PC Disciplined Timing Workshop

MICHAEL CAMILLERI

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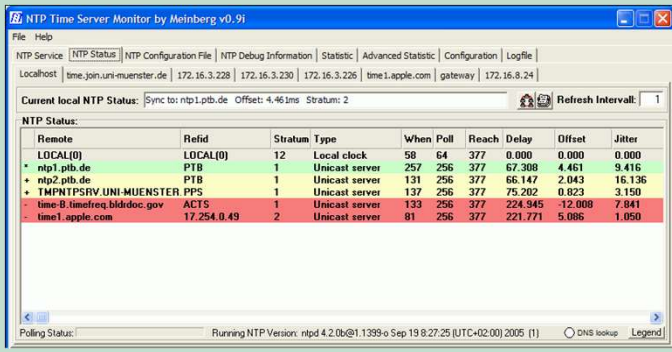
What is PC Disciplined Timing?

Uses the PC internal clock as the time source for timestamps

PC internal clock is *disciplined* to follow an external time source

External Time Sources:

- **Internet Network Time Protocol (NTP) server time**
- **Local GPS NTP server**
- **GPS PPS receiver**
- **GPS NMEA receiver**
- **Shelyak Timebox II**



How is the PC Time Disciplined?

NTP (or other software) checks the *offset* between PC clock and the time source

Adjusts the PC internal clock rate (PPM) making it run a bit faster to catch up or a bit slower to slow down

Only does a hard *STEP* correction if there is a large time error (e.g. > 128 ms) or the user forces a restart

Unless your PC has a temperature corrected Real Time Clock (RTC) it will drift with changes in temperatures and processing load

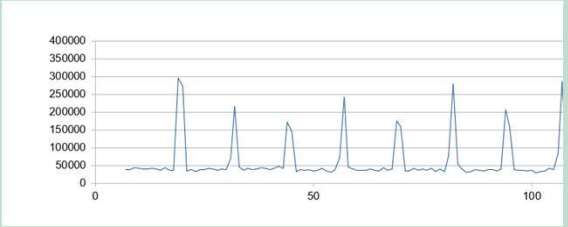
GPS Flash Timing for Camera Delays

PC timestamps when the frame is received by recording software, e.g. SharpCap

MUST measure and account for delays in the camera itself and Windows

Use GPS Flash Timing to do this

One off calibration to start, check and update periodically



Line Delay Calculator

Select Camera Setting	Row	Per Line Delay	Line 0 delay	Occulted Star Y line	Delay
A	1	-0.040	17.6	316	**4.9** ms

Note: Line delays would usually be 5-20 ms for a small sensor monc
Large sensor colour cameras could have delays of 50-100 ms or m

Camera Line Delays Specific Camera Settings

Setting	Camera	PC Name	Camera Area	Binning	Tilt	Pan	Colour Space	File Format	Per Line Delay	Line 0 delay
A	asi462mm	AstroPC	816x822	2	280	68	RAW16	ADV	-0.040	17.6
B	Svbony 305 M Pro	AstroPC	800x800	2	300	70	RAW16	ADV	-0.035	15.0

Why PC Disciplined Timing?

Enables PC to be used for occultations with any CMOS camera

Cheap and easy way for new observers to start

Suitable for remote and unattended setups

Gives an independent backup time source for other methods

Enables testing of the timing accuracy for other systems

Workshop Order of Service

Setting up NTP timing

Operating and Monitoring NTP timing

Adding GPS PPS or NMEA timing

Measuring Camera delays with GPS Flash timing

Putting it all together – full recording workflow

Windows Issues – PC drift, processing delays

Key Documents

Occultation Timing Using a GPS Disciplined PC

GPS Flash Timing to Timestamp Occulation Recordings

These documents have links to software, drivers and calculation workbooks

Copies of software, drivers and documents are available on a USB drive in the workshop

Setting up NTP Timing

Install Meinberg NTP

Start in **Occultation Timing Using a GPS Disciplined PC**, section “Installing NTP”

Brief instructions here

Download and install Meinberg NTP software
https://www.meinbergglobal.com/english/sw/ntp.htm#ntp_stable

Install under **C:/** or **Desktop** – somewhere you have full access

Use default settings

Ensure the override system time option is selected

Enable logging

Select Oceania Server Pool or your region

Install Meinberg NTP Server Monitor

Download and install Meinberg NTP Server Monitor software

https://www.meinbergglobal.com/english/sw/ntp-server-monitor.htm

Install under C:/ or Desktop – somewhere you have full access

Use default settings

Check NTP working

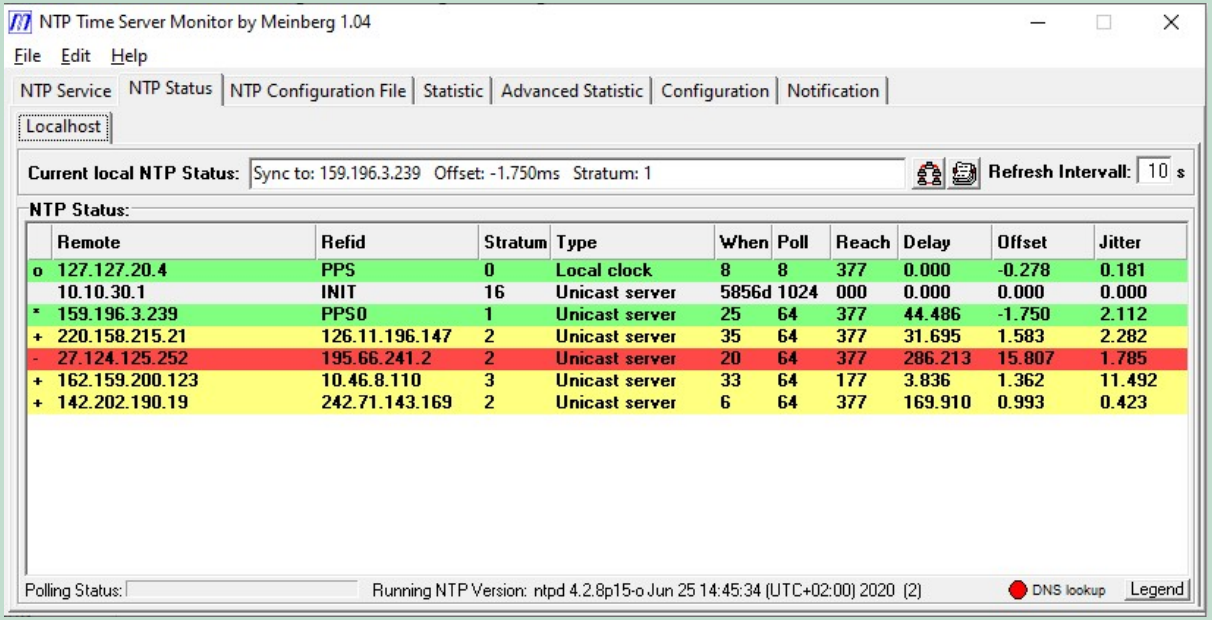
Open the NTP Server Monitor app

Go to NTP Status

Should look something like this

Your Offset likely to be tens of ms

If no servers connected, ensure you have internet connection



Should not have to restart PC but ask for help if not getting to this point

Understanding NTP stats

Remote: IP address of the remote time source

Refid: Label (either from the source or your own label)

Stratum: Level in the time hierarchy – distance from the primary UTC souce

When: How many seconds since the time source was polled

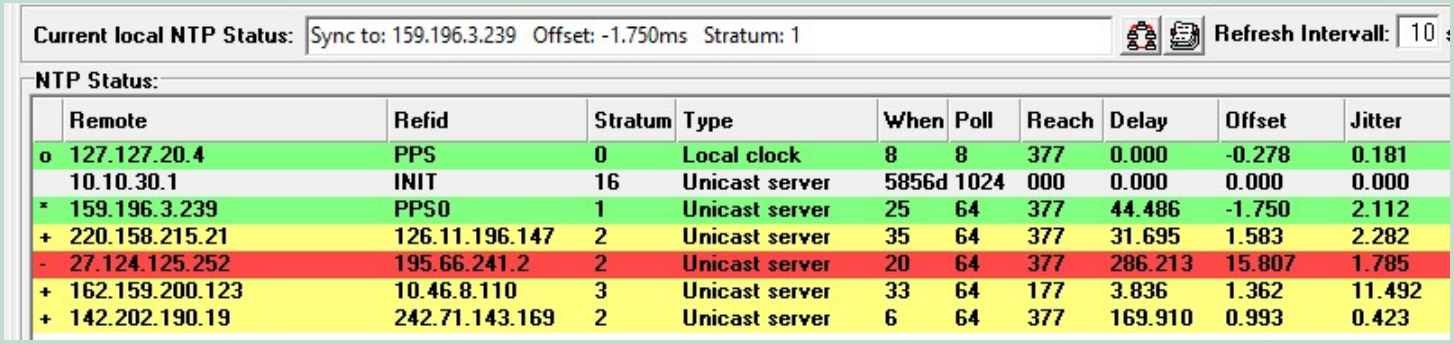
Poll: Interval in seconds between polling

Reach: Complex binary encoding – 377 means all last 8 polls have been good

Delay: Time in ms between sending the request and the response coming back. The lower the better

Offset: Offset in time between the PC clock and the time source. Lower is better

Jitter: Measure of stability. Lower is better



	Remote	Refid	Stratum	Type	When	Poll	Reach	Delay	Offset	Jitter
o	127.127.20.4	PPS	0	Local clock	8	8	377	0.000	-0.278	0.181
	10.10.30.1	INIT	16	Unicast server	5856d	1024	000	0.000	0.000	0.000
*	159.196.3.239	PPS0	1	Unicast server	25	64	377	44.486	-1.750	2.112
+	220.158.215.21	126.11.196.147	2	Unicast server	35	64	377	31.695	1.583	2.282
-	27.124.125.252	195.66.241.2	2	Unicast server	20	64	377	286.213	15.807	1.785
+	162.159.200.123	10.46.8.110	3	Unicast server	33	64	177	3.836	1.362	11.492
+	142.202.190.19	242.71.143.169	2	Unicast server	6	64	377	169.910	0.993	0.423

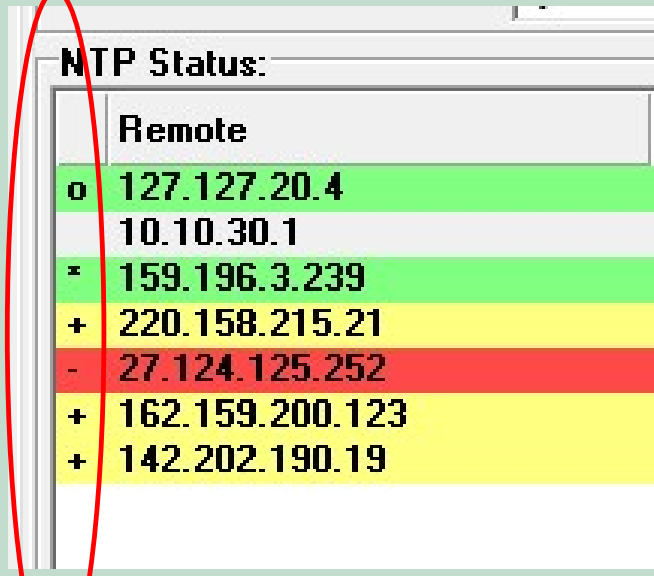
Understanding NTP Status

Asterisk ():* currently using for time synchronization.

Plus (+): acceptable for synchronization if the primary server becomes unavailable

Minus (-): unacceptable for time synchronization.

“o” – time source is using GPS PPS



https://reeve.com/Documents/Articles%20Papers/Reeve_MeinbergMonGuide.pdf

OR - Check NTP working via Command Line

Windows Command Prompt with the command “ntpq -p”

Should look something like this

```
C:\Users\admin>ntpq -p

     remote           refid      st t when poll reach   delay   offset  jitter
==============================================================================
 +161-65-172-9.ip .GNSS.          1 u   63  128  377   18.504   -0.399   1.812
 +ntp1.ntp.net.nz .GPS.           1 u   27  128  377    4.961   +0.838   2.882
 *ntp2.ntp.net.nz .GPS.           1 u    5  128  377    4.319   +2.888   1.183
 -ns1.tdc.akl.tel 202.46.178.18   2 u  127  128  377    3.292   +2.971   2.730
 -ns2.att.wlg.tel 202.46.178.18   2 u   31  128  377   19.394   -2.216   2.636
```

Configure more accurate NTP servers

Much better NTP server time is possible with careful selection of servers.

See section "Selecting Internet NTP Servers" in **Occultation Timing Using a GPS Disciplined PC** for guidance

For NZ use the National Measurements Standards NTP Server

Add localised city pool servers from Auckland, Wellington or Christchurch - https://ntp.net.nz/pages/aup.html

ALWAYS comply with their Acceptable Use policies or risk getting blocked!

Edit NTP Configuration
See file ‘NTP Server Config for NZ.txt’

```
# NZ Measurement Standards Official NZ time server, traceable to UTC
server pool.msltime.measurement.govt.nz iburst minpoll 6 maxpoll 7
# Local pool servers in Auckland - do not add extra parameters as you may violate their terms of use
server s1.ntp.net.nz
server s2.ntp.net.nz
# Wellington Server
server s3.ntp.net.nz
# Christchurch Server
server s4.ntp.net.nz
# Servers from another public NZ pool
server 1.nz.pool.ntp.org iburst minpoll 6 maxpoll 7
server 2.nz.pool.ntp.org iburst minpoll 6 maxpoll 7
```

Outside New Zealand

- Most National Lab NTP servers will be geoblocked, so find your own
- In Australia see https://www.industry.gov.au/national-measurement-institute/nmi-services/physical-measurement-services/time-and-frequency-services - NTP servers
- Have to register to use it
- NIST in the US may have publicly accessible servers
- Also try to find a pool of servers local to your city or state
- Want to get small NTP delays, < 10 ms if possible

Homework – connect to a National Standards NTP server and local pool servers

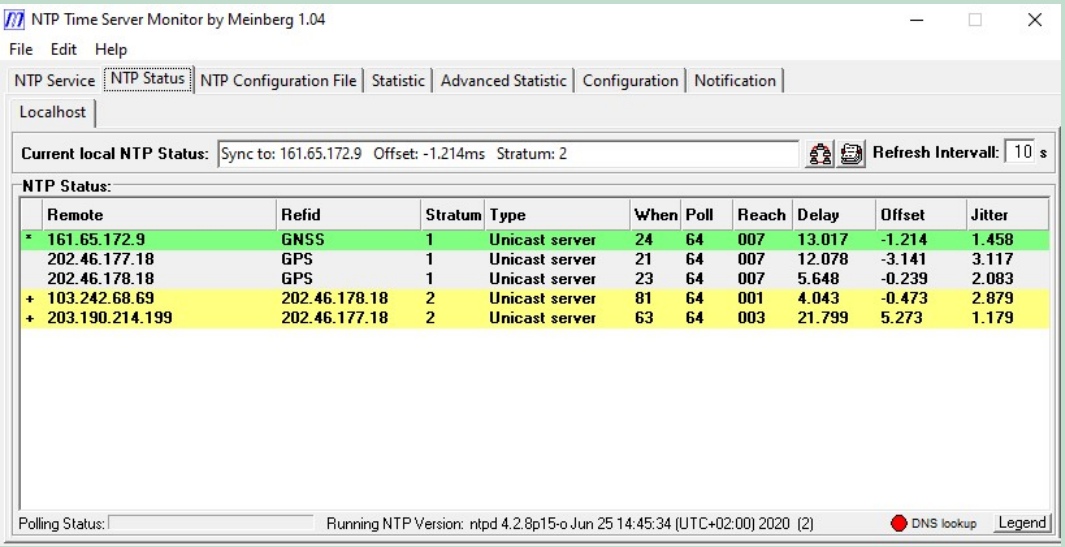
Please share how you did it ...

Restart NTP

- Either use the **NTP Service | Restart** option in Meinberg NTP Server Monitor (might not work due to user permission)
- **Or** find the restartntp.bat batch script under C:\NTP\Bin
- Now is a good time to get these Stop/Start/Restart working
- In see section ‘Enable NTP Loggin’ for more details
- Suggest add the shortcuts to your desktop
- May need to set to ‘run as administrator’

Pause whilst a bunch of people curse Windows for a while...

NTP Now working with low offset



- This is mine from Auckland
- Usually ~12 ms delay to MSL
- Offsets usually a few ms
- Likely worse from Whakatane
- YMMV-

Congratulations!

- You now have PC time that is **FORMALLY TRACEABLE** to UTC through your National Standards Lab NTP server
- Monitor your delays and offsets and it is possible to calculate your timing accuracy

Setting up GPS PPS Timing

Doing better than NTP

- NTP is traceable when set up and monitored properly however your PC time will still drift
- GPS PPS can be used to discipline the PC clock to < 1 ms of UTC
- Highly stable PC time – almost eliminates drift
- PC time can then be used as-is for timestamps
- Just need to measure camera acquisition (later in workshop)

Brace Yourself...

- Now work directly from **Occultation Timing Using a GPS Disciplined PC**
- You should have a GPS PPS USB device available (5 are in the workshop to share)
- Skip to in section “Setting up the GPS Receiver on Windows PC”
- Go step by step – ask for help if you need it
- Rent-a-tech-savvy-kid if you have access to one
- Drivers are in the files provided in the workshop

Next Step: Setting up PPS driver DLL

- Go to section “Setting up the PPS driver DLL”
- Go step by step – ask for help if you need it
- Drivers should already be installed via NTP

Next Step: Setting up GPS PPS Time in NTP

- Go to section “Setting up GPS PPS Time in NTP”
- Go to subsetction “Configuration for GPS PPS time source”

Next Step: Setting up GPS PPS Time in NTP

- Go to section “Setting up GPS PPS Time in NTP”
- Go to subsection “Configuration for GPS PPS time source”
- Once done Restart NTP and check NTP Monitor
- Don’t think you have to restart the PC but not sure

Congratulations!

- You should now have PC time disciplined to < 1 ms, possibly < 0.5 ms
- It should be much more stable than NTP server time alone with little or no drift under load or temperature change
- You also have NTP server time as an **INDEPENDENT TIME SOURCE**
- **Your PC time could be made formally traceable to UTC by monitoring the offsets with a formal error of a few ms**

GPS Flash Timing for Camera Acquisition Delays

Recording Timestamps and Camera Delays

- Your PC time should be accuracy to < 1 ms

BUT

- Your camera and recording software have acquisition delays which MUST be measured
- These delays are different for every camera and change with the camera settings
- Rolling Shutter cameras have delays which vary by the Y line.
- Measure these delays using GPS Flash Timing

GPS Flash Timing and Delay Measurement Setup

- Work from **GPS Flash Timing to Timestamp Occulation Recordings** for initial GPS flash timing setup
- VK172 GPS available in room – x6.
- Install SharpCap if needed
- Install camera drivers if needed
- Work from **GPS Flash Timing to Timestamp Occulation Recordings** section “Camera Acquisition Delays” to measure the line delays
- Use workbook Line Delay Calculator (download your own copy)
- Files on the USB drive in the workshop

Measure Camera Acquisition Delays

- Black out the camera
- GPS flash a short recording (5-10 s)
- Can use your laptop webcam if can’t get a working camera
- Use workbook Line Delay Calculator (download your own copy)

Pause while people mess around with documents, files and camera recordings

Congratulations! You can now measure camera dealys

- Measure the delays for your setup with your usual camera settings
- Can now us PC discipline timing and apply the calculated delays without having to GPS flash time every recording
- Suitable for remote and unattended observations

Questions
More Help
More Detail

The End

Reach out if you need help later