Methodology of Evaluation of the National Geodetic and Cartographic Resource

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SUMMARY

In the paper there were specified the organizational structures of the geodetic and cartographic resource. There were provided basic rules of resource valuation concentrating on utilization of the cost-based method. There were specified basic algorithms of establishing a value of different types of geodetic and cartographic documentation that the resource is comprised of. Implementation works that have been carried out on experimental objects enabled to estimate initially the value of the national geodetic and cartographic resource at €5.2 billion.

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1. INTRODUCTION

Collections of maps as well as photogrammetric, remote sensing materials, registers, computer databases and other elaborations created as a result of geodetic and cartographic works are stored in the national geodetic and cartographic resource. This collection of documents can be compared to a huge library which contains, instead of works of writers and publicists, the results of work of surveyors, cartographs, computer scientists and soil specialists, connected with providing data and information on all phenomena that happen on the surface of Earth.
These data, collected for years, represent a great value as a result of work of many specialists who obtained, collected and converted information into data sets which now serve the society.
The market economy is always accompanied by the conception of value which determines the economic purpose of all economic decisions taken. The legal regulations binding in Poland state that the aforementioned collections of data and information are the property of the National Treasure, and the register of its assets is value-based.
As a result of these facts there has been prepared a methodology of establishing a value of the geodetic and cartographic resource.

2. ORGANIZATIONAL STRUCTURES OF THE NATIONAL GEODETIC AND CARTOGRAPHIC RESOURCE

The national geodetic and cartographic resource is divided into three groups: the central resource, regional (voivodship) resources and district resources. The organizational structure of geodetic and cartographic resource is given in Figure 2-1.

Division of the national geodetic and cartographic resource		
Central resource (1)	Regional (voivodship) resources (1-16)	District resources (1-378)
Organizational units maintaining the resource		
Head Surveyor of the Country	Marshalls of Voivodships	District Chief Officials

Figure 2-1. Organizational structure of the national geodetic and cartographic resource

2.1 Central Resource

The central resource is collected with division into assortment groups containing: materials concerning geodetic, gravimetric and magnetic control networks, documents of astronomic, satellite, gravimetric and magnetic measurements, topographic elaborations, photomaps and

orthophotomaps of national importance, geodetic and cartographic documents regarding measurements of state and voivodships' borders, national register of borders including their description, register of areas of the fundamental territorial division units and thematic elaborations of national-wide importance.
The central resource is maintained by a specialized unit – the Central Office of Geodetic and Cartographic Documentation subordinate to the Head Surveyor of the Country.

2.2 Regional (Voivodship) Resources

The voivodship resources are composed of materials of voivodship-wide importance, such as: photomaps and orthophotomaps, voivoship databases of the country terrain information system, thematic elaborations of regional importance, geodetic and cartographic documents concerning specialized elaborations of voidvodship-wide importance.
Voivodship resources are maintained by voivodship centres of geodetic and cartographic documentation subordinate to marshalls of voivodships. Professional supervision is provided by head surveyors of voivodships.

2.3 District Resources

District resources are composed of: the cadastre, the base map, the cadastre of land infrastructure network, geodetic and cartographic documents concerning measurement and description of borders of districts and participating municipalities, photomaps and orthophotomaps of district importance, geodetic documentation connected concerning consolidation works, district databases of the country terrain information system, thematic elaborations of district-wide importance.
District resources are maintained by district centres of geodetic and cartographic documentation subordinate to district chief officials. Professional supervision is provided by district head surveyors.

3. BASIC RULES OF VALUATING OF THE GEODETIC AND CARTOGRAPHIC RESOURCE

3.1 Establishing of a Value of the Resource Basing on the Capitalized Profits Netto

In the first stage of research there was considered an idea of establishing the resource value basing on the capitalized income netto. The income is made up of fees that clients obtaining geodetic and cartographic materials (maps, lists of coordinates, cadastral data, data on transactional values of properties, etc.) are charged with.
Therefore there has been performed an inquiry into:
- amount of income from enabling access to geodetic and cartographic materials
- costs of purchase of materials, salaries of employees of the units maintaining the resources (central, voivodship and district)

The value of operational profit netto was established using the following equation.

$$D_j = \sum_i P_{i,j} - K_j \tag{3.1}$$

where
D_j – operational profit netto of the j-th type of resource (district, voivodship, central)
$P_{i,j}$ – income of units maintaining the resource from distribution of the *i*-th type of materials collected in the j-th type of resource
K_j – operational costs of the *j*-th type of unit maintaining central, voivodship or district resource
i – type of geodetic and cartographic documents sold to clients
j – type of resource (central, voivodship, district)
According to the investigation carried out, it turned out that the value $D_j < 0$. A conclusion is that the incomes are not greater or even equal to the expenditures associated with costs K_j that are composed of: employees' salaries, maintenance and furnishing of the j-th centre of geodetic and cartographic documentation, costs of purchase of materials, rental fees and others.
Due to the fact that operational profit netto D_j (eq. 3.1) is lower than 0 ($D_j < 0$) there was no possibility of establishing market value of geodetic and cartographic resource using the method discussed. The reason for the fact that the operational profit netto $D_j < 0$ are the rules of calculating fees for distribution of materials and information from the resource. These fees are set administratively. The current fees were introduced by the Ministry of Infrastructure in 2004.
Summarizing, in the course of the research carried out it was established that the organization of maintenance and distribution of the national geodetic and cartographic resource in our country does not fulfill the criteria of the capital-based formula and the profit approach cannot be applied for valuation of the geodetic and cartographic resource.

3.2 Establishing of Value of the National Geodetic and Cartographic Resource Basing on the Cost-based Formula

The considerations from p. 3.2 proved, that the profit-based formula cannot be used to valuate the resource due to specific economic and organizational preconditions. Therefore it is proposed to compute value of the resource using the method of replacement costs.
Moreover, when utilizing this method for resource valuation, it is also proposed to establish costs of replacement of the assortments existing in the resource by the ones having the same functions and similar utilization parameters but produced using currently used technologies and materials.

Using the proposed methodology of valuation there would be established a reconstruction value of different assortments constituting the resource. The reconstruction value is in fact a sum of necessary expenses (costs) that should be paid on the date of valuation in order to create a replica of the valuated assortment (regarding both the form of valuated document and the technology of its production) taking into consideration its deterioration – namely the loss of utilitarian and physical value.
Performing an evaluation of the national geodetic and cartographic resource basing on the formula presented requires completing of the following steps:

- identification of types of assortments of the national geodetic and cartographic resource,
- specification of number of units,
- evaluation of the cost of production of a single unit from the given assortment,
- establishing of a level of deterioration of the assortment's utilitarian value.

Applying this rules a value of the j-th assortment of the resource is given by the equation:

$$W_j = n \cdot C \cdot k_1 \cdot k_2 \tag{3.2}$$

where:
W_j – reconstruction value of j-th type of the resource assortments,
n – number of units of this assortment (points, hectares, kilometers, parcels, map sections, lists) established in the process of assortment identification,
C – cost of production of a unit using current technologies,
k_1 – coefficient denoting "technical deterioration" of materials of the j-th assortment due to the lack of updating on the date of valuation
k_2 – coefficient denoting "technical-technological deterioration" of existing materials (precision of elaborations, analog data, physical deterioration, etc.)
Let us now consider the rules of establishing parameters from eq. 3.2

4. PRODUCTION COSTS OF A UNIT OF THE GIVEN RESOURCE ASSORTMENT

The source of information for the cost of production of a unit are the data from tenders in the area that is subject to valuation (district – for district resource; voivodship – for voivodship resource; country – for the central resource).
It is worthwhile to establish unit prices in a specified time period, e.g. the last 5 years, for computation of a coefficient of price change. This enables to specify the expected unit production cost on the date of valuation.
In such case a unit production cost on the date of valuation is computed using the equation:

$$C_{DW} = C_p \cdot (1 + R \cdot t_1) \tag{4.1}$$

where:
C_{DW} – cost of unit production on the date of valuation
C_p – initial costs of unit production adopted for calculations. The initial costs equal to:
– actual unit costs of production of the given assortment on the date of its production, or
– actual unit costs of production of the given assortment in the last years before valuation (e.g. 3-5 years).
R – coefficient of price change
t_1 – number of months between the date of valuation and the date established for the initial costs (C_p)
The coefficient of price change is computed using the equation:

$$R = \frac{C_p - C_w}{C_w \cdot t_i} \tag{4.1a}$$

where:
R – coefficient of price change

C_p – mean unit prices obtained in tenders in a later year (closer to the date of resource valuation)
C_w – mean unit prices obtained in tenders in an earlier year (further off from the date of resource valuation)
t_i – time intervals expressed as a number of months between the moments of acquisition of prices from the geodetic works' market (corresponding to the earlier price C_w and the later price C_p)
If there is a large amount of data available on the prices of production of the given resource assortments in the given period of time (4-5 years), one can use statistical methods of computing either linear or non-linear trend of prices' change.
Mathematically the linear trend can be expressed as a linear function *f(t)*:

$$f(t) = a \cdot t + b \tag{4.1b}$$

Parameters *a* and *b* can be computed using the data samples of production prices for a given assortment in time (the least squares method can be utilized for example). Then the unit price C_d can be computed on the given date of valuation.

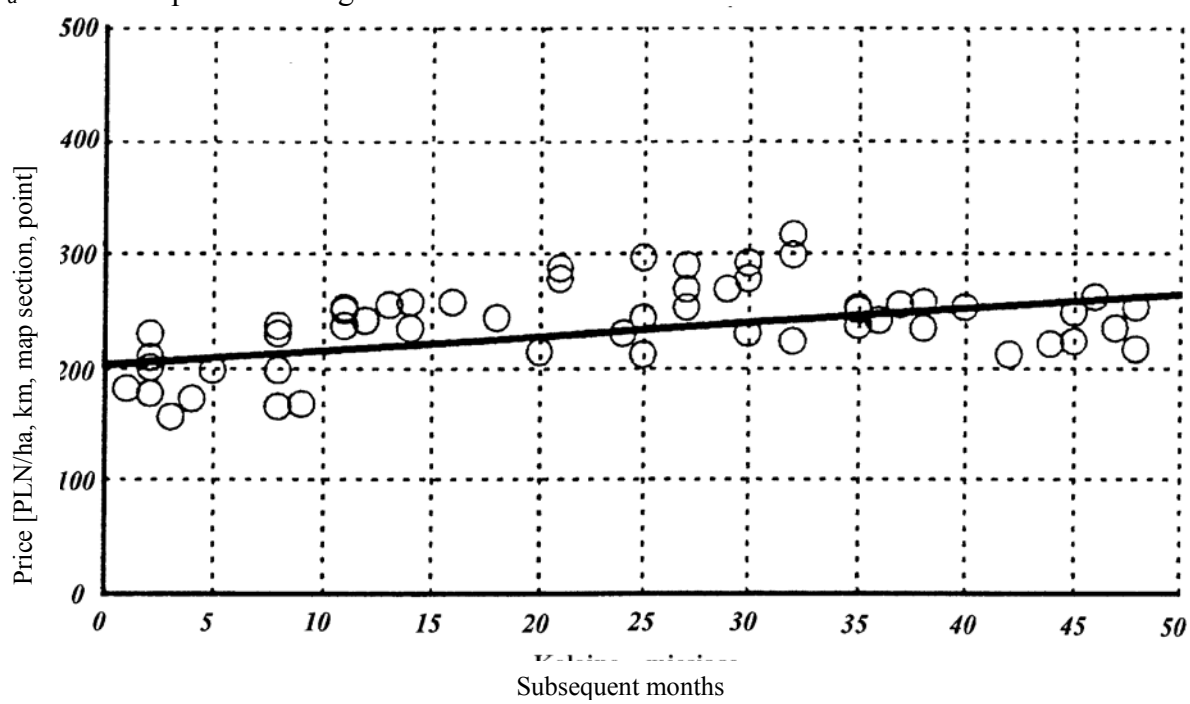

Figure 4-1. Prices of geodetic works – linear trend

5. TECHNICAL DETERIORATION OF RESOURCE MATERIALS DUE TO LACK OF UPDATING ON THE DATE OF VALUATION (COEFFICIENT k_1)

Outdatedness of the materials existing in the resource is a common phenomenon resulting from progressing social-economic development of the country. However, the level of outdatedness is different with respect to specific materials that can be found in the resource.
The level of outdatedness depends on:
– binding legal regulations enforcing maintenance of specific types of materials up-to-date,

– type of terrain that the materials collected in the resource refer to (city areas, urban-agricultural areas, agricultural and forest areas).

The legal regulations binding in Poland oblige to maintain up-to-date specific types of geodetic and cartographic documentation. This concerns the following documentation: geodetic, gravimetric and magnetic control networks, the cadastre and the base map. With reference to these kinds of documentation a value of the coefficient k_1 (eq. 3.2) should be close to one ($0.9 \leq k_1 \leq 1.0$). Values of this coefficient lower than 1.0 would be the result of a delay caused by the lack of financial resources necessary for keeping the documents mentioned up-to-date. This concerns especially the cadastre and the base map. A basis for establishing the value of k_1 coefficient was formed by investigations carried out in randomly selected areas.

With reference to the rest of resource documents the value of k_1 coefficient is established taking into account the type of documentation, date of its preparation as well as results of investigations in chosen areas.

6. TECHNICAL-TECHNOLOGICAL DETERIORATION OF EXISTING ELABORATIONS

The technical-technological deterioration of materials existing in the resource is the result of legal regulations as well as technical standards (technical instructions) binding in the period of their production. The evaluation of technical-technological deterioration of a given assortment of the resource (coefficient k_2 in eq. 3.2) is performed taking into consideration precision characteristics of elaborations as well as data storage format (analog, digital).

Currently obliging, according to the binding legal regulations, is the digital data storage. Thus, when evaluating the resource materials, the evaluation of amount of costs necessary to convert analog data into digital, would have assigned a significant weight during k_2 coefficient computation.

A value of k_2 coefficient would depend on the precision characteristics of the elaboration and the form of map storage (analog, digital) according the following equation:

$$k_2 = \frac{C_1}{C_1 + C_2} \tag{6.1}$$

where:
C_1 – cost of production of a single unit of a given type of assortment e.g. the base map, the cadastral map in digital format, extrapolated to the date of valuation
C_2 – costs of transformation form analog data into digital data and of production of the digital base map, the digital cadastral map etc.

In the eq. 6.1 some simplification was assumed. C_1 parameter value was defined as a production cost of a single unit of a given assortment in digital format instead of analog format. This is due to the possible difficulties that could arise when trying to establish unit

costs of elaborations in the analog format, which virtually do not exist on the market of tenders and orders.

7. ESTABLISHING VALUE OF UNIQUE GEODETIC DOCUMENTATION

The unique character is associated with elaborations that were produced once and are not repeated as a rule. These elaborations consist of: documentation of establishment of the EUREF-POL and POLREF networks, basic vertical class I control networks, documentation of connectivity of the basic vertical class I control network with levelling lines of neighboring countries, the network of automatic tide gauges, gravimetric control networks, calibration bases, documentations concerning absolute measurements of gravity force acceleration in absolute points, documentations concerning magnetic control network, systems of central banks of horizontal and vertical control networks and others.

Value of these documentations is established based on the original costs of their production corrected using the price change coefficients provided by the Central Statistical Office.
Value of this type of documentation is calculated using the equation:

$$W_i = (\sum_{r1} K_{Ni.r1} \cdot \frac{a_{kr.j}}{b_{kr.r1}} + \sum_{r2} K_{Ti.r2} \cdot \frac{a_{kr.j}}{c_{kr.r2}}) \cdot n \qquad (7.1)$$

where:
W_i – value of the *i*-th type of documentation
$K_{Ni.r1}$ – costs of analyses and research connected with the preparation of a project for producing *i*-th type of documentation in year *r1* per unit (point, object, databank etc.)
$a_{kr.j}$ – coefficient of increase of goods' and services' prices in the *j*-th year of valuation according to the Central Statistical Office data
$b_{kr.r1}$ – coefficient of increase of goods and services prices in the *r1*-th year of performing analyses and research connected with preparation of the project
$K_{Ti.r2}$ – costs associated with the implementation of the project for producing *i*-th type of documentation in the *r2*-th year of technical execution per unit (point, object, databank, etc.)
$c_{kr.r2}$ – coefficient of increase of goods and services prices in the *r2*-th year of performing technical works connected with the project implementation
r1 – years when the analyses and research connected with the preparation of a project were performed
r2 – years when the project implementation (technical works) was performed
n – number of units (points, objects, data banks, etc.)

8. CONCLUSION

In literature no references can be found to the problem of valuation of the documentation concerning the national geodetic and cartographic resource. However, the methodology of valuation of properties and their constituting parts is well written in law and literature. The analysis carried out revealed that:
- the method of organization and distribution of the national geodetic and cartographic resource, under legal conditions binding in Poland, does not fulfill the criteria of capital-based

formula and application of the profit approach for establishing value of the resource is infeasible,
- it is possible however to use the cost-based formula for valuation of the national geodetic and cartographic resource . Using this formula it is assumed that the value of the resource is established using cost-based approach and the method of costs of replacement are applied.

While utilizing this method, it was proposed, if it is only possible in the valuation of resource assortments, to establish the value of assortments basing on the expenditures necessary to produce them or other types of assortments having similar features and functions at the time present. For their valuation there should be used market unit prices of their production, taking into account the current technologies and materials. Additionally, each time a degree of "technical deterioration" of the resource materials resulting from their topicality, as well as a degree of "technical-technological deterioration" should be established.
The valuations of the national geodetic and cartographic resource carried out on the test objects as well as during the implementation works enabled to initially estimate the value of resource at €5.2 billion.

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