

RECOMMENDATION ITU-R P.1058-2

DIGITAL TOPOGRAPHIC DATABASES FOR PROPAGATION STUDIES

(Question ITU-R 202/3)

(1994-1997-1999)

The ITU Radiocommunication Assembly,

considering

- a) that the application of propagation prediction models requires topographical information;
- b) that future propagation prediction models will be able to make use of more detailed topographic information;
- c) the need to provide practical engineering advice on the preparation of digital topographic maps for propagation prediction;
- d) that data exchange is required between different administrations;
- e) that it is desirable to establish a worldwide topographic database,

recommends

- 1 that topographic database coordinate systems should be determined according to § 2 of Annex 1;
- 2 that the horizontal spacing of data values in a topographic database should be determined taking into account the information contained in § 5 of Annex 1;
- 3 that topographic databases should unambiguously identify sea and lake surfaces, including their heights;
- 4 that topographic databases should contain information about ground cover, either man-made or natural, and include details of the type and height of the ground cover;
- 5 that the additional information contained in Annex 1 should be taken into account when setting up a topographic database.

ANNEX 1

1 Introduction

Digital topographic databases established for the purpose of propagation predictions need to contain information which is related to the type of prediction being undertaken. For frequencies above about 30 MHz, information about the terrain height and ground cover is currently needed. For detailed propagation predictions for frequencies above about 1 000 MHz, especially in urban areas, information about the location, size and orientation of individual buildings is currently needed in addition to terrain height information.

It is to be expected that increasingly sophisticated prediction models will be developed which will permit more detailed propagation predictions but which will also demand more detailed information and, potentially, a reduced horizontal spacing for the data samples.

The purpose of this Annex is to provide guidance on the type of information which should be contained within topographic databases and on suitable values of horizontal spacing for the data samples.

It must be noted that a very wide range of uses for topographic databases can be foreseen and also that a very wide range of ground cover information can be identified. In any individual geographic region, it is unlikely that all types of ground cover will be found and this has an important implication with regard to the data storage. While a universal set of ground cover information could be developed, many of the categories would be irrelevant in the majority of specific topographic

database applications. This implies a requirement for unnecessary storage capacity. Under such circumstances, it does not seem appropriate at present to develop a set of ground cover categories which would be used in the same way in all applications. Guidance can, however, be given on the categories which have been found appropriate and those which seem likely to be worth further investigation.

No universal storage format can be proposed for similar reasons to those given above. However, it is considered to be desirable that propagation prediction computer routines should access the database by means of suitable interface software. In this way, the contents and structure of the database may be modified as more information becomes available and, with suitable changes to the interface software, the propagation prediction routines are unaffected.

In order to effect a satisfactory exchange of a topographic database, for example between administrations or from a supplier to a customer, it is essential either that suitable interface software is supplied with the database or that full information about the database contents and storage scheme are supplied.

2 Coordinate systems

Topographic data can be referenced to any of several coordinate systems. These normally fall into one of two major categories:

- angular coordinates, normally latitude relative to the Equator and longitude relative to a reference meridian, normally Greenwich;
- a rectangular projection applied to a particular area of the Earth's surface according to a defined mathematical projection.

The principal characteristics of these two systems can be summarized as follows:

- latitude-longitude coordinates provide global coverage without discontinuity, but with a non-linear relationship between coordinate values and ground distances. In particular the scale factor between longitude and ground-distance varies with latitude;
- rectangular projections approximate to a linear and scale-invariant relationship between coordinates and ground distances over a defined geographic area, but must be redefined for different areas to avoid significant distortion. Many national mapping agencies adopt a rectangular projection for paper maps, and for this reason the most detailed topographic data for a given area are often indexed at regular intervals of the local projection.

Many national mapping systems are based on the transverse Mercator projection. The universal transverse Mercator (UTM) system is a set of such projections based on uniform definitions for different longitudes, with northings referenced to the Equator. This provides a useful degree of standardization. In some cases there is a preference for projections optimized for accuracy at a specific latitude as well as longitude, in which case individual values for earth ellipticity are usually chosen in order to minimize errors. There are also a number of non-transverse Mercator projections.

The most suitable choice of coordinate system can depend on several factors, including:

- where the highest accuracy is important there is an advantage in retaining the source coordinate system, since conversion to a different system will usually result in a loss of accuracy;
- when extracting short path-profiles data indexed to a rectangular projection provides a useful simplification, since a straight line in the coordinate-space will approximate to a straight line on the ground. The discrepancy when compared with a true great-circle path will depend on the projection system and the path orientation and length. As a general guide, a straight line in a rectangular projection is typically sufficiently accurate for propagation studies up to about 100 km. However, actual discrepancies will vary according to the projection in use, and will tend to be greater for West-East path orientations and at higher latitudes. Users should evaluate worst-case errors when laying-out path profiles as a straight line in a rectangular projection;
- latitude-longitude coordinates are valuable in providing continuous coverage over wide areas. When great-circle geometry is used to avoid excessive non-linearity, the use of latitude-longitude coordinates avoids the need for many coordinate conversions to a rectangular projection.

In view of the above factors it is not practicable to recommend a single coordinate system for all purposes. For international coordination the use of latitude-longitude is recommended in view of its ability to cover the entire surface of the Earth without discontinuities. In cases where a rectangular projection is needed on the basis of practicality, the use of UTM coordinates is preferable on the grounds of uniformity.

The above discussion is summarized in Table 1.

TABLE 1

Coordinate systems

Parameter	Latitude-longitude	UTM	Other
Applicability	Complete Earth	Most of Earth	Usually local
Grid cell shape	Curvilinear trapezoid	Good approximation to square	Usually good approximation to square
Scale-factor variation	Varies with latitude	Good approximation to constant	Usually good approximation to constant
Boundaries	None	According to longitude	Varies

3 Geodetic datum

A geodetic datum is the set of reference values upon which a coordinate system must be based. The WGS 84 datum, which is based on the GRS 80 geoid, is recommended for international coordination.

4 Database compatibility

When combining topographic or mapping data from different sources care must be taken to ensure compatibility. In general misalignments will occur unless all data are based on the same geodetic datum and coordinate system.

5 Horizontal spacing in a macroscopic database

The value of horizontal spacing between data-points which should be used in a topographic database depends upon the use to which the data will be put. It is not practicable to recommend a particular value. In practice horizontal spacings in the approximate range 20 m to 1 km, or the equivalent in latitude-longitude, are typical. Various propagation-prediction models not only have different requirements for horizontal resolution, but differing sensitivity to changes in horizontal resolution. It should not be assumed that increasing horizontal resolution with a given propagation method always improves prediction accuracy.

6 Accuracy of terrain height data

The accuracy of propagation prediction models can be strongly affected by the accuracy of terrain height data in a topographic database. The accuracy of terrain heights is typically expressed as a root-mean-square (r.m.s.) error value. Horizontal resolution, vertical accuracy, and the propagation method in use, will all affect the calculated result. In general, the more detailed deterministic propagation methods require greater resolution and accuracy in topographic data, but details will vary in individual cases. An r.m.s. error of 15 m in terrain height data has been found acceptable for many purposes.