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CHANGES IN THE ACTUALITY OF TOPOGRAPHIC MAP CONTENTS

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Abstract: Problems of the actuality of topographic map contents. The problem of measuring actuality level of map contents. Possible forms of the function of change in map content actuality. Simple linear form, non-linear form, another possible way of solving of measuring map contents actuality.

Keywords: actuality of topographic map contents, possible forms of the function of changes in map content actuality.

1. Introduction

This article deals with problems of the actuality of topographic map contents. The actuality means the level of accord of the map content with the real situation of the depicted area. In this meaning the actuality represents an important criterion determining the general utility value of topographic map, see [1] and [4].

The level of the actuality changes relatively very often in dependence on various factors, it degrades. This natural decreasing of content actuality results into the reduction of utility value. As this fact is immediately perceived and unfavourably accepted by map users, regular revisions of all topographic maps be done.

Analyses given in [2] proved that by increasing average actuality of topographic maps, it is possible to increase their general utility value, too. To project and plan convenient and timely measures, it is however necessary to know natural tendencies and the way of mathematical expressions of the decrease in the actuality level of separate map sheet contents and main causes that influence this decrease.

This article presents experience reached at the Department of Military Land Information of the Military Academy in Brno during solving all these problems mentioned above.

First it is necessary to find such a form of mathematical function of the decrease in the actuality level of topographic map content which is enough reliable and applicable for practical use. Three possible ways that can meet these requirements under certain conditions are introduced.

2. The problem of measuring actuality level of map contents

The criterion of map content actuality can be measured by the number of changes in a map content, it may also be expressed in percentage terms, see e.g. [5, p. 249]. The ivestigation of these data for every map sheet and for a given period of time is painstarking and could even hardly be done. It was found out, too, that only this technical information is not sufficient to determine the actuality level of map contents. This results into the

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necessity to find another procedure which would be more reliable, more economical and also applicable for partical use.

Tackling this problem we can presume that a complete accord of topographic map content with the depicted area exists for a very short period of time $T_0 = 0$. If the map content remains unchanged for a longer period of time, the level of its actuality will be decreasing because of changes in the depicted area, and the map actuality reaches such a level at a certain period of time T_{mez} that the map can be made no use of any more. The general utility value of this map designated as $U(T)$ is zero, or considerably decreased and must be revised.

Scientific analyses and experience show that topographic maps achieve this deadline of their actuality (i.e. the deadline of their utility level) when 15% to 25% of their content have been changed. This can be also caused by the fact each disaccord of the map content with the depicted area evokes doubts about truthfulness of other information even in such cases when they are true. But this factor is dependent on the professional education of map users.

A convenient parameter for expressing the influence both the number of changes and the degree of professional education of map users can be this deadline of actuality T_{mez}. It may differ for every map in dependance on the character of the depicted area. The following forms of the mathematical function which expresses the decrease in the actuality of topographic map content make use of this parameter (deadline of actuality) as the parameter characterizing separate map sheets.

3. Possible forms of the function of change in map content actuality

With respect to the given task, it is necessary to presume that this function is a component of the composed function expressing the general utility value of the map $(U)T$ within the time T, see [1]. This function can be generally expressed:

$$U(T) = U(T^*_{vm}) \, . \, f(T) \ , \qquad (1)$$

where

$U(T^*_{vm})$ is the level of the utility value of map standard at the time of its publication T^*_{vm} given by the norm, see [1], [2],

$f(T)$ is the studied mathematical function expressing a change in the map content actuality within the time T, the form of which can be made on different presumptions.

3.1. Simple linear form of the function

In the simplest case it is possible to presume that the change in the map content actuality occurs in linear dependence on the time:

$$\frac{df(T)}{dT} = a \ ,$$

where a is a constant.

This condition satisfies the function $f_1(T)$ in general form

$$f_1(T) = a\,T + b \qquad (2)$$

where b is a constant, too. The values of both constants can be specified from the conditions:

$$f_1(T^*_{vm}) = 1 \ ,$$

$$f_1(T_{mez}) = c \ , \qquad (3)$$

where the value c introduces users´ evaluation of the actuality level of map content at the time when the map is not able to serve the purpose for which it has been compiled. This constant can be specified within interval from 0 to 0.3 in the dependence on the level of users´ professional readiness.

After substituing conditions (3) into the formula (2) we get the following relations for constants a and b:

$$a = \frac{1 - c}{T^*_{vm} - T_{mez}} \ ,$$

$$b = c - \frac{(1 - c)\,T_{mez}}{T^*_{vm} - T_{mez}} \ . \qquad (4)$$

We can adjust the general relation (2) using the previous results and then we get:

$$f_1(T) = \frac{(1 - c)\,(T_{mez} - T)}{T_{mez} - T^*_{vm}} + c \ . \qquad (5)$$

The aplication of this relation has practical meaning only for. For a farther period of time when it is necessary to presume in this simplificated case:

$$f_1(T) = c \ . \qquad (6)$$

3.2. A more precise non-linear form of the function

The attempts to specify more precisely the form of the function on the basis of statistical processing of the real number of changes being found out during repeated revisions of topographic maps were not very successfull. The reached results, however, show:

a) a real course of the function $f(T)$, in addition is the mentioned level of users´ professional readiness, considerably depends on the character of the area depicted by the map and to a certain extent on a map content generalization,

b) the decrease in the actuality level of map content diminishes in dependence on the growing time T within a time unit and it reaches zero value when $T \to \infty$.

For this non-linear course of the change in map content actuality satisfied the following form:

$$\frac{df(T)}{dT} = F(T) . \qquad (7)$$

Taking into account the mentioned diminution of the decrease in map content actuality within a time unit it is possible to choose the function in the following form:

$$F(T) = a\, e^{-bT} \qquad (8)$$

where a and b are suitable chosen constants.

After substituing this form into the relation (7) a differential equation arises:

$$\frac{df(T)}{dT} = a\ e^{-bT}.$$

By solving this differential equation we get the general form of the studied function:

$$f_2(T) = -\frac{a}{b} e^{-bT} + c, \qquad (9)$$

where c is a constant, too.

The size of this constant can be assessed under the condition

$$\lim_{T \to \infty} f_2(T) = 0 ,$$

from this $c = 0$.

For practical use of the relation (9) it is convenient to presume the formula

$$f_2(T^*_{vm}) = 1 ,$$

resulting into

$$\frac{a}{b} = -e^{bT^*_{vm}} .$$

After introducing these results into the general form of the relation (9) and after its partial modification we get the following relation:

$$f_2(T) = e^{-b(T-T^*_{vm})} . \qquad (10)$$

The value of the constant b is dependent of the deadline T_{mez} and can be expressed by the approximate relation

$$b \cong \frac{d}{T_{mez}}, \qquad (11)$$

where d is a constant from interval <1;2> chosen in dependence on the relative representation of map content elements with different time stability.

It is necessary to verify the size of this constant experimentally; in our condition it is approaching more to the right boundary of the present interval. In an ideal case when the speed of the decrease in the actuality of all elements is approximately the same, it is possible to choose constant $d \cong 1$. There is also another way how to define this function.

3.3. Another possible way of solving the problem

An important cause which slows the speed of the decrease in the map content actuality within the growing time T is fact that the elements once changed in the map content cannot decrease the actuality level in the future. This fact appears in the definition of the function $f(T)$ in the following way.

Every topographic map contains information about various topographic objects. At the time $T_0 = 0$ when the map content and the depicted area are completely in accord, let topographic map have $n(0)$ true information (all data are correct). Then we have

$$n(0) = \sum_{p=1}^{P(K)} n_p(0), \qquad (12)$$

where

$P(K)$ is a total number of elements (various kinds of data) in topographic map content,

$n_p(0)$ is a number of true elements (data) of p^{th} kind within the time $T_0 = 0$.

The probability of the occurance of the change of elements (data) of any p^{th} kind in the map within a time unit (the speed of the decrease in the actuality) can be expressed by the parameter a_p, which area of relevance is

$$0 < a_p < 1. \qquad (13)$$

Under this presumption it is possible to derive relations for a number of true elements (data) of p^{th} kind after elapsing $1, 2, \ldots T$ time units:

$$n_p(1) = n_p(0) - a_p n_p(0) = n_p(0)[1 - a_p],$$

$$n_p(2) = n_p(0) - a_p n_p(0) - a_p[n_p(0) - a_p n_p(0)] = n_p(0)[1 - a_p]2$$

$$n_p(3) = n_p(0)[1 - a_p]^2 - a_p\{n_p(0)[1 - a_p]^2\} = n_p(0)[1 - a_p]3$$

$$\vdots$$

$$n_p(T) = n_p(0)[1 - a_p]^T. \qquad (14)$$

The parameter a_p is dependent on the character, namely on the level of urbanisation of the area depicted by the map. In each, generally in j^{th} topographic map of the i^{th} scale, it might be different and should be designated as $a_p^{(ij)}$. Its determination for all kinds of elements (data) in the content of every topographic map can hardly be achieved. It is possible, however, to access an average value $\bar{a}(ij)$ of this parameter for every map. This is approximately

$$\bar{a}^{(ij)} \simeq \frac{1}{T^{(ij)}_{mez}} \quad . \tag{15}$$

Using the results (14) and (15) it is possible to make a third type of the general relation for a change in topographic map content actuality (indexes *i, j* are omitted)

$$f_3(T) = b\,[1 - \frac{1}{T_{mez}}]^{T} . \tag{16}$$

Because of practical reasons the initial condition is

$$f_3(T^*_{vm}) = 1 ,$$

than the value of constant *b* will be

$$b = [1 - \frac{1}{T_{mez}}]^{-T^*_{vm}} .$$

Substituting this result into the general form (16) we get

$$f_3(T) = [\,1 - \frac{1}{T_{mez}}]^{(T-T^*_{vm})} . \tag{17}$$

4. Conclusion

For the effective planning of topographic map revisions, it is necessary to know the instantaneous situation as well as supposed decrease in their content actuality. To determine approximately the necessary data for each map sheet and for any period of time some of the derived relations (5), (10) or (17) can be used. For the use of any of these relation the knowledge of the deadline of actuality T_{mez} should be known for each map sheet. This parameter is influenced especially by the character of the depicted area, by the level of map content generalization and by the degree of the map users' professional education. It must, therefore, be determined for each map sheet in advance. At present this parameter is being determined for topographic maps of the scales 1:25,000, 1:50,000, 1:100,000, 1:200,000 of our territory.

The most important results mentioned in this article are applied in the new project of a new system of the permanent evaluation of topographic map quality value [3]. A reasonable use of proposed relations (5), (10) or (17) seems to be very effective, despite of their approximate values, for decision making about further topographic map revisions. This is important for us especially at present for the amount of financial and technical means needed for accomplishing this task is limited.

The necessity to follow permanently the level of the actuality of topographic map content results from the fact that topographic maps are an important source of data for the GIS. The proposed way of the investigation of changes in topographic map actuality can be contribution to these problems.

5. References

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Resumé

Zákonité změny aktuálnosti obsahu topografických map

Aktuálnost obsahu topografických map je úroveň souladu jejich obsahu se skutečným stavem zobrazeného území a je považována za významné kritérium určující celkovou užitnou hodnotu map. Zvyšováním aktuálnosti topografických map lze tedy nejefektivněji zvyšovat jejich celkovou užitnou hodnotu.

K projektování a plánování vhodných a včasných opatření je třeba znát zákonité tendence a způsob matematického vyjádření poklesu úrovně aktuálnosti obsahu jednotlivých mapových listů, i základní příčiny, které tento pokles ovlivňují.

V příspěvku jsou shrnuty poznatky a zkušenosti získané při řešení uvedených problémů na Katedře vojenských informací o území Vojenské akademie v Brně. Uvedeny jsou tři možné matematické způsoby vyjádření poklesu úrovně aktuálnosti obsahu topografických map. Jednoduchý lineární tvar funkce změny aktuálnosti obsahu mapy, přesnější nelineární tvar funkce a jiný možný způsob řešení úlohy.

Pro efektivní plánování obnovy topografických map mohou být použity vztahy (5), (10) nebo (17). Pro uplatnění kteréhokoliv uvedeného vztahu by měla být známa mezní doba zastarání pro každý mapový list. Tento parametr je závislý na charakteru území, na úrovni generalizace mapového obsahu a na stupni profesionálního vzdělání uživatelů. Byl již určen pro všechny listy topografických map měřítek 1:25 000, 1:50 000, 1:100 000, a 1:200 000 z území ČR.

Nejdůležitější výsledky zmíněné v tomto článku jsou zahrnuty do nového projektu nového systému hodnocení jakosti a užitné hodnoty topografických map. Využití navržených vztahů (5), (10) nebo (17) se jeví i při využití přibližných hodnot jako velice efektivní v procesu rozhodování o dalším postupu

obnovy topografických map. Toto je velice důležité speciálně v současnosti, protože finanční a technické prostředky vyčleněné na obnovu map jsou přísně limitovány.

Nutnost průběžně sledovat úroveň aktuálnosti obsahu topografických map je zdůrazněna též skutečností, že topografické mapy jsou významným zdrojem dat pro GIS. A protože GIS lze podle [6] snadněji zneužít ke zkreslení výsledků řešení úlohy, než je tomu u tradiční topografické mapy, je nutné se snažit o názornější znázornění (vizualizaci) rozhodujících ukazovatelů jakosti těchto dat, jak je o tom pojednáno v [7].

Navržený způsob zjišťování změn aktuality topografických map může být přínosem i pro rozvoj digitálních technologií, protože topografické mapy jsou důležitým zdrojem dat pro GIS a pro tvorbu digitálních ekvivalentů map.

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