Rapport BIPM-98/1

BUREAU INTERNATIONAL DES POIDS ET MESURES

DIFFERENTIAL TIME CORRECTIONS FOR GPS TIME EQUIPMENT LOCATED AT THE OP, CH, SP, VSL, DTAG, PTB, NPL, TUG, IEN AND OCA: SECOND EVALUATION

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Abstract

Following a suggestion at the 4th meeting of the CCDS Working Group on Two-Way Satellite Time Transfer (TWSTT), the BIPM decided to conduct a series of differential calibrations of GPS equipment located in European time laboratories equipped with two-way stations. Repeated calibrations of this kind should provide valuable information about the stability of GPS time equipment and serve as provisional differential calibrations for two-way equipment. This report concerns the second such exercise. It took place from 1 October 1997 to 12 January 1998 and involved the circulation of a portable GPS time receiver among ten laboratories in Europe.

Resumé

Suivant une suggestion exprimée lors de la 4e réunion du Groupe de travail du CCDS sur les comparaisons d'horloges par aller et retour sur satellite, le BIPM a décidé de conduire une série d'étalonnages différentiels des équipements de réception du temps du GPS, situés dans des laboratoires de temps européens équipés de stations bidirectionnelles. Des étalonnages répétés de ce type devraient fournir de précieuses informations sur la stabilité des équipements GPS et servir d'étalonnages différentiels provisoires aux équipements bidirectionnels. Ce rapport concerne la seconde de ces campagnes. Elle a eu lieu entre le 1 octobre 1997 et le 12 janvier 1998 et a consisté à transporter un récepteur du temps du GPS d'un site à l'autre selon une boucle fermée qui a impliqué dix laboratoires en Europe.

INTRODUCTION

Following a suggestion at the 4th meeting of the CCDS Working Group on Two-Way Satellite Time Transfer [1], the BIPM conducted a series of differential calibrations of GPS equipment located in seven European time laboratories equipped with two-way stations [2, 3]: the National Physical Laboratory (NPL), Teddington, United Kingdom, the NMi Van Swinden Laboratorium (VSL), Delft, the Netherlands, the Deutsche Telekom AG (DTAG), Darmstadt, Germany, the Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany, the Technical University of Graz (TUG), Graz, Austria, the Istituto Elettrotechnico Nazionale Galileo Ferraris (IEN), Turin, Italy, and the Observatoire de la Côte d'Azur (OCA), Grasse, France. A consortium of Swiss laboratories (CH) based in Bern also participated in this exercise as did the Swedish National Testing and Research Institute (SP), Boras, Sweden. These laboratories are not equipped with two-way stations, but their GPS time equipment has to be calibrated.

The GPS time equipment located at the Observatoire de Paris (OP), Paris, France, was chosen as reference. To check the reproducibility of the measurements, the exercises were organized as round trips beginning and ending at the OP. Although the OP is not equipped with a two-way station, it serves as pivot laboratory for the GPS links used for TAI computation. The OP receiver also serves as reference for many international comparisons of GPS time equipment. It has been compared ten times in the last twelve years with the NIST 'on line', absolutely-calibrated GPS time receiver. The differences between these two receivers have never exceeded a few nanoseconds.

Repeated determinations of the differential time corrections between GPS time equipment located in the laboratories visited should:

- improve the accuracy of involved GPS time links,
- provide valuable information about the stability of GPS time equipment,
- serve as provisional differential calibrations of the two-way equipment.

This report details the second such exercise. It took place from 1 October 1997 to 12 January 1998. Succeeding visits are scheduled to take place at four to five month intervals.

EQUIPMENT

All the receivers involved in this comparison are single-channel, C/A code, 0.5 V trigger level, NBS type receivers. Their principal characteristics are:

OP:	Maker: Allen Osborne Associates, Type: NBS/TTR5, Receiver Ser. No: 051, Internal delay: 54 ns.
CH:	Maker: Allen Osborne Associates, Type: NBS/TTR5A, Receiver Ser. No: 275.
SP:	Maker: Allen Osborne Associates, Type: NBS/TTR6, Receiver Ser. No: 425.
VSL:	Maker: VSL, Type: NBS/TTR5, Receiver Ser. No: 01.
DTAG:	Maker: VSL, Type: NBS, Receiver Ser. No: 19.
PTB:	Maker: Rockwell Collins, Type: NBS/TTR5.
NPL:	Maker: Allen Osborne Associates, Type: NBS/TTR5A, Receiver Ser. No: 276.
TUG:	Maker: NBS, Type: NBS, Receiver Ser. No: 03.
IEN:	Maker: Allen Osborne Associates, Type: NBS/TTR5, Receiver Ser. No: 031.
OCA:	Maker: Allen Osborne Associates, Type: NBS/TTR5, Receiver Ser. No: 053.

Portable receiver:	Maker:	Allen Osborne Associates,
BIPM3	Type:	NBS/TTR6,
	Receiver Ser. No: 277.	

As these receivers use identical software of NBS type, any imperfections in the software cancel during a zero-baseline comparison. The main source of errors is thus variations in hardware.

The portable BIPM3 receiver was equipped with four cables:

- portable IF (Intermediate Frequency) antenna cable C1: 235.5 ns, uncertainty of 0.40 ns (1 σ).

- portable LO (Local Oscillator) antenna cable C2.

- portable IF (Intermediate Frequency) spare antenna cable C3: 232.1 ns, uncertainty of 0.40 ns (1 σ).

- portable IF local UTC cable C4: 170.0 ns, uncertainty of 0.40 ns (1 σ).

Delays in the cables C1, C3 and C4 were measured at the BIPM using the pulse method with a time intervallometer steered by an external frequency source, an HP 5071A clock. 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 [4].

Delays in cables C1 and C4 were also measured at the laboratories visited. Results are reported in Appendix I. Different methods of measurement were employed. We observe that group delay measurements using the MITREX modem at 70 MHz [4] differ from those given by the pulse method by about 2 ns for the C1 cable and may reveal the ultimate accuracy of the pulse method. However, any imperfection in the measurement delay of portable equipment, if constant throughout the trip, cancels in the determination of differential time corrections between the laboratories involved.

Detailed information on the equipment at each location is provided in Appendix II.

CONDITIONS OF COMPARISON

For the present comparison, the portable equipment took the form of the receiver, its antenna and a calibrated antenna cable. The laboratories visited supplied a) a 5 MHz reference signal, 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 uncertainties of a few centimetres. During the comparisons the receivers were programmed with the *BIPM Common-View International Schedule No 29* for Europe.

RESULTS

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

$dt_{k,i}$=[*UTC*(k)-*GPS time*]$_{BIPM3,i}$-[*UTC*(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, this exhibits white phase noise up to an averaging interval of about one day. We illustrate this in Figure 1 which shows the computation for the OP over about twenty days period following the trip.

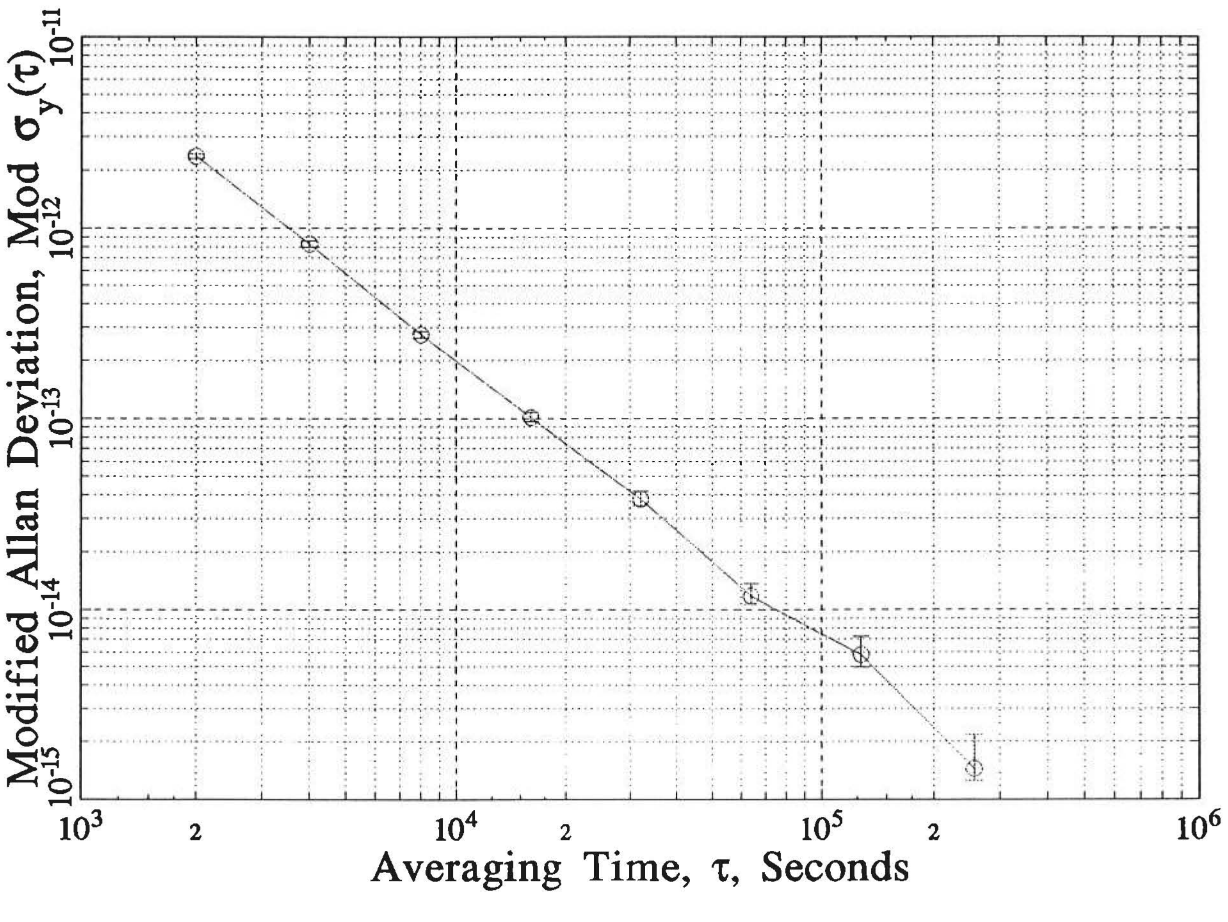

Figure 1. Square root of the modified Allan variance of the time series dt_{OP} for the period: 22 December 1997 – 12 January 1998.

One-day averages are reported in Figure 2 and Appendix III. The level of noise for a one-day period is reported in Table 1.

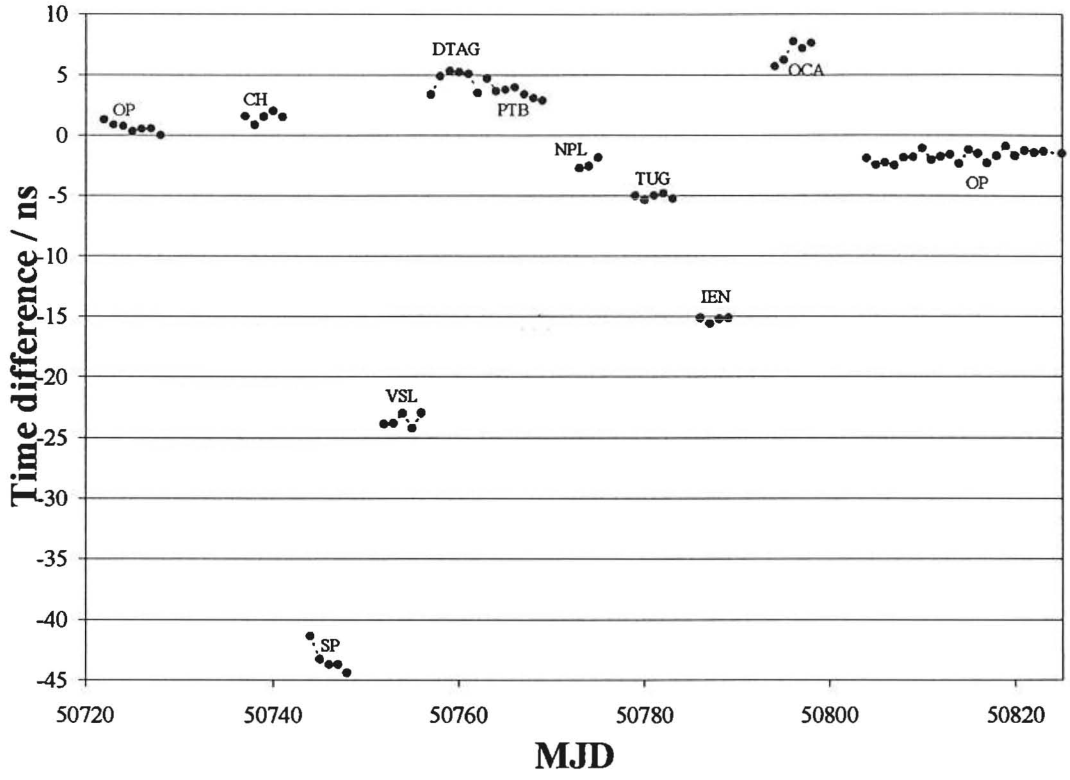

Figure 2. Daily averages of $dt_{k,i}$ for each laboratory.

The one-day averages exhibit systematic effects which we characterized by the dispersion of the daily mean also listed in Table 1. These systematic effects are caused by hardware instability, often linked to the sensitivity of GPS time equipment to environmental conditions [5,6,7].

Next, we computed mean offsets for the full duration of comparison at each location, and the corresponding standard deviations of individual common views (Table 1).

Table 1. Mean offsets for the full duration of comparison at each location.

Lab	Period 1997	Total number of common views	Mean offset /ns	Standard deviation of individual common view /ns	Level of noise for 1 day /ns	Dispersion of daily mean /ns
OP	1-7 Oct	315	0.6	2.6	0.3	0.4
CH	16-20 Oct	119	1.5	1.6	0.3	0.4
SP	23-27 Oct	108	-43.2	3.6	0.6	1.1
VSL	31 Oct-4 Nov	64	-23.6	2.2	0.6	0.6
DTAG	5-10 Nov	162	5.0	2.6	0.3	0.9
PTB	11-17 Nov	261	3.7	2.6	0.3	0.6
NPL	21-23 Nov	79	-2.3	3.0	0.6	0.5
TUG	27 Nov-1 Dec	178	-5.1	2.0	0.3	0.2
IEN	4-7 Dec	147	-15.3	1.4	0.2	0.2
OCA	12-16 Dec	91	7.0	2.5	0.6	0.9
OP	22 Dec-12 Jan	291	-1.7	2.7	0.4	0.5

The repeated measurements at the OP give an indication of the reproducibility of the comparisons. At the beginning and at the end of this exercise they show offsets of 0.6 ns and -1.7 ns (Table 1 and Figure 2). In between (76 days), the portable receiver was packed and unpacked, with associated vibrations and temperature changes. Changes of a few nanoseconds in differential delays between local and portable receivers were observed during calibration in several of the laboratories visited (Figure 2). The possibility that changes also occurred in the delay of the OP receiver is not excluded. It is now well documented, and generally admitted, that GPS time equipment is sensitive to external temperature [5, 6, 7].

From the preceding table, after averaging the two measurements at the OP, we derived differential time corrections which should be added to the values derived during the GPS comparisons of the time scales kept by the laboratories visited. They are reported in Table 2. In the same table we report calibration results from the 1st trip [8].

Table 2. Differential time correction d to be added to$[UTC(k_1)-UTC(k_2)]$ and estimated 1 σ uncertainty $u(d)$ for the period of comparison.

$[UTC(k_1)-UTC(k_2)]$	1st trip		2nd trip	
	d/ns	u(d)/ns	d/ns	u(d)/ns
[UTC(VSL)-UTC(OP)]	-2	3	-23	2
[UTC(DTAG)-UTC(OP)]	+3	3	+6	2
[UTC(PTB)-UTC(OP)]	+2	3	+4	2
[UTC(NPL)-UTC(OP)]	-4	3	-2	2
[UTC(TUG)-UTC(OP)]	-10	3	-5	2
[UTC(IEN)-UTC(OP)]	-17	3	-15	2
[UTC(OCA)-UTC(OP)]	+4	3	+8	2
[UTC(CH)-UTC(OP)]			+2	2
[UTC(SP)-UTC(OP)]			-43	2

The uncertainties given in this table are conservative. They are mainly influenced by the uncertainty due to the 'round-trip' reproducibility at the OP, but some other elements are significant, particularly the effect of changing the portable antenna cable during the 1st trip, and the level of noise in individual receivers.

DISCUSSION

The results of the second series of BIPM differential calibrations of GPS time equipment in European time laboratories equipped with two-way stations mostly confirm the results of the first trip to within the uncertainties involved.

For all laboratories but VSL, we observe that between the first and the second trip there were changes in delays, all in the same direction, of 2 ns to 5 ns. This can be accident but, alternatively, it could indicate that the delay of the reference receiver at the OP or, more probably, the delay of the portable receiver, changed by a few nanoseconds. The sign and value of 'closure' at the OP supports this conclusion. The probability that all the other receivers changed their delays in the same sense is very small.

The large discrepancy observed between the two results at the VSL seems to result from a fault during set-up of the portable receiver BIPM3 during the second trip [9]. The results of the first trip for VSL are also confirmed by independent calibration using a portable ROVER GPS+GLONASS receiver which was in operation at the VSL at the same time as BIPM3 during the second trip [10].

To clarify the matter of changes in the GPS time equipment delays we await the results of the next calibration rounds.

Acknowledgements

The authors wish to express their gratitude to their colleagues from the laboratories visited for their unreserved collaboration, without which this work could not have been accomplished.

REFERENCES

[1] The CCDS Working Group on Two-Way Satellite Time Transfer, *Report of the 4th Meeting*, Turin, October 1996.

[2] J.A. Davis, P.R. Pearce, D. Kirchner, H. Ressler, P. Hetzel, A Söring, G. De Jong, F. Baumont, L. Veenstra, "Two-Way Satellite Time Transfer Experiments Between Six European Laboratories Using the INTELSAT (VA-F13) Satellite", *Proc. 8th EFTF*, pp. 296-314, March 1994.

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[4] 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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[8] W. Lewandowski and P. Moussay, "Determination of Differential Time Corrections between GPS Time Equipment Located the OP, NPL, VSL, DTAG, PTB, TUG, IEN and OCA", *Rapport BIPM-97/5*, October 1997.

[9] G. de Jong, personnal communication, December 1997.

[10] J. Azoubib, G. de Jong, W. Lewandowski, "Determination of Differential Time Corrections for Multi-Channel GPS and GLONASS Time Equipment Located at 3S Navigation, BIPM and VSL", *Rapport BIPM-97/6*, Part 1 of 2, November 1997.

Appendix I

Measurement of portable cables at the visited laboratories

Laboratory	BIPM C1 cable /ns	BIPM C4 cable /ns	Measurement method
BIPM	235.5 ± 0.4 (1σ)	170.0 ± 0.4 (1σ)	Pulse method
OP (before trip)			
CH	235.95	170.3	Pseudo-reflectometry
SP	235.8	170.0	Pulse method (0.5V)
VSL	234.5		Mitrex
VSL	236.8	170.7	Pulse method (0.5V)
PTB	234.7		Mitrex
PTB	235.3		Pulse method
NPL			
TUG	234.8		Mitrex
IEN	234.7	169.7	Mitrex
IEN	236.0	170.4	Pulse method (0.5V)
OCA	236.7		Pulse method (0.5V)
OP (after trip)	236.5 ± 0.3 (1σ)	170.5 ± 0.3 (1σ)	Dual weighing method

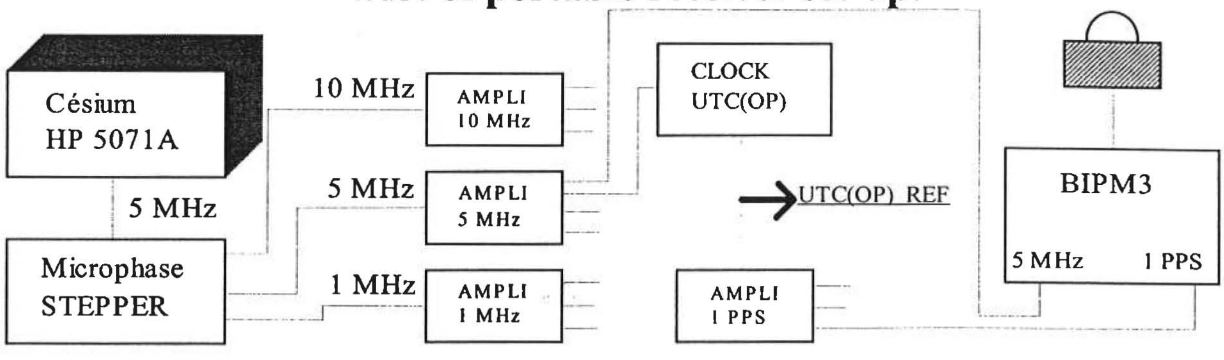
Appendix II

**Set-ups of local and portable equipment at each location
(forms filled at laboratories)**

BIPM GPS calibration information sheet

Laboratory:	LPTF
Date and hour of the beginning of measurements:	05-08-97 07h52 UT
Date and hour of the end of measurements:	10-10-97 23h34 UT

Plot of portable receiver set-up:



Rise time of the local UTC pulse: 5 ns

Receiver information

	Local:	Portable: BIPM3
• Maker:	Allen Osborne Associates	Allen Osborne Associates
• Type:	TTR5	TTR6
• Serial number:	SN 051	SN 277
• Receiver internal delay :	54 ns	57 ns
• IF Antenna cable identification:	n° 505	C1
Corresponding cable delay :	168 ns	236 ns
• UTC cable identification:	n° 503	n° 494
Corresponding cable delay :	37 ns	48 ns
Delay to local UTC :	304 ns	315 ns
• Receiver trigger level:	0.5 V	0.5 V
• Coordinates reference frame:	ITRF 88	ITRF 88
Latitude:	48°50’09’’.2369	48°50’09’’.0999
Longitude:	02°20’05’’.8730	02°20’05’’.7389
Height:	124.51 m	124.58 m

Description of the local method of cable delay measurement:

Dual weighing method using a time interval counter HP 5370 triggered by 1 PPS from BNM-LPTF hydrogen maser.
The time base of the time interval counter is steered by 10 MHz maser.
The process is repeated twice.
Final result is the mean value of both evaluations of the cable delay.

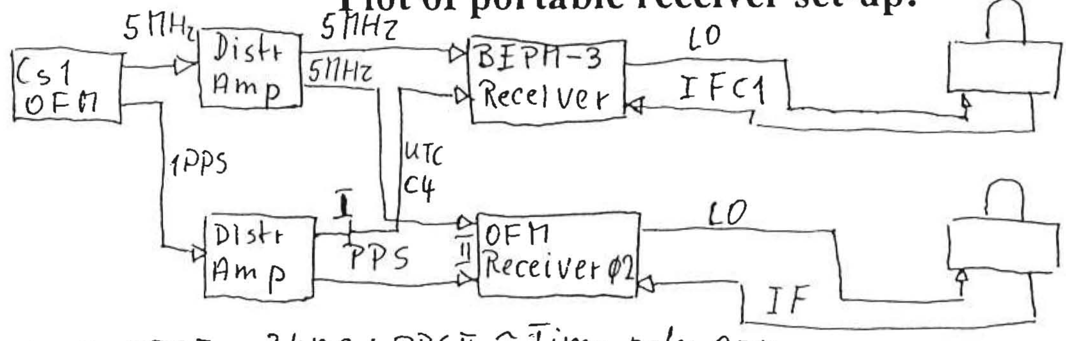
Cable delay control

Cable identification	delay measured by BIPM	delay measured by local method
BIPM portable IF antenna cable C1	235.5 ns	236 ns
BIPM portable UTC cable C4	170.0 ns	

BIPM GPS calibration information sheet

Laboratory:	OFMET Wabern (CH)
Date and hour of the beginning of measurements:	MJD 50737, 16.10.97; 14h14 00 (UT)
Date and hour of the end of measurements:	MJD 50741, 20.10.97; 07h 50 00 (UT)

Plot of portable receiver set-up:



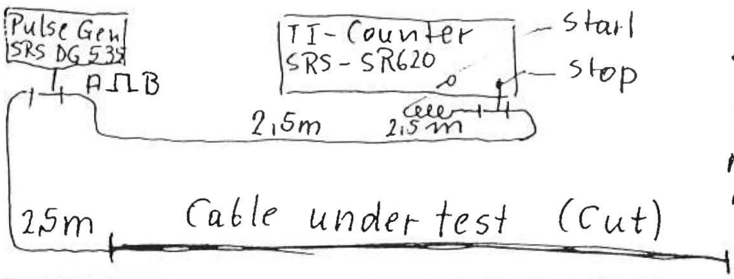
PPS II − PPS I = −3,4 ns ; PPS II ≙ Time refer. OFM

Rise time of the local UTC pulse: 22 ± 2 ns (10 − 90%; 5 V_p in 50 Ω)

Receiver information

	Local:	Portable: BIPM3
• Maker:	Allen Osborne Associates	Allen Osborne Associates
• Type:	TTR 5A	TTR6
• Serial number:	0275	SN 277
• Receiver internal delay :	71.0	57 ns
• IF Antenna cable identification:	IF	IF C1
Corresponding cable delay :	229 (header) measured: 235.2	236
• UTC cable identification:		UTC C4
Corresponding cable delay :	0	170.0
Delay to local UTC :	0 (Ref plane PPS OFM)	166,6
• Receiver trigger level:	~1V	0.5 V
• Coordinates reference frame:		
Latitude:	46° 55' 25,9513"	46° 55' 25,8855"
Longitude:	+007° 27' 53,7099"	+007° 27' 53,7099"
Height:	+ 609,56 m	+ 609,56

Description of the local method of cable delay measurement:



"Pseudo-reflectometry"
The TI counter is first calibrated without "Cut", then a second measurement is done with "Cut" trigger level: 0,1V
Uncertainty (estim): ± 1ns

Cable delay control

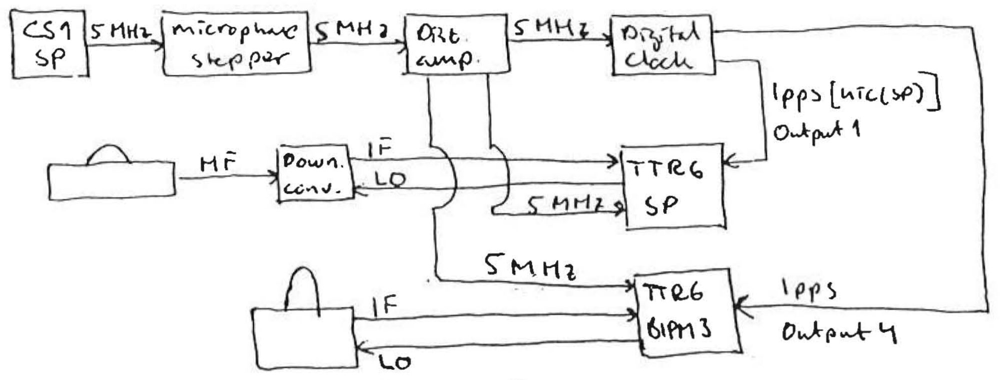
Cable identification	delay measured by BIPM	delay measured by local method
BIPM portable IF antenna cable C1	235.5 ns	235,95 ns
BIPM portable UTC cable C4	170.0 ns	170,3 ns

20.10.97 / PR

BIPM GPS calibration information sheet

Laboratory:	SP, Sweden
Date and hour of the beginning of measurements:	MJD 50744; 1997 oct. 23; 10 h 32 m UTC
Date and hour of the end of measurements:	MJD 50748; 1997 oct. 27; 08 h 55 m UTC

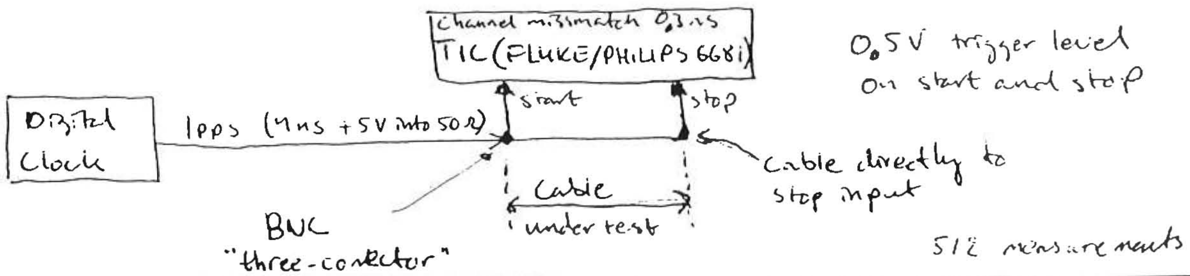
Plot of portable receiver set-up:



Rise time of the local UTC pulse: <4ns (stated) +5V into 50 Ω

Receiver information		
	Local:	**Portable: BIPM3**
• Maker:	Allen Osborne Associates	Allen Osborne Associates
• Type:	TTR6	TTR6
• Serial number:	SN 425	SN 277
• Receiver internal delay :	50ns (default)	57 ns
• IF Antenna cable identification:	HF + (Down. conv.) + IF	IF C1
Corresponding cable delay :	512.0 ns (512 ns entered in rec.)	235.5 ns (236 ns entered in rec.)
• UTC cable identification:	SP UTC Cable	UTC C4
Corresponding cable delay :	7.1 ns (7 ns entered in rec.)	170.0 ns (170 ns entered in rec.)
Delay to local UTC :	7.1 ns	170.0 ns
• Receiver trigger level:	0.5 V	0.5 V
• Coordinates reference frame:	ITRF93	ITRF94
Latitude:	57° 42' 53.8460" N	57° 42' 54.7069" N
Longitude:	12° 53' 28.8470" E	12° 53' 27.2203" E
Height:	+219.98 m	+224.88 m

Description of the local method of cable delay measurement:



512 measurements

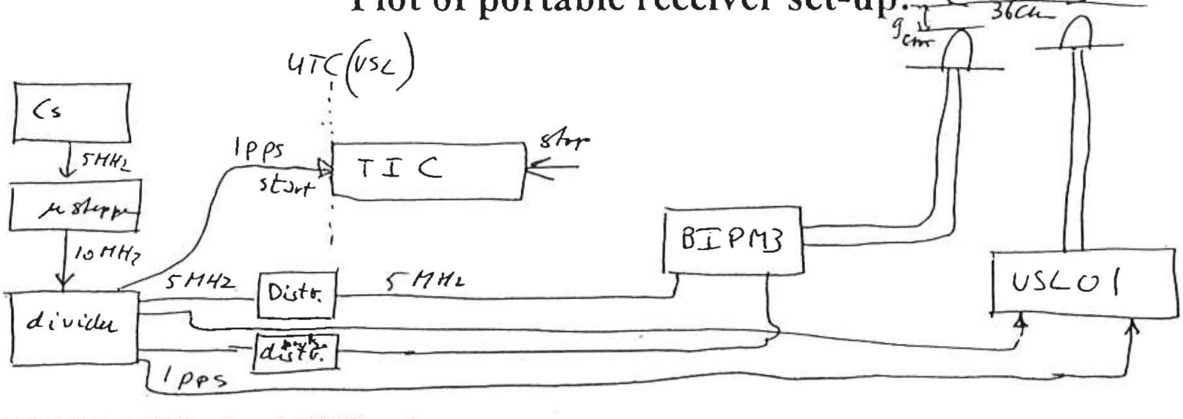
Cable delay control		
Cable identification	delay measured by BIPM	delay measured by local method
BIPM portable IF antenna cable C1	235.5 ns	170.3 ns − 0.3 (channel mismatch) = 170.0 ns
BIPM portable UTC cable C4	170.0 ns	236.1 ns − 0.3 = 235.8 ns

27 oct 1997 [signature]

BIPM GPS calibration information sheet

Laboratory:	VSL	
Date and hour of the beginning of measurements:	97-10-31	13:30 UTC
Date and hour of the end of measurements:	97-11-04	6:00 UTC

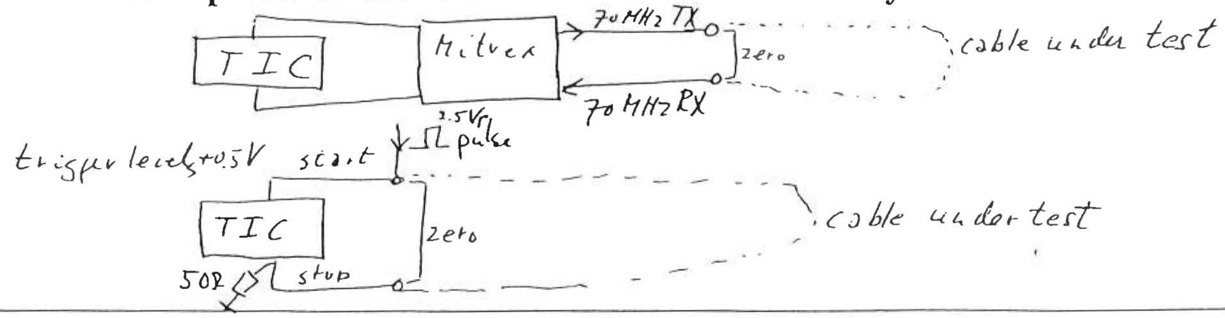
Plot of portable receiver set-up:



Rise time of the local UTC pulse: ______

Receiver information		
	Local:	**Portable: BIPM3**
• Maker:	VSL	Allen Osborne Associates
• Type:	NBS-type	TTR6
• Serial number:	VSL01	SN 277
• Receiver internal delay :	63.9 ns	57 ns
• IF Antenna cable identification:	Cable 8	cable 9
Corresponding cable delay :	657.6 ns	651.3 ns (tentative value)
• UTC cable identification:	VSL	VSL
Corresponding cable delay :	—	—
Delay to local UTC :	5.45 ns	34.8 ns
• Receiver trigger level:	0.5 V	0.5 V with external 50Ω
• Coordinates reference frame:	IERS	IERS
Latitude:	[illegible]	
Longitude:	[illegible]	
Height:	[illegible]	

Description of the local method of cable delay measurement:

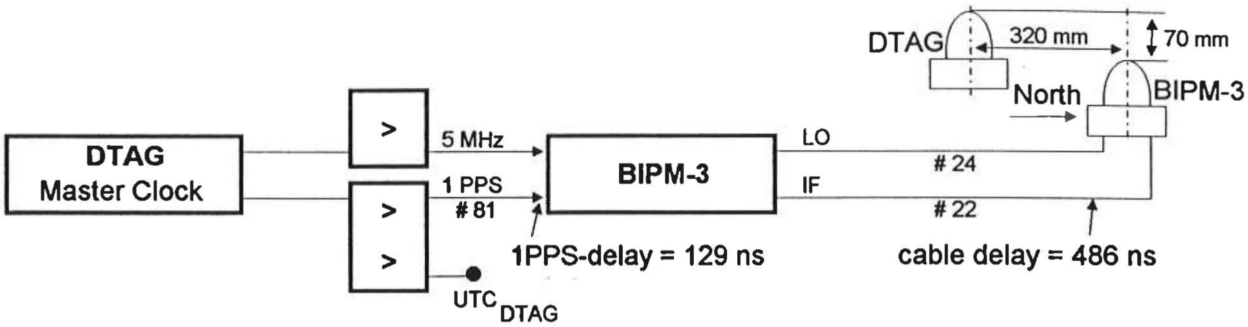


Cable delay control		
Cable identification	delay measured by BIPM	delay measured by local method
BIPM portable IF antenna cable C1	235.5 ns	234.5 ns (Mitrex) 236.8 ns (pulse @ 0.5V)
BIPM portable UTC cable C4	170.0 ns	170.7 ns (pulse @ 0.5V)

BIPM GPS calibration information sheet

Laboratory:	DTAG
Date and hour of the beginning of measurements:	Nov. 06, 1997 08:00 UTC
Date and hour of the end of measurements:	Nov. 10, 1997 08:30 UTC

Plot of portable receiver set-up:

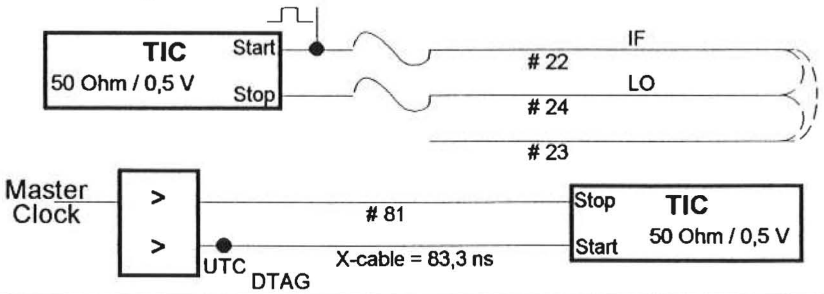


Rise time of the local UTC pulse: 11 ns

Receiver information

	Local:	Portable: BIPM3
• Maker:	Van Swinden Laboratory	Allen Osborne Associates
• Type:	NBS	TTR6
• Serial number:	19	SN 277
• Receiver internal delay :	61,1 ns	57 ns
• IF Antenna cable identification:	# 21	# 22
Corresponding cable delay :	486 ns	486 ns
• UTC cable identification:	# 28	
Corresponding cable delay :		
Delay to local UTC :	- 64,3 ns	129 ns
• Receiver trigger level:	0,5 V	0.5 V
• Coordinates reference frame:	WGS 84	
Latitude:	N 49° 52' 5,624''	
Longitude:	E 008° 37' 29,762''	
Height:	+ 204,16 m	

Description of the local method of cable delay measurement:



22 + # 24 = 905,5 ns
22 + # 23 = 901,5 ns
24 + # 23 = 835,2 ns

TIC reading: 45,7 ns
1PPS-delay = 129 ns

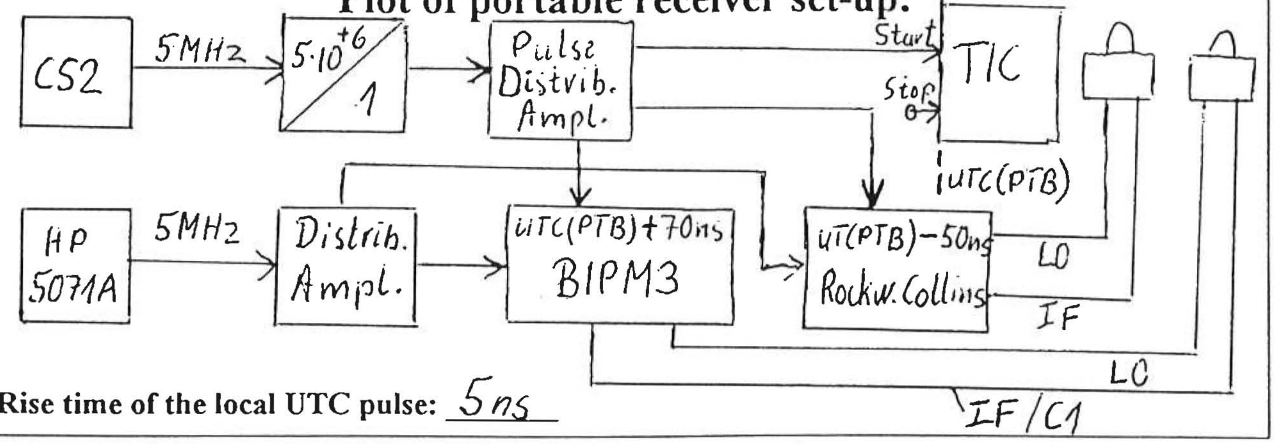
Cable delay control

Cable identification	delay measured by BIPM	delay measured by local method
BIPM portable IF antenna cable C1	235.5 ns	-
BIPM portable UTC cable C4	170.0 ns	-

BIPM GPS calibration information sheet

Laboratory:	PTB
Date and hour of the beginning of measurements:	50763 97-11-11 09:50 UTC
Date and hour of the end of measurements:	50769 97-11-17 07:52 UTC

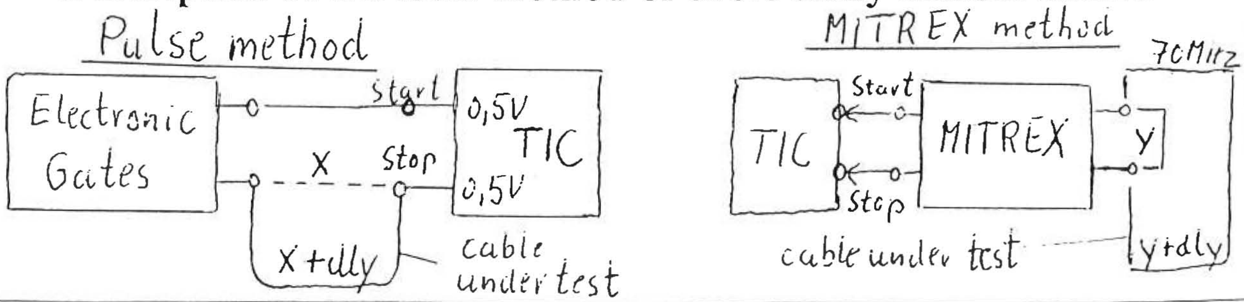
Plot of portable receiver set-up:



Rise time of the local UTC pulse: 5ns

Receiver information		
	Local: PTB01	**Portable: BIPM3**
• Maker:	Rockwell Collins	Allen Osborne Associates
• Type:	NBS - type	TTR6
• Serial number:	—	SN 277
• Receiver internal delay :	77 ns	57 ns
• IF Antenna cable identification:	AT06/IF	C1
Corresponding cable delay :	626ns (676ns)	235 ns
• UTC cable identification:	PTB	PTB
Corresponding cable delay :	—	—
Delay to local UTC :	-50ns (0ns)	70ns
• Receiver trigger level:	0,5V	0.5 V
• Coordinates reference frame:	ITRF 88	ITRF 88
Latitude:	N 52° 17' 44,481"	N 52° 17' 46,080"
Longitude:	E 10° 27' 39,728"	E 10° 27' 34,895"
Height:	156,61 m	130,2 m

Description of the local method of cable delay measurement:

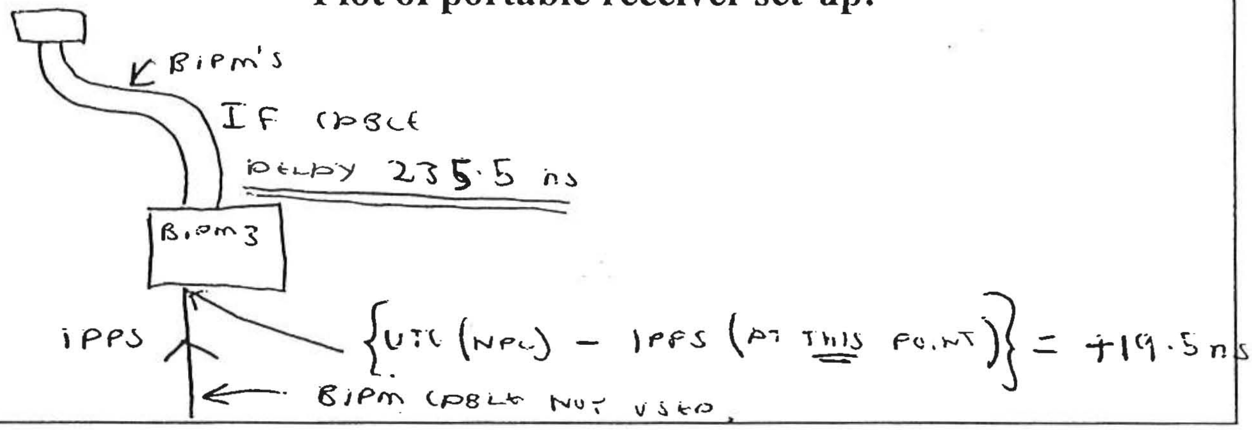


Cable delay control		
Cable identification	delay measured by BIPM	delay measured by local method
BIPM portable IF antenna cable C1	235.5 ns	235,3ns (pulse method)
BIPM portable ~~UDO~~ cable: ~~C4~~ C1	~~170.0 ns~~	234,7ns (MITREX method)

BIPM GPS calibration information sheet

Laboratory:	NPL
Date and hour of the beginning of measurements:	50771 19:58
Date and hour of the end of measurements:	50776 11:38.

Plot of portable receiver set-up:



Receiver information

	Local:	Portable: BIPM3
• Maker:	ALLEN OSBORNE ASSOCIATES	Allen Osborne Associates
• Type:	TTR 5A.	TTR6
• Serial number:		SN 277
• Receiver internal delay :	68.5 ns.	57 ns
• IF Antenna cable identification:		
Corresponding cable delay :	124.5 ns	235.5 ns
• UTC cable identification:	—	—
Corresponding cable delay :	—	—
• Delay to local UTC :	7 ns	19.5 ns
• Receiver trigger level:	DON'T KNOW.	0.5 V
• Coordinates reference frame:	DON'T KNOW	DON'T KNOW.
Latitude:	51° 25' 15.3368'	15° 25' 15.3710'
Longitude:	359° 39' 40.3364'	359° 39' 40.2883'
Height:	66.45 m.	66.23 m

1PPS ENTERS RECEIVER.

Description of the local method of cable delay measurement:

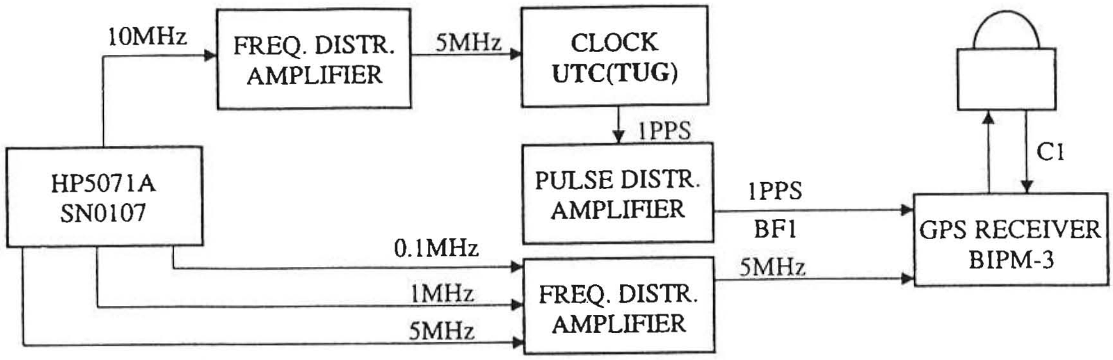
Cable delay control

Cable identification	delay measured by BIPM	delay measured by local method
BIPM portable IF antenna cable C1	235.5 ns	NOT MEASURED.
BIPM portable UTC cable C4	170.0 ns	NOT USED.

BIPM GPS calibration information sheet

Laboratory:	TUG
Date and hour of the beginning of measurements:	1997-11-27 10:30
Date and hour of the end of measurements:	1997-12-01 08:50

Plot of portable receiver set-up:

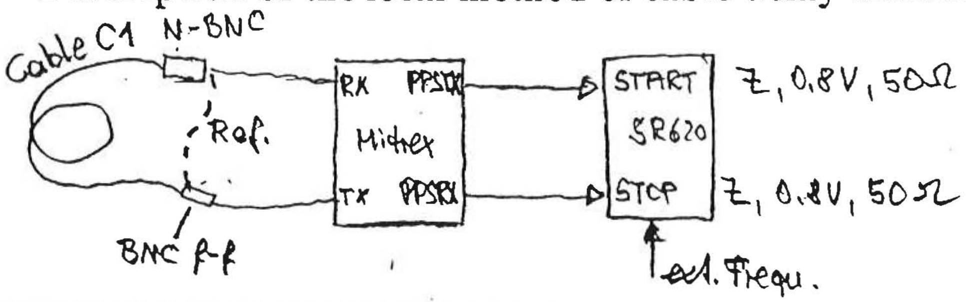


Rise time of the local UTC pulse: 5 ns

Receiver information

	Local:	Portable: BIPM3
• Maker:	NBS	Allen Osborne Associates
• Type:	NBS	TTR6
• Serial number:	12	SN 277
• Receiver internal delay :	55,6 ns	57 ns
• IF Antenna cable identification:	412A	C1
Corresponding cable delay :	222 ns	236 ns
• UTC cable identification:	A1	BF1
Corresponding cable delay :	34,3 ns	40,7 ns
Delay to local UTC :	34.3 ns	108,0 ns
• Receiver trigger level:		0.5 V
• Coordinates reference frame:	ITRF 88	ITRF 88
Latitude:	N 47° 04' 1.6882	N 47° 04' 01,6395
Longitude:	E 15° 29' 36.6710	E 15° 29' 36,6710
Height:	540.31 m	540,31 m

Description of the local method of cable delay measurement:



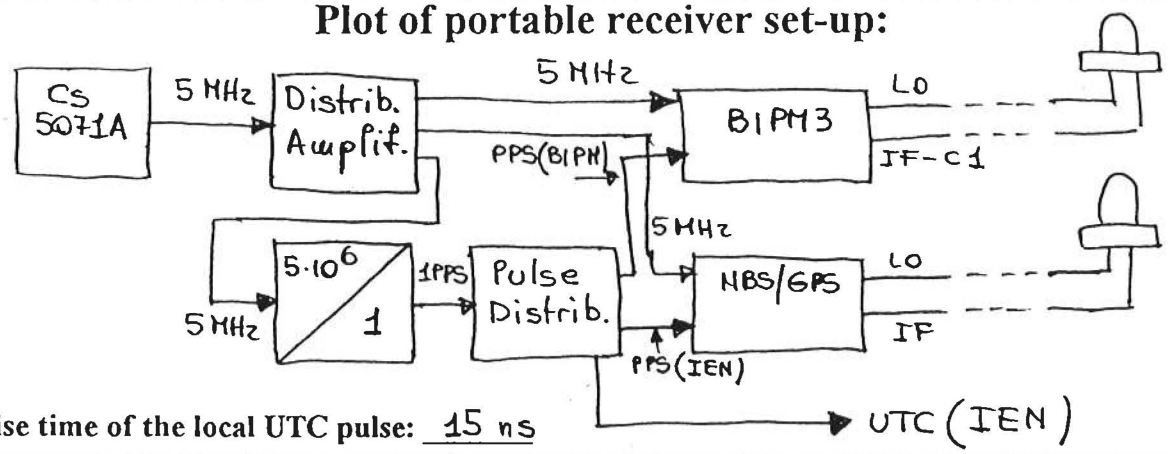
Cable delay control

Cable identification	delay measured by BIPM	delay measured by local method
BIPM portable IF antenna cable C1	235.5 ns	234.8 ns
BIPM portable UTC cable C4	170.0 ns	

BIPM GPS calibration information sheet

Laboratory:	IEN
Date and hour of the beginning of measurements:	50786 ; 97-12-04 ; 10:10 UTC
Date and hour of the end of measurements:	50791 ; 97-12-08 ; 7:26 UTC

Plot of portable receiver set-up:



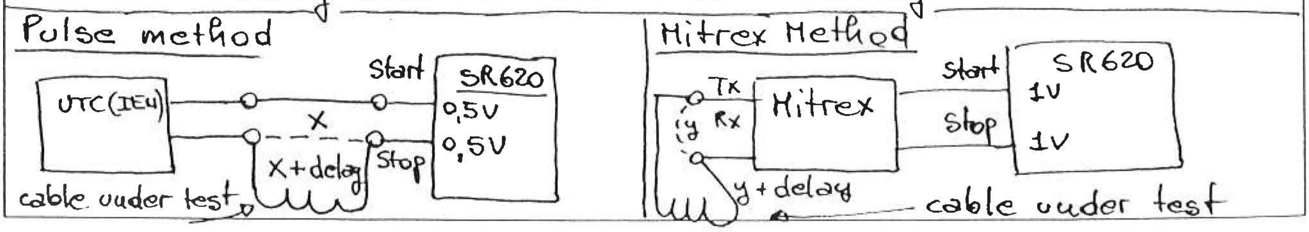
Rise time of the local UTC pulse: 15 ns

Receiver information

	Local:	Portable: BIPM3
• Maker:	NBS	Allen Osborne Associates
• Type:	NBS/GPS Time Transfer	TTR6
• Serial number:	031	SN 277
• Receiver internal delay :	253 ns (*)	57 ns
• IF Antenna cable identification:	IF	C1
Corresponding cable delay :	(nominal value: 230 ns)	236 ns
• UTC cable identification:	IEN	IEN
Corresponding cable delay :	not available	not available
Delay to local UTC :	12,0 ns	14,2 ns
• Receiver trigger level:	0,5 V	0.5 V
• Coordinates reference frame:	ITRF88	ITRF88
Latitude:	45° 00' 54,048" N	45° 00' 53,987" N
Longitude:	7° 38' 20,709" E	7° 38' 20,686" E
Height:	306,64 m	306,64 m

Description of the local method of cable delay measurement:

(*) We cannot supply separately the contribution of the IF antenna cable delay and internal receiver delay



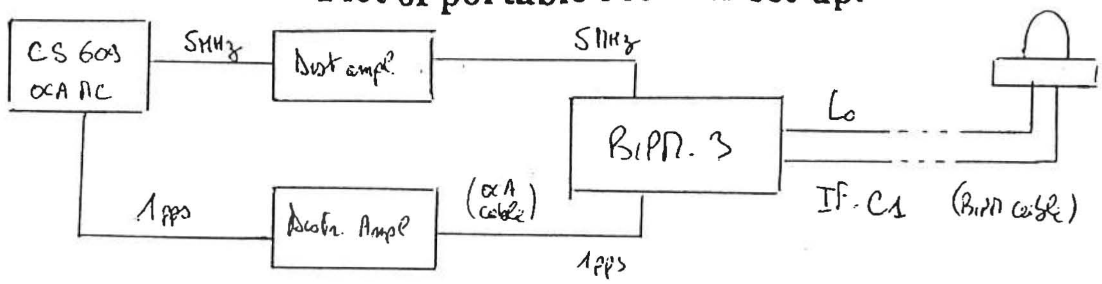
Cable delay control

Cable identification	delay measured by BIPM	delay measured by local method
BIPM portable IF antenna cable C1	235.5 ns	Pulse meth. : 236,0 Mitrex : 234,7
BIPM portable UTC cable C4	170.0 ns	Pulse method: 170,4 ns Mitrex method: 169,7 ns

BIPM GPS calibration information sheet

Laboratory:	OCA - CERGA
Date and hour of the beginning of measurements:	1997 - 12 - 12 - 50794 17 : 38 UT
Date and hour of the end of measurements:	1997 - 12 - 16 - 50798 7 : 30 UT

Plot of portable receiver set-up:

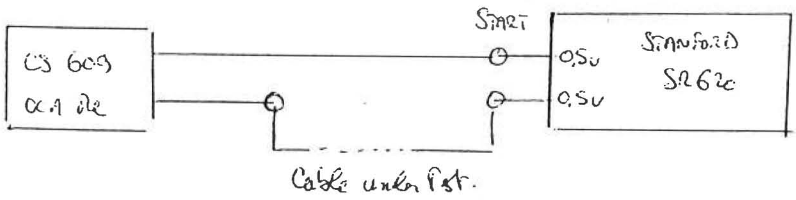


Rise time of the local UTC pulse: ______

Receiver information

	Local: NBS07	Portable: BIPM3
• Maker:	Allen Osborne Associates	Allen Osborne Associates
• Type:	TTR 5	TTR6
• Serial number:	S/N 053	SN 277
• Receiver internal delay :	194 ns Receiver + Ifantenna	57 ns
• IF Antenna cable identification:	(TOTAL delay)	C1
Corresponding cable delay :		236 ns
• UTC cable identification:	OCA	OCA
Corresponding cable delay :	–	–
Delay to local UTC :	85.1 ns	92 ns
• Receiver trigger level:	0,5 v	0,5 v
• Coordinates reference frame:		
Latitude:	43° 45′ 17,3779″ N	43° 45′ 17,3779″ N
Longitude:	06° 55′ 16,8229″ E	06° 55′ 16,8641″ E
Height:	1322.50	1322.50

Description of the local method of cable delay measurement:



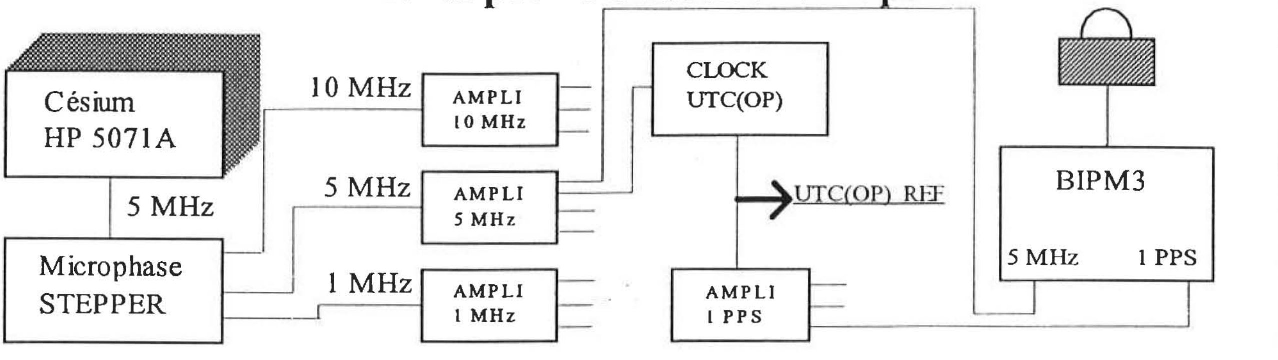
Cable delay control

Cable identification	delay measured by BIPM	delay measured by local method
BIPM portable IF antenna cable C1	235.5 ns	236.7 ns
BIPM portable UTC cable C4	170.0 ns	NOT USED

BIPM GPS calibration information sheet

Laboratory:	LPTF
Date and hour of the beginning of measurements:	12-22-97 17h14 UT
Date and hour of the end of measurements:	01-14-98 09h00 UT

Plot of portable receiver set-up:



Rise time of the local UTC pulse: 5 ns

Receiver information

	Local:	Portable: BIPM3
• Maker:	Allen Osborne Associates	Allen Osborne Associates
• Type:	TTR5	TTR6
• Serial number:	SN 051	SN 277
• Receiver internal delay :	54 ns	57 ns
• IF Antenna cable identification:	n° 505	C1
Corresponding cable delay :	168 ns	236 ns
• UTC cable identification:	n° 503	n° 494
Corresponding cable delay :	37 ns	48 ns
Delay to local UTC :	304 ns	315 ns
• Receiver trigger level:	0.5 V	0.5 V
• Coordinates reference frame:	ITRF 88	ITRF 88
Latitude:	48°50'09''.2369	48°50'09''.0999
Longitude:	02°20'05''.8730	02°20'05''.7389
Height:	124.51 m	124.58 m

Description of the local method of cable delay measurement:

Dual weighing method using a time interval counter HP 5370 triggered by 1 PPS from BNM-LPTF hydrogen maser.
The time base of the time interval counter is steered by 10 MHz maser.
The process is repeated twice.
Final result is the mean value of both evaluations of the cable delay.

Cable delay control

Cable identification	delay measured by BIPM	delay measured by local method
BIPM portable IF antenna cable C1	235.5 ns	236.453 ns ± 300 ps
BIPM portable UTC cable C4	170.0 ns	170.475 ns ± 300 ps

Appendix III

Daily results of the comparisons

Lab	Date 1997	Number of individual common views	Mean offset /ns	Standard deviation of individual common view /ns	Standard deviation of the mean /ns
OP	Oct 1	46	1.29	2.75	0.41
	Oct 2	43	0.88	2.75	0.42
	Oct 3	43	0.76	2.02	0.31
	Oct 4	45	0.33	2.64	0.39
	Oct 5	45	0.51	2.50	0.37
	Oct 6	45	0.54	2.41	0.36
	Oct 7	48	0.00	2.72	0.39
CH	Oct 16	13	1.62	2.61	0.72
	Oct 17	33	0.91	1.56	0.27
	Oct 18	31	1.58	1.24	0.22
	Oct 19	32	2.07	1.28	0.23
	Oct 20	10	1.57	1.11	0.35
SP	Oct 23	18	-41.32	3.10	0.73
	Oct 24	27	-43.23	3.94	0.76
	Oct 25	29	-43.67	3.49	0.65
	Oct 26	26	-43.67	3.37	0.66
	Oct 27	8	-44.35	3.38	1.20
VSL	Oct 31	10	-23.80	2.78	0.88
	Nov 1	18	-23.74	1.56	0.37
	Nov 2	17	-22.93	2.61	0.63
	Nov 3	17	-24.15	1.99	0.48
	Nov 4	2	-22.90	0.85	0.60
DTAG	Nov 5	8	3.44	4.09	1.44
	Nov 6	34	4.92	2.09	0.36
	Nov 7	39	5.34	2.39	0.38
	Nov 8	37	5.25	2.18	0.36
	Nov 9	39	5.12	2.99	0.48
	Nov 10	5	3.58	3.24	1.45

Lab	Date 1997	Number of individual common views	Mean offset /ns	Standard deviation of individual common view /ns	Standard deviation of the mean /ns
PTB	Nov 11	20	4.74	2.46	0.55
	Nov 12	45	3.70	2.08	0.31
	Nov 13	47	3.80	2.73	0.40
	Nov 14	47	4.01	2.48	0.36
	Nov 15	47	3.43	2.89	0.42
	Nov 16	46	3.11	2.96	0.44
	Nov 17	9	2.91	2.14	0.71
NPL	Nov 21	20	-2.70	2.84	0.63
	Nov 22	28	-2.53	2.32	0.44
	Nov 23	31	-1.81	3.51	0.63
TUG	Nov 27	23	-5.01	2.32	0.48
	Nov 28	46	-5.33	1.96	0.29
	Nov 29	45	-5.01	1.78	0.27
	Nov 30	45	-4.83	1.63	0.24
	Dec 1	19	-5.28	2.78	0.64
IEN	Dec 4	18	-15.09	1.20	0.28
	Dec 5	44	-15.55	1.83	0.28
	Dec 6	42	-15.18	1.22	0.19
	Dec 7	43	-15.09	1.19	0.18
OCA	Dec 12	8	5.72	2.39	0.84
	Dec 13	30	6.25	2.94	0.54
	Dec 14	28	7.79	2.16	0.41
	Dec 15	19	7.22	2.18	0.50
	Dec 16	6	7.65	1.97	0.81
OP	Dec 22	12	-1.91	3.15	0.91
	Dec 23	47	-2.45	3.27	0.48
	Dec 24	46	-2.25	2.73	0.40
	Dec 25	44	-2.49	2.89	0.44
	Dec 26	47	-1.84	3.03	0.44
	Dec 27	45	-1.78	2.53	0.38
	Dec 28	46	-1.06	2.90	0.43
	Dec 29	44	-2.01	2.79	0.42
	Dec 30	47	-1.74	3.01	0.44

Lab	Date 1997	Number of individual common views	Mean offset /ns	Standard deviation of individual common view /ns	Standard deviation of the mean /ns
OP	Dec 31	46	-1.58	2.34	0.34
	Jan 1	44	-2.32	2.29	0.35
	Jan 2	46	-1.16	2.36	0.35
	Jan 3	46	-1.48	2.70	0.40
	Jan 4	44	-2.27	2.97	0.45
	Jan 5	44	-1.65	2.50	0.38
	Jan 6	47	-0.88	2.63	0.38
	Jan 7	47	-1.67	2.25	0.33
	Jan 8	46	-1.24	2.58	0.38
	Jan 9	46	-1.40	2.35	0.35
	Jan 10	40	-1.29	2.74	0.43
	Jan 12	43	-1.49	2.64	0.40