GHANA

CIVIL AVIATION AUTHORITY

ADVISORY CIRCULAR
AC-AD-028

PROTECTION OF AIRPORT LANDS AND CIVIL AVIATION INSTALLATIONS

GENERAL

Ghana Civil Aviation Authority (GCAA) Advisory Circulars from Aerodrome Safety and Standards (ASAS) contain 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.

PURPOSE

This Advisory Circular provides methods, acceptable to the Authority, for showing compliance with Part 24 and Part 27 of the Ghana Civil Aviation (Aerodrome) Regulations, 2011, LI 2004, as well as explanatory and interpretative material to assist in showing compliance.

REFERENCE

The Advisory Circular relates specifically to the Aerodrome GCARs and Manual of Standards (MOS).

STATUS OF THIS AC

This is the first AC to be issued on this subject.

FORWARD

This Advisory Circular (AC) provide guidance to Aerodrome operator, Developers and Planners on the minimum standards required by GCAA for the protection of civil aviation installations (navigational aids and other telecommunications systems).

APPROVAL

Issue No : 01	Approved by: Director-General	2015

GHANA CIVIL AVIATION AUTHORITY
GCAA
DIRECTOR-GENERAL

Contents

1. GENERAL

Aerodrome Safety and Standards (ASAS) Division and of carry out assessment consultation with Air Navigation Services (ANS) Division to ensure the protection of civil aviation installations (navigational aids and other telecommunications systems).

Consultation with the Director General must take place at an early stage in the project in order to avoid costly redesign or undue pressure when seeking building and site approvals. It is recommended that consultation take place at the building concept stage, before site approval is sought.

It is the responsibility of the Director General to ensure that full co-ordination takes place with operational authorities where there is any operational impact anticipated.

2. INTRODUCTION

Airways facilities at an airport permit the safe navigation of aircraft within the airspace of an airway, and include; navigation aids along the airway and for approach and landing at aerodromes, communication facilities, meteorological facilities and air traffic control (ATC) facilities.

The airways facilities for the safe, efficient operation of aircraft in the terminal area surrounding an airport and on the airport manoeuvring area need, in most instances, to be located on or at the perimeter of the aerodrome. Some of these facilities, in particular the precision approach facilities, must be positioned in precise geometric relativity to runways or runway centerline extensions. Most facilities have associated site clearance areas surrounding the site location to ensure proper operation of the facility.

Nothing should be permitted to derogate the signals generated by any existing or planned electronic navigational aids (NAVAID) or an existing ATC facility.

The siting criteria for these facilities define the minimum requirements for uncompromised performance of each facility. In situations where non-compliance or infringement does not result in the facility being unsafe or completely unserviceable, it functions may be degraded. Such degradation may, however, necessitate the facilities removal from service.

General requirements for airways facilities are a finite site for their physical installation, i.e. shelters, foundations, towers, antennae plus a reasonable service area around the physical features. In many instances, there is also a requirement for a clearance zone around this space, in some instances relatively extensive, for the purpose of ensuring transmission of electromagnetic waves without interference from extraneous sources, or for the purpose of unimpeded vision in the cases of ATC towers or rescue and firefighting service (RFFS) stations.

Airways facilities at an aerodrome may include any or all of the following:

(a) navigation aid facilities
- o ILS (instrument landing system)
- o DME (distance measuring equipment)
- o VOR (very high frequency omni-direction radio range)
- o NDB (non-direction beacon)

(b) radar sensor sites

(c) air/ground and point-to-point communications systems including radio bearer systems and satellite communications sites

*(d) air traffic services centres

*(e) fire stations (and satellite fire station); and

*(f) ATC towers.

*Facilities that are not covered in the scope of this paper

3. OBSTACLE LIMITATION SURFACES

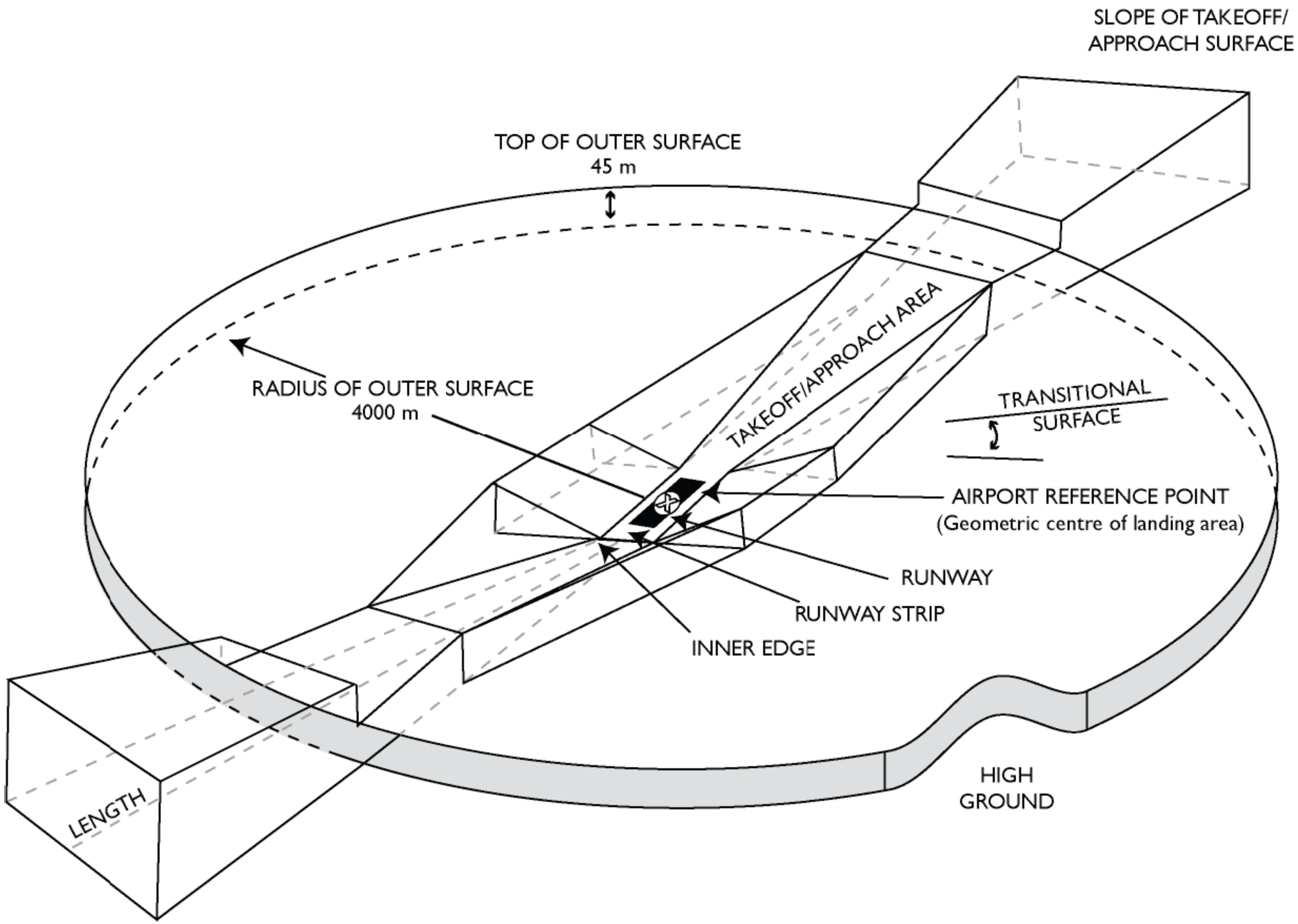

Figure 1: OBSTACLE LIMITATION SURFACES

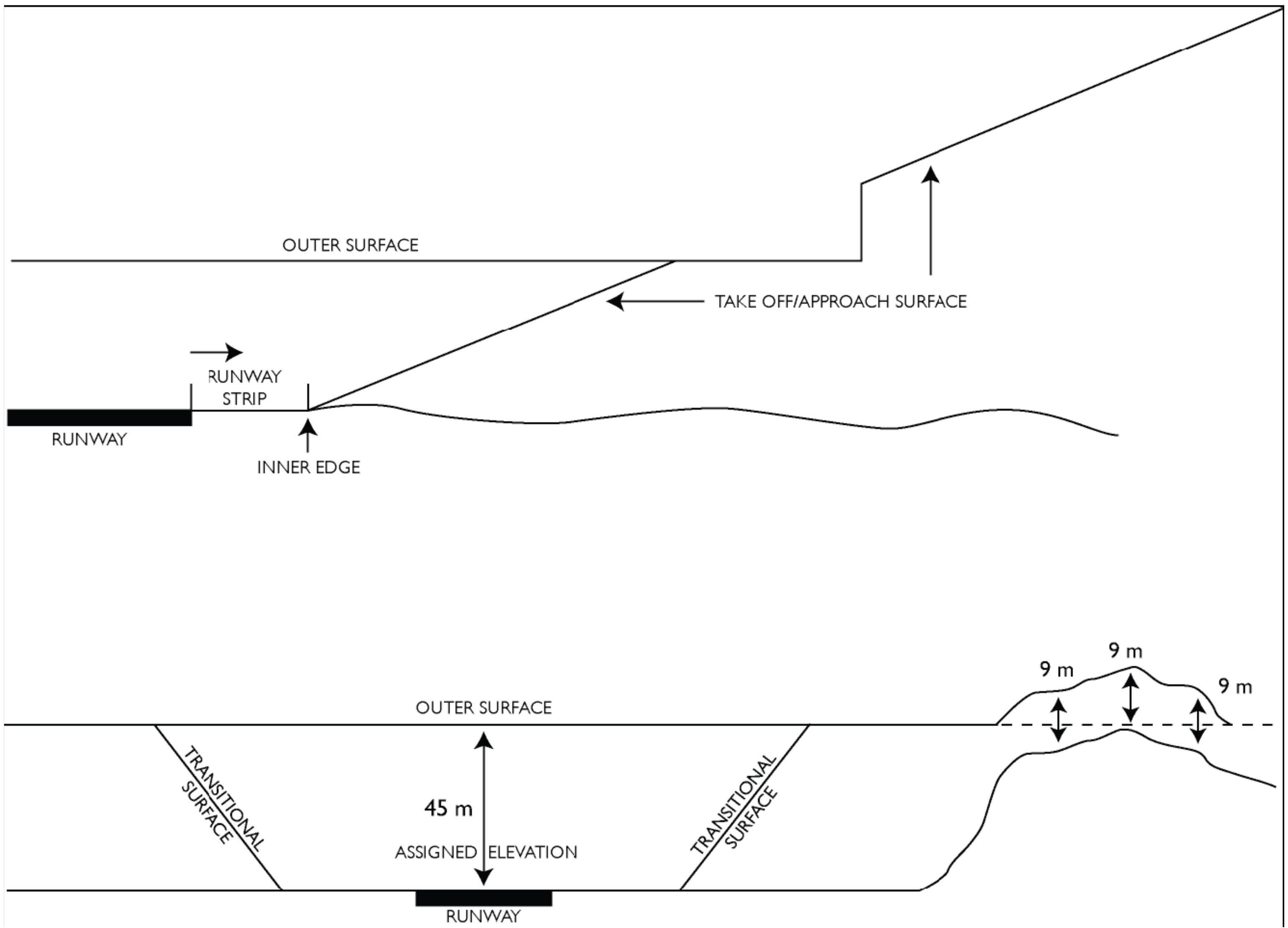
OUTER SURFACE
TAKE OFF/APPROACH SURFACE
RUNWAY
STRIP
RUNWAY
INNER EDGE
9 m
9 m
9 m
OUTER SURFACE
TRANSITIONAL
SURFACE
45 m
ASSIGNED ELEVATION
TRANSITIONAL
SURFACE
RUNWAY

Figure 2: OBSTACLE LIMITATION SURFACES (SIDE VIEW)

4. NAVIGATIONAL AIDS

The location of the radio navigation aids is largely determined by the air route or approach path on which they are to be used; they cannot normally be moved without some consequential change to or restriction placed on the approach path or air route.

There are sets of siting considerations that must be addressed when siting a NAVAID on airport property.
These include consideration of runway-associated safety elements, system object clearance areas, the footprint of the system, critical area impact on airport operations, interference to/from other systems, and installation considerations.

Except for NDBs, radio navigation aids are more complex in terms of the transmitting equipment, the antenna design and the electromagnetic fields, which are created about them. The accuracy of the paths defined by a particular navigation aid is determined not only by the transmitting facility but is largely dependent on the reflection of its signals from the objects about the facility; the terrain, vegetation, buildings, power lines, aircraft, other vehicles, fences, ditches, etc. In designing a facility, the position of these objects is taken into account. For example, sites are chosen so that these objects will provide least signal degradation; the vegetation is cleared, the ground levelled in key areas, and power lines may be moved or buried.

For the facility to remain a useful part of the airways system these environmental characteristics have to be maintained and any proposals for change need to be carefully examined.

(A) VHF OMNI-DIRECTIONAL RADIO RANGE (VOR) FACILITIES

The CAA should normally purchase an area approximately 125 m square in which to locate this equipment and then seeks restrictive easements covering two areas adjacent to the site.

- **Vehicle movements.**
  - No aerodrome roadways, taxiways, public roads, tramways and railways, trees, fences, wire lines, structures, machinery or buildings shall be closer than a 300m radius centred on the geometric centre of the site, except with the prior written consent of the Director General, GCAA and only where calculations show that the proposed obstruction has no impact on the operation of the navigational aid.

  - Vehicles used by aerodrome maintenance staff are not to be parked within a 300 m radius.

- **Restricted area.**
  - No unauthorised personnel and vehicles within a 300 m radius of the facility. Wooden signs or wooden fencing only may be used to clearly define the restricted area.
  - Movement of vehicles between the VOR building and VOR antenna is prohibited.

- **Site maintenance.**
  Grass and scrub within 150 m of the site must be mown or cut regularly.
  No grass cutting equipment to be parked within a 300 m radius of the VOR building.

- **Services.**
  All cables (e.g. power and telephone) are to be placed underground within 300 m radius of a VOR facility. Cables can be run above the ground from 300 m to 600 m radius from a VOR, if they are aligned radially to the VOR.

- **Clearance zone.**
  - No structure, building, trees, fences, towers or large continuous metallic objects such as overhead power lines, masts, water towers or large metal-clad buildings is permitted within 600 m radius of the VOR if they will extend above which will penetrate beyond above the horizontal plane as measured from the array centre or which subtend an elevation angle of one degree as seen from the VOR site. Structures which subtend an angle of greater than 1° are to be analyzed for potential interference prior to being approved.

  - The second zone is an area enclosed by a circle with a radius of 600 m centred on the geometric centre of the site but excluding the area within 300m. Within this area, the height, measured to the highest point of structures and buildings having large metal content, and wire lines and fences shall not subtend a vertical angle of more than 1.2° or extend more than above the horizontal plane as measured from the array centre. These limits may be increased by 50% for fences or lines which are essentially radial or which subtend an angle of not more than 10" measured in the horizontal plane. Wooden structures or buildings with negligible metallic content may subtend vertical angles up to 2.5°. No structures, buildings, wire lines or fences shall be permitted without written permission from the Director General, GCAA.

***Note*:**
In the event that a Doppler type VOR is used, the designated areas can be reduced by at least one half as long as the optical line-of-sight requirement of the NAVAID is retained. Advice and prior approval must be obtained from the Director General on this type of installation.

(B) DME FACILITIES

- **Vehicle movements.**
  No restriction.

- **Restricted area.**
  No restricted areas

- **Site maintenance.**
  No requirement for grass or scrub clearing, within a radius of 300 m but grass must not be allowed to grow above the height of the DME antenna mounting point on the DME mast.

- **Services.**
  - Overhead Low Vault power (LV) and control lines are allowable in the vicinity of the DME site provided that they do not project above the mounting point of the DME antenna to the DME mast.
  - Overhead 2 kV-22 kV High Vault (HV) lines must be at least 400 m distant, while HV lines in excess of 22 kV must be at least 1 km distant from the DME antenna system.

- **Clearance zone.**
  - Small structures, small buildings, overhead lines and fences are allowable adjacent to the DME antenna location within a 600 m radius, providing that they do not project above the mounting point of the DME antenna to the DME mast.
  - Larger obstructions such as multi-storey buildings, hangers, bridges, etc, may interfere with DME system performance and any proposal to erect large structures above a one degree elevation angle as seen from the DME antenna within a 5 km radius from the DME antenna location may affect the performance of the system.

(C) VHF DIRECTION FINDING SYSTEMS (VHF/DF)

Siting requirements for VHF/DF are of major importance. In particular, the equipment requires that:

- within 45 m of the site: Ground to be level ±1º and surface roughness ±30cm
- within 90 m of the site: Ground to be clear of trees, masts, metal fences and vehicles.
- within 180 m of the site: Ground to be clear of buildings, car parks and small metal structures.
- within 365 m of the site: Ground to be clear of built-up areas, hangars, railways and other metallic structures.

In general, a clear line-of-sight through shall be maintained between the antenna system and local flying aircraft.
It is essential that the DF antennae be separated from any VHF air/ground communication (transmitting) antennae to the greatest extent practical, but by at least 2 km and be separated from any antennae transmitting a high power broadcast by at least 8 km.

(D) INSTRUMENT LANDING SYSTEM (ILS)

Instrument landing system (ILS) facilities are a highly accurate and dependable means of navigating to the runway in Instrument Flight Rules (IFR) conditions. When using the ILS, the pilot determines aircraft position primarily by reference to instruments. The ILS *consists of:*

a. the localizer transmitter;
b. the glide path transmitter;
c. the outer marker (can be replaced by an NDB or other fix);
d. the approach lighting system.

ILS is classified by category in accordance with the capabilities of the ground equipment. *Category* I ILS provides guidance information down to a decision height (DH) of not less than 200 ft. Improved equipment (airborne and ground) provide for *Category* II ILS approaches.

A DH of not less than 100 ft. on the radar altimeter is authorized for Category II ILS approaches.

The ILS provides the lateral and vertical guidance necessary to fly a precision approach, where glide slope information is provided. A precision approach is an approved descent procedure using a navigation facility aligned with a runway where glide slope information is given. When all components of the ILS system are available, including the approved approach procedure, the pilot may execute a precision approach.

In all cases, it is desirable that land planners consult engineers of the GCAA concerning details of Instrument Landing Systems (ILS) installed or planned at the airport in question. As an interim measure, ILS standards will be applied for all Microwave Landing System (MLS) installations.

Generally, an ILS is made up of five major components:

- the localiser,
- glide path, and
- three markers (inner, middle and outer markers),
- remote monitor and
- locator beacons.

The component facilities perform specific functions and are separately located on the approach path to and alongside the runway they serve. Different siting requirements and restrictions to access and movement apply to each site.
The location for these components varies according to the terrain; however, typical locations are as follows;

(a)	Localizer	335 m outward from the stop-end of the runway on the extended centre line.
(b)	Glide Path	320 m (variable) in from the threshold for a 3.0° glide path. The antenna will typically be 122 m (Null Reference type) or 152 m (M-Array type) from the runway centre line, depending on the type of antenna, and may be located on either side of the runway (usually located on the opposite side of existing or planned taxiways).
(c)	Middle Marker	1050 m ±150m outward from the threshold of the runway in the approach direction and within 75 m of the extended runway centre line.
(d)	Outer Marker	7.2 km (nominal) outward from the threshold of the runway in the approach direction and within 75 m of the extended runway centre line. Limit: 6.5 km to 13 km.
(e)	Back Marker	7.2 km from the end of the runway in the departure direction and within 75 m of the extended runway centre line. Limits: 6.5 km to 13 km.

The **most significant sources of interference for ILS facilities are metallic objects** having appreciable horizontal dimensions such as structural steel towers, metal-clad buildings and power/telephone transmission lines. These objects reflect the ILS signals in unwanted directions, distorting the information provided to aircraft.

High voltage power lines and substations radiate electromagnetic noise (EMN) due to corona, gap discharge, etc. This EMN may inhibit reliable reception of ILS signals. In addition, EMN radiated by industrial-scientific medical (ISM) apparatus such as dielectric heaters and plastic welders can also interfere with the reliable reception of ILS signals.
For planning purposes, all runways should be considered to be equipped with an ILS at each end. Therefore the restrictions outlined below should be applied to both ends of the runway. The requirements listed below may affect land use outside the airport property boundary.

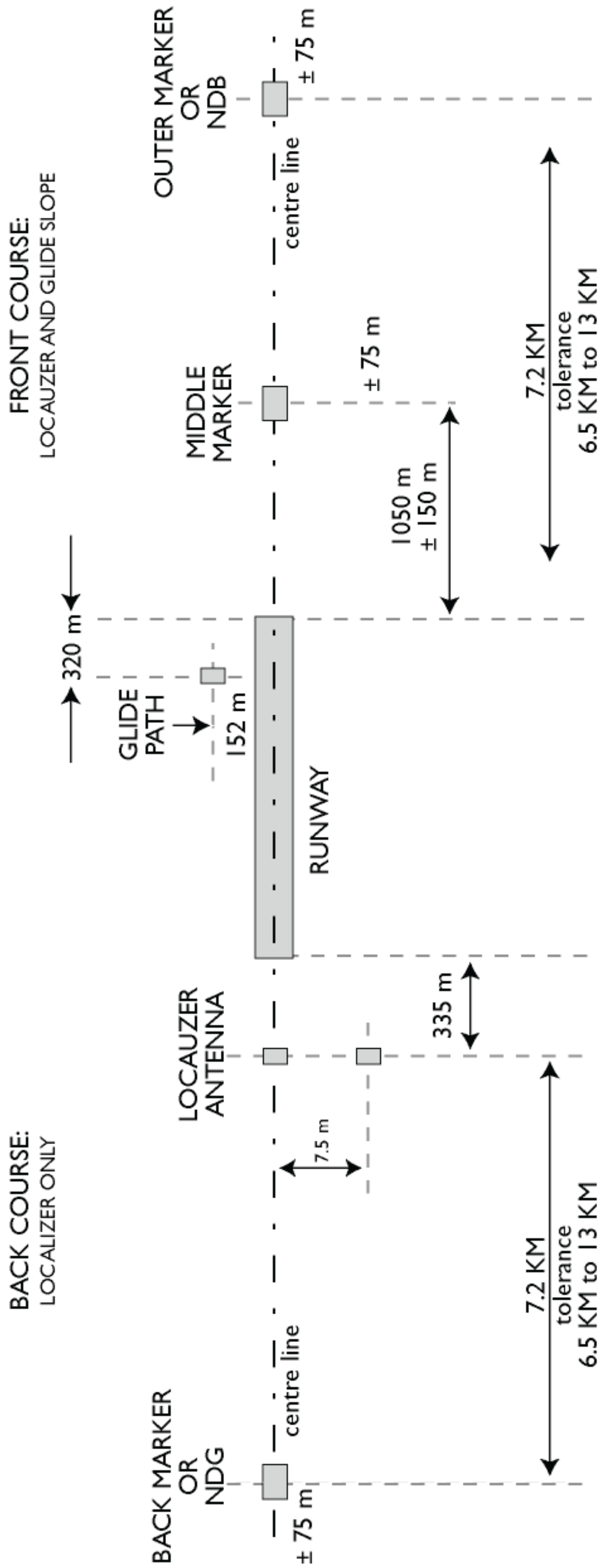

Figure 3: TYPICAL SITE CONFIGURATION

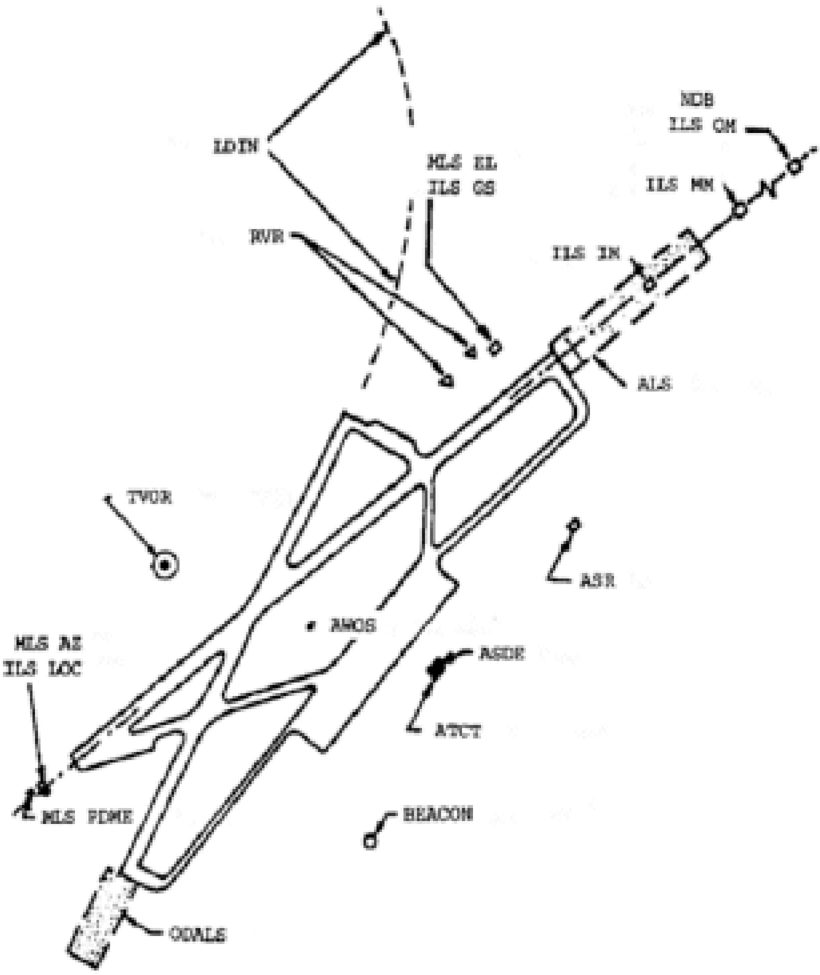

Figure 4: TYPICAL NAVAID PLACEMENT

- **Services (electromagnetic compatibility).**
  It is important to ensure that EMN radiated by power lines, substations and ISM apparatus will not interfere with the proper reception of ILS guidance signals in the approach path. Within the site areas all power and control cables must be laid underground.

  - power lines with voltages greater than 100kV should be no closer than 1.8 km from the runway centre line and no closer than 3.2 km from the ends of the runway;

  - electrical substations for voltages greater than 100 kV should be no closer than 3.2 km from the centreline of the runway and no closer than 16 km from the ends of the runway;

- power lines and substations should be designed, constructed and maintained using state of the art techniques to minimize radiated EMN in the ILS frequency bands; and

- ISM apparatus should be restricted from operating within the rectangular area extending 1.5 km on either side of the centre line of the runway to the outer markers.

Special sites or sites not conforming to the above criteria should be discussed with the Director General of the GCAA on an individual basis.

- **Construction.**
  No construction or variation to access is permitted within the critical or sensitive areas without the prior approval of the GCAA.

- **Aircraft.**
  Aircraft shall not enter or remain within a critical area whilst the ILS is in use.

- **Vehicles and Plant.**
  Vehicles and plant shall not enter nor remain within a critical or sensitive area whilst the ILS is in use. Vehicles operating within the critical area may cause the equipment to automatically shut down.

- **Road Use**.
  Approval may be granted for the use of constructed roadways where the type and size of vehicle has been assessed and determined to be acceptable.

- **Access Control.**
  Access to the critical area shall be controlled by the responsible ATC officer.

- **Signs.** Signs shall be provided to delineate the boundaries of the critical area.

- **Critical/Sensitive Areas.**
  The occurrence of interference to ILS signals is dependant on the total environment around the ILS antennas, and antenna characteristics. The environment, for the purpose of developing protective zoning criteria, can be divided into two types of area, the critical areas and the sensitive areas.

  The **critical area** is an area of defined dimensions about the localiser and glide path where vehicles, including aircraft, will cause unacceptable disturbances to the ILS performance.

The **sensitive area** is an area extending beyond the critical area where the parking and/or movement of vehicles, including aircraft, may affect the ILS performance.

(i) Localiser

- The primary component of the ILS is the localizer, which provides lateral guidance. The localizer is a VHF radio transmitter and antenna system using the same general range as VOR transmitters (between 108.10 MHz and 111.95 MHz). Localizer frequencies, however, are only on odd-tenths, with 50 kHz spacing between each frequency. The transmitter and antenna are on the centerline at the opposite end of the runway from the approach threshold.

  The localizer *back course* is used on some, but not all ILS systems. Where the back course is approved for landing purposes, it is generally provided with a 75 MHz back marker facility or NDB located 3 to 5 NM from touchdown. The course is checked periodically to ensure that it is positioned within specified tolerances.

- The signal transmitted by the localizer consists of two vertical fan-shaped patterns that overlap, at the center (see **ILS Localizer Signal Pattern** figure, below). They are aligned with the extended centerline of the runway. The right side of this pattern, as seen by an approaching aircraft, is modulated at 150 Hz and is called the "blue" area. The left side of the pattern is modulated at 90 Hz and is called the "yellow" area. The overlap between the two areas provides the on-track signal.

  The width of the navigational beam may be varied from approximately 3º to 6º, with 5º being normal. It is adjusted to provide a track signal approximately 700 ft wide at the runway threshold. The width of the beam increases so that at 10 NM from the transmitter, the beam is approximately one mile wide.

The *reception range* of the localizer is at least 18 NM within 10º degrees of the on-track signal. In the area from l0º to 35º of the on-track signal, the reception range is at least 10 NM. This is because the primary strength of the signal is aligned with the runway centerline.

Site.

- The localiser antenna is located on the extended centreline of the runway typically 400 m from the stop-end.
- The localiser shelter is generally located 90 m to the side of the antenna system.

Critical area.

- The critical area for a localiser extends 90 m either side of the runway centreline commencing from 10 m behind the localiser antenna and extending forward to a point of 360 m in front of the antenna (see Figure 1).

Sensitive area.

The sensitive area commences at the localiser antenna origin and extends forward in a sector ±10 degrees of the runway centreline. Within this sector obstructions shall be less than 0.5 degrees elevation, when measured from ground level at the antenna base (see Figure1).

Site preparation.

The critical area shall be prepared to have a lateral gradient of not greater than ±1%, longitudinal gradient of not grater than ±1% and shall be graded smooth to within ±75 mm of design levels.

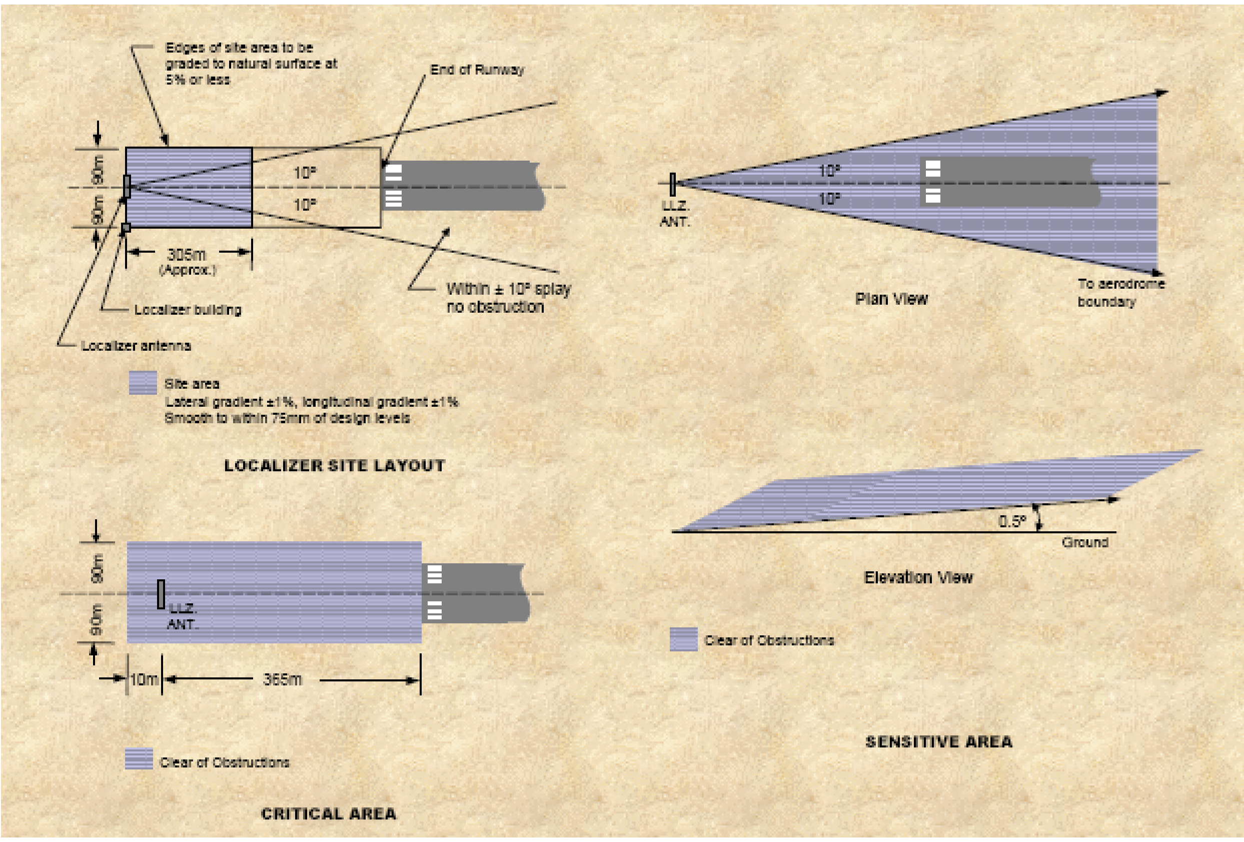

Figure 5 – LOCALISER SITE PREPARATIONS AND OBSTRUCTIONS

Figure 6 – ILS LOCALIZER SIGNAL PATTERN

Interference from Structures

Refer to Figure 4

Area A *:* Circle 75m radius centered on the localizer array. No objects higher than 1.2 m.

Area B *:* Rectangle 365m x 610 m centered on the localizer array. No metallic objects higher than 1.2 m, no non-metallic objects higher than 2.5 m.

Area C *:* The area originating at the centre of the localizer array covering an arc of 36° in the direction of the runway and terminating 6100 m from the localizer array; or to the distances specified for the takeoff approach surfaces, the transitional surfaces, and the horizontal surfaces; whichever is the lesser.

No metal-walled structure should subtend a total vertical angle greater than 0.8º, no structural steel work should subtend a total vertical angle greater than 1.6º and no non-metallic object should subtend a total vertical angle greater than 2.4°. Trees are included in this latter category. Note that these are "bottom-to-top" subtended angles measured from the antenna elements, with no reference to the horizon or the horizontal plane being meant (See Figure 5 of Navaids siting). Within the remaining 324º these restrictions can be relaxed by a factor of approximately 2. Restrictive easements are normally obtained from the GCAA in coordination with the land development authorities when necessary.

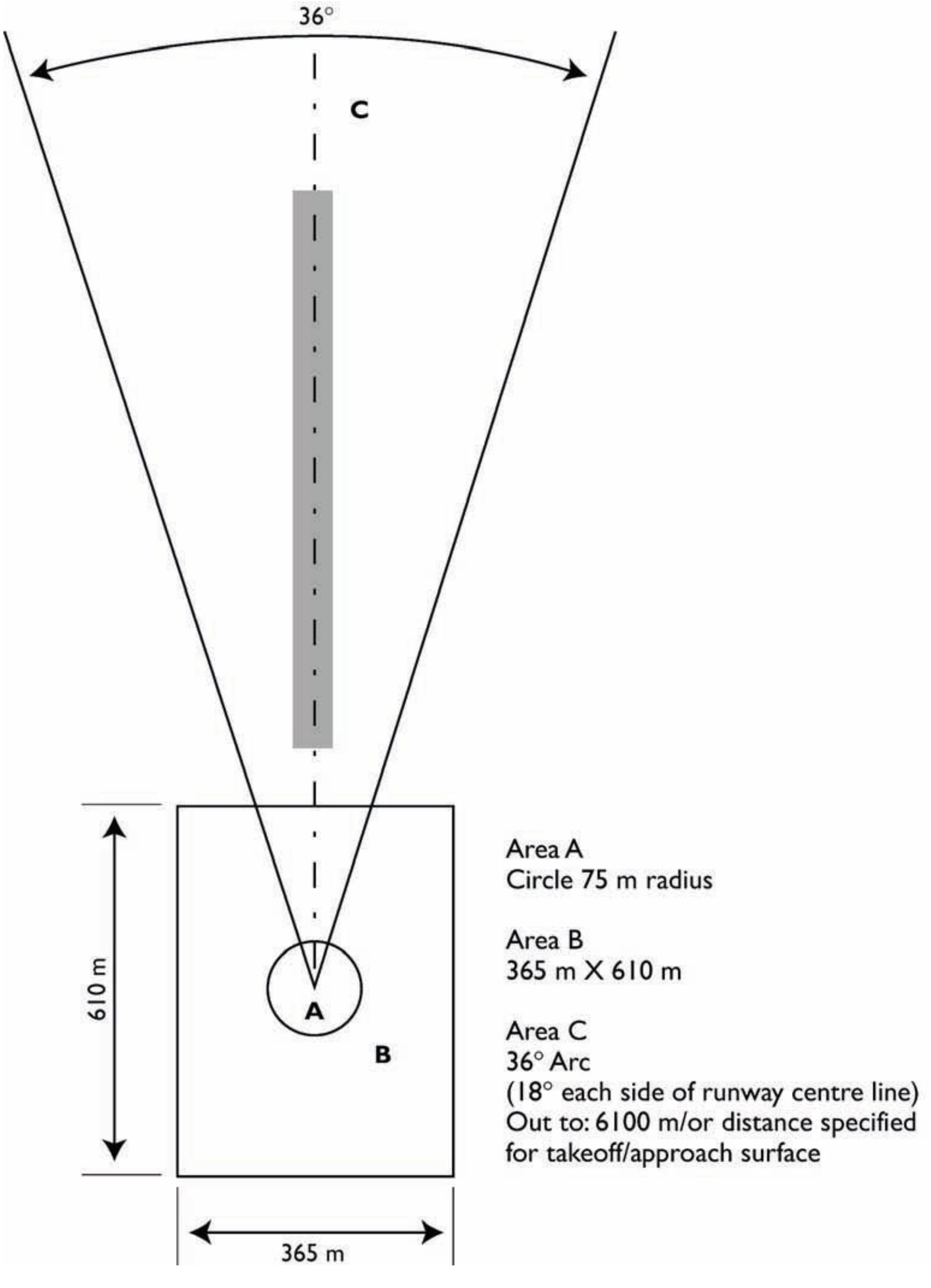

Figure 7: RESTRICTIONS FOR ILS LOCALIZER

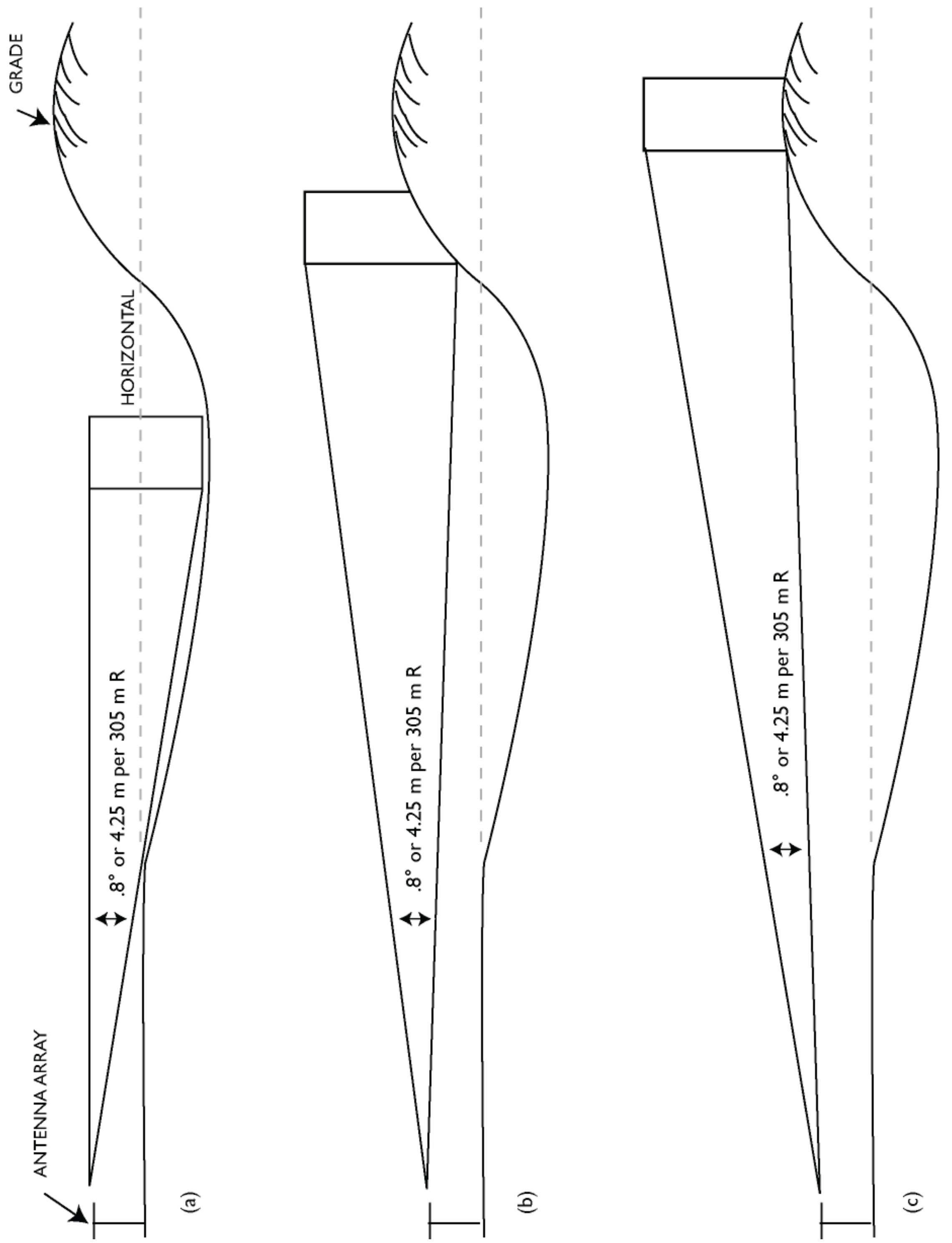

Figure 8: EXAMPLES SHOWING APPLICATION OF LOCALIZER RESTRICTIONS IN AREA C

In the vicinity of the runway no large surfaces are to be constructed parallel to the runway centre line. Large surfaces will be considered only if they are:

(a) perpendicular to the runway centre line;

(b) at an angle to the runway such that reflections will occur away from the ILS course;

(c) radial to the localizer antenna; or

(d) in the electromagnetic shadow of other structures.

Airport service roads must not intercept the front course or back course of the localizer within 180 m of the array.

If a service road must cross the back course, it should be at least 180 m from the array and the antenna counterpoise should be a minimum of 2.5 m above the road elevation. "No Parking No Stopping" signs should be erected at both ends of that portion of the road subtending an angle of ± 25º from the extended runway centre line, measured from the antenna array.

NOTES:

(1) Generally, the orientation of large surfaces should be such as to cause minimum interference to any ILS on the airport. Surfaces radial to a transmitting antenna generally present minimum interference.

(2) In addition, all surfaces parallel to runway centre lines, or with an orientation, which may cause interference, should contain as little metal as possible.

(3) Generally, the "mirror" concept may be used to determine where reflections will cause scalloping on the runway and/or extended centre line. Reflecting objects close to the runway centre line will cause scalloping of greater amplitude than objects farther from the centre line.

(4) Thin metallic and non-metallic vertical objects such as masts and poles (without guy wires) are excluded from the above restrictions.

(5) The effects of large parked aircraft must be considered. The orientation of such aircraft should be specified to ensure minimum interference to the ILS signals.

(6) If it is planned to utilize the localizer back course, it will be necessary to duplicate Area "C" in the back course approach direction.

(7) If any part of the restricted area depicted in Figure 4 is outside the airport boundary, restrictive easements should be obtained to avoid future encroachment on restrictions.

(8) Identical restrictive areas exist at the other end of the runway.

(ii) Glide Path

- The glide slope provides vertical guidance to the pilot during the approach. The ILS glide slope is produced by a ground-based UHF radio transmitter and antenna system, operating at a range of 329.30 MHz to 335.00 MHz, with a 50 kHz spacing between each channel. The transmitter is located 750 to 1,250 feet (ft) down the runway from the threshold, offset 400 to 600 ft from the runway centerline. Monitored to a tolerance of ± 1/2 degree, the UHF glide path is "paired" with (and usually automatically tuned by selecting) a corresponding VHF localizer frequency.

Like the localizer, the glide slope signal consists of two overlapping beams modulated at 90 Hz and 150 Hz (see **Glide Slope Signal Pattern** figure, below). Unlike the localizer, however, these signals are aligned above each other and are radiated primarily along the approach track. The thickness of the overlap area is 1.4º or 0.7º above and 0.7º below the optimum glide slope.

The glide slope signal is received by a UHF receiver in the aircraft. In modern avionics installations, the controls for this radio are integrated with the Localizer controls so that the proper glide slope frequency is tuned automatically when the localizer frequency is selected.

Site

- The glide path system is normally installed for a threshold crossing height of 15 m, with a path angle of 3 degrees. The glide path tower should be situated on the non-taxiway side of the runway approximately 300 m back set from the threshold and between 150 m to 175 m from the runway centreline.

- The special earth mat laid between the glide path antenna and the monitor pick-ups must be inspected at regular intervals. Growth of grass is to be prevented by applying weed killer as necessary.

Critical area

The critical area for a glide path extends 700 m forward of the antenna and either side of a line, parallel to the runway centreline, which passes through the antenna tower (See Figure 2).

Sensitive area

The sensitive area includes the critical area plus an area bounded by lines at ±30 degrees to a ray commencing at the antenna and extending parallel to the runway centreline towards the threshold. An allowance of 0.5 degrees elevation is permitted for constructions outside the critical area

Remote monitors

Remote monitors are a non-executive monitor of the localizer located in the far field, typically in the area of the middle marker.

The sensitive area is detailed in Figure 10.

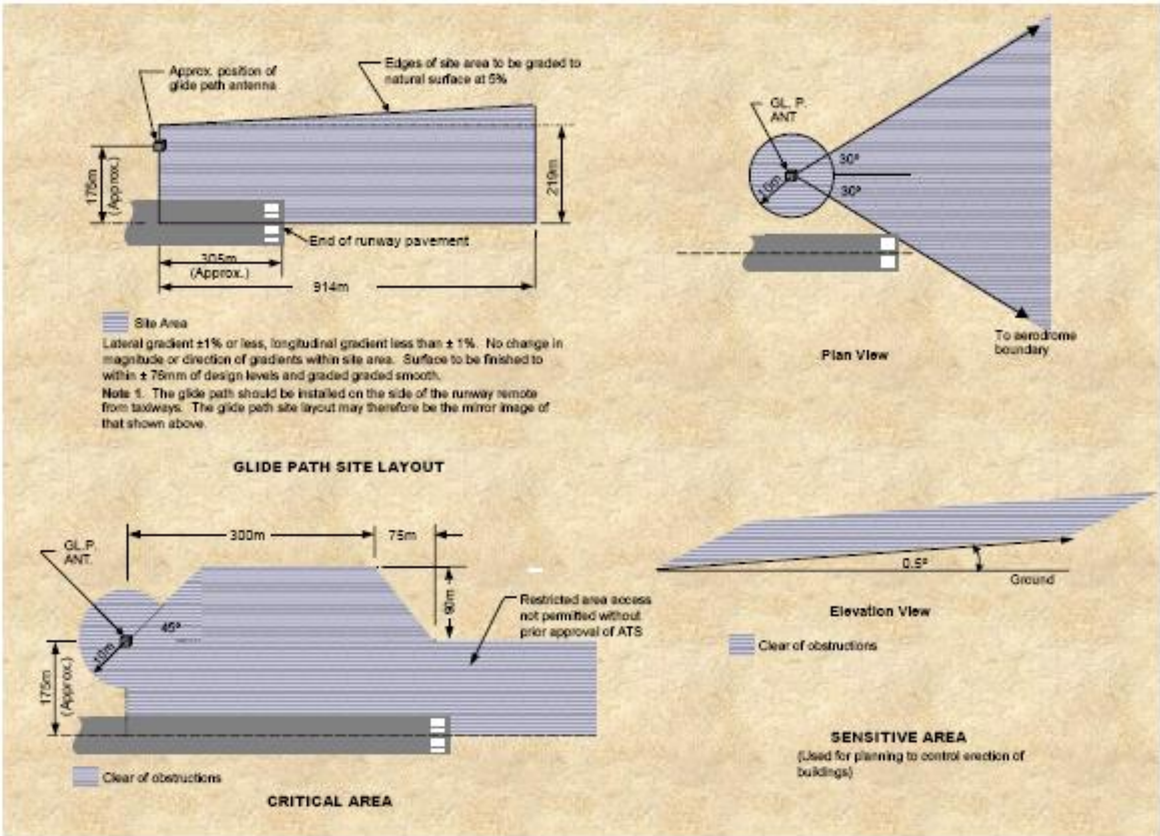

Figure 9 - ILS GLIDE PATH SITE PREPARATIONS & RESTRICTIONS

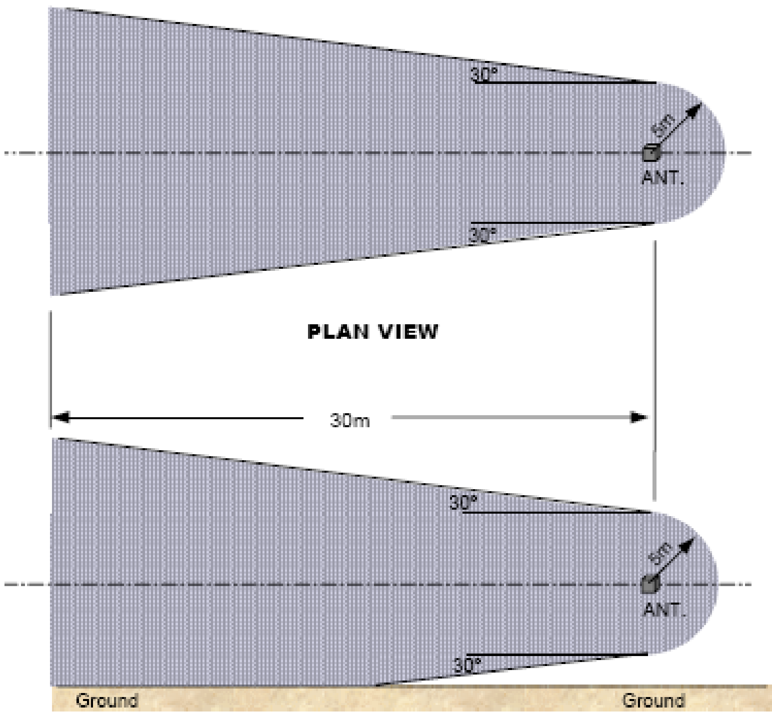

Figure 10 - ILS Remote monitor antenna sensitive area

(iii) Image Type Glide Path Restricted Areas

The restricted areas for image type glide paths are depicted in Figure 6. They are areas D, E and F.

Area D The area originating at the glide path antenna covering an arc of and extending 1500 m in the approach direction. No metallic fences, power lines, telephone lines, buildings, roads or railroads.

NOTE:

This is the "ideal" situation. In practice, compromise will be necessary at existing airports. Horizontal bars in approach lighting systems should be avoided within 600 m of the glide path antenna. At CAT II sites in particular, every effort should be made to ensure that existing encroachments on these restrictions are not aggravated. An obstruction-free area of 900 m minimum is highly desirable but this should be extended to 1500 m if circumstances permit, particularly in the case of a categorized facility.

Area E A triangle with a base 150 m wide extending from the glide path antenna in the direction away from the runway with the apex intersecting Area "D" at approximately 570 m in the approach direction.

Same restrictions as Area "D".

Area F Triangular area between Area"D" and the runway.
Same restrictions as Area "D".

NOTES:

(1) The glide path may be located on either side of the runway, depending on local site conditions, taxiways, runways, etc.

(2) Identical restrictive areas exist at the other end of the runway.

(3) If any part of the restricted area depicted in Figure 4 is outside the airport boundary, restrictive easements should be obtained to avoid future encroachment on restrictions.

(iv) Marker Beacons

- Instrument landing system marker beacons provide information on distance from the runway by identifying predetermined points along the approach track. These beacons are low-power transmitters; that operate at a frequency of 75 MHz with 3 W or less rated power output. They radiate an elliptical beam upward from the ground. At an altitude of 1,000 ft, the beam dimensions are 2,400 ft long and 4,200 ft wide. At higher altitudes, the dimensions increase significantly.

- **Outer Marker (OM)**
  The outer marker should be located 3.9 nautical miles from the threshold of the runway. If this distance is unsuitable, it may be located between 3.5 and 6 nautical miles from the threshold within 250 ft of the extended runway centerline. It intersects the glide slope vertically at approximately 1,400 ft above runway elevation. It also marks the approximate point at which aircraft normally intercept the glide slope, and designates the beginning of the final approach segment. If the marker is situated off the extended runway centreline, it should be not more than 75 m from it.The signal is modulated at 400 Hz, which is an audible low tone with continuous Morse code dashes at a rate of two dashes per second. The signal is received in the aircraft by a 75 MHz marker beacon receiver. The pilot bears a tone over the speaker or headset and sees a blue light that flashes in synchronization with the aural tone (see the **Marker Beacon Lights** figure, above right**)**. Where geographic conditions prevent the positioning of an outer marker, a DME unit may be included as part of the ILS system to provide the pilot with the ability to make a positive position fix on the localizer. In most ILS installations, the OM is replaced by an NDB.

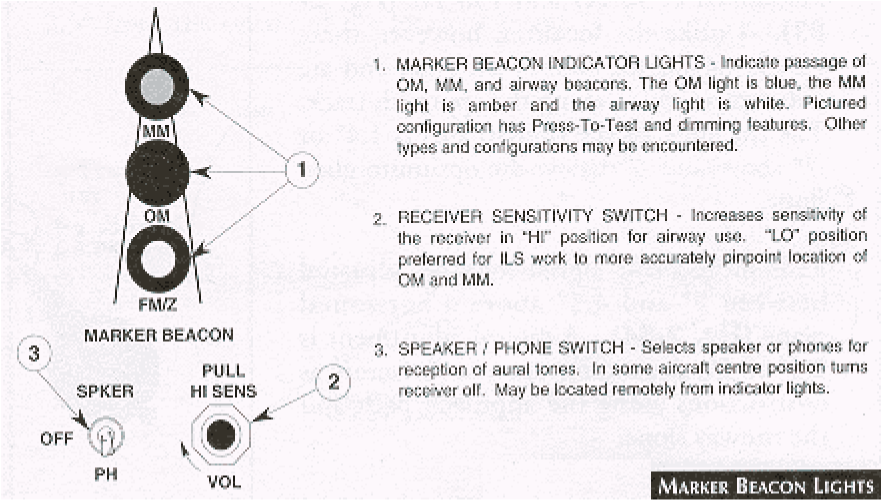

Figure 11: MARKER BEACON LIGHTS

- **Middle Marker (MM**)

  The middle marker is located approximately 0.5 to 0.8 NM from the threshold on the extended runway centerline. The middle marker crosses the glide slope at approximately 200 to 250 ft above the runway elevation and. is near the missed approach point for the ILS Category I approach.

  The middle marker should be located 1050 ±150 m from the landing threshold at the approach end of the runway, and not more than 75 m from the extended centreline of the runway.

- **Inner Marker (IM)**

  The inner marker should be located between 75 m and 450 m from the threshold and not more than 30 m from the extended centreline of the runway. Care must be taken in siting the inner marker to avoid interference between it and the middle marker.

- **Obstructions.**

  Buildings, power or telephone lines, or clumps of trees should not extend above an elevation angle of 30 degrees from a point 1.5 m above ground level at the location of the marker beacon antenna.

- **Vehicular movement.**

  No special requirements.

- **Services.**
  Within 15 m of the antenna, all power and telephone lines are to be laid underground. Beyond this distance any overhead construction should meet the obstruction limits as above.

- **Electrical interference**
  No requirements.

- **Restricted area**
  No special requirements

- **Maintenance of site**
  Grass, shrubs, etc., should be kept cut to a reasonable level, e.g. less than 0.6 m. Trees on the site should not be allowed to infringe the obstruction limits as above.

(v) Locator Beacons/Back Marker (BM)

- The back course marker (BM), if installed, is normally located on the localizer back course approximately four to six miles from the runway threshold. The BM low pitched tone (400 Hz) is beard as a series of dots. It illuminates the aircraft's white marker beacon light. An NDB or DME fix can also be used and in most locations replace the BM.

- All requirements as for non-directional beacons (NDB) below.

(vi) Non-Directional Beacons (NDB)

Obstructions.

- Surrounding area within a radius of 150 m of the antenna should be free of buildings exceeding 2.5 m in any dimension; vegetation should be kept below a height of 0.6 m.
- Small buildings of substantially non-metallic construction extending less than 2.5 m in any dimension may be erected no closer than 60 m to the antenna.
- Overhead power and telephone lines serving the NDB should be kept at least 150 m clear of the antenna. Steel towers and masts should subtend elevation angles less than 3 degrees measured from ground level at the centre of the NDB antenna system.

Vehicular movements.

With the exception of authorized vehicles no vehicle shall approach the antenna within a distance closer than 60 m.

Services.

Power and telephone cables should be underground to a depth of 0.45 m within 150 m of the antenna.

Restricted area.

No special requirements. Where necessary, fencing should be provided to keep cattle and horses clear of the earthmat area.

Site maintenance.

- No special requirement other than to keep undergrowth from exceeding a height of 0.6 m and to maintain a neat appearance of the site. Ploughing is not permitted over any portion of the earth mat area.
- Grazing of sheep is permissible but cattle and horses must be kept clear.

5. RADAR SENSOR SITES (Air Traffic Control Radars)

The size and construction material of buildings and other structures must be controlled to ensure that the radar coverage volume is not reduced and that the number of false targets detected is not increased.

The radar coverage volume for all types of radar systems can be reduced by a structure blocking the transmit or receive signal path. The severity of this blockage is proportional to the size of the structure and varies according to its location with respect to critical airspace.

False targets are usually a problem only with the Secondary Surveillance Air Traffic Control Radar System. They are created by transmitted or received signals being reflected from structures. The magnitude of the reflection is proportional to the size of the structure and the electrical behaviour of the material used. Non-metallic materials can reduce the magnitude of the reflection.

(A) PRIMARY SURVEILLANCE RADAR (PSR)

(i) within 300 m of the radar site, no building or other structure should be allowed to exceed a height of 5 m below the geodetic height of the antenna platform. The preference is to have no structure at all or to have trees surrounding the site.

(ii) from 300 to 1 000 m from the radar site, the upper limit on the height of an allowable structure is increased at a rate of approximately 0.007 m per metre. Thus at a distance of 1000 m from the site, the structure can be as high as the geodetic height of the antenna tower platform.

(iii) beyond 1000 m from the radar site, no site protection requirement is specified; however, it is preferable not to have any large structure exceeding 0.25º above the radar horizon. Large structures are defined as having an azimuth of more than 0.43°.

No structure that blocks critical airspace should be allowed.

The consequences of building such a structure should be brought to the attention of those responsible for approving the proposal for construction.

(B) SECONDARY SURVEILLANCE RADAR (SSR)

The provisions given above for a Primary Radar System apply as well for a Secondary Surveillance Air Traffic Control Radar System. In addition, it is essential that all buildings or other structures within 1000 m of the radar be constructed with non-metallic materials having a low reflectivity at frequencies from 1.0 to 1.1 GHz.

(C) PRECISION APPROACH RADAR (PAR)

Within 900 m of the approach area to a runway served by a Precision Approach Radar System, no reflecting objects (trees, buildings or other structures) are allowable.

(D) AIRPORT SURFACE DETECTION EQUIPMENT RADAR (ASDE)

No structure should be built on the airport that blocks the line-of-sight from the ASDE radar antenna to any runway, taxiway, intersection, etc., unless it is approved by the Director General, CAA, in co-ordination with the Director, Air Traffic Services. The blockage would have to be judged operationally insignificant.

(E) WEATHER RADAR

No structures exceeding the height of the radar antenna should be built within a radius of 300 m of weather radars. The Director, General will co-ordinate the necessary approvals with Environment Canada, which is responsible for siting weather radars.

Site requirements.

- The site requirement for existing types of radar sensors is a rectangular area about 50 m by 40 m, including sufficient space for a crane to maneuver and an antenna maintenance pad.

- For new sites, the above dimensions may be reduced, depending on whether or not standby power generation is co-located.

Clearance requirements.

Radar transmission clearance requirement are intended to prevent the following:

- Any construction, which geometrically intrudes above the existing skyline as seen by the radar, will have an effect. There will be holes in the coverage by new constructions blocking line of sight between radar and aircraft.

- Interference with near fields of the antenna, which may disturb the antenna pattern in the far field. This applies within 500 m of most radars.

- Diffraction and bending of signals by edges and thin objects which can cause incorrect radar determined location, loss or confusion of radar tracks etc. Likely hazards in this regard are poles such as lighting poles.

- Reflections of the radar signals from fixed or mobile surfaces. Reflections cause aircraft to appear on radar screens in more than one location.

- The following clearance requirements are to be maintained:
    - No intrusion within 1 km of the radar into a height surface 5 m below the bottom of the antenna.
    - No intrusion between the radar and the possible location of any desired targets, i.e. approx. above 0.5degrees elevation at any distance.
    - No metallic or other electrical reflective surfaces anywhere which subtend an angle of more than 0.5 degrees when viewed from the radar, eg. fences, power lines, tanks as well as many buildings. All overhead power lines within 1 km must be aligned radially from the radar or be located at least 10 degrees below horizontal from the antenna.
    - No radio interference emitters within 2 km having any component of transmission in the radar bands, eg. welders and electrical transmission lines. No electrical transmission lines within following specified distances:

Line Capacity	**Distance**
2 kV – 22 kV	400 m
22 kV – 110 kV	1 km
above 110 kV	2 km

- Other electronic equipment which may be affected by the radar transmissions should not be located where the radars may interfere with their performance.

(a) Terrain

Terrain within 1000 m of the antenna is of prime importance to the performance of the radar system. The terrain should have either a rough surface (variations of 1 m or more) or be

well covered with trees and shrubs, preferably of a coniferous variety. Terrain of this type will reduce the amount of ground reflection.
Beyond 1000 m, rough or vegetated terrain, as described above, or low, small buildings (e.g., residential housing) are preferred.

(b) Coverage
The Primary and Secondary Surveillance Radar Systems should be located more than 500 m from the edges of areas where large, wide-bodied aircraft are known to remain for sustained periods of time. Structures or natural growth should not block the line-of-sight from the radar to the airspace on approach to runways or to other critical airspace.

(c) Consultation
If large structures (e.g., warehouses, power lines, hangars, etc.) are to be constructed within 10 000 m of a radar, it is essential that the GCAA be consulted regarding the location, building material and orientation of the structures prior to authorization of the construction.

(d) Precautions against Exposure of Personnel to Radio Frequency Radiation from Radar Systems.
The primary surveillance radar transmitters on airports radiate high power beams of radio frequency energy. In close within the transmitted radar beam may be such that persons could be subjected to radiation exposure levels in excess of the safe limits. Airport staff is therefore to be cautioned against approaching any location within a 500 m radius of a primary radar antenna and which is between 5 m below and 50 m above the horizontal level of the bottom of the antenna.

6. COMMUNICATION FACILITIES

VHF/UHF transmitters and receivers must be located in an environment as free as possible from sources of electrical noise. This noise can be caused by engine ignitions, electric motors, electrical switching gear, high tension line leakage, diathermic and industrial heating generators and many household appliances. Such electrical noise generators should be kept at least 1.6 km from the radio antennae; in no circumstance should they be closer than 500 m.

Intermodulation problems, which can be caused by high powered, AM, FM and TV stations can be avoided by locating such equipment at least 8km from the transmitters and receivers.
To prevent the screening of airspace, all structures shall not subtend a vertical angle of more than within 1.5 km of the radio antenna or extend more than 1.2° above the horizontal.

Metallic structures, which may cause reflection of communication signals, should not be constructed within 300 m of a transmitter/receiver installation without prior consultation with the GCAA.

Site requirements.

The physical site requirements will vary significantly depending on the type of communications facility, and it is therefore not possible to specify a general requirement (other than for Satellite ground station sites).

Clearance requirements.

Reliable VHF/UHF communications require a clear line-of-sight path between the base station and aircraft and vehicles using the facilities. The construction of buildings, towers, etc. may prevent reliable communications.

Satellite Ground Stations.

The site requirement is a square area of dimension 25 m by 25 m. The clearances required around satellite ground stations are shown in Figure 4.

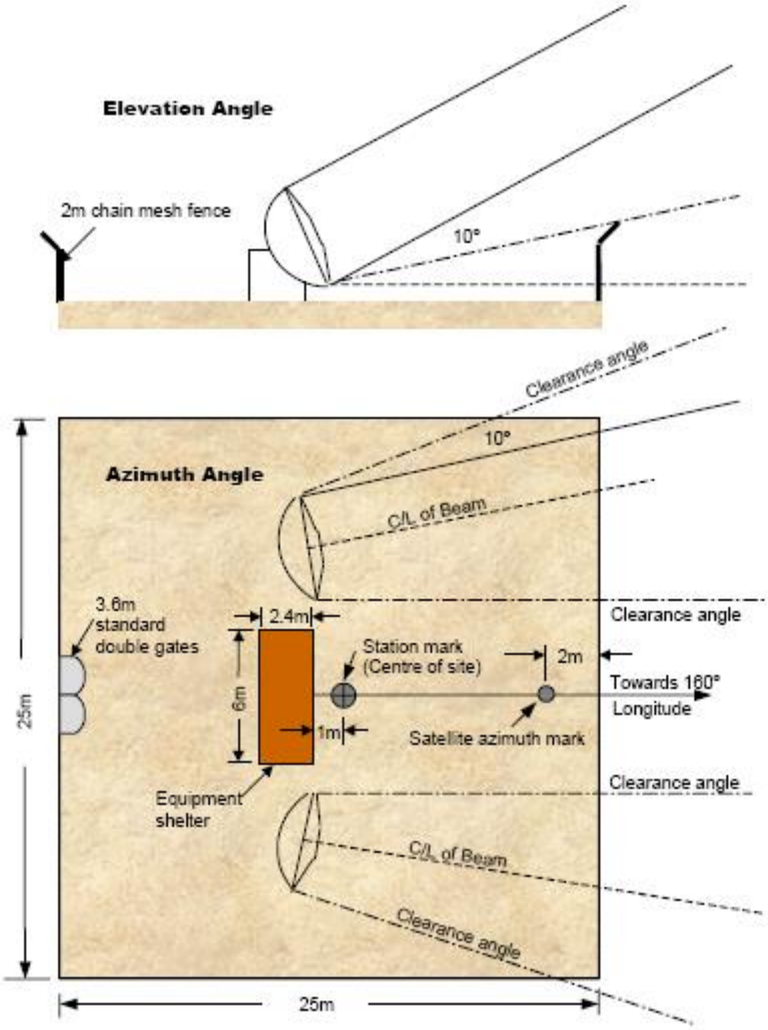

Figure 12: COMMUNICATIONS SATELLITE GROUND STATION MANNED CENTRE SITE

APPENDICE

APPENDIX 1

Proposed Navigational Aids Equipment and Structures			
Remote Transmitter/Receiver (RTR)	Provides communications between air traffic control specialists and pilots in the terminal airspace.	Typical 140 feet by 140 feet site includes four antenna towers and one equipment building, which may contain an engine generator.	Three siting criteria are surrounding terrain, ground conductivity, and ambient radio frequency noise.
Tactical Aircraft Control and Navigation (TACAN) at Very High Frequency Omnidirectional Range (VOR) TACAN only (TACR)	TACAN provides Omnidirectional azimuth information primarily for military users of the national air space and distance information to all national air space users.	TACR has footprint similar to that of VOR.	Same as for VOR.
Tower Building (TOWB)	Provides a support structure and/or accommodation for supplemental facilities for an ATCT	Same as for ATCT.	Same as for ATCT.
Visual Approach Slope Indicator (VASI)	Provides visual approach slope information.	Footprint depends on configuration. A VASI can be two-bar or three-bar VASI system. Two-bar system light units are arranged in bars called upwind (farthest from the threshold) and downwind (nearest to the threshold) bar. A VASI-2 is a two-bar system consisting of two light units, one unit in each bar. A VASI4 consists of four light units, two units in each bar. A VASI-12 consists of twelve light units, six light units in each bar. Three-bar system light units are arranged in bars called the upwind, middle, and downwind bar. There are two glide paths projected by the three-bar system that are seen by the pilot, the upwind zone for long-bodied aircraft and the downwind zone for other aircrafts. A VASI-6 consists of six light units, two light units in each bar. A VASI-16 consists of 16 light units, six light units in the downwind and middle bars, and four light units in the upwind	A two-light unit VASI can be accommodated in a footprint with overall dimensions, in the case of two-bar VASIs, of approximately four feet by 700 feet, plus 300 feet or minus 200 feet. Units with more box units would have the same length dimensions, with spacing between boxes within the upwind bar and downwind bar of sixteen feet, plus or minus six feet. Three-bar VASIs would encompass an additional length of 700 feet, plus 300 feet or minus 200 feet. All light units of the two-box, four-box, and six-box configurations are typically located on the left side of the runway (as viewed from the approach direction). Where terrain or cross runways, etc., make

		bar.	this impractical, they may be located on the right side of the runway. VASIs are located fifty feet, plus or minus ten feet, to the side of the runway. FAA Order 6850.2A figures show layouts of the different VASI configurations.
Very High Frequency Omnidirectional Range (VOR)	Provides separate am and fm signals to the airborne avionics to determine the azimuth of the aircraft from the VOR site at a given time.	A typical VOR site will require use of approximately 72 acres. • With few exceptions, all obstructions within a 1000 feet radius of the antenna must be removed. Normal grazing and crop raising may be permitted in this area, except at mountain top facilities where antennas are four feet high. • Single trees (up to 30 feet in height) may be tolerated beyond 500 feet. At mountain top sites, no trees within 1000 feet should be visible from the antenna array. • Ordinary farm-type wire fences about four feet high are not permitted within 200 feet of the antenna; chain type fences (six feet or more in height) are not permitted within 500 feet of the antenna. • Power and control line extensions should be installed underground for a minimum distance of 600 feet from the antenna. Overhead power and control lines may be installed beyond 600 feet but should be essentially radial to the antenna for a minimum distance of 1200 feet.	If on airport, should be located in an area adjacent to the intersection of the principle runways in order to provide approach guidance to the ends of these runways. It should not be located closer than 500 feet to the centerline of any runway or 250 feet to the centerline of a taxiway. And, no part of the facility shall penetrate any surface defined in paragraphs 77.25, 77.28, or 77.29 of the Federal Aviation Regulations. If off airport, consider selecting a site so that one or more of the course radials will provide an approach procedure to the primary bad weather runway in accordance with FAA Order 8260.3B. Other considerations include ground slope and ground smoothness, nearby structures and objects such as long wires, trees, cylinders, planes, and combinations of these

Automatic Surface Observation System (ASOS)	ASOS provides weather observations that include: temperature, dew point, wind, altimeter setting, visibility, sky condition, and precipitation.	Specific footprint depends upon the type of sensor, whether the airport has precision instrument runways, and whether the sensors are on-airport or off-airport. Typically, sensors are on-airport and occupy an area of 50 feet by 50 feet.	ASOS sensor sighting must not violate runway or taxiway object free areas, runway or taxiway safety areas, obstacle free zones or instrument flight procedures surfaces. Notwithstanding these constraints, sensor exposure should minimize or eliminate effects of manmade or geographical obstructions. The tower used to mount the wind sensor is not considered an obstruction to the sensor collection system, but it will (with the exception of the temperature, dew point, and pressure sensors) be at least 3 meters away from other sensors. Sensors should be placed as far away as practicable from cultivated land to reduce contamination by dust and dirt. It may be necessary to increase the heights of some sensors based on the average maximum show depth for the location. Specific siting information is in FAA Order 6560.20B and in the U.S. Department of Commerce/National Oceanic and Atmospheric Administration Office of the Federal Coordinator for Meteorological Services and Supporting Research standard entitled "**Federal Standard for Siting Meteorological Sensors at Airports FCM-S4-1987"**.

Airport Traffic Control Tower (ATCT)	Provides an observation platform from which air traffic controllers direct air and ground traffic for the airport.	A typical ATCT site will range from 4 to 6 acres. Additional land may be needed for combined flight service stations/towers	• There must be maximum visibility of the airport's traffic patterns. • There must be a clear, unobstructed, and direct line of sight to the approaches, to all runways or landing areas, and to all runway and taxiway surfaces. • A tower penetrating an FAR Part 77 surface is an obstruction to air navigation. As such, it is presumed to be a hazard to air navigation until an FAA study determines otherwise. • The ATCT must not derogate the signal generated by any existing or planned electronic NAVAID or an ATC facility. • The proposed site must be large enough to accommodate current and future building needs, including employee parking spaces.
Glide Slope (GS)	Radiates an electronic signal from an antenna above a reflecting surface. The reflected signal travels to the receiving antenna of incoming aircraft. Pilot uses the reflected radiation signal to fly a prescribed angle of descent to the runway.	Includes an antenna tower, a 10ft x 12ft fiberglass equipment shelter, and a cleared and uniformly graded ground reflective plane for the broadcast signal. Tower height may be up to 65 feet, depending on terrain and specific type of glide slope system used. GS is connected to the adjacent taxiway by a paved road. The ground reflective plane measures approximately 300 feet x 1,200 feet.	Glide slope is located on a line parallel to the runway centerline. The glide slope may be located on either side of the runway. Most reliable operation occurs when it is on the side that provides the least interference from buildings, power lines, moving vehicles, and aircraft and which has the greatest extent of smooth terrain outbound from the antennas. Glide slopes should be a minimum of 400 feet from the runway centerline.

Localizer (LOC)	Provides horizontal course guidance during an approach procedure. The horizontal guidance information indicates to the pilot of incoming aircraft whether the aircraft is right of, left of, or aligned with the runway centerline.	Antenna width may vary from 45.5 feet to 105 feet (perpendicular to the runway). A equipment shelter (typically 8' x 16') is required to support the LOC. Category II and III localizer systems include a far field monitor.	Localizer is normally near the end of the runway opposite the desired approach. Minimum distance from the stop end of the runway is the greater of 600 feet or the end of the runway safety area. When sufficient area is available, the localizer will be beyond 1000 feet from the stop end of the runway. Maximum standard distance from the stop end of the runway to the LOC is 2000 feet. The equipment shelter must not be within 250 feet of the extended runway centerline and should be within ±30 degrees of the antenna's longitudinal axis. FFM is sited at the opposite end of the runway from the localizer, often near the inner or middle marker.
Locator Outer Marker (LOM)	In precision approaches, there may be an NDB collated with the OM. If so, the marker is referred to as the locator outer marker (LOM). Indicates a position at which an aircraft at the appropriate altitude on the localizer course would intercept runway non-directional beacon (NDB) radiates a signal which provides directional guidance to and from the transmitting antenna	Same as for outer marker.	The LOM is located at the outer marker site.
Medium Intensity Approach Lighting System and Runway Alignment Indicator Lights (MALSR)	Provides visual information on runway alignment, height perception, roll guidance, and horizontal references as the FAA standard for category I precision landings.	2400 feet in length when the glide slope is 2.75 degrees or greater; 3000 feet when the glide slope is less than 2.75 degrees. The approach light plane is 400 feet wide centered on the extended runway centerline, runway alignment indicator lights (RAIL) excepted. The primary plane of the RAIL extends 200	The power and control station must be no closer than 400 feet to the MALSR centerline. Typically, this is located 1000 feet from the runway threshold.

		feet beyond the last flashing light in the RAIL and has a total width in the RAIL portion of 100 feet.	
Outer Marker (OM)	Indicates a position at which an aircraft at the appropriate altitude on the localizer course would intercept runway glide slope.	Compact marker beacon system consists of a vertical stacked array antenna and a small solid state transmitter with a battery pack standby power source designed for mounting on a standard telephone pole. If siting problems (e.g., prevalent vandalism) dictate need for a marker plot, a 6 foot by 6 foot plot will be used. Most solid-state markers are housed in a transportable shelter. The shelter is approximately 6 by 6 or 8 by 8 feet. A fenced 16 by 18-foot plot is used for these shelters.	4 to 7 nautical miles from threshold (with tolerance of ±800 feet both longitudinal and lateral).
Remote Communications RCO	Provides communication between pilots and AFSS for weather and flight plans.	Typically collocated, frequently with VOR.	Three siting criteria are surrounding terrain, ground conductivity, and ambient radio frequency noise.
Runway End Identifier Lights (REIL)	Provides rapid and positive identification of the end of a runway.	Each REIL light unit is typically mounted on a pad with approximate dimensions of three feet by three feet.	Optimum location is 40 feet from each runway edge and in line with the existing runway threshold lights. Light units may be located laterally up to 75 feet from the runway edge and longitudinally up to 30 feet downwind and 100 feet upwind from the line of threshold lights.
Precision Approach Path Indicator (PAPI)	Furnishes the pilot with visual approach slope information to provide guidance for safe descent.	Basic configuration consists of four lamp housing assemblies (LHAs) arranged on a single bar on a line perpendicular to the runway centerline.	LHAs are located on the left side of the runway, as viewed from the approach direction. Where terrain, cross runways, or taxiways make this arrangement impractical, the

			LHAs may be located on the right side of the runway. The PAPI must be sited and aimed so that it defines an approach path with adequate clearance over obstacles and a minimum threshold crossing height. The PAPI is typically located approximately 1000 feet past the runway threshold. The inboard LHAs shall be no closer than 50 feet from the runway edge or to other runways or taxiways. The PAPI LHAs must have a lateral separation of 30 feet, and the distance between LHAs shall not vary by more than one foot.