

DISCUSSION CONCLUDING AAS 13-515

JOHN SEAGO noted that ROB SEAMAN showed an analemma indicating the equation of time for Mars expressed in units of “hours”. SEAGO asked if the amplitude was Mars hours or Earth hours. SEAMAN said that these units are roughly the same, and he would need to verify.*

One of the things that KEVIN BIRTH found intriguing about the proposal to eliminate the leap second is that it seems likely to create a disjunction between ‘days’ and ‘dates’. In BIRTH’s opinion, SEAMAN’s description of a ‘day’ would remain as an astronomical fact. But at this point, ‘dates’ are being measured in terms of counts of seconds. BIRTH thought it might be useful to think of the distinction between ‘day’ and ‘date’, in that there could be a political decision as to when a ‘date’ begins and how long it actually lasts.

SEAMAN responded that a *general* timekeeping system can be really strange, whereas a *civil* timekeeping system has to have some connection to the Sun in the sky, even though that connection could be quite esoteric. If leap seconds are eliminated, then civilization would have to consider exactly the point raised by BIRTH. Civilization would also have to figure out what to do later with the embargoed leap seconds. This seemed to be the whole point of various leap-minute and leap-hour proposals, and there must be something like that. In a systems-engineering sense it is incoherent to simply pretend that noon will be allowed to become midnight—that just does not make any sense. One must also consider the connection to the longitude system and the prime meridian, and whether or not it is directly connected to the day and Greenwich Mean Time. This connection needs to be somehow explained if the entire mapping between Time and the rotation of the Earth is changed.

In listening to PAUL GABOR’s talk, it occurred to GEORGE KAPLAN that eliminating leap seconds from UTC is exactly like the ancient Egyptian calendar which had 365 days because that was a convenient thing. The proposal ignores a natural phenomenon and becomes only a way of tagging events which gradually loses coherence with nature in some sense. SEAMAN replied “you can fool some of the people some of the time, but eventually you need Julius Caesar and then Pope Gregory to come along and fix things.” BIRTH rejoined “Or, you have what the Mayans did, which is a highly technical class of timekeepers with a calendar that runs free without any association of anything astronomical whatsoever.” It was the duty of the esoteric timekeepers to tell the population the relationship between what is happening in the sky and timescale. SEAMAN amusingly countered that while Mayans are still around, the Mayan civilization is not. The audience laughed, after which BIRTH added that they still do have these esoteric specialists.

DENNIS MCCARTHY had a number of comments. First, the ‘day’ is not an SI unit officially, but it is recognized as a unit by the SI, defined as 86400 atomic seconds. MCCARTHY thought

* *Editors’ Note:* The units were Mars hours, which are 2.7% longer than Earth hours. SEAMAN’s presentation included analemmas from sources which used both Earth and Mars units; however, the analemma being discussed was designed to provide Martian solar time for the NASA Mars24 clock.

SEAMAN brought up an interesting question about how to tell time on other planets, an issue which must be faced eventually. To generalize SEAMAN's comments, MCCARTHY said that the natural time unit on another celestial body seems to be the synodic day as measured by, say, "a stick in the sand." MCCARTHY's question was how to measure that. One can conceptualize, but for a timescale to be useful, it must have a realization. It would be somewhat difficult unless an atomic clock was taken to, say, Mars, and calibrated against the synodic day as observed on Mars. SEAMAN thought this could be part of a mission to Mars. MCCARTHY agreed that would be the means to do it, because a proper time [in a relativistic sense] would be formed. SEAMAN agreed "I think atomic time is wonderful; I just don't think it is a replacement for synodic time." MCCARTHY said it was a question of how it would be measured; it is something that mankind would have to face.

MCCARTHY also wondered how to measure the synodic period of Uranus. SEAMAN said that a differential rotator would be the approach, but the fact that it is on its side could complicate its measure. MCCARTHY said he could see it as a challenging thing to do. SEAMAN agreed, adding that over approximately half of the Uranian year the Sun happens to be aligned more or less with the low latitudes, and the varying poles actually impedes coming up with a good marker. KAPLAN said it would be done the same way one might measure Earth rotation from the South Pole; the Sun makes a circle in the sky and the shadow returns after one day. SEAMAN added that differential rotation should play some part.

STEVE ALLEN said that he tracks the time-zone news group, and recent news was of Israel starting daylight-saving time in March. But Israel was not legally on daylight-saving time because the Knesset has not gotten around to approving that yet. So "the guy in charge made the announcement for everyone to change their clocks and life goes on." And eventually the Knesset will pass a law retroactively saying that Israel has been on daylight-saving time since March. ALLEN's point was that technology leads the way and then the legal systems follow "and then life goes on." SEAMAN replied that the retrospective nature of some timescales is an interesting talking point, UT1 being the one most memorable.

JIM KIESSLING asked if it is simply, as SEAMAN pointed out, that the synodic day is in fact an angle which has only a historic relationship that affects the time, with the various timekeeping communities occasionally rendering atomic time as an approximate daily angle. Although SEAMAN would take exception to the idea of an angular representation as "monitoring the time", there is a lot of possibility to moving the angular representation to an application model, somehow offering a way to transmit the atomic timescale and then realize it at different levels in the various systems. KIESSLING did not disagree, but clarified that a large issue is associated with clumsy handling of discontinuities and inserting and potentially removing seconds, and this really has to do with the fact that these are attempts to represent one unit as a substitution of another unit with a certain expectation of regularity, except that regularity is not underpinning. KIESSLING said there are variations in the duration of the day associated with the mean solar day: "that is not a proper timescale; that is an angle measurement." SEAMAN said that the term "proper timescale" was something of a value judgment. KIESSLING asked if solar time is regular; SEAMAN thought that they were two different things, and both were aspects of time.

KIESSLING pointed out the fact that a changing rotation rate results in a lack of predictability. SEAMAN replied that atomic clocks are very precise; they are not accurate without some procedure to calibrate them against some external measure of time. KIESSLING asked, "Philosophically, what is the requirement for aligning a count of cycles to anything else?" KIESSLING acknowledged that periodically we may wish to synchronize in order to reference some other count of cycles. SEAMAN said that is the issue under debate; leap seconds perform the synchronization and

the ITU-R has never seriously considered any other option beyond just “getting rid of leap seconds.” SEAMAN cited MCCARTHY’s 1999 paper,¹ which offered various options that went unconsidered. The ITU-R proposal to redefine UTC without leap seconds is the one option that SEAMAN thinks is not actually a solution via the engineering requirements. Periodically (or, aperiodically) one has to worry about synch to the external measure. KIESSLING said that, selfishly, he cares about UT. But for entirely different reasons it is very nice to have a regular timescale, but other than occasionally working out the relationship between the two, one is an angle measurement and the other one is, in fact, a timescale. KIESSLING said that SEAMAN had made an elegant point about UT being an angle, which was perhaps stronger than SEAMAN wished.

SEAMAN replied that civil time—whatever it is—has to have a meaning, and ‘solar time’ is close to that meaning. One might make an assumption or change some things around, but noon cannot become midnight; SEAMAN found that socially incoherent and nobody would put up with that. SEAMAN illustrated by way of a numerical example: pick some noticeable adjustment amplitude at which even some politician would have to take notice—something like an hour, and certainly less than 24 hours. And take a timespan over which political inaction would become unacceptable—a decade or more—and just divide them. Using these numbers, it turns out that the tolerance for civil timekeeping and solar time is less than a second a day to avoid having a leap hour every decade. Having a leap hour every decade would not be a possible political solution, so somewhere between 86399 and 86401 SI seconds is going to be the length of the day on the Earth no matter what else. Thankfully the difference between solar time and atomic time is milliseconds now, and “that is why there is just this small crowd here now and not hordes in the streets.”

CHRIS TUASON noted that the time zones put us well over an hour from solar time in a lot of places; he thought that one might take a wide time zone, and add to that some kind of daylight saving adjustment, to establish an amplitude that is politically noticeable. SEAMAN recalled “the ultimate talking point” is that a large change to civil time could be hidden in a daylight-saving time adjustment within a time zone—without the understanding that only 15% of the world practices daylight-saving time. SEAMAN added that time zones would be another way of casting TUASON’s UTA proposal. SEAMAN noted that leap hours through continuously changing time zones was one thing on the leap-second discussion list that nobody believed would happen.

BIRTH said “never underestimate the ability of humans to do strange things.” BIRTH thought that noon could become midnight because noon has become midday. “Noon” was originally the ninth canonical hour of the day, which would have been around three o’clock in the afternoon.² “Noon” is now midday; the reason for this is that noon was the traditional time for the major meal of the day, when the monks got hungry. However, BIRTH thought that midnight becoming noon might be a bit more difficult. SEAMAN said his argument at the Exton Colloquium was expressed using science fiction where he picked *Journey to the Center of the Earth* and *Barsoom* (Mars).^{*} But he could have picked Isaac Asimov’s *Nightfall*, where nightfall occurs every few thousand years. “There are a lot of these weird time systems in science fiction, and it is really hard to wrap your head around how a society would actually adapt.”

ARNOLD ROTS said the Trans-Siberian Railroad runs on Moscow time across nine time zones, which is “actually very disconcerting” when traveling. It makes life very difficult, and one does not want to miss the train. But ROTS worried more about BIRTH’s distinction between ‘day’ and ‘date’, and thought it disturbing if the ‘date’ no longer corresponded with the ‘day’. The informal SI unit of ‘day’, as MCCARTHY pointed out, was an added complication. In order to keep these

^{*} http://futureofutc.org/2011/program/presentations/AAS_11-661_Seaman.ppt.pdf

things as tightly coupled together as possible, and to avoid as much trouble as we can, ROTS thought the leap second was the best solution in the end.

As an aside to ROTS comments, RUSSELL REDMAN noted that China has one official time zone, but this seems to be exploring the limits of people's tolerance to this. REDMAN was warned by tour guides when he visited Xinjiang in the far west of China that they have their own time zone. REDMAN never identified whether this time zone enjoyed any support from the State; he felt it was just an informal time zone. REDMAN also did not know who invented it;^{*} it struck him that the local Uighur people one-hundred years ago were pastoralists and they probably did not have time zones at all, or any conceptions of that, and probably not even clocks. There had also been massive Han emigration to have people to run the oil fields, and there had also been lots of interaction across the Russian border. It struck REDMAN as perfectly sensible that a Han emigrant that is used to getting up at 6 o'clock in the morning to go to work would still get up at 6 o'clock in the morning to go to work and they might invent their own time zone to do it. But REDMAN's group had specifically warned to be really careful when talking about time to the local people because it was easy to get confused.

SEAMAN said there is a statistic floating around that something like 20% of the world's population is in UTC + 8^h. Right now, Arizona does not observe daylight-saving time, except that the Navajo Nation does, except that the Hopi Nation entirely within the Navajo reservation does not, except that there is a small piece of the Navajo reservation within the Hopi reservation which does. So if one drives from Holbrook to Flagstaff through the reservations, one's clock has the potential to be reset six times [during the summer].

KAPLAN noted an odd thing that occurred in February when the Chelyabinsk meteor exploded over Russia. It was obvious that this occurred right after sunrise, yet the local clocks were indicating something like 9:23 a.m. local time. KAPLAN said that several years ago Russia decided to reduce the number of time zones, such that the time zone adjacent to Moscow's zone is +2 hours. This two-hour discontinuity makes the sunrise at 9:20 in the morning in February at this particular place.

ALISON PECK added that Chile has two problems like that. One problem is that they want to be in the same time zone as the East coast of the United States for business purposes; this means that the Sun comes up in winter after 8 a.m. for a city of almost 7 million people at -33 degrees latitude. PECK admitted that this "almost killed" her, and that it was almost impossible to get work done like that. Another problem is that the Chilean Navy makes the decision "on the fly" as to when to change to daylight-saving time. There is a pre-set schedule to which the country is supposed to conform, and that is what Google calendar and other scheduling software reference, but the changeover is almost never actually on that day, so there is about three or four weeks during the year when everybody's calendar and clocks are wrong.

REFERENCES

¹ McCarthy, D.D., W.J. Klepczynski (1999), "GPS and Leap Seconds—Time to Change?" *GPS World*, November, pp. 50–57.

² Birth, K. (2012), *Objects of Time: How Things Shape Temporality*. Palgrave Macmillan, New York. p. 62.

^{*} *Editors' Note: Ürümqi Time*, also known as *Xinjiang Time*, is a declaration of the People's Congress of Xinjiang Uyghur Autonomous Region, and is recognized predominately by the Uighurs.