Providing statistical stability of qualimetric studies on the basis of geochronological tracking

Ya A Ivakin¹²³, E G Semenova³, A G Ruchev³ and M S Smirnova³⁴

¹ St. Petersburg Federal Research Center of the Russian Academy of Sciences, 14th line V.O., 39, St. Petersburg, 199178, Russian Federation
² Concern OCEANPRIBOR JSC, Chkalovsky prospect, 46, St. Petersburg, 198226, Russian Federation
³ Saint-Petersburg State University of Aerospace Instrumentation, 67A, Bolshaya Morskaya Str., Saint-Petersburg, 190000, Russian Federation
⁴ E-mail: maris_spb@inbox.ru

Abstract. Geochronological tracking has received wide recognition as an appropriate scientific and methodological tool and an effective information technology of qualimetric research in the interests of ensuring high quality of transport services, transportation efficiency, analysis of the facts of insufficient meeting the needs of the population with spatially remote services, etc. On the basis of geochronotrack, a procedure has been developed for statistical verification of research hypotheses about stable trends in changes in the quality of various spatio-temporal processes. The reliability and validity of accepting a particular hypothesis in the framework of a qualimetric research is determined by the representativeness of the volume of initial data on geographical movements, considered as a selection from the general population. This article is devoted to the analysis of this dependence and the development of an algorithm for assessing the specified stability (significance).

1. Introduction

Qualimetric statistically significant analysis of the intensity of the remote provision of services in the information space is the basis for making decisions to ensure the quality of functioning of various spatio-temporal systems. Geochronological tracking has gained wide recognition as an appropriate scientific and methodological tools and effective information technology of relevant qualimetric researches in the interests of justifying and rationalizing route networks for providing services, logistics of remote services, analyzing the facts of stable trends in changing the quality of various spatio-temporal processes, etc. Basic principles, procedures and algorithms for geochronological tracking are described in [1-5]. Its mathematical essence is to find and assess the statistical significance of the isomorphism of the corresponding graphs: the final geochronotrack graph is presented as a base graph in the structure of which a subgraph isomorphic to the given one is revealed, i.e. the presence of a one-to-one mapping of one graph to a subgraph of another is established. The incidence relation in this case remains [3]. The graph, to which a subgraph is defined as part of the base graph of geochronological tracking, topologically describes one or another specific research hypothesis about the stable feature in the movement of service centers, objects or other entities in the information (including geographical) space. Further, the degree of stability in the recognition of the research hypothesis about the revealed feature
in displacements is determined using the statistical apparatus of confidence level and confidence
intervals [4].

At the same time, the reliability and validity of accepting a particular hypothesis in the framework
of the qualimetric research is determined by the representativeness of the volume of initial data on
displacements, considered as a selection from the general population. The statistical significance
(stability) of the results of the qualimetric study based on geochronological tracking depends on the
sufficiency of the recorded initial data on the movements of the objects under study. In other words, to
accept the research hypotheses based on geochronotrack with a given confidence level, the necessary
and sufficient (relevant) number of recorded single spatial displacements, considered as single statistical
tests, must be provided. The substantiated development of the mathematical and statistical apparatus
and the methodology for linking the confidence level of accepting the hypotheses of the research based
on geochronotrack with the initial number of displacements taken into account is the essence of
ensuring the statistical stability (significance) of the conclusions of these researches.

2. Results
In the general scientific sense, the reliability of the research conclusions is the property of such an object
of the infosphere, as newly obtained knowledge to consistently and invariably develop functionally
suitable and reliable results for the given initial data and the input conditions [7]. The confidence level
of the results truth of a particular test or research is an indicator with a quantitative measure for assessing
the specified reliability in the context of the conditions for conducting qualimetric studies based on
geochnorotrack, is. In this case, the confidence level of the results truth is set a priori and is ensured
in the course of retrospective studies by conducting a relevant (first of all, sufficient) number of
elementary tests.

The above-described variant of considering the statistical essence of the research carried out made it
possible to interpret it within the framework of a standardized apparatus for ensuring and calculation of
reliability indicators in the technology [8]. The specified apparatus was developed, tested and
recommended for use within the framework of the current national system of normative and technical
regulation. It is applicable to the subject area of geochronotrack-based qualimetric research.

Interpretation of the mathematical and statistical apparatus, ensuring the required confidence level to
the obtained conclusions of the conducted research based on geochronological tracking comes down to
determining the main input and output variables of the specified apparatus in the categories of the
analysis of the movements of the investigated entities (objects), as well as setting the general boundary
conditions for its application. In particular, the volumes of tests N (the total number of single
displacements taken into account in the track (observations)) established in the developed methodology
are based on the assumption that single tests are statistically independent and the value of the confidence
level of the truth of the conclusions obtained is constant.

Based on the results of the full volume of tests N, in each of the studied geochronotrack
characteristics one of the following, alternative, research decisions is made.

A. the observed (registered) and averaged according to N single test acts value of the numerical
parameter (qualitative manifestation) of the geochronotrack is accepted as true with a confidence level
P (i.e., acceptance of the value as true, with a certain level of trust);

B. the observed (registered) and averaged according to N single test reports value of the numerical
parameter (qualitative manifestation) of the geochronotrack is not accepted as true (i.e., the deviation of
the value as true, with a certain level of trust).

In the framework of geochronotrack, alternative B. means the need either to reduce the a priori
level of the required confidence level of the correct research decision making, or to further increase the
total number N of single tests (displacements taken into account)) to confirm the reliability of the
research decisions made. In some cases - changes in the organization of the qualimetric research.

With regard to the methodology for determining the necessary and sufficient (relevant) number of
one-time tests in the course of qualimetric studies based on geochronological tracking to ensure the
required level of confidence in the final results, the following designations of input and output quantities, variables of the scientific and methodological concepts are adopted:

- $P$ - the a posteriori, i.e. accumulated in the track the confidence level of the truth of a particular result of a qualimetric research, the value of a numerical parameter (qualitative manifestation) of one or another track arc;
- $P_\alpha$ - the a priori probability level of confidential acceptance of the value of a numerical parameter (qualitative manifestation) of a particular track arc;
- $P_\beta$ - the a priori level of the probability of a confidence deviation (inconsistency, non-recognition of the truth) of the value of the numerical parameter of one or another arc of the track;
- $Q$ - the posteriori value of the probability of the risk of incorrect acceptance of the particular result of the qualimetric study, the value of the numerical parameter (qualitative manifestation) of the geochronous track arc;
- $Q_\alpha$ - the a priori value of the addition’s probability to the unit of the probability level of the confidence value acceptance of the numerical parameter (qualitative manifestation) of one or another track arc, that is,

$$Q_\alpha = 1 - P_\alpha,$$

(1)

- $Q_\beta$ - the a priori value of the additions probability to the unit of the probability level of the confidence deviation (discrepancy, non-recognition of the truth) of the numerical parameter value of one or another track arc, that is

$$Q_\beta = 1 - P_\beta,$$

(2)

The presence of the specified parameters of qualimetric research (2) and (3) based on geochronological tracking according to [9] determines the so-called resolving coefficient $D$, equal to the ratio of the additions values to the unit of the probability level of the confidence acceptance of the observed value in the research to the level of the deviation probability:

$$D = Q_\beta / Q_\alpha = (1 - P_\beta) / (1 - P_\alpha);$$

(3)

- $N$ - the total number of single tests (the volume of displacements of objects or artifacts taken into account in the geochronotrack);
- $n$ - the a posteriori number of facts of the correct implementation of single tests (i.e., displacements of objects, artifacts, etc., taken into account) and the successful acceptance of the observed value, of the result of each single test;
- $r$ - the a posteriori number of deviation facts taken into account, due to various reasons, of the observed value, of the result of each single test, i.e. from the number of displacements of objects, artifacts, etc., taken into account;

At the same time, it is obvious that at each specific moment of the data recording as part of a geochronotrack, the following ratio is correct:

$$N = n + r;$$

(4)

- $\xi$ - the limiting (maximum allowable, threshold) total recorded number of deviations, due to various reasons, of the result of each single movement taken into account in the process of qualimetric research;
\(\alpha\) - the a priori (prescriptive, initial for a retrospective research) value of the risk of incorrect acceptance of the observed value, of the result of geochronological tracking;

\(\alpha_1\) - the a posteriori (recorded during the study) value of the risk of incorrect acceptance of the geochronotrack result;

\(\beta\) - the a priori (prescriptive, initial for a qualimetric study) value of the risk of incorrect deviation when it is necessary to accept the observed value;

\(\beta_1\) - the a posteriori (recorded during the experiment) value of the risk of incorrect deviation when it is necessary to accept the result of geochronotracking;

\(P_z\) - the required confidence level of ensuring the reliability of the results of the qualimetric research based on geochronotracking, which is specified in the normative (a priori for the entire range of researches) documents.

The initial a priori data for determining the relevant volume of tests \(N\) (i.e. the volume of the displacements of objects or artifacts in the geochronotrack, taken into account) in order to confirm the reliability probability indicators of the conclusions of the qualimetric research, their parameters are:

- the values of the a priori probability levels of confidence acceptance \(P_\alpha\) and deviations \(P_\beta\) of the observed values of the numerical parameter (qualitative manifestation) of one or another arc of the geochronological track, which determine resolution factor \(D\).
- the a priori values of the risks of incorrect acceptance of values, results of a qualimetric research \(\alpha\) and incorrect deviation when it is necessary to accept the value or qualitative results of specified research \(\beta\).

Generally, the method for determining the necessary and sufficient (relevant) number of one-time tests (displacements of objects or artifacts taken into account) in the course of qualimetric studies based on geochronological tracking to ensure the required level of trust to the final results includes three main (generalized) stages:

- preparation of initial data for calculating the necessary and sufficient number of single tests in the course of geochronological tracking of a qualimetric study;
- calculation and assessment of the confidence interval for accepting the observed value, the result of each single test (displacement) at the assigned (a priori) risk values (or confidence level);
- making a final research decision on the relevant number (volume) of single tests.

A consistent description of each of these stages allows you to reveal the content of the proposed methodology as a whole.

Preparation and selection of initial data for determining the scope of tests should be carried out in the following sequence:

- based on the analysis of the previously obtained experience of experimenting with the geochronological tracking concepts, and also based on the objective limited resources of qualimetric researches, the values of the probability of trust acceptance \(P_\alpha\) and confidence deviation (discrepancy, non recognition of the truth) \(P_\beta\) of the observed value of the parameters of the analyzed or synthesized geochronological track are established a priori
- the sizes of the risks of incorrect acceptance of the value, of the result of qualimetric research \(\alpha\) and of incorrect deviation, in case of the need to accept value \(\beta\) are established a priori.
The values of the indicated levels $P_\alpha$ and $P_\beta$ are initially set based on the limiting possibilities of accumulating spatio-temporal information about the movements of objects taken into account in the process of geochronotacking. It is recommended to set $P_\alpha$ and $P_\beta$ in such a way that value $P_j$ is in interval $\left(\frac{(P_\beta + P_\alpha)}{2}, P_\alpha\right]$ closer to a priori level $P_\alpha$ of the probability of the trust acceptance of the observed value of the parameter (qualitative manifestation) of the geochronological track. The levels can be set in two equivalent ways: $(P_\alpha$ and $P_\beta)$ or $(P_\alpha$ and $D)$. In the second method, the value of the resolution coefficient $D$ is recommended to be selected from series: 1.5; 1.75; 2.0; 3.0.

- Risk values $\alpha$ and $\beta$ are set as follows: The risk value of incorrect deviation, in case of the need to accept observed value $P_j$, is set subjectively, in relation to the features of the implemented geochronotrack architecture, in accordance with the accepted norms or standards of the subject area of the future application of the qualimetric research results. Traditionally, the value of the risk of the incorrect acceptance of the observed value, of test result $\alpha$ is set a priori according to subjective appreciation, equal to value $\beta$ or greater than it. In this methodology, based on the principle of equal probability of unbiased statistical errors, it is assumed that

$$\alpha = \beta$$  \hspace{1cm} (5)

On the basis of (6), values of risks $\alpha$ and $\beta$ are accepted (given below in tables 1 and 2) equal. Risk values in accordance with [10] are recommended to be selected from the range: 0.05; 0.1; 0.2; 0.3.

According to [10], it is not recommended to establish initial data that combine large values of the resolution coefficient $D$ with small values of risks $\alpha$ and $\beta$. Such initial data should be changed by decreasing the value of the resolution coefficient $D$ and increasing the values of risks $\alpha$ and $\beta$. Accordingly, the recommended ratios of the initial data to determine the volume of tests (i.e., the volume of displacements of objects or artifacts taken into account in the geochronotrack) are given in table 1.

The calculation and assessment of the confidence interval for the acceptance of values, the results of each unit movement at the assigned (a priori) values of the risk (or confidence level) must be carried out in the following sequence:

- Due to the unbiased nature of assessment $P_\alpha$ concerning the meaning of $P_j$, as a point estimate for a posteriori confidence level of the truth of the qualimetric research particular result the value of the parameter (qualitative manifestation) of a geochronological track, frequency $P$ is taken, defined as

$$P = \frac{n}{N}$$  \hspace{1cm} (6)

| Table 1. - Recommended ratios of initial data for geochronotrack analysis. |
|------------------|---------|---------|
| No. | $D$    | $P_\alpha$ | $\alpha = \beta$ |
|------|--------|------------|------------------|
| 1    | 1.50-1.75 | 0.9995      | 0.05             |
| 2    | 0.9990  | 0.9950      | 0.10             |
|      |        |             | 0.20             |
|      |        |             | 0.10             |
| 3    | 1.75-2.00 | From 0.99 to 0.90 with step 0.01 | 0.20 |
|      |        |             | 0.30             |
| 4    | 2.00-2.50 | 0.8500      | 0.30             |
| 5    | 3.00    | 0.8000      | 0.20             |
The volume of single tests (i.e. the volume of displacements of objects or artifacts taken into account in the geochronotrack) $N$ to confirm the conclusions of the qualimetric research is a parameter that determines the size of the confidence interval $I$ for probability $P$, i.e. the task of calculation $N$ sufficient to confirm the a priori required reliability of the estimate of the truth of the particular result of the qualimetric research of the value of the numerical parameter (qualitative manifestation) of the geochronological track comes down to a typical mathematical task of constructing a confidence interval and assessing the reliability of a certain probability according to the frequency of an event observed in the process of iterative qualimetric research. A detailed mathematical solution to this problem is given in [6,8,10].

In general, during $N$ testing confidence interval $I$ in which the unbiased estimate of the truth of a particular result of a qualimetric research occurs with confidence level $1 - \alpha$ (at $\alpha = \beta$), the value of the parameter (qualitative manifestation) of the geochronotrack is determined from the summary ratio:

$$I = \frac{P + D}{2N} \pm D \sqrt{\frac{P(1-P)}{N} + \frac{D^2}{4N^2}} \left(1 + \frac{D^2}{N}\right)$$  \hspace{1cm} (7)

Specified relations (7) and (8) allowed, within the framework of this particular methodology, to algorithmically connect the total number of unit movements of objects (the total volume of single tests) $N$ and the ultimate (maximum allowable, threshold) total number of deviations due to various reasons of the analyzed value, the result of each single displacement test observed in the of geochronotrack process $c$ with the initial data described in Table 1. Taking the value of probability level $P_\alpha$ of the trust acceptance of the observed parameter value (qualitative manifestation) of the geochronotrack as a priori corresponding to the objectives of confirming the level of the required confidence level of ensuring results reliability in complex qualimetric study $P_j$, specified for the entire range of studies, the ratios of the abovementioned test values are determined to confirm the desired characteristics of geochronotrack. Some of the results of this determination are shown in table 2.

Making a research decision on the relevant number (volume) of single tests - the displacements of objects (artifacts) in the geochronotrack, taken into account, is carried out by performing the following logical steps:

Based on the interpretation of the essence of the geochronotrack arcs and the cumulative nature of accounting for single displacements, the definition and substantive interpretation of the initial data is made to determine the relevant volume of the displacements taken into account. At the same time, it is recommended to adhere to the ratios of the initial data presented in table 1.

According to the selected parameters of the initial data, log in to table 2 is performed, from which it becomes possible to determine the total number of single tests (the volume of accounted displacements of objects (artifacts) in the geochronological track) $N$ and the limiting (maximum allowable, threshold) total accounted number of deviations facts, due to various reasons, of the result of each single test observed in the process of retrospective researches $c$, failure to achieve which during the implementation of the entire volume of single tests means the adoption of alternative A.) (observed and averaged according to $N$ single acts of test-displacements value of the parameter (qualitative manifestation) the geochronotrack is accepted.
as true with confidence level $P$). The achievement or excess of current value $C$ over the tabulated value means the fact of alternative research decision $B$ acceptance. The value of the parameter (qualitative manifestation) of the geochronotrack observed and averaged according to $N$ single acts of testing - displacements is not accepted as true.

Table 2. Values of the volume of the displacements of objects (artifacts), taken into account, in the geochronotrack with the provided confidence level of the results of the qualimetric researches.

| $P$ | $D$ | $\alpha = \beta = 5\%$ | $\alpha = \beta = 10\%$ | $\alpha = \beta = 20\%$ | $\alpha = \beta = 30\%$ |
|-----|-----|----------------|----------------|----------------|----------------|
|     |     | $N$ | $c$ | $N$ | $c$ | $N$ | $c$ | $N$ | $c$ |
| 0.9 | 1.5 | 474 | 58 | 288 | 35 | 134 | 16 | 53 | 6 |
| 1.75 | 227 | 30 | 138 | 18 | 64 | 8 | 27 | 3 |
| 2 | 135 | 19 | 86 | 12 | 39 | 5 | 18 | 2 |
| 3 | 41 | 7 | 23 | 4 | 14 | 2 | 8 | 1 |
| 0.85 | 1.5 | 294 | 54 | 181 | 33 | 79 | 14 | 35 | 6 |
| 1.75 | 141 | 28 | 87 | 17 | 42 | 8 | 18 | 3 |
| 2 | 85 | 18 | 53 | 11 | 21 | 4 | 12 | 2 |
| 3 | 26 | 7 | 16 | 4 | 9 | 2 | 5 | 1 |
| 0.8 | 1.5 | 204 | 50 | 127 | 31 | 55 | 13 | 26 | 6 |
| 1.75 | 98 | 26 | 61 | 16 | 28 | 7 | 13 | 3 |
| 2 | 60 | 17 | 36 | 10 | 19 | 5 | 9 | 2 |
| 3 | 17 | 6 | 9 | 3 | 4 | 1 | 4 | 1 |

- For multistage retrospective researches, the assessment of the level of trust to the posterior values of geochronotrack parameters is carried out for each stage of such a study. Further, the summarized estimated confidence level to the results of a multistage qualimetric study is correlated with the prior for the entire range of studies, i.e. the required, confidence level of ensuring the reliability of the results in a series of similar stages-tests of the complex study, is calculated according to the formulas of conditional and total probabilities. The essence of the problem of the indicated calculation is disclosed in [11, 12].

3. Discussion
The solution to the problem of achieving the necessary statistical significance (stability) of the results of the qualimetric study based on geochronological tracking is to ensure the sufficiency of the considered initial data on the movements of the objects under study when constructing the corresponding geochronological track. When solving this problem, an understandable and traditional measure of the indicated significance (stability) of the results of the qualimetric study in the form of the confidence level was introduced. For various gradations of the indicated probability and the risk level in its acceptance, the volume (relevant amount) of the displacements of objects or artifacts, taken into account, in the geochronotrack is determined, considered as the total number of single tests that must be provided during the synthesis of the corresponding specified track. If the revealed ratio of the specified volume and the number of facts of deviations of certain single displacements is not exceeded, the hypothesis of the qualimetric research is accepted with the desired confidence level.

The boundary conditions for the obtained solution of the problem of achieving statistical stability of the results of qualimetric research based on geochronological tracking are defined as the limits of applicability of applications of the probability theory and mathematical statistics.

Further directions for improving the methodology for determining the necessary and sufficient (relevant) number of one-time tests in the course of qualimetric studies based on geochronological tracking to ensure the required confidence level towards the results and conclusions of the study are associated with its algorithmization and automation, integration into modern geoinformation and
logistics systems focused on applied research and solution to spatio-temporal, analytical problems in related areas [14-18].

Thus, the presented version of the methodology for solving the problem of achieving statistical stability of the results of the qualimetric study based on geochronological tracking makes it possible to ensure and significantly expand the applicability of the scientific and methodological apparatus of geochronological tracking to new classes of applications. In turn, this fact makes it possible to expand the applicability of the mathematical apparatus for testing the hypotheses of qualimetric studies based on geochronological tracking for various subject areas and new objects of study, to achieve its more effective integration into the corresponding software applications for geoinformation, logistic systems.

4. Conclusion
The development of the mathematical and statistical apparatus and the methods for determining the necessary and sufficient (relevant) number of one-time tests in the course of qualimetric research based on geochronological tracking will allow to develop appropriate scientific and methodological tools and the resulting information technologies of retrospective geospatial research, arising from it, in the interests of engineering, logistics, as well as transport services. It is also obvious that the works on the development of applied geochronotacking algorithms as such are promising. These works include the introduction and integration of the appropriate information technologies, artificial intellectuality, integration and fusion of information, virtualization, etc. into the relevant geoinformation applications.

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References
[1] Ivakin Ya A et al. 2019 Rational algorithm for testing hypotheses of retrospective studies of the use of water transport based on geochronological tracking Bulletin of the State University of Marine and River Fleet named after Admiral S O. Makarov 11(3) 448-60 DOI: 10.21821 / 2309-5180-2019-11-3-448-460
[2] Ivakin Ya A and Potapychev S N 2016 Geochronological tracking - a specialized GIS toolkit for historical research Historical Informatics. Information Technologies and Mathematical Methods in Historical Research and Education 1-2 3-11
[3] Ivakin Ya A and Potapychev S N 2018 Information technology of geochronological tracking for testing hypotheses of retrospective studies of the use of water transport Bulletin of the State University of Marine and River Fleet named after Admiral SO Makarov 10(2) 452-61 DOI: 10.21821 / 2309-5180-2018-10-2-452-461
[4] Ivakin R Ya, Ivakin Ya A and Potapychev S N 2020 An optimized algorithm for statistical testing of hypotheses of retrospective studies based on geochronological tracking Proceedings of educational institutions of communication 6(1) 86-93 DOI: 10.31854 / 1813-324X-2020-6-1-86-93
[5] Ivakin Ya A and Potapychev S N 2020 Information technology of research of the peculiarities of the use of products of hydroacoustic equipment based on geochronological tracking Information technologies and telecommunications 8(2) 109-19 DOI 10.31854 / 2307-1303-2020-8-2-109-119
[6] Codescu M, Horsinka G, Kutz O, Mossakowski T and Rau R 2015 DO-ROAM: Activity-Oriented Searh and Transport Navigation with OpenStreetMap GeoSpatial Semantics Proceedings of the 6th International Conference (GeoS 2015) 88-108
[7] Schmid A V 2020 Revolution in the field of philosophy and technologies for making corporate decisions Retrieved from: http://4cio.activetextbook.com/active_textbooks/34#page642
[8] Khlebenskikh L V et al. 2017 Production automation in the modern world Young scientist 16(150) 308-11 Retrieved from: https://moluch.ru/archive/150/42390/
[9] McConnel S 2004 Code Complete: A Practical Handdook of Software Construction (NewYork:
MicrosoftPress)
[10] Fowler M, Beck K, Brant J, Opdyke Wand Roberts D2019 Refactoring: improving the project (SPb: "Dialectics")
[11] McConnell S 2010 Code Perfect. Master class (M.: Publishing house "Russian edition")
[12] McConnel S 2006 Software Estimation: Demystifying the Black Art (Developer Best Practices) (NewYork: MicrosoftPress)
[13] 2021 GOST R 27.403-2009. Test plans to control the probability of failure-free operation Retrieved from: http://docs.cntd.documnet/1200078695
[14] Shatokhin A V 2020 Information and accompanying network - a new approach to the operation of sonar weapons National Defense 1(82) 62-7
[15] Korotkov A V, Kristalny B V and Kurnosov I N 2007 State policy of the Russian Federation in the development of the information society (Moscow: Ltd Train)
[16] Potapychev S N and Ivakin Ya A 2018 The use of geospatial data for intelligent support for dispatching decisions Vestnik of SPbGUTiD Series 1. Natural and technical sciences 2 24-32
[17] Shatokin A V, Ivakin Ya A and Neshtenko V S 2020 Coordination of services of enterprises of marine instrumentation in the interests of the system of operation of hydroacoustic weapons of the Navy Marine collection 11 12-54
[18] Shatokin A V and Ivakin Ya A 2020 A modern approach to the participation of marine instrumentation enterprises in maintaining the technical readiness of the naval hydroacoustic weapons Marine radio electronics 4(21) 56-67