Three-Dimensional Aerial Zoning around a Lebanese Airport

by

Oussama C. Jadayel and Rita Y. Ibrahim

GIS Center,
Faculty of Engineering,
University of Balamand,
P.O. Box: 100, Tripoli,
LEBANON

oussama.jadayel@balamand.edu.lb
rita.y.ibrahim@balamand.edu.lb

Abstract

To ensure safety of aerial operations around aerodromes, regulatory standards have been outlined by the International Civil Aviation Organization. Such guidelines are accurate geometric definitions of the physical characteristics of an airport and the obstacle limitation surfaces underlying its operational areas. Kleia'at is an airbase located in north Lebanon serving a small number of military and general aviation aircraft. With plans to transform it into a regional civilian airport and increase its traffic capacity, formal zoning becomes essential. The GIS Center at the University of Balamand has joined forces with the Lebanese Air Force to achieve a 3-D GIS visual model for Kleia'at. The model was developed to conform to international standards and could be extended as a support tool for airport management. The object of this paper is to report on how the model was developed by a team of academics, Air Force personnel and University students.

Keywords *Lebanon, Obstacle Limiting Surface, GIS, Zoning, Airport*

1. Introduction

Improving the quality of aerial operation within and around airports remains a matter of prime importance to the international aviation community. Given the vast areas airports occupy, GIS tools have a very important role to play in every aspect their management and operational enhancement. Many airport authorities have relied on geo-technologies to improve their facilities and services. Dubai Department of Civil Aviation for example developed a system which is used to overlook its utilities, pavements and built up areas [1]. In a more recent work, Arafa et. al. [2] designed a system through which locational airport and tourist information could be passed to passengers using Cairo Airport. Additionally, their system included an aircraft ground control support system. Examples from the west include the work of Iza [3], who mapped bird strike information at Santa Barbara airport and that of Murphy [4] who looked at the application of remote sensing in airport planning and development.

In the present work, attention is directed towards establishing a visual model for obstacle clearance limits around a Lebanese airport. Obstacle clearance limits are defined very accurately by the International Civil Aviation Organization (ICAO) as three-dimensional surfaces which built up structures cannot penetrate without hindering the safety of aerial activity. Although these surfaces are generically defined in Annex 14 to the to the Convention on International Civil Aviation [5] to take into consideration operational procedures at any airport, their actual in-situ configurations depend upon the physical layout of the particular airport to which they apply. In this respect, geographical modeling becomes vital for clarifying areas and zones that are restrictive to the installation of obstacles and structures which could interfere with aeronautical activity. Besides, this procedure is instrumental in promoting safety and enhancing transparency and planning of construction and development activities.

The object of this paper is to present how a three-dimensional obstacle clearance model for Kleia'at airport in North Lebanon was developed. The model was developed at the GIS Center at the University of Balamand in collaboration with the Lebanese Air Force. The model serves as a pilot which can be extended to other local and regional airfields.

2. Airport Description

Kleia'at is one of three active airports in Lebanon. It is located by the Mediterranean coast at a distance of about 90 km north of Beirut and some 7 km from the northern Lebanese border with Syria. It has two opposite runways designated 06 and 24 magnetic. The reference point of the airport is taken to be the midpoint of the runway at a latitude of N34^{o} 35.139', a longitude of E 36^{o} 00.183' and an elevation of 7 m above sea level. The airport is basically a military airbase which also caters for some general aviation and training traffic. With recent government plans to transform it into a regional civilian airfield, pressures are exerted to obtain accurate three-dimensional aerial zoning in order to define its obstacle limiting surfaces.

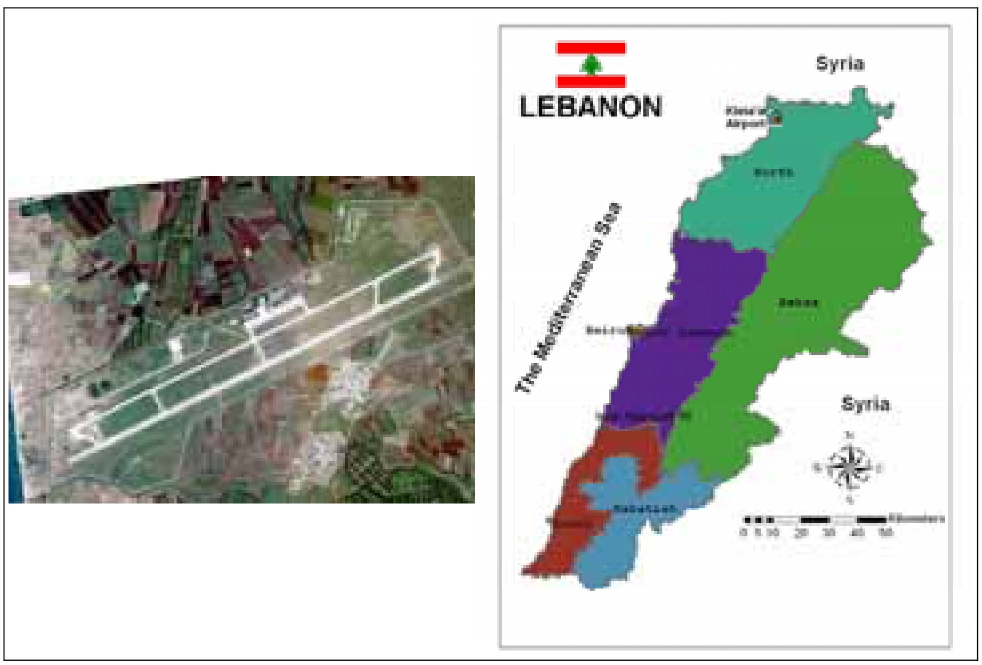

Figure (1): A map of Lebanon showing the location of Kleia'at and a satellite image of the airport.

3. Zoning Specifications

Prior to initiating the zoning definitions for the Kleia'at, the airport ICAO reference codings had to be acquired. These codes reflect information relating to the physical dimensions of the available runways. Additionally, the classifications of the approach types possible also had to be agreed upon since both have a direct bearing on the geometry of the obstacle limiting surfaces. Since the runway at Kleia'at is 2850 m long and is 48 m wide, the airport was coded as 4D[1]. Kleia'at is currently a non-instrument approach airport. However, future plans are to transform it into a CAT I precision approach airport. Accordingly, the surface definitions for the 4D-CAT I instrument approach runways 06 and 24 are given in table (1) below.

Table (1): Obstacle Limitation Surface Definitions for 4D-CAT I Instrument Approach Runways (Information extracted from ref. [5])

SURFACE DEFINITION	SURFACE DIMENSION
CONICAL	
Slope	5 %
Height	100 m
INNER HORIZONTAL	
Height	45 m
Radius	4000 m
INNER APPROACH	
Width	120 m
Distance from Threshold	60 m
Length	900 m
Slope	2 %
APPROACH	
Length of Inner Edge	300 m
Distance from Threshold	60 m
Divergence (Each Side)	15 %
First Section	
Length	3000 m
Slope	2 %
Second Section	
Length	3600 m
Slope	2.5 %
Horizontal Section	8400 m
Length	
Total Length	15000 m
TRANSITIONAL	
Slope	14.3 %

Furthermore the limitations given in table (2) are pertinent to any runway used for take-off and subsequent climb outs. Since both runways 06 and 24 are to be used for take off, this data has to be taken into account in the design of the GIS model.

Table (2): Obstacle Limitation Surface Definitions for Departure Runways (Ref. [5])

SURFACE DEFINITION	SURFACE DIMENSION Departure Runway
TAKE-OFF CLIMB	
Length of Inner Edge	180 m
Distance from Runway End	60 m
Divergence (Each Side)	12.5 %
Final Width	1200 m
Length	15000 m
Slope	2 %

4. The GIS Model

In order to achieve the three-dimensional model which defines the obstacle limiting surfaces around Kleia'at airport, a clear methodology had to be adopted. Such methodology comprised three sequential logical steps as follows:

[1] Code number 4 indicates that the runway is longer than 1800 m. Code letter D indicates that it is wider than 36m but less than 52 m.

- Step 1: Geographical definition of the physical characteristics of the airport under consideration (runways, aprons, taxiways, dispersal, built-up units, facilities, terrain elevation contour lines etc.)
- Step 2: Designing the two-dimensional model which outlines the zones of the obstacle limiting surfaces (conical, inner horizontal, approach surfaces, departure surfaces, transition surface, etc.).
- Step 3: Extending the 2-D model to 3-D by introducing appropriate heights and slopes as per tables (1) and (2) above as well as taking into consideration the elevation of the terrain.

4.1 Geographical Definition of the Airport Physical Characteristics

The first step in the development of the GIS model involves an accurate definition of the physical characteristics of Kleia'at airport. For this purpose, an ortho-rectified satellite image of 1m resolution was used to define the paved areas of the aerodrome, such as runways, taxiways, aprons and intersections. Also, this image was used to identify the airport buildings and its structural facilities in addition to locating essential features pertaining to the zoning procedure such as the start and end of each runway as well as runway centerline and the airport reference point. Elevation contours were introduced to the GIS as digitized at 10 m intervals from 1:20k maps, and those are shown with other features in figure (2).

Figure (2): An ortho-rectified satellite image showing the elevation contours, airport boundaries, paved areas, runways, reference point as well as built up units.

4.2 Two-Dimensional Extents of the Obstacle Limiting Surfaces

In this part of the work, the starting point was to define the runway zone; a rectangular feature of 150 m either side of the runway centerline, and extending 60 m from each threshold. The approaches relative to each runway, in terms of longitudinal distance from each end of the runway zone and in terms of the lateral angular expanse, were fixed as per table (1). The same procedure was applied to the departure surfaces. In either case, the longitudinal limits extended to 15 km from the narrower edge of the runway zone. In addition to the above, the circles which encompass the inner horizontal surface and the conical surface were included, and these were centered at the reference point with radii of 4 km and 6 km respectively. All these features, in addition to the transition zone along the runway, are schematically shown in figures (3) and (4).

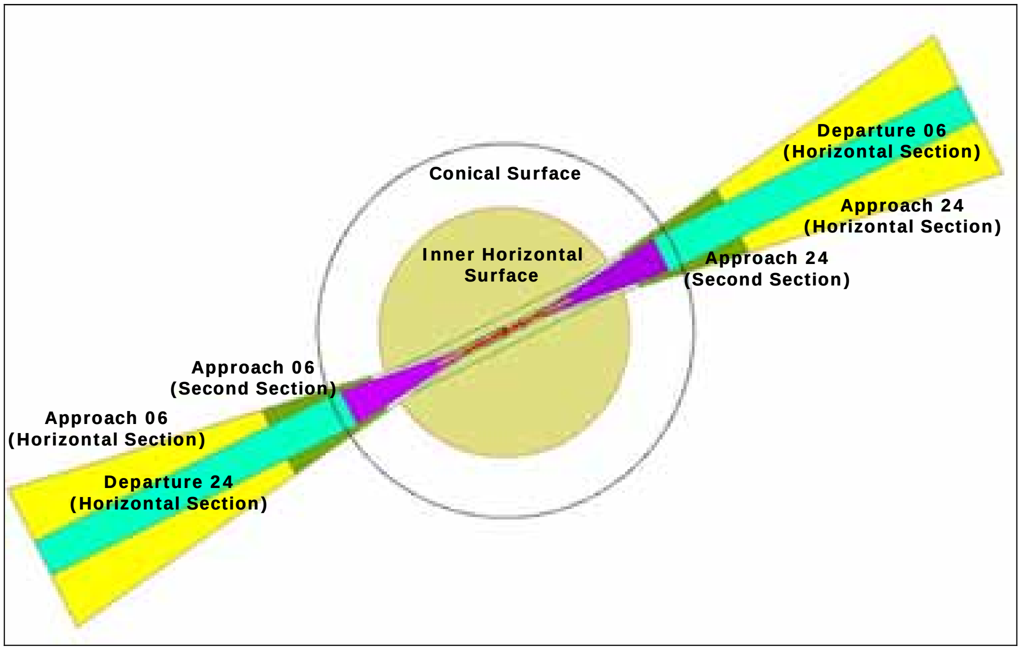

Figure (3): Two-dimensional mapping of the obstacle limiting surfaces for Kleia'at airport as per ICAO requirements of tables (1) and (2).

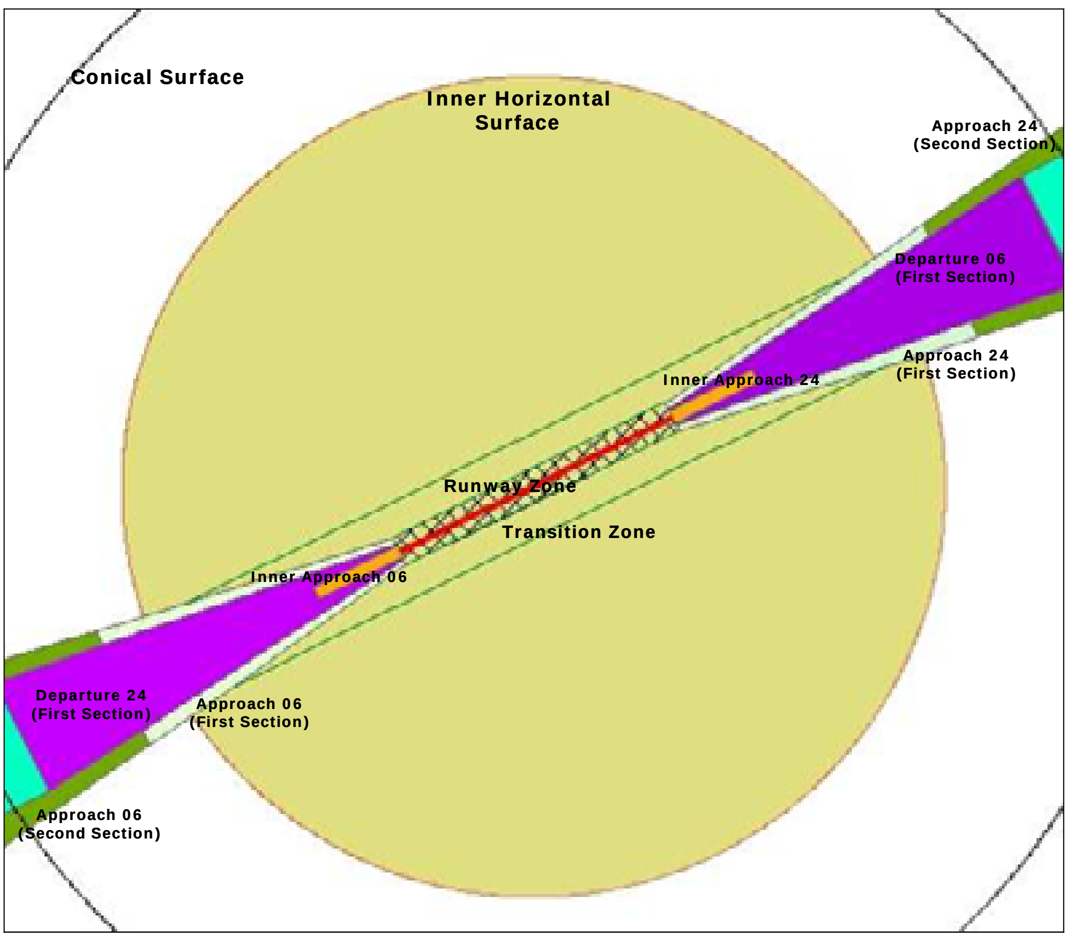

Figure (4): A magnified map of the Inner Horizontal Surface and the underlying obstacle limiting surfaces

4.3 Three-Dimensional Modeling

Once the 2-D GIS model of the obstacle limiting surfaces was ready, appropriate elevations of the various points defining those surfaces were fixed. In particular, the airport reference point was set at 7 m above sea level, while the edges of the runway zone either side of the thresholds were set at 5 m and 13 m. The elevations of the boundaries of the various sections of the approach and departure clearance surfaces were also given. The upper level of the transition zone was made to intersect with both the departure surfaces as well as the inner horizontal surface at 45 m above ground level as required by table (1). Around the latter, the conical surface projected upwards and outwards to 100 m at a rate of 5%. The 3-D model is shown in figure (5) below.

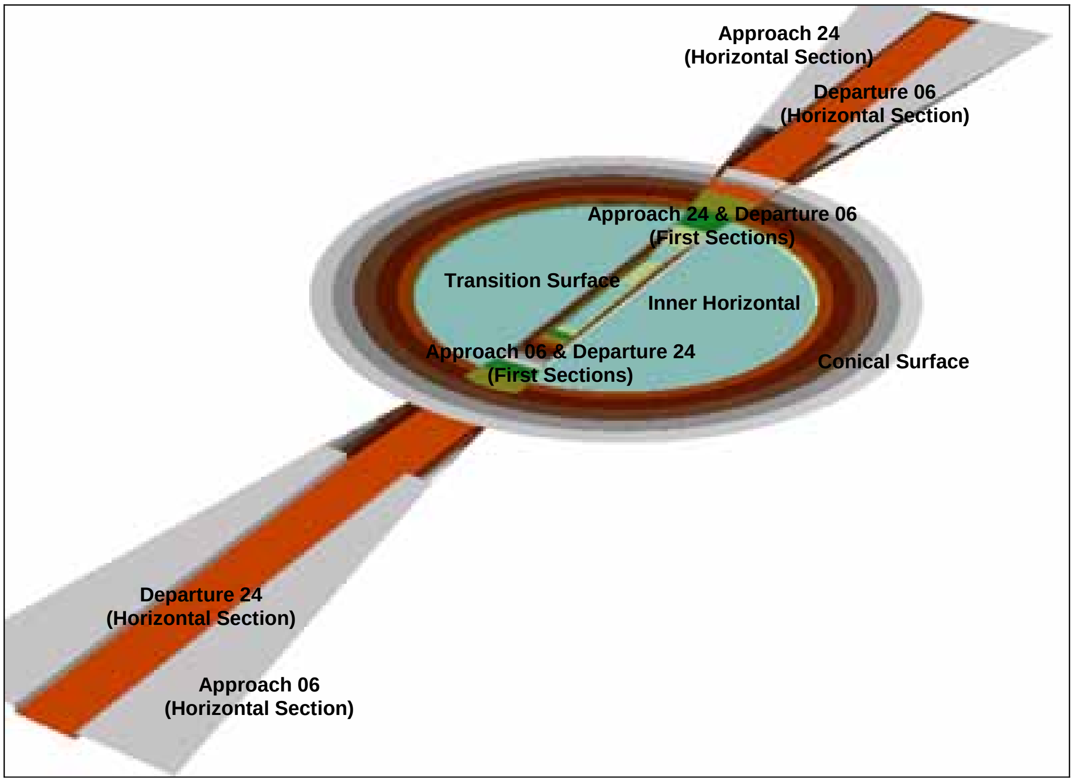

Figure (5): The three-dimensional model of the obstacle limiting surfaces of Kleia'at airport

5. Sample Results and Discussion

The GIS model has made it possible to clearly assess the geometry of the obstacle limiting surfaces for Kleia'at airport. As such, maximum permitted obstacle elevations, such as high-tension cables, aerials, built up structures, etc. under these surfaces could be obtained with relative ease and accuracy as a function of their distance from the airfield and the height of the terrain from sea level.

The GIS model also permitted the identification of the cadastral areas which are subject to zoning restrictions, and these are given in figure (6). Consequently, it becomes adamant that the airport authority and the Civil Aviation Authority work with these municipalities to ensure that the aerial zoning criteria are properly implemented.

Also from the figure, it is evident that the airport conical surface as well as parts of the Departure 06 and Approach 24 surfaces extend beyond the Lebanese northern border with Syria. This makes it essential that bilateral discussions on the subject are initiated between the two countries to ensure safety of aerial operation.

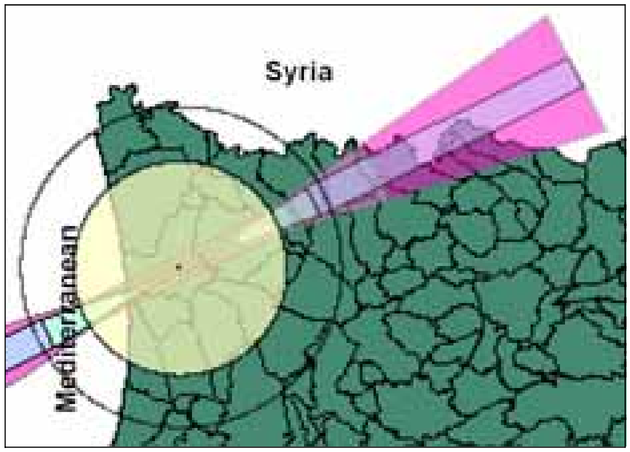

Figure (6): Cadastral areas in north Lebanon affected by the aerial zoning of Kleia'at airport

Figure (7) shows a 3-D view of the approach, departure and transition surfaces as they are distributed over the north-easterly Lebanese terrain. Such a representation on the GIS permits the difference between the terrain and limiting surface elevations to be acquired and the subsequent deduction of obstacle height limits at any location beneath the surfaces. Of course similar representations could be obtained for the inner horizontal and conical surfaces.

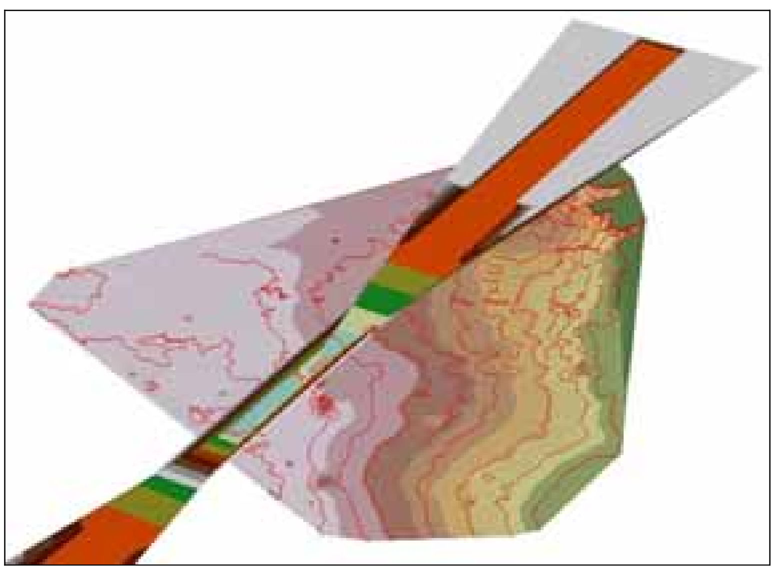
Figure (7): The runway zone and the approach and departure surfaces shown relative to the surrounding terrain

6. Conclusions

In this paper, the powers of GIS were harnessed for purposes of aerial navigation and aerial zoning in Lebanon. The application of GIS to Kleia'at airport made it possible to visualize the complicated 3-D geometries of obstacle limiting surfaces and served in the identification of areas that are subject obstacle height restriction around the airfield. It was found that the obstacle limiting surfaces extended well beyond the Lebanese border.

It is essential that the procedures discussed herein be applied to the other Lebanese aerodromes and be regularly updated to meet with new ICAO requirements. Moreover, the work should be extended to incorporate existing obstacles to ensure that they meet the required standards and be used as a decision support system for erecting future installations in the aerodrome proximity. Additionally, the available GIS can easily be used as a tool to manage the airport facilities, pavements and civil works.

Acknowledgements

The authors would like to thank the following organizations and persons:

- The Lebanese Air Force Command and the LAF cadet officers who helped in the work.
- The University of Balamand for providing its facilities for the success of the present work.
- Students of the University of Balamand who, through their dedication and enthusiasm, made this work possible.

References

1. "GIS for DCA", Dubai Department of Civil Aviation, Special Achievements in GIS, 22nd ESRI International User Conference July 8–12, 2002, http://gis.esri.com/uc2002/sag/list/index.cfm
2. "Airport Management and Development System", Arafa, M. R., Zanaty, A.A., Hasan, L.M., Paper No. 2259, 25th ESRI International User Conference, San Diego, CA, USA, July 25-29, 2005.
3. "Birdstrike Data with ArcView at Santa Barbara Airport", Iza, S., Paper No. 1178, 24th ESRI International User Conference, San Diego, CA, USA, August 9–13, 2004.
4. "Remote Sensing for Airport Development and Transportation Planning", ISPRS Symposium: Integrated Remote Sensing at the Global, Regional and Local Scale, Denver, CO, USA, 10-15 November 2002. http://www.isprs.org/commission1/proceedings02/paper/00084.pdf
5. "International Standards and Recommended Practices, Aerodromes, Annex 14 to the Convention on International Civil Aviation", Vol. I: Aerodrome Design and Operations, International Civil Aviation Organization, Second Edition, July 1995.