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EUROPEAN UNITS OF MEASUREMENT

BEFORE THE INTRODUCTION OF THE DECIMAL METRIC SYSTEM (XVII-XX CENTURY).

THEORETICAL AND APPLIED ASPECTS

AUTHOR'S SUMMARY

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Existential for every science is the problem with the “blank spots” in its field of research. It is a commonly accepted fact that the solution of that problem is crucial for its further development, particularly in the interdisciplinary climate of modern science. This also applies to the present of historical metrology in Bulgaria, and will determine its future. Scientific strategy and tactics are important because historical metrology is one of the scientific areas with intrinsic applied functions – to science and to social practice.

In Bulgarian and foreign reference books the etymology of the term “metrology” is explained by the combination of the Greek words μέτρον - measure and λόγος – science, i.e. science of measurement. (In the Bulgarian version of Wikipedia it is derived only from μέτρον – measure: http://bg.wikipedia.org/wiki/Метрология). In the current parameters of the research its object are the methods and tools for measuring, the extraction of information about the characteristics of objects through measurement with certain accuracy and reliability.

Metrology is divided into three main parts - theoretical, applied (practical) and legislative. The major stages in the development of metrology as a science are chronologically determined: first, by the adoption of the standard of the meter in the eighteenth century, second, by the developed by Taus in 1832 absolute metric system of units of measurement and third, by the creation of an international system of units (SI) in 1960.

Among the main problems metrology has to solve are:

• establishment of a general theory of measurement,

• formation the units of physical quantities,

• establishment of standards and patterns,

• development of the basic principles in the so-called Legal Metrology,

• development and standardization of measurement,

• development of methods for determining the point of measurement.

It is interesting to note that on the web site of the Bulgarian Institute of Metrology (http://bim.government.bg/) it is mentioned that the scope of metrology extends to: 1. measurements – methods, validation, assessment of their accuracy; 2. observations – the opportunities of measurement, i.e. reading the data of measurement; 3. measuring instruments – their characteristics studied in terms of their intended use; 4. units of measurement and standards – their establishment, reproduction, reduction and distribution. It is emphasized that in general metrology can be divided into scientific, industrial (technical) and legal. Seeking for common ground with history, in the chapter “History of metrology” I found out that the beginning of metrology was laid in 1888 with the adoption of the Law on Weights and Measures. At the same time history of metrology as a separate field dates from 1948, when the Inspection for Rationalization and Standardization was established. It existed for a year before it was converted into Supreme Council for Standardization. Then new structural reforms were made and the following institutions were established: Institute of Standardization, Metrology and Measurement Tools (1964–1970), State Inspectorate for Technical Control of the Quality of Production (1964–1970), Committee on Quality, Standardization and Metrology to the Council of Ministers (1970-1975), State Committee on Standardization, etc.

However, I could also not find anything as regards the links between metrology and history. I continued my search on the web site of the Union of Metrologists in Bulgaria, which is a national, non-profit, non-political, creative professional association established in Varna on November 1, 1990. Its major objectives are as follows: protection of the artistic and professional interests of its members, raising the prestige of their professions and creating conditions to improve their professional skills and performance, promotion and enhancement of the role and importance of

metrology, support for the effective participation of Bulgaria in the European and international structures and agreements, as well as developing scientific and technical policy in the areas related to metrological activities, promoting international excellence and innovation, support for the development of the necessary specific and lasting knowledge, awareness and attitude in their practical knowledge and investigating, collecting and disseminating national and international achievements, search for publications on topical issues (see detailed Statute of the Union of Metrologists – http://www.smb-bg.org/documents/).

We should not blame modern metrologists for neglecting the auxiliary functions of metrology to historical knowledge, because their aims and objectives are focused on the present and future of metrology as a science, which is actually a general trend on a world scale. Yet, it should be kept in mind that metrology does not begin with the introduction of the metric system. Measures and measuring units have existed as far back as antiquity. What is actually the subject matter of historical metrology, which feels more or less like "the abandoned child" in the family of all sciences? The present study is dedicated to the formation and cloning of metrological knowledge, the stages it has gone through, the different “types” of metrology, their relation to history and the sources on which it is built, the development of historical metrology in Bulgaria in a European context. We hope it would build a bridge between the exact sciences and the humanities and give an answer to the question what makes metrology an auxiliary science of history.

* * *

The unit by which the measurement process is conducted is called a measure. It is an arbitrary in origin value created by man initially for his own use and is relatively constant in a given society, adopted by common consent or will of the community without legal documents.

The initial forms of primitive measurements were made by men intuitively, subconsciously, long before they learned to read and write. It was determined by the needs of the people's material and spiritual practice.

The urgent need for precision and accuracy in measurement was driven by the development of public relations at the different levels of civilization and closely linked to it. It is generally accepted that both measurement and measures appeared together with counting and the first forms of numerical expression. Measurement is considered to be an active process related to the exploration of the world, expressed in numerical form with the units of measurement – the measures. It is no accident that ancient Japanese had a saying "Everything starts with the units."

The need for accuracy in measurement was closely related to the level of communication – interpersonal or within the social group. Probably that is the reason why the first measures that have occurred at a very early stage of human development were approximate and personal.

Schematically and conventionally speaking, the individual compared the objects of measurement to himself and used his own parameters. The words of the ancient Greek scholar Protagoras (1st century BC) "man is the measure of all things" are quite telling, even though they were not said in this connection. As early as the dawn of civilization "fingers", "spans", "elbows", "steps", and many other parts of the body gradually turned into measures that man could fit all places and occasions. In the specialized literature they were given the name "anthropometric" (from Greek "άνθρωπος" – man and "μέτρον" – measure). They are ubiquitous in all nations, their dimensions being strictly specific and different for the different communities. The development of primitive agriculture brought to the emergence of other measures related to the cultivation of land – the measures of area. The harvest and yields brought to the emergence of the measures of capacity. On this occasion Paul Lafargue wrote that "the

division of the land has given rise to the notion of measure of area and the appearance of vessels – of measures of capacity."

With the advent of the first forms of barter in the primitive societies appeared the need to measure the quantity of products that were subject to exchange. While for liquids and cereals vessels could still be used as measures of capacity, for some other "goods" that way of measurement was no longer acceptable and fair. It was not convenient to measure the more expensive goods such as food, ore, and later metals in this way. As a result was invented a way to measure the amount of substances by weight with the help of a double-arm lever, pans and weights, which were actually the first scales.

We should keep in mind that at this stage of development measures were of highly subjective nature. "Do not measure the other with your own measures," used to say ancient Russians. With the increasing sophistication of economic life, the development of trade, the progress in culture, the subjective nature of the measuring units gradually decreased. The comparative values which had come into being on the spur of the moment, were replaced by units of measurement that stood in increasingly more exact mathematical correlation to each other. Regular correlations between measures of different kinds were established (measures of length, area, capacity, volume). This pattern is also seen in the measurement systems of the ancient East – Babylon, Persia, Egypt, in ancient Rome and Greece. It builds on the achievements in the field of geometry. For example, the oldest measurement system that has reached us – the Babylonian one, is based on the principle of sexadesimal division, where as units of area and volume were used standards in the form of squares and cubes with sides that were equal to the length of the units. In this connection we might point to the statement of the Russian scientist D. Prozorovski that "when the weights, volume and length started to be divided in right proportion, the measurement of the bodies got mathematical character and that made metrology an autonomous system of knowledge".

“Social requirements” to measurement accuracy gradually increased. In an ancient text the requirements to the first “metrologists” are marked didactically: “If you become a land-surveyor or measurer, be well up in your calculations, take care and do not miss an instant without checking them, because mathematics is a fierce science ... And when you measure ... do not say “I shall measure that and leave the other,” for great disparity might occur in the measurement.”

As a result of the growing commercial, cultural and political ties, measurement systems, as well as individual measures started to borrow from each other and be transmitted from one nation to another. Under the influence of the Babylonian system measurement units were established in many countries of the Mediterranean region. For example, the Babylonian measure of weight “talent” appeared later in ancient Egypt, Syria, Palestine, Persia, Phoenicia and Greece. At the same time the Roman Empire obliged the conquered territories to use the Roman measurement system. Byzantium continued to use the Roman measures which had been borrowed from the Egyptian “orgia”, “modii”, “iuger” and many others.

In the Middle Ages, as a result of the increased trade contacts the Arab measures started to exert strong influence on the measures and measurement systems in the Near and the Middle East. Many of them are found on the territory of present Turkey, Iran and the countries of Central Asia. If in the antiquity one could speak of a certain unity in the measurements in the centralized states that was not the case in the age of feudalism. This is especially true for the early Middle Ages, characterized by fragmented natural economies, low centralization of power, underdeveloped road network and poor trade exchange.

In this stage of development of measures and measurement systems, one could notice a clear trend of differences – each country, region, city and village used its own measures. In this regard, having in mind divided France (which also applied to the other European countries of that time),

the Polish economic historian W. Kula wrote: “Each feudal lord was entitled to use his own weights and measures and to control them. This naturally led not only to metrological confusion and chaos, but also to abuses in the trade and taxation, which in its turn resulted in discontent among the population.”

It was a typical phenomenon measures with one and the same name to have different sizes. Thus in France the measure of weight “livra” was 490.4 grams in Paris, 492.1 g in Bordeaux, 425.3 g in Lyon, 402.1 g in Marseille. In the different cantons in Switzerland existed 15 different measures of length under the common name “toisse.” In the larger cities, even the different guilds had their own measures.

However, if the metrological problems in Europe were big, in the Balkans (like every negative event) they were multiplied. In the situated on two continents Ottoman Empire diversity was extremely rich. As the famous authority on Muslim metrology Walter Hinz wrote, only an extreme necessity could make a man slip into the mess of Muslim measures and balances on which sources are full of contradictions – seemingly accurate, but actually often fictitious information. A message of V. Turner from 1820 notes that it was impossible to fix any common standard of the measures and balances in Turkey, where almost every town had its own specific measures and balances. The Ottoman Empire appeared to be an instrument for imposing in Europe Asian measures such as arshin, oka, kile, meziur and many others, which enriched the metrological picture.

The situation in the Bulgarian lands which made part of the Ottoman Empire was the same. For example, the measure of cereals “kile” in Balchik was 60 oka, in Berkovitsa – 54 oka, in Vratsa – 120 oka, in Dobrich – 75 oka, in Karlovo – 120 oka, in Kyustendil – 100 oka, in Lovech – 87 oka, in Pleven – 100 oka, in Plovdiv – 100 oka, in Razgrad – 60 oka, in Ruse – 60 oka, in Samokov – 50 oka, in Svishtov – 80 oka, in Sofia – 100 oka, in Yambol – 24 oka. Similar was the situation with the other popular

measure – the “arshin.” Not accidentally, Bulgarian folklore is full of proverbs and phrases like “Everybody measures others by his own arshin,” “Measure with one and the same arshin”, “Measure with somebody else’s arshin,” etc. Arshins with the size of 60 cm, 63.7 cm, 65 cm, 68 cm and 75.8 cm were used at one and the same time.

The great diversity of measures and measurement systems hindered trade contacts and gave rise to difficulties of economic nature. If people from different countries, but even from different regions of the same country wanted to trade with each other, many calculations of the values of one or another measure had to be made. To overcome these obstacles people started preparing manuals which included information about the measures and the money used in the different countries, cities and regions. Later on handbooks for dealing with the measures started to appear.

In the Middle Ages such informative reference books appeared first in the Italian cities. This is explained by the fact that trade relations and interests stretched quite far and involved areas with different metrological systems. Even the merchants of Genoa and Venice, famous all over Europe, were not able to remember them. The manuals appeared first in the form of manuscripts and later started to be printed in large numbers. Similar guides appeared also among the trade circles in Russia in the second half of the sixteenth century, but much later in the Bulgarian lands. It was not only traders who had a need of the materials. They were also needed by geometricians and agrimensores.

The different reference books, manuals and books containing explanations about the variety of measures laid the foundations of metrology as a descriptive science. The classics from the early twentieth century defined the metrology created in this way as “collected information” and “descriptions” of measures, weights and coins used to determine the values of the substances. It described the common measures and

measurement systems used in different times and in different countries, their origins and converted them respectively to the then used systems.

The establishment of the metric system in France laid the beginning of the unification of measures and measurement systems nationwide. France's example in this respect was followed by other countries. This move towards unification of the measurement systems launched the “physical” trend in metrology. Along with the new measures, metrology also acquired new meaning. (It is a known fact that the old descriptive metrology completely avoided issues related to the experimental reproduction of the measuring units and their comparison.) This area of study was regarded as purely physical. In the course of time this attitude changed. Metrology could no longer be defined as “description” or “collected information” about measures. It became a science of the measuring units and standards, which dealt with specially fixed prototypes reproducing the size of the units of length, mass and their derivative standards of the first kind.

The metric system based on the physical values of length – meter and of mass – kilogram, became an integral part of the measurements in physics, they themselves being reproduced with its help. The result of this emphasis on this area of study related to the physical experiments was dropping out of the reach of modern metrology of the measures of occasional nature. The measures of value – the coins were dropped out. Local measurement systems also gradually died out. In this period, metrology started to take shape as a science of the measures, measures being understood as the linear measures and their derivatives – the square, the cubic and the measures of capacity, and weights being understood as the measures of mass. Descriptive metrology turned to the past and became an important auxiliary historical science – historical metrology. Coins as measures of value passed into the field of study of numismatics.

In 1875 the European countries signed a metric convention which made the metric system valid for its members, and its dissemination and introduction an issue of international nature. The contracting parties obliged themselves to establish an International Bureau of Weights and Measures with the aim to set national and international standards of metric measures, the preservation of international standards, comparing these standards with the national ones and establishing the exact correlation between the measuring units and the measures of non-metric nature that were still used in some countries.

The International Bureau of Weights and Measures became the first research institute of its time dealing particularly with metrology research. The work of this office raised the accuracy of measurement to unprecedented level of precision. The proven effectiveness of the new measures based on physical laws, contributed to the rapid implementation and use of the metric system in the whole world (except for the UK and the USA which still use their traditional national measures).

Bulgaria was one of the first countries to adopt the system in 1888 and already celebrated a centennial anniversary. In 1911 Bulgaria joined the Convention. As of January 1, 1985 the number of the states signatories of the Convention is 47, and more than 120 states have brought it into use.

It could be assumed that the unity of the measuring units in the world was the reason for the full “rebirth” of metrology. We should point first to the physical studies aimed at the improvement of the methods of measuring with the help of metric measures and the increase in the accuracy of measuring. Certainly that was not the only change in metrology. Gradually, it was enriched with new measuring units. The boost in the development of electronics required new measures in the field of electricity. In their search took part the most prominent scientists in that area of the time. As a result was created the system of measuring units (centimeter, gram, second) that linked all possible values with the three mechanical units. This system

received international recognition at the Electrical Congress of Paris. After the measures of electricity, the measures of light, heat, mechanical measures, etc., came into being.

The international cooperation in the field of unification of the international measures, the beginnings of which were laid by the metric convention had not ceased ever since. It is a typical feature of modern metrology. The international system of the SI units was established, which deals with seven major units: of length – meter, of mass – kilogram, of time – second, of size of the electric current – ampere, of thermodynamic temperature – kelvin, of amount of substance – mole, of light intensification – candela. The derivative units are drawn from the basic ones. They are presented as products of the major ones at different degrees (square meter – m^2, cubic meter - m^3, meter per second – m/s). To the additional units belong the measures of angle (radian and steradian, which could be referred both to the basic and to the derivative units).

Outside the international system were adopted:

• units that can be used parallel with the international system (minute for time; minute and second for angle, hour, day; degree - also for angle; liter; ton; electron volt; atomic mass unit, astronomical unit, parsec);

• units which are admitted temporarily (nautical mile, knot, angstrom, ar, ha, barn, bar, normal atmosphere, gal, curie, roentgen, rad);

• units from the system centimeter, gram, second (erg, dyne, poise, stokes, gauss, oersted, maxwell, stilb, phot)

• other items that are recommended to be excluded – fermi, metric carat, torr, kilogram force, calorie, micron, x unit, stere, gamma, and replaced by units from the international system.

In the late nineteenth century the increase in the volume of the metrological work and the understanding of the critical importance of the

accuracy of measurement for the progress of science and technology resulted in the establishment of metrology institutes in many countries. Many renowned scientists spoke enthusiastically about their work. The eminent Russian chemist Dmitri Mendeleev wrote: “Measures and weights are the main tools of knowledge in nature.” On another occasion, he said that “science has begun from the moment it started to be measured.” The British physicist Lord Kelvin has explicitly stated that “everything is known in such a degree in which it can be measured.” Even more explicit was the Russian researcher G. Yacoby, who pointed out that “no exact science or applied science, not a single experience could do without measuring.”

The particular importance attributed to the research in this field took its effect. The Physico-Technical Institute in Germany in 1887, the General Office of Weights and Measures in Russia in 1893, the National Physical Laboratory in England (1899), the National Bureau of Standards in the USA (1901) were established.

In 1921 the metric convention was reviewed and the aims and objectives of the International Bureau of Weights and Measures were extended. The metrological institutes carried out broad research activities in resolving the tasks. They enriched metrology with valuable achievements in exact measurements and created the final outlook of metrology as separate physical discipline with strictly differentiated field of research. In our time this metrology is divided into three main areas: theoretical, applied and legal.

Theoretical Metrology covers the general theoretical problems associated with measurement and the ensuring of unity of measurement. It is divided into two main areas: theory of measurement and theory of how to ensure unity of measurement. The first part of the research includes measuring instruments, measurement errors, methods of evaluation, the form of presentation of results and development of basic initial positions and concepts. The second area deals with the study of general problems

associated with ensuring unity of measurements, the units of physical values, verification schemes and the bases for establishing a system of metrological support of the national economy.

Applied Metrology is also divided into two parts. The first includes the development of new principles and methods of measuring and processing the results of the observations in the particular measurements, the activity on providing unity of measuring devices, standardization of the metrological characteristics of the measuring devices and determining the level of their accuracy. The second is related to the provision, reproduction and transmission of the size of the units, it includes fundamental development of model measuring devices, of standards – standard samples of the composition and features of the substances and materials, standard reference data.

Legislative Metrology combines the activity on the regulation of the general rules, requirements and standards for measuring. The current stage of development of metrology is characterized by its organic link with industry. All of its major issues are aimed at solving its main task – metrological support of the national economy. It includes establishment and application of scientific organizational bases, technical devices, rules and regulations necessary to achieve unity and accuracy of measurement.

Both direct and indirect scientific information shows that as early as the Middle Ages great importance was attached to the research on the old measures and measurement systems of the ancient peoples. What needs did they meet?

In my view the interest in the research on the old measures and weights is associated with the wave of new critical approach to ancient history which has started during the Renaissance.

Probably a lot of unnecessary work has been put in to calculate the actual weight of the columns of the Temple of Solomon. It happened that

young people who had particularly lush hair were not allowed to cut it for an entire year in order to weigh how much the hair cut weighed thereafter. This measuring was due to the fact that the hair of Salon that was cut once a year weighed 200 shekels, which was the standard for royal weight. This method of reproduction of royal standard was the most practical in restoring the old Israeli measure the shekel. In the Great French Encyclopedia under the title “Words relating to weights and measures” detailed attention is paid to these methods of assessment and reconstruction of the values of the old measuring units.

The first group of studies dealing with historical metrology problems is closely related to medical science. Not surprisingly as early as the sixteenth century the Italian naturalist Giorgio Agricola attributed to historical metrology the task to discover with accuracy the nature of the Greek and Roman weights that would make it possible for medics to recover medical knowledge of the ancient texts on medicine in such a way that to avoid making dangerous errors when dosing medications according to these texts. Although conventionally speaking, the beginning of this research was laid already in the 12th century. Traditional medicine in medieval Europe dates back to ancient Greek and Roman sources. Information from this field of knowledge was bequeathed to Europe mainly by the Arabs, as for Bulgaria – it came through Byzantium.

There are numerous examples to show that ancient reports were first translated into Arabic and then once again translated into Latin. This made the educated people of that time to make a new critical reading of the text so that to get to the original text. This task was helpful in resolving issues related to determining substances. Much more difficulties occurred when it came to the dosing of drugs, as well as to weights and measures used in ancient medicine. The research for the purposes of medicine in this area was based on the established opinion that ancient physicians were skilled and knew better than us. To be a good doctor, according to our

predecessors, it was necessary to understand Galen, and for that one needed to know the weights and measures from the time of Caesar Traian.

Such a belief underlies also other studies, the agronomic ones. In the second half of the 17th century a French scientist little-known in Bulgaria took upon himself to understand ancient agriculture, but he faced a number of metric difficulties. To prepare the ground for his agronomic considerations, he decided to explore the weights and measures used in this area. In 1780 he published a book devoted to this issue.

A third group of old studies on the history of weights and measures is related to socio-group struggle which was intensified at the end of the existence of the medieval society. In France this phenomenon was part of a process called consumer response. It was based on a certain return to the sources. Through old diplomas and other legal acts forgotten feudal rights, nobility, hereditary coats of arms started to be proven. That process was advantageous and “desired” by all. The villagers were convinced that the old taxes were lower, while the masters thought they would prove their greater value.

This task, however, was difficult to achieve technically. The dominant social group with its financial resources started to recruit employees who were to protect its interests. These were people with paleographical skills, who knew how to decipher texts, who had solid knowledge in the field of law and mathematics. Thus, if a case a divergence occurred between the feudal lord and the peasants that person gave a competent assessment which as a rule was always most favorable for their employer. These individuals had two main tasks. One was to find metrological rights in the old documents which were left in oblivion. These documents were often associated with the different types of natural levies and obligations. The other task was to try to increase the amount of services that were constantly used. In this case is observed the conspicuous tendency to prove that that the old measures of tax collection were higher than the ones

used in the particular time. Because of that social-group modality the studies of that kind distort the truth about the value of the old measures and one could hardly rely upon them.

The awakened interest of the historians during the Middle Ages to measures used in antiquity resulted in the appearance of scientific papers on that issue. The first more significant work was that of Mikhail Nendros in the sixteenth century. In 1537 was published the book of L. Paktus which focuses on the ancient Roman unit of weight and value the libra. Thus basis of the research the on the history of the units of the ancient peoples was laid.

The works of German, French, English, Italian and Flemish scientists from the 17th, 18th and especially the 19th century successfully explore the widely spread in ancient Babylon, Egypt, Rome, Greece and Byzantium measurement systems and units and their continuity. In 1882 the German historian Friedrich Hultz included in his book also the metrology of ancient Greece and Rome. In the 1893 was published the book of S. Letmann “Old Babylonian Weights and Measures,” the underlying idea of which being that all measurement systems in antiquity were derivatives of the Babylonian ones. One of the fundamental works in this period was the book of Russian scientist F. Petrushevskyi “General Metrology”. It covers not only the old Russian measures, but also the measures used in Central and Western Europe in his time, as well as those used in the ancient world.

The appearance, worldwide spread and introduction of the decimal metric system in the European countries at the end of 19th and early 20th century posed new problems and tasks to the researchers in this field. Practice necessitated to equalize the then used measurement systems in the different countries which were already outdated to their metric equivalents. This led to a new wave of research, mostly in the form of tables and manuals which give an idea of the actual values in the metric

equivalent of the old measures and measurement systems for individual countries, regions and cities.

Though slowly, historical metrology got over this period of accumulation of comparative material. That was a long empirical phase through which other sciences had also passed and without which it would be difficult to move forward. At the beginning of its development historical metrology focused on the patient collection and classification of rich metric information to come to the later stage of its methodological reflection.

Gradually the research on the history of the ancient measures and measurement systems, together with the used in the Middle Ages from the different countries, cities, and estates and the used by the population popular measures laid the beginning of a separate branch of study. They became known under the name “Historical Metrology”. At the end of the 19th and in the early 20th century, it found its place among the generally called auxiliary historical sciences. Its main function became the establishment of the nomenclature of the old measures and their quantification in commonly used measures in the present.

In this regard historical-metrological knowledge has multifaceted significance for history. To the fore came its heuristic function in establishing the origin of the documents, their dating, geographical and social localization, as well as the detection of forgeries.

Along with the other source indicators, historical metrology finds incomparably broader application in the quantitative analysis of the written sources about the socio-economic, legal and cultural history. The historians would not be able to work properly with the different register customs books, testaments, acts transactions, contracts, grants, etc., unless the information contained in them is not interpreted and updated with quantitative accuracy. The factual clarification of this accuracy is a major task of historical metrology.

Nowadays its research objectives are quite broad. In the 1970s, on the initiative of the Croatian scientist Z. Herkov in Zagreb was established International Committee on Historical Metrology. The active work of the committee gave its results. From 28th to 30th October 1975 in Zagreb was held the first International Congress of Historical Metrology. In 1977 in Edinburgh took place the second one, and in 1983 in Linz (Austria) – the third. Two international scientific conferences were also organized. This laid the beginning of a new and broader treatment of the science. Already at the first congress it was suggested that historical metrology should no longer content itself with its traditional obligation by using quantitative methods to convert the old units of measurement – Hebrew, Greek and Roman, which had passed to the Middle Ages and the later centuries – to their equivalent from the established metric system. It continued to be a traditional, but now a secondary task. Its subject was enriched thematically with the political and social aspects of metrological relations. Many other promising areas of research, such as the historical development of the science metrology, the emergence, implementation and difficulties in the establishment of the metric system in the different regions of the world were opened. Questions related to the evolution of the measurement methods and devices in different periods were raised.

The congress in Zagreb came to the conclusion that historical metrology has managed to reclaim more or less its autonomy in the list of the auxiliary historical sciences. Of course, putting an emphasis on this effort, we are not speaking about a hierarchy certain sciences. The aim was to get away from the old pre-metrological positions which had proved to be quite limited, in order to define better its current interests and to multiply its intellectual heritage. There was no need to present additional arguments to show that historical metrology was a part of a scientific field with various problems of its own. From this point of view the need of theoretical and applied generalizations and conclusions could be better

formulated. This need prompted a review of both the inherent objectives and the tasks of the science, and the methods it should use.

In a summary report to the First Congress of Historical Metrology the Italian scientist U. Tucci, outlining the old and the new directions in the development of the science, pointed out that the object of study could remain the same, but it should be understood in a broader or narrower sense. It could be defined more broadly, either in comparison with other auxiliary sciences – such as chronology or numismatics, or with metric systems which do not include only units of length, area, volume and weight. Thus, some areas of research would seem common with that of chronology, for example. That was because there was something which united the subject of these studies, at least in the eyes of sociologists and philosophers interested in the division of nature into space and time, but at the same time, the author emphasized that there was a risk some generalizations based on identical measurement to make an ill turn if an appropriate consideration was not brought into line with what was to be measured.

Henceforth, a birth was given to a good tradition of international congresses and conferences, which continues to this day.

It is known that many sciences can study the same subject, but explore its different aspects, approach it from different points of view and use specific methods, elucidating different characteristics of it and presenting the results in a peculiar way.

The subject of historical metrology - the old metrics and measurement systems – overlaps with that of ethnography, etymology, archeology, numismatics, history of architecture, mathematics and physics. This has brought to the emergence of interdisciplinary studies, which while resolving particular problems of the different sciences, reveal different aspects of the history of measures. Hence the creation of different branches in historical metrology, which are pre-metrological areas of

historical research in metrology according to the method applied. In my opinion the following areas should be distinguished:

– *First, ethnographic area of study.*

In ancient times appeared the popular measures that were brought forth from the needs of the people's material and spiritual activities. Typical of them is the fact that they did not differentiate the measure from the measurer. As a rule, it received the name of the measurer. Originally parts of the human body were used, and later - different tools. With the development of society the amount of these measures and their distinctness increased. The relatively stable parameters of the popular metric units led to the emergence of average standards based on the normal average conditions. Proportions between the popular measures were established. The result was a likeness of a system of measures, which the Russian nineteenth-century metrologist F. Petrushevskyi called primitive or natural measurement systems.This steadiness of the popular measures and their ability to be grouped in simplified metrological systems created the preconditions for the establishment of the national measures as the basis of the official metrological systems.

Popular measurement units are of interest also to ethnologists, as the measures and concepts of measurement were among the first manifestations of popular culture. These studies became commonly known as "popular metrology". It studies the layer of historical metrology which is closely related to folk art and tradition, i.e. it studies weights and measures from the aspect and using the methods of the ethnographic science. Subject of popular metrology is the emergence, continuity of popular measures, their development through the ages, the ethnic influences on them and finding their place in the traditional folk culture.

– *Secondly, the etymological area.*

Generally each measure got its name in direct relation to the way of measuring. Therefore, to understand the history and nature of a metrological term, it was necessary to make an etymological analysis of each term. Already in 1737 the Russian scientist V. N. Tatishev in his “Предложении о сочинении истории и географии Российской” suggested the need to collect information about the measuring units of the various peoples and their localization based on their names.

As early as the nineteenth century P. Butkov, D. Prozorovski, S. Kuznetsov, N. Belyaev made their contribution to the research on the terminological analysis of the different measures. Their focus was on the old Russian measures of length, distance, weight.

In the twentieth century studies devoted to popular metrological terms of the Slavic peoples were made by I. Dzendzelevski on the terminology of the weights and measures in the Subcarpathian region and by V. Vinnik – on the measures in the Ukrainian language. Old-Byelorussian metrological terms based on materials from written sources from the fifteenth-seventeenth centuries are the subject of the book of K. Scurat. G. Romanova also made an etymological analysis of 205 metrological terms in the Russian language.

Scientific experience shows that historians and ethnographers can not explore the old measures without a thorough etymological analysis of metrological terms. Quite often, it gives a real notion of their content. Due to such analysis one could get an idea of the initial real values and the origin of one or another measure. In the long process of historical development, some of the measures lost connection with their specific application, with the functions that were once vested in them by practice itself. Etymological analysis reveals precisely this particular connection.

– *Third, archaeological zone.*

Already in 1886 when defining metrology as a science the Russian scientist D. Prozorovski made the following significant statement: “When the word metrology is transferred to the field of archeology, then it has a different nature - it becomes a study about the history of the measuring units and as such renders great assistance to resolving historical tasks.” In this case, though naively for today, the author overlaps historical metrology with one of its branches, known in literature as archaeological metrology. It is known that during archaeological excavations on the territory of the ancient and medieval villages among the detected objects of material culture quite often are being found well preserved old measuring units, weights, remnants of scales and other measuring devices. In publications devoted to them, archaeologists pay attention to their origin, form, manufacturing, dating, local distribution and metric equivalent.

– *Fourth, architectural area.*

With the development of human material and spiritual culture there was an increase in the technical requirements for the tools of production and the products manufactured by them. This has brought to a continuous modification and improvement of the measurement of these products. Ever since the time of Vitruvius and Barbaro it was a known fact that in shipbuilding, engineering, construction of various missiles, etc. sizing was made by applying a module. This could be explained by the possible existence of an established belief among the designers and builders that simple relationships were not only more comfortable to apply trace and construct. They were the result of regularities that were yet untested but valid for all cases.

In his work “On architecture”, examining the proportions of the monuments of Roman architecture, Vitruvius found out that the architectural object which was the subject of measuring, was actually a physical embodiment of a conceived architectural composition, bearing the marks of all mathematical corrections that proportions required. It was

expected the object to be a perfect expression of that composition, but the detailed measurements showed that in the course of the construction it was impossible for the perfect project to come true. Its perfection was compromised and it deviated more or less from the pre-established architectural composition. This deviation is expressed in percentage between measured and calculated. Based on the existence of private and elementary sizes in the form of the greatest divider, the Italian scientist came to a conclusion about the similarity between these dimensions of the different objects and assumed that the particular and common elementary size was a measure that was essentially generic and served as a general measure of the entire diversity of uniform with it but quantitatively different values and it was called a module. He did not stop there, but reproduced also the human proportions while substantiating them with anthropometric measures used for measuring in the construction. Vitruvius laid the beginning of this method for reconstruction of the measures used in the construction of ancient buildings. The method was perfected in the nineteenth century by the British scientist Flanders Petrie. He called this branch of study “inductive metrology,” which is widely spread and used today.

– *Fifth, numismatic area.*

Numismatics studies the history of minting coins and ingots, their place in the commodity-money relations, monetary reform, paper money, etc. Studying the coins, numismatics seeks to answer questions about their weight, size, value and nominal systems, the percentage of precious metals and impurities in them, as well as issues related to the deterioration of the sample and the reduction of the weight while keeping previous nominal values. This gave rise to the formation of a circle of issues which were to become generally known as “numismatic metrology.” Sources for it are the written records of the given age, the weights for determining the weight of the coins and the coins themselves. The researchers in this field study the variety of meaning of the particular names of the weights and

measures, coupled with the coins and the monetary systems, the inaccuracy in the measurement techniques, the regular and irregular changes in the weight during the process of minting and the changes in the weight due to oxidation, etc.

These studies are important for historical metrology in a very broad area, such as the measures and coins from antiquity, because quite often in this period coins were a measure of value and weight at the same time.

– *Sixth, mathematical area.*

Turning to the most ancient history of mathematics, researchers face a number of metrological problems. Is it not that mathematics itself sprang up from the practical needs of people engaged with the measurement of the area of plots of land, the capacity of vessels and the calculation of time.

The first units of measurement and measurement systems were the initial manifestations of the mathematical thinking of the people, who developed and transformed them from natural units, as the measures are, into abstract numbers. Geometry emerged precisely to resolve the different human problems associated with the measurement of area, the construction of buildings, irrigation facilities and roads.

Issues such as how, with what means and in which way ancient people have calculated length, width, area and volume are an area common with the history of mathematics and it finds a place in their research.

– *Seventh, physical area.*

The modern scientific metrology is a part of technical physics. Its subject area includes also the physical values and their systems, standards and modes of transmission of the sizes of the measuring units from the standards to the model and working measuring equipment and the general methods for processing measurement results. A common area of research

for the two metrological sciences are the physical values of length, volume, mass, the work with the equipment needed to measure them. A curious proof of the integration of the research in this regard is Isaac Newton, who, turning to the historical roots of physics, was inspired to write a treatise on the ancient Egyptian “Holy Elbow.” Later on the research in this direction was continued by A. Jacobson and A. Machabey who give us insight into the ways and means of measuring and make us familiar with particular measuring devices and measures. From the more recent research of interest to us are the studies of the Japanese scientist S. Ivota who explores the raising of the level of accuracy in the measurement with scales in different periods, as well as the study of D. Prokich on the history of measurement of mass throughout the centuries.

The works dealing with scientific metrology also pay attention to the introduction of the metric system, its implementation and place in this branch of the science, as the technical aspects remained within the range of scientific metrology, and the social ones - in the subject of historical metrology.

These subject areas of historical metrology show the interdisciplinary nature of the science itself, on the one hand, while on the other – they reveal opportunities for its methodological enrichment and broadening the range of information it gives to historical science.

In my opinion, a more modern treatment of historical metrology as an auxiliary historical science would come to the following conclusions about its subject and tasks:

1. In the metrological research, which focuses on the history of the measuring units of the ancient peoples, it is necessary and appropriate to add to the measures of length, area, volume and capacity of loose and liquid substances and weight the measuring units of value, because in ancient times they usually coincided with the measures of weight.

2. In the Middle Ages, and later when the currency names gradually detached from the original names of weight, they should be related to numismatics and more precisely – to the so-called branch of “numismatic metrology”.

3. The measuring units of time enter the subject area of historical metrology, but only when they are closely related to expression of measures of distance and area. Measuring units of this type are a very typical phenomenon both for Antiquity and the Middle Ages, but also for later periods, up until the introduction of the metric system.

4. Besides the formally existent measures and measurement systems in different countries, cities and settlements, it is necessary to add the popular measures which have evolved as a product of anonymous and collective popular tradition and were a result of the direct connection of man with labor practices. They are not endorsed by formally adopted laws, have no established standards as the government measures, but live on by tradition and are quite steady in time, being transmitted from generation to generation, with minor differences in the values. They lay in the basis of the official measures.

5. To the subject of the historic metrology should be added also the units of tax, duty, customs taxation and some measures of quantity and number used in trade. On the one hand, they could be converted and compared with other measures, on the other – they affect one of the essential aspects of the quantitative characteristics of many products.

6. In the subject area should also be included the variety of devices used in measurement which are inextricably linked to the measures of length, area, volume, capacity, weight. For example, it is impossible, in our view, to make a comprehensive study of the weights, if not exploring also the measurement devices used for it – the scales.

7. It is also necessary to include in the science's subject area some border and hence unexplored by any science areas, such as the trends of unification of the measures and measurement systems, the role of the social conditions for the creation of conventional measures, the establishment of a single measurement system – the metric one and the difficulties accompanying its implementation in different parts of the world. An interesting transitional area is the natural extension of the measures of weight – those of mass.

The measures and measurement systems of the past carry rich anthropological and quantitative information because, as a social product each measure is a kind of expression – category of human relations and informs us about them in a certain way.

The relationship between measures, their names and area of distribution can shed light on many aspects of the cultural and commercial relations between different ethnic groups, countries and civilizations. The growing unification of the measures is an indicator of one of the most important developments in the history of mankind - the process of its cohesion and unity. Quite appropriate in this regard is the assessment of the father of quantitative history the French historian Marc Bloch on the importance of the metrological knowledge for the historian. In one of his books he points out: "Metrological research seems ungrateful at the first glance, but in the hands of the erudite researcher it becomes a powerful tool for revealing important aspects of the history of civilization."

Issues related to the old measures and measurement systems have attracted the attention of researchers from different branches of Bulgarian historical science. I shall focus on the main areas of study and the narrowly specialized research within the perimeter of historical metrology.

Measurement and measures are among the first acts of manifestation of popular culture and as such they are a subject of study of ethnography. Ethnographers explore the layer of metrology which is closely related to

popular culture, folk tradition, customs and rights. Bulgarian ethnography has made a valuable contribution to the study of the origin of the old measures, their value, names and practical application.

Already in the studies of Rakovski on the history of the Bulgarian people we find some empirical material, though scattered. Information on the used popular measures and weights is found in the ethnographic work of D. Marinov. He describes how people measured fields, meadows, vineyards, forest reserves and also fluids. The author gives us an idea of the system of division of the vessels - measures of capacity used in the distribution and measurement of the collected milk in the sheepfolds. D. Marinov mentions and describes measures used for particular farm products. Thus we learn that butter was measured in “lumps”, hay in “the amount a pitchfork can lift”, corn was gathered in “baskets”, and the harvested and collected sheaves - in “shocks.” The author does content himself with the arrangement of the measures used in the everyday life of the Bulgarians, but also gives their values, equalized to the then official measures. He also pays attention to the measures of which could not be attributed directly to historical metrology, but give an idea of the exchange relations of that time.

Mentioning and analysis of old measures is found also in the study of I. Shishmanov dedicated to the old Roman road from Belgrade to Constantinople. The author gives information about the Roman measurement system of length, equated to the Turkish and the European measurement systems. Material for the old measures, their values and area of use is found also in the collection of folklore of K. Shapkarev.

More significant information about the Bulgarian national measures is found in complex studies on the material and spiritual culture of the Bulgarian people.

In his studies on different branches of Bulgarian national culture one of the prominent Bulgarian ethnographers Hristo Vakarelski provides

information about the measures of length and area used by the Bulgarian people. The old measure of wine “pitcher” was studied by L. P. Vince. The author proves the Bulgarian origin of this measure and its use in the everyday life.

A comprehensive study of traditional Bulgarian folk measures from an ethnographic point of view was made by V. Sharlanova. The author focuses on some theoretical problems falling within the scope of historical metrology, offers definition of the subject and tasks of historical and in particular of popular metrology, which is a branch of the history of the measuring units. V. Sharlanova makes a historiographical review of the research on historical metrology in Bulgaria and abroad. On the basis of extensive source material, the author examines the measures and measurement systems in the Bulgarian lands since ancient times, during the First and the Second Bulgarian Empire and the period of Ottoman rule, up until the introduction of the European decimal metric system after the National Liberation. In this book the attention is focused on the traditional popular measures and measurement systems of length and distance, surface, capacity and volume, weight, time. It traces in details the process of dying out of these measures and measurement systems, and their replacement with the European metric system. For the first time in Bulgaria was composed a guide of the used popular measures, which gives comprehensive information about the names and their values.

In the course of archaeological research in Bulgaria has been found a great number of material records which could be attributed to historical metrology. These are different measures of weight used in the past in trade. The majority of the measures published in Bulgaria belong to the weight standards – exagii associated with the Roman and Byzantine metric and monetary systems. Museum collections keep measures dating from the Roman and early Byzantine era that have been found mostly in southern Bulgaria. They are made of bronze, lead, glass, etc. Many of them are parallelepiped-shaped, and more rarely are found measures with a

discoid shape. These weights used to be melted in the mints in the cities, and on them were engraved signs and letters certifying their exact weight and the system under which they were made. During archaeological excavations in the Byzantine settlement near Pernik were discovered five exagii. They helped to established for the first time an entire system for determining the weight of the gold coins in the Bulgarian lands. Finds from the region of Nove, Silistra, the Shumen Fortress and Preslav were also published. Near Razgrad were found marble weights dating from antiquity. Such were found also in Pavlikeni. From the late antique city Gradishte near Gabrovo date four weight measures. The authors of these publications give us insight into the appearance of the measures, their practical application, dating, systems of division, grouping, and their metric equivalents.

Another group of research with its own specific method focuses on the reconstruction of old measures and measuring systems used in the construction of religious buildings, etc. Fundamental in this respect is the work of L. Dinolov “Contribution to the metric study of medieval religious architecture in Bulgaria.” The author tries to identify how the medieval religious buildings in Bulgarian lands were sized. To this end, he makes a metric analysis of twenty-five sites with different horizontal and upright configuration. The study provides data on the metrology and the metric systems, and the characteristics of measurement as psychophysiological and physio-experimental activity. As a result of detailed photographing of the studied objects, this book gives metric registration, which served as raw material subject to processing and deciphering. To get a clearer picture of the measures, the author converts the sizes of various elements of the buildings to the Byzantine metric system. Among the identified values he seeks for the one that suits best the necessary for the particular object fortress. This is the so called “rectification” of the measurement systems. In the process of rectification the author comes to the conclusion that in medieval religious architecture there actually existed a module. As

evidence of that L. Dinolov attaches to the metric analysis a table for each of the studied sites. The author focuses in details on the used anthropometric measurement units, illustrating them with photos to show their approximate size and equating them to the decimal metric system.

In this respect of interest is the article of D. Vassileva, dedicated to the Thracian measure of length “step”. In her attempt to restore this old measuring unit used in the construction of Thracian buildings, the author gives rich information on the anthropometric measuring units of length used in antiquity. She points also their real values, converted into metric units. This article demonstrates the unity of measuring in the various Thracian architectural monuments. The author reveals the common module that was used in them and reconstructs that measure.

Of great interest among researchers are the measures and measurement systems used within the Ottoman Empire, particularly in the Bulgarian lands. This period of the historical and economic development of the Bulgarian lands is characterized by a great variety of measures. An evidence of that is a document from V. Turner of 1820, which notes that it was impossible to fix any common standard of weights and measures in Turkey, where almost every town had its own specific weights and measures.

This variety of measuring units is typical of the Middle Ages, but it seems it has flourished “most splendidly” in the Muslim lands. In this state of the old measures it is easy to understand why in their analysis of the economic phenomena many researchers of the social and economic life of that period pay great attention to the measures and measurement systems used in the different regions of the empire. Such are the studies of I. Sakazov, N. B. Mihov, N. Todorov and M. Kalitsin, B. Tsvetkova, Y. Spisarevska, V. Mutafchieva, Str. Dimitrov.

G. Galabov attaches to the published Turkish sources on history and law rich commentary notes on the old measures. The above mentioned

authors provide information about the most commonly used measuring units in the economic life of the Ottoman Empire. There is a great variety in the values of the measures such as “kile”, “arshin”, “donum”, “oka”, etc., which can be explained with the feudal fragmentation and the lack of connections between the different parts of the empire, as well as with the decentralization of power. In this regard, the German scholar W. Hintz notes that “if not having a particular need nobody would dare to stick into the mess of Muslim metrology” and that “sources are abundant in contradictory, at the first glance precise, but indeed often false information.”

The great interest in the economic history of the Ottoman Empire, including the Bulgarian lands, justifies and increases the interest in historical metrology. This connection is shown quite figuratively by the Hungarian scholar Istvan Kis, who in his study on economic history compares it with a giant, whose two eyes represent the history of measures and the history of money and prices.

In a book dedicated to some issues of Balkan economy in the sixteenth-nineteenth centuries, L. Berov notes that it could be noticed a great variety in the weights and measures used in different regions of the empire and even in the narrow confines of the different ethnic communities, such as the Bulgarian lands, the Serbian lands, etc., due to the unfinished process of formation of a unified national market. This diversity is in the focus of attention of the same author in his article dealing with the problems of metrology in the Balkans during the period of Ottoman rule. In this article he presents many of the measuring units used in the economy that were specific for the economic life in this period. The author has given detailed information about their place in the practice and the values of the measures of area “mattock”, of weight “oka”, “load”, “mut”, of length “elbow”, “arshin”, of capacity of holding cereals “kile”, “half a bushel”, “quarter of a bushel”. Thoroughly are explored also the different values of measures with one and the same name in different regions of the empire. In determining these values L. Berov has used the method of comparative analysis with similar

measures used in Constantinople, Veles, Russia, Denmark, England. This article is a valuable resource for the study of the quantitative phenomena in the economic life of Bulgaria in the period 16th-19th c.

Some problems of historical metrology in the publications of documents in Bulgaria are clarified by D. B. Cohen. The author justifies the need for such a study with the lack of rules for making commentary notes to documents containing texts with old measures. He believes archeography has gained considerable experience in the publishing of documents from the Middle Ages in commenting on texts which need to be updated. D. Cohen discusses also issues related to the equation of the old measuring units to the present ones, emphasizing their subjective nature and pointing to some basic rules in dealing them in the work with the documents. Measures should be viewed in close connection with the document, in which they are mentioned, and when determining their values one should be guided by the state laws on weights and measures, markets, taxation, ports, cities, etc. valid at the particular time. The author of this article makes an extensive use of comparative analysis in specifying a certain measurement system, individual measures and designations and the cases in which they were applied. He argues that only after comparing them or if verifying the data with results from other studies we could get closer to their real values. D. Cohen points out that in Bulgaria too little work is done on the problems of historical metrology.

The lack of a uniform system of weights and measures in our lands until the Liberation and in the first decade afterwards gives ground to the same author to further develop and summarize a number of problems related to historical metrology in Bulgaria He did that in his article “On the subject of historical metrology and some more spread old measures of length and weight in Bulgaria and the Bulgarian lands.” In this article D. Cohen touches upon some undeveloped theoretical problems on the subject of historical metrology, specifies its tasks and perimeters of study as an auxiliary historical discipline and distinguishes it from history and

numismatics. The same author seeks for the sources of Bulgarian historical metrology in several directions: Old-Bulgarian written records, Greek and Latin sources on Bulgarian history. In his view, the main sources are the Turkish, French, German sources on our history, as well as some normative documents, monographs. Very important data on historical metrology is contained in various laws, regulations, orders, vizier letters to vilayets and particular cities issued by the Ottoman authorities.

In this article D. Cohen points the link of historical metrology with other branches of the scientific knowledge such as archival science, bibliography, historical geography, numismatics, epigraphy, economic history, history of the state and law.

To some of the old measures of length and area used in agriculture and their values is devoted the article of N. Savov “Some old measures and weights in Bulgarian agriculture.”

The emergence and development of capitalist relations has led to the expansion of trade contacts, which in turn strengthened the processes of unification as regards the great number and variety of measurement systems in the different countries. An important stage in the history of measures is associated with the international system of measuring units that was established with the aim to achieve unity in the used measures and measuring devices in all fields of science, technology and economy. The emergence of this system is associated with the French Revolution, when a decision of the National Convention of April 7, 1795 introduced rational units valid “for all peoples and for all times.” Gradually the decimal metric system was adopted and entered the practice of the European countries.

This important period in the history of the measuring units was reflected in the pre- and post-liberation Bulgarian press. These are different tables which equate the existing old measures to the new European measures and inform about the history of the decimal metric system. Such was the purpose and content of the published in 1884 book of I. Yurdanov

“The metric system or practical introduction to the new measures.” In 1892, V. N. Ikonomov published on ninety pages “Guide on the metric system, supplemented by some of the most important foreign measures.” The book of the Varna middle school teacher M. Katarov of 1921 “Measures, coins and exchange rates” was prompted by the need that has emerged in the schools to know how to handle the measuring units. From that book the reader becomes familiar with the terms “measuring”, “measure,” the needs arising from the introduction of the new measurement system in Bulgaria, receives information of the existent in that period English, Turkish and Russian measures in Bulgaria. Similar was the guide compiled by G. Yonkov in 1934 “Commercial calculation for business schools and self-educated people.” The studies dealing with scientific metrology also pay due attention to the history and spread of the decimal European measurement system. The issues related to the dying out of the old measures and measurement systems in Bulgaria and their replacement with the new European measurement system are presented in the studies of G. Georgiev, V. Sharlanova, Hr. Stoycheva, D. Cohen and M. Vekov.

In recent years were published complete and in-depth studies which contributed to the establishment of metrology as a key auxiliary historical science in Bulgaria. In 2005 came out the “Thracian tombs - architectural metric study,” in which architect Darina Vasileva presented the Thracian measures and measurement systems, and the corresponding values “step”, “palm”, “finger”, “obol”, “talent” and others. In the field of popular metrology V. Sharlanova published the results of her research in the monograph “Bulgarian popular measures.” In 1998 M. Vekov presented in his book the most used measures in the Bulgarian lands in the 18th-19th centuries (Bulgarian Historical Review, 1998, № 1-2, p 102-138), analyzing in separate articles 331 metrological terms of European and Asian origin. Later on, on the basis of this study, which was enriched with new source material, was published in German the book “The historical metrology of Bulgaria in the 15th-19th centuries”, presenting the theoretical and practical

aspects of metrology in Bulgaria and the Eurasian influences. In 2004, Hristo Haritonov published an encyclopedic reference book summarizing what has been accumulated by several generations of metrologists and numismatists ("Old measures, weights and coins in Bulgaria, 12th–20th centuries"), which is accessible to the average reader. On the recent history of metrology is dedicated "The metric system in Bulgaria. Metric reforms and metrology activities, 18th–20th centuries," which builds a bridge between the modern and the historical metrology from the position of the international decimal metric system.

Historical sciences, including historical metrology, study facts, events, phenomena that have ceased to exist, but have left traces in the human memory or any written and other records, traces of the material and spiritual activity in the past. Involved in the process of knowledge, they carry information about various aspects of this activity. Historical sources are different in origin, time and place of creation, type and method of the "fixed" and encoded in them quantitative information about the past. Among them, because of their specifics, are worth mentioning the sources of historical metrology. They are numerous and diverse. Their essential characteristic features give grounds for making the following typology.

In my view, in the first group of sources on historical metrology, are the numerous iconographic images which have come to us from different periods. For example, the scale is an attribute of the Egyptian god Amon-Ra. The angel also holds a scale in his hand in many scenes of the final judgment on the doors of Romanesque and Gothic cathedrals. Painted in one way or another, they give us accurate and truthful information on the study of measuring devices and the ways they were used.

Similar is the source material related to measures of surface, but in this respect there are also valuable iconographic documents. This group includes various drawings and sketches found in handbooks or manuals on geometry, trade and agriculture. Having played the role of illustrations, they

contain interesting factual information about the type, name and functions of the measures and weights used in the past.

Another significant group of sources are preserved in the original form and available to this day lines of measurement, weights, vessels used for measuring of capacity and the like. However, the preservation of a bigger number of such monuments is hampered by the fact that a large part of them were made of perishable material (wood, leather, clay, stone) and are subject to time.

Measures preserved in the “original” are found in museums dedicated to the material history, ethnography, science, culture and technology. In Bulgaria, such measures are preserved in the archaeological museums in Sofia, Plovdiv, Varna, Yambol, Targovishte. The measures carved in stone in front of shopping plazas and town halls also give us metrological information. Some of them are preserved in museums, while others are exhibited in their natural environment. In any case they contain information about measures of local character. The fact that not so many measures in the original have survived to this day should not astonish us, because throughout the ages numerous attempts for the unification of weights and measures, including the metric reform have been carried out. These changes each time were associated with orders to destroy the old measures that had already lost their mandatory nature. Maintaining them after each reform often became punishable with the new order. In the museums are often found measuring devices – mostly scales, and not weights and lines of measurement, because the measuring device itself did not loose its value. In the metric reforms only the weights lost their power and only they were affected by the regulation for destruction. Their breaking, deformation or dissection was being encouraged, as the affected owners were given new ones, and the control over their destruction was an obligation of the state authorities.

Sources for the study of the history of the old measures are not only those preserved in the original. To a third group of bearers of metrological information could be related objects from the everyday life. Their size gives an idea of the popular standards of the measures (of course, we have to trust to the generations of artisans who have handled them). In this sense, sources on historical metrology are the old architectural monuments, the width of the fabrics, the size of bricks. For example, when the three dimensions of the brick appear to be proportionate, where the proportion between width and length determine with no residue the height, or in the case of the fabric, where also the width is proportionate to length – all this is not accidental. It indicates the presence of correlations, actual functioning of measures in a given society in accordance with the popular standards.

Valuable sources of historical metrology are folklore, rituals, customs, sayings, proverbs, songs and stories. They give us information about the use of different measures, their place in people's lives, the interpersonal relationships associated with the measurement process.

Another category of sources which has appeared much later are the handwritten and later printed “manuals” (speaking in the modern language – reference books). The “handbooks” that have appeared in early Middle Ages were rather commercial, whereas the later ones are already teaching aids for handling measures. To some extent, the commercial materials are more informative, because they provide information on the weights and measures in different areas or regions. In this respect, we must add that their credibility is not easy to confirm. As forerunners of this kind of works are considered Epiphanius from Cyprus (4^{th} c. AD) and Ananias of Sirat (Armenian mathematician from the 7^{th} c. AD). Since the Middle Ages the manuals from the Italian cities were the most numerous. Their commercial interests spread on large territories, affecting areas which had different metric systems, which even merchants were not able to remember. This necessitated the appearance and use of “handbooks” originally

handwritten, and later printed. Belatedly, already in the late fourteenth century similar works appeared also among the trade circles in Russia. That was the famous “Trading Book” [Torgovaya kniga], the authors of which were probably people actively involved in the internal and external trade of the country. Such a guide of the seventeenth century in the Greek language is kept in the library of the Rila Monastery.

Undoubtedly, not only merchants needed such handbooks but also geometricians and agrimensores whose activity was mainly associated with measurement. Reference books related to such activities can be found already in ancient Egypt. As an example of this early period can be pointed the so-called Rhind Papyrus. It was bought from Luxor, and later bequeathed to the British Museum. It dates from the time when in Egypt ruled the hioks – around 1880 BC., but as the scribe Ahmes assures, the manuscript is based on an original from the Middle Kingdom of 3000-–1800 BC. Besides other information, the papyrus informs also about the calculation of the necessary amount of grain for making bread and beer, calculation of surfaces and volumes, the conversion of some measures of grain into othersIn the Middle Ages such work was published in 1556 in Krakow under the title “Geometry as a science of measuring.” To this type of works belongs the book of L. P. Magnitsky – “Arithmetic”, published in 1703 which has had a second edition because of its relevance in Moscow in 1914.

Another large group are the written sources of official origin. These are legislative collections of the authorities, regulations, records, inventories. It includes also personal documents, such as reports and travelogues.

Richest in information about the measures in the Bulgarian lands during the Ottoman rule are the sultan kanunames, laws, regulations, orders, vezier letters to the vilayets, cities, ports, markets. They are related to the collection of taxes, fees, levies or refer to the management of land,

forests, fiefs and rights. Among them are also the records about the income from the land and estates, the kadi records and the acts of sale.

Last but not least is the group of sources related to the history of the introduction of the metric system. It includes all documents related to the establishment and use of the metric measures. Information about this process is found in the Hatti Humayun of February 18, 1856, a vezier order of November 19, 1869, “The statute for comparing and reviewing new measures and weights” that has come into use, a bill on the weights and measures in Eastern Rumelia of 1879.

I have discussed in more details the system-structural characteristic of historical knowledge to outline better the development of metrology as an auxiliary science of history in Europe and Bulgaria. It has its own subject of study, its sources and specific methodology. It is interdisciplinary in nature because it draws expertise from the fields of the exact sciences, historical information about the economic and political developments in the society, the theoretical advances in the source studies which give the most correct algorithm on the critique of historical sources. This interdisciplinarity increases the cognitive function of historical metrology in the reconstruction of the economic, political, cultural and technological development of the peoples in the different pre-metric periods.

The dissertation “*European Units of Measurement before the introduction of the decimal metric system (XVII-XX century). Theoretical and applied aspects”* is a result of almost 25 years of research, analysis and interdisciplinary synthesis and traces the development of metrology and its subsidiary - historical metrology, to "fill" a number of "blank spots" in order to answer numerous questions, some of which have not been solved so far in European scientific literature.

The introduction is called "Introduction to metrology." It explains the motivation behind the choice of subject. The first motive (hopefully someone won't find it insignificant) is the widespread virtual incompetence in determining the substantive subject of metrology and the scientific prerequisites which determine the subject of study and the specific methodology of historical metrology. The second motive was determined by the heuristic possibilities of interdisciplinary methodology. Studies of scientific results in these fields of knowledge prompted awareness of the necessity to bridge the exact sciences and the humanities and to answer the question of how metrology is being affirmed as an auxiliary historical science. Third, to reveal successively the long road of metrology, which did not start with the introduction of the decimal measurement system, since there had been measures and measurements before that, all the way back to the dawn of civilization. Fourth motive – to present through comparative, quantitative and etymological analysis the different units and systems existing through the centuries, distinctive with their tendency to be autonomous - each country, county, town or village had used its own measures, up until their unification with the introduction of the decimal metric system. That is to say to demonstrate the metrological richness and diversity (far too abundant on the Balkans), which is reflected in one way or another in the historical documents. But the units of measurement have a different type of diversity defined by the object of measurement, which is being clarified in the following chapters.

These include *measures for space*, which are the subject of the first chapter. They are conditioned by our three-dimensional world, where measurement is performed through measures of length, area and volume. The attention to pre-decimal forms of measuring space arises from the fact that they can rightfully be regarded as the first type of measurement ever.

The prehistoric man had had "at hand" the first perfect, natural and close to himself measuring device - his own body. Thus, measures such as finger, span, elbow, step, etc. had been used since the dawn of mankind. In addition to these human measures, known in the scientific literature as *anthropometrics,* man had also resorted to a number of other means.

In the first subsection we reveal the specifics of the *measures of length* in the European metrological practice over the centuries, including the Bulgarian folk tradition. Historical sources and folklore have preserved their diversity. The diversity and especially the differences are distinctive for the area-related measures too (second subsection). The measures of volume (third bullet point) come as a natural continuation of the units for measuring length and area. They had resulted from mans practical needs to measure heterogeneous materials.

In response to the question, namely the need to fill in the "blank spots" in metrology, the first chapter ends with Appendix 1, a list of their quantitative natures and proportions. Studied and recalculated are over 800 metrological terms, including these of Europe and its colonies. Special attention is being given to measures from the Balkans and Bulgaria. For the first time there is a reasoned and detailed analysis of the measure *arshin* (*cubit)*, essential for all Eastern European measurements. Listed are the traditional folk measures as well as the regional and official ones. One example is *GREKH, GRE, GREI, GREK, KIR* - Turkish linear measure of length (from ghirah, guirakh, kekarhe, as the URUPA, or 1/8 of the step, is called); in Muslim metrology it is a partition of the arshin (1/16), and varies as follows: 1. Bazaar's arshin grekh (4.25 cm); 2. Endeze grekh (sewing arshin) (5.10 cm).

The second chapter of the study "*Measuring the volume (measures for dry products and liquids)*" brings to light the specifics of the volume measures. Subsection 1 explains the technology of measuring grain over the centuries. The different areas with Bulgarian population had extremely varied manner for measuring liquids (Subsection 2). There was diversity in techniques for measuring liquids in all European nations, which required the accumulation of Appendix 2. More than 900 measures have been studied and summarized for the first time - some have different values for the different products and are given in liters. The strongest example of the rich measurement diversity is *KILE, KILO* – an Ottoman measure (from Arab. kejl, keyl – take measures) with a double meaning: 1. A measure for

volume and weight of liquid and bulk products; it is also called MERITSA in Bulgarian and it is considered a successor of the Byzantine *yagoditsa*; very common for measuring grain, mainly wheat, all over the Balkan Peninsula; there are many variables and regional variations: 1. The Constantinople kile (approx. 35 liters); Constantinople kile for wheat (23-24 oka); for corn and rye (21-22 oka); barley (18-19 oka); oats (15-16 oka); other grains (22 oka); 2. The Balchik kile (11 l / 60 oka); 3. The Berkovitsa kile (100 l / 54 oka); 4. The Bitola kile (96 oka), the Bitola kile for wheat (80-90 oka), for barley (65-70 oka), for corn (82-85 oka), for oats (48-52 oka); 5. The Burgas kile (55.5 l / 930 oka); 6. The Varna kile (111 l / oka 60, 148 l / 80 oka, 162.8 l / 88 oka); 7. The Vidin kile (166.5 l / 90 oka – the data is from the XVI century and 1856; 148 l / 80 oka – 1853; 185 l / 100 oka); 8. The Galats kile (415.83 l / 240 oka); 9. The Vratsa kile (222 to 229.4 l / 120 to 124 oka); 10. The Dobrich kile (138 l / 75 oka); 11. The Dobrudzha kile (129.5 l / 70 oka - 1832); 12. The Danube kile (138,75 l / 75 oka, 128 l / 69 oka - 1889); 13. The Westbulgarian kile (38.85 l / 21 oka - 1861); 14. The Karlovo kile (103.6 l / 56 oka - 1886); 15. The Kladovo kile (120 oka); 16. The Korchan kile (40 oka); 17. The Kyustendil kile (186 l / 100 oka); 18. The Lovech kile (185 l / 87 oka - XVI century); ... 46. The Shumen kile - 111 l / 60 oka (XVI century); 47. The Southern Bulgarian kile - 88.8 l / 48 oka; 48. The Yambol kile - 44.4 l / oka 24 (XVI century). 2. It was used as a measure for the area of cropped lands; one kile corresponded to 3-4 dyunyuma land.

The third chapter presents information about the measures of weight (Subsection 2), number and amount (Subsection 3), tracing their development since antiquity in a wide temporal and geographical span. The comprehensive retrospective look presents for the first time the dynamic development of their tools as well. The quantitative analysis in Appendix 3 shows more than 900 units of measurement with various dimension values and names depending on the material being measured. Particular attention is given to the Ottoman units, which - unlike the European, had not derived from the Roman metrology. For example, *ARPA* – an old Turkish unit of weight of small objects weighing as much barley grain (approx. 25 mg);

KANTAR – unit of weight; from the Latin *centensarius* ('100 liters or lb '), then passes into the Byzantine metrology, where it is borrowed from the Arabs and Turks; widely popular throughout the Mediterranean and the Balkan Peninsula; its earliest occurrence in our lands is in the Bulgarian Venetian Trade Agreement from 1352; varieties: The Constantinople kantar (44 oka); The Samokov kantar (60 oka); The Varna kantar (44 oka); The Western Bulgaria kantar (10 oka).

The fourth and last chapter of the study, "*The old measures - an attempt for a historical and metrological characterization*", provides new heuristic solutions to the many "blank spots" in the theoretical understanding of this applied historical science. A first attempt is made for shedding light on the old measures in the European social practice and historiography (subsection 1). A typology of the sources for the historical metrology is proposed (subsection 2), which addressee is both this scientific field and the managers of the scientific world. The theoretical model - in its synchrony and diachrony, points the location of historical metrology in the system of historical sciences (subsection 3). There is also an emphasis on the human nature of the measures in a semantic and functional aspect. This is a first attempt for applying the methods of social anthropology to the historical Metrology (subsections 4 and 5). There is an exposition of the relations and dependencies between the magnitude of the units of measurement and the value of the measured material (subsection 6) and the chronological limits of variability of the pre-decimal measures by subject and chronological lines (subsection 7). Variability with negative consequences for the social practice - and there had been attempts to counteract them as early as the pre-decimal age – until, albeit with objective and subjective "obstacles", unification was achieved, when the French Decimal Metric System (The National Convention decided on April 7, 1795 on introducing universally valid rational units) became an international one (subsections 8 and 9).

The thesis ends with a conclusion, a list of references and a summary in English.

The total of 2600 measures of length, area, volume, weight, number, quantity, listed here provide the foundation for one - in a relative sense new metrological language with which to decipher the numerical and quantitative characteristics of many processes and phenomena from the past. This is a necessary leap, determined by the current requirements for improving the methodology and the applied functions of each scientific field.

* * *

The main contributions of this study can be summarized as follows:

1. It’s the first detailed analysis in historical literature of the

technology of measuring space in Europe, the Balkans and Bulgaria through the detection of general relations, analogies and extrapolations used in the measurement of lengths, heights, distances, areas and volumes. The theoretical justification is supported by a collection of more that 800 meteorological terms not only in Europe, but also in its colonies in Africa, Asia, America, used in the social practice mostly in the XVII-XX century.

2. An entirely new approach is the quantitative "photography" of the measures of volume for liquid and dry bulk products, accompanied by a historical metrological analysis of the same period, when trading and market relations were becoming more intense and the metrological misunderstandings and frauds increased. They were determined by the specificity of the measured materials, when almost every commodity was measured by various measures. This study brings a significant order to the field of measurements, supported by the conversions and systematization of more than 900 meteorological terms used in the pre-decimal era of metrology.

3. It points the metric equivalent of more than 900 units of measurement for mass, weight, count and amount, used in Europe and its

colonies mostly in the outlined period. Given the specifics of this form of measurement the analysis of their genesis often goes back to antiquity and the Middle Ages. The quantification and comparative study of these measurements for Bulgaria and the Balkans is the first of its kind.

4. This summarized metrological information of about 2600 metrological terms significantly enriches the metrological language and vocabulary, and after numerous recalculations give numerical and quantitative characteristics in an accessible for the modern scientists form. These are the heuristic functions of metrology.

5. It is the first complete analysis in terms of historiography and source studies of the place of the old measures in the metrological knowledge and its main auxiliary function in history, leading to greater accuracy in the scientific research in the fields of physics, ethnology, archival science, anthropology, etc.

6. It is the first attempt at detecting the characteristics of the pre-decimal measures from different angles and with different methods associated with semantic and functional nature of these measures, their place and function in the economic life, their variable geographical and chronological lines and the hidden metrological traps that are everywhere.

7. It gives the first account of the French measurement system history and the difficulties that have accompanied the unification process, until it became the International System of Units (international designation SI, from French: Système international d'unités) - the most widely used in science, economy and technology.

Publications of docent dr. Mancho Vekov on the subject of the dissertation

“European units of measurement before the introduction of the decimal metric system (XVII-XX century). Theoretical and applied aspects”

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