Update on TWSTFT and Related Activities at PTB

Dirk Piester

20th Meeting of the CCTF WG on TWSTFT, BIPM, Sèvres, 6-7 September 2012

PTB‘s Time Dissemination Group

A. Bauch (head)

J. Becker

D. Piester

T. Polewka

+

E. Staliuniene (non permanent)

M. Rost (non permanent, until March

+

A. Hoppmann (partly)

Tasks and Work

Generation of UTC(PTB)

together with Unit of Time Group

Dissemination of Time

Low Frequency Transmitter DCF77

NTP-Servers

European Telephone Time Service

Remote Comparisons

GPS

GLONASS

TWSTFT

TWSTFT

PTB01: link to European and U.S. laboratories

satellite: T-11N
frequencies: Ku-band
modem: SATRE, 1 MCh/s
data format: ITU-R TF.1153-2 (individual)

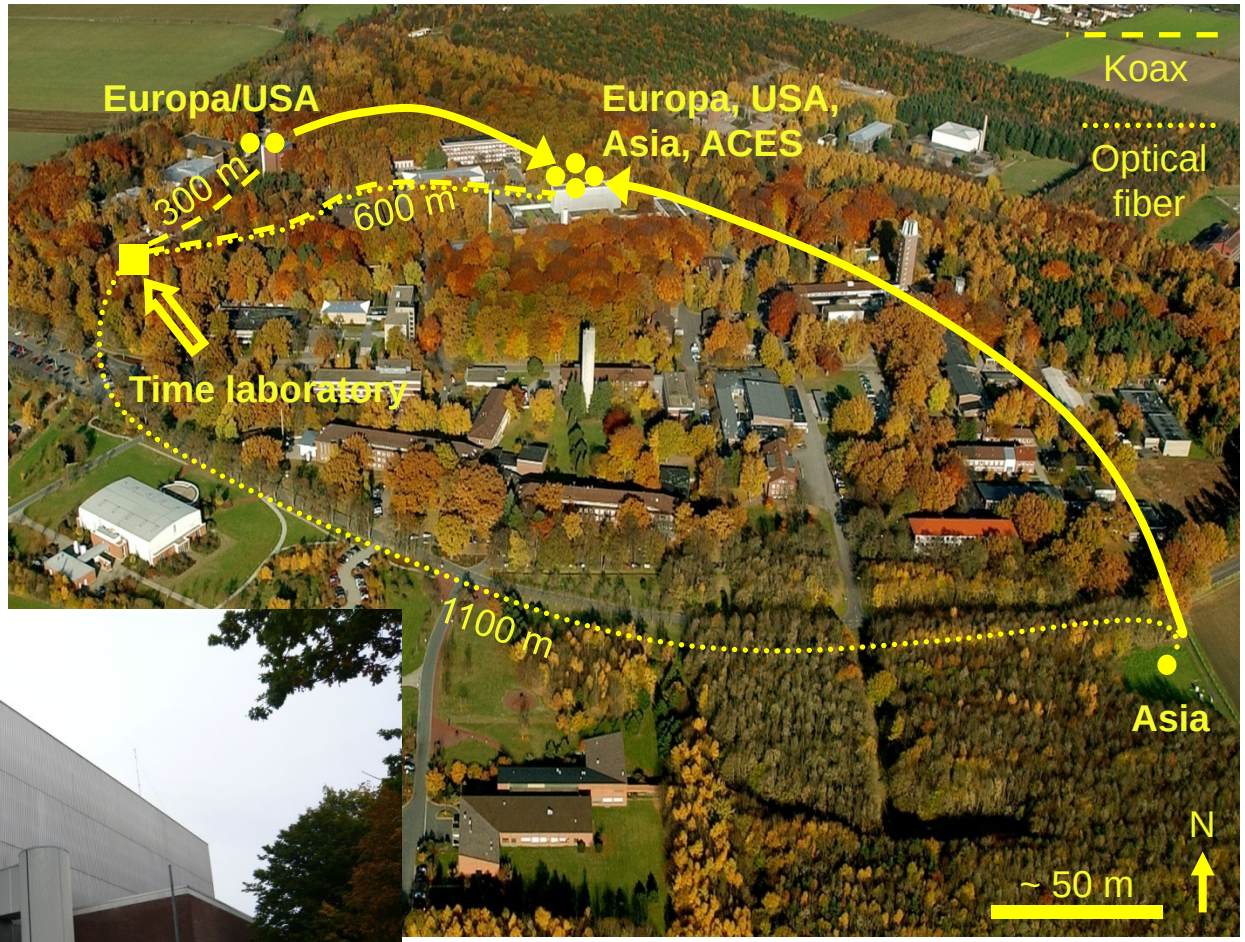
PTB03: link to Asia and Russia

satellite: Intersputnik AM2 available from 2010-10
frequencies: Ku-band
modem: SATRE, 2.5 MCh/s @ BW = 2.5 MHz
data format: ITU-R TF.1153-2 (individual)

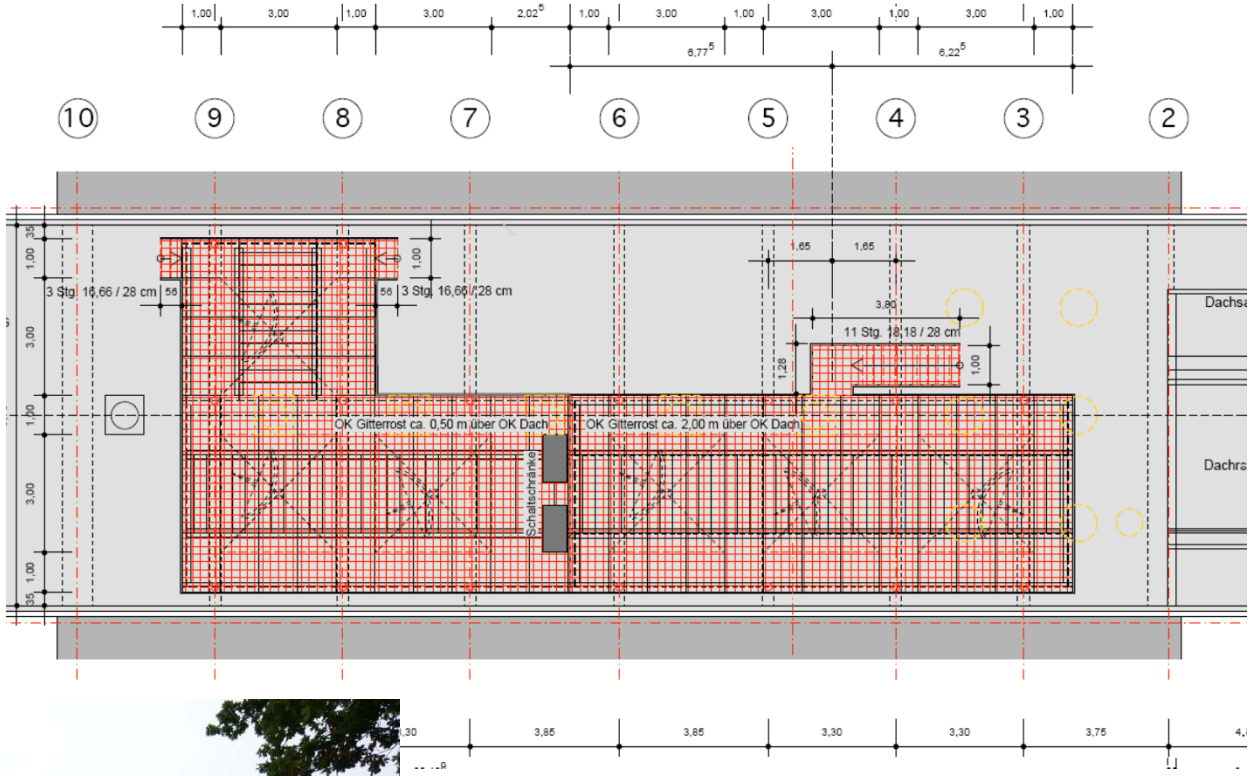
PTB04: spare Ku-band station

New location for antennae ensemble

One site dedicated for the TWSTFT stations



New location for antennae ensemble



Space for fixed and mobile TWSTFT stations, ACES ground terminal

New location for antennae ensemble

2010

New location for antennae ensemble

2011

New location for antennae ensemble

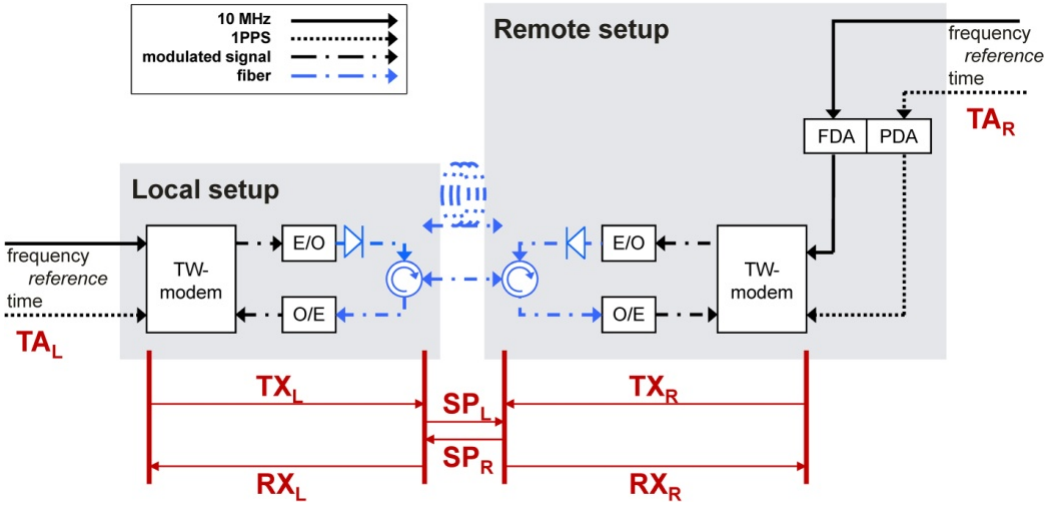
2012

Cables and fibers are installed
PTB04 station will be installed soon.
Equipment for new PTB05 station ordered

Experiment

Measure the time difference of 1pps of a passive hydrogen maser (PHM) at IQ in Hannover with UTC(PTB) in Braunschweig through a 73 km fiber connection.

This fiber connection has been used to demonstrate highly stable frequency transfer.
[Terra et al., Appl. Phys. B **97** 2009]



Use Satellite Time and Ranging Equipment (SATRE) modems in a two-way configuration for time transfer through the fiber.

Both modems are supplied with 10 MHz and 1 pps reference signals.

Frequency: 70 MHz
Chiprate: 20 Mcps (BW ≈ 40 MHz)

Optical wavelength: 1550 nm

Compare the results with that of a GPS link, which was calibrated using well-established procedure.
[Feldmann et al., Proc. PTTI 2010, 509-526]

Experiment

What are the necessary steps?

Connect all components to UTC(PTB) (10 MHz and 1 pps).

Determine the common clock difference for the optical fiber link using a short fiber.

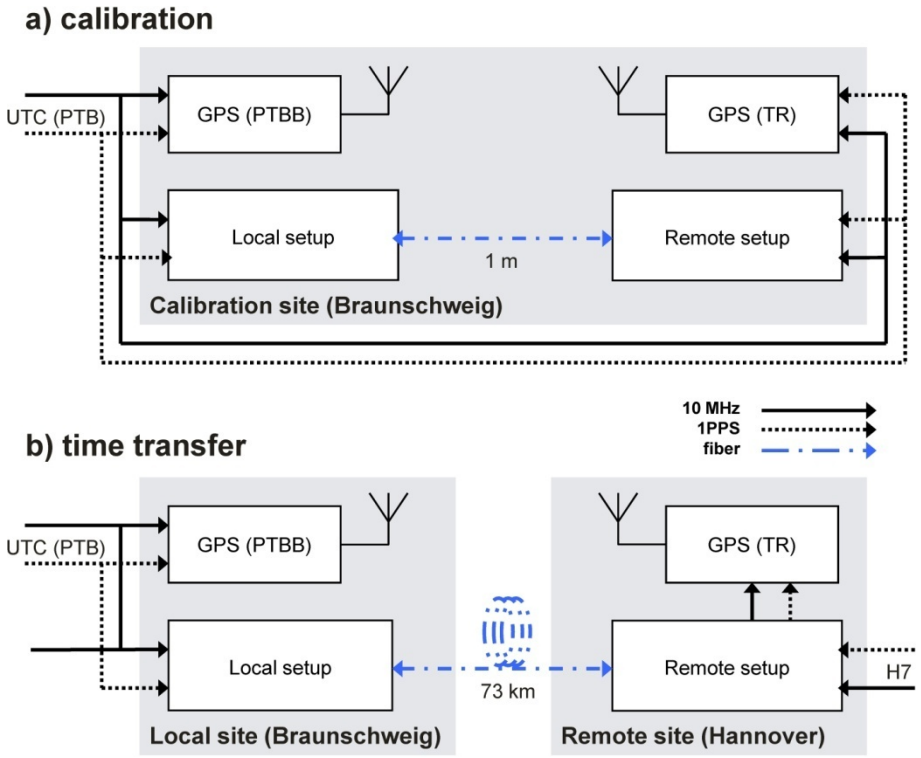
Determine the common clock difference between the GPS receivers.

Move the remote setup of the optical fiber link and the travelling GPS receiver to the remote site. Connect them to the remote reference clock, which is a passive hydrogen maser (PHM).

Determine the clock offset by means of the fiber connection as well as the GPS time transfer link.

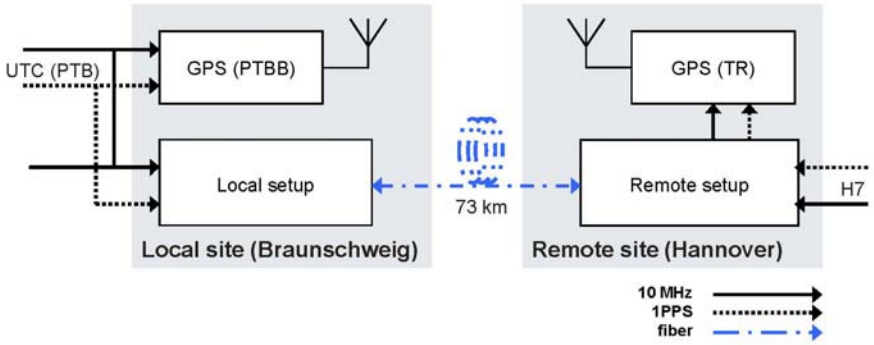
Bring the complete remote setup back to the calibration site and repeat the common clock difference measurements.

Determine all uncertainty contributions along the time transfer chain starting from the UTC(PTB) reference point to the reference point of PHM



Experiment

Fourth: Time Transfer between IQ and PTB



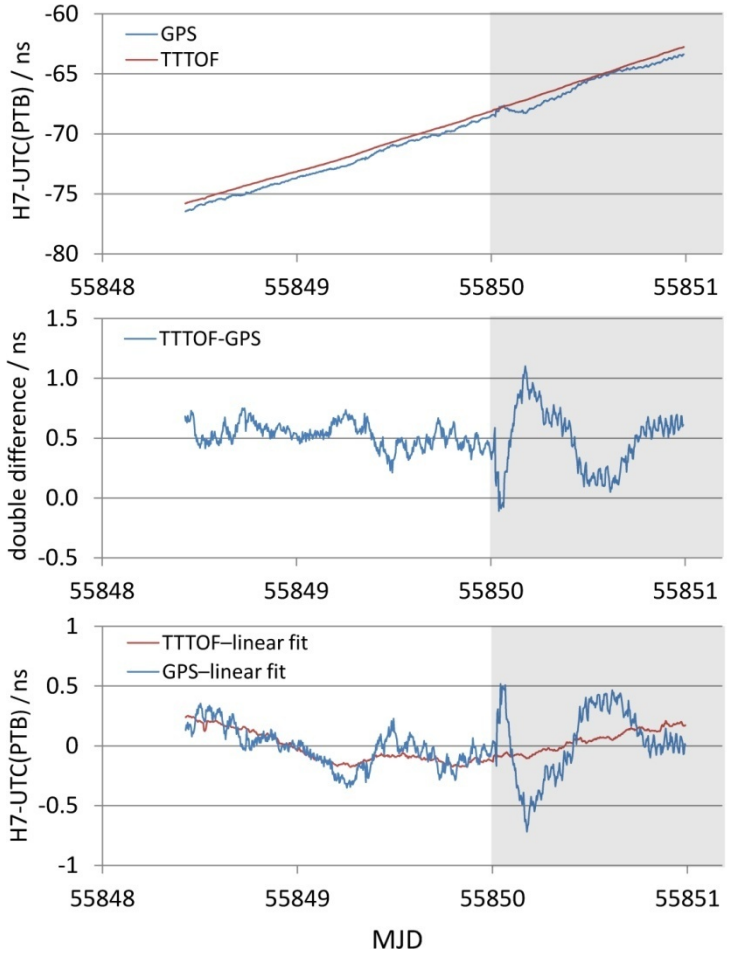
Compare PHM (IQ, Hanover) with UTC(PTB) in Braunschweig

Distance: 73 km optical fiber

By means of:
1) Time transfer through optical fibers
2) GPS PPP time transfer

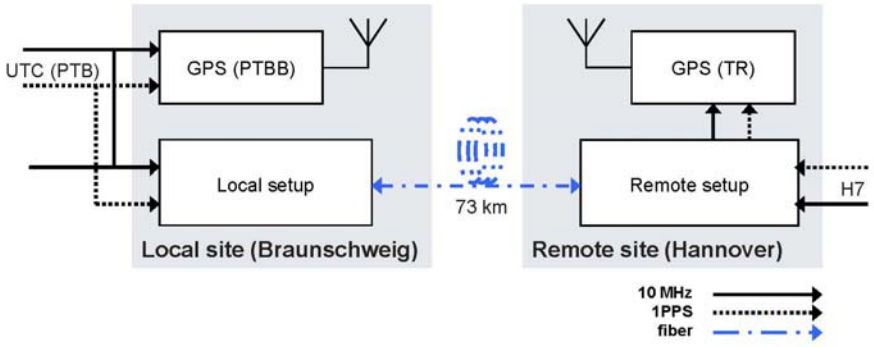
Agreement between both techniques:
Double difference ≈ 0.5 ns

Subtraction of linear clock phase drift reveals that noise of GPS PPP time transfer is dominant.



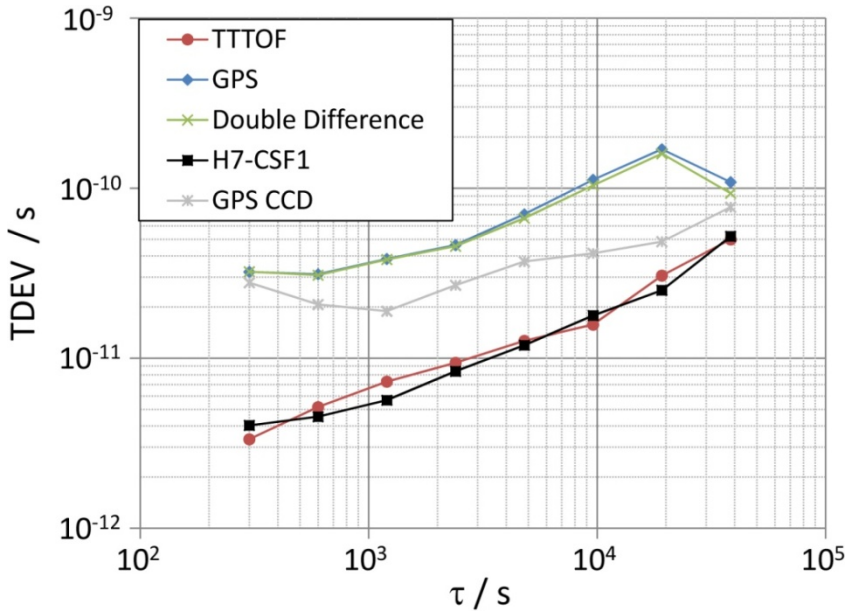
Experiment

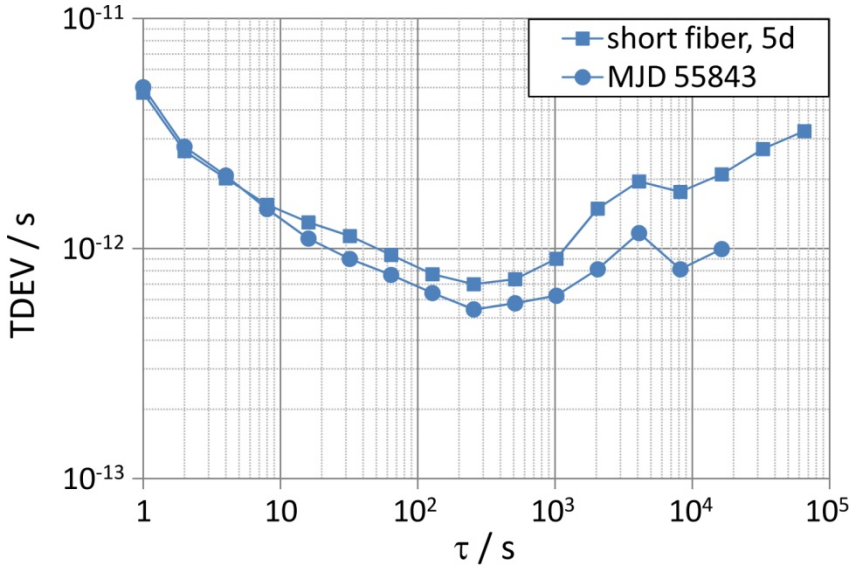
Fourth: Time Transfer between IQ and PTB



Optical fiber time transfer is limited by instability of PHM

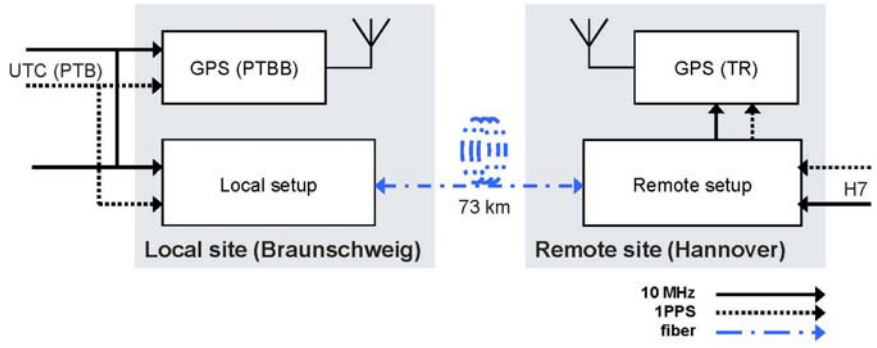
GPS PPP common clock performance at PTB is slightly better than on the baseline Hannover-Braunschweig.

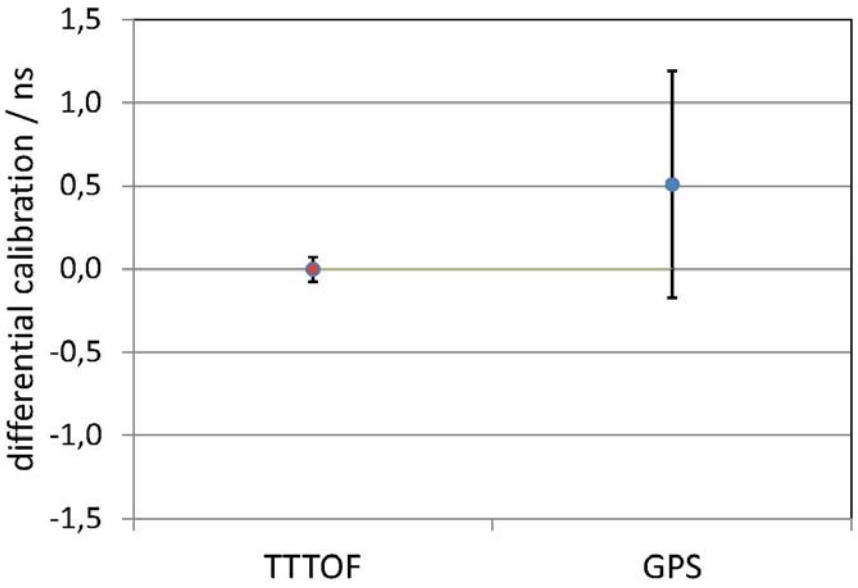




Results

Fourth: Uncertainty budget evaluation





Uncertainty budget for optical fiber time transfer

uA common clock difference:	
Raw two-way measurement	6 ps
TIC modem "local"	36 ps
TIC modem "remote"	10 ps
uA link:	
Raw two-way measurement	6 ps
TIC modem "local"	29 ps
TIC modem "remote"	10 ps
uB:	
Reference 1pps calibration	36 ps
Closure	40 ps

Estimated uncertainty for the optical fiber link:
73 ps (k = 1)

Estimated uncertainty for the GPS PPP link:
0.7 ns (k = 1)
Uncertainty evaluation see e.g.
[Feldmann et al., Proc. PTTI 2010, 509-526]

Difference between both techniques:
≈ 0.5 ns

Thanks for your attention!
Благодаря за вниманието!
感谢您的关注
Děkuji vám za pozornost
Dank voor uw aandacht!
Merci pour votre attention!
Σας ευχαριστώ για την προσοχή σας
Grazie per l´attenzione!
ご清聴ありがとうございます
감사합니다
Ačiū už dėmesį
Dziękuję za uwagę!
Obrigado pela vossa atenção
Спасибо за внимание
¡Gracias por su atención!
Tack för er uppmärksamhet!
உங்கள் கவனத்திற்கு நன்றி!
Danke für Ihre Aufmerksamkeit!