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Towards compatible land use planning around public airports (Applied case study: Marsa Alam International Airport)

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ABSTRACT

This study presents a guide for planners and airports land use commissions about incompatible land uses around public airports that can cause creation of hazards on air navigation and reductions in airport utilization resulting from obstructions to flight paths and incompatible land use resulting from construction near airport. The main target of this research is contributing in putting criteria and restrictions of land uses planning around international Airports (Case Study Marsa Alam International Airport) from Safety and Airspace Protection factors point of view. In this context, the description of land uses around Marsa Alam International Airport was according to the existing land use plan for the nearest urban area.The results of the applied case study showed that some land uses are incompatible with safety factor according to the applied criteria. For unused areas, permitted and prohibited land uses must be determined for each area relative to its location within safety zones. On the other hand, from airspace protection point of view, it was clearly found that height restrictions are necessary for land uses planning around airports and protection of aircraft in flight. Also, residential and other uses around airports must be compatible with airports and the airports approach/departure corridors as a condition of continuity and allowed uses.

Keywords: Airports Land Use Commissions (ALUC); Airport Land Use Compatibility Plan (ALUCP); Airport Influence Area (AIA); Traffic Pattern; Safety Compatibility Factor; Airspace Protection Compatibility Factor; Build Operate Transfer (B.O.T).

INTRODUCTION

Public airports considerably contribute in local economy and job creation[(1)]**.** Together with the socioeconomic benefits of airports, it has environmental impacts on surrounding areas. Land uses around airports are inseparable factor of its operation. The main challenge ahead of airport authorities is to find a balanced approach for maximizing airport's capacity and on the other hand, minimizing the accompanying negative environmental impacts[(1)] as a result of incompatible land uses. Airports' authorities, in response to awareness of environmental issues should be contributing in compatible land uses planning around airports. Compatible land use planning around airports is one of the most important factors affecting airport's operation and surrounding societies.Many Egyptian airports specially, Red Sea Governorate airports do not have clear strategy and accurate criteria about the most important factors that affecting land uses around. Safety and Airspace Protection are main compatibility factors, these factors have a direct impact on land uses planning around airports and also important for achieving environmental compatibility for land uses around airports[(2)]. This paper presents and includes the following: An evaluation of land uses around one of the Egyptian public airports and determines land use compatibility recommendations in all safety zones; Prohibited and allowed land uses in all safety zones around; Establishment of Obstacle Limitation Surfaces around airport's runway; Determinationof imaginary surfaces elevations and the existing obstructions around airport's runway; and Studying the existing and future land uses around the airport. Also, this paper contributes in providing a criteria to Airports Land Use Commissions (ALUC) in establishing Airports Land Use Compatibility Plans (ALUCP) to ensure compatible land uses around airports.

METHODOLOGY

This research based on theoretical analysis to the main compatibility factors (Safety and Airspace protection) that affecting land uses around airports and then applied framework was developed from this theoretical analysis. The research discussed the land use compatibility planning around public airports in Safety and Airspace protection point of view into three sections as follows: The first section, reviewed public airports, Operational systems and traffic patterns, and showed the influence areas. The second section, presented public airports land uses and its compatibility factors.Finally, the research discussed the applied case study of Marsa Alam International Airport as follows: reviewing airports that serve tourism in Red Sea Governorate; evaluating existing land use around Marsa Alam airport; studying the effect of compatibility factors (Safety and Airspace Protection) on it; and determining recommendations that can apply when developing future land use planning around the airport.

1. INTERNATIONAL AVIATION AIRPORTS

1.1General

An international airport is an airport with customs and border control facilities enabling passengers to travel between countries. International airports are usually larger than domestic airports and often feature longer runways and facilities to accommodate the heavier aircraft commonly used for international and intercontinental travel. International airports serve as hubs and also host domestic flights. International airports have commercial relationships with and provide services to airlines and passengers from around the world. Technical standards for safety and operating procedures at international airports are set by international agreements. The International Air Transport Association (IATA), formed in 1945, is the association of the airline companies. The International Civil Aviation Organization (ICAO) is a body of the United Nations succeeding earlier international committees going back to 1903. Both IATA and ICAO served to create regulations over airports which the airports themselves had no authority to debate[(3)].

1.2 Airport's Operation and Management Systems

There are two main known options in the world to manage airports and air navigation services: Government ownership and Private ownership.There are subtypes under each main type[(4)] as shown in Table (1).

Table1: Airport’s Operation and Management Systems

Government-owned airports	Privatized airports
Within a local government department Autonomous airport authority Within a multimodal transport authority Within a civil aviation department Privatized company with shares owned by the local authority	Solitary private airport. Partially government owned airport. Part holding of a multiairport operator Subsidiary company to a conglomerate. Government-owned but leased on concession Public/private consortium using build-own-operate-transfer (B.O.O.T).

1.3 Airport's Traffic Pattern

Is known as the traffic flow which is prescribed for aircraft landing at, taxiing on, or taking off from any runway[(5)] as shown in Figure (1).

Fig. 1. Standard Traffic Pattern

1.4 Airport Influence Area (AIA)

AIA is an important part of the ALUCP, it is the area in which existing or future airport-related noise, and overflight, safety and/or airspace protection factors may significantly affect land uses or necessitate restrictions on those uses[(6)]. The ALUC usually establishes the AIA boundary based on: The location and configuration of the airport(s) included in the plan; and the extent of the noise and safety impacts associated with the airport(s). The geographic area for noise impacts is typically described by CNEL contours and overflight areas, while safety impacts are mapped according to airport safety zones and the airspace surfaces.

2. COMPATIBILITY CONCERNS and LAND USES

The policies regarding airport land uses compatibility are focused on four concepts categories: noise; safety; overflight; and airspace protection. This research istaking / analyzing on safety and airspace protection factors[(7)].

2.1 Airport Compatible Land Uses

Defined as those uses that can coexist with a nearby airport without either constraining the safe and efficient operation of the airport or exposing people living or working nearby to unacceptable levels of noise or hazards (American Planning Association, 2010).

2.2 Safety

The aim of safety is to limit uses that have potential impacts in the following two categories: Uses hazardous to airspace and overflights[6] such as: Tall structures; Visual obstructions (smoke, glare, steam, dust, lights); Wildlife and bird attractants (wetlands, crops, open water);and Uses that affect accident severity for example [High concentrations of people uses (schools, mosques churches, arenas), Risk-sensitive uses (nursing homes, hospitals, flammables), and Open lands].

2.3 Airspace Protection

Airspace Protection factor can accomplish by placing limits on the height of man-made structures and other objects in the airport vicinity, and restrictions on other uses that potentially pose hazards to flight[8].

2.4 Defining Airport Land Uses Planning Safety Zones

In 2016, the Idaho Transportation Department Division of Aeronautics, published an updated guidebook (Idaho Airport Land Use Guidelines) to provide a more streamlined document to educate airport owners/operators (airport sponsors), local planning and zoning representatives, local elected officials, and the general public in order to better understand the unique aspects of airports as they relate to compatible land use planning throughout the state[9]. The recommendations provided in this guidebook are applicable to all public-use airports in the state of Idaho and apply to all political subdivisions that own/operate a public-use airport, or are either impacted by or may impact a public-use airport. Many elements covered in these guidelines are required by either Idaho Code, Idaho Administrative Rules, FAA Policy and Guidance or the Code of Federal Regulations (CFR). Table (2) represents the Airport Land Use Compatibility / General Land Use Recommendations for all uses that located in safety Zones. The uses divided into three types as follows: Prohibited; Allowed with Conditions; and Allowed uses.

Conditions typically include

- Require Fair disclosure Statement as a condition of development.
- Limit residential density to low-density and avoid high-density development.
- Limit commercial uses to low-density and avoid high intensity commercial uses such as large retail box stores.
- Locate development as far as possible from extended centerline, if no reasonable alternative exists.
- Be mindful of bird and wildlife attractant and consider proximity of the airport as well as potential negative impact before development.
- Refer to FAA AC 150/5200-33 and 150/5200-34, as amended, for guidance.
- Table 2 represents types of compatible land use in safety zones[10].
- Table 3: represents the allowed and prohibited land uses that located in safety zones[10].
- Table (4) represents the average number of dwelling units (du) per gross acre for residential uses maximum densities in each safety compatibility zone[10].

Table 2: Types of compatible land use in safety zones

Land Uses	Runway Protection Zone (1)	Side Line Zone (5)	Inner Approach /Departure Zone (2)	Outer Approach /Departure Zone (4)	Traffic Pattern Zone (6)	Airport Influence Area
Residential						
Single-family, nursing homes, multi-family, apartments, condominiums, mobile home, parks.	Prohibited	Prohibited	Prohibited	Allowed with Conditions	Allowed with Conditions	Allowed with Conditions
Transient lodging (i.e. hotels and motels)	Prohibited	Prohibited	Prohibited	Allowed with Conditions	Allowed with Conditions	Allowed with Conditions
Public						
Schools, libraries, churches, mosques	Prohibited	Prohibited	Prohibited	Prohibited	Allowed with Conditions	Allowed with Conditions
Parking and cemeteries	Prohibited	Allowed	Allowed with Conditions	Allowed with Conditions	Allowed	Allowed
Commercial/Industrial						
Offices, retail trades, light industrial, general manufacturing, utilities, extractive industry	Prohibited	Allowed with Conditions	Allowed with Conditions	Allowed with Conditions	Allowed with Conditions	Allowed with Conditions
Airport revenue-producing enterprises	Prohibited	Allowed with Conditions	Allowed with Conditions	Allowed with Conditions	Allowed with Conditions	Allowed with Conditions
Agricultural and Recreational						
Cropland	Allowed	Allowed	Allowed	Allowed	Allowed	Allowed
Livestock breeding, zoos, golf courses, riding stables, water recreation	Prohibited	Prohibited	Allowed with Conditions	Allowed with Conditions	Allowed with Conditions	Allowed
Outdoor spectator sports, parks, playgrounds	Prohibited	Prohibited	Prohibited	Allowed with Conditions	Allowed with Conditions	Allowed with Conditions
Amphitheaters	Prohibited	Prohibited	Prohibited	Prohibited	Allowed with Conditions	Allowed with Conditions
Open space	Allowed	Allowed	Allowed	Allowed	Allowed	Allowed
Bird and Wildlife Attractants						
Sanitary Landfills	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited	Allowed with Conditions
Water treatment plants, water impoundments	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited	Allowed with Conditions
Wetlands Mitigation	Prohibited	Allowed with Conditions	Allowed with Conditions	Allowed with Conditions	Allowed with Conditions	Allowed with Conditions

(red)	Prohibited	(orange)	Allowed with Conditions	(green)	Allowed

Table 3: Safety compatibility zones – Prohibited and allowed uses

Safety zone		Prohibited and allowed uses
Zone 1	Runway Protection Zone	Prohibit all new structures. Prohibit residential land uses. Avoid non - residential uses.
Zone 2	Inner Approach/ Departure Zone	Prohibit hazardous uses (e.g. aboveground bulk fuel storage). Prohibit children's schools, day care centers, hospitals, nursing homes. Prohibit residential uses except on large agricultural parcels. Limit non - residential uses to activities which attract few people (uses such as shopping centers, most eating establishments, theaters, meeting halls, multistory office buildings, and labor-intensive manufacturing plants unacceptable).
Zone 3	Inner Turning Zone	Limit residential uses to very low densities (if not deemed unacceptable because of noise). Avoid non - residential uses that have moderate / higher usage intensities (e.g., major shopping centers, fast food restaurants, theaters, meeting halls, buildings with more than three aboveground habitable floors are generally unacceptable). Prohibit children's schools, large day care centers, hospitals, nursing homes. Avoid hazardous uses (e.g. aboveground bulk fuel storage).
Zone 4	Outer Approach/ Departure Zone	In undeveloped areas, limit residential uses to very low densities (if not deemed unacceptable because of noise). Avoid non - residential uses that have moderate / higher usage intensities (e.g., major shopping centers, fast food restaurants, theaters, meeting halls, buildings with more than three aboveground habitable floors are generally unacceptable). Prohibit children's schools, large day care centers, hospitals, nursing homes.
Zone 5	Sideline Zone	Avoid residential uses unless airport related (noise usually also a factor). Allow all common aviation-related activities provided that height-limit criteria are met.
Zone 5	Sideline Zone	Limit other nonresidential uses similarly to Zone 3, but with slightly higher usage intensities.
Zone 5	Sideline Zone	Prohibit children's schools, large day care centers, hospitals, nursing homes.
Zone 6	Traffic Pattern Zone	Allow residential uses. Allow most non-residential uses; prohibit outdoor stadiums and similar uses with very high intensities. Avoid children's schools, large day care centers, hospitals, nursing homes.

Table 4: Maximum residential density – percentage required open land for safety compatibility zones

Safety Compatibility Zones		Maximum Densities	
		Required Open Land	Residential (d.u./acre)
		Average number of dwelling units (du) per gross acre	
Zone 1	Runaway Protection Zone	All remaining	0
Zone 2	Inner Approach/ Departure Zone	30%	0
Zone 3	Inner Turning Zone	20%	≤ 1 du. u./5 acre
Zone 4	Outer Approach/Departure Zone	No requirements	≤ 1 du. u./5 acre
Zone 5	Sideline Zone	10%	≤ 1 du. u./10 acre
Zone 6	Traffic Pattern Zone	No	No limit

2.5 Defining Airspace around Airport

To assist airport owners and local resident in determining the extent of airspace that must be considered as part of their local planning and zoning process, this section defines the airspace surfaces.

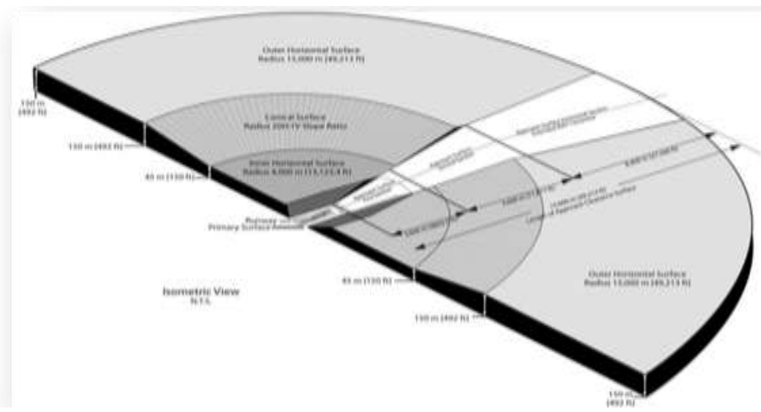

Fig. 2. Class B - IFR Runway Airspace Imaginary Surfaces

For public-use civilian airports, Part 77 identifies the following "imaginary" airport airspace surfaces: Primary Surface; Approach Surface; Transitional Surface; Horizontal Surface; and Conical Surface. These surfaces are designed to protect the airspace aircraft use to approach or depart an airport from obstructions to air navigation. The shape and dimensions of these surfaces are based on the size of aircraft that predominantly use or is planned to use the runway and type of approaches (visual, non-precision and precision) in use or planned for a particular runway end[11]. Figure (2) shows the shape of Class B IFR Runway Airspace Imaginary Surfaces.

Notes:

- Visual Runways: Existing and future runways intended solely for the operation of aircraft using visual approach procedures, with no instrument approach procedure identified or planned by the FAA.
- Non-Precision Instrument Runways: Runways equipped with an existing or planned, ground-based instrument approach procedure with only horizontal guidance or area type navigation equipment, and for which no precision instrument approach procedure has been identified by the FAA.
- Precision Instrument Runways:

Runways having an existing or planned, instrument approach procedure utilizing an Instrument Landing System (ILS), or a Precision Approach Radar (PAR).

3. Applied case study: Marsa Alam international airport

3.1 MarsaAlam International Airport (RMF)

Marsa Alam International airport (RMF) was built 66km from southwest Marsa Alam town, in response to the increasing needs of European travelers to this southern Red Sea destination, along with other airports on the Red Sea such as Sharm el-Sheikh International Airport, being inaugurated on 16 October 2003, (Fig. 3). It is called Marsa Alam International Airport. RMF airport was built to serve Marsa Alam town which has now many tourism and accommodation facilities, it is growing to be a favorite tourist destination competing with Hurghada and Safaga in this field. RMF airport is the first airport in Egyptian aviation. History operating under a complete B.O.T system. RMF airport is open 24 hours a day and serving. International and domestic flights(12). RMF airport

is considered one of al airports with 600 pax. /Hour

Capacity. RMF airport has easy and quick access to the terminal building. RMF airport has a modular design terminal building with area about 7000 m^2, which can be easily expanded to accommodate up. To 4 million passengers a year. All areas in RMF airport, including the secure "check-in" hall.

There are fully air-conditioned and a number of restaurants, duty-free shops, and other retail outlets are provided for passengers. RMF airport has all services and aids necessary for safe operation, including rescue services, fully equipped control tower, navigational aids and support facilities. Figure 4 shows the boundary of RMF airport(12). The Egyptian Civil Aviation Authority is the "Competent Administrative Authority" for the review and licensing of RMF airport. The airport was awarded to EMAK Marsa Alam for Management and Operation of Airports, an Egyptian Shareholding Company established under Law No.8 of 1997. Also, Figure (5) shows traffic pattern of RMF airport.

Fig. 3. Red Sea Governorate's airports

Fig. 4. RMF airport property boundary

Fig. 5. RMF airport traffic pattern

Summary of facilities found at RMF airport (Table 5).

Table 5. A summary of RMF airport's facilities.

No.	A summary of facilities				
1	Name	MarsaAlam International Airport			
2	Country	Egypt			
3	Province	Red Sea Governorate			
4	Town City	MarsaAlam			
6	Total Airport Area	21000000 m2			
7	Ownership	EMAK MarsaAlam for Management and Operation Airports SAE			
8	Operator	M.A. AL-Kharafi Group of Kuwait			
9	Airport Type	Public / Civil (Medium Airport)			
10	IATA Code	RMF			
11	ICAO Code	HEMA			
12	Coordinates	N (25° 33′ 25″) - E (34° 35′ 01″)			
13	Elevation AMSL	251 ft / 77 m			
14	Main Runway	Direction	Length	Width	Surface
		15/33	3240 m	45 m	Asphalt
15	Weather and Navigational Aids for Airport	Items		Condition	
				Yes	No
		Lighted Wind Cone		√	
		Limited Aviation Weather Reporting Station (LAWRS)		√	
		Airport Beacon		√	
		Airport Traffic Control Tower (ATCT) – (FullyEquipped)		√	
		Automated Surface Observing System (ASOS)		√	
		Runway Lighting Edge, ALS		√	
16	Runway Lighting Intensity	High (Edge ALS)		√	
17	Instrument Approach Navigation Aids	ILS (15L – 33R)			√
		GPS (33R) - RNAV		√	

		GPS (15L) - RNAV	√	
		VOR-DME	√	
18	Critical Aircraft	All Jets Category "D"		
19	Runway code number	4		
20	Runway Approach type	Runway has both Simple Approach and Precision Approach Lighting, Runways with an Instrument Approach		
21	Visual approach aids of runway	VASI-4L (25R), PAPI-4R (7L) and MALSR (25R)		

4. Existing land uses around RMF airport

Marsa Alam City is located in eastern Egypt and on the west coast of the Red Sea. It is one of the fastest growing holiday destinations on the Red Sea Governorate. Although until recent times it was a small fishing village, Marsa Alam's popularity has been grown since RMF airport constructed in 2001.Due to the recent development of RMF, airport Marsa Alam City became the one of the biggest attraction points for tourism in Egypt. The total area of Marsa Alam City about 38433 km^2.To the northwest there exist Port Ghalib resort which is located on the east of Al-Qusair- Marsa Alam road; which include: Hotels /Resorts; Residential/Villas; Commercial/ Entertainment; Services; and Golf Courses. Also, on the west of Al-Qusair- Marsa Alam road, there exist West Community. To the southeast there exist Port Ghalib resort on the east of east, Al-Qusair- Marsa Alam road. Figure 5 shows the existing land use near and around RMF airport[12].Also, on the west of Al-Qusair- Marsa Alam road, there exist West Community. To the southeast there exist Port Ghalib resort on the east of east, Al-Qusair- Marsa Alam road. Figure (5) shows the existing land use near and around RMF airport[12].

4.1 Safety factor

Safety compatibility zones:

For general aviation airports as in case of RMF airport, there exist six safety zones and two safety areas, in addition to AIA. The shapes and dimensions of the zones are largely based on accident data and other analyses prepared by the FAA The dimensions of safety zones and safety areas of RMF airport[15,17] were collected and presented in Table (6). Figure (6) shows the shape of safety zones at both runway directions 33 and 15.

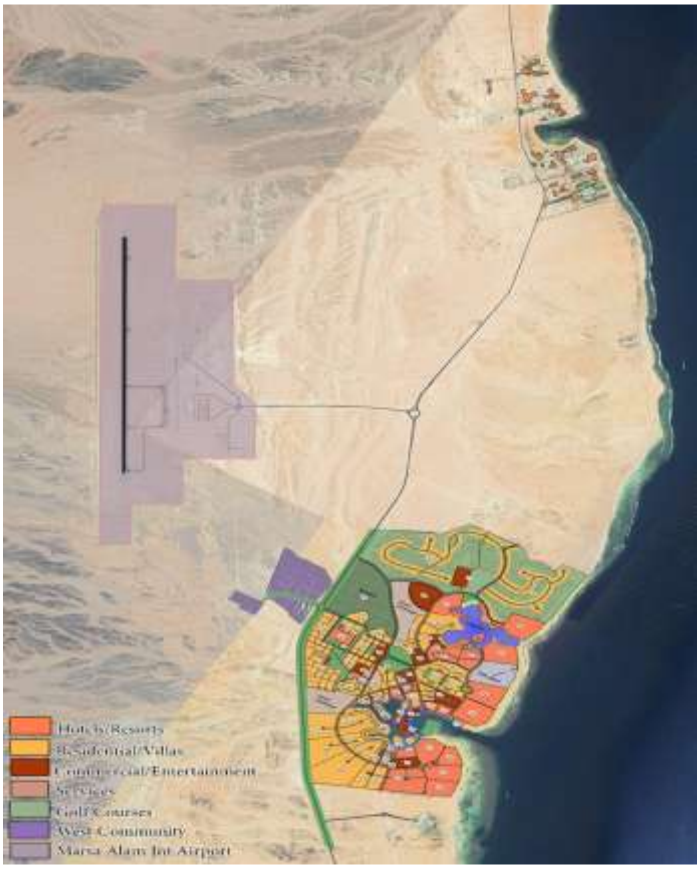

Fig. 6: Existing land uses near and around RMF airport

Table 6: Safety compatibility zones dimensions of RMF airport's runway (prepared by researchers)

Zone No.	Safety Zones/Area	RWY direction	Radius (m)	Length (m)	Width (m) Inn/out	Angle	Notes
---	Runway end Safety Area (RESA)	15	---	≥ 240	≥ 120	---	RWY code 4
---	Clearway	15	---	≥ 2000	150	---	Slope of 1.25%
1	Runway protection zone	33-15	---	750	300/525	---	
2	Inner approach/ departure zone	33-15	---	1000	450	---	
3	Inner turning zone	33-15	1800	---	---	40°	
Zone No.	Safety zones/area	RWY direction	Radius (m)	Length (m)	Width (m) Inn/out	Angle	Notes
4	Outer approach/ departure zone	33-15	---	1200	300	---	
5	Sideline zone	33-15	---	Along RWY	600	---	Till intersect ITZ
6	Traffic pattern zone	33-15	1800 m	7070 m	3600 m	---	

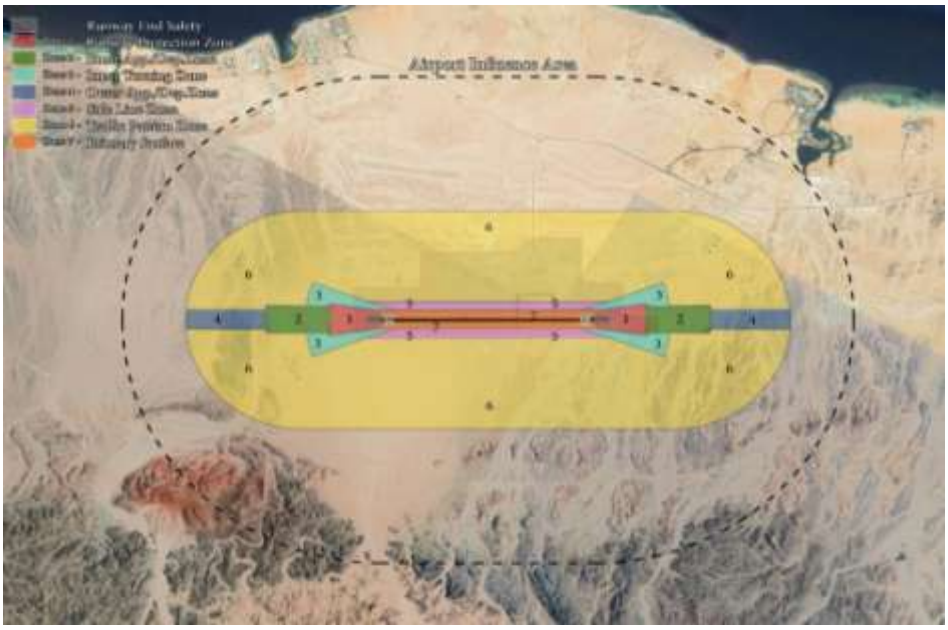

Fig. 7: Safety zones, Safety areas and AIA of RMF airport's runway

Safety compatibility criteria:

As a result of the distinct levels of risk in each safety compatibility zone, airport land use compatibility commission of RMF airport should differentiate allowed and prohibited land uses according to safety compatibility zones. The above Figure (7) shows safety zones, safety areas and AIA.The prohibited and allowed uses in each safety compatibility zone for RMF airport are the same as listed in Table (3). The average number of dwelling units (du) per gross acre for residential uses maximum densities in each safety compatibility zone are the same as listed in Table (4).

Safety evaluation:

According to Table (4), the allowed and prohibited land uses that located in Zone 6 (traffic pattern zone) as follow: Allow residential uses; Allow most non-residential uses but prohibit outdoor stadiums and similar uses with very high intensities; and Avoid children's schools, large day care centers, hospitals, nursing homes. Also, according to Table (3) the allowed and prohibited land uses in zone 6 (traffic pattern zone) as follow: Water treatment plants and water impoundments are prohibited. Figure (7) shows land uses that located in zone 6 and compatible / incompatible land uses are listed in Table (7).

Table 7: Land uses Located in zone 6 – Traffic Pattern Zone

Area code no.	Existed / proposed land use	Areas zones location	Height	Safety analysis	
				Comp.	Incomp.
6-1	Power station	Traffic Pattern Zone	+5	√	--
6-2	Unused land	Traffic Pattern Zone	--	--	--
6-3	Unused land	Traffic Pattern Zone	--	--	--
6-4	Mosque	Traffic Pattern Zone	+1	--	√
6-5	Commercial	Traffic Pattern Zone	+1	√	--
6-6	Residential area - condominiums	Traffic Pattern Zone	+3	√	--
6-7	Unused land	Traffic Pattern Zone	--	--	--
6-8	Unused land	Traffic Pattern Zone	--	--	--

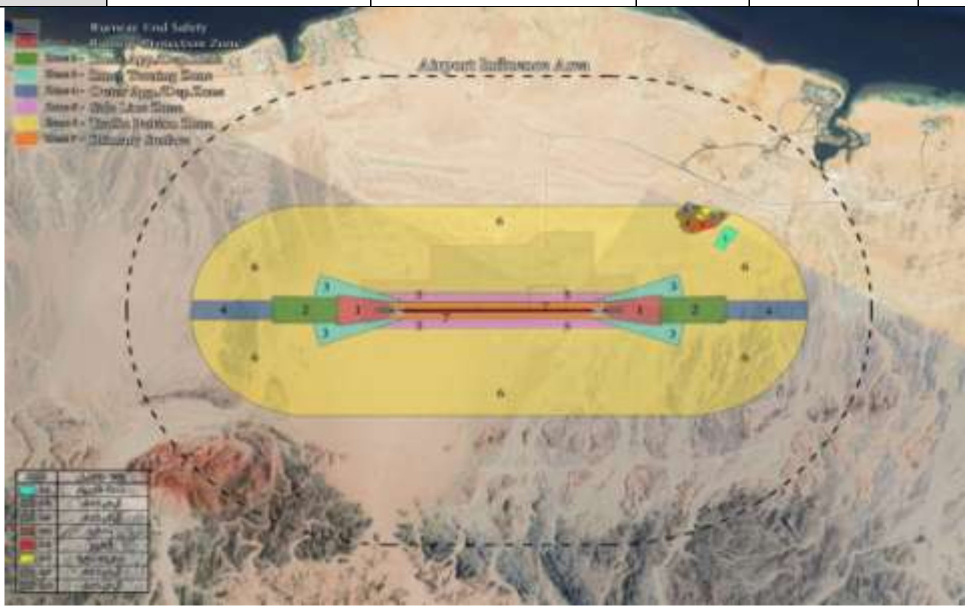

Fig. 7: Land uses located in zone 6 – Traffic Pattern Zone (prepared by researcher)

5. Airspace protection

5.1 Overview:

Federal airspace related regulations 14 CFR 77 – "Part 77" Title 14 CFR Part 77, safe, efficient use, and preservation of the navigable airspace, provides the basis for airspace protection requirements at public-use airports at the federal level by identifying and defining critical airspace surfaces around airports.Airspace requirements are determined by the weight of the aircraft that predominantly operate at an airport and the type of instrument approach, existing or planned.

Obstacle limitation surfaces - Egyptian civil aviation regulations (ECAR Part 139-23):

Dimensions and slopes of obstacle limitation surfaces-approach runways[16, 18] were collected and presented in Table (8).

Table 8: Dimensions and slopes of obstacle limitation surfaces-approach runways

Surfaces and dimensions	Runway classification (precision approach category)		
	I		П or Ш
	Code number		Code number
	1, 2	3, 4	3, 4
Conical			
Slope	5%	5%	5%
Height	60 m	100 m	100 m
Inner horizontal			
Height	45 m	45 m	45 m
Radius	2500 m	4000 m	4000 m
Inner approach			
Width	90 m	120** m	120** m
Distance from threshold	60 m	60 m	60 m
Length	900 m	900 m	900 m
Slope	2.5%	2%	2%
Approach			
Length of inner edge	150 m	300 m	300 m
Distance from threshold	60 m	60 m	60 m
Divergence (each side)	15%	15%	15%
Transitional			
Slope	14.3%	14.3%	14.3%
Inner transitional			
Slope	40%	33.3%	33.3%
Balked landing			
Length of inner edge	90 m	120** m	120** m
Distance from threshold	Distance to the end of strip	1800* m	1800* m
Divergence (each side)	10%	10%	10%
Slope	4%	3.33%	3.33%

Notes:
All dimensions are measured horizontally unless specified otherwise.
* Or end of runway whichever is less.
** Where the code letter is F, the width is increased to 155 m.

Establishment of Obstacle Limitation Surfaces aroundRMF airport'srunway:

The airspace around RMF airport's runway must be maintained free from obstacles to permit the aircraft operations conducted safely and to prevent RMF airport from becoming unusable by the growth of obstacles around it.The following obstacle limitation surfaces are essential elements of a height zoning regulation associated with a precision approach runway category I (15/33) for RMF airport's runway: Primary surface; Conical surface; Inner horizontal surface; Approach surface; Transitional surfaces; and Balked landing surface.Dimensions and slopes of obstacle limitation surfaces were collected and listed in Table (9), also Figure (8) shows the shape of obstacle limitation surfaces[16].

Table 9: Dimensions and slopes of obstacle limitation surfaces around RMF airport's runway

No.	Surfaces and dimensions	Runway classification
		Precision approach category I – code number 4
1	Primary surface Width Length Slope	300 m RWY Length + 120 m Slope of the nearest point on RWY
2	Inner approach surface Distance from threshold Width of inner edge Divergence (each side) Width of outer edge Slope Length (horizontal)	60 m 120 m 15% (7.34:1) 390 m 2% 900 m
3	Transitional Surface Slope Low level High level Length (horizontal)	14.3% (7:1) Level of primary surface 45 m +77m =122 m AMSL 315 m from the end of primary surface
4	Inner Horizontal Surface Radius from RWYcenterline Length (horizontal) High level	4000 m 3535 m 122 m AMSL
5	Outer Horizontal Surface Radius from RWY centerline Length (horizontal) High level	15000 m 8900 m 227 m
6	Conical Surface Slope Low level High level Total height Length (horizontal)	5% (20:1) 122 m AMSL 227 m AMSL 150 m 2100 m
7	Approach Surface – Sec. 1 Length (horizontal) Divergence	3000 m 15%
	Approach Surface – Sec. 2 Width of inner edge Width of outer edge Slope Length (horizontal) Divergence	1200 m 2280 m 2.5% 3600 m 15%
	Approach hor. surface – sec. 3 Width of inner edge Width of outer edge Slope Length (horizontal)	2280 m 3504 m 0% 8400
8	Balked landing surface Length of inner edge Distance from threshold	120 m 1800 m or end of runway whichever is less.
No.	Surfaces and Dimensions	Runway Classification Precision Approach Category I – Code Number 4
	Divergence (each side)	10%

	Slope	3.33%
9	<u>Take - off Climb surface -Section 1</u> Length of inner edge Distance from runway end Divergence (each side) Final width Slope	300 m 60 m 12.5% (8:1) 1200 m 2%
	<u>Take - off Climb surface Section 2</u> Length of inner edge Distance from runway end Divergence (each side) Final width Total length of take – off surface	1200 m 3660 m 0% 1200 m or 1875 m 15000 m

Fig. 8: Imaginary Surfaces around RMFairport's runway (Prepared by Researchers)

Elevations of imaginary surfacesand existing of obstructions around RMF airport's runway:

Table 10: Elevation of imaginary surfaces and obstructions around RMF airport's runway

No.	Type of surfaces	Elevation AMSL		Slope	Width	Obstructions	
		Lower	Upper			33	15
1	Primary Surface	The level of nearest point on RWY (+77 m)	The level of nearest point on RWY (+77 m)	0	300 m	Not exist	Not exist
2	Transitional Surface	+77 m AMSL	+122 m AMSL	7:1	315 m	Not exist	Not exist
3	Inner Horizontal Surface	+122 m AMSL	+122 m AMSL	0	3535 m	Not exist	Not exist
No.	Type of surfaces	Elevation AMSL		Slope	Width	Obstructions	
		Lower	Upper				
4	Conical Surface	+122 m AMSL	E+150 m AMSL	20:1	2100 m	Not exist	Not exist
5	Outer Horizontal Surface	+227 m AMSL	+227 m AMSL	0	8900 m	Not exist	Not exist

The maximum allowable height for any facility within Influence area of RMF airport determined by The Egyptian Civil Aviation Authority (CAA) in coordination with the concerned bodies, as well as the aircrafts' speeds, engines capacities and other conditions ensuring not exceeding the levels referred to.

Fig. 9: The imaginary surfaces of RMF airport's RWY (Prepared by Researchers)

The above Table (10) presents the types of imaginary surfaces, elevation of each one and the existing obstructions in both directions of RWY 33-15. Also, the above Figure 9 shows the imaginary surfaces of RMF airport's RWY that were drawn on contour map to clarify the relation between allowable height limits from the natural ground levelthis relation can be used for determining height of facilities that may construct within influence area of RMF airport. Figure (10)

(Section B-B) illustrates the relationship between imaginary surface elevations and natural Earth in the transverse direction of runway (west direction).

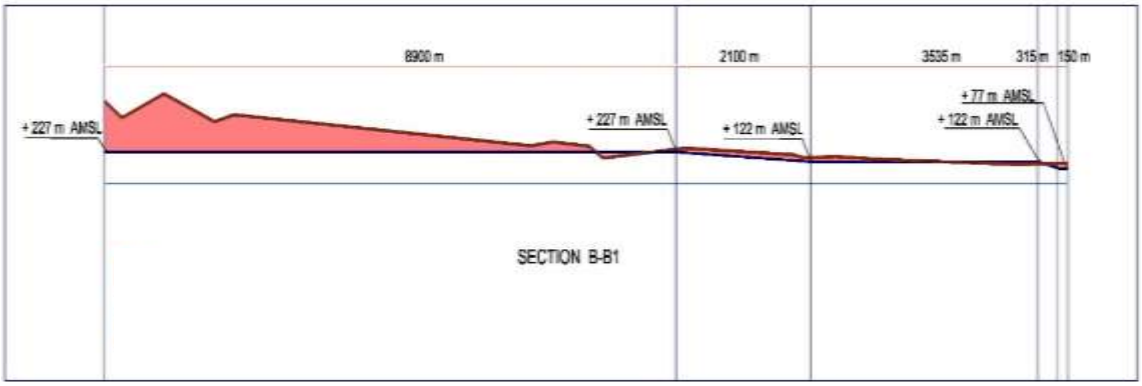

Fig. 10. Section B-B(Cross section)

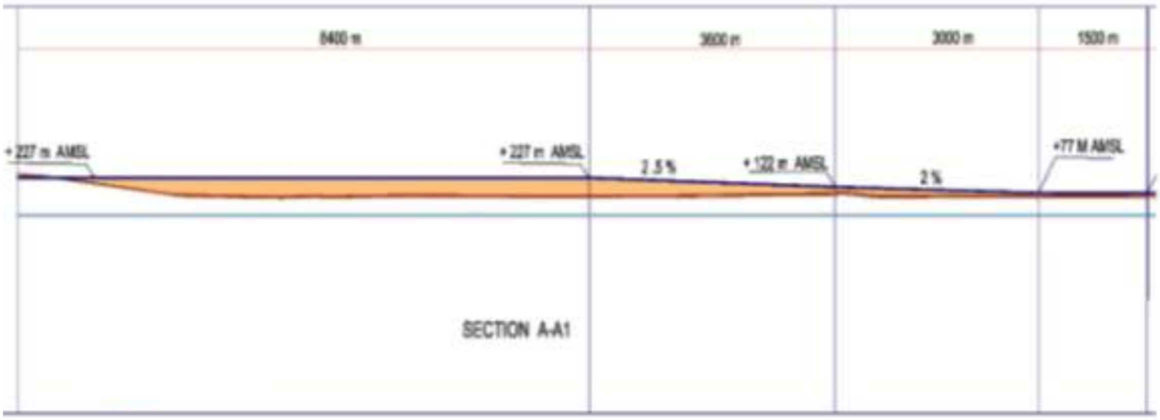

Fig. 11. (Section A-A) illustrates the relationship between Approach surface elevations and natural earth in longitudinal direction of runway (north - south direction).

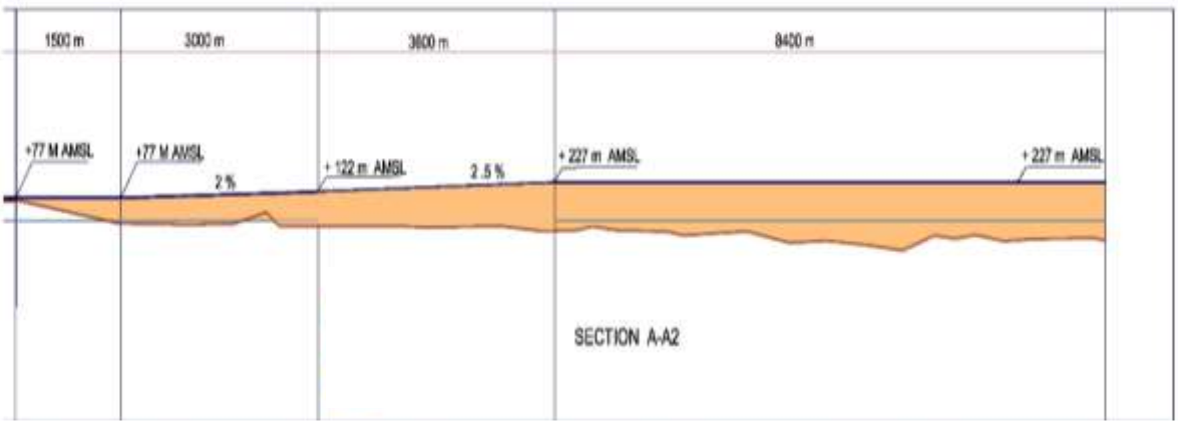

Fig. 11. Section A-A (Longitudinal section – Approach direction

RESULTS AND DISCUSSION

- RMF airport is located outside the urban space of Marsa Alam city, it is about 66 km from the city, so it does not represent any conflict with the city and its urban space.On the other hand, the impact of RMF airport is only on the nearest urban gathering area, it has not and it hasn't any impact on the future strategic plan of Marsa Alam City. Because each safety compatibility zone has a distinct level of risk, so airport land use officials can differentiate the allowed land uses from and prohibited according to safety compatibility zones.
- Planners and land use officials around airports should refer to Table 5 when they are planning residential land uses to determine the densities per acre.
- For RMF airport's safety zones, there are no land uses in these zones except in zone - 6 (Traffic pattern zone). The existing uses in zone -6 are: Power station, which is not inconsistent with the permitted uses in Traffic Pattern Zone; Mosque, which is high intensity use that is may inconsistent with uses in the Zone- 6; For unused lands, uses type in Table (3) should be taking in consideration (permitted and prohibited land uses) before determining type of uses.
- With refer to Figure (10), the elevations of natural land are higher than the imaginary surfaces (range from +14 to + 147 m AMSL) along the section B-B. As a result, no constructions are permitted in these areas.
- In approach direction as shown in the longitudinal section (Fig.11), the elevations of the approach surfaces look higher than natural land. It is more suitable for safe landing.
- In take-off direction, the elevation of take-off climb surface looks higher than natural ground except for the last part of it as shown in Figure (11) (Section A-A1).
- According to the longitudinal section A-A, which clarifies the difference in elevations between the heights of the imaginary surfaces and the natural land, it is possible to specify the height of any required facility.

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Towards compatible land use planning around public airports (Applied case study: Marsa Alam International Airport)

نحو تخطيط متوافق لاستعمالات الأراضي حول المطارات: (دراسة حالة مطار مرس علم الدولي)

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المستخلص

يعتبر هذا البحث بمثابة دليلا للمخططين ومسئولي استخدامات الأراضي بالمطارات حول الاستعمالات غير المتوافقة للأراضي حول المطارات العامة والتي يمكن أن تسبب مخاطر على الملاحة الجوية واحداث تخفيضات في فائدة المطار ناتجة عن وجود عوائق في مسارات الطيران ذات الصلة باستخدام الأراضي غير المتوافق الناتج عن البناء بالقرب من المطار. هدف البحث الرئيسي هو المساهمة في وضع معايير وقيود لتخطيط استعمالات الأراضي حول المطارات الدولية طبقا عوامل السلامة وحماية المجال الجوي. في هذا السياق، وقد اعتمد البحث في الدراسة علي المنهج العلمي التحليلي التوصيفي من خلال دراسة عملية تطوير وتخطيط توافق تلك الاستعمالات للارضي المحيطة بالمطارات وتقييم مدي توافق من خلال التطبيق علي عوامل (تأثير السلامة وعوامل السلامة التي تؤثر علي نوعية الاستعمالات الاراضي بها. ومن ثم تم اتباع المنهج التحليلي التطبيقي من خلال تحليل الوضع الراهن والرصد لمنطقة الدراسة (مطار مرسي علم الدولي) للوصول الي معايير وقيود لتخطيط استعمالات الاراضي لتلك المناطق وتحديد الاستخدامات المسموحة والمحظورة بها . كما يهدف البحث من خلال الدراسة التطبيقية والميدانية لاستعمالات الأراضي حول مطار مرسى علم الدولي وفقًا لاستخدامات الأراضي الحالية لأقرب منطقة حضرية. وذلك من خلال دراسة وتحليل لبعض استعمالات الأراضي حول المطارلاتتوافق مع عامل الأمان وفقًا للمعايير المطبقة بالنسبة للمناطق غير المستخدمة، يجب تحديد استخدامات الأراضي المسموح بها والمحظورة لكل منطقة بالنسبة لموقعها داخل مناطق الأمان.

من ناحية أخرى، ومن وجهة نظر حماية المجال الجوي ودراسة قيود الارتفاع ضرورية لتخطيط استخدامات الأراضي حول المطارات وحماية الطائرات أثناء الطيران ومتوافقة مع المطارات وممرات الاقتراب / ممرات المغادرة كشرط للاستمرارية والاستخدامات المسموح بها.

الكلمات الدالة : لجان استعمالات الاراضي المطارات – خطة توافق استعمالات الاراضي للمطار – منطقة تأثير المطار – نمط ونموذج حركة المرور – عامل توافق الامان – عامل توافق حماية المجال الجوي – نظام البناء وحق الانتفاع .