DISCUSSION CONCLUDING AAS 13-511

CHRIS TUASON said that he definitely expected resistance to the proposal of *Adapted Universal Time* (UTA), because the total proposal represents a major change to the way a 'day' is defined. ANDREW MAIN thought that the proposal combined four elements that are best considered separately, because "the whole [of UTA] is not greater than the sum of its parts." First, UTA introduced small leaps on order of milliseconds each day, which MAIN believed would not be easier for computers. Second, the proposal advanced the notion of everyone using the universal day as their (local) civil time. However, the 1884 Meridian Conference[1] rejected any suggestion of proposing that notion, because it was outside their scope and that is not how civil time works; civil time is decided by each jurisdiction individually. Third, the interval within a leap is represented as part of a $25^{\underline{th}}$ hour instead of a $61^{\underline{st}}$ second of minute. That idea is not new; that was actually the way the current UTC system was originally described.[2] However, the other notation can be used equally well, so that element just drops out. Finally, the use of 'letter-hours' is independent of the other aspects.[3] TUASON replied that one practical advantage of using letter-hours is that it becomes obvious that UTA is being used, which is something different than UTC.

Considering RUSSELL REDMAN's earlier description of a "binary" timescale, GEORGE KAPLAN asked how a computer is supposed to account for these milliseconds added to the end of each day if the computer is maintaining time as a sequential count of seconds from some epoch, like GPS does. Specifically, if the Mean Stretch Adjustment (MSA) value was 0.003 s, what would be the next value after 86400.003 s? SERVANDO DIAZ replied that, under UTA, the next value would be represented as part of the next hour. KAPLAN clarified that he was talking about a timescale that would not maintain units of hours, but only an internal sequence of seconds. TUASON said that the paper proposes that UTA be maintained to nanosecond precision, so accounting should be performed with a continuous sequence of nanoseconds, or, "continuous clock ticks".

DIAZ added that while the UTA representation from a computer would appear to belong to the next hour, the computer's internal count need not use hours. Whatever unit of duration is used, it just keeps on accumulating in sequence. KAPLAN therefore surmised that there must be a grand table somewhere which must be used to calculate the duration in seconds between observations made years apart; thus, he wondered how that calculation should be made. TUASON replied that this approach is not much different than the way intervals are computed in UTC now. There would be atomic timestamps that are periodically adjusted to UT1, except that the adjustment is daily. DIAZ affirmed that a daily record would need to be maintained in a table.

ARNOLD ROTS said that, for practicality, computers that need to handle this should keep two timescales internally and record them both as part of the datestamp, otherwise one might get lost. TUASON did not look at it that way; he saw it as one timescale, and when the user needs UTC, the internal scale is converted to UTC.

MAIN thought that the discussion might be promoting an incorrect supposition that this approach would be easy for computers because it could just ignore the table at lower levels. That does not work; computers would be a millisecond or so off every day immediately after midnight

and doing it that way "means you are 'lying' to the computers. Google did it in a very specific way; the 'leap smear' was applied very smoothly over a long period. They worked out how to 'successfully lie' to the computers." But the UTA approach proposes "lying to every computer, worldwide, every day." TUASON did not believe that UTA was lying to computers; rather, Google was lying in that the 'leap smear' changed the duration of the second. UTA changes "the definition of the day" to better reflect the rotation of the Earth.

DENNIS MCCARTHY said UTA was "changing the frequency of the second" and did "not see any difference" between the UTA approach and the situation in the 1960's where broadcast frequencies were annually offset with respect to the cæsium standard. KAPLAN responded that frequency adjustments were not being proposed by DIAZ and TUASON, but MCCARTHY replied "that is essentially what he is doing." The room echoed with dispute, with MAIN countering that TUASON had "not talked about frequency offsets."

MCCARTHY clarified that TUASON was proposing to change the length of one second at the end of the day, which MCCARTHY felt was totally impractical, and added "what you are essentially doing is changing the frequency of UTC." KAPLAN answered "They are not doing that. They are adding another kind of count at the end of the day." MCCARTHY said "It is another count, but it is frequency—'kind' is the same thing as frequency." Again, the room echoed with debate. JIM KIESSLING said the count is not a regular number as it is the one that changes at the end of the day; it is continuously variable. ARNOLD ROTS felt that the problems associated with the proposal were not unlike having a definition of duration based on a tropical year which varied.

TUASON clarified that the proposal did not change the definition of the second or the definition of the minute. "What is being changed is the definition of one day. One day is not 24 hours under UTA; it is 24 hours plus the *millistretch*." With regard to computers maintaining two timescales, it is one timescale which can be converted. DIAZ added that a computer would take UTA and convert it to the computer's way of reading it, but in a sense computers would keep their own timescale.

KEN SEIDELMANN observed that the length of the UTA day would need to be adjusted daily to stay close to UT1. This would require everyone to keep track of tiny step-adjustments that change daily. TUASON said that was not necessarily the case; the millistretch value would be prescribed according to some predictive formula that might be held constant for years. DIAZ added "…*if* you decide to do it that way," with SEIDELMANN responding "that's a big *if*." TUASON clarified that the value of the millistretch would not be permanently fixed but it would be functionally related to the slope of predicted ΔT. SEIDELMANN responded that the slope of ΔT changes unpredictably, but TUASON replied that if a tolerance of $|\mathrm{UT1}-\mathrm{UTA}| < 0.9$ s continues to be maintained, then one could foresee using a single millistretch value that would not need to change for very long periods of time. DIAZ rhetorically asked how else we should live with a new timescale running alongside the computer timescale; the new timescale is indeterminate because one does not really know the acceleration or deceleration of the Earth's rotation. TUASON further acknowledged that the structure of UTA would make it feasible to do more frequent updates to maintain tighter tolerances.

ROB SEAMAN thought the contribution DIAZ and TUASON was "great" as it "generated a lot of interesting discussion," and there were possibly more aspects that could be discussed further. SEAMAN admired the willingness of DIAZ and TUASON to put their "heads in the lion's mouth"—an illustration which prompted chuckling among the audience. In reply, TUASON appreciated that the lion's mouth did not "totally close". TUASON said their contribution attempted thinking "out of the box—perhaps too far out!" One purpose of the contribution was that, even if people disagree with the ideas as presented, it might spur lines of thinking yet to be considered.

REFERENCES

[1] US Government (1884), *International Conference held at Washington for the purpose of fixing a prime meridian and a universal day, October 1884: Protocol of the Proceedings*. Gibson Bros., Washington, D.C.

[2] Commission 31, Resolution 9.4., from De Jager, C. (ed., 1970), *Transactions of the International Astronomical Union*. Vol. 14. Fourteenth General Assembly, Brighton 1970. A: Reports on Astronomy; B: Proceedings, D. Reidel.

[3] Fleming, S. (1876), *Uniform Non-Local time (Terrestrial Time)*. Ottawa, Canada.
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