Leap Second Survey Results

The June 30/July 1, 2012 leap second caused some confusion and concern among the stations, prediction providers, and analysts. This documents pulls together some of the experiences and some of the issues that we need to address.

Stations

This section is based on answers received to an ILRSsta mail query regarding problems experienced by the stations around the time of the leap second.

1) Many stations have hardware that adds the leap second at the right epoch.
2) Software at many stations does not use the leap second flag.
3) Some stations were not on duty or had weather problems over the June 30/July 1 change.
4) Key personnel were at times not available due to the weekend or vacation.
5) Some stations had a difficult time tracking or even finding certain satellites with predictions from certain providers.

Predictions

The leap second issue revolves around the prediction providers taking the endorsed course of action and doing something predictable, and the stations changing their clocks at the right time.

The CPF manual says that if a leap second is scheduled, **there must be a leap second flag in the predictions, and the provider should not have applied the leap second to the predictions.** This allows predictions for times before and after the leap second to coexist without a discontinuity. The stations must apply the leap second to the hardware at the correct epoch, and also to the predictions after the leap second occurred until the flag changes back to "0" in a subsequent prediction file.

If a provider has inadvertently applied the leap second to the predictions as well as setting the leap second flag, then there will be a one-second time-bias in the predictions after the time of leap second insertion, which the stations have no way to anticipate. So, it is quite important to follow the procedures precisely.

If there is no leap second flag in the predictions, the assumption is that the provider has applied the leap second to the predictions for times after leap second insertion. The stations must still apply the leap second to the hardware at the correct epoch.

If there is no leap second flag, the predictions will have a discontinuity for passes straddling the time of leap second insertion (assuming the station clock inserts the leap second automatically). If a station uses a 10-point interpolator, the discontinuity will be smoothed over 10 prediction records centered at the leap second insertion time. The greatest error will be at the leap second insertion time. For low satellites, this transition would happen over +/- 5 minutes centered on the leap second, but for most high satellites, +/- 1.25 hours (and +/- 4 hours for Etalon).

Because of this discontinuity and the potential of a one second time bias until the end of the predictions, the leap second flag must be used correctly by both the prediction providers and the stations.

Errors Observed

1. Most prediction providers (5) did not set the leap second flag.
2. Two providers set the flag improperly.
3. Two providers handled the leap second properly.

Providers that used the leap second flag incorrectly were contacted and will rectify the problem by the next leap second. Those who did not use it at all have not yet been contacted.

Predictions were and continue to be missing in a few cases. For at least one satellite there are no predictions from either EDC or CDDIS for July 1. July 1 predictions for several satellites were on EDC but not on CDDIS, probably as a consequence of the power outage at GSFC during on June 30 and July 1.

Analysis Centers

The analysis centers were also affected by leap second issues, such as: normal point time tag errors, internal leap second handling, and an error on the part of the USNO.

USNO inadvertently inserted the second leap second twice in their EOP files; this was not caught until the afternoon of July 1. This caused some bad data fits and confusion for several analysis centers and prediction providers until the source of the problem was found and corrected. In one case, the problem was not caught and the effects of the bad USNO input remained for a couple weeks.

One analysis center had to manually insert the leap second (a procedure that has since been automated). This, together with the USNO issue and some station(s) not applying the leap second, made for a difficult transition.

The absence of key personnel during the time of leap second insertion only made the problems worse.

The creation of predictions at another center required maintenance of an "artificial" continuous UT1-UTC series, one without the 1-second discontinuity. This required extra labor and care for a few days on either side of the leap second.

There is only one station that reported to have significant time tag problems due to the leap second, and it had a one-second time bias for the first 10 hours (15 passes) on July 1st. Another station reportedly submitted one pass with a time-tag problem.

Conclusion

There are several aspects of leap second handling that could be improved.

1) **PREDICTION PROVIDERS AND STATIONS MUST USE THE LEAP SECOND FLAG, AND USE IT CORRECTLY**
2) **STATIONS MUST APPLY THE LEAP SECOND PROPERLY TO ACCOMMODATE THE PREDICTIONS.**
3) Several SLRmail messages from the ILRS (most likely from the Central Bureau) reminding station personnel, analysts, and prediction centers of the leap second should be sent in the

months, weeks, and days prior to leap second insertion.

4) USNO input should not be trusted blindly, as this is an exceptional process for them as well as us.
5) Key personnel may want to consider postponing vacation time scheduled around the date of leap second insertion. This can be problematic when the leap second is inserted on weekends, and, typically, the leap second is inserted on January 1 or July 1, both prime vacation times.
6) Many stations automatically update their clock for the leap second. Those that don't should find a way to either automatically update it or to automatically remind the station staff to manually update it.
7) To assist stations, modified CPF sample code that handles the leap second flag and suggestions on its integration should be provided.