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Runway Orientation Problems – A Case Study of Middle Euphrates International Airport MEIA

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Abstract

It has been planned to design and construct a major international airport at the middle Euphrates region of Iraq to support the commercial development plan and serve the pilgrim's occasional visit to the holly shrine at Holy Karbala and Najaf provinces. The airport site is 30 km west of Karbala at the edge of the great western desert. The design includes construction of two parallel runways of 4500 m length, and 2300 m center to center apart. Metrological data regarding the wind intensity, duration, direction and speed have been obtained for the site, and the wind rose diagram has been drawn. The selected project area practices a calm wind speed throughout the past 25 years. The runway orientation of maximum coverage was designed to be NW-SE (315–135). The site was adjacent to power station plant and problems arise with the interference of the 35 m height chimney of the plant with the air field. Four alternatives have been considered to solve such problem based on a comparative analysis. The first one was to move the location of the runways system to the North West in order to reduce the portion of Obstacle Limitation Surface (OLS) approach surface above the power plant. The second was to increase the center to center distance between the runways to 3000 m in order to have the power plant out of the OLS approach surface. The third alternative was to increase the spacing between runways to 3000 m and shift the second Runway to the extreme north. The fourth alternative was to change the orientation by 15° clockwise to a new one of (330–150) with minimal effect of 3% on wind coverage. The paper presents the details of such alternatives and finalizes the decision on runway orientation based on economic justification and site condition.

Keywords*: Comparative analysis; metrological data; orientation; runway; wind coverage*

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INTRODUCTION

It was decided to establish an international airport at Holy Karbala governorate, the two major issues are required to be considered; the first issue is that the airport should be located at 30 km west of the city center, while the second issue is that the airport should be located within the administrative boundaries of the Holy Karbala province. Based on these, the final site selected was located west of Euphrates River as shown in plate 1. The airport site is located within the gypsoferious desert land, and midway between Najaf and Karbala.

Collection of Metrological data

The Metrological organization was in charge of measuring and supplying of data from 24 stations across the country; these stations have daily records on climatic conditions for the regions on which they exist. Such data covers the past 20 year's period for the whole country. The wind data which includes wind direction, speed and percentage intensity (duration) have been collected, from Holy Karbala, Najaf and Hilla metrological stations. Such data were fed to the database of the developed software[1] and to the Federal Aviation Administration (FAA) software.

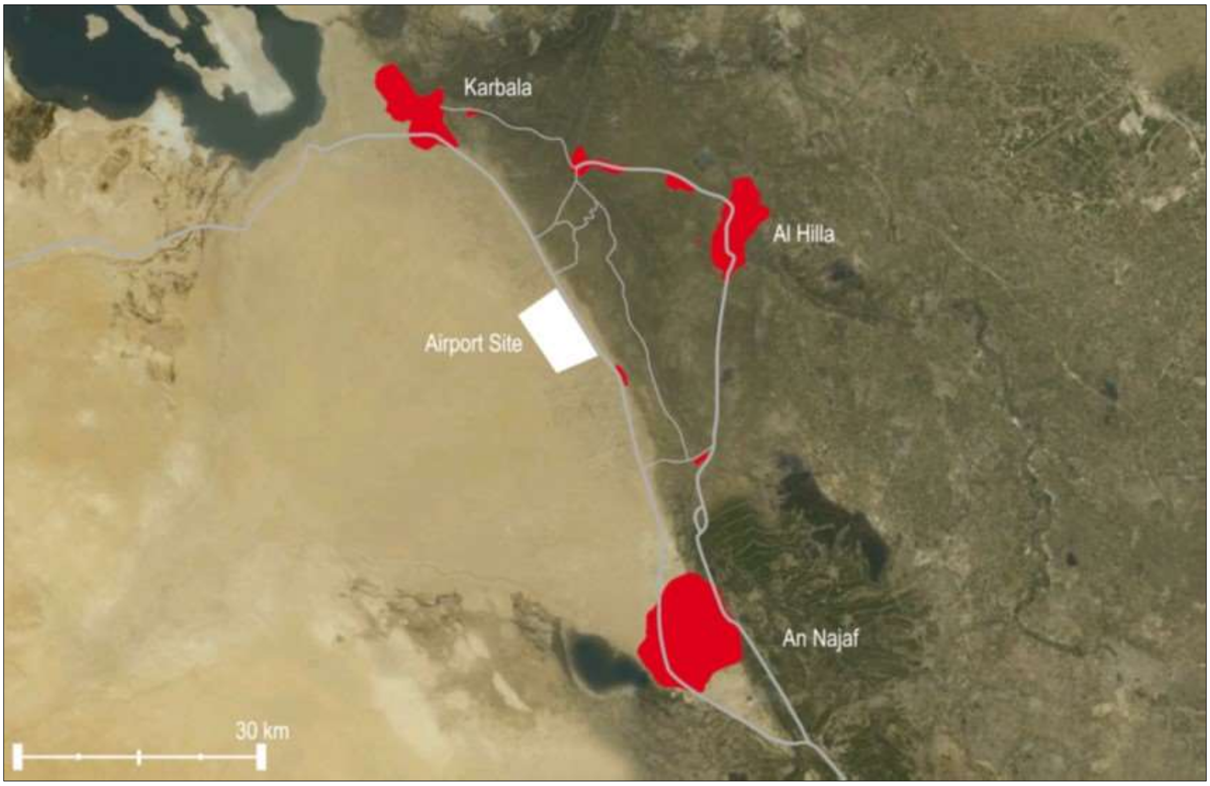

Plate 1: *Site Location of MEIA Airport.*

DESIGN OF RUNWAY ORIENTATION

Wind coverage was calculated using a wind rose, which graphically depicts wind data. The wind rose is essentially a compass rose with graduated concentric circles representing wind speed. Each box in the wind rose represents a compass direction and, when filled, indicates the percentage of time wind travels in that direction at that speed[2].

The wind rose template has a polar coordinate system that is made of circles and radial lines. Circles on the template represent the wind speed, while the radial lines illustrate the angles or the wind blowing directions. Each cell bounded by two circle segments and two radial lines, which stores the percentage of time, that the winds correspond to a given direction and velocity range. The circle with label represents the speed of crosswinds the runway will experience during its operations, and it is less than that of the allowed crosswinds. A transparent runway template is placed on the wind rose to represent the proposed runway that accommodates the size and operating characteristics of aircraft[3]. The template is rotated around the center of the wind rose in order to search for an optimal runway orientation. At each rotating angle, the total percentage of allowable crosswinds in the wind rose that are covered by the template is calculated, and a best angle that can give the maximum percentage of coverage is determined. Figure 1 shows the work sheet of the method, while Figure 2 illustrates the wind rose diagram.

The optimized runway orientation obtained was (SE-NW; 135/315) orientation. The wind coverages for various crosswind components are illustrated in Table 1. The metrological data of the three governorates were fed to the software, it was noticed that data of holy Karbala was similar to those of Hilla and Najaf, and the variation was not significant. It was considered to use the data of holy Karbala for the wind rose analysis.

Table 1: *Wind Coverage Analysis*.

Crosswind component	Wind coverage results, (135/315) orientation
37 km/h (20kt)	99.51%
24 km/h (13kt)	97.27%
19.5 km/h (10.5kt)	94.86%

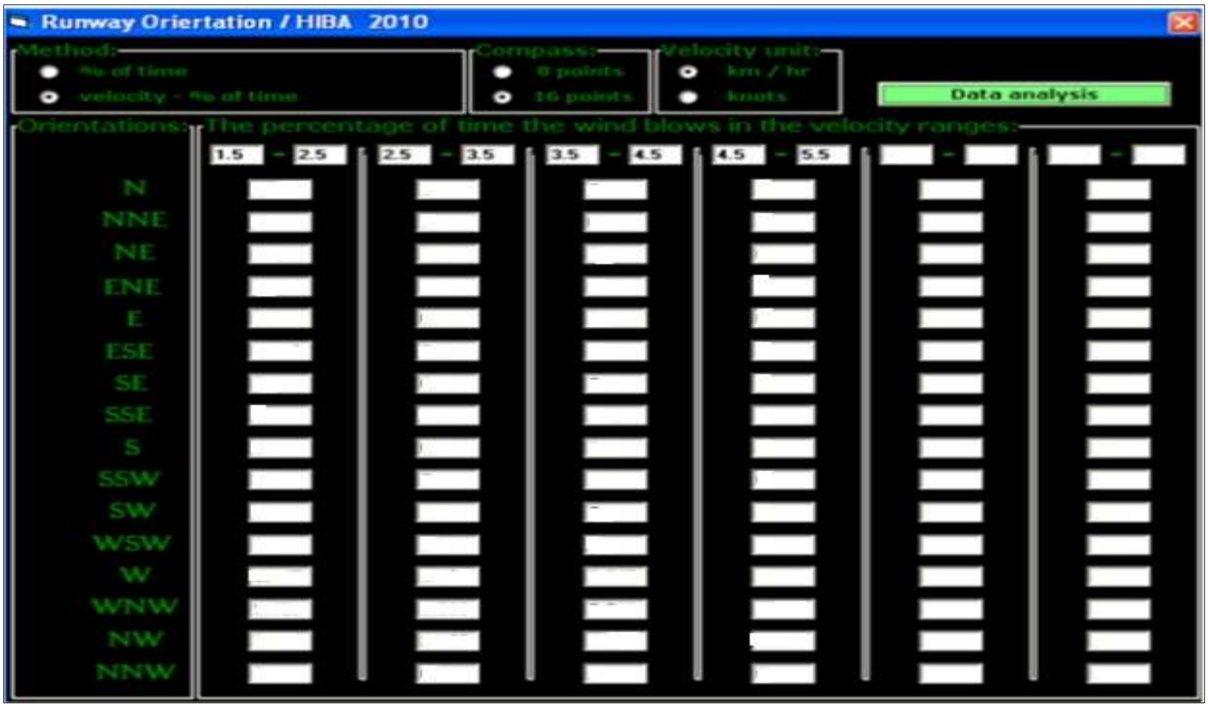

Fig. 1: *Work Sheet for Wind Rose.*

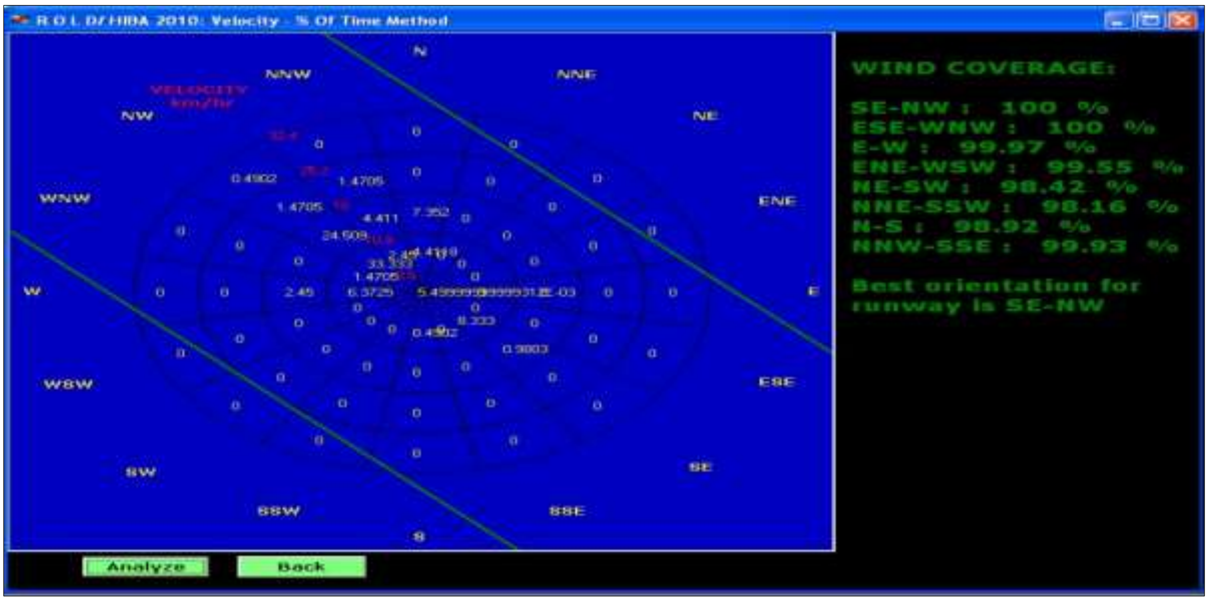

Fig. 2: *The Wind Rose Diagram.*

SITE PROBLEMS WITH RUNWAY ORIENTATION

Problems arise while checking the designed orientation with the airport site, at the 315 side; an oil refinery exists with a chimney of 50 meters height. This chimney will interfere with the Obstacle Limitation Surface approach (OLS). As per ICAO[4], the location of OLS above the power plant chimney was not recommended. The proximity of the refinery to the airport can be managed regarding the obstacles created by the refinery facilities. The risks associated with the refinery smokes also appear to be manageable in terms of visibility, since opaque smokes are not expected during normal operations. However, with the height of chimney, the refinery obstacles are a deviation from ICAO recommendations based on a specific safety case analysis (ICAO, Annex 14) as per ICAO recommendation and commissioned by the Civil Aviation Authority. On contrary, the Iraqi Environmental Regulation provided by MOT states that the refinery projects should be located 15 km from the "main infrastructures" or "basic designs" in the wind direction and 10 km in the other direction. If this regulation apply to the airport, a change of the airport site or of the refinery would be required. It has to be noted that the benchmark of existing major international airports located within distances of refineries similar to the MEIA case tend to show such locations are acceptable. Figure 3 illustrates a schematic longitudinal section of Approach Obstacle Limitation Surface from the northern threshold (sketch for illustration, not drawn to scale but figures are exact). The longitudinal distance between the second stage runway northern threshold and the power plant further corner, which is the most remote location where the chimney can be located is 7400 m. Figure 3 represents that the top of the chimney is located only 100 m below the Approach Surface, whereas FAA recommendation is to avoid overflight of such chimney by less than 300 m from the top of the chimney. Figure 4 depicts the chimney location and the designed orientation.

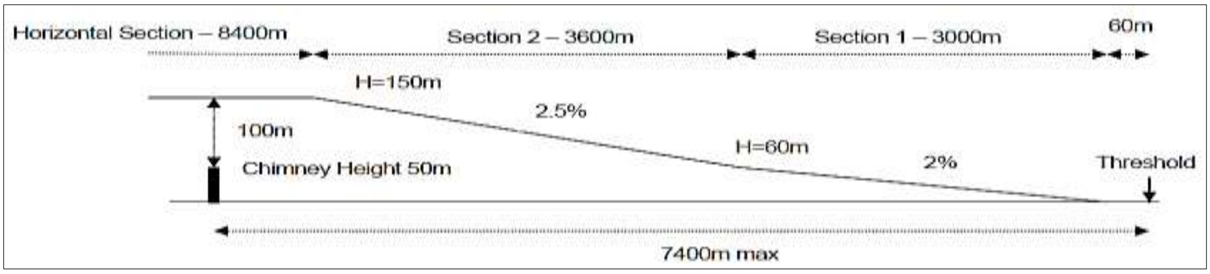

Fig. 3: *Typical Section of the OLS above the Runway.*

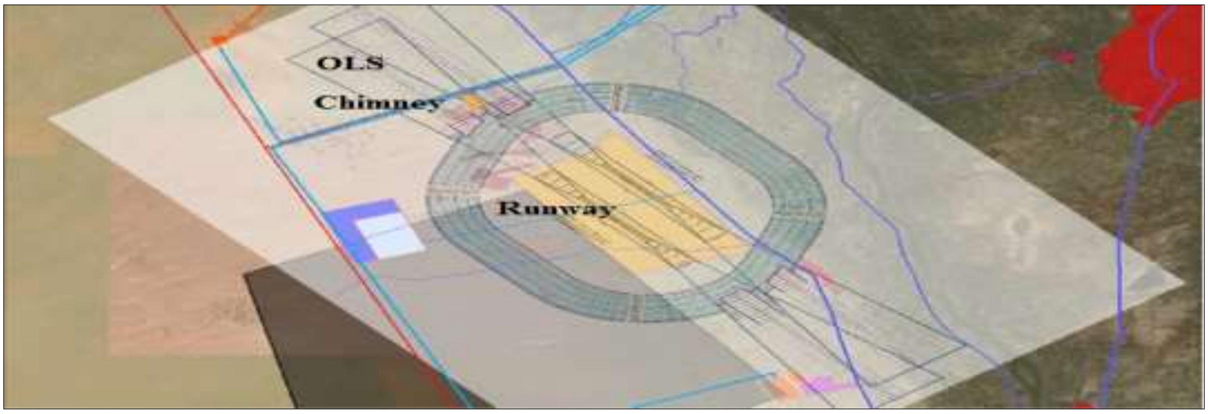

Fig. 4: *Chimney Location and the Designed Orientation.*

Different alternatives have been considered. The first alternative (Option 1) consists of moving the runway system to the North West in order to reduce the portion of OLS approach surface above the power plant. Figure 5 illustrates the runway orientation and the chimney location for this option but this doesn't solve the problem. The second alternative (Option 2) consists of increasing the distance between the two runways In order to have the power plant out of the OLS approach surface. Figure 6 demonstrates option 2. This alternative is not recommended since the chimney still lies under the approach surface and implies conflicts with the land-use, so this option does not work safely.

The third option was increasing the spacing between runways to 3,000 m and locating the second runway at the extreme north, the Instrument Landing System (ILS) approach lighting ramps for runway threshold 31R and 13L are outside the Airport Site boundary. The power plant chimney would still be located under the approach surface as shown in Figure 7. In addition, with a centerline spacing of 3,000 m, the spacing between the runways needs to be increased by 700 m. This has many impacts such as increase in cross-taxiway length by 700 m, corresponding to an additional cost of Code F taxiways, excluding shoulders, increase in road system length, apron, taxiing times and airline fuel costs to compensate the increased spacing.

However, in this case it is not possible to avoid a situation in which the Power Plant would still be located under the approach surface of both runways and the power plant chimney under the approach surface of either runway 1 or runway 2. ILS approach lighting ramp of runway 15L and airport fence would lie outside of site boundary, and within the 5 km perimeter around the power plant, which does not comply with the environmental regulation considered in the site selection. The first runway OLS would not represent an issue. However, in this approach, the constraints result from the second airport runway. With a 135/315 orientation it is not possible to find a suitable location inside the Airport site for runways and associated ILS approach systems so that the Karbala gas power plant is outside the OLS approach surface of the second runway.

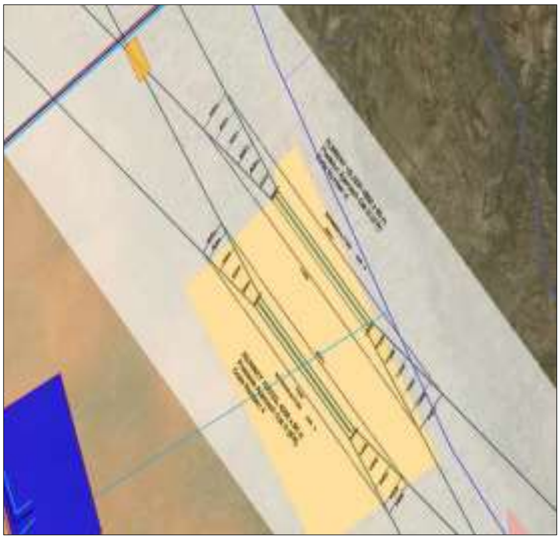

Fig. 5: *Runway Orientation 135/315 Shifted to North-West*

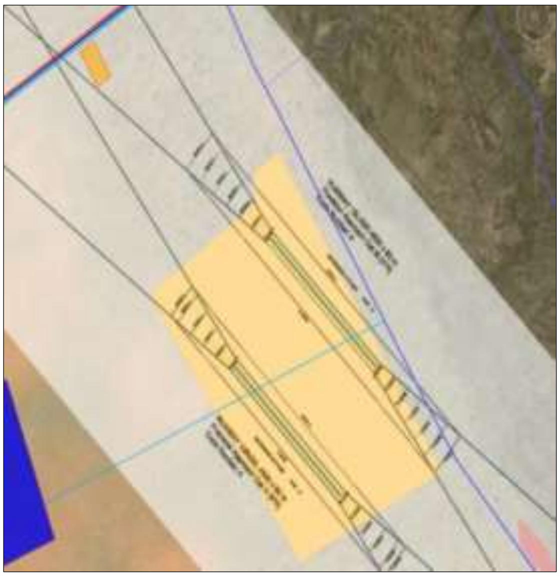

Fig. 6: *Runway Orientation 135/315 with 3000 m Centerline spacing*

The fourth option is to change the orientation by 15 ° clockwise to a new one of (330–150) and check the impact of wind coverage. Figure 8 shows the fourth option. The new orientation data were fed to FAA software, the metrological data of the three governorates were fed to the software, and the new wind rose was obtained as demonstrated in Figure 9. The above three alternatives are not recommended, since its negative impacts in terms of costs, operations and flexibility by far outweigh the very slight benefit in term of wind coverage. Furthermore, it is not possible to avoid having the power plant inside the approach surface of runway 2 in any of the layouts considering a 135–315 runway orientation. Then alternative four was assessed as possible alternative to overcome the problem of orientation.

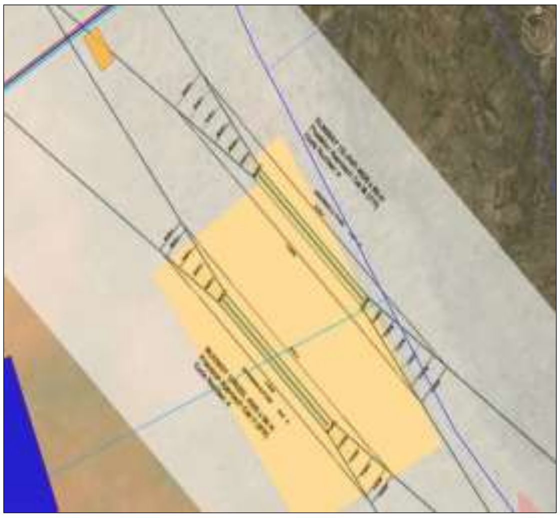

Fig. 7: *Runway Orientation 135/315, Second Runway Shifted to North and Keeping*

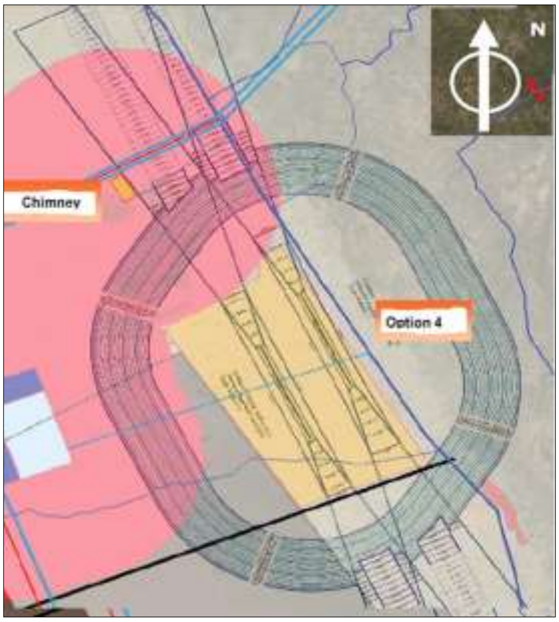

Fig. 8: *Runway Orientation 150/330, 3000 m Centerline Spacing.*

WIND COVERAGE ANALYSIS

Table 2 illustrates the wind coverage analysis for the metrological data obtained from Holy Karbala station. The analysis was based on both runway orientations and three different crosswind components. As shown in the table, the coverage difference between the two orientations is only 1.11% for aircraft with reference field length under 1,200 m (light general aviation piston or turboprop aircraft) when considering the wind data from Karbala station. This represents only 4 days of runway unavailability over a year for small aircraft for the 150/330 orientation compared to the 135/315 orientation. Figure 10 shows typical output of FAA software for 20 knots of cross wind component.

Table 2*: Wind Coverage Analysis –Data for Karbala Station.*

Crosswind component	Aero plane Reference Field Length	Wind Coverage Results – Runway Orientation 330/150	Wind Coverage Results – Runway Orientation 315/135	Difference
37 km/h (20kt)	1500 m or over	99,44%	99.51%	0.07%
24 km/h (13kt)	1200 m or up to but not including 1500 m	96.67%	97.27%	0.60%
19.5 km/h (10.5kt)	Under 1200 m	93.75%	94.86%	1.11%

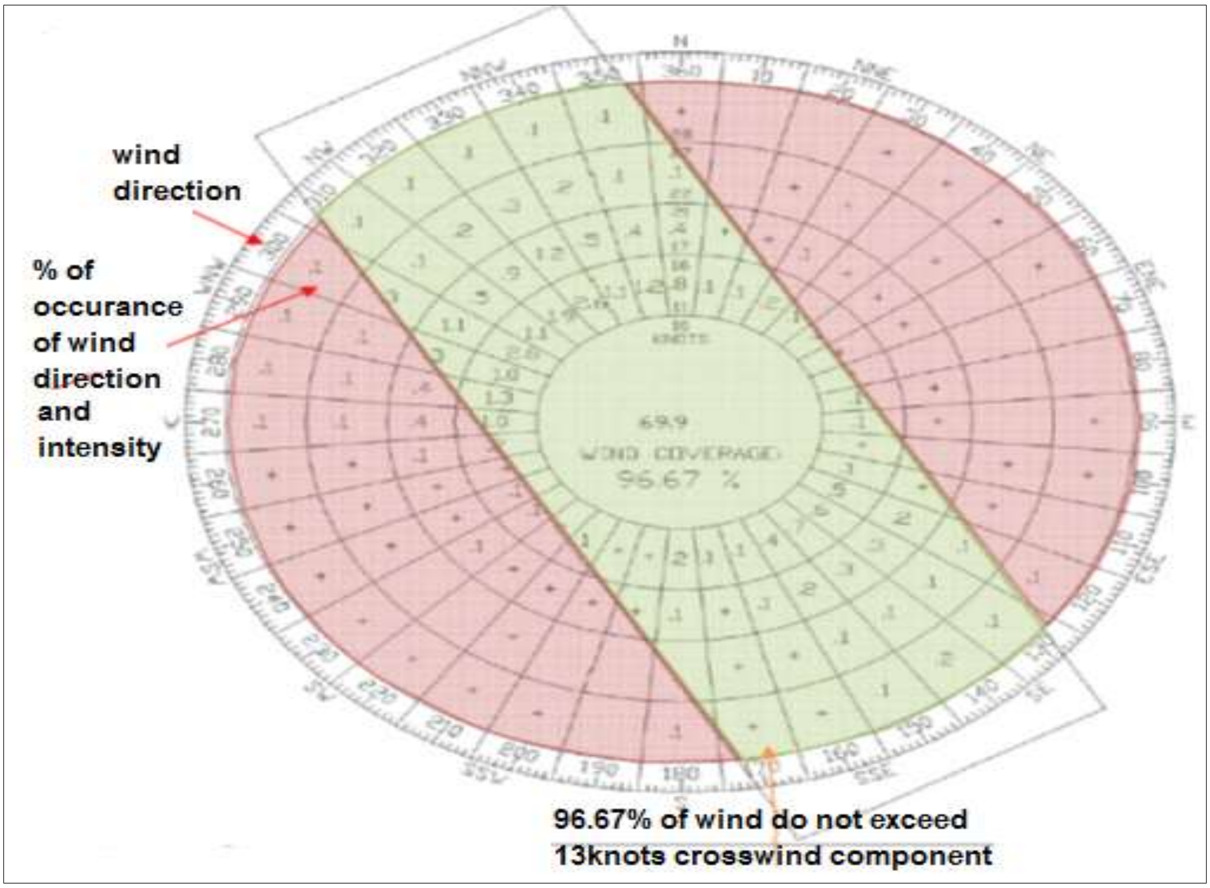

Fig. 9: Wind Rose Diagram for the 150/330 Orientation using FAA Software.

NUMBER OF RUNWAYS: 1 WIND OBSERVATIONS
STATION: KARBALA
RUNWAY ORIENTATION: 330.00 DEGREE
CROSSWIND COMPONENT: 20.00 KNOTS
TAILWIND COMPONENT: 10 KNOTS
WIND COVERAGE: 99.44 %

HOURLY OBSERVATIONS OF WIND SPEED (KNOTS)

DIRECTION	0-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41 OVER	TOTAL
1	0	73	33	10	4	0	0	0	0	120
2	1	122	87	27	6	4	0	1	0	248
3	0	133	87	32	13	3	3	0	0	271
4	1	47	41	14	3	0	1	0	0	107
5	0	85	44	11	1	1	1	0	0	143
6	0	135	54	9	3	0	2	1	0	204
7	0	52	33	9	0	0	0	0	0	94
8	1	103	46	18	1	0	0	0	0	169
9	0	193	60	21	5	0	2	0	1	282
10	0	43	18	6	0	2	1	0	0	70
11	0	114	58	19	1	2	0	0	0	194
12	0	229	154	104	32	14	8	2	1	544
13	0	134	121	107	52	22	17	6	1	460
TOTAL:	19	7365	5960	3592	1476	405	225	50	11	19103

F1-Help F2-Save F3-Retrieve/Clear F5-Files F8-Quit F9-HGL/PD1/DXF

Fig. 10: Typical Output of FAA Software for 20 Knots of Cross Wind Component.

CONCLUSIONS

Based on the analysis conducted, the following conclusions may be drawn:

1- In the site selection for a new airport, it is essential to conduct an intensive investigation on the existence of industrial properties nearby the site, which could restrict or interfere the development and operation of the airport, and its possible future expansion.

2- An intensive wind coverage study should be conducted using new metrological data based on more than one metrological station; the (climate-change) issue should be taken into consideration.

3- The impact of changing the runway orientation slightly on the wind coverage could be assessed by back calculation process as explained in this work.

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