WORKING GROUP A: THE FUTURE OF UTC SUMMARY OF THE DISCUSSION

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The discussion was introduced by Judah Levine, who presented background information on how Coordinated Universal Time (UTC) is computed at present:

a. UTC is derived from International Atomic Time (TAI), which is computed by the International Bureau of Weights and Measures (BIPM) using a weighted average of the times of an ensemble of about 200 cesium clocks and hydrogen masers that are located at various National Metrology Institutes and Timing Laboratories. The frequency of TAI is steered from time to time using data from a number of primary frequency standards. The frequency of UTC is identical to that of TAI except during a leap second.

b. The time of UTC is maintained within ±0.9 s of UT1, a time scale based on the rotation of the Earth, and additional integer "leap" seconds are added to UTC to maintain this relationship. Although both positive and negative leap seconds are defined by the standard, only positive leap seconds have ever been used, since the length of the UTC day is systematically too short relative to UT1. A leap second is announced in advance by the International Earth Rotation Service and is inserted into UTC as the last second of the last day of a month. The last minute of the day is 61 seconds long when a positive leap second is inserted, and the name of the extra leap second is 23:59:60. Leap seconds have always been inserted at the ends of June or December, but other months might also be used in principle.

c. Although a leap second has not been required since the end of 1999, the long-term average interval between leap seconds is somewhat more than 1 year, and that average interval is expected to continue to decrease for the foreseeable future, so that leap seconds will be required more and more frequently in the future.

Following this short introduction, Dr. Levine invited comments from the audience on the points that he mentioned or on any other issues related to UTC. The general discussion that followed concentrated primarily on the following two topics.

Topic 1: UTC should be made the legal time in the United States?

Background: Although the US is a signatory to the Treaty of the Meter, and US laboratories contribute data to the BIPM for the purposes of computing TAI and UTC, the legal time in the US is defined by

local Mean Solar Time, which is derived from Mean Solar Time on the Greenwich meridian with appropriate integer-hour offsets based on bands of longitude (time zones). The difference between local Mean Solar Time at the center of a time zone and UTC can be as large as ±0.9 s, and this difference could be significant in any application that depended on the legal definition of time where the required accuracy was higher than 1 s. Although there is no known opposition to this change, a proposal by NIST for a technical amendment has been pending for some time with no action scheduled.

There was some discussion about the exact wording of the change, and it was suggested that the matter should be referred to the Department of State for further study.

Topic 2: Leap seconds: Shall we keep the current system or change it? If we decide to change, what should the new system be?

The arguments for keeping the leap second system more or less as is are:

a. Many astronomical calculations implicitly depend on the fact that the difference between UT1 and UTC is small, so that the two can be used more or less interchangeably. This would not be true if leap seconds were no longer added to UTC.

b. The dating of ancient events is often possible only because they can be related to some known astronomical event, such as an eclipse. This job will become more difficult for future arche-ologists if the current close relationship between UT1 and UTC is abandoned.

c. The public relations problem. Religious groups and others who define holidays or other observances based on the times of local sunrise or sunset may be inconvenienced and may feel that they are being discriminated against. The UTC times of sunrise, noon, and sunset will slowly diverge from the "traditional" values. At present, these effects would be of order 1 minute per century if leap seconds were abandoned, so that the impact is more a matter of perception than any actual serious problem.

The arguments for abandoning the practice of adding leap seconds are:

a. Implementation of leap seconds causes problems and confusion.

1. The clocks in most computer systems cannot represent the leap second, and are effectively stopped for 1 second when it occurs. Thus, two consecutive seconds are assigned the same time tag. Leap seconds can occur in the middle of a working day in Asia and Australia.

2. Timing, navigation, and other systems depend on a smooth time scale, and this smoothness is disrupted during a leap second. These systems are used continuously, and changing the time at which a leap second was inserted would not lessen the impact of the event.

3. Leap seconds are relatively rare events, and they are often added at the wrong time or with the wrong sign because operators of timing facilities are not sufficiently familiar with them.

b. Leap seconds in UTC encourage the proliferation of private time scales, such as GPS system time. The number of these time scales is likely to increase in the future. The use of private time scales is not desirable in principle, and it can also be the source of additional confusion.

c. The potential difficulties with civilian applications are exaggerated. The current system of time zones results in offsets of up to ±30 minutes between local apparent solar time and the time of the zone, and there is an additional annual variation between mean and apparent solar times with an amplitude of about

15 minutes (the "equation of time"). Neither of these effects has ever caused any difficulties. However, these effects are well-known and can be calculated in advance, so that they do not introduce the same sort of uncertainty as leap seconds, which are not regular or predictable.

d. The problems associated with leap seconds are expected to become more serious as the average interval between them decreases. There are some estimates that the interval between leap seconds will be significantly less than 12 months by the year 2050.

After considerable discussion, the general opinion of those present was that a plan to stop adding leap seconds to UTC was the best solution, that no time step in UTC should accompany this decision (so that the existing leap seconds would be preserved) and that this new scale should replace all other scales that are in common use. There was some disagreement about whether this new scale should continue to be called UTC or whether some other name (such as International Time) might be more appropriate. There was no clear consensus on this last point of the name concerning the new scale. One proposal was to implement this change in 2022, the 50th anniversary of the introduction of the current leap-second system. This date was suggested so as to provide sufficient advance notice for those users who currently depend on the equivalence between UT1 and UTC.