Rapport BIPM-2008/02

BUREAU INTERNATIONAL DES POIDS ET MESURES

DETERMINATION OF THE DIFFERENTIAL TIME CORRECTIONS FOR GPS TIME EQUIPMENT LOCATED AT THE OP, NTSC, HKO, TL, SG, AUS, KRIS, NMIJ, and NICT

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Abstract

The BIPM continues a series of differential calibrations of GPS equipment located in time laboratories contributing to TAI. This report details measurements which took place from 23 July 2004 to 21 February 2005, involving GPS time equipment located at the Observatoire de Paris (OP, Paris, France), the National Time Service Center of China (NTSC, Lintong, P.R. China), the Hong Kong Observatory (HKO, Hong Kong, P.R. China), the Telecommunication Laboratories (TL, Chung-Li, Taiwan), the Standards Productivity and Innovation Board (SG, Singapore), the Consortium of Laboratories in Australia (AUS, Sydney, Australia) the Korea Research Institute of Standards and Science (KRIS, Daejeon, Rep. Of Korea), the National Metrology Institute of Japan (NMIJ, Tsukuba, Japan), and the National Institute of Information and Communications Technology (NICT, Tokyo, Japan).

INTRODUCTION

The BIPM is conducting a series of differential calibrations of GPS equipment located in time laboratories contributing to TAI.

As for previous trips, the GPS time equipment located at the OP was chosen as reference. To check the reproducibility of the measurements, the calibrations were organized as round trips beginning and ending at the OP. The OP has often served in the past as the reference laboratory for GPS calibrations. Over the last twenty years its GPS time receiver has been compared several times with the NIST absolutely-calibrated reference GPS time receiver. The difference between these two has never exceeded a few nanoseconds.

Repeated determinations of the differential time corrections for the GPS time equipment located in the various laboratories should:

- improve the accuracy of the access to UTC of participating laboratories;
- provide valuable information about the stability of GPS time equipment; and
- serve as provisional differential calibrations of the two-way equipment at the laboratories.

This report details an exercise which took place from 23 July 2004 to 21 February 2005. Succeeding visits are scheduled to take place at four to five month intervals.

EQUIPMENT

Details of the receivers involved are provided in Table 1. More information about the set-up of equipment at each location is provided in Appendix I.

Table 1. GPS equipment involved in this comparison.

Laboratory	Receiver Maker	Receiver Type	Receiver Ser. No
OP	AOA	TTR-5	051
NTSC	NTSC Laboratory	NTSCGPS-1	-
HKO	EMDE Electronics	TTS-2	053
TL	NML/Topcon	Euro-80 Dual Frequency	-
SG	NML/Oncore	Oncore VP card	-
AUS	NMIA/Topcon	Topcon Euro-80	8RQRFKXT534
KRIS	Javad	Euro-80	IRT0112301
NMIJ	AOA	TTR-6	484
NICT	Javad	Euro-80	8PN45EETDKW
BIPM portable receiver	EMDE Electronics	TTS-2	036

The portable BIPM receiver is equipped with a C128 cable. Its delay measured at the BIPM is 187.75 ns with a standard deviation of 0.4 ns.

This delay was measured using a double-weight pulse method with a time interval counter steered by an external frequency source (an Active Hydrogen Maser CH1-75, KVARZ). We measured at the very beginning of the linear part of the rising pulse at each end of the cable using a 0.5 V trigger level [1].

The delay of this cable was also measured at the visited laboratories. The results are reported in Appendix II.

CONDITIONS OF COMPARISON

For the present comparison, the portable equipment comprised the receiver, its antenna and a calibrated antenna cable. The laboratories visited supplied: (a) a 10 MHz reference signal; and (b) a series of 1 s pulses from the local reference, UTC(k), via a cable of known delay. In each laboratory the portable receiver was connected to the same clock as the local receiver and the antenna of the portable receiver was placed close to the local antenna. The differential coordinates of the antenna phase centres were known at each site with standard uncertainties (1σ) of a few centimetres.

RESULTS

The processing of the comparison data obtained in laboratory *k* consists first of computing, for each track *i*, the time differences:

$$\mathrm{d}t_{k,i} = [UTC(k) - GPS\ time]_{\mathrm{BIPM},i} - [UTC(\mathrm{k}) - GPS\ time]_{k,i}\ .$$

The noise exhibited by the time series dt_k is then analysed, for each of the laboratories visited, by use of the modified Allan variance. In each case, white phase noise was exhibited up to an averaging interval of about one day. We illustrate this in Figure 1.

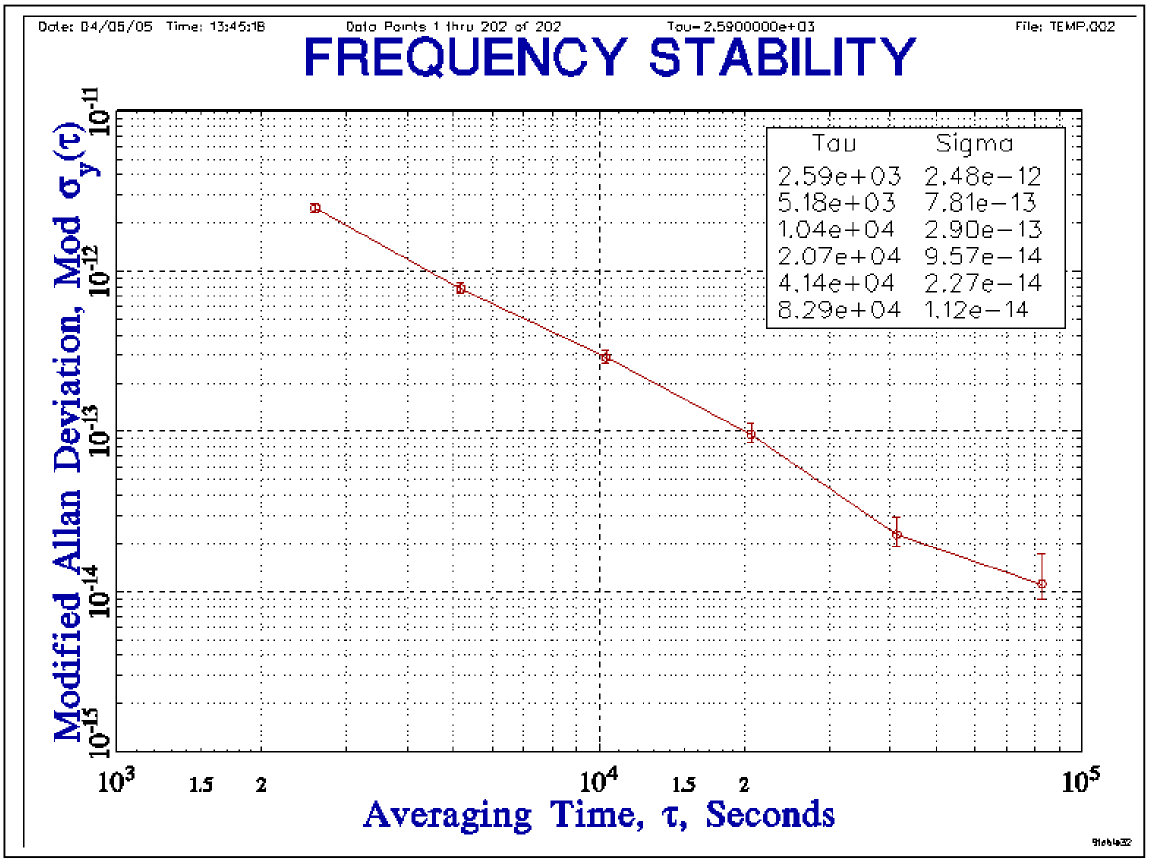

Figure 1. Square root of the modified Allan variance of the time series dt_{OP} for the period: 16 February 2005 to 21 February 2005.

The one-day averages are reported in Figure 2 and Appendix III. The level of noise for one-day averaging period is reported in Table 2.

[REF(Lab*k*)-(GPS TIME)] $_{\mathrm{BIPM}}$ **-[REF(Lab*k*)-(GPS TIME)]** $_{\mathrm{Lab}k}$

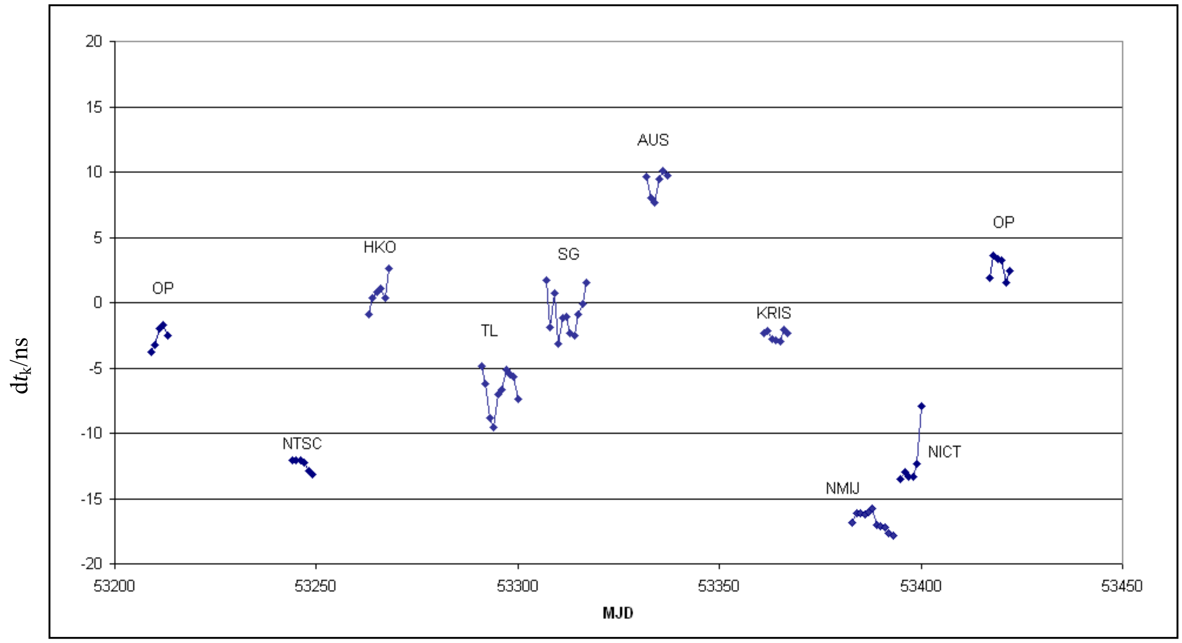

Figure 2. Daily averages of $dt_{k,i}$ for each laboratory *k* (see Appendix III).

Next, we computed mean offsets for the full duration of comparison at each location, and the corresponding standard deviations of individual common view measurements (see Table 2).

Table 2. Mean offsets for the full duration of the comparison at each location.

Lab	Period	Total number of common views	Mean offset /ns	Standard deviation of individual common view observations /ns	Level of noise for 1 day /ns	Dispersion of daily mean /ns
OP	23/07 – 27/07/04	173	-2.49	3.24	0.5	0.88
NTSC	27/08 – 01/09/04	2697	-12.35	1.71	0.3	0.48
HKO	15/09 – 20/09/04	586	0.38	1.89	0.3	1.15
TL	13/10 – 22/10/04	3098	-6.66	3.55	0.9	1.55
SG	29/10 – 08/11/04	3267	-1.18	7.12	1.0	1.63
AUS	23/11 – 28/11/04	1966	9.05	3.22	0.4	0.99
KRIS	22/12 – 28/12/04	2148	-2.49	2.35	0.3	0.36
NMIJ	13/01 – 23/01/05	463	-16.69	4.54	0.5	0.70
NICT	25/01 – 30/01/05	1531	-13.04	3.37	0.5	2.14
OP	16/02 – 21/02/05	203	2.77	3.55	0.5	0.83

The "closure" – the difference between the first and last sets of measurements made at the OP – was within a several nanoseconds, which is within acceptable limits. After averaging the results of the two sets of measurements at the OP, we derived differential time corrections which should be made (added) to time differences derived during the GPS comparisons of the time scales kept by the laboratories. The results are summarized in Table 3.

Table 3. Differential time correction *d* to be added to[$UTC(\mathrm{k}_1) - UTC(\mathrm{k}_2)$], and its estimated uncertainty *u*(*d*) for the period of comparison (1σ).

[*UTC*(k_1)-*UTC*(k_2)]	*d*/ns	*u*(*d*)/ns
[*UTC*(NTSC)-*UTC*(OP)]	-12.5	3.0
[*UTC*(HKO)-*UTC*(OP)]	0.2	3.0
[*UTC*(TL)-*UTC*(OP)]	-6.8	3.0
[*UTC*(SG)-*UTC*(OP)]	-1.3	7.0
[*UTC*(AUS)-*UTC*(OP)]	8.9	3.0
[*UTC*(KRIS)-*UTC*(OP)]	-2.6	3.0
[*UTC*(NMIJ)-*UTC*(OP)]	-16.8	4.0
[*UTC*(NICT)-*UTC*(OP)]	-13.2	3.0

The uncertainties given in this table are conservative. They are mainly driven by the uncertainty due to the 'round-trip' reproducibility at the OP.

For information we provide in Table 4 results of some past calibrations between NIST and OP.

Table 4. Some past calibrations between NIST and OP: *d* are differential time corrections to be added to [*UTC*(NIST)-*UTC*(OP)], and *u(d)* are estimated uncertainties for the periods of comparisons.

Date	*d*/ns	*u(d)*/ns	Reference
July 1983	0.0	2.0	[2]
January 1985	–7.0#	13.0	[3]
September 1986	0.7*	2.0	[4]
October 1986	–1.4*	2.0	[4]
January 1988	–3.8*	3.0	[5]
April 1988	0.6*	3.0	[6]
March 1995	–3.7*	1.0	[7]
May 1996	–0.7*	1.5	[8]
May 2002	–5.0*	3.0	[9]
July 2003	–5.6*	1.9	[10]
December 2003	-4.6*	3.0	[11]

NBS03 receiver at NIST
* NBS10 receiver at NIST

CONCLUSION

These measurements are part of a series of differential calibrations of GPS equipment located time laboratories contributing to TAI. They improve accuracy of the access to UTC of participating laboratories.

The present measurements were performed under good conditions with an acceptable closure of travelling equipment at the OP. The GPS time equipment of most of participating laboratories were showing good are acceptable level of noise. Only at the SG the receiver was exhibiting unusually high level of noise, most likely due to a problem of antenna and ionosphere modelling in local receiver.

Acknowledgements

The authors wish to express their gratitude to their colleagues for unreserved collaboration they received. Without this, the work could not have been accomplished.

REFERENCES

[1] G. de Jong, "Measuring the propagation time of coaxial cables used with GPS receivers," *Proc. 17th PTTI,* pp. 223-232, December 1985.
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[6] BIPM Letter of 15 June 1988, BG/9G.69.
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[8] M.A. Weiss, "Calibration of OP Receiver AOA51 Against NIST Receiver NBS10" March 1996.
[9] W. Lewandowski, P. Moussay, "Determination of the differential time corrections for GPS time equipment located at the OP, IEN, ROA, PTB, NIST, and USNO", *BIPM Report -2002/02*, July 2002.
[10] M.A. Weiss, "Calibration of OP Receiver AOA51 Against NIST Receiver NBS10" July 2003.
[11] W. Lewandowski, L. Tisserand, "Determination of the differential time corrections for GPS time equipment located at the OP, PTB, AOS, KRISS, CRL, NIST, USNO and APL", *BIPM Report -2004/06*.

<u>Appendix I</u>

Set-ups of local and portable equipment at each location
(forms completed by the participating laboratories)

BIPM GPS calibration information sheet

Laboratory:	NTSC
Date and hour of the beginning of measurements:	27 August 2004
Date and hour of the end of measurements:	1 September 2004

Receiver setup information

	Local: NTSCVPN3	Portable: BP0N
• Maker:	NTSC Laboratory	EMDE Electronics
• Type:	NTSCGPS-1	TTS-2
• Serial number:		S/N 036
• Receiver internal delay (GPS) :	261.4ns	8.0
• Receiver internal delay (GLO) :		-
• Antenna cable identification:	Non-specified	C128
Corresponding cable delay :	214.5ns±0.17ns	187.75 ns ± 0.4 ns
• Delay to local UTC :	49.6ns	
• Receiver trigger level:	0.4V	0.5 V
• Coordinates reference frame:	ITRF	ITRF
Latitude or X m	-1735234.67m	-1735232.86m
Longitude or Y m	4976845.85m	4976844.72m
Height or Z m	3580528.79m	3580530.89m

Antenna information

	Local:	Portable:
• Maker:	3S Navigation	Motorola
• Type:	TSA-100	GPS
• Serial number:		AN16N00210
If the antenna is temperature stabilised YES		
• Set temperature value :	23.9°C /Cooler and 40.5°C /Heater	60 °C

Local antenna cable information

• Maker:	/
• Type:	/
• Is it a phase stabilised cable:	No
• Length of cable outside the building :	About 8meters

General information

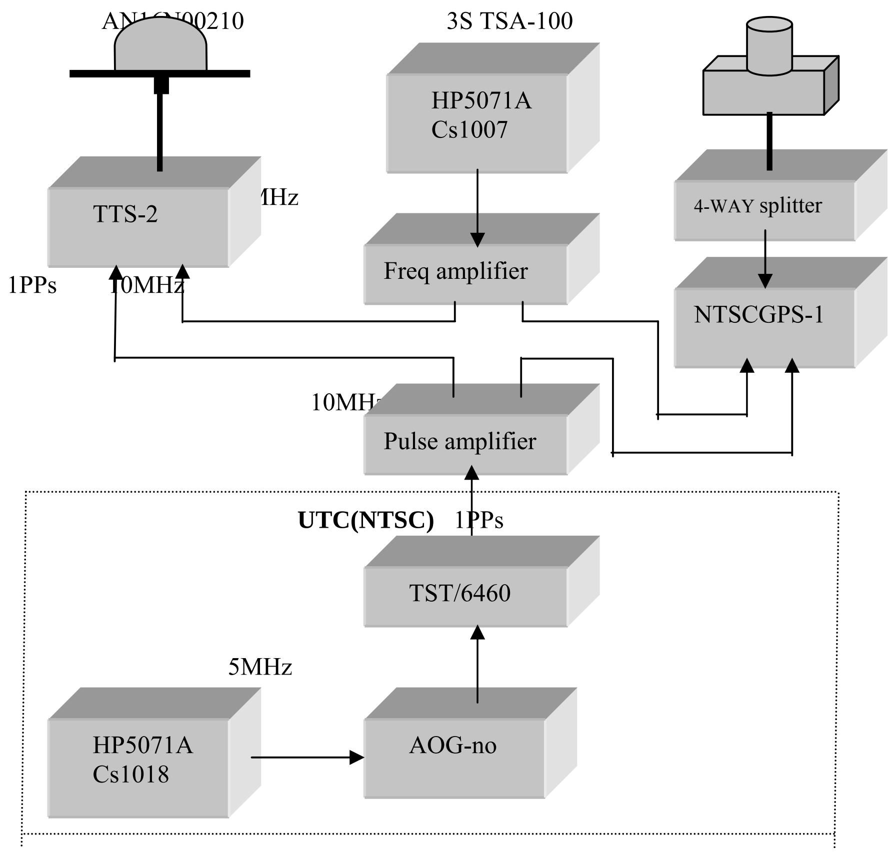
• Rise time of the local UTC pulse:	5ns
• Is the laboratory air conditioned:	yes
• Set temperature value and uncertainty :	21°C±1°C
• Set humidity value and uncertainty :	55.1%±5.7%

Cable delay control

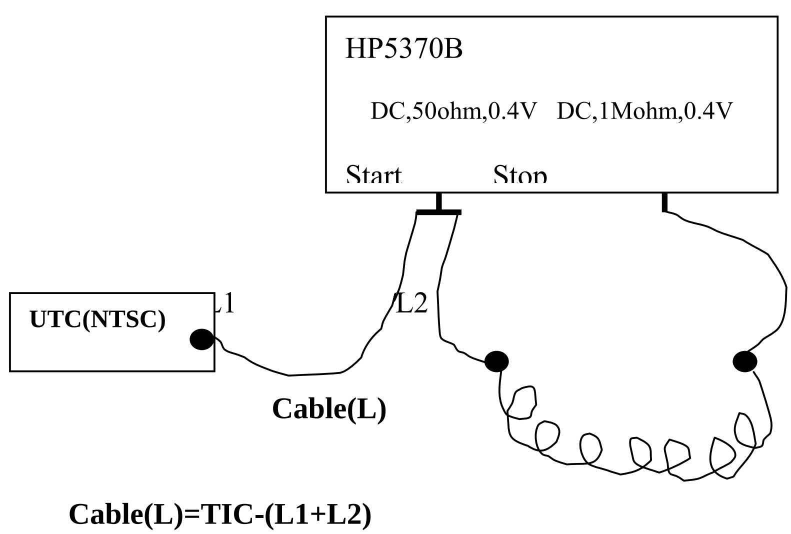
Cable identification	delay measured by BIPM	Delay measured by local method
BIPM C128	187.75 ns ± 0.4 ns	187.42±0.14ns

Plot of the experiment set-up:

Link to the local UTC of both receivers and Antenna positions



Description of the local method of cable delay measurement:



BIPM GPS calibration information sheet

Laboratory:	Hong Kong Observatory
Date and hour of the beginning of measurements:	**15 September 2004, 04:00 UTC**
Date and hour of the end of measurements:	**20 September 2004, 01:45 UTC**

Receiver setup information

	Local:	**Portable: BP0N**
• Maker:	EMDE Electronics	EMDE Electronics
• Type:	TTS-2	TTS-2
• Serial number:	S/N 053	S/N 036
• Receiver internal delay (GPS) :	2.8 ns	8.0 ns
• Receiver internal delay (GLO) :	-	-
• Antenna cable identification:	A-017	-
Corresponding cable delay :	411.7 ns	498.0 ns
• Delay to local UTC :	3.9 ns	5.5 ns
• Receiver trigger level:	0.5 V	0.5 V
• Coordinates reference frame:	ITRF	ITRF
Latitude or X m	22°18'8.4589" (-2417748.22 m)	22°18'8.4602" (-2417748.76 m)
Longitude or Y m	114°10'27.8690" (5386166.85 m)	114°10'27.8896" (5386166.58 m)
Height or Z m	65.604 m (2405446.56 m)	65.632 m (2405446.61 m)

Antenna information

	Local:	**Portable:**
• Maker:	Motorola	Motorola
• Type:	GPS	GPS
• Serial number:	-	AN16N00210
If the antenna is temperature stabilised		
• Set temperature value :	60 °C	60 °C

Local antenna cable information

	Local:	**Portable:**
• Maker:	Belden	Nexans
• Type:	H-500	RG213/U
• Is it a phase stabilised cable:	No	No
• Length of cable outside the building :	96.0 metres	100.03 metres

General information

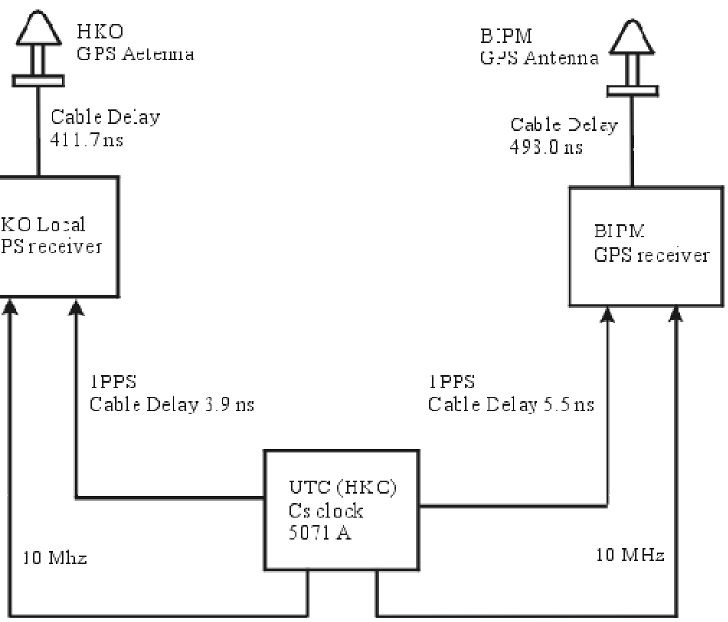
• Rise time of the local UTC pulse:	5 ns
• Is the laboratory air conditioned:	Yes
• Set temperature value and uncertainty :	18°C ± 2°C
• Set humidity value and uncertainty :	/

Cable delay control

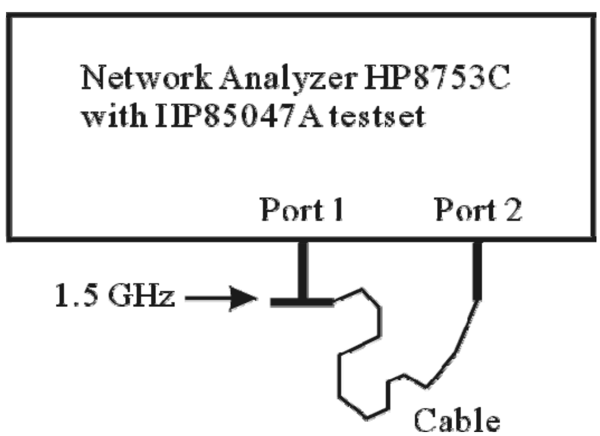
Cable identification	Delay measured by BIPM	Delay measured by local method
BIPM C128	187.75 ns ± 0.4 ns	187.28 ns by HP8753C @2.5Hz
HKO 100-m long cable	-	498.0 ns by HP8753C @1.5Hz

Plot of the experiment set-up:

Link to the local UTC of both receivers and Antenna positions



Description of the local method of cable delay measurement:



BIPM GPS calibration information sheet

Laboratory:	TL
Date and hour of the beginning of measurements:	2004/10/13(MJD 53291) UTC 03:30
Date and hour of the end of measurements:	2004/10/22(MJD 53300) UTC 05:30

Receiver setup information

	Local:	Portable: BP0N
• Maker:	NML/Topcon	EMDE Electronics
• Type:	Euro-80 Dual Frequency	TTS-2
• Serial number:		S/N 036
• Receiver internal delay (GPS):	45.1 ns	8.0
• Receiver internal delay (GLO):		-
• Antenna cable identification:		C128
Corresponding cable delay:	119.1 ns	187.75 ns ± 0.4 ns
• Delay to local UTC:	30.7 ns	32.29 ns
• Receiver trigger level:	0.5 V	0.5 V
• Coordinates reference frame:		
Latitude:	24 57 12.73152384	24 57 12.821226
Longitude:	121 9 52.5621528	121 9 52.031036
Height:	201.445	202.562

Antenna information

	Local:	**Portable:**
• Maker:	Ashtech	Motorola
• Type:	Choke ring	GPS
• Serial number:	Ash701945C_M	AN16N00210
	If the antenna is temperature stabilized	
• Set temperature value:	—	60 °C

Antenna cable information

• Maker	Beldon
• Type	RG-8
• Is it a phase stabilised cable:	No
• Length of cable outside the building:	15 m

General information

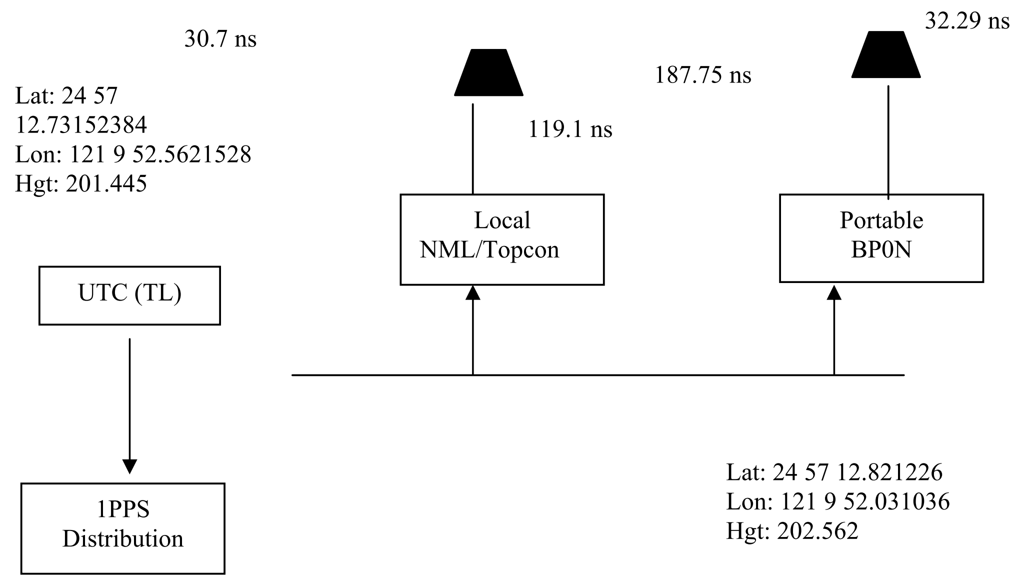
• Rise time of the local UTC pulse:	
• Is the laboratory air conditioned:	Yes
• Set temperature value and uncertainty:	23 ± 1 °C
• Set humidity value and uncertainty:	50 ± 5 %

Cable delay control

Cable identification	delay measured by NML	delay measured by local method
NML-IF Antenna cable	187.75 ± 0.4 ns	187.4 ± 1 ns

Plot of the experiment set-up:

Link to the local UTC of both receivers and Antenna positions



Description of the local method of cable delay measurement:

Using HP network analyzer for measuring cable delay.

BIPM GPS calibration information sheet

Laboratory:	SG (SPRING Singapore)
Date and hour of the beginning of measurements:	29 Oct 2004 (MJD53307) UTC 9:38:00
Date and hour of the end of measurements:	8 Nov 2004 (MJD53317) UTC 1:14:00

Receiver setup information

	Local:	**Portable: NML**
• Maker:	NML/OnCore	EMDE Electronocs
• Type:	OnCore VP card	TTS-2
• Serial number:		S/N 036
• Receiver internal delay (GPS) :	-30ns	8.0 ns
• Receiver internal delay (GLO) :		-
• Antenna cable identification:	SPRING cable 4	C128
Corresponding cable delay :	(344±2) ns	187.75 ns ± 0.4 ns
• Delay to local UTC :	(16 ± 2) ns	657 ns ± 2 ns
• Receiver trigger level:		0.5 V
• Coordinates reference frame:	WGS 84	WGS 84
Latitude:	1 17 31.0164	1 17 31.1959
Longitude:	103 47 07.8152	103 47 07.6285
Height:	67.07 m	67.01 m

Antenna information

	Local:	**Portable:**
• Maker:	Motorola	Motorola
• Type:	GPS	GPS
• Serial number:	ANT62301A2	AN16N00210
If the antenna is temperature stabilised		
• Set temperature value :	—	60°C

Antenna cable information

	Local:
• Maker:	Huber+ Suhner
• Type:	Sucofeed 7/8 inch HF
• Is it a phase stabilised cable:	No
• Length of cable outside the building :	84 m

General information

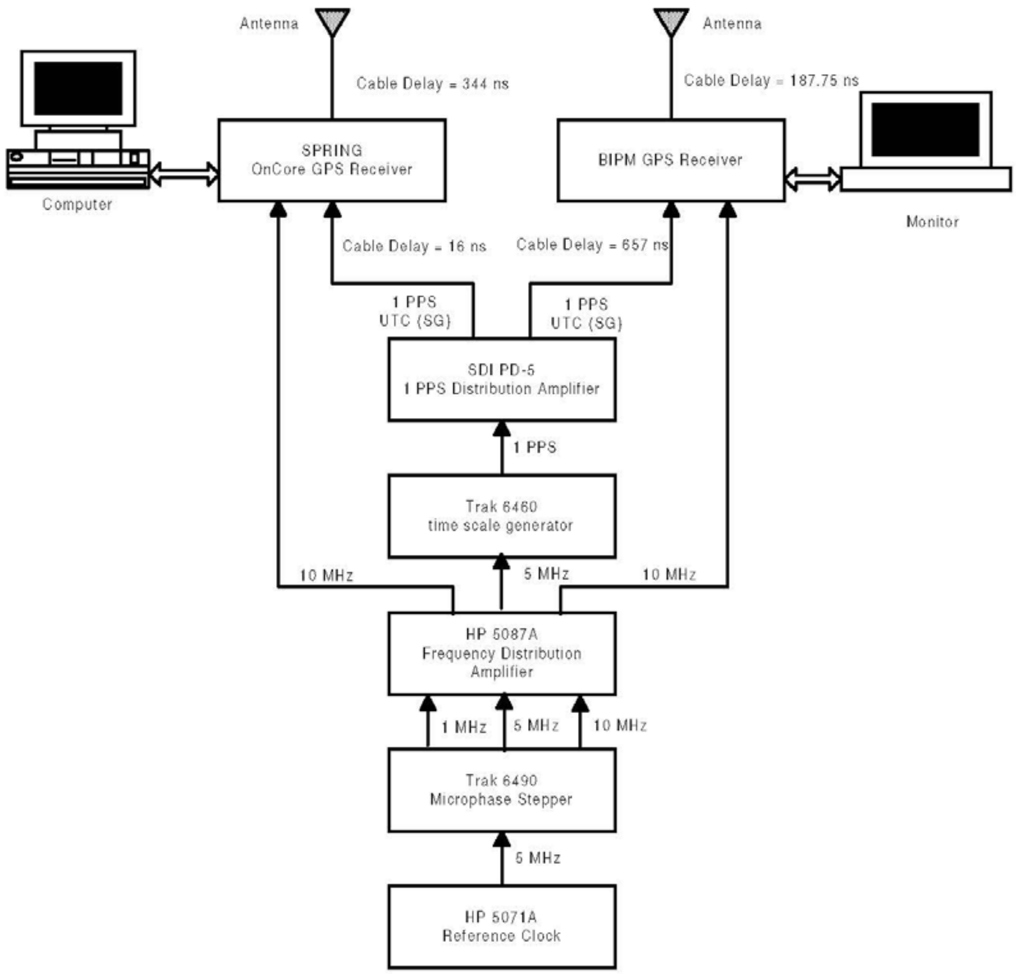
• Rise time of the local UTC pulse:	(4.31 ± 0.12) ns
• Is the laboratory air conditioned:	Yes
• Set temperature value and uncertainty :	23 ± 1 °C
• Set humidity value and uncertainty :	55 ± 5 % rh

Cable delay control

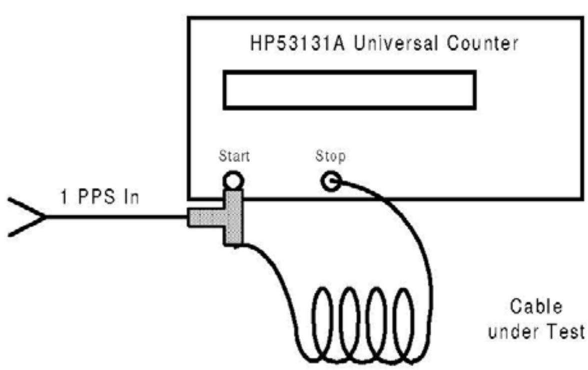
Cable identification	delay measured by BIPM	delay measured by local method
NML-IF Antenna cable	(187.75 ± 0.4) ns	(186.6 ± 2.0) ns

Plot of the experiment set-up:

Link to the local UTC of both receivers and Antenna positions



Description of the local method of cable delay measurement:



BIPM GPS calibration information sheet

Laboratory:	NMIA (Sydney, Australia)
Date and hour of the beginning of measurements:	**23/11/2004 (MJD 53332) 00:04 UTC**
Date and hour of the end of measurements:	**29/11/2004 (MJD 53337) 22:15 UTC**

Receiver setup information

	Local:	**Portable: BP0N**
• Maker:	NMIA/Topcon	EMDE Electronics
• Type:	Topcon Euro-80	TTS-2
• Serial number:	8RQRFKXT534	S/N 036
• Receiver internal delay (GPS) :	46.5 ns nominal (uncalibrated)	8.0 ns
• Receiver internal delay (GLO) :		
• Antenna cable identification:	TCDF-1	C128
Corresponding cable delay :	75.9 ns ± 1 ns	187.75 ns ± 0.4 ns
• Delay to local UTC :	68.9 ns ± 1 ns	53.9 ns ± 1 ns
• Receiver trigger level:	1.0 V	0.5 V
• Coordinates reference frame:	ITRF 93	ITRF 2000
~~Latitude or~~ X m	–4 648 200.298	–4 648 199.743
~~Longitude or~~ Y m	2 560 484.035	2 560 483.876
~~Height or~~ Z m	–3 526 505.358	–3 526 506.128

Antenna information

	Local:	**Portable:**
• Maker:	Topcon	Motorola
• Type:	Regant-1	GPS
• Serial number:	RA0122	AN16N00210
If the antenna is temperature stabilised		
• Set temperature value :	N/A	60 ºC

Local antenna cable information

• Maker:	Rojone
• Type:	LMR400
• Is it a phase stabilised cable:	No
• Length of cable outside the building :	14 m

General information

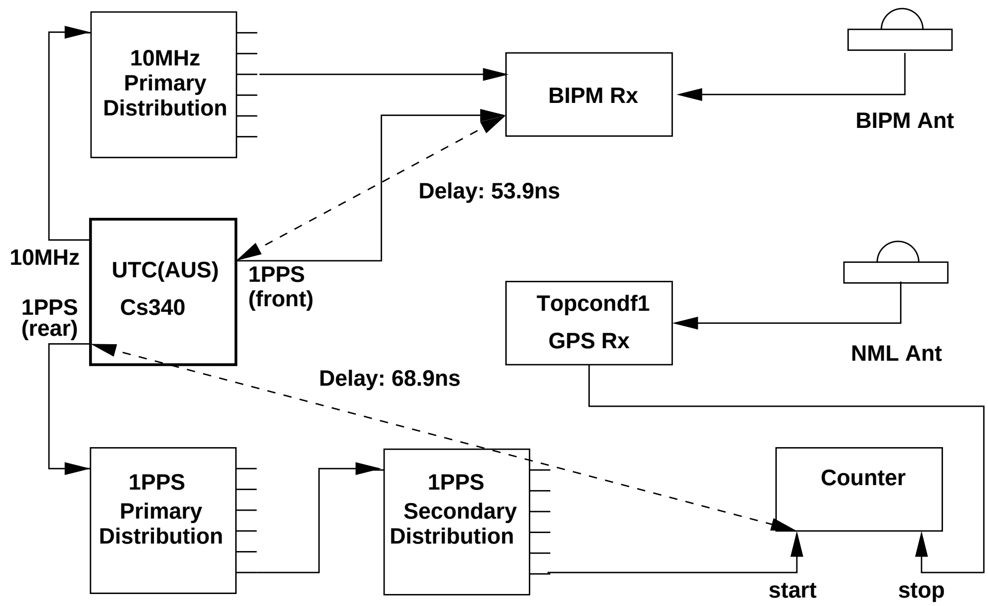
• Rise time of the local UTC pulse:	2.5 ns [10%–90%, using a 1 GHz CRO]
• **Is the laboratory air conditioned:**	Yes
• Set temperature value and uncertainty :	(20.3±1.0) ºC [measured range over calibration]
• Set humidity value and uncertainty :	(50 ± 10) %

Cable delay control

Cable identification	delay measured by BIPM	Delay measured by local method
BIPM C128	187.75 ns ± 0.4 ns	187.2 ns ± 1 ns

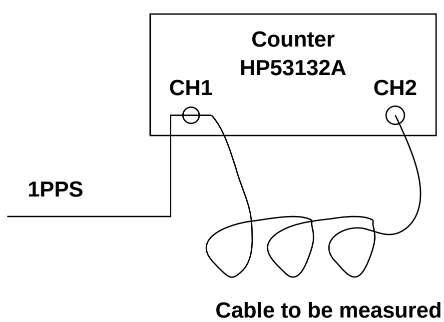
Plot of the experiment set-up:

Link to the local UTC of both receivers and Antenna positions



The epoch of UTC(AUS) is defined as the epoch at which the 1pps pulse exits the front panel of Cs 340, and all cable delays are measured relative to this point.

Description of the local method of cable delay measurement:



	CH1	CH2
Trigger	1.0V	1.0V
Termination	1M	50 ohm

Mode: Time interval Ch1 to Ch2

Notes:

1. **For antenna measurements adapters to BNC were used on each end of the cable.**
2. **Delay Values are Mean and Standard Deviation of 100 measurements.**

The counter is externally referenced to Cs 340 via 10 MHz secondary distribution. The delay of the C128 antenna cable was measured with adapters to BNC added to each end of the cable.

Values reported for cable delays are the mean of 100 measurements, as calculated by the counter. The typical standard deviation of these measurements is 0.1ns. However, we observe a typical day-to-day variation of up to ±0.5 ns in the delay measured for a given cable, and we therefore estimate the uncertainty of this measurement method at ±1 ns.

BIPM GPS calibration information sheet

Laboratory:	
Date and hour of the beginning of measurements:	
Date and hour of the end of measurements:	

Receiver setup information

	Local:	Portable: BP0N
• Maker:	Javad	EMDE Electronics
• Type:	Euro-80	TTS-2
• Serial number:	IRT0112301	S/N 036
• Receiver internal delay (GPS) :	36.5	8.0
• Receiver internal delay (GLO) :		-
• Antenna cable identification:	E80-1	C128
Corresponding cable delay :	114.8	187.75 ns ± 0.4 ns
• Delay to local UTC :	22.4	
• Receiver trigger level:	0.5 V	0.5 V
• Coordinates reference frame:		ITRF
Latitude or X m	- 3120132.700 m	36°23′18.108″
Longitude or Y m	+4085468.179 m	127°22′10.278″
Height or Z m	+3763043.611 m	123.63 m

Antenna information

	Local:	Portable:
• Maker:	Javad	Motorola
• Type:	RegAnt 1	GPS
• Serial number:		AN16N00210
If the antenna is temperature stabilised		
• Set temperature value :		60 °C

Local antenna cable information

• Maker:	Times Microwave systems
• Type:	LMR-400 DB
• Is it a phase stabilised cable:	No
• Length of cable outside the building :	4 m

General information

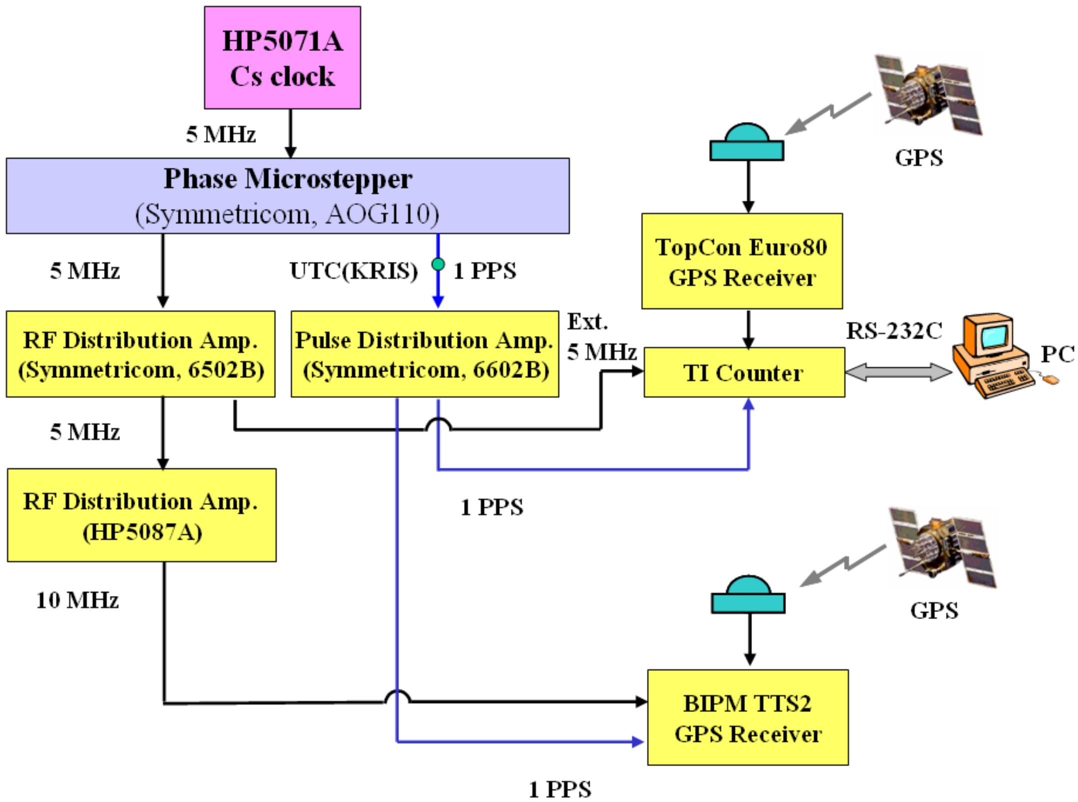
• Rise time of the local UTC pulse:	4 ns
• Is the laboratory air conditioned:	Yes
• Set temperature value and uncertainty :	23°C ± 1°C
• Set humidity value and uncertainty :	50% ± 5%

Cable delay control

Cable identification	delay measured by BIPM	Delay measured by local method
BIPM C128	187.75 ns ± 0.4 ns	187.15 ns ± 0.147 ns

Plot of the experiment set-up:

Link to the local UTC of both receivers and Antenna positions



Description of the local method of cable delay measurement:

1. We used an SRS model 620 time interval counter with an external 5 MHz reference from AOG110.
2. Set up a reference 1pps signal into the 'start' gate of the counter using a BNC Tee adapter.
3. One end of a short BNC cable used for connecting UTC(KRIS) and BIPM TTS2 receiver was connected to the open end of the Tee, and the other end to the 'stop' gate.
4. We measured 100 samplings of the time interval, with trigger level of 0.5 V, 50 Ohm impedance.-A
5. Changed 'start' and 'stop' gate, measured again.-B
6. Delay is obtained as (A+B)/2.
7. Repeated 4-6 with a BNC-to-TNC adapter attached.
8. We calculated the contribution by BNC-to-TNC adapter from the results 6 and 7.
9. Repeated 4-6 with the C128 cable + BNC-to-TNC adapter.
10. We calculated the C128 cable delay from the results 8 and 9.

BIPM GPS calibration information sheet

Laboratory:	**NMIJ**
Date and hour of the beginning of measurements:	**2005-01-13 09:22 UTC**
Date and hour of the end of measurements:	**2005-01-24 00:22 UTC**

Receiver setup information

	Local:	**Portable: GMBP0N**
• Maker:	**AOA**	BIPM
• Type:	**TTR-6**	TTS-2
• Serial number:	**484**	(default)
• Receiver internal delay (GPS) :	**50.0**	(default)
• Receiver internal delay (GLO) :	**-**	(default)
• Antenna cable identification:	**none**	(default)
Corresponding cable delay :	**259.0 ns**	187.75 ns
• UTC cable identification:	**none**	(default)
Corresponding cable delay :	/	(default)
Delay to local UTC :	**27.0 ns**	**148.69 ns**
• Receiver trigger level:	**0.5 V**	(default)V
• Coordinates reference frame:	**ITRF-88**	**WGS-84**
X:	**-3962297.92 m**	**-3962302.17 m**
Y:	**3308877.72 m**	**3308874.60 m**
Z:	**3733535.01 m**	**3733523.17 m**

Antenna information

	Local:	**Portable:**
• Maker:	**AOA**	Motrola
• Type:	**GPS**	GPS
• Serial number:	**682**	(default)
If the antenna is temperature stabilised		
• Set temperature value :	-	-

Local Antenna cable information

• Maker:	FUJIKURA
• Type:	RG-58A/U + RG-55/U (Jointed with a connector)
• Is it a phase stabilised cable:	No
• Length of cable outside the building :	15 m (approx.)

General information

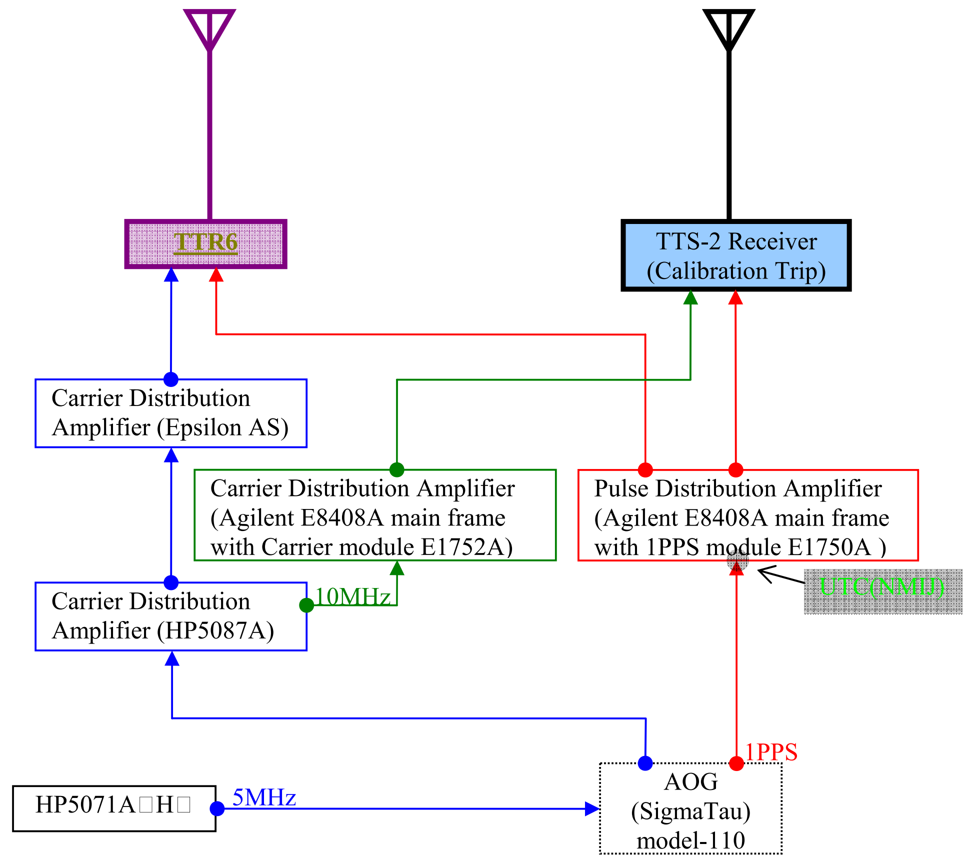
• Rise time of the local UTC pulse:	3.5 ns
• Is the laboratory air conditioned:	YES
• Set temperature value and uncertainty :	23.5 +/- 1.0 degree C
• Set humidity value and uncertainty :	50.0 %

Cable delay control

Cable identification	delay measured by BIPM	delay measured by local method
BIPM Antenna cable	(default)	(not measured)

Plot of the experiment set-up:

Link to the local UTC of both receivers and Antenna positions



Description of the local method of cable delay measurement:

(not measured)

BIPM GPS calibration information sheet

Laboratory:	NICT TOKYO JAPAN
Date and hour of the beginning of measurements:	25 Jan. 2005 (MJD 53395) UTC:06h42m30s
Date and hour of the end of measurements:	30 Jan. 2005 (MJD 53400) UTC:01h02m00s

Receiver setup information

		Local: TTR6	Local:E-80	Portable: BP0N
• Maker:		AOA	Javad	EMDE Electronics
• Type:		TTR-6	Euro-80	TTS-2
• Serial number:		451	8PN45EETDKW	S/N 036
• Receiver internal delay (GPS) :		44.8ns	47.2ns	8.0
• Receiver internal delay (GLO) :		-	-	-
• Antenna cable identification:		TTR6(219.6ns)	E80	C128
Corresponding cable delay :		250.0ns	152.15ns	187.75 ns ± 0.4 ns
• UTC cable identification:		GPS G	UTC(NICT)1pps C3	UTC(NICT)1pps B4
• Delay to local UTC :	Header Value	316.1ns	344.123ns	477.333ns
	Meas. Value	305.331ns	325.789ns	
• Receiver trigger level:		0.5 V	0.4 V	0.5 V
• Coordinates reference frame:		WGS-84	WGS-84	WGS-84
Latitude or X m		-3942161.90m	-3942164.215m	-3942163.452m
Longitude or Y m		3368284.20m	3368281.976m	3368282.695m
Height or Z m		3701886.69m	3701887.149m	3701886.321m

Antenna information

	Local: TTR6	Local:E80	Portable:
• Maker:	AOA	Javad	Motorola
• Type:		RegAnt 1,	GPS
• Serial number:	Down Converter S/N449	S/N RA0238	AN16N00210
If the antenna is temperature stabilised			
• Set temperature value :			60 °C

Local antenna cable information

• Maker:		Times Microwave-systems	
• Type:	RG58AU	LMR-400 DB	
• Is it a phase stabilised cable:	No	No	
• Length of cable outside the building :	Approx. 18 m	Approx. 18 m	Approx. 18 m

General information

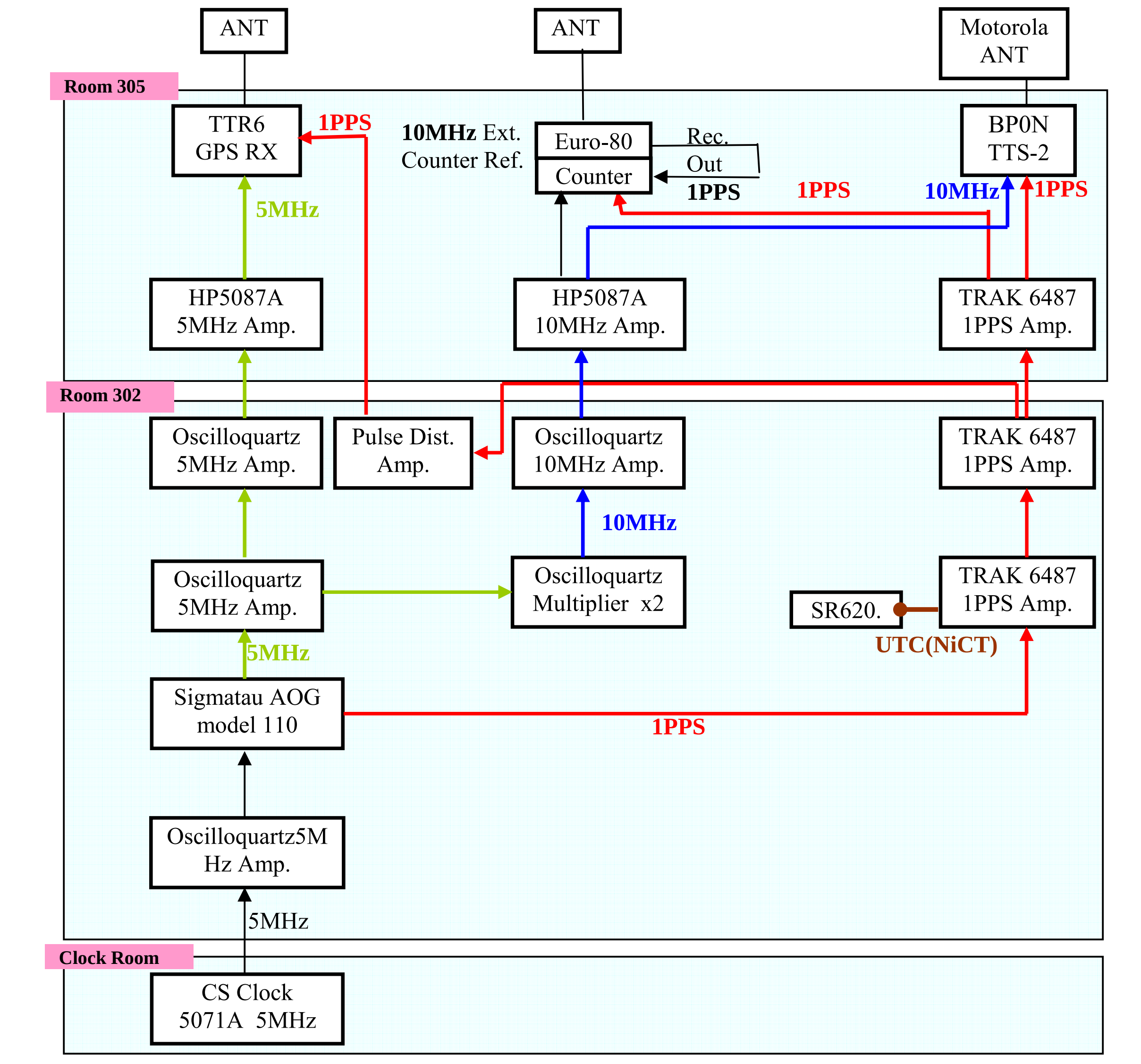
• Rise time of the local UTC pulse:	~2ns(from 0 Vdc to 0.5 Vdc)
• Is the laboratory air conditioned:	YES
• Set temperature value and uncertainty :	GPS RX Room 20□±2□
• Set humidity value and uncertainty :	N/A

Cable delay control

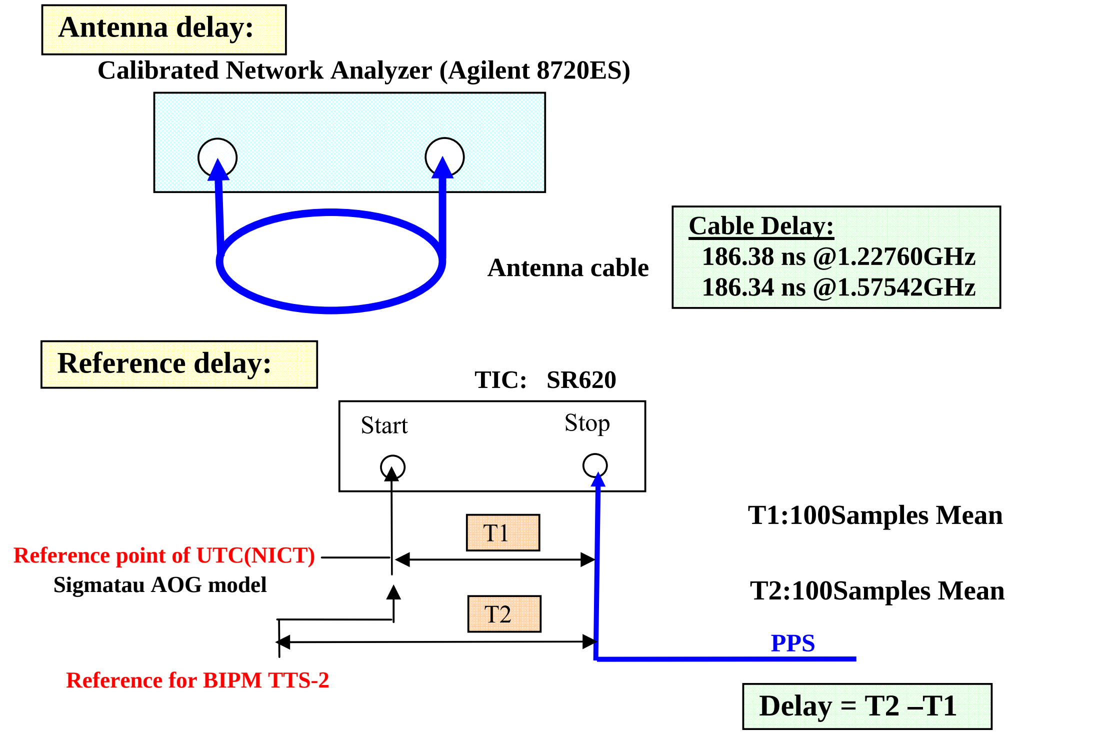
Cable identification	delay measured by BIPM	Delay measured by local method
BIPM C128	187.75 ns ± 0.4 ns	186.38 ns : by Agilent8720ES@1.22760GHz 186.34 ns : by Agilent8720ES@1.57542GHz

Plot of the experiment set-up:

Link to the local UTC of both receivers and Antenna positions



Description of the local method of cable delay measurement:



Appendix II

Measurement of portable cables at the visited laboratories

Laboratory	**BIPM C128 cable /ns**	**Measurement method**
BIPM	187.75 ± 0.4	Double Weight Pulse method
OP (before trip)	-	-
NTSC	187.42 ± 0.14	Pulse method
HKO	187.28	Network Analyzer
TL	187.4 ± 1	Network Analyzer
SG	186.6 ± 2	Pulse method
AUS	187.2 ± 1	Pulse method
KRIS	187.15 ± 0.147	Double Weight Pulse method
NMIJ	-	-
NICT	186.34	Network Analyzer
OP (after trip)	-	-

Appendix III

Daily averages of d$t_{k,i}$ for each laboratory k

LAB k	MJD	Mean offset /ns	Standard deviation of individual common view observations /ns	Standard deviation of the mean /ns	Number of individual common views
OP	53209	-3.80	2.98	0.65	21
	53210	-3.27	2.99	0.44	46
	53211	-2.00	2.60	0.39	44
	53212	-1.68	3.94	0.59	45
	53213	-2.51	3.27	0.77	18
NTSC	53244	-12.08	1.61	0.09	349
	53245	-12.11	1.54	0.06	565
	53246	-12.06	1.62	0.07	547
	53247	-12.28	1.96	0.09	515
	53248	-12.88	1.57	0.07	557
	53249	-19.18	1.79	0.14	165
HKO	53263	-0.91	1.85	0.19	98
	53264	0.34	1.85	0.17	124
	53265	0.83	1.76	0.16	122
	53266	1.06	1.67	0.15	118
	53267	0.34	1.76	0.16	123
	53268	2.60	0.57	0.40	2
TL	53291	-4.87	4.57	0.27	297
	53292	-6.25	3.57	0.19	342
	53293	-8.88	3.60	0.19	350
	53294	-9.54	4.21	0.23	331
	53295	-7.01	2.32	0.12	345
	53296	-6.67	2.33	0.13	345
	53297	-5.14	2.59	0.14	343
	53298	-5.50	2.51	0.14	341
	53299	-5.67	2.42	0.13	325
	53300	-7.36	3.37	0.38	79
SG	53307	1.74	7.25	0.53	187
	53308	-1.86	7.13	0.40	320
	53309	0.70	7.22	0.39	343
	53310	-3.12	6.64	0.36	347
	53311	-1.13	6.75	0.36	345
	53312	-1.10	6.83	0.37	345
	53313	-2.37	7.22	0.39	343
	53314	-2.51	6.93	0.37	350
	53315	-0.092	7.27	0.41	322
	53316	-0.09	7.00	0.38	341
	53317	1.52	5.99	1.22	24
AUS	53332	9.61	2.80	0.15	328
	53333	7.98	3.37	0.18	333
	53334	7.70	3.39	0.18	354
	53335	9.42	2.94	0.16	342
	53336	10.06	2.83	0.16	296
	53337	9.77	3.10	0.18	313

LAB	MJD	Mean offset /ns	Standard deviation of individual common view observations /ns	Standard deviation of the mean /ns	Number of individual common views
KRIS	53361	-2.37	2.30	0.15	230
	53362	-2.14	2.53	0.14	324
	53363	-2.76	2.27	0.13	316
	53364	-2.87	2.38	0.14	299
	53365	-2.95	2.31	0.13	315
	63366	-2.04	2.28	0.12	340
	53367	-2.32	2.20	0.12	324
NMIJ	53383	-16.83	4.75	0.91	27
	53384	-16.13	4.55	0.69	44
	53385	-16.13	4.71	0.71	44
	53386	-16.22	5.06	0.75	45
	53387	-16.03	4.75	0.72	44
	53388	-15.76	4.35	0.65	45
	53389	-17.03	3.83	0.58	43
	53390	-17.09	4.51	0.74	37
	53391	-17.17	4.53	0.68	44
	53392	-17.64	4.80	0.72	45
	53393	-17.82	4.11	0.61	45
NICT	53395	-13.48	3.09	0.20	248
	53396	-12.94	2.84	0.16	311
	53397	-13.33	3.03	0.17	324
	53398	-13.37	3.13	0.17	338
	53399	-12.32	4.31	0.25	296
	53400	-7.96	3.06	0.82	14
OP	53417	1.92	3.63	0.71	26
	53418	3.56	3.40	0.53	41
	53419	3.31	3.41	0.54	40
	53420	3.28	3.45	0.54	41
	53421	1.55	3.49	0.55	41
	53422	2.40	3.91	1.04	14