

## DISCUSSION CONCLUDING AAS 13-524

RUSSELL REDMAN admitted that he liked “market-based” solutions. A claim made by many people, and which probably has a substantial fraction of truth behind it, is that “a timescale without leap seconds is better than one with.” If an unadjusted atomic timescale was therefore made available as a tool to be used in parallel with UTC, and then libraries implemented them correctly—which means fixing the bugs in the current implementations of UTC— and then people were allowed to use them, we would find out which one is better because people will choose the one that works best. And then, ten years after that has been done, we will have a fair comparison: how many people used this one versus how many people used that one, and why. KEN SEIDELMANN said he would agree with that procedure and would go along with that, but SEIDELMANN also predicted during his presentation that the increased accuracies coming with clocks will require other technology changes to take place and that may well cause some unforeseen transformation to take hold ten or twenty years from now, and that is when a significant change should take place—not now.

KEVIN BIRTH said he would disagree with the logic behind REDMAN’s proposal, based on historical evidence. The town clock in Berlin in the mid-18<sup>th</sup> century had hands installed to indicate both local apparent solar time and mean time, but the residents of Berlin rebelled and insisted that the mean-time hands be removed. So, if two timekeeping options were available for ten years, BIRTH was not sure that the public would necessarily come up with the best long-term solution. SEIDELMANN suggested that we have a more sophisticated and wider audience today; BIRTH evoked jollity by rejoicing that “we are same species that we were 200 years ago.”

CHRIS TUASON wondered if navigation satellites could disseminate UT1. DENNIS MCCARTHY said that was being planned for GPS III. TUASON asked if other navigations system would disseminate UT1 as well, to which MCCARTHY replied “Yes.” However, SEIDELMANN said his point was about the case when GPS is not available in an emergency situation. JIM KIESSLING commented that it was possible to “coast through” such anomalies, providing that the appropriate timescales and tools are available. To that SEIDELMANN added that one must be appropriately prepared. KIESSLING agreed, saying that the timescale needed to maintain a tie to UT1. SEIDELMANN added that he was speaking with regard to having a backup in an emergency situation.

GEORGE KAPLAN asked about changing the name of the timescale. If leap seconds are removed from UTC and the name is changed to, say, *International Time*, that creates a situation where no country has that timescale as their legal time, and that name would not appear in interface control documents for some very complex systems. People then have to decide what timescale they are going to use, and everybody in the world is forced to make a market-based decision. Does not the possibility of mass confusion arise if one country decides to stay with UTC, or create its own version of UTC, and another one does something different? STEVE ALLEN said that is where Israel is right now, because Israel is on daylight-saving time but not *legally* on daylight-saving time, and nothing is breaking. So nothing would break in the case of a name change.

KIESSLING said that in terms of the documentation, and the legal materials, and all that work to conform to a time standard, the name change actually exposes the cost of the decision. If the name did not change, the decision cost is not exposed yet there still is a need to change the documentation to reflect a change. SEIDELMANN added that the attendees had seen lists of countries and references to their legal code; if UTC is changed then a legal question exists throughout and “lawyers could have a field day with this situation.” However, SEIDELMANN would expect countries to stay with UTC at the start, because that is available and that is what they have been doing. But if they found the alternative to be advantageous then they could initiate a legal procedure to make a change.

KAPLAN said this could result in some countries having midnight offset a different number of seconds than others, but ANDREW MAIN noted that this situation already exists at the sub-second level. SEIDELMANN said such things remain the prerogative of sovereign nations to decide, which seemed no different than managing time zones. ARNOLD ROTS noted that there are plenty of countries that do not rely on the term ‘UTC’ in their legal codes and that did not seem bothersome as a legal issue. SEIDELMANN replied that they might have ‘mean solar time’ or ‘Greenwich time’, for which UTC currently serves and is about “as close you can get.” ARNOLD ROTS added that a number of countries say ‘world time’ and that could mean anything. ALLEN thought that the time running in operational systems is the time of everyone’s concern: “as long as they keep running, it will be okay.”

BIRTH noted that there is case law and precedent for dealing with two co-existing timescales in former Commonwealth nations (British colonies). Back before the period of 1752, the New Style and Old Style calendars ran concurrently, with only the Old Style calendar being the official legal calendar. So there are nations out there that have legal precedent for dealing with this particular situation. SEIDELMANN noted the situation today for, say, China or Israel, where the Gregorian calendar is used for international purposes but cultural calendars are used internally. BIRTH agreed and acknowledged that there are actually a lot of different nations with existing case law for dealing with different ways of reckoning time, and how to reconcile them or deal with disputes having to do with time.

KAPLAN recalled that, in the United States, codified time zones were based on the mean solar time of standard meridians until 2007; with MCCARTHY’s involvement the law was changed mentioned UTC specifically. KAPLAN tried to imagine a discussion around the table within Congress about changing the legal basis to “this new timescale called *International Time*.” Then, if somebody brings up the fact that it is just an atomic scale not based on the Sun at all, the whole discussion comes back again. And then, multiply that discussion by almost every country around the world...

BIRTH thought that courts would settle the issue first, because that is what happened at the turn of the 20<sup>th</sup> century with regard to zone time versus local time. The Standard Time Act of 1918 actually came after a series of court cases that set precedents which actually defined what that law would be. So in the United States, BIRTH thought that Congress would “get to it late in the game.”

MCCARTHY did not think the issue would much involve Congress, because the United States has provisions for technical issues such as this. He could not “remember the official name of the publication but these things are published as guidance for lawyers and take precedence over any other law. And it is meant specifically for technical issues such as this which does not require an Act of Congress to handle. It can say something as simple as ‘for all intents and purposes for legal cases, courts should recognize *this* as equivalent to *that*,’ which would be the case here.” KAPLAN replied “That is fine, but who makes that decision and on what basis?” MCCARTHY thought it might be the U.S. Department of Commerce because that department deals with physi-

cal standards, and someone from NIST would be able to tell MCCARTHY the name of the document.\* Regardless, MCCARTHY had been “assured that this sort of thing exists specifically for technical issues which do not require all the lawyers in the world to be involved.”

REDMAN said that basically the same kind of system exists in Canada. The government can issue an *order in council* that instructs lawyers on how to interpret for legal purposes terms like “time on the Greenwich meridian”, GMT, and Universal Time. It does not go before Parliament, it does not require debate, it is based on the best technical advice available and it becomes the law of the land.† They do not even have to go back and revise the laws, but they can if they want. (TUASON wondered lightheartedly if this was coming from a country that does not have a written constitution; REDMAN affirmed in jest that actually Canada has a written constitution, although it is a “wimpy one”.) BIRTH said there may be nations where it is an issue but many nations have existing precedent and policies and procedures for dealing with it. This is largely because nations have gone through major time changes before. Going from local time to zone time was a *major* change for much of the world, and it was dealt with.

Considering some of the potential options raised by SEIDELMANN, KIESSLING wondered if it was “possible to think about deprecating UTC” by promulgating something like TAI and generating UTC on demand for those applications that need it. REDMAN thought it was not necessary to deprecate UTC; however, if software is going to be fixed properly, he supposed a TAI-like atomic timescale would need to be distributed. REDMAN said that most of the mess with the coding right now was due to workarounds from an early bug that was never fixed. MAIN said “there is a tendency to screw it up because most programmers are not experts on time.” Software developers are working from pre-existing programs and existing APIs that did not account for this, so it is a mess.

KIESSLING had seen a human tendency even by the expert programming community to do weird base-60 computations on something that should be a continuous counting scale, and then “they act like they have to do weird things about smoothing.” Because there was international expertise on the other side of the table on time APIs, KIESSLING posed the question: “why are you guys messing around with this base-60 stuff? Generate it on demand, but there is no reason to calculate by that.” JOHN SEAGO asked if the answer to KIESSLING’s question could be held until the general roundtable discussion to follow, so that discussion specific to SEIDELMANN’s presentation might conclude first.

MAIN noted that SEIDELMANN had raised a point about whether UTC qualifies as being ‘continuous’. MAIN thought that MCCARTHY’s presentation had “made a fairly good point by looking at mathematical definitions” but MCCARTHY’s definitions really applied to a single scalar variable and UTC timestamps are not adequately described in terms of a single scalar variable. Thus, MAIN thought that the mathematical concept of ‘continuous’ did not really apply. MAIN construed SEIDELMANN as making the point that one can get a continuous scale out of UTC by labeling the seconds differently, but that amounts to a translation to TAI. To MAIN’s comment, SEAGO interpreted SEIDELMANN as suggesting that there is more than one definition of ‘continuous’. SEAGO said a mathematical definition might lead to questions about whether calendar representations of time are continuous, or whether clock representations of time are continuous because

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\* *Editors’ Note:* MCCARTHY afterwards affirmed that the document was the *Federal Register*, the daily journal of the United States Government.

† *Editors’ Note:* The discussion concluding AAS 13-505 also contributes to the subject of Canadian orders in council in relation to UTC.

time of day rolls over from 23:59:59 to 00:00:00, and so on. But SEAGO understood SEIDELMANN as talking about the *primary* definition of ‘continuous’, namely, whether a sequence (of seconds, days, *etc.*) is interrupted or not interrupted.

TUASON said the discontinuity comes in the wave-form issue when one is constrained to use a certain set of labels and one does not have a 61<sup>st</sup> second and it becomes discontinuous. KIESSLING remarked that there were handling issues at the 61<sup>st</sup> second simply because of the choices made. SEAGO noted that behavior “would not be UTC as it is currently defined.” KIESSLING added “...but that is not UTC’s problem. The problem is how people are choosing to interpret it. The definition of UTC explicitly states the handling for the leap second and the software people choose not to deal with it literally.”

MAIN said that is not the issue being dealt with here. The problem here is if one takes the sexagesimal notation and a timescale such as TAI or UT1, one can take the sexagesimal parts and put them together mathematically into a single real value that increases in a continuous manner at an essentially constant rate. (SEIDELMANN clarified that technically, UT1 does not have a constant rate, to which MAIN agreed and apologized.) Continuing, MAIN said that with UTC, if one has these sexagesimal parts which are put together by any such mathematical expression, one gets a scalar variable that is discontinuous. Thus, to interpret UTC as continuous, essentially SEIDELMANN must not be treating the labels the way UTC does.

SEIDELMANN replied that if one goes to a dictionary and looks up the word ‘continuous’ as he did, then one will find the concept of ‘continuous’ as he presented it—the *dictionary* definition. MCCARTHY had brought up a *mathematical* definition for differential equations, which SEIDELMANN guessed was not continuous. However, SEIDELMANN’s actual point was that neither ‘continuous’ nor ‘discontinuous’ seemed to be the right word for the situation. MAIN thought it was absolutely right to say that ‘continuous’ was not necessarily the right word; a much more useful word would be ‘uniform’, because it is fairly clear that UTC is *not* uniform. TUASON added that UTC is “not uniform in terms of the *label*,” to which MAIN agreed. BIRTH further suggested that UTC is uniform at the level of seconds, but at the level of minutes UTC ceases to be uniform because of the leap seconds. And thus there are hours that are not uniform, and days that are not uniform, and so on, and this is part of the problem of meeting expectations of scalability discussed earlier (AAS 13-523). ROB SEAMAN said it seemed to him that days are not uniform because of the effects that DANIEL GAMBIS showed in his presentation (AAS 13-522), and not “because of the leap second.”

KIESSLING thought that “the internal definition of how they come up with leap seconds is not discontinuous, how people nominally interpret that assuming that we are talking about base-60—effectively you are not; you have some alphanumeric labels which people are choosing to interpret in a conventional fashion that is base 60.” KIESSLING again suggested “deprecating UTC” by distributing TAI and generating UTC on demand from TAI as needed. MAIN thought that the recommendation to generate UTC locally “does not sound much like deprecation,” with REDMAN affirming that “‘deprecate’ is not the right word.” At most, MAIN thought, KIESSLING’s proposal deprecated the direct use of UTC for clock synchronization. KIESSLING clarified that the use of UTC in mathematical operations, where one has to kludge around things because of the way the definitions are being treating, is something to be grossly avoided. SEIDELMANN preferred the option of keeping what people have and to recognize what people might already be using to support a uniform capability. KIESSLING said he was not arguing against SEIDELMANN’s solution, but wanted to emphasize that there were software problems tied to an inflexible understanding of what developers think the time code means.