DISCUSSION CONCLUDING AAS 13-520

STEVE ALLEN felt that ARNOLD ROTS' paper was "pretty much the astronomical equivalent" of the previous papers AAS 13-518 and AAS 13-519, which "is to say wrapping a bunch of metadata around it, and hoping that the community will actually say 'that is good enough, or not too rich, or not too complex,' and all these issues get brought up. And there is no less coercion to use it, other than people will understand your data better and you will understand your data better if you wrap it up in this way."

ROB SEAMAN believed that the working group ROTS mentioned in his presentation had not yet heard back from the Vatican. There might be some interesting work there; the people ROTS had written about wanted to finally digitize all their old manuscripts and put them in a format that would last hundreds of years. To do this, SEAMAN said it cannot be put into a JPEG* file interchange format, it must be put it in a format that is published in the literature and there are not a lot of formats like that. DAVA SOBEL likened such to Egyptian writings; SEAMAN adding that carving in stone is a lot more permanent.

RUSSELL REDMAN took note of ROTS' observation that distribution of the leap-second file is not onerous. Although it is not an issue for astronomical data generally, REDMAN wondered about what is to be done for stand-alone systems, which for reasons of security, cannot contact the Internet. At that point, even a tiny text file becomes onerous, because somebody has to do something about it. REDMAN would really like to find some mechanism where that information could be distributed through something like GPS so that stand-alone systems can get it passively. ROTS clarified that he was indeed talking about astronomical data, which in that case it is not onerous. But in most other situations, ROTS still felt it was not onerous, because the update process involved typing one line from a piece of paper every six months. REDMAN agreed in principle, yet cited the fact that there is a number of NTP servers that remain misconfigured, and that should be the same thing. There are some systems where people dare not make changes, so if the change cannot be automated they will not do it. SEAMAN said that the point that the problem does not go away because of historical leap seconds applies to archives of financial data, real-estate data, *etc*.

JOHN SEAGO said the Exton colloquium pointed out that it was possible (although perhaps unobvious) to back out information regarding the total number of previous leap seconds from GPS, in addition to when the next leap second will occur.[1] ANDREW MAIN said there was more to REDMAN's point: GPS does not give a historical table of when the leap seconds occurred. MAIN said that he and REDMAN would like to see things like GPS and radio time broadcasts "chop up the historical leap-second schedule into little packets and insert those every now and again" so that the whole table can be picked up over time. REDMAN agreed, saying that if one waited long enough, one should be able to get the whole table in principle and "not just the bit from now on."

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* Joint Photographic Experts Group

SEAGO asked if table distribution would be a more appropriate task for time signals via short-wave radio. REDMAN was unsure of the correct channel of communication, except that it should be something that the stand-alone system could safely use without having to worry about somebody sneaking in a virus. MAIN said the leap-second schedule is data useful to use with time signals that give on-time markers, and those systems in general give data that is not absolutely necessary to interpret the timestamps. So it fits ontologically very well into that kind of structure. ROTS guessed that it could be easily encoded in roughly 200 bits.

MARTIN BURNICKI said that there is a need to somehow transport the number of leap seconds into systems where no software updates are made. Also, as far as any recommendation to distribute TAI and compute UTC from it using the leap second file, the Olson timezone database already has the algorithms to use the "right" timezones. However, this database uses a different file format from the NIST. If ROTS was using the NIST leap second file, and if NTP uses the NIST leap second file, then BURNICKI would really appreciate if all the various time formats could be merged so that the NIST format was standardized and could be used with the Olson tz database. ALLEN said that at the Exton colloquium, DANIEL GAMBIS presented a paper on behalf of his colleagues about possibly enhancing the formats for IERS publications.[2] ALLEN felt that any features that are "wished for" should be incorporated into that effort. MAIN said some notes about file formats for a leap-second table would be in his paper. ALLEN thought that ideally the IERS could issue a "this-satisfies-all-the-requests list" but it would take some work to put together that agreement. ROTS clarified that for their purposes they use the U.S. Naval Observatory's leap-second file, and it would be sufficient for their purposes to add a semi-annual timestamp to that file to give sufficient trace-back.

SEAGO asked if ROTS recommended using (TAI−UTC) to recover TAI from UTC broadcasts, or recommended TAI broadcasts to recover UTC. ROTS' suggestion was to distribute (TAI−UTC) as a supplementary value with broadcast UTC. SEAGO noted that approach was currently advocated under ITU-R Recommendation TF.460-6 which defines UTC. ROTS said that switching it around to broadcast TAI might better satisfy those who want a timescale distributed without leap seconds. REDMAN said that "either way works." DENNIS MCCARTHY added that (TAI−UTC) is already distributed by IERS *Bulletin A*.

REDMAN said that the availability of (TAI−UTC) is one of the puzzling things from those "who jump up and down and insist that you cannot distribute TAI. In fact, if you distribute UTC and in the same packet give (TAI−UTC), then you have distributed TAI! So where is the issue?" Although there is a semantic issue as to what exactly the term 'TAI' means and whether it refers to something that only the BIPM distributes, if one accepts that broadcast UTC is 'what the BIPM distributes' then everyone is free to use the term 'TAI' in reference to UTC plus (TAI−UTC). But the BIPM has been insisting that 'TAI' is distributed *post hoc* via BIPM *Circular T* only and nothing else is allowed. With regard to distributing (TAI−UTC), JIM KIESSLING commented that "the difference is the same as the item itself" in that all the available information is provided. Whether its means of distribution is through GPS broadcasts or some other accurate method, recovered TAI may not be the same in a legal sense, but for all engineering intents and purposes it is hard to find a difference. REDMAN agreed.

GAMBIS said that when the BIPM began to disseminate its preliminary version of UTC, which is normally based on only a few good clocks, it appeared that the difference between the preliminary version and definitive TAI with a one-month delay was at the level of a few nanoseconds. REDMAN concurred, saying that the good time services nominally maintain an accuracy of about three (3) nanoseconds, and that "distribution of TAI is a semantic issue; it has nothing to do with engineering—nothing!"

BURNICKI wondered why there is not the same semantic issue for distributing UTC, because broadcast UTC is distributed by various national institutes and not the BIPM. MAIN exposed that BIPM *Circular T* actually describes the differences between the various realizations of TAI in the form of UTC: it is expressed as 'UTC−UTC(*k*)'! BURNICKI felt that this representation could also be used in the same way to express national realizations of TAI. Many attendees agreed. REDMAN said there is politics in the semantics here, and the semantic issues needed to be resolved so that people can simply write documentation; it covers nothing more than that.

REFERENCES

[1] 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. 230.

[2] Deleflie, F., D. Gambis, C. Barache, J. Berthier (2011), "Dissemination of UT1−UTC Through the Use of Virtual Observatory." Paper AAS 11-680, from *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. pp. 317-323.