EUROPEAN ORGANISATION
FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL

SURVEYING

OF

NAVIGATION FACILITIES

EUROCONTROL
Standard Document
Reference 007-97

AMENDMENT TABLE

Edition	Date	Description	Sections/Pages Affected

Change proposals, comments and requests for copies should be directed to:

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ANNEXES

FOREWORD

1 Responsible Body

This Standard has been developed by the WGS 84 Implementation Group and is maintained by EUROCONTROL Division DEI 2.

2 EATCHIP Work Programme Document

This Standard is a part of the EATCHIP Work Programme Document (EWPD), Specialist Domain 07 - Navigation, Executive Task 1 - Improved Navigation Means & Procedures, Domain Executive View 3 - Area Navigation Implementation, Specialist Task 14.

3 Approval of the Document

3.1 This Standard is adopted in accordance with the procedures outlined in the "Directives for EUROCONTROL Standardisation Ref. 000 - 2 - 93".

3.2 This Standard becomes effective upon approval by the European Organisation for the Safety of Air Navigation (EUROCONTROL) Permanent Commission.

4 Technical Corrigenda and Amendments

4.1 This Standard is kept under review to ascertain required amendments or technical corrigenda by the Standards Group and the Standards Office.

4.2 The procedures for the maintenance of this Standard are laid down in the "Directives for the Uniform Drafting and Presentation of EUROCONTROL Standard Documents. Ref. 000 - 1 - 92".

5 Editorial Conventions

5.1 The format of this Standard complies with the "Directives For The Uniform Drafting and Presentation of EUROCONTROL Standard Documents".

5.2 The following practice has been adhered to in order to indicate at a glance the status of each statement:

- Normative Elements have been printed in light face roman text;
- *Recommended Elements* have been printed in light face italics, the status being indicated by the prefix **Recommendation**.

5.3 The following editorial practice has been followed in the writing of specifications:

- for Normative Elements the operative verb "shall" is used;
- for Recommended Elements the operative verb "should" is used.

6 Relationship to Other Standard Documents

This Standard is related to:

ICAO Annex 4 (Aeronautical Charts)
ICAO Annex 11 (Air Traffic Services)
ICAO Annex 14 (Aerodromes)
ICAO Annex 15 (Aeronautical Information Services)
DMA TR 8350.2-A
Directives For The Uniform Drafting And Presentation Of Eurocontrol Standard Documents Ref 000-1-92

7 Status of Annexes to this Document

There are 8 Annexes to this Standard, the status of each being defined as follows:

- Annex A Normative
- Annex B Normative
- Annex C Normative
- Annex D Normative
- Annex E Normative
- Annex F Recommended
- Annex G Informative
- Annex H Informative

8 Language Used

The original version of this document is in the English language.

INTRODUCTION

1 This document sets out the minimum requirements for the surveying of the geographical position of radio navigation aids and points whose coordinates contribute to air navigation (navigation points) brought about by the implementation of World Geodetic System of 1984 (WGS 84). The document has been prepared by EUROCONTROL in support of the programme for the implementation of WGS 84. The material has been prepared by the Survey Standards Task Force which was established by the WGS 84 Implementation Group in June 1993.

2 In February 1994, the Council of the International Civil Aviation Organization (ICAO) adopted Amendment 28 to Annex 15, *Aeronautical Information Services*, to the Convention on International Civil Aviation, which mandates the use of the World Geodetic System of 1984 (WGS 84) as the common geodetic reference system for civil aviation. The amendment became effective on 28 June 1994. The Amendment specifies an applicability date of 1 January 1998 by which time all WGS 84 related aeronautical coordinates must be promulgated in state Aeronautical Information Publications (AIP).

3 EUROCONTROL, on behalf of the European Civil Aviation Conference (ECAC) member States has been coordinating the implementation of WGS 84 in Europe. A WGS 84 Implementation Group was established with membership consisting of representatives of National Administrations, geodetic organisations and industry from the ECAC member States.

4 As a result of various study projects, and a WGS 84 Implementation Workshop organised by EUROCONTROL, which took place in June 1992, a WGS 84 Implementation Work Programme was prepared. This was approved by the EUROCONTROL Committee of Management, in March 1993. One of the principal elements of that work programme was the development of this Standard for surveying of radio navigation aids and navigation points (hereinafter referred to as "navigation facilities").

5 This document lays down minimum accuracies. The particular accuracy values have been based on perceived operational requirements, and are in accord with the resolution and accuracy requirements laid down in the Annexes to the Convention on International Civil Aviation. The accuracies can in many cases easily be exceeded using modern survey instrumentation. It is for National Administrations to decide if the achievable higher accuracies shall be a requirement. Whilst every effort has been made to predict the resolutions and accuracies which will be required for coordinates in order to support future navigation, there can be no guarantee that the figures included in this document will meet all such future requirements.

6 This document does not address the issue of data integrity. Production of positional data of required accuracy and consistency does not ensure that data will arrive at the point of use without corruption. The issue of data integrity is not yet directly covered in Annexes to the Convention on International Civil Aviation, although the subject is being considered in various forums. Integrity is not considered to be part of the survey process but commences on declaration of coordinates.

1. SCOPE

1.1 Application of Requirements

The requirements contained in this document apply to all navigation facilities and to all aerodromes designated by National Administrations. The requirements relate to the surveying, with respect to WGS 84, of the geographical coordinates of navigation facilities.

NOTE - The term "designated" is not necessarily in use in all States. For the purposes of this document the following interpretation has been given.

The requirements apply to all aerodromes with runways for which there are declared instrument approach procedures. Where an aerodrome applies for instrument approaches for one or more of its runways, where previously no such approach had existed, then a survey is to be provided in accordance with the requirements laid down in this document.

Where coordinates are published in a State AIP and declared to be WGS 84 then the determination of those coordinates shall be in accordance with this document.

Where coordinates are published not using this document they are to be marked in the States AIP with an asterisk to indicate that they are calculated not in accordance with this document.

1.2 Coordinates

The requirements of this document cover the determination of only horizontal coordinates, i.e. latitudes and longitudes. WGS 84, for the purposes of this document, is considered to be only a horizontal datum. Where height data is determined refer to point 2 in paragraph 4.7.2 and Annex G.

The results of the surveying of WGS 84 related geographical positions of navigation facilities are required to be reported to the National Administration in accordance with the provisions of the Annexes to the Convention on International Civil Aviation.

1.3 Facilities Covered

1.3.1 The facilities covered in this document are those radio navigation aids and points whose coordinates contribute directly to air navigation. Such ground located equipment whose declared coordinates contribute directly to the positioning of aircraft or to the definition of required flight trajectory is defined, for the purpose of this document, as being "navigation critical". This navigation critical equipment includes all ground aids (e.g. DME, VOR, and TACAN) and those points, such as runway thresholds, which define the target for approach.

1.3.2 The survey requirements for surveillance facilities, such as radar, are included in this document only where surveillance data from different States is shared.

1.3.3 The list of facilities to be surveyed is given in Table 4.1.

1.3.4 This document does not provide for conversion of computed points such as for data shared between States. However it is recommended that where there are common coordinate points that they are derived by the use of common approved methods (e.g. software) by bilateral agreement.

1.4 Description of Facilities

All navigation facilities which require geographical coordinates are described within this document. The particular point on navigation facilities for which the coordinates are required is specified.

1.5 Compatibility with ICAO Requirements

The definitions and requirements stated in this document are such that they are not in conflict with the requirements and recommendations laid down by the Convention on International Civil Aviation and the Annexes thereto. Where the International Civil Aviation Organization (ICAO) definitions and specifications are insufficient to support the task of surveying they have been elaborated in this document from other sources without compromising the original ICAO provision.

1.6 Taxiway Surveying

This document does not include any requirements for the surveying of aerodrome taxiway points. It is expected that supplementary requirements in this regard will be published at a later date when operational and user requirements have been established.

1.7 Heliports

For those designated heliports and helicopter landing areas with instrument approach procedures, the coordinates of the Touch Down (TD) and Final Approach and Take-Off Area (FATO) shall be determined.

1.8 Obstacles

This document does not include obstacle surveys which are already covered in ICAO Annex 14. Where there is a requirement to quote obstacle coordinates these should be determined in accordance with ICAO Annexes 4,14,15.

1.9 National Requirements

This document applies to those facilities that are required for WGS 84 (reference 1.3). Where there is a need to survey other facilities these may be surveyed as a National requirement. e.g ILS (reference note 4 in section 4.7).

2. REFERENCES

The following Documents and Standards contain provisions which, through references in this text, constitute provisions of this EUROCONTROL Document.

At the time of publication of this EUROCONTROL Standard Document, the editions indicated for the reference documents and standards were valid.

Any revision of the referenced ICAO Documents shall be immediately taken into account to revise this EUROCONTROL Document.

Revisions of the other referenced documents shall not form part of the provisions of this EUROCONTROL Standard Document until they are formally reviewed and incorporated into this EUROCONTROL Standard Document.

In the case of conflict between the requirements of this EUROCONTROL Standard Document and the contents of the other referenced documents, this EUROCONTROL Standard Document shall take precedence.

There are no specific documents referenced in this EUROCONTROL Standard Document.

3. DEFINITIONS & ABBREVIATIONS

3.1 Definitions

For the purposes of this EUROCONTROL Standard Document, the following definitions shall apply:

NOTES

1. All definitions are based on ICAO where available (references provided). Where ICAO definitions are not available the label **(Non ICAO)** has been added at the end. In such cases a generic definition has been provided in some cases based on an ICAO description and/or specification (references provided).

2. The geodetic definitions given here are sufficient for aviation purposes. They are not intended as definitive geodetic statements.

3.1.1 **Accuracy:** The degree of conformity with a standard, or a value accepted as correct. Precision is the degree of uniformity of repeated measurements or events. For example, repeat measurements of the distance between two points may exhibit a high degree of precision by virtue of the relative uniformity of the measurements. However, if a "short" tape was used in the measurements, accuracy will be poor in that the measured distance does not conform to the true distance between the points.

In surveying and mapping, a "true" value can never be determined exactly. However, a true value can be closely approximated by a series of repeated measurements using very accurate measuring equipment and techniques. These measurements should be made using several independent methods. These close approximations can then be used for estimating the accuracy of other survey systems.

Owing to uncertainties in measurements, all surveying and mapping accuracy standards that are expressed in terms of an allowable difference from a true value should include a statement of error probability. For example, "Horizontal accuracy will be ± 2 metres at the 2 sigma (approximately 95 percent confidence) level." This indicates that statistically, the measured value will be within 2 metres of the true value 95 percent of the time. This practice provides a confidence level for the measured values. **(Non ICAO)**

3.1.2 **Aerodrome Survey Control Network:** Any arrangement of points at an aerodrome, consisting generally of ground markers, for which coordinates have been determined and to which, by survey observations, the positions of other facilities can be related. **(Non ICAO)**

3.1.3 **Aerodrome Reference Point (ARP):** The designated geographical location of an aerodrome. **(ICAO Annex 14 Vol I).**

NOTE - The derived position of the approximate "centre of mass" of all usable runways. This point is not strictly the centre of mass of runways since runway width, thickness, or material is not considered in the computation. The ARP is generally not monumented, therefore not recoverable or surveyable on the ground. **(Non ICAO**)

3.1.4 **Aiming Point Marking:** An aiming point marking should be provided at a heliport where it is necessary for a pilot to make an approach to a particular point before proceeding to the touchdown and lift-off area. **(Recommendation ICAO Annex 14 Vol II, 5.2.6.1.)**

The aiming point marking shall be located within the final approach and take-off area. **(Location, ICAO Annex 14 Vol II, 5.2.6.2)**

The aiming point marking shall be an equilateral triangle with the bisector of one of the angles aligned with the preferred approach direction. **(Characteristics, ICAO Annex 14 Vol II, 5.2.6.3)**

3.1.5 **Airside:** That part within an airport which is usually subjected to special security procedures requiring an airport airside security pass and clearance. **(Non ICAO)**

3.1.6 **Datum:** As used in surveying and mapping, a quantity, or set of quantities, used as a reference for calculating other quantities, such as positions and elevations. The horizontal control datum for civil aviation is World Geodetic System 1984 (WGS 84). **(Non ICAO)**

3.1.7 **Datum Transfer:** The act of establishing a datum at the aerodrome with respect to the designated local geodetic datum. **(Non ICAO)**

3.1.8 **Displaced Threshold (DT):** A threshold not located at the extremity of a runway. **(ICAO Annex 14)**

NOTE - A threshold that is located at a point on the runway other than the designated beginning of the runway. The displaced area is available for takeoff or rollout of aircraft. A displaced threshold bar should be painted on the usable landing surface. **(Non ICAO)**

3.1.9 **Distance Measuring Equipment (DME):** Equipment (airborne and ground) used to measure, in nautical miles, the slant range distance of an aircraft from the DME navigational aid. DME is usually frequency paired with other navigational aids, such as a VOR or Localizer. **(Non ICAO)**

NOTE - The following are descriptions from **ICAO Annex 10 :**

1. **DME/N:** Distance measuring equipment, primarily serving operational needs for en-route or TMA navigation, where the "N" stands for narrow spectrum characteristics (to be distinguished from "W").

2. **DME/P:** The distance measuring element of the Microwave Landing System (MLS), where "P" stands for precise distance measurement. The spectrum characteristics are those of DME/N.

3. **DME/W:** Distance measuring equipment, primarily serving operational needs for en-route or TMA navigation, where the "W" stands for wide spectrum characteristics (to be distinguished from "N").

3.1.10 **European Reference System (EUREF)**: Various survey campaigns undertaken to densify the ETRF 89 network. **(Non ICAO)**

3.1.11 **European Terrestrial Reference Frame 1989 (ETRF 89):** A precise geodetic reference frame which consists of a limited number of survey stations throughout Europe whose relative positions are known to an accuracy of the order of 10 cm and which forms the basis for geodetic survey in Europe. Its associated ellipsoid is Geodetic Reference System 1980 (GRS 80). **(Non ICAO)**

3.1.12 **Final Approach and Take-Off Area (FATO):** A defined area over which the final phase of the approach manoeuvre to hover or landing is completed and from which the take-off manoeuvre is commenced. Where the FATO is to be used by performance Class I helicopters, the defined area includes the rejected take-off area available. **(ICAO Annex 14 Vol. II)**

3.1.13 **Geoid:** The hypothetical surface of the earth that coincides with mean sea level. The geoid is an equipotential surface to which, at every point, the plumb line is perpendicular. Because of local disturbances of gravity, the geoid is irregular in shape. (See Reference Ellipsoid.) **(Non ICAO)**

3.1.14 **Glide Path:** A descent profile determined for vertical guidance during a final approach. **(ICAO Lexicon)**

3.1.15 **GPS:** A specific global positioning system based on a satellite constellation. **(Non ICAO)**

3.1.16 **Heliport:** An aerodrome or a defined area on a structure intended to be used wholly or in part for the arrival, departure and surface movement of helicopters. **(ICAO Annex 14)**

3.1.17 **Instrument Approach Procedure (IAP):** A series of predetermined manoeuvres by reference to flight instruments with specified protection from obstacles from the initial approach fix, or where applicable, from the beginning of a defined arrival route to a point from which a landing can be completed and thereafter, if a landing is not completed, to a position at which holding or en-route obstacle clearance criteria apply. **(ICAO Annex 4)**

3.1.18 **Instrument Landing System (ILS):** A precision instrument approach system which normally consists of the following electronic components: (**ICAO description, Annex 10 3.1.2.1)**

- VHF (Very High Frequency) localizer equipment, associated monitor system, remote control and indicator equipment;
- UHF (Ultra High Frequency) glide path equipment, associated monitor system, remote control and indicator equipment;
- VHF marker beacons, associated monitor systems, remote control and indicator equipment, except as noted below.

NOTE - Where the provision of VHF marker beacons is impracticable, a suitably located DME, together with associated monitor system and remote control and indicator equipment shall be an acceptable alternative to part or all of the marker beacon component of the ILS. **(ICAO Annex 10 3.1.7.6.6)**

3.1.19 **Localizer (LLZ):** The component of an ILS which provides course guidance to the runway. **(Non ICAO)**

3.1.20 **Locator:** An LF (Low Frequency)/MF (Medium Frequency) NDB (Nondirectional Radio Beacon) used as an aid to final approach. **(ICAO Annex 10 3.4.1)**

3.1.21 **Manoeuvring Area:** That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, excluding aprons. **(ICAO Annex 14)**

3.1.22 **Microwave Landing System (MLS):** MLS is a precision approach and landing guidance system which provides position information and various ground to air data. **(Non ICAO)**

NOTE - The following is a specification reference **ICAO Annex 10 3.11.3.1:**

"The basic configuration of the MLS shall be composed of the following:

- Approach azimuth equipment, associated monitor, remote control and indicator equipment;
- Approach elevation equipment, associated monitor, remote control and indicator equipment;
- a means for encoding and transmission of essential data words, associated monitor, remote control and indicator equipment;
- DME, associated monitor, remote control and indicator equipment".

3.1.23 **Monumentation:** The physical structure, emplacement and description of survey control points. **(Non ICAO)**

3.1.24 **Movement Area:** That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, consisting of the manoeuvring area and apron(s). **(ICAO Annex 14)**

3.1.25 **National Administration:** The designated state civil aviation authority. **(Non ICAO)**

3.1.26 **Non-Directional Radio Beacon (NDB):** An LF/MF radio beacon transmitting non directional signals whereby the pilot of an aircraft equipped with direction finding equipment can determine his bearing to or from the station. When the NDB is installed in conjunction with an Instrument Approach Procedure, it is normally called a Locator. **(Non ICAO)**

3.1.27 **Obstacle:** All fixed (whether temporary or permanent) 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. **(ICAO Annex 14)**

NOTE - See also Significant Obstacle.

3.1.28 **Precision Approach Procedure:** An instrument approach procedure utilising azimuth and glide path information provided by ILS/MLS or (Precision Approach Radar) PAR. **(ICAO Annex 4)**

3.1.29 **Radio Detection and Ranging (RADAR):** A radio detection device which provides information on range, azimuth and/ or elevation of objects. **(ICAO Lexicon)**

3.1.30 **Runway:** A defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft. **(ICAO Annex 4)**

3.1.31 **Reference Ellipsoid (formerly called Reference Spheroid):** A geometric figure, usually determined by rotating an ellipse about its shorter (polar) axis, used as a surface of reference for geodetic surveys. The reference ellipsoid closely approximates the dimensions of the geoid, with certain ellipsoids fitting the geoid more closely for various areas of the earth. **(Non ICAO)**

3.1.32 **Significant Obstacle:** Any natural terrain feature or man-made fixed object, permanent or temporary, which has vertical significance in relation to adjacent and surrounding features and which is considered a potential hazard to the safe passage of aircraft in the type of operation for which the individual chart series is designed. **(ICAO Annex 4)**

3.1.33 **Survey Control:** A system of points with established positions and/or elevations which are used as fixed references for surveying or for correlating map features. Local control is a survey control system established in a local area and which may or may not be tied to the National Geodetic Control Networks. **(Non ICAO)**

3.1.34 **Tactical Air Navigation (TACAN):** An ultra-high frequency electronic air navigational aid which provides suitably equipped aircraft with a continuous indication of bearing and slant range to the TACAN station. **(Non ICAO)**

3.1.35 **Threshold:** The beginning of that portion of the runway usable for landing. **(ICAO Annex 14)**

3.1.36 **Touchdown:** The point where the predetermined glide path intercepts the runway. **(ICAO Annex 10)**

NOTE - "Touchdown" as defined above is only a datum[1] and is not necessarily the actual point at which the aircraft will touch the runway. **(ICAO Annex 10)**

3.1.37 **Touchdown and Lift-Off Area (TLOF):** A load bearing area on which a helicopter may touch down or lift-off. **(ICAO Annex 14 Vol II)**

3.1.38 **Touchdown Zone:** The portion of a runway, beyond the threshold, where it is intended landing aeroplanes first contact the runway. **(ICAO Annex 14 Vol I)**

3.1.39 **Very High Frequency Omnidirectional Radio Range (VOR):** A very high frequency, radio navigational aid which provides suitably equipped aircraft with a continuous indication of bearing to and from the VOR station. **(Non ICAO)**

3.1.40 **Very High Frequency Omnidirectional Radio Range/Tactical Air Navigation (VORTAC):** A navigational facility consisting of two components, VOR and TACAN, which provide three services: VOR azimuth, TACAN azimuth, and TACAN slant range. **(Non ICAO)**

3.1.41 **World Geodetic System of 1984 (WGS 84):** An earth-centred, earth-fixed global reference system. **(Non ICAO)**

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[1] "datum" here does not imply geodetic survey datum.

3.2 Abbreviations

AIP	Aeronautical Information Publication
ARP	Aerodrome Reference Point
ATC	Air Traffic Control
CERCO	Comité Européen des Responsibles de la Cartographic Officielle
Cos	Cosine
DEI	Directorate EATCHIP Implementation
DMA	Defense Mapping Agency (US)
DME	Distance Measuring Equipment
DME/N	Distance Measuring Equipment/Narrow
DME/P	Distance Measuring Equipment/Precision
DME/W	Distance Measuring Equipment/Wide
DT	Displaced Threshold
DVOR	Doppler VOR
EATCHIP	European ATC Harmonisation and Integration Programme
ECAC	European Civil Aviation Conference
ETRF	European Terrestrial Reference Frame
EUREF	European Reference System
EUROCONTROL	European Organisation for the Safety of Air Navigation
EWPD	EATCHIP Work Programme Document
FATO	Final Approach and Take-off Area
GPS	Global Positioning System
GRS	Geodetic Reference System
IAP	Instrument Approach Procedure
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
ITRF	International Terrestrial Reference Frame
Lat	Latitude
LF	Low Frequency
Long	Longitude
LLZ	Localizer
MF	Medium Frequency
MLS	Microwave Landing System
NDB	Nondirectional Radio Beacon
NM	Nautical Mile
PANS	Procedures for Air Navigation Services (ICAO)
PAR	Precision Approach Radar

RADAR	Radio Detection and Ranging
RNAV	Area Navigation
TACAN	Tactical Air Navigation
TD	Touch Down
TLOF	Touchdown and Lift-Off Area
TMA	Terminal Area
UHF	Ultra High Frequency
VHF	Very High Frequency
VOR	Very High Frequency Omnidirectional Radio Range
VORTAC	Very High Frequency Omnidirectional Radio Range/Tactical Air Navigation
WGS 84	World Geodetic System of 1984

4. SPECIFICATIONS

4.1 Geodetic Datum Specification

4.1.1 The geodetic datum to which all facilities shall be referenced is the World Geodetic System of 1984 (WGS 84).

4.1.2 This shall be achieved by connecting to a global geodetic reference frame.

4.1.3 The geodetic reference frame to which aeronautical positions in Europe are referenced shall be ETRF 89.

4.2 Quality Control

All coordinate data which meet the provisions of this document shall be such that their quality can be demonstrated.

4.3 Survey Accuracy Requirements

The geographical coordinate accuracy of the various facilities has been set in accordance with both current and anticipated operational requirements.

4.4 Position Accuracy

4.4.1 All position accuracies shall relate to a probability of 95% (2 x sigma) containment unless where otherwise stated.

4.4.2 Survey accuracies shall be such that the overall error budget is sufficient to support the positional accuracy requirement of facility laid down in this document.

4.5 Units

4.5.1 Units of measurement shall be in accordance with the survey custom and practice of the particular State.

4.5.2 All published positions and dimensions shall be in accordance with the requirements laid down by ICAO.

4.5.3 In this regard, positions shall be published in the form of sexagesimal degrees (Degrees Minutes Seconds and decimals of a Second) to the resolutions laid down by ICAO in Annexes to the Convention on International Civil Aviation.

4.5.4 Dimensions and distances shall be quoted in one of the following units:

- metres;
- feet (1 ft = 0.3048 m);[2]
- Nautical Miles (1 NM = 1852 m).

[2] United Kingdom, Weights and Measures Act 1985

4.6 Aerodrome Survey Control Network

4.6.1 In order to determine the position of navigation facilities at, and in the vicinity of, designated aerodromes, a network of survey control stations shall be established at each such aerodrome.

4.6.2 The network shall consist of a minimum of two intervisible survey stations at a minimum lateral separation of 500 metres.

4.6.3 Recommendations

1) The aerodrome survey control network should consist of a minimum of four stations so as to provide sufficient redundancy to be able to sustain the loss of one survey station and still enable orientation to be checked.

2) Survey stations should be strategically located so as to provide maximum utility in subsequent surveys.

3) The geodetic network points and the datum transfer should be of the highest quality.

NOTE - The monuments of existing aerodrome survey control networks may be used for the purposes laid down in this document.

4.6.4 Control Network Accuracy Requirements

4.6.4.1 The network shall have an accuracy consistent with the need to provide control for the survey of navigation facilities to the accuracies set out in this document.

4.6.4.2 Recommendation *The aerodrome survey control network should have an internal consistency of better than 10 cm.*

4.6.5 Mathematical Transformation

4.6.5.1 Mathematical transformation methods based on a single set of average transformation parameters, which relate known/existing datums to WGS 84, shall not be used for the purpose of determining the coordinates of the aerodrome survey control network.

4.6.5.2 Transformation methods shall not be used except where the quality of the original co-ordinates can be assured and where the transformation method utilises the local transformation parameters, determined by the geodetic transfer survey appropriately.

4.6.6 Monumentation of Aerodrome Survey Control Stations

4.6.6.1 Station Construction

The survey stations shall consist of standard types of survey monument (See Annex B). Different types of monument will be appropriate for different locations and ground conditions on the aerodrome and it is for the surveyor, under the guidance of the National Administration, to decide on the most appropriate type.

4.6.6.2 Recommendations

1) Investigation should be made prior to the installation of survey stations to ensure that underground cables and services are not affected by the installation.

2) Where the survey network consists of fewer than the recommended four stations, substantial monuments should be used.

4.6.6.3 Station Numbering

Each survey station shall carry individual identification. This will ensure that, where a station has been destroyed and subsequently replaced by a new station in approximately the same location, mis-identification does not occur.

4.6.6.4 Recommendations

1) Station labelling and numbering should be such that there is no doubt as to the provenance or identity of the survey station.

2) Uniform labels (e.g. stamped disks) should be used at individual aerodromes for all survey stations.

3) An unambiguous numbering system, identifying the aerodrome, year and station number should be used (See Annex B).

4) Where an existing, substantial topographic surface feature is used as a survey station, the station number should be clearly marked with durable paint.

NOTE - When an existing station is not used and it is not possible to relabel, a high quality description may be prepared.

4.6.6.5 Station Location Plan

An aerodrome survey network plan, at a scale of 1/2000, or other appropriate standard cartographic scale indicating the location of all survey stations and principal topographic features, shall be prepared.

4.6.6.6 Station Descriptions

Comprehensive aerodrome survey network station descriptions shall be prepared consisting of a written description and a clear diagram indicating tie dimensions and direction indicators to other visible points on the aerodrome network, and so that they are orientated to True North, or alternatively, have the direction of True North indicated on the description.

4.6.6.7 Recommendations

1) A photograph of the station showing background detail should be included in the description.

2) Inspections should be made to check on the general condition of the aerodrome survey network and any disturbance or damage recorded.

4.6.7 Determination of Control Coordinates

4.6.7.1 One of the following methods of coordinate determination shall be used to fix the positions of the aerodrome survey control network.

4.6.7.2 Direct Geodetic Connection

Survey measurements shall be taken to connect the aerodrome survey control network to the ETRF 89 geodetic frame in such a way that the survey error in the connection does not contribute significantly to the coordinate error of the aerodrome network. This is the preferred option, in that it consists of the most accurate method of observation and incorporates a directly observed connection to the approved geodetic reference frame.

4.6.7.3 Recommendation *Static differential GPS connections should be made to preferably three points on an appropriate geodetic network, but in all cases to a minimum of two.*

4.6.7.4 Derived Geodetic Connection

4.6.7.4.1 Where the local relationship between the existing geodetic control network and WGS 84 is known to an accuracy commensurate with the requirements laid down in this document then an officially approved transformation method may be used to determine the coordinates of an existing aerodrome survey control network. Where this method is adopted, a full description of the transformation method and the values of the transformation parameters shall be included in the report.

4.6.7.4.2 Full details of the connection of the existing aerodrome survey control network to the existing geodetic network, shall be included in the survey report. (In this regard, an 'existing' network is taken to mean one which existed at the aerodrome prior to the implementation at that aerodrome of WGS 84).

4.6.8 Determination of Local Relationship Between the Known Existing Datum and WGS 84

4.6.8.1 Where existing relative surveys need to be related to WGS 84 (e.g. aerodrome obstacle surveys) observations shall be taken to determine the local relationship (difference in Latitude, Longitude, orientation and scale) between the known existing datum and WGS 84, except where the required information is provided by a derived geodetic connection.

4.6.8.2 Where used, the local relationship between the known existing geodetic datum and WGS 84 shall be determined to an accuracy commensurate with the relative accuracy of the data to be transformed.

4.6.8.3 The values and accuracies of the local relationship shall be declared in the survey report.

4.6.9 Report Requirements

Where no national reporting standard exists, all survey work undertaken to determine the coordinates of navigation facilities at aerodromes shall be reported in the format laid out in Annex D. Where existing national reporting practice differs from that shown in this document, the National Administration may make a case in the report in support of their national standard, where the national standard can be shown to be compatible.

4.7 Facilities and Corresponding Minimum Survey Accuracy Requirements

Table 4.1 - Facilities and Corresponding Minimum Survey Accuracy Requirements

	OPERATION OR FUNCTION	ITEMS REQUIRING ACCURATE COORDINATE DATA	ACCURACY of PUBLISHED DATA [1] (95%, 2 x sigma containment)
1	En-Route Navigation	NDB	100 metres
2	Departure and Arrival Procedures, and Non-Precision Approach	[2] DME/N, TACAN, VOR, VORTAC Collocated VOR/DME, LOCATOR and ILS Localizer where used for offset approaches	30 metres
3	Final Approach (Precision, All Categories)	DME/P [3] ILS Localizer, Glide Slope [4]	3 metres
4	Landing and Take-Off	Runway Centre Line, Runway Threshold, MLS (Elevation, Azimuth), Heliports	1 metre
5	Datum Transfer	Aerodrome Survey Control Network	10 cm relative
6	En-Route Surveillance	Area Radar	10 metres

NOTES

1. Where new surveys are being undertaken, it is suggested that the survey accuracies given in Annex G are applied.
2. In Europe the majority of en-route or off airfield radio navigation aids are also used for non precision approaches in which case the most stringent accuracy should be applied.
3. DME offset from the threshold are not required for Area Navigation (RNAV) operations, therefore their survey accuracy is not included in the table.
4. Whilst ILS is not used in area navigation systems, it may need to be calibrated for high accuracy comparison.

4.7.1 Table 4.1 lays down the minimum accuracies that shall be achieved.

NOTE - These accuracies can in many cases easily be exceeded using modern survey instrumentation.

4.7.2 **Recommendations**

1) All survey observations should be made and recorded to the resolution and accuracy of the equipment used so that future requirements for surveys of greater precision might be met.

2) Where surveys are undertaken using equipment or techniques which yield height data, as well as horizontal position, then these should be comprehensively recorded for future use and included in the survey report.

4.8 Survey Requirements for Aerodrome Facilities

4.8.1 Runway Centrelines and Thresholds

4.8.1.1 For surveying purposes the centreline reference point of a runway shall be the centre-line of the defined landing area on the load bearing surface.

4.8.1.2 Where the edge of the runway is irregular, or connected to a taxiway, an appropriate theoretical line shall be selected which best identifies the probable edge of the runway.

4.8.1.3 Where the thresholds are marked by appropriate threshold markers then these shall be taken as the threshold point.

4.8.1.4 Where no threshold marker exists, the threshold shall be determined by the National Administration and marked according to ICAO Annex 14.

4.8.1.5 Where no threshold marker exists, and there is no other indication of the threshold position then the centreline of the threshold lights immediately in advance (in the direction of landing) of the threshold paint markings (piano keys) shall be taken as the threshold.

4.8.1.6 Where there is no threshold marker, or threshold lighting, then the surveyor shall select an appropriate point for survey in accordance with Annex C.

4.8.1.7 Survey witness marks shall be installed to enable the threshold survey point to be re-established in the event of re-surfacing, re-painting or verification.

4.8.1.8 In addition, two associated runway centreline points, at a separation of not less than 10% of the runway length, shall be surveyed to aid collinearity testing.

4.8.1.9 The surveyor shall, in processing the survey data, determine and report on the collinearity of the three points.

4.8.1.10 **Recommendation** *Where a runway has a threshold at each end then the two thresholds and two further runway centreline points should be surveyed, the collinearity then being determined for the group of four points.*

4.8.1.11 The distance from the point surveyed as the threshold to the end of the paved surface at the near end of the runway shall be determined to an accuracy of 10 cm.

4.8.2 Derived Threshold Coordinates

4.8.2.1 Where a point has been selected for survey which is not coincident with the runway threshold, but offset along the centreline, then the coordinates of the threshold shall be determined by the National Administration. A method of calculation for this task is shown in Annex F.

4.8.2.2 The newly derived threshold coordinates shall be submitted to the same collinearity check as specified in Paragraph 4.8.1.9.

4.8.3 Aircraft Stands

4.8.3.1 The front, nose-in point of the stand, where the taxiway centreline intersects the limit of the stand, shall be surveyed.

4.8.3.2 Numerous different stand paint markings exist and a diagram shall be prepared by the surveyor showing the arrangement of markings in use together with an indication of the point surveyed. Where all the stands at the aerodrome are marked uniformly then only a single diagram need be prepared.

4.8.4 All Other Aerodrome Radio Navigation Facilities

For all other aerodrome radio navigation facilities which require survey, the centre of the transmitting antenna shall be surveyed except where a different specific survey point is standardised for the facility as indicated in Annex C.

4.8.5 Survey Report Requirements

Where no national reporting standard exists, all survey work undertaken to determine the coordinates of navigation facilities at aerodromes shall be reported in the format laid out in Annex D. Where existing national reporting practice differs from that shown in this document, the National Administration may make a case in the report in support of their national standard, where the national standard can be shown to be compatible.

4.9 Surveying Requirements for Off-Aerodrome Radio Navigation Facilities

4.9.1 Off-Aerodrome Radio Navigation Facilities

4.9.1.1 The coordinates of off-aerodrome radio navigation facilities shall meet the accuracy requirements laid down in Table 4.1.

4.9.1.2. Where existing coordinates of off-aerodrome radio navigation facilities which meet the accuracy and quality requirements are converted to WGS 84 mathematically then the conversion process shall be shown to be such that the required coordinate accuracies are maintained.

4.9.1.3. Where the quality of existing coordinates cannot be determined then they shall be redetermined to the accuracy laid down in Table 4.1.

4.9.1.4. **Recommendation** *In all cases surveyed coordinates should be published in preference to coordinates determined by graphical methods.*

4.9.2 Description of Off-Aerodrome Radio Navigation Facilities

4.9.2.1 The descriptions of off-aerodrome radio navigation facilities are shown in Annex C. For navigation facilities not described in Annex C the horizontal coordinates of the geometric centre of the facility antenna shall be surveyed.

4.9.2.2 Where coaxial collocated VOR/DME are surveyed, the position of the DME element shall be taken as the position.

NOTE - For non coaxial collocated VOR/DME greater than 30 metre it will be necessary to survey both antenna.

4.9.2.3 Where it is not possible to connect directly to ETRF 89 the method of local connection shall be described.

4.9.3 Survey Report Requirements

4.9.3.1 Where no national reporting standard exists, all survey work undertaken to determine the coordinates of en-route/off-aerodrome navigation facilities shall be reported in the format laid out in Annex D. Where existing national reporting practice differs from that shown in this document, the National Administration may make a case in the report in support of their national standard, where the national standard can be shown to be compatible.

4.9.3.2 The geodetic connection shall be fully described in detail where monumented survey control stations are not installed as part of an off-aerodrome radio navigation facility survey.

4.10 Use of Software

4.10.1 Where software is used for any of the survey processing it shall be demonstrated that it functions correctly.

4.10.2 This demonstration shall take the form of a written report showing that the software produces the same results as standard computation.

4.11 Digital Format for the Delivery of Data

A standard format shall be used for the delivery in digital form for all survey data.

5. QUALITY CONTROL

5.1 Quality Assurance

5.1.1 All coordinates produced in accordance with the requirements of this document shall be such that their quality can be assured.

5.1.2 Recommendation

1) The data acquisition should be managed by the use of a suitable quality system which:

- *assigns responsibilities;*
- *uses procedures to ensure quality records are maintained;*
- *uses methods for auditing of the reports and procedures;*
- *provides effective corrective action where non conformances are identified.*

2) Where there are National requirements, such as for the management of the coordinate data, these should be considered when implementing a quality system.

5.1.3 For all coordinates surveyed in accordance with the provisions of the directives, evidence shall be presented which confirms that the required accuracies have been met.

5.1.4 For those coordinates which cannot be proven to have met the required accuracies they shall be marked in accordance with 1.1.

5.2 Calibration of Survey Equipment

5.2.1 All survey equipment used for the taking of measurements in relation to surveys covered by this document shall be shown to be calibrated and to perform to an accuracy appropriate to the task.

5.2.2 Equipment calibration shall be shown to be valid for the time of use.

5.2.3 Details of the calibration shall be included in the survey report.

5.3 Positional Survey Accuracies

5.3.1 Survey accuracies shall be such that the accumulated errors of observations and computations is sufficient to support the positional accuracy requirements for facilities laid down in this document.

5.3.2 An analysis of the accumulated error shall be presented for each survey including but not limited to:

1) The accumulated error being presented in its component parts, each showing the accuracy achieved and that the result is consistent with the survey technique used.

2) The accumulated error calculations being clearly reported and compared against the declared accuracy requirement as in 04.7.1.

5.4 Quality Records

5.4.1 All coordinates shall be traceable to their source of production by an unbroken audit trail.

5.4.2 Information on the source of production shall include:

- name of surveyor;
- surveying organisation;
- date of survey;
- method of survey;
- equipment used.

5.4.3 Any coordinates for which such information (5.4.2) and such an audit trail (5.4.1) are unavailable shall be deemed not to have met the requirements of this document.

5.4.4 Any supplementary data which is included in the survey but which is known not to comply with the requirements of this document shall be labelled as non-compliant.

5.4.5 Records shall be maintained for all designated coordinates which are published in the national Aeronautical Information Publication (AIP).

5.5 Auditing

All survey work shall be recorded and reported in such a way that the quality of the coordinates produced can be audited by the National Administration, those experts acting on their behalf, or designated military authority.

5.6 Non-Compliance

5.6.1 Where the audit shows that certain coordinates do not reach the standards of accuracy and quality laid down in this document, the non-compliance shall be indicated by the National Administration to the survey organisation.

5.6.2 The precise areas in which the data quality is deficient shall be indicated by the National Administration.

5.7 Corrective Action

5.7.1 The survey organisation shall undertake corrective action in accordance with all indications of non-compliance.

5.7.2 The survey organisation shall make supplementary submissions to the National Administration showing that appropriate corrective action has been undertaken with respect to the specified deficiencies.

5.8 Quality Control Procedures

NOTE - The above requirements outline the basis of the quality control required under this standard. A more elaborate treatment of quality control procedures can be found in the EUROCONTROL WGS 84 Implementation Manual.

ANNEX A (NORMATIVE)
WGS 84 AND ETRF89

A.1 Geodetic Relationships

The following definitions elaborate upon those quoted in Section 3, Definitions and Abbreviations. The geodetic descriptions given here are sufficient for aviation purposes. They are not intended as definitive geodetic statements.

A.2 World Geodetic System of 1984 (WGS 84)

WGS 84 is defined by the United States Department of Defense. Details of the datum can be found in the following publication:

DMA TR 8350.2-A
DMA Technical Report
SUPPLEMENT TO DEPARTMENT OF DEFENSE WORLD GEODETIC SYSTEM 1984 TECHNICAL REPORT

A.3 Geometric Constants of the WGS 84 Ellipsoid

Semi-major axis	a = 6378137.000 m
Semi-minor axis	b = 6356752.314 m
First eccentricity	e = 0.0818191908426
(First eccentricity)^2	e^2= 0.00669437999013
Flattening	f = 1/298.257223563

A.4 European Terrestrial Reference Frame 1989 (ETRF 89)

A precise geodetic reference frame which consists of a limited number of survey stations throughout Europe whose relative positions are known to an accuracy of the order of 10 cm and which forms the basis for geodetic survey in Europe. It has an associated ellipsoid, known as GRS 80, which has effectively the same parameters as that of WGS 84. The absolute differences between ETRF 89 and WGS 84 are, within Europe, of the order of 1 metre. ETRF 89 provides a convenient means by which WGS 84 can be accessed in Europe.

ETRF is a subset of the International Terrestrial Reference Frame (ITRF) which is a global reference frame. The values for the coordinates of this frame for epoch 1989.0 have been adopted as the realisation of WGS 84 in Europe giving the specific framework is known as ETRF 89.

A.5 European Reference System (EUREF)

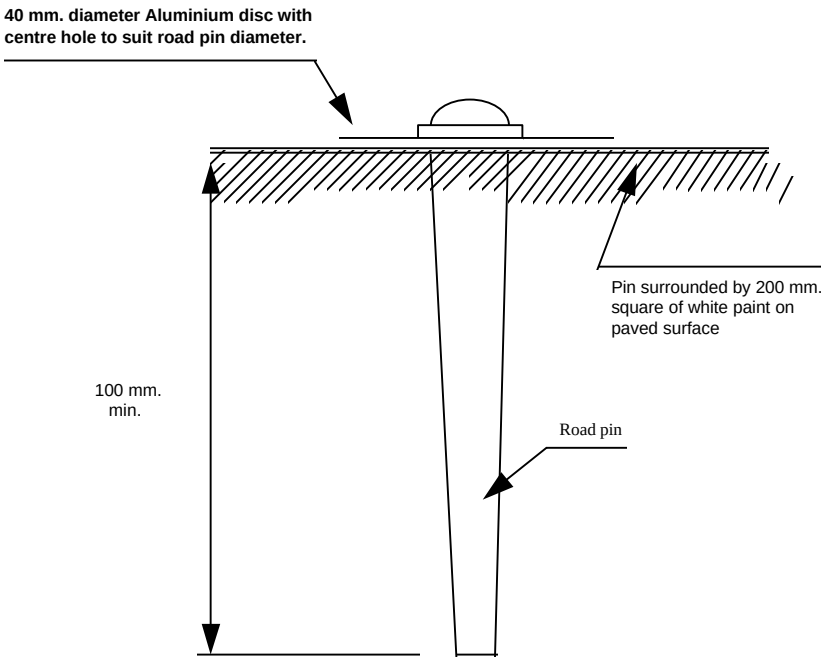
The European Reference System (EUREF) is the name given to official geodetic networks established by various national and regional survey campaigns which were undertaken to densify the ETRF 89 network. These may carry various year numbers (such as EUREF 91) and be related to only one particular region. They may carry the name of the national network. In each case, however, they derive their controlling coordinates from ETRF 89 and, for the purposes of this document are considered to be compatible with ETRF 89 and, consequently, a realisation of WGS 84.

Further details may be obtained by correspondence with national geodetic organisations or through the Comité Européen des Responsibles de la Cartographic Officielle (CERCO) via national geodetic organisations.

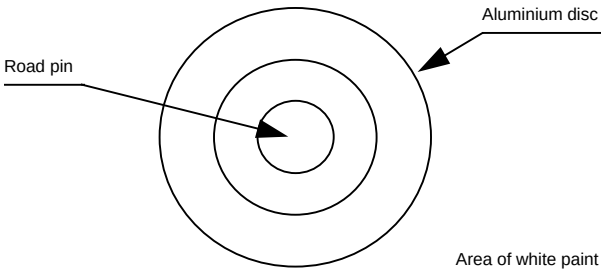
ANNEX B (NORMATIVE) MONUMENTATION

B.1 Where survey markers are installed they shall be of a type appropriate for the task and for the surface and ground type in which they are installed. Designs of suggested survey markers are shown in this section, but other types of marker shall be equally appropriate.

B.1.1 Survey Monumentation Type 1

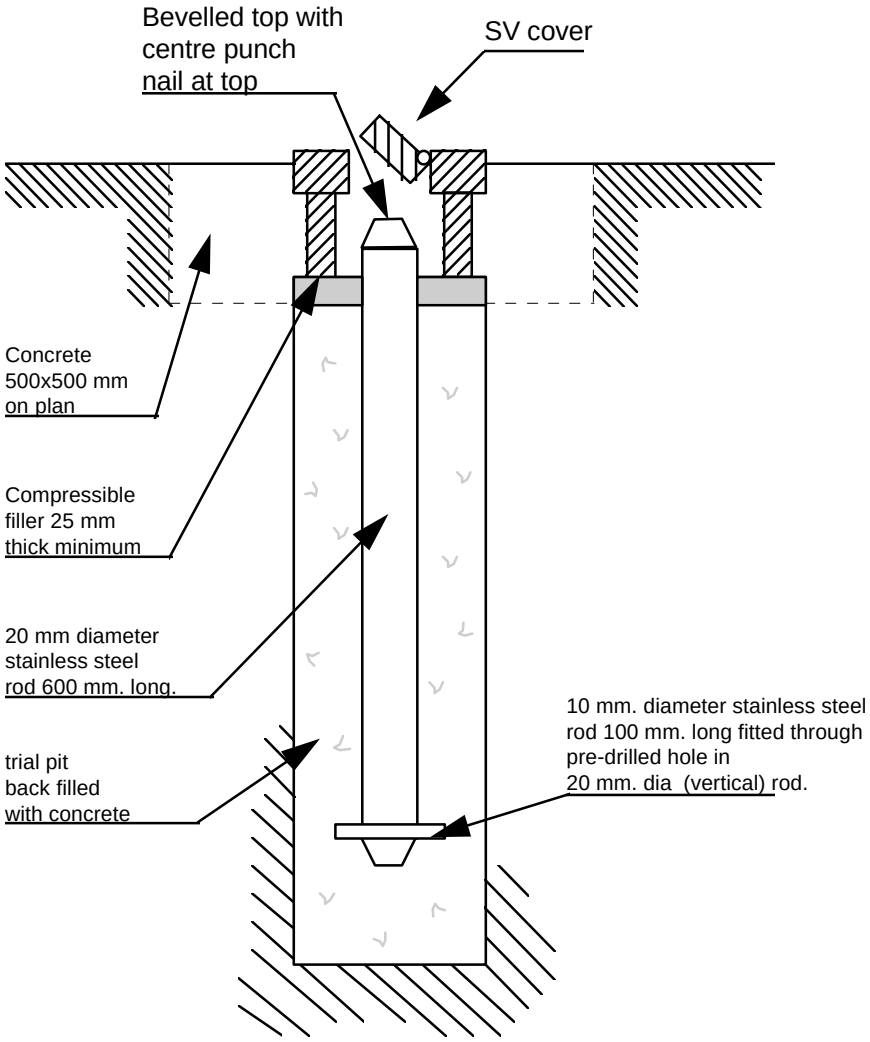


CROSS SECTION
FULL SIZE

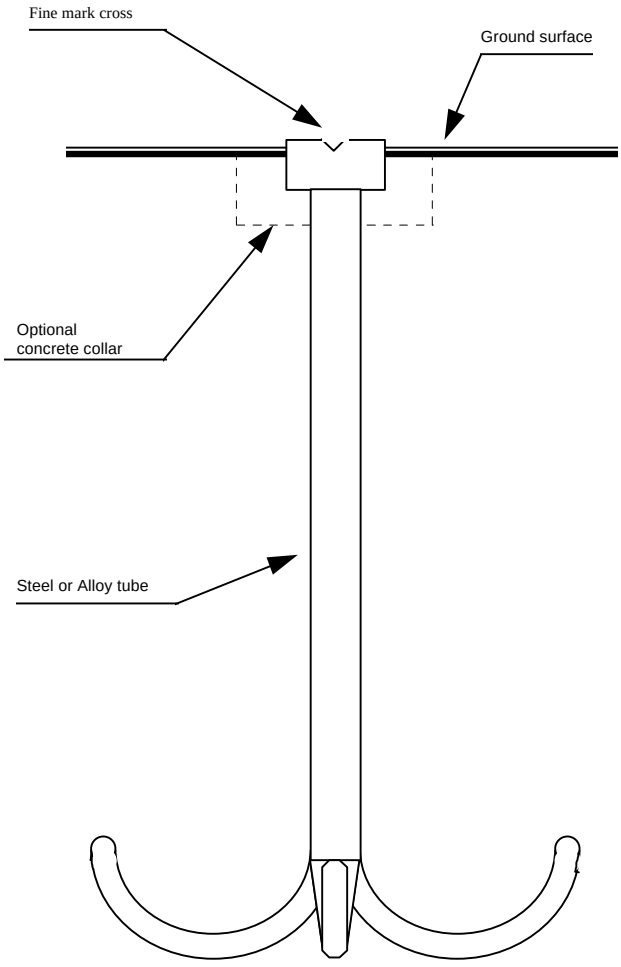


PLAN
FULL SIZE

B.1.2 Survey Monumentation Type 2



B.1.3 Survey Monumentation Type 3



Length to be agreed according to ground conditions.
The illustration is diagrammatic only and is not intended
to refer to any particular proprietary type.

B.2 Example Numbering System for Survey Markers

Recommendations

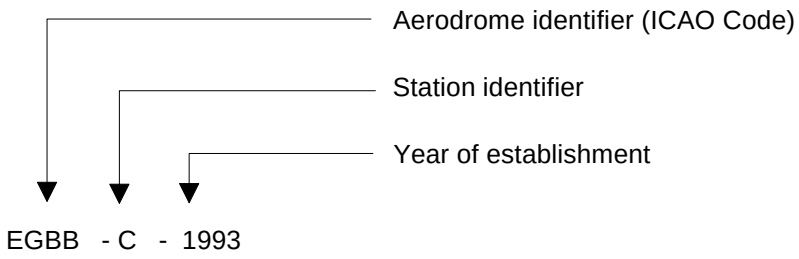
1) Each survey control point which forms part of the aerodrome survey control network should be marked in the field with a unique identification number.

2) The system of numbering should include the aerodrome identifier, the station identifier and the year of establishment. Although the aerodrome identifier will be the same for each station at that aerodrome, and therefore serve no local purpose, its inclusion is important for identification purposes in digital databases.

3) Station identifiers, be they alphabetic or numeric, should be assigned chronologically with the construction of the station. The inclusion of the year number allows the time of establishment to be referenced and mitigates against confusion where replacement stations have been established. Alternatively, a simple consecutive numbering system can be used.

4) Whilst numbering systems will vary from State to State, it is important that each system should include a means whereby the stations are not confused with other surveys which may be conducted at the aerodrome. A simple consecutive numbering system alone, without other identifiers, would not be suitable.

Example



ANNEX C (NORMATIVE)
DESCRIPTION OF FACILITIES

C.1 Threshold

C.1.1 In order to standardise the determination of threshold points for survey purposes, the following guidance is provided.

C.1.2 Where the location of the actual threshold is not known and imbedded threshold lights do not exist, then the most appropriate diagram shall be selected to indicate the point surveyed.

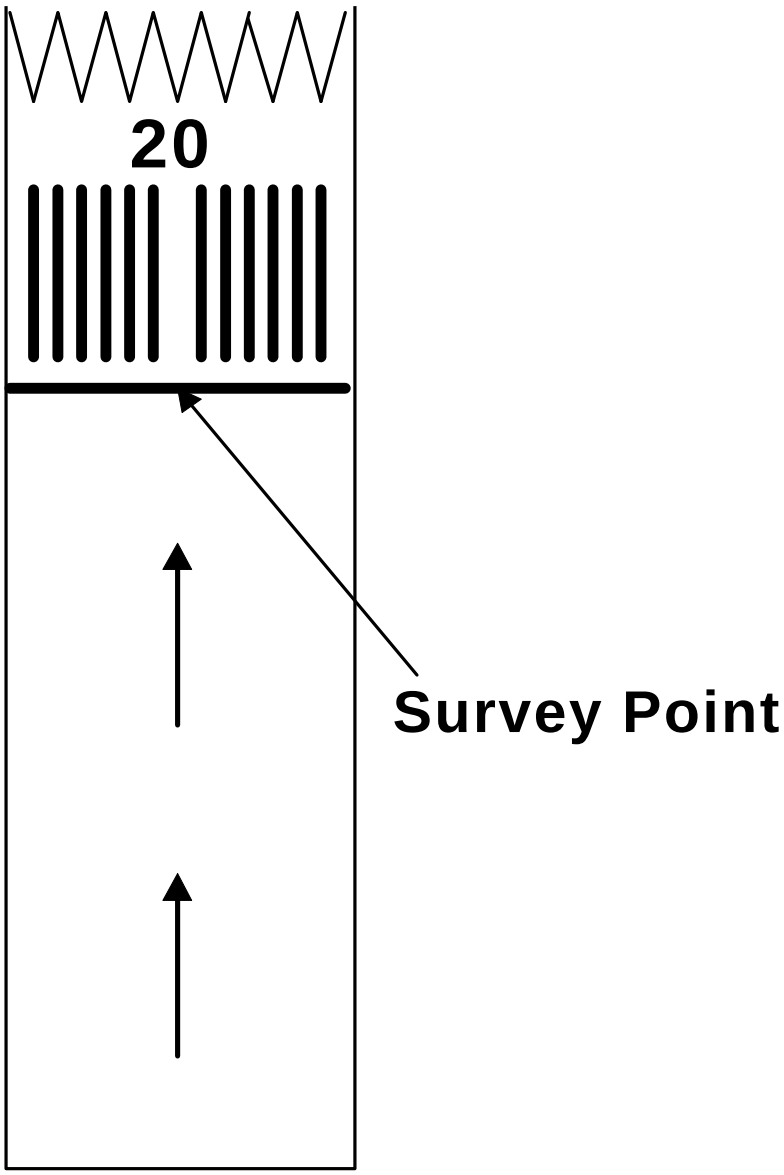
C.1.3 Where none of the diagrams of Annex C is appropriate, a new diagram shall be prepared, showing the actual arrangement of markings and the point selected for survey.

C.1.4 Wing-bar threshold lights and lights installed ahead of the runway hard surface have no direct survey status with respect to thresholds.

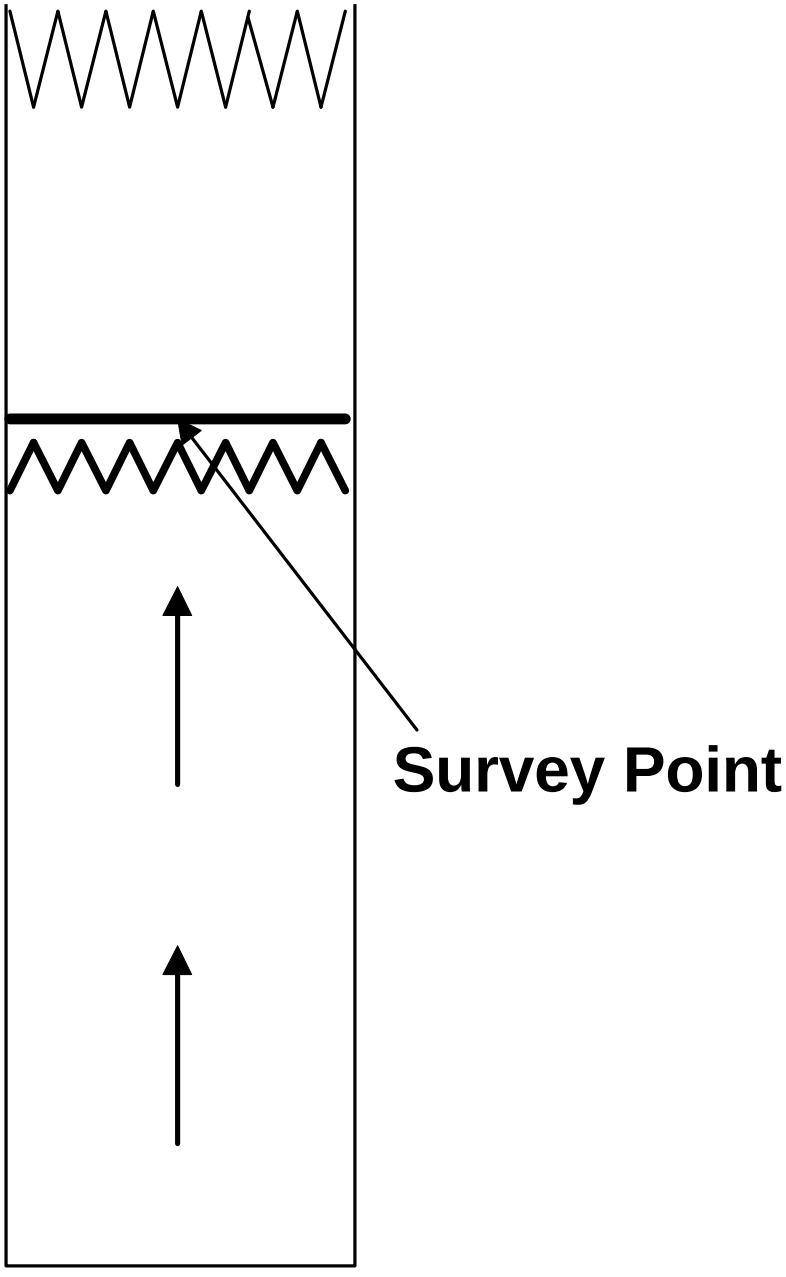
C.1.5 Where existing national standards are used then the survey report shall indicate the equivalence to the diagrams shown in this Annex.

C.1.6 The following illustrations indicate the planimetric position to be surveyed.

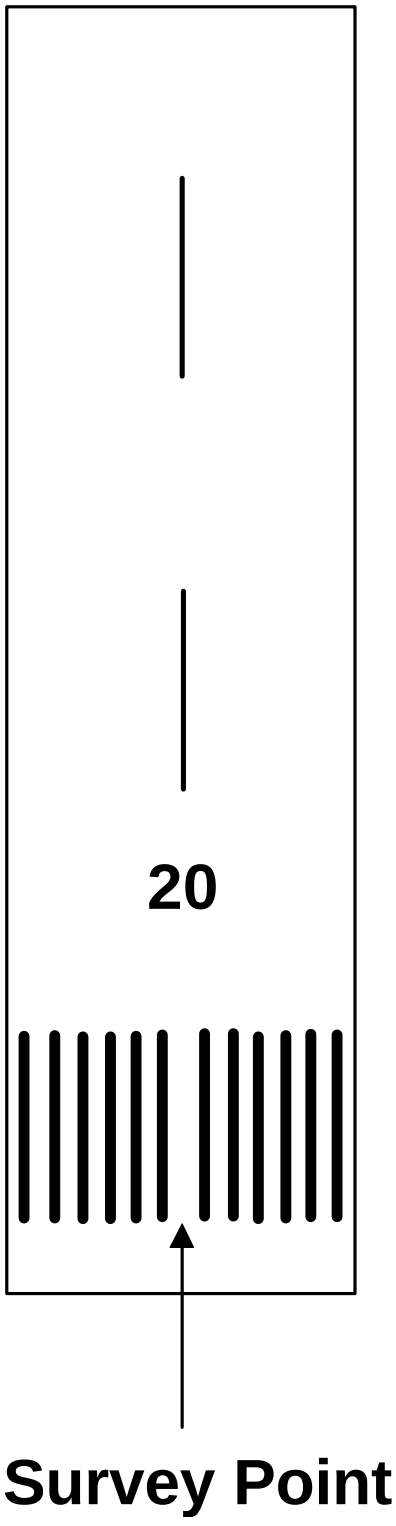
C.1.6.1. Marking Example Type 1 (Normative)



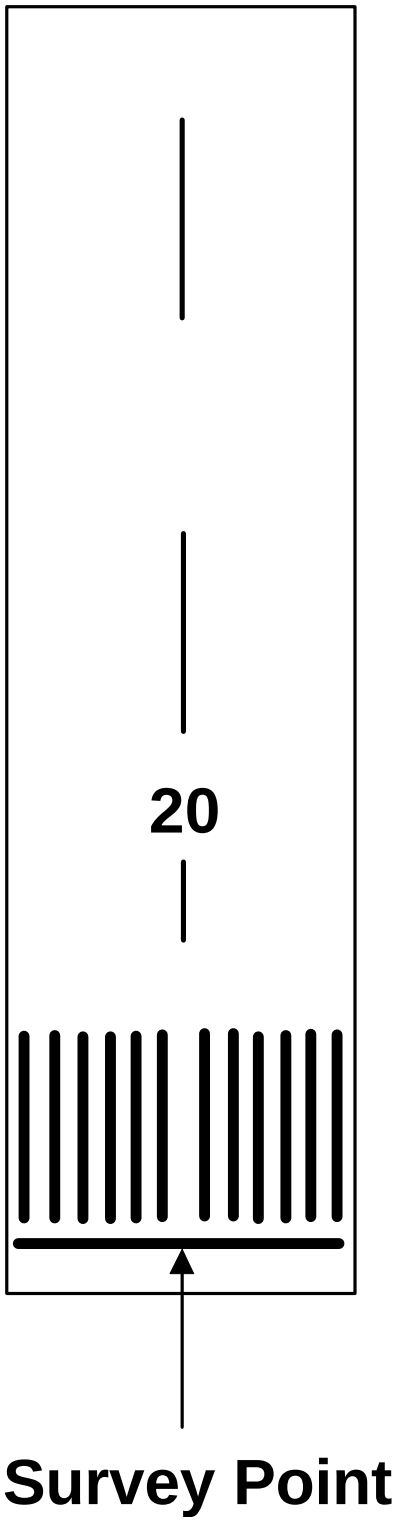
C.1.6.2. Marking Example Type 2 (Normative)



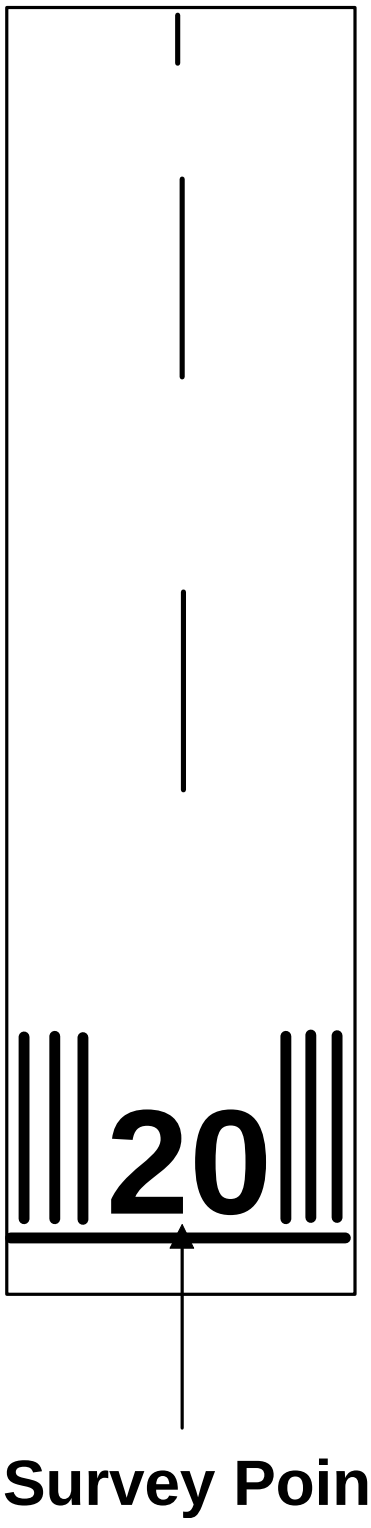
C.1.6.3. Marking Example Type 3 (Informative)



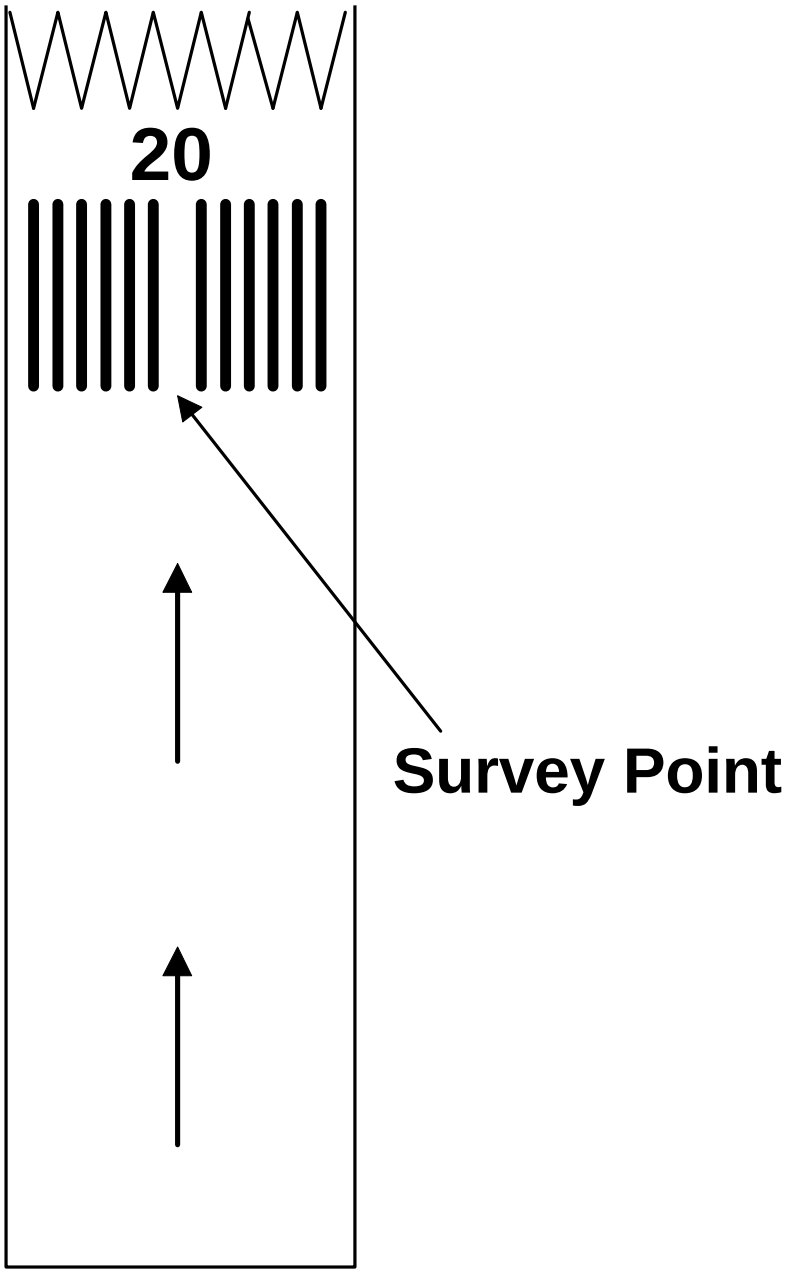
C.1.6.4. Marking Example Type 4 (Informative)



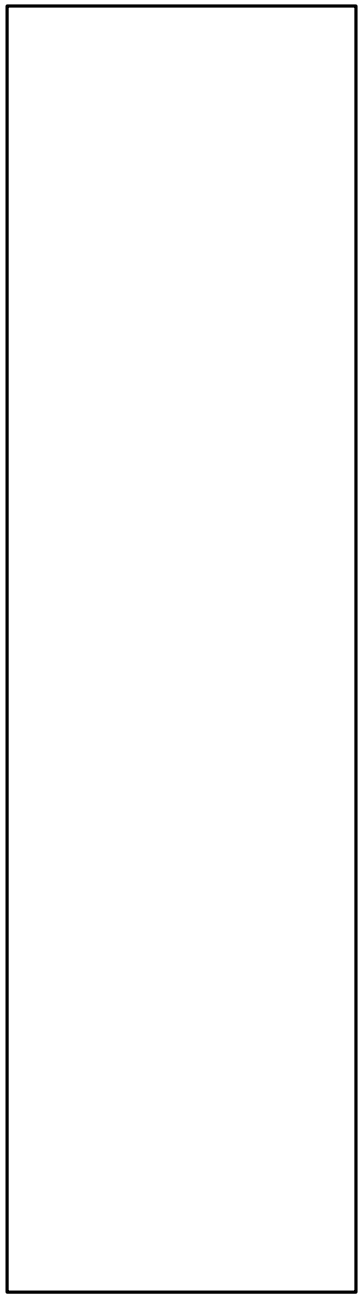
C.1.6.5. Marking Example Type 5 (Informative)



C.1.6.6. Marking Example Type 6 (Informative)

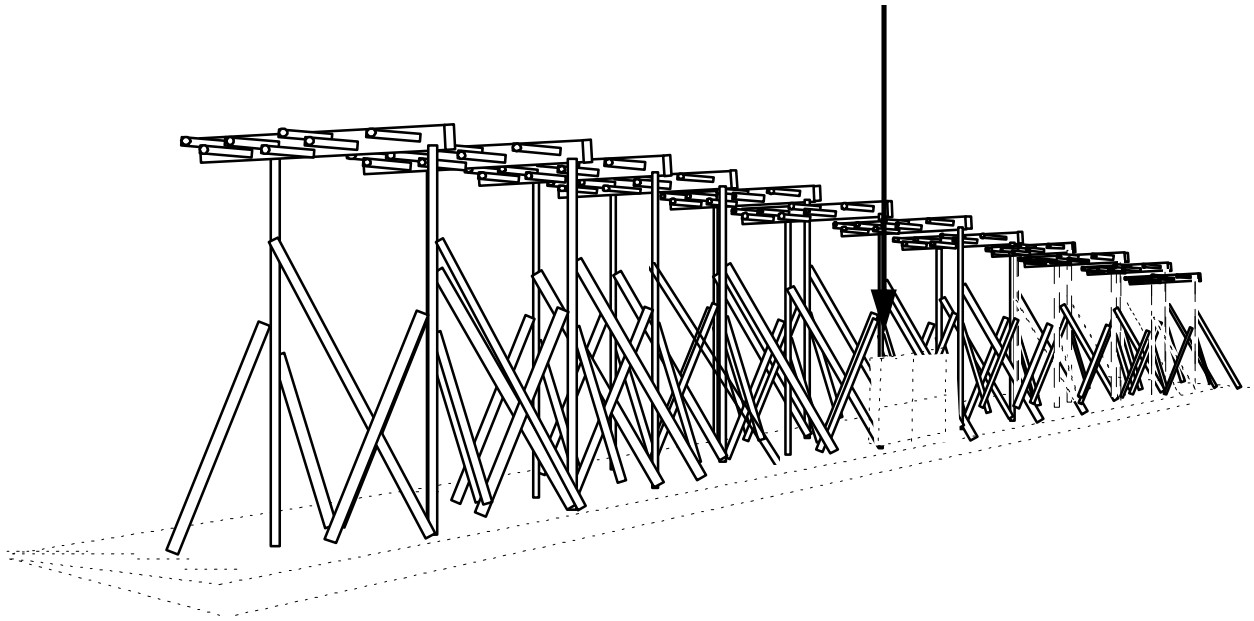


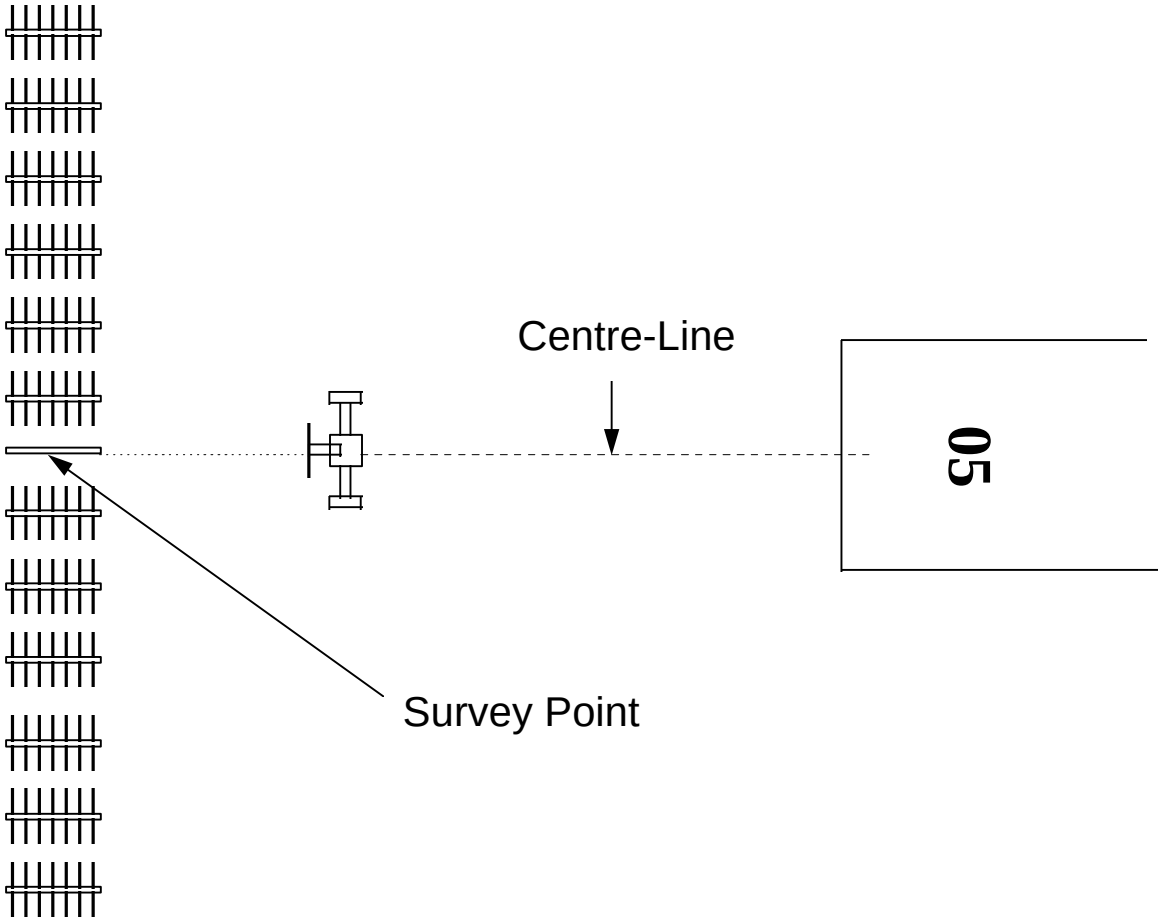
C.1.6.7. Marking Example 7 - Blank Template (Informative)



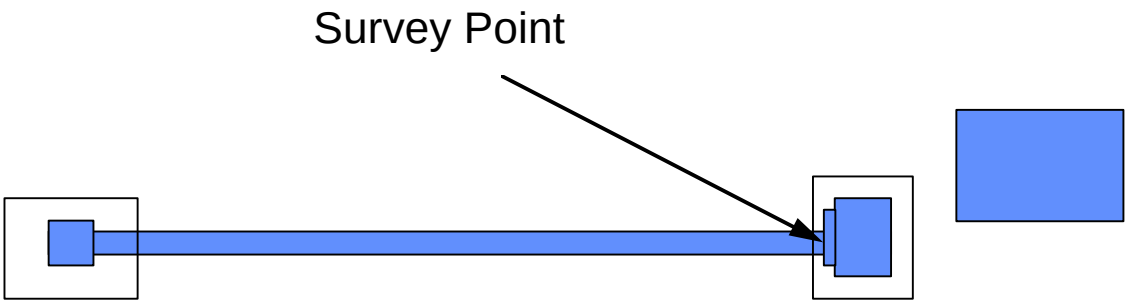
Survey Point

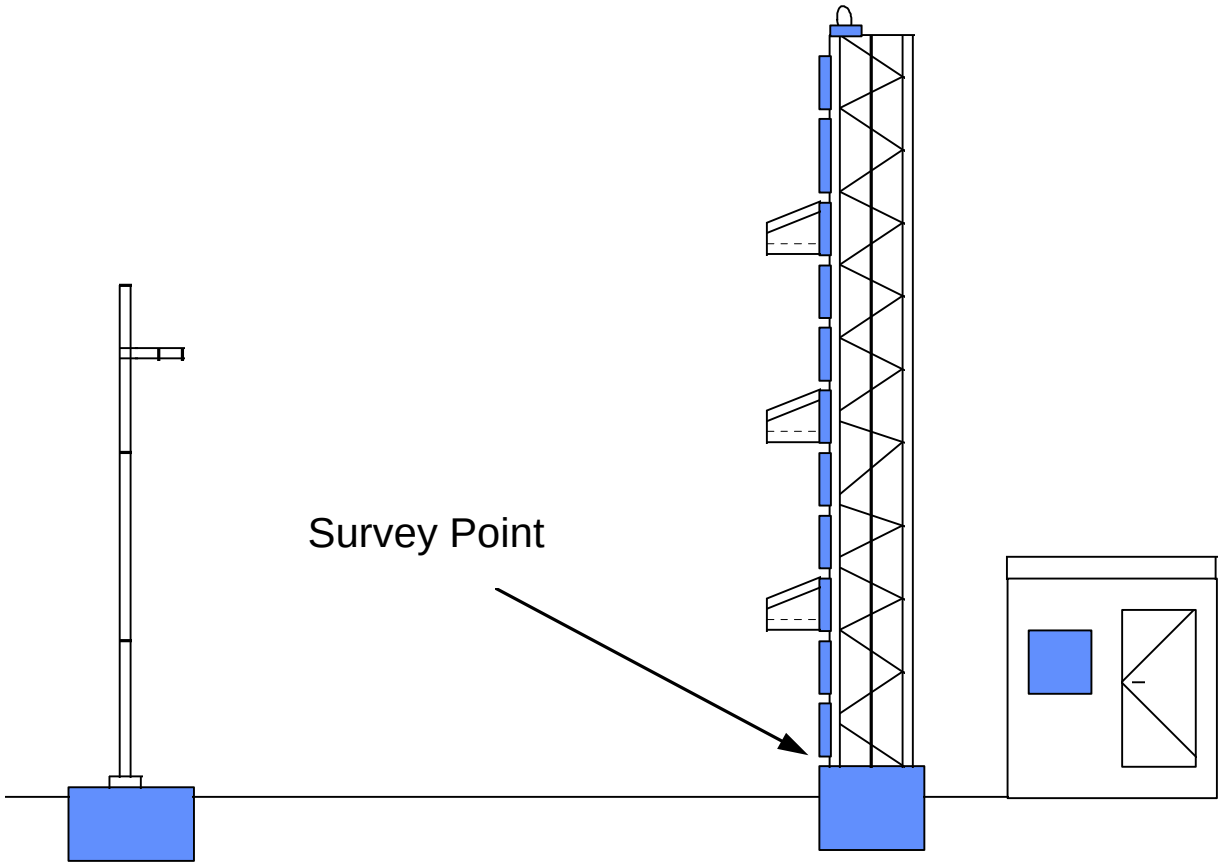
C.2a ILS Localizer (Example)



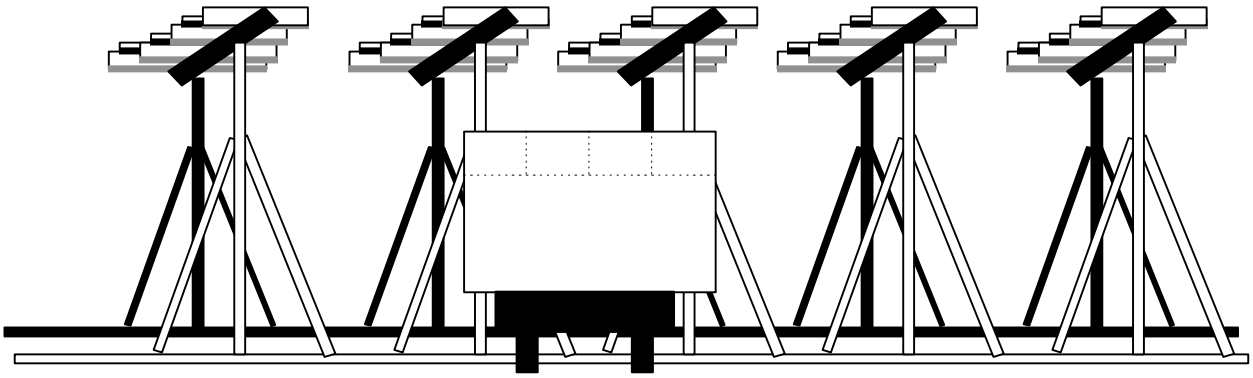


C.2b ILS Glide Path (Example)



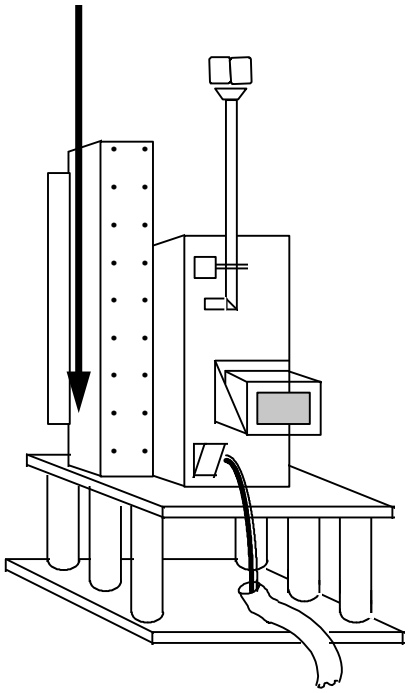


C.3a MLS Azimuth (Example)



NOTE - It is recommended that you refer to the local authority for the survey point.

C.3b MLS Glide Path (Example)



C.4

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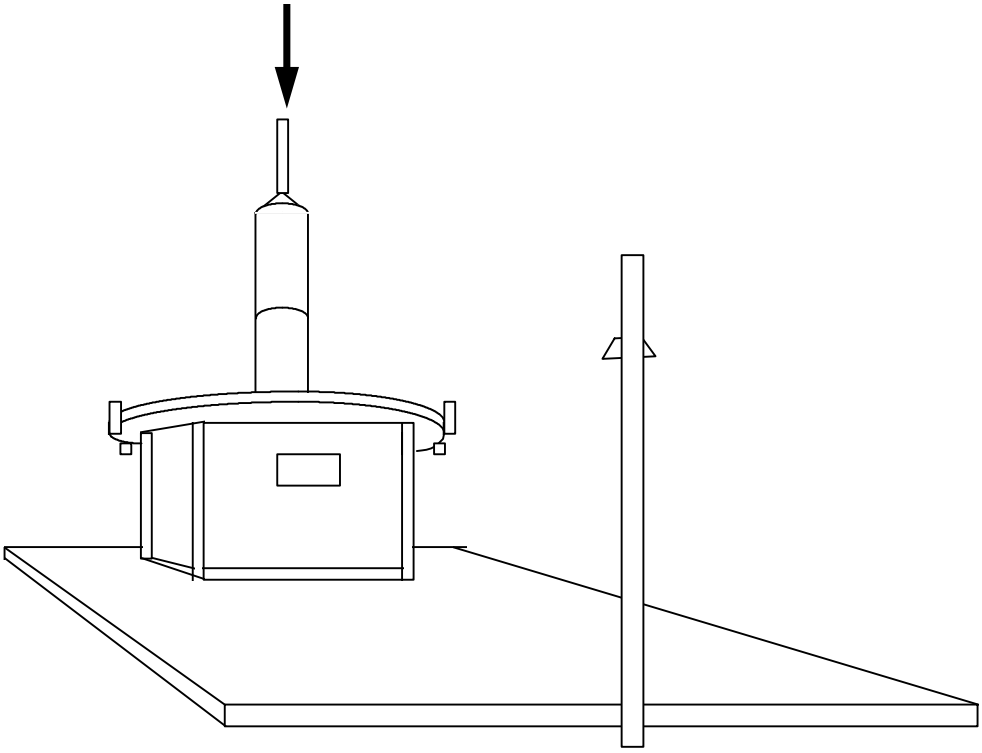
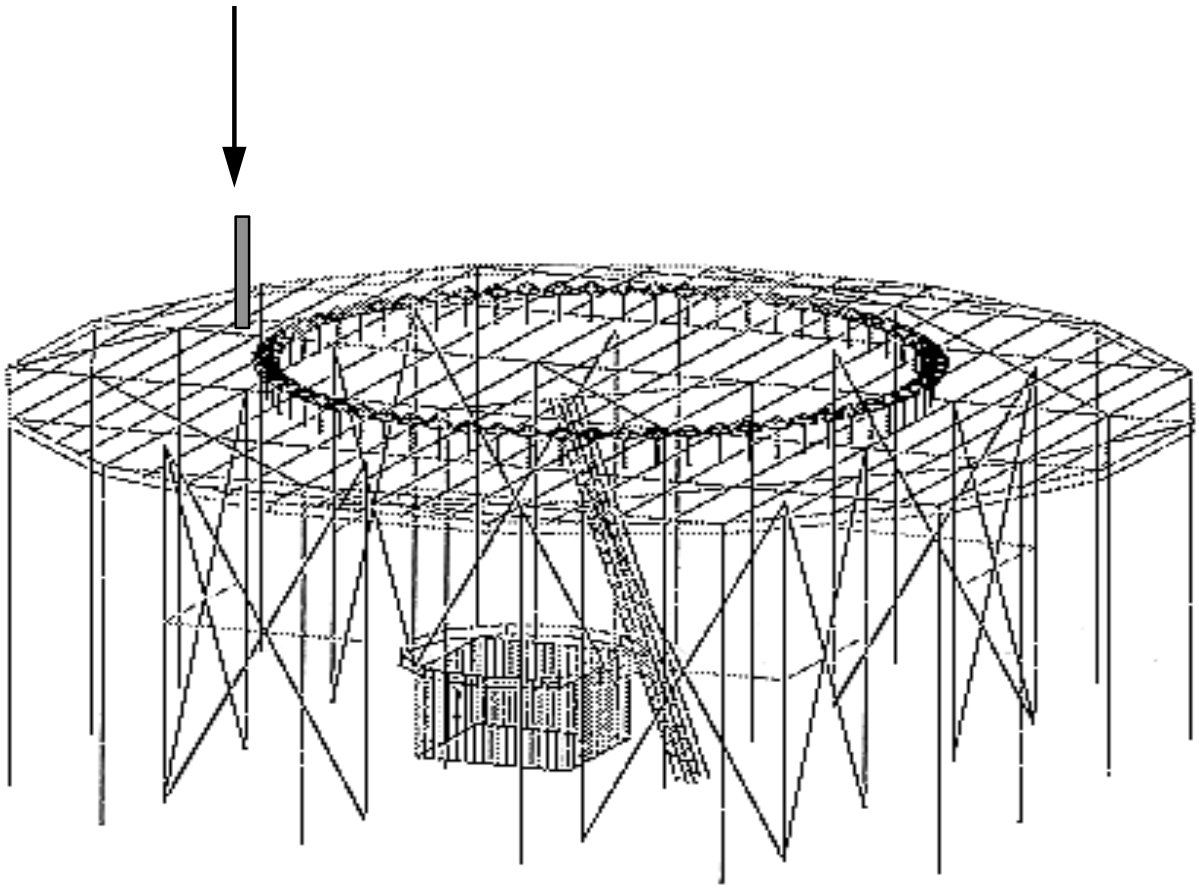
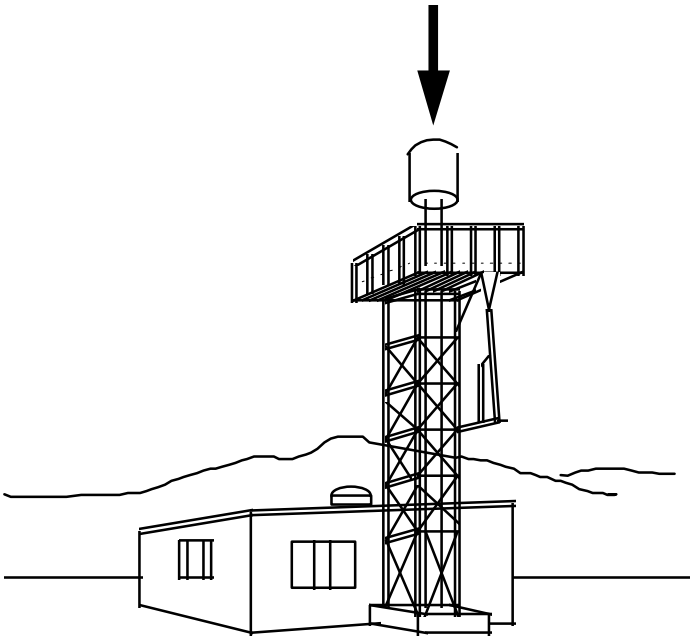
C.5 VOR/DME (Example)



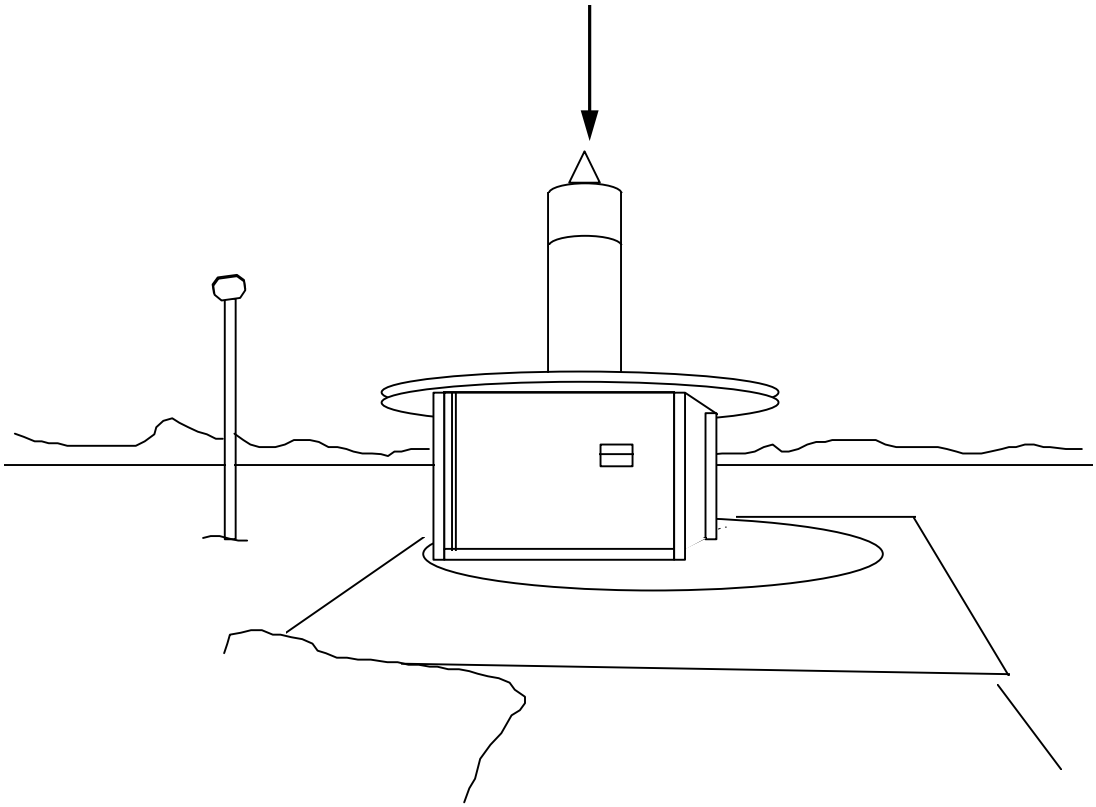
C.6 DVOR/DME (Example)



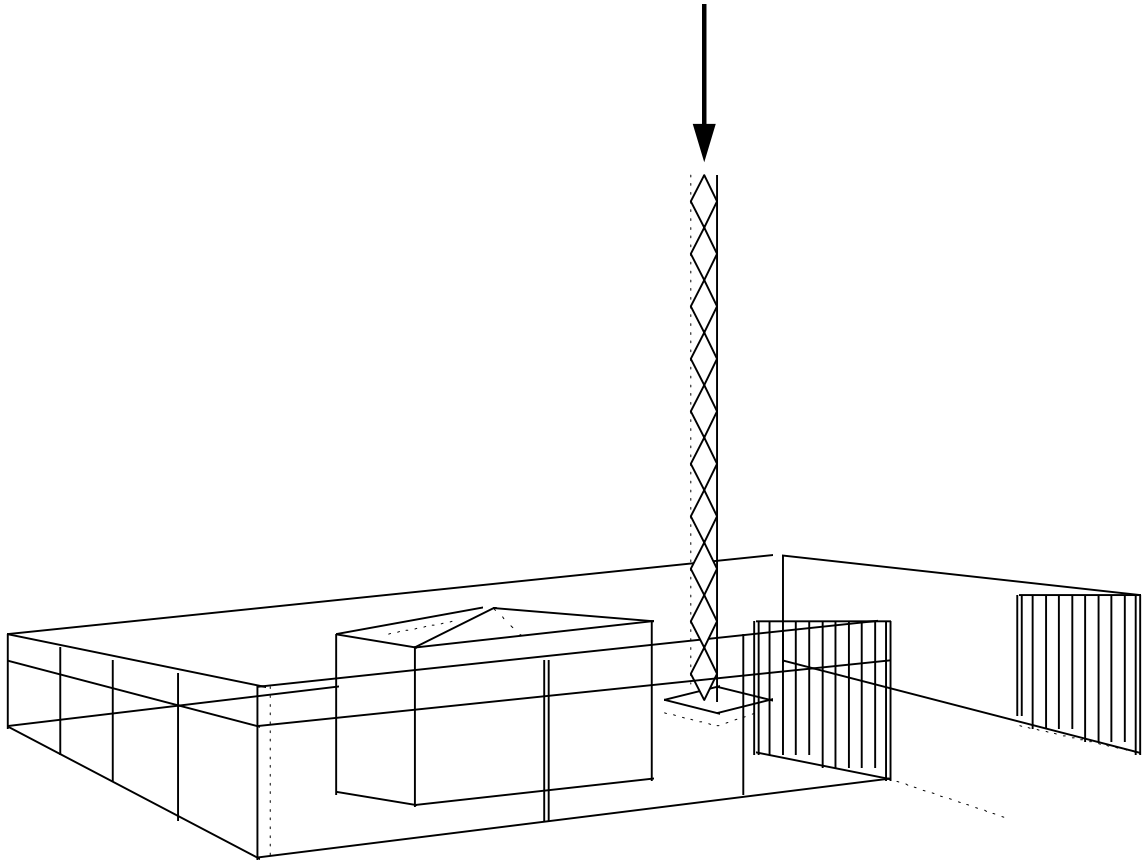
C.7 TACAN (Example)



C.8 VOR (Example)



C.9 NDB, LOCATOR (Example)



ANNEX D (NORMATIVE)
SURVEY REPORTS

D.1 Geodetic Connection

D.1.1 A survey report conforming to the following general format shall be provided.

Table D.1 - Contents List - Geodetic Connection

1	Receipt note signed on behalf of the commissioning organisation indicating the date of receipt of the survey report and confirming its completeness.
2	Historical data (Dates and general purpose of survey, names of surveyor and survey organisation etc.).
3	Description of the method of survey.
4	Details of the datum connection and the source of the control coordinates (i.e. original descriptions and coordinate lists from the National Geodetic Organisation, or lists cross-referenced to previous surveys).
5	Control network diagram.
6	Survey station descriptions.
7	Schedule of points surveyed showing date of monumentation, description and survey.
8	Quality control report indicating equipment calibration information, the method of checking of the survey. Demonstrable evidence that the accuracy requirements have been met, including details of the error budget analysis.

D.1.2 Records of actual observations shall be provided in a separate indexed volume.

D.1.3 Cross references to observations shall be made in the survey report.

D.2 Aerodrome Survey

D.2.1 A survey report conforming to the following general format shall be provided.

Table D.2 - Contents List - Aerodrome Survey

1	Receipt note signed on behalf of the commissioning organisation indicating the date of receipt of the survey report and confirming its completeness.
2	Historical data (Dates and general purpose of survey, names of surveyor and survey organisation etc.).
3	Description of the method of survey.
4	Details of the observations made cross referenced to the control survey (i.e those observations that provide connection to the control points).
5	Facility survey plan and cross referenced witness diagrams (where necessary).
6	Schedule of points surveyed showing coordinates and date of survey.
7	Quality control report indicating equipment calibration information, the method of checking of the survey. Demonstrable evidence that the accuracy requirements have been met including details of the error budget analysis.

D.2.2 Records of actual observations shall be provided in a separate indexed volume.

D.2.3 Cross references to observations shall be made in the survey report.

D.3 Radio Navigation Aid Survey

D.3.1 A survey report conforming to the following general format shall be provided.

Table D.3 - Contents List - Off-Aerodrome Survey

1	Receipt note signed on behalf of the commissioning organisation indicating the date of receipt of the survey report and confirming its completeness.
2	Historical data (Dates and general purpose of survey, names of surveyor and survey organisation etc.).
3	Description of the method of survey.
4	Details of the local connection for the individual radio navigation aids.
5	Survey diagram showing the local survey connection by which the coordinates of the centre of the aid were obtained.
6	Schedule of points surveyed showing coordinates and date of survey.
7	Quality control report indicating equipment calibration information, the method of checking of the survey. Demonstrable evidence that the accuracy requirements have been met including details of the error budget analysis.

D.3.2 Records of actual observations shall be provided in a separate indexed volume.

D.3.3 Cross references to observations shall be made in the survey report.

ANNEX E (NORMATIVE) HELIPORT DATA

E.1 Heliport Survey Points

In order to clarify the points to be surveyed for the WGS 84 requirement concerning those heliports for which coordinates are required to be published, the following guidance is provided, reference ICAO Annex 14 Volume II.

E.1.1 The order of accuracy of the field work shall be such that the resulting operational navigation for the phases of flight will be within the maximum deviations, with respect to an appropriate reference frame, as indicated herein: **(ICAO Annex 14 Vol 2, 2.1.2)**

The geometric centre of the touchdown and lift-off area, thresholds of the final approach and take-off area (where appropriate): one metre. **(ICAO Annex 14 Vol 2, 2.1.2 'b')**

E.1.2 The geographical coordinates of the geometrical centre of the touchdown and lift-off area and/or of each threshold of the final approach and take-off area (where appropriate) shall be measured and reported to the aeronautical information services authority in degrees, minutes, seconds and hundreds of seconds. **(ICAO Annex 14 Vol 2, 2.4.2)**

E.1.3 **Recommendation** *Where there is an aiming point marking (refer E.4) the geometric centre of the equilateral triangle should be taken as the surveyed point.*

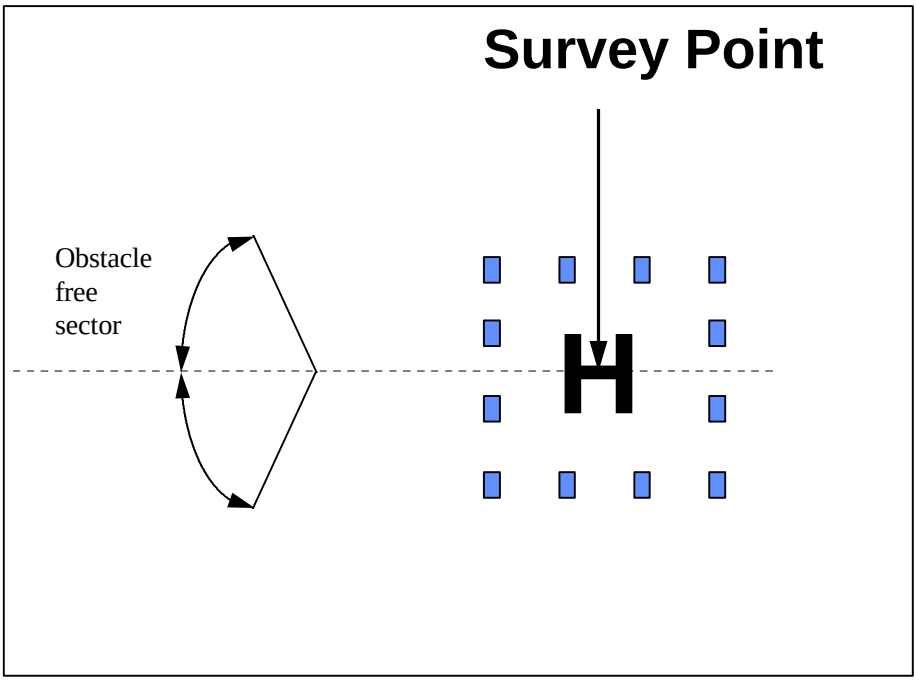
E.2 Aiming Point Marking

E.2.1 **Recommendation** *An aiming point marking should be provided at a heliport where it is necessary for a pilot to make an approach to a particular point before proceeding to the touchdown and lift-off area.* **(ICAO Annex 14 Vol II, 5.2.6.1)**

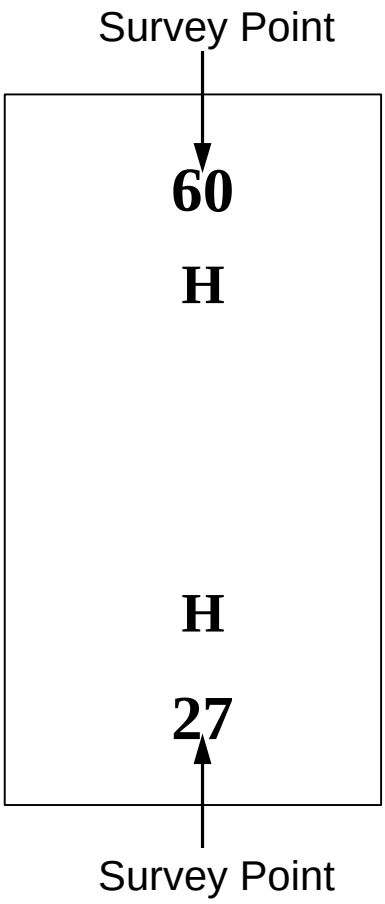
E.2.2 The aiming point marking shall be located within the final approach and take-off area. **(ICAO Annex 14 Vol 2, 5.2.6.2).**

E.2.3 The aiming point marking shall be an equilateral triangle with the bisector of one of the angles aligned with the preferred approach direction. **(ICAO Annex 14 Vol 2, 5.2.6.3)**

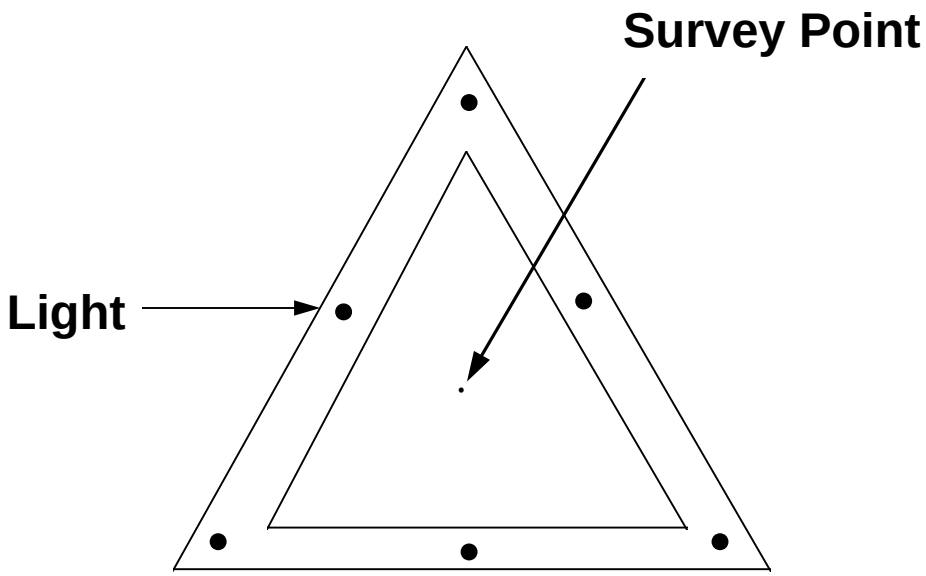
E.3 Heliport Identification



E.4 FATO Threshold



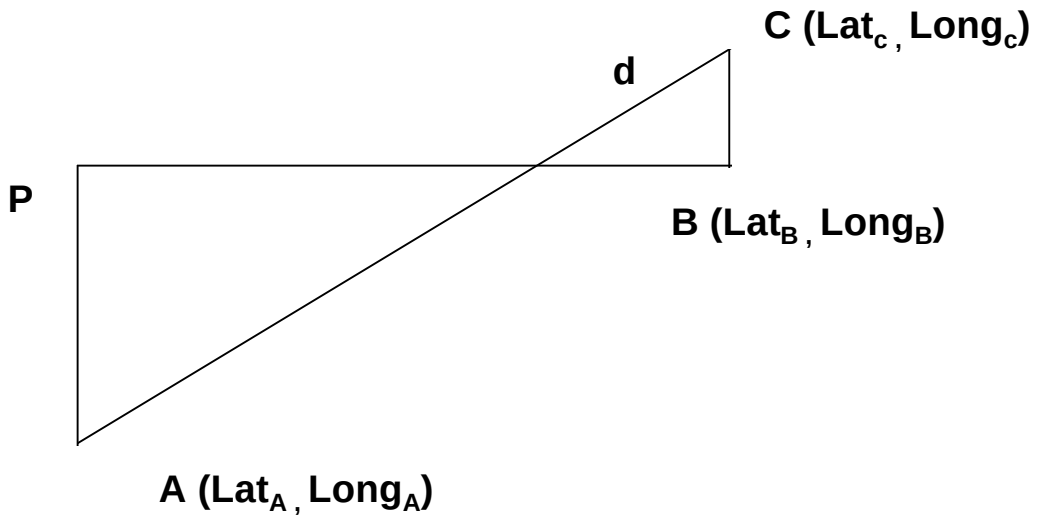
E.5 Aiming Point



ANNEX F (RECOMMENDED)
COMPUTATION OF THRESHOLD COORDINATES

F.1 **Recommendation** *Where the point surveyed does not coincide with the threshold then the threshold coordinates can be derived from those surveyed by using the following method.*

F.2 Computation of coordinates of a threshold longitudinally offset from the point surveyed.



Angles in decimal degrees.

Given: A (Lat_A, $Long_A$) Runway centreline point
B (Lat_B, $Long_B$) Surveyed point
d (metres) Longitudinal offset to new threshold

Find: C (Lat_C, $Long_C$)

$PB = (Long_B - Long_A) \times 1852 \times 60 \times \cos((Lat_B + Lat_A)/2)$

$PA = (Lat_B - Lat_A) \times 1852 \times 60$

$AB = +\sqrt{(PB^2 + PA^2)}$

$k = d/AB$

$Lat_C = Lat_B + k(Lat_B - Lat_A)$
$Long_C = Long_B + k(Long_B - Long_A)$

NOTES

1) Using the naming convention described, the above formula works for all cases. Where the offset is from **B** towards **A** the dimension **d** should be entered as negative.

2) Longitudes West of Greenwich should be entered as negative.

3) These are approximate formulae and should only be used where **d** is small (i.e. less than 200m).

ANNEX G (INFORMATIVE)
SURVEY ACCURACIES

General

The following are suggested accuracies as guidelines for new on and off aerodrome survey programmes.

Definitions

Primary Network:	The National ETRF reference points
Ellipsoidal Height:	Distance of the measured point along a perpendicular to the reference ellipsoid. (+ve for points above the ellipsoid).
Orthometric height:	Distance of the measured point to the geoid (+ ve for points above the geoid).

Height

Although height is not a requirement in the WGS 84 programme it is recommended that where new surveys are made that measured heights (ellipsoidal and orthometric) and the accuracy with which they are determined, are noted.

NOTE - Accuracies for the vertical component have been proposed in Draft Amendment 29 to ICAO Annex 15 and consequential amendments to Annexes 4, 11 and 14.

Survey Control - Aerodrome Control Network

Application:-	**Horizontal Accuracy[1]**
Connection to the primary network	5 cm
Relative accuracy of the aerodrome network to the primary network	10 cm

Aerodrome survey

Application:-	**Horizontal Accuracy[1]**
All points to be measured for final approach, landing and take off.	30 cm

Off Aerodrome survey

Application:-	**Horizontal Accuracy[1]**
All points to be measured for en-route navigation, non-precision approaches. Equipment associated with TMA (Terminal Area) procedures.	3 m

[1] Positional accuracies are as per 4.4.

ANNEX H (INFORMATIVE)
BIBLIOGRAPHY

H.1 The following documents were used as reference material in the preparation of this Standards Document.
(ICAO document unless otherwise stated).

H 1.1	Annex 4	Aeronautical Charts
H.1.2	Doc 8697 - AN/889/2	Aeronautical Chart Manual
H.1.3	Annex 11	Air Traffic Services
H.1.4	Annex 14	Aerodromes Vol. I + II
H.1.5	Doc 9137 - AN/898	Airport Services Manual Part 6: Control of Obstacles
H.1.6	Annex 15	Aeronautical Information Services
H.1.7	Doc 8126 - AN/872	AIS Manual
H.1.8	Doc 4444 - RAC/501/12	PANS - Rules of the Air and Air Traffic Services
H.1.9	Doc 8168 - OPS/611	PANS - Air Operations Vol. I + II
H.1.10	Doc 9274 - AN/904	Manual on the Use of the Collision Risk Model for ILS Operations.
H.1.11	Doc 9426 - AN/924	Air Traffic Services Planning Manual.
H.1.12	Doc 9476 - AN/927	Manual of Surface Movement Guidance and Control Systems (SMGCS).
H.1.13	DMA TR 8350.2-A	DMA Technical Report SUPPLEMENT TO DEPARTMENT OF DEFENSE WORLD GEODETIC SYSTEM 1984 TECHNICAL REPORT. PART 1. METHODS TECHNIQUES AND DATA USED IN WGS 84 DEVELOPMENT.
H.1.14	Doc 9157	Aerodrome Design Manual (Part 4).
H.1.15	Annex 10	Aeronautical Telecommunications.
H.1.16	Doc 8400	ICAO Abbreviations and Codes.