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An Airport for Makkah

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ABSTRACT. The city of Holy Makkah is the third largest in the Kingdom of Saudi Arabia. It is the Islamic capital of the Muslim world and is visited annually by millions of worshippers from within and outside the Kingdom. However, it is not directly served by air transportation, Jeddah, which has a major international airport and is located 72 kms to the west of Makkah serves as its gateway.

This study addresses the merits of having an airport in Makkah. It explores some of the theoretical and practical aspects which deal with the rationale for such an airport. It also investigates several sites in Makkah and attempts to establish an interest in investing in an airport. This could be further developed in a feasibility study and consequently a master plan.

KEYWORDS: airport, sites, Makkah, transportation.

1. Introduction

1.1 *Background*

The Kingdom of Saudi Arabia has emphasized air transportation as one of the crucial sectors in its development. Over the last twenty years, the aviation activity in the Kingdom has witnessed rapidly accelerated development. Saudia, which is the only national air carrier, boasts a modern all jet fleet which stands at 137 aircraft almost half of which were acquired over the past three years. It includes Boeing 747's, Airbus A300-600, Boeing 777, MD-90, MD-90 and Boeing 737s [1]. The fleet serves 24 airports most of which are equipped with long runways, and modern facilities. These include four international

airports (Jeddah's King Abdul Aziz, Riyadh's King Khaled, Prince Mohamed Airport in Madinah, and King Fahad International Airport in Dammam). Table (1).

TABLE (1). Total passenger traffic at Saudi Arabia's domestic and international airports 1996 (000's).

NO.	AIRPORT	PASSENGER TRAFFIC	% OF TOTAL
1	ABHA	1,023.7	4.0173
2	ARAR	85.2	0.3343
3	BAHA	186.6	0.7323
4	BISHA	145.5	0.5710
5	DHAHRAN *	2,878.0	11.2941
6	AL - GASSIM	332.8	1.3060
7	GIZAN	497.8	1.9535
8	GURAYAT	70.7	0.2774
9	HAFR-AL-BATIN	0.2	0.0008
10	HAIL	283.3	1.1117
11	AHSA-HOFUF	30.6	0.1201
12	JEDDAH *	9,298.0	36.4879
13	AL- JOUF	131.5	0.5160
14	AL MADINAH	1,247.4	4.8951
15	NEJRAN	229.8	0.9018
16	AL-QAISUMAH	74.2	0.2912
17	RAFHA	33.5	0.1315
18	RIYADH *	7,845.0	30.7860
19	SHARAWRAH	54.0	0.2119
20	TABUK	457.6	1.7957
21	TAIF	325.7	1.2781
22	TURAIF	16.6	0.0651
23	WEDJH	25.7	0.1009
24	YANBU	209.0	0.8202
	TOTAL	25,482.4	100

Source: PCA (1997) [2]

One of the notable aspects of the airport distribution within the Kingdom's air transportation system is that Makkah, which is the third largest city in Saudi Arabia, does not enjoy direct air service. Figure 1 shows Makkah's position vis-a-vis the Kingdom's airports. Despite the fact that Makkah often becomes the Kingdom's largest city in terms of population during certain seasons of the year, it does not have an airport. King Abdul Aziz International Airport (KKIA) in Jeddah provides the air gateway to Makkah especially during Hajj (the 12th month in the Hijra calendar wherein the pilgrimage occurs). The link between

KKIA and Makkah is an eight-lane expressway which covers 72 kilometers between the two cities of Jeddah and Makkah. A less significant air link to Makkah is via Taif airport. This is approximately 88 kilometers away from Makkah but it is a rather difficult drive due to the terrain between Taif and Makkah. There is also another less mountainous, but longer (110 kms.) drive from Makkah to Taif Airport. Figure 2 illustrates the regional setting.

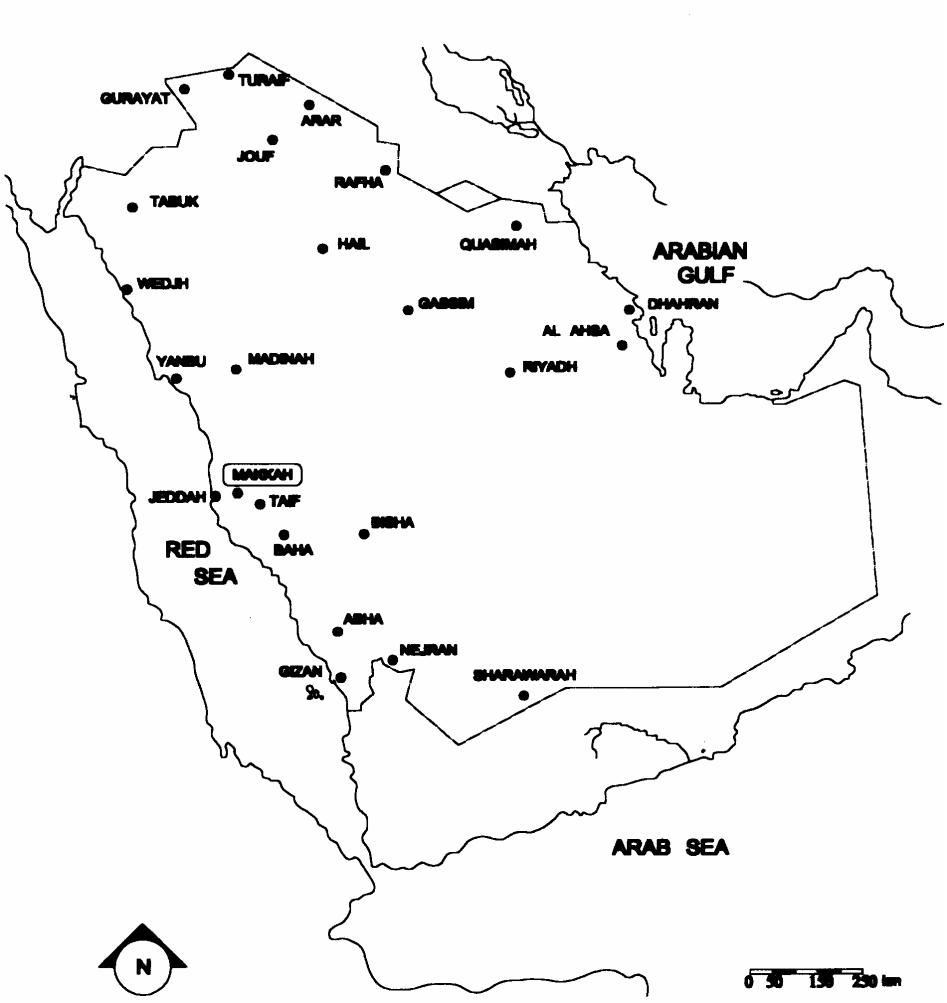

FIG. 1. Makkah in the national space, and the Kingdom airports.

1.2 *Objective and Overview*

The objective of this paper is to attempt to justify an airport for Makkah. There is an implicit judgment that direct air service to Makkah is beneficial.

This study aims to delineate the benefits of the airport and to illustrate that the airport can be realized. In attempting to achieve this aim, the study begins by reviewing the expected merits of an airport on the regional economy. The review will address both general theoretical aspects as well as practical aspects of siting the facility in Makkah. This will be followed by an overview of the natural environmental and economic conditions in the region. Some preliminary, yet fundamental components of the airport plan will also be presented. These components will be discussed within the context of demand and supply of air service and will include aspects such as siting, estimates of air travelers, mix of aircraft and institutional concerns. Finally, the main conclusions will be presented.

2. The Rationale for the Airport

2.1 *Theoretical Aspects*

Airports have varied impacts on different levels of the national economy. Several studies have outlined some of these impacts and their main findings are as follows [3, 4]:

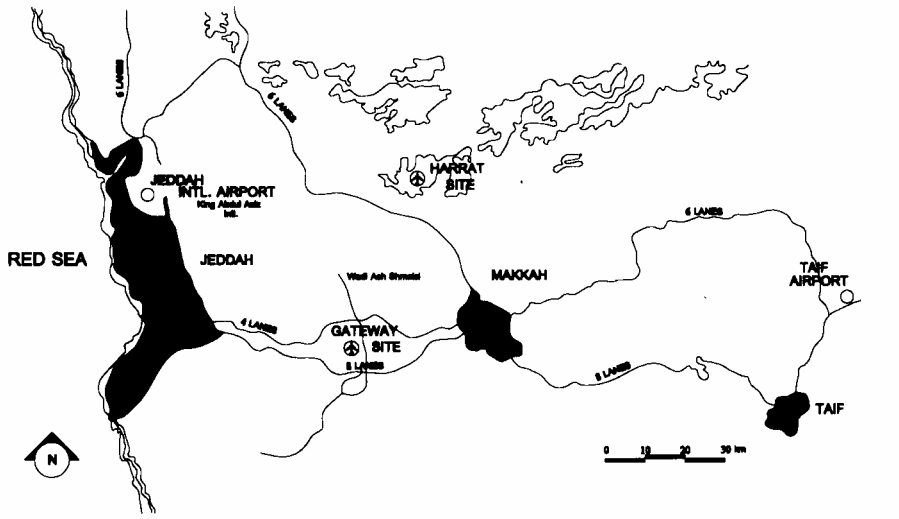

FIG. 2. Regional airport setting.

A. Airports allow for the provision of air access to the nation's airport system completing an intricate and time efficient transportation network.

B. Airports can act as catalysts for business activities and

industrial growth within a region. They can also act as an important factor in retaining existing businesses and industries.

C. Airports facilitate the expansion of the job market and income due to their own demand for support services and indirectly through their catalytic effects as mentioned above.

The above generally imply airport impacts which act favorably upon the community's economic structure. A more detailed description of impacts separates them into primary and induced impacts [5]:

A. Primary Impacts

Refer to effects of first round expenditures associated with airports and their operations. These could also be subdivided into direct impacts which accrue to a community from employment and payroll by the airport as well as purchases of goods and services by that airport. Indirect impacts, i.e. ones filled by the direct impacts such as: the increased accessibility, including increased value added and tourism due to the airport operation.

B. Induced Impacts

The economic impacts that result when direct impacts spread throughout the region are induced impacts, whereas primary impacts were due to first round expenditures. Induced ones are due to second, third, fourth, and subsequent rounds of spending which lead to secondary, tertiary, quaternary, and subsequent effects, i.e. they operate through the multiplier effect.

In summary, the total economic impact of airports may be viewed as being composed of the following:

TOTAL IMPACT = PRIMARY (Direct + Indirect Elements)
+ INDUCED (Multiplier Spending)

It is important to note that in evaluating the benefits of any airport, additional net value added becomes a crucial element. The additional contribution that the airport makes to a community in terms of income, jobs, and opportunities is of paramount significance. Value added represents local impacts that do not "leak out" of the community i.e. it is gross revenue less leakages - payments to factors of production outside the local economy (transfers, subsidies to non-residents, spending on non-locally manufactured goods and services, etc.)

In addition to the above, there are benefits to the region due to the construction and operation of an airport. Throughout history, cities have tended to grow at locations which provided considerable savings in transportation costs[6]. This has amplified their comparative or absolute advantage. Airports play a modern day counterpart to seaports in the past by enlarging market areas, strengthening exporting capabilities and increasing inter-regional trade between the region and its environs.

Some of the above aspects can be applied to Makkah and this will be discussed later in this paper.

2.2 *Practical Aspects*

There are aspects of airport development which are specific to the Holy city of Makkah. Firstly, the establishment of an air corridor between Makkah and Madinah will further strengthen the linkage between them as Islam's holiest cities. In addition to the obvious benefits of faster passenger and cargo movement, there is the tie-in demand of "Umrah/Visitation". Umrah represents a brief religious visit to the Holy city of Makkah where certain religious duties are performed without being specific to a certain time of the year. It is performed by millions of Moslems annually. Visitation of the Prophet Mohammed's mosque in Madinah is equally desirable and is often tied to Umrah. It is thus assumed here that visitors to Makkah who perform Umrah would greatly benefit from having direct air access to Madinah to perform visitation. This would be especially true for visitors whose destinations are far and whose time to perform these activities is short. As a case in point, visitors from the capital city of Riyadh who perform Umrah and visitation typically travel to Jeddah - which enjoys the greatest frequency of flights from and to Riyadh. These visitors would then seek surface transportation to Makkah via the eight-lane expressway linking Jeddah and Makkah. This, in itself, is quite efficient because private and public transportation moves freely and swiftly between the two cities covering the distance between the airport to central Makkah which is 95 kilometers away in a short time. However, the benefit of the proposed Makkah airport would be when these visitors head for Madinah. The available options would be to head back to King Abdul Aziz International Airport in Jeddah and catch a flight to Madinah (there are approximately 55 flights per week including at least eight wide body jet flights). The other option would be to use surface transportation to Madinah. There is a good six-lane expressway linking the two holy cities which are 447 kilometers apart. This is where aircraft -even propeller driven commuter type airplanes would be advantageous in covering this distance.

The second practical aspect of the proposed airport is related to the efficiency element of capacity utilization. In Makkah, the absorptive capacity of the city is planned and geared toward absorbing the huge numbers of pilgrims which occurs in the twelfth (pilgrimage) Hijra month for a period of less than one month. During the rest of the year, most of that capacity is underutilized with the exception of the Holy Month of Ramadan - particularly the last ten days - where millions travel to Makkah to perform Umrah. The seasonal pattern of traffic is shown in Figure 3. It is important to note that Ramadan (the ninth month) has the highest traffic count, but that Dhul Hijja (the twelfth month) actually has the highest number of visitors who are primarily pilgrims. Since movement to Makkah is restricted to large vehicles during that month, the traffic count by itself is misleading. Therefore, the second practical aspect of the airport is to increase the frequency of visits to Makkah outside of the ninth and twelfth months with the ultimate aim of providing access to the underutilized facilities during those off-peak times.

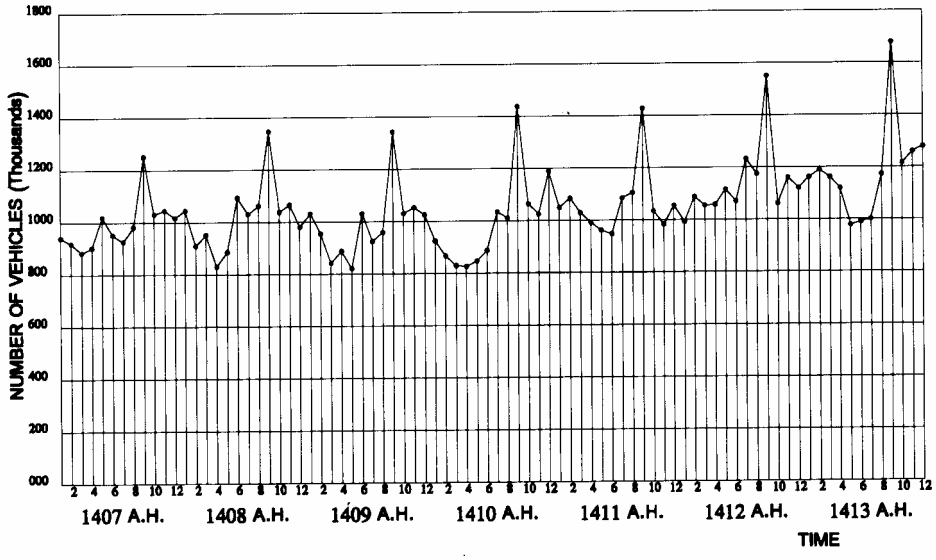

FIG. 3. Traffic count toward Makkah.

Source: (1KFHR 1415) [7]

The third practical aspect of the proposed airport is to relieve the expected congestion of the Jeddah-Makkah Expressway. According to the Regional Plan conducted as part of the Makkah Region Comprehensive Development Plans [8], an expected severe congestion of that expressway is likely to occur on or before 1425 A.H. (2015). The number of daily person trips in the Makkah / Jeddah corridor was expected to increase from approximately 38,000 in 1403 A.H. to almost 200,000 in 1425 A.H. The figures for the Makkah to Madinah

corridor were 1,700 in 1403 and expected to increase to 10,000 in 1425 [8]. That regional plan foresaw that the expected congestion could be relieved by the following measures:

(i) Building a new Expressway from the vicinity of King Abdul Aziz International Airport to Makkah-Madinah Expressway.
(ii) Construction of a new high speed rail link between Jeddah and Makkah
(iii) Upgrading the old Jeddah/Makkah road to expressway standard
(iv) Allowing the existing expressway further penetration to the city proper (the second ring road)

These measures need not be mutually exclusive to the proposed airport. The record indicates that airport projects are realized much more effectively than any rail projects on record in Saudi Arabia. The institutional set up for starting an airport is much more capable than for designing and constructing a high speed rail system. Furthermore, an airport would link Makkah directly with twenty three other domestic destinations and potentially numerous international destinations. Should the government decide to utilize other international airports besides Jeddah Airport for Hajj traffic as a first stop and then channel that traffic by air to Makkah, then that option would also be available. This represents a rather remote, albeit an important aspect to be considered in justifying the airport.

3. The Setting

This section aims at exploring elements which are relevant to the siting and operation of an airport in Makkah.

3.1 *Geographic and Climatic Elements*

The region's terrain starts out flat at the Red Sea with the flat coastal plain of Tihama and Hijaz range and gradually rises eastward towards the Sarawat Mountain range and the Red Sea Escarpment east of Makkah [9]. The areas surrounding Makkah have several wadis in all directions as well as the Harrat Mountains to the north of the city. The wadis are primarily braided channels which are filled with sand and gravel. Some of this sand occurs as low dunes and thin mobile sheets. Since the dunes are generally less than 2 meters high, the wadis tend to be very flat. The Harrat mountains are flat top basalt ranges with the two major formations being Harrat Rahat which runs from just north of Makkah to just south of Madinah for about 300 kilometers. Also significant is Harrat Al Nahimiyah which is also a basalt flat top range north of Makkah with an area of approximately 62 square kilometers.

The Holy city of Makkah itself is located between latitudes 20 degrees and 22 minutes North and between longitudes 39 degrees 20 minutes and 40 degrees 30 minutes East. It is 277 meters above sea level and within the city proper, which covers an area of 5900 hectares. There are substantial differences in elevations formed by wadis and mountains (Ministry of Municipal and Rural Affairs, 1988).

Makkah's difficult topography is coupled to an equally difficult climate. It has little rainfall (less than 150 mm per year). The prevailing wind appears to be from the southwest about 50% of the time and from the northeast and northwest. In summer, the Samoom - a hot and dry wind blows from the southeast. (Al Angari, 1977). The weather is generally clear with a maximum cloud cover of 3 octas and an annual average of 2 octas. Surface winds have a mean speed of 4 knots from the north, but gusts of up to 36 knots have been reported from the southeast. Average maximum temperatures are about 38.5 degrees Centigrade and average minimums are approximately 24.5 degrees Centigrade. (Meteorological and Environmental Protection Agency, 1988). The implications of this information will be addressed later.

3.2 *Makkah's Economy*

There are three principal activities that provide the economic base of Makkah which are: Hajj, Umrah, and transfers from the central government for capital and current expenditures. Hajj is a seasonal activity which occurs in a period of a few days, but its logistical aspects cover a much wider time span which typically lasts for approximately a month or more. During that period, millions of Moslems perform Hajj and consequently, billions of riyals are injected into the local economy for purchases of goods and services. In 1983, an estimate was put at approximately six billion riyals injected into the local economy by approximately 2.5 million Moslems who performed Hajj. The number of Moslems performing Hajj is expected to increase over time if capacity is available. However, the government of Saudi Arabia has imposed quotas to regulate the number of Hajjis and insure proper service provision. Subsequently, the number of Hajjis has declined over time as shown in Table 2.

The second activity that provides the economic base is income from Umrah, a religious visit which, unlike Hajj, is not tied to a certain time period and is accomplished in a few hours whereupon the majority of visitors would leave the city, especially those who are visiting from within the Kingdom. According to the regional plan, the number of visitors who perform Umrah can exceed the total permanent population of the city especially during the month of Ramadan.(Ministry of Municipal and Rural Affairs, 1985).

TABLE (2). Number of people performing haj over the period 1400 – 1415

YEAR	NUMBER
1400	1,949,634
1401	1,943180
1402	2,011,555
1403	2,501,706
1404	1,664,478
1405	1,589,706
1406	1,600,475
1407	1,619,324
1408	1,379,556
1409	1,466,995
1410	1,483,294
1411	1,628,189
1412	1,011,437
1413	992,813
1414	995,611
1415	1,041,203

The third principal activity is government transfers from miscellaneous projects dealing with Hajj, urban development, and other activities. There are continuous efforts by the government to provide more and better Hajj facilities and services and consequently, there are tremendous capital and current outlays for these projects. As a case in point, the expansion of the Holy Mosque, has cost several billion riyals in order to provide a better service for more moslems. Projects in the Holy environs (Mina and Arafat) also require great expenditures. There is a multi-billion riyal allocation for the new campus for Umm Al Qura University in Makkah. There are also several urban development and transportation programs which also require capital and recurring annual outlays for maintenance.

An additional substantial injection into Makkah's economy is the relatively recent urban renewal efforts by the private sector. The attempts to upgrade the built environment of the central area of the city have involved large outlays for land purchases and/or construction projects [13]. These activities have also involved land speculation and general increase in land values in the central area.

The above activities imply a two-fold effect on the economy. First, there is the direct first round riyal spending effect. Next, the income and consequent

spending of those first round riyals within the region generate a multiplier process that generates and supports income and employment in other sectors of the economy. The multiplier for Makkah has been estimated in the Regional Plan to be 1.36 i.e. every riyal spent would yield an additional 1.36 riyals to the local economy. The effect is felt by the whole economic structure of Makkah. The elements of Makkah's economic structure and their percentage composition are shown below [8].

Employment Composition in Makkah's Economic Structure

	Sector	**Percentage**
A)	**Production**	
	Agriculture	1.8
	Mining/Manufacturing	9.1
	Utilities	2.3
	Construction	9.0
	Total	22.2
B)	**Services**	
	Trade	16.1
	Transport	9.0
	Finance	2.6
	Other Services (includes government)	50.1
	Total	77.8

The economy is thus geared toward service provision more so than the Jeddah economy and the overall national average for Saudi Arabia. Institutions in the private sector tend to be small with 64% of the total 7293 establishments employing less than 50 people [8].

In the context of the theoretical framework discussed earlier, the primary impact would be the local employment at the airport and the much larger indirect primary impact due to the increased volume of business by the much larger number of visitors. Unfortunately, neither of these impacts could be quantitatively estimated since the size of the facility and the additional number of visitors is not known. Estimates for the direct component of the primary impact of the airports at Jeddah and Riyadh have been estimated to be 912,500,000 Riyals per annum [14].

Obviously, the Makkah facility would be much smaller than this figure but it would be expected to generate hundreds of millions of riyals into the regional economy especially once the induced impacts become effective.

In summary, Makkah is dependent to a great degree on an economic base which is seasonal and is compressed into a short time span (Hajj, during the twelfth month). Umrah related activities tend to occur more frequently during Ramadan (the ninth month), but also occur throughout the year. Government transfers for projects are substantial, but it would be incorrect to assume that these are a source of income because they are not meant to be a permanent long term flow of income to Makkah's economy.

Hajj receives a great deal of attention from a plethora of powerful government agencies. It is a planned activity whose dynamics are catered for. Umrah, however, does not have institutional support despite its role and potential for Makkah's economy. Additionally, Makkah can and should house major international Islamic organizations which is not the case as yet [8]. Based on these views, any facility which would ease the friction of distance and increase Makkah's accessibility would also be beneficial to its economic base and to its overall development. Better access to Makkah could realize the objective of increasing off-peak visits, and reduce the effect of sharp seasonal peaks which are inefficient from a resource utilization viewpoint.

4. Airport Supply and Demand Elements

To start an airport in Makkah, a wide array of factors has to be studied to guide facility, environmental, financial, and economic planning. These factors could and should be quantified. Such factors as demand, supply, traffic, and air space elements would probably require a study each in itself and be considered at the Master Plan level. The aim here is to provide rough estimates of supply and demand factors, sufficient to justify the existence of the airport, but not to specify the exact facility requirements which are beyond the scope of this study.

4.1 *Demand Assessment*

The method by which demand will be assessed here is judgmental. It rests on the historically derived local saying that Jeddah is the "dehliz" for Makkah i.e. it is that part of a traditional house which represents the entrance and through which passage is necessary to get inside the house. This was based on Jeddah's historical role as a seaport through which access to Makkah was provided. Today, Jeddah remains the gateway through its airport as well as seaport terminals. The key in assessing the demand for Makkah's airport under this method is by looking at the demand - present and forecast - for Jeddah's passenger traffic figures.

TABLE (3A). Passenger projection (1996-2000) for Jeddah lines [13].

Line (Round Trip)	1996 Actual	1996 Change 1995 - 96	1997 Estimated	1997 Change 1996 - 97
ABT(Baha)	64,144	9.5 %	62,861	-2.0 %
AHB(Abha)	383,193	-0.1	385,109	0.5
AJF(Jouf)	21,558	8.7	23,175	7.5
BHH(Bisha)	51,773	3.8	53,378	3.1
DHA(Dhahran)	501,489	1.9	506,504	1.0
EAM(Najran)	74,578	9.2	76,815	3.0
EJH(Wajh)	13,043	3.3	13,460	3.2
ELQ(Gassim)	114,042	0.5	118,604	4.0
GIZ(Gizan)	226,517	1.1	229,915	1.5
HAS(Hail)	42,990	3.9	42,560	-1.0
HOF(Hofuf)	6,722	3.8	7,394	10.0
MED(Medina)	589,033	-3.9	589,033	0.0
RAE(Arar)	11,654	-1.1	11,887	2.0
RAH(Rafha)	657	14.7	657	0.0
RUH(Riyadh)	1,582,563	-0.3	1,582,563	0.0
SHW(Sharoorah)	12,342	-7.3	11,293	-8.5
TIF(Taif)	8,679	32.6	10,241	18.0
TUI(Turaif)	1,673	-0.7	1,506	-10.0
TUU(Tabuk)	202,505	3.0	206,555	2.0
URY(Gurayat)	13,150	19.5	13,729	4.4
WAE(Wadi Al Duwaiser)	15,498	2.3	16,087	3.8
YNB(Yanbu)	180,345	5.1	187,559	4.0
Total	4,118,148	0.5	4,150,558	0.8

Source: Corporate Planning Department, Saudi Arabian Airlines (SAUDIA), 1417.

Three levels of demand representing a low, medium, and high estimate were foreseen which were basically 15%, 25%, and 35% respectively of the existing passenger air traffic to Jeddah (Table 4). Of all passengers flying to Jeddah, these proportions represent the share of passengers wishing to travel to Makkah. This was done for all stations except for Madinah where the level of demand as a proportion of Madinah-Jeddah traffic was estimated at 20%, 30%, and 50% for low, medium, and high figures. This is justified by the assumption that the attraction between Madinah and Makkah is much stronger than for other cities

due to their religious attraction. Additionally, passenger traffic between Jeddah and Taif was assumed to be non-existent due to their proximity to Makkah (Figure 2). Other cities with very thin lines were not considered since it was not considered reasonable that Saudia would lose revenue on those lines. Another important element here is that all stations shown are domestic airports. If the airport for Makkah should become an international one, more air passenger traffic would be accommodated. This assumption is based on the fact that hundreds of thousands of visitors arrive from overseas destinations to Jeddah and then travel by road to Makkah to perform Umrah. Table (3) (A and B) represents the national airline's estimate of future growth on domestic lines from Jeddah up to the year 1995.

TABLE (3B). Passenger projection (1996-2000) for Jeddah lines.

(Round Trip)		1997 - 98		1998 - 99		1999 - 00
ABT(Baha)	64,118	2.0 %	65,401	2.0 %	66,709	2.0 %
AHB(Abha)	392,811	2.0	397,525	1.2	402,295	1.2
AJF(Jouf)	23,754	2.5	24,348	2.5	24,957	2.5
BHH(Bisha)	54,446	2.0	55,807	2.5	57,202	2.5
DHA(Dhahran)	511,569	1.0	524,358	2.5	540,089	3.0
EAM(Najran)	77,968	1.5	79,597	2.1	81,259	2.1
EJH(Wajh)	13,798	2.5	14,141	2.5	14,495	2.5
ELQ(Gassim)	120,248	1.4	121,915	1.4	123,604	1.4
GIZ(Gizan)	234,513	2.0	237,291	1.2	240,101	1.2
HAS(Hail)	43,411	2.0	44,279	2.0	45,165	2.0
HOF(Hofuf)	7,320	-1.0	7,452	1.8	7,586	1.8
MED(Medina)	597,868	1.5	606,837	1.5	615,939	1.5
RAE(Arar)	12,085	1.7	12,286	1.7	12,490	1.7
RAH(Rafha)	667	1.5	680	1.9	694	2.1
RUH(Riyadh)	1,614,214	2.0	1,654,570	2.5	1,704,207	3.0
SHW(Sharoorah)	11,406	1.0	11,735	2.9	12,074	2.9
TIF(Taif)	10,579	3.3	10,843	2.5	11,115	2.5
TUI(Turaif)	1,536	2.0	1,567	2.0	1,606	2.5
TUU(Tabuk)	211,719	2.5	217,012	2.5	222,437	2.5
URY(Gurayat)	14,004	2.0	14,214	1.5	14,427	1.5
WAE(Wadi Al Duwaiser)	16,328	1.5	17,145	5.0	18,002	5.0
YNB(Yanbu)	189,949	1.3	192,369	1.3	194,820	1.3
Total	4,224,311	1.8	4,311,370	2.1	4,411,273	2.3

Source: Corporate Planning Department, Saudi Arabian Airlines (SAUDIA). 1417.

TABLE (4). Expected passenger traffic of Makkah airport in 2000

Line (Round Trip)	Jeddah 1996 Actual	Jeddah 2000 Projected	Expected Growth 1996 - 2000	Makkah 1996			Makkah 2000		
				Low	Middle	High	Low	Middle	High
ABT(Baha)	64,144	66,709	4.00 %	9,622	16,036	22,450	10,006	16,677	23,348
AHB(Abha)	383,193	402,295	4.98	57,479	95,798	134,118	60,344	100,574	140,803
AJF(Jouf)	21,558	24,957	15.77	3,234	5,390	7,545	3,744	6,239	8,735
BHH(Bisha)	51,773	57,202	10.49	7,766	12,943	18,121	8,580	14,301	20,021
DHA(Dhahran)	501,489	540,089	7.70	75,223	125,372	175,521	81,013	135,022	189,031
EAM(Najran)	74,578	81,259	8.96	11,187	18,645	26,102	12,189	20,315	28,441
ELQ(Gassim)	114,042	123,604	8.38	17,106	28,511	39,915	18,541	30,901	43,261
GIZ(Gizan)	226,517	240,101	6.00	33,978	56,629	79,281	36,015	60,025	84,035
HAS(Hail)	42,990	45,165	5.06	6,449	10,748	15,047	6,775	11,291	15,808
MED(Medina)	589,033	615,939	4.57	117,807	176,710	294,517	123,188	184,782	307,970
RUH(Riyadh)	1,582,563	1,704,207	7.69	237,384	395,641	553,897	255,631	426,052	596,472
TUU(Tabuk)	202,505	222,437	9.84	30,376	50,626	70,877	33,366	55,609	77,853
YNB(Yanbu)	180,345	194,820	8.03	27,052	45,086	63,121	29,223	48,705	68,187
Total	4,034,730	4,318,784	7.04	634,661	1,038,134	1,500,510	678,615	1,110,493	1,603,965

Sources: Corporate Planning Department, Saudi Arabian Airlines (SAUDIA), and authors' calculations

Notes:

1. Low, Middle, and High projections are based on 15%, 25%, and 35% of Jeddah market share respectively except Madinah where 20%, 30%, and 50% of the market share were assumed.
2. Very thin lines whose passenger traffic in 1996 was under 20,000 per year were not included. These include Wajh, Hofuf, Arar,Rafha, Sharoorah, Taif, Turaif, Gurayat, and Wadi Al-Dawaser.

It can be seen from the figures - even by considering the low estimates of passenger traffic, that Makkah can serve up to 678000 domestic passengers by the year 2000 using very conservative market share estimates.. This would definitely justify the existence of sufficient demand without even considering international travel. Furthermore, the fact that Say's law as applied in transportation might also operate to boost demand i.e. that supply creates its own demand, would also create additional demand for the service if it becomes available.

4.2 Supply Aspects

(i) *Siting*

One of the traditional reasons which was used in justifying not having an airport in Makkah was its topography. Unlike Jeddah which has plenty of flat terrain, Makkah's physiography is quite challenging. There are, as mentioned earlier, several mountains and considerable changes in elevation within the city proper as well as its environs. Upon close investigation of different sites, it was found that three sites could accommodate an airport for Makkah. These sites were visited by the authors. One of them actually has a restricted use airport for military purposes only and is thus excluded from the analysis. The two other sites are the Harrat Site which is located 38.5 kilometers north of central Makkah. It is 6 kilometers from the Makkah-Madinah Expressway north of the small village of Al Jumum. It lies on top of the Harrat mountain chain and enjoys a flat terrain unrestricted by natural or urban factors. (Figure 2).

The other site is the Gateway site which is located along the major Ashumaisi wadi which runs in the north-south direction west of Makkah. It is 19 kilometers from the central city and is shown in Figure 2.

A preliminary site analysis was conducted by utilizing criteria set by the Federal Aviation Administration [15]. These are shown in Table (5) and they indicate that both sites are acceptable for an airport with the site atop Harrat Mountain being more advantageous especially if a larger facility was more appropriate.

One of the fundamental supply aspects is the type and size of facility desired i.e. should Makkah's airport be a Stolport? International Airport? Multi runway large airport? Stolports are Short Take Off and Landing facilities designed for STOL aircraft. These facilities require a shorter runway as well as a steeper glideslope (7.5 degrees versus 2.5 degrees for conventional approaches), which would also imply that the whole facility would be sited in a much more confined space. e.g. the approach-departure surface slope is usually

set at 15:1 and its length is 10,000 feet [16]. The runway length itself will vary according to elevation, temperature, and types of aircraft. Lengths of 2000 - 3000 feet are not uncommon for STOL Ports.

The question of planning for excess capacity for the airport in Makkah is not a difficult one to answer. The excess capacity that a large airport would provide would be very advantageous insurance since it would imply that if the demand estimate discussed earlier in this paper should prove to be too conservative, an additional absorptive capacity for passengers and cargo would satisfy the demand and/or the growth in that demand. Therefore, an airport capable of handling approximately one million passengers per year would be a good starting point with the provision for increasing the capacity requirements if the need arises. This figure is based upon the expected passenger traffic for Makkah in 2000. An international airport is not viewed as being needed based on Jeddah's airport capability in handling international flights. If and when Jeddah's airport requires relief in its operations, Makkah's airport could then be expanded to meet the additional international flights. The areas of the sites are approximately 62 square kilometers for the Harrat and 61 square kilometers for the Gateway site. Both are suitable for such an airport but the Harrat site has the advantage of accommodating future expansion, if necessary, in addition to the other attributes over the Gateway site mentioned earlier.

One of the important siting issues is the type, length, and number of required runways. These issues were tackled by reviewing meteorological data related to wind direction and speed as well as temperature and cloud cover data. Cloud cover is not a serious concern for Makkah's airport since the data shows an octa cover of 2 as an annual average [12]. The implication of this is that good visibility conditions would prevail and therefore either a visual, or at best, a non-precision approach runway i.e. one providing horizontal runway centerline guidance to landing aircraft would be required.

Runways should be parallel to the direction of the prevailing surface winds as much as possible. The available data indicates that the mean winds are northerly and calm - less than 5 knots per hour. However, maximum wind data shows gusts reaching 36 knots per hour and varying from north to south to north westerly. This data implies that the main runway should be a north-south runway. This needs to be examined in light of more geographically precise climatic data from the chosen site prior to the design stage since the existing MEPA station provided the above data was not located at either of the proposed site.

TABLE (5). Site comparison.

CRITERIA	SITE RATING		COMMENTS
	GATEWAY	HARRAT	
1. Operational capability	Good	Excellent	Gateway site might involve nnise abatement due to its proximity to the city. Both sites should allow for 2 degrees glideslope appproaches. Gateway site is likely to be subject to more pronounced micro climate due to surrounding mountains.
2. Capacity potential	Limited	Excellent	Gateway site is rather limited to north-south expansion and may be cons-trained by conurbation between Jeddah and Makkah.
3. Ground access	Very good	Very good	Gateway site is 19.5 kms from the city center linked by 8-lane expressway. Long run congestion foreseen. Harrat site is 39 kms. from the city center linked by 6-lane expressway.
4. Development costs	High	Moderate	Gateway site is expected to suffer from very high land aquisition costs due to its proximity and the desirability of that land and its being not part of public domain.
5. Environmental consequences			
(A)Noise	Moderate	Excellent	Gateway is close to the city.
(B) Impact on flora and fauna	Expected to be small	Expected to be small	Both lines have negligible effect on flora and fauna. Requires research, but is expected to be very small on field observations.
(C) Air and water quality	Small effect	Small effect	
(D) Land use changes	Moderate effect	Minimal effect	Land use would affect the supply of habitable land around the city for the gateway site.
(E) Effect on historic, archaelogical, cultural, or architectural resources.	High	High	Both sites can provide open spaces in the contiguous airport area for recreation.
6. Soci-economic factors	High	Very high	Harrat site will revive the village of Al Jumum which is close by, in addition to its macroeconomic effects.

The distances from both the Harrat and the Gateway sites to domestic major destinations are shown in Figures 4 and 5. These distances were measured from Jepessen High Altitude En-route Charts [17]. They do not represent the shortest distance between a proposed site and its destination since they follow specific air routes which may involve "dog leg" paths due to navigational facilities requirements. Expected block times to several larger destinations are shown below. They have been estimated based on current block speeds from Jeddah for Saudia's jet fleet.

Two additional issues related to the sites are their location vis-a-viz the Harram boundary beyond which only Moslems are allowed. Even though both are outside the boundary, which is advantageous for hiring and operational flexibility in terms of having non-Moslem workers, the Gateway site is right at the periphery of the Harram and is thus weakened by this point.

The second issue is related to obstruction clearance requirements. The criteria specified in FAR Part 77 define imaginary surfaces in relation to the airport in general and to the runway(s) in particular.

TABLE (6). Estimated block times.

Destination	From Harrat Site	From Gateway Site
Albaha	0:33	0:35
Abha	0:55	1:00
Bisha	0:48	0:50
Dhahran	1 :55	2:00
Nejran	1 :10	1:15
Al Gassim	1 :10	1:15
Gizan	1 : 10	1:05
Hail	1 :20	1 :25
Madinah	0:50	0:50
Riyadh	1 :15	1 :20
Tabuk	1 : 10	1 : 15
Yanbu	1 :00	1:15

Source: Authors' estimates

TABLE (7). Imaginary surface dimensions – FAR Part 77 (feet) [16].

NO.	ITEM	NON-PRECISION	PRECISION
1	WIDTH OF PRIMARY SURFACE AND APPROACH SURFACE AT INNER END	1,000	1,000
2	RADIUS OF HORIZONTAL SURFACE	10,000	10,000
3	APPROACH SURFACE WIDTH AT OUTER END	4,000	16,000
4	APPROACH SURFACE LENGTH	10,000	50,000
5	APPROACH SLOPE	34 : 1	50 : 1

Source: Horonjeff 1986[18]

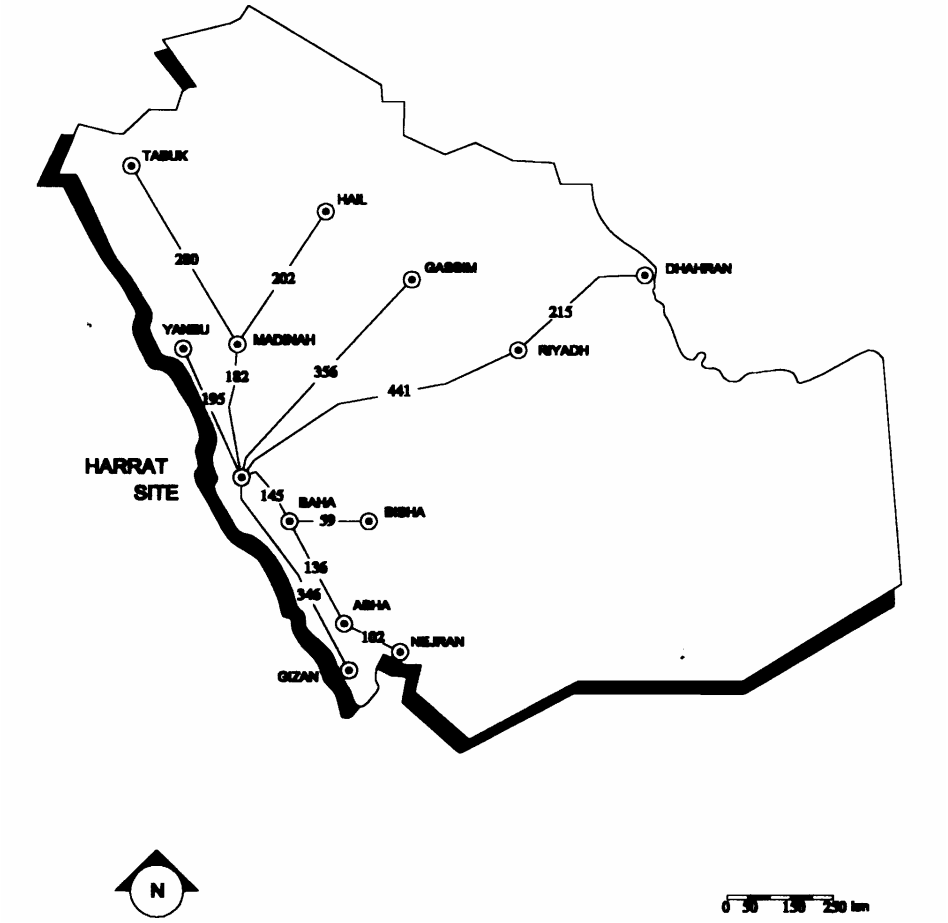

FIG. 4. Air distances from Harrat site – nautical miles.

TABLE (8). Sample commuter type short field aircraft [20 – 22].

AIRCRAFT	TYPE	PAYLOAD	SEATS	REQUIRED FIELD LENGTH	CRUISE SPEED (KNOTS)
BOEING DE HAVILLAND DASH 8	TWIN TURBOPROP	5216 KGS	50	3,430	286
BRITISH AERO SPACE 146-100	4 ENGINE TURBOFAN	8000 KGS	82	4,300	305
AEROSPATIALE ATR 42	TWIN TURBOPROP	4915 KGS	50	3,410	268
FOKKER 50	TWIN TURBOPROP	5856 KGS	50	3,480	287

Sources: Flight International (1987)[20], Boeing Canada (1988)[21], British Aerospace (1982)[22].

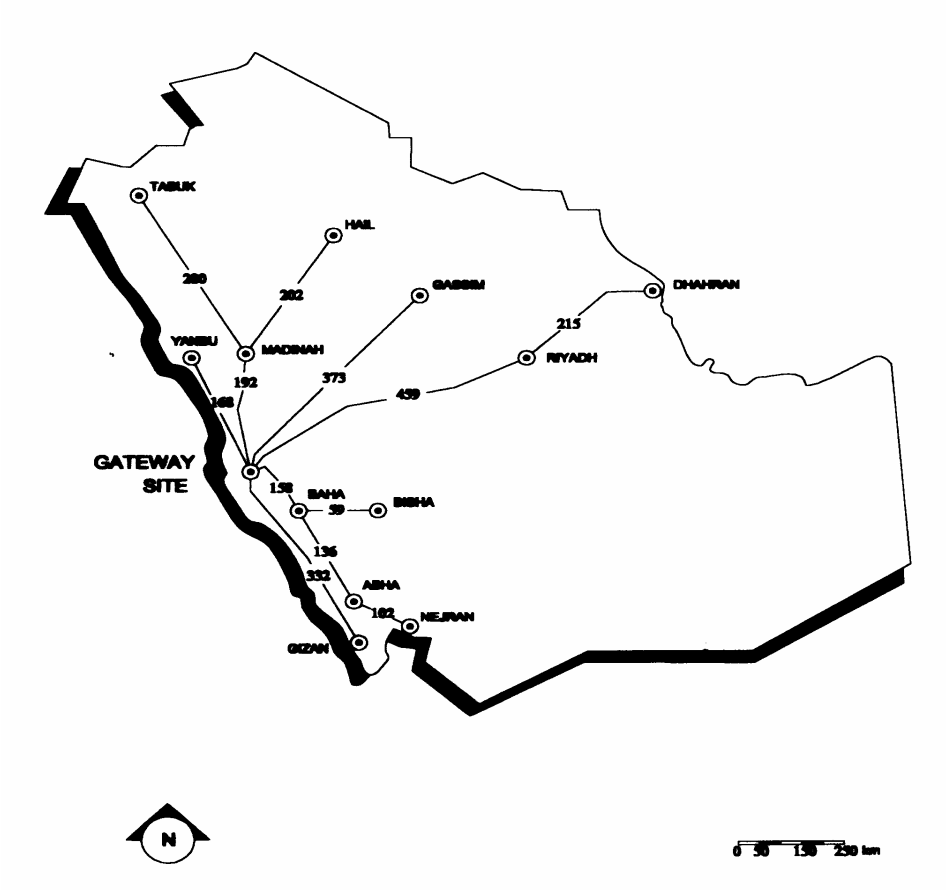

FIG. 5. Air distances from Gateway site – nautical miles.

Based on preliminary field estimates, both sites can satisfy FAR 77 requirements which are shown below for precision and non-precision runways. As stated earlier, only the former will be required based on existing meteorological data.

The above is a preliminary estimate and it assumes a north-south orientation for the runway. If another orientation becomes dictated due to wind direction, the Gateway site might face some problems due to its proximity to the city and due to the presence of mountainous terrain in some of the surrounding areas. The space requirement of the proposed airport is intimately related to its runway needs. This is, in turn, closely related to the type of aircraft to be used which will be discussed below.

(ii) ***Aircraft Types***

Even though it was tempting to use the national airline's existing fleet for runway space planning, there is always a likelihood that the future fleet mix might involve commuter type turboprop aircraft whose runway needs would be considerably less than the current needs for an all-jet fleet. There is also the temptation to opt for the maximum runway length possible, 10,000 to 12,000 feet, to accommodate wide body jets on international routes since that represents an insurance against unforeseen growth or demand underestimation. The standards used for runway length were the requirements for the Boeing 737-200 which is the workhorse of the domestic routes in Saudia. These aircraft requirements vary by operational takeoff weight, runway elevation, climatic conditions, and flap positions on takeoff [19]. Based on Saudia's requirements, a 6,500 feet runway would be the minimum desirable despite the fact that the operator's runway length requirements could be less than that. At that runway length, a very broad range of aircraft could be accommodated. Some of the more prominent ones - which would be candidates for future air fleet considerations are: ATR 42, ATR 72, and Boeing De Havilland Dash 8. (Table 8).

The above data for field length reflect standard conditions. Actual needs for Makkah's hot and high conditions were unavailable. The actual field lengths would thus have to be increased. The rationale behind including relatively slow aircraft here is that they would be economical to acquire and operate without much sacrifice in their block speeds versus existing jet aircraft.

5. Conclusions and Recommendations

(1) There are several benefits expected from siting a new airport in Makkah. These includes establishing an air corridor between the two holy cities

of Makkah and Madinah, increasing the capacity utilization of facilities in Makkah which are seasonably used, relieving future congestion in the Jeddah-Makkah expressway, and providing insurance for additional Hajj traffic if that need should arise and gateways other than Jeddah become candidates for Hajj air terminals.

(2) There are also benefits due to the airport in terms of primary as well as induced impacts of having the facility in Makkah. Makkah's economy is service oriented and is geared toward catering for Hajj and Umrah. Hajj itself is fixed in time and is thus limited due to the logistics and safety requirements whereas the potential for Umrah is very great. To the extent that it can be increased throughout the year, Makkah's economy will benefit and all the visitors performing Umrah will also benefit. It should be noted that there are also benefits to the Kingdom as a whole due to the better link between the two holy cities and the overall national space.

(3) There is sufficient demand for a facility in Makkah based on the assumption that a proportion of Jeddah's traffic intends to head for Makkah. The Hajj traffic to Makkah was not even considered as part of the analysis and neither was the additional demand which would result due to the availability of the service (i.e. demand induced by the supply). The estimated figure of approximately one half million passengers per year is likely to underestimate true demand.

(4) Two sites were found to be suitable for siting an airport for Makkah. The site atop the Harrat Mountains to the north of Makkah was found to be far superior in terms of its development potential, its expected development costs, and operational capability. It was close enough to Makkah to be convenient and yet it was far enough so as not to compete with other land uses or to create an incompatible use. The site located at the Shumaisi wadi was not unacceptable from a physical viewpoint, but its development costs especially land acquisition costs would probably be extremely high.

(5) There exists a caveat regarding costs. The Presidency of Civil Aviaition already faces challenges in the economics of operating the existing airports. However, there are opportunities in high traffic airports which are currently underutilized. User fees promise to provide an economically viable instrument which is not burdensome on users.

(6) There appeared to be a concern for minimal spacing between the airports. Such distance was set at forty kilometers. This does not weaken the results of the preliminary siting choice because both sites are beyond that distance from King Abdul Aziz International Airport.

The above conclusions could be viewed as being "necessary but not sufficient conditions" for investing in an airport for direct air service to Makkah. There is a great need for considering the array of costs of that service including economic, social, and environmental costs. These costs could then be analyzed and compared to the expected benefits in a benefit cost analysis or at least in a cost effectiveness analysis. The cost component of the airport has not been considered yet due to the fact that this study attempted to illicit the interest in justifying the airport rather than provide an exhaustive feasibility study.

Finally, it is important to shed some light on the issue of institutional readiness and capability. The Kingdom's air transportation system is managed and operated by a group of institutions headed by the Ministry of Defense and Aviation which supervises the Presidency of Civil Aviation (PCA), the International Airports Projects (IAP), and Saudia, the national carrier. These organizations have the capability to investigate further the feasibility of the proposal for Makkah's airport.

Authors Note:
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References

[1] **www.saudiairlines.com 2002.**
[2] Presidency of Civil Aviation (PCA), Ministry of Defence and Aviation, PCA Statistical Yearbook, Jeddah,1997
[3] **Fadaak, T**., *A Guideline for Evaluating the Economic Impacts of General Aviation Airports*, Unpublished Paper, Portland State University, (1982).
[4] *The Airport and its Influence on the Community*, Federal Aviation Administration, Washington, D.C., (1967).
[5] *Community Impact of the Port of Portland Aviation Facilities*, Economic Research Associates (ERA), The Port of Portland, Oregon, (1979).
[6] **Renaud, B**., *National Urbanization Policy in Developing Countries*, Oxford University Press, London, (1979).
[7] Institute of The Custodian of the Two Holy Mosques for Haj Research. (IKFHR) Makkah Traffic Count, 1414. Makkah, 1415.
[8] *Makkah Region Comprehensive Development Plans: The Regional Plan*, Ministry of Municipal and Rural Affairs. Report Number 3, Project 208, (1985).
[9] **Al-Suhaili, M**. and **Moore, T.,** *Explanatory Notes to the Geologic Map of the Makkah Quandrangle. Sheet 21D. Kingdom of Saudi Arabia*, Directorate General of Mineral Resources, Jeddah, Saudi Arabia, (1989).
[10] *Atlas of Saudi Cities*, Ministry of Municipal and Rural Affairs, Riyadh, (1988).
[11] **Al-Angari, K.M**., Geographical Evolution of the Urban Structure of Mecca, Saudi Arabia, Master Thesis, University of Oregon, (1977).
[12] "Data from Makkah Station (21 Degree 29 Minutes N and 39 Degrees 50 Minutes E)", Meteorological and Environmental Protection Agency (MEPA), (1989).

[13] **Fadaak, T**. and **Farahat, A**., *The Challenges of the Haram District Urban Renewal Project,* Unpublished Final Report of Research Sponsored by College of Engineering, King Abdul Aziz University, (1988).
[14] **Amin, S.Y**., The Relationship between International Airport Development and Cities in the Kingdom of Saudi Arabia (in Arabic), Presented at the *Eighth General Conference of the Organization of Arab Cities*. Riyadh, (1986).
[15] *Airport Master Plans,* Federal Aviation Administration Advisory Circular 150/5070-6A. Washington, D.C., (1985).
[16] **Ashford, A.** and **Wright, P.**, *Airport Engineering*, John Wiley, New York, (1984).
[17] **Jeppesen**, *MiddleEast/South Asia High Altitude Enroute Charts*, Jeppesen-Sanderson, Inc., (1988).
[18] **Horonjeff, R.** and **McKelvey, X.,** *Planning and Design of Airports,* McGraw Hill, Singapore, (1986).
[19] *Boeing 737-100/200 Aircraft Characteristics: Airport Planning D6-58325 Rev. D*, Boeing Aircraft Company, Seattle, (1988).
[20] *Flight International*, No 4065, 6 June (1987).
[21] *Dash 8 - Series 300*, Boeing Canada, De Havilland Division, Ontario, (1988).
[22] *British Aerospace 146*, British Aerospace, BAE Hatfield, (1982).

نحو دراسة جدوى لإنشاء مطار في مكة المكرمة

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المستخلص . بالرغم من مكانة مكة المكرمة باعتبارها المدينة المقدسة الأولى في العالم الإسلامي ، وكونها ثالث أكبر مدن المملكة العربية السعودية، فإنه لا يوجد بها مطار مدني . و مبررات ذلك هي أن مطار الملك عبد العزيز في جدة ، التي تقع على مسافة حوالي سبعين كيلومترًا ، يؤدي الغرض المطلوب لخدمة الحجاج والمعتمرين لبيت الله الحرام. يحاول هذا البحث تبرير البدء في إجراء دراسة جدوى لإنشاء مطار في مكة المكرمة. يبدأ بإلقاء الضوء على النواحي النظرية، والعمليـ ـة المتعلقة بأهميـ ـة وجود ميناء جوي في أم القرى، ثم يقدم تحليلاً مبدئيًا لموقعين مناسبين للمطار على أمل أن تكون هذه الدراسة نقطة انطلاق للبحث في جدوى ومخطط عام للمشروع المقترح.