

DISCUSSION CONCLUDING AAS 13-523

JIM KIESSLING said DENNIS MCCARTHY's presentation was "kind enough to bring up the happy little term *risk*." KIESSLING felt that MCCARTHY formulated a position for the "nominal situation", but asked what happens when the current methods of UTC dissemination are interrupted in circumstances of disaster due to solar weather, human agency, *etc.* How does one address the societal risks there? MCCARTHY said that UTC has been disseminated in a number of ways: through shortwave radio signals, and through navigation systems such as LORAN and GPS, and very low-frequency radio signals. "All those things would presumably still be there." In addition, new and much more improved means of dissemination will be needed in the future; optical fiber is currently being used. "Right now our development of atomic clocks is hindered by our inability to disseminate time."

KIESSLING was a little surprised by MCCARTHY's answer, because KIESSLING was under the impression that a lot of the backups referenced by MCCARTHY no longer existed, due to the cessation of LORAN and other services. MCCARTHY said he was not referring to those as 'backups'; rather, they have been there historically and "we could always return to those if we had to handle something like that." Some people still use LORAN-C, and in the end 'targets of opportunity' could be used, that is, using every communication system and every communication tower as a navigation signal. MCCARTHY looked forward to coming decades when time would be disseminated by a variety of ways and presumably GNSS will not be as critical as it is today. It is easy today because it is cheap.

STEVE ALLEN noted that, in all of the original documents from the CCIR, and the understanding in textbooks written since, is that 'Universal Time' means 'solar time'. The latest proposal from the ITU-R to drop leap seconds says nothing about that, and ALLEN understood MCCARTHY as saying that 'Universal Time' is *not* 'solar time'. ALLEN was wondering if the 'we-need-more-information' people at the last Radiocommunication Assembly thought that "Universal Time is not solar time" should be acknowledged in whatever the ITU-R adopts, or, should that point be fixed afterwards? MCCARTHY submitted that the issue is: "What is 'time'?" some repeatable phenomenon is needed to measure time. Until the advent of really good pendulum clocks of the 1930's, Earth rotation was the best source—"that was time." MCCARTHY said that we have since "turned it around. We call it a 'timescale' because the Earth's rotation was the best way to look at it." But MCCARTHY disagreed with this; he would say that one is using the measurement of angle as a means of determining time—"that is perfectly fine, but it really is an angle."

ALLEN's concern was over the conceptual aspects; he did not think it was going to be easy for people to understand that Universal Time was not solar time unless the change comes along with an affirmative statement like the one MCCARTHY just made, *e.g.*, "that 'Universal Time' is not 'solar time'." ALLEN was not sure that claim could be sold before the ITU-R delegation. MCCARTHY replied "Universal Time has precious little to do with the Sun today." UT1 is determined from "measuring the Earth's rotation and has nothing to do with the Sun." It is based historically on Newcomb's expression for the fictitious mean sun. ALLEN asked whether Aoki *et al.*¹ already undid that for us. MCCARTHY said there was interesting story behind that article's long

listing of authors, but yes, that undid it; it produced a point which has no relationship to the Sun, which is said in that paper. The only thing that UT1 is maintaining is no breaks in time. JOHN SEAGO apologetically interrupted to say that one could arguably claim that Newcomb himself broke away from the actual Sun as soon as he prescribed a convention for the mean sun and the tropical year. So, although debate over the precise meaning of ‘solar time’ could be carried to extremes, SEAGO felt that Universal Time was a sufficient approximation for mean solar time for many cases. KEN SEIDELMANN interjected that he would speak to that issue in the subsequent presentation (AAS 13-524).

To MCCARTHY’s presentation, KEVIN BIRTH would have added a couple of common cultural expectations for civil time scales. In terms of the cultural uses of timescales, something missing from MCCARTHY’s list was that a lot of people assume that the timescale “is scalable from the smallest unit that they would care to measure to the largest.” But what we have as a result of our cultural inheritance is this sort of hodge-podge of an SI second that is defined atomically, a day that is defined polysemously, and a year that does not really match up to anything. And yet there is this assumption that one should be able to easily convert from one to the other. Thus, one of the problems within the whole debate about redefining UTC is that it is “lose/lose”: no matter which way the definition goes it will not be a truly scalable system from the smallest unit to the largest.

According to BIRTH, the other common application of timescales missing from MCCARTHY’s presentation was to “provide a means of representing other ways of conceiving time, including those that are not scalable.” Jews, Muslims, Hindus, and a variety of other people with whom BIRTH had worked often think about representing a specific moment, or the coincidence of different phenomena, within that scale. BIRTH thinks that these other ways of conceptualizing time, in a form that is culturally recognizable and understandable, is also a very important application of timescales.

BIRTH added that there is another problem with the way timekeeping is taught. The level of expertise expected of most people with regard to time is what they learned in kindergarten: “the day is 24 hours, an hour is 60 minutes, a minute is 60 seconds, you put together 365 days...” One can see the problem: the civil use of time assumes a scalability that really is not matched by the technical definition. MCCARTHY took from BIRTH’s comments that, whatever timescale is chosen for a civil standard, it has to be relatable in some way to culturally diverse methods of recognizing time.

GEORGE KAPLAN thought that everyone in attendance would probably agree that the addition of leap seconds to a timescale based on SI seconds is “sort of a kludge” which is the best that can be done. Also, “it is great to sit around the table and talk” about all the ideas for laying out what should ideally be in a timescale, and whether UTC matches up with that, and so on. But KAPLAN supposed that the technical decisions are going to be made on whether a change will cause more trouble than not changing. KAPLAN did not think that the decision was going to be made on all the other considerations, in spite of their validity. “When push comes to shove, people are going to say ‘Is it going to be worse if we take [leap seconds] away, or is it going to be worse if we keep them?’” MCCARTHY added “Which is more likely to result in a disaster?” KAPLAN agreed but rephrased it more generally as “What are the unforeseen consequences of going the way we are or making a change?”

MCCARTHY declared “It is so easy at this point just to do nothing until a disaster occurs.” At that, ROB SEAMAN admitted he had been quietly contemplating a polite way to express his criticisms, because SEAMAN knew that MCCARTHY was “a nice guy” and was looking forward to productively working with MCCARTHY on the IAU Working Group on UTC. However, SEAMAN professed that MCCARTHY’s presentation was like a trip to the supermarket where a big bag of

apples was picked up, but oranges were really needed. SEAMAN said there were multiple points made within each of MCCARTHY's presentation slides which long discussions on the leap-seconds mailing list* could "rip to shreds". That mailing list group was characterized negatively during a lunchtime meeting of the IAU UTC Working Group, but SEAMAN thought that review by that group presented a useful process for refining such arguments.

SEAMAN acknowledged that UT1 being an angle does not imply that UTC is not a proxy angle—until the ITU-R wants to stop it from serving as that. Although MCCARTHY's presentation asserted that not changing UTC would increase risks, SEAMAN countered that changing UTC would increase other risks. If SEAMAN were limited to only one point, it would have been the first one KIESSLING raised about risk—"there *are* risks here." And, if SEAMAN could have a second point, it would have been that "there are *costs* here," especially for the astronomical community to which SEAMAN and MCCARTHY belong. Changing UTC would be "multi-millions of dollars—a very expensive thing" to do to astronomers.

MCCARTHY replied that "we can argue about costs" but MCCARTHY's take-away from the previous day's discussions was that an enormous amount of resources had been devoted to working around the leap second. MCCARTHY also said he must disagree with any claim that UT1 is not an angle: "UT1 is an angle. UT1 is an angle. There is no doubt about that." SEAMAN agreed that UT1 is an angle, but SEAMAN's point was that, until the ITU-R redefines it, UTC also functions as an angle. MCCARTHY replied "UTC is *not* an angle; it is not measured as an angle. UT1 is a measured angle. I can go out and measure it. I can observe it. I cannot go out of here and find UTC in the sky."

Continuing, SEAMAN noted that MCCARTHY had made a point about the word 'Universal' in several slides, but that is not the complete term. The complete term is 'Universal Time', and at least two of MCCARTHY's slides indicated that 'Universal Time' was 'solar time'. MCCARTHY replied that "it is based *loosely* on solar time, yes." SEAMAN clarified that it is based to within a second. SEAGO asked if MCCARTHY could revisit his presentation slide regarding the name of UTC so that the audience could see what was being discussed. MCCARTHY indulged, and SEAGO asked if SEAMAN was referring to MCCARTHY's presentation point that "'Universal' refers to the use of the same time for the entire Earth [which] began with [the] International Meridian Conference in 1884." SEAMAN said that was but one instance.

On MCCARTHY's slide, SEAGO noticed an extended excerpt from the proceedings of the International Meridian Conference which started "The scheme set forth in the recommendations has in view three principal objects..."² and which enumerated the global nature of the International Meridian Conference's objectives. SEAGO said he was unsure from what part of the International Meridian Conference proceedings that quote came from[†] because "there was a lot of discussion which took place within those proceedings." However, SEAGO noted that the *Final Acts* of the 1884 proceedings—what was agreed to in the end—determined "[t]hat this universal day is to be a *mean solar day*; is to begin for all the world at the moment of mean midnight of the initial meridian..."³ Thus, SEAGO claimed that the 1884 International Meridian Conference essentially defined, insofar as they could, the 'universal day' to be a 'mean solar day on the Greenwich meridian'. MCCARTHY replied that the delegation had no other choice. SEAGO answered "But it has al-

* <http://six.pairlist.net/mailman/listinfo/leapsecs>

[†] *Editors' Note*: The quote was excerpted from lengthy observations by Sandford Fleming, the delegate of Great Britain representing the Dominion of Canada, regarding a resolution before the Conference. Mr. Fleming preferred the terms 'Cosmic day' and 'Cosmic time', which were not adopted.

ways meant that;” even as far back as the 1884 International Meridian Conference, where MCCARTHY said the term originated, ‘universal time’ has always been used in the context ‘mean solar time at Greenwich’. MCCARTHY agreed that Universal Time “has always been used in that context.” SEAGO explained that he meant that ‘Universal’ had become “synonymous with it.” MCCARTHY would not say the two were ‘synonymous’ although he would say that UT “has always been used in that context” of Greenwich mean time. ALLEN then noted that the CCIR documents themselves say that it was synonymous at the time they were adopted: “It is in the record.”⁴

SEAGO asked if MCCARTHY had an example since the 1884 International Meridian Conference where the term ‘Universal Time’ was *not* used as a synonym for the time of the mean solar day on the Greenwich meridian. MCCARTHY replied “*Coordinated Universal Time* is a perfect example. It uses ‘Universal’ and has nothing to do with the Sun.” SEAGO inquired why UTC was not synonymous—to within one second—with the mean solar day on the Greenwich meridian. “Is it [UTC] a realization of ‘Universal Time’, or is it not?” RUSSELL REDMAN responded: “Yes, yes it is; it most emphatically is, and there is a bounded difference between that and UT1. That is the definite relation.” SEAGO wondered if MCCARTHY disagreed with REDMAN’s response, or disagreed that use of the term ‘Universal Time’ in ‘Coordinated Universal Time’ is a reference to UT as REDMAN described it. MCCARTHY said he would agree, but that “it has nothing to do with the measurement of the Sun.” SEAGO stressed that the discussion was about the meaning of the term ‘Universal’ in the context of UTC, that is, whether ‘Universal’ as an adjective is to be coupled with ‘Time’ to imply ‘Universal Time’ in an astronomical sense. MCCARTHY thought it was “safe to say that ‘Universal Time’ refers to a timescale based on the Sun” and to leave it at that. SEAGO suggested that to argue that the word ‘Universal’ was decoupled from the word ‘Time’ in the context of UTC ignores “all the terminological developments of the 20th and 21st centuries.”

SEAMAN asked if MCCARTHY could comment on what was wrong with the consensus decision made at the 2003 Torino Colloquium to simply define a new timescale. MCCARTHY said “That’s fine. It does not make any difference what you call it.” MCCARTHY really had no concern about calling UTC something else. SEAMAN asked if there was some part of this that required the term ‘Universal Time’ to be abandoned. MCCARTHY said the name of the timescale eventually used does not make too much difference. “We can call it anything just as long as people know what it is.” MCCARTHY felt that there was no need to change the term ‘Coordinated Universal Time’, but he could also “understand the business of the ISO standards and all that kind of stuff. We’ve sort of not done that in the past; when we changed the definition of UTC in the past, we did not change its name.” KEN SEIDELMANN replied that the definition of UTC did not really change; what changed were the methods used to keep UTC within the bounds of UT1 for reasons that were technical and were required, but the basic concept was not changed. As it related to the relationship between UT1 and UTC, CHRIS TUASON threw out the analogy of analog-to-digital conversion—“we are using atomic time to discretize an analog signal” if one is willing to think along those terms. TUASON said this means that it really still is the mean solar day; MCCARTHY added “that is exactly it.”

JIM KIESSLING asked what additional risks MCCARTHY perceived in retaining leap seconds, based on his expertise. MCCARTHY asked “Risks?” KIESSLING replied “Risks—you had said some disaster would occur. That is a pretty strong statement.” KIESSLING admitted that he was not an expert in timekeeping, although he thought there might be an issue with regard to timekeeping continuity. However, thus far there had not been a disaster in dealing with discontinuity to justify a significant change that would allow the two standards to drift apart. MCCARTHY said he used to not be concerned about disasters either “except for the fact that we have had some stories about some near misses in recent times related to air-traffic control.” KIESSLING said he had

“crawled into the air-traffic control very seriously recently” and the big issue that KIESSLING saw was “the marvelous non-metric use of pressure altitude.” MCCARTHY said the air-traffic control issue was not necessarily navigational but was more interruptions in software when leap seconds occur. SEAGO interjected that MCCARTHY provided a specific example related to database conflicts in air-traffic control systems, which was recorded in the Exton proceedings.⁵ KIESSLING said he would visit those proceedings, but added that “anyone who has a real-time system driving air-traffic control that worries about talking to UTC in terms of actual control is an idiot.” MCCARTHY put it this way: he “would not want to travel in the air when a leap second is being inserted.” ALLEN recounted the irony that forty years ago the argument was on the other side, per his opening presentation. SEAGO added that it was, in fact, problems with air-space management that gave us the leap second.

Based on his years of experience, MARTIN BURNICKI said that when the intervals between leap seconds decrease again, the risks will also decrease, because developers will become more aware of the leap second and will take care of them just like the daylight-saving standard. MCCARTHY said he recognized the familiar argument of “the more leap seconds we have, the better we will be because everybody will know what do to.” BURNICKI replied that the problems started after the long period of seven years during which no leap seconds were observed. MCCARTHY felt that people forgot to account for leap seconds in the equipment.

SEAMAN said there are best practices for system engineering that are specifically targeted for risk analysis. To SEAMAN, it seemed that if the question of risk comes up on either side of the debate, it would be prudent to perform a study to actually investigate. Basically every attendee was volunteering resources more or less from their organizations to be at this meeting; there was no money for spending on this so far.

REFERENCES

¹ Aoki, S., B. Guinot, G.H. Kaplan, H. Kinoshita, D.D. McCarthy, P.K. Seidelmann (1982), “The New Definition of Universal Time.” *Astronomy and Astrophysics*, Vol. 105, No. 2, pp. 359-361.

² US Government, International Conference held at Washington for the purpose of fixing a prime meridian and a universal day, October 1884: Protocol of the Proceedings. p. 120.

³ *Ibid.* p. 202.

⁴ International Radio Consultative Committee (1978), XIVth Plenary Assembly, Kyoto, Recommendations and Reports of the CCIR: Standard Frequencies and Time Signals. Vol. VII, p. XI

⁵ Seago, J.H., R.L. Seaman, S.L. Allen (2011), *Decoupling Civil Timekeeping from Earth Rotation—A Colloquium Exploring Implications of Redefining UTC*. American Astronautical Society Science and Technology Series, Vol. 113, Univelt, Inc., San Diego. p. 232.