

## DISCUSSION CONCLUDING AAS 13-512

Paper AAS 13-512 was read aloud by JOHN SEAGO on the behalf of HENNO BOOMKAMP, former chair of the International Association of Geodesy (IAG) Working Group 1.1.1, who was unable to participate in person. STEVE MALYS asked if the work of IAG Working Group 1.1.1 had concluded. SEAGO replied that this particular IAG Working Group no longer existed because of reorganization within the IAG around 2011. Being aware of survey activity taking place ahead of the 2012 ITU-R Radiocommunication Assembly, the Working Group had formulated an opinion in anticipation. Ultimately, the Working Group was never required to supply its opinion, and so the Working Group Chair contributed the opinion to the proceedings of this colloquium as a venue for capturing various perspectives on timekeeping. MALYS asked if SEAGO's reading was the actual Working Group paper; SEAGO affirmed that he directly presented the language of the Working Group contribution.

ARNOLD ROTS thought the position authored by BOOMKAMP was "eminently sensible". As someone who manages a data archive, ROTS felt the need to emphasize BOOMKAMP's comment that, if the leap second is dropped, it is not going to solve any of the issues with existing data, the archives of which are incredibly valuable.

ANDREW MAIN found an interesting parallel in the point that switching to a larger leap step, such as a leap minute or leap hour, seemed tantamount to abandoning UTC as we know it. However, we have already been through a similar situation with the redefinition of UTC from the era of rubber seconds. The same claim could have been made that, by moving to leap seconds, UTC as it existed "would have been abandoned." STEVE ALLEN reminded the audience that, at that time, the claim was that "Planes Will Crash!"—a playful reference to his own colloquium contribution AAS 13-502.

SEAGO asked if MAIN meant that a claim might have been made that UT (Universal Time) would have been abandoned. MAIN clarified that he meant "abandoning UTC as it existed for the rubber-seconds era." Shifts in frequency were a fundamental feature of that era and that feature was abandoned with leap seconds. Of course, frequency shifting was abandoned for good reason, and the fact that it was replaced with something that did not involve frequency shifting is not a compelling reason against that action. Nonetheless, there seemed to be an implication in BOOMKAMP's paper that we must not do anything to abandon UTC and MAIN thought that implication was unjustified. However, ROTS disagreed very much with MAIN's assessment. The difference is that a large body of archived data now exists with very accurate timing, which did not exist during the era of rubber seconds. MAIN conceded that ROTS' point seemed to be a good one.

DENNIS MCCARTHY thought that the upshot of the paper was that geodetic-satellite analysts had already transformed their time from UTC to a timescale more useful to them. This would not make the UTC issue go away because the analysts had already taken care of it. Assuming that they already archived their data onto a scale like Terrestrial Time (TT) and would continue to archive their data that way, MCCARTHY felt that they were effectively saying "We have handled the problem, thank you very much." If so, ROB SEAMAN remarked that this approach provided a proof of concept that the UTC issue does not need to "go away" because "other projects could do

the same thing.” ROTS added that the data from their X-ray missions is archived this way, but flight operations still work in UTC, the dissimilarity of which causes problems.

SEAGO said that, if future leap seconds are taken out of the UTC timescale, it will not take very long before people start to assume that there are no leap seconds in UTC—past, present, or future. People will then be caught by surprise when they start to use UTC retroactively as a uniform timescale, especially when processing historical data. To SEAGO, an implicit point from BOOMKAMP’s contribution was that this situation potentially devalues historical archives of precise scientific data that were very expensive to accumulate and are still very valuable, because future software will reach a point where it will no longer be able to deal with older data tagged to something called “UTC”.

RUSSELL REDMAN basically agreed with the logic of BOOMKAMP’s contribution, it striking him as “very sensible”. REDMAN’s main conflict is with a political side issue about which others should be cautious. REDMAN has observed that one very commonly hears the suggestion of “Oh, we can just use GPS time.” The fact of the matter is that GPS time cannot be used as an authoritative time source in any country in the world. There are 55 national administrations that run time services, and in 54 of those countries the national time service gives the authoritative time within their national borders which it is *not* from an American source. And even within the United States, GPS is not an authoritative source of UTC. It has a known offset from UTC which is ten times bigger than the uncertainty. To anybody within the time services, that kind of offset is like “fingernails on a chalkboard”—they just will not listen to it. “GPS time is *really* convenient, and it is better than anything else that can be had right now, but it is not authoritative.”

SEAGO did not disagree with REDMAN’s assessment of the political situation, but ‘TAI’ is often referenced with regard to satellite-analysis applications that BOOMKAMP discussed. However, this would most likely be some national realization of UTC plus the integral offset (TAI–UTC), rather than the BIPM’s realization. SEAGO also suspected that similar things might be happening with the operational employment of GPS time from UTC, or UTC from GPS time. SEAGO also disclosed that in satellite operations it is not unheard of to come across satellite ephemerides or other data with time tags offset from UTC to a degree that ties them to a GPS epoch, because there are growing numbers of data sets that are being referenced to GPS time, which is not necessarily a good thing. As a practical engineering matter, ALLEN added that “television broadcasts in the U.S. and Canada are tied to GPS—never mind that it is not legal.”<sup>1</sup> REDMAN replied that “this will bite us as some point, but maybe not for a while.”

JIM KIESSLING raised a point regarding the matter of large data archives; given the continuously decreasing cost of electronic storage and electronic processing, would it not be incredibly gainful to retag archives of historic data? SEAGO replied that storage may be less of a concern now than before, but the required amount of data processing might depend on the data set. KIESSLING failed to see that as a significant objection. SEAMAN remarked that it is certainly not an advantage to the alternative position of leaving UTC alone, to which KIESSLING agreed. ROTS added that one cannot force all data archives to be reprocessed. KIESSLING did not disagree, but he said that if reprocessing archives is advanced as a major objection, then it seemed reasonable to ask how much effort and expense might be involved to convert over to a “continuous” timescale. SEAGO said that he had familiarity with some projects where this had been done; it was possible but not necessarily easy or inexpensive. SEAMAN said that, for communities like his and KIESSLING’s, which are aware of the issue in the first place, all this data was accumulated under the thinking that ‘Universal Time’ *means something*. By redefining ‘Coordinated Universal Time’, we would not only be devaluing UTC but we would be devaluing ‘Universal Time’ as a concept.

MCCARTHY asked ROTS to clarify the observational archives to which he was referring and to what timescales they are currently being tagged. ROTS replied that he was talking generally about all the various observational data that institutions may have “stashed away somewhere.” For the NASA archives, it depends on how the code was written for a particular mission. MCCARTHY therefore surmised that archived data could be cataloged with respect to various numbers of time-scales, including UTC, adding that “NASA never got over ‘GMT’.” ROTS said that missions in which he is involved are being forced to use TT, but he is aware of other missions that are still using UTC. There are many ground-based observatories that tag with respect to UTC. The Very Large Array (VLA) tags with respect to TAI. It just depends what was required or what people have done. MCCARTHY asked if archives are transformed to a consistent timescale when they are redistributed. ROTS replied that he only distributes what he has, and other sources will distribute whatever they have, and users will get whatever they get. MCCARTHY concluded that these users “have to deal with the zoo of timescales on their own today” and that will always be an issue regardless of whatever is done to UTC in the future.

MARTIN BURNICKI said that he did not understand the significance of the distinction being made between UTC and TAI. As he understood the situation from a technical point of view, caesium standards generate frequency which is counted, which is effectively TAI, and this is basically the product that is used to inter-compare the time signals from national time-service institutes. Then, an adjustment is made in terms of whole seconds, which is UTC. When the occasional leap second occurs, the offset is incremented by another whole second. So basically, UTC provides a linear timescale that is TAI. BURNICKI does not understand why people try to refer to GPS time, which is derived from TAI. If historic leap-second information is available, one can always use TAI time stamps to record data where a linear scale is needed, and from there convert these stamps to UTC and then to local time. So BURNICKI was not sure where all these problems are seen.

SEAGO confessed that he was probably not the best person to speak toward BURNICKI’s questions, but admitted that there are arcane distinctions that some people seek to make; namely, that TAI is only a background timescale used by the BIPM for monitoring UTC. International UTC is not available from the BIPM in real time, but real-time UTC originates from various national standards. If one adds the integral offset (TAI–UTC) to broadcast UTC, one is effectively getting a real-time version of TAI from a national standard, but seemingly the BIPM does not approve of the term ‘TAI’ being applied to the real-time output of national standards. MAIN considered that to be a political difference, not technical.\* SEAGO continued that one would be compelled to label the national outputs as something like ‘TAI(*k*)’, where *k* identified the national source, but it does not appear that anyone makes this technical distinction.

## REFERENCES

<sup>1</sup> Advanced Television Systems Committee, Inc. (7 October 2011) ATSC-Mobile DTV Standard, Part 2 - RF/Transmission System Characteristics, Document A/153 Part 2:2011, Section 5.3.2.13.1, p. 58. (URL: [http://www.atsc.org/cms/standards/a153/a\\_153-Part-2-2011.pdf](http://www.atsc.org/cms/standards/a153/a_153-Part-2-2011.pdf))

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\* *Editors’ Note:* The discussion concluding AAS 13-520 adds to this point.