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INTERNATIONAL CIVIL AVIATION ORGANIZATION

EUROPEAN GUIDANCE MATERIAL ON MANAGING BUILDING RESTRICTED AREAS

- Second Edition -

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SUMMARY

For the same CNS facilities widely differing protection zones are utilised by member states. This has led to the confusion of developers, planners, airport operators and others interested in the progressive development in, on and around sites where CNS facilities are necessarily located. This guidance material proposes harmonised protection zones and defines for the most common facilities a building restricted area (BRA). Buildings within this BRA have potential for causing unacceptable interference. All building activities in this area should be assessed. A process for the assessment of these buildings is identified herein.

1. Introduction

1.1 Under the European Air Navigation Planning Group (EANPG) the All-Weather Operation Group (AWOG) addressing the sustainability of All Weather Operations (AWO) was presented with a paper highlighting a problem with the determination of Building Restricted Areas (BRAs').

1.2 It has been identified by numerous member states that the control of buildings and the approval processes employed may lead to widely ranging allowances of what is permitted.

1.3 The AWOG set up a Project Team on Building Restricted Areas (PT/BRA) to elaborate respective European Operational Requirements (OR) and develop guidance material in order to ensure signal in space requirements are maintained within specification for the respective Communication, Navigation and Surveillance (CNS) facilities used in support of the AWO.

1.4 In the context of this guidance material the definition of the word "Building" will be as defined in section 3 of this document.

1.5 Guidance material by its very nature is for guiding the user and hence the process identified herein allows a two step approach to the decision making process of whether a building causes unacceptable interference.

1.6 The principle behind this guidance material is to provide a readily accessible, practical standard procedure. This will enable member states to assess building applications to a known process.

1.7 It is provided for use by member states to aid the procedure of evaluating all planning applications for buildings.

1.8 It is recommended that the appropriate engineering authority be contacted for correct interpretation of the shapes included in the procedure. This is to ensure the shapes are used correctly for the appropriate facility.

2. SCOPE

2.1 This document establishes guidance material for determining whether the physical presence of a building may have an adverse effect on the availability or quality of CNS signals of the following ICAO recognised facilities:

- DME N
- VOR
- Direction Finder
- NDB
- GBAS (VDB & Receiver stations)
- ILS (Localiser, Glide-path, & Markers)
- SBAS (ground monitoring station)
- MLS (Azimuth & Elevation)
- VHF Communication
- Primary Radar
- SSR

2.2 Degradation of the signal in space caused by electromagnetic interference (EMI) is not covered in this guidance material.

2.3 The obstacle restrictions that are given in this guidance material do not take into account the effect of the proposed buildings upon VFR / IFR aeronautical operations. The criteria for evaluating buildings from an operational point of view are contained within Annex 14 (Aerodromes) and in ICAO Doc. 8168 (PANS OPS).

2.4 Satellite Up/Down links, VHF/UHF Ground/Ground communication facilities, Microwave links and HF facilities are not considered within this document.

2.5 Critical and Sensitive areas are based on the guidance found within Annex 10 and are not considered within this document.

2.6 Monitoring sites and radio links are not considered within this document.

2.7 PAR facilities are excluded from this document.

2.8 Military communication facilities are not considered within this document.

2.9 MLS and GNSS advanced operations are not considered within this document.

3. Definitions

3.1 Building

3.1.1 The development of the guidance material has been with the notion of building in mind. However the guidelines developed apply equally well for other objects whether moving or stationary, temporary or permanent causing interference to the radio signals of CNS facilities, such as machines, constructions used for the erection of buildings as well as excavation and spoil or even vegetation.

3.2 Building Restricted Area (BRA)

3.2.1 In the context of AWO, the BRA is defined as a volume where buildings have the potential to cause unacceptable interference to the signal-in-space in the service volume of CNS facilities for AWO. All CNS facilities have BRA defined which are not limited to actual site boundaries of the facility but extend to significant distances from the facility.

3.2.2 Buildings mentioned in 6.4 & 7.7 should be assessed even when outside the BRA limits.

4. General procedure

4.1 The general procedure is a two-step process (see **Figure 1**) for the approval of buildings that may adversely affect CNS facilities.

4.2 The analysis carried out under both processes should be formally recorded. The intention is that Step 1 should be an expedient evaluation and Step 2 should involve in-depth analysis.

4.3 For Step 1: Use the General Input Screening method for all applications. This screen is to be used by the appropriate authorities (for example: Airport, Planning, Local Official, Government Authorities who conduct the initial review of building applications) in order to ascertain whether approval can be given directly or it should be passed to the appropriate engineering authorities (Air Traffic Safety Electronic Personnel - ATSEP).

4.4 For Step 2: The ATSEP should carry out detailed analysis. This should cover all aspects of the CNS facility to be protected and the possible effects of the proposed building on the signal in space provided by these facilities.

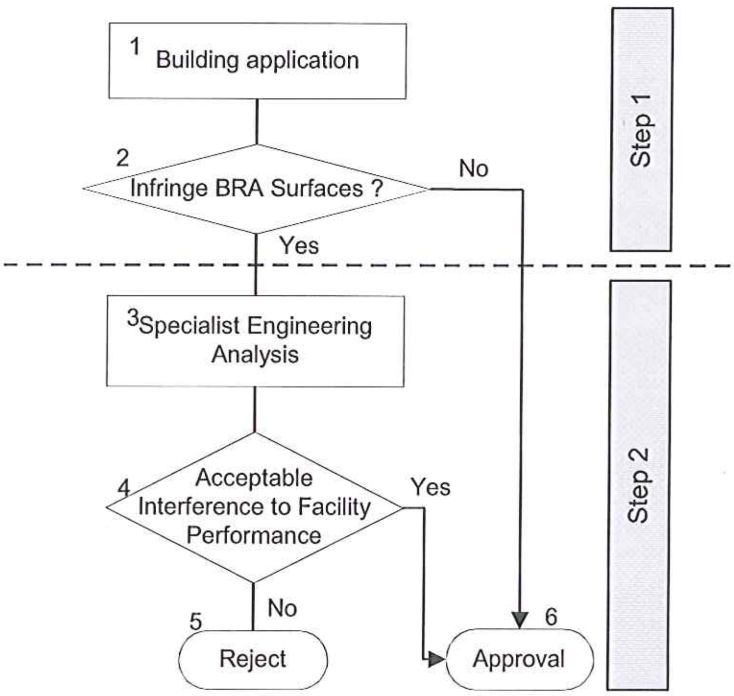


Figure 1: Guidance review process

Definitions and explanation applicable to Figure 1

Step 1

4.5 Building application

4.5.1 The application for a new building or modification to an existing or planned building.

4.6 Infringe surfaces

4.6.1 This is where the generic screening method is applied to the proposal to determine if the BRA surfaces are infringed. In case of non-infringement the process is terminated and the application is recorded as approved.

Step 2

4.7 Specialist engineering analysis

4.7.1 When an infringement of the BRA is identified, the application is handed over to the responsible engineering authorities for the CNS facilities. This is in accordance with the relevant formal approval process. The engineering authority will conduct appropriate analysis based on theory, experience and existing conditions.

4.8 Interference to facility performance

4.8.1 The results of the ATSEP analysis determine if the interference effects are acceptable or not. Where conflicting analysis or studies arise it is recommended that first consideration be given to altering the proposal.

4.9 Application rejection

4.9.1 The building applicant is notified of the rejection of the application by the appropriate authority. This does not preclude any modification that may be made to the application. Following rejection of the building proposal it may be possible to modify and re-submit the application. A modified proposal is subjected to the applicable review processes as identified in Figure 1.

4.10 Application approval

4.10.1 Approval for the building application is given when interference effects to facility performance are accepted.

5. Details of the two-step process

5.1 Step 1

5.1.1 The signal in the service volume for all CNS facilities must be protected from unacceptable interference. In order to achieve this, each type of facility must have its own safeguarded surface as defined by a shape of a certain form. The dimensions of the shape are dependent upon individual facility types.

5.1.2 Omni-directional facilities are assessed using the shape formed from a cone and cylinder (sees **Figure 2.1 and 2.2**).

5.1.3 Directional facilities are assessed using an adapted shape (see **Figure 3**).

5.1.4 Local terrain and environmental constraints may modify the application of the shapes.

5.1.5 The shapes generated, when applied to different CNS facilities, represent the individual safeguarded surfaces of these individual facilities.

5.1.6 Where these shapes overlap, they are identified as being "clustered" (e.g. at an airport). This then forms a 3 dimensional picture, which is represented as one shape and will form the basis of the overall airport BRA map. The facility that requires the most restrictive BRA takes precedence in step 1 and triggers a step 2 review.

5.1.7 The appropriate authority applies the BRA map as a template, including elevation information for the screening process.

5.1.8 It has been noted that the Critical and Sensitive areas, for particular system installations and runway profiles, need to be tailored by the ATSEP. These tailored areas are based on the guidance found within Annex 10. They are not considered in this document.

5.2 Step 2

5.2.1 The appropriate engineering authority that has responsibility for the CNS facilities in question conducts the second step of the review process.

5.2.2 This engineering authority conducts an analysis of the building proposal. The analysis is based on, although not limited to the experience and expert knowledge of the engineers undertaking the task. The procedure may cover theoretical analysis, numerical simulation and modelling in order to identify significant effects of the proposed building in the current environment.

5.2.3 During the analysis work, the engineers involved will gain an understanding as to the extent of the impact on the CNS facilities affected. There are three possible results from the initial analysis of the building application:

a) The effects are unacceptable.

b) Some effects are identified. Where this is the case or any doubt exists then further detailed analysis will need to be conducted.

c) Negligible effects.

5.2.4 The output of these analyses results in an approval or rejection answer to the building application. It is recommended that where a definite answer is not forthcoming then the engineering authority should protect the facility by refusing the application.

5.2.5 If the result of the analysis is to reject the application there may be feedback available from the ATSEP. This is in order to allow some comment on the nature of the proposal and the aspects, which in their view are causing the unacceptable effects on the CNS facilities.

5.2.6 The rejection of the application does not preclude the applicant from re-submission. This may take the form of a new or modified building application, which is then re-assessed against the conditions extant at time of re-submission.

6. BRA for omni-directional facilities

6.1 The cylinder is referenced to the ground terrain; the cone is referenced to a horizontal plane. Where irregular terrain is present the BRA shape is adapted.

6.2 The BRA is considered to provide worst case protection.

6.3 Direction finder figures may require modification if the antenna is installed at a high level.

6.4 It is recommended that buildings such as skyscrapers, large excavating works, TV towers and other high towers should be assessed at all times even outside the BRA for omni-directional facilities. Particular attention should be paid to clusters of buildings and overhead power lines. For surveillance and communication facilities it is recommended that wind turbine(s) should be assessed at all times even outside the BRA for omni-directional facilities. Additional guidance on the assessment of wind turbine developments for navigational facilities is given in Appendix 4.

Figure 2.1: Omni - Directional BRA Shape (three dimensional representation)

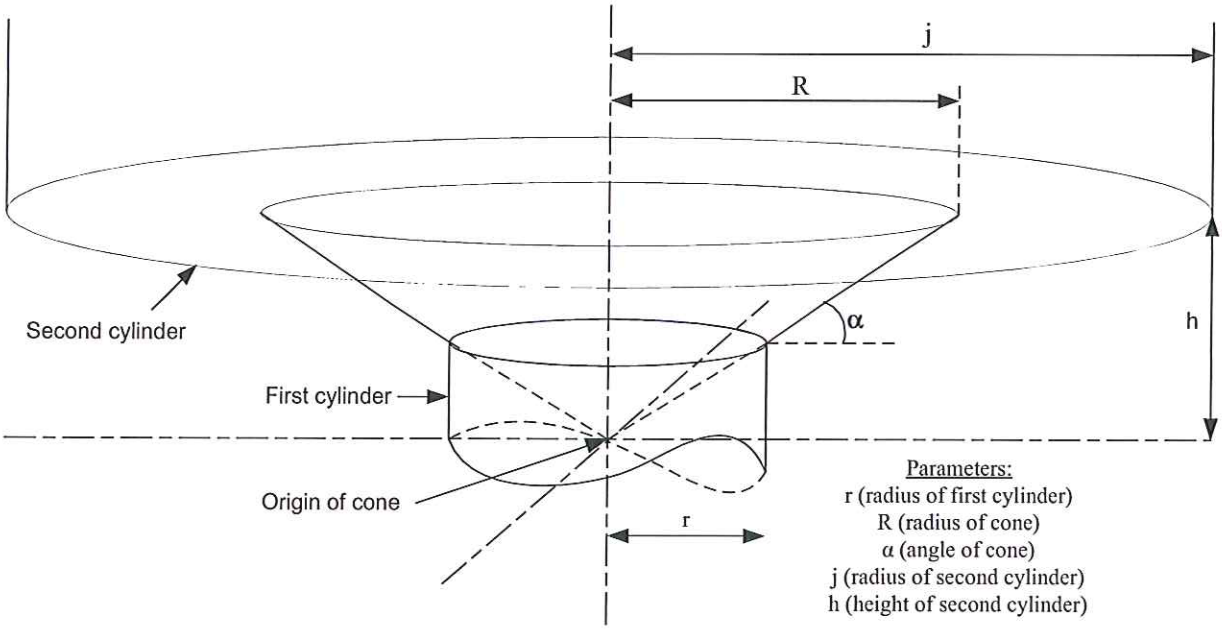
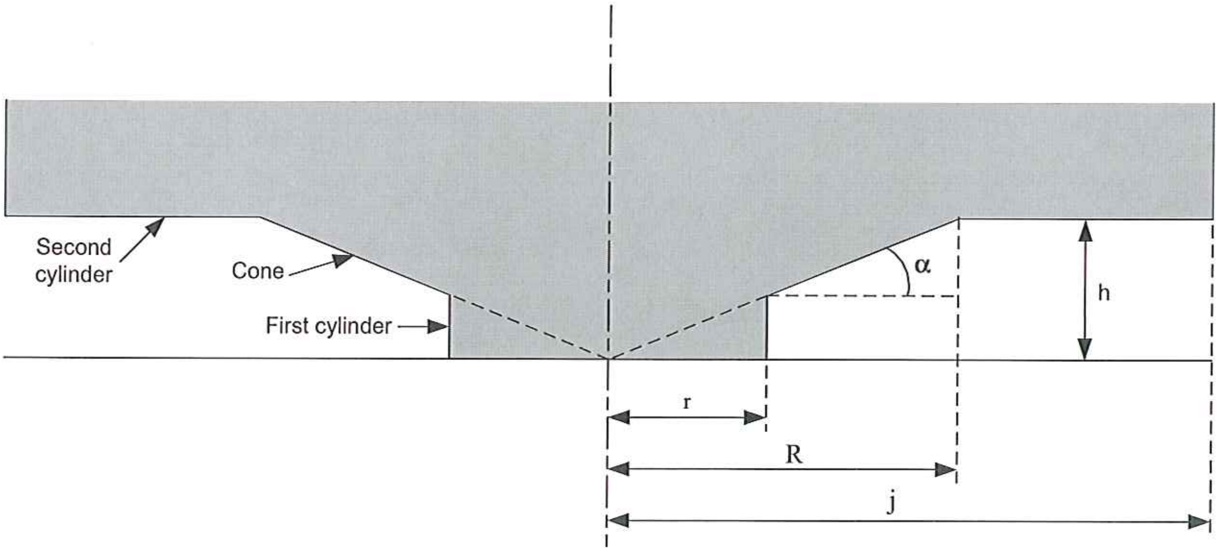


Figure 2.2: Omni - Directional BRA Shape (side elevation view)



7. BRA for directional facilities

7.1 The directional BRA dimensions for variants of localiser systems will differ significantly, this is due to the aperture and antenna designs.

7.2 Wide aperture arrays (typically 24 / 25 element) will have additional protection through the use of the medium aperture BRA figures. Hence the guidance figures presented in table 2 only represent the BRA figures for medium aperture antenna arrays for facility performance category III facilities.

7.3 The end fire array glide-path will require a narrower protection zone due to the directivity of the antenna system.

7.4 MLS operations are to be taken as straight in approaches only, with narrow beam antennas. Advanced operations are not yet covered in the guidance material and hence Out of Coverage Indication (OCI) and back azimuth protection are not given. If advanced operations are planned then appropriate protection should be established.

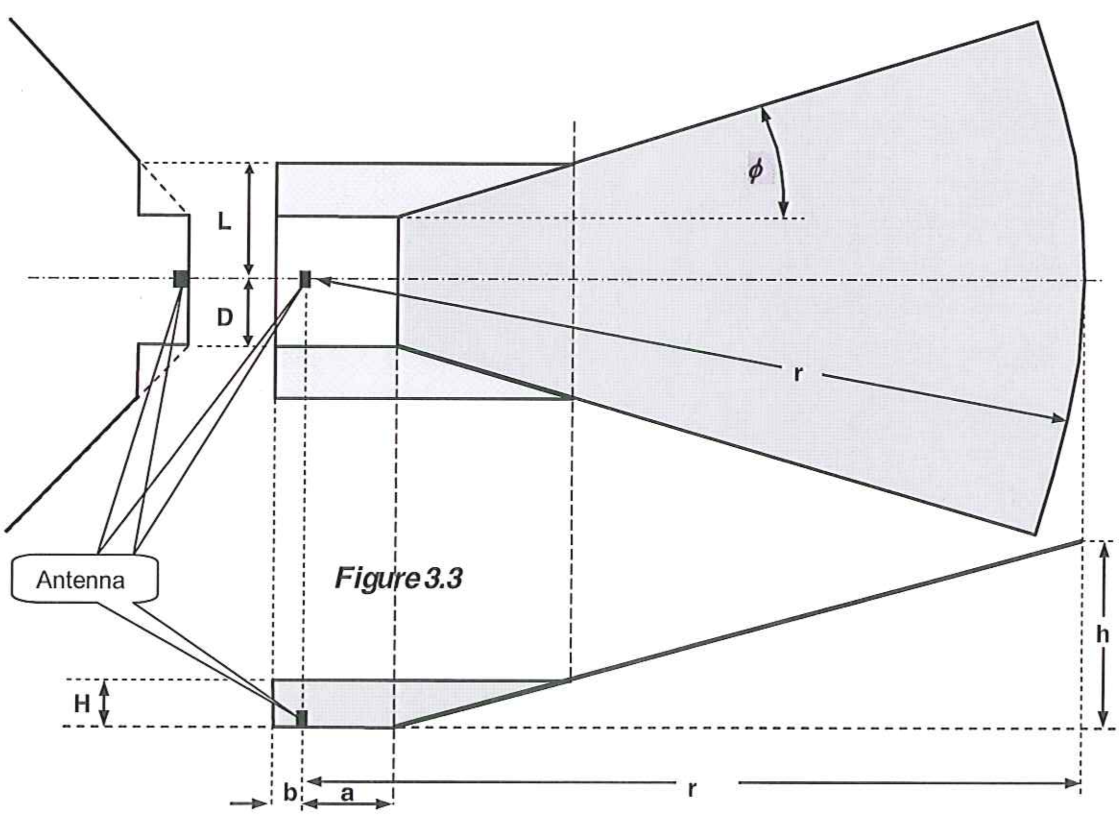
7.5 Directional DME is assumed to be associated with landing systems. BRA volumes in both directions should be established where DME is used for go around procedures.

7.6 The directional shape is orientated by the appropriate ATSEP.

7.7 It is recommended that buildings such as , skyscrapers, large excavating works, TV towers and other high towers should be assessed at all times even outside the BRA for directional facilities. Particular attention should be paid to clusters of buildings and overhead power lines. Additional guidance on the assessment of wind turbine developments for navigational facilities is given in Appendix 4.

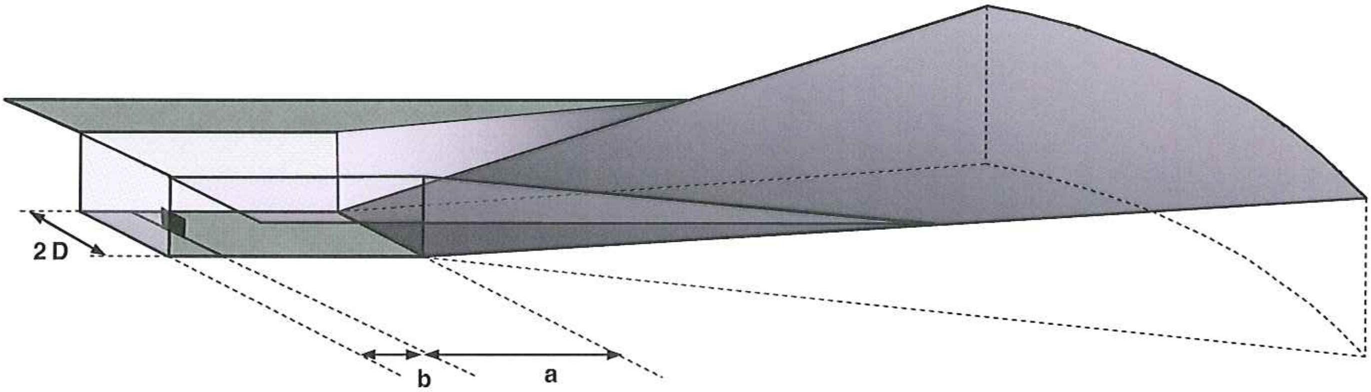
Figure 3 Directional facilities shape

Figure 3.1 ***Figure 3.2***



Shape to be applied for the directional facilities
Figure 3.1 End elevation
Figure 3.2 Plan elevation
Figure 3.3 Side elevation

Figure 3.4 - Directional facilities perspective



8. General notes for omni-directional and directional facilities

8.1 Where facilities are co-located the most stringent BRA volume applicable should apply.

8.2 Non-standard installations (for example: height above 7m, mountain-top site, offset localiser) require careful assessment because changes in the radiation pattern will occur and hence more specific shapes may be required.

8.3 More capable antenna arrangements or advanced technology (e.g. wide aperture, out of phase clearance, Doppler techniques) will allow the reduction of the protection zone applied by the ATSEP.

8.4 Annex 14 surfaces are applicable and should also be taken into account.

8.5 The shapes are applicable from ground terrain upwards.

8.6 Local terrain and environmental constraints (e.g. humped runways) may modify the application of the shapes.

APPENDIX 1 – Navigational facilities

Table 1: Harmonised guidance figures for the omni-directional navigational facilities in accordance with Figures 2.1 and 2.2

*Type of **navigation** facilities*	*Radius (r – Cylinder) (m)*	*Alpha (a – cone) (°)*	*Radius (R- Cone) (m)*	*Radius (j – Cylinder) (m) Wind turbine(s) only*	*Height of cylinder j (h -height) (m) Wind turbine(s) only*	*Origin of cone and axis of cylinders*
DME N	300	1.0	3000	N/A	N/A	Base of antenna at ground level
VOR	600	1.0	3000	15000	52	Centre of antenna system at ground level
Direction Finder (DF)	500	1.0	3000	10000	52	Base of antenna at ground level
Markers	50	20.0	200	N/A	N/A	Base of antenna at ground level
NDB	200	5.0	1000	N/A	N/A	Base of antenna at ground level
GBAS ground Reference receiver	400	3.0	3000	N/A	N/A	Base of antenna at ground level
GBAS VDB station	300	0.9	3000	N/A	N/A	Base of antenna at ground level
VDB station monitoring station	400	3.0	3000	N/A	N/A	Base of antenna at ground level

- The heights and surfaces specified for wind turbine(s) apply to the tip of the turbine blade when vertical. Where the terrain cannot be considered to be flat, for example in the case of sloping terrain, then all wind turbine proposals should be assessed out to the full radius of cylinder j or the BRA adapted to the actual terrain.

Table 2: Harmonised guidance figures for the directional navigational facilities in accordance with Figure 3

*Type of **navigation** facilities*	*A* *(m)*	*b* *(m)*	*h(m)*	*r* *(m)*	*D* *(m)*	*H* *(m)*	*L* *(m)*	*ϕ* *(°)*
ILS LLZ *(medium aperture single frequency)*	Distance to threshold	500	70	a+6000	500	10	2300	30
ILS LLZ *(medium aperture dual frequency)*	Distance to threshold	500	70	a+6000	500	20	1500	20
ILS GP M–Type (dual frequency)	800	50	70	6000	250	5	325	10
MLS AZ	Distance to threshold	20	70	a+6000	600	20	1500	40
MLS EL	300	20	70	6000	200	20	1500	40
DME (directional antennas)	Distance to threshold	20	70	a+6000	600	20	1500	40

Notes:

- The parameters (a) and (b) originate from the base of the antenna and follow the terrain.
- (r) originates from the base of the antenna and is referenced to the horizontal plane.
- ϕ is measured in a horizontal plane.
- Other specific notes pertaining to omni or directional shapes are included in the respective section of the procedure.
- In case of advanced operations supported by either MLS or GNSS, specific adaptation to the respective BRA will have to be made.

APPENDIX 2 – Communication facilities

Table 3: Harmonised guidance figures for the omni-directional Communication facilities in accordance with Figures 2.1 and 2.2

*Type of **communication** facilities*	*Alpha (a – cone) (°)*	*Radius (R- cone) (m)*	*Radius (r – cylinder) (m)*	*Origin of cone*
VHF Communication Tx	1.0	2000	300	Base of antenna at ground level
VHF Communication Rx	1.0	2000	300	Base of antenna at ground level

Notes:

- ATIS – is a service which is considered to have sufficient protection within VOR or VHF facilities.
- ADS – ADSB & VDL mode 4 –VDL ground stations – This is considered to be protected within the VHF Communication protection volumes (includes all VDL modes / VDL data links in Communication due to the frequency of operation).
- Directional communication facilities may exist in support of AWO however it is recommended that protection should be established based on the omni directional shape.

APPENDIX 3 – Surveillance facilities

Table 4: Harmonised guidance figures for the omni-directional Surveillance facilities in accordance with Figures 2.1 and 2.2

*Type of **surveillance** facilities*	*Alpha (a – cone) (°)*	*Radius (R- cone) (m)*	*Radius (r – cylinder) (m)*	*Origin of cone*
PSR	0.25	15000	500	Base of antenna at ground level
SSR	0.25	15000	500	Base of antenna at ground level

Notes:

- SMR protection should be implemented in accordance with Line of Sight requirements.
- ASMGCS has to fulfil ICAO operational requirements. ASMGCS systems may be composed out of several different sub systems some ICAO recognised some not. The ICAO recognised facilities BRA are given in this document. BRA for the non-ICAO recognised facilities have to be developed to conform to their specific requirements.

"APPENDIX 4 – Wind-Turbine(s) Assessment for Navigational Facilities

The guidance figures given in Appendix 1 Table 2, together with the application of ICAO Annex 14 surfaces, should provide sufficient protection for all directional facilities. The guidance figures given in Appendix 1 Table 1 should provide sufficient protection for all omni-directional facilities. The Step 2 "Specialist engineering analysis" process for VOR and Direction Finders (DF) is discussed in more detail below:

VOR

The impact of wind turbine(s) on VOR is difficult to assess for several reasons, including:

a) the worst case errors may be experienced when the turbine blades are stationary (due to either high or low wind speeds). The actual error is a function of the orientation of the turbine and position of the turbine blades when stationary.

b) the worst case error is due to the cumulative effect of a number of turbines, each of which may be acceptable individually. The cumulative effect at any position in the coverage volume is very sensitive to the exact location and orientation of the individual turbines.

c) the largest errors are likely to be experienced at the limit of coverage and at low elevation angles.

d) it is unlikely that the worst case errors can be confirmed by flight inspection due to the factors listed above.

Proposed wind turbine developments should be assessed to a distance of 15 km from the facility. Further assessment is required for any turbines within 600 m, or if any turbines infringe a 1 degree slope from the centre of the antenna at ground level to a distance of 3 km,or if they infringe a 52 m horizontal surface from a distance of 3 km to 15 km. Where the terrain cannot be considered to be flat, for example in the case of sloping terrain, then all wind turbine proposals should be assessed out to 15 km or the BRA adapted to the actual terrain.

In most cases single wind turbine developments are acceptable at distances greater than 5 km from the facility, and developments of less than 6 wind turbines are acceptable at distances greater than 10 km from the facility. However if VOR performance is already marginal this may not be acceptable. In cases where there are existing wind turbine(s) within the 15 km zone the assessment of new proposals needs to consider the cumulative affect of all the turbines, bearing in mind that the worst case error due to the existing wind turbine(s) is unlikely to have been measured by flight inspection.

Computer simulations can be used to assess the effect of wind turbine(s) on VOR using worst case assumptions as outlined above. In determining the acceptability of proposed wind turbine developments it is necessary to consider how much degradation of performance can be allowed. This requires consideration of the VOR error budget. The VOR bearing error at the output of the airborne receiver is made up of three main components. These are ground system errors, errors due to multipath, and airborne receiver errors. The ground system error is specified in ICAO Annex 10 to be within plus or minus 2°. The Annex 10 standards do not specify the other error components but the guidance material states that a radial signal error of plus or minus 3° (95% probability) is achievable in practice. The material in ICAO Annex 11 – Attachment A "Material relating to a method of establishing ATS routes defined by VOR", makes the assumption that the VOR accuracy is as stated in this Annex 10 guidance material. Further guidance on flight inspection of VOR given in ICAO Doc 8071 states that the displacement of the course by a bend should not exceed 3.5° from either the correct magnetic azimuth or on the course average as provided by the facility. Since the 3.5° tolerance applies to the displacement from the correct magnetic azimuth this tolerance includes ground system errors as well as multipath errors.

To determine an appropriate tolerance for wind turbine developments it is necessary to take account of the flight inspection tolerances described above as well as the maximum radial alignment errors due to the ground station, including any north alignment errors due to changes in the magnetic variation. The existing bearing errors due to other sources of multipath, and the operational use of the facility in the sector affected also need to be considered. In assessing simulation results it is also appropriate to include a margin to allow for any uncertainty in the fidelity of the model. Taking all these factors into account it is clear that it would not be appropriate to allow a proposed development to cause a bend as large as 3.5°. For example some engineering authorities have used a tolerance of 1° when assessing the acceptability of proposed developments using computer simulation. This is also consistent with the use of VOR to support RNAV operations.

While the BRA is the same for conventional and Doppler VOR, the Doppler VOR is less susceptible to multipath interference.

Direction Finders (DF)

The impact of wind turbine(s) on DF is difficult to assess for the reasons given above for VOR.

Proposed wind turbine developments should be assessed to a distance of 10 km from the facility. Further assessment is required for any turbines within 500 m, or if any turbines infringe a 1 degree slope from the base of the antenna at ground level to a distance of 3 km, or if they infringe a 52 m horizontal surface from a distance of 3 km to 10 km. Where the terrain cannot be considered to be flat, for example in the case of sloping terrain, then all wind turbine proposals should be assessed out to 10 km or the BRA adapted to the actual terrain.

In most cases single wind turbine developments are acceptable at distances greater than 3 km from the facility, and developments of less than 6 wind turbines are acceptable at distances greater than 6 km from the facility. However if DF performance is already marginal this may not be acceptable. In cases where there are existing wind turbine(s) within the 10 km zone the assessment of new proposals needs to consider the cumulative effect of all the turbines, bearing in mind that the worst case error due to the existing wind turbine(s) is unlikely to have been measured by flight inspection.

Computer simulations can be used to assess the effect of wind turbine(s) on DF using worst case assumptions as outlined above. In determining the acceptability of proposed wind turbine developments it is necessary to consider how much degradation of performance can be allowed. The existing bearing errors due to other sources of multipath, and the operational use of the facility in the sector affected also need to be considered. In assessing simulation results it is also appropriate to include a margin to allow for any uncertainty in the fidelity of the model.

– END –