EVALUATION OF POSITIONAL ACCURACY OF DIGITAL TOPOGRAPHIC MAPS AT SCALE 1:25 000 (DTM25) ON THE BASIS OF STANAG 2215 STANDARD

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Abstract:

The paper describes the results of the positional accuracy assessment of digital topographic maps at scale 1: 25 000 produced by the Serbian Military Geographic Institute (MGI). The test for the horizontal and vertical accuracy compliance of map sheets is done by comparing the planimetric and height coordinates of the ground points to the coordinates of the same points as determined by a check survey of higher accuracy. In this research STANAG 2215 standard was used and the methodology of its use is discussed in detail. The results of positional accuracy assessment for the digital topographic maps at scale 1:25 000 produced by the Military Geographic Institute have confirmed the highest level of accuracy defined by STANAG 2215 standard.

Key words: positional accuracy, STANAG 2215 standard, digital topographic maps, Military Geographical Institute.

Introduction

Positional accuracy represents the nearness of those values to the entity's "true" position in the coordinate system (Drummond, 1995), (Tveite, 1999). Positional accuracy is one element of the spatial data quality, which
is defined as the accuracy of the position of features within a spatial reference system (Stanislawski et al, 1996), (Zandbergen, 2008), (Drobnjak et al, 2016). Also, positional accuracy may be defined as a degree to which the digital representation of a real-world entity agrees with its true position on the earth’s surface (Congalton & Plourde, 2002), (Devillers & Jeansoulin, 2010).

It consists of three sub-elements of data quality:

– Absolute or external accuracy – closeness of the reported coordinate values to the values accepted as or being true;

– Relative or internal accuracy – closeness of the relative positions of features in a dataset to their respective relative positions accepted as or being true;

– Positional accuracy of gridded data – closeness of the gridded data spatial position values to the values accepted as or being true.

Evaluation of positional accuracy is reduced to a comparison of the coordinates of individual points read from maps with a reference, several times more accurate coordinates of the same points positioned corresponding geodetic measurements in the field, or taken from other sufficiently accurate sources (Goodchild & Hunter, 1997). The basic problem in assessing the positional accuracy of the maps is the choice of measures of accuracy (i.e. accuracy estimators), as well as a corresponding set of points that represent a particular map sheet and that represent entirety of whole map (Bozic & Radojcic, 2011), (Petrovič, 2006).

An example of successful positional accuracy estimation of digital topographic maps is represented by the Army Geographic Institute of Portugal, who has made the assessment of the positional accuracy of a vector data digital topographic map at scale 1:25 000 using STANAG 2215 standard. In the article (Afonso et al, 2006), the obtained results of estimates of positional accuracy are divided into specific areas by the year of production of spatial data, as it was done in this paper.

Positional accuracy has traditionally been evaluated using control points. These points are defined as “well defined points”, and their use has been conditioned by classical topographic field surveying methods (Bozic & Radojcic, 2011). Following this idea, there are very many statistical Positional Accuracy Assessment Methodologies like: NMAŠ, NSSDA (FGDC 1998), STANAG 2215 (NATO 2002). Also, those methodologies represent point-based positional accuracy assessment methods and many of them are stated as standards for the positional control of cartographic products by national mapping agencies. Some of these methods have recently been analyzed in detail using a simulation process and compared in a more general manner by the same authors. Nevertheless, researchers have criticized these standards for being limited to well defined points, and
also for failing to address more complex elements like linear and polygon ones. It is not possible to assume that all features can be characterized by an error in the position of the well-defined points (Bozic & Radojcic, 2011).

On the other hand, the most widely applied methods for the line-based positional accuracy assessment of 2D lines are: the Hausdorff Distance (HDM) (Ariza-López et al. 2011), the Mean Distance (MDM) (Skidmore & Turner, 1992), the Single Buffer Overlay (SBOM) (Goodchild & Hunter, 1997) and the Double Buffer Overlay (DBOM) (Tveite, 1999). All the methods present an asymmetric or directional behavior which means that results depend on the direction of the assessment. The asymmetry comes from intervening elements in the distance estimation formula being applied. All the results are understood as uniform errors along the lines but we know that the distribution is non-uniform in lines; and that is a limitation of all of them.

Figure 1 shows two examples of errors in the evaluation of positional accuracy of the test data set. Section 1 shows a road portion which is wrong mapped, while Section 2 shows a public object in the scale (hospital), also mapped at wrong positioning in relation to the reference data of the universe of discourse.

<table>
<thead>
<tr>
<th>Universe of discourse</th>
<th>Tested dataset</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Universe of discourse" /></td>
<td><img src="image2.png" alt="Tested dataset" /></td>
</tr>
</tbody>
</table>

**Figure 1 – Example of positional inaccuracy**

**Рис. 1 – Пример позиционной неточности**

**Слика 1 – Пример положајне нетачности**

**Methods and materials**

In STANAG 2215, the absolute horizontal accuracy is defined as the uncertainty in the horizontal position of a point with respect to the
horizontal datum required by a product specification, caused by random and any systematic errors, and is expressed as a circular error at the 90% confidence level – CMAS (NATO, 2002). In a similar manner, the absolute vertical accuracy is defined as the uncertainty in the vertical position of a point with respect to the vertical datum, caused by random and any systematic errors, and is expressed as a linear error at the 90% confidence level – LMAS (NATO, 2002).

The process of evaluation of horizontal positional accuracy begins with the first step, where we calculate the circular error or circular error estimate – CE (defined as the distance in the horizontal plane between a true or known position and the measured or derived position and may involve the use of several circular error confidence levels). The circular error takes into consideration that a certain percentage of the error in the two axes E (Eastings coordinates) and N (Northings coordinates) will lie within a circle of a certain radius of the mean error (Ariza López & Atkinson, 2008). The circular standard deviation of the measured differences between the product and reference data sets, marked with \( \sigma_C \) may be computed from the linear standard deviations of E and N (NATO, 2002):

\[
\sigma_c = \sqrt{\frac{\sigma_E^2 + \sigma_N^2}{2}}
\]

where

- \( \sigma_c \) is the circular standard deviation (with a confidence level of 39.35%),
- \( \delta E_i, \delta N_i \) are individual differences of measured and reference coordinates of the E and N axis, respectively,
- \( \bar{\delta E} \) and \( \bar{\delta N} \) are the arithmetic means of the difference between the axes and
- \( n \) is the number of the diagnostic points.

Then the outlier detection is performed. The residuals \( R \) with a value higher of \( M_2 \cdot \sigma_c \), should be tested according to:

\[
R = \sqrt{\sum (\delta E_i - \bar{\delta E})^2 + \sum (\delta N_i - \bar{\delta N})^2} > M_2 \cdot \sigma_c
\]

where \( M_2 \) is computed depending on the size of a sample (i.e. degrees of freedom, \( n-1 \)):

\[
M_2 = \sqrt{2.5055 + 4.6052 \cdot \log_{10}(n-1)}
\]
STANAG 2215 standard regulates a test to determine whether or not a computed bias is significant, by compare values of $\delta E$ and $\delta N$ with zero. The bias should be considered to be significant at the 90% confidence level if zero does not lie in the range $(\bar{x} - t_{10\%} \cdot \sigma_x)$ and $(\bar{x} + t_{10\%} \cdot \sigma_x)$, where:

- $\sigma_x = \frac{\sigma_x}{\sqrt{n}}$
- $\bar{x}$ – mean value along the axis E or N ($\bar{\delta E}$ or $\bar{\delta N}$)
- $\sigma_x$ – root-mean-square error per coordinate axis, E or N
- $t_{10\%}$ – value which ensures a confidence level of 90% based on a $t$ distribution for $n-1$ degrees of freedom.

The absolute horizontal accuracy at the 90% confidence level when there is no systematic error (i.e. when $\bar{\delta E}$ and $\bar{\delta N}$ do not significantly differ from zero) is calculated with (NATO, 2002):

$$CMAS = 2.146 \cdot \sigma_c$$

(4)

When the products contain a bias (i.e. when $\bar{\delta E}$ and/or $\bar{\delta N}$ significantly differ from zero), then:

$$CMAS = \sigma_c \cdot \left[ 1.2943 + \left( \frac{d}{\sigma_c} \right)^2 + 0.7254 \right]$$

(5)

where $d$ is the mean error vector (bias):

$$d = \sqrt{\left(\bar{\delta E}\right)^2 + \left(\bar{\delta N}\right)^2}$$

(6)

In accordance with STANAG 2215, map products at scale 1:25000 are classified by the CMAS in five position accuracy classes (Table 1).

<table>
<thead>
<tr>
<th>Rating</th>
<th>Measurement at Product Scale</th>
<th>Value of Circular Map Accuracy Standard (CMAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.5 mm</td>
<td>12.5 m</td>
</tr>
<tr>
<td>B</td>
<td>1.0 mm</td>
<td>25 m</td>
</tr>
<tr>
<td>C</td>
<td>2.0 mm</td>
<td>50 m</td>
</tr>
</tbody>
</table>
For vertical accuracy evaluation, STANAG 2215 demands at least 167 check points per data set, like for horizontal accuracy evaluation. In the vertical accuracy evaluation procedure, the first step is to calculate the height differences between the measured height and the reference height \( \delta H_i \), then its differences from the mean value of all differences and calculate the linear standard deviation:

\[
\sigma = \sqrt{\frac{\sum (\delta H_i - \bar{\delta H})^2}{n-1}}
\]

(7)

Then, the tests for blunders and systematic errors are performed, in the same way as for horizontal accuracy evaluation. Finally, we have to evaluate the linear error with the 90% confidence level. If \( \delta H \) is not significantly differing from zero, the LMAS is calculating as:

\[
LMAS = 1.645 \cdot \sigma
\]

(8)

and in the opposite case:

\[
LMAS = \sigma \cdot \left[ 1.645 + 0.92 \cdot \left( \frac{\bar{\delta H}}{\sigma} \right)^2 - 0.28 \cdot \left( \frac{\bar{\delta H}}{\sigma} \right)^3 \right]
\]

(9)

By the value of the LMAS, STANAG 2215 divides all cartographic products at scale 1:25 000 into five classes (Table 2).

<table>
<thead>
<tr>
<th>Rating</th>
<th>Measurement at Product Scale</th>
<th>Value of Circular Map Accuracy Standard (CMAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>&gt;2.0 mm</td>
<td>Poorer than Rating C</td>
</tr>
<tr>
<td>E</td>
<td>Not determined</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 – The cartographic products classification by vertical positional accuracy \( (\alpha=0.10) \)

Таблица 2 – Классификация картографических изданий по вертикальной позиционной точности \( (\alpha=0.10) \)

Таблица 2 – Класификација картографских публикација на основу вертикалне положајне тачности \( (\alpha=0.10) \)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Value of Linear Map Accuracy Standard (LMAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.5 m</td>
</tr>
<tr>
<td>1</td>
<td>5 m</td>
</tr>
<tr>
<td>2</td>
<td>10 m</td>
</tr>
<tr>
<td>3</td>
<td>Poorer than Rating S</td>
</tr>
<tr>
<td>4</td>
<td>Not determined</td>
</tr>
</tbody>
</table>
STANAG 2215 standard requires a minimum of 167 diagnostic (well-defined) points per sheet or a defined test area. In this standard, the assessment of the accuracy is also based on comparisons between the values on the product being assessed and more accurate data. A well-defined point is one that can be easily and uniquely identified on the map and in the field. STANAG 2215 insists that all types of geographic elements must be involved (Bozic & Radojcic, 2011).

In this research, the test area for the positional accuracy assessment was covered by 49 sheets of a digital topographic map at scales of 1:25 000 (DTM25), as shown in Figure 2. The marked rectangles in Figure 2 represent the tested sheets of the digital topographic maps at scale 1:25000.

For every sheet of DTM25 in the test area, we assigned to the 167 well-defined points, chosen from nearly all thematic layers of digital topographic maps. A larger number of those points are collected in the field measurement using a GPS receiver, while the coordinates of remaining points are determined using 3D stereorestitution (Drobnjak et al, 2014).

The field measurements were carried out with one GPS Trimble Geoexplore receiver. The receiver was tested on control points. The accuracy of the GPS positioning in the national map grid system, as defined by the root mean square error of a single point, was 1.41 m. The coordinates obtained by GPS measurements and 3D stereorestitution were compared with the map coordinates of the common points using the PAAT (Positional Accuracy Assessment Tool) tool ESRI ArcGIS software (Esri ArcGIS, 2014).

Figure 2 – Test area for positional accuracy assessment
Рис. 2 – Местность тестирования, выбранная для оценки позиционной точности
Слика 2 – Тест-подручје за оцену положајне тачности
The PAAT tool used the root mean square error, which is denoted by RMSE for assessing the positional accuracy. RMSE is the second root of the mean sum of squared differences of coordinates read from the map and the corresponding reference ("true") coordinates. The absolute horizontal accuracy is the uncertainty of two-dimensional position (relative to the horizontal datum) and is expressed as circular errors with 90, 95 and 99% confidence levels. On the other hand, absolute vertical accuracy is the uncertainty of one-dimensional position (relative to the vertical datum) and is expressed as a linear error with 90, 95 and 99% confidence levels. Accuracy is communicated in those units in which coordinates are expressed in nature (meter), which enables a direct comparison of different products, regardless of the differences in scale or resolution.

The PAAT has the ability of the automatic testing and elimination of gross errors. A testing statistic called $3 \sigma$ threshold is used for this (Figure 3). If a specific positional error is greater than the value of $3 \sigma$, the program eliminates it, leaving the possibility to keep these points if we wish to do that (ESRI, 2012).

The report of the positional accuracy assessment results using the PAAT tool consists of a text file for the appropriate test area, the vector data of the reference and the test points in a standard ESRI Shapefile vector format and metadata in accordance with ISO 19115 and FGDC standards in the form of an XML file. Since the PAAT tool does not have...
an integrated analysis of positional accuracy on the basis of STANAG 2215 standard, the results of the analysis have been exported to the Excel format (Drobnjak et al., 2016).

Results

Table 3 shows the results of an analysis of the absolute positional accuracy of using the aforementioned quality measures with classification of digital topographic maps according to STANAG 2215 standard for all test areas that were analyzed in the experimental research activities by year of production of spatial data.

Table 3 – Positional accuracy assessment results of the tested area

<table>
<thead>
<tr>
<th>Ord. num</th>
<th>Test area/map sheet</th>
<th>standard STANAG 2215</th>
<th>CMAS</th>
<th>LMAS</th>
<th>Classification related to CMAS</th>
<th>Classification related to LMAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Šira okolina Ljiga (ukupno 8 listova DTK25)</td>
<td>9.111</td>
<td>2.456</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>NL 34-11/7-4-1 Rudnik</td>
<td>10.715</td>
<td>2.046</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>NL 34-11/7-4-3 Gornji Milanovac</td>
<td>9.696</td>
<td>1.964</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mean value =</td>
<td>9.841</td>
<td>2.226</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>NL 34-11/9-2-3 Zagubica</td>
<td>10.042</td>
<td>2.102</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>NL 34-11/9-3-4 Resavica</td>
<td>11.287</td>
<td>2.351</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>NL 34-11/9-4-4 Zlot</td>
<td>10.449</td>
<td>2.452</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>NK34-2/3-1-2 Zabrega</td>
<td>10.334</td>
<td>2.326</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>NK34-3/1-1-4 Zajačar</td>
<td>8.193</td>
<td>1.109</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>NK34-3/1-3-4 Mišćević</td>
<td>9.287</td>
<td>2.021</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mean value =</td>
<td>9.849</td>
<td>2.060</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>NL34-10/3-2-3 Hrtkovci</td>
<td>9.221</td>
<td>0.789</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>NL34-10/3-4-2 Grabovci</td>
<td>8.501</td>
<td>1.061</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>NK34-5/6-2-2 Moštanica</td>
<td>10.605</td>
<td>2.785</td>
<td>A</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>NK34-5/6-2-4 Vranje</td>
<td>7.785</td>
<td>2.428</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>NK34-5/6-4-1 Bujanovac</td>
<td>10.304</td>
<td>1.617</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>NK34-5/6-4-3 Biljača</td>
<td>9.178</td>
<td>1.578</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>NK34-5/9-2-1 Zujnice</td>
<td>9.253</td>
<td>1.854</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>NK34-6/4-3-2 Dukat</td>
<td>12.195</td>
<td>4.805</td>
<td>A</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>NK34-6/4-1-1 Jelašnica</td>
<td>8.402</td>
<td>1.995</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>NK34-6/4-1-3 Bujkovac</td>
<td>9.253</td>
<td>3.197</td>
<td>A</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>NK34-6/4-3-3 Trgovište</td>
<td>9.335</td>
<td>2.465</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mean value =</td>
<td>9.458</td>
<td>2.216</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>NK34-2/9-4-3 Bojnik</td>
<td>7.468</td>
<td>0.690</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>NK34-3/8-3-3 Dimitrovgrad</td>
<td>7.276</td>
<td>1.247</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>NK34-5/3-1-4 Međveda</td>
<td>9.751</td>
<td>2.415</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>NK34-5/3-2-2 Leskovac</td>
<td>7.679</td>
<td>0.679</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>NK34-6/1-1-1 Vlasotince</td>
<td>7.503</td>
<td>1.252</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>NK34-6/1-1-2 Kruševica</td>
<td>8.066</td>
<td>2.425</td>
<td>A</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
From Table 3, it can be concluded that all 40 test areas analyzed in the experimental study of the horizontal positional accuracy of the DTM have a value of the circular error as the map accuracy standard is less than 12.5 meters (CMAS < 12.5 m) and belong to the best "A" map class according to the classification of STANAG 2215 standard. Also, it can be concluded that, in the analysis of the vertical positional accuracy of the 40 analyzed test areas, 35 test areas have a value of linear errors as the map accuracy standard of less than 2.5 meters (LMAS < 2.5 m) and belong to the best "0" map class according to the classification of STANAG 2215, while five test areas have a LMAS value between 2.5 and 5 meters (2.5 m<LMAS<5 m) and belong to the class "1" according to the classification of STANAG 2215. From everything shown and mentioned, it can be concluded that the analyzed DTM produced by the MGI have a high level of geometrical, positional accuracy.

The graphical representation as a diagram of the circular error value as the map accuracy standard (LMAS) by a production year is shown in Figure 4.
The graphical representation of the LMAS value by a production year is shown in Figure 5.

Table 4 shows the standardized report on the results achieved by positional accuracy assessment and the classification of digital topographic maps related to STANAG 2215 standard for the test area which covers one sheet of DTM25, nomenclature NK34-5/6-2-4, Vranje.
Table 4 – Standardized report of a positional accuracy assessment for the tested area
Таблица 4 – Стандартизованный отчет о позиционной точности на тестируемой местности
Таблица 4 – Стандартизованная оценка положения на тестированной местности

<table>
<thead>
<tr>
<th>DATUM</th>
<th>1/Scale</th>
<th>25000</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT DATA</td>
<td>Lower</td>
<td>MPV</td>
</tr>
<tr>
<td>Mean E difference</td>
<td>-1.6636</td>
<td>-1.2341</td>
</tr>
<tr>
<td>Mean N difference</td>
<td>0.7770</td>
<td>1.2712</td>
</tr>
<tr>
<td>Mean H difference</td>
<td>-0.2803</td>
<td>-0.0920</td>
</tr>
<tr>
<td>Standard deviation E</td>
<td>3.0895</td>
<td>3.3653</td>
</tr>
<tr>
<td>Standard deviation N</td>
<td>3.5552</td>
<td>3.8726</td>
</tr>
<tr>
<td>Standard deviation H</td>
<td>1.3548</td>
<td>1.4758</td>
</tr>
<tr>
<td>Circular Standard Error</td>
<td>3.330</td>
<td>3.628</td>
</tr>
<tr>
<td>No. plan points</td>
<td>168</td>
<td>Degrees of Freedom</td>
</tr>
<tr>
<td>No. height points</td>
<td>168</td>
<td>Degrees of Freedom</td>
</tr>
</tbody>
</table>

OUTLYING POINT CHECK
- Circular Tolerance: 12.9497
- Tolerance for N diff: 12.3455 -11.074 < N diff < 13.617
- Tolerance for H diff: 4.7047 -4.797 < H diff < 4.613

ANALYSIS
- Lower | MPV | Upper |
- Bias-free Estimate of LMAS | 2.2286 | 2.4275 | 2.6693 |
- Linear Point-to-Point Accuracy | 3.1517 | 3.4331 | 3.7750 |
- (Intermediate quantity b/Sigma) | 0.0679 | 0.0624 | 0.0567 |
- Significance of Avg H diff: NO | NO | NO |
- Absolute LMAS (bias model 1) | N/A | N/A | N/A |
- Absolute LMAS (bias model 2) | N/A | N/A | N/A |
- Selected LMAS figure | 2.2286 | 2.4275 | 2.6693 |
- Adjusted LMAS figure | 2.4266 |
- Rating | 0 |

PLAN:
- Bias-free estimate of CMAS | 7.1472 | 7.7853 | 8.5607 |
- Plan Point-to-Point Accuracy | 10.1076 | 11.0101 | 12.1067 |
- Systematic Shift | 1.7717 |
- Significance of Shift | YES | YES | YES |
- (Intermediate quantity d/SigmaC) | 0.5320 | 0.4884 | 0.4441 |
- Absolute CMAS with bias | 7.6550 | 8.2573 | 8.9949 |
- Selected CMAS figure | 7.6550 | 8.2573 | 8.9949 |
- Adjusted CMAS figure | 8.2542 |
- Rating | A |
Conclusion

Knowledge of positional accuracy is of fundamental importance both for map users and for manufacturers. Unlike most online properties, its horizontal positional accuracy can be fully examined and quantified in an exact way. This paper presents the results of an assessment of the positional accuracy of digital topographic maps in a scale of 1:25 000 produced in the Military Geographical Institute. The evaluation of positional accuracy verified and confirmed that the analyzed digital topographic maps produced in the Military Geographical Institute have a high level of geometric positional accuracy.

The obtained results of the positional accuracy assessment have the same level of accuracy to the specifications considered in the STANAG 2215 standard, which indicates that the MGI obtains the best classification as defined in STANAG 2215 standard.

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ОЦЕНКА ПОЗИЦИОННОЙ ТОЧНОСТИ НА ЦИФРОВОЙ ТОПОГРАФИЧЕСКОЙ КАРТЕ МАСШТАБА 1:25 000 (ТК25), РАЗРАБОТАННОЙ В СООТВЕТСТВИИ СО СТАНДАРТОМ «STANAG 2215»

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Резюме:
В статье описываются результаты оценки позиционной точности цифровых топографических карт, масштаба 1: 25 000, разработанных сербским Военно-географическим институтом (ВГИ). Испытание на соответствие горизонтальной и вертикальной точности отдельных листов карт осуществляется путем сравнения контурных и высотных координат наземных точек с координатами тех же точек, которые определяются контрольным обзором с более высокой точностью. В данной работе подробно представлена методология применения стандарта STANAG 2215, в соответствии с которым было проведено настоящее исследование. Результат позиционной оценки точности цифровых топографических карт в масштабе 1:25 000, разработанных Военным географическим институтом, подтвердил высокий уровень точности, определенный стандартом STANAG 2215.

Ключевые слова: позиционная точность, стандарт STANAG 2215, цифровые топографические карты, Военно-географический институт.
Сажетак:
У раду се описују резултати оцењивања положајне тачности дигиталних топографских карата у размери 1:25 000, произведенних у Војногеографском институту (ВГИ) Републике Србије. Тестирање хоризонталне и вертикалне положајне тачности појединачних листова карата урађено је поређењем планиметријских и висинских координата тест-тачака са кореспондентним тачкама веће тачности одређених теренским премером. У истраживању је коришћен стандард STANAG 2215 и детаљно је описана његова методологија. Резултати овог оцењивања потврдили су највиши ниво тачности дефинисан стандардом STANAG 2215.

Кључне речи: положајна тачност, стандард STANAG 2215, дигиталне топографске карте, Војногеографски институт.

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