The Martian Time Poll: One Martian Year Of Data

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[2000]

Abstract
The design of a Martian time-keeping system must be as much a social construct as an astronomical one if it is to gain wide acceptance within the Martian community. Not only must such a system accurately mark the passage of the Martian diurnal and annual cycles; it must also incorporate features that satisfy human social needs. What kind of a clock and calendar do Martians want? The Martian Time Web Site began conducting an on-line poll in September 1998. The Martian Time Poll consists of 25 questions on the basic elements of Martian time-keeping. The results of the first Martian year of data are reported and discussed.

Introduction
As we humans establish ourselves as a multiplanetary species, spreading throughout the Solar System during this new century, we will leave behind the 24-hour day and the 365-day year. These are cycles that are peculiar to Earth, and as a product of billions of years of evolution on this planet, we are designed to operate by them. Humans will have no use for diurnal periods that are hundreds of hours long. Similarly, years of 12 or 29 times the duration of the terrestrial year (the orbital periods of Jupiter and Saturn, respectively) will be of no practical use in human affairs. We define a standard unit, the second, in as abstract a way as possible for the physical sciences, but time is a social measurement, first and foremost. We awaken, we work, we eat, and we sleep. We gather to transact business and recreate. We are born, we mature, and we die. How will we measure ourselves, our biological and social needs, according to the passage of time on alien worlds? What social measurements of time will we bring with us from Earth to make our new homes less alien? To what physical cycles of these new worlds will we adapt ourselves and our new societies?

The study of extraterrestrial social measurements of time has been confined almost entirely to Mars, although systems have recently been proposed for the Galilean satellites of Jupiter (Gangale 1998). There are a number of reasons why Mars dominated the subject. Mars in one of the nearest planets to Earth, and therefore one on which humans are likely to establish themselves in advance to voyages to other worlds. Furthermore, in the past half-century, while we have come to know both Venus and Mars as being less hospitable environments than pre-spacefaring civilization had hoped, Mars has clearly emerged as the best prospect for humanity's second home. Finally, the cycles of Mars are Earthlike enough that humans living there will find it terribly inconvenient to ignore them. Living and working by Earth's 24-hour day, humans would find themselves rising 40 minutes earlier each Martian sol. The Gregorian calendar will be useless for marking the regular passage of the Martian dust storm season and other annual weather phenomena, much which has yet to be discovered. Martian society will require a Martian clock and calendar for its own specific, localized purposes, and will refer to Earth's Universal Time only as its off-world interests require.

History Of Ideas:
The first ideas on Martian time-keeping arose 120 years ago as novelists began to speculate on the possibility of a Martian society. The earliest tales envisioned humans encountering indigenous Martian civilizations. Later, as our increasing scientific knowledge of Mars reduced the prospect of advanced forms of Martian life, the trend was toward stories about humans establishing their own cultures on Mars. As incidental minutiae in a fictional narrative, the subject often received superficial treatment, lacking the detail to be a complete and useful system (Heinlein 1949, Clarke 1951, Piper 1957). Occasionally, such ideas were based on a faulty knowledge of astronomy (Burroughs 1913, Compton 1966, Lovelock and Allaby 1984). Even when complete systems were described that fairly accurately accounted for the orbital factors of Mars, they did not take into account all the time-keeping needs of a human society (Greg 1880).

The first complete Martian calendar was developed by an astronomer who was active in the calendar reform movement in the 1930s (Aitken 1936). Another astronomer invented a complete time-keeping system in the 1950s, going so far as

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to have a functioning Earth-Mars clock-calendar constructed (Levitt 1954). Not only did these systems accurately reflect the astronomical phenomena of Mars, but they also took into account many of the sociological aspects of time-keeping.

More ideas on Martian time-keeping have been generated as interest in sending humans to Mars has increased. The Case for Mars series of conferences included two presentations on Martian time (Mackenzie 1989, Gangale 1997). In the 1990s, roughly 20 authors wrote on the subject. The first commercially printed Martian calendar is available for the current Martian year (Graham and Elliott 1999). A number of real-time Martian clocks are currently posted on the World Wide Web. Links to several dozen on-line Martian time-keeping topics are available on the Martian Time Web Site at www.martiana.org, along with an in-depth discussion of the systems that are known to the primary author of this presentation.

The Social Construction Of Measurement:

A clock or a calendar does more than "tell time," it "measures the measurers," it tells the story of those who constructed it and where they came from. Measurement and all who do it are part of human culture (Sydenham 1979, p. 29). The roots of measurement are in the social process itself – even when it strives to be precise, scientific, and abstract. The study of the history of measurement has demonstrated that the procedures that natural and social scientists use in measurement were invented to solve problems of everyday life (Duncan 1984, p. 2). For instance, during the fifth millennium BC, Egyptian priest-astronomers recognized that the solar cycle heralded the rise and fall of the Nile. The Sun eventually became all-consuming object of astronomical observation, entirely displacing the Moon in importance, which was the primary astronomical time-keeping device for most other cultures. The Egyptians were the first to develop a calendar based solely on the solar cycle, in which the months were uniform divisions of the year that were divorced from the phases of the Moon. The scientist usually comes into the picture when the measuring instrument needs to be improved. An excellent example is the idea of measuring temperature with a thermometer, a vague concept that was made less vague through instrumentation (p. 2).

We take our familiarity with the dimensions of Nature for granted. However, the historical study of measurement has revealed that not only are the familiar units of mass, distance, and time socially constructed, but the physical dimensions themselves are social constructs and have not always been conceived of in the same way throughout history (p. 14). There has been an evolution toward greater abstraction and standardization, but the fact remains that Nature does not dictate the duration of a second or an hour. The hour has not had a fixed duration over human history (p. 15). The duration of a second, until recent history, was not agreed upon. Until 1967, "time was bound up with the classical mechanics of Newton; today it is defined in terms of quantum mechanics, and it is not certain that the two are the same (Danloux-Dumesnils 1969, p. 64)." It is the quest for ever greater precision in measures that led to the discovery of their illusory character (Langevin 1961). In trying to tie the metric system to Nature, its creators discovered that the system was not so natural and immutable. The International Meter is 0.2 mm shorter than the Metre des Archives, based now on a different standard than a fraction of the arc of meridian (Duncan 1984, p. 22). By 1928, the distinguished physicist P. W. Bridgman wondered whether, "from a strict operationist standpoint, physics was justified in treating as one and the same concept the notion of length pertaining to ultramicroscopic dimensions, the tactual concept suited to everyday life, and the optical concept, which is required for astronomical measures of length (p. 15)."

The truth of the matter is that there is an "idealization of the measurement process" which our scientific method is so dependent upon (pp. 120-121). Much of the philosophy of science is a neat *ex post facto* rationalization (p. 120). Our definitions of physical measurements and our conceptualizations of the architecture of the Cosmos are only as solid as our experience of everyday life. As we move outward into the Cosmos, the new challenges we face as a people redefine our experiences. In seeking to accommodate this process, we will enhance our vision of the universe and invent new instrumentation to measure it. Time measurement, as any other of our measurements, illustrates how social needs and processes influence the framework and conventions of physical measurement. Timing, sequence, tempo, and duration are fundamental features of social events (Duncan 1984, p. 30, citing Zerubavel 1982). It is logical to expect that so long as those features remain tied to the everyday experiences of current terrestrial life, they will not change much. However, when the everyday experiences of humans ranges farther afield, those features will change. They may even begin to change as humans start to consider new data from possible human ecological niches elsewhere in the solar system.

So, it was no mere idle exercise in creativity to gauge the attitudes and opinions of those interested in timing, sequence, tempo, and duration on Mars, even though no actual Martian respondents exist. We do stand on the verge of the acquisition of the Red Planet, with new data being deposited periodically into the human collective consciousness regarding conditions there. *We are becoming Martian.* What would those "becoming Martian" have to say about temporal measurement on Mars?

Methods

The history of time-keeping on Earth suggests that people resist change, even small and prudent ones. An example of this is the reform of the Julian calendar that was promulgated by Pope Gregory XIII in 1582, which deleted one leap day every 400 years. The Gregorian calendar did not completely replace the Julian calendar for civil purposes until the 20th century, and even today the Julian calendar continues to be observed as a religious calendar by Orthodox Christians, despite the fact that it is now off by 14 days. History is replete with examples of more radical reforms that failed. Thus the authors surmised that the proposed design features in Martian time-keeping that most closely mimicked terrestrial time-keeping conventions would be the ones best received. As Niccolo Machiavelli observed, "It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than the creation of a new system . . . The hesitation . . . arises . . . in part from the general skepticism of mankind which does not really believe in an innovation until experience proves its value."

At the same time, the authors were mindful of the possibility that the demographic that was likely to respond to the Martian Time Poll, i.e., the Internet community in general and Mars enthusiasts in particular, both representing pioneering populations, would be to some degree more sophisticated and more open to innovation than society as a whole. But to what degree? In this respect, the Martian Time Poll was an exploratory study – polling for responses in order to frame testable hypotheses and to later be able to ask cogent research questions.

The Martian Time Web Site began conducting an on-line poll on 20 September 1998. The Martian Time Poll consists of 25 questions on the basic elements of Martian time-keeping. The questions break down into two categories. The first of these deals with the structural details of time-keeping: how many hours should there be to a Martian sol, how many months to a Martian year, et cetera? The second set of questions pertains to the nomenclature of Martian time: should we devise new names for the Martian units of time, and how should we name the sols of the week and the months of the year? This presentation reports only the results of the questions that address the preferred structure of a Martian clock and calendar. While preferences regarding the shape of a Martian time-keeping system are certainly influenced by culture, it must be noted that most of human society has become familiar with the 24-hour, 60-minute, 60-second clock and the structure of the Gregorian calendar to varying extents. That which we call Universal Time becomes more truly universal every day. On the other hand, the names that we apply to these common elements of time are heavily influenced by history, language, and culture. Since the Martian Time Poll is entirely in English, the results of the questions addressing the nomenclature of Martian time will, to some degree, be culturally biased.

Another possible bias in the poll was that some respondents might not understand all the questions. A Frequently Asked Questions page is available on the web site, which they may or may not have seen.

The data reported in this presentation were recorded on 29 July 2000. At that time, the poll had been open for 708 days, 21 days longer than a Martian year. The results are presented in tabular form in the Appendix. For each question, there was a drop-down list of options from which the respondent could choose. As noted in the Appendix, some questions were added to the poll at later dates, as were response options to individual questions in some cases.

Results

For each of the 14 structural questions, the total number of respondents is reported, then the number and percentage of respondents to the highest ranked responses. The lowest ranked responses are reported as a group. Finally, there is a discussion of the data.

1. How should the Martian sol be divided?
Of 109 respondents, 52 (47.71%) chose to “stretch the second” to make up for the 3% longer length of the Martian sol to imitate an Earth day of 24 hours, 60 minutes to an hour, 60 seconds to a minute. This choice was far and away the most popular of the possible selections. The other 57 respondents’ choices were distributed over 16 other configurations and a choice to respond “No opinion.” “No opinion” was the second-most popular choice with 12 respondents (11.01%) opting for it. The range of response for the 16 other configurations was 0 to 8 respondents.

Refer to Figure 3.1 below.

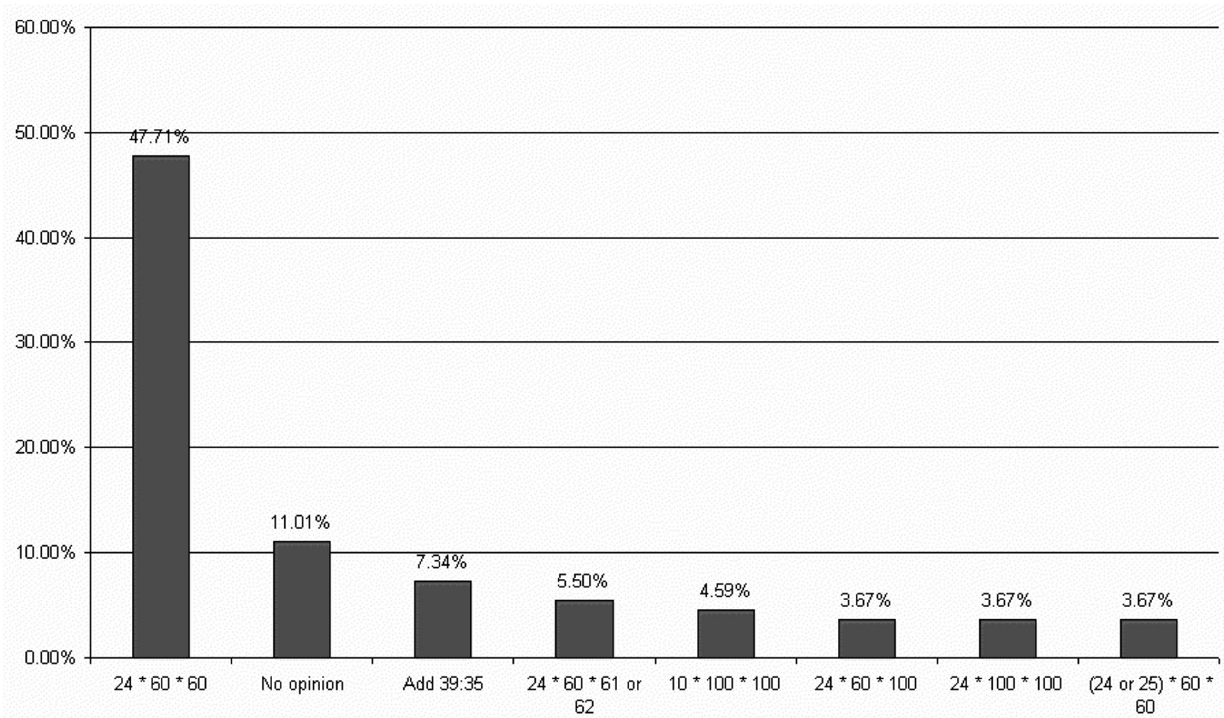

Figure 3.1

This is a dramatic example of taking what works on Earth and stretching it to make it work on Mars. A recurring theme in the data is that if the proposition is straightforward enough, people choose the most conservative option every time. The Martian sol is only 2.7% longer than the Earth day, and simply stretching the familiar units of time by this small amount would be insensible to most people.

But as physicist Robert L. Forward once insisted in a letter to the primary author, “A second is a second is a second!” Yes, there must always be a universally accepted standard technical unit of time, but it is the society that owns time, not the scientists and engineers. The Martian unit of time that mimics the standard second might one day be called by a more distinctive name, but that is a subject for a future presentation.

It is instructive to note here that in the late 18th century, the idea of dividing the day by powers of ten was proposed as part of the metric system, and was discarded early on. Ideas on “metric time” for Mars appear destined to a similar fate. In a sense, the Martian clock is already a *fait accompli*, since the stretched 24-60-60 clock was used routinely at the Jet Propulsion Laboratory during the operation of the Viking 1, Viking 2, and Pathfinder landers on the surface of Mars.

2. Should Martian months always begin on the same sol of the week?
Of 109 respondents, 50 (45.87%) chose “No” and 36 (33.03%) chose “Yes.” The next popular choice was “No opinion” with 16 respondents making up 14.68% of the response to this question. The two other selections had a range of response of 3 to 4 respondents.

Refer to Figure 3.2 below.

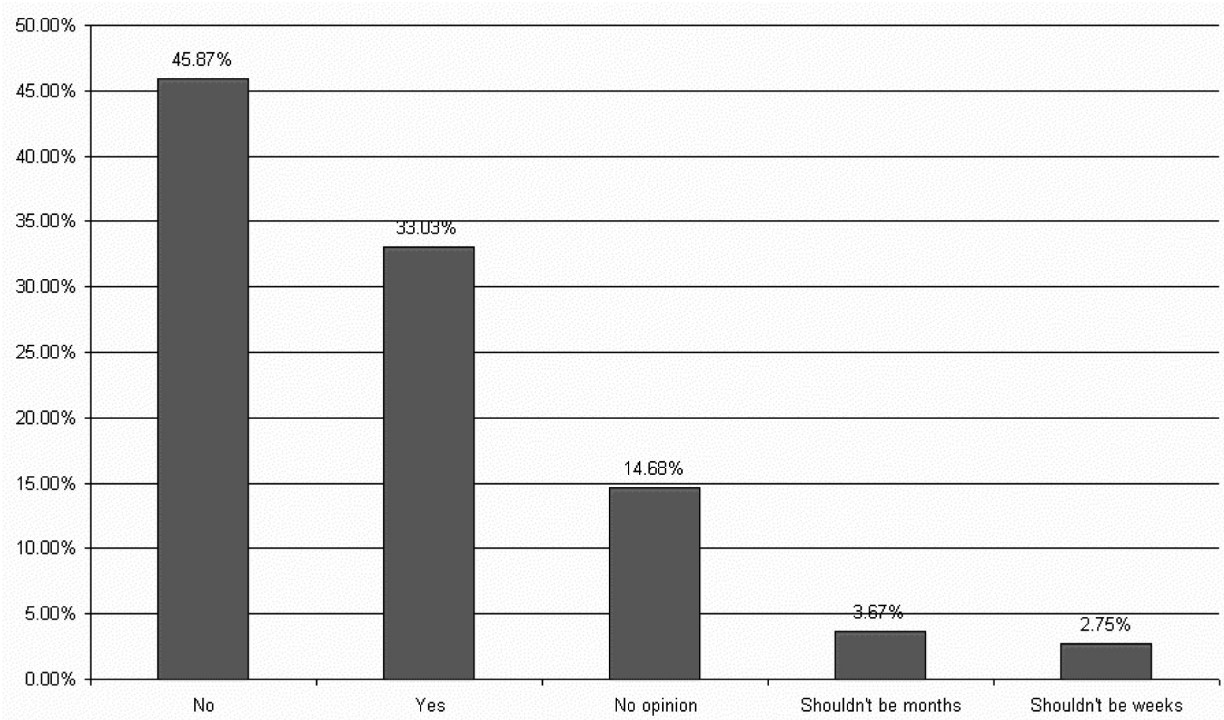

Figure 3.2

Once again, the data can be interpreted as being a conservative response. On the Gregorian calendar, the day of the week beginning a calendar month varies not only from one month to the next, but from year to year for any given month. This chaotic system has been in place since the seven-day week was incorporated into the calendar during the reign of the Roman emperor Constantine I. Several attempts at reform in the late 19th and early 20th centuries sought to regularize the calendar and make it "perpetual," i.e., make each calendar year identical. One proposal, championed by George Eastman of Kodak (Eastman 1926), would have had each month begin on Sunday, and while the International Fixed calendar never gained acceptance as a civil calendar, some major corporations continued to use it for accounting purposes toward the end of the 20th century. Another proposal, the World calendar, would have had months begin on various days of the week in a regular pattern that repeated every three months (McCarty). The failure of these reforms on Earth suggests that the current system is not a great inconvenience to most people. The response to Question 2 of the Martian Time Poll shows that the idea of regularizing each month of the calendar year is so unfamiliar as to outweigh whatever advantages it might have. However, in the response to Question 14, we will see that there is support for some sort of a perpetual calendar for Mars.

3. How many major divisions of the Martian year should there be?

Of 109 respondents, 62 (56.88%) opted for four major divisions of approximately 167 sols each. This choice was the most popular choice. The next popular choice was "No opinion" with 21 respondents (19.27%). The third-most popular choice was eight major divisions with approximately 84 sols each with 18 respondents representing 16.51% of the response to this question. The other two choices received 3 and 5 responses.

Refer to Figure 3.3 on the next page.

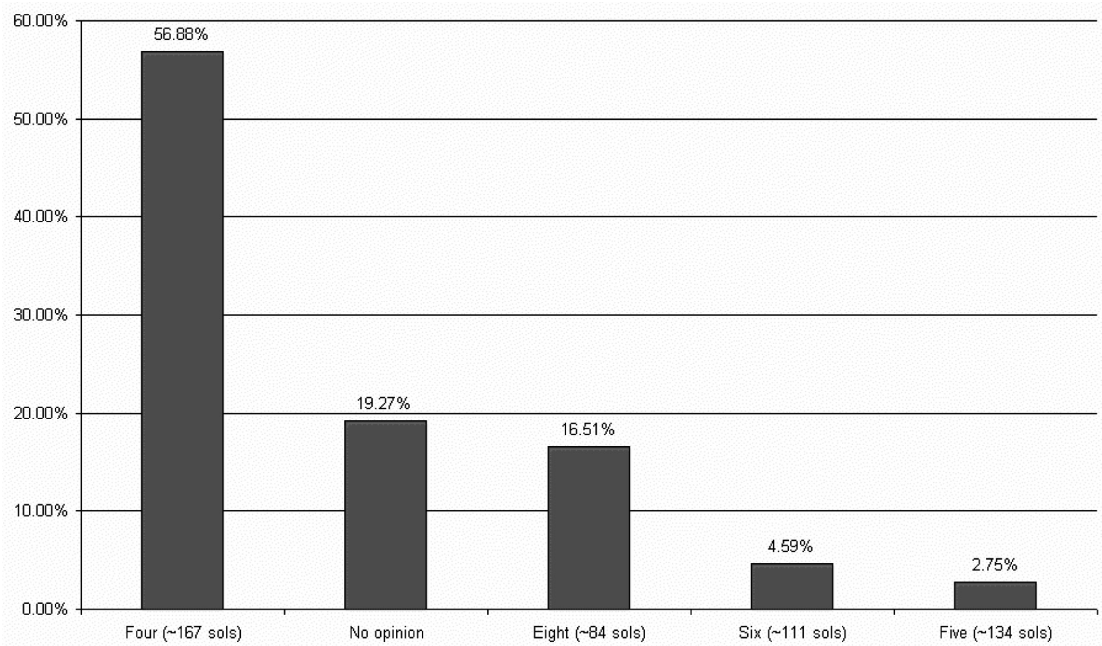

Figure 3.3

Much of Earth's population lives in temperate zones, where the passage of the year through spring, summer, autumn, and winter are obvious, and the response to Question 3 reflects the desire to retain these seasonal concepts on Mars. However, it should be noted that in Earth's tropical climates, the year tends to be viewed in terms of wet and dry seasons. The human experience of the Martian climate may be similarly bifurcated, as tropical populations may be more affected by the passage of the dust storm season, or of aphelion and perihelion, while the four seasons marked by the equinoxes and solstices may have a more pronounced effect on the temperate zones.

4. Should the Martian calendar have a leap sol or a leap week?

Of the 109 respondents, 81 (74.31%) chose the leap sol. "No opinion" was the next popular choice with 16 respondents representing 14.68% of the response to this question. The leap week was selected by 12 respondents (11.01% of the response). Refer to Figure 3.4 below.

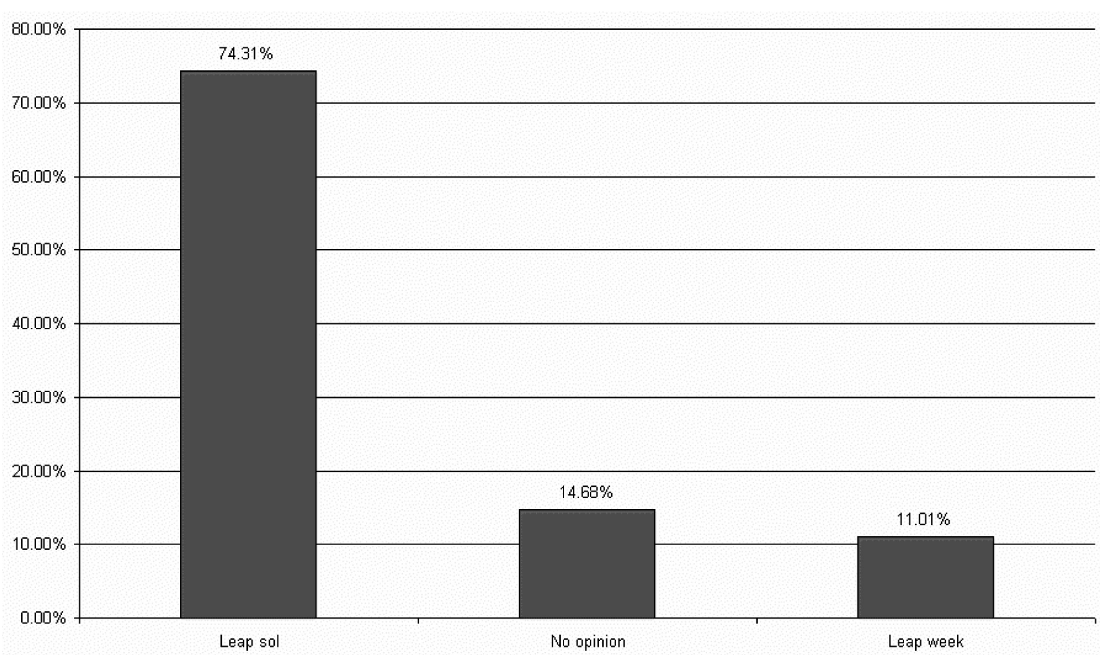

Figure 3.4

The leap week is a device used on some perpetual calendars to keep the months and weeks in synchronization. In the case of the seven-sol week, which was overwhelmingly preferred by respondents (see the responses for Question 7), such calendars vary the length of the Martian year between 95 and 96 weeks, i.e., either 665 or 672 sols. On the other hand, perpetual calendars that use leap sols must either include sols that do not count as part of a week if 95 weeks are counted, or periodically shorten weeks to only six sols if 96 weeks are counted, since the Martian year contains approximately 668.6 sols. There is no example of a leap week calendar in practice on Earth, so respondents preferred the traditional leap year calendar.

5. Should Martian months be of equal duration, or should they span equal arcs in Mars' orbit?

Of the 109 respondents, 74 (67.89%) selected months of equal duration, a nearly 3 to 1 advantage over months spanning equal arcs, an option chosen by 25 respondents (22.94%). The responses to the three other options ranged from 2 to 5, with "No opinion" leading the pack.

Refer to Figure 3.5 below.

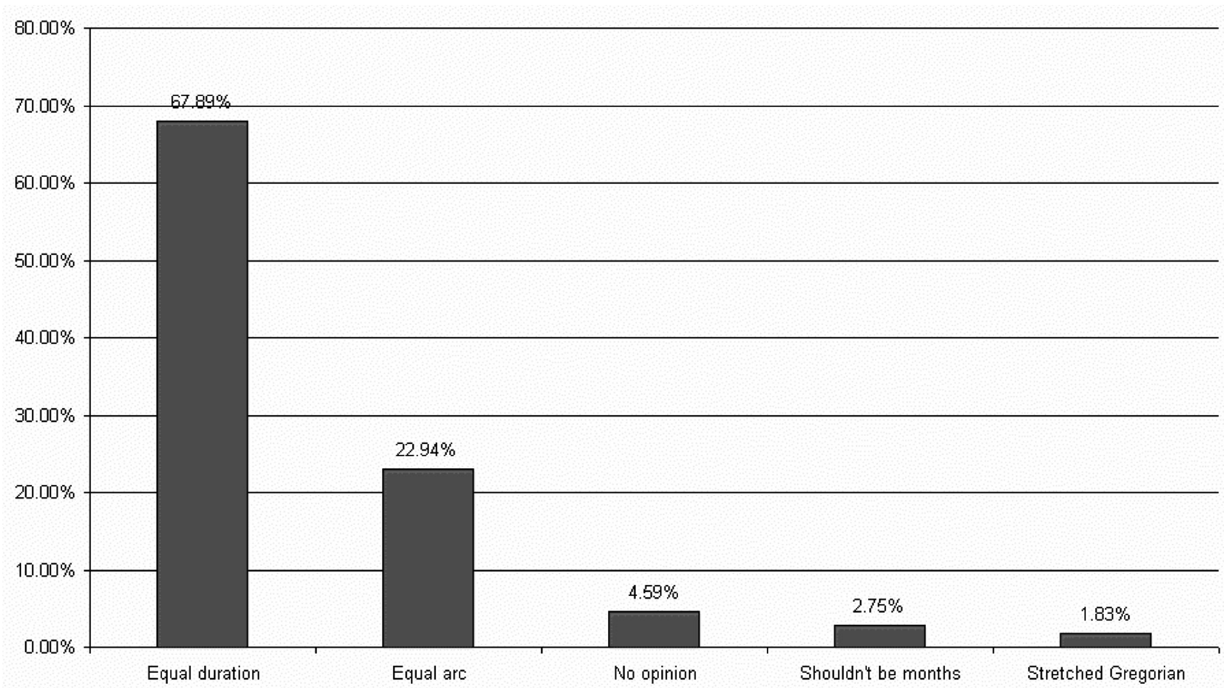

Figure 3.5

Nearly all Earth calendars divide the year into approximately equal segments of time, based either on the 29.53-day lunar cycle or on divisions of the solar year. While it is true that on the Gregorian calendar, February is two days shorter than any other month, most people do not consider this arrangement to be inconveniently lopsided. The unattractiveness of the equal-arc type of calendar for Mars may chiefly lie in the fact that it results in months containing highly variable numbers of sols because of the ellipticity of the Martian orbit. For example, in the best-known equal-arc calendar (Zubrin 1993), the 12 months vary from 46 to 66 sols. Moreover, there are only two months that have the same number of sols, requiring a mnemonic rhyme to be much more than a simple ditty. The difficulties that Martian accountants would face in dealing with such calendars can scarcely be imagined.

6. How many sols should there usually be in a Martian month? (Equal duration months)

Of the 109 respondents, 49 (44.95%) favored a calendar of 24 months containing 28 sols each. This was more than twice the number of selections for the second-most popular choice, a calendar of 12 month containing 56 sols each, which was favored by 22 respondents (20.18%). Other options, which ranged from 0 to 7 choices, ranked no higher than "No opinion."

Refer to Figure 3.6 below.

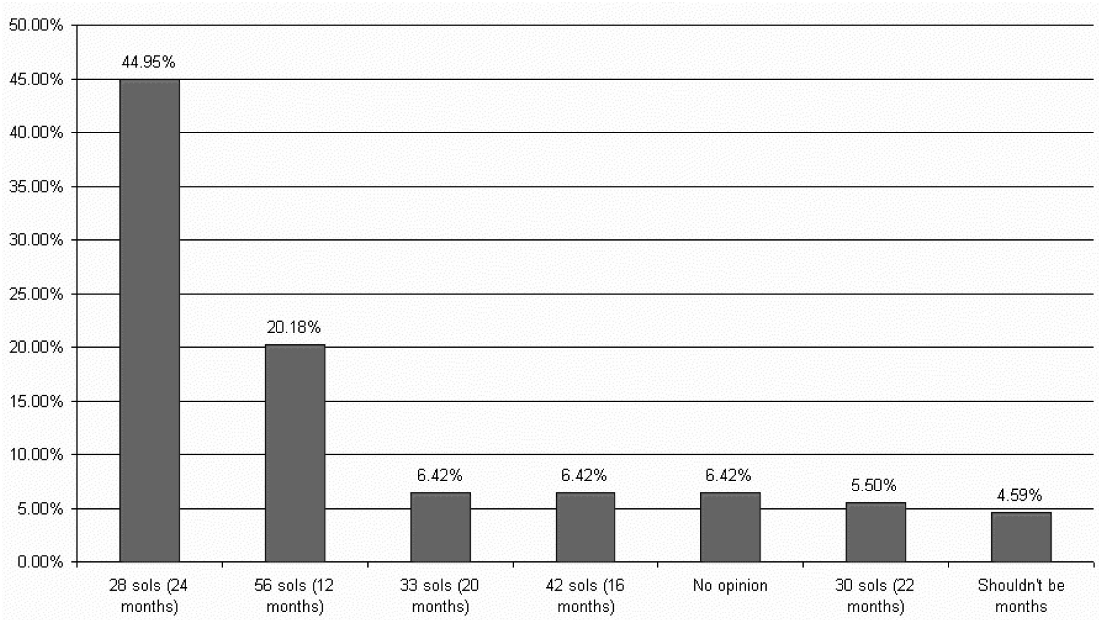

Figure 3.6

Nearly two-thirds of the respondents preferred a year that is divisible either by 12 or 24. The advantage of these two numbers is that they have a lot of other numbers as factors. For a variety of sociological purposes, the 12-month year can be divided by 2, 3, 4, and 6. The 24-month year can be further divided by 8, and since eighths of a Martian year are analogous to quarters of an Earth year, a standard accounting period, it is possible that the eighth would be a useful period of time for reporting Martian finances. Surely Martian investors will want to count their money about as often as their Terran counterparts, and as was remarked early in the Space Age, "No bucks, no Buck Rogers." Another advantage of calendars comprising 24 months of 28 sols each is that such systems accommodate a fundamental human biological cycle. The statistical average of the menstrual cycle is about 28 sols. Since the purpose of a calendar is to mark the passage of time in human terms, the more human factors that are designed into a calendar, the better.

7. How many sols should there be in a Martian week?

Of the 109 respondents, 75 (68.81%) chose a 7-sol week, nearly a 4 to 1 advantage over the second most popular choice, a 10-sol week, which was selected by 19 respondents (17.43%). The other four options received between 0 to 6 choices.

Refer to Figure 3.7 on the next page.

As mentioned in the discussion of Question 1, the application of powers of ten to units of time was originally envisioned in the metric system. Revolutionary France enacted a calendar (Weisstein 1996) comprising 10-day weeks, however it was widely ignored and was eventually discarded by Napoleon Bonaparte. The Soviet Union made several short-lived attempts to deviate from the 7-day week. It is clear from the responses to Question 7 that calendars that retain this ancient scheme are far more likely to gain acceptance.

8. On what sol should the Martian calendar year begin?

Of the 109 respondents, 51 (46.79%) opted for the vernal (northward) equinox. An equal number of respondents were distributed nearly evenly in their choices, 10 to 11 each, for the anniversary of the first human landing, 16 sols after the winter solstice (January 1st), "No opinion," perihelion, and the winter (southern) solstice. The remaining respondents selected from among the eight remaining choices with a range of response of 0 to 2.

Refer to Figure 3.8 on the next page.

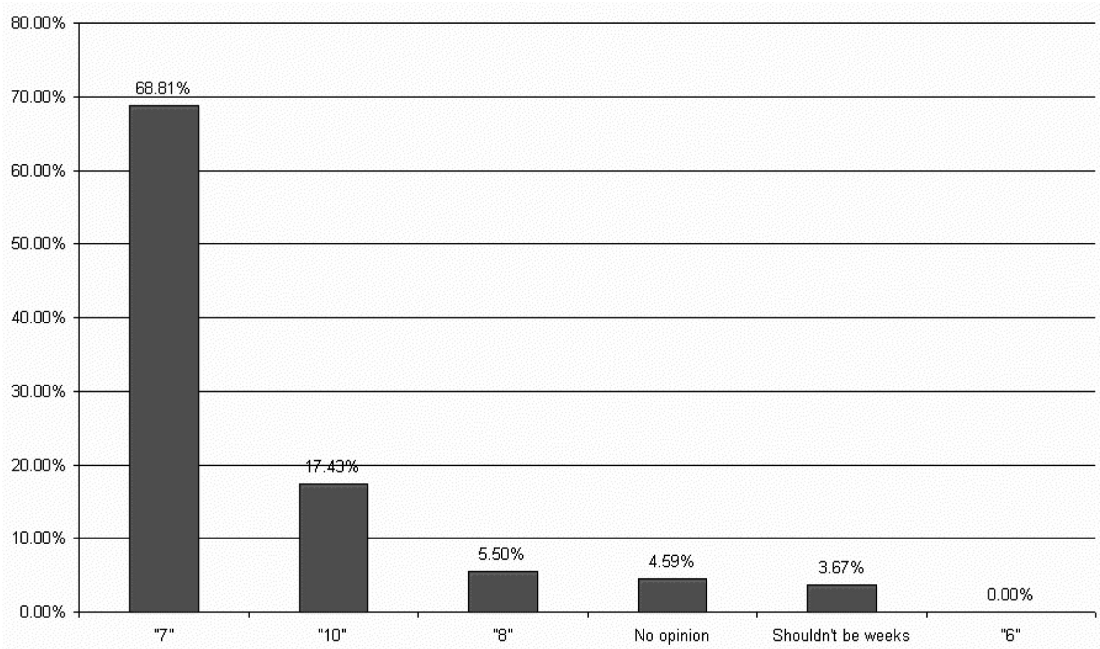

Figure 3.7

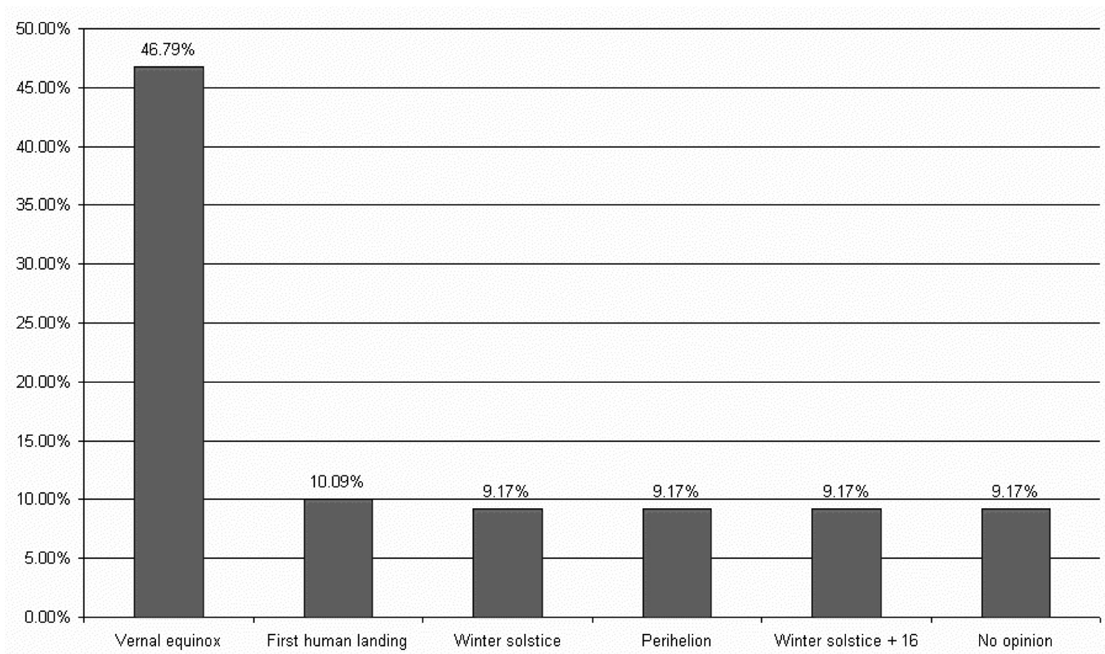

Figure 3.8

There was a consensus in favor of marking the beginning of the Martian calendar year with some annual astronomical event. There were 73 (66.97%) responses in this general category. This is one of three examples of the respondents deviating significantly from the Gregorian calendar (Questions 13 and 14 being the other two). However, it should be pointed out that the Roman calendar originally began on the vernal equinox, and that most of the other calendars of Earth were tied to a specific astronomical event. Also, it has been standard astronomical practice for centuries to reference the longitudinal position of celestial objects from the point of the vernal equinox.

9. What event should mark the first Martian calendar year?
Of the 109 respondents, 31 (28.44%) selected the first human landing on Mars as the epoch from which to count the Martian calendar years. This was double the number of choices of the second-most popular choice, the Viking 1 landing, representing 15 respondents (13.76%). A close third was "No opinion" at 13 responses (11.93%). Combined, the Viking 1 landing and "No opinion" received 28 choices (25.69%), a bit less than the front-runner. The 11 other choices received between 0 to 9 responses, but accounted for 50 (45.87%) responses.

Refer to Figure 3.9 below.

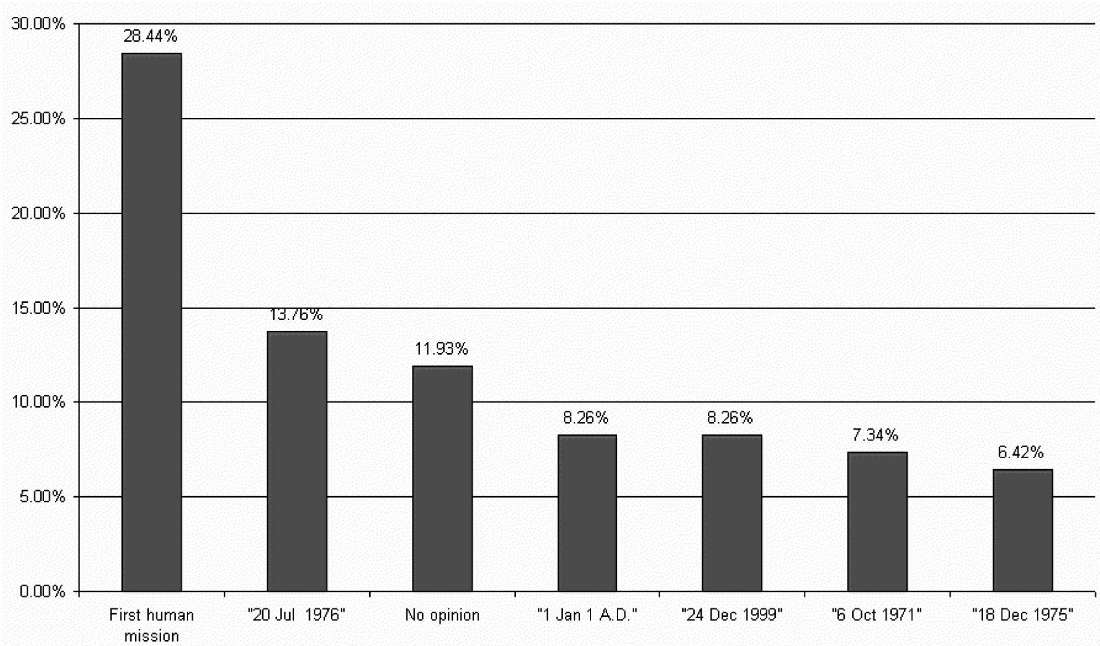

Figure 3.9

Of the 14 structural questions in the Martian Time Poll, this one produced by far the lowest ranking first choice. The weak consensus expressed by the respondents was to begin counting the Martian calendar year with an event that has yet to occur.

10. Should the first Martian calendar year be numbered 0 or 1?
Of the 109 respondents, 52 (47.71%) favored beginning the counting of Martian calendar years with the year 1, while 51 (46.79) preferred a year 0. This was a nearly even split, with a slight preference for beginning with the year 1. Understandably, so simple a question with so few choices has resulted in only 6 (5.50%) respondents expressing "No opinion."

Refer to Figure 3.10 on the next page.

This is the one question in the Martian Time Poll that failed to produce a consensus. We humans are rather schizoid when it comes to counting. There was no year 0 in the Gregorian calendar, nor do the months begin with a zero day. These social measurements date from an ancient time when the concept of zero was largely unknown outside the world of mathematicians. Yet in the modern world it has become common practice to begin each day with the 24-hour clock reading 00:00:00.

11. What would be an acceptable leap year scheme for a Martian calendar?
Of the 67 respondents, 34 (50.75%) preferred leap years to occur in odd-numbered years and years divisible by 10. This is a 3 to 1 advantage over the nearest competitor, the idea of having some scheme that produces three leap years every

five years, which received 11 (16.42%) choices. A close third was the concept of having no predefined scheme at all, but rather inserting leap years as astronomical observations pointed out the need for them. The “By observation” option received 9 (13.43%) responses, barely ahead of “No opinion,” which received 8 (11.94%) responses. The two other choices received 2 and 4 responses

Refer to Figure 3.11 below.

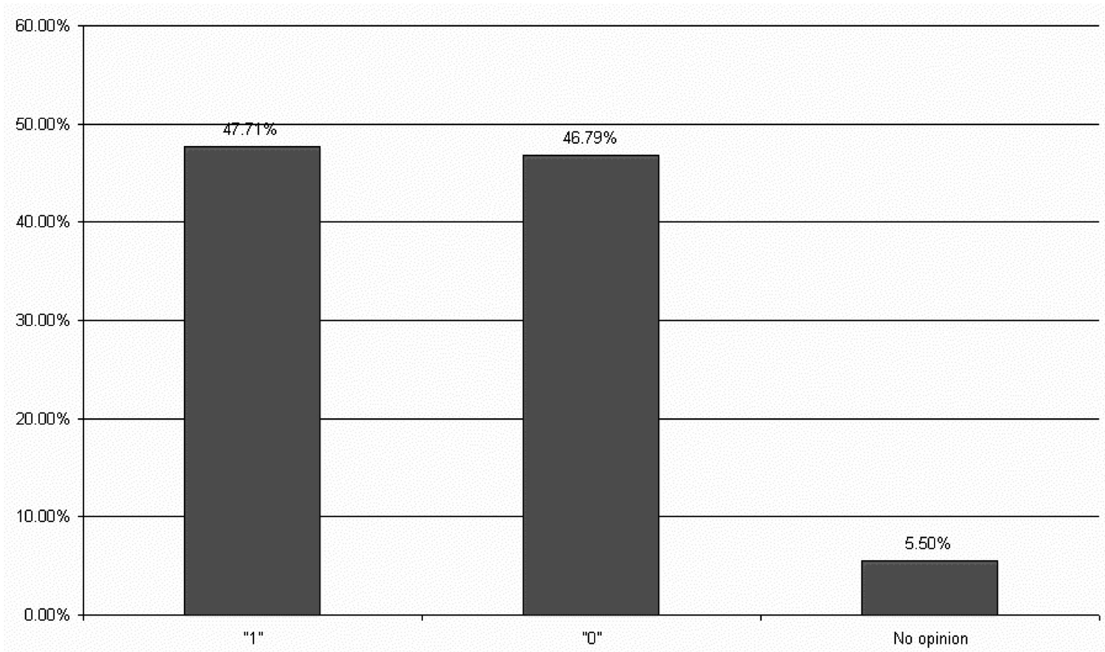

Figure 3.10

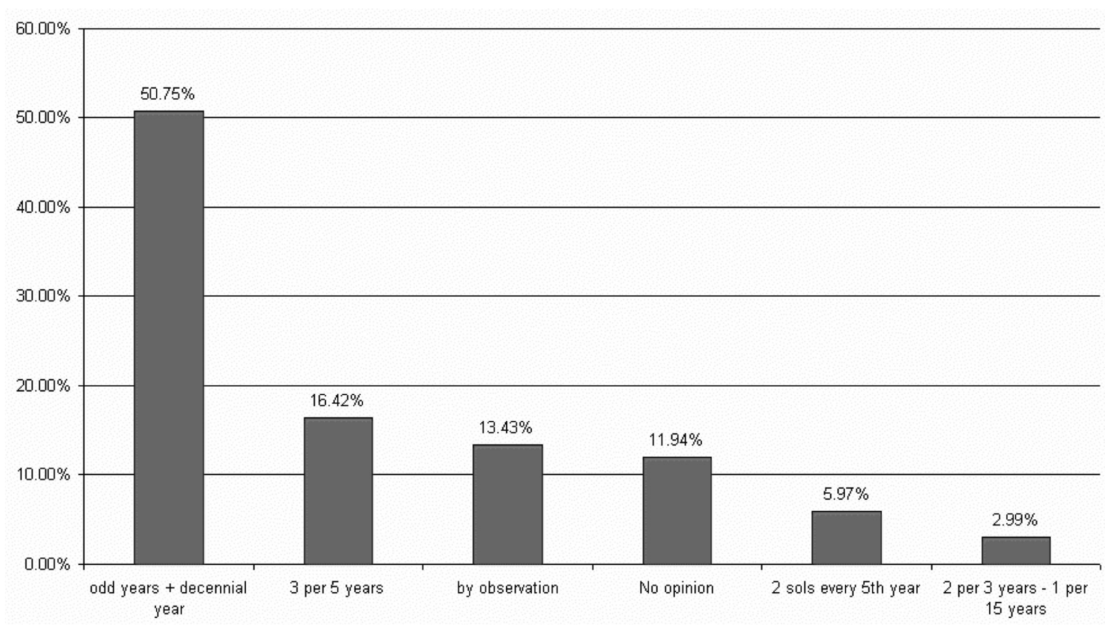

Figure 3.11

This was a rather complex question, and it is surprising that it produced such a clear result. The preferred algorithm produces six leap years every 10 years, which is necessary since the Martian year contains approximately 668.6 sols. A pattern that is repeatable every five years would be a bit more accurate; however, the most popular scheme is the simplest to remember, while other patterns require more of an explanation.

12. How should the length of calendar year vary?
Of the 67 respondents, 51 (76.12%) chose to have calendar years of either 668 or 669 sols. A far distant second, "No opinion" received 10 (14.93%) choices, while the six other options received between 0 to 3 choices.

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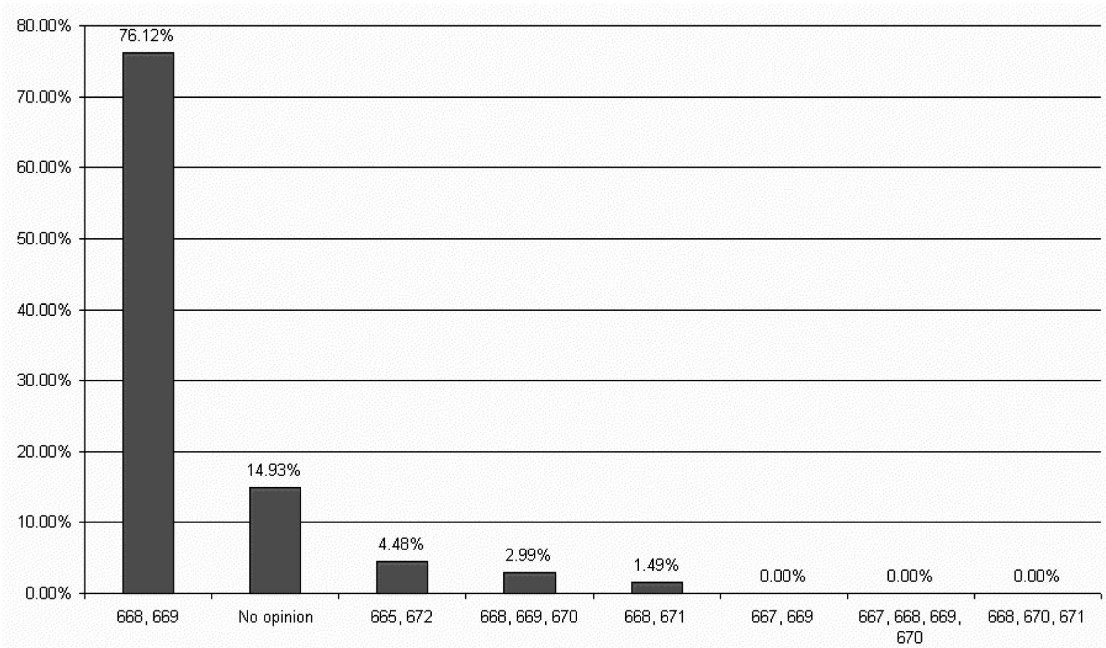

Figure 3.12

Again, people chose the simplest and smoothest solution. Other choices either required calendar years of three different lengths rather than only two, or required the length of the years to vary by more than one sol. In contrast, the calendar years on Earth are either 365 or 366 days; there are only two types of calendar years and they vary by only a day. Unsurprisingly, the preferred solution for Mars embodies the same principles.

13. When should the leap sols occur?
Of the 55 respondents, 32 (58.18%) favored placing the leap sol at the end of the year. Placing the leap sol at mid-year was favored by 7 (12.73%) respondents. Choices for the six other options ranged from 2 to 4.

Refer to Figure 3.13 on the next page.

The response to this question marked a significant departure from Earth's Gregorian calendar, in which the leap day occurs at the end of the second month (February). Only two (3.64%) respondents opted for this scheme on a 12-month Martian calendar, and in the case of a 24-month Martian calendar, only three (5.45%) people chose to have the leap sol at the end of the fourth month. Certainly most people are unaware of the fact that the Roman year originally began with March and that February was once the last month of the year, where it made sense to put the leap day.

14. Should the calendar be perpetual (each year occurring on the same sol of the week)?
Of the 55 respondents, 28 (50.91%) preferred a perpetual calendar, while 19 (34.55%) chose to have a non-perpetual calendar. The two other choices received 3 to 5 choices.

Refer to Figure 3.14 on the next page.

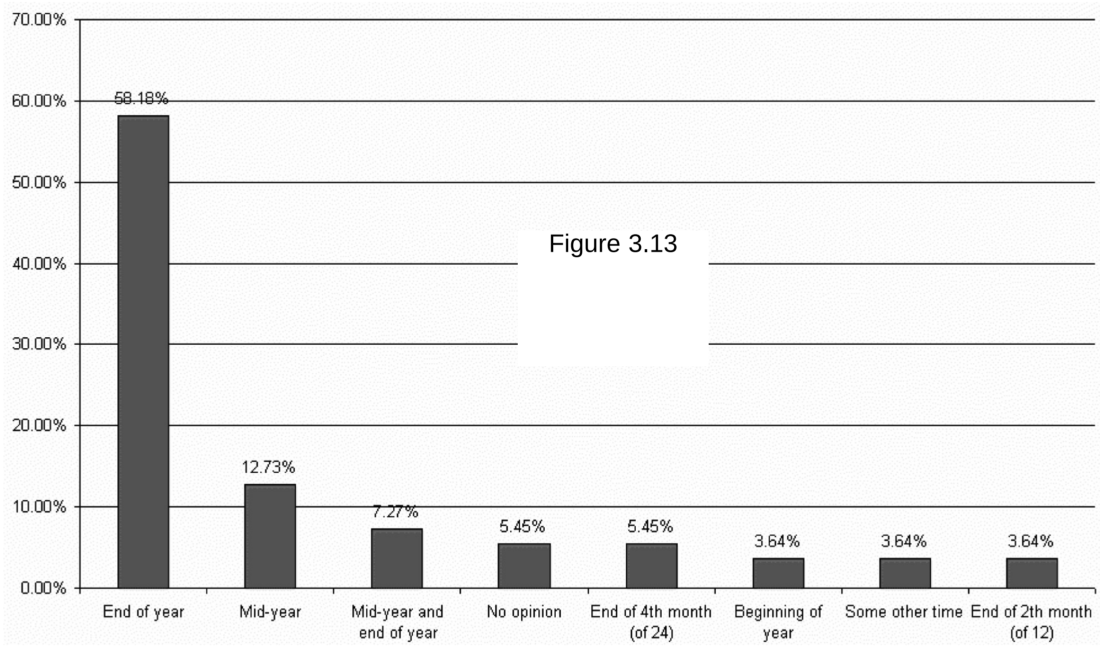

Figure 3.13

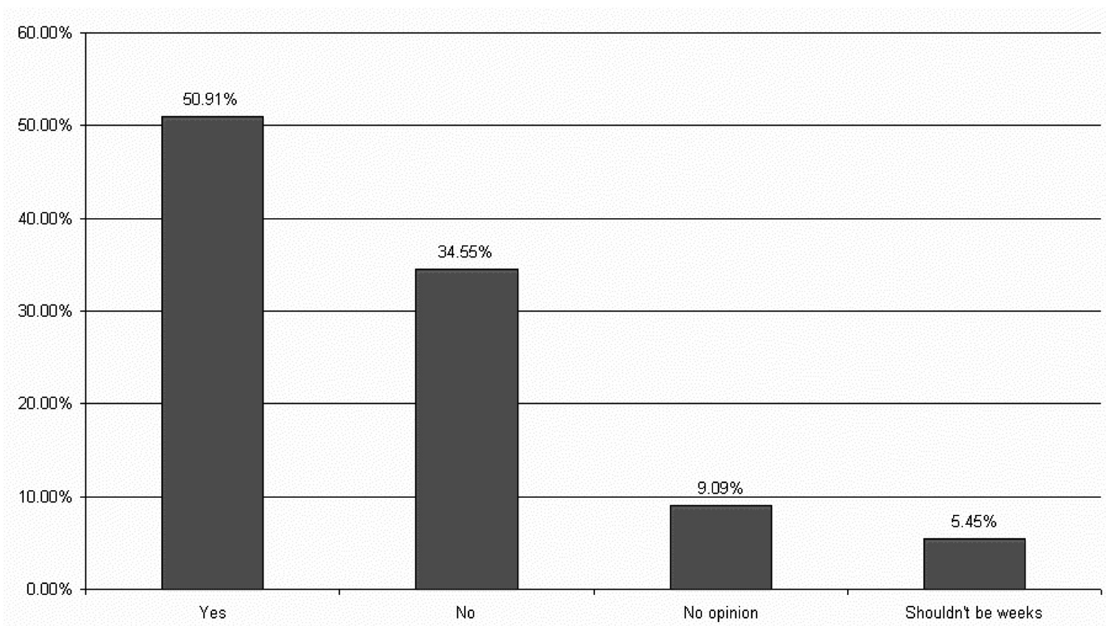

Figure 3.14

Again, we see here a response that deviated from current practice on Earth. Ideas on regularizing the calendar in terms of reconciling the months and the 7-day week in a repeatable pattern go back at least as far back as 18th century Maryland, when a colonist writing under the pen name of Hirossa Ap-Iccim dedicated a perpetual calendar to George II (Ap-Iccim 1745). As discussed earlier, the cause of calendar reform experienced a golden age on Earth in the late 19th and early 20th centuries, then lost momentum. And so, decade after decade and century after century, none of us knows on what day of the week the 12th of next month will fall without referring to a printed calendar. We seem all but resigned to this inconvenience here on Earth, but the response to Question 14 indicates support for a perpetual calendar for Mars. Some proposals establish a repeatable pattern over a period of a year or two, while others have every month invariably begin with the first day of the week.

Discussion And Conclusion

Regarding the division of the Martian sol into sub-units of time, the overwhelming favorite was the 24-60-60 clock, in which the hour, minute, and second are stretched by 2.7% to accommodate a diurnal cycle that is just a bit longer than Earth's.

The results also demonstrate clearly that respondents preferred an Earth-like, modern Western calendar for Mars, consisting of:

- Four seasons.
- A seven-sol week.
- A leap sol versus a leap week.
- Common years comprising 668 sols and leap years totaling 669 sols.
- Equal duration months of approximately 28 sols each.

The leap year scheme preferred by respondents was the simplest one to express: odd-numbered years plus decennial years.

The three notable exceptions to the Gregorian calendar were the desire to:

- Begin the year on the vernal equinox.
- Place the leap sol at the end of the year.
- Begin each year on the same sol of the week (a perpetual calendar).

While starting the new year on or near the vernal equinox is not a feature of the most modern Western calendar, it was a feature of past Western calendars and non-Western ones extant on Earth today. All of these latter calendars were informed by the view that the arrival of spring was the beginning of the new year and the end of winter, appealing to both the hunter-gatherer and the agriculturist. It is interesting that post-industrial respondents want to import this artifact from the Old World to the new.

Placing the leap sol at end of year rather than somewhere else inside the year is a logical idea, but not a new one. This was once a feature of the Roman calendar that is the basis of the Gregorian calendar. What we see here is a popular desire to return to a basic concept that got lost during several thousands of years of priests and politicians tinkering with time.

The quest for a perpetual calendar, one in which all common years and all leap years are identical in relation to the days of the week, is over 250 years old. The most momentous innovation in time-keeping in the Western world occurred more than 2000 years ago, when Gaius Julius Caesar, wielding absolute power, took Rome from a lunar calendar to a solar one designed by a Hellenistic Egyptian astronomer. The reform instituted by Pope Gregory XIII in 1582 was an extremely modest one that merely eliminated one leap day every 400 years, a reform that was required for the calendar to keep in step with the seasons. Even so, Protestant and Orthodox Europe ignored this prudent reform for centuries. Social inertia may doom further attempts at calendar reform on Earth, but on Mars we will have a new society, possibly more disposed to judge ideas on their merits rather than on their history. For the most part, the Martian Time Poll has shown that the proto-Martian community is firmly wedded to the time-keeping traditions that have served humanity well on Earth; it remains to be seen how Martian society will evolve new social measurements suited to its otherworldly environment.

Two issues of Martian time that remain to be resolved are:

- Defining the epoch as the year 0 or 1.
- Calibrating the epoch to a Gregorian date.

There is no consensus whatsoever regarding whether to begin counting the Martian years with 0 or 1. There are a number of social measurements that start from 0, while many others begin with the number 1. We speak of "the eleventh hour" as a metaphor for time running out, but if 11 p.m. begins that last hour of the day, why don't we then speak of the beginning of the day as "the zeroth hour?" If the Martian calendar began with the year 0, calculating the intervening years between a date before the epoch and after it would be a simple matter. If one was born in the year -22 and died in the year 11, that person lived to be 33 Martian years old, more or less. Starting with a year 0 would also mean that the next century would begin with the year 100. This makes intuitive sense, whereas on Earth many people are confounded by the fact that the new millennium won't really arrive until 2001. However, if Mars were to have a year 0, would we then speak of the years 0 through 99 as "the zeroth century?"

The weak consensus expressed by the respondents was to begin counting the Martian calendar year with an event that has yet to occur. This presents a problem to those who would like to begin using a Martian calendar as soon as possible, for without an epoch, we cannot possibly know what year it is! On the other hand, to those who believe that the adoption of a calendar should be a decision left to future Martians, this is not an issue.

The Martian Time Poll will continue to collect data. Old questions may be reconsidered. New questions may be posed. The educational value of the Martian Time Web Site will be enhanced to better ensure that respondents are well informed on the issues. In particular, as consensus develops regarding the structure of Martian time, the questions of nomenclature will become more relevant, and a carefully considered questionnaire will need to be designed to avoid cultural biases as much as possible on these issues.

Who speaks for Mars? Who has the power to decide the shape of Martian time? The decision is not one to be rendered by Caesar, nor is it conceivable that the Roman Catholic Church will play as important a role as it did in the 16th century. Neither the League of Nations nor the United Nations acted decisively on calendar reform in the 20th century. Does the promulgation of a system of time for another world fall within the purview of NASA? JPL? The IAU?

We believe that it is the people who are "becoming Martian," those who somehow have a vested interest in Mars and its acquisition, who will develop the social measurements of Mars. A question that the proto-Martian community must ask itself is whether a clock and calendar could be important symbols of the emerging Martian culture on Earth, whether the early adoption of such a system of social measurement could be a factor in the coalescing of a cultural identity, which in turn could serve to hasten the date of the first human landing. We must ask ourselves whether we who are Earthbound, yet whose hearts are bound to Mars, are Martian enough to take a hand in designing tomorrow.

Acknowledgments

Thanks are in order to Bill Woods, Lance Latham, and Alan Hensel for contributing many of the questions for the Martian Time Poll.

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