

Australian Standard[®]

**Siting of radiocommunications
facilities**

**Part 3: Fixed location satellite
earth stations**

This Australian Standard was prepared by Committee TE/14. It was approved on behalf of the Council of Standards Australia on 30 November 1990 and published on 15 April 1991.

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Australian Broadcasting Corporation
Australian Electrical and Electronic Manufacturers Association
Civil Aviation Authority
Confederation of Australian Industry
Consumer Electronics Suppliers Association
Department of Defence
Department of Industry, Technology and Commerce
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PREFACE

This Standard was prepared by the Standards Australia Committee TE/14, Radio Communication. It is one Part of a series on the subject of siting of radiocommunications facilities, the other Parts of which are yet to be finalized, except for AS 3516.1 published as *Part 1—LF, MF and HF Transmitting and HF Receiving Facilities*.

The Standard was prepared at the request of the Interdepartmental Telecommunications Advisory Committee (AIDTAC) in order to specify those aspects of satellite earth stations which could influence the siting of such a facility. It is intended to take account of interference to the earth station from domestic or industrial sources, interaction with other radiocommunication sources and the resultant effect of the signals emitted by the earth station on services and equipment in the vicinity. The general effect of such facilities on the environment has also been taken into account.

The need for a Standard according to AIDTAC, was that although it is possible to prepare Regulations, in the case of Telecommunications, it is impossible to implement such Regulations because of the many Authorities involved. The Interdepartmental Committee believed therefore, that a Standard providing guidance to organizations and individuals at all levels involved with the planning, approval, construction, installation and maintenance of telecommunications or broadcasting services, and of electric power generation and distribution systems providing power to the earth station, could benefit those operations.

The Standard and its appendices provide information for organizations on:

- (a) the possible effect of siting of earth stations on the public;
- (b) effects which the certain or planned development has in the vicinity of such facilities: and
- (c) environmental concerns.

Because of the very wide range of types and sizes of possible earth station, some parts of the Standard may be applicable only in particular cases. The Standard should only be applied after due account has been taken of the size and function of the particular earth station, in consultation with all the parties concerned.

Reference is made, in this Standard to 'relevant authorities'. At the time of writing the Department of Transport and Communications is responsible for the allocation and licensing of communications facilities and also for the protection of such facilities in general, from electromagnetic interferences. The Civil Aviation Authority is responsible for air safety and air-traffic control, both aspects of the overall problem being dependent on the control of radiofrequency interference.

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STANDARDS AUSTRALIA

Australian Standard**Siting of radiocommunications facilities****Part 3: Fixed location satellite earth stations****SECTION 1 SCOPE AND GENERAL**

1.1 SCOPE This Standard concerns the siting of satellite earth stations at specific geographic locations. The Standard is concerned with those aspects of the site which affect the following aspects of the earth station:

- (a) The efficiency of operation of the earth station.
 - (b) Potential interference to and from the signals which the earth station is intended to transmit and receive.
 - (c) The potential impact which emissions from the earth station might have on the adjacent communities.
- It should be emphasized that the Standard cannot specify the practical requirements at every site due to—
- (i) the wide variety in types of service intended;
 - (ii) the geographical and environmental situations; and
 - (iii) any interaction which may occur between (i) and (ii).

For these reasons the Standard should not be applied without reference to the parties concerned.

1.2 REFERENCED DOCUMENTS The following documents are referred to in this Standard:

AS

1170 SAA Loading Code

1170.2 Part 2: Wind loads

1289 Methods of testing soils for engineering purposes

1768 Lightning protection

2121 SAA Earthquake Code

2772 Radiofrequency radiation

2772.1 Part 1: Maximum exposure levels—RF radiation—300 kHz to 300 GHz

2772.2 Part 2: Principles and methods of measurement—RF radiation—300 kHz to 100 GHz

2915 Solar photovoltaic modules—Performance requirements

3301 Approval and test specification—Particular requirements for microwave ovens

BS

6656 Guide to prevention of inadvertent ignition of flammable atmospheres by radiofrequency radiation

6657 Guide to prevention of inadvertent ignition of electro-explosive devices by radiofrequency radiation

ITU Radio Regulations 1982 (Revised 1985, 1986 and 1988)

CCIR Recommendation 580-1

1.3 DEFINITIONS For the purposes of this Standard the definitions below apply.

1.3.1 Satellite

1.3.1.1 *Geosynchronous satellite*—an earth satellite whose period of revolution is equal to the period of rotation of the earth about its axis.

1.3.1.2 *Geostationary satellite*—a geosynchronous satellite whose circular and direct orbit lies in the plane of the earth's equator and which thus remains fixed relative to the earth; by extension, a satellite which remains approximately fixed relative to the earth.

1.3.1.3 *Category A missions*—(near earth) satellite missions with altitudes less than 2 000 000 km above the surface of the earth.

1.3.1.4 Category B missions—(deep space) satellite missions with altitudes equal to or greater than 2 000 000 km.

1.3.2 Frequency

1.3.2.1 Radiofrequency (RF)—frequencies arbitrarily lower than 420 THz that can be propagated in space without an artificial guide. As the unit of frequency is the hertz (Hz), frequencies shall be expressed:

- (a) in kilohertz (kHz), up to and including 3000 kHz.
- (b) in megahertz (MHz), above 3 MHz, up to and including 3000 MHz.
- (c) in gigahertz (GHz), above 3 GHz, up to and including 3000 GHz.
- (d) in terahertz (THz), above 3 THz, up to and including 420 THz.

Reference Australian Spectrum Plan published by Department of Transport and Communications.

1.3.2.2 Operating frequency—assigned frequency at which an earth station transmits or receives signals.

1.3.3 Transmission

1.3.3.1 Radio path—line of travel taken by radio signals (including interference)—a straight line unless deflected by some means such as reflection, refraction or diffraction.

1.3.3.2 Satellite link—a radio link between a transmitting earth station and a receiving earth station through a satellite.

A satellite link comprises one up-link and one down-link.

1.3.3.3 Coverage area—geographical area associated with a space station for a given service and a specified frequency within which, under specified technical conditions, it is feasible for radiocommunications to be established with one or several earth stations, either for reception or transmission or both.

1.3.3.4 Polarization—polarization of an electromagnetic radiation describes the orientation in space of the electric field vector of the radiation.

Polarization is quantitatively defined by the polarization angle which may be constant (linear polarization) or rotating with time (elliptical and circular polarization).

1.3.3.5 Polarization angle—the angle between the local horizontal and the electric field vector, measured in the plane normal to the direction of propagation.

The linear polarization angle is measured in a positive anti-clockwise sense, whilst looking in the direction of propagation. Circular polarization is right-handed when the electric field vector rotates with time in a clockwise direction, whilst looking in the direction of propagation.

1.3.3.6 (a) Hydrometeors—water or ice particles which may exist in the atmosphere or be deposited on the surface of the ground.

NOTE: Rain, fog clouds, snow and hail are the major hydrometeors.

(b) <i>Rain attenuation</i> <i>Rain scatter</i> <i>Rain depolarization</i>	}	disturbing effects of hydrometeors on a radio path
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1.3.3.7 Antenna beamwidth—is a quantitative measure of the degree of focus, of electromagnetic energy and is defined as twice the angle away from the direction of maximum power (transmitted or received) at which the power level has decreased to half the maximum.

NOTE: This parameter can only be measured at a large distance from the antenna, i.e. $>2D^2/\lambda$.

where

D = antenna diameter

λ = wavelength of operating frequency

1.3.3.8 Shielding (topographic)—hills and other obstacles form a barrier to the radio path, where this is desired it is termed shielding, if undesired it is an obstruction.

1.3.3.9 Margin (predicted)—predicted excess carrier-to-noise ratio required above minimum acceptable carrier-to-noise ratio to offset potential signal losses.

1.3.3.10 Availability—the percentage of time a satellite communication system exceeds a specified performance objective.

1.3.4 Frequency sharing

1.3.4.1 Interfering Signal—a signal that impairs the reception of a wanted signal.

1.3.4.2 Interference—the effect of an interfering signal.

1.3.4.3 Permissible interference—observed or predicted interference which complies with quantitative interference and sharing criteria contained in the ITU Radio Regulations or in CCIR Recommendations or in special agreements as provided for in the ITU Radio Regulations.

1.3.4.4 Harmful interference—interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with the Radiocommunications Act 1983.

Harmful interference to the services being carried by an earth station is interference which is sufficiently severe to endanger the service if it is a radionavigation or safety of life service, or seriously to degrade the performance of the station in the case of other services.

1.3.4.5 Accepted interference—interference at a higher level than that defined as permissible interference and which has been agreed upon between two or more administrations without prejudice to other administrations.

1.3.4.6 RF protection ratio—minimum value of the wanted-to-unwanted signal ratio, usually expressed in decibels, at the receiver input, determined under specified conditions such that a specified reception quality of the wanted signal is achieved at the receiver output.

1.3.4.7 Coordination area—area associated with an earth station outside of which a terrestrial station sharing the same frequency band neither causes nor is subject to interfering emissions greater than a permissible level.

1.3.4.8 Coordination contour—line enclosing the coordination area.

1.3.5 Antennas.

1.3.5.1 Antenna pointing vector—the line from the earth station to the satellite which should coincide with the bore sight of the antenna.

1.3.5.2 Azimuth—the angle between the plane normal to the local horizontal containing the line looking true north and the plane normal to the local horizontal containing the antenna pointing vector. See Figure 1.1.

Azimuth is measured positive clockwise from the true north, and may be stated alternatively as angles east or west of true north.

1.3.5.3 Elevation—the vertical angle, between the local horizontal plane and the antenna pointing vector. See Figure 1.1.

Elevation is measured as a positive angle with respect to the local horizontal.

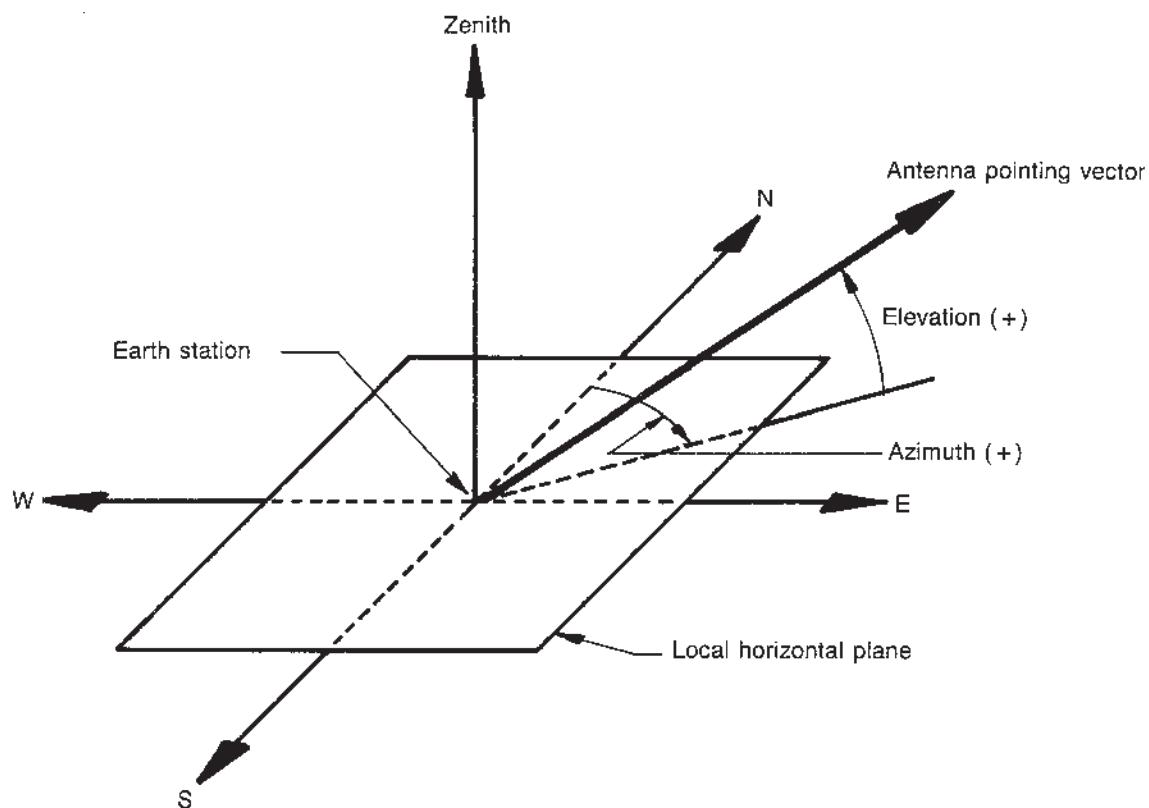


FIGURE 1.1 DIAGRAM ILLUSTRATING AZIMUTH AND ELEVATION

1.3.5.4 Sub-satellite point—the point of intersection of the earth's surface with the line from the centre of the earth to the spacecraft or satellite under consideration.

1.3.5.5 Zenith—the direction directly (vertically) above the earth station.

1.3.5.6 Hour angle—is measured in the plane which contains the circle of latitude at the earth station. It is the angular distance between the projection of the earth station's zenith on that plane and the projection of the antenna pointing vector. The hour angle is zero when both lines coincide and increases with rotation of the second line in a westerly direction. See Figure 1.2.

1.3.5.7 Declination—is the angular distance between the antenna pointing vector and the projection of that vector on the plane which contains the circle of latitude at the earth station. The zero reference for declination is the plane containing the circle of latitude. The declination is positive towards the North and negative towards the South. See Figure 1.2 which shows a negative declination.

NOTE: The above definitions differ from those used by astronomers who use 'the line from the centre of the earth to the celestial body' instead of 'the line from the earth station to the satellite' (antenna pointing vector). In the case of astronomy, the object being observed is usually at such a distance that the difference between these two lines is negligible, but this is not so for near earth satellite applications.

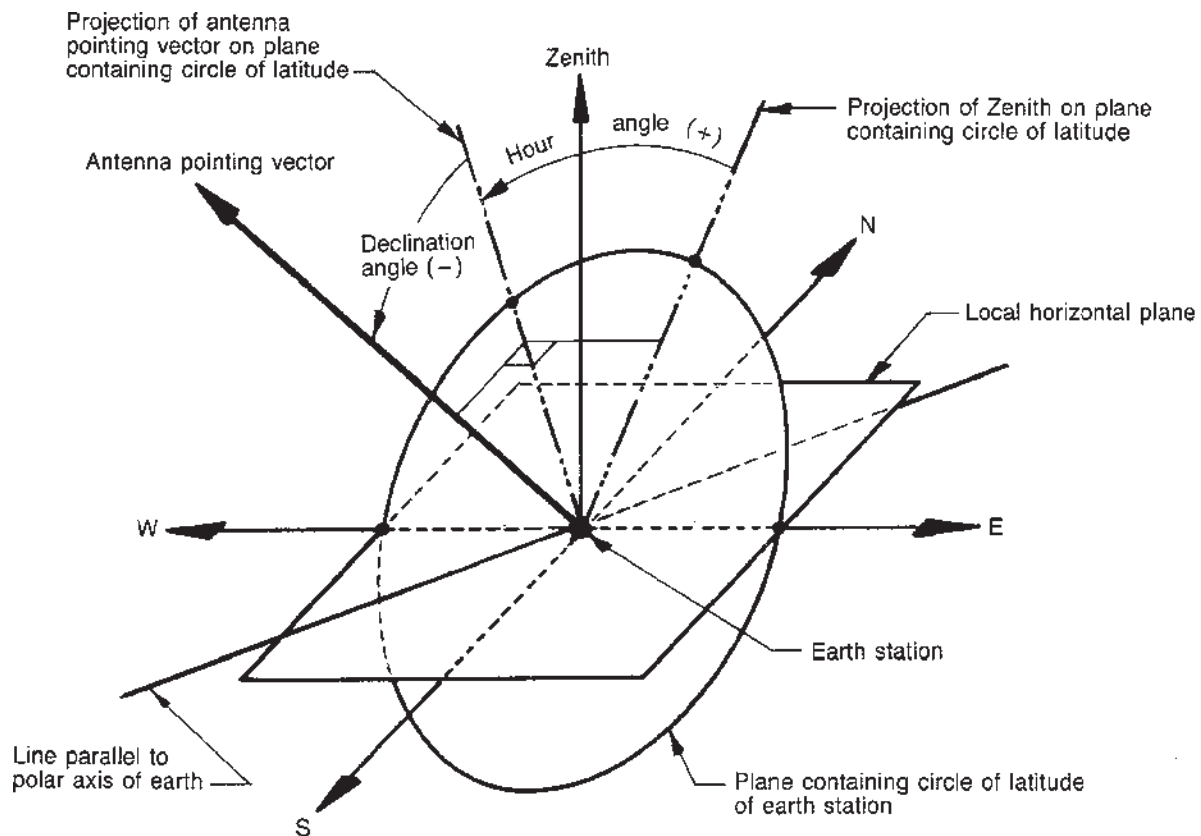


FIGURE 1.2 DIAGRAM ILLUSTRATING HOUR ANGLE AND DECLINATION

1.3.5.8 *x*-Vector—the projection of the zenith line on the plane which contains the East-West axis together with the antenna pointing vector.

1.3.5.9 *x*-Coordinate—the angle described between the earth station's zenith and the *x*-vector. See Figure 1.3 and 3.2.1(c)(iii).

x-angle is measured positive from zenith towards the South and negative from zenith towards the North.

1.3.5.10 *y*-Coordinate—the angle described between *x*-vector and the antenna pointing vector within the plane which contains these vectors together with the East/West axis. See Figure 1.3 and Clause 3.2.1(c)(iii).

The *y*-angle is measured positive from the *x*-vector towards the East and negative from the *x*-vector towards the West.

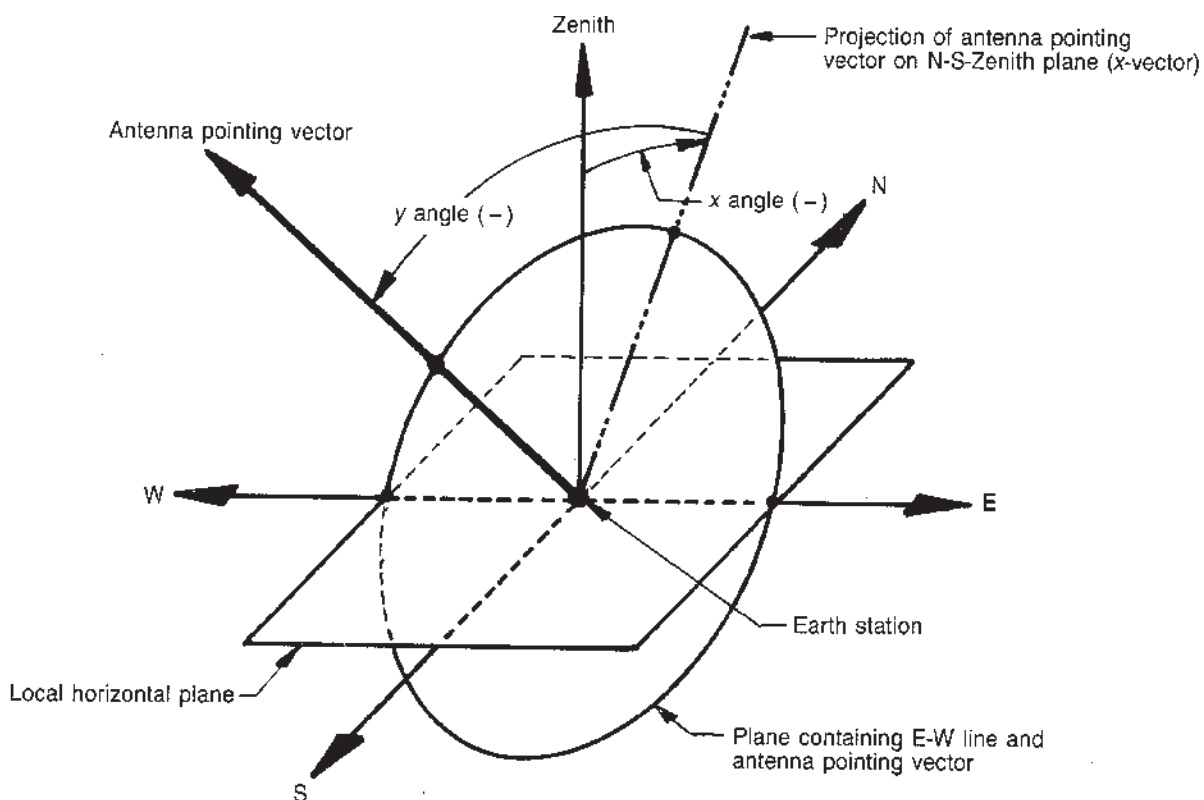


FIGURE 1.3 DIAGRAM ILLUSTRATING *x* AND *y* COORDINATES

1.3.5.11 *Antenna gain*—the ratio, expressed in decibels, at a particular frequency, of the power flux density, in a given direction, to the power flux density that would be obtained if the power accepted by the antenna was radiated isotropically.

NOTE: The above definition is for transmit gain. As the antennas normally used for earth stations obey the law of reciprocity, the receive and transmit gains are identical at the same frequency.

1.3.5.12 *Electrical noise* (Thermal noise)—a random electrical signal which is generated in all electrical/electronic circuits by the random movement of electrons. The available power per unit bandwidth is directly proportional to the temperature of the circuit because the movement of electrons (thermal noise) increases with temperature.

1.3.5.13 *Radio noise*—there are a number of natural phenomena, within or outside the earth's atmosphere which produce electromagnetic radiation which, because of its random nature, is called 'radio noise'. Electromagnetic radiation with similar characteristics resulting from man's activities is also called radio noise. Radio noise received by an antenna produces a signal similar to electrical noise.

Some amount of radio noise is always present and, together with any interference also present, and the electrical noise produced by the antenna components, determines the weakest (smallest) wanted signal which can be successfully received.

1.3.5.14 *System noise*—the combination of radio noise received by an antenna and the electrical noise produced by the antenna components (including the low noise amplifier).

1.3.5.15 *Noise temperature*—the temperature of a resistor having an available thermal noise power per unit bandwidth equal to that of the receiving system at a specified frequency.

Noise temperature is commonly used as a measure of the amount of noise and the unit used is the kelvin (K). The lower the temperature (the smaller the number), the smaller the amount of noise.

1.3.5.16 *Noise figure* Noise figure is an alternative to noise temperature in measuring the performance of a low noise amplifier or mixer. It can be related to noise temperature by the following expression:

$$\text{Noise figure } (N_F) = 10 \log_{10} (1 + T_E/T_O)$$

Where T_O is 290K and T_E is the effective input noise temperature.

1.3.5.17 *Receiving function figure of merit (G/T)*—the gain of an antenna, expressed as a power ratio, divided by the system noise temperature.

However, as antenna gain is normally expressed in decibels, G/T is usually expressed as:

$$G/T = G - 10 \log T$$

G = antenna gain, in decibels

T = system noise temperature, in kelvin. G/T is often expressed as dBK or dB/K.

1.3.5.18 *Equivalent isotropically radiated power (eirp)*—in a given direction, the gain of a transmitting antenna multiplied by the net power accepted by the antenna from the connected transmitter.

Equivalent isotropically radiated power defines the strength of the signal transmitted in a given direction and is normally expressed in decibels relative to one watt radiated isotropically (dBW).

1.3.5.19 *Bore-sight*—the direction of maximum power transmission or reception sensitivity of an antenna. Under normal conditions of operation the bore-sight of the earth station will coincide with the line between an earth station antenna and the satellite.

1.3.6 Miscellaneous

1.3.6.1 *Parameters*—technical characteristics or constraints of a system or equipment.

1.3.6.2 *CCIR*—International Radio Consultative Committee.

1.3.6.3 *ITU*—International Telecommunication Union.

1.3.6.4 *Switching centre*—a node in a telecommunications network which redirects traffic from source or origin to a destination.

SECTION 2 BASIC SYSTEM NEEDS

2.1 OVERVIEW OF SITING FACTORS

2.1.1 General A satellite earth station is only a part of a total communication link or system and has certain basic requirements to function with optimum efficiency.

The primary considerations in siting an earth station relate to both the transmission and reception of information through the station. However, many secondary factors in the design of an earth station affect the working and reliability of a station and hence its ability to act as an efficient link in a system. These factors, which are later discussed in more detail, are listed below in three categories:

2.1.2 Radiocommunication factors (See Section 2) The following communication factors should be taken into account:

- (a) *Satellite coverage area*: Earth station to be located within the coverage area of the satellite;
- (b) *Earth station antenna characteristics*: Mechanically and electrically, the antenna is a critical (and often non-duplicated) component of the earth station.
 - (i) *Mechanical considerations are*: Structural strength and rigidity, pointing and tracking ability, design life.
 - (ii) *Electrical considerations are*: receive figure of merit, transmitted power, radiation pattern.

2.1.3 Propagation and interference factors (See Section 4)

- (a) The following propagation factors apply to satellite earth stations:
 - (i) *Ionospheric effects*: Scintillation, Faraday rotation, dispersion etc.;
 - (ii) *Tropospheric effects*: Atmospheric gases and hydrometeors can cause signal absorption, depolarization and scattering.
- (b) *Interference to and from the earth station*:
 - (i) *Interference to the station's receiving function from non-communications sources* — should not exceed an acceptable limit;
 - (ii) *Interference to and from other communications systems* — coordination may be required with other radio services through the appropriate authority.

2.1.4 Other factors Several miscellaneous factors may need to be taken into account, as listed below, and described in further detail in Appendix E:

- (a) *Proximity to user* — for some applications this may be a very important factor. It includes such issues as terrestrial communication circuits (e.g. linking with a switching centre), and access for operational and maintenance purposes.
- (b) *Natural hazards* — Consider the impact of hazards due to flood, earthquake, fire, cyclone and the like.
- (c) *Constructional aspects* — The design of antenna foundations and supporting structures dependent on site conditions. AS 1170.2 provides criteria for wind loading assessment; AS 2121 provides criteria for seismic force assessment and AS 1768 provides criteria for lightning protection provisions.
- (d) *Services to the station* — access roads, power, water and other services.
- (e) *Economic considerations* — the final compromise between the above factors will depend on the economic considerations which apply in each case.
- (f) *Other aspects of earth station transmissions* — The siting of a satellite earth station has potential impact on the surrounding community in five ways:
 - (i) *Biological* Australian Standard AS 2772.1 prescribes a non-occupational (general public) maximum exposure level for exposure to radiofrequency transmission.
 - (ii) *Domestic* Compliance with the ITU Radio Regulations should normally preclude any direct interference with domestic radio and entertainment electronic equipment.
 - (iii) *Environmental* Development of new facilities will usually involve the consideration of an environmental impact assessment. Appendix D provides further detail on this subject.
 - (iv) *Industrial* Industrial facilities which could potentially be affected by satellite earth stations include those using or storing explosives or fuel stores, sensitive electronic equipment and operational airborne equipment.
 - (v) *Planning* Consultation with local planning authorities may be considered to aid assessment of future development in the locality of an earth station site.

SECTION 3 RADIO COMMUNICATION FACTORS

3.1 SATELLITE COVERAGE AREA Satellite antennas are frequently designed to provide shaped radiation patterns which are not symmetrical. The transmit and receive capabilities of satellites are normally described by contoured ground plot patterns of radiated power (eirp), and receive figure of merit (G/T).

These contours are needed to carry out earth station site selection. Reference (7) contains satellite coverage contours for the AUSSAT Satellite system.

3.2 EARTH STATION ANTENNA CHARACTERISTICS

3.2.1 Mechanical considerations Structural strength and rigidity are necessary elements to achieve the desired pointing and tracking ability. The site factors which need to be considered are: wind loadings (both prevailing and peak wind), thermal gradients, and climatic environment. There are four mechanical antenna performance factors which need to be specified and are affected by the above site factors:

- (a) Reflector surface accuracy (affected by wind loading and thermal gradients) which is determined by the electrical performance required for RF antenna gain and cross-polarization performance;
- (b) Antenna structure mechanical resonant frequency which is determined by the requirement for tracking accuracy and stability. The resonant frequency can be excited by wind loading leading to antenna pointing errors;
- (c) Antenna mount pointing flexibility and accuracy which are determined by the purpose of the antenna and the satellites with which it will operate. There are three commonly used antenna mounting systems, which are—
 - (i) Elevation/azimuth, which in practice, take many forms, depending on the size of the antenna and the amount of movement needed. The following description of a typical antenna of about 13 m diameter which is required to be adjustable over a wide range will illustrate the principles involved. The base of the structure is supported by wheels which run on a horizontal semi circular track. Rotation of the structure on this track provides the azimuth adjustment. The base of the antenna dish is attached to a point on the structure which is vertically above the centre of the circle of which the track is a segment. The attachment is by means of a bearing which allows rotation in a vertical plane, and this rotation is controlled by a suitable means to provide the elevation adjustment. See Figure 1.1.
 - (ii) Hour angle/declination (also called ‘polar’ or ‘equatorial’), which in practice comprise two rotating gear wheels which are at right angles to each other. The bottom gear rotates around a central fixed axis which is parallel to the true North/South rotational axis and therefore provides an East/West scanning motion relative to the axial movement of the earth. This positional (angular) coordinate is known as the hour angle. The second gear wheel is attached to the back of the antenna and provides a North/South positioning coordinate known as declination. An hour angle/declination mount at the equator becomes similar to an x-y mount and at either pole would be equivalent to an azimuth/elevation mount. It should be noted that the hour angle and declination axes are at right angles and that the declination axis is horizontal only when the hour angle is zero. See Figure 1.2.
 - (iii) x-y which in practice is constructed with two rotating gear wheels which rotate in planes at right angles to each other. They are aligned so that one rotates in the vertical plane containing the North/South axis and tracks the x-coordinate, whilst the other rotates in an inclined plane containing the East/West axis and tracks the y-coordinate. When both the x- and y-coordinates are zero, the two wheels are in the midpoint of their range of rotation and the antenna is pointing vertically up at the earth station zenith. The angle rotated by the first from the vertical is the x-angle and this sets an inclined plane of movement for the subsequent y-angle of rotation. See Figure 1.3.

Elevation/azimuth and hour angle/declination antenna mounts are suited best for geostationary satellites and deep space (Category B) missions. For near earth (Category A) missions an x-y mount is usually best suited.

- (d) Since the antenna is normally a non-duplicated component of the earth station, its structural design and construction should consider the economic trade-off between the capital cost of special corrosion protective measures and the potential operating cost in the future of structural repairs combined with loss of service (i.e. revenue) due to antenna downtime.

3.2.2 Electrical considerations Two antenna system performance requirements, (a) receive figure of merit and (b) transmitted power, are both influenced when operating close to the horizon profile.

In addition, the figure of merit may also be degraded when there are other obstructions, such as buildings or trees within or close to the antenna beam. Appendix A provides a more detailed discussion of ‘Defining the space in front of an antenna to be kept free of obstructions’.

- (a) Receive figure of merit is progressively reduced at elevation angles below 10° due to the increasing level of ground noise received by the antenna through its sidelobes and due to increasing length of the atmospheric path. This effect needs to be taken into consideration in calculation of link design;