

Report of the working group on time transfer standards

Judah Levine
NIST, Boulder
jlevine@boulder.nist.gov

Activities of working group

- Informal membership
- Meeting at PTTI every year
 - Supported by NIST
 - Suggestions for different time and place?

Summary of the Report ...

- Additions to data format to support systems in addition to GPS
 - Discussed at last PTTI
 - Proposal distributed to laboratories
- Multipath problems and effects on calibration
 - Long-standing problem

Current data format with changes

```
PRN CL  MJD  STTIME
```

```
hhmmss
```

```
n17 18 53055 000600
```

```
n29 18 53055 002200
```

```
6xD4 53055 003800
```

n=1 for GLONASS, n=2 for Galileo, ...

x=single letter for augmentation system

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This figure shows a portion of the format currently used to report GPS data. The suggestions for changes are shown in color. We suggest that GLONASS data be identified using a PRN number of 100+the actual PRN number of the satellite. When data from the Galileo system become available, we suggest reporting these data using a PRN number of 200+the actual prn number of the satellite. If additional systems come into general use, we will reserve the other digits in this position to identify these data. This proposal should not affect any current application. In fact, using an identifier of 100+the satellite number is the current practice for identifying GLONASS data.

We suggest using the column after the PRN number to identify data from an augmentation system, such as WAAS or EGNOS. These data are less likely to be used for time comparisons, but we propose that the format should support these systems. The column following the PRN number is specified as a space in the current format description, so that the proposal should not affect any current application, since this position in the data is not currently used for any purpose. The only potential problem is that an application that expects a space in this position may have to be modified to accept a letter as well. The details of which letter will be assigned to which service will be decided in the future as data from these systems become available.

Multipath reflections

- Magnitude ≈ 10 ns p-p
- Irregular amplitude and period
 - Not white phase noise
 - Not averaged by 13-minute track time
- 4-minute daily advance of tracking schedule masks size of effect
 - Converted to a satellite-dependent bias
- Type "B" uncertainty

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The effect of multipath reflections is not averaged very well by the current format, since the period is not close to 13 minutes and is irregular in any case. Furthermore, the daily 4 minute advance of the tracking schedule tends to convert the effect of multipath to a constant offset that is different for each satellite. It is difficult to estimate the magnitude of this effect using the current tracking formats.

Estimating the effect

- Replace 13-minute track with multiple shorter tracks
 - Variation estimates multipath
- Simplify computation of track value
 - Rationale no longer necessary
 - Other advantages (P3 compatibility, ...)
- Calibration at more than 1 antenna position
 - 1 day with offset of few meters is sufficient

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It would be easier to estimate the effect of multipath if the current 13 minute tracks were replaced by multiple shorter tracks, since the variation from track to track and from day to day would provide an estimate of the size of the problem. In order to remain consistent with the older receivers that can only track for 13 minutes, the shorter tracks would have to be a simple fraction of the 13 minute value. One possibility would be to use a smaller number of 15 second averages – perhaps an average of about 2-3 minutes.

In addition, the complex computations of the current 13 minute track are not really appropriate any longer. They were designed to allow the older hardware to track the satellite in real time, but there is no reason to do this complicated averaging any longer. Furthermore, many newer receivers and most carrier phase systems cannot average the data in this way, since they produce a data point every 30 seconds. This rate cannot be made perfectly consistent with the technical specifications for reporting data, since these specifications are based on 1 second data. The problem is that the different methods average the noise in a different way, so that the two methods are likely to be different, especially when multipath is a serious problem.

One way of estimating the effect of multipath is to calibrate a receiver with the antenna at several positions. Moving the antenna even a few meters is sufficient for estimating the effects of multipath reflections. The effect can also be observed using a relatively small amount of data – a few days is sufficient.