Airport	Civil	CAT-I
Kayseri	LTAU	ASR	Erkilet Airport	Civil/Military	CAT-I
Kütahya	LTBZ	KZR	Zafer Airport	Civil	CAT-II
Malatya	LTAT	MLX	Malatya Airport	Civil/Military	CAT-I
Muğla	LTBS	DLM	Dalaman Airport	Civil/Military	CAT-I/II
Muğla	LTFE	BJV	Milas-Bodrum Airport	Civil/Military	CAT-II
Sivas	LTAR	VAS	Sivas Nuri Demirağ Airport	Civil	CAT-I
Zonguldak	LTAS	ONQ	Zonguldak Airport	Civil	CAT-I

Table 3. Number of days with snow on a monthly basis at Konya Airport.

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
2019	9	4	3	2								6
2020	14	5	5									
2021	5	5	7	4								5
2022	13	4	18	1								1

Table 4. Number of snow-covered days at Konya Airport on a monthly basis.

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
2019	10		2	1								3
2020	6	3	5									
2021	3	8	4	2								15
2022	13	18	13									

Table 5. Maximum snow height (cm) at Konya Airport on a monthly basis.

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
2019	10		1									2
2020	4	4	4									
2021	2	10	3	4								23
2022	30	27	21									

Table 6. Number of days with monthly fog events at Konya Airport.

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
2019	10	1	1	2							11	8
2020	3	1	1		1							3
2021	7										2	10
2022	4	7									3	14

Table 7. Number of rainy days at Konya Airport on a monthly basis (manual measurement).

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
2019	19	8	6	12	8	13	3	2	3	5	7	18
2020	9	9	13	12	9	10	2	1	3	3	5	10
2021	8	5	12	7	2	12	2	1	6	5	6	12
2022	14	9	12	1	10	8	2	1	5	6	7	7

The minimum temperature values for the same period are shared in Figure 2 in graphic form. In Figure 2, the number of days when the temperature drops below zero is 72, 77, 85, and 93, respectively, by year.

As it is known, heavy fog and rain are also meteorological events that cause delays, missed approaches and flight diverts. In this process, the number of foggy and rainy days at Konya Airport and the total amount of precipitation are given in Table 6-8, respectively.

Table 8. Total monthly precipitation at Konya Airport (mm=kg/m²).

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
2019	47.7	20.6	21.9	44.8	6.8	62.8	19.6	8.4	6.6	4.8	35.4	81.7
2020	48.7	36.5	51.8	35.3	43.5	23.9	0.9	0.4	6.9	4.1	19.6	20.1
2021	25.2	11.9	51.1	29.1	2.0	47.1	46.3	9.8	29.1	2.7	16.0	89.4
2022	70.6	48.0	55.1	1.0	39.9	10.4	7.9	2.0	11.5	24.2	10.9	7.9

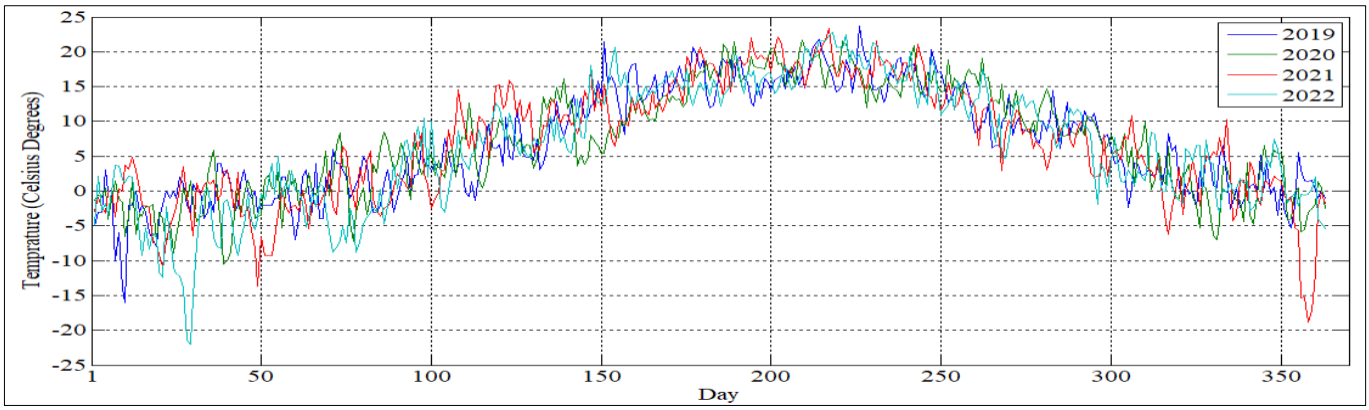

Figure 2. Minimum air temperatures for 4 years at Konya Airport.

4.2 The Impact of ILS on Konya Airport Flights

In addition to making the pilots' job easier, ILS also has benefits such as reducing the number of undesirable situations such as flight cancellations, diverts, and delays. As it is known, cancellation is a situation where the flight does not take place at all. Divert is the event that the airplane makes its planned landing at another airport due to reasons that prevent it from taking place at the relevant airport. Delay is the inability to start the planned flight until all the conditions that constitute an obstacle to the flight are eliminated.

The number of planned landings and take-offs at Konya Airport in the 4 years covering the years 2019-2022 is given in Table 9. The reason for using the term “planned” here is that the numbers of unforeseen cancellations, diverts and delays are also included in this total number.

Table 9. The number of flights planned at Konya Airport according to the years.

Year	The number of planned landings	The number of planned departures
2019	2945	2945
2020	3168	3168
2021	3411	3411
2022	3627	3627

In the same period, cancellation, divert, and delay events caused by snow, ice, and people (company policy) at Konya Airport are presented in Table 10. When Table 10 is examined, it is understood that the landings were realized safely due to the ILS, except in extreme snow and ice conditions. The

cancellation of only 9 of the descents with a total of 13151 shared in Table 3, and the absence of any diverts, clearly demonstrates how important ILS is during landings. However, when the numbers of cancellations and diverts originating from the company in the same table are examined, it is seen that there were 123 cancellations and 11 diverts in the same period. Figure 3, where numerical data is visualized, better reveals this difference's size.

Table 10. Cancellation, divert, and delay situations caused by snow, ice, and company at Konya Airport

Year	Due to snow and ice			Sourced from company policy		
	Cancellation	Divert	Delay	Cancellation	Divert	Delay
2019	0	0	2	14	0	53
2020	0	0	7	8	0	29
2021	1	0	12	13	8	69
2022	8	0	9	88	3	280
Total	**9**	**0**	**30**	**123**	**11**	**431**

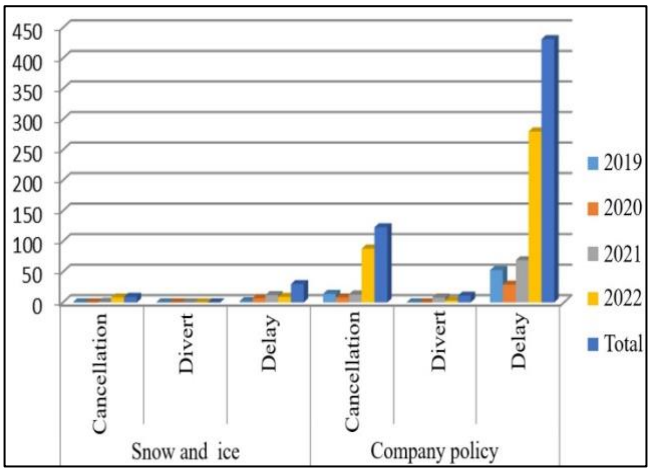

Figure 3. The number of cancellations, diverts, and delays at Konya Airport due to snow, ice, and company policy.

Since the category was created according to the fog factor in the visibility distances, the cancellation, divert and delay events caused by fog at Konya Airport in the 2019-2022 period were evaluated separately from the cancellation, divert, and delay situations caused by snow, ice, and the company policy. These data are shared in Table 11, Table 12, and Table 13, respectively.

These data, presented in Tables 11-13, have been graphed and shared in Figure 4 for easier comparison.

Table 11. Distribution of fog-related cancellations at Konya Airport by years. (VD: View distance)

Year	VD<300m	300m<VD<550m	550m<VD
2019	20	37	4
2020	0	1	0
2021	6	2	6
2022	10	4	3

Table 12. Distribution of fog-related diverts at Konya Airport by years. (VD: View distance)

Year	VD<300m	300m<VD<550m	550m<VD
2019	1	2	0
2020	0	1	0
2021	1	0	0
2022	0	0	0

Table 13. Distribution of fog-related delays at Konya Airport by years. (VD: View distance)

Year	VD<300m	300m<VD<550m	550m<VD
2019	12	9	21
2020	6	3	1
2021	2	4	9
2022	8	18	10

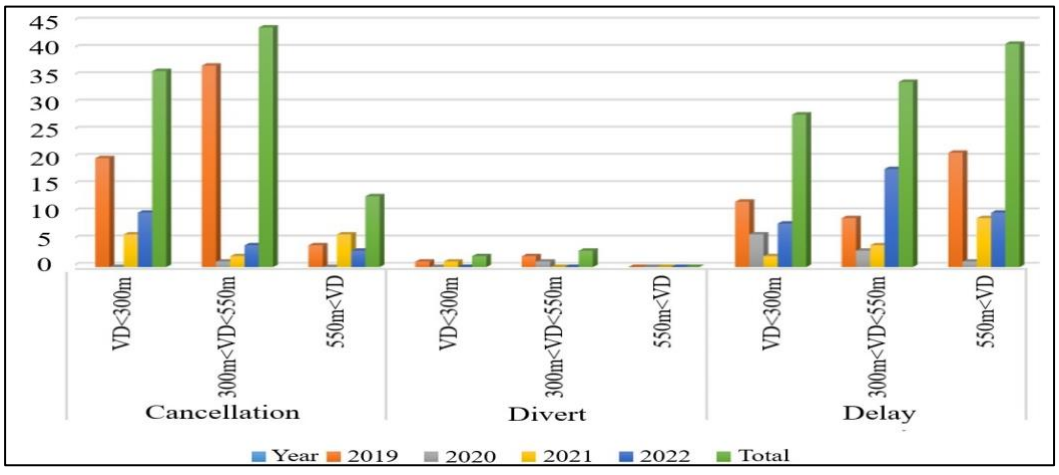

Figure 4. The number of cancellations, diverts, and delays due to fog at Konya Airport.

When Tables 11-13 and Figure 4 are examined together, it will be understood that the number of cancellations in the case when the view distance is dropped between 300 m and 500 m due to fog is higher than in the other two view distance situations. The total number of cancellations experienced on 13151 flights during this period is 93. This means that only 0.707 % of the total flights are canceled. It is seen that the total number of delays due to fog in these 4 years was higher than the total number of cancellations and realized as 103.

When the fog-induced divergence numbers, which clearly demonstrate the importance of ILS, are examined, it is seen that only 5 diverts have occurred in these 4 years. This means that diverts occur in only 0.038% of the total flight. Even when this rate of only 0.038% is taken into consideration, the importance of ILS is revealed.

5. Conclusion

In this study, the effect of ILS on the number of disruptions in flights was investigated specifically at Konya Airport. In this context, meteorological events such as snow, ice, and fog, as well as human (company policy) sourced cancellation, divert, and delay events in a total of 13151 flights to Konya Airport in the 2019-2022 period were revealed with numerical data. In light of the numerical data obtained, it was seen that only 0.707% of the total flight was canceled. It was observed that the divert rate was similarly very low and remained at 0.038%. In light of these data, it has been revealed that ILS not only provides safe flights but also prevents possible passenger complaints and financial losses by reducing the number of diverts, therefore ILS is also of great importance in terms of customer satisfaction.

In this study, information was also given about the usage status and ILS structures of some airports in our country. In this context, it has been observed that CAT-I is generally used as the ILS category in our country, but there are also CAT-II and CAT-III infrastructures, which are more sensitive than CAT-I.

In fog-induced situations, the pilot factor comes to the fore. In cases where the visibility is the same, the flight may be canceled, diverted, or delayed. In these cases, the pilot's experience, training, and decision-making skills come to the forefront. The most important issue that will affect the pilot's decision-making status is the operational infrastructure of the ILS system.

It should not be forgotten that the pilot who will perform the flight should have a rested, trained, and healthy body/mind composition and should perform the flight accordingly.

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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