# TOLERANCES IN DIGITAL MAPPING

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ABSTRACT :

The automated cartography involves digital map achievement. The paper deals with the problems of digital map resolution and accuracy and the usual tolerances in digital mapping : the map resolution tolerance or fuzzy tolerance, the tolerance ensuring digitizing accuracy or tic match tolerance (maximum allowable tic registration error), the join map tolerance, the weed tolerance etc.

KEY WORDS : Digital mapping, Resolution, Accuracy, Tolerance

## 1. DIGITAL MAP RESOLUTION

The digital map resolution expresses the precision for the appearance of map object localization and form for a given scale. The resolution expressed in terrain measuring units decreases with the decreasing of map scale, because the details must be smooth and simplified or even not be represented. The minimum sizes of terrain objects that must be represented on maps are called sometimes "the minimum mapping sizes" and are given as census values in the map series construction directions. Digital map data may be raster or vectorial data. The resolution analysis for one of the data type may be extended to the other one.
One can determine the minimum size of the elementary raster cell through two ways, using cartographic or stereophotogrammetric grounds.

The cartographic ground supposes that a drawing of a separate cartographic image asks the resolution of 14 lines/mm, supposing the minimum line width 0.1 mm on the map. This reason leads to the resolution 1.7 m in the ground for the base map 1:25,000 scale.

The stereophotogrammetric ground supposes the elementary cell size as the spot size required in digital stereophotogrammetry for contours representation interval. In the case of digital correlation techniques, the longitudinal parralax error $\sigma_{p_{x''}}$

$$\sigma_{p_{x''}} \leqslant kl \qquad (1)$$

where k is a constant and expresses the degree at which can result a stereoscopic correlation with a spot size l. Considering the height error $\sigma_h$ as a function of longitudinal parralax, after some transformations, the size spot l will be

$$l = \frac{1}{k}\,\frac{B}{H}\,\sigma_h \qquad (2)$$

For the confidence degree 0.10, the height tolerance will be $3,3\sigma_h$. If the contour interval is 5 m, $\sigma_h$ = 1.5 m (for the 1:25,000 scale map).
For B/H = 0.6 and $0.4 \leq k \leq 1.0$ results $0.90 \leq l \leq 2.25$ m.

## 2. DIGITAL MAP ACCURACY

The map accuracy belongs to the map resolution.
There are many factors that influence accuracy of the details position among which the source data quality, the map scale, the cartographic accuracy on source cartographic material, the minimum line width etc. We summarize here only the study of the digitizing accuracy and the coordinates transformation accuracy.

### 21.1. Digitizing accuracy

The vectorial digitizers may be assimilated with the photogrammetric monocomparators and the accuracy may be studied with the wellknown methods (Jeypalan, 1972). The digitizing accuracy test implies the test for pointing accuracy, the test for repetability etc. We used a grid on plane glass with a very good practical accuracy. For the ARISTOGRID digitizer, using a grid with 2304 points, we obtained the values : the maximum differences between three measurements in each point were 0.04 mm for x and 0.03 mm for y, the standard repetability error 0.02 mm, the maximum standard error in point 0.021 mm and the standard error of all the measurements 0.12 mm,
The conclusion was that the values indicated by the manufacturer are very good and the digitizer may be used for multiple measuring purposes.

### 2.2. The transformation accuracy

For the transformation of coordinates from the digitizer system to the map projection coordinate system one can use the similarity (the linear-conformal transformation), the affine transformation, the projective transformation or the polinomial transformation in the general form

$$X = x + Ag \qquad (3)$$

where A is the transformation matrix, g is the vector of individual transformations parameters, x is the vector of measured tic coordinates and X is the vector of coordinates in the digital map projection system. The parameters g may be determinated using a least square adjustment because the redundant operations are applied to set the basic equation system. We used the coordinates transformation subroutines of a special cartographic library. In the table nr.1 are given transformation parameters for one 1:25,000 scale topographic map sheet

Table no.1

| Parameters | Transformation | | |
|---|---|---|---|
| | Linear conformal | Affine | Projective |
| No.of points | 4 | 4 | 6 |
| The unit weight tolerance | 1.125 | 0.980 | 0.920 |
| Maximum location error (m) | 1.5 | 1.4 | 1.2 |

From that test results the conclusion that in an automated mapping system must use all three transformations, the selection of one of them being the user's choice.

## 3. TOLERANCES IN DIGITAL MAPPING

In digital mapping one uses planimetric tolerances like the map resolution tolerance, topology build tolerance, the match tolerance, weed tolerance etc., and height tolerance.

### 3.1. Map resolution tolerance

In §1 resulted the map resolution of coordinates 1.7 m for 1:25,000 scale topographic map (0.7 mm on the map sheet). Considering the tolerance value 3 times bigger, results the value 0.2 mm on the map.
In the graph theory sense, the map resolution tolerance may be defined like the threshold value of a distance between two end-points of the arc (nodes). As a rule, this tolerance is used to join the arcs in one node (ESRI,1989).

### 3.2. Topology build tolerances

Topology build tolerances are dangle lenght and node match tolerance. The dangle lenght is the minimum lenght allowed for dangling arcs. Any dangling arc less than this value of the tolerance is deleted.
The node match tolerance is the minimum distance between nodes. All the nodes within the node match tolerance of each other are snapped together. As a rule, the dangle lenght and the node match tolerance have the same value.

### 3.3. Weed tolerance

The weed tolerance is used for the decreasing of the number of points of a linear feature in cartographic meaning or of an arc in topological meaning, especialy in cartographic generalization.

### 3.4. Tic registration tolerance and tic match tolerance

Considering the case with redundance, the RMS error $\sigma_0$ is calculated automaticaly,

$$\sigma_0=[\Sigma(V_x^2+V_y^2)/(2n-k)]^{1/2} \qquad (4)$$

where n is the number of tics (with the coordinates in both systems), k is the number of parameters and $V_x$ and $V_y$ are the residuals.
The tolerance is t times bigger than the RMS error, when t is determined with the Student distribution (table no.2).

Table no.2

| Transformation | n | k | 2n-k | t(p=0.95) |
|---|---|---|---|---|
| Linear-conformal | 4 | 4 | 4 | 2.776 |
| Affine | 6 | 6 | 6 | 2.447 |
| Projective | 6 | 8 | 4 | 2.776 |

The accurate digitizing will give the low RMS error. If the fuzzi tolerance is 0.07 mm (on the map sheet), the digitizing accuracy must be 0.025-0.031 mm. One can determine the match tolerance depending on the acceptable error described in national mapping standards.

### 3.5. The height tolerance

For the accuracy studies of DTM, from practice and theory the function of the terrain surface (Kubik,1988) is

$$V(d) = kd^R \qquad (5)$$

where d is the distance between points, R is the terrain rugozity, V(d) is the variance of the height, with the value k for d = 1. The height tolerance T is

$$T= tk^{1/2}d^{1/2}\left[\frac{1}{6}+\frac{2}{(R+1)(R+2)}\right]^{1/2} \qquad (6)$$

where t is the Student distribution factor :

## 4. ACKNOWLEDGEMENTS

The planimetric and altimetric digital mapping tolerances have a remarcable importance in data capture and in data processing. The concrete values determination requires additional studies, in the same time with the computer algorithms programming and the automated tehnologies design.

## 5. REFERENCES

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