NEMETODE Technical Note #03
Maintaining Accurate Time on a UFO Capture PC

This document provides a guide on how to ensure that the timing accuracy of the clock onboard a PC is maintained to an acceptable level. While targeted specifically at operators of SonotaCo's UFO Capture Software, the information may of course be of value to more general users of other software. Within the NEMETODE team a common third-party timing correction software solution has been implemented (Dimension 4 by Thinking Man Software [1]). This document also discusses experiments that have been carried out to determine its accuracy and discusses a "saw-tooth" reporting issue that has been of concern to some users.
Other timing correction solutions are available and irrespective of the one chosen, elements of this document should be of use to those interested in troubleshooting timing issues. The recommendations are based on user experience within the NEMETODE team and on input from others. Where possible the author has included references to the rationale behind the recommendations provided.

Introduction

The date and time on a PC is typically maintained by an oscillating crystal embedded within a chip located on the PC motherboard that is powered by a backup battery. This is how a PC "remembers" the correct date and time while it is powered off and why the date / time can reset itself to a point in the distant past if / when the battery is removed.
The date and time is "read" from this chip when the PC boots up. Thereafter (until the PC is rebooted) the onboard clock is maintained by the CPU. Depending on how hard the CPU is working (doing other tasks), the clock can drift. In addition, different manufacturers use different implementations of these clock-chips leading to additional errors. A drift of >1s per day is not uncommon and so after a week the onboard time may be in error by more than 7s.
When combining meteor data from a number of UFO Capture stations UFO Orbit applies, by default, a 3s time window when matching up multi-station events so it is important that the date / time of all NEMETODE meteor capture PCs is accurately maintained.
The Windows OS has a built-in Time Service which synchronises PC clock time with an Internet Time Server, but by default it usually does this only once per day: as already stated this means that the PC clock time can drift by a second or more until its next synchronisation. The Windows Time Service (W32Time) can be configured to synchronise the PC clock on a more frequent schedule, e.g. hourly, and it can be set up as an NTP client to synchronise with more than one internet time server [2]. This process is beyond the scope of this document. It is therefore recommended that this functionality is disabled, that the PC is set to GMT and that Daylight Savings Time is disabled.

Dimension 4

To keep UFO Capture PCs running at the same clock time many observers use Dimension 4 (D4) software to synchronise their PC clocks with internet time servers – this typically results in team members' PC clocks being synchronised to better than 0.5s.

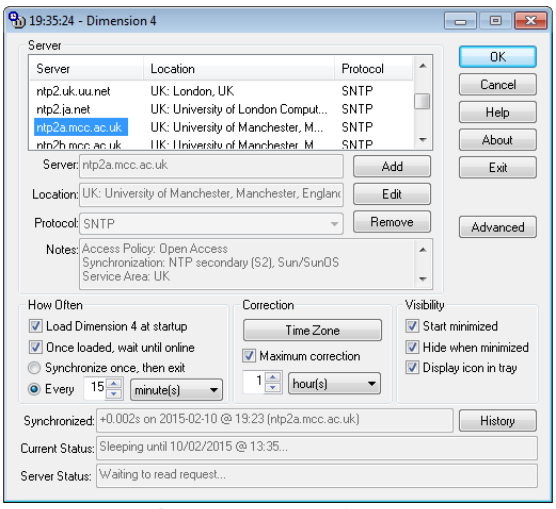

Figure 1: The Dimension 4 Configuration Screen.

Once installed, it is recommended to configure D4 to synchronise every 15 minutes with a geographically local SNTP service. In the British Isles these include the University of London, Cambridge, Manchester or Trinity College, Dublin. If the internet connection is lost for any reason, D4 will continue to attempt to seek and apply time corrections until the internet connection is re-established. If multiple PCs are connected to the same internet connection, users may wish to have each PC synchronise at different intervals (e.g. 13, 15 and 17 minutes respectively). If the internet connection has been lost for a period of time, this means that the PCs are not all attempting to repeatedly synchronise at the same instant.
It is important to remember NOT to close the program but to minimse it to the taskbar. If it is closed then it will no longer be running and hence will not seek or apply any time corrections. This being the case the program can be re-launched from the Start menu. In order to keep the taskbar clear, the Configuration Screen (see Figure 1) does have a checkbox that gives users the option to hide the program from the taskbar when minimised.
If it was running when the PC was previously instructed to shutdown, D4 will usually auto-launch and the small grey D4 icon: is displayed on the taskbar. There may however be occasions when this does not happen and it is therefore worth getting into the routine of verifying that the icon is present when checking the PC. It is also recommend to periodically hover the mouse pointer over the icon: doing so pulls up a message bar indicating when the last synchronisation took place (see Figure 2).

Figure 2: Hovering the mouse pointer over the D4 icon on the taskbar (highlighted by the red arrow) pulls up a message bar indicating when the last synchronisation took place. Right clicking the icon provides options to "Synchronise Now" or "Open" the program.

The Dimension 4 timing corrections are stored in a History Log (selecting the "History" button in the lower right of the Configuration Screen, as shown in Figure 1, brings up another dialogue box from which the history can be saved locally as a .TXT file). This shows that with a good internet connection to a relatively nearby time source most corrections are of the order of 10ms, and rarely >1s. (Corrections of 100ms are quite acceptable). Broadband speed, domestic loading and proximity to a time server can have an effect (see Figure 3).

William Stewart (Ravensmoor) has developed a spreadsheet D4 Analysis.xls [3] to display the corrections in tabular and graphical form (see Figure 3). This can be used to evaluate historic timing corrections in order that the observer can ascertain if the PC clock has drifted an unacceptable amount (and hence if corrections need to be applied to collected data):

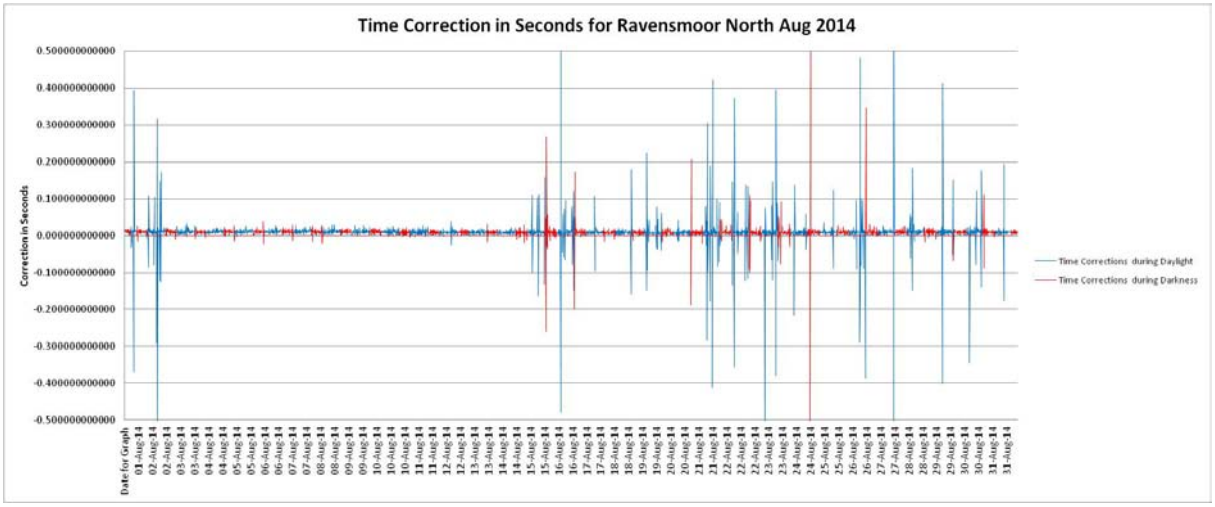

Figure 3: Graphical display of Dimension 4 timing corrections. Time corrections between sunset and sunrise (i.e. during the night) are displayed in red, those applied between sunrise and sunset (i.e. during the day) are in blue. Note the relative stability of the timing corrections during the first half of the month compared to the second half resulting from the fact that the observer and his family were on holiday and hence there was minimal domestic traffic on his local internet connection.

How accurate is Dimension 4?

A number of tests were performed using an independent time source, a very precise GPS VTI (Global Positioning Satellite-synchronised Video Time-and-Date Inserter) [4] giving UTC timestamps accurate to 100 microseconds. (It is not mandatory to use a GPS 1PPS unit to repeat these tests. An analogue radio-controlled clock could be used - resynchronise it with its time source then video record its minute hand as it makes its 60s jump. This usually takes <0.1s to complete. Do not use a clock with a LCD display; they are sluggish, particularly in cool conditions, when the display can take 1s or more to update.)

Dimension 4 was run in its usual mode, applying corrections every 15 minutes. The GPS VTI and UFO Capture PC had reached a steady state before the tests, i.e. the GPS unit had synchronised with the satellites and updated its internal almanac, and the PC was receiving consistently small timing corrections from the Dimension 4 program.

The camera was a Watec 910HX operating at 1/50th sec exposure setting. The PAL video standard of 25 frames per second (50 fields per second), gives a time interval of 0.02s per field, so there is an inherent uncertainty of ±0.01s in the timings from these tests. In addition, there is a camera latency of 0.02s [5].

In UFO Capture's Input sheet the 'superimpose' setting was temporarily changed from '%m' (100 msec) to '%M' (1 msec) for better comparison with the GPS VTI timestamps.

Numerous short videos were recorded for each test and they were analysed at field level using Limovie [6].

Test 1 Dimension 4 time versus GPS VTI time

The video camera was pointed at the front panel of the GPS VTI and UFO Capture was used to detect and record the 1Hz flashes of the GPS receiver's red LED, which blinks within microseconds of receiving each 1PPS (1 pulse per second) signal (see Figure 4). The resultant AVI, JPG and xml files were used in the analysis.

Figure 4: Consecutive frames from UFO Capture recording the LED flash of the GPS VTI.

The "seconds" values of the flash detections by UFO Capture were very close to the exact GPS 1PPS "whole-second" instants (see Table 1)

GPS VTI (s)	**Dimension 4 UFO Capture (s)**	**Difference (s)**
1	0.95	-0.05
9	8.93	-0.07
9	9.03	+0.03
55	54.99	-0.01

Table 1: Comparing Dimension 4 timings with GPS VTI LED flash instances.

These minor differences were consistently <0.1s, often <0.05s. (If the camera latency of 0.02s was applied to these results the time difference would still be <0.1s)

The UFO Capture Input sheet 'superimpose' setting '+msec' also has an effect here. Its default value is 33msec, which is the duration of a single NTSC (American format) video frame, 0.033s. The PAL value is 40 msec. As a test, '+msec' was temporarily set to 0 and a correspondingly slight shift in reported timings was noted. Currently, we're not concerned about such small intervals of time, e.g. 0.04s, so it is suggested that '+msec' is left at its default value.

Test 2 UFO Capture display latency

Whilst performing Test 1 it was noted that there was a slight delay between the 1PPS LED flashes on the GPS VTI and when they appeared in the UFO Capture window. The video camera was used to record the UFO Capture time line on the PC screen before and after each scheduled timing correction whilst the GPS VTI embedded UTC timestamps into the video feed (see Figure 5).

Figure 5: Recording the latency of the UFO Capture screen: the upper value is the time as reported by the UFO Capture software while the lower figure is the time imprinted into the live video stream by the GPS Time-and-Date Inserter.

Analysis of the video recordings confirmed a delay of between 0.2s and 0.3s. This was caused by latency (hardware and/or software) within the UFO Capture PC. Test 1 showed that events are recorded and logged with negligible delay but there was a time lag of about 0.25s before they were displayed in the UFO Capture Live Preview/Detect window (see Figure 6).

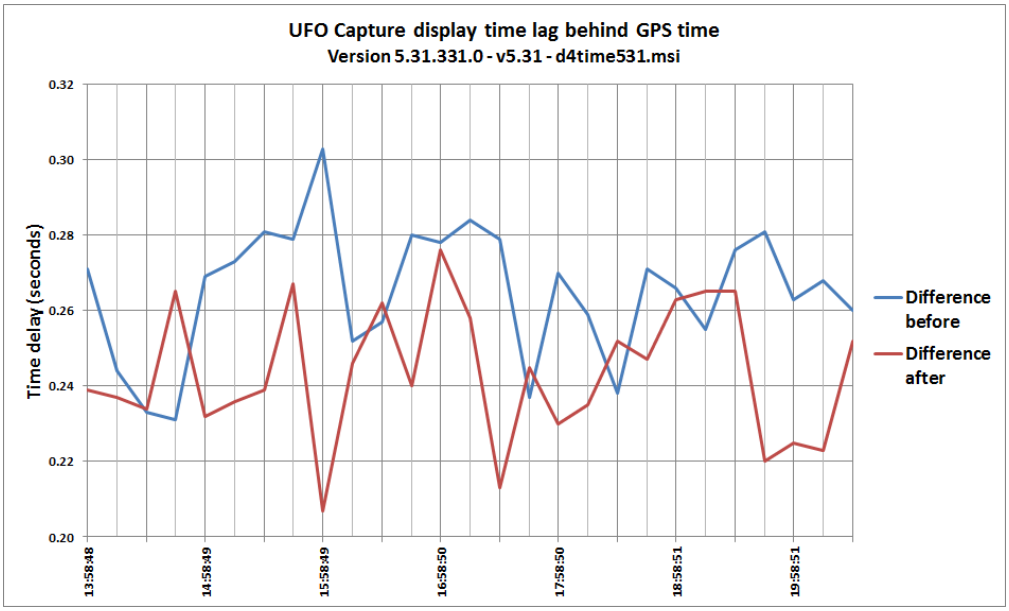

Figure 6: UFO Capture screen display time lag measured before and after each 15 minute timing correction. It varied between 0.2s and 0.3s with an average of approximately 0.25s.

Analysis of the latest versions of Dimension 4

When reviewing the Dimension 4 History.txt file, which logs the timing corrections that have been applied to the PC onboard clock, members of the NEMETODE team questioned the behaviour of the program as some reported it to be quite stable with corrections of around 0.05s, whereas others had seen a regular saw-tooth pattern with a series of corrections up to 0.5s. This was found to be dependent on the version of Dimension 4 that was being used.

Tests of the saw-tooth version of Dimension 4: Version 5.31.331.0 (v5.31, d4time531.msi)

Test 2 was repeated and the timestamps from the GPS unit showed that Dimension 4 soon stabilised and its corrections were consistently ≤ 0.05s.

However, the Dimension 4 History Log gave different results. The graph (Figure 7) shows the saw-tooth pattern that is characteristic of this version. The observed corrections (in red) do not always agree with the History Log (in blue). The sequence begins with a timing correction of ~0.6s (after PC start-up, which is expected behaviour if the PC has been shut down for several hours), followed by small corrections, then the History Log shows values climbing to ~0.5s then reverting back to match the GPS-measured values of ~0.05s. This cycle repeated itself 2 hours later.

The tests showed no evidence of the large saw-tooth variations. These appear to be around 10x the corrections measured with the GPS unit. PC clock updates >0.3s would also be detectable by eye however no such changes were observed. It is not known why this version of Dimension 4 reports such (unobserved) corrections when it doesn't appear to apply them, unless there is an explanation in the coding logic in the program.

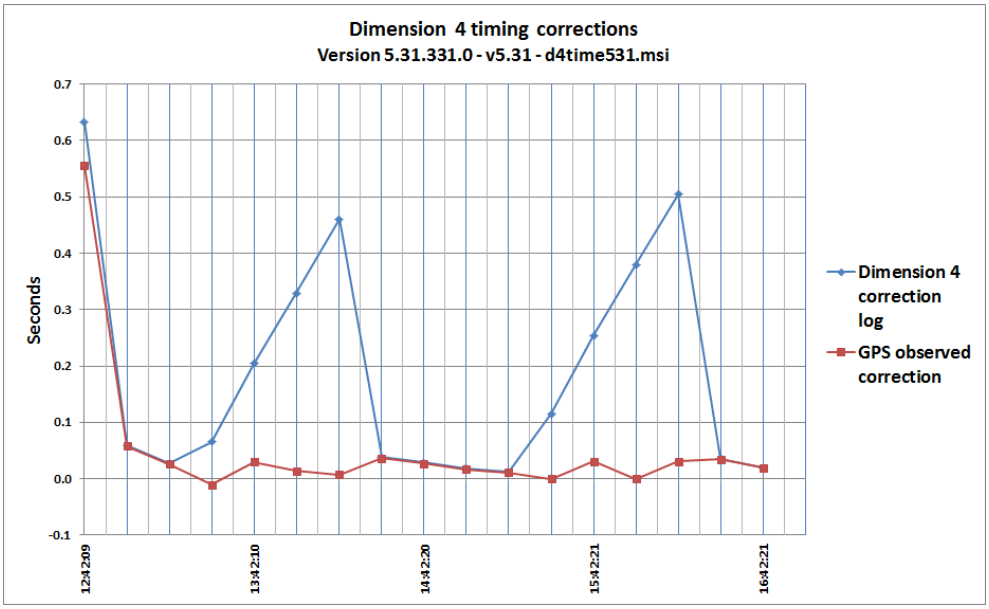

Figure 7: The time corrections of Dimension 4 version 5.31.331.0.

Tests of the 'stable' version of Dimension 4: Version 5.3.26.0 (v5.3, d4time53.msi)

The same tests as performed above confirmed the time corrections given in its History.txt log. The values were consistently small, rarely exceeding 0.05s. An example of the results is presented in Table 2.

Time	**Dimension 4 Correction (History.txt) (s)**	**GPS Measured Correction (s)**
16:50:58	0.053	0.053
17:05:58	0.019	0.019
17:20:58	0.017	0.017
17:35:58	0.013	0.038
17:50:59	0.015	0.021

Table 2: Time corrections for Dimension 4 version 5.3.26.0 (v5.3, d4time53.msi) confirming that this version is stable and does not produce the saw-tooth pattern seen in 5.31.331.0 (v5.31, d4time531.msi).

Date	**Version**
16th August 2000	4.3
01st April 2004	5.0
23rd February 2013	5.3
04th April 2014	5.3.1

Table 3: Release dates and URLs for previous versions of Dimension 4, courtesy of the Internet Archive. Note that the archiving is not performed daily and hence the version is likely to have been released on or before the date stated. The Change History for Dimension 4 is listed at http://www.thinkman.com/dimension4/updates.htm and mentions versions 5.1 and 5.2. It is assumed that these versions came out between 26th January 2013 and 23rd February 2013 and were not picked up by the internet archive trawl.

Conclusions

Dimension 4 is a good, simple to use freeware program for maintaining accurate time on a UFO Capture PC. The saw-tooth behaviour apparent in version 5.31 is a curious pattern limited to the History.txt data and is not representative of the actual timing corrections that have been applied, hence it can be confirmed that it is stable and performs similarly to v5.3.

References

[1] http://www.thinkman.com/dimension4/
[2] Nick James, *personal communication*, 10th August 2014
[3] http://nemetode.org/Tools/Dimension%204%20Output%20Analysis%20Template%2020140922.xls
[4] http://videotimers.com/home.html
[5] http://www.dangl.at/ausruest/vid_tim/vid_tim1.htm#wat910hxccir
[6] http://www005.upp.so-net.ne.jp/k_miyash/occ02/limovie_en.html

Version 1

Alex Pratt, First Issue, Released 20th November 2015

Acknowledgements & Feedback

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If you have any questions, feedback or recommendations then please contact the author at arp@nemetode.org