Napoli_2004

INTERPLANETARY CALENDARS

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A CIVIL CALENDAR FOR MARS

In 1985, Mars needed a calendar. The thought of a calendar for Mars first came to me through the John Carter series written by Edgar Rice Burroughs, but by 1985 I realized that there was no fully-developed and publicized calendar for Mars based in real figures for Mars. I was writing my own Martian stories and realized that my working class hero needed a calendar for his work and recreation schedule, that is, that the society he was helping build would need a unique calendar for Mars.

Because I was concerned with how a calendar could be used by pioneers of Mars, I avoided models that came to me with strengths in other areas. For instance, using Martian hours and minutes built on Martian seconds just slightly longer than terrestrial seconds would allow for 24 hours on Mars that makes for easy navigation, but constant conversions between terrestrial and Martian time measurements when attempting to share scientific data between the two worlds, two communities of humanity. Using twelve months for a Martian year seemed to extend the length of a month too far considering the length of the Martian year.

My original Areannum™ had fifteen months of forty five days, except the last month, and weeks of nine days, except the last week. This was done to lengthen all periods on Mars in observance of the lengthy year and even the slightly longer day, but didn't overcome my growing objection to changing traditional time periods unnecessarily. However, later the calendar went through a number of adjustments that were more concerned with maintaining user-friendly periods that weren't too far removed from those used in terrestrial calendars.

Today, the Areannum™ consists of 25 months of 26 or 27 days and weeks of seven days. This arrangement allows for monthly periods that approximate the lunar sidereal period, which is the basis of the universal human month used in all the interplanetary calendars (ICs). Neither of Mars's two swift moons have periods useful as calendar months, except in multiples. Instead, I considered colonies on the Earth's moon (hereafter, the Moon) to be of central importance to colonies throughout the solar system. Technologies necessary for the colonization of the Moon are those necessary for the colonization of Mars, Ganymede, and even Titan to some degree. Interplanetary travel will eventually go through the Moon, rather than Earth, because of the fuel savings and other considerations.

The Earth will eventually become a big pantry for the Moon colony, a reserve of all the niceties of our terrestrial biosphere, but not necessarily the leading destination.

The Earth will become a starting point and an ending point for interplanetary travelers, but rarely a mid-point. For interplanetary migrants, the Moon will be Destination One in the Earth system and it will supply them with the goods of Earth. Of course, artificial satellites of Earth can also do this, but it is more likely that once significant development of the Moon has occurred, traffic will be routed to the Moon and satellites of it rather than barely overhead of our delicate biosphere. Travel between orbits of the Earth and orbits of the Moon are easily accommodated for the exchange of goods and personnel. The Moon then becomes analogous to a metropolitan airport outside the city proper with shuttle services into the city and back.

THE AREANNUM™

The future of human interplanetary society was my main consideration in developing interplanetary calendars. These considerations shaped the very first Areannum™ and guided every modification since the summer of 1985. In 1996, I finally had a computer and software capable of producing an acceptable physical version of the calendar. Previously, I had simply made tables of raw data using a manual typewriter without the spacious cells of wall calendar tables, one per month per page. Now, I could make something that actually looked like a calendar and by now all the data had come in from the Voyager missions to trust the accuracy of the figures I was using.

By the end of June 1997, I had developed and printed the first set of interplanetary calendars. I sent them off to various NASA sites and visited NASA Glenn (then NASA Lewis) in my hometown, Cleveland, Ohio. They were well received and I was encouraged to continue working on them. My goal was to produce a commercial grade version of these calendars which I had and have published in black and white without pictures, but introductory text and all the relevant measurements and constructions included. In 2001, I began work as an astronomy instructor where I run a portable planetarium show for students K – 8 as well as K – 12 and college students, teachers and parents in outreach.

Soon after completing the first set of interplanetary calendars, I became aware of the discovery of planets outside our solar system. This allowed me to consider calendars for them, which I call Extranna™. Finally, more recent discoveries of Kuiper Belt Objects (KBOs) has led me to consider expanding the Plutannum™ into coverage of these many bodies, thus the Plutannum™ became the Plutanna™. I already had the Minor Planna™ for asteroids and the Oortanna™ for comets, which has since been changed in name to simply the Comanna™. These additions joined the original set of ICs to make the now complete set that was developed in the following order: Areannum™, Joviannum™, Saturannum™, Urannum™, Neptannum™, Plutannum™, Mercannum & Mercudiary™, Venannum & Venudiary™, Terrannum™, Minor Planna™, Comanna™, Extranna™, and Plutanna™. It should be noted that the last four calendars listed are not completely developed and will continue to grow as new discoveries are made. The published versions of them highlight selected representative bodies for full coverage and this list changes from version to version.

Calendar Days

In the Areannum™, each day is either 25 or 24 hours with a regular pattern of three days of 25, 25, and 24 hours respectively being used throughout the calendar. This pattern allows for the average calendar day to approximate the nearly $24^{2}/_{3}$ hours per day on Mars. A few 25 hour days of this pattern are altered to 24 hour days in order to create a more accurate average of hours per day per year. This method of utilizing varying hour days is employed in all the interplanetary calendars and allows for the use of universal human hours built of universal human minutes built of universal human seconds. This is the primary feature of ICs that allows the IC system to generate calendars for any stellar orbiting body of interest to human explorers.

Because of the use of the universal time unit, the calendar for Mars is interplanetary. That is, travelers between Earth and Mars need not change their basic time units or encumber themselves with constant conversions. There is a new calendar to learn, but it is engineered to be easily adjusted to by maintaining useful traditions.

With the use of the universal time unit, calendars devised for the other planets of the solar system and anywhere else humanity decides to explore, first with telescopes, then with robots and humans, can be accomplished similarly without the need for conversions. Human error, specifically conversion errors have caused the loss of entire space exploration vehicles, millions of dollars of hardware, and opportunities for increased knowledge about the solar system. Clearly, a reduction in the need for conversions at the human level has benefits.

There are other models of Martian calendars, but none for all the other planets that I have seen and none for Mars that predate the first Areannum™. However, Robert Zubrin makes a strong case for a Mars calendar that uses Martian time units with a rather simple conversion factor: 1.0275 times the terrestrial equivalent. I had considered such a model, but for my purposes, which were considerations as a civil calendar, it did not seem appropriate. It is highly appropriate for Mars-only considerations. Should a society on Mars arise that wants nothing to do with people from Earth or anywhere else, then the Zubrin calendar is the clear choice. But, the Zubrin calendar also has significant utility. In 1985, I decided to allow someone else to work that angle. Robert Zubrin did just that.

In 1985, I realized that a Martian calendar devised as the Earth's own calendar with Martian seconds, minutes, and hours, would allow for the easiest navigation and ultimate user-friendliness, but does not allow for an interplanetary calendar system without multiple conversions. My first calendar was interplanetary from the start. Again, this is how I envisioned the lifestyle of the end-users. Still, for the near future and for navigational purposes, the native Martian calendar (Zubrin model) works wonderfully. It is my belief that both models, the Areannum™ and the Zubrin model, will be used in the future.

Just as personal digital time keeping devices (clocks and watches) make it easy to program the cycles of hours per day in the Areannum™, (although, I can imagine creative watchmakers toiling to create a mechanical watch for Areanna™ timekeeping) electronic navigational systems can be programmed to convert between the Mars standard and the interplanetary human standard. Humans could be allowed to use the human standard with the occasional expert navigator learning both, but relying largely on the human standard when navigating with equipment. For those wishing to navigate the old fashioned way, the Zubrin model would, of course, still be around for reference and still be in use in the programming of navigational computers. Mars timekeeping from A to Z is necessary for differing applications.

It should be noted that there are now many calendars being proposed for Mars, but none that are interplanetary in the sense that the Areannum™ is. I would like to mention here the Mars Pulse Calendar designed by Peter Kokh. I think that the most interesting idea he proposes in the Mars Pulse Calendar is the renaming of seasons to be less hemisphere biased. The seasons of winsum, vertum, sumwin and tumver proposed as replacements are wonderful. I have met and talked with both Robert Zubrin and Peter Kokh and hope to work with them in the future on Martian calendars. They have some great ideas on the topic. Of course, they are not alone.

The day on Mars is 24 hours, 39 minutes, and 34.6 seconds long. The pattern of three calendar days of 25, 25, and 24 hours length with the occasional 25-hour day shortened to a 24-hour day accurately approximates the correct day period. The variance between the calendar day and the actual day is not so great that it would cause problems for human users. It is also a regular, daily adjustment, so it sets up its own custom. Whereas, the adjustment for daylight savings time in the US is sometimes noticeable, the adjustment in the Areannum™ would grow less noticeable by the regularity of it. Also, there is never a day in the Areannum™ that is shorter than the terrestrial day. There are only many days that are one hour longer. As far as biorhythms, including the circadian rhythm goes, I do not believe it is so absolute that the human body could not adjust. In fact, there are far more difficult adjustments for the human body to make on Mars than an extra hour in most of the days.

The week has been returned to the standard seven days (Areannum™ calendar days) to maintain tradition and to most closely approximate the terrestrial week, again, so that all calendars in the SolSpace Calendar™ (the calendar for the entire solar system that is based on the Terrannum™, but includes all the calendars of the solar system) are part of a single, universal human interplanetary calendar system. The names for the days of the week are the Western standard, but should be accompanied by the qualifier, “On Mars,” when used in conversation or literature. The names could and probably should be changed at some later date, but I am not making the suggestion now. Previously I had named the days differently.

Each year has either 669 or 668 calendar days in it. The first, third, fifth, sixth, eighth, and tenth years of every ten years are the long, 669-day variety. The rest are 668-day years. Once every 200 years, the tenth year is a 668-day year beginning with year 200. This maintains the accuracy of days per year over the centuries. Within the months of the Areannum™, the third, eighth, thirteenth, eighteenth, and twenty-third months have their final 25-hour day reduced to a 24-hour day.

Tracking Lunar Time

The months of the Areannum™ approximate the months of the Terrannum™ rather than the current Gregorian terrestrial calendar because the months of the Terrannum™ approximate the sidereal rotation of the Moon. This is done to recognize the importance of tracking the sidereal motion of bodies in the solar system for stellar navigation to and from points on the surface of these bodies. While it is understood that the calendar months are not useable for precise stellar navigation, they are nonetheless modeled to approximate the sidereal motion in order to remind us that there is this need.

The need is then satisfied by the regular notation of various "lunes" that are used to far more accurately approximate the sidereal position of the Moon. The lunes are used to calibrate all the interplanetary calendars and track lunar positions. Lunes are either 656 or 655 hours long. There are ten lunes in a set of lunes called a "decalune" which is then altered by an hour over long periods to maintain accuracy.

The third, sixth and ninth lune of every decalune is 655 hours long with the others all being 656 hours long except that every 5 decalunes the sixth lune is 656 hours long except every 1,000 decalunes where the sixth lune is 656 hours long. This creates an accuracy in tracking the sidereal period of the moon to a fraction of a second per millennium.

Each lune in a decalune is named after Moon deities from cultures around the world and throughout history. Once a celestial navigator aboard an interplanetary vessel gets used to using the lunes, he or she will have no difficulty navigating to or from points on the Moon based on what time and date it is with final accuracy being checked against the ship's computer. The lunes of the IC decalune are: Mawu (656), Khons (656), Nanna (655), Yarikh (656), Soma (656), Chang-O (655), Selena (656), Diana (656), Tsuki-Yomi (655), and Ix Chel (656).

Martian Time Zones

Martian time zones in a Martian society that uses the Areannum™ can be modified to allow for the easy tracking of time in days of different hours. Time zones are already sweeping approximations as used on Earth. They do not track the actual time for most of the planet. The time zones would begin with the standard 15° of latitude per hour. The final time zone could then be split into two zones of 7.5° for calendar days with 25 hours. This allows for the vast majority of the planet to maintain a single zone and only 2.1% of the planet is required to adjust between being the twenty-fourth and the twenty-fifth time zone. All other time zones would keep their position and simply follow the number of hours in the calendar day.

Would Martian seconds, minutes, and hours be easier for Martians? Yes. Would they be easier for interplanetary travelers? No. Would they be easier for the interplanetary exchange of timed data? No. Would they be easier for navigation? Yes. So, again, the Zubrin model is ideal for navigational computers and Martian centrists, the Areannum™ is ideal for an interplanetary society. Both have a place in the future, clearly, so long as humans persist in expanding into the solar system, our celestial neighborhood.

Calendar Months

Because the months of interplanetary calendars approximate the sidereal period of the Moon, there are 25 months in the Areannum™. Each month is either 26 or 27 calendar days long. The months are named for stars that appear high in the midnight sky of Mars during that month. The stars are taken from constellations of the "zodiak". The zodiak is a modification of the zodiac used in naming the thirteen months in the Terrannum™. The zodiak is simply the zodiac plus Cetus. There are actually thirteen constellations that the sun passes through: the standard twelve zodiacal constellations and Ophiucus. However, the sun also grazes Cetus. I found it more useful in keeping the position of the zodiakal constellation or star in sync with its namesake month to utilize Cetus rather than Ophiucus. The whale stands in for the serpent bearer.

The seasons of Mars are more unequal in length than those of Earth due to the exaggerated eccentricity of the orbit of Mars about the sun. Mars travels at speeds that vary more over its orbit than the Earth does. This results in the unequal seasonal periods. Zubrin makes a strong case for twelve long months of unequal lengths to accommodate the difference in seasons and maintain the twelve month symmetry we are familiar with already. However, these long months would little resemble their terrestrial counterparts in duration and it must be noted that the Gregorian calendar that the Western World uses today does not precisely align itself with the seasons, so there is no tradition of seasonal precision we must observe, but rather an approximation.

It would be nice to include the marking of the seasons with the beginning of months, but we are not currently doing so, so it is no loss not to do so. Also, maintaining months of near equal duration throughout the solar system and its many interplanetary calendars has significant advantages to the interplanetary lifestyle, commerce, information sharing, and records keeping. Contracts that feature monthly payments and/or services would be strained to maintain equal dispersal of them. Equal-length months are superior in a civil calendar, even more so in an IC system.

Happily, it so happens that the months of the Areannum™ separate the year into two seasonal halves. That is, with the Areannum™ starting on the northern winter solstice of Mars, again, in keeping with traditional approximation but more precisely, the northern winter and spring occupy the first thirteen months of the Areannum™ and the northern summer and fall occupy the latter twelve months of the Areannum™. The equinoxes occur in the late middle of the month, but again, the US civil calendar has this feature for all the season starts. Zubrin makes a case for starting the calendar as astronomers do, with the northern vernal equinox. The problem with this, as I see it, is that all others are asked to adjust their concept of the year to fit this specialized profession. Of course, there are other calendars for Earth on Earth and not all of them start with the winter solstice, or its approximation.

Still, the rest of the world has come to use the Western calendar as its business calendar. Whereas, capitalism as we know it may not survive into the future without serious modification, the lineage begins with the use of the calendar that uses the northern winter solstice approximation to start the year. There may be objections by merchants to placing the New Year before Christmas, thus splitting the holiday season, but then, they may enjoy starting the year strong and fiscal years are more flexible than calendar years anyway. Of course, people on Mars may want to celebrate holidays according to their occurrence on Earth, so as not to have to wait so long between them as the Martian year would force.

MORE INTERPLANETARY CALENDARS

Beyond Mars and the Areannum™, there are the rest of the calendars for the solar system. The Joviannum™ contains the first usage of artificial days that I have termed "deas". These artificial days are calendar days that do not correspond to the native day determined by the rotation of the planetary system's primary. Deas are only used when the planet in question is not likely to support human habitation. Even in a scenario where a city in the appropriate strata of Jupiter's clouds floats and supports a community of humans, those humans would be more biologically disposed to using a calendar day that approximates the terrestrial day rather than, say, 9- or 10-hour days for Jupiter. Mars is luckily very close to Earth in its rotation period otherwise we would have to get into the use of native days not close to terrestrial days, because the surface of Mars does lend itself to human colonization with some work.

THE JOVIANNUM™

After establishing deas, it is necessary to break the Jovian year up into terrestrial year length periods so that installments of physical calendars can be accommodated and the terrestrial year can be noted in approximation. Thus, the Joviannum™ features the first calendar period longer than a month, but shorter than a year: the "zodia". Zodia are slightly less than one terrestrial year long and there are twelve of them in one Jovian year, which is approximately 11.86 terrestrial years long. The Joviannum™ comes in zodia installments. There are 361 or 360 deas in a zodia. There are 27 or 28 deas per month in each zodia and 13 months per zodia. There are 24 or 23 hours per dea in the Joviannum™. The zodia are named for the constellation of the zodiac that lines up with Jupiter and the sun for that zodia. This repeats the heliocentric mode of naming employed in the Areannum™ and the Terrannum™.

The four Galilean moons of Jupiter are nicely arranged and offer possibilities for native time units. These are noted within the Joviannum™, but do not make up calendar months. Again, the approximate sidereal period of the Moon is used.

THE SATURANNUM™

The Saturannum™ also uses deas, as do all the rest of the calendars of the solar system. The Saturannan deas are also 24 or 23 hours long and the months are likewise 27 or 28 deas long. There are 358 or 359 deas per "zodiastra", which is the Saturannan period longer than a month, but shorter than a year, and there are 13 months per zodiastra and 30 zodiastra per year. The zodiastra are named after stars of the zodiac, in the way that the months of the Areannum™ are named.

THE URANNUM™

The Urannum™ has deas of 24 or 23 hours and months of 27 or 28 deas long. There are 365 or 366 deas per "constella", of which there are 84 per Urannan year and 13 months per constella. Constella are named after constellations in use by astronomers today.

THE NEPTANNUM™

The Neptannum™ has deas of 24 or 23 hours and months of 27 or 28 deas. There are 364 or 365 deas per "nereida", which are named after the Neptunian moon, Nereid, which has a period close to a terrestrial year. There are 165 nereida per Neptannan year and 13 months per nereida. Nereida are named after the Nereids and other water nymphs from global mythology.

THE PLUTANNA™

The Plutanna™ is a calendar for multiple objects, but features the Plutannum™. The Plutannum™ has deas of 24 or 23 hours and months of 27 or 28 deas. There are 364 or 365 deas per "stella", of which there are 248 in each Plutannan year and 13 months per stella. The stella are named after stars in the Milky Way galaxy. Other Kuiper Belt Objects (some of which are called Plutoids) are featured in the Plutanna™. They likewise have stella and deas and alternate with Pluto as the featured body of the particular calendar installment. The Plutannum™ is always included in at least its condensed form in the Plutanna™.

THE MERCANNUM & MERCUDIARY™

The Mercannum & Mercudiary™ comes in installments that include 2 solar days, 4 years, 6 sidereal days, and 12 months. It has deas of 24 or 23 hours and months of 29 or 30 deas. There are 88 deas and 3 months per year, yet the months are named over a 2-year period to allow for differentiation between periods of the solar day. The names of the Mercannan months are: Caelus (sky), Sidus (star), Diluculus (dawn), Crepusculus (dusk), Somnus (sleep), and Noctus (night).

The orbital period (revolution) of Mercury about the sun is 87.969 Earth days or 2,111.256 hours. The sidereal period (sidereal day) of Mercury is 58.6462 Earth days or

1,407.5088 hours. The solar day of Mercury is 175.938 Earth days or 4,222.512 hours. These are the figures used in creating the Mercannum & Mercudiary™, which contains two Mercurian solar days equaling four Mercurian years equaling six Mercurian sidereal days equaling twelve Mercannan months. Remember that all the months of the interplanetary calendars are based on the period of the Moon. The Mercannum & Mercudiary™ has months that are closer to the synodic period of the moon than the sidereal period. This is unavoidable, but acceptable.

THE VENANNUM™ & VENUDIARY™

The Venannum™ has deas of 24 or 23 hours while the Venudiary™ has deas of 24 or 25 hours. The two calendars are included in the Venannum & Venudiary™. The Venannum™ has months of 25 or 24 deas while the Venudiary™ has months of 27 or 28 deas. The months of the Venannum™ and of the Venudiary™ are named after goddesses of love and beauty from cultures around the world and throughout history. The names are different for both calendars within the single physical calendar, but there is a lot of overlap between the two.

CALENDARS FOR SMALLER BODIES AND DISTANT PLANETS

The Minor Planna™, Comanna™, and Extranna™ feature different bodies in individual installments. The Minor Planna™ records the periods of the asteroids. The Comanna™ records the periods of comets. Both feature calendar periods between a month and a full orbit in length, except with short orbit objects. Extranna™ feature newly discovered planets around other stars when their orbital periods are known. Knowledge of the rotation periods is not necessary for non-terrestrial type planets however rotation periods for terrestrial type planets would be very welcome knowledge.

EDUCATING WITH INTERPLANETARY CALENDARS

The system of generating interplanetary calendars is patent pending. Colorful versions of all the calendars with expanded information regarding the planets and their exploration, along with information on careers in space and space science, educational programs in space science, and input from space scientists and students are in the works now and will be published soon. The Areannum™ with pictures and expanded text should be available in 2005. With success, the Joviannum™ and Saturannum™ will be available soon after. If everything goes well, the rest of the calendars will be released in their full version too. Special deals will be arranged for educators to receive calendars and calendar sets for the classroom at a discount. ICs continue to be published in black and white without pictures at this time. They are copyrighted by William Lloyd Napoli and printed by Earthman's Press™, a division of Earthman's Enterprises LLC in Cleveland, Ohio.

Earthman's Education Services Inc. (EES), a nonprofit public charity, is making classes available in the study of interplanetary calendars and the solar system with ICs and other planetary calendars. To this end, EES and Superior Planets, a group of interested teachers, parents, and students, have come together to create Interplanetary Colony One

(IC1), the first group of students to work with the ICs. IC1 will study and eventually write for the ICs. They are Cleveland students, at this point, who will work with ICs from very near the start of the IC Education Project. The Harvard Calculators were an inspiration in putting together IC1. The students of IC1 hope to demonstrate that ICs can be used and understood by other young students and novices to interplanetary study and hope to launch themselves into futures rich with science, technology, engineering, and mathematics. By being way ahead of the curve in understanding ICs, these students will be able to contribute to them for years to come and will be the first class of experts in them and their use.

THE FUTURE OF THE SOLAR SYSTEM

The preservation of celestial objects is of concern to me however I am not a purist in this concern. I believe the pioneers of human expansion throughout the solar system should be allowed to exploit the materials reserves of minor bodies, but that their scientific value must first be assessed and the relevant data ascertained before they are relegated to raw materials to aid human expansion. When these future interplanetary miners are sent out to explore such solar orbiting reserves they should be accompanied by scientists or their remote robotic agents from the beginning, to ensure the scientific value of these bodies is realized.

Also, I believe that not all bodies of any type should be allowed to perish in the industry of human expansion throughout the solar system. We should never eliminate all examples of a class of objects. There should always remain at least a few Atlas asteroids, a few Aten and Apollo asteroids, and most of the large Trojan asteroids. The asteroid belt should not be stripped bare either.

Still, I can see the value of sending a barrage of comets and asteroids upon the surface of Mars at some point. This would stimulate the reheating of its interior and perhaps restore volcanic activity if undertaken on a huge scale. This could be useful to the terraforming of Mars. The comets would bring valuable water, ammonia and amino acids and asteroids would bring useful minerals that could be salvaged out of the impact sites when the bombardment ceases. However, the moving of thousands of celestial bodies in a coordinated bombardment would be a monumental task and hugely expensive. But, if a second habitable planet was the end, the cost might be justified.

It might even be necessary to find a way to give Mars a major moon once its core is restored to a molten state in order to activate and maintain the dynamo that creates a sustainable and significant magnetosphere. I call this the marriage of Ceres and Ares in considering the use of Ceres as a moon of Mars. How all this would be accomplished is left for planetary engineers, a field that is not yet established. It is a benefit of being a science fiction writer that I am able to consider these wildly futuristic possibilities without the astrophysicist's burden of mathematically proving them to be workable. Still, in my writings I do try to make them plausible. So, because the Ceres to Mars mass ratio is one ninth that of the Moon to Earth mass ratio, I look for and invent other factors to make the aforementioned marriage more agreeable to Martian pioneers.

All this may never come to pass, but if it does or events similarly affecting the planets in significant ways occur then the cycles of time for the worlds of the solar system may be altered. If this happens, the calendars that consider the bodies whose rhythms are changed will need revision. It is the process of generating interplanetary calendars that allows for necessary revisions to be undertaken. The calendars themselves are open to alteration as traditions give way to new methods of measurement, new information and new conditions. It is the concept of ICs and I hope the utility of the ICs outlined here that is undeniable, not any of the specific features, even though they may appear to be and may turn out to be for millennia to come.

WHAT AN AREANNAN MONTH LOOKS LIKE IN THE AREANNUM™

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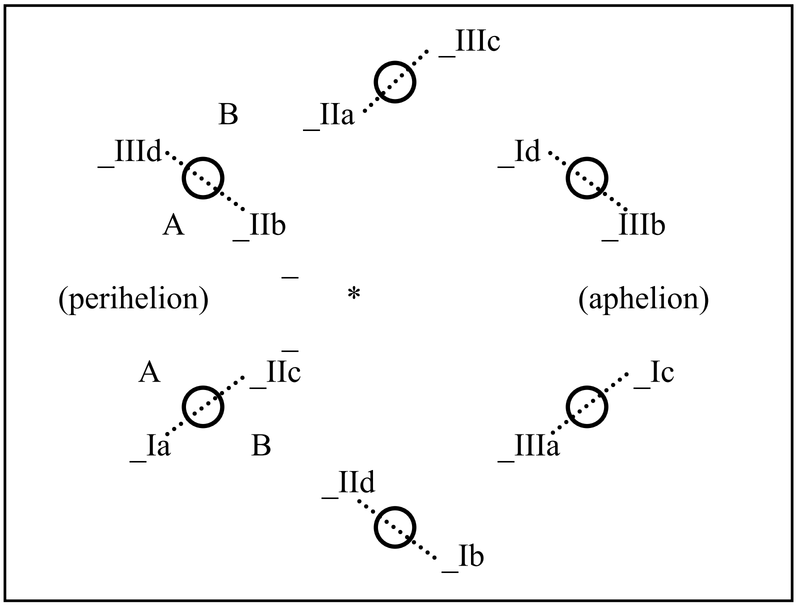
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
Exobiology: the study of extraterrestrial life.	**Cryptography**: the study of codes and code breaking.	**Cartography**: the study and production of maps.	25 1	25 2	24 3	25 4
25 5	24 6	25 7	25 8	24 9	25 10	25 11
24 12	25 13	25 14	24 15	25 16	25 17	24 18
25 19	25 20	24 21	25 22	25 23	24 24	25 25
24 26	24 27	**Microgravity**: gravity less than that on Earth.	**Carbon Dioxide**: CO_2; what humans exhale and plants inhale.	**EVA**: extra-vehicular activity, as in space walks.	**Chronometry**: the study and measurement of time.	**Astrophysics**: the study of the nature of space and the universe.

SYNCHRONY BETWEEN THE DAYS AND YEARS OF MERCURY

I found it helpful to create a guide to understanding the synchronic relationship of solar days, years and sidereal days in the cycles of Mercury. I am including it here.



1 solar day = _ + _ = 2 years (revolutions) = 3 sidereal periods (rotations) = I + II + III

_ = strange motions of the sun = (_IIb – _IIc) 0° and 180° longitude, one of the two at alternating perihelia: apparent sunrise to near noon, solar parallax, then return to normal motion through 3 month long sunrise to sunset; (A) 90° and 270°, one of the two at alternating perihelia: apparent sunrise, lack of sun's motion, sunset at same horizon where it rose, then sunrise again; (B) 90° and 270°, the other of the two from the previous case at alternating perihelia: sunset, sunrise at same horizon where it set, then sunset again

The points labeled in the above diagram represent 0° and 180° longitude. These are the Mercurian "hot poles". Each faces the sun for an extended period at alternating perihelia and so heats up far more than the rest of Mercury ever does. Thus 90° and 270° longitude are relatively cool, the "warm poles". However, the north and south poles are cooler still and daytime (under the light of the sun) on Mercury is very hot, while nighttime (outside of the light of the sun) is very cold no matter where on Mercury. The change in temperature on Mercury is the widest of all the planets, over 1000°F.