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# DIGITAL TERRAIN MODEL OF EUROPE

*Slavko Pečnik*
*Inštitut za geodezijo in fotogrametrijo FAGG, Ljubljana*
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## Abstract

*A range of $8^{o}$ x $12^{o}$ (890 x 840 km of actual) size with basic grid 5' x 5' (9,3 x 6,7 km) has been chosen as a testing area for the outline scheme of The Digital Terrain Model of Europe. In the process of DTM generation the basic 5' x 5' grids were condensed to a reasonable value. The goal of the project The Digital Terrain Model of Europe is to build a digital data base for the area that is covered with four models and to make a special application with the program system SCOP.*
**Keywords:** *digital terrain model of Europe, Geodetic workshop, modified polyconic projection, Radenci, SCOP, 1994*

## INTRODUCTION

A Digital Terrain Model (DTM) is a computer-supported representation of the Earth's surface, which is gaining importance in Slovenia. The applicability of DTMs knows almost no limits and to a great extent depends on the requirements and demands of users. Local DTMs were developed in the early phase of development of digital terrain models, which cover smaller, entirely local areas. A tendency to set up digital databases of regional DTMs has appeared lately, which include areas of large dimensions. Large-scale cartographic sources and with grids on the order of magnitude from 30 x 30 m (made in the USA) to 230 x 230 m (made for Northern Italy) were used. Two digital terrain models were made for Slovenia with quadratic grids of 100 x 100 m and 500 x 500 m, which are compatible. The paper presents a cartographic source and the mathematical properties needed for the formation of a digital terrain model. A Modified Polyconic projection and the mathematical elements of a digital terrain model of a test area are also presented, as well as a method for the acquisition of input data used. The application "Axonometric Presentation of Models" enabled by the SCOP program system was chosen for the presentation of the set-up of the digital database.

## CARTOGRAPHIC SOURCE AND ITS MATHEMATICAL PROPERTIES

A proposal by Austrian geographer and a professor at the University of Vienna, Prof. Albrecht Penck, for the preparation of an international map of the world (IMW) at 1:1 000 000 scale was accepted at the Vth International Congress of

Geographers in Bern in 1891. At subsequent conferences the following mathematical basis was determined for it:

- Sheet size
  - Sheets will comprise an area of $4^{o}$ of geographic latitude and $6^{o}$ of longitude, possibility of joining sheets (London, 1909);
- Cartographic grid
  - Meridians and parallels of latitude are presented for each degree (London, 1909);
- Projection
  - The map projection should fulfill the following requirements:
    - meridians will be presented as straight lines
    - parallels will be presented as parts of eccentric circles
  - Deformation of the carrying material (paper) will prevent the preparation of a conforming or equivalent projection.

The International Map of the World at a scale of 1:1 000 000 in a Modified Polyconic projection was chosen from among the available cartographic material for the preparation of an outline scheme.

## MODIFIED POLYCONIC PROJECTION

The projection is derived from a modification of an American Polyconic projection with the following characteristics:

- the border parallels in each sheet are arcs of eccentric circles with their centre on the extension of the central meridian.
- the linear projection scale along the parallels equals n=1
- all meridians are mirrored as straight lines
- the central meridian is shortened by a value $s=0{,}271 \cos^2 \varphi$ (in mm), while the two meridians at a distance of $\pm 2^{o}$ from the central meridian are mirrored without deformations, m=1.
- the cartographic grid is calculated at $1^{o}$.

### Construction of the cartographic grid

Construction of the grid of meridians and parallels on sheets is based on rectangular coordinates of characteristic cross-sections of a $1^{o}$ grid, with characteristic symmetry with regard to the central meridian.

### Coordinate system

The coordinate system was determined on the basis of known coordinates of characteristic cross-sections of a degree-grid and the known length of the central meridian, shortened by the appropriate value. The coordinate beginning of each sheet is in the intersection point of the central meridian and the southernmost parallel.

## MATHEMATICAL ELEMENTS OF THE MODEL AND CONTENT

A compromise solution was adopted with regard to the available cartographic source and its mathematical properties, i.e. each sheet should represent an independent model, which is also the characteristic of the Modified Polyconic projection. Four independent models were thus formed which can be joined into one model in any randomly selected projection. The maps chosen for the preparation of an outline scheme comprise an area of size $8^{\circ} \times 12^{\circ}$, which in nature is an area of size approximately 890 x 840 km.

### Coordinate system of the model

The rectangular coordinate system is designed as required by the Regulations on the Preparation of Maps, and with an additional "Z" component represents a relatively well-oriented model with accurately determined coordinates of cross-sections of a geographic grid.

### Scale and units of the model

All cross-section coordinates (y, x) of points were calculated at an accuracy of 1/1 000 mm at map scale 1: 1 000 000. This is justified by the fact of the given accuracy of the input data for the projection which are stated in the tables. At the same time these values represent a unit of one metre in nature. The "Z" coordinate was estimated at an accuracy of one metre in nature. This serves to establish the relation of equal accuracy and equal measurement units for both the positional and height presentation of the acquired data.

### Cartographic grid

The basic cartographic grid of the projection is a degree-grid which is condensed to a density of five arc minutes (5'). The described density of the grid is the smallest distance between cross-sections which serve as the method of acquisition of input data. This distance in nature is on the order of magnitude of approximately 9 kilometres, depending on $\varphi$ and $\lambda$. At the same time this is also the density of the digital terrain model in question, which can be additionally condensed with the SCOP program. The rectangular coordinates of cross-section of the cartographic grid (hereinafter "profile points") (y, x) were calculated on the basis of input data of the projection with the use of linear interpolation. The height component "Z", however, is interpolated from cartographic material using a previously made transparency with profile points.

### Content of acquisition

The geographic content which is the basis of the map and is required for the setting up of the base of the acquired digital terrain model is divided into two groups:

- the basic group of acquired data are the so-called point elements:
  - reference points
  - cross-sectional points
  - height points, given by height,
- line elements represent an additional group, which in the case of a closed polygon represents a plane element:
  - the coastline of the mainland
  - lake outline
  - the coastline of islands.

## DATA ACQUISITION METHODS

The basis idea for data acquisition comprises a separate calculation of position coordinates (y, x) of points along cross-sections of equal latitude on one hand and manual acquisition of the "Z" component of identical points on the other, which is a consequence of non-existence or unavailability of published originals which would enable other methods of data acquisition. This above all means scanning of the surface and later automatic or semi-automatic vectorization of raster image. This method is the simplest form of indirect data acquisition and with this, analog-digital transformation of data acquired from a cartographic source. The method of work, dependent on the available cartographic source, dictated the writing of a computer program which will solve the problem of data acquisition, i.e. the calculation of position coordinates of points along the cross-sections.

## APPLICATION AXONOMETRIC PRESENTATION OF MODELS

The calculated coordinates of reference points and the knowledge of the distribution of reference points serve for a statement of the limits for generating a DTM and an axonometric presentation. In the phase of test processing of data it was established that in comparison with length, the height component "Z" of the points comprising the analysis should be increased by a factor enabling a real presentation of the relief. A multiplication factor with a value of Z=5 was chosen for the preparation of an axonometric presentation, which means an increase in height by a five-fold value of the input data. The analyzed DTM grid was additionally condensed to a grid which in nature has the dimensions of 2 500 x 2 500 m, while on the map, at a scale of 1:1 000 000, it is 2,5 mm. Such a grid and the selection of a bell-shaped curve as the basic function enabled a generation of a DTM for the entire area. The selection of the basic function smoothened the digital model of relief which in practice meant the rounding of all transitions.

The SCOP.PERSPECT module enables the preparation of axonometric presentation with a randomly chosen perspective of the discussed model. A part of the results can be seen in the enclosure. Axonometric presentation is only one of the possibilities of using the digital database of the DTM which was set up in the process for the preparation of a graduate thesis entitled Digital Terrain Model of Europe.

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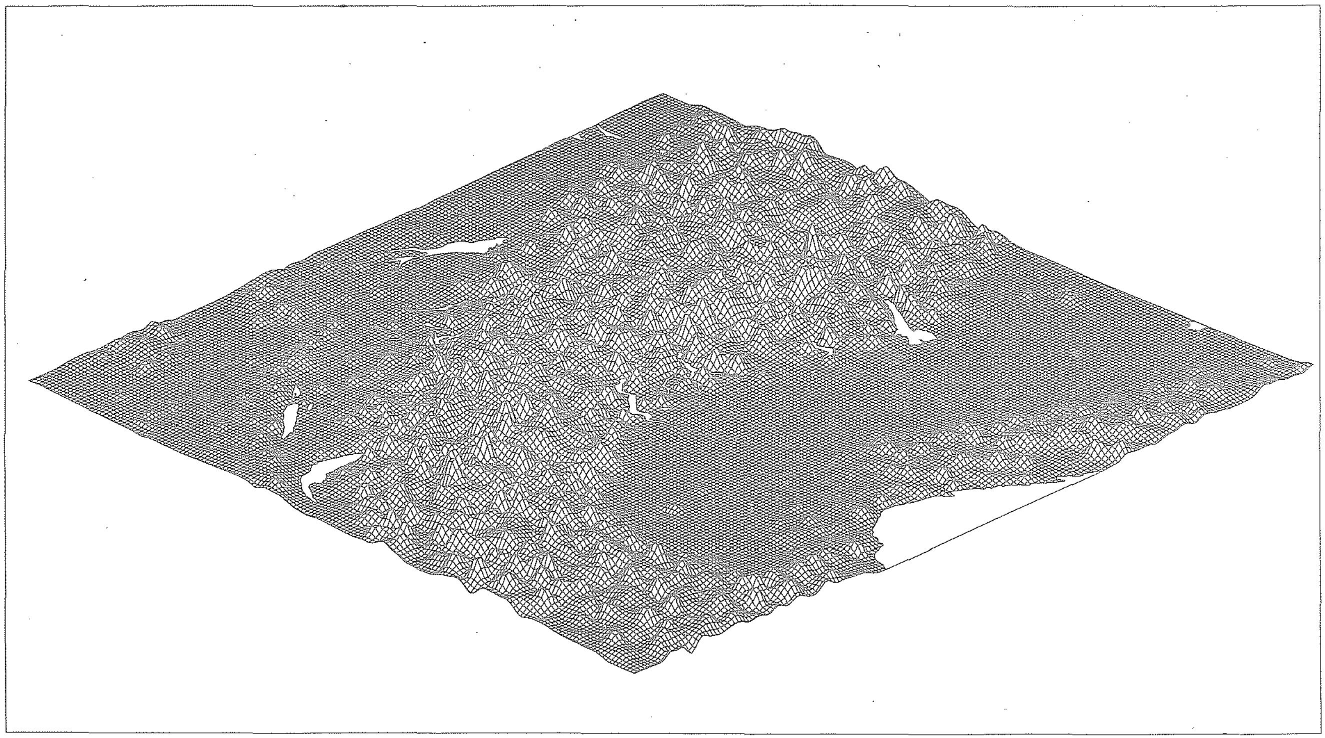
AXONOMETRIC PRESENTATION OF MODEL No. 305 (facing NE)



**Axonometry of the MOD305 Model**

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|---|---|
| *nomenclature* | *L32* |
| *direction of view* | *SW to NE* |
| *area covered by the model* | *lower left: SE part of France*<br>*upper left: NE part of France*<br>*upper middle: S part of Germany*<br>*upper right: W part of Austria*<br>*middle: Switzerland and N Italy*<br>*lower middle: the Bay of Genoa* |

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