# IMPLEMENTATION OF A STANDARD FORMAT FOR GPS COMMON VIEW DATA*

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Abstract

*A new format for standardizing common view time transfer data, recommended by the Consultative Committee for the Definition of the Second, is being implemented in receivers commonly used for contributing data for the generation of International Atomic Time. We discuss three aspects of this new format that potentially improve GPS common–view time transfer: (1) the standard specifies the method for treating short term data, (2) it presents data in consistent formats including needed terms not previously available, and (3) the standard includes a header of parameters important for the GPS common–view process. In coordination with the release of firmware conforming to this new format the Bureau International des Poids et Mesures will release future international track schedules consistent with the new standard.*

## INTRODUCTION

A new format for standardizing common view time transfer data, recommended by the Consultative Committee for the Definition of the Second (CCDS), is being implemented in receivers commonly used for contributing data for the generation of International Atomic Time (TAI). The primary means of remote clock comparison for generating TAI is common–view GPS time transfer[1] . The global accuracy for this type of time transfer is currently less than 10 ns[2] . Understanding the sources of inaccuracy, the BIPM initiated an effort to standardize data–taking methods used in receivers and data transfer methods used for reporting to the BIPM. By combining this effort with the use of good coordinates, precise GPS satellite ephemerides, and measured local ionospheric delays, we hope to increase the accuracy for common–view time transfer[3] .

One of the major motivations for standardization is the implementation of Selective Availability (SA) in GPS satellites. With SA, GPS timing is degraded as a way of limiting the navigation accuracy available to the standard positioning service (SPS) user. This follows since navigation in GPS is accomplished using measurements of time as received from satellites. If common–view time transfer is performed strictly, that is, with measurements taken on identical seconds, and with receivers which process the signals and the data identically, then the GPS satellite clocks cancel completely. SA makes this need for strict common–view even more important. We include in this paper some direct satellite data with SA and predict the effects on common–view time transfer due to differences in receivers. Thus, a standard can improve time transfer by allowing common–view time transfer to be done with different receivers and still cancel the effects of the satellite clock.

The new format has potential to improve GPS common–view time transfer due to a number of elements: (1) the standard specifies the method for treating short term data, (2) it presents data in consistent formats including needed terms not previously available, and (3) includes a header of parameters important for the GPS common–view process. Essential to common–view time transfer is that stations track satellites according to a common schedule. In coordination with the release of firmware conforming to this new format the Bureau International des Poids et Mesures (BIPM) will release future international track schedules consistent with the new standard. In this paper we summarize information about the short–term data processing, the header and the data format. When developing the standard for a receiver, one should obtain all the detailed information as reported in the Technical Directives[4] .

## SHORT TERM DATA PROCESSING

Data processing is performed as follows:

1. Pseudo–range data are recorded for times corresponding to successive dates at intervals of 1s. The date of the first pseudo–range data is the nominal starting time of the track. It is referenced to UTC and appears in the data file under the acronyms MJD and STTIME.

2. Least–squares quadratic fits are applied on successive and nonoverlapping sets of 15 pseudo–range measurements taken every second. The quadratic fit results are estimated at the date corresponding to the midpoint of each set.

3. Corrections are applied to the results of (2) to obtain estimates of the local reference minus the Satellite Vehicle (SV) clock (REFSV) and of the local reference minus GPS time (REFGPS) for each 15 second interval.

4. The nominal track length corresponds to the recording of 780 short–term measurements. The number of successive and nonoverlapping data sets treated according to (2) and (3) is then equal to 52. For full tracks, the track length TRKL will thus equal 780 s.

5. At the end of the track, least–squares linear fits are performed to obtain and store the midpoint value and slope for both REFSV and REFGPS. Since these two are related deterministically by nearly a straight line they will have the same rms deviation around the fit, which is also stored as DSG. In addition, least–squares linear regression gives the midpoint and slope of the ionospheric and tropospheric model values, and the ionospheric measurements if they exist.

## THE EFFECTS OF SA

We investigate the effects of SA by taking measurements every 15 s of GPS – UTC(NIST) tracking different satellites from horizon to horizon. We took data sequentially from three different satellites on two consecutive days, November 21–22, 1994. The satellites had pseudo–random code numbers (PRN's) 20, 22, and 25. Figures 1–3 show the data from the three satellites, and Figures 4–6 show the time deviation TDEV of the three, respectively.

The new standard will cancel all the clock dither when used for common–view GPS time transfer, provided that each of the two receivers involved track the same satellites over the same time periods. If there is a difference of 15 s in the tracking, for example if one receiver tracks 15 s less than the other, then the clock dither of SA will corrupt the common–view time transfer. We can estimate this by looking at the expected dispersion in time at due to SA at 15 s. The rms of the three TDEV values for $\tau$=15 s is 11 ns. From the TDEV plots we see that the slope on the log–log plots starts consistent with a model of $\tau^0$ from 15–30 s. If we assume a model of flicker phase modulation (PM) for $\tau$=15 s this implies an expected time dispersion of 13 ns[5] . Over a 13 min track there are 52 estimates of REFGPS and REFSV each from a quadratic fit over 15 s of data. Let us consider the case where one track is a full–length track and the matching track in another receiver is 15 s short. If we can assume that the effects of one 15 s point average down in the linear fit as the square root of the total number of points, then we can expect the effect on the common–view time transfer to be

$$\frac{13\text{ns}}{\sqrt{52}} = 1.8 \text{ ns}. \tag{1}$$

Thus SA could add approximately 2 ns to a common–view uncertainty budget with only a mis–match of 15 s from exact common–view. With a goal of 1 ns we see the reason why a standard for data taking can help common–view time transfer.

Many users receive GPS time directly from the satellites without using the common–view method to compare with another lab. From considering the TDEV of SA, we can design a filter that averages SA optimally, to allow users to obtain the best possible restitution of GPS time[6] . From the three TDEV analyses we see a bump rising from 1 min and dropping at 16 min. This effect could be due in part to a periodic behavior with a period of approximately 16 min[7,8] . Averaging can improve the GPS restitution if the TDEV values drop with increasing <insert 4>. Yet there is no indication in these data that the TDEV values drop significantly beyond 16 min. This may be due to effects at the beginning and end of the tracks when the elevation is low. This suggests limitations on the potential for filtering SA. Yet our data were taken using a single channel receiver. A multi–channel receiver could improve on filtering. It may be that the combination of SA signals still drop in TDEV, allowing improvement from averaging.

## THE DATA FORMAT

The data format consists of:

1. a file header with detailed information on the GPS equipment,
2. a line header with the acronyms of the reported quantities,
3. (3) a unit header with the units used for the reported quantities,
4. (4) a series of data lines, one line corresponding to one GPS track. The GPS tracks are ordered in chronological order, the track reported in line n occurring after the track reported in line (n-1). Each line of the data file is limited to 128 columns and is terminated by a carriage-return and a line feed. The format for one line of data can be represented as follows:

### No measured ionospheric delays available

```
000000000000000000000000000000000000000000000
000000000111111111122222222223333333333444444
123456789012345678901234567890123456789012345 6
PRN*CL**MJD**STTIME*TRKL*ELV*AZTH***REFSV*****
*************hhmmss**s**.1dg*.1dg****.1ns*****
*12*12*12345*121212*1234*123*1234**+1234567890*
```

```
00000000000000000000000000000000000000000000000011
44455555555555666666666677777777778888888888999999999900
78901234567890123456789012345678901234567890123456789 01
*SRSV*****REFGPS****SRGPS**DSG*IOE*MDTR*SMDT*MDIO*SMDI*
.1ps/s*****.1ns****.1ps/s*.1ns*****.1ns.1ps/s.1ns.1ps/s
+12345**+1234567890**+12345*1234*123*1234**+123*1234**+123*
```

```
11111111111111111111111111
00000000111111111122222222
23456789012345678901234567 8
CK
**
12optionalcommentsoptionalc
```

## Measured ionospheric delays available

```
000000000000000000000000000000000000000000000
000000000111111111122222222223333333333444444
123456789012345678901234567890123456789012345 6
PRN*CL**MJD**STTIME*TRKL*ELV*AZTH***REFSV*****
*************hhmmss**s**.1dg*.1dg****.1ns*****
*12*12*12345*121212*1234*123*1234**+1234567890*
```

```
0000000000000000000000000000000000000000000000000000011
4445555555555666666666677777777778888888888999999999900
7890123456789012345678901234567890123456789012345678901
*SRSV*****REFGPS****SRGPS**DSG*IOE*MDTR*SMDT*MDIO*SMDI*
.1ps/s*****.1ns****.1ps/s*.1ns*****.1ns.1ps/s.1ns.1ps/s
+12345**+1234567890**+12345*1234*123*1234**+123*1234**+123*

111111111111111111111111111
000000001111111111222222222
234567890123456789012345678
MSIO*SMSI*ISG*CK
.1ns.1ps/s.1ns**
1234**+123*123*12optcomments
```

The following is an example of what the data looks like, using fictitious data.

### Example (fictitious data)

```
GGTTS GPS DATA FORMAT VERSION = 01
REV DATE = 1993-05-28
RCVR = AOA TTR7A 12405 1987 14
CH = 15
IMS = 99999 or IMS = AIR NIMS 003 1992
LAB = XXXX
X = +4327301.23 m
Y = +568003.02 m
Z = +4636534.56 m
FRAME = ITRF88
COMMENTS = NO COMMENTS
INT DLY = 85.5 ns
CAB DLY = 232.0 ns
REF DLY = 10.3 ns
REF = 10077
CKSUM = C3 or CKSUM = 49
```

No measured ionospheric delays available

```
PRN CL  MJD  STTIME TRKL ELV AZTH   REFSV      SRSV      REFGPS     SRGPS  DSG
IOE MDTR SMDT MDIO SMDI CK
             hhmmss  s  .1dg .1dg    .1ns     .1ps/s     .1ns     .1ps/s .1ns       .1ns.1ps/s
  3 8D 48877  20400  780 251 3560   -3658990   +100        +4520   +100   21 221    64  +90
-27 BBhello
 18 02 48877  35000  780 650  910  +56987262  -5602        +5921  -5602  350 123   102  +61
281  +26 52
 15 11 48878 110215  765 425 2700     +45893  +4892        +4269  +4890  306  55    54  -32
+15 A9
 15 88 48878 120000  780 531 2850     +45992  +4745        +4290  +4745  400  55    57  -29
+16 18receiv. out of operation
```

Measured ionospheric delays available

```
PRN CL  MJD  STTIME TRKL ELV AZTH   REFSV      SRSV      REFGPS     SRGPS  DSG
IOE MDTR SMDT MDIO SMDI MSIO SMSI ISG CK
             hhmmss  s  .1dg .1dg    .1ns     .1ps/s     .1ns     .1ps/s .1ns
.1ns.1ps/s.1ns.1ps/s.1ns.1ps/s.1ns
  3 8D 48877  20400  780 251 3560   -3658990   +100        +4520   +100   21 221    64  +90
-27  480  -37  18 F4hello
 18 02 48877  35000  780 650  910  +56987262  -5602        +5921  -5602  350 123   102  +61
281  +26 9999 9999 999 89no meas ion
 15 11 48878 110215  765 425 2700     +45893  +4892        +4269  +4890  306  55    54  -32
+15  599  +16  33 29
 15 88 48878 120000  780 531 2850     +45992  +4745        +4290  +4745  400  55    57  -29
+16  601  +17  29 00rec out
```

The definitions of the acronyms used in the data format follow. Note that a * stands for a space, ASCII value 20 (hexadecimal). Text to be written in the data file is indicated by ' '.

### File header

Line 1: 'GGTTS*GPS*DATA*FORMAT*VERSION*=*01, title to be written.

Line 2: REV*DATE*=*' YYYY'-'MM'-'DD, revision date of the header data, changed when 1 parameter given in the header is changed. YYYY-MM-DD for year, month and day.

Line 3: 'RCVR*=*' MAKER'*'TYPE'*'SERIAL NUMBER'*'YEAR'*', maker acronym, type, serial number, first year of operation, and eventually software number of the GPS time receiver.

Line 4: 'CH*=*' CHANNEL NUMBER, number of the channel used to produce the data included in the file, CH = 01 for a one-channel receiver.

Line 5: 'IMS*=*' MAKER'*'TYPE'*'SERIAL NUMBER'*'YEAR'*', maker acronym, type, serial number, first year of operation, and eventually software number of the Ionospheric Measurement System. IMS = 99999 if none.

Line 6: 'LAB*=*' LABORATORY, acronym of the laboratory where observations are performed.

Line 7: 'X*=*' X COORDINATE '*m', X coordinate of the GPS antenna, in m and given with at least 2 decimals.

Line 8: 'Y*=*' Y COORDINATE '*m', Y coordinate of the GPS antenna, in m and given with at least 2 decimals.

Line 9: 'Z*=*' Z COORDINATE '*m', Z coordinate of the GPS antenna, in m and given with at least 2 decimals.

Line 10: 'FRAME*=*' FRAME, designation of the reference frame of the GPS antenna coordinates.

Line 11: 'COMMENTS*=*' COMMENTS, Any comments about the coordinates, for example the method of determination or the estimated uncertainty.

Line 12: 'INT*DLY*=*' INTERNAL DELAY '*ns', internal delay entered in the GPS time receiver, in ns and given with 1 decimal.

Line 13: 'CAB*DLY*=*' CABLE DELAY '*ns', delay coming from the cable length from the GPS antenna to the main unit, entered in the GPS time receiver, in ns and given with 1 decimal.

Line 14: 'REF*DLY*=*' REFERENCE DELAY '*ns', delay coming from the cable length from the reference output to the main unit, entered in the GPS time receiver, in ns and given with 1 decimal.

Line 15: 'REF*=*' REFERENCE, identifier of the time reference entered in the GPS time receiver. For laboratories contributing to TAI it can be the 7-digit code of a clock or the 5-digit code of a local UTC, as attributed by the BIPM.

Line 16: 'CKSUM*=*' XX, header check–sum: hexadecimal representation of the sum, modulo 256, of the ASCII values of the characters which constitute the complete header, beginning with the first letter 'G' of 'GGTTS' in Line 1, including all spaces indicated as * and corresponding to the ASCII value 20 (hexadecimal), ending with the space after '=' of Line 16 just preceding the actual check sum value, and excluding all carriage returns or line feeds.

Line 17: blank line.

## Acronyms

The following are the defintions of the acronyms

| | |
|---|---|
| PRN: | Satellite vehicle PRN number. |
| CL: | Common–view hexadecimal class byte. |
| MJD: | Modified Julian Day. |
| STTIME: | Date of the start time of the track in hour, min and second referenced to UTC. |
| TRKL: | Track length, 780 for full tracks, in s. |
| ELV: | Satellite elevation at the date corresponding to the midpoint of the track in 0.1 degree. |
| AZTH: | Satellite azimuth at the date corresponding to the midpoint of the track in 0.1 degree. |
| REFSV: | Estimate of the time difference of local reference minus SV clock at the middle of track from the linear fit, in 0.1 ns. |
| SRSV: | Slope of the linear fit for REFSV 0.1 ps/s. |
| REFGPS: | Estimate of the time difference of local reference minus GPS time at the middle of the track from the linear fit, in 0.1 ns. |
| SRGPS: | Slope of the linear fit for REFGPS 0.1 ps/s. |
| DSG: | [Data Sigma] Root mean square of the residuals to the linear fit for REFGPS in 0.1 ns. |
| IOE: | [Index of Ephemeris] Three digit decimal code (0-255) indicating the ephemeris used for the computation. |
| MDTR: | Modelled tropospheric delay at the middle of the track from the linear fit, in 0.1 ns. |
| SMDT: | Slope of the modelled tropospheric delay resulting from the linear fit in 0.1 ps/s. |
| MDIO: | Modelled ionospheric delay resulting from the linear in 0.1 ns. |
| SMDI: | Slope of the modelled ionospheric delay resulting from the linear fit in 0.1 ps/s. |
| MSIO: | Measured ionospheric delay resulting from the linear fit in 0.1 ns. |
| SMSI: | Slope of the measured ionospheric delay resulting from the linear in 0.1 ps/s. |
| ISG: | [Ionospheric Sigma] Root mean square of the residuals to the linear fit in 0.1 ns. |
| CK: | Data line check–sum: hexadecimal representation of the sum, modulo 256, of the ASCII values of the characters which constitute the data line, from column 1 to space preceeding the check–sum. (both included). There can be optional comments on the data line after the check sum out to the 128 character line length. These characters are not included in the line check–sum. |

# CONCLUSIONS

The new GPS data format, along with the prescription for processing short term data, can help improve common–view time transfer. Especially with the implementation of SA, common–view tracks can be significantly degraded if the two receivers tracking in common view do not work identically. The new standard can help us move toward a goal of 1 ns time transfer accuracy across intercontinental distances using GPS time transfer in common–view.

## REFERENCES


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## QUESTIONS AND ANSWERS

**DAVID ALLAN (ALLAN'S TIME):** I would like to just highlight the importance of the paper you presented on this new standard. Just to tell everybody, we believe, as we go through the theory of all the errors in common view, that with this new standard that an accuracy of one ns is achievable. To date, only about four ns has been documented just by way of where we are versus where we think the standard can take us. So I think it's very important work for the operational aspects, for clock input to TAI and UTC. So thank you for sharing it with us.

The other point that I would like to make is on the TDEV plot, that it is not a necessary and sufficient condition that if you have a hump in the data that it's due to a periodic event. There are at least two, and probably more, basic processes in the essay spectrum, and if one looks at longer–term data, in fact, this is confirmed; and there is not necessarily just the 60–minute type periodic phenomena. It's really two pretty much separate parallel processes; and, in fact, period modeling is not the best model that one would want to use.

I simply want to point out that it's not a necessary and sufficient condition, given a hump, that there is a periodic event.

**M.J. VANMELLE (ROCKWELL):** A couple of things. The rubidium is on 20 and not on 25. So it's hard to tell between rubidiums and cesiums there.

Also, did you ever do the experiment on the satellites that don't have SA on them, like number ten? Do you get that same two ns error with 15 seconds separation?

**MARC A. WEISS (NIST):** No, it's lower. I'm sorry, at 15 seconds, I'm not sure. There should be very short–term –- I'm not sure what we were trying.

**HAROLD CHADSEY (USNO):** A quick question for you. You were talking about the fact that when you do the common view that everything drops out. What about geometrical effects? Also, the fact that speed of the wave is not constant through the atmosphere, and you'll be effected more through a thick atmosphere than through a small atmosphere?

**MARC A. WEISS (NIST):** What I said that the effects of Selective Availability cancel completely if you do exact common– view time transfer and use a post–process ephemeris. Of course, the effects of ionosphere and troposphere are still there. Those need to be dealt with. The ionosphere, by measuring, and the troposphere can be helped also with measurements. They need to be if we're going to get the best we can.

**GERNOT M. WINKLER (USNO):** I think the time has come to start a little controversy, because we are all too peaceful down here. You have somehow attacked obliquely one of the tenants of my gospel which I have been preaching for 10 years. That is the melting pot method can average out by having a sufficient amount of data –- it can average out the effects of Selective Availability. Your comment was that you cannot be sure that biases are averaging out.

I want to remind you that the common view –- that's true; I mean, the common view cancels the effect of Selective Availability; but in the Selective Availability, the satellites themselves are not correlated; and the noise, which is superimposed, is strictly bounded. So if you have these conditions and a sufficient amount of data collection, you completely suppress the individual noise. It just depends on how much data you need. And it turns out that if you have an eight–channel receiver and you average about six hours, that you cannot distinguish the resulting time transfer data from what we obtain with the keyed receiver.

The great advantage of a melting–pot method, compared to the common view, is that it is a robust method. You obtain perfection just commensurate with the effort that you have. You have internal checks on the result which you have, because we have a statistic of the variations. In a case of the common view, you have nothing. We know that in practice your one ns or two ns accuracy cannot be achieved. The question is, how do you check operation in an automatic system? How do you check that you really can rely on a single data point in comparison to the melting pot where you always have lots of data? Whatever happens, it will produce an outlier which is rejected.

So, I wanted to bring that out because there is a great difference in the basic philosophy. In the common view, theoretically you have a superior method; but in practice, I maintain there are weaknesses; and do you lack a measure of performance as compared to the melting–pot method where you have everything you need? Do you have really a robust method which protects you against outliers of whatever magnitude in fact?

**MARC A. WEISS (NIST):** I would like to respond to that. Thank you, Dr. Winkler. I know for years now we've had differences on this. It's going to wake people up a little bit. One point is that we don't have only a point in common view. We can do pretty much everything with common view that you do with a melting pot, and more. That with the melting pot, if you have a eight–channel receiver at two locations, then why not take the eight channels of data simultaneously at the two locations and cancel all the effects of SA, and then use robust statistics on the resulting data where all the biases have been cancelled, and all that's left is the noise? So I think all the statistics that you do with melting pot are still there with common view.

The other thing is that because data are bounded does not in itself imply that averaging brings you down to a single correct number. It may, in fact -- I don't doubt that it has worked on many occasions; but simply saying that they're bounded does not -- there's no reason that it should average down correctly.

**GERNOT M. WINKLER (USNO):** But we have a check, because you look at the distribution of your measurement points. On that you simply add all that area, which we have to do to obtain the competence of that area.

**MARC A. WEISS (NIST):** I don't agree with that. You can have all the data averaging down to the wrong number. I understand that that is not what you've found by doing it. But there's no guarantee that that always will happen.

**CLAUDINE THOMAS (BIPM):** Of course, I will have some words. For TAI, we have 46 contributing laboratories, I mean, laboratories keeping local UTC; and most of them are using GPS now. First of all, all of these laboratories, except maybe USNO, have only one channel CA code receiver. That is to say, except for USNO, no one has one channel receivers which are given reliable measurements. So obviously, we have no data to do the measurements at the present time. Maybe it will come, but that's not the case for the moment. That's the first point.

The second point is that view of the BIPM for the computation of TAI has always been to try to reduce errors in the physical phenomena which are invoked; for instance, for the ionospheric delay, we like to use measured ionospheric delays as they are labelled. For the position of the satellite, we like to use precise satellite ephemerides. For the antenna coordinates, huge work was done some years ago by my colleague, Dr. Lewandowski (he can speak about that) in which he found accurate positions for the antennas. So we have always tried to phase all our sources and trying to reuse them. That was our viewpoint and that is what we did until now. That was the way we worked.

The last point, of course, common-view time transfer is done, it's computed. To find time difference between two local UTCs, we have a range, of course, for a long-distance time link, like between NIST and OP; we have a range common view for, let's say, two or three days. So we have some kind of average of course. For a smaller distance, like between Paris and PTB, Germany, we have a range, let's say, of less than one day. So that is to say we have some kind of average too.

I would say that what we are doing at the present time is the best we can do with the data we have.

**RICHARD KEATING (USNO):** You've stated that with common view, you're eliminating all these errors. I assume that's because of symmetry. But that's a theoretical position. When you get down to actual practice, reality doesn't always follow theory. I just have to ask you, how confident are you that you have no biases in common view? Can you really say that you can average and you are not getting any biases?

**MARC A. WEISS (NIST):** Well what would a bias be due to?

**RICHARD KEATING (USNO):** Well, for example, I'll give you an example. I have seen estimates of precise ephemeris accuracies. They've ranged from anything from one meter to 20 meters. There is a real possibility there that your precise ephemerides may not be as accurate and may contain real biases.

**MARC A. WEISS (NIST):** I think that's a good point in fact. Biases have to be due -- if you look at the common-view process, you have the satellite and then you have the ground stations on the earth; and then you have the atmosphere. So if you measure it exactly at the same time -- the only thing I'm claiming that cancels exactly is Selective Availability. In fact, the only thing I know for sure that cancels is clock dither. The ephemeris cancels to the extent that an error is perpendicular to the line between the satellites. If there is an error in the satellite position, it will add an error to common-view time transfer. And in fact, with precise ephemerides, prior to having the laser reflector, we had no way of knowing if they were accurate. They were simply consistent.

Errors can also come in the atmosphere due to ionosphere and due to troposphere, due to multi-path at the stations, and due to coordinate errors. So all of those things can add errors. It's going to be true whether you're using melting pot or common view or anything. Those are all in GPS. Whenever you do GPS, you're concerned about ephemeris, ionosphere, troposphere, and multi-path, and coordinates.

I think a point that I would really like to stress about that -- and I think your point is well made -- is that it's the difference between accuracy and stability; that you can have numbers that agree perfectly, that are extremely well consistent and are consistently wrong. For example, if you took a commercial cesium clock -- and this is the difference between a commercial cesium and a laboratory primary standard. If you have a commercial cesium and it's produced by a manufacturing technique, and there's a millimeter error in the end-to-end phase shift in the cavity, all the clocks will have that; and they'll all be off in frequency because of that, in exactly the same way; and all the other effects will average down and you'll end up with a bias that does not average.

That's an example of the difference between stability and accuracy. I think we need to be very careful when we use the word "accuracy." We're not talking about something that you can average; we're talking about something that you have to prove.

**GERNOT M. WINKLER (USNO):** You're example is making my point. How do you find out that all of these cesiums have a bias?

**MARC A. WEISS (NIST):** You evaluate them.

**GERNOT M. WINKLER (USNO):** You evaluate them and you look at the statistical distribution of what there frequencies are; and you compare them with a standard. You found out how it is.

**MARC A. WEISS (NIST):** But you don't compare with another standard. You evaluate them independently; you measure the effects through something that's completely independent.

**CLAUDINE THOMAS (BIPM):** There's a very big question of the difference between stability, precision and accuracy of course. There were some fundamental and formal papers about that at the BIPM. We consider that an accuracy is characterized by an uncertainty given as a one sigma value which was from the quadratic sum of the different uncertainties which are estimated from the different sources of errors which appear within common-view time transfer. I have already at the BIPM tried to do that, and I think that we can estimate an uncertainty of about 10 ns, it's eight to ten ns, one sigma for long-distant GPS common view, using precise satellite ephemerides from the IGS, and ionospheric measurements and with the hypotheses that the receivers themselves are correctly calibrated, which may not be the case; and which could add, of course, a bias. So let's say eight to ten ns, one sigma as the accuracy of GPS common views.