SIERRA LEONE CIVIL AVIATION AUTHORITY

ADVISORY CIRCULAR

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Aerodrome Site Selection

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1 GENERAL

Sierra Leone Civil Aviation Authority Advisory Circulars from Aerodrome and Ground Aids (AGA) Division contains information about standards, practices and procedures that the Authority has found to be an Acceptable Means of Compliance (AMC) with the associated Regulations.

An AMC is not intended to be the only means of compliance with a Regulation, and consideration will be given to other methods of compliance that may be presented to the Authority.

1.1 Purpose

This Advisory Circular describes the process of selection and evaluation including an assessment of the shape and size of the area required for the airport, the location of sites having potential for development, and an examination and evaluation of alternative sites.

1.2 Description of Changes

This AC is the first to be issued on this subject

1.3 References

(a) SLCAR Part 14A – Aerodrome Design and Operations Standards

(b) SLCAR Part 14E – Establishment of Aerodromes

(c) ICAO Doc 9184 Part 1 – Airport Master Planning

(d) ICAO Doc 9157 Part 1 – Runways

(e) ICAO Doc 8168 Part 1 - PANS-OPS

1.4 Cancelled Documents

Not Applicable

2 AERODROME PLANNING

The contents of this Advisory Circular only serves as a guide to advise airport consultants, engineers, and planners on aerodrome development. Detailed planning, facilities' design and construction rest with the aerodrome owner, in line with the applicable regulations.

However, to achieve the desired objectives of a viable aerodrome, planning is key to identifying all the requirements needed to economically design the airport facilities.

Planning provides the sound foundation necessary for realization of the maximum advantages of good design, prudent investment and efficient operations and management. Planning of airports is complicated by the diversity of facilities (such as; runways, taxiways, aircraft aprons, passenger terminal buildings, technical building, Control tower, perimeter fence and access gates, AIS and Aero-met Briefing Room, Meteorological stations, Firefighting station, utilities building and parking areas for aircraft maintenance, roads, parking area for vehicles used by passengers, aircraft operators and all occupants of the airport, and cargo buildings) and services which are necessary for the movement of aircraft, passengers, cargo and ground vehicles associated with them, and the necessity to integrate their planning.

The type of operations at a particular aerodrome dictates the size and facilities needed to be provided.

2.1 Planning Procedures

Planning procedures for the individual facilities which make up a total airport are the same for any airport master plan.

The major stages for airport planning are:

2.1.1 Forecasts:

Develop long-term forecasts covering aviation operational, economical and other factors on which future planning of the proposed aerodrome can be based.

The Forecast should be provided to justify the need and capacity required, by carrying out appropriate survey to acquire statistical data of people that have travelled by air, and the extent of cargo movement for at least in the last two (2) years or more.

Furthermore, the forecast should also be extended to those that are interested in travelling by air as well as estimating the population and economic viability that will aid the forecast, and any other information that may be needed.

2.1.2 System concepts:

Develop concepts for the basic systems of operation and identify the developments that will be required to meet the forecast needs of all airport users. In addition, stating the type of operation (day light only or including night operations) will determine the extent and type of facilities required to support the desired system.

2.1.3 Airport master plan:

Determine an ultimate over-all layout that will best exploit the potential of the site, making the fullest use of any natural features, bearing in mind the physical characteristics of every element involved in the intended aerodrome. Priority should be given to the location of the control tower with respect to 360 degrees azimuth view, RFFS station, security and other related facilities and services.

2.1.4 Airspace evaluation:

Critical examination of the airspace over the proposed aerodrome to ensure safe and economical flight operations is required. This can be achieved considering the critical designed aircraft, topography of the supposed control area or terminal area, any adjacent aerodrome, establishment of the visual segment surface (VSS) to determine fly-ability into the aerodrome, as well as determination of the location of site for the type(s) of NavAids recommended for operations

3 AERODROME SITE SELECTION

The starting point in selection of an aerodrome site or the assessment of the suitability of an existing site is the definition of the purpose for which the aerodrome is required. This requires consideration of forecast future demands and the quantity and type of traffic to be accommodated. It is then necessary to define the type of aerodrome and the operational systems for the forecast passenger and/or cargo traffic. Based on this information, the actual process of site selection falls into several major steps commencing with; an assessment of the shape and size of the area required for the aerodrome, the location of sites with potential for development, and followed by examination and evaluation of these sites.

3.1 Major Steps in the Site Evaluation and Selection Process

The major steps involved in any site evaluation or selection process whether for an existing airport or for an entirely new airport includes:

(i) broad determination of the land area required;

(ii) evaluation of factors affecting airport location;

(iii) preliminary office study of possible sites;

(iv) site inspection;

(v) environmental study;

(vi) review of potential sites;

(vii) preparation of outline plans and estimates of costs and revenues;

(viii) final evaluation and selection;

(ix) report and recommendations

3.1.1 Broad determination of the land area required;

Before inspection of any potential sites, including existing sites, it is necessary to make a broad assessment of the land area likely to be required. This can be achieved by considering the space necessary for runway development which generally forms the major proportion of land required for an airport.

This requires consideration of the following factors for rough assessment of the order of magnitude of land required:

(i) runway length;

(ii) runway orientation;

(iii) number of runways;

(iv) combination of length, number and orientation of runways;

(v) suitability and siting of NAVAIDS/Landing aids; and

(vi) standard spacing between facilities most especially runway-taxiway where taxiway is parallel; runway-apron where taxiway is perpendicular to the runway to form an outline runway scheme.

3.1.1.1 Runway Length

(a) Selecting a design runway length is one of the most important decisions an airport designer makes. To a large degree, the runway length determines the size and cost of the aerodrome and controls the type of aircraft it will serve.

(b) The runway must be of adequate length to allow safe landings and take-offs by current aircraft and by aircraft expected to use the aerodrome in future operations. Runways must accommodate differences in pilot skill and a variety of aircraft types and operational requirements.

3.1.1.1.1 Factors Influencing Runway Length

(a) The following factors strongly influence the required runway length:

(i) Performance characteristics of aircraft using the aerodrome

(ii) Landing and take-off gross weights of the aircraft (MTOW)

(iii) Elevation of the aerodrome

(iv) Average maximum air temperature at the airport

(v) Runway gradient

(b) Other factors causing variations in required runway length are humidity, crosswinds and the nature and condition of the runway surface.

3.1.1.1.2 Runway Length Required for Take-off

(a) To facilitate the publication of quantitative specifications for the physical characteristics of aerodrome, the aerodrome reference code is employed consisting of two elements. As indicated in Table 1, the first element is a number based on the aerodrome reference field length, and the second element is a letter based on the aircraft wingspan and outer main gear wheel span. The code number or letter selected for design purposes is related to the critical aeroplane characteristics for which the facility is provided. For a given aeroplane, the reference field length can be determined from the flight manual provided by the manufacturer. It is noted that the airplane reference field length is used only for the selection of a code number. It is not intended to influence the actual runway length provided.

(b) In certain instances, it may be desirable to convert an existing or planned field length to the reference field length. The reference field length is computed by dividing the planned or existing length by the product of three factors representing **local elevation *Fe*, temperature *Ft*, and gradient *Fg* conditions**:

$$\textbf{Reference field length} = \frac{\text{planned or existing field length}}{Fe \times Ft \times Fg}$$

3.1.1.1.3 Required Field Length

There are three basic corrections required to be applied for calculating the lengths of runways for all types of aerodromes. These are elevation, temperature and gradient.

Correction for Elevation

The required field length increases at a rate of 7% per 1000 ft. (300m) elevation above mean sea level. Thus, the elevation factor *Fe* can be computed by the following equation:

$$Fe = 0.07 \times E + 1$$

Where:

E = airport elevation (in thousands of feet (m))

Correction for Temperature

(a) The field length that has been corrected for elevation should be further increased at a rate of 1% for every 1°C by which the aerodrome reference temperature exceeds the temperature in the standard atmosphere (15°C at sea level) for that elevation.

(b) The aerodrome reference temperature (T) is defined as the monthly mean of the daily maximum temperatures (24 hrs) for the hottest month of the year. It is recommended that the aerodrome reference temperature be averaged over a period of years. The temperature in the standard atmosphere is 15°C at sea level, and it decreases approximately 1.981 degrees for each 1000-ft (300m) increase in elevation. The equation for the temperature correction factor becomes:

$$Ft = 0.01[T\ (°\ C) - (15 - 1.981E)] + 1$$

Note:

Aerodrome reference temperature = $T_1 + \frac{T_2 - T_1}{3}$

Where:

T_1 = the monthly mean daily temperature for the hottest month of the year.

T_2 = the monthly mean of the maximum daily temperature for the same month.

The values of T_1 and T_2 for each month are determined over a period of years. On any day, it is easy to observe the maximum and minimum temperature: t_2 and t_1 respectively.

Mean Daily temperature = $\frac{t_1 + t_2}{2}$

Maximum daily temperature = t_2

For a 30-day month, therefore, Monthly Mean of Mean Temperature. T_1 = **1/30** of the thirty days value of $\frac{t_1 + t_2}{2}$ obtained once every day in the hottest month, all added together.

Similarly, Monthly Mean of Mean Temperature. T_1 = **1/30** of the thirty days value of $\frac{t_1 + t_2}{2}$ obtained once every day in the hottest month, all added together

Note - If however, the total corrections for elevation and temperature exceeds 35%, the required corrections should be obtained by means of specific study.

(c) The operational characteristics of certain aeroplanes may indicate that these correction constants are not appropriate, and that they need to be modified by results of aeronautical study based upon conditions existing at a particular site and the operating requirement of such aeroplanes.

Correction for Gradient

Where the basic length determined by take-off requirements is 900m and over, it is recommended that the runway length that has been corrected for elevation and temperature be further increased at a rate of 10% for each 1% of effective runway gradient G. This recommendation is applicable for take-off conditions when the runway code number is 2, 3, or 4. Thus, for take-off conditions for runway code numbers 2, 3, or 4, the gradient factor is:

$$F_g = (0.10G + 1)$$

3.1.1.2 Runway Orientation and Crosswind Component

(a) Determination of a runway orientation is a critical task in the planning and design of an aerodrome. The direction of the runway controls the layout of the other aerodrome facilities such as control tower, terminal building, taxiway/apron configurations, hangars etc. It is a critical task in the assessment of an aerodrome site.

(b) Due to the obvious advantages of landing and taking off into the wind, runways should be oriented as closely as practicably in the direction of prevailing winds. Aircraft may not manoeuvre safely on a runway when the wind contains a large component at right angles to the direction of travel. The point at which this component (called the crosswind) becomes excessive will depend upon the size and operating characteristics of the aircraft. In the wind analysis, determining allowable crosswind is critical, and it is the basis of the Aerodrome Reference Code (ARC) shown in table 1 below.

Table 1: Aerodrome Reference Code

Code Element 1	
Code number	Aeroplane reference field length
1	**Less than 800 m**
2	**800 m up to but not including 1 200 m**
3	**1 200 m up to but not including 1 800 m**
4	**1 800 m and over**
Code Element 2	
Code Letter	Wingspan
A	**Up to but not including 15 m**
B	**15 m up to but not including 24 m**
C	**24 m up to but not including 36 m**
D	**36 m up to but not including 52 m**
E	**52 m up to but not including 65 m**
F	**65 m up to but not including 80 m**

(c) In Chapter 3 of the SLCAR Part 14A, the allowable crosswind (in kilometers per hour and knots) is based entirely on the aeroplane reference field length (ARFL), and the maximum permissible crosswind components as:

(i) 37 km/h (20 kt) in the case of aeroplanes whose reference field length is 1 500 m or over, except that when poor runway braking action owing to an insufficient longitudinal coefficient of friction is experienced with some frequency, a cross-wind component not exceeding 24 km/h (13 kt) shall be assumed;

(ii) 24 km/h (13 kt) in the case of aeroplanes whose reference field length is 1 200 m or up to but not including 1 500 m; and

(iii) 19 km/h (10 kt) in the case of aeroplanes whose reference field length is less than 1200 m.

(d) The SLCAR Part 14A section 3.1.1 requires that runway(s) shall be oriented so that the usability factor of the aerodrome is not less than 95% minimum. (The usability factor is the percentage of time during which the use of the runway system is not restricted because of an excessive crosswind component.) Where a single runway or set of parallel runways cannot be oriented to provide a usability factor of at least 95%, one or more crosswind runways may need to be provided.

(e) After the maximum permissible cross-wind component is selected, the most desirable direction of runways for wind coverage can be determined by examination of the wind characteristics for the following conditions:

(i) The entire wind coverage regardless of visibility or cloud ceiling; and

(ii) Wind conditions when ceiling is between 60 m and 300 m and/or the visibility is between 0.8 km and 4.08 km.

3.1.1.2.1 Weather Data

(a) Weather records should be obtained from the Sierra Leone Meteorological Agency. The wind velocities are generally divided into 22.5 degree increments 16 points of the compass. The weather records contain the percentage of time certain combinations of ceiling and visibility occur e.g. ceiling, 500 to 274 m; visibility, 4.8 to 9.7 km, and the percentage of time winds of specified velocity occur from different directions, e.g. NNE, 4.8 to 8.5 km/h (2.6 to 4.6 kt). The directions are in reference to true north.

(b) Wind data for an entirely new location may not be available. If that is the case, records of nearby measuring stations should be consulted. If the surrounding area is fairly level, the records of these stations should indicate the winds at the site of the proposed aerodrome. If the terrain is hilly however, the wind pattern is often dictated by the topography, and it is dangerous to utilize the records of stations some distance from the site. In that event, a study of the topography of the region and consultation with long- time residents may prove useful.

3.1.1.2.2 Wind Rose Analysis

(a) The orientation of the runway is in part the result of the aircraft performance characteristics. On take-off and landing, aircraft must fly in the direction of the prevailing wind.

(b) The convention for numbering runways is to provide a runway designation number which is the azimuth of the runway in degrees from magnetic north divided by ten. A graphical procedure utilizing the “wind rose” is typically used to determine the “most appropriate” runway orientation insofar as prevailing winds are concerned, as depicted in Figure 1. Wind roses are based on true north orientation.

3.1.1.2.3 Optimizing Aerodrome Runway Orientation

(a) Any of the under listed methods can be used to analyze the wind rose that is generated from the available weather data in order to have the best aerodrome runway orientation.

(b) However, the applicant’s report of the wind rose analysis must show/record the crosswind component of each of the available orientation leading to the choice of the preferred orientation.

3.1.1.2.4 Wind Rose Analysis – The Conventional Approach

(a) A conventional approach often used in determining the runway orientation is called the wind rose method. The method uses a wind rose template to arrange velocity, direction, and frequency of wind occurrences within a certain period of time **(between 5-10 years)**.The directions of the runways can be determined graphically as follows;

(b) Example: assume that the wind data for all conditions of visibility are those shown in Table 2. From these data a wind rose can be plotted as shown in Figure 1.

The percentage of winds which corresponds to a given direction and velocity range is marked in the proper sector on the wind rose. Optimum runway directions can be determined from the wind rose by the use of a strip of transparent material on which three parallel and equally spaced lines have been plotted. The middle line represents the runway centre line, and the two outside lines are tangent to the selected allowable cross-wind component

(c) The transparent strip is placed over the wind rose in such a manner that the centre line on the strip passes through the centre of the wind rose. With the centre of the wind rose as a pivot point, the transparent overlay is rotated until the sum of the percentages included between the outside lines is a maximum. When one of the outside lines on the transparent strip divides a segment of wind direction, the fractional part is estimated visually to the nearest 0.1 per cent. This procedure is consistent with the accuracy of the wind data.

(d) The next step is to read the bearing of the runway on the outer scale of the wind rose where the centre line on the transparent strip crosses the direction scale. Because true north is used for published wind data, this bearing usually will be different from that used in numbering runways which are based on the magnetic bearing. In reference to Figure 1, it will be noted that a runway oriented 150 to 330 degrees S30°E true will permit operations 95 per cent of the time with the cross wind components not exceeding 24 km/h or 13 kt.

(e) Thus far the procedure has been illustrated as it applies to wind records with a velocity break at 24 km/h or 13 kt. However, it can also be used to obtain estimates of wind coverage for any other velocity break. The concentric circles on the wind rose are drawn to scale and represent breaks in the wind velocity data. Suppose the break was at 19 km/h instead of 24 km/h 10 kt instead of 13 kt. Then the two parallel lines representing the 24km/h or 13 kt maximum allowable cross-wind component would not be tangent to the 19 km/h or 10 kt circle but would lie outside of it. An estimate must then be made of the fractional percentage segment between the 19 km/h 10 kt circle ahead of the 24km/h 13 kt parallel lines and added to the percentage segment between the 19 km/h 10 kt circle and the 24 km/h 13 kt parallel lines and added to the percentage lying within the 19 km/h 10 kt circle.

Table 2: Wind Data

Wind direction	Percentage of winds 7~24 km/h (4~13 kt)	26~37 km/h (14~20 kt)	39~76 km/h (21~41 kt)	Total
N	4.8	1.3	0.1	6.2
NNE	3.7	0.8	—	4.5
NE	1.5	0.1	—	1.6
ENE	2.3	0.3	—	2.6
E	2.4	0.4	—	2.8
ESE	5.0	1.1	—	6.1
SE	6.4	3.2	0.1	9.7
SSE	7.3	7.7	0.3	15.3
S	4.4	2.2	0.1	6.7
SSW	2.6	0.9	—	3.5
SW	1.6	0.1	—	1.7
WSW	3.1	0.4	—	3.5
W	1.9	0.3	—	2.2
WNW	5.8	2.6	0.2	8.6
NW	4.8	2.4	0.2	7.4
NNW	7.8	4.9	0.3	13.0
Calms — (0~6 km/hr (0~3 kt))				4.6
Total				100.0

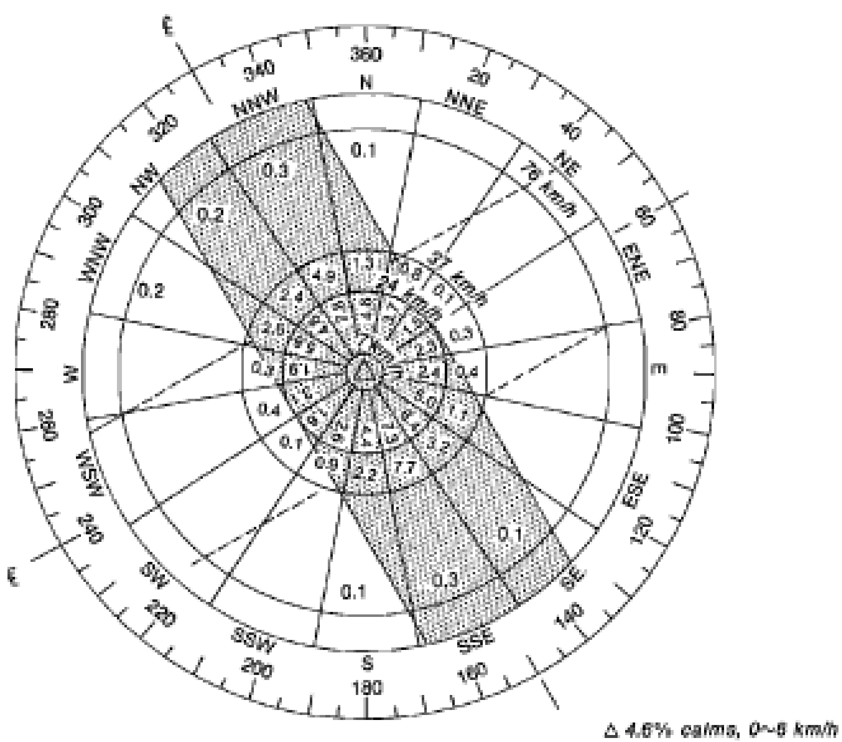

Figure 1 – Typical Wind Rose

3.1.1.2.5 Low visibility wind analysis

The next step is to examine wind data during the restricted visibility conditions cited previously, and plot a wind rose for this condition. From this analysis it can be ascertained whether the runways are capable of accepting aircraft at least 95 per cent of the time when restricted visibility conditions prevail. The analysis will also yield information on the percentage of the total time each of the conditions prevails. An example of the form on which restricted visibility data are tabulated is shown in Figure 2.

Figure 2 represents observations of winds in one compass direction only, in this instance from the northeast. The total number of observations for all compass directions is 24,081, of which 1,106 are for winds from the northeast. To complete the analysis, charts of this type would have to be plotted for other compass directions. For the purpose of this example, it was assumed that a ceiling of 290 m was equivalent to 300 m. The circled number 7 means that there were seven observations made when the wind was from the northeast with velocities varying from 8 to15 km/h(4 to 8 kt), ceiling between 0 and 30 m, and visibility between 0 and 400 m. The crosshatched area conforms to the ceiling and visibility criteria previously cited.

NE wind								Total observations: 24 081	
Ceiling groups in metres	Velocity groups in km	Visibility — metres							
		0~400	400~800	800~1 200	1 200~1 600	1 600~2 400	2 400~4 800	4 800+	Total obs.
300	1~7	4		1	2	4	14	202	227
	8~15	1	5	1	3	6	17	383	416
	16~23	2			1		5	277	285
	24~47							114	114
	48+								
	Total	7	5	2	6	10	36	976	1 042
180 thru 270	1~7		1			1		1	3
	8~15			1	1	1	1	8	12
	16~23				1		3	4	8
	24~47								
	48+								
	Total		1	1	2	2	4	13	23
150	1~7			1				1	2
	8~15						2		2
	16~23								
	24~47								
	48+								
	Total			1			2	1	4
120	1~7			1					1
	8~15				1	1	2		4
	16~23						1		1
	24~47								
	48+								
	Total			1	1	1	3		6
90	1~7	1	1		1	1	1		5
	8~15	1						1	2
	16~23						1	1	2
	24~47								
	48+								
	Total	2	1		1	1	2	2	9
60	1~7					1			1
	8~15	1	1	1			1	1	5
	16~23						1		1
	24~47				1				1
	48+								
	Total	1	1	1	1	1	2	1	8
30	1~7	3							3
	8~15	(7)	1						8
	16~23		3						3
	24~47								
	48+								
	Total	10	4						14
	% by velocity groups		1.6~7 km 10	8~15 km 19	16~23 km 12	24~47 km 5	48 km		

Observations to be considered because of ceiling conditions

Observations to be considered because of visibility conditions

Observations to be considered because of ceiling and visibility conditions

Figure 2 – Sample data for analysing wind coverage in a specific direction during periods of restricted visibility

3.1.1.2.6 Wind Rose Analysis – The Airport Design Software

The Federal Aviation Administration (FAA) developed a program as part of the Airport Design Software to help users determine the orientation of runways (FAA 1989). The program provides a spreadsheet template for the calculation of the percentage of wind coverage given inputs of wind data and runway direction specified by the user. The program is useful to automate the optimization process of runway orientation. However it does not consider the "partial coverage" issue and lacks graphical capabilities to allow users to determine the partial coverage and display the suitable alignment.

3.1.1.2.7 Wind Rose Analysis – The GIS-Based Wind Rose Method

The best type of wind rose method is the GIS-based wind rose method. The GIS-based wind rose method takes advantages of GIS spatial analysis functions to deal with the partial coverage problem. By formulating the wind rose and runway templates as GIS themes, the new wind rose method avoids intensive geometric computations involved in solving the partial coverage problem.

3.1.1.3 Number of Runways

(a) ICAO Annex 14, Chapter 3 and Attachment A, contains information regarding the factors affecting the number of runways. A sufficient number of runways are required to meet the forecast aircraft traffic demand, i.e. the number of aircraft, mixture of aircraft types and the mixture of arrivals and departures to be accommodated in one hour during the busiest periods.

(b) The 95 per cent usability specified in SLCAR Part 14A with regard to surface cross-wind velocity is a minimum. At busy airports, an inability to operate for the remaining period of 5 per cent, potentially 18 days per year, can represent a serious disadvantage. Consequently, in addition to the primary runways, one or more secondary runways may need to be planned to accommodate aircraft traffic under strong cross-wind conditions. Secondary runways may be provided where airport maintenance work is considered likely to prove disruptive to the regularity of air service desired. However, as cross-wind runways would require to be used only under high headwind components, their length can be considerably shorter than the main runways.

3.1.2 Evaluation of factors affecting airport location:

While considering airport development, the following factors should be considered and documented.

3.1.2.1 Aviation activity

Consult aircraft operators, potential operators, and pilot organizations

3.1.2.2 Development of surrounding area:

Contact the relevant planning authorities and agencies to obtain plans of existing and future land use.

3.1.2.3 Atmospheric conditions:

Obtain data on presence of fog, haze, smoke, etc., which may consequently reduce visibility and the capacity of an aerodrome. List any special local weather factors; for example, variations in weather pattern, prevailing winds, fog, low cloud, rainfall, turbulence, etc.

3.1.2.4 Accessibility to ground transport:

Note the location of roads, railways, and public transport routes.

3.1.2.5 Availability of land for expansion of an existing aerodrome or for the establishment of a new aerodrome:

Availability of suitable land for the future expansion of an aerodrome is necessary. Study aeronautical, land, road and topographical maps and aerial photographs, etc. Study topographical maps to ascertain areas with suitable slopes and drainage. Review geological maps showing distribution of soil and rock types. Ascertain location and availability of construction materials, quarries, etc. Ascertain general land values for various areas and usage such as residential, agricultural, pastoral, and industrial.

3.1.2.6 Topography:

Note significant factors affecting cost of construction such as the need for excavation or filling, drainage and poor soil conditions.

3.1.2.7 Environment:

Note locations of wildlife reserves and migratory areas. Also note noise-sensitive areas such as schools and hospitals.

3.1.2.8 Presence of other airports:

Note locations of existing airports and ATS routes together with their associated airspace and any future plans to change them.

3.1.2.9 Availability of utilities:

Note locations of main power and water supplies, sewage, telephone services, fuel, etc.)

3.1.3 Preliminary office study of possible sites:

After the approximate size and type of aerodrome has been determined as in section 3.1.1 above and locational factors have been tabulated as section 3.1.2 above, the next step is to analyze these factors, and having done so, to plot possible new aerodrome sites or additional land requirements for an existing aerodrome, on charts and maps. This preliminary study should eliminate undesirable sites or determine the adequacy of an existing site before costly site inspections are undertaken.

3.1.4 Site inspection:

After listing all the potential sites considered worthy of further investigation, a thorough field and aerial inspection is required to provide a basis for assessment of the advantages and disadvantages of each site. Airports should be sited so that aircraft operations can be carried out efficiently and safely, so that they are compatible from a social viewpoint and so that the cost of development is kept at the optimum level, taking all factors into account. The factors of major importance may be grouped under operational, social and cost considerations.

3.1.4.1 Airspace Operational Considerations

(a) The SLCAR Part 14A and the Procedures for Air Navigation Services - Aircraft Operations contains detailed information on holding and approach-to-land procedures and instrument approach systems and aids - procedures and obstacle clearances.

(b) Adequate airspace is so important for the efficient operation of an airport that special attention is required to ascertain that each site is satisfactory in this regard and, if not, to determine the extent and likely effect of any restrictions. A site close to a demand centre but with some restrictions on airspace may be preferable to a site with no airspace restrictions but so remote or difficult of access that it creates little or no traffic demand. Such factors have to be weighed to achieve the best balance. When two airports have to share the same airspace, their combined aircraft movement rates may be restricted.

(c) Instead of being able to operate completely independently of each other to the limit of their individual capacities it will be necessary to phase aircraft movements, each airport with the other, in order to maintain the necessary physical separation between aircraft. Therefore, new airports should be located so that any overlap with the airspace required for aircraft using other airports, and the resultant limitation of total capacity, is minimized. For the same reason, potential airport sites need to be studied in relation to ATS routes so that similar problems are avoided.

3.1.4.2 Obstacles

(a) Details of obstacle restriction requirements are included in SLCAR Part 14A. The SLCAA-AC-AGA011 Rev01 - Control of Obstacles, provides further information including guidance on obstacle surveys.

(b) In general, because of the large areas of land involved - 15 km on the axes of runways from the airport boundary, it is difficult to obtain sites which provide all the clearances desired and, consequently, features such as high terrain, trees and structures which constitute obstacles need to be avoided. It is important to maintain clearance from masts and similar inconspicuous skeletal structures because, although marking and lighting can assist in directing attention to them, it does not offer complete protection particularly during conditions of reduced visibility.

(c) Any objects which limit the available flight path may limit the efficiency of operations. If tall structures exist in, or near, areas otherwise suitable for instrument approaches, non-standard procedure heights may need to be adopted, with consequent effect on the duration of approach procedures and the demand of useful altitude allocations to aircraft in associated holding patterns. Such structures may furthermore limit desirable flexibility of radar vectored initial approaches and the ability to turn en-route during the departure climb.

(d) In assessing the potential of any site to provide clear approaches, the approaches should be gauged against the maximum runway lengths envisaged in the master plan. If the site is suitable for maximum planned lengths, it will likely place few restrictions, if any, on earlier phases of the plan.

3.1.4.3 Hazards

Local factors can be important in relation to the location of individual sites. For instance, industry can produce smoke which may be concentrated in certain directions by the prevailing wind. As a result, visibility in some areas may be restricted and VFR operations precluded. Sites adjacent to wildlife reserves, lakes, rivers and coastal areas, refuse dumps and sewage outfalls, etc., may not be desirable because of the danger of aircraft collision with birds. This is of special importance where faster, larger aircraft are involved. The location of sites relative to the migratory patterns and routes of birds, especially large birds such as swans and geese also requires consideration. The SLCAA-AC-AGA010A Rev01 – Wildlife Hazard Management, contains detailed information on assessing the potential bird hazard at a site.

3.1.4.4 Weather

Weather conditions can vary significantly between sites in the same general area. Wind distribution in association with visibility and ceiling are of primary importance in deciding on runway orientation and the need to make provision for operations under all-weather or only visual conditions. Particular localities may be subject to fogs, turbulence or higher rainfall which can affect the efficiency and regularity of operations.

3.1.4.5 Approach and landing aids

For details of visual aids, see ICAO Annex 14, Chapter 5 and the Aerodrome Design Manual, Part 4. See SLCAR Part 10A for references regarding siting and clearance requirements for radio-navigation non-visual aids. Aids to navigation, approach and landing are an essential element of the air transport system. Non-visual electronic aids for guidance, especially under low cloud ceiling and restricted visibility conditions, are more significant from an airport siting viewpoint because of the clearances required from objects power lines, large buildings, moving vehicles, etc., which can affect their reliability of operation. They have to be sited relative to the airports, airspace and aircraft flight paths to be served and potential sites should include suitable areas for their installation.

3.1.4.6 Social Considerations

Airports need to be sited very carefully relative to adjacent populated areas, and runways should be aligned so that flight paths do not pass over concentrations of population while aircraft are below certain heights. However, airports also need to be located adjacent to the towns and commercial areas they serve. Generally, a compromise between these two opposing principles will be required to obtain the site with the best over-all merit.

3.1.4.7 Proximity to demand centres

Airports should be conveniently situated in terms of travelling time and distance from both existing and future population centres and the commercial and industrial areas which they are intended to serve. The location of potential sites requires consideration, therefore, from the over-all viewpoint of passengers, shippers of air cargo, aircraft operators and staff, labor force, etc. The acceptability of the location of a site relative to the areas it serves can be measured in terms of journey time and cost. As a guide to the relative merits of individual locations, time contours for the various travel modes can be drawn in relation to the centres of the various areas of demand. For example, by considering road transport and the speed limits on roads connecting the areas of demand, time contours in convenient increments of, say, 5 to 10 minutes can be plotted for both present and future.

3.1.4.8 Ground access

(a) Fast and convenient access facilities for passengers and freight are essential for an airport to provide efficient service. Potential airport sites with inefficient or inadequate transport systems which do not permit smooth flow of traffic at all times will necessitate expenditures to overcome these deficiencies. Locations offering convenient connection to an adequate road network, and, as appropriate railways and waterways, are preferable, all other factors being equal.

(b) The authorities responsible for roads and public transport systems should be informed of any proposals for construction of new airports and major extensions to existing airports during the early stages of investigation. Their assistance should be sought in acquiring details of existing facilities and their planned development. This will ensure that these authorities are fully informed and will establish an environment for future co-operation.

(c) When ground travel times are approximately equal between several potential sites, the journey cost is a major factor. The convenience of passengers who travel by surface to the airport is also a point for the most careful consideration. For example, a multi-lane road with limited cross traffic is obviously preferable to a congested road with numerous traffic lights or a narrow mountainous road. In addition to private motor vehicles, it is important to take account of public transport systems such as public bus, rail, taxi or, in certain cases, vertical or short take-off V/STOL aircraft.

3.1.4.9 Noise

(a) Aircraft noise in the vicinity of airports is a serious problem. Factors to be included in airport planning include the measurement and description of aircraft noise, land-use control, ground run-up and flight noise abatement operating procedures, aircraft noise certification, human tolerance to aircraft noise, the effect of increased traffic and the introduction of future aircraft types on noise in the vicinity of airports.

(b) It is not always feasible to site an airport sufficiently far away from population centres to prevent an adverse social reaction. Remotely located airports are both unrealistic and costly and defeat the objective of reducing over-all door-to-door travel times. It is important, therefore, to obtain or control sufficient land to overcome or reduce the noise problem for both the airport and the population. The potential degree of noise disturbance needs to be assessed in terms which will indicate the relationship between the level and duration of the noise exposure and human reaction.

(c) In attempting to assess the extent of future noise disturbance at potential sites, the forecast aircraft movement rate and timing of airport development, and the aircraft types and hours during which aircraft operations will take place are important. However, long-term estimates and assessments of noise disturbance can be expected to be somewhat speculative and less reliable than those for a short term. More detailed information on noise evaluation may be found in ICAO Annex 16, Volume I - Aircraft Noise.

(d) The noise level produced by aircraft operations at and around the airport is generally considered a primary environmental cost associated with the facility. Most noise exposure lies within the land area immediately beneath and adjacent to the aircraft approach and departure paths. Noise levels are generally measured through some formulation of decibel level, duration, and number of occurrences. A large number of noise measuring techniques exist see Annex 16. Proper site selection and adjacent land use planning can serve to greatly reduce, if not eliminate, the noise problem associated with the airport.

3.1.4.10 Land use

(a) The advantages and disadvantages of different sites will be influenced by the surrounding forms of land use. Airports should be located so that a compatible situation is created or preserved and existing forms of land use are not affected by aircraft operations. This may obviate the need for costly land acquisition and facilitate the introduction and administration of land control measures which may be considered necessary to avoid noise or obstruction problems. In general, sites with approaches over water, but free of bird hazards, and where aids to approach can be installed where necessary etc., should prove preferable to those locations adjacent to residential areas.

(b) In the case of a potential site where changes of land use are necessary, there may be obvious social problems and also legal and economic difficulties. Purchase or compulsory acquisition with the attendant legal technicalities and delays may be necessary in certain instances, but arrangements with the appropriate authorities to exert control of development to preserve existing compatible land use may offer less of a future problem. The Airport Planning Manual, Part 2, provides more detail on land use.

3.1.4.11 Cost Considerations

In order to achieve suitable returns from the investment necessary for their construction, airports should be located so that the cost of development work is minimized. Thus, topography, soil and construction materials, availability of services and land values are of particular importance.

3.1.4.12 Topography

(a) Topography is important because the slope of the terrain, the location and variation of natural features such as trees and water courses, and the existence of structures such as buildings, roads, overhead lines, etc., can affect the requirements for clearing, filling, grading and drainage. Natural slope and drainage of the land are important from a design and construction point of view because they determine the earthworks and grading operations necessary to produce the desired gradients and thus the cost of preparing the site. Terrain which conforms closely to desirable levels and which is well drained may produce significant cost advantages.

(b) In areas where tropical diseases are endemic, airport planning should include the practical considerations whereby the possibility of disease vectors penetrating into aircraft is nil, taking into account internationally accepted mosquito flight ranges. Recommendations in this respect are specified in the World Health Organization's Guide to Hygiene and Sanitation in Aviation referring to vector control at airports. To keep the area within the perimeter of an airport free from mosquitos in their larval and adult stages it is necessary to maintain active anti-mosquito measures within a protective area extending for a distance of at least 400 m around that perimeter. Water areas which cannot be eliminated and may breed mosquitos will need to be treated accordingly.

3.1.4.13 Soil and construction materials

Classification of natural soils at potential sites is important from a cost viewpoint. General soil surveys and sampling are necessary to allow the mapping of various soil types and to locate extensive areas of rock. The location of water supplies is also relevant because their availability and the distance over which they have to be carried will affect the cost of construction. Expert advice should be sought in these matters.

3.1.4.14 Services

Potential airport sites should, if possible, be adjacent to power and water supplies, sewage and gas mains, drainage and telephone lines, etc. Availability of these services may eliminate the need to provide them specifically for the airport and so reduce costs.

3.1.4.15 Land values

(a) Airports require adequate space for future development and the value of land is a factor to be considered. In general the demand for air transport is related to the population it serves, and, as a result, a large proportion of future airport development work can be expected adjacent to metropolitan areas. With the growth of urban populations, rising standards of living and more extensive road systems, areas occupied by metropolitan districts will continue to expand. Land values generally increase significantly as areas change from rural to urban use so that early reservation of suitable sites will often enable airports to be better located and at lower costs.

(b) Construction of new roads and utilities required for an airport often pass through, or adjacent to, unused land which then becomes attractive to develop. The number of personnel employed at larger airports creates a demand for housing and servicing industries which, if allowed to develop indiscriminately, could adversely affect the efficiency of the airport. When the suitability of a site is being considered, unless planning control over the area can be exerted to prevent its development for incompatible purposes, the question may arise whether adequate land for future development is available. Initial acquisition of all land considered necessary safeguards the possibility of future expansion and may often prove to be the cheapest course of action. However, simply comparing the estimated costs of purchasing land at the present and in the future ignores the important factor of time and is not a satisfactory basis for deciding whether to buy land in advance. Money paid immediately is worth more than money spent in the future because if expenditure is deferred, the money can be invested and produce an immediate return. A sound basis for decisions can be provided by converting future payments to a common time basis of present worth. Current land values and movements in property prices and the possibility of housing, industrial, agricultural or other developments which may increase values require consideration.

3.1.5 Environmental Study:

(a) Environmental factors should be carefully considered in the development of a new airport or the expansion of an existing one. Studies of the impact of the construction and operation of a new airport or the expansion of an existing one upon acceptable levels of air and water quality, noise levels, ecological processes, and demographic development of the area must be conducted to determine how the airport requirements can best be accommodated.

(b) Aircraft noise is the most severe environmental problem to be considered in the development of airport facilities. Much has been done to quiet engines and modified flight procedures, which has resulted in substantial reductions in noise. Another effective means for reducing noise is through proper planning of land use for areas adjacent to the airport. For an existing airport this may be difficult as the land may have already been built up. Every effort should be made to orient air traffic away from built up areas.

(c) Other important environmental factors include air and water pollution, industrial wastes and domestic sewage originating at the airport, and the disturbance of natural environmental values. An airport can be a major contributor to water pollution if suitable treatment facilities for airport wastes are not provided. The environmental study must consider how water pollution is to be overcome.

(d) The construction of a new airport or the expansion of an existing one may have a major impact on the natural environment. This is particularly true for large developments where streams and major drainage courses may be changed, the habitats of wildlife disrupted, and wilderness and recreational areas reshaped. The environmental study should indicate how these disruptions might be alleviated.

(e) More detail on land use and environment management consideration is found in ICAO Doc 9184 - Airport Planning Manual, Part 2.

3.1.6 Review of potential sites:

At this stage, sufficient information should be available to reduce the number of sites to those meriting detailed consideration. The planner should review the results of the office study and field investigation. Based on this review, sites which are unsuitable and do not warrant further examination should be omitted;

3.1.7 Preparation of outline plans and estimates of costs and revenues:

Consideration of the relative merits of the remaining sites requires:

(i) detailed site surveys, including obstacle surveys;

(ii) preparation of outline airport layouts for each site;

(iii) preparation of broad cost estimates covering the total capital and operating expenditure required including all associated off-airport items such as access roads, communications to population centres, planning control of surrounding areas and estimates of annual percentage changes in land values for the probable life of the airport; and the anticipated phasing of expenditure.

(iv) when expansion or abandonment of existing sites is in question, the determination of the depreciated and current values of any existing installations together with the value of all other off-airport associated assets including easements, public utilities, noise zones, etc.

3.1.8 Final evaluation and selection:

(a) When a number of alternative sites that complies with the applicable standards are under consideration, the question of cost plays a large part in the final choice. If all potential sites were of equal merit, logical decisions would be possible on the basis of least cost. Unfortunately, a clear-cut situation does not normally arise in practice and it is usually necessary for varying degrees of advantage and disadvantage to be weighed before reaching a decision. Economic factors are of great importance because the rate and pattern of growth of an economy are influenced not only by the level of capital investment but by the manner in which capital is used. Generally, capital is scarce and can be employed in a number of alternative ways. Capital can be wasted by diversion to uneconomic uses but when employed intelligently and efficiently, a lesser amount may achieve a given result.

(b) The site selection phase for a new airport requires an in-depth analysis of alternative sites, looking closely at such factors as physical characteristics of the site, the nature of surrounding development, land cost and availability, ground access, and the adequacy of surrounding airspace. The final choice of one site over others is often quite subjective. For example, there is probably no objective way to compare the disadvantages of increased noise in some part of the community with the advantages of improved air service for the metropolitan area as a whole. The consultant should not assume that the site selection process described here conclusively results in the selection of the best site. The “right” choice depends on how decision makers weigh various criteria.

(c) The authority responsible for financing airport development may face at any time requests to increase expenditure for many other purposes. Whatever the intrinsic merit of individual projects when considered in isolation, the problem which often occurs is that not all proposals can be accommodated simultaneously within the over-all finances available. Proposals for expenditure on airports need to be considered on their own merits, but it may also be necessary to consider them against the relative merits of competing proposals. The need for cost effectiveness has led to increasing attention being given to the measurement and weighing of benefits and costs through the technique known as cost-benefit analysis. Cost-benefit studies endeavor to compare benefits from projects with their costs in a way which overcomes the difficulties associated with the time phasing of the project. By analyzing the estimated stream of benefits and costs over the anticipated useful life of the airport it is possible to determine cost-benefit ratios which serve as a guide to the value of the project and the choice of the best site.

(d) Two different types of cost-benefit analysis are necessary - an operational cost-benefit analysis and a social cost-benefit analysis. The final evaluation requires an assessment based on the comparison of operational, social and cost efficiencies:

Operational:

(i) land availability;

(ii) airspace availability;

(iii) effect of any restrictions on operational efficiency;

(iv) potential capacity

Social:

(i) proximity to demand centres;

(ii) adequacy of ground access;

(iii) potential noise problems;

(iv) current land use and need for control measures

Cost:

(i) cost-benefit analysis

3.1.9 Report and recommendations:

A comprehensive report supported by drawings, etc., should be prepared, containing:

(i) The results of the site inspection and evaluation;

(ii) Ranking of sites in order of merit, supported by reasons for selection; and

(iii) Recommendations for further action.