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Metric time, metric angle and metric calendar: description, advantages and stages of transition

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Abstract

The current systems of units for time and angle, as well as the calendar, are archaic and have many weaknesses, in particular, they are not based on the decimal system, not rational and are unpractical. The article substantiates the need for their gradual replacement with metric time (MT), metric angle (MA) and metric calendar (MC). The basic versions of MT, MA and MC are described, which can be further developed. In them, base units, their multiples and submultiples are introduced as in the metric system, making the values of time and angles decimal numbers, which simplifies data recording and speeds up calculations. The base unit of MT, a decimal second (desecond), is 0.864 times shorter than the SI second and in a day, instead of 86400 seconds, there are 100000 deseconds. 100 deseconds form a milliday (deminute) and 100 millidays form a deciday (dehours). In MC, the day remains the base unit of the calendar time and contains 10 decidays, or 1000 millidays, or 100,000 deseconds. Multiples and submultiples of the time units are formed as decimal powers of a desecond and a day with metric prefixes. Multiple units of a day are decaday (10 days), centiday (100 days), kilo-, mega-, giga- and teradays. The days of our epoch are counted from January 1, 2001. Epochs of history are entered by 100 kilodays, or 274 years (near, middle and early history), by megadays (2.74 thousand years) and ten megadays (27.4 thousand years). Then May 18, 2022 is 7808th day of our epoch, 107808th day of near history and 1007808th day at shifting to megadays. In geology and astronomy, epochs contain gigadays (2.74 million years) and teradays (2.74 billion years). In MA with decimal angle is introduced as an exact analogue of MT, which simplifies data recording and calculations in engineering, geography and astronomy. A full angle (360 degrees) contains 10 zones, a zone has 100 deminute, and a milliday has 100 deseconds. On the sphere there are 10 zones of longitude (meridians) and 5 zones of latitude (parallels), where the latitude of the north pole is 0 and the south pole is 5. MC is based on MT, but decades are divided into two five day weeks, and 100 days (centidays) are divided into 4 months of 25 days. Centidays and months are only numbered and have no names. The year is a non-system unit for accounting for seasonal and traditional dates. Simplicity, rationality, greater precision and quickness at using MT, MA and MC are decisive in science, technology, economics, education and many other areas of society, and therefore a complete or partial transition to them is inevitable. During the transition period, they can be applied individually and in organizations in cases of obvious advantages and efficiency improvements.

Content

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1. Introduction

Measurements of time and angle are basic in science, technology and economics, and in society as a whole. If the rational metric system for many base units has been used since the 18th century, which greatly simplified and enhanced measurements and calculations, then the systems of units of time and angles have still remained archaic and not rational due to combining different number systems (12, 60 and 90). The decimal number system for them has not been introduced systematically and is only partially used in practice.

At the same time, many derived units in the natural sciences and technology contain units of time and angles, so that the advantages of the decimal number system for other units (mass, distance, energy, etc.) had to be combined with the inconveniences of the non-decimal number system for time and angles. In practice, these inconveniences were avoided by partially introducing decimal time and angles: sometimes multiples and submultiples of a second (10^3 seconds, 10^{-3} seconds or milliseconds, etc.), a year (10^3 years) and an arcsecond were used.

Initially, non-decimal units of time and angles arose to adapt to the mechanisms of clocks and goniometers. But in the epoch of electronics, this is already an anachronism and these units have become only a tribute to tradition. Since this tradition leads to unnecessary waste of the forces and resources of society, to difficulties and confusion in operating by data, a new tradition should be created and rational decimal time and angles should be introduced into practice in the full form. Angular units in astronomy and geography, due to the rotation of the Earth, are closely related to units of time (time zones), and therefore the transition to decimal time requires a transition to decimal angles. The current calendar is also inconvenient, not rational, full of historical anachronisms and should also be reformed.

In the present article *metric time* (MT), *metric angle* (MA) and *metric calendar* (MC) in their basic versions are described and the necessity to transition to them is substantiated. In them, the values of time and angles become decimal numbers, which simplifies data recording and speeds up arithmetic operations. MC is based on MT and the dates are given in days of the given epoch, multiples of days are formed using metric prefixes (deca, centi, kilo, mega, giga, tera). For calendar purposes, a decaday (decade) is divided into two weeks of 5 days, and centiday is divided into 4 months of 25 days. The year becomes a non-systemic unit used mainly to account for seasonal and traditional dates.

It is shown that MT, MA and MC, being rational, simple and practical, meet the requirements of the new epoch and can be used individually and in organizations as a basic system, using other systems when necessary. Discomfort due to old habits will disappear over time, while simplicity and rationality, increasing accuracy and speeding up calculations are decisive in science, technology, economics, education and in many other areas of society.

In the first part of the article MT, MA and MC are briefly described, in the second part their applications in various fields and the problems of the transition period are discussed. The article focuses on the essence of each of the three problems and its solution, and the presentation is carried out at a level that is sufficient to understand the basic ideas and principles, as well as their most important consequences. Therefore, a minimum of historical and technical details of the former systems are given, because more details can be easy find in the literature [1-5]. More details of the new systems, figures, tables and formulas for the transition from other systems will be presented in future publications.

Abbreviations: MT - metric time, MA - metric angle, MC - metric calendar.

2. Metric time, metric angle and metric calendar

2.1. Metric time (MT)

In the current International System of SI units, the basic unit of time - a *second* (s or sec.) is defined, on the one hand, as equal to 9 192 631 770 oscillation periods of cesium-133 radiation (*International Atomic Time*, TAI). On the other hand, the number of periods is chosen so that the calendar day of 24 hours is equal to the mean solar day (*Coordinated Universal Time*, UTC). Then the hour was divided into 60 minutes, the minute - into 60 seconds, and, as a result, the day contained 1440 minutes or 86400 seconds.

Due to the small variability of the mean solar day, in practice it is necessary to add or subtract the so-called *leap second*. In this article, which discusses the problems and reform of the current calendar time, there is no need to clarify the details of the reconciliation of atomic time (TAI) and calendar time (UTC), since below only the calendar second will be considered.

Both at the beginning of the transition to the metric system, and in subsequent reforms, its principles could not be extended to the multiples of a second. The reasons were mainly technical difficulties (specifics of mechanical watches, high cost of replacing a huge number of watches) [4,5]. But in our epoch, watches are mainly electronic and there are no technical obstacles to their adaptation to MT. Therefore, given the clear advantages of MT, it is necessary to start the process of transition to MT.

In the present article a basic version of MT is described, which, firstly, takes into account achievements of previous partial applications and is free of their weaknesses, and secondly, MT is introduced together with MC as a part of a unified metric system of chronometry.

MT is based on *decimal time*, which has been known in various forms for a long time and has been used in astronomy in its simplest form since the middle of the 19th century (Julian days) [1-3]. The base unit of decimal time is a *desecond* (decimal second), which is entered as 1/100000 of a calendar day. Multiples of desecond are entered as powers of ten: 100 deseconds, equal to 1/1000 of a day, form a *milliday* (decimal minute or deminute), and 100 millidays, equal to 1/10 of a day, form a *deciday* (decimal hour or dehour). As a result, a calendar day contains 10 decidays, or 1,000 millidays, or 100,000 deseconds.

Thus, if earlier a day was equal to 86400 seconds, then in MT they are equal to 100000 deseconds. This means that a desecond is shorter than the previous second and is equal to 0.864 parts of it. In TAI, a desecond lasts 686 226 284 577 792 periods of oscillation of cesium-133 radiation. The introduction of MT naturally leads to a *modified* SI system in which all units and constants, including the second or its multiples and submultiples, will change.

In MT, for multiples of a day, the standard prefixes of the metric system are introduced: deciday (or decade, 10^1), centiday (10^2 days), and for degrees as multiples of three: kiloday (10^3 days or 2.74 years), megaday (10^6, 2.74 thousand years), gigaday (10^9 days or 2.74 million years) and teraday (10^{12} days or 2.74 billion years).

For dating past epochs in history, the first day for counting of days can be shifted by one or more epochs of 100 kilodays (274 years), a megaday (2.74 thousand years) or 10 megadays (27.4 thousand years), gigadays (2.74 million years) or teradays (2.74 billion years), which will make dating rational in geology and astronomy also.

Thus, MT includes the following basic elements:

1. The choice of the base unit as a desecond, introducing its multiples and submultiples;
2. Accounting for calendar time in days, which simplifies the introduction of MC, and recording deciday (dehours), millidays and deseconds as decimal fractions of a day;
3. The introduction of multiples of a day with prefixes of metric system (deci-, centi-, kilo-, mega-, giga- and teradays), and historical epochs with such a number of days.
4. Dating our epoch by the number of days from the starting day January 1, 2001;

5. Selection of the starting days at the beginning of each epoch, introducing, if necessary, a total count of the number of days for several epochs.

The number of days of our epoch so far consists of four digits, for example, the date May 10, 2022 is 7800-day, August 18, 2022 is 7900-day and November 26, 2022 is 8000-day. Starting from May 19, 2028, 10,000 days of our epoch, the number of days will consist of five digits until 2274, i.e. during 246 years.

Let us give an example of recording the moment of time of an event of our epoch. A moment of time with an accuracy of a deciday (dehour) is 7800.1, up to a milliday (deminute) - 7800.122, up to a desecond - 7800.12233 etc. Let's compare the same time in two systems:

- In former system: April 17, 2022 18 hours 39 minutes 59.328 seconds.
- In MT this moment is: 7777.77777 (i. e. 7777th day 7 hours 77 minutes 77 seconds).

Applications of MT and problems of transition are considered below in Section 2.1.

2.2. Metric angle (MA)

By analogy with MT, it is also proposed to switch to a decimal angle, which will simplify and make rational calculations with angles in technics, geography and astronomy.

The decimal system for the angles was partially used and only for the right angle, which, instead of 90 degrees in the usual system, was assumed to be equal to 100 gradians (grads). The grad (also called the gon in Europe) is used in geodesy, mining and geology and is an official unit in a number of countries. The advantages of the decimal system are also used in the fact that decimal submultiples of a grad are introduced, replacing arc minutes and arc seconds.

In the present article a transition to metric angles (MA) is proposed, in which the base unit is not a right angle $\pi/2$, as for a gradian, but a full angle 2π. Submultiples are decimal fractions of a full angle - angular zone, deminute, and desecond. A full angle is divided into 10 arc zones, an arc zone into 100 arc deminuts, and an arc deminute into 100 arc deseconds.

Thus, in MA, a full angle contains 10 arc zones, or 1000 arc deminutes, or 100,000 arc deseconds. MA is much simpler than the current system, where the full angle contains 360 degrees, or 21600 arc minutes, or 1 296 000 arc seconds.

For spherical angles, in addition to the full angle 2π for meridians, the half angle π for latitudes is introduced. In MA, therefore, five arc zones of latitude cover both hemispheres, northern and southern. The latitude of the north pole is 0, the equator is 2.5, and the south pole is 5. Each zone is also divided into 100 minutes, and minutes into 100 seconds.

Spherical coordinates on the Earth and in the sky then contain 10 time zones (meridional) each of 36° and 5 climatic zones (by parallels) also of 36°. Two polar zones above 54° (North and South), two middle zones (from 16° up to 54° in both hemispheres) and an equatorial zone (between 16° of North and South) practically coincide with the climatic zones, given that there are also transitional climatic zones.

Notice that the introduction of MA will lead to a modification of the SI system, since all units and constants containing angular units will change.

Practical applications of MA are considered below in Section 2.2.

2.3. Metric calendar (MC)

The base unit of time in the calendar is the *calendar day*, which then forms the *calendar year* of 365 days in a normal year and 366 days in a leap year (every 4 years). In SI, day and year are non-systemic units.

A tropical year, the time between the positions of the Sun on two adjacent days of the vernal equinox, is 31556925.1 seconds or 365.242189 days. Four calendar years contain 1461 calendar days, while four tropical years contain 1460.968756 days, i.e. shorter and the calendar year is ahead of the tropical one by 0.031244 days in 4 years. A lead of one day will accumulate in 128 years and by 3 days in 384 years. Therefore, in the Gregorian calendar, every 400 years,

3 years are not considered leap years - these were 1700, 1800 and 1900 and will be 2100, 2200 and 2300 [5].

Thus, the Gregorian calendar solved the problem of accounting for leap years, but inherited almost all of other shortcomings of the Julian calendar. Namely, the year contains one month of 28 or 29 days (February), 4 months of 30 days (April, June, September and November) and 7 months of 31 days (January, March, May, July, August, October and December), in addition to that unequal months alternate randomly. The number of days in the quarters is different - the first contains 90 (or 91) days, the second - 91 days, the third and fourth contain 92 days each. A week consists of 7 days and therefore the months (except February in a non-leap year) and the year as a whole do not contain an integer number of weeks. Only the second quarter and the first in a leap year contain 13 weeks. The number of working days and days off is different in different months and quarters. New Year falls on different days of the week.

This list does not exhaust the shortcomings of the Gregorian calendar, and therefore alternative calendars have been proposed to correct them. Some of them are well known and were even used at different times in different countries [4,5]. Their disadvantage was that the main goals were to preserve, firstly, the annual periodicity and, secondly, the remnants of lunar calendars (a month of about 30 days and a week of 7 days). These goals were achieved at the cost of abandoning the advantages of the metric system.

The main goals of MC are to achieve simplicity and rationality, as well as practicality. These goals are achieved by taking into account the positive experience of previous calendars and eliminating their main shortcomings. In the present article the basic form of MC is described, which is the simplest, opening the way to the opportunities of the metric system, although it also contains new inconveniences. At solving such a multifaceted, ambiguous and contradictory task as the formation of a rational calendar, inconveniences and compromises are inevitable. However, there must be a clear understanding that this is a choice between fundamental shortcomings that exclude rationality, and partial inconveniences precisely because of the transition to rationality.

In MC, the shortcomings of the previous calendars were corrected by abandoning the link to the annual periodicity and to the remnants of the lunar calendars for months and weeks, which made it possible to choose more optimal and natural numbers of days of the week, months and larger periods of time within the metric system. In MC:

1. MT is taken as a basis and basic accounting is carried out in days of a given epoch.
2. Basic multiples of a day are 10 days (deciday, decade), 100 days (centiday) and 1000 days (kiloday, thousand days).
3. Decidays (decades) are divided into two 5-day weeks.
4. Centiday is divided into 4 months of 25 days (or 5 weeks). Centidays and months are only numbered and have no names (for example, first month of 78th centiday).
5. Historical epochs of 100 kilodays, mega-, giga-, and teradays are introduced.

Thus, in MC, as in the simplest rational calendar, the base periods are decades and centidays, the decades, for practical purposes are divided into two weeks of 5 days, and centidays – to 4 months of 25 days. The annual chronology becomes non-system and can be used in parallel with MC to account for seasonal and traditional dates. The initial year 2001 contains 14 months of 25 days and also includes 15 (or 16) days of the 15-month. Tables for the 20th and 21st centuries are presented in the Appendix.

The division into decades, centidays, five centidays and kilodays, following continuously, extremely simplifies planning and accounting, and is also adequate to the nature of the activities of the main part of the population and organizations that have long been not tied to the season of the year (different in different regions of the planet), and to the very year.

In MC, the weekly and monthly periodicities become shorter, and the quarterly periodicity, replaced by a centiday one, will become longer. Replacing the annual periodicity with longer

periodicities, five centidays (1.37 or 1.36 years) and kilodays (2.74 or 1.73 years), provides a number of advantages in non-seasonal, long-term and continuous areas of activity. The inconvenience with annual accounting is easily overcome by arranging the days and seasons of the year in the tables of days, decades and centidays, making all calculations in MC and finding the corresponding dates in the year as the number of the day of the given year.

Practical applications of MC will be discussed further in section 2.3.

3. Practical applications of metric time, metric angle and metric calendar

3.1. Applications of metric time

The advantage of MT is that the dating of moments and time intervals in any field of activity is given in the form of decimal numbers, which unify and simplify recording and calculations, allowing one to simply and quickly perform arithmetic operations.

Since the 19th century, astronomy has used the simplest form of decimal time - *Julian days* [1-3,5]. However, the initial day was chosen irrationally, the unit of time is also the same, day, and there are multiples and submultiples of a day.

These three shortcomings are corrected in MT by the introduction, as powers of 10:

1. Submultiples of a day: *deciday* (dehour), *milliday* (deminute) and *desecond*;
2. Multiples of a day: deci-, centi-, kilo-, mega-, giga- and teradays;
3. Different starting days for different epochs on different time scales.

These advances to MT make it convenient dating of events and determine time intervals between events in days and fractions of a day. At the same time, the beginning of Julian days corresponds to 10000000 - 2451911 = 7548089 days of the epoch, shifted back by 10 megadays before the beginning of our epoch (01.01.2001). In applications, it is also necessary to take into account that in MT epochs begin at the beginning of the first day, and Julian days - at noon.

In the natural sciences and engineering, the introduction of a desecond of MT will increase, as a power of 1/0.864, the values of those derived units and world constants that are proportional to the positive powers of the former second. And quantities and world constants containing powers of a reciprocal second will decrease as powers of 0.864.

The transition to MT will lead to the production of decimal clocks, as well as changes in software products that include time. In a mechanical watch with rotating hands and a circular dial, only the dial will change, since the hands move almost continuously (can show the time in both systems on one dial with two scales, which was previously done). In a digital clock, the indication of the date in MB in days with an accuracy of up to a second will be simplified and looks like, for example, 7800.12345.

In humanitarian sciences, MT will lead to a unified dating of events in the past and prognoses for the future, with a quick and easy calculation in hours, days, weeks and years of intervals between events. There appears a possibility of rational division into historical epochs, which simplifies the chronology in history, archeology, economics, political sciences, etc.

For events in the epoch of *near history*, it is convenient to shift the beginning back from 01.01.2001 by 100 kilodays, which is 274 years 56 days according to the Gregorian calendar (1800 and 1900 are not leap years). This corresponds to the beginning day of near history, November 5, 1725. Then the date of our epoch 7800 will be written as 107800-day of near history. At the same time, events before the beginning of our epoch are written in five digits.

> *Example*. August 6, 1957 is 84305th day of near history. Therefore, those who born on this day (like me) lived 23495 days until May 10, 2022 or 107800th day (about 16 thousand days were awake, about 7.5 thousand days were asleep). Their 65th birthday will be on 107888-day, 70th birthday on 109714-day, 80th birthday on 113367-day, 90th birthday on 117019-day and 100th birthday on 120672-day. Subtracting 107888 from anniversaries gives the number of days between the 65th anniversary and this anniversary, for example, from the 65th to the 70th anniversary 109714 - 107888 = 1826 days.

At a shift of two or three periods of 100 kilodays (274 years), only the first digit will change: instead of 107800-day there will be 207800-day or 307800. These epochs could be called the epochs of *middle history* (1451-1724) and *early history* (1177-1450).

For the events of ancient history, it is convenient to move the beginning back from 01.01.2001 by one megaday (million days), equal to 2739 years 220 days. This epoch will cover the main part of world history from the 8th century BC (except for the most ancient civilizations) and therefore it can be called a *historical epoch*. Then 7800-day of our epoch is 1007800-day of the historical epoch and is supplemented in front with numbers up to 100.

A shift of 10 megadays will cover 27.4 thousand years, and this epoch can be called an *extended historical epoch*. Then the above day is 10007800-day.

An epoch covering 100 megadays, or 274 thousand years, can then be called the *epoch of man*. And, finally, an epoch of 1 gigadays (billion days), equal to 2.74 million years, covers almost the entire history of the origin and dominance of man on our planet, and therefore it can be called the *extended epoch of man*.

3.2. Applications of metric angle

MA significantly simplifies calculations in trigonometry, both in planar and spherical. Setting the values of trigonometric functions from arguments in the form of decimal numbers is also much easier (except for special angles).

In geography (geodesy and cartography) and astronomy, MA arises naturally, since when counting the daily rotation of the Earth in MT, 10 time zones are formed on the earth and in the celestial sphere, which will determine spherical coordinates with arc zones in the form of 1/10 of a full angle by 36° each. Along the parallels, 5 climatic zones are formed (from the north to the south pole) also by 36 ° each.

Therefore, new globes and maps of the Earth's surface will be created in new MA angular coordinates. Navigation instruments will also change, since their scales will be in MA and, if necessary, will be duplicated by the scale in the former angular units.

The effectiveness of MA in engineering and technology (in navigation, industry, transport, communications, architecture, space technology, military affairs, etc.) is due to the fact that calculations with angular coordinates were artificially complicated precisely because of the archaism of the former angular units. The unification of the designations of angles and the ability to operate with them as with decimal numbers greatly simplifies and speeds up the recording and ordering of data, as well as calculations, increases their accuracy and gives greater clarity, which is also important in the education system for specialties in these industries.

3.3. Applications of metric calendar

In the natural sciences and technology, MC is used in its simplest form as MT, when time is recorded in seconds and its fractions. But at dating of events in these sciences themselves (dating of discoveries, publications, organization of science and planning), MC can be used in its full form, which simplifies and speeds up accounting and planning.

In humanitarian sciences, medicine, media industry, tourism, arts and sports, MC is also convenient and practical, and at the same time introduces a number of changes to the current event dates, standards, time schedules, planning, etc.

MC gives the greatest effect in the economy and the social sphere, since the unification of months with the same number of days and weeks, the introduction of centidays as a basis for periodicity simplifies the organization of production and recreation, accounting and analysis.

The 5-day week provides new opportunities for the organization of work and leisure, leads to an increase in productivity there and the level of employment:

1. If there are three days off in a ten-day period (distributed over 5-day weeks as 1.5 + 1.5, 1 + 2 or 0 + 3), then in the old calendar in 70 days there will be 10 seven-day weeks with 50 working days and 20 days off, while MC will have 7 decades with 49 working days and 21 days off. Therefore, during the year there will be 5 more days off in MC.

2. In MC, the annual periodicity is replaced by a hundred-day periodicity, and therefore vacations can be given for 7 working days at the end of each centiday (9 working and one vacation decade). For a year, this will be 25.5 working days of vacation.

3. At the same time, there will always be 1.5, 2 or 3 days off before and after the vacation, which gives an effective 11.5, 12 or 13 days of rest at the end of each centiday.

Although in MC the number of working days per year is almost a week less, which is only 1.7% of the total working time per year, but due to more frequent and longer resting, the productivity of employees will increase by a higher percentage (several percent), which compensates for shortage of hours. This effect can be tested in experiments in some industries.

One of the problems in using calendars with a number of days in a week other than 7 was the inconsistency with the traditions of the world religions. MC, however, brings two positive factors to this issue. Firstly, in a 5-day week, it will become convenient to visit religious institutions on the fourth day of the week, when employees are released from work around noon or can rest at the end of the decade. Secondly, MC makes it possible to visit these institutions more often than before - not 52 times a year, but 73 times. In all religions, a person must be modest when comparing his abilities with higher powers and therefore can rest more often than they do, receiving new powers from more frequent appeal to them. If the calendar contributes to this, then this leads to new traditions that correspond to the essence of religion, and not its external form.

In the future, people in everyday life and production activities can use the simple and convenient MC in the described basic or modified form, and use the annual calendar only to account for seasonal events and traditional dates (family, national and religious). People in one or two generations will get used to such a natural division of calendars and will even be surprised that for the sake of traditions, which, although important, take up no more than 5% of the time in a year, the remaining 95% of the time experienced a lot of inconvenience due to the forced use archaic and not rational chronometry and calendar.

4. Conclusion

The transition from archaic units of measurement to the metric system based on the decimal number system was at one time the most important progressive step that contributed to the development of science, technology, economics, education and many other areas of society. However, this transition has so far remained half-hearted, since it has only partially affected the units of time and angular units, which is why most of the chronology, including the calendar, as well as everything related to angles, was produced in non-decimal units, which are inconvenient for accounting and complicate calculations.

In the present article, in order to fill these gaps in the metric system, the basic versions for MT, MA and MC are proposed, which take into account the positive experience of previous systems and their shortcomings that created artificial difficulties are excluded. In them, records of time moments, angles and dates are standardized and simplified, set to decimal numbers.

MT, MA and MC can be applied individually, in industries, countries and regions, while in parallel with other systems. Inconvenience will disappear over time, and simplicity, increased accuracy and faster calculations in them are the decisive factors in science, technology, economics, education and many other areas of society.

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