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Decimal Time: Misadventures of a Revolutionary Idea, 1793–2008

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Abstract

This article traces the idea of decimalized systems of time reckoning, from their first articulated designs and implementation in the French revolution to our day. The paper analyzes how decimal time was the product of a broader rationalizing project that successfully reformed weights and measures (with the invention of the decimal metric system) and money (with the introduction of the *franc* as a decimal currency), but failed in bringing the chronological and calendrical reform into fruition. Finally, some hypotheses are suggested to explain why contrary to the global success of the metric system and decimal currency, plans for a fully decimalized time system were never accepted.

Keywords
decimal time, Republican calendar, decimalization, decimal metric system, decimal currency

A Time for the Twenty-First Century?

In 2008 David Chanson, grandson and great-grandson of Swiss watchmakers, launched a series of peculiar wristwatches that instead of having a 12 hour dial, are fractioned into 10 *divides*, and each *divide* is decimally divided as well. Chanson argues that the decimal system that inspired his timepieces is more logical than the current division of 60 minutes and 60 seconds. He considers that for people to accept decimal time it would require a period of adaptation, but it is not, he says, an insurmountable effort, and compares it with the introduction of the metric system in England and the euro in the European Union.

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Even if so far the only buyers of these decimal watches have been collectors (and there are no signs of interest among the general public), newspapers around the world reported on Chanson's creation with a mixture of surprise and admiration. In Australia it was said that the Swiss designer is "ahead of his time," and in Spain that "Chason invented the clock of the twenty-first century".[1] Curiously, decimal time is an idea that has been considered since the end of the eighteenth century and was temporarily utilized during the French revolution. And contrary to Chanson's optimism, history tell us that changing our system of time reckoning has proven to be a much more intricate task than the decimalization of currency and weights and measures.

Sadly, the history of decimal time (especially after the French revolution) has received almost no attention at all from scholars.[2] Its brief existence in actual practice has been dismissed as an extravagant excess of the French revolution. But decimal time ought to be an important topic of research, precisely *because it does not exist*. The absence of a decimal system of time reckoning in a world where decimal numerical notation and decimal divisions for measurement are the norm should have drawn more interest.

This article traces the history of decimal time, especially after the French revolution, and in the final section some hypotheses are offered to explain why our principal systems of measurement work on a decimal basis, except for time.

Decimals Are not Natural

The widespread idea that decimal counting, dividing, and grouping is something "natural" because humans have ten fingers is an anachronism based on the fact that nowadays almost all our mensuration and reckoning systems are numbered and ordered by groups of 10, and that the currently prominent numeral system has 10 as its base (i.e. our positional notation system with Hindu-Arabic numerals). Decimals are so prevalent today that is difficult for people to imagine a non-decimal world. However, prior to the eighteenth

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1) "Swiss Designer's 'Logical' Watch Is Ahead of its Time," *The Canberra Times*, December 29, 2008; "David Chanson inventa el reloj del siglo XXI," *Noticiasdot.com*, December 31, 2008.

2) One exception is Richard A. Carrigan, Jr., "Decimal Time," *American Scientist* 66 (1978): 305–313, and "Lessons for the Metric System: Decimal Time," in *The Metric Debate*, ed. David F. Bartlett (Boulder, Colorado: Associated University Press, 1980), 99–115; even though he omits crucial events in the history of decimal time.

century the use of decimals for everyday and scientific practices was an oddity.[3] Throughout history the overwhelming majority of the systems of measurement have used other numbers besides 10 as their basis; duodecimal (base-12), hexadecimal (base-16), vigesimal (base-20), and sexagesimal (base-60) were much more common systems than decimals—and in some countries and professional activities these forms of division are still alive and well, like the foot of 12 inches, the pound of 16 ounces, and the degree of 60 minutes of arc.

We can certainly find examples of decimal grouping and divisions in history. Like the Roman decimation, where an army was punished for cowardice in combat and one of every ten soldiers was executed (i.e. were decimated). Or the tithe, the recollection of a tenth part of the personal annual income to support the clergy.[4] However, even after the global spread of Hindu-Arabic numerals in early modern history, decimals systems of measurement, division and reckoning were a rarity in *practice*, even if the *idea* of a most ambitious plan of decimalization existed in Europe at least since the sixteenth century.

Decimal Time before the French Revolution

At least since 1585, when the Flemish mathematician Simon Stevin published *De Thiende*, which laid the modern foundations for expressing decimal fractions (even though he did not invent the decimal point as such), the idea of decimalizing coinage and weights and measures had been floating in the air. European scientists and administrators hoped to implement a comprehensive reform of the systems of measurement that would standardize the innumerable local measures and coins and, at the same time, implement a new arithmetic base to facilitate calculations.[5]

During the eighteenth century philosophers and mathematicians started to consider that time should also be part of the overhaul. In 1754, D'Alembert wrote, in the entry "Decimal" in the *Encyclopédie*, that "It would be very desirable that all divisions, for example of the *livre*, the *sou*, the *toise*, the day,

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3) For a historical refutation of the belief that the decimal system is based on humans having ten fingers, see Witold Kula, *Measures and Men* (Princeton: Princeton University Press, 1986), 82–86.

4) For other examples of this "decimal principle" see *The Sociology of Georg Simmel* (New York: Free Press, 1964), 171–174.

5) On the failure of repeated tries to reform the system of measurement prior to the French revolution see Kula, *Measures and Men*, 161–184.

the hour, etc. would be from tens into tens. This division would result in much easier and more convenient calculations and would be very preferable to the arbitrary division of the *livre* into twenty *sous*, of the *sou* into twelve *deniers* of the day into twenty-four hours, the hour into sixty minutes, etcetera."[6]

In 1788 a couple of texts advanced more detailed ideas about temporal decimalization. Sylvain Maréchal published *L'Almanach des Honnêtes Gens*, an antecedent of the Republican calendar, that postulated the division of months in three *décades* of ten days each. Also that year appeared *Découverte d'étalons justes, naturels, invariables et universels*, by Claude-Boniface Collignon, that suggested a decimal division of the day, hours, minutes and seconds.[7]

At that moment in history, however, to eliminate the "arbitrary divisions" of duodecimal and sexagesimal systems in time reckoning and weights and measures, and creating a base-10 system to facilitate the computations made by scientists, was nothing but a dream.[8] The Church kept a tight grip on timekeeping (priests regulated the calendar and church bells were the pacemakers of daily activities). And feudal lords had the right to establish their own weights and measures and were very successful in repelling all attempts made by monarchs to implement a centralized system of measurement (such a reform would decrease their economic power in their own fiefs to the advantage of the central authorities and large scale merchants). Consequently, even if the intellectual basis for the creation of decimal systems of mensuration and reckoning were in place, any realistic plan of reform was impossible due to the religious, political, and economic institutions that controlled time and measures. But the events of 1789 were about to open the door for these plans to finally materialize.

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6) Quoted in Ruth Inez Champagne, "The Role of Five Eighteenth Century French Mathematicians in the Development of the Metric System" (PhD diss., Columbia University, 1979), 145.

7) Paul Smith, "La division décimale du jour: l'heure qu'il n'est pas," in *Genèse et diffusion du système métrique*, ed. J.-C. Hocquet and Bernard Garnier (Caen: Editions-diffusion du Lys, 1990), 125–126; George Gordon Andrews, "Making the Revolutionary Calendar," *The American Historical Review* 36 (1931): 516.

8) Only within their own domain, in areas that barely touched everyday activities, scientists could introduce decimals, as Anders Celsius did in 1741 with his temperature thermometer, which separated by 100 degrees the points of reference of his scale (the freezing and boiling points of water). This was a marked departure from the previous scales by Roemer and Fahrenheit, both based on a sexagesimal system, see Herbert Arthur Klein, *The Science of Measurement* (New York: Dover, 1988), 295–321.

The Decimal Revolution of 1789

The French revolutionaries aimed for "the decimalization of everything measured or metered."[9] Legislators and members of the Academy of Sciences took very seriously the idea that *all* divisions should be from tens into tens. As part of a plan for a thorough restructuration of all methods of measurement they redesigned customary weights and measures, the circumference, money, and time to fit into the decimal grid.[10]

Reforming a system of measurement involves changing one, two or all the nuclear elements of the system to be modified:

- the units of measurement (their magnitude, size, or amount),
- the names of the units,
- and the system of grouping and division (like base-10 or base-12, for example).

All combinations can take place in changing these elements. It is common that a unit varies in its magnitude but keeps its name and subdivisions (like adjusting the *size* of the inch). Also common is that a unit changes its magnitude and multiples but keep its name (e.g. the decimal American *dollar* that replaced the eight-*real* Spanish *dollar*). And there have been some particularly radical reforms that change the three elements at once, like the one that the French aimed in the 1790s. They decided to create units with new magnitudes, provided an *ad hoc* nomenclature for those units, and obliterated duodecimal, hexadecimal, and sexagesimal divisions in favor of the decimal system. Their objective was not only to improve scientific procedures; they actually sought to reorganize social life by rationalizing weights and measures, money, and the calendar—in other words, standards that regulate economy, political administration, and everyday life.

First was the modification of weights and measures. A reform in this area had been demanded for a long time and was one of the most common topics of complaint (especially by the third estate) in the lists of grievances collected for the Estates-General of 1789.[11] Plans for a metrological overhaul

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9) John L. Heilbron, *Weighing Imponderables and Other Quantitative Science Around 1800* (Berkeley: University of California Press, 1993), 249.

10) On decimalization as a general tendency during the revolution, see Ken Alder, *The Measure of all Things* (New York: The Free Press, 2002), 125–159; Denis Guedj, *El metro del mundo* (Barcelona: Anagrama, 2003), 141–157; Kula, *Measures and Men*, 250–251.

11) Kula, *Measures and Men*, 185–227.

started the summer of that year and culminated in 1795 with the creation of the decimal metric system, an elegant scheme with three interrelated basic units—meter, liter, and gram—that replaced hundreds of local measures that coexisted in a disorganized fashion all around France. The new units were decimally divided using a set of prefixes to multiply (deca-, hector-, kilo-) or divide (deci-, centi-, milli-) the measure by a factor of ten. The election of decimals was a particularly radical option, because people in general were not familiar with decimal fractions and the use of the decimal point, something that created numerous complications for the popularization of the system. This plan, nevertheless, served as the blueprint for the other projects.[12]

The currency reform was the second in the list and concluded with the creation of the *franc* in 1793,[13] which replaced the *Louis d'or*, the *écu* and other monetary units. The franc was divided into 10 *decimes* and 100 *centimes*. A very similar scheme had been put in place just recently in the United States, following a plan by Thomas Jefferson, with the dollar fractioned into 10 dimes and 100 cents.[14]

The third reform was the creation of a new calendar and time-reckoning system, also known as the Republican calendar. Since much has been written about it, there is not necessity to describe the French calendar in great detail here.[15] But a brief look at its architecture is instructive to see how its designers decimalized it.[16]

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12) On the project of decimalization of weights and measures see Champagne, "The Role of Five Eighteenth Century French Mathematicians," 141–156.

13) Adrian Tschoegl, "The International Diffusion of an Innovation: The Spread of Decimal Currency," *Journal of Socio-Economics*, 39 (2010): 105.

14) See C.D. Hellman, "Jefferson's Efforts towards Decimalization of United States Weights and Measures," *Isis* 16 (1931): 266–314.

15) Of especial interest among the large body of literature on the republican calendar: Eviatar Zerubavel, "The French Republican Calendar: A Case Study in the Sociology of Time," *American Sociological Review* 42 (1977): 868–877; Andrews, "Making the Revolutionary Calendar," 515–532; Baczko Bronislaw, "Le calendrier républicain," in *Les lieux de mémoire*, ed. Pierre Nora (Paris: Gallimard, 1997), 67–106; James Friguglietti, "The Social and Religious Consequences of the French Revolutionary Calendar" (PhD diss., Harvard University, 1966); also by Friguglietti, "Gilbert Romme and the Making of the French Republican Calendar," in *The French Revolution in Culture and Society*, ed. N. Andrews (New York: Greenwood Press, 1991), 13–22; Mona Ozouf, "Revolutionary Calendar," in *A Critical Dictionary of the French Revolution*, ed. F. Furet and M. Ozouf (Cambridge, Mass.: Harvard University Press, 1989), 538–546; and Matthew John Shaw, "Time and the French Revolution, 1789-Year XIV" (PhD diss., University of York, 2000).

16) For works focused on the decimalization of time in the French revolution: Paul Smith,

The revolutionaries kept the year of 12 months, but instead of the irregular months of the Gregorian calendar (varying from 28 to 31 days of duration) they decided to have a more symmetrical division, with months of 30 days each. Given that this only accounted for 360 days, the five extra days required to approximate the solar year were placed at the end of each year without being count in any month. The calendar marked the beginning of a novel period in human history, the Republican era, and they set day one of this new epoch on September 22, 1792, the day when the French republic was proclaimed, after the abolition of the monarchy.

Months in the calendar were "divided into three equal parts, of ten days each, called *décades*, and distinguished from one another as first, second, and third."[17] The day was divided into ten parts or hours, each part into ten others, and "so on up to the smallest measurable portion of duration."[18] The hundredth part of the hour was called *decimal minute*, and the hundredth part of the minute *decimal second*.

With this diagram, all divisions of time, from the month to the second, were decimal, which implied the challenge to replace two different sets of "old" time units. On the one hand, the ten-day *décade* was meant to substitute the seven-day week (10 vs. 7); very important here was the elimination of Sundays as a day of rest, in favor of the *décadi*, the tenth of the *décade*. On the other hand, the decimal day had to replace the twelve-hour day with its "ante meridiem" and "post meridiem" periods (10 vs. 12), and the decimal hour had to take the place of the hour of 60 minutes and 60 seconds (10 vs. 60).

The decimalized day, hour, and minute survived just 17 months (from November 24, 1793 to April 7, 1795), and was barely used in practice. Some clocks and timepieces were manufactured to display decimal time,[19] but the whole plan was buried before it had any chance to fly. Among the reasons adduced to suspend the proposal were the high costs of replacing clocks and

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"La division décimale du jour," 123–134; Louis Marquet, "24 heures ou 10 heures? Un essai de division décimale du jour (1793–1795)," *L'Astronomie* 103 (June 1989): 285–290; Shaw, "Time and the French Revolution," 93–100.

17) "Decree Establishing the French Era, November 25, 1793 (4 Frimaire, Year II)," in *A Documentary Survey of the French Revolution*, ed. John Hall Stewart (New York: Macmillan, 1951), 509.

18) "Decree Establishing the French Era," 509, 512.

19) Numerous pictures and descriptions of decimal clocks can be seen in *Les heures révolutionnaires*, eds. Yves Droz and Joseph Flores (Besancon: Association Francaise des Amateurs d'Horlogerie Ancienne, 1989).

watches, and popular confusion due to the novelty of the decimal units—not very convincing arguments considering that the metric system faced the same adversities, and was pushed through nonetheless. More persuasive was the argument that counting hours was not a commercial activity susceptible to police regulation and the old practices would continue "due to the immense force of habit"[20] (this was an implicit acknowledgment that these reforms had to be introduced more by state force than by the popular agreement).

The rest of the calendar, including the *décade*, persisted 12 years (from 1793 to 1805). The new ten-day "week" was the most controversial element of the whole calendar. It represented a disruption of the rhythms of commerce, festivities, and labor, and a direct confrontation against religious practices.[21] Even if dechristianization was not necessarily the primary objective in the mind of the designers of the Republican calendar, it certainly became an antireligious weapon in the hands of the most radical sectors of the revolution.[22] The entire experiment produced mixed results. Some embraced enthusiastically the new calendar, but in general it created confusion and many people simply kept using the "old" calendar and week. At the end, Napoleon restored the Gregorian calendar and the seven-day week as part of his reconciliation with the Church.

As one can see, the three major decimal reforms of the revolution ended having very different fates in France. The metric system is not only still employed in France but it is universally used in the world. The franc lasted until 2002, when another decimal currency replaced it, the euro. And the Republican calendar was never broadly used and survived little more than a decade. (See Chart 1).

The three decimal systems of measurement and reckoning also had opposite fortunes outside France. Decimal time was not used in other countries. By contrast, today approximately more than 99 per cent of the people in the world live in countries that use exclusively decimal currencies (except Madagascar and Mauritania); and roughly 95 per cent of the world population lives in countries where the decimal metric system is the only legal system of weights and measures (Liberia, Myanmar, and the United States are the only nations

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20) See Marquet, "24 heures ou 10 heures?," 287.

21) On the social consequences of eliminating the seven-day week (and Sundays) see Eviatar Zerubavel, *The Seven Day Circle: History and Meaning of the Week* (New York: The Free Press, 1985), 27–35.

22) Friguglietti, "Gilbert Romme," 18–19; Ozouf, "Revolutionary Calendar," 541.

Chart 1. Measures before, during, and after the French Revolution

	Old Regime Measures	**Revolutionary Measures**	**Duration of Revolutionary Measures**	**Current Measures**
Day, hours and minutes	24-hour day, hour of 60 minutes, minute of 60 seconds	10-hour day, hour of 100 minutes, minute of 100 seconds	2 years (1793–1795)	24-hour day, hour of 60 minutes, minute of 60 seconds
Calendar	Gregorian calendar	Republican calendar	12 years (1793–1805)	Gregorian calendar
Money	*Louis d'or*, and others	Decimal *franc*	207 years (1795–2002)	*Euro* (decimal)
Weights and measures	Medieval weights and measures	Decimal metric system	214 years … (since 1795)	Decimal metric system

outside the metric sphere). In the final section of this article, some hypotheses are suggested to explain why, contrary to the global success of the metric system and decimal currencies, plans for a fully decimalized time system were never accepted. But before that we will see what happened to decimal time *after* the French revolution, a topic that has received very little attention by historians.

Decimal Time in the Second Half of the Nineteenth Century

The interest in decimal time from the heydays of Napoleon to the 1870s was erratic to say the least. In 1856 appeared *The Decimal System as a Whole*, a sole pamphlet written by a Liverpool watchmaker, Richard Dover Statter, which applauded the advantages of a base-10 system of time reckoning.[23] And there are reports that in 1870 the subject was addressed before the Paris Academy, by the astronomer Antoine-Joseph Yvon Villarceau and other scientists.[24] But these discussions did not gain any traction, and decimal time looked at that point as alive as the Egyptian calendar.

23) See Carrigan, "Decimal Time," 309.
24) "The Decimal Division of Time and Angles," *Science* 4 (1896): 871.

But the international debates surrounding the creation of a global standard of time reference—which culminated in the International Meridian Conference of 1884—renewed the interest of scientists and government officials around the world on prospects for utilizing a decimal time system, and also gave France a fresh opportunity to try to expand decimals to the realm of time measurement.

In the second half of the nineteenth century the railroad and the telegraph compressed time and space and with that appeared the need for a uniform time standard. These new means of communication and transportation required a single timetable to coordinate communities that up to that point had been regulated by their own local time. That was the practical basis for the creation of standard time zones.[25] And the growing need to follow strict schedules and regulate social activities with more punctuality actually made decimal time more pertinent than before, because people had to make more complicated time calculations on a daily basis.[26]

The Canadian engineer Sandford Fleming is usually credited for the invention of the standard-time zone system—to which he certainly contributed greatly. But parallel to Fleming's work, a group of experts congregated in the American Metrological Society (AMS) developed a similar plan. Actually, when Fleming received no help from England (Canada was then a British dominion) to promote his scheme, the AMS backed him up. The president of the Society, F.A.P. Barnard, successfully lobbied the American government to host an international conference to fix a common prime meridian, and in 1882 president Chester Arthur invited the governments that held diplomatic relations with the United States to be part of a conference in Washington in 1884.[27]

Since its creation in 1873, decimalization had been an important subject matter in the AMS. From the 1870s to the 1890s, the society mounted several campaigns to secure legislation in favor of the complete adoption of the metric

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25) Eviatar Zerubavel, "The Standardization of Time: A Sociohistorical Perspective," *The American Journal of Sociology* 88 (1982): 7.

26) Actually, it was reported that in certain parts of Italy and India there were quadrants of railroad clocks that were divided into 100 minutes, "The Decimal Division of the Circle," *Architecture and Building* XXVIII (April, 1898), 118.

27) The *Proceedings of the American Metrological Society*, from 1873–1888, include the reports of the Committee on Standard Time and other related articles. On the role of the AMS on time standardization, see Ian Bartky, "The Adoption of Standard Time" *Technology and Culture* 30 (1989): 25–56; Peter Galison, *Einstein's Clocks, Poincaré's Maps* (New York: Norton, 2003), 113–128.

system in the United States. And one of the most active members of the Society was the young librarian Melvil Dewey, fervent supporter of the metric system and creator of the Dewey decimal system of library classification. Dewey's design uses decimals to organize all human knowledge by arranging books in a specific and repeatable order with 10 main *classes*, each consisting in 10 *divisions*, and each division with 10 *sections*, all of them with a pre-assigned number. Each field of knowledge and discipline have a traceable place arranged within a clear framework. Alongside Jefferson's decimalization of currency, Dewey's classification has to be considered one of the most significant contributions of America to decimalization.

The opportunity of having a decimal time system was also addressed by the members of the AMS. In 1879, Frederick Brooks published a paper on "The Division of the Day," where he advocated for a decimal partitioning of the day and showed a good deal of optimism on the eventual disappearance of duodecimal systems:

> [The] division by twelve has no more to do with natural phenomena than the division of the zodiac into twelve signs. Twelve is a convenient mathematical quantity and has therefore been much used. Small wares are sometimes sold by the dozen and gross, and were formerly paid for in shillings and pence: but twelve pence in the shilling is getting to be obsolete, many goods are now sold by the hundred, and the introduction of the Metric System of weights and measures will naturally suggest the thought of a decimal system of measuring time. [...] the hour with its customary sub-division into 60 minutes or 3,600 seconds, will be regarded as a case of arrested development, a monstrous feature on the face of our metrology.[28]

Apparently the other members of the society did not discard the idea of a decimal time system, but they were not as enthusiastic as Brooks, and the AMS did not push the topic any further—something understandable considering that it had its plate already full with the metric and the prime meridian campaigns.

Heading into the 1884 conference in Washington, some discussions were advanced in the General Conference of the International Geodetical Association, held in Rome in 1883. Besides dealing with the problem of a prime meridian, the subject of the decimal system of dividing the circle and time was

[28] Fredek. Brooks, "The Division of the Day," *Proceedings of the American Metrological Society* II (1979): 4.

"received with unanimity",[29] but no concrete action was taken to achieve that purpose. The following year the topic was debated again.

The International Meridian Conference brought together delegates from thirty countries "for the purpose of fixing upon a meridian proper to be employed as a common zero of longitude and standard of time-reckoning throughout the globe," and it was in many ways a confrontation between England and France for world scientific supremacy. The main purpose of the French delegation was to avoid the adoption of the Greenwich meridian as the international meridian for longitudes. But that was a lost battle from the beginning. The majority of the countries represented at the conference, lead by the English and Americans, supported the selection of Greenwich. Defeated on that front, the French moved to plan B: if France was to accept the British meridian, then England had to correspond by adopting the decimal metric system.[30] This reciprocation was suggested on several occasions during the meetings, but the adoption of systems of weights and measures was not part of the topics established for the conference and was ruled out.

The final resource of the French delegates, who were systematically beaten in all their proposals, was to use the Conference to advance the use decimal time among scientists. The astronomer Pierre Jules in a plea to the delegates to adopt decimal time said that:

> at the time of the establishment of the metrical system the decimal division had been extended to the measurement of angular space and of time. [...] As to time, the reform was introduced too abruptly, and, we might say, without enough discretion, and it came into conflict with old habits and was quickly abandoned; but as to the division of angular space, in which the decimal division presented many advantages, the reform sustained itself much better, and is still used for certain purposes. [...] It is, therefore, now evident that the decimal system, which has already done such good service in the measurements of length, volume, and weight, is called upon to render analagous services in the domain of angular dimensions and of time. [...] if we failed at the time of the Revolution, it is because we put forward a reform which was not limited to the domain of science, but which did violence to the habits of daily life. It is necessary to take the question up again, but with due regard to the limits which common sense and

[29] This according to General Richard Strachey, one of Great Britain's delegates at the Washington conference, *International Conference Held at Washington for the Purpose of Fixing a Prime Meridian and a Universal Day, October, 1884: Protocols of the Proceedings* (Washington, D.C.: Gibson Bros., 1884), 185.

[30] Spaniards and Italians supported the French in this *quid pro quo*, see *International Conference*, p. 88.

> experience would prescribe to wise and well-informed men. I think that the character of the reform would be well defined by saying that it is intended especially to make a new effort towards the application of the decimal system in scientific matters.[31]

In addition to this request, the renowned geologist Alexandre-Emile Béguyer de Chancourtois sent to each delegate a detailed proposal "to supersede the present mode of measuring both angles and time by a system in which the entire circumference and the length of the day should each be first divided into four equal parts, and then each of these parts should be subdivided decimally." And J.P. Merritt, from Ontario, sent a letter to the Conference recommending "redistribution of time according to the decimal system." No scientific arguments were voiced to oppose these ideas, and even John Couch Adams, director of the Cambridge Observatory, recognized that "for certain purposes, the decimal division of the circle is very valuable."[32] But there were objections in the direction that those propositions were not within the limits received by the delegates from their respective governments.

At the end an agreement was reached: no punctual actions to implement decimal time would be suggested, but further reflection on the matter was encouraged. In this line, the seventh resolution of the meeting reads, "that the Conference expresses the hope that the technical studies designed to regulate and extend the application of the decimal system to the division of angular space and of time shall be resumed, so as to permit the extension of this application to all cases in which it presents real advantages."[33] It was a political compromise, but some years later new technical studies, indeed, appeared.

In the Sixth International Geographical Congress, held in London in 1895, decimal time again became a theme of debate. Three different projects were expounded: those of Joseph de Rey-Pailhade and Henri de Sarrauton on behalf of the Geographical Society of Toulouse and the Oran Geographical Society, respectively, and Joaquín de Mendizábal y Tamborel, representing the Sociedad Científica Antonio Alzate, from Mexico.[34] All of them were keen to the idea of decimalizing time, but they differed on what was the most appropriate way to do it.

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31) *International Conference*, 183–184.

32) *International Conference*, 153–156, 186.

33) *International Conference*, 203.

34) For a detailed account of these plans see the report by the Vice President of the Congress, Rafael Torres Campos, *La geografía en 1895. Memoria sobre el VI Congreso Internacional de Ciencias Geográficas celebrado en Londres* (Madrid: Fortanet, 1896), 36–64.

Rey-Pailhade (1850–1934) deserves a special mention in the history of decimal time. He was a French mining engineer and doctor, who did much to maintain the international attention over decimal time from the 1880s to the 1910s. He was the president of the Comité pour la Propagation des Méthodes Décimales, in charge of disseminating information among scientific and commercial circles about the possible applications and advantages of decimal methods. He worked restlessly in favor of chronological decimalization and advanced the cause in three different areas: designing a system of decimal division of the day, divulgating news about decimal time for the larger public, and contributing to the study of the history of decimal time (his labor of documentation, held in the municipal library of Toulouse, consists of 73 volumes!).[35] The essence of Rey-Pailhade's project in the London Congress was to divide the day into 100 *cés* (abbreviation of *centijour*) and use decimal subdivisions, *centicés* (a one hundredth of cé) and *dimicés* (a ten thousandth of cé).[36]

Sarrauton's system presented a key difference from that of Rey-Pailhade, instead of decimalizing the day, it conserved the 24-hour day and only the hour would be divided (into 100 minutes and 10,000 seconds). Sarrauton did not want to make *tabula rasa* of the past and recognized the established place of the hour (i.e. the twenty-fourth part of the day) as a universally accepted unit. He tried in that way to avoid a permanent divorce between the general public and the savants, but still have some of the advantages of decimals.[37]

In Mendizábal y Tamborel's proposal, the basic unit was the sidereal day, that he called *tropo* (from the greek *tropos*, "a turn"), with multiples of *decitropo*, *centitropo*, and *microtropo*. Contrary to Sarrauton, the Mexican geographical engineer was of the opinion that the new chronological regime had to cut

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35) Rey-Pailhade produced an industrial quantity of writings on decimal time. See for instance *Le Temps décimal, avantages et procédés pratiques, avec un projet d'unification des heures des colonies françaises* (Paris: Gauthier-Villars, 1894); "L'application du systeme décimal a la mesure du temps et des angles," *Revue Scientifique* 32 (1895): 315–316; "Le temps décimal a Toulouse pendant la Révolution," *Bulletin de la Société de Géographie de Toulouse* 18 (1899): 534–541.

36) Rey-Pailhade, "Simultaneous and Parallel Application of Decimal Arithmetic to the Measure of Time and Angles," in *Report of the Sixth International Geographical Congress* (London: John Murray, 1896), 255.

37) Campos, *La geografía en 1895*, 54–62. Sarrauton also wrote several articles on decimal time, see for example, "L'heure décimale," *Revue Scientifique* 34 (1897), 201–210.

sharply from previous systems. The experience provided by the metric system, he said, had shown that a definitive break with the ideas of the past was the most effective way to introduce the reform to the public.[38]

At the end all these proposals did not amount to much in the Congress and only a less than warm resolution was obtained: "The Congress request the Geographical Societies represented at it to consider the question of application of the decimal system to angular and time measurements, and to report on the subject to the next Congress."[39] Once again scientists did not openly oppose the idea of decimalizing time, but they were not interested in backing it fully.

To make things worst for the members of the decimal camp, in the last two decades of the nineteenth century a number of articles in opposition to decimalization in general and decimal time in particular appeared in different English-speaking countries. Among them was a series of opinion-editorials by Herbert Spender, published in *The Times*, in 1896[40]—that where widely read in both sides of the Atlantic—and also publications by lesser-known figures, like the Canadian R.E.W. Goodridge, who wrote a pamphlet *On the Proposed Change of Time Marking to a Decimal System: A Plea that the Duodecimal System be Retained*.[41]

At this juncture it was clear that some political muscle was needed to pull a reform through, and the French government was willing to lend a hand. In 1896 the Minister of Public Instruction instructed the Bureau of Longitude to study the pertinence for France of adopting decimal time and abandoning the customary time system. The Bureau of Longitude had been founded in 1795—ironically the same year that the decimal day and hour were suppressed—to perfect and develop nautical navigation, standardization of time-keeping, and astronomical observation. Actually, many of the scientists who participated in the design of the metric system and the republican calendar were founding members of the Bureau, like Delambre, Méchain, Lagrange, Laplace, and Borda.

To carry on the study solicited by the Minister, the president of the Bureau appointed in 1897 a Commission of Time Decimalization, with the

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38) Campos, *La geografía en 1895*, 53–54; see also Joaquín de Mendizábal y Tamborel, "La división decimal del ángulo y del tiempo," *Boletín de la Sociedad Mexicana de Geografía y Estadística* III (1895): 490–492, and Amado A. Chimalpopoca, "División decimal de la circunferencia," *Boletín de la Sociedad Mexicana de Geografía y Estadística* III (1895): 484–489.
39) *Report … International Geographical Congress*, 785–786.
40) These articles were collected in Herbert Spencer, "Aginst the Metric System," in *Various Fragments* (London: Appleton, 1914), 142–170, 225–239.
41) Winnipeg: Manitoba Daily Free Press, 1886.

renowned mathematician Henri Poincaré as its secretary. If some of the major mathematicians of the eighteenth century were not able find an effective plan to decimalize time, probably one of the major mathematicians of the nineteenth century would do it.[42]

The work of the Commission was not smooth. Its members clashed on how drastic a possible reform should be and whether prevalent chronological conventions should be obliterated or left intact—in many ways resembling the debates that took place in the London congress. The more radical on the Commission sought the full decimalization of the day, hour and minute. Putting that plan into practice, however, not only would create discontent among the people, but it would also require significant changes in standards and instruments for navigation, the electrical industry, railroad systems, and the like. As Poincaré stated, looking for an intermediate position, "we cannot break completely with the past, because not only must we take account of public repugnance, but scientists themselves have a tradition to which they remain tied."[43]

In a negotiated solution, the Commission concluded to divide the day into 24 hours and to decimalize the hour and its subdivisions; to have a circumference of 400 degrees with the degree decimally subdivided; and to find approval for this scheme in an international congress.[44] But this compromise left many unhappy in the Commission and failed to generate support at the international level. The whole adventure ended with the Ministry of Foreign Affairs informing the Bureau of Longitude that the government would not sponsor the plan.[45]

Finally, in 1899, two members of the French Chamber of Deputies, Gouzy and Delaune, introduced a proposal for a law to divide the day into 24 hours, the hour into 100 minutes, and the minute into 100 seconds, but it never passed.[46] Thus, at the start of the new century, the last official attempts to decimalize time in France came to nothing.

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42) Galison, *Einstein's Clocks, Poincaré's Maps*, 162–174 provides a detailed account of the debates that took place in the Commission and the role of Poincaré on it.

43) Quoted in Galison, *Einstein's Clocks, Poincaré's Maps*, 165.

44) Henri Poincaré, "Rapport sur les résolutions de la commission chargeé de l'étude des projects de décimalisation du temps et de la circonférence," in *Oeuvres de Henri Poincaré* (Paris: Gauthier-Villars et Cie, 1952), 8: 664, see also in that volume "La décimalisation de l'heure et de la circonférence," 676–679.

45) Galison, *Einstein's Clocks, Poincaré's Maps*, 173.

46) Marquet, "24 heures ou 10 heures?," 290; Carrigan, "Decimal Time," 309.

Decimal Time in the Twentieth Century

For decades little happened with decimal time after the last French push in the 1890s. Only occasional petitions were published here and there,[47] but no serious plan was articulated. However a significant development occurred in 1960, with the formal integration of time with the other decimal systems of measurement, when the General Conference on Weights and Measures unveiled the International System of Units (SI). The SI is the present name of the metric system. Originally, the metric system had three base units: meter (length), liter (volume), and gram (mass). For everyday life purposes, this system is pretty much intact, but it has suffered many alterations and additions in the scientific world. Today the SI has seven base units: meter (length), kilogram (mass), second (time), ampere (electric current), kelvin (thermodynamic temperature), candela (luminous intensity), and mole (amount of substance).

All these units use the SI prefixes to denote decimal subdivisions, including the second. Thus microsecond means one millionth of a second, nanosecond one billionth of a second, and so forth with pico-, femto-, atto-, zepto-, and yoctosecond, the latter being one septillionth of a second. In theory, with these prefixes now it is possible to use decimal terms to express spans larger than the second, like kilosecond (one thousand seconds) or megasecond (one million seconds), but these multiples are not actually used.

As a result, today we are decimal in the larger and smaller units of time reckoning. Years are decimally grouped in decades, centuries and millennia, and seconds are divided in groups of ten using the prefixes of the SI. Thus, from the year up time units increase decimally, and from the second down they decrease decimally as well. What do we have in between? The year divided into 12 months, months divided into 28, 29, 30, or 31 days; the seven-day week, days divided into either 24 hours or two sets of 12 hours (depending if one uses the 24-hours clock or the AM/PM designation), the hour of 60 minutes, and the minute of 60 seconds. Strikingly, our modern-scientific civilization regulates its temporal life following a "system" that combines decimal, duodecimal, and sexagesimal systems.

Near the end of the last century, new technological developments opened the door again for decimal time. If the railroad and the telegraph created the

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47) See for example Frank J. Moles, "An Auxiliary System for the Measurement of Time," in *The Metric System of Weights and Measures: The National Council of Teachers of Mathematics* (New York: Teachers College, 1948), 225–233.

necessity for uniform standard time and time zones, the newest revolution in communications may challenge some of the principles of the temporal arrangement established in the 1880s.

In 1998 Swatch Group, the Swiss timepiece manufacturer, launched what they called Swatch Internet Time, or "beat time". This system allows people in different parts of the planet who are simultaneously connected through the internet to use a single global time without time zone differences (and without daylight saving time). Swatch's scheme removes time zones altogether by establishing an Internet Time meridian or Biel Meantime (BMT), that takes its name from Swatch's headquarters in Biel, Switzerland (even though a day in internet time actually begins at midnight Central European Winter time).

Swatch Internet Time divides the day into 1000 "beats". Midday, for examples, means 500 beats (expressed @500) and takes place concurrently in Nairobi, Kabul, Denver, or anywhere else in the world. According to the company "Internet Time exists so that we do not have to think about timezones. For example, if a New York web-supporter makes a date for a chat with a cyber friend in Rome, they can simply agree to meet at an "@ time"—because internet time is the same all over the world."[48]

Despite its potential as a standard to coordinate the massive amount of activities carried out daily through the internet around the globe, Swatch Internet Time has not been very successful and it is only used in limited areas. However, it is based on the legitimate premise that the internet works at the same time all over the world without having to conform to geographical particularities and is then free to ignore time zones, seasonal adjustments, and national conventions. Of course, internet time does not have to be decimal (it can pretty well follow the usual 24-hour day and 60-minute hour and keep fulfilling the same function), but it is worthy of note that its makers chose to divide the day in a thousand parts, probably to emphasize its novelty.

Why Is there No Decimal Time?

Decimal time was a very good idea that never caught on. Its origin was full of promise, but its history is one of repeated rejection. One of the ironies—or tragedies—in its history is that the more serious attempts to institute decimal time were coupled with projects that enjoyed extraordinary success. In the

48) "Swatch Internet Time." Swatch Group. http://www.swatch.com/zz_en/internettime.html.

1790s, decimal time was the twin reform of the metric system, but only the meter turned out to be a universal unit of measurement. Decimal currencies, another invention parallel to decimal time, became a ubiquitous feature in modern societies. In the 1880s, French scientists tried fruitlessly to link decimal time with the establishment of the system of time zones, one of today's central pieces for temporal coordination. Decimal time is a foiled project while its fellow proposals are now universally used. How can we account for these divergent destinies?

Decimal time did not fail due to its "overemphasis on the totality of the obliteration of the traditional system of units of time and time-reckoning."[49] The metric system also broke radically with the past but was accepted anyway. All the more, the metric system might have been even more radical, since it did not carry any of the previous units of measure used in France prior to the revolution; the Republican calendar kept using the 365-day year and the day itself, and in that regard it was not completely new. Dealing with novelty and rupturing with the past do not appear to be among the main reasons why decimal time failed.

It also has been said that decimal time did not stick, while the meter did, because the "calendrical reform entailed France's international isolation, whereas the metric reform did not."[50] This assertion makes sense for today's world, but not for Europe in the 1790s. When it was created the metric system represented international isolation for France in the realm of weights and measures (essential for all commercial transactions) as much as the republican calendar did for temporal orientation. When the meter, liter, and kilogram were established *nobody* in the world—except for their inventors—knew what they were, what magnitudes they represented, what their names meant, and how their subdivisions related to each other. Despite the problems caused by the lack of standardization, there were many similarities among the units of length, volume, and weight in Western Europe prior to the revolution. They usually represented different magnitudes, but they had common names and the same logic for grouping and divisions. The metric measures broke that shared understanding, *within* and *outside* France, the same as decimal time and the new calendar—but the metric system prevailed nevertheless. International isolation does not account for these differences.

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49) Zerubavel, "The French Republican Calendar," 874–875.
50) Zerubavel, "The French Republican Calendar," 876.

The key to understanding the metric success and the chronological and calendrical failure is that the metric system wanted to substitute a *multitude of systems* of measurement; while the republican calendar aimed to replace *one system* of time reckoning. In other words, the metric system confronted a disarray of local and uncoordinated measures, while decimal time clashed against a well established system. In this regard, it is not surprising that a reform of weights and measures was a popular demand and the metric system helped to solve a pressing need felt for different social groups. And the open indifference faced by decimal time can be explained by the fact that only a tiny group of savants and politicians perceived the traditional time systems as a problem that needed to be fixed.

Another reason is that metrication was sponsored by scientific societies and large scale merchants, and financed and implemented by national states all over the world. Besides, the set of institutions and political authorities that allowed the existence of pre-metric units of measurement in Europe (namely feudal rights and lords) were demolished by the modern states. And something similar happened with decimal currencies, the diffusion of which was in concert with "the spread of national fiduciary money produced under government monopoly."[51] Decimal money replaced duodecimal and vigesimal monetary systems because it counted with permanent support from national states during the last two centuries. Decimal time in contrast has been an *institutional orphan* ever since the French authorities decided to drop it out; not even scientific and engineering societies (usually the more enthusiastic groups in promoting decimal systems) could present a common front to push in favor of chronological decimalization.

The difficulties—and ultimate failure—to establish decimal time can teach us a final lesson. The use of decimals for counting, calculating, and measuring is not a given. The predominance of decimals is the product of historical contingencies and negotiations. If certain circumstances had been present time reckoning would be fully decimalized—and the scenario of not having a decimal system of measurement was a possibility as well. If the groups and institutions that supported the metric system had been less influential, it could have faced the same fate as decimal time. But this also means that the future is open, and decimal time may someday find more favorable conditions to flourish—but there are no guarantees.

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51) Tschoegl, "The International Diffusion … Decimal Currency," 101.