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Master's thesis for the Degree of Master in Cartography

METHODOLOGY FOR CALCULATING THE INFORMATION(FONT) LOAD OF THEMATIC MAPS ON THE EXAMPLE OF BELARUSIAN MAPS

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Allowed to defend _____________

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CONTENT

ANNOTATION

Viachaslau Alifirenka. Methodology for calculating the information(font) load of thematic maps on the example of Belarusian maps.

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Annotation. The question of a well-read, informative and pleasant to view map has been relevant for as long as this science has existed. Maps are used in various areas of our life and it is necessary that a person does not get lost in the information provided on it. This is especially true for educational maps that are created for teaching students and schoolchildren in educational institutions. Cards, in this case, should not repel the reader, but rather should attract the information contained on it and help to quickly understand it. Therefore, the font load of maps in this case plays an important role. In this work, a method for calculating the font load is created, which will allow authors to create understandable maps for the reader. The purpose of this master's thesis is to optimize the methodology for calculating the information, namely the font load of thematic maps on the example of Belarusian maps.

To achieve this goal, it is necessary to solve the following tasks:

1) Make a review the literature and articles on the methodology for calculating the information load of maps;

2) Develop a method for calculating the font load of maps;

3) Carry out the selection of data for the study of the created methodology;

4) Create a database of areas of letters of the Russian alphabet of various spellings of the studied fonts;

5) Check the developed methodology.

Master's thesis contains 80 pages, 70 figures, 7 tables, 29 formulas, 10 annexes, summary in Lithuanian and English.

Keywords: Information load, font load, graphics load, thematic maps, graphics load calculation method, font load calculation method, calculation method, thematic maps, Belarusian maps, Russian alphabet, font, letters, square.

INTRODUCTION

Mankind has long been using visual ways to display the terrain. It was important for people to understand exactly where they were and where they should be. At all times, there were graphic elements on the maps, which became more convenient and understandable for perception over time. Signing settlements, rivers, as well as any landmarks that help not to get confused in the map, has been and remains one of the important stages in compiling a map. When applying the names of settlements, rivers, lakes, and other necessary names, it is necessary to choose the method of writing them in such a way that they are easy to find on the map and that they are easy to understand.

Thus, maps are collectors of a large amount of material that needs to be conveyed to people in a visual way. Cartographic materials are used in almost all spheres of human activity. The maps are used in science, industry, medicine, etc. Maps are used both in wartime and in peacetime. At present, the number of digital cartographic materials has increased, but the use of printed versions also does not stop. When compiling both printed and digital materials, it is necessary to take into account the load exerted not only by graphic elements, text, but also by the fonts with which they are applied to maps.

The person who will look at the map should not get lost in the information presented on it. He must also clearly see all the inscriptions that are located on it.

In this regard, it is necessary that the information be evenly distributed on the map, in order to avoid overflowing the map with graphic materials. You also need to choose fonts that will be easy to use and will not overburden the entire map. There are methods for calculating the graphic load of maps, as well as for calculating the font load. The elements on the map, in addition to the graphic load, also have a semiotic meaning. Thus, the problem of loading maps with graphic elements, one of which is the font, seems to be relevant.

To study this problem, four thematic maps were selected from the atlas for the 10th grade of the Belarusian school. These cards were chosen because they are materials that are used to teach children. And this means that the chosen cards should be understandable, should not scare away students, but on the contrary should attract them and be convenient for performing various kinds of tasks.

The most common map fonts that were chosen for the study are Times New Roman and Calibri. All the inscriptions on them are made in Russian, so the research in the master's work was carried out on the letters of the Russian alphabet, of which there are thirty-three.

The novelty of the developed method lies in the fact that a database of areas of all letters of the Russian alphabet has been developed to calculate the font load, and the gap between letters in a word is taken into account when calculating the font load, thus taking into account the length of the word.

This method can become promising for the development of both digital and printed maps. It can greatly simplify the development of maps.

The purpose of this work is to optimize the methodology for calculating the information, namely the font load of thematic maps on the example of Belarusian maps.

Tasks to be completed to achieve this goal:

1) Make a review the literature and articles on the methodology for calculating the information load of maps;

2) Develop a method for calculating the font load of maps;

3) Carry out the selection of data for the study of the created methodology;

4) Create a database of areas of letters of the Russian alphabet of various spellings of the studied fonts;

5) Check the developed methodology.

1. OVERVIEW OF PREVIOUS INVESTIGATIONS

This chapter will consider three articles that are aimed at studying the information and font load.

These articles indicate that the researchers who dealt with the issue of calculating the load of maps came to an agreement that the load of the card is divided into intellectual and graphic loads.

1.1 Method for calculating the graphic information load

This method is described in the 2011 summary of Linas Bevaini's doctoral dissertation.

Some of the goals of the work were:

1) Develop a methodology for calculating the graphic-information loads of cartographic images of educational maps adopted for younger students.

2) Evaluate the optimal values of graphic-information loads of training maps adopted for younger students.

During the first part of the pilot study, students were divided into three groups in accordance with paragraph 9.3.3.2 of the Fundamentals of the educational program in geography:

1. Satisfactory level of performance.

2. Basic level of achievements.

3. Higher achievement levels.

According to Piaget's theory, the level of students' understanding of the content of the map can have a direct relationship between the levels of general intelligence. It is estimated that different levels of intelligence of students usually differ. When students are divided into three types, there is a greater opportunity to more accurately determine the graphic information load on the map to the appropriate level for different age groups (Table 1.1). [5]

Table 1.1. The time intervals during which students at different performance levels must complete tasks on the map.

Levels / **Classes**	**Upper level**	**Basic level**	**Satisfactory level**
10	1 – 2 min	2 – 4 min	5 – 7 min
9	2 – 3 min	3 – 5 min	6 – 9 min
8	3 – 4 min	4 – 7 min	8 – 10 min
7	5 – 7 min	7 – 9 min	9 – 12 min
6	6 – 8 min	8 – 10 min	10 – 15 min

The students received simple tasks, but framed in such a way that they should be based on spatial thinking and analysis in determining the content of the map legend.

The tasks were set by the following main conditions:

1. When analyzing the contents of a map, mentally divide it into layers of graphical data.

2. Recognize and differentiate characters by category.

3. Find certain items.

4. Indicate their location on the map.

The reaction of students to the content of the map and the end time of the task made it possible to determine in which fragment the graphic information load is correct for understanding by students of a particular class level.

Taking into account such factors as the human factor, which often occurs when students' attention is distracted, and similar factors, it was accepted on the condition that, in order to conclude that the graphic information load in the map fragment (based on the results of the assignment) is adequate to the established deadlines, to get at least 80% of each group of students, of which at least 60% of the tasks must be completed properly.

Each student belonging to the specified level of performance received a map with a different graphic and information load.

A total of 157 cards were analyzed. These maps were used to calculate and set the overall optimal mapping loads.

Students analyzed thematic maps using a specialized program, adding or removing information layers, trying to understand the content of the maps. It was important to pay attention to the reaction and perception of students when changing the information layers of the content of maps they read with different graphic information load.

In the course of this study, the term total optimal card load was introduced.

General optimal map load - this is the optimum content of graphic information load in the map centered on the pupil of a certain age ability to understand the optimum amount of information.

The goal of the second part of the study was to create a formula and use it to calculate the overall optimal map loading in training maps for various atlases.

As a result of the calculations, indicators of the overall optimal loading of the map were determined and it was indicated which maps are suitable for the respective classes and which are not.

In the second part of the study, using the formula, the researcher determined the overall optimal map load in training maps. [5]

After the first part of the study, a formula was created for four cartographic elements that affect the overall optimal map loads: line features, areas, points, and notes. To calculate the four cartographic elements, a conditional area on the map was taken - 25 square centimeters. 25 square centimeters was a conventional area, and depending on the situation, calculations could be made for the entire map. The scale of the map was not used in the calculations, since according to the generalization, the total optimal loads of the map should be the same when using different scales (Fig. 1.1, Fig. 1.2).

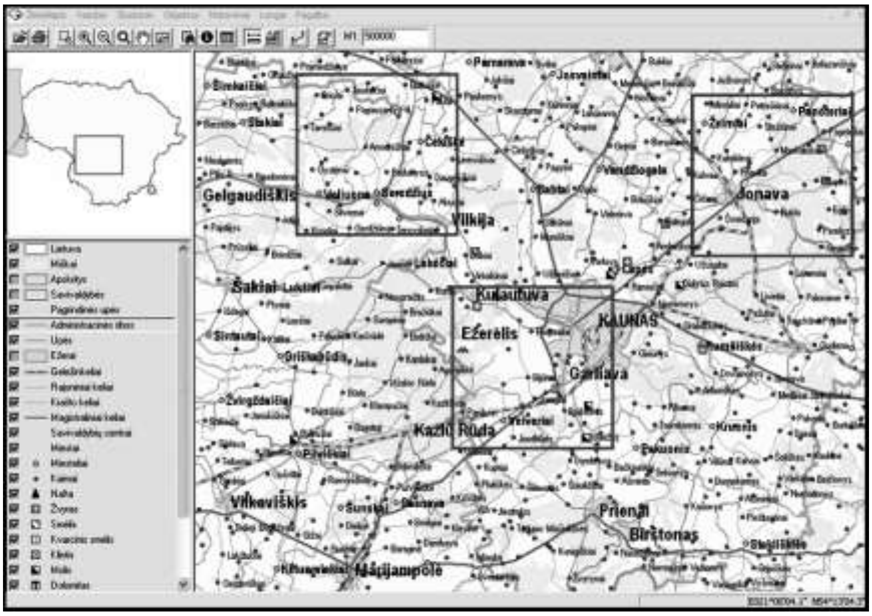


Fig. 1.1. "Lithuanian mineral" map fragment 1, where VI class students performed the task.

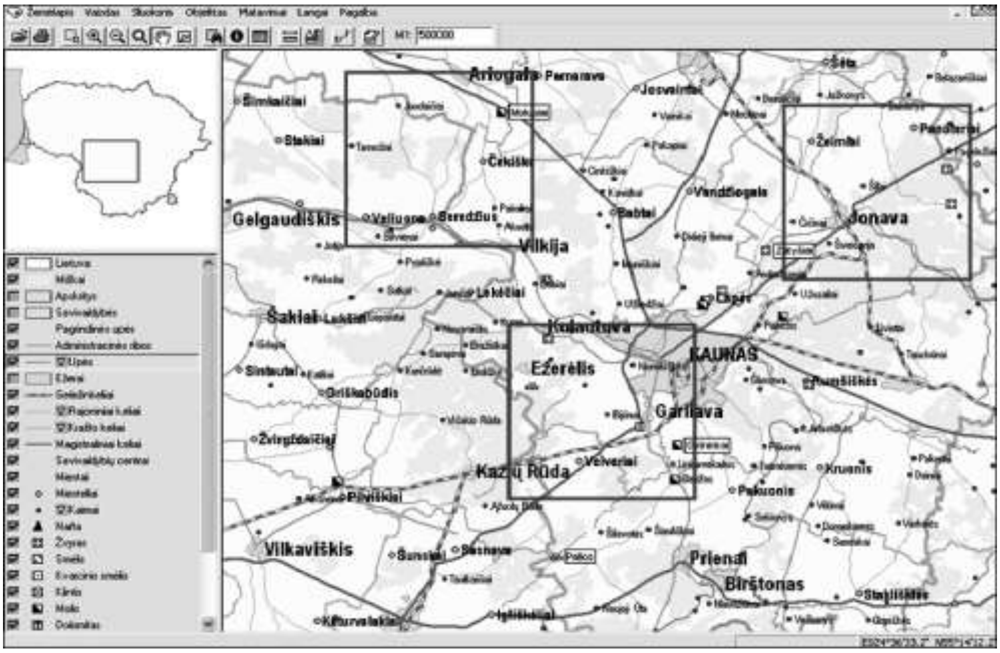


Fig. 1.2. Selected "Lithuanian minerals" map fragment 2, where VI class students performed the task.

The indicator of the total optimal load of the card is calculated by the formula (1.1):

$$L_m = L_l + L_a + L_p + L_n \qquad (1.1)$$

L_m - An indicator of the overall optimal map load, indicating the density of cartographic symbols in the corresponding area.

L_l - The sum of linear signs in a conditional area on the map.

$$L_l = \frac{\sum l}{c} \quad (1.2)$$

l - The quantity of linear objects.

c - A conditional area in the map.

L_a - The sum of area signs in the conditional area in the map.

$$L_a = \frac{\sum a}{c} \quad (1.3)$$

a - The quantity of area objects.

c - A conditional area in the map.

L_p - The sum of point signs in the conditional area in the map.

$$L_p = \frac{\sum p}{c} \quad (1.4)$$

p – The quantity of point signs.

c - A conditional area in the map.

L_n - The sum of the letters of notes in the conditional area in the map.

$$L_n = \frac{\sum n}{c} \quad (1.5)$$

n – The quantity of letters of notes.

c - A conditional area in the map.

During the electronic maps analysis there were identified three categories of general optimal map load for each analyzed map:

1. Low graphic information load;

2. Optimal graphic information load;

3. Overload of graphic information.

Using formula (1.1), calculations were obtained to express low, optimal and overload of graphical information in the corresponding intervals.

Experimental calculations showed that the optimal index of general optimal map load for 6th classes is about 8. The optimal index of general optimal map load for 7th – 8th classes is about 12 and for 9th – 10th is about 22. [5]

As can be seen from figure. 1.3, 3 intervals of the total optimal loading of the map for 6 - 10 classes are allocated. The interval of the overall optimal loading of the map for the 6th grade is from 4 to 9, for the 7-8 grades - from 6 to 13, and for the 9-10 grades - from 11 to 18.

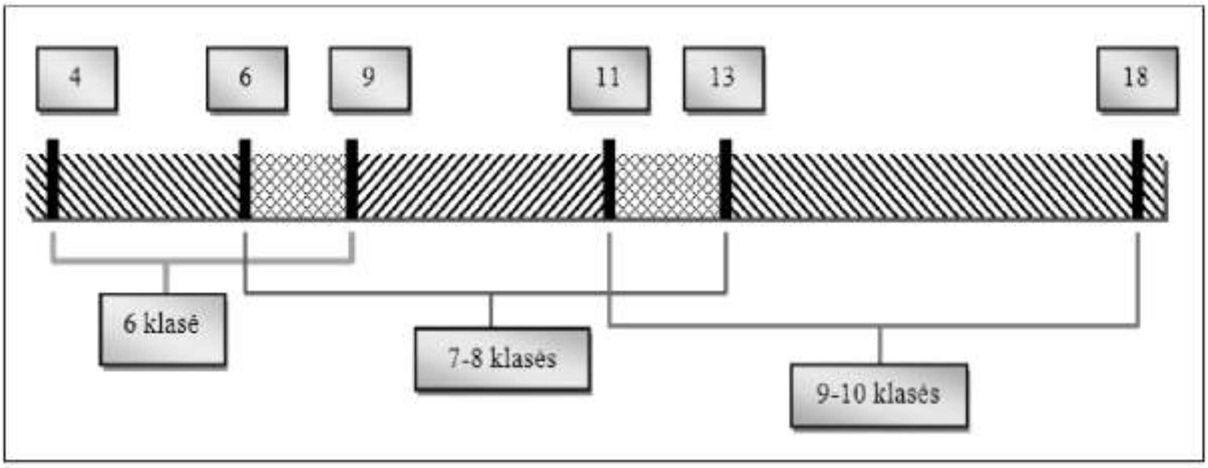


Fig. 1.3. Intervals of general optimal map loads for VI – X classes.

1.2. Method for calculating the text information load of maps

The method mentioned in this paragraph is described in the article by Artūras Bautrenas: “METHOD FOR EVALUATION OF TEXT LOAD OF THEMATIC CARDS”.

The text load of printed maps was estimated by the number of words per 1 dm^2. This is a pretty rough estimate because the actual area each individual letter occupies is not estimated (Fig.1.4). [6]

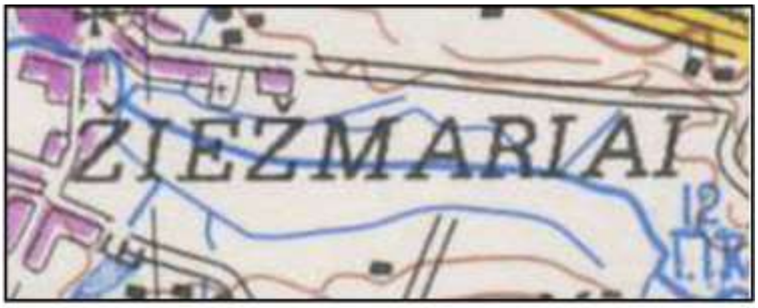


Fig.1.4. Text on top of a cartographic image.

The research method consisted in the fact that at first three parameters were identified that directly affect the area occupied by the symbol: the physical dimensions of the symbol (height and width of the symbol), the font used to write a particular character, and the writing style of the font.

After examining over 130 different thematic maps, it was found that the four font families most commonly encountered are "Gungsuh", "Helvetica", "Times New Roman" and "Verdana" (Fig. 1.5).

Each of these fonts (Fig. 1.5) can be written in Regular, Italic, Bold, and Italic Bold styles.

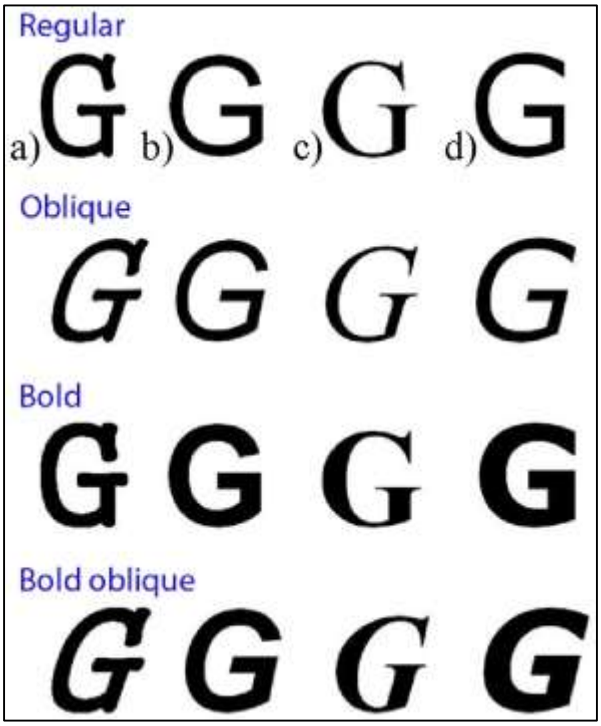


Fig. 1.5. The area of a symbol depends on the selected font and style: a - "Gungsuh", b - "Helvetica", c - "Times New Roman", d - "Verdana".

The area of the symbol visible on the computer screen depends on its visual magnification, i.e. the real area of the symbol does not change, but only its visible visual area changes (Fig. 1.6). Such a statement was made by analyzing computer programs designed to work with text.

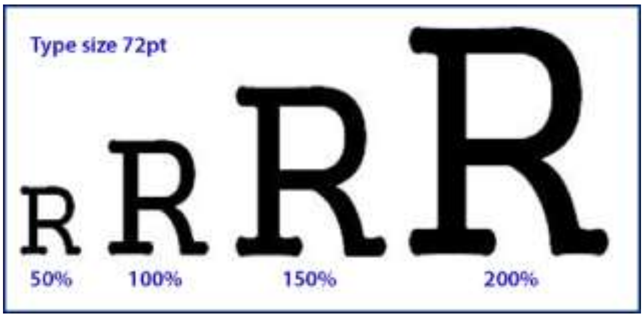


Fig. 1.6. The visible symbol area depends on its visual enlargement.

The image on a computer screen is made up of discrete elements called pixels, so the image of any character changes by increasing or decreasing the number of pixels used to display it. By counting how many pixels were used to display a character, and knowing the area of one pixel, it is easy to calculate the area of the entire character. However, the area of each pixel is directly dependent on the assigned density that is used to display the character, i.e. on the number of pixels per inch. [6]

By counting how many pixels in a known width and height, it became possible to calculate the area of a pixel (1.6).

$$P = (W_{mm}/W_{pix})\times(H_{mm}/H_{pix}) \quad (1.6)$$

P - pixel area (mm^2).

W_{mm}, H_{mm} – bitmap image width and height (mm).

W_{pix}, H_{pix} - bitmap image width and height (expressed in pixels).

When counting pixels, it is very important not only to calculate the total number of pixels, but also to determine which pixels belong to the symbol and which to the background of the bitmap. For these large volume calculations, the RIA computer program was used. Determining the number of colors in a bitmap file is the main goal of this program. Since this is not enough for the study, this program has been modified and supplemented with new functions, i.e. generation of bitmap files for individual characters, recognition of colors of individual characters and calculation of the area of the character. [7]

To determine the dependence of each pixel, i.e., whether the pixel belongs to the symbol or the background of the bitmap file, you must convert the set pixel color to the RGB color model.

All pixels whose color is recognized as belonging to the symbol color are summed. After the scanning of the raster file is completed, the final area of the symbol is calculated by formula (1.7).

$$S = \sum T_{pix} \times P \quad (1.7)$$

S – symbol area mm^2.

T_{pix} – pixel belonging to a symbol.

P – pixel area mm^2.

Next, the control area of printed characters of different sizes was measured.

If one can calculate the area of a character seen on a computer screen, one can also measure the area of a printed character. To calculate the coefficient of change in areas (visible and printed), 180 characters of different sizes were randomly selected, which were printed on paper with a resolution of (1200x1200 dpi). [6]

One way to measure the area of a printed character is to rescan it and paste the resulting raster image into any computer program designed for drawing (for example, any version of AutoCAD).

When printing selected characters on paper and then rescanning them, geometric inconsistencies of various sizes will necessarily be detected in the resulting. These inconsistencies must be removed before character vectorization, otherwise the calculated areas will be inaccurate.

By inserting the scanned image into AutoCAD, you can calculate the corrections (1.8) needed to convert the bitmap.

$$K_X = L_X / S_X \; ; \; K_Y = L_Y / S_Y \quad (1.8)$$

K_X, K_Y - correction coefficients of a bitmap image in the direction of coordinate axes (X, Y)

L_X, L_Y - exact box measurements (mm), which should be arrived at after bitmap image transformation

S_X, S_Y - measurements of a pasted bitmap image box (mm).

Comparing the actual, i.e. printed, character areas with calculated values (Fig. 1.7), it was noticed that the area differences change in a linear relationship.

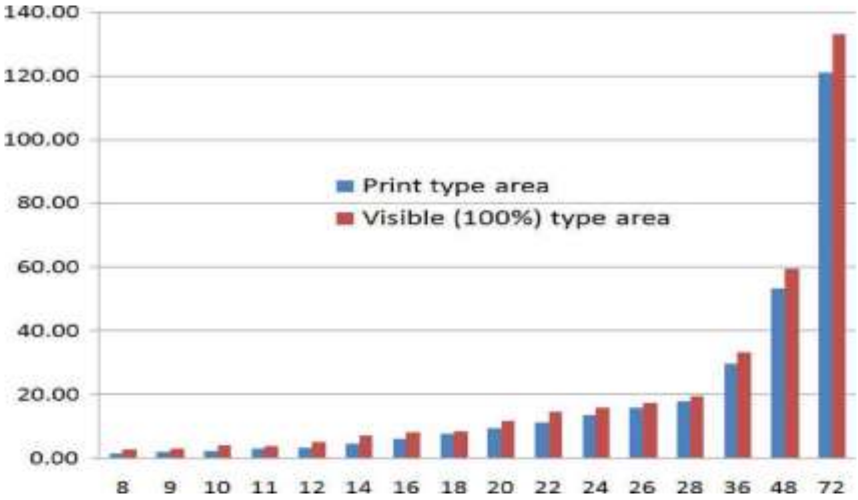


Fig. 1.7. Comparison of the printed symbol area with the calculated visible area of a symbol.

Since it was found that the visible and printed areas change linearly, the formula for the conversion factor (1.9) of the visible area of the symbol (mm^2), or its size (pt) to the area of the printed symbol (mm^2), was obtained.

The formula for the conversion factor:

$K_z = \sum_1^n (PA_{pt}/S_z)/n$ (1.9)

K_z - recalculation coefficient of an area of a specific symbol, when the visible area is enlarged by 100, 110, 120, 130, 140 or 150%.

PA_{pt} - directly measured symbol area when its size varies from 8 to 72 pt.

S_z - visible symbol area (1.7), when the image on a computer screen is enlarged by 100, 110, 120, 130, 140 or 150%.

n - number of symbols in the same size (from 8 to 72pt).

To check the values of the transformation coefficients of the calculated areas, a computer program was created that is able to read the full list of the names of settlements, hydronyms, numbers, single characters and other textual information (Fig.1.7). It recognizes and counts all characters. It is possible to calculate the approximate area of all symbols and estimate the text load of the map (1.10) by the average transformation coefficients (1.9) of the symbol areas determined during the study. Since the records on the card are usually not identical, the TextLoad program provides the ability to check information about each word or individual character (Fig. 1.7), i.e. specifically for each note, what font, character size and writing style will be used. After each such check, the value of the text load is corrected and the final text load of a particular map is calculated.

Text load of the map:

$$F_T = \frac{A_M}{A_T} \quad (1.10)$$

F_T - text load of a map.

A_M - printed area of a mapped territory (cm^2).

A_T - area of all the text symbols on a printed mapped territory (mm^2).

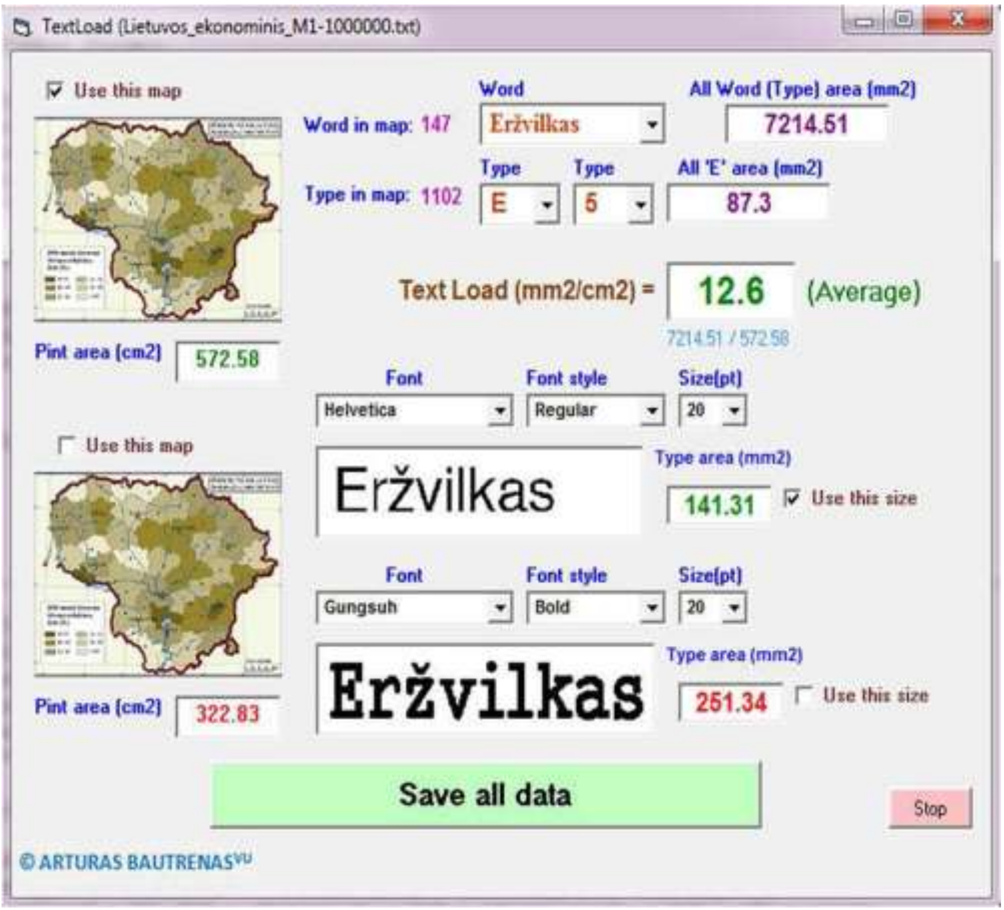


Fig. 1.8. Control window of the "TextLoad" computer programme.

As a result of this research, five categories of text load estimates were developed:[7]

1) Very low, when $F_T \leq 5$ mm^2/cm^2;

2) Low, when $5 > F_T \leq 10$ mm^2/cm^2;

3) Average, when $10 > F_T \leq 20$ mm^2/cm^2;

4) Heavy, when $20 > F_T \leq 35$ mm^2/cm^2;

5) Very heavy, when $F_T > 35$ mm^2/cm^2.

1.3. Developing Versatile Graphic Map Load Metrics

Based on current trends and ideas, the authors proposed three approaches to measuring the graphics load of maps using raster map formats: average darkness (AD), image compression (IC), and edge detection (ED). [1]

All three approaches meet predefined conditions:

• Based on card image processing;

• Ease of use;

• Measured on an accessible platform in a short time;

• Applicable to a wide range of card styles;

• Can be measured over a well-defined range of values.

The first medium-darkness (AD) approach develops the idea that the darker the pixels in the map image compared to empty bright pixels, the more loaded the map is. The Image Compression (IC) approach is based on comparing the sizes of uncompressed and compressed image files.

In contrast, the third edge detection (ED) approach uses an edge detection filter to evaluate the presence of both hard and soft edges in a map image.

All measurements were made in the IrfanView 4.52 program using the built-in tools.

It is necessary to describe in detail each of the methods in order to understand this research.

1.3.1. Measuring Map Load Using Average Darkness Approach

The AD metric principle comes from the assumption that the darker the map, the more graphically loaded it is. The AD approach assumes that maps mostly have a light background, and map symbols are made in darker colors. Therefore, the more content there is on the map, the darker the map should be. Conversely, for most empty maps, a light background is expected to cover most of the map area, with medium darkness lower. This approach improves upon the old principle of map load calculation, used primarily for topographic maps with a standardized map key. [18]

Some modern thematic maps, however, use a variety of graphic styles and color schemes, including reverse design, which is expected to be problematic for evaluating map loading. Although, nevertheless, most maps, including thematic ones, use the principle: the more intense the phenomenon, the darker (more intense) the color. The AD metric principle can be compared to how much ink it takes to print a map in black and white versus how much ink it takes to print a black area of the same size. [29]

Each image file, representing a map from the dataset, was processed in IrfanView 4.52 to obtain map graphics load values according to the AD metric. The average brightness of a pixel was calculated using the histogram tool. The software calculated the brightness of each pixel as $0.299R + 0.587G + 0.114B$ (1.11) (which is a multiple of each RGB channel). The resulting number was on a scale from 0 to 255, with 0 representing black and 255 white. [1]

The L_{AD}, value representing the card load according to the AD metric must be converted using Equation (1.12).

$$L_{AD} = \frac{100\%}{255} \times (255 - BRT) \qquad (1.12),$$

where BRT represents the average pixel brightness index displayed in IrfanView.

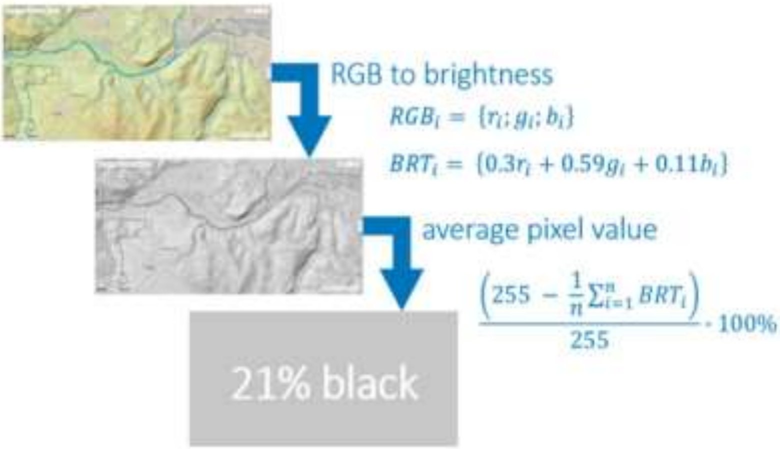


Fig. 1.9. Principle of the average darkness (AD) metric.

1.3.2. Measuring Map Load Using Image Compression Approach

Another approach to measuring graphics card load has been developed to account for differences in compression efficiency. The IC metrics used the ratio of the compressed image file to the uncompressed size in KB representing each map from the dataset. Various image file formats and their compressed forms were studied, resulting in IC1-IC3 scores. [24]

The IC1 metric calculates the ratio of the size of a lightly compressed JPG file (90/100 quality) to the size of an uncompressed TIF file. Whereas, the IC2 metric instead used a highly compressed JPG file (quality 20/100) in the numerator. The IC3 metric quantified the ratio of the size of an LZW-compressed TIF file to an uncompressed TIF file.

All converted format images were processed in IrfanView and the card load values L_{IC1}, L_{IC2} and L_{IC3} were calculated. Equations (1.13 - 1.14):

$$L_{IC1} = \frac{s_{JPG90}}{s_{TIF}} \qquad (1.13)$$

$$L_{IC2} = \frac{s_{JPG20}}{s_{TIF}} \qquad (1.14)$$

$$L_{IC3} = \frac{s_{TIFLZW}}{s_{TIF}} \qquad (1.15)$$

Where:

S represents respective image file size in kB;

JPG90 is a map image stored in JPG format with quality 90/100, JPG20 with quality 20/100;

TIFLZW is a map image stored in TIF format with LZW compression;

TIF represents a map image stored in uncompressed TIF file format.

1.3.3. Measuring Map Load Using Edge Detection Approach

The edge detection (ED) approach uses a filter to detect edges on map images. This experiment used a fuzzy approach, considering both sharp and soft edges, unlike some articles on the topic, using a binary principle that distinguishes between edge and non-edge pixels. [28]

The principle of the ED method is that the larger and sharper the edges on the map, the higher its graphic load. [28]

While large areas covered in the same color make the map look simple, the color transitions represented by adjacent map symbols make the map more complex. Some researchers also describe this idea. Three indicators ED1-ED3 have been developed. [14] The first step in all of them consisted of measuring the map loading value LED using the built-in filter to convert each map image into an edge detection image. Brighter colors in an image with edge detection indicate sharper edges (Figure 1.10). [15]

Fig.1.10. Edge detection image of one of the maps from the Ref-Set.

The edge detection image was then processed similarly to the AD metric by examining the average brightness of the middle pixel (Figure 1.10).[1]

The process of calculating the loading of the map L_{ED1} is presented in equation (1.16):

$L_{ED1} = \frac{100\%}{255} \times EDD$ (1.16), where

EDD represents the average pixel brightness of the edge detection image displayed in IrfanView.

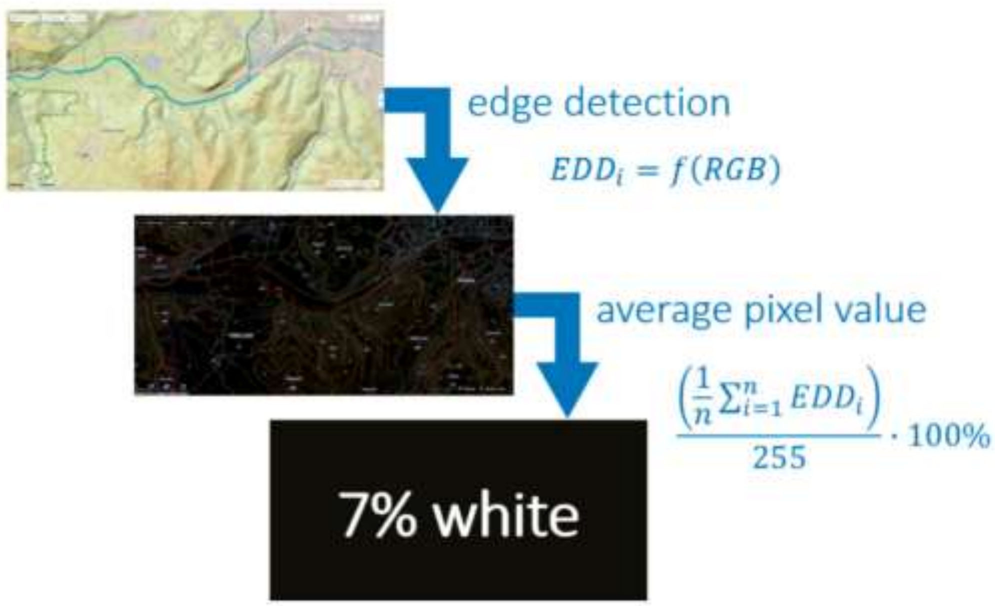


Fig. 1.11. Principle of the ED1 metric.

The map loading values L_{ED2} and L_{ED3} were obtained by taking the root of the L_{ED1} value according to equations (1.17) and (1.18):

$$L_{ED2} = \sqrt{L_{ED1}} \quad (1.17)$$

$$L_{ED3} = \sqrt[3]{L_{ED1}} \quad (1.18)$$

The main conclusion that can be drawn from this article:

The edge detection method is an approach that has proven to be the most applicable for almost all types of maps, and it should be improved. [18]

Metrics based on average pixel darkness and image compression (AD, IC1, IC2, and IC3) were found to be suitable for determining user-perceived map loading loads for limited map styles only. The AD method has been shown to be successful in estimating the load of maps with bright backgrounds and darker symbols, typically topographic maps. [24]

2. THEORETICAL PART

2.1. Definition of information load and its varieties

Map load, along with similar terms such as map complexity or map density, is defined to quantify the content of a map. As Harry et al. need to consider, the level of complexity of a map can affect readability for users. Thus, designing maps with an appropriate level of map loading results in adequate map complexity and emphasizes its essential role for disciplines where the efficiency of the map reading process is critical, such as crisis management. [21] [17]

Researchers dealing with the issue of map loading have come to a consensus on dividing it into an intellectual (also called informational) cartographic load and a graphic (visual) cartographic load.

Information load - the total number of characters and other information contained on the map.

However, subsequent studies led to the fact that graphic and font loads were introduced into the information load, based on the contents of the map. Thus, the information load was divided into font and graphic. [16]

2.2. Font load

Font load is measured by areal or numerical indicators. Area load is the area occupied by 1 mm^2 by 1 cm^2 signature fonts; numerical load - the number of signatures per 1 cm^2 maps.

The calculation of the font load by a numerical indicator gives less objective results, because the signatures on the maps have rather sharp differences in their graphic means (size, width, boldness). [31]

The total font load depends on the number of required inscriptions, their heterogeneity and the nature and density of placement. Significant adjustments to the font load are made by the choice of certain types of fonts, the specifics of their design, size, weight, etc.

The largest font load is on general geographical maps (especially reference ones) - 50-70% of the entire graphic load, with the main share falling on the inscriptions of settlements. According to [28] calculations, the inscriptions of geographical objects on a map at a scale of 1:3000000 occupy 12-18 mm^2, of which the signatures of settlements - 10-16 mm^2 with a total graphic load of 20-30 mm^2 2 per 1 cm^2. The maximum number of signatures of settlements on this map is allowed no more than 140, the minimum is 60, the optimal is 120 signatures per 1 dm^2.

As the scale decreases, the font load increases. Thus, on a general geographical map of the world at a scale of 1: 1000000, the maximum density of signatures of settlements is about 300, the minimum is 80, and the optimal is 200 signatures per 1 dm^2. [28]

On small-scale maps, a change in the nature of the signatures is observed; explanatory captions related to details are excluded, the names of large geographical objects are depicted as a whole only on overview maps (signatures of orographic regions, names of republics, regions, etc.). The inscriptions of such objects require larger sizes and correspondingly large areas on the map.

Knowing the average areas of labels of different values and ranks and their number, it is possible to calculate the total area font load of the entire map, individual elements, as well as areas with different density of labels. Taking into account the font load is especially important in the design of maps, since by changing the type of font or its graphic means (height, boldness, width), with the same number of inscriptions, you can weaken or, conversely, increase the overall graphic load of the map. The average area of the inscription [28] determines, based on the height, the width of the letters of the average length of the signature (the number of letters). He set the average number of letters for settlements at 8,4. [31]

2.3 Graphic load

Map graphic load is a property of the map that determines the amount of graphic content in the map. [1]

It indicates the visual complexity of a map and helps cartographers tailor maps and other geospatial visualizations to achieve their goal. As a rule, the design of a map should allow the user to quickly, comprehensively and intuitively obtain relevant spatial information from the map. [1]

It is also an important characteristic for map generalization. Finding information quickly on a map has always been an important issue in cartography, especially in crisis management and military cartography. However, it is important that the map be easily readable in school maps as well. Thus, the optimal map loading level may vary depending on the purpose of the map, the user's skill, knowledge, and environmental conditions. [29]

2.4 Cartographic fonts and their classification

Since this work studies maps compiled using the Russian alphabet, the features of cartographic fonts compiled using the Cyrillic alphabet will be considered.

Fonts are the personality of the map. They can be serious and authoritative or light-hearted and affable. Whatever their tone, they must be legible in the complex contexts that are characteristic of mapping. They should be easy to read in small sizes and from different angles on a variety of media. They are often read among many other labels that are close together. In addition, card captions may contain unfamiliar words that cannot be deciphered if they are illegible. [13]

A font is a graphic style of letters and numbers. Depending on the technique of execution, handwritten, drawn, engraved and typographic fonts are distinguished. [3] [4]

The classification of cartographic fonts is based on the principles adopted in the classification of typographic fonts, approved by GOST No. 3489-52, with some changes and additions. [8]

Cartographic fonts are subdivided, depending on the most important graphic features: contrast (the ratio of the thickness of the main and additional strokes), the presence and shape of undercuts, characteristic (typical) features in the style of individual letters, into five main groups and one additional (Fig.2.1).

The **first group** includes mainly contrasting ones with non-smooth connecting elements and thin long undercuts (Fig. 2.1(a))

In **the second** - medium contrast with smooth connecting elements and short undercuts (Fig. 2.1 b);

In **the third** - low-contrast fonts with smooth connecting elements and rectangular undercuts

(Fig. 2.1(c));

Fourth, low-contrast typefaces with non-smooth sharp connections and rectangular undercuts

(Fig. 2.1(d));

Fifth, low-contrast fonts without undercuts (Fig. 2.1(e));

The additional **sixth group** includes fonts that cannot be assigned to any of the above groups, for example, artistic fonts (Fig. 2.1(f)).

Fig. 2.1. Main font groups.

Within each group, fonts are divided into typefaces, united by the general nature of their design.

The **first group** includes: literary, universal and hydrographic typefaces;

In **the second**, an ordinary typeface;

In **the third**, the GSWA typeface (Great Soviet World Atlas), capital, new, clear, original and academic typefaces;

In **the fourth** - bar typeface;

Fifth, chopped, topographic and ancient typefaces.

The transition typeface is included in the **additional group** of fonts.

Fonts of the same typeface are divided into:

a) print and italic fonts, as well as straight, slant to the right and slant to the left;

b) fonts of narrow, narrowed, normal, expanded and wide styles;

c) light, bold, bold and transparent fonts. [3] [4]

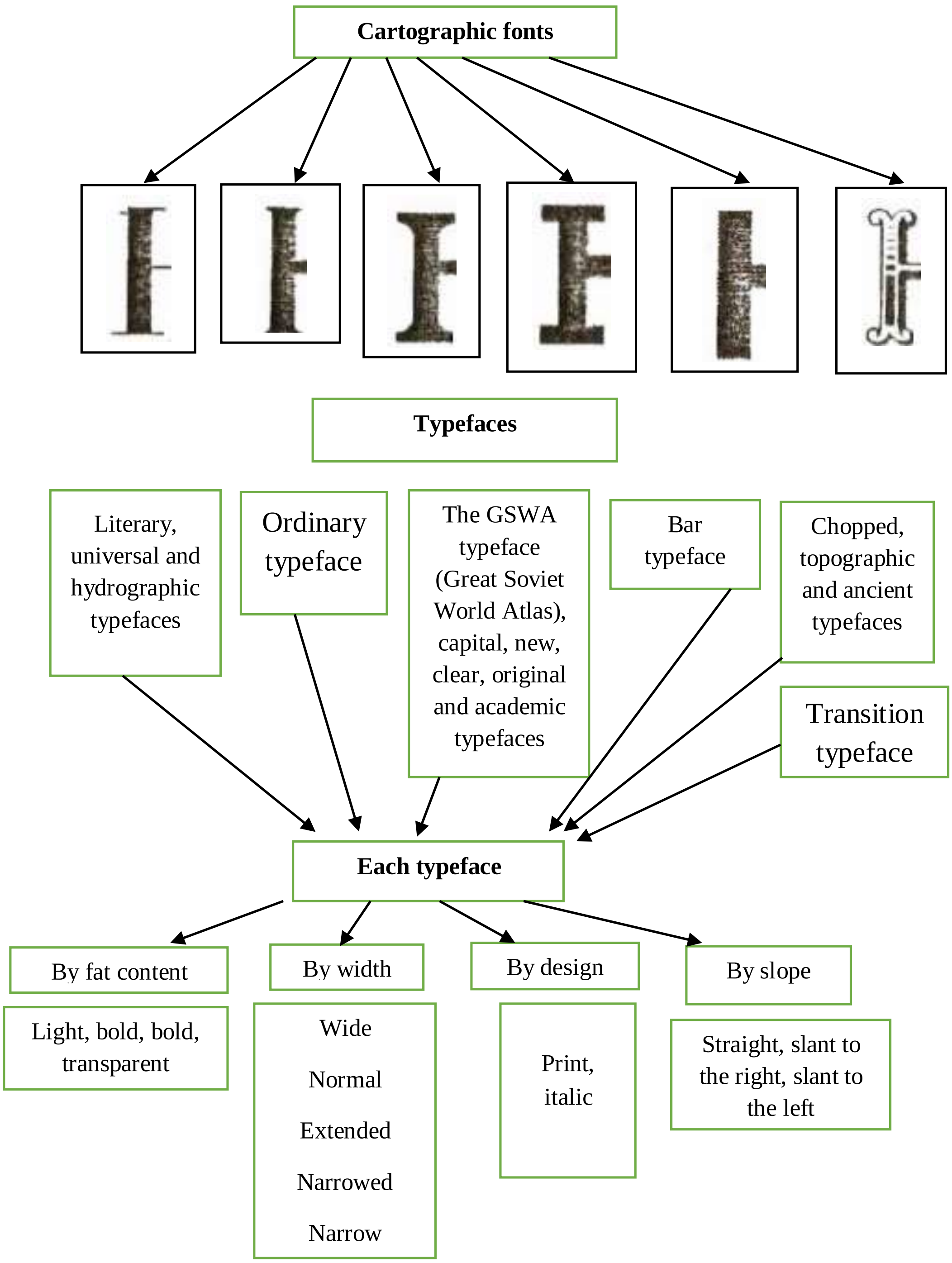


Fig. 2.2. Font classification

2.5. Font features

Fonts have the following features: [31]

● **Font contrast** – the ratio of the thickness of the main element to the additional one. The greater the difference in element thickness, the more contrasting the font. There are contrast, medium contrast and low contrast fonts. Medium-contrast fonts with a ratio of 2:1 are well readable;

● **Lightness (boldness)** – the ratio of the thickness of the main element (a) to the width of the intra-letter space (b).

Allocate

Core (the thickness of all elements is 0.1 - 0.2 mm);

Light (a < 0.5b),

Normal (a ~ 0.5b);

Bold (a = b);

Bold (a > b) fonts;

● **Width** - the ratio of the width of the letter (l) to its height (h). The width is:

Narrow (l < 2/3h);

Normal (from l ~ 3/5h to l ~ 5/6h);

Wide (l > h);

There are also types of fonts - narrowed and expanded;

● **Orientation** - straight, inclined to the right and left;

● **Style** - printed, italic. In block fonts, uppercase and lowercase letters have basically the same pattern, while in cursive fonts they have mostly different patterns;

● **Size** – height of font letters;

● **Font color** is an important figurative tool that affects the readability, visibility and artistic qualities of map font design.

2.6. Font Properties

Fonts used on maps for geographical names and explanatory captions must meet several requirements: be clear and legible against a colored background, compact (small), suitable for reproduction in printing, clearly distinguishable from each other (important when the inscriptions intersect), artistic (aesthetic). [4]

Readability

It is very important that the inscriptions on the map are perceived quickly, accurately and do not require much eye strain. Difficulties arise from the features of the map: the inscriptions on the map are usually given on a colored background or on hatching and are overlapped by conventional signs; on the map, many names may be unfamiliar, so every letter matters on the map. For good readability of fonts, simplicity of outlines, clarity of forms and distinguishability of individual letters from each other are necessary. The simplicity of fonts also affects the perception of the main content of the map: the inscriptions distract attention, the more complex the font design, the more attention the inscription takes. The color of the inscriptions contributes to the improvement of the readability and distinguishability of fonts. The readability of fonts is affected by the rationality of the placement of inscriptions. [30]

For readability of the font, undercuts are used - drop-shaped and corner elements, arrows and legs, roundings of different patterns at the end of letters and numbers (Fig. 2.3).

Fig. 2.3. Undercut forms. 1 – rectangular; 2 – leg; 3 – drop; 4 – swallow; 5 – arrow

The compactness of the font allows either to increase the load of the map with inscriptions, or, with the same number of them, to reduce the space they occupy and make it easier to read the main content of the map. The compactness of a font depends on the nature of its design, the width of the letters, the thickness of the main elements, the distance between the letters. The greatest influence is exerted by the change in the width of the letters of the font and the nature of the pattern, since with the same width of letters, fonts of different types will differ in compactness due to the specifics of the style. [31]

The degree of font compactness is characterized by the area of the inscription occupied on the map. Its value is easily determined by the height, average width of the letter and the length of the inscription.

The compactness of fonts is especially important for reference cards, where it is necessary to place a large number of labels per unit area of the card and at the same time ensure good readability. On thematic maps, the compactness (economical) of fonts makes room for the main content of the map. On wall educational maps, provided that the inscriptions are readable from a distance, the compactness of the font is of less importance. [34]

Transparency (blackness) is associated with the features of the pattern of letters and the boldness of fonts. It is determined by the area of all strokes of the main and additional elements of the signature letters (absolute blackness). The ratio of the area occupied by stroke elements to the entire area of the signature is taken as the relative blackness of the font. Fonts with a high percentage of black overload the map and make it difficult to read line elements. But excessive thinness of strokes is detrimental to readability. The greatest transparency of fonts is used on small-scale reference maps, where the minimum thickness of the main elements of the letters is 0.06 - 0.08 mm. [21] [3]

Aesthetics

The essential quality of all map fonts. Views on the aesthetics of fonts have changed depending on the style of card design in different historical eras. For example, on maps of the XV - XVI centuries. fonts with various decorative details adorning the map predominated. Such "monograms" sometimes made it difficult to read the inscription.

The basis of modern aesthetic requirements are the beauty of the picture, legibility, rationality of proportions, harmonious combination with the nature of the design of other elements of the map, the appropriateness of the use of artistic fonts. [30]

Print Reproducibility

The property of high-quality reproduction of fonts is associated with manufacturing techniques and methods for printing cards. Modern technology for the production and printing of fonts makes it possible to reproduce fonts of any design, including those with contrasting combinations of basic and additional elements, thin undercuts and connections. [21]

2.7. Examples of map fonts

Fig. 2.4. Literary font [8]

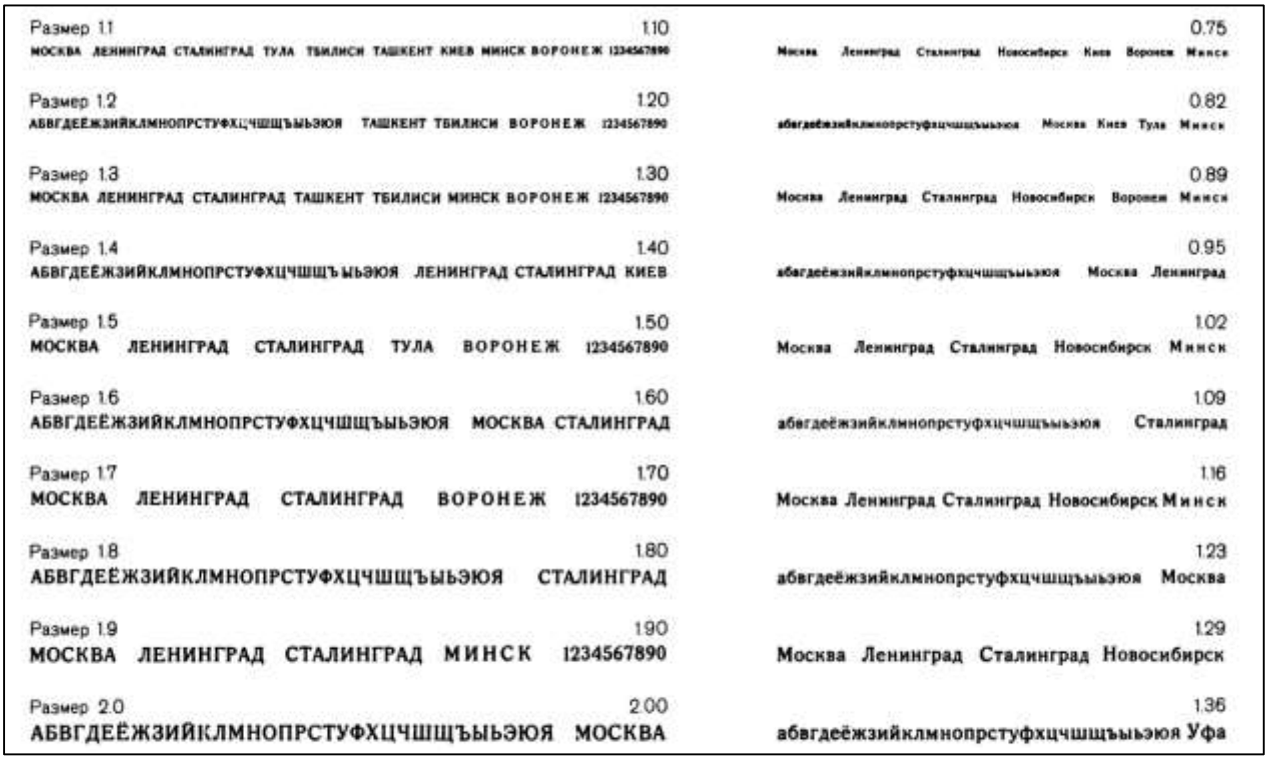


Fig. 2.5. Universal font [8]

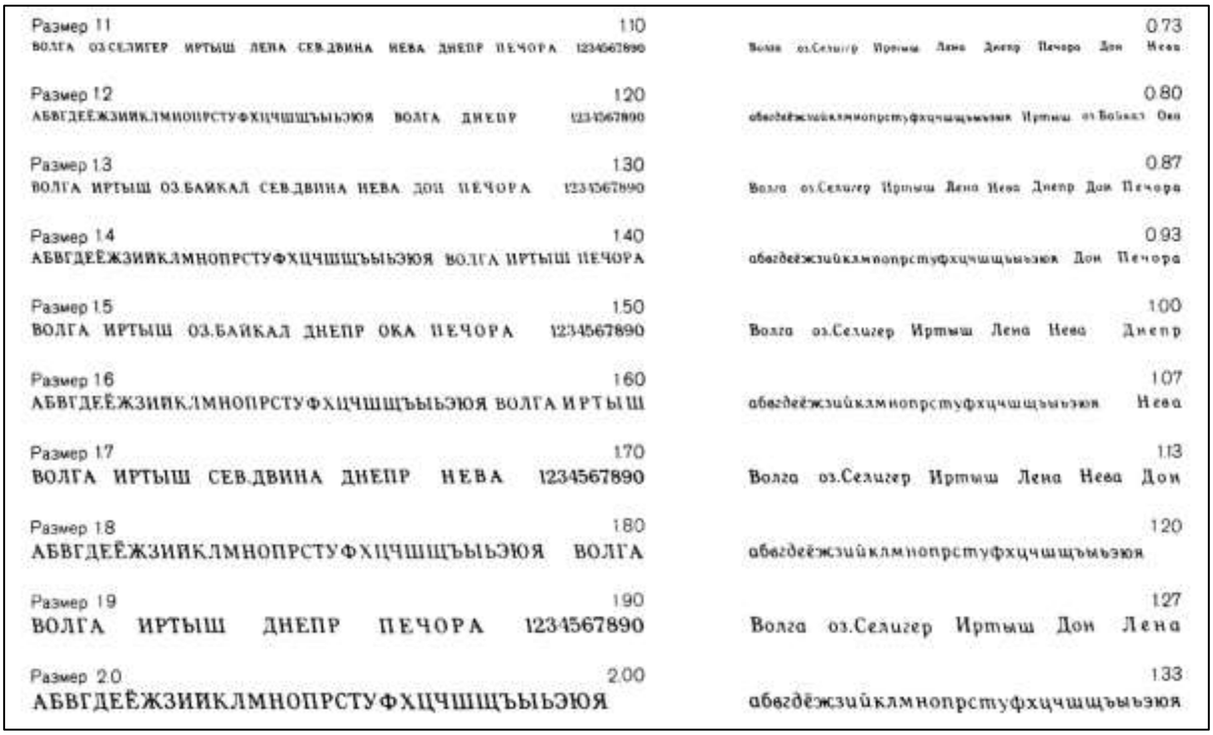


Fig. 2.6. Hydrographic italic font [8]

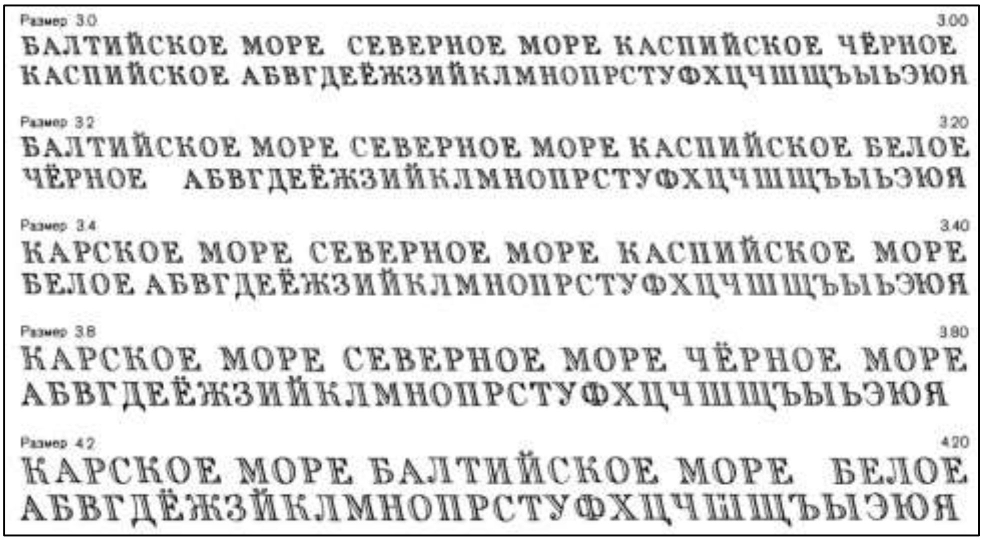


Fig. 2.7. Regular transparent font with left slant [8]

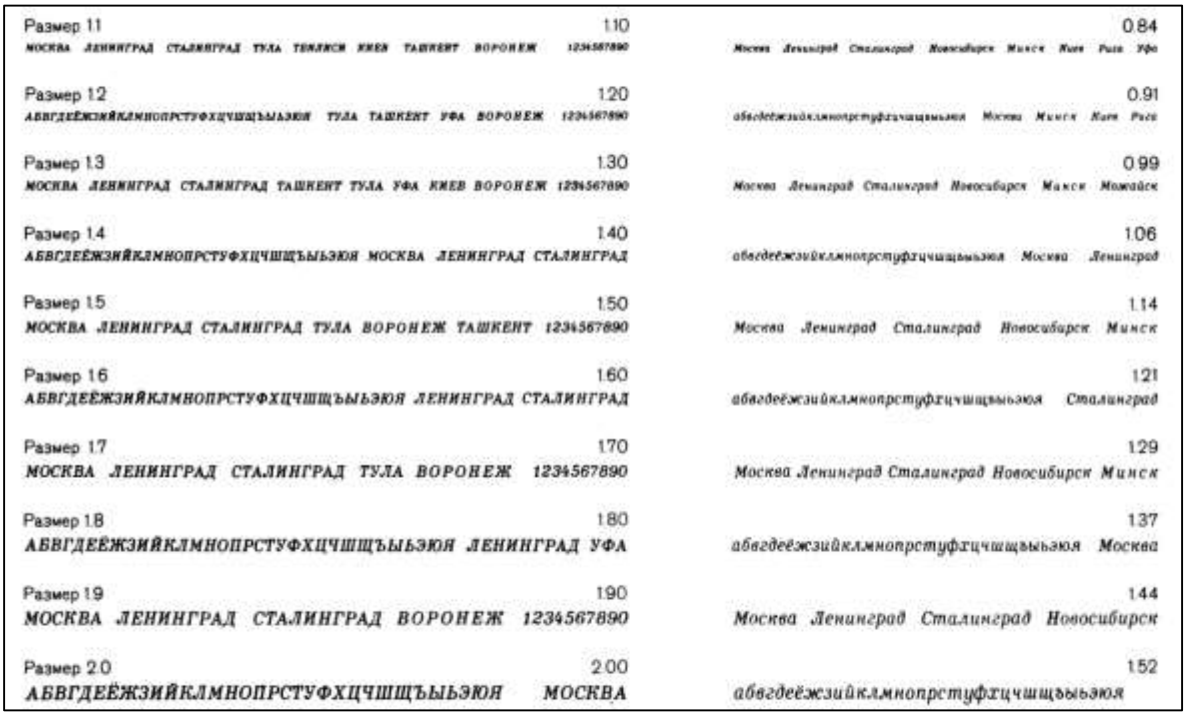


Fig. 2.8. GSWA (Great Soviet World Atlas) italic font [8]

2.8. Applying map fonts to maps

When designing the content and design of the map, fonts are used:

• for geographical names and various explanatory captions directly in the map content;

• for external design (map title, titles of charts and graphs, etc.);

• for the design of the legend (headings of different meanings, decoding symbols, etc.);

• for signatures of output data, additional texts, etc. [25]

In the content of the map, fonts perform a variety of functions:

• serve for signatures of a large group of geographical names (Fig. 2.9);

• enhance the readability of individual cartographic symbols (for example, signatures of rivers at the source, in bends, near the mouth), emphasize the specifics of the sign design and its size by the difference in font size;

• expand the characteristics of the object transmitted by the sign, for example, the sign of the sea route is supplemented by indicating the direction and distance in kilometers (Fig. 2.9);

• act as conventional signs, directly conveying the qualitative and quantitative characteristics of objects; [4]

• can act as a separate method of cartographic representation - the method of inscriptions or a visual means of the method of areas, for example.

The qualitative side of the object is displayed mainly by the type, orientation and color of the font. In figure 2.9, the division of settlements by type of settlement is shown by a combination of a picture, a slanted font, and the use of uppercase and lowercase letters. The height of the letters shows the number of inhabitants in this locality. [20]

Fig. 2.9. Some types of fonts and their use

The color of the font differentiates objects of different meanings, promotes the division of the contents of the map into plans. For example, on maps performed in color, all water bodies are labeled in blue (blue) color.

Size (sometimes combined with boldness) displays the size and relative value of objects. The limits for changing font sizes in the content of maps are determined by the type and nature of their use. For example, in the conventional signs "Guidelines for the compilation and preparation for publication of a topographic map at a scale of 1:1,000,000" on a general geographical map at a scale of 1:1,000,000, the size range is from 1.1 to 5.0 mm, on reference desktop maps of the Atlas of the World (1999) - from 0.8 to 4 mm. On wall maps of a higher school, font sizes range from 2.0 to 10–15 mm in the content of the map, and up to 25–35 mm in its general design (name of the map, captions in the legend, etc.) (Fig. 2.10) [28]

Fig. 2.10. The choice of symbols and fonts for signatures of settlements for general geographical maps: a - desktop, b - wall use.

The spacing of adjacent font sizes is important. Too small intervals (0.1 mm) provide poor perception of differences in font sizes. The choice of intervals is especially important for a multistage characterization of the object's size. For example, to display settlements by the number of inhabitants (11 gradations) with a size range of 1.1 - 3.6 mm and intervals of 0.2 - 0.4 mm, complete differentiation of steps is achieved only when using such graphic fonts as size, drawing , fat content, width, orientation.

In the map legend, the use of cartographic fonts is associated with the features of its structure, the nature of the explanations of the symbols:

• detailed or brief descriptions of signs;

• identification signatures containing classification names of different rank categories;

• index systems, digital, alphabetic explanations.

The readability of the legend is directly dependent on its font design. A special system of fonts is being developed in terms of type and size, depending on the complexity of the legend structure. The type and size of fonts are set in accordance with the different significance of the classification categories they designate (Fig. 2.11). For a clear graphical structure of the legend, a series of fonts, multi-stage in appearance and size, with their vertical and horizontal arrangement (Fig. 2.12) is required. [20]

Fig. 2.11. Graphical design of the system of signs of a complex map

Fig. 2.12. Fonts showing the subordination of categories in the map legend with their vertical and horizontal arrangement.

It is important to calculate the distances both between the inscriptions of various classification groups of certain ranks, and the explanatory signatures of the symbols themselves. This technique enhances the visibility of the classification structure of the legend, more clearly highlights the subordination of subdivisions. The choice of types and sizes of fonts depends on the purpose, the nature of the use of the map, the conciseness of the inscriptions themselves and the availability of free space within the sheet allotted for the legend. [25]

For a specific map, series of maps or atlas, a specific font system is developed. The number of types of fonts used on one map depends on the type and complexity of its content. General geographic maps require a greater variety of fonts. In the instructions and manuals of topographic and survey topographic maps of different scales, there are special font samples for individual content elements. For example, for all signatures on a general geographical map at a scale of 1:1,000,000, 11 types of typefaces are accepted, and taking into account differences in boldness, width, orientation, writing in capital or lowercase letters, 22 types of fonts are accepted. On thematic maps, a limited number of fonts is given - no more than 6, and in complex atlases it is reduced to 3 - 4 types of different patterns. [28]

2.9. Placement of inscriptions on geographical maps

Inscriptions are an important element of content, inherent in all geographical maps, with the exception of silent ones. They explain the depicted objects, indicate their quantitative and qualitative characteristics, and provide reference information. All inscriptions are divided into three groups: toponyms, terms and explanatory inscriptions.[25]

Toponyms - own geographical names of objects of mapping. These can be oronyms - the names of relief elements (for example, Narodnaya, Vesuvius), hydronyms - the names of water bodies (for example, Baikal, Laptev), ethnonyms - the names of ethnic groups, zoonyms - the names of objects of the animal world, etc. The study of toponyms on the map is carried out by cartographic toponymy - a section of cartography at the junction with toponymy. [17]

Terms - concepts that define the role of a geographical object (for example, a mountain, a ridge, a volcano, a sea, a hill, a bay, a peninsula, an area, etc.).

Explanatory notes include:

a) quality characteristics (“birch”, “spruce”, “wooden”),

b) quantitative characteristics (absolute and relative heights, depths, average height and thickness of trees and average distances between them in the forest);

c) chronometric inscriptions (dates of geographical discoveries, the founding of a city, the onset of any phenomena, such as early frosts);

d) explanations for traffic signs (“Cook Way”, “Brazil Current”);

e) digitization of meridians and parallels and explanations for the grid lines ("Southern Arctic Circle", "Northern Tropic").

f) alphabetic or numerical indices explaining a particular phenomenon on the map (for example, alphabetical indices on a geological map, numerical indices on a map of peoples, alphanumeric indices on a soil map). Not to be confused with letters and numbers as cartographic symbols, such as letters for mineral deposits, elevation/depth marks, etc.; [10]

Inscriptions enrich the map, but with a large number of them, they can worsen its readability. Determining the optimal number of labels, their correct placement and writing is an important task for the map compiler. The selection of inscriptions is determined by the purpose, subject, scale of the map and the nature of the mapped area. The inscriptions on the maps may differ in the nature of the font, set, size of letters (pins), color, capitalization. Typically, the size of the font determines the size or relative value of objects (for example, a large industrial site), the shape and color of the font display the qualitative differences between the objects. So, for example, on topographic maps, types of settlements are distinguished in fonts. The color of the inscription indicates that the object belongs to a certain map content group. So, on general geographic maps, hydrography inscriptions are printed in blue, settlements in black, relief in brown, political and administrative divisions in red, etc. Sometimes inscriptions are given in different colors to show the state affiliation of objects (for example, islands). [2]

The placement of inscriptions is subject to several important requirements:

• the belonging of the inscription to a certain geographical object should not be in doubt;

• the inscriptions are located as far as possible in free places, they should not obscure (or break) the essential details of the map;

• it is important that the placement of labels in their totality reflects the relative density of the corresponding objects on the ground.

Also, when placing inscriptions on maps, the nature of the localization of objects is taken into account - point, line or areal. [4]

Placement of inscriptions of objects localized in a point (point) - names of settlements, centers of industry, mineral deposits, power plants, etc. The inscription should be placed in the immediate vicinity of the object (0.3 - 0.5 mm), without doubting its belonging to this object. When choosing a location, it should be remembered that it should not cover important elements of the map's content, or such a position of the inscription is chosen in which it covers the smallest part of the line image (Fig. 2.13). If this is not possible, then one of the "transparent" fonts should be used. [10]

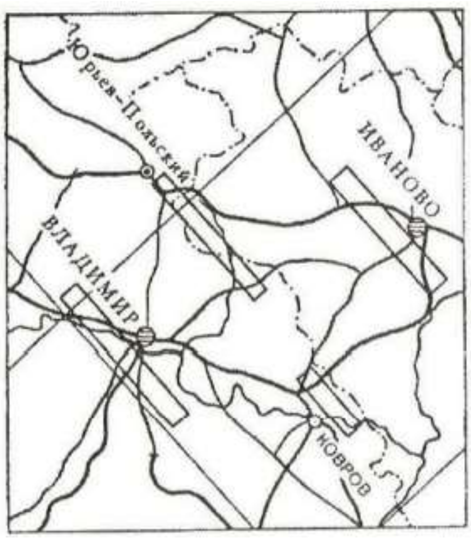


Fig. 2.13. Placement of inscriptions of settlements(▭ - unsuccessful placement of inscriptions).

Fig. 2.14. Placement of inscriptions of different types of geographical objects

The preferred place for placing the inscription is to the right and against the middle of the object to which it refers. With a large concentration of settlements in a small area, placing an inscription on the right is not always possible. A free arrangement is allowed, sometimes even curved (curved), but providing a clear belonging of the inscription to the corresponding object. Settlements located on the banks of the river are signed from the bank where the settlement is located. [11]

Settlements located on both banks of the river are signed from the bank on which the administration is located:

a) in the presence of a cartographic grid, the inscription is placed along the parallels (parallel to the parallels) (Fig. 2.13);

b) in the absence of a cartographic grid, the inscription is placed horizontally (i.e. for a map with a rectangular frame - parallel to the northern and southern frames of the map) (Fig. 2.15).

For maps built in polar azimuth projections, i.e. maps of the polar territories, the inscriptions are also placed horizontally.

Fig. 2.15. Placing an inscription in the absence of a cartographic grid

Placement of inscriptions of objects localized along the line - the names of rivers, streets, roads and other transport routes, etc. The inscription should be placed in the immediate vicinity of the object, without giving rise to doubts about belonging to this object. Linear objects are signed parallel to the sign of the object or along its axis. [3]

The construction of the inscription of the names of the rivers along a smooth curved line is shown in figure 2.16. Italic oblique fonts are most often used for river names. The slope of each letter is oriented from the normal (perpendicular) to the curve (Fig. 2.16(a)). The type of font and the angle of inclination of the letters is the same for all the names of the rivers on the map. In roman signatures, the axis of each letter is perpendicular to the curve (Fig. 2.16(b)). For large rivers, different font sizes are used, and signatures are placed at the source, in areas with a sharp change in flow, below the confluence of large tributaries and in the mouth part of the river; at the same time, the font sizes gradually increase from its upper reaches to the mouth (Fig. 2.16(c)). The names of the rivers on the maps are most often signed with a capital letter, without a term designation.

For rivers, the width of which is depicted on a map scale, the names are signed along the middle axis of the sign, if necessary, the arrow indicates the direction of the flow (Fig. 2.16(d)). The inscription should be legible without turning the map. [4]

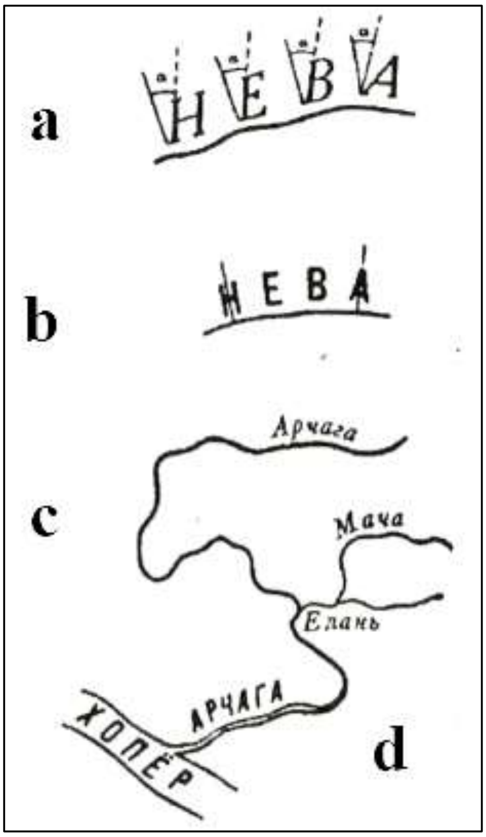


Fig. 2.16. Placing river labels on maps

Placement of inscriptions of objects localized by area - the names of oceans, seas, lakes, states, physical and geographical countries, plains, mountain ranges, etc.:

a) Labels for objects that occupy a significant area on the map are placed on the area of the corresponding object along a smooth curve along the major axis of the contour so as to identify this area with the label. This indication is especially important for objects whose boundaries are not marked on the map.

Fig. 2.17. Placement of inscriptions of orographic objects on the map

With a significant area of the object, its name is placed over the entire area and signed in large font and in discharge (they measure the length of the object, divide by the number of letters and thus determine the distance between the letters in the word). [4]

b) Inscriptions to objects that have a small area (for example, to small states, islands or lakes), are placed, firstly, according to the rules of "point" objects. In this case, the inscription is placed, depending on the configuration of the object, near the contour along its elongated axis, and in case of a rounded shape - to the right of the object or in another free place from the line load of the map (Fig. 2.18). Secondly, using a digital footnote. If a footnote is used, remember that the numbers must be in the same font as the inscriptions of the names of similar objects. [20]

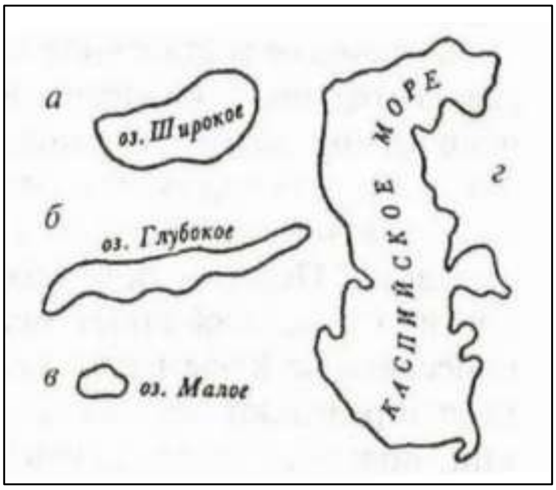


Fig. 2.18. Placement of labels for areal objects

In the process of compiling a map, there may be a different sequence of placing inscriptions on the original. It is possible to make inscriptions simultaneously with drawing objects on the original, but in this case there may be large overlaps of inscriptions with each other or other elements of the map content. Therefore, it is more rational to place inscriptions on the original in free or less loaded places after all elements of the map content have been drawn. At the same time, the location of the main geographical names, which are signed in larger fonts, and the inscriptions forming the foreground, is determined on the original, and then other names of secondary importance are located. [24]

To save space, standard explanatory labels and geographical terms are usually placed on the map in abbreviated form, and the accepted abbreviations are deciphered in a table of conventional signs. [3]

Many thematic maps contain only generic inscriptions and their own geographical names. There are thematic maps, completely devoid of inscriptions, on which all the content is transmitted by graphic conventional signs.

2.10. Features of the letters of the Russian alphabet

In the alphabet of any language there are letters that have their own characteristics, for example, various kinds of undercuts, or different thicknesses in certain places of the letter. The letters of the Russian alphabet are no exception. There are 33 letters in the Russian alphabet. There are uppercase and lowercase letters.

In all fonts, letters consist of combinations of elements: vertical, horizontal, oblique, rectilinear, rounded. Five groups are defined:

1) Letters and numbers formed by rectilinear elements located vertically and horizontally (Н, Г, Е, П, Т, Ц, Ш, Щ);

2) Letters consisting of combinations of vertical and oblique lines (М, Д, И, Л);

3) Letters consisting of combinations of oblique lines (А, У, Х);

4) Letters and numbers consisting of curved lines (С, О, З, Э);

5) Letters and numbers, consisting of combinations of straight and curved lines (Б, В, Ъ, Ь, Ы, Р, Ч, К, Ж, Я, Ф, Ю);

Separate elements of letters can be thick (poured) and thin (hairy). The poured elements are called the main ones, and the hair elements are called the secondary ones. The widest part of the poured element is called the thickness and is a certain value. The height of a single letter or number is called its size. The height of the letter determines its width and the thickness of the main element.

For my work, or rather for the calculations that will be presented in the experimental part, an important parameter of the letters is the width of the letter.

Therefore, in this paragraph, I focus on the width of the letters of the Russian alphabet. The information for this chapter comes from two sources that provide slightly different information about width and letter classification. Where **w** is the width of the letter and **h** is the height of the letter.

First option

Uppercase:

Normal (middle) letters: (Б, В, Г, Е, Ё, З, И, Й, К, Л, Н, О, П, Р, С, Т, У, Х, Ц, Ч, Ь, Ъ, Э, Я);

w = 0,5*h   (2.1)

Wide letters: (Ж, Ф, М, Ш, Ы, Щ, Ю, Д); w = 1,5*(0,5*h) (2.2)

The letter (A) is a peculiar exception; w = (0,5*h) + 0,25 (2.3)

Uppercase letters are 1.5 times higher than lowercase ones. Where do the formulas for calculating the widths of lowercase letters come from.

Lower case:

Normal (medium) letters: (б, в, г, д, е, ё, з, и, й, к, л, н, о, п, р, с, т, у, х, ц, ч, ь, ъ, э, я) w = $0,5*\frac{h}{1,5}$ (2.4)

Wide letters: (ж, ф, м, ш, ы, щ, ю, д); w = 0,5*h   (2.5)

The letter (a) is a peculiar exception; w = $(0,5*\frac{h}{1,5}) + 0,25$ (2.6) [10]

Second option

Uppercase and lowercase letters are calculated using the same formula [11]

Narrow letters: (Б, В, Г, Е, Ё, Ь, Ъ, б, в, г, е, ё, р, ь, ъ); $w = h \times \frac{6}{9}$ (2.7)

Middle letters: (А, Д, З, И, Й, К, Л, Н, П, Т, У, Х, Ц, Ч, Я, а, д, з, и, й, к, л, н, п, т, у, х, ц, ч, я); $w = h \times \frac{7}{9}$ (2.8)

Wide letters: (Ж, М, О, С, Ф, Ш, Щ, Ы, Э, Ю, ж, м, о, с, ф, ш, щ, ы, э, ю);

$w = h \times \frac{8}{9}$ (2.9)

In the experimental part, these two options and formulas from them will be used for calculations.

3. EXPERIMENTAL PART

3.1 Methodology scheme

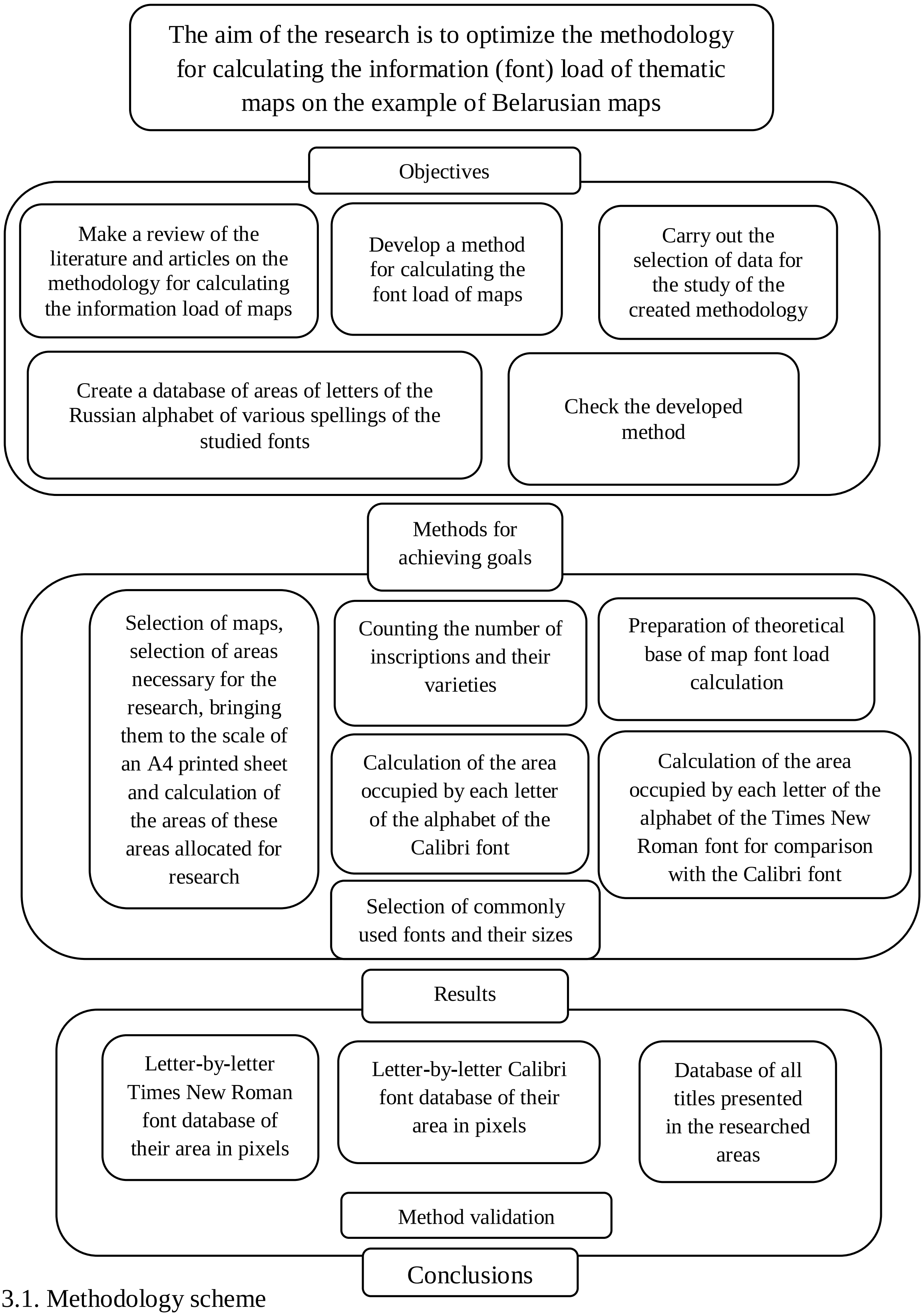


Fig. 3.1. Methodology scheme

3.2. Selection and preparation of research objects

For the study, four thematic maps were selected from the atlas of the geography of Belarus for the 10th grade. These maps were chosen because they are educational and should be easy to read for students. Names should be clearly visible on such maps, and they should not confuse or frighten students.

Fig. 3.2. Political-Administrative Map of the Republic of Belarus

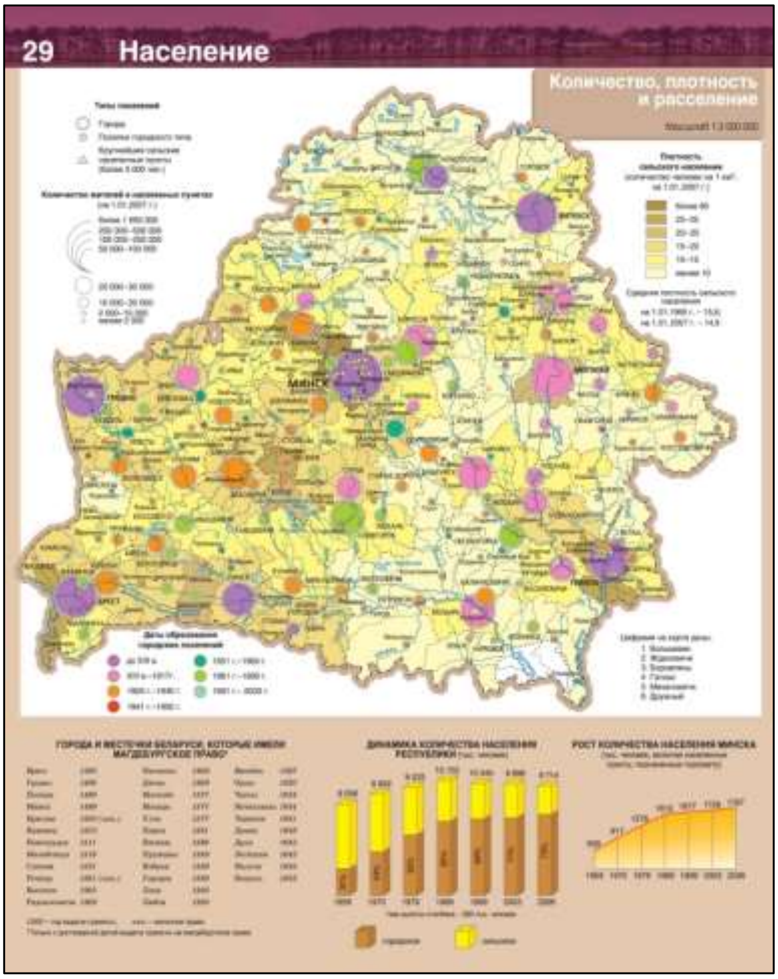


Fig. 3.3. Map of the Number, Density and Distribution of the Population of the Republic of Belarus

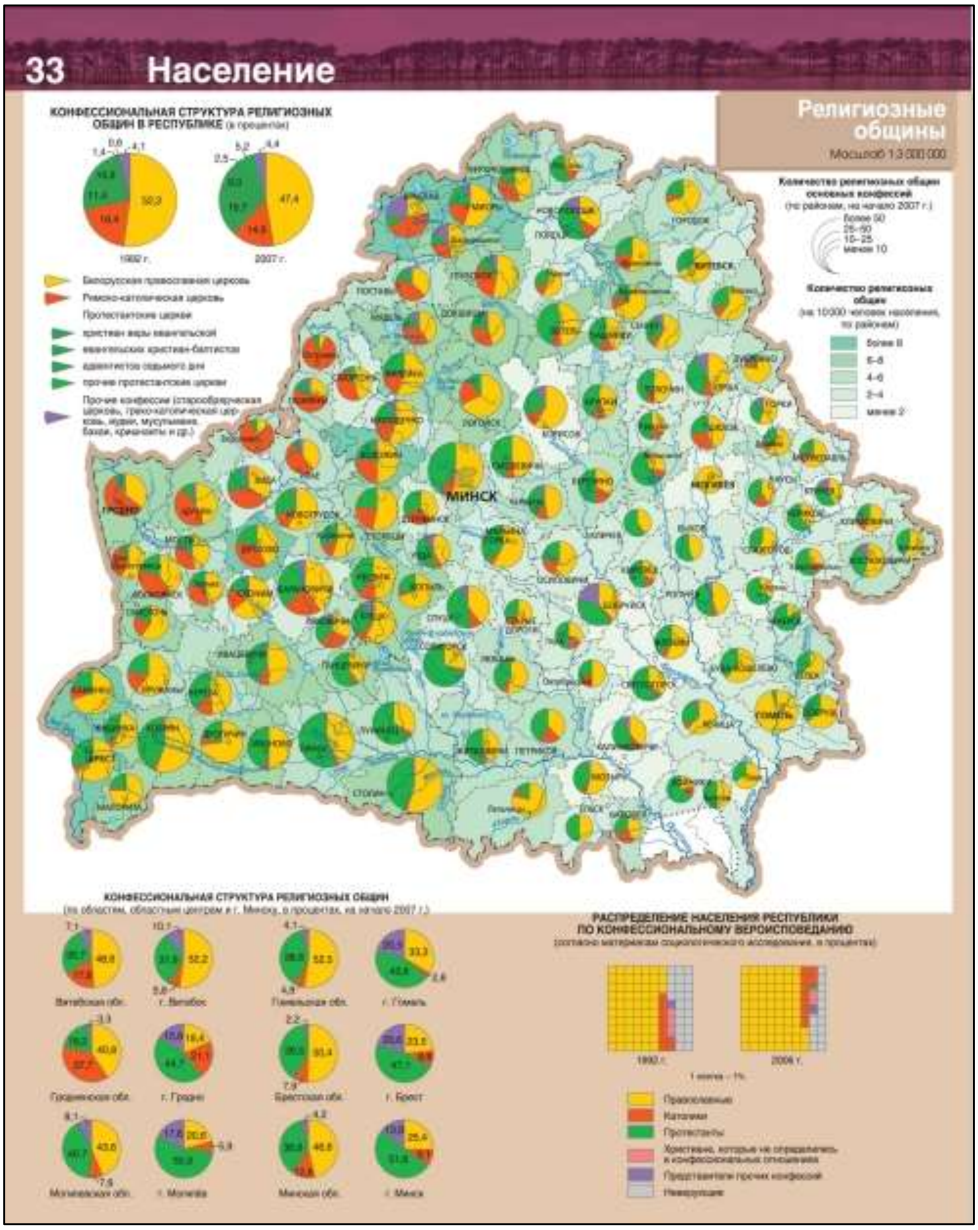


Fig. 3.4. Map of Religious Communities of the Republic of Belarus

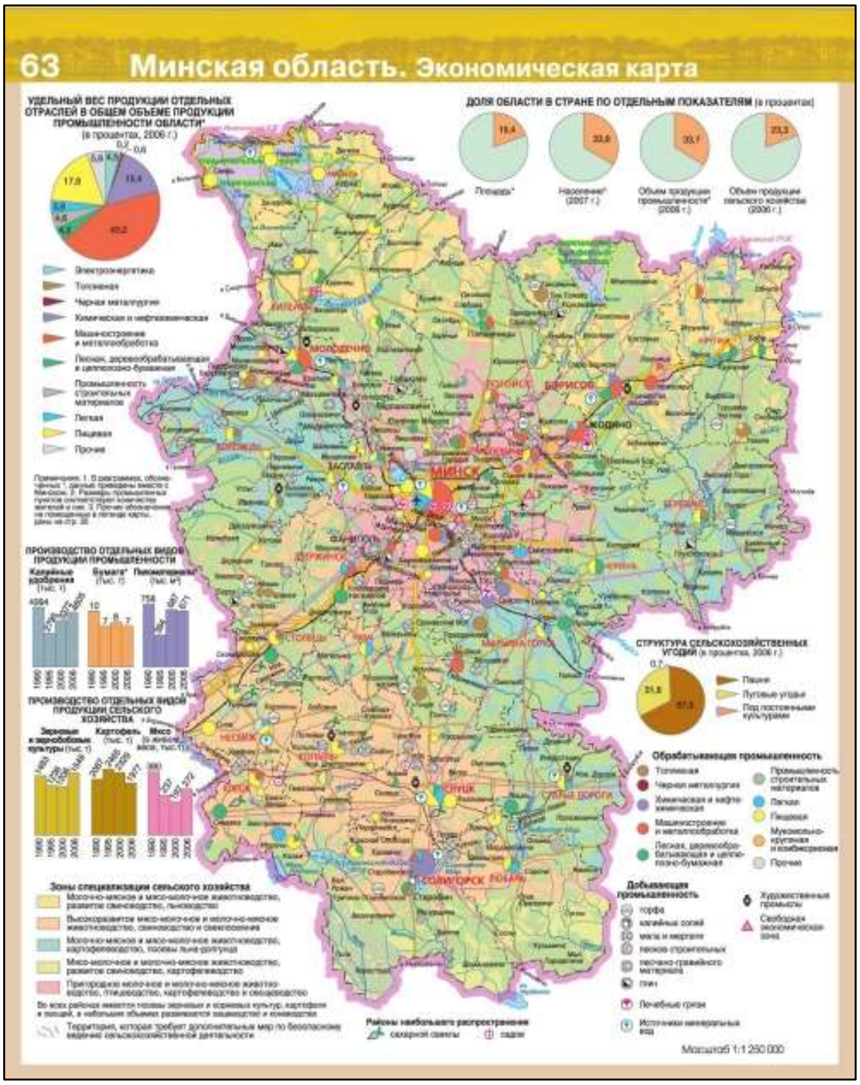


Fig. 3.5. Economic map of the Minsk region of the Republic of Belarus

Then it is necessary to prepare the selected objects for further research.

The next steps are:

1) Selection of fragments with the area under study.

To do this, using a graphic program, the area of interest on the map was selected from all four maps (Fig. 3.6 – Fig. 3.9).

2) Bringing the selected fragments of maps to the size of the printed area, which they occupy on an A4 sheet;

To do this, it was necessary to load the page cut from the digital atlas into the AutoCAD program and first check whether the cut page corresponds to the A4 printed format. A4 sheet size is 210 x 297 mm. Then measure the area of interest. Then insert the previously selected fragment into the AutoCAD program and bring it to the size that was found by finding the area of the area of interest on the already checked and, if necessary, converted page (Fig. 3.10 – Fig. 3.13).

3) Allocation of the boundary of the studied area of maps, calculation of their areas, as well as counting the number and classification of inscriptions on them. (Table 3.1).

Fig. 3.6. The area highlighted from the Political-Administrative Map of the Republic of Belarus

Fig. 3.7. The area highlighted from the Map of the Number, Density and Distribution of the population of the Republic of Belarus

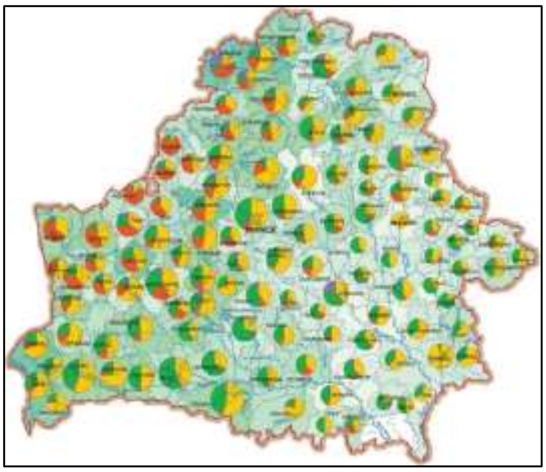


Fig. 3.8. The area highlighted from the Map of Religious Communities of the Republic of Belarus

Fig. 3.9. The area highlighted from the Economic Map of the Minsk region of the Republic of Belarus

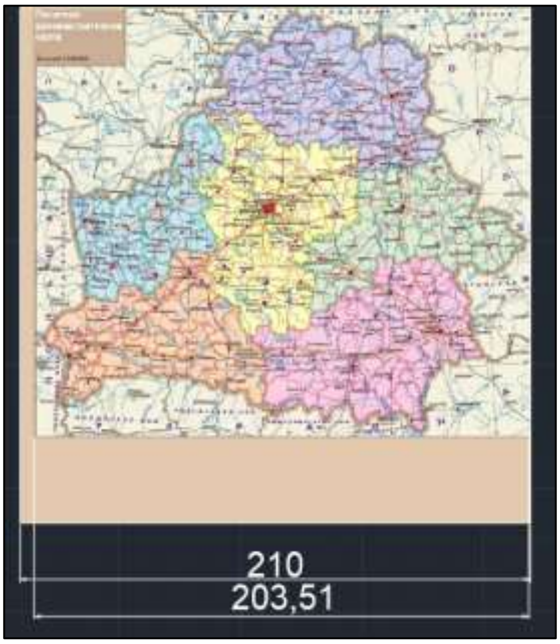


Fig. 3.10. Bringing the Political-Administrative map of the Republic of Belarus to the scale of the printed version and measuring the size of the study area.

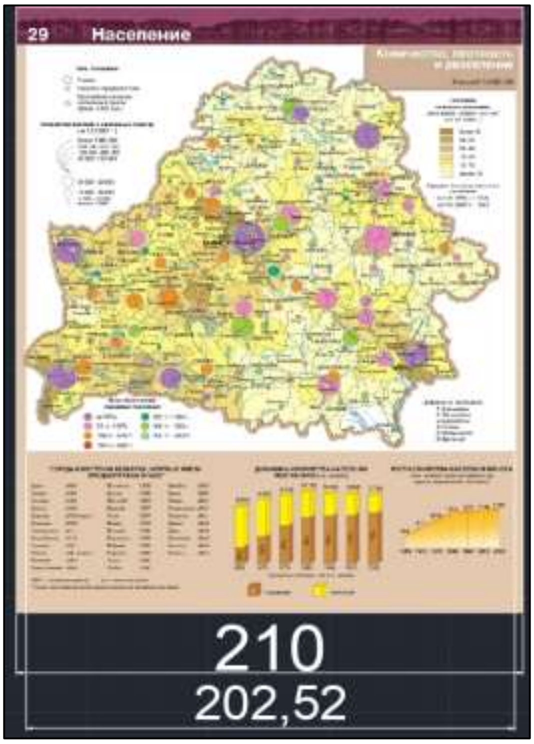


Fig. 3.11. Bringing the Map of the Number, Density and Settlement of the Population of the Republic of Belarus to the scale of the printed version and measuring the size of the study area

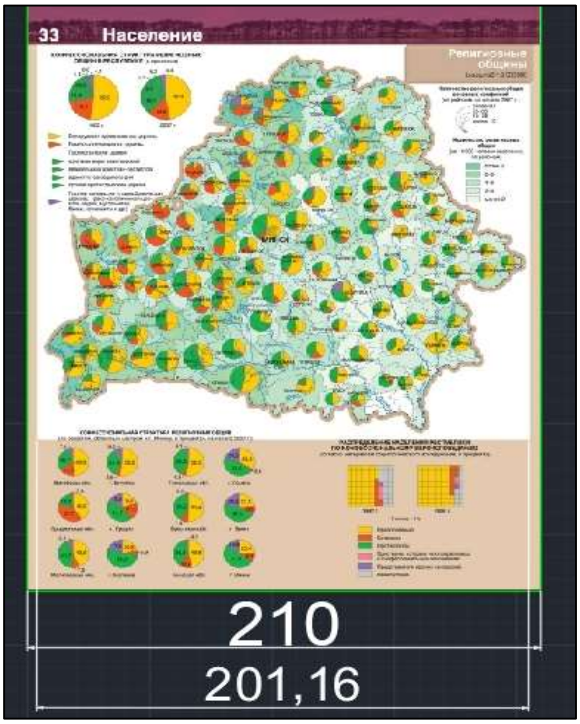


Fig. 3.12. Bringing the Map of the Religious Communities of the Republic of Belarus to the scale of the printed version and measuring the size of the study area

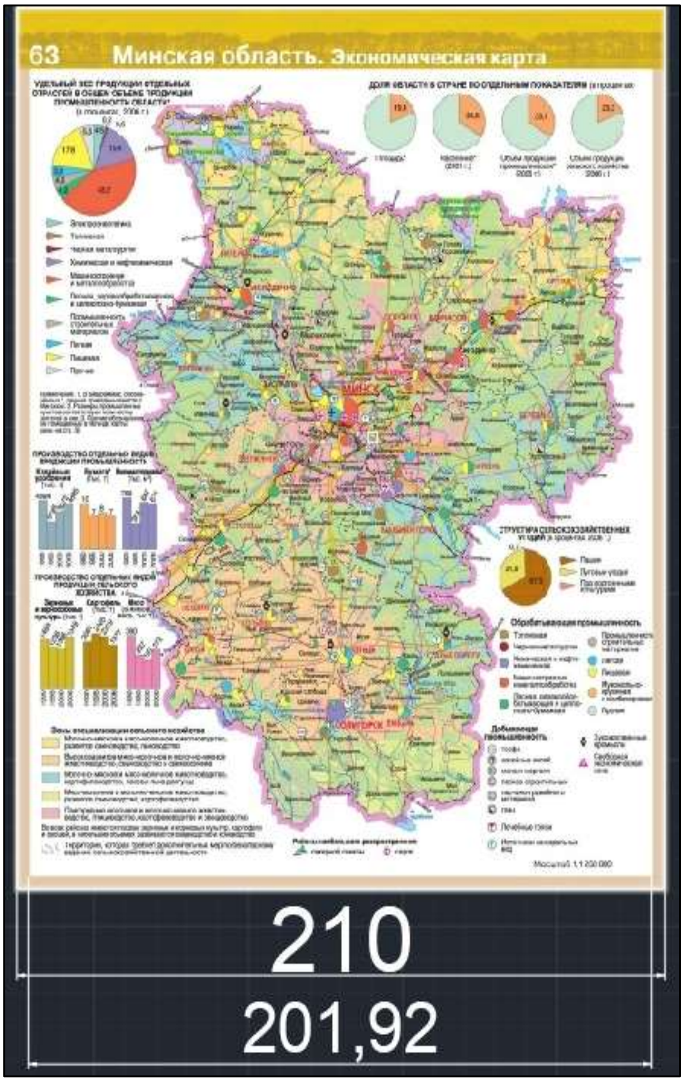


Fig. 3.13. Bringing the Economic Map of the Minsk Region of the Republic of Belarus to the scale of the printed version and measuring the size of the study area

Table 3.1. Area, number and classification of names of the studied areas of maps.

Title	Square, mm^2	Total inscriptions (amount)	City names in capital letters (amount)	Hydronyms (amount)	Locality names written in uppercase and lowercase letters (amount)
Political-Administrative map of the Republic of Belarus	19742,72	269	114	43	128
Map of the Number, Density and Settlement of the Population of the Republic of Belarus	19950,04	262	114	40	122
Map of the Religious Communities of the Republic of Belarus	19817,46	152	99	42	22
Economic Map of the Minsk Region of the Republic of Belarus	30258,58	376	27	78	345

Having studied all the maps of the atlas, as well as the studied areas of the maps, it was revealed that they use the Calibri font of 12 and 11 points in size. The bold, italic, and bold-italic styles of these fonts are used.

The Times New Roman font is also used, but it is only explored in this paper for comparison with Calibri.

Based on the above, all the names of each studied fragment of the maps were entered into separate files, divided by types of inscriptions, fonts used for writing, font sizes, font style, and also by the way of writing: uppercase letters, lowercase letters, a combination of uppercase and lowercase letters, The figures 3.14 – 3.15 show fragments of such files. The rest of the files will be shown in the appendix of this master's work.

ВЕРХНЕДВИНСК	БЕРЕЗИНО
БРАСЛАВ	ФАНИПОЛЬ
МИОРЫ	ДЗЕРЖИНСК
ДИСНА	ЧЕРВЕНЬ
НОВОПОЛОЦК	МАРЬИНА ГОРКА
ПОЛОЦК	СТОЛБЦЫ
ГЛУБОКОЕ	УЗДА
ПОСТАВЫ	БЕРЁЗОВКА
ДОКШИЦЫ	НОВОГРУДОК
ЛЕПЕЛЬ	МОСТЫ
ЧАШНИКИ	ЩУЧИН
СЕННО	ДЯТЛОВО
НОВОЛУКОМЛЬ	СЛОНИМ
ДУБРОВНО	СКИДЕЛЬ
ОРША	ВОЛКОВЫСК
ТОЛОЧИН	СВИСЛОЧЬ
БАРАНЬ	КЛИЧЕВ
МЯДЕЛЬ	КИРОВСК
ВИЛЕЙКА	БЫХОВ
МОЛОДЕЧНО	ОСИПОВИЧИ

Fig.3.14. A fragment of a database of names of settlements written in Calibri font size 12 (Annex 4).

оз. Освейское
оз. Дривяты
Дрыса
Зап. Двина
Дисна
Березина
оз. Нарочь
Вилия
Вилейское вдхр.
Березина
Нёман
Птичь
Случь
Краснослободское вдхр.
Вилия
Щара
Нёман
Ясельда
Днепровско-Бугский канал

Fig. 3.15. A fragment of the database of names written in Calibri font size 11 in italic style (Annex 3).

3.3. Calculation of the areas occupied by letters

In order to calculate the area occupied by each letter, it was first necessary to photograph all 33 uppercase and lowercase letters of the Russian alphabet. Photographs of each letter were taken with a size of 100x100 pixels at a magnification of 500% using a special program. The photo resolution was 300x300dpi.

The calculation of the areas was carried out in the program created by Arturas Bautrenas, which is called PIX analyser.

The question arose of what color of letters is better to calculate, since there are letters of different colors on the map. First, for comparison, I took a photo of the capital letter A in black and red, in order to understand which color of the letter is the most optimal for testing the methodology.

Fig. 3.16. Photograph of a size 12 Calibri capital letter A taken in black and red.

The photo of the letter is loaded into the PIX analyzer program and the first step is to calibrate it. Letters are calibrated in height. Calibration was carried out for each letter, as distortions are possible when photographing letters from the screen.

To calculate the height of the letters, the formula is used:

$h = \frac{a}{b} \times c \times P$ (3.1)

a – 25,4 inch;

b – 72 dpi;

c – 0,72 (72%);

P - font size

In research, I take a value of 0.72 (72%) because typically, the font height is around 72% of the font size. And also due to the fact that the entire letter occupies, on average, such a percentage on the printed surface.

Table 3.2. Calculated value of letter heights

Size, pt	h, mm
8	2,032
10	2,54
11	2,794
12	3,048
14	3,56

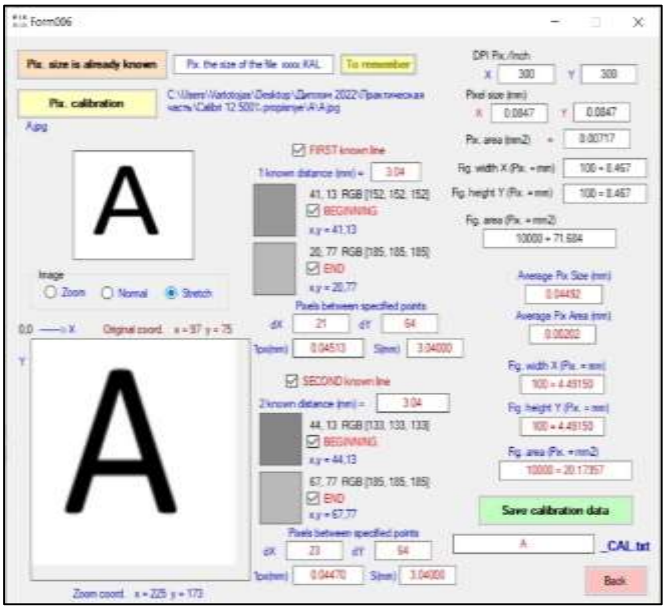


Fig. 3.17. Letter calibration.

Then, knowing the calibration factor, it is necessary to measure the area in mm^2 occupied by the letter.

The area was measured in two ways: by removing the background, by highlighting the letter without taking into account the background. The final area value was calculated as the average between these two values. In both cases, a ±10 color filter_RGB was applied.

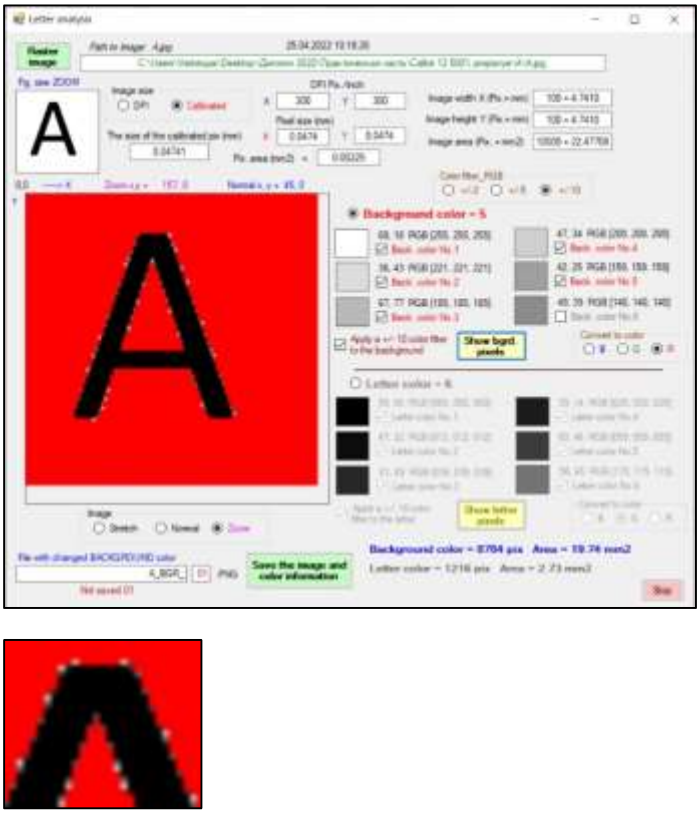


Fig. 3.18. Calculation of the area of the letter A in black by removing the background.

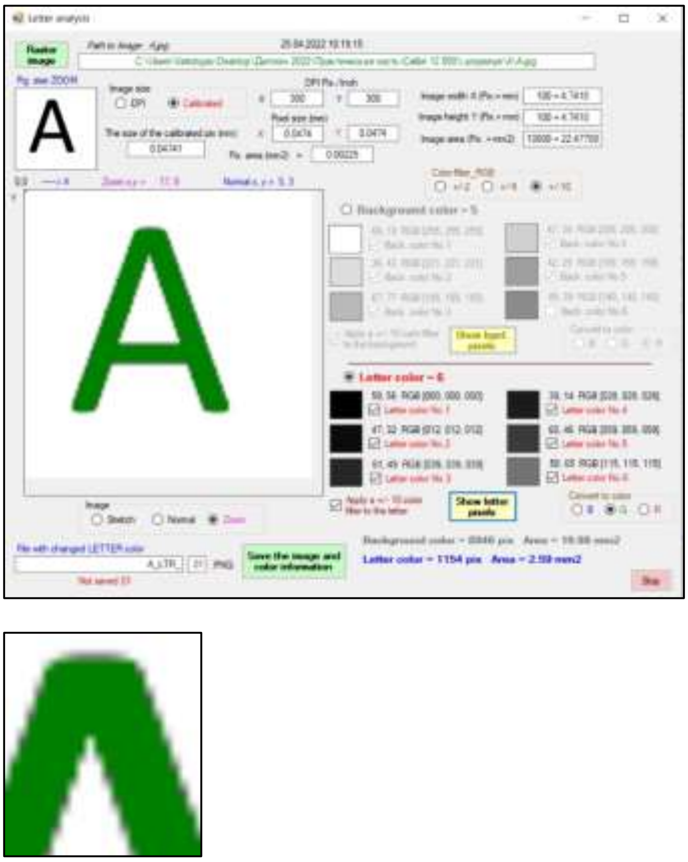


Fig. 3.19. Calculation of the area of the black letter A by selecting the letter without taking into account the background.

Fig. 3.20. Calculation of the area of the letter A in red by removing the background.

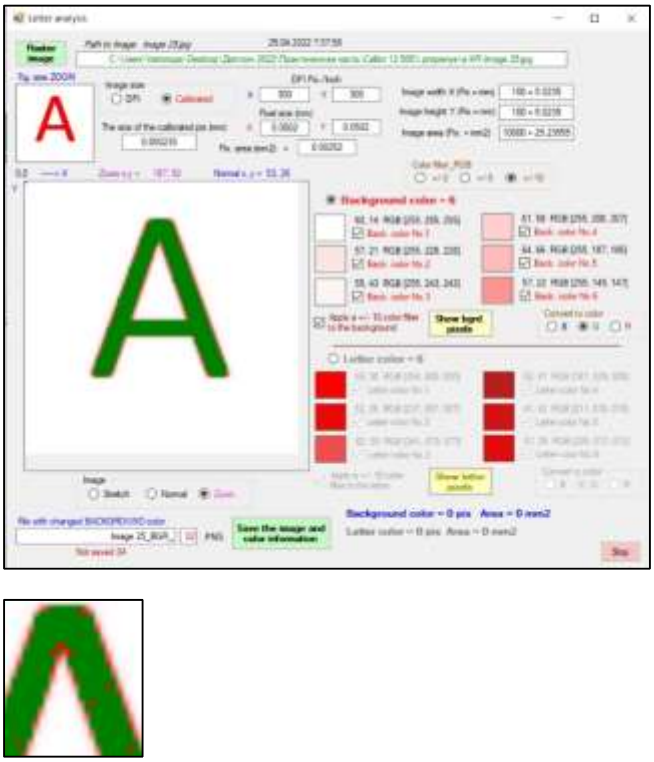


Fig. 3.21. Calculation of the area of the red letter A by selecting the letter without taking into account the background.

Table 3.3. Calculated values of the area of the capital letter A of the Calibri font, 12 points in size, made in black and red.

Letters	Area background, mm²	Area letter, mm²	Average, mm²
A	2,72	2,6	2,66
A	2,65	2,3	2,5

When analyzing a red letter, it was found that during the application of two methods, many shades of different colors appear, which negatively affects the measurement of the area occupied by the letter (fig. 3.20, fig. 3.21). Thus, it was decided to analyze only black letters. This choice was also made because the gray color has relatively constant values of the RGB parameter, but different intensities, which slightly affects the calculation results.

Thus, using these two methods of finding the area of a letter and the average between the values of these two areas, a database of uppercase and lowercase letters of the Calibri font in size 8, 10, 11, 12, 14 points of various writing styles, was created. A database of Times New Roman letter sizes of 11, 12 and 14 points was also created.

Letters	Area background mm^2	Area letter mm^2	Average mm^2	AVERAGE SUM/33
А	2.72	2.6	2.66	2.869393939
Б	2.86	2.8	2.83	
В	3.18	3.15	3.165	
Г	1.54	1.67	1.605	
Д	3.06	3.07	3.065	
Е	2.31	2.52	2.415	
Ё	2.13	2.19	2.16	
Ж	3.94	3.77	3.855	
З	2.64	2.53	2.585	
И	2.78	3.18	2.98	
Й	2.76	2.83	2.795	
К	2.63	2.68	2.655	
Л	2.28	2.44	2.36	
М	4.18	4.17	4.175	

Fig. 3.22. A fragment of the table of areas of the letters of the Calibri font, 12 points in size (Annex 8).

Letters	Area background mm^2	Area letter mm^2	Average mm^2	AVERAGE SUM/33
А	3.28	3.2	3.24	3.490909
Б	2.91	2.83	2.87	
В	4.03	3.85	3.94	
Г	1.81	1.85	1.83	
Д	3.21	3.08	3.145	
Е	2.9	2.86	2.88	
Ё	2.09	2.01	2.05	
Ж	5.27	5	5.135	
З	3.17	3.03	3.1	
И	4.37	4.18	4.275	
Й	2.72	2.58	2.65	
К	3.64	3.49	3.565	
Л	3.14	3.04	3.09	
М	5.69	5.39	5.54	

Fig. 3.23. A fragment of the table of areas of letters in the Calibri font, 11 points in size, made in bold italic style.

The entire database of words and letters is placed in the digital format of the master's thesis.

3.4. Calculation of word areas

Word area was also measured using the program PIX analyzer.

Fig. 3.24. Interface of the PIX analyzer program section for calculating the area of words.

In this program, it was necessary to load pre-prepared files with words written in a specific font of a certain size and style. For example, files called:

“NAS.PUNKTY CALIBRI_Rergular_UPERCASE_12.txt”;

“HYDRONYMY CALIBRI_Italic_Sentence_11.txt”;

“STOLICA CALIBRI_Bold_UPERCASE_14.txt”;

From Figure 3.22 in the program, after downloading the file, is needed to select the font size, the font itself, the style of writing words, which letters were used in words (uppercase, lowercase, a combination of uppercase and lowercase letters(sentence)).

Thus, a database was created of all the names placed on the studied maps written in the Calibri font in size 8, 10, 11, 12, 14 created by various writing styles. Also, a database was created of all the names placed on the studied maps in Times New Roman font, size 11, 12, 14.

Words areas are calculated using three methods:

1) Letter-by-letter calculation (calculation by pixels);

In this method, a file was loaded into the program, the total number of words and letters was counted, according to the already formed database of the areas of each letter, the program calculated the total area of letters and words in this file, as well as the number of words and letters (Fig.3.25).

After the program has calculated the area, it saves the results in a separate file (Fig.3.26). The file indicates the total area of letters, as well as the total area of words. Thus, such files were created for each studied map.

Fig. 3.25. Letter-by-letter calculation (calculation by pixels)

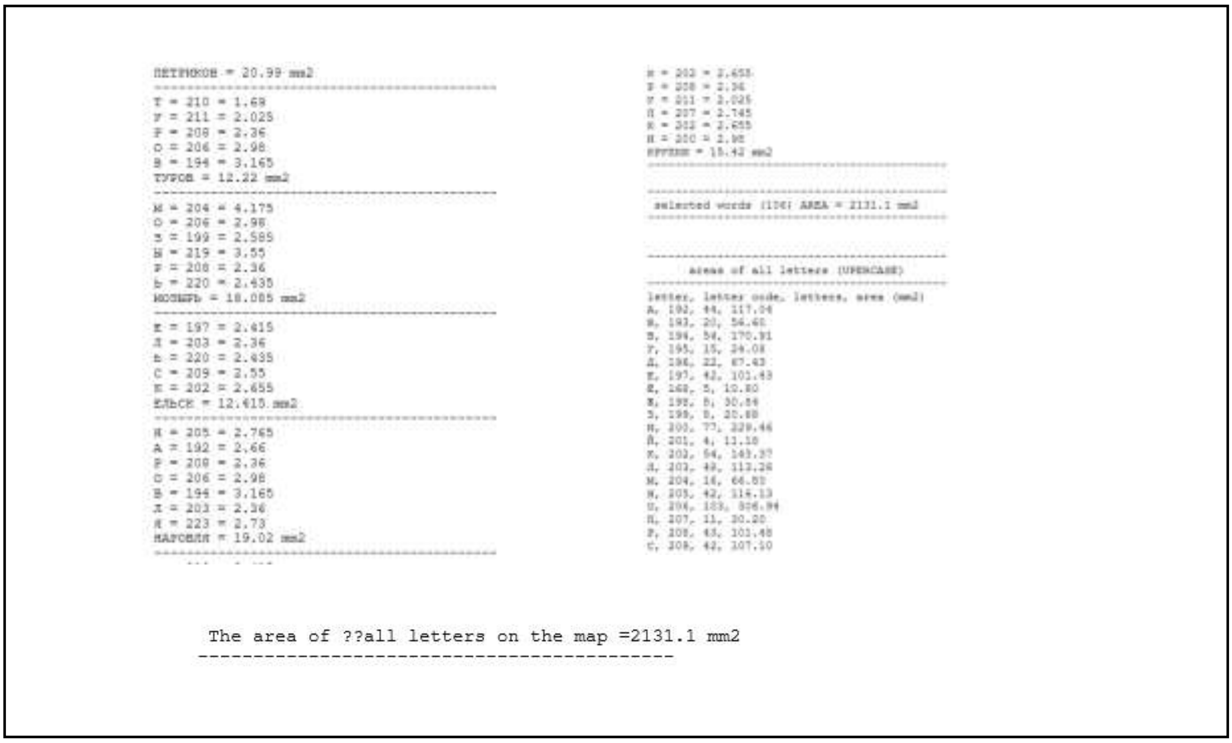


Fig. 3.26. A fragment of the file obtained after calculating the area using the method of letter-by-letter calculation.

The database of the remaining files will be specified in the appendix.

2) Calculation of the areas of words, taking into account the widths of the letters and their classification in the first option, indicated in paragraph 2.10;

In the program, this method is denoted as W, M, +A.

The calculation of the height of the letter was carried out according to the formula 3.1.

This formula is displayed in fig.3.25.

This method also took into account the spacing between letters in words. The value of the gap between letters in words was taken as the average value of the sum of the average gaps from all four maps (Table 3.4). The space between words is denoted by the letter g.

The width of the letters was calculated using the formulas 2.1 - 2.6. These formulas are displayed in fig. 3.27.

The program according to this method takes into account the length of all letters of words, the length of all gaps in a word and their area, and based on all these calculated data, it calculates the area of a word.

First is needed to put a pre-prepared file into the program and it will calculate the entire area of words in this file.

As in the previous method, the program places all the calculated data in a separate file (Fig. 3.28).

Fig. 3.27. Calculation of the area of words by the method W, M, +A.

```
В = 194 = 0.500 = 1.524 = 4.645 = M
Е = 197 = 0.500 = 1.524 = 4.645 = M
Т = 210 = 0.500 = 1.524 = 4.645 = M
К = 202 = 0.500 = 1.524 = 4.645 = M
А = 192 = 0.500 = 1.524 = 4.645 = M
spaces In the word = 4
length of the gaps = 0.52 x 4 = 2.08 mm
space area in the word = 3.048 x 2.080 = 6.340 mm2
letters in the word = 5
letters length = 7.620 mm
letters area = 23.25 mm2
ВЕТКА = 29.58984 mm2
-------------------------------------------
Д = 196 = 0.750 = 2.286 = 6.968 = W
О = 206 = 0.500 = 1.524 = 4.645 = M
Б = 193 = 0.500 = 1.524 = 4.645 = M
Р = 208 = 0.500 = 1.524 = 4.645 = M
У = 211 = 0.500 = 1.524 = 4.645 = M
Ш = 216 = 0.750 = 2.286 = 6.968 = W
spaces In the word = 5
length of the gaps = 0.52 x 5 = 2.60 mm
space area in the word = 3.048 x 2.600 = 7.925 mm2
letters in the word = 6
letters length = 10.668 mm
letters area = 32.54 mm2
ДОБРУШ = 40.4648 mm2
-------------------------------------------
Г = 195 = 0.500 = 1.524 = 4.645 = M
О = 206 = 0.500 = 1.524 = 4.645 = M
Р = 208 = 0.500 = 1.524 = 4.645 = M
О = 206 = 0.500 = 1.524 = 4.645 = M
Д = 196 = 0.750 = 2.286 = 6.968 = W
О = 206 = 0.500 = 1.524 = 4.645 = M
К = 202 = 0.500 = 1.524 = 4.645 = M
spaces In the word = 6
length of the gaps = 0.52 x 6 = 3.12 mm
space area in the word = 3.048 x 3.120 = 9.510 mm2
letters in the word = 7
letters length = 11.430 mm
letters area = 34.87 mm2
ГОРОДОК = 44.37976 mm2

selected words (106) AREA = 4856.2 mm2
```

Fig.3.28. A fragment of the file obtained after calculating the area of the words using the W, M, +A method.

The database of the remaining files will be specified in the appendix.

3) Calculation of the areas of words, taking into account the widths of the letters and their classification in the second option, indicated in paragraph 2.10;

In the program, this method is denoted as W, M, N.

The calculation of the height of the letter was carried out according to the formula 3.1.

This formula is displayed in fig.3.29.

This method also took into account the spacing between letters in words. The value of the gap between letters in words was taken as the average value of the sum of the average gaps from all four maps (Table 3.4). The space between words is denoted by the letter g.

Table 3.4. Average spacing between letters in words.

Title	Average g, mm	Total average g, mm
Political-Administrative map of the Republic of Belarus	0,342	0,52
Map of the Number, Density and Settlement of the Population of the Republic of Belarus	0,617	
Map of the Religious Communities of the Republic of Belarus	0,454	
Economic Map of the Minsk Region of the Republic of Belarus	0,657	

The width of the letters was calculated using the formulas 2.7 - 2.8. These formulas are displayed in Fig.3.30.

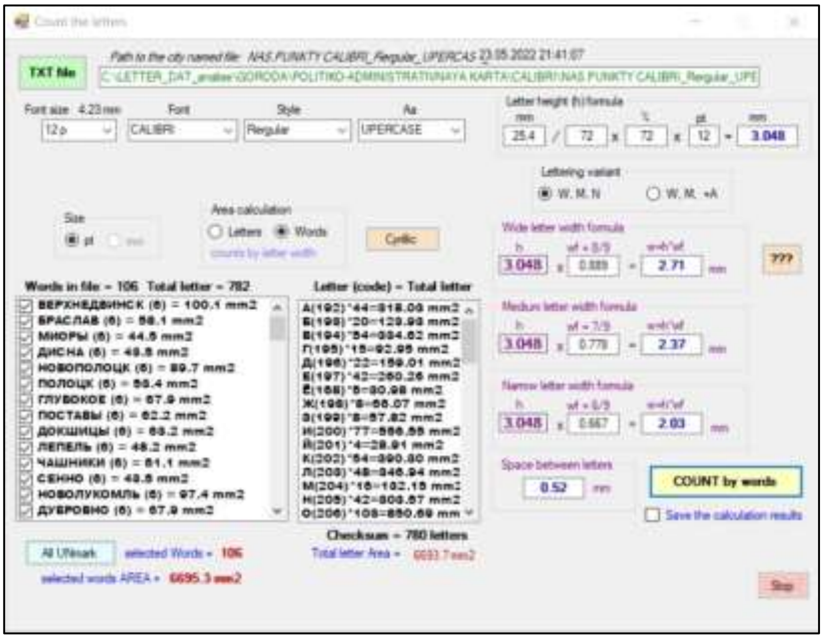
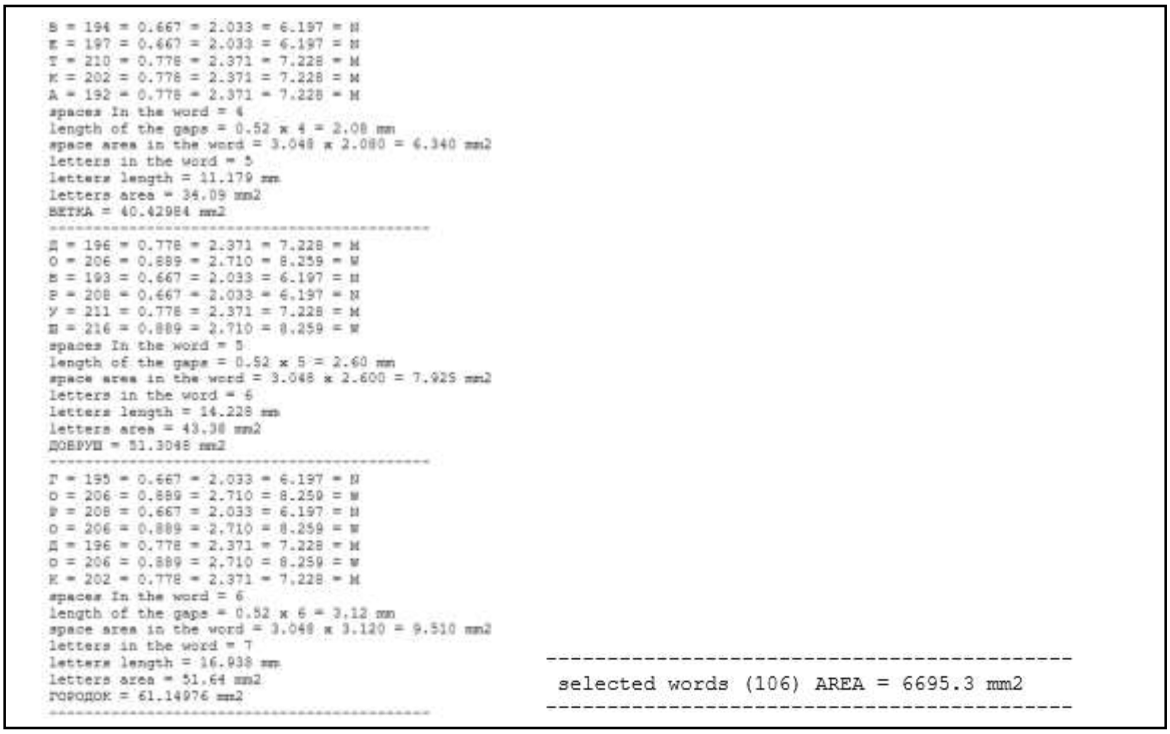


Fig.3.29. Calculation of the area of words by the method W, M, N

The program according to this method takes into account the length of all letters of words, the length of all gaps in a word and their area, and based on all these calculated data, it calculates the area of a word.

First is needed to put a pre-prepared file into the program and it will calculate the entire area of words in this file.

As in the previous method, the program places all the calculated data in a separate file (Fig. 3.30).


```
В = 194 = 0.667 = 2.033 = 6.197 = N
Е = 197 = 0.667 = 2.033 = 6.197 = N
Т = 210 = 0.778 = 2.371 = 7.228 = M
К = 202 = 0.778 = 2.371 = 7.228 = M
А = 192 = 0.778 = 2.371 = 7.228 = M
spaces In the word = 4
length of the gaps = 0.52 x 4 = 2.08 mm
space area in the word = 3.048 x 2.080 = 6.340 mm2
letters in the word = 5
letters length = 11.179 mm
letters area = 34.09 mm2
ВЕТКА = 40.42984 mm2
------------------------------------------------
Д = 196 = 0.778 = 2.371 = 7.228 = M
О = 206 = 0.889 = 2.710 = 8.259 = W
Б = 193 = 0.667 = 2.033 = 6.197 = N
Р = 208 = 0.667 = 2.033 = 6.197 = N
У = 211 = 0.778 = 2.371 = 7.228 = M
Ш = 216 = 0.889 = 2.710 = 8.259 = W
spaces In the word = 5
length of the gaps = 0.52 x 5 = 2.60 mm
space area in the word = 3.048 x 2.600 = 7.925 mm2
letters in the word = 6
letters length = 14.228 mm
letters area = 43.38 mm2
ДОБРУШ = 51.3048 mm2
------------------------------------------------
Г = 195 = 0.667 = 2.033 = 6.197 = N
О = 206 = 0.889 = 2.710 = 8.259 = W
Р = 208 = 0.667 = 2.033 = 6.197 = N
О = 206 = 0.889 = 2.710 = 8.259 = W
Д = 196 = 0.778 = 2.371 = 7.228 = M
О = 206 = 0.889 = 2.710 = 8.259 = W
К = 202 = 0.778 = 2.371 = 7.228 = M
spaces In the word = 6
length of the gaps = 0.52 x 6 = 3.12 mm
space area in the word = 3.048 x 3.120 = 9.510 mm2
letters in the word = 7
letters length = 16.938 mm
letters area = 51.64 mm2
ГОРОДОК = 61.14976 mm2
------------------------------------------------

------------------------------------------
selected words (106) AREA = 6695.3 mm2
------------------------------------------
```

Fig. 3.30. A fragment of the file obtained after calculating the area of the words using the W, M, N. method.

3.5. Font load calculation

The font load was calculated using the formula:

$$F_L = \frac{S_M}{S_W} \qquad (3.2)$$

F_L - map font load

S_M - printed area of the map (mm^2)

S_W - the area of all words in the printed area (mm^2)

Based on the information indicated in paragraph 2.2, the calculation of the maximum, optimal and minimum font load for maps with a scale of 1:1000000 to 1:3000000 with a step of 250000 was carried out (Table 3.5).

Table 3.5. Font load of maps in scale from 1:1000000 to 1:3000000 in increments of 250000.

Scale	Maximum font load (words on dm^2)	Optimal font load (words on dm^2)	Minimum font load (words on dm^2)
1:1000000	300	200	80
1:1250000	280	190	78
1:1500000	260	180	75
1:750000	240	170	73
1:2000000	220	160	70
1:2250000	200	150	68
1:2500000	180	140	65
1:2750000	160	130	63
1:3000000	140	120	60

Using the calculated values obtained by the methods described in paragraph 3.4, Excel tables were created for each of the four studied maps, in which the font load was calculated.

Names	L (mm^2)	W,M,N(mm^2) words	W, M, +A (mm^2) words	FL = SM/SW
Italic senten 11	661.5	1723.6	990.5	0.28739704
Rerg Sent 11	2732	6766.8	3805.2	0.78531722
Rerg Uper 12	2131.1	6695.3	4856.2	0.50076174
Bold Uper 12	117.6	259.2	192.3	
Bold Uper 14	31.8	59.4	42.2	
Sum	5674	15504.3	9886.4	

Fig. 3.31. Calculation of the font load of the Political-Administrative map of the Republic of Belarus (Calibri font).

Names	L (mm^2)	W, M, N (mm^2) words	W, M, +A (mm^2) words	FL = SM/SW
Rerg Uper 12	2131.1	6695.3	4856.2	0.271332755
Italic Sent 11	2503.9	6468.2	3631.8	0.759066052
Italic Sent 11	628.7	1661.3	954.2	0.485046586
Bold Uper 12	117.6	259.2	192.3	
Bold Uper 14	31.8	59.4	42.2	
Sum	5413.1	15143.4	9676.7	

Fig. 3.32. Calculation of the font load of the Map of the Number, Density and Settlement of the Population of the Republic of Belarus (Calibri font).

Names	L (mm^2)	W, M, N (mm^2) words	W, M, +A (mm^2) words	FL = SM/SW
Rerg Sent 11	32.1	72.6	41.7	0.159904373
Rerg Sent 12	531.9	1322.7	727.2	0.458953657
Rerg Uper 12	1797.6	5650.9	4096.1	0.307435824
Italic Sent 11	657.9	1730.5	993.1	
Bold Uper 12	117.6	259.2	192.3	
Bold Uper 14	31.8	59.4	42.2	
Sum	3168.9	9095.3	6092.6	

Fig. 3.33. Calculation of the font load of the Map of the Religious Communities of the Republic of Belarus (Calibri font).

Names	L (mm^2)	W, M, N(mm^2) words	W, M, +A (mm^2) words	FL = SM/SW
Rerg Sent 11	6964.1	17337.4	9734.6	0.286084085
Rerg Uper 12	394	1242.4	910.3	0.726464869
Italic Sent 11	1139.7	3067.4	1732.6	0.416936199
Bold Uper 12	126.9	275.2	196.2	
Bold Uper 14	31.8	59.4	42.2	
Sum	8656.5	21981.8	12615.9	

Fig. 3.34. Calculation of the font load of the Economic Map of the Minsk Region of the Republic of Belarus (Calibri font).

Based on the data from figures (3.31 - 3.34), graphs of font load values were plotted for each method of calculating the area of a word.

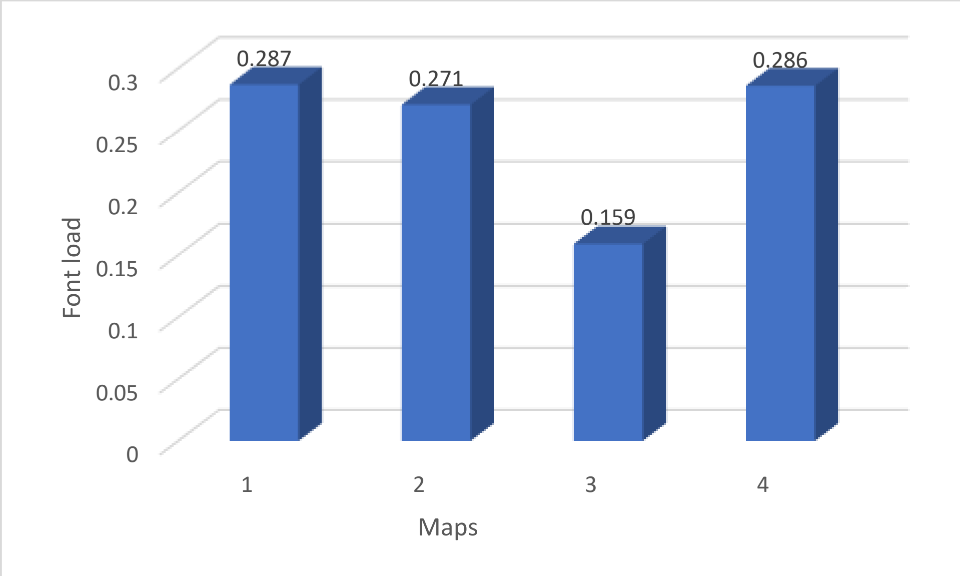


Fig. 3.35. Graph of font load values obtained using the letter-by-letter (calculation by pixels) method for calculating the area of words.

Where

1 - Political-Administrative map of the Republic of Belarus;

2 - Map of the Number, Density and Settlement of the Population of the Republic of Belarus;

3 - Map of the Religious Communities of the Republic of Belarus;

4 - Economic Map of the Minsk Region of the Republic of Belarus.

If we take the maximum value of font load as 0.5, then

1) Political-Administrative map of the Republic of Belarus has the optimal font load according to the method of letter-by-letter (calculation by pixels) calculation of the area of words.

2) Map of the Number, Density and Settlement of the Population of the Republic of Belarus has the optimal font load according to the method of letter-by-letter (calculation by pixels) calculation of the area of words.

3) Map of the Religious Communities of the Republic of Belarus has the minimal font load according to the method of letter-by-letter (calculation by pixels) calculation of the area of words.

4) Economic Map of the Minsk Region of the Republic of Belarus has the optimal font load according to the method of letter-by-letter (calculation by pixels) calculation of the area of words.

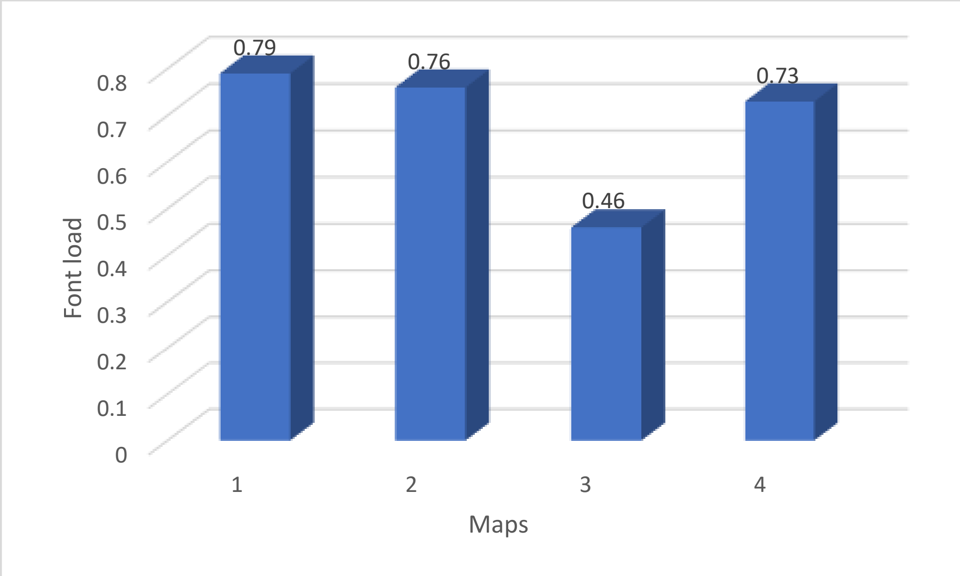


Fig. 3.36. Graph of font load values obtained using the W, M, N method for calculating the area of words.

Where

1 - Political-Administrative map of the Republic of Belarus;

2 - Map of the Number, Density and Settlement of the Population of the Republic of Belarus;

3 - Map of the Religious Communities of the Republic of Belarus;

4 - Economic Map of the Minsk Region of the Republic of Belarus.

If we take the maximum value of font load as 1, then

1) Political-Administrative map of the Republic of Belarus has the maximum font load according to the W, M, N method of calculation of the area of words.

2) Map of the Number, Density and Settlement of the Population of the Republic of Belarus has the maximum font load according to the W, M, N method of calculation of the area of words.

3) Map of the Religious Communities of the Republic of Belarus has the optimal font load according to the W, M, N method of calculation of the area of words.

4) Economic Map of the Minsk Region of the Republic of Belarus has the maximum font load according to W, M, N method of calculation of the area of words.

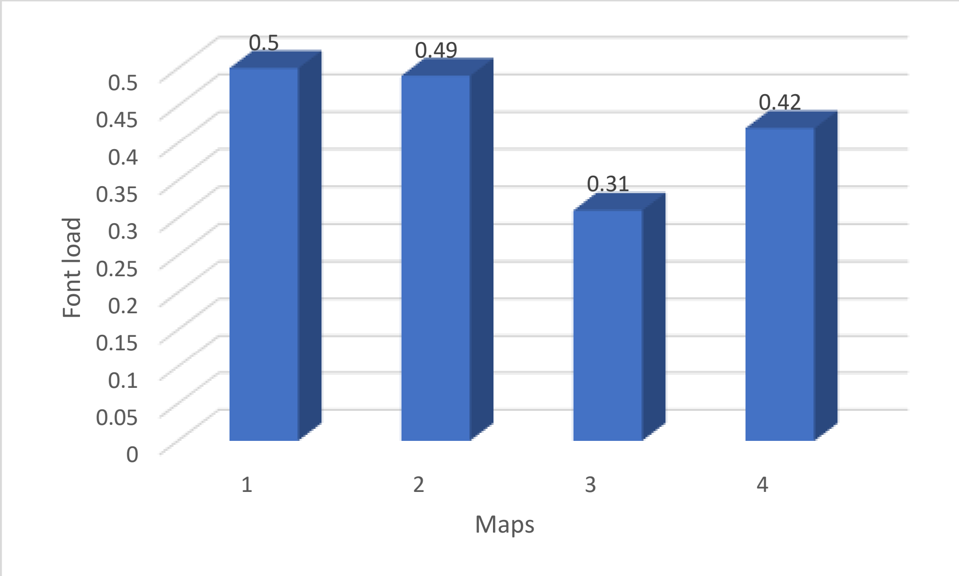


Fig. 3.37. Graph of font load values obtained using the W, M, +A method for calculating the area of words.

Where

1 - Political-Administrative map of the Republic of Belarus;

2 - Map of the Number, Density and Settlement of the Population of the Republic of Belarus;

3 - Map of the Religious Communities of the Republic of Belarus;

4 - Economic Map of the Minsk Region of the Republic of Belarus.

If we take the maximum value of font load as 1, then

1) Political-Administrative map of the Republic of Belarus has the optimal font load according to the W, M, +A method of calculation of the area of words.

2) Map of the Number, Density and Settlement of the Population of the Republic of Belarus has the optimal font load according to the W, M, +A method of calculation of the area of words.

3) Map of the Religious Communities of the Republic of Belarus has the minimal font load according to the W, M, +A method of calculation of the area of words.

4) Economic Map of the Minsk Region of the Republic of Belarus has the optimal font load according to the W, M, +A method of calculation of the area of words.

Names	L (mm^2)	W, M, N (mm^2) words	W, M, +A (mm^2) words	FL = SM/SW
Rerg Sent 11	654	1723.6	990.5	0.285522931
Rerg Sent 11	2705	6766.8	3805.2	0.785317223
Rerg Uper 12	2173.5	6695.3	4856.2	0.500761736
Rerg Uper 12	82.2	259.2	192.3	
Rerg Uper 14	22.3	59.4	42.2	
Sum	5637	15504.3	9886.4	

Fig. 3.38. Calculation of the font load of the Political-Administrative map of the Republic of Belarus (Times New Roman font).

Names	L (mm^2)	W, M, N(mm^2) words	W, M, +A (mm^2) words	FL = SM/SW
Rerg Sent 11	2603.6	6468.2	3631.8	0.275673598
Rerg Uper 12	2173.5	6695.3	4856.2	0.759066052
Rerg Sent 11	618.1	1661.3	954.2	0.485046586
Rerg Uper 12	82.2	259.2	192.3	
Rerg Uper 14	22.3	59.4	42.2	
Sum	5499.7	15143.4	9676.7	

Fig. 3.39. Calculation of the font load of the Map of the Number, Density and Settlement of the Population of the Republic of Belarus (Times New Roman font).

Names	L (mm^2)	W, M, N (mm^2) words	W, M, +A (mm^2) words	FL = SM/SW
Rerg Sent 11	33.1	72.6	41.7	0.15855203
Rerg Sent 12	520.1	1322.7	727.2	0.45895366
Rerg Uper 12	1839	5650.9	4096.1	0.30743582
Rerg Sent 11	645.4	1730.5	993.1	
Rerg Uper 12	82.2	259.2	192.3	
Rerg Uper 14	22.3	59.4	42.2	
Sum	3142.1	9095.3	6092.6	

Fig. 3.40. Calculation of the font load of the Map of the Religious Communities of the Republic of Belarus (Times New Roman font).

Names	L (mm^2)	W, M, N(mm^2) words	W, M, +A (mm^2) words	FL = SM/SW
Rerg Sent 11	6891.3	17337.4	9734.6	0.283000663
Rerg Uper 12	395.8	1242.4	910.3	0.726464869
Rerg(hidr) Sent 11	1166	3067.4	1732.6	0.416936199
Rerg Uper 12	87.8	275.2	196.2	
Rerg Uper 14	22.3	59.4	42.2	
Sum	8563.2	21981.8	12615.9	

Fig. 3.41. Calculation of the font load of the Economic Map of the Minsk Region of the Republic of Belarus (Times New Roman font).

Comparing the values of the font weights of maps compiled using the Calibri font and the Times New Roman font, I can say that the values of the font weight turned out to be the same.

I can say that such a similarity will not always be, because when analyzing the letters of the Times New Roman font and the Calibri font, it was noticed that some letters have a large difference in the occupied area. Therefore, such a similarity can be obtained if the names are dominated by letters that are similar in terms of space occupied in these two fonts.

Having calculated the font load of the map according to the method specified in paragraph 2.2, table 3.6 was compiled.

Table 3.6. Calculation of the font load of maps according to the method from paragraph 2.2.

Title	Scale	Words on dm^2	Words on cm^2	Maximum load	Optimal load	Minimal load
Political and Administrative map of Belarus	1:2500000	137	1.37		+	
Population map of Belarus	1:3000000	131	1.31	+		
Map of the confessional population of Belarus	1:3000000	77	0.77			+
Economic map of Minsk region	1:1250000	124	1.24		+	

Comparing the methodology developed in the course of this master's work with the methodology described in paragraph 2.2. I can say that the developed technique is not inferior to the technique described in paragraph 2.2 of this work. On the contrary, it is more accurate, since it uses a letter-by-letter calculation(calculation by pixels) of areas, takes into account the spaces between letters in words, as well as the length of the entire word.

CONCLUSIONS

As a result of the work carried out, I can draw the following conclusions.

1) A review of the literature and articles on the calculation of the graphic and font loads of maps was carried out. Based on the results of this review, it was noted that when calculating the font load of maps, the areas occupied by words are found, which means that the area next to the letter is taken into account, which is not an entirely accurate method, since it does not take into account the area of each letter separately, as well as the spaces between letters in words.

2) A methodology has been developed for calculating the font load of maps, which includes a letter-by-letter calculation (calculation by pixels) of the areas of words, as well as two methods for calculating the areas of words, taking into account the height of the letters, the spaces between the letters in the words and the length of the word.

3) The selection of data for the study of the developed methodology was carried out. Four thematic maps were selected from the atlas of the geography of Belarus for the 10th grade.

4) A database was created of the areas of all letters of the Russian alphabet, both lowercase and uppercase, written in Calibri font in size 8, 10, 11, 12, 14 points, using bold, ordinary, italic and bold italic writing styles. A database of all letters of the Russian alphabet, both lowercase and uppercase, was also created, written in Times New Roman font in sizes 11, 12 and 14 points, using an ordinary writing style. The database was created in excel files in the amount of 21 files in the Calibri font and in the amount of 5 files in the Times New Roman font.

5) A database has been created of all the names present on the studied maps, classified by the type of names, the way of writing and the font used in writing. The database was created in txt format files in the amount of 25 pieces in the Calibri font and in the amount of 21 pieces in the Times New Roman font. The total number of inscriptions on all maps was 1059 words.

6) The method of letter-by-letter calculation (calculation by pixels) of the areas of words is the most suitable when compiling digital maps. And two methods for calculating the areas of words, taking into account the height of letters, the spaces between letters in words, and the length of a word, are suitable for compiling both digital and printed versions of maps.

7) The developed method of font loading of maps was tested. Based on the results of its verification, I can say that it is not inferior to existing methods, but on the contrary, it is more accurate, since it uses a letter-by-letter calculation (calculation by pixels) of areas, takes into account spaces between letters in words, as well as the length of the entire word.

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SUMMARY

Viachaslau Alifirenka

Methodology for calculating the information(font) load of thematic maps on the example of Belarusian maps.

In this master's thesis, literature sources on the properties of cartographic fonts, signs of cartographic fonts, features of placing inscriptions on a map, classification of cartographic fonts, and features of the letters of the Russian alphabet were studied. Scientific articles were also studied, the object of study of which was the graphic and text load of maps. After studying this literature, I came to the conclusion that it is necessary to improve the method for calculating the font load of maps.

In the course of the work, four thematic maps were selected from the atlas of the geography of Belarus for grade 10, a database of all names was created, the maps studied were classified according to the types of names, the fonts used to write them, the ways they were written: using uppercase, lowercase and a combination of uppercase and lowercase letters, their writing styles: regular, bold, italic, bold italic. The total number of inscriptions on all maps was 1059 words.

A unique database of areas of letters of the Russian alphabet was created, written using the Calibri font of size 8, 10, 11, 12, 14 points, using the usual, bold, italic, bold italic style of writing them. A database was created of the areas of the letters of the Russian alphabet written using the Times New Roman font of size 11, 12, 14 points, using the usual style of writing.

A methodology has been developed for calculating the font load of maps, which includes a letter-by-letter calculation (calculation by pixels) of the areas of words, as well as two methods for calculating the areas of words, taking into account the height of the letters, the spaces between the letters in the words and the length of the word.

The developed method of font loading of maps was tested. Based on the results of its verification, I can say that it is not inferior to existing methods, but on the contrary, it is more accurate, since it uses a letter-by-letter calculation (calculation by pixels) of areas, takes into account spaces between letters in words, as well as the length of the entire word.

I can say that the method of letter-by-letter calculation (calculation by pixels) of the areas of words is the most suitable when compiling digital maps. And two methods for calculating the areas of words, taking into account the height of letters, the spaces between letters in words, and the length of a word, are suitable for compiling both digital and printed versions of maps.

The developed methodology is promising for use in compiling any type of maps, both digital and printed.

Keywords: Information load, font load, graphics load, thematic maps, graphics load calculation method, font load calculation method, calculation method, thematic maps, Belarusian maps, Russian alphabet, font, letters, square.

SANTRAUKA

Viachaslau Alifirenka

Teminių žemėlapių informacijos (šrifto) apkrovos skaičiavimo metodika Baltarusijos žemėlapių pavyzdžiu.

Šiame magistro darbe buvo nagrinėjami literatūros šaltiniai apie kartografinių šriftų savybes, kartografinių šriftų ženklus, užrašų išdėstymo žemėlapyje ypatumus, kartografinių šriftų klasifikaciją, rusiškos abėcėlės raidžių ypatybes. Taip pat buvo tiriami moksliniai straipsniai, kurių tyrimo objektas buvo žemėlapių grafinis ir tekstinis krūvis. Išstudijavus šią literatūrą, priėjau išvados, kad būtina tobulinti žemėlapių šrifto apkrovos skaičiavimo metodą.

Darbo metu iš Baltarusijos geografijos atlaso 10 klasei buvo atrinkti keturi teminiai žemėlapiai, sukurta visų vardų duomenų bazė, tirti žemėlapiai suskirstyti pagal vardų rūšis, šriftus, kuriais jie rašomi, jų rašymo būdai: naudojant didžiąsias, mažąsias ir didžiųjų bei mažųjų raidžių derinį, jų rašymo stiliai: įprastas, paryškintas, kursyvas, paryškintas kursyvas. Bendras užrašų skaičius visuose žemėlapiuose buvo 1059 žodžiai.

Sukurta unikali rusiškos abėcėlės raidžių sričių duomenų bazė, parašyta naudojant 8, 10, 11, 12, 14 taškų dydžio šriftą Calibri, naudojant įprastą, paryškintą, kursyvą, paryškintą kursyvą jų rašymo stilių. Sukurta rusiškos abėcėlės raidžių, parašytų 11, 12, 14 taškų Times New Roman šriftu, įprastu rašymo stiliumi, plotų duomenų bazė.

Sukurta žemėlapių šrifto apkrovos skaičiavimo metodika, kuri apima žodžių plotų skaičiavimą po raidę (skaičiavimą pikseliais), taip pat du žodžių plotų skaičiavimo būdus, atsižvelgiant į aukštį. raidžių, tarpai tarp raidžių žodžiuose ir žodžio ilgis.

Buvo išbandytas sukurtas žemėlapių šriftų įkėlimo metodas. Remdamasis jo patikrinimo rezultatais, galiu pasakyti, kad jis nėra prastesnis už esamus metodus, o, priešingai, yra tikslesnis, nes naudoja plotų skaičiavimą raidėmis (skaičiuojama pikseliais), įtraukia į sąskaitos tarpai tarp raidžių žodžiuose, taip pat viso žodžio ilgis.

Galiu pasakyti, kad sudarant skaitmeninius žemėlapius tinkamiausias žodžių plotų skaičiavimo po raidės (skaičiavimas pikseliais) metodas. O du žodžių plotų skaičiavimo būdai, atsižvelgiant į raidžių aukštį, tarpus tarp raidžių žodžiuose ir žodžio ilgį, tinka tiek skaitmeninei, tiek spausdintinei žemėlapių versijai sudaryti.

Sukurta metodika yra perspektyvi naudoti rengiant bet kokio tipo žemėlapius – tiek skaitmeninius, tiek spausdintus.

Raktiniai žodžiai: Informacijos įkėlimas, šrifto įkėlimas, grafikos įkėlimas, teminiai žemėlapiai, grafikos apkrovos skaičiavimo metodas, šrifto apkrovos skaičiavimo metodas, skaičiavimo metodas, teminiai žemėlapiai, baltarusių žemėlapiai, rusiška abėcėlė, šriftas, raidės, kvadratas.

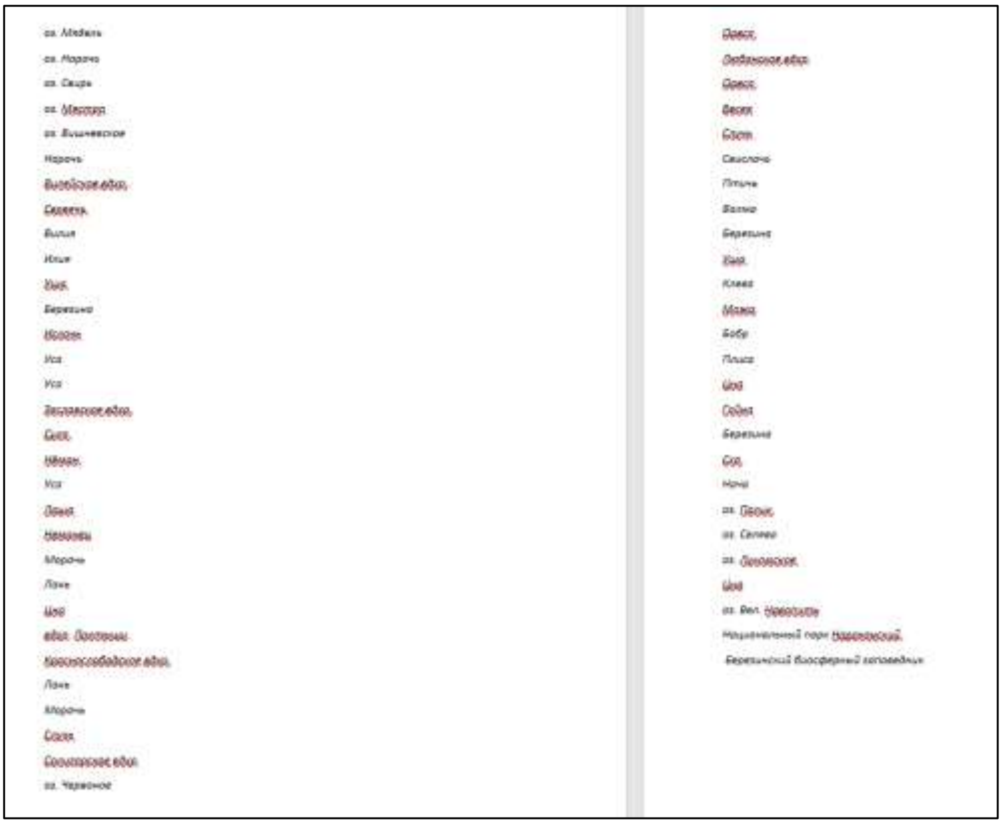
ANNEXES

The entire database of words and letters is placed in the digital format of the master's thesis.

Annex 1

МЯДЕЛЬ
ВИЛЕЙКА
ЛОГОЙСК
КРУПКИ
СМОЛЕВИЧИ
ВОЛОЖИН
БЕРЕЗИНО
ДЗЕРЖИНСК
ЧЕРВЕНЬ
СТОЛБЦЫ
ФАНИПОЛЬ
ЗАСЛАВЛЬ
УЗДА
МАРЬИНА ГОРКА
НЕСВИЖ
КОПЫЛЬ
КЛЕЦК
СЛУЦК
СТАРЫЕ ДОРОГИ
ЛЮБАНЬ

A.1. City names written in capital letters in size 12 Calibri font.



A.2. Hydronyms written with a combination of uppercase and lowercase letters in Calibri font size 11 in italics.

оз. Освейское
оз. Дривяты
Дрыса
Дисна
Зап. Двина
Улла
Березина
Вилия
оз. Нарочь
Вилейское вдхр.
Днепр
Птичь
Нёман
Друть
Сож
Беседь
Ипуть
Припять
Уборть
Моства
Ствига
Стыр
Ясельда
Зап. Буг

A.3. Hydronyms written with a combination of uppercase and lowercase letters in Times New Roman size 11.

МЯДЕЛЬ	СТОЛБЦЫ
ДОКШИЦЫ	УЗДА
ЛЕПЕЛЬ	МАРЬИНА ГОРКА
ЧАШНИКИ	ОСИПОВИЧИ
НОВОЛУКОМЛЬ	ЧЕРВЕНЬ
СЕННО	СМОЛЕВИЧИ
СМОРГОНЬ	БЕРЕЗИНО
ОШМЯНЫ	КЛИЧЕВ
ВИЛЕЙКА	БЫХОВ
МОЛОДЕЧНО	ЧАУСЫ
ВОЛОЖИН	СЛАВГОРОД
ЗАСЛАВЛЬ	КРИЧЕВ
ЛОГОЙСК	МСТИСЛАВЛЬ
ЖОДИНО	ЧЕРИКОВ
БОРИСОВ	КЛИМОВИЧИ
КРУПКИ	КОСТЮКОВИЧИ
ТОЛОЧИН	СВИСЛОЧЬ
ШКЛОВ	ВОЛКОВЫСК
БАРАНЬ	СЛОНИМ
ОРША	БАРАНОВИЧИ
ДУБРОВНО	ЛЯХОВИЧИ

A.4. City names in Times New Roman size 12 capital letters.

Annex 5

ВИТЕБСК

МОГИЛЁВ

ГРОДНО

БРЕСТ

ГОМЕЛЬ

A.5. The names of the regional capitals are written in Calibri font size 12 in capital letters in bold style.

Россоны

Ушачи

Шумилино

Бешенковичи

Лиозно

Островец

Вороново

Круглое

Белыничи

Дрибин

Корма

Краснополье

Хотимск

Кореличи

Зельва

Бол.Берестовица

Лельчицы

Брагин

Лоев

Октябрьский

Глуск

A.6. City names written in Calibri 12 size font in uppercase and lowercase letters.

Letters	Area background mm^2	Area letter mm^2	Average mm^2
А	2.39	2.27	2.33
Б	2.65	2.59	2.62
В	3.35	3.16	3.255
Г	1.28	1.25	1.265
Д	3.74	3.56	3.65
Е	2.24	2.2	2.22
Ё	1.7	1.64	1.67
Ж	3.92	3.74	3.83
З	2.34	2.23	2.285
И	3.37	3.24	3.305
Й	2.39	2.21	2.3
К	2.62	2.48	2.55
Л	2.31	2.22	2.265
М	4.44	4.2	4.32
Н	2.91	2.75	2.83
О	3.23	3.1	3.165
П	2.61	2.49	2.55
Р	2.06	1.95	2.005
С	3.02	2.84	2.93
Т	1.61	1.57	1.59
У	2.1	1.92	2.01
Ф	3.21	3.04	3.125
Х	2.58	2.42	2.5
Ц	3.23	3.09	3.16

A.7. Square capital letters written in Calibri 12 size italic style.

Letters	Area background mm^2	Area letter mm^2	Average mm^2	AVERAGE SUM/33
а	5.16	5.01	5.085	4.808636
б	3.18	3.03	3.105	
в	5.47	5.28	5.375	
г	2.89	2.99	2.94	
д	4.2	4.17	4.185	
е	4.98	4.8	4.89	
ё	3.17	3.03	3.1	
ж	7.44	7.19	7.315	
з	4.5	4.25	4.375	
и	5.78	5.93	5.855	
й	3.53	3.58	3.555	
к	5.04	4.82	4.93	
л	5.07	4.93	5	
м	7.69	7.42	7.555	
н	5.07	5.07	5.07	
о	5.04	4.9	4.97	
п	5.21	5.29	5.25	
р	3.46	3.42	3.44	
с	4.3	4.09	4.195	
т	3.19	3.25	3.22	
у	2.66	2.54	2.6	
ф	3.11	3.03	3.07	
х	4.67	4.46	4.565	
ц	3.03	3.1	3.065	
ч	3.88	3.8	3.84	
ш	7.64	7.73	7.685	

A.8. Squares of lowercase letters written in Calibri font size 12 in bold style

Letters	Area background mm^2	Area letter mm^2	Average mm^2	AVERAGE SUM/33
а	4.71	4.51	4.61	4.070606
б	2.59	2.46	2.525	
в	4.52	4.35	4.435	
г	3.44	3.25	3.345	
д	2.81	2.69	2.75	
е	4.23	4.05	4.14	
ё	2.81	2.68	2.745	
ж	7.07	6.79	6.93	
з	3.92	3.72	3.82	
и	3.47	3.33	3.4	
й	2.76	2.6	2.68	
к	4.27	4.07	4.17	
л	3.27	3.09	3.18	
м	6.17	5.86	6.015	
н	4.81	4.56	4.685	
о	4.19	4.03	4.11	
п	4.51	4.34	4.425	
р	2.77	2.68	2.725	
с	3.35	3.22	3.285	
т	7.31	7	7.155	
у	2.06	1.97	2.015	
ф	2.79	2.67	2.73	
х	2.87	2.72	2.795	
ц	2.99	2.86	2.925	
ч	3.34	3.17	3.255	
ш	7.49	7.09	7.29	

A.9. Squares of lowercase letters written in Calibri font size 11 in bold style.

Letters	Area background mm^2	Area letter mm^2	Average mm^2	AVERAGE SUM/33
А	2.12	1.97	2.045	2.861212121
Б	2.9	2.77	2.835	
В	3.92	3.56	3.74	
Г	1.86	1.83	1.845	
Д	2.95	2.81	2.88	
Е	2.47	2.48	2.475	
Ё	1.74	1.65	1.695	
Ж	4.24	3.91	4.075	
З	2.42	2.22	2.32	
И	3.4	3.37	3.385	
Й	2.26	2.23	2.245	
К	2.83	2.78	2.805	
Л	2.47	2.33	2.4	
М	3.97	3.74	3.855	
Н	3.25	3.27	3.26	
О	2.95	2.79	2.87	
П	3.01	2.98	2.995	
Р	2.38	2.29	2.335	
С	2.09	1.96	2.025	
Т	1.74	1.7	1.72	
У	1.76	1.62	1.69	
Ф	3.64	3.4	3.52	
Х	2.72	2.57	2.645	
Ц	2.93	2.92	2.925	
Ч	2.48	2.33	2.405	
Ш	4.6	4.3	4.45	

A.10. Squares of capital letters written in Times New Roman font size 12.