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CHAPTER 1

SURFACES

1.1 GENERAL

The effective utilisation of an aerodrome may be considerably influenced by natural features and manmade constructions inside and outside its boundary. These may result in limitations on the distances available for take-off and landing and on the range of meteorological conditions in which take-off and landing can be undertaken. For these reasons certain areas of the local airspace must be regarded as integral parts of the aerodrome environment. The degree of freedom from obstacles in these areas is as important to the safe and efficient use of the aerodrome as are the more obvious physical requirements of the runways and their associated strips.

1.1.2 The significance of any existing or proposed object within the aerodrome boundary or in the vicinity of the aerodrome is assessed by the use of two separate sets of criteria defining airspace requirements. The first of these comprises the obstacle limitation surfaces particular to a runway and its intended use detailed in Chapter 4 of ECAR 139 - Aerodromes. The broad purpose of these surfaces is to define the volume of airspace that should ideally be kept free from obstacles in order to minimise the dangers presented by obstacles to an aircraft, either during an entirely visual approach or during the visual segment of an instrument approach. The second set of criteria comprises the surfaces described in the Procedures for Air Navigation Services - Aircraft Operations (PANSOPS) (Doc: 8168), Volume II - Construction of Visual and Instrument Flight Procedures. The PANS-OPS surfaces are intended for use by procedure designers for the construction of instrument flight procedures and for specifying minimum safe altitudes/heights for each segment of the procedure. The procedure and/or minimum heights may vary with aeroplane speed, the navigational aid being used, and in some cases the equipment fitted to the aeroplane.

1.1.3 The surfaces of ECAR 139 are intended to be of a permanent nature. To be effective, they should therefore be enacted in local zoning laws or ordinances or as part of a national planning consultation scheme. The surfaces established should allow not only for existing operations but also for the ultimate development envisaged for each aerodrome. There may also be a need to restrict obstacles in areas other than those covered by ECAR 139 if operational minima calculated using the PANS-OPS criteria are not to be increased, thereby limiting aerodrome utilisation.

1.2 ECAR 139 –OBSTACLE LIMITATION SURFACES

1.2.1 Function of the surfaces

1.2.1.1 The following paragraphs describe the function of the various surfaces defined in Chapter 4, and in certain instances include additional information concerning their characteristics. For the benefit of the reader, several illustrations of obstacle limitation surfaces are included in Appendix 1.

1.2.2 Outer horizontal surface

1.2.2.1 In the experience of some States, significant operational problems can arise from the erection of tall structures in the vicinity of airports beyond the areas currently recognised in ECAR 139 as areas in which restriction of new construction may be necessary. The operational implications fall broadly under the headings of safety and efficiency.

1.2.2.2 Safety implications. It is particularly desirable to review carefully any proposal to erect high masts or other skeletal structures in areas which would otherwise be suitable for use by aircraft on wide visual circuits, on arrival routes towards the airport or circuit, or on departure or missed approach climb-paths. Avoidance by marking or lighting cannot be relied upon in view of the relatively inconspicuous character of these structures, especially in conditions of reduced visibility, and notification of their existence will similarly not always guarantee avoidance.

1.2.2.3 Efficiency Implications. If tall structures are erected in or near areas otherwise suitable for instrument approach procedures, increased procedure heights may need to be adopted, with consequent adverse effects on regularity and on the duration of the approach procedure, such as the denial of useful altitude allocations to aircraft in associated holding patterns. Such structures furthermore limit desirable flexibility for radar vectored initial approaches and the facility to turn en route during the departure climb or missed approach.

1.2.2.4 In view of these potentially important operational considerations, authorities may consider it desirable to adopt measures to ensure that they have advance notice of any proposals to erect tall structures. This will enable them to study the aeronautical implications and take such action as may be at their disposal to protect aviation interests. In assessing the operational effect of proposed new construction, tall structures would not be of immediate significance if they are proposed to be located in:

(a) an area already substantially obstructed by terrain or existing structures of equivalent height; and
(b) an area which would be safely avoided by prescribed procedures associated with navigational guidance when appropriate.

1.2.2.5 As a broad specification for the outer horizontal surface, tall structures can be considered to be of possible significance if they are both higher than 30 m above local ground level, and higher than 150 m above aerodrome elevation within a radius of 15 000 m of the centre of the airport where the runway code number is 3 or 4. The area of concern may need to be extended to coincide with the obstacle-accountable areas of PANS-OPS for the individual approach procedures at the airport under consideration.

1.2.3 Inner horizontal surface and conical surface

1.2.3.1 The purpose of the inner horizontal surface is to protect airspace for visual circling prior to landing, possibly after a descent through cloud aligned with a runway other than that in use for landing.

1.2.3.2 In some instances, certain sectors of the visual circling areas will not be essential to aircraft operations and, provided procedures are established to ensure that aircraft do not fly in these sectors, the protection afforded by the inner horizontal surface need not extend into those sectors. Similar discretion can be exercised by the appropriate authorities when procedures have been established and navigational guidance provided to ensure that defined approach and missed approach paths will be followed.

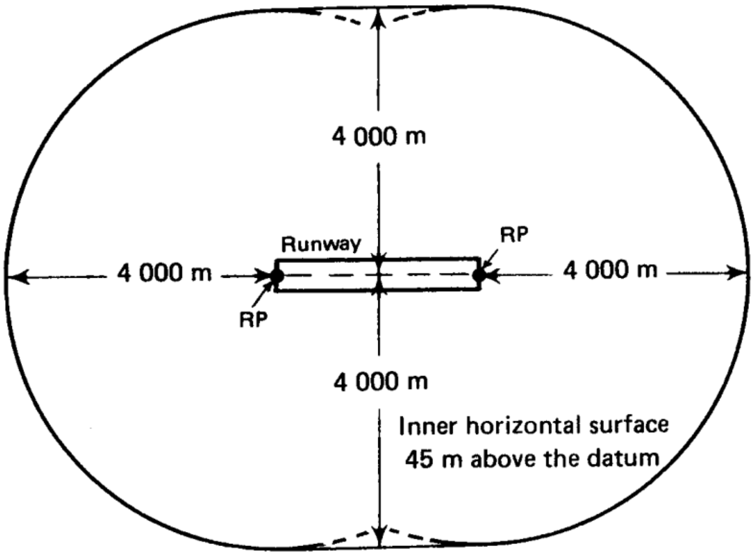

Figure 1-1. Inner horizontal surface for a single runway
(where the runway code number is 4)

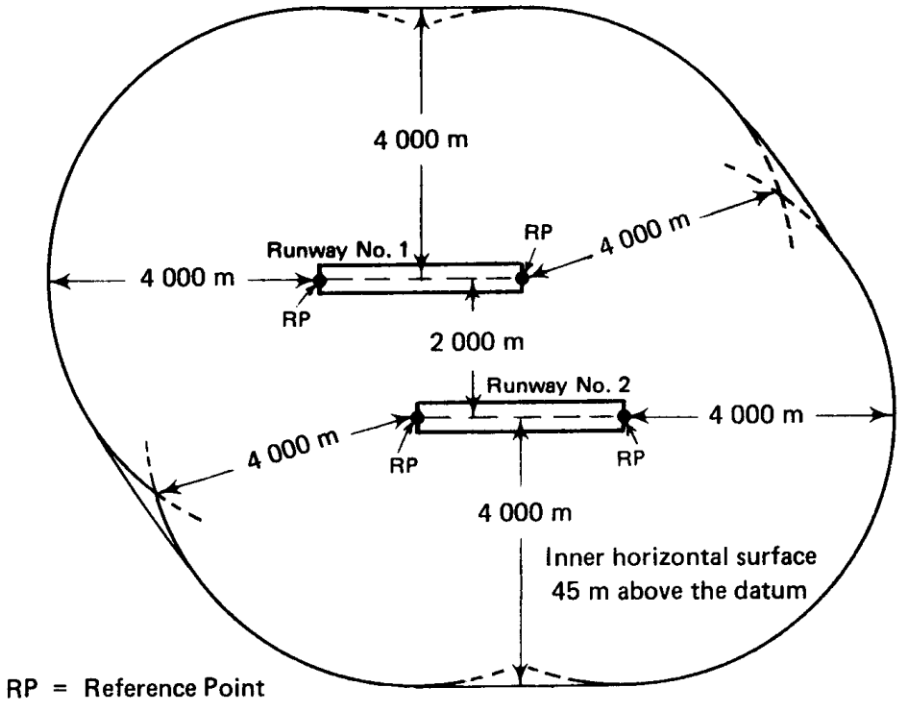

Figure 1-2. Composite inner horizontal surface for two parallel runways
(where the runway code number is 4)

1.2.3.3 Whilst visual circling protection for slower aircraft using shorter runways may be achieved by a single circular inner horizontal surface, with an increase in speed it becomes essential to adopt a race-track pattern (similar to PANS-OPS) and use circular arcs centred on runway ends joined tangentially by straight lines. To protect two or more widely spaced runways, a more complex pattern could become necessary, involving four or more circular arcs. These situations are illustrated at Figures 1-1 and 1-2 respectively.

1.2.3.4 Inner horizontal surface - elevation datum. To satisfy the intention of the inner horizontal surface described above, it is desirable that authorities select a datum elevation from which the top elevation of the surface is determined. Selection of the datum should take account of:

(a) the elevations of the most frequently used altimeter setting datum points;
(b) minimum circling altitudes in use or required; and c) the nature of operations at the airport.

For relatively level runways the choice of datum is not critical, but when the thresholds differ by more than 6rn, the datum selected should have particular regard to the factors above. For complex inner horizontal surfaces (Figure 1-2) a common elevation is not essential, but where surfaces overlap the lower surface should be regarded as dominant.

1.2.4 Approach and transitional surfaces

1.2.4.1 These surfaces define the volume of airspace that should be kept free from obstacles to protect an aeroplane in the final phase of the approach-to-land manoeuvre. Their slopes and dimensions will vary with the aerodrome reference code and whether the runway is used for visual, non-precision or precision approaches.

1.2.5 Take-off climb surface

1.2.5.1 This surface provides protection for an aircraft on take-off by indicating which obstacles should be removed if possible, and marked or lighted if removal is impossible. The dimensions and slopes also vary with the aerodrome reference code.

1.2.6 The inner approach, inner transitional an balked landing surfaces

1.2.6.1 Together, these surfaces (see Figure 1-3) define a volume of airspace in the immediate vicinity of a

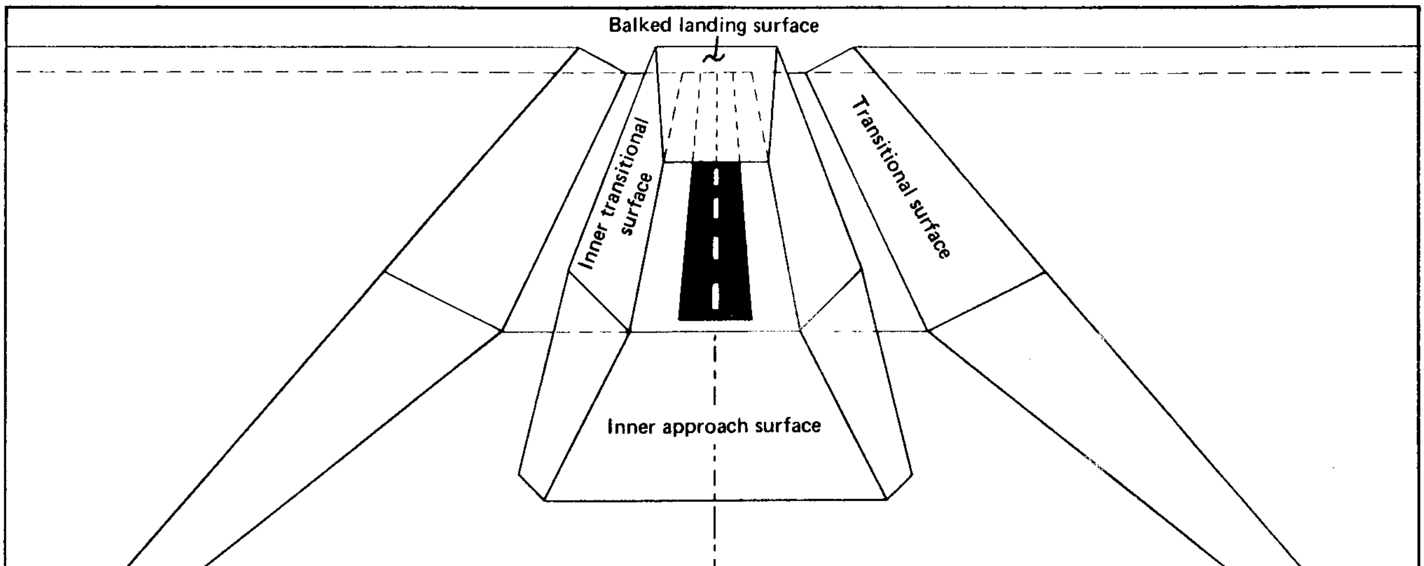

Figure 1-3.

precision approach runway which is known as the obstacle-free zone (OFZ). This zone shall be kept free from fixed objects, other than lightweight frangibly mounted aids to air navigation which must be near the runway to perform their function, and from transient objects such as aircraft and vehicles when the runway is being used for category 11 or 111 ILS approaches. When an OFZ is established for a precision approach runway category 1, it shall be clear of such objects when the runway is used for category I ILS approaches.

1.2.6.2 The OFZ provided on a precision approach runway where the code number is 3 or 4 is designed to protect an aeroplane with a wingspan of 60 m on a precision approach below a height of 30 m having been correctly aligned with the runway at that height, to climb at a gradient of 3.33 per cent and diverge from the runway centre line at a splay no greater than 10 per cent. The gradient of 3.33 per cent is the lowest permitted for an all-engine-operating balked landing. A horizontal distance of 1800 m from threshold to the start of the balked landing surface assumes that the latest point for a pilot to initiate a balked landing is the end of the touchdown zone lighting, and that changes to aircraft configuration to achieve a positive climb gradient will normally require a further distance of 900 m which is equivalent to a maximum time of about 15 s. A slope of 33.33 per cent for the inner transitional surfaces results from a 3.33 per cent climb gradient with a splay of 10 per cent. The splay of 10 per cent is based upon recorded dispersion data in programmes conducted by two States.

1.2.6.3 The OFZ for a precision approach runway category 1 where the code number is 1 or 2 is designed to protect an aeroplane with a wing span of 30 m to climb at a gradient of 4 per cent and diverge from the runway centre line at a splay no greater than 10 per cent. The gradient of 4 per cent is that of the normal take-off climb surface for these aeroplanes. When allied to a 10 per cent splay, it results in a slope for the inner transitional surfaces of 40 per cent. The balked landing surface originates at 60 m beyond the far end of the runway from threshold and is coincident with the take-off climb surface for the runway.

1.3 PANS-OPS SURFACES

General

1.3.1.1 The PANS-OPS surfaces are intended for use by procedure designers primarily in the construction of instrument flight procedures which are designed to safeguard an aeroplane from collision with obstacles when flying on instruments. In designing procedures, the designer will determine areas (horizontally) needed for various segments of the procedure. Then he will analyse the obstacles within the determined areas, and based on this analysis he will specify minimum safe altitudes/heights for each segment of the procedure for use by pilots.

1.3.1.2 The minimum safe altitude/height specified for the final approach phase of a flight is called "obstacle clearance altitude/height (OCA/H)”. A missed approach procedure initiated by the pilot at or above this altitude/height will ensure that, even if the pilot has no outside visual reference to the ground at any point, the aeroplane will pass safely above all potentially dangerous obstacles. The pilot may descend below the OCA/H only if he has visually confirmed that the aeroplane is correctly aligned with the runway and that there are sufficient visual cues to continue the approach. The pilot is permitted to discontinue the approach at any point below the OCA/H, e.g. if the required visual reference ceases to be available. Such a late missed approach is called balked landing. Because the initiation point of the balked landing procedure is known more accurately than the initiation point of the missed approach procedure, a smaller airspace needs to be protected.

Note. - Not all of the above is applicable to category III operations carried out with no decision height.

1.3.1.3 The size and dimensions of the obstacle-free airspace needed for the approach, for the missed approach initiated at or above the OCA/H and for the visual manoeuvring (circling) procedure are specified in PANS-OPS. Aeroplanes continuing their descent below the specified OCA/H, and therefore having visual confirmation that they are correctly aligned, are protected from obstacles by the ECAR 139 obstacle limitation surfaces and related obstacle limitation and marking/lighting requirements. Similarly, the ECAR 139 surfaces provide protection for the balked landing. In other than low visibilities, it may be necessary for the pilot to avoid some obstacles visually.

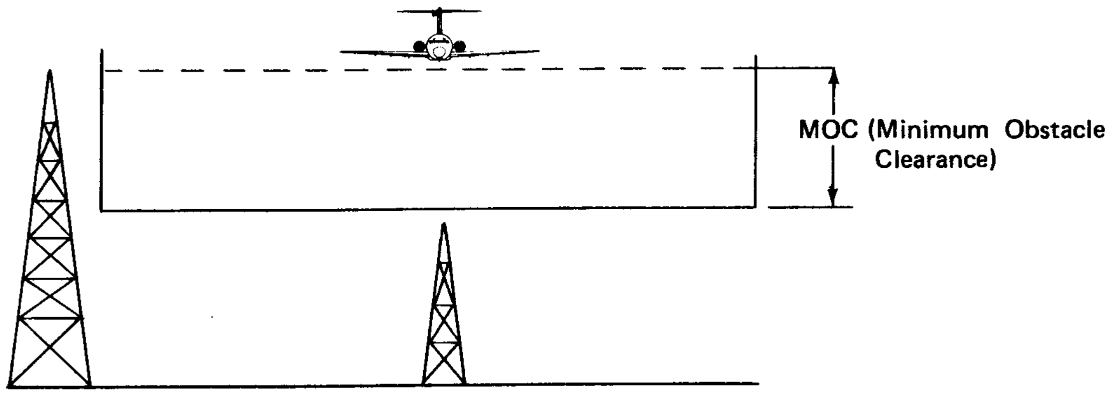

Figure 1-4.

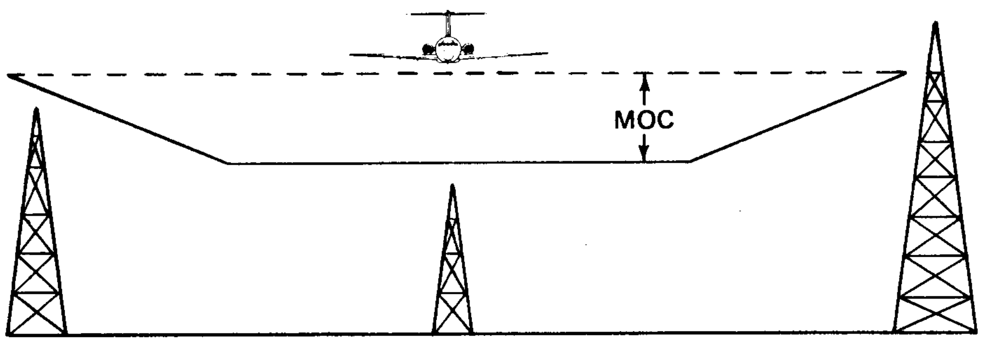

Figure 1-5.

1.3.1.4 The airspace required for an approach (including missed approach and visual circling) is bounded by surfaces which do not usually coincide with the obstacle limitation surfaces specified in ECAR 139. In the case of a non-precision approach, missed approach and visual manoeuvring, the surfaces have a rather simple form. Typical cross-sections of such obstacle-free airspace are shown in Figures 1-4 and 1-5. The plan view of such an obstacle-free area depends on the characteristics of the navigational facility used for the approach but not on the characteristics of the aeroplane. A typical plan view is shown in Figure 1-6.

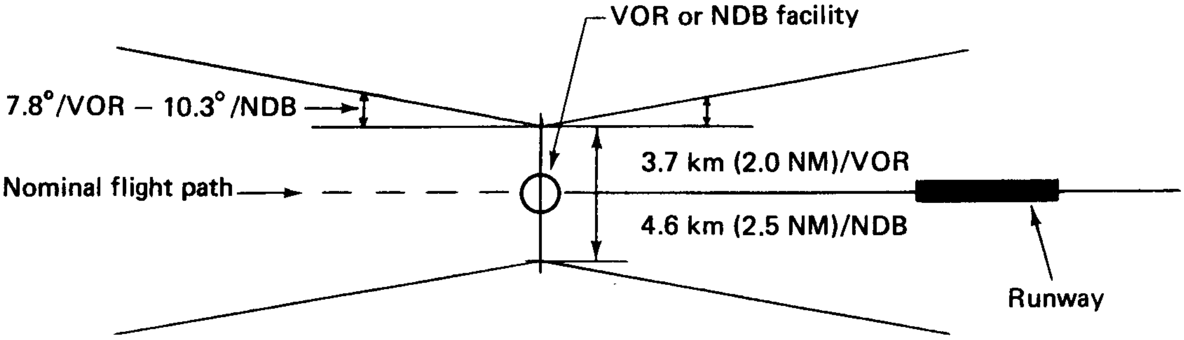

Figure 1-6.

1.3.1.5 In the case of a precision approach, the form of the obstacle-free airspace becomes more complicated because it depends on several variables, such as aeroplane characteristics (dimensions, equipment, performance) and ILS facility characteristics (facility

performance category, reference datum height, localizer course width and the distance between the threshold and localizer antenna). The airspace can be bounded by plane or curved surfaces which have resulted in “basic ILS surfaces”, “obstacle assessment surfaces (OAS)” and the Collision Risk Model (CRM) (see further, 1.3.2 to 1.3.4 below).

1.3.2 Basic ILS surfaces. “The basic ILS surfaces” defined in PANS-OPS represent the simplest form of protection for ILS operations. These surfaces are extensions of certain ECAR 139 surfaces, referenced to threshold level throughout and modified after threshold to protect the instrument missed approach. The airspace bounded by the basic ILS surfaces is however usually too conservative and therefore another set of surfaces, “obstacle assessment surfaces”, is specified in PANS-OPS.

1.3.3 Obstacle assessment surfaces. The obstacle assessment surfaces (OAS) establish a volume of airspace, inside which it is assumed the flight paths of aeroplanes making ILS approaches and subsequent missed approaches will be contained with sufficiently high probability. Accordingly, aeroplanes need normally only be protected from those obstacles that penetrate this airspace; objects that do not penetrate it usually present no danger to ILS operations. However, if the density of obstacles below the OAS is very high, these obstacles will add to the total risk and may need to be evaluated (see 1.5.2 below). The above airspace (funnel) is illustrated in Figure 1-7. It is formed by a set of plane surfaces; an approach surface (W), a ground or "footprint" surface (A) and a missed approach surface W; all bounded by side surfaces (X and Y). The dimensions of the surfaces are tabulated in PANS-OPS, Volume 11. The lateral boundaries of the funnel represent estimates of the maximum divergence of an aeroplane from the runway centre line during the approach and missed approach so that the probability of an aeroplane touching the funnel at any one point is 1:10-7 or less. The probable flight paths, both vertical and lateral, for aeroplanes tracking the ILS beams during an approach, have been based on a consideration of possible tolerances in both the ground and airborne navigational equipment and the extent to which the pilot may allow the aeroplane to deviate from the beam whilst attempting to follow the ILS guidance (pilot age). The probable flight paths in the missed approach are based on arbitrary assumptions of minimum climb performance and maximum splay angle of the aeroplane in a missed approach manoeuvre. Note that, as mentioned in 1.3.1.5, the precise dimensions of a funnel do vary with a number of factors. Having defined this volume of airspace, simple calculations allow an OCA/H to be calculated which would protect the aeroplane from all obstacles. The difference between the basic ILS surfaces and the OAS is that the dimensions of the latter are based upon a collection of data on aircraft ILS precision approach performance during actual instrument meteorological conditions, rather than existing ECAR 139 surfaces.

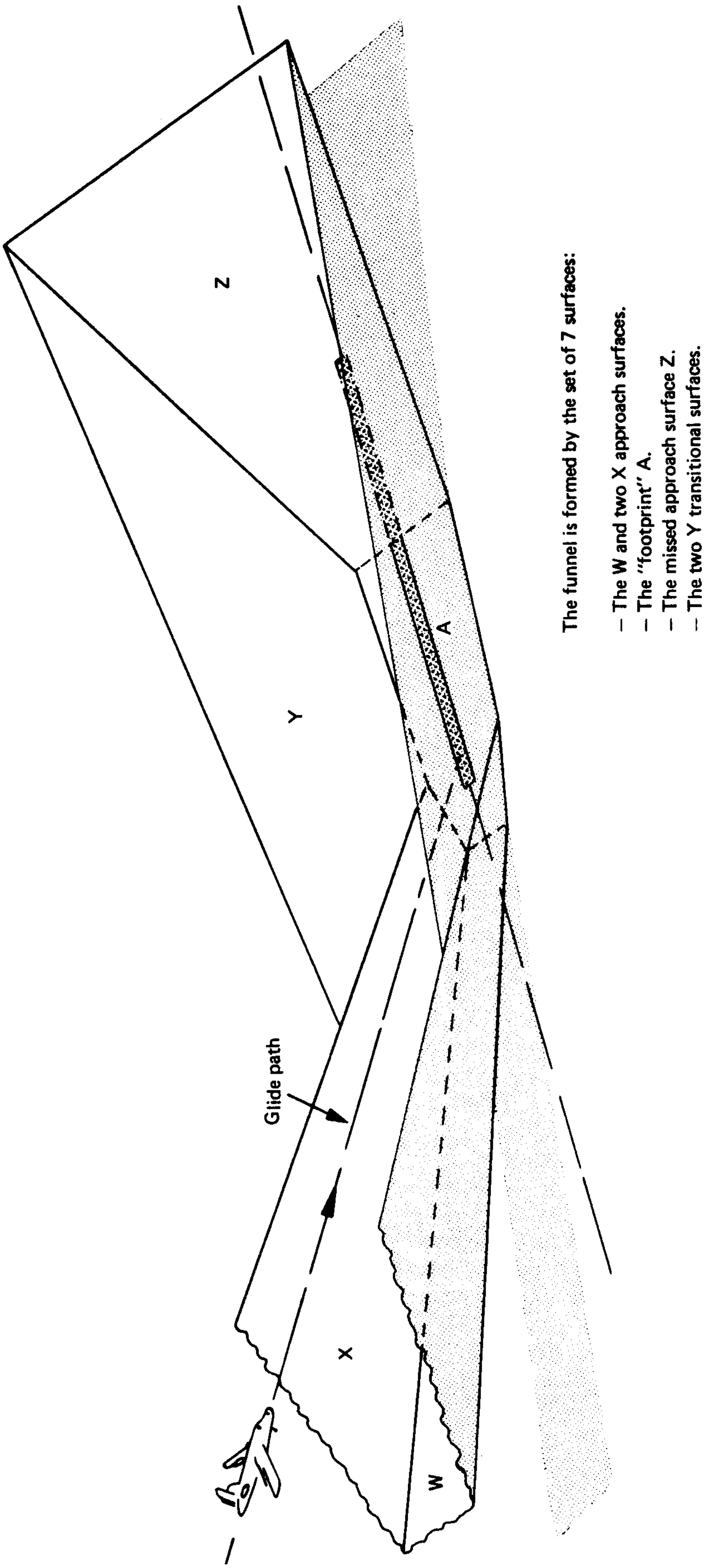

Figure 1-7. The approach funnel (OAS)

1.3.4 ILS Collision Risk Model (CRM). The approach funnel of the OAS was designed against an over-all risk budget of one accident in 10 million approaches (i.e. a target level of safety of I X 10-7 per approach). One consequence was that an operational judgement was required to assess the acceptable density of obstacles in the vicinity of the OAS, although they might be below the surface itself. In addition, the OAS were overprotective in certain areas, because they were relatively simple plane surfaces designed to enclose a complex shape and to allow easy manual application. As a consequence of these factors, a more sophisticated method of relating obstacle heights and locations to total risk and OCA/H was developed. This method was embodied in a computer programme called the Collision Risk Model (CRM). It enables a far more realistic assessment of the effects of obstacles, both individually and collectively. The actual construction of the approach funnel (illustrated in Figure 1-8) involves some fairly detailed mathematics and cannot be done manually. However, its application is easy, because all calculations will be done by a computer. The Collision Risk Model is widely available. (ECAA offers the service and the programme is available for purchase to interested users. For further details see 1.5 below).

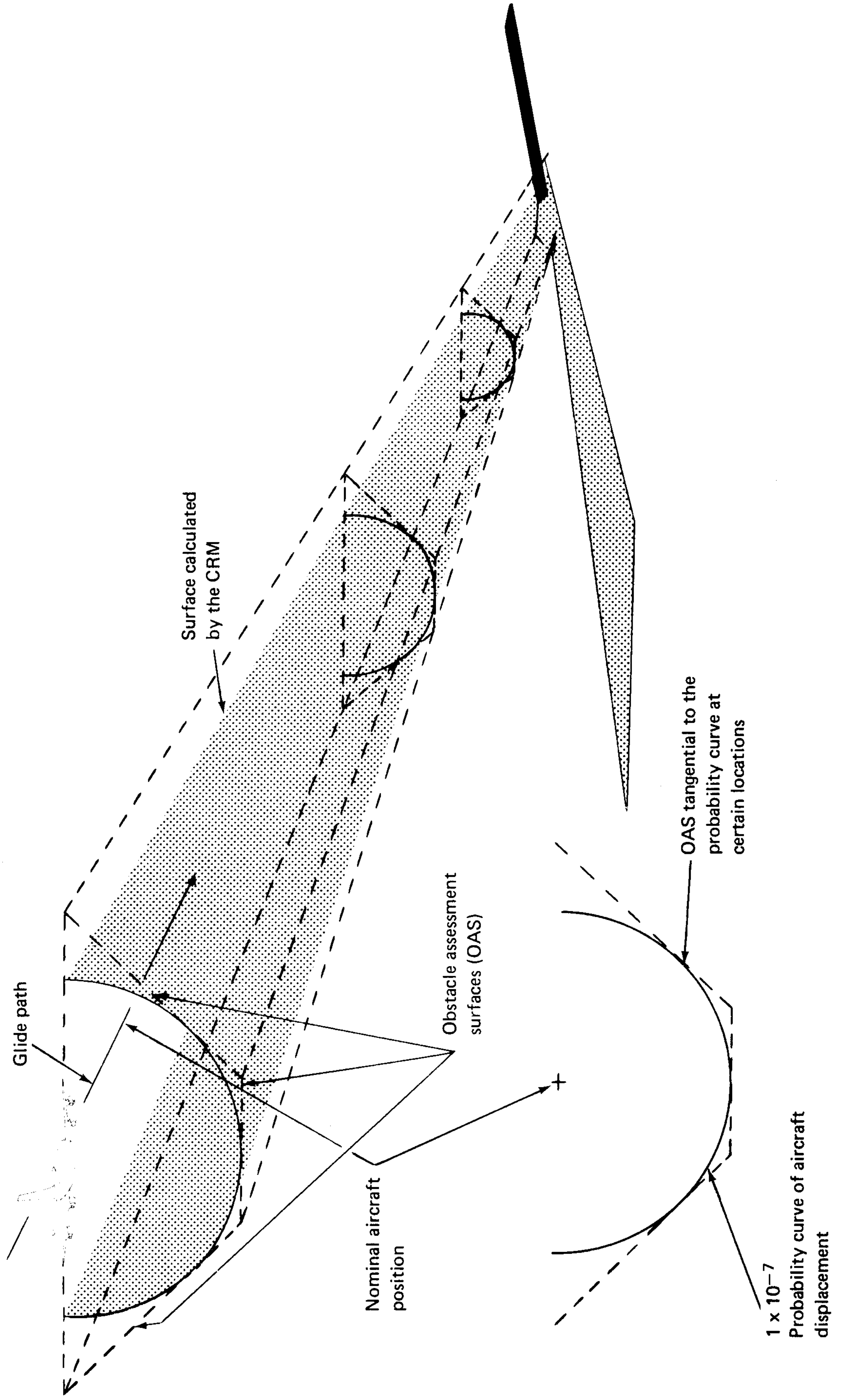

Figure 1-8. The approach funnel (CRM)

1.3.5 Visual manoeuvring (circling procedure). Visual manoeuvring (circling procedure), described in the PANS-OPS, is a visual extension of an instrument approach procedure. The size of the area for a visual manoeuvring (circling) varies with the flight speed. It is permissible to eliminate from consideration a particular sector where a prominent obstacle exists by establishing appropriate operational procedures. In many cases, the size of the area will be considerably larger than that covered by the ECAR 139 inner horizontal surface. Therefore circling altitudes /heights calculated according to PANS-OPS for actual operations may be higher than those based only on obstacles penetrating the inner horizontal surface area.

1.3.6 Operational minima. In conclusion, it must be stressed that a runway protected only by the obstacle limitation surfaces of ECAR 139 will not necessarily allow the achievement of the lowest possible operational minima if it does not, at the same time, satisfy the provisions of the PANS-OPS. Consequently, consideration needs to be given to objects which penetrate the PANS-OPS surfaces, regardless of whether or not they penetrate an ECAR 139 obstacle limitation surface, and such obstacles may result in an operational penalty.

1.4 INNER TRANSITIONAL AND BALKED LANDING SURFACES VERSUS Y SURFACES AND MISSED APPROACH SURFACE

When establishing the obstacle-free zone for precision approach category 11 operations, the Obstacle Clearance Panel (OCP) created the inner transitional and balked landing surfaces. When developing the new approach procedures contained in PANS-OPS, Volume II, First Edition, instead of using these surfaces for obstacle assessment, the OCP used the Y surface and a new surface referred to as the missed approach surface (see Figure 1-7). Both sets of surfaces are required. In determining the need for the two sets of surfaces, the difference between the objectives of ECAR 139 and PANS-OPS has to be taken into account. The surfaces in PANS-OPS are intended for assessing the impact of objects on the determination of the obstacle clearance height, which in turn is used in determining approach minima and ensuring that the minimum acceptable safety level is achieved (i.e. probability of collision with objects is not more than 1:10-7) . ECAR 139 surfaces are intended to define the limits around airports to which objects can extend. A further difference, and one specifically associated with these surfaces, is that PANS-OPS provides obstacle assessment for operations down to the obstacle clearance height and, for most aeroplanes, for a missed approach with one engine inoperative executed above or at this height. The ECAR 139 surfaces are intended to protect a landing from the obstacle clearance height, or a balked landing executed with all engines operative and initiated below the obstacle clearance height. In the missed approach case, the PANS-OPS surfaces (see 1.3.2 to 1.3.4 above), which include a missed approach surface, are the controlling surfaces. The obstacle assessment surfaces (OAS) fall below a portion of the ECAR 139 inner approach surface and below that portion of the transitional surface near the end of the touchdown area. In cases such as these, the ECAR 139 surfaces are used to determine OCH. In the landings and balked landing, the inner transitional and balked landing surfaces are the controlling surfaces.

1.4.2 The PANS-OPS and ECAR 139 surfaces are different for several reasons. A missed approach is to be executed at or above the obstacle clearance height. At this point, the aircraft can not be assumed to be aligned with the runway as precisely as in the case of a balked landing, as the pilot may never have had visual reference to the runway. The width required for executing the missed approach is therefore wider than for a balked landing; thus the use of the transitional surfaces, which are wider apart than the inner transitional surfaces. Secondly, since the missed approach may be assumed to be executed with one engine inoperative, the climb rate will be less than for a balked landing executed with all engines operating, and consequently the slope of the missed approach surface must be less than that of the balked landing surface. As the missed approach operation by definition has to be initiated at or above the obstacle clearance height, the origin of the missed approach surface may be closer to the threshold than that of the balked landing surface.

1.5 BACKGROUND OF THE COLLISION RISK MODEL

1.5.1 The Collision Risk Model (CRM) is a computer programme that calculates the probability of collision with obstacles by an aeroplane on an ILS approach and subsequent missed approach. The CRM was developed by the Obstacle Clearance Panel as a result of an extensive data collection programme followed by detailed mathematical analysis. The CRM is an important part of the criteria for ILS operations described in Part III of the PANS-OPS, Volume II.

1.5.2 Obstacle assessment and obstacle clearance calculations can be carried out by using obstacle assessment surfaces (see 1.3.3 above). However, this manual method, although simple in concept, involves tedious numerical calculations and is thus time-consuming, particularly if the number of obstacles is high. Furthermore, it suffers from two main drawbacks:

(a) Firstly, the requirement that the OAS be of simple form (a set of plane surfaces) to allow easy manual application of the criteria, results in the surfaces being overprotective in certain areas, particularly in the vicinity of the runway. This is precisely the area where critical obstacles (glide path antenna, holding aircraft, etc.) are most likely to be sited. Hence, under the OAS criteria, such obstacles may unnecessarily prevent aeroplanes operating to low minima.

(b) Secondly, the use of the OAS implies that these surfaces could become solid walls without any operational penalty in terms of an increase in OCA/H. Clearly such a situation would degrade safety. If left entirely to the operational judgement of the procedures specialist to decide at what point there exists an excessive density of obstacles around the runway, an insufficient operational penalty could result.

1.5.3 Therefore, although the OAS criteria are designed to achieve a specified target level of safety, they may result in a greater level of safety being imposed and consequently unnecessarily prevent operations to low minima or, alternatively, they may result in the safety of operations being degraded below the required standards. The CRM has been developed in response to these problems. It will:

(a) provide risk computations (separately for all obstacles and for individual obstacles) to a specific set of conditions and runway environment; and

(b) provide minimum acceptable OCA/H values for a specific set of conditions and runway environment.

1.5.4 The CRM may also be used to assist:

(a) in aerodrome planning (in evaluating possible locations for new runways in a given geographical and obstacle environment);

(b) in deciding whether or not an existing object should be removed; and

(c) in deciding whether or not a particular new construction would result in an operational penalty (i.e. in an increase in OCA/H).

1.5.5 Doe 9274-AN/904, entitled Manual on the Use of the Collision Risk Model (CRM) for ILS Operations, provides a comprehensive description of the CRM and instructions for its use.

CHAPTER 2

CONTROLLING OBSTACLES AT AN AIRPORT

2.1 BACKGROUND

2.1.1 In the early days of aviation, the rights of property owners were considered to extend from the surface downward to the centre of the earth and upward to infinity. Accordingly, the owner was free to erect structures on his land to unlimited heights and any encroachment in the airspace by others constituted a trespass. This meant that aircraft could not fly over private property at any altitude without permission of each property owner. Obviously, that policy could have prevented the development of civil aviation and scheduled air transportation. Gradually, courts and legislatures have modified the ownership doctrine to specify that a property owner has exclusive rights to the airspace over his land only to the greatest height which he might reasonably be expected to use, with a right of free public transit through the air above such height.

2.1.2 When buildings encroach on the airspace needed for aircraft operations, a conflict of interest arises between property owners and airport operators. If such differences cannot be resolved, it may be necessary for the national authority charged with approving aircraft operating procedures to establish restrictions limiting operations in the interest of safety. Such restrictions might take the form of requiring displaced thresholds (resulting in a reduction in effective runway length), higher weather minima for operations, reductions in authorised aircraft masses and possibly restrictions of certain aircraft types. Any of these actions could seriously affect orderly and efficient air transportation to an airport and adversely affect the economy of the communities served by the airport.

2.1.3 Control of obstacles in the vicinity of airports is, therefore, a matter of interest and concern to national governments, local communities, property owners and airport operators. There are severe legal, economic, social and political limitations to what can be achieved by any of these interests with respect to an existing airport where obstacles already exist. Even in the ideal situation of developing a new airport in an open area with no obstacles, prevention of future obstacles may be difficult because historically airports have expanded towards neighbouring communities and, conversely, communities have grown towards the airport boundaries. Every effort should be exerted by all interested parties to prevent erection of future obstacles and to remove or lower existing obstacles.

2.2 LEGAL AUTHORITY AND RESPONSIBILITY

2.2.1 National governments generally have the basic authority and primary responsibility to establish criteria for the limitation of obstacles and to provide guidance and assistance to those directly concerned with control of obstacles. These criteria should take the form of the obstacle limitation surfaces set forth in Chapter 1, and should be compatible with those in ECAR 139, Chapter 4. In addition, national authorities should make clear to community and airport officials the social and economic problems which may result from failure to maintain obstacle limitation surfaces free from obstacles.

2.2.2 In addition to setting criteria, government agencies should, where feasible or necessary, authorise local community officials to adopt zoning regulations to limit heights of buildings and trees to minimise future penetrations of obstacle limitation surfaces. Also, governments should authorise airport operators (or local communities) to acquire air easements or property rights (where such authority does not already exist), including the power to condemn property in the public interest by the exercise of eminent domain. Governments may also adopt rules and regulations designed to ensure notification of possible future obstacles in the interest of safety of aircraft operations.

2.2.3 Local community bodies such as municipal or county administrations, planning agencies and construction licensing authorities should, when properly authorised, adopt height zoning regulations based on appropriate obstacle limitation surfaces, and limit future developments accordingly. They may require property owners or developers to give formal notice of any proposed structure which may penetrate an obstacle limitation surface. Local bodies should co-operate closely with airport operators to ensure that the measures taken provide the greatest possible degree of safety and efficiency for aircraft operations, the maximum economic benefits to neighbouring communities and the least possible interference with the rights of property owners.

2.2.4 Ultimate responsibility for limitation and control of obstacles must, in practice, rest with the airport operator. This includes the responsibility for controlling obstacles on airport property and for arranging the removal or lowering of existing obstacles outside the airport boundaries. The latter obligation can be met by negotiations leading to purchase or condemnation (where authorised) of air easements or title to the property.

2.2.5 Each airport manager should designate a member of his staff to be responsible for the continuing process of making sure that airport approach, departure and manoeuvring areas remain clear of obstacles which may jeopardise safety. The airport manager, or his designee, should work closely with government agencies at all levels, national and local, to ensure that all possible steps have been taken to prevent erection of obstacles, including providing information to zoning authorities on the location, length, orientation and elevation of runways on which obstacle limitation surfaces are based. The airport manager must maintain constant vigilance to prevent erection of obstacles around his airport and he should alert other agencies to potential problems which may arise under their jurisdiction. In order to fulfil these obligations, the airport manager should establish a programme of regular and frequent visual inspections of all areas around the airport in order to be sure that any construction activity or natural growth (i.e. trees) likely to infringe any of the obstacle limitation surfaces is discovered before it may become a problem. This inspection programme should also include a daily observation of all obstacle lights, both on and off the airport, and corrective action in the case of light failure.

2.2.6 In summary, once the national government has set forth the necessary criteria, the principal methods of controlling obstacles available to community authorities and airport operators are height zoning, purchase of casements and purchase of property. Each of these issues is dealt with in greater detail in the following paragraphs.

2.3 HEIGHT ZONING

2.3.1 Enactment of zoning regulations incorporating height limits related to airport obstacle limitation surfaces is a difficult and complex process but a necessary one. A Model Zoning Ordinance to achieve this objective is presented in Appendix 2. As a general rule, any community desiring to adopt such an ordinance will need legal authority to do so from a higher level of government. Even when so authorised, the effectiveness of height zoning as a means of protecting airports may be severely limited.

2.3.2 It has become a well-established principle of law that zoning cannot be so restrictive as to deprive a property owner of his right to the use of his property without adequate compensation. Many height zoning ordinances have been ruled invalid by the courts when property owners have claimed invasion of their property rights.

2.3.3 Such considerations limit the effectiveness of height zoning, particularly in the most critical areas close to runway ends, where obstacle limitation surfaces may require very low heights. Any height zoning must recognise this fact and provide for a minimum allowable height which is reasonable in terms of existing land use in the vicinity. Even so, local opposition to aircraft operations and to any form of restrictions on use of property may give rise to legal challenges leading to possible invalidation of any but the most carefully drafted zoning ordinance.

2.3.4 Height zoning, and indeed any form of zoning, cannot be made retroactive. Existing structures and trees which do not conform to the zoning limits are generally permitted to continue as non-conforming uses. Obstacles of this nature must be dealt with by other methods, such as purchase of easements or property rights.

2.3.5 The fact that obstacle limitation surfaces for a single airport may overlie the property of several independent communities or legal jurisdictions further complicates the problem of adopting effective zoning. Airport operators have no zoning powers, and must rely on the co-operation of neighbouring communities. This may involve as many as thirty or forty separate jurisdictions, some of which may be unco-operative. In some cases, higher governmental bodies have authorised the creation of regional planning groups with the power to adopt uniform zoning standards. For example, in one such instance, a state government has authorised establishment of joint airport zoning boards with membership from the airport operator and each surrounding municipality. The board is empowered to adopt land use restrictions within 3.2 km of the airport boundary under approach areas, and 1.6 km elsewhere. The board may also enact height-restriction zoning within 1.6 and 2.4 km from the airport boundary.

2.3.6 As suggested by the above, land use zoning may also be helpful in certain areas as a means of preventing erection of obstacles. Where feasible, undeveloped areas may be zoned for uses which do not normally involve tall structures. Such uses may include agriculture, recreational activities, parks, cemeteries, auto parking and low (one-story) industrial buildings.

2.3.7 As outlined in Appendix 2, typical zoning ordinances generally include a statement of the purpose of or necessity for the action, a description of the obstacle limitation surfaces which should conform to the surfaces described in Chapter 1, and a statement of allowable heights which should conform to the specifications in ECAR 139, Chapter 4. Provisions are also made for a minimum allowable height, for existing non-conforming uses, for marking and lighting of obstacles and for appeals from the provisions of the ordinance.

2.4 PURCHASE OF EASEMENTS AND PROPERTY RIGHTS

2.4.1 In those areas where zoning is inadequate, such as locations close to runway ends or where existing obstacles are present, the airport operator should take steps to protect the obstacle limitation surfaces. These steps should include removal or reduction in height of existing obstacles, as well as measures to ensure that no new obstacles may be erected in the future.

2.4.2 An airport authority could achieve these objectives either by purchase of easements or property rights. Of these two alternatives, the purchase of easements would often prove to be more simple and economical. In this case, the airport authority secures the consent of the owner (after paying suitable compensation) to lower the height of the obstacle in question. This may be done by direct negotiation with the property owner. Such an agreement should also include a provision to prevent erection of future obstacles, if height zoning limits are not in effect or are inadequate to protect obstacle limitation surfaces.

2.4.3 Where negotiations to obtain easements are not successful, then the airport operator should give consideration to the second alternative, i.e. purchase of the property. The airport operator could resort to the acquisition of the property by condemnation if the government has authorised such action. In such cases, the airport operator must pay a reasonable compensation to the property owner, i.e. at the fair market value of the property.

2.4.4 One major airport operator has been specifically authorized to use the power of condemnation for obstacle clearance to a maximum distance of 4.8 kin, from the ends of the runways. Condemnation of property for the purpose of installing navigational aids is also authorized, but without the restriction as to distance.

2.4.5 Purchase of property rights involves several obstacles. If the property to be acquired would be removed from the tax rolls, as is often the case when the airport is publicly owned, the community officials and the airport neighbours may oppose the action because of the added tax burden on other properties. Also, neighbours of the affected property may object to acquisition by the airport for a number of reasons. Ownership of property which is not needed for airport purposes may be a burden to the airport operator because of the added expense of maintaining the property.

2.4.6 The tax exemption problem could be met by agreement to pay a sum in lieu of taxes, but this could be an extra expense to the airport operator for property which is not really needed. A better solution, where feasible, would be to sell the bulk of the property to private owners subject to protective covenants designed to prevent creation of future obstacles. Resale of property would, of course, have to be consistent with applicable zoning in the area. Beyond a distance of about 300 m from a runway end and land needed for approach lighting systems or other navigational aids, the airport operator should be able to sell most other land subject to appropriate height and use restrictions. Such sales would help to recover a substantial part of the cost of acquisition, would eliminate the continuing cost of maintenance and would return the land to the tax rolls. Appropriate use restrictions would include those mentioned in Section 2.3 above, if such uses are authorised by zoning regulations and acceptable to the community.

2.5 NOTIFICATION OF PROPOSED CONSTRUCTION

2.5.1 One of the difficult aspects of obstacle control is the problem of anticipating new construction which may penetrate obstacle limitation surfaces. Airport operators have no direct means of preventing such developments. As noted above, they should conduct frequent inspections of the airport environs to learn of any such projects. Although there is no legal obligation for airport operators to report proposed construction when they become aware of it, their own self-interest and the need to protect the airport indicate the wisdom of bringing such matters to the attention of the appropriate authorities. Of course, where an obstacle is to be located on airport property, such as electronic or visual aids, the airport operator is responsible for reporting such projects.

2.5.2 Several countries have enacted legislation or adopted regulations designed to assign responsibility for reporting new construction projects. The obligation to report such construction may rest with local agencies such as planning bodies or construction licensing authorities or with the developer himself. In some cases, height limits have been specified; these are generally consistent with the criteria of ECAR 139, Chapter 4, below which local authorities may authorise a project without higher review. If any part of a proposed development appears to penetrate an obstacle limitation surface, then the project should be referred to the appropriate civil aviation authority for review. This review would examine the effect of the envisaged construction on air navigation in general and on operational procedures in use in particular. If the conclusion of the above study is that the proposed construction can be permitted under some conditions, these should also be identified, e.g. display of obstacle marking and lighting, compliance with other appropriate measures for continued safety of air navigation, etc. Finally, all concerned should be notified of the new construction through charts (in accordance with Annex 4 - Aeronautical Charts) and through Notices to Airmen (NOTAM) or Aeronautical Information Publications (AIP) pursuant to Annex 15.

2.5.3 Among other States, the Federal Republic of Germany, the United Kingdom and the United States have established procedures for reporting proposed construction. Highlights of such procedures (in effect as of the indicated dates) are summarised for information:

(a) Federal Republic of Germany (FRG) - Aeronautics Act (Amended 8 January 1961)

Articles 12 through 19 deal with control of construction in the vicinity of licensed airports. The provisions of these articles specify that the authority competent for granting construction licences may license the construction of buildings only with the consent of the aeronautics authorities when construction is within a radius of 1.5 km from the airport reference point (see Section 2.6 below) or on the take-off, landing and safety areas. Consent of the aeronautics authorities is also required if construction is intended to exceed specified height limits within various larger radii from the airport reference point, or within specified distances within the approach zones.

(b) United Kingdom (UK) - CAP 168 "Licensing of Aerodromes", December 1978, Chapter 4 - The Assessment and Treatment of Obstacles

Section 11 specifies that, under the Town and Country Planning (Aerodromes) Direction 1972, the Civil Aviation Authority safeguards certain important aerodromes against future developments which might prejudice their actual or potential use for flying purposes. A safeguarding map is deposited with the local planning authority, showing the height above which new construction near an aerodrome may interfere with its use. The planning authority is required to consult the Civil Aviation Authority about any development exceeding the appropriate reference level. If a licensee (airport operator) becomes aware of a proposed development which in his opinion infringes any criterion or would inhibit intended development of the aerodrome, he should request the planning authority to take this into consideration in determining the application.

(c) United States (US) - Federal Aviation Regulations, Part 77 (Amended 4 March 1972)

Section 77.11 requires each person proposing specified kinds of construction or alteration to give "adequate notice" to the Administrator of the Federal Aviation Administration (FAA) together with supplemental notices 48 hours before the start and upon completion. Section 77.13 requires sponsors to notify the Administrator of any construction or alteration of more than 200 ft above ground level at its site, or of greater height than an imaginary surface extending outward and upward at a slope of 100 to I for a horizontal distance of 20 000 ft from the nearest point of the nearest runway at any public airport having at least one runway more than 3 200 ft in length. Steeper slopes are specified for airports with shorter runways and for heliports. Notice is also required for certain highway and rail construction, certain construction in an instrument approach area and construction of certain airports, in which case the "sponsor" would obviously be the airport operator. The FAA has also issued an Advisory Circular (AC 70/7460-2G, 30 November 1977) describing and illustrating for construction sponsors the requirements and procedures for submitting a notice of proposed construction.

2.6 ESTABLISHMENT OF OBSTACLE LIMITATION SURFACES

2.6.1 The following obstacle limitation surfaces are essential elements of a height zoning regulation associated with a precision approach runway:

(a) Conical surface;
(b) Inner horizontal surface; c) approach surface; d) transitional surfaces; and e) balked landing surface.

Of these surfaces, only the balked landing surface does not form part of the height zoning regulations for non-instrument and non-precision approach runways. In the case of take-off runways, the only surface which affects the height zoning regulation is the take-off climb surface. The dimensions and slopes of all of the above-mentioned surfaces are specified in ECAR 139, Tables 4-1 and 4-2, and a brief description of the surfaces also appears in Chapter 1 of this Manual.

2.6.2 The government agency responsible for civil aviation should establish obstacle limitation surfaces consistent with those defined in ECAR 139. Airport operators should provide government agencies and local planning bodies (for use in developing height zoning limits) with pertinent information about each airport, including:

(a) Location, orientation, length and elevation of all runways;
(b) Locations and elevations of all reference points used in establishing obstacle limitation surfaces;
(c) Proposed categories of runway use - no instrument, no precision approach or precision approach (category 1, 11 or 111);
(d) Plans for future runway extension or change in category.

2.6.3 It would be desirable to base all obstacle limitation surfaces on the most critical airport design features anticipated for future development, since it is always easier to relax a strict standard than to increase the requirements of a lesser standard if plans are changed. Some major airports make a practice of attempting to protect all runways to the standards required for category III precision approaches, to maintain maximum flexibility for future development.

2.6.4 Aerodrome reference point. ECAR 139 calls for the establishment of an aerodrome reference point to be used as the designated geographical location of the aerodrome. This reference point should be located near the geometric centre of the aerodrome. Locations of aerodrome reference points should be measured and reported to the nearest second of latitude and longitude. These figures may also be converted into terms of local grid systems for the convenience of community authorities concerned with zoning or limitation of construction. Elevations of reference points should be measured and reported to the nearest metre above a specified datum, such as mean sea level.

2.6.5 Inner horizontal surface. Although ECAR 139 does not specify a point of origin for the inner horizontal surface, a common usage has evolved in several major aeronautical States. Originally, the inner horizontal surface was defined as a circle with its centre at the airport reference point. As airports grew larger and runway patterns became more complex, this circle proved inadequate, and efforts were made to describe a larger surface by designating a secondary reference point and constructing an elliptical surface based on the two reference points as foci. More recently, it has been found preferable to designate a reference point at or near each runway end. These reference points are usually located at the end of the runway strip (60 m from the runway end where the runway code number is 3 or 4) and on the extended runway centre line. The inner horizontal surface is then constructed by striking an arc of the proper radius from each such reference point. The boundary of the surface is completed by straight lines tangent to adjacent arcs. Such a surface is illustrated in Chapter 1, Figure 1-2. The conical surface originates from the periphery of the surface so constructed. Where significant differences exist between runway end elevations (of the order of 6 m or more), it would be desirable to establish the elevation of the inner horizontal surface 45 m above the lowest reference point elevation to provide a greater margin of safety.

2.7 OBSTACLE SURVEYS

2.7.1 Identification of obstacles requires a complete engineering survey of all areas underlying the obstacle limitation surfaces. Such surveys are generally conducted by governmental authorities with the co-operation of the airport operator (see Chapter 4 of this manual). In the absence of a governmental survey, the airport operator should consider making the necessary survey with his own staff or with the assistance of a consultant or local operators.

2.7.2 Initial survey. The initial survey should produce a chart presenting a plan view of the entire airport and its environs to the outer limit of the conical surface (and the outer horizontal surface where established), together with profile views of all obstacle limitation surfaces. Each obstacle should be identified in both plan and profile with its description and height above the datum, which should be specified on the chart. More detailed requirements are contained in Chapters 3 and 4 of Annex 4, describing Aerodrome Obstruction Charts. Engineering field surveys may be supplemented by aerial photographs and photogrammetric to identify possible obstacles not readily visible from the airport.

2.7.3 Periodic surveys. The airport operator should, as previously suggested, make frequent visual observations of surrounding areas to determine the presence of new obstacles. Follow-up surveys should be conducted whenever significant changes occur. A detailed survey of a specific area may be necessary when the initial survey indicates the presence of obstacles for which a removal programme is contemplated. Following completion of an obstacle removal programme, the area should be resurveyed to provide corrected data on the presence or absence of obstacles. Similarly, revision surveys should be made if changes are made (or planned) in airport characteristics such as runway length, elevation or orientation. No firm rule can be set down for the frequency of periodic surveys, but constant vigilance is required. Changes in obstacle data arising from such surveys should be reported to the aviation community in accordance with the provisions of Annex 15 -Aeronautical Information Services.

2.8 REMOVAL OF OBSTACLES

2.8.1 When obstacles have been identified, the airport operator, with the assistance of local community agencies, should make every effort to have them removed or reduced in height so that they no longer constitute an obstacle. This will require negotiation with the owner of the property. If the obstacle is a single object such as a tree, a television antenna or a chimney, it may be possible to reach agreement to reduce the height to acceptable limits without adverse effect. In other cases, such as a building, it may be necessary to arrange for removal of the entire structure. This will, in all probability, require purchase or condemnation of the property. In either case, the airport operator must be prepared to compensate the property owner for any loss of value.

2.8.2 Where agreement can be reached for the reduction in height of an existing obstacle, the agreement should include a written aviation easement limiting future heights over the property to specific levels which conform to the pertinent obstacle limitation surfaces, unless effective height zoning has been established (see Sections 2.3 and 2.4 above).

2.8.3 Trees. In the case of trees which are trimmed, agreement should be reached in writing with the property owner to ensure that future growth will not create new obstacles. Property owners can give such assurance by agreeing to trim trees when necessary or by permitting access to the premises for the purpose of having such trimming done by representatives of the airport operator.

2.8.4 Some aids to navigation, both electronic (such as ILS components) and visual (such as approach and runway lights), constitute obstacles which cannot be removed. Such objects should be frangible designed and constructed, and mounted on frangible couplings so that they will fail on impact without damage to an aircraft. Guidance on the frangibility requirements of visual and non-visual aids to navigation is contained in Chapter 5 of this manual. Where necessary, such objects should be marked and/or lighted.

2.9 SHIELDING

2.9.1 In many countries the principle of shielding is employed to permit a more logical approach to restricting new construction and prescribing obstacle marking and lighting. It also reduces the number of cases of new construction requiring review by authorities. Shielding principles are employed when some object, an existing building or natural terrain, already penetrates above one of the obstacle limitation surfaces described in ECAR 139. If it is considered that the nature of an object is such that its presence may be described as permanent, then additional objects within a specified area around it may be permitted to penetrate the surface without being considered as obstacles. The original obstacle is considered as dominating or shielding the surrounding area.

2.9.2 The Seventh Session of the AGA Division introduced the principle of shielding to ECAR 139. Though the Division recognised the use of shielding in the specifications of ECAR 139, it did not draft specifications concerning the details of its employment. The Division did discuss how shielding should be employed but decided to leave this material as guidance for the present time.

2.9.3 It was generally agreed that the formula for shielding should be based on a horizontal plane projected from the top of each obstacle away from the runway and a plane with a negative slope of 10 per cent towards the runway. Any object which is below either of the two planes would be considered shielded. The permission to allow objects to penetrate an obstacle limitation surface under the shielding principle should, however, be qualified by reference to the need for an aeronautical study in all cases.

2.9.4 The shielding effect of immovable obstacles laterally in approach and take-off climb areas is more uncertain. In certain circumstances, it may be advantageous to preserve existing unobstructed cross-section areas, particularly when the obstacle is close to the runway. This would guard against future changes in either approach or take-off climb area specifications or the adoption of a turned take-off procedure.

2.9.5 The permanency of the immovable obstacle which is to be considered as shielding an area should be given very careful review. An object should be classed as immovable only if, when taking the longest view Possible, there is no prospect of removal being practicable, possible or justifiable, regardless of how the pattern, type or density of air operations might change.

2.9.6 In use, the methods for determining the extent of area shielded by a permanent obstacle and permissible height limits around it vary between States. It has often been found difficult to apply firm policies on this matter, and generally an aeronautical study is carried out to review the exact effect the construction of a new object will have. Several States, notably Austria, Chile, Czechoslovakia, Egypt, the Lao People's Democratic Republic, the Kingdom of the Netherlands and Switzerland, have reported that they followed the guidance provided above. To give some guidance on alternative shielding concepts, the practices of several selected States are given in Appendix 3.

2.10 MARKING AND LIGHTING OF OBSTACLES

2.10.1 Where it is impractical to eliminate an obstacle, it should be appropriately marked and/or lighted so as to be clearly visible to pilots in all weather and visibility conditions. ECAR 139, Chapter 6 contains detailed requirements concerning marking and/or lighting of obstacles. Some guidance on the characteristics of high intensity obstacle lights is included in the Aerodrome Design Manual, Part 4, Visual Aids.

2.10.2 It should be noted that the marking and lighting of obstacles is intended to reduce hazards to aircraft by indicating the presence of obstacles. It does not necessarily reduce operating limitations which may be imposed by the obstacle. ECAR 139 specifies that obstacles be marked and, if the airport is used at night, lighted, except that:

(a) Such marking and lighting may be omitted when the obstacle is shielded by another fixed obstacle; and
(b) The marking may be omitted when the obstacle is lighted by high intensity obstacle lights by day.

Vehicles and other mobile objects, excluding aircraft, on movement areas of airports should be marked and lighted, unless used only on apron areas.

2.10.3 Installation and maintenance of required marking and lighting may be done by the property owner, by community authorities or by the airport operator. The airport operator should make a daily visual inspection of all obstacle lights on and around the airport, and take steps to have inoperative lights repaired. In some cases, principally at commercial or industrial sites, the property owner may provide for maintenance, repair and replacement of lights. Otherwise, the airport operator should have agreements permitting his representatives to enter the property and perform the necessary maintenance. Many airport operators have found it helpful to use dual light fixtures with an automatic switch to the second light fixture if the first one fails. Such an arrangement provides greater assurance of continued obstacle lighting and reduces the number of visits to replace inoperative lamps.

2.11 REPORTING OF OBSTACLES

2.11.1 ECAR 139, Chapter 2 specifies that the location, top elevation and type of each significant obstacle on or in the vicinity of an aerodrome shall be made available. Specifications concerning the services to which the above details are to be made available and the manner in which they are to be published are prescribed in Annexes 4 and 15. From the standpoint of safety and regularity of civil aviation, every effort should be made to comply with the above requirements.

2.11.2 Whenever an obstacle, either temporary or permanent in nature, is identified, it should be reported promptly to the aviation community. To this end, the agency conducting the obstacle survey (government or airport operator) should be responsible for seeing that information on obstacles is promptly transmitted to the authority responsible for disseminating aeronautical information, viz. aeronautical information service. As indicated in Section 2.5, reporting of new construction may be done by the project sponsor, the local planning body, the construction licensing authority or the airport operator. The airport operator has the most direct interest in seeing that information is properly disseminated and, through visual inspections and periodic surveys, is most likely to be aware of the presence of new obstacles. It is, therefore, in his best interest for the airport operator to report all data on obstacles, including marking and lighting, to the aeronautical information service for further distribution. Reports may be verbal, but should he confirmed in writing as soon as possible.

2.11.3 Annex 15 contains detailed requirements on methods of disseminating aeronautical information, including data on obstacles. In addition to NOTAM, which may be given either Class I distribution (by means of telecommunication) or Class 11 (by other means), material may be issued in the form of Aeronautical Information Publications (AlPs) or Aeronautical Information Circulars. Where a critical situation may exist, information should be disseminated by verbal reports from the air traffic control to aircraft in the vicinity. AIPs should contain (among other items) current information on obstacles and obstacle marking and lighting. Each AIP should be amended or reissued at regular intervals as may be necessary to keep it up to date.

2.11.4 Obstacle information from obstacle surveys or other sources, such as reports from airport operators, is also presented in the form of Aerodrome Obstruction Charts A and B, Instrument Approach Charts, Visual Approach Charts and Landing Charts, which are described in Chapters 3, 4, 8, 11 and 12 of Annex 4. Charts produced in conformity with the provisions of Annex 4 may form a part of the AIP, or may be distributed separately to recipients of the AIP.
A high degree of co-operation among government and local authorities, airport operators and property owners is required to control obstacles and to provide a safe environment for efficient operation of aircraft at airports.

CHAPTER 3

TEMPORARY HAZARDS
PREFERRED PROCEDURE FOR DEALING WITH TEMPORARY HAZARDS ON RUNWAY STRIPS

3.1 INTRODUCTION

3.1.1 The term "temporary hazard" includes work in progress at the sides or ends of a runway in connexion with airport construction or maintenance. It also includes the plant, machinery and material arising from such work and aircraft immobilised near runways.

3.1.2 The prime responsibility for determining the degree of hazard and the extent of tolerable obstacle must ultimately rest with the competent authority who should take into account:

(a) Runway width available;
(b) Types of aircraft using the airport and distribution of traffic;
(c) Whether or not alternative runways are available;
(d) The possibility of cross-wind operations, bearing in mind seasonal wind variations;
(e) The weather conditions likely to prevail at the time, such as the visibility and precipitation. The latter is significant as it adversely affects the braking coefficient of the runway, and thus an aircraft's controllability during ground run;
(f) The possibility of a compromise between a reduction in runway length and some degree of the approach surface infringement.

3.1.3 All such hazards should be promulgated by NOTAM and marked and lighted in accordance with the requirements of ECAR 139. For unforeseeable hazards, such as aircraft running off runways, pilots must be informed by Air Traffic Control of the position and nature of the hazard.

3.2 RESTRICTIONS FOR NON-INSTRUMENT AND NON-PRECISION APPROACH RUNWAYS

3.2.1 Three zones alongside runways can be identified and are shown on Figure 3-1 as I, II and III.

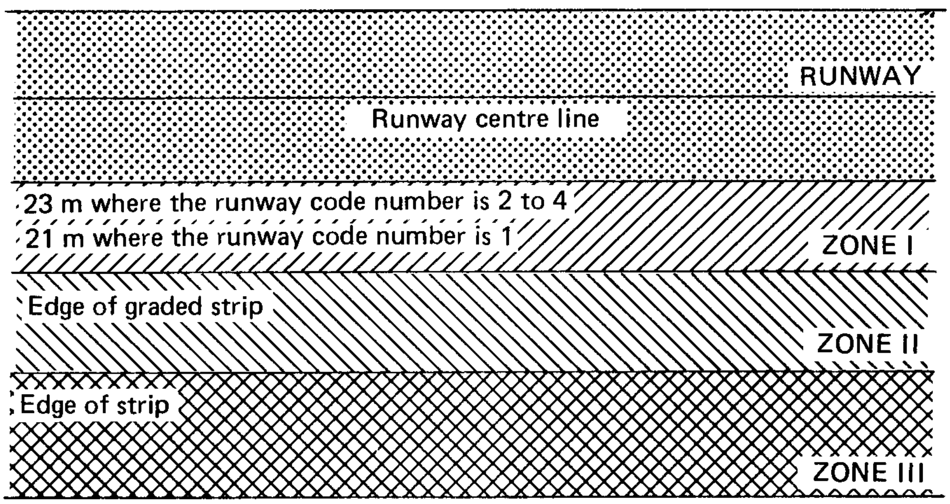

Figure 3-1. Limits of zones

Zone I
3.2.2 This zone lies within:
23 m of the runway edge where the runway code number is 2, 3 or 4;
21 m of the runway edge where the runway code number is 1.

3.2.3 Work may take place in this zone on only one side of the runway at a time. The area of the obstacle should not exceed 9 m2 , but narrow trenches may exceptionally be allowed up to 28 m2. Any obstacle permitted should be limited in height to provide propeller or pod clearance for the type of aircraft using the aerodrome, and in no case should the height exceed 1 m above the ground. Any piles of earth or debris which could damage aircraft or engines must be removed. Trenches and other excavations should be backfilled and compacted as soon as possible.

3.2.4 No plant or vehicles should operate in this zone when the runway is in use.

3.2.5 An aircraft immobilised in this zone would automatically require the closure of the runway.

Zone II

3.2.6 This zone extends from the outer edge of Zone 1 to the edge of the graded strip for each class of runway.

3.2.7 The restrictions to be applied depend on the type of operation taking place and the weather conditions.

3, 2.8 With a dry runway and not more than 15 kt cross-wind component for runways of code number 4, and 10 kt cross-wind component for runways of code number 2 or 3, the following work may be permitted:

(a) Visual flight conditions
   (1) Unrestricted areas of construction, with the length of excavation or excavated material parallel to the runway being kept to a minimum. The overall height of excavated material shall be limited to 2 m above the ground.
   (2) All construction equipment should be mobile and kept within normal height limits.
   (3) The runway may continue in use when an aircraft is immobilised in this zone.

(b) Instrument flight conditions
   (1) Unrestricted areas of construction, with the length of excavation or excavated material parallel to the runway being kept to a minimum. The overall height of excavated material shall be limited to 2 m above the ground.
   (2) All construction equipment should be mobile and kept within normal height limits.
   (3) When an aircraft becomes immobilised in this zone, the runway should be closed.

Zone III

3.2.9 This zone applies only to non-precision approach runways used in conditions of poor visibility or low cloud base. It extends outwards from the edge of the graded strip to the edge of the strip required for missed approaches, i.e. 150 m from the runway centre line.

3.2. 10 There are no restrictions on the work in this area. However, care must be taken to ensure that the work and the vehicles associated with the work do not interfere with the operation of radio navigational aids. The critical zones for radio aids are described in Annex 10, Attachment C.

Note. - Contractor's permanent and semi-permanent plant and mobile equipment withdrawn from the strips should not infringe the transitional surfaces described in ECAR 139.

Runway ends

3.2.11 In the case of work adjacent to the runway ends, the maximum possible use should be made of alternate runways or the displacement of the threshold so that the obstacle does not fall within the effective strip length or penetrate the associated approach surfaces. However, where landing distance may be critical, it may be safer to permit such an infringement near the runway end rather than displace the threshold.

3.3 RESTRICTIONS FOR PRECISION APPROACH RUNWAYS

3.3.1 Precision approach runways category III. ECAA Circular 148, entitled Surface Movement Guidance and Control Systems, details what special procedures should be followed to ensure safety when operations are taking place under low visibility conditions. The restrictions concerning the movement of vehicles and personnel detailed therein should be observed. In particular, no work should be permitted on any part of the movement area when the runway is being used. All equipment should be outside the obstacle-free zone and all personnel should be withdrawn from the movement area. The restrictions concerning the height of piles and debris in 3.2.3 and 3.2.8 are equally applicable to precision approach runways category Ш.

3.3.2 Precision approach runways category I and H. No work should be permitted within the OFZ when the runway is in use. All equipment and personnel should be outside the obstacle-free zone. The restrictions concerning the height of piles and debris in 3.2.3 and 3.2.8 are equally applicable to these runways.

3.4 PRE-CONSTRUCTION MEETING

3.4.1 It is an excellent practice for the contractor, airport operator and traffic control authority (where traffic control exists) to meet well in advance of the start of construction. This meeting can then consider such matters as discussed above, and agree on:

(a) means of control of construction vehicles so as to minimise interference with aircraft operations;

(b) scheduling of construction activities to conform as much as possible to periods of minimum aircraft activity; c) disposal of excavated material, storage of construction materials and equipment, and conditions of work site at the end of the period of work.

CHAPTER 4

AIRPORT EQUIPMENT AND INSTALLATIONS WHICH MAY CONSTITUTE OBSTACLES

5.1 INTRODUCTION

5.1.1 All fixed and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight, are obstacles. Certain airport equipment and installations, because of their air navigation functions, must inevitably be so located and/or constructed that they are obstacles. Equipment or installations other than these should not be permitted to be obstacles. This Chapter discusses the sitting and construction of airport equipment and installations which of necessity must be located on: a runway strip; a runway end safety area; a taxiway strip, or within the taxiway clearance distance specified in ECAR 139, Table 3-1, columns 5 and 6; or on a clearway, if it would endanger an aeroplane in the air.

5.1.2 When airport equipment, such as a vehicle or plant, is an obstacle, it is generally a temporary obstacle. However, when airport installations, such as visual aids, radio aids and meteorological installations, are obstacles, they are generally permanent obstacles.

5.1.3 Any equipment or installation which is situated on an airport and which is an obstacle should be of minimum practicable mass and height and be sited in such a manner as to reduce the hazard to aircraft to a minimum. Additionally, any such equipment or installation which is fixed at its base should incorporate frangible mountings (see 5.2).

5.1.4 The degree to which equipment and installations can be made to conform to the desired construction characteristics is often dependent on the performance requirements of the equipment or installation concerned. For example, frangibility and low-mass construction characteristics may have an adverse effect on the rigidity of a transmission meter support.

5.1.5 Many factors must be considered in the selection of aid fixtures and their mounting devices to ensure that the reliability of the aids is maintained and that the hazard to aircraft in flight or manoeuvring on the ground is minimal. It is therefore important that appropriate structural characteristics of all aids which may be obstacles be specified and published as guidance material for designers. To this end, some guidance on the frangibility requirements of airport equipment and installations is included in 5.3.

5.2 FRANGIBILITY

5.2.1 The frangibility of an object is its ability to retain its structural integrity and stiffness up to a desired maximum load, but on impact from a greater load, to break, distort or yield in such a manner as to present the minimum hazard to aircraft.

5.2.2 An object which meets the above requirements is said to be frangible.

5.3 TYPES OF AIRPORT EQUIPMENT AND INSTALLATIONS WHICH MAY CONSTITUTE OBSTACLES

5.3.1 General

5.3.1.1 There are many types of airport equipment and installations which, because of their particular air navigation functions, must be so located that they constitute obstacles. Such airport equipment and installations include:

(a) ILS glide path antennas;
(b) ILS inner marker beacons;
(c) ILS localizer antennas;
(d) Wind direction indicators;
(e) Landing direction indicators;
(f) Anemometers;
(g) Ceilometers;

(h) Transmisso meters; elevated runway edge, threshold, end and stop way lights;
(j) Elevated taxiway edge lights; k) approach lights;
(1) Visual approach slope indicator system (VASIS) lights;
(m) Signs and markers;
(n) Components of the microwave landing system (MLS);
(o) Certain radar and other electronic installations and other devices not itemised above;
(p) VOR or VOR/DME when located on aerodromes; q) precision approach radar systems or elements;
(r) VHF direction finders; and
(s) Airport maintenance equipment, e.g. trucks, tractors.

5.3.1.2 There is wide variation in the structural characteristics of these aids currently in use. Nevertheless, it is necessary that States develop material on appropriate structural characteristics of these aids for the guidance of designers. Details of the structural nature of ILS antennas and transmission meters employed by certain States are given below (5.3.2 through 5.3.4), together with guidance material developed by the Visual Aids Panel on the structural requirements of runway, taxiway and approach lights, and other aids (5.3.5 through 5.3.7).

5.3.2 ILS glide path antennas
5.3.2.1 Federal Republic of Germany. ILS glide path antenna masts used in the Federal Republic of Germany consist of thin-walled large-diameter tubes which are slightly cone-shaped and made from fibreglass material with short glass fibres (see Figure 5-1). These masts can resist considerable wind loadings but they will break with the application of a load such as would be imposed in the event of impact by an aircraft (see Figure 5-2).

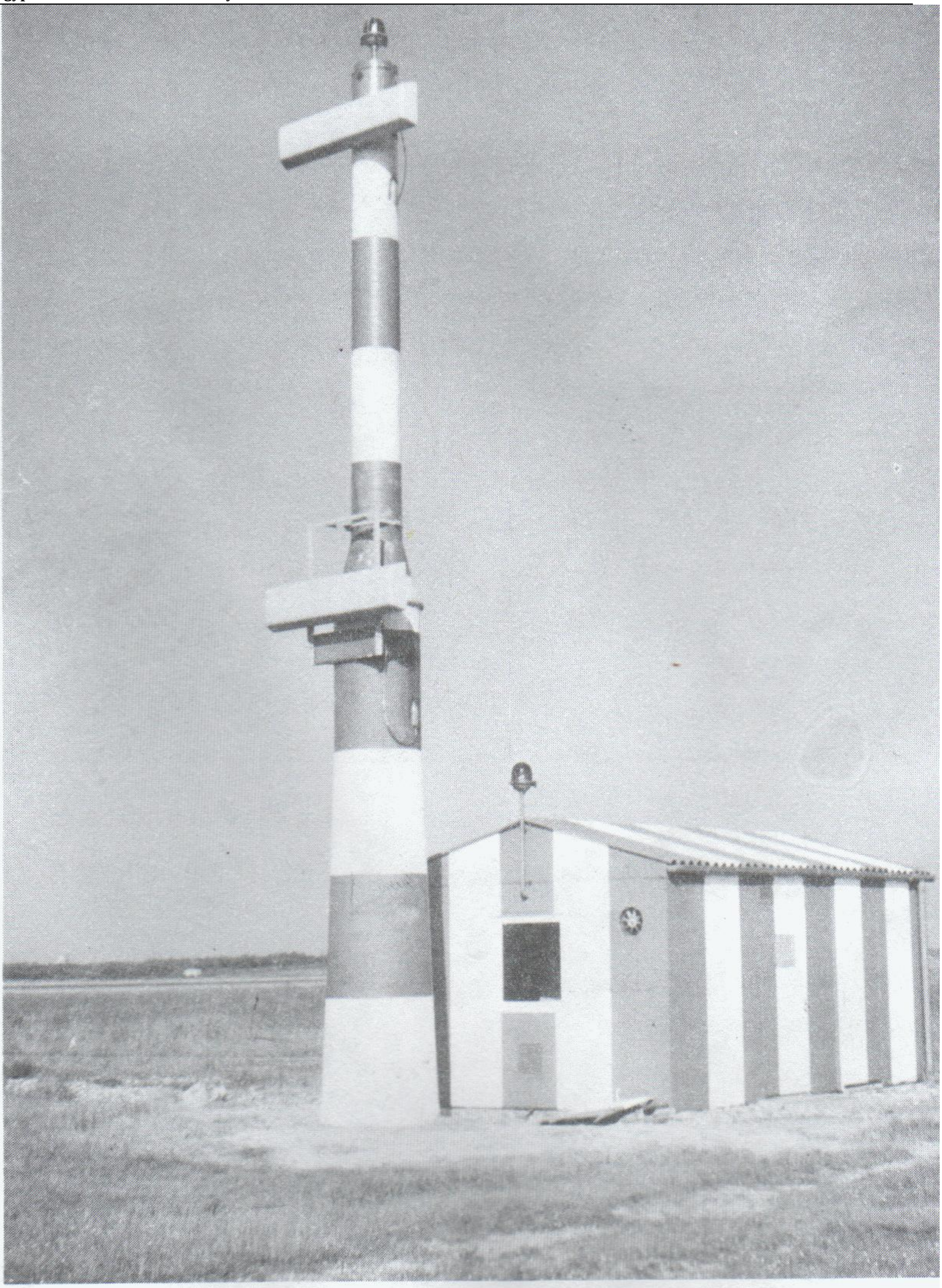

Figure 5-1. ILS glide path antenna

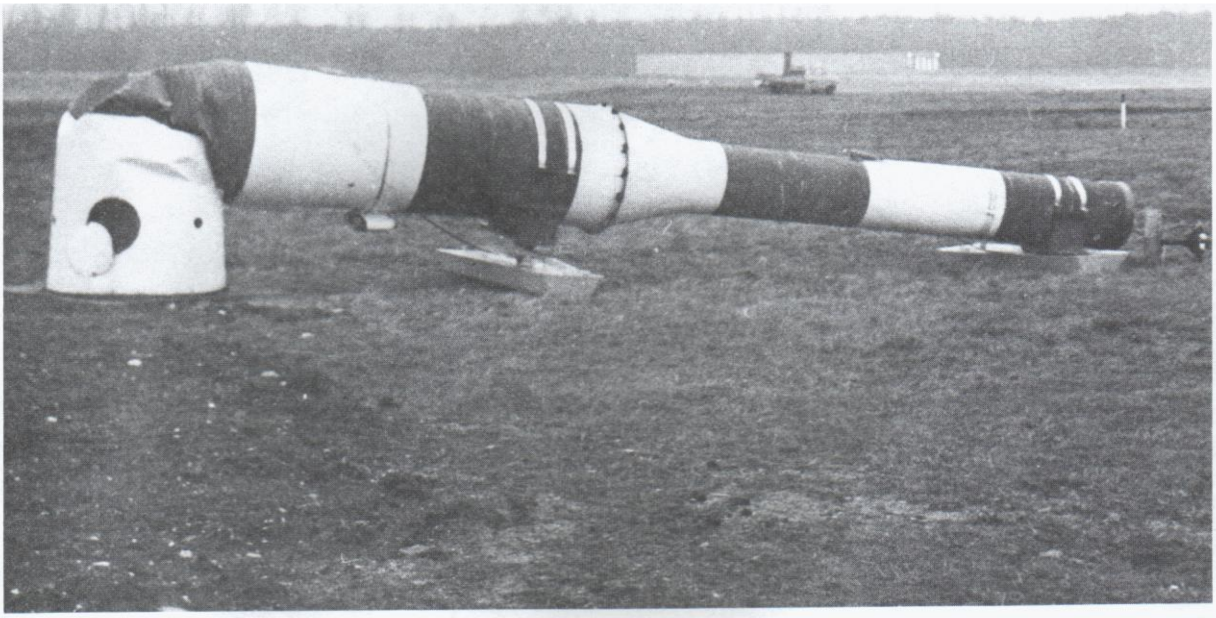

Figure 5-2. Fractured ILS glide path antenna

5.3.2.2 France. In France, the masts of ILS glide path antennas are made of steel angle members. Their cross-section is an equilateral triangle with I m sides, and they have welded braces at 0.7 m vertical intervals. Depending on the type of glide path, the mast height varies between 15 and 17.5 m. A compromise between strength (wind resistance) and frangibility is made by a weakening in the upper section of the tower, 10 m from the ground, obtained by saw cuts in the gusset plates connecting sections of the structure. The calculated direct failure load is 492 kgf applied at the top of the mast.

5.3.3 ILS localizer antennas

5.3.3.1 United Kingdom. One of the localizer antennas in use within the United Kingdom is the horn type. The horn antenna system is constructed of low-mass, low-impact strength materials. The major support brackets are mechanically fused to shear on impact, and the truncated corner reflector consists of closely spaced stainless steel wires stretched horizontally between the end spars of the main frame. The main frame is mounted on support brackets which are secured to a concrete base to produce an array of approximately 5.5 m in height. The antennas are 25 to 50 m in length. In the event of an aircraft overrunning the runway and colliding with the antenna, the fuse pins in the front support brackets shear, and the entire frame folds back to the ground causing minimal damage to the aircraft. Similarly, on collision from the rear, say on a low approach, the array will fold forward.

5.3.3.2 Federal Republic of Germany. ILS localizer antenna supports used in the Federal Republic of Germany consist of thin-walled tubes made from fibreglass material with short glass fibres. The maximum height of the installation is about 3 m (see Figure 5-3). The reflectors of the localizer antennas are rods approximately 2.5 m long, which are held by springs only. When exposed to loads in excess of the design load, they jump out of their supports and thus minimise the hazard to an aircraft overrunning the runway.

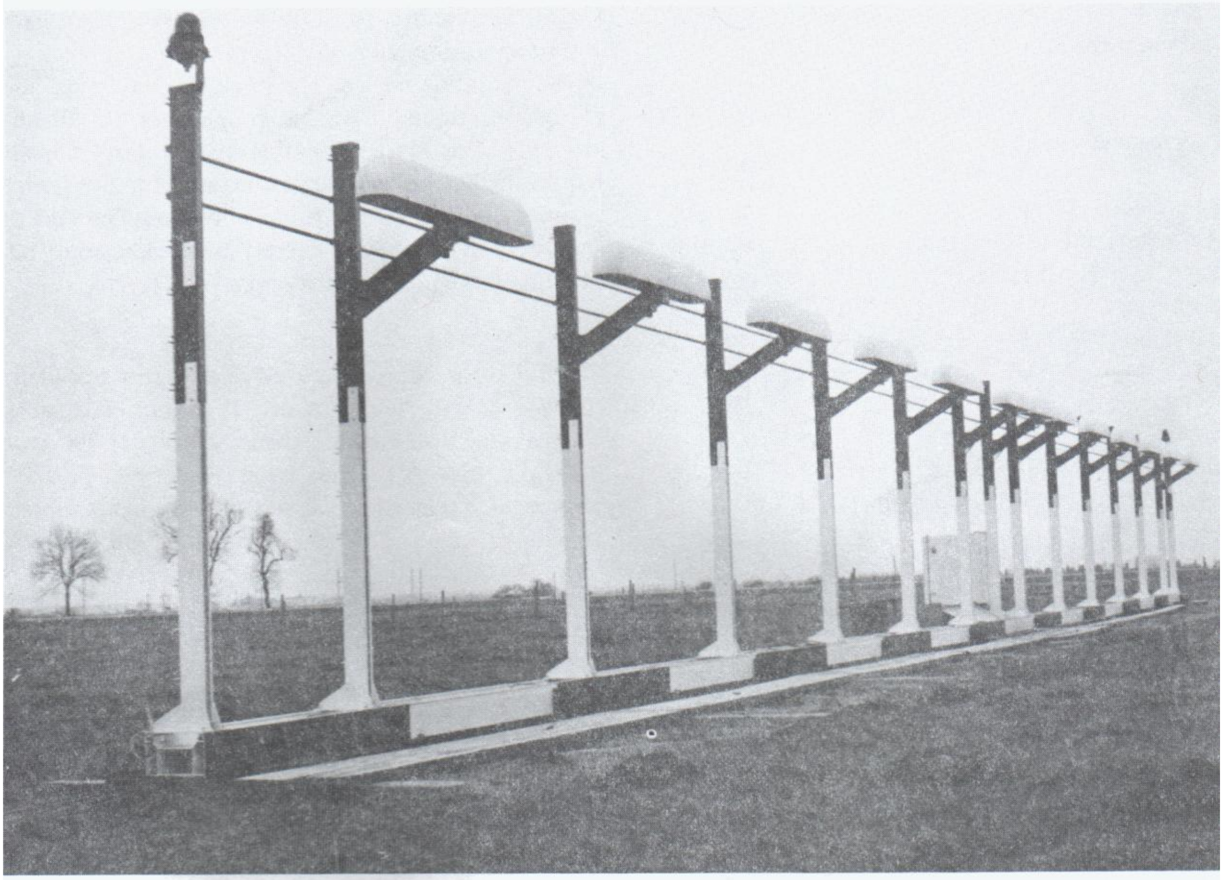

Figure 5-3. ILS localizer antenna array

5.3.3.3 Australia. One type of localizer antenna employed in Australia comprises aluminium-clad balsa wood spars supported by aluminium tubing. The supporting structure incorporates shear pins at critical points to allow the structure to collapse under impact.

5.3.3.4 France. Localizer antennas used in France are parabolic reflectors with a span of 35 m, made up of 19 vertical steel tubes connected by copper wire. These steel tubes have a diameter of 70 mm, and are 3.75 mm thick. They are braced by a strut at an angle of 45' secured at the mid-point of the antenna height. The reflecting surface consists of 56 horizontal copper wires of 2.5 mm diameter. The reflector is designed to withstand dynamic pressure resulting from a non-icing wind at 125 km/h, and to resist elastic deformation likely to interfere with radiation at wind speeds suitable for landing operations. The central tubes are weakened at a point 1.5 m from the top by drilling a ring of twelve 9 mm holes. The calculated direct loads at fracture are: 108 kgf applied in the normal landing direction; and 44 kgf in the opposite direction. (These loads vary according to the angle of application associated with curvature of the reflector and tension exerted by the wires.)

5.3.4 Transmission meters

5.3.4.1 United Kingdom. In the United Kingdom, transmission meters and reflectors are each contained in a brittle glass fibre housing having the following physical characteristics:

Maximum mass Greatest mass concentration

Height	-	1.83 m
Diameter	-	0.74 m
	-	89 kg
	-	34 kg at a height of approximately 1.5 m

The units are held in position by a single-necked bolt to produce a structure that will break off under a lateral load of 227 kgf.

5.3.4.2 Federal Republic of Germany. On airports within the Federal Republic of Germany, transmissometers are mounted on a base constructed of asbestos cement, glass-reinforced polyester or aluminium cast pipes. The manufacturers claim that these transmissometer mountings will rupture at a bending moment of 400 N.m.

5.3.4.3 Kingdom of the Netherlands. In the Kingdom of the Netherlands, the structure on which the transmissometer is placed is constructed of hollow aluminium tubes that, although sufficiently strong by themselves, bend or break easily should an aircraft collide with them. The structure is attached to a sunken concrete foundation by means of breakable bolts.
Note. - The guidance material on the structural requirements of certain visual aids in 5.3.5 through 5.3. 7 was developed by the Visual Aids Panel,

5.3.5 Elevated runway edge, threshold, end, stop way and taxiway edge lighting 1 The height of these lights should be sufficiently low to ensure propeller and engine pod clearance. Wing flexes and strut compression under dynamic loads can bring the engine pods of some aircraft to near ground level. Only a small height can be tolerated, and a maximum height of 36 cm is advocated.

5.3.5.2 These aids should be mounted on frangible mounting devices. The impact load required to cause failure at the break point should not exceed 5 kg.m and a static load required to because failure should not exceed 230 kg applied horizontally 30 cm above the break point of the mounting device. The desirable maximum height of light units and frangible coupling is 36 cm above ground. Units exceeding this height limitation may require higher breaking characteristics for the frangible mounting device, but the frangibility should be such that, should a unit be hit by an aircraft, the impact would result in minimum damage to the aircraft.

5.3.5.3 In addition, all elevated lights installed on runways of code letters A and B should be capable of withstanding a jet engine exhaust velocity of 300 kt, and lights on runways of code letters C, D and E, a lower velocity of 200 kt. Elevated taxiway edge lights should be able to withstand an exhaust velocity of 200 kt.

5.3.6 Approach lighting system
5.3.6.1 Guidance on the frangibility of approach lights is more difficult to develop, as there is a greater variation in their installation. Conditions surrounding installations close to the threshold are different from those near the beginning of the system; for example, lights within 90 m of the threshold or runway end are required to withstand a 200 kt blast effect, whereas lights further out need only withstand a 100 kt blast or the natural environmental wind load. Also, the terrain close to the threshold can be expected to be near the same elevation as the threshold, thus permitting the lights to be mounted on short structures. Farther from the threshold, support structures of considerable height may be required.

5.3.6.2 To minimise the hazard to aircraft that may strike them, approach lights should have a frangible device, or their supports be of a frangible design.

5.3.6.3 Where the terrain requires light fittings and their supporting structure to be taller than approximately 1.8 m and they constitute the critical hazard, it is considered that it is not practicable to require that the frangible mounting device be at the base of the structure. The frangible portion may be limited to the top 1.8 m of the structure, except if the structure itself is frangible. Though there is some question of the need to provide frangibility for approach lights installed beyond 300 in before the threshold (as these lights are required to be below the approach surface), it is recognised that protection needs to be provided for aircraft that might descend below the approach or take-off surfaces. A frangible top portion of 1.8 m is considered to be a minimum specification, and a longer frangible top portion should be provided where possible.

5.3.6.4 In all cases, the unit and supports of the approach lighting system should fail when an impact load of not more than 5 kg.m and a static load of not less than 230 kg is applied horizontally at 30 cm above the break point of the structure.

5.3.6.5 Where it is necessary for approach lights to be installed in stop ways, the lights should be inset in the surface when the stop way is paved. When the stop way is not paved, they should either be inset or, if elevated, meet the criteria for frangibility agreed for lights installed beyond the runway end.

5.3.7 Other aids (for example, VASIS, signs and markers)

5.3.7.1 These aids should be located as far as practicable from the edges of runways, taxiways and aprons as is compatible with their function. Every effort should be made to ensure that the aids will retain their structural integrity when subjected to the most severe environmental conditions. However, when subjected to aircraft impact in excess of the foregoing conditions, the aids will break or distort in a manner which will cause minimum or no damage to the aircraft.

5.3.7.2 Caution should be taken, when installing visual aids in the movement area, to ensure that the light support base does not protrude above ground, but rather terminates below ground as required by environmental conditions so as to cause minimum or no damage to the aircraft overrunning them. However, the frangible coupling should always be above ground level.

APPENDIX 1

ILLUSTRATIONS OF OBSTACLE LIMITATION SURFACES OTHER THAN THOSE CONSTITUTING AN OBSTACLE-FREE ZONE

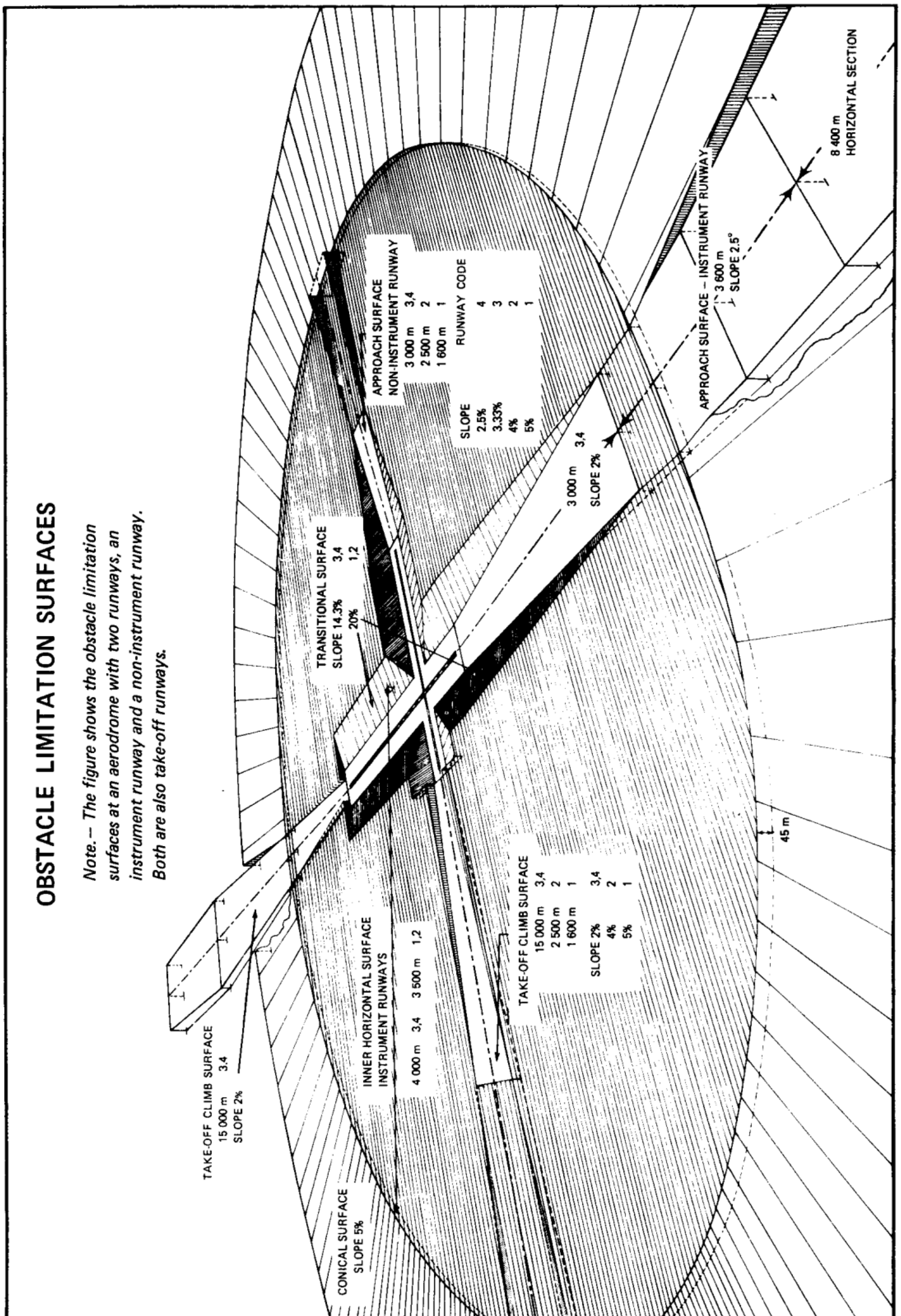

Figure A-1-1

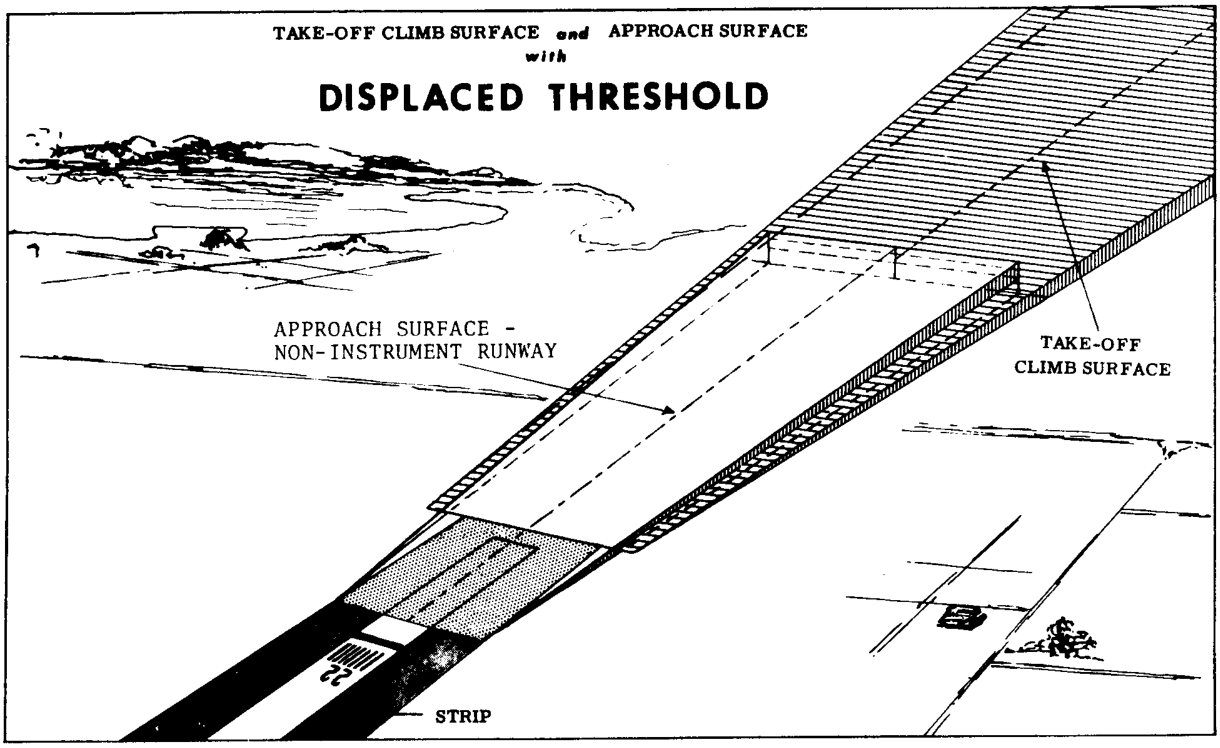

Figure A-1-4

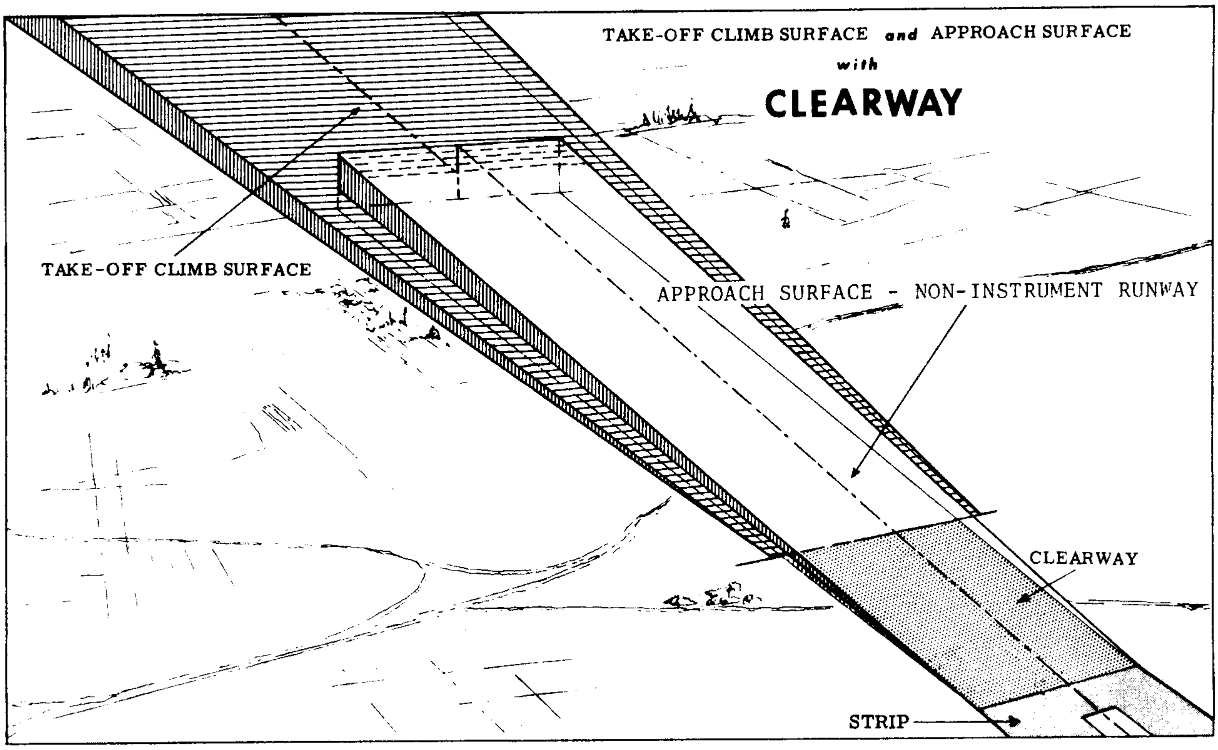

Figure A-1-5