МРНТИ 90 .01. 01 УДК
006.91(094)
DOI 10.64513 Smart/2025.2.19

Development of a methodology for analyzing the state of measurements and forecasting the needs for measurements for the economic sectors of the Republic of Kazakhstan, taking into account international experience

Sattybaeva K.Z.
Kazakh National Technical University named after K.Satpayev, Kazakhstan, Almaty

Abstract

Based on international experience (BIPM, PTB, EMPIR, etc.) and analysis of the current state of Kazakhstan's metrological infrastructure, an adapted scientific and practical approach to the development of a methodology for analyzing the state of measurements and forecasting measurement needs for sectors of the economy of the Republic of Kazakhstan is proposed, which is based on a combination of quantitative and qualitative methods of analysis and foresight forecasting.

The proposed methodology is based on a hybrid model that includes methods of expert discussion and questioning, content analysis of strategic documents and scientific publications, analysis of BIPM data and information systems, as well as scenario planning and identification of gaps between measurement capabilities and measurement needs.

Key words: analysis, forecasting, measurement capabilities, standards, measuring instruments

Introduction

The issue of methodology for analyzing the state of measurements and forecasting the needs for measurements on the scale of the economy or branches of the economy of the state has been little studied in scientific research to date. At the same time, the existing studies consider separately the methodology for analyzing the state of measurements and the methodology for forecasting the needs for measurements.

In Kazakhstan, methods for analyzing the state of measurements are used, the object of which is the state of measurements in a particular organization, enterprise or measuring laboratory - these methods are established in national standards: ST RK 2.237-2012 [1] and ST RK 2.254-2012 [2].

Regulatory documents on the analysis of the state of measurements used in the USSR deserve separate consideration, since these are the only documents to date that contain a methodology for conducting an analysis of the state of measurements, the object of study of which is the economic sector as a whole [3, 4, 5].

A special feature of the approach to the analysis of the state of measurements in the context of an entire sector of the economy of the Soviet period is the "matrix" structure of the analysis: information on the state of measurements at the level of the entire sector is formed from the generalization of information on the state of measurements at all enterprises operating within the framework of this sector. The implementation of such an approach is possible only under the conditions of the presence of a clearly coordinated state-level structure of the metrological service, which includes the metrological services of enterprises, the metrological services of sectoral ministries and departments coordinating the implementation of metrological work within the sector, and the state metrological service coordinating the implementation of metrological work on the scale of the country's economy.

In the current conditions of development of the system for ensuring the uniformity of measurements of the Republic of Kazakhstan, this approach cannot be implemented, since metrological services at enterprises are created voluntarily at the discretion of the enterprises themselves, and the concept of “metrological service” was excluded from the Law of the Republic of Kazakhstan dated June 7, 2000 “On Ensuring the Uniformity of Measurements” as amended in 2018 [6].

The task of analyzing the state of measurements on the scale of industries and the country's economy falls entirely on the authorized state body in the field of ensuring the uniformity of measurements and the state scientific metrology center (SSMC).

Proposals for the development of a methodology for analyzing the state of measurements and forecasting the measurement needs of economic sectors of the Republic of Kazakhstan

Analysis of the state of measurements and forecasting of the measurement needs of the economic sectors of the Republic of Kazakhstan (hereinafter referred to as analysis and forecasting of the measurement needs) is carried out with the aim of determining the current state of metrological support for economic sectors, existing problems and gaps, forming reliable knowledge of the needs of the state, business and society in measurements and developing, on their basis, substantiated proposals for the further development of the national measurement infrastructure.

The proposed methodology is based on international experience in the practical application of foresight forecasting methods and strategic planning for the development of national or regional metrological infrastructure [7], [8], [9], [10], [11] and consists of nine sequentially implemented stages.

Stage 1. Determination of industry priorities and areas of analysis by analyzing strategic and program documents related to the development of science, technology, economics and technological modernization. Such sources include:

- The Message of the President of the Republic of Kazakhstan, the Development Strategy of the Republic of Kazakhstan, the National Development Plan of the Republic of Kazakhstan and other current state strategic program documents,
- development programs and strategies across industries,
- national projects,
- concepts, roadmaps, development plans by industry or area of activity ,
- strategic documents of international and regional metrological organizations (BIPM , COOMET , EURAMET).

The content of these documents is analyzed, problems and tasks requiring metrological support are identified and systematized.

Analysis of strategic documents of international and regional metrological organizations [12], [13] [14] [15] allows us to identify global and regional trends in measurement needs, compare international priorities with national needs, and justify the need to modernize or develop new measurement standards and methods.

Based on the analysis results, a list of key industries/economy sectors is formed for which the development of measurement infrastructure is critically important.

2. Collection and systematization of data using information resources, within the framework of which it is recommended to carry out the following types of work:

2.1 Monitoring domestic scientific research and publications on issues of technology development in priority sectors in order to determine measurement needs.

A search and selection of scientific literature and publications in the media of the Republic of Kazakhstan is carried out using keywords and concepts related to measurements and technologies within industries; it is recommended to use the patent database of the Republic of Kazakhstan, scientific publications, magazines and online publications of specialized industry focus as sources of information. Content analysis is carried out to identify topics related to the problems of measurements and metrological support of the technologies under consideration.

2.2 Analysis of the measurement capabilities of verification/calibration laboratories in Kazakhstan

It is proposed to conduct an analysis of the provision of verification/calibration by types of measurements by analyzing the areas of accreditation of existing verification and calibration laboratories in Kazakhstan in terms of groups of measuring instruments subject to verification/calibration, in accordance with the CC BIPM classification [16]

It is recommended that the analysis be presented in the form of Table 1.

Table 1 – Measuring capabilities of the PL/CL of Kazakhstan

Code of the type of measurement according to the CC classifier BIPM	Measured value/Name of the group of verified/calibrated measuring instruments	Covered measurement range	Name of the submarine/cable system, region of placement	Maximum and minimum values of measurement uncertainty	Metrological traceability of PL/KL standards*
1.	2.	3.	4.	5.	6.

* name of the state standard of the Republic of Kazakhstan or, if it is not available, an indication of the foreign NMI from which the unit is taken

In this case, all groups of measuring instruments according to the CC BIPM classification are entered into the 2nd column, this will allow to identify as much as possible the uncovered areas of measurements by types of measurements in Kazakhstan

Conducting such an analysis is a very labor-intensive process, which can be solved by including codes according to the CC BIPM classification in the areas of accreditation of PL/CL, which will automate the process of data collection and analysis.

2.3 Analysis of information data from the Register of the State Security Service of the Republic of Kazakhstan

The analysis of data contained in the register of the State Measurement Instruments of the Republic of Kazakhstan is carried out in order to assess the current state of the metrological base, identify the relationship between domestic production and import of measuring equipment, gaps in ensuring metrological traceability within the country and the level of import dependence in the development of measuring instruments, reference materials, measuring instruments, and obtaining metrological services.

The obtained data must be structured by types of measurements and objects of the State Measurement System of the Republic of Kazakhstan.

At this stage, it is recommended to use forms of tables 2 – 6.

Table 2 – Analysis of approved types of measuring instruments

Type of measurements	Code By BIPM classifications	Number of types of measuring instruments of domestic production	Number of types of measuring instruments of foreign manufacture	Types of measuring instruments not provided with metrological traceability in the Republic of Kazakhstan
1.	2.	3.	4.	5.

Table 3 – Analysis of domestically produced measuring instruments

Code By BIPM classifications	Family SI	Number of types of measuring instruments	The number of similar measuring instruments of	Comparison of metrological characteristics (SI type	Proposals for support of domestic measuring instruments manufacturers

		of domestic production	foreign manufacture registered in the register of the State Measurement Instruments of the Republic of Kazakhstan	with the best characteristics)	
1.	2.	3.	4.	5.	6.

Table 4 – Analysis of approved types of standard samples

View measurements	Code By BIPM classifications	Number of types of domestically produced GSO	Number of types of foreign-made GSO	Proposals for import substitution
1.	2.	3.	4.	5.

Table 5 – Analysis of registered MVI

View measurements	Code By BIPM classifications	Object of measurement	Number of registered MVIs developed in the Republic of Kazakhstan	Number of MVIs according to the registration procedure	MVI included in the lists of the Technical Regulations of the EAEU
1.	2.	3.	4.	5.	6.

Table 6 – Analysis of verification methods

View measurements	Classification code cations BIPM	Family SI	Total number of registered verification methods	Number of verification methods in the form of national standards	Proposals for standardization of verification methods in the form of ST RK
1.	2.	3.	4.	5.	6.

2.4 Analysis of applications for metrological services (verification, calibration, development of state standard reference materials, measurement methods, etc.) received by the State Scientific Medical Center

To conduct this analysis, the State Scientific Medical Center must maintain a list of all applications received for metrological services, for which they were refused, indicating the reasons for the refusal. The analysis of this list will allow us to generate information on the types, ranges and characteristics of measurements in Kazakhstan for which there are no possibilities for metrological traceability to the state standard, and to analyze the reasons (lack of the necessary technical base, or limited metrological characteristics of the existing standards, etc.).

Based on the results of the analysis, information is generated in the form of table 7.

Table 7 – Analysis of applications for metrological services at the State Scientific Medical Center

View services	BIPM Measurement Code	Required metrological characteristics	Reason for refusal of SSMC to provide services	Criticality level for industry/activity *	Suggestions for meeting the need for the service
1.	2.	3.	4.	5.	6.

* Assessed on a three-level scale:
3 - high
1 - average
2 - short

4. Survey of enterprises and organizations

The questionnaire contains a structurally organized set of questions that allow one to obtain the most complete information possible about the current level of metrological support and the problems in this area that organizations face in their daily activities.

Based on the survey results, the following diagrams are generated:

– distribution of enterprise activities according to OKED codes;

– frequency of mentioning areas of activity in the field of OEI (according to data from Table 8);

– average values of the assessment of the demand for measurements by types of measurements (according to data from Table 9);

– frequencies of mentioning critical technologies of the RK in relation to measurements in the areas of activity in the field of OEI, as well as frequencies of mentioning the influence of measurements and areas of application of measuring instruments on critical technologies of the RK (according to data from Table 10);

– provision of measurements in areas of activity in the field of OEI with standard samples, %;

– provision of measurements in areas of activity in the field of OEI with measurement methods, %.

Table 8 – Frequency of mentioning areas of activity to ensure the uniformity of measurements

№p/p	Scope of activity in the field of OEI	Frequency of mentions
1.	2.	3.

Table 9 – Average values of assessments of the demand for measurements by types of activities in the field of OEI (on a 10-point scale)

№p/p	Type of measurements	Average score
1.	2.	3.

The assessment of the level of demand for measurements by types of measurements by average values is carried out according to the following gradation:

– Not more than 5 – low ;

– more than 5, but not more than 7.5 – average;

– more than 7.5 – high .

Table 10 – Dependence of critical technologies on the number of types of measurements performed in the field of activity in the field of OEI

№p/p	Critical Technology	Number of measurement types
1.	2.	3.

To analyze the degree of influence of the results of the application of SI (SO) on critical technologies, the following gradation of the degree of influence for average values is used:

– Not more than 5 – weak ,

– more than 5, but not more than 7.5 – average,

– more than 7.5 – strong .

Taking into account the introduced gradation, Table 11 is formed, in which critical RK technologies are entered, for which the degree of influence of the use of measuring instruments (SI) of the types of measurements and special measuring instruments specified in the cells is assessed as strong and medium, respectively.

Table 11 – Degree of influence of the use of SI (SO) on critical technologies

№p/p	Critical Technology	Types of measurements or special SI (SO)	
		strong degree of influence	medium degree of influence
1.	2.	3.	4.

5 Conducting expert discussions and developing development scenarios

The next stage involves forming groups of experts in specific industries or types of measurements, and holding a series of seminars to develop scenario forecasts for the development of a system for ensuring the uniformity of measurements in Kazakhstan.

The pool of experts should include representatives of government agencies, the quasi-public sector, national companies, development institutions, business associations, industrial enterprises, accreditation entities, who have knowledge in the field of technical and technological development of their industry or in providing metrological services for objects and measurements within the industry and organization.

With the participation of these experts, two interactive seminars are held, at which key drivers of change are identified and a detailed vision of three scenarios for future development is developed: traditional, regressive and transformational.

Based on the results, a detailed description of three predicted development scenarios is formed, describing key features, changes and their consequences, as well as proposed strategic transformations for the purpose of improvement.

6 Comparative analysis of the state reference base and SMS

The analysis of the state reference base of Kazakhstan is carried out by comparing the technical capabilities of state standards and declared CMC of Kazakhstan with the best international and regional analogues, identifying deficiencies, discrepancies in uncertainty levels, and also forming proposals for improving the state reference base.

Data is collected on the state standards of Kazakhstan, which are categorized by types and groups of measurements in accordance with the classifiers of the BIPM Consultative Committees ; for each state standard, information is provided on the availability of the CMC in the BIPM KCDB [17], including the main metrological characteristics; a comparison is made of the characteristics of the measurement capabilities of the state standards of Kazakhstan with the characteristics of the best CMC in the world and CMC of the countries of regional integration associations, which include Kazakhstan (for example, the EAEU or the United Territory Territory).

The analysis identifies areas where there are no registered CMCs, or where the measurement uncertainty values significantly exceed international and regional analogues

The ratio of the uncertainty of measurements of Kazakhstan to the international level, K_{int}, %, is determined by the formula:

$$K_{int} = \frac{U_{KZ}}{U_{best\ int}} \times 100\ \% \qquad (1)$$

Where:

U_{KZ} — expanded uncertainty of Kazakhstan for a specific value;

You are $_{\text{the best int}}$ — the best value of uncertainty for a given quantity published in the KCDB BIPM .

The ratio of the uncertainty of measurements of Kazakhstan to the regional level, K $_{\text{reg}}$, %, is determined by the formula:

$$K_{reg} = \frac{U_{KZ}}{U_{best\ reg}} \times 100\ \% \qquad (2)$$

Where:

You are $_{\text{the best reg}}$ — the best value of uncertainty for a given quantity among countries of one region (for example, COOMET).

CMC coverage , C , %, by types of measurements is determined by the formula:

$$C = \frac{N_{CMC}}{N_{total}} \times 100\ \% \qquad (3)$$

Where:

N $_{\text{CMC}}$ is the number of dimensions for which Kazakhstan has CMC ;

N $_{\text{total}}$ — total number of measurements according to the BIPM classification .

The results are presented in Table 12.

Table 12 – Comparative analysis of the level of SMS in Kazakhstan

View measurements	Code By BIPM classifications	Name state standard of the Republic of Kazakhstan	Relative to international level, K $_{\text{int}}$	Ratio to regional level, K $_{\text{reg}}$	SMS coverage level, C
1.	2.	3.	4.	5.	6.

7 Identification of "gaps" between the measurement capabilities of Kazakhstan at the present stage and the needs of the economy and society in measurements

At this stage, the results of previously conducted surveys, analysis of information data from the Register of the State Scientific Inspection Service of the Republic of Kazakhstan, and analysis of rejected consumer applications to the State Scientific Medical Center are processed. At this stage, a cross-anaysis is conducted between the collected data and the lists of priority development areas and technologies, as well as international trends in the field of metrology.

Based on all the data obtained, diagrams of the relationship between capabilities and needs are formed in terms of measurement categories for each type of measurement under consideration, including information in the form of tables 8 and 9.

Table 13 – Analysis of measuring instruments exported for verification/calibration

Measurement code by classification CC BIPM icator	Name and type measuring instruments	Measurement range	Measurement error	Place verification/calibration	Standards used for verification/calibration	Possibility of verification Deniya in Kazakhstan (name PL/KL)
1.	2.	3.	4.	5.	6.	7.

8 Developing recommendations for forecasting measurement needs

Based on the collected data, recommendations are formed in key areas:

– on the development of metrological support for services for verification/calibration of measuring instruments in Kazakhstan (according to Table 14);

– for new measurement tasks requiring the development of appropriate standards, SI, SO, MVI (according to the form of Table 15);
– on the creation of new state standards, standards (in the form of table 16);
– on the modernization of state standards (according to the form of table 17)

Table 14 – Recommendations for the development of metrological support for services for verification/calibration of measuring instruments in Kazakhstan

Code of the type of measurement according to the BIPM classification	Types of measuring instruments not provided with verification/calibration	Measuring equipment (standards, measuring instruments, reference standards) required for verification/calibration	Scope (industry, area/type of activity)	Criticality level for ensuring metrological independence
1.	2.	3.	4.	5.

Number of stakeholders	Estimated costs for equipment acquisition	Economic efficiency (expected payback, income)	Source of funding	Proposed solution
6	7	8	9	10

Table 15 – New measurement tasks

Type of measurements	Measurement task
1.	2.

Table 16 – Proposals for the development of new standards of units of measurement

Type of measurements	Measurement task	Type and name of the standard	Metrological characteristics
1.	2.	3.	4.

Table 17 – Proposals for the modernization of state standards of units of measurement

Type of measurements	Measurement task	Name of the standard	Description of changes in metrological characteristics
1.	2.	3.	4.

9 Preparation of an analytical report

The final document includes key findings, structured tables, a map of metrological needs and proposals.

Proposed structure of the final analytical report

1. Introduction
2. Initial data, key development drivers, priority sectors and directions.
3. Analysis of information data on the current state of measurements.
4. Results of the survey
5. Comparative analysis of the state reference base and CMC of Kazakhstan
6. Metrological gaps
7. Development scenarios
8. Roadmap for the development of the state system for ensuring the uniformity of measurements for the planning period under consideration.

Conclusions

The key result of this study is the formation of a universal, adaptable tool applicable both at the scale of individual industries and the economy as a whole. The methodology takes into account both the best

international practices (BIPM, PTB, EMPIR) and the specifics of the Kazakhstan OEI system. A structure of analytical tables and questionnaires is proposed, ensuring the completeness and comparability of data.

It should be emphasized that the developed methodology represents a preliminary conceptual model, the practical implementation of which requires further verification, testing and institutional consolidation within the framework of program documents on the development of metrology.

The application of the proposed approaches of the methodology will allow:

– ensure strategic orientation of the development of the metrological infrastructure of Kazakhstan;

– effectively allocate resources for the development of new benchmarks and standards;

– identify promising areas of research and placement of metrological infrastructure facilities;

– improve coordination between government, science and industry.

References

1 ST RK 2.237-2012 "GSI RK. Analysis of the state of measurements, control and testing at an enterprise, in an organization"

2 ST RK 2.254-2012 "GSI RK. Assessment of the state of measurements in analytical, testing and measuring laboratories"

3 RD 50-466—84 "Methodological guidelines. Analysis of the state of measurements in sectors of the national economy and industry. Methodology of organization and procedure for conducting work"

4 RD 34.11.111-89 Methodological guidelines “Analysis of the state of metrological support at energy enterprises and in industry institutes” - Soyuztekhenergo , Moscow, 1990.

5 Head Organization of the Metrological Service of the USSR Ministry of Health. Methodological Guidelines for Conducting an Analysis of the State of Metrological Support for Measurements in Sanitary and Epidemiological Stations – Moscow, 1984.

6 Law of the Republic of Kazakhstan "On Ensuring the Uniformity of Measurements" dated June 7, 2000 N 53-II

7 Katharine E. Barker Deborah Cox Thordis Sveinsdottir, (2011), “Foresight on the future of public research metrology in Europe”, Foresight, Vol. 13 Iss 1 pp. 5 – 18

8 Ministry of Industry and Trade of the Russian Federation "Forecast of the needs of the economy and society in measurements for 2020-2025" - Moscow , 2019.

9 M. Cundeva -Blajer, M. Nakova , V. Sapundziovski , K. Demerdziev , Improvement of metrology infrastructure in the area of extreme impedance calibrations, Acta IMEKO, vol. 13 (2024) no. 3, pp. 1-6. DOI: 10.21014/ actaimeko.v 13i3.1765.

10 Harald Bosse et al " AdvManuNet : a networking project on metrology for advanced manufacturing". euspen's 20th International Conference &Exhibition, Geneva, CH, June 2020.

11 Anita Przyklenk et al 2021 Meas. Sci. Technol. 32 111001

12 Official website of BIPM . URL : https://www.bipm.org

13 Official website of COOMET . URL : https://www.coomet.org

14 Official website of APMP . URL : https : // metrologyasiapacific.com

15 Official website of EURAMET . URL : https://euramet.org

16 Official BIPM website . Coordination. CIPM MRA. KCDB. URL: https://www.bipm.org/kcdb/

Список источников

1. Государственная система обеспечения единства измерений Республики Казахстан. Анализ состояния измерений, контроля и испытаний на предприятии, в организации : СТ РК 2.237–2012. – Астана, 2012.

2. Государственная система обеспечения единства измерений Республики Казахстан. Оценка состояния измерений в аналитических, испытательных и измерительных лабораториях : СТ РК 2.254–2012. – Астана, 2012.

3. Методические указания. Анализ состояния измерений в отраслях народного хозяйства и промышленности. Методика организации и порядка проведения работ : РД 50-466–84. – М. : Госстандарт СССР, 1984.

4. Методические указания. Анализ состояния метрологического обеспечения на предприятиях энергетики и в отраслевых институтах : РД 34.11.111–89. – М. : Союзтехэнерго, 1990.

5. Методические указания по проведению анализа состояния метрологического обеспечения измерений в санитарно-эпидемиологических станциях. – М. : Минздрав СССР, 1984.

6. Республика Казахстан. Закон «Об обеспечении единства измерений» от 7 июня 2000 г. № 53-II. – Астана, 2000.

7. Barker K. E., Cox D., Sveinsdottir T. Foresight on the future of public research metrology in Europe // Foresight. – 2011. – Vol. 13, № 1. – P. 5–18.

8. Министерство промышленности и торговли Российской Федерации. Прогноз потребностей экономики и общества в измерениях на 2020–2025 гг. – М., 2019.

9. Cundeva-Blajer M., Nakova M., Sapundziovski V., Demerdziev K. Improvement of metrology infrastructure in the area of extreme impedance calibrations // Acta IMEKO. – 2024. – Vol. 13, № 3. – P. 1–6. – DOI: 10.21014/actaimeko.v13i3.1765.

10. Bosse H., et al. AdvManuNet: a networking project on metrology for advanced manufacturing // euspen's 20th Int. Conf. & Exhibition. – Geneva, 2020.

12. Przyklenk A., et al. // Measurement Science and Technology. – 2021. – Vol. 32. Международное бюро мер и весов (BIPM) [Электронный ресурс]. – Режим доступа: https://www.bipm.org

13. Евро-Азиатское сотрудничество национальных метрологических институтов (COOMET) [Электронный ресурс]. – Режим доступа: https://www.coomet.org

14. Азиатско-Тихоокеанская метрологическая программа (APMP) [Электронный ресурс]. – Режим доступа: https://metrologyasiapacific.com

15. Европейская ассоциация национальных метрологических институтов (EURAMET) [Электронный ресурс]. – Режим доступа: https://euramet.org

16. Международное бюро мер и весов. Координация. Соглашение CIPM MRA. База данных KCDB [Электронный ресурс]. – Режим доступа: https://www.bipm.org/kcdb/

Саттыбаева К. З.
Қ. Сәтбаев атындағы Қазақ ұлттық техникалық университеті, Қазақстан, Алматы

Қазақстан Республикасының экономика салалары үшін өлшемдердің жай-күйін талдау және өлшемдерге деген қажеттіліктерді болжау әдістемесін халықаралық тәжірибені ескере отырып әзірлеу

Аңдатпа

Халықаралық тәжірибеге (BIPM, PTB, EMPIR және т.б.) және Қазақстанның метрологиялық инфрақұрылымының қазіргі жай-күйін талдауға негізделе отырып, Қазақстан Республикасы экономика салалары үшін өлшемдердің жай-күйін талдау және өлшемдерге деген қажеттіліктерді болжау әдістемесін әзірлеудің бейімделген ғылыми-практикалық тәсілі ұсынылады. Бұл тәсіл сандық және сапалық талдау әдістерін, сондай-ақ форсайттық болжауды үйлестіруге негізделген. Ұсынылып отырған әдістеме сараптамалық талқылау және сауалнама жүргізу әдістерін, стратегиялық құжаттар мен ғылыми жарияланымдарға контент-талдау жасауды, BIPM деректері мен ақпараттық жүйелерін талдауды, сондай-ақ сценарийлік жоспарлау мен өлшеу мүмкіндіктері мен өлшеу қажеттіліктері арасындағы алшақтықтарды анықтауды қамтитын гибридтік модельге негізделген.

Түйінді сөздер: талдау, болжау, өлшеу мүмкіндіктері, стандарттар, өлшеу құралдары

Саттыбаева К.З.
Казахский национальный технический университет им. К.Сатпаева, Казахстан, Алматы

Разработка методологии анализа состояния измерений и прогнозирования потребностей в измерениях для отраслей экономики Республики Казахстан с учетом международного опыта

Аннотация

На основе международного опыта (BIPM, PTB, EMPIR и др.) и анализа текущего состояния метрологической инфраструктуры Казахстана предлагается адаптированный научно-практический подход к разработке методологии анализа состояния измерений и прогнозирования потребностей в измерениях для отраслей экономики Республики Казахстан, основанный на сочетании количественных и качественных методов анализа и форсайт-прогнозирования. Предлагаемая методология базируется на гибридной модели, включающей методы экспертного обсуждения и анкетирования, контент-анализ стратегических документов и научных публикаций, анализ данных и информационных систем BIPM, а также сценарное планирование и выявление разрывов между измерительными возможностями и потребностями в измерениях.

Ключевые слова: анализ, прогнозирование, измерительные возможности, стандарты, средства измерений