

TimeBox II  
PF0081  
User Manual



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# Table des matières

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<b>1</b>	<b>Introduction</b>	<b>3</b>
1.1	Versions history . . . . .	3
1.2	Introduction . . . . .	3
1.3	Content of the package . . . . .	3
1.4	Quick Start-Up . . . . .	4
<b>2</b>	<b>General principle</b>	<b>5</b>
2.1	The dating of stellar occultations . . . . .	5
2.2	How it works . . . . .	5
<b>3</b>	<b>The TimeBox II</b>	<b>6</b>
3.1	Main specifications . . . . .	6
3.2	Getting started . . . . .	6
3.3	About the GNSS antenna . . . . .	6
3.4	Le bouton Reset . . . . .	6
<b>4</b>	<b>The software</b>	<b>7</b>
4.1	Software Options . . . . .	9
4.1.1	Stop synchronisation . . . . .	9
4.1.2	Synchronize now . . . . .	9
4.1.3	Automatic COM Port Opening . . . . .	9
4.1.4	Automatic Synchronisation . . . . .	9
4.1.5	Switch to local / UTC time . . . . .	10
4.1.6	PPS LED Duration . . . . .	10
4.2	Advanced Fonctions . . . . .	10
4.2.1	Select language . . . . .	10
4.2.2	Intentional time shift . . . . .	10
4.2.3	Window always visible . . . . .	10
4.2.4	Firmware Upgrade . . . . .	10
4.3	TimeBox II remote control . . . . .	11
4.3.1	The Reset Button . . . . .	11

## 1.1 Versions history

Version	Date	Description
A	22 janvier 2025	First version

## 1.2 Introduction

You have in your hands a TimeBox II, a small device that allows you to date observations to within a few milliseconds of an absolute time reference (UTC time, for example). The primary purpose of this system is to enable observations of occultations of stars by asteroids - which requires this type of precise dating - but we can imagine any other type of use that requires precise absolute dating.

In its initial version, the TimeBox was created and designed by César Valencia-Gallardo. César is an amateur astronomer who understood the need for a precise dating device. He proposed the system to Shelyak Instruments for industrial development. The TimeBox II was developed by Shelyak Instruments in close collaboration with César - in particular, he checked in detail that the dating accuracy remained at the same level.

This document explains how TimeBox II works and how to use it in detail.

This documentation, as well as the software that accompanies the TimeBox II, is available on the Shelyak Instruments website.<sup>1</sup>

## 1.3 Content of the package

TimeBox comes with the following accessories :

- TimeBox II (voir fig. 1.1)
- GNSS antenna (ref EL0200), with a 5m cable (fig. 1.2)
- USB cable (ref EL0369), with a 0.50m cable (fig. 1.3)

The TimeBox II is powered by your PC's USB connector. With these accessories, you've got everything you need to start working.



FIGURE 1.1 – Timebox II



FIGURE 1.2 – GNSS antenna and its cable



FIGURE 1.3 – USB cable

1. <https://www.shelyak.com>



FIGURE 1.4 – Back face, with SMA connector



FIGURE 1.6 – The TimeBox II with the cables connected



FIGURE 1.5 – USB-C connector

## 1.4 Quick Start-Up

Can't wait to get your TimeBox II up and running? Then connect the antenna to the TimeBox II, plug the TimeBox II USB cable into your computer, install the TimeBox II software (it's a simple .exe file you can download from the Shelyak website), and launch it. Follow the on-screen instructions... in a few minutes at most, your PC's clock will be synchronised with GNSS time (which can be considered as absolute time).

A short video showing the use of TimeBox II in normal conditions (with automatic connection) is available at the following address :

<https://youtu.be/LJvSWYihZ1M>

The video can also be accessed using the QRcode fig. 1.7



FIGURE 1.7 – Video link

## 2.1 The dating of stellar occultations

When an asteroid passes in front of a star – looking at it from Earth – its brightness (magnitude) decreases for a few seconds. This drop in brightness is relatively easy to observe with modest equipment (a small telescope equipped with a CCD camera). The duration of the occultation gives precise information about the size of the asteroid.

The asteroids we are talking about here, in the solar system, are smaller than the Earth and as the stars are infinitely further away, the occultation of the star actually casts the asteroid's shadow on the Earth. This shadow generally covers a band of a few tens of kilometres.

If several astronomers make the same observation, evenly distributed over the Earth (around the band covered by the occultation), it is possible to trace the entire cross-section of the asteroid. Provided, however, that each observation is dated precisely, to within a few milliseconds.

Every computer has a clock that can be used to date an observation. But it turns out that these clocks are not very accurate – they can easily drift by several seconds a day. On a day-to-day basis, this is not a problem, because it is rare to need to date an activity very precisely. WOn top of that, the PC clock is reset regularly when it's connected to the Internet. But in our case, occultation observations are often made far from cities, and far from the Internet, while the precision required to date the observed phenomenon is very high!

The objective of TimeBox II is to ensure this precise dating. In designing this device, we are determined to contribute to the development of these exciting observations, which are simple for any observer, but which take on an incredible dimension when carried out collectively.

## 2.2 How it works

The principle behind TimeBox is simple. A GNSS module<sup>1</sup> capable of measuring absolute time with a

high degree of accuracy (a few microseconds), which is necessary for calculating position on earth (this is the primary function of a GNSS module or equivalent). TimeBox II therefore embeds such a GNSS module, and regularly sends the precise (absolute) date to the computer. The software associated with TimeBox II constantly compares the time coming from the GNSS module with the time on the PC, and makes the necessary corrections when too a too high discrepancy is detected. The algorithm used ensures gentle corrections, to avoid date jumps that would alter the quality of the observations. To be fully accurate, the software needs to 'observe' the PC's drift for a few minutes. To do this, it's a good idea to start TimeBox II at least a few minutes before your observation.

The TimeBox II software only takes care of setting the PC's time. It does not interfere in any way with the other software on your computer (for example, your acquisition software). So there's no need to worry about compatibility with your software, whatever it may be. This is also the reason why TimeBox II can be used for any other Windows application that needs precise absolute dating.

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1. GNSS = Global Navigation Satellite System. In everyday language, this is often referred to as GPS, but there are now several geolocation systems, of which GPS is the oldest, but no longer the only one.

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# 3

## The TimeBox II

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### 3.1 Main specifications

- Dimensions : 70 x 40 x 18 mm
- Weight : 60 grams (sans les câbles)
- power supply : through the USB port (5V, 100mA max)
- Connectors : USB-C (connexion to the PC) and SMA (GNSS antenna)
- PPS LED : when the GNSS module is synchronised with the satellites (a minimum of 4 satellites detected is required), the LED is synchronised with the PPS (Pulse Per Second) signal. The width of the PPS pulse is variable ; it is the rising edge (ignition) that is synchronised with the PPS signal.
- Time accuracy : less than 2 ms (milliseconds) compared with GNSS time

### 3.2 Getting started

Plug TimeBox II into a USB port on your PC (you don't need a USB3 port, a USB2 is more than enough)... and that's it!

TimeBox starts up automatically as soon as you connect it to your PC; it is powered by the USB connector.

The LED indicates the operating status :

- As long as the software has not been started on the PC, the LED is ON continuously.
- As soon as the software is connected to TimeBox II (see below), the LED flashes rapidly, indicating that the module is searching for satellites. This usually only lasts a few seconds<sup>1</sup>.
- When several satellites are detected (at least four), the LED flashes in 'PPS' (Pulse Per Second) mode, i.e. it beats per second, based on the GNSS signal. The moment of illumination is precisely triggered by the GNSS module, but the duration of illumination is adjustable (by default 100ms).

### 3.3 About the GNSS antenna

The GNSS module has an internal antenna, but its sensitivity is very low compared with the external antenna. It is therefore strongly recommended (and even more) to connect the external antenna supplied with TimeBox II. Similarly, the GNSS signal is very easily detected (in a few seconds) outdoors, but it can take much longer (or even be impossible) inside a building. If you're testing indoors, at the very least, try to place the GNSS antenna near a window.

*Note* : The GNSS antenna supplied with TimeBox II is perfectly standard. You can replace it with any commercially available GNSS antenna, it just needs to be fitted with an SMA connector (this is a very standard connector in the field).

### 3.4 Le bouton Reset

Pressing the Reset button on TimeBox II interrupts synchronisation. See the software section for more details.

*Note* : The Reset button interrupts synchronisation, but does not perform a 'real reset' of the microcontroller.

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1. It's possible that on first use, or if you haven't used TimeBox II for a long time, or if you've been on a long journey, satellites detection may take up to a few minutes.

# 4

## The software

The TimeBox II software can be found on the Shelyak Instruments website<sup>1</sup>. It's a simple .exe file that can be saved anywhere on your hard drive. No installation is required; in Windows words, it's a 'portable application'.

The software is free, so you can download it as many times as you like, and install it on several PCs.

An important technical note : the software must be started in administrator mode. This means that you must have administrative rights for your computer. This constraint comes from Windows, which requires these rights to modify the time and date. If you start the software in standard mode, you will be prompted to restart with administrator rights. If you continue without these rights, the software will be able to run, but in passive mode : it will tell you the time difference, but will not be able to correct it.

When you launch the software, you will see the main window (fig. 4.1).

Once you have connected TimeBox II to one of your PC's USB ports, you can click on the 'No COM port, click to select' indication. The software will suggest which USB ports might host TimeBox (fig. 4.2). Select the COM port to which your TimeBox II is actually connected.

Note that this port is then memorised, and subsequent re-connection can be made automatically.

As long as the connection has not been established, the circle (which is in fact a 'three-quarter circle') is grey. When the connection is established, the circle changes to orange (fig. 4.3).

As soon as the connection is established, the GNSS module starts looking for satellites. The software requires at least 4 satellites to be detected. When this number is reached, it displays the number of satellites detected in real time (fig. 4.4). This number is constantly changing as the satellites move around the earth. When enough satellites have been detected, the circle turns red (fig. 4.4). A few seconds after the satellites have been detected, you will see the two times simultaneously (the PC time and the GNSS time), as well as the difference between the two. You will also see the GNSS coordinates and altitude of your observation site. (fig. 4.5).

The actual synchronisation of the PC clock with the

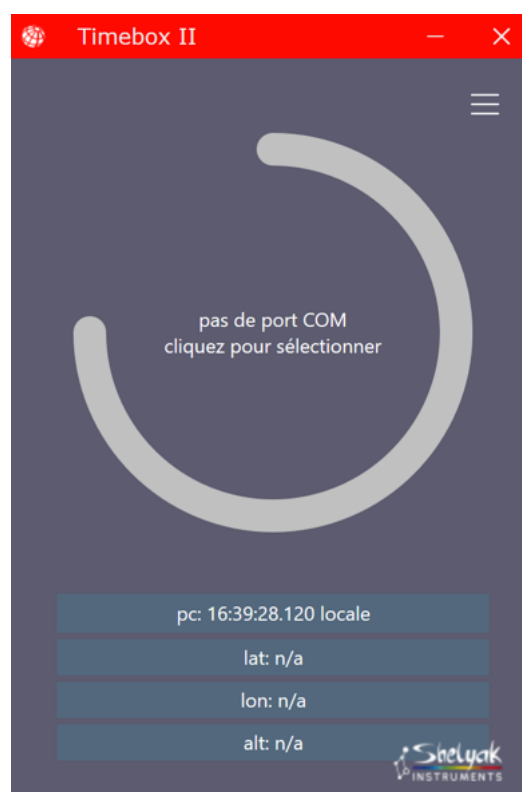


FIGURE 4.1 – Main window, TimeBox II software

1. [urlhttps://www.shelyak.com](https://www.shelyak.com)





FIGURE 4.2 – Connexion to the TimeBox II

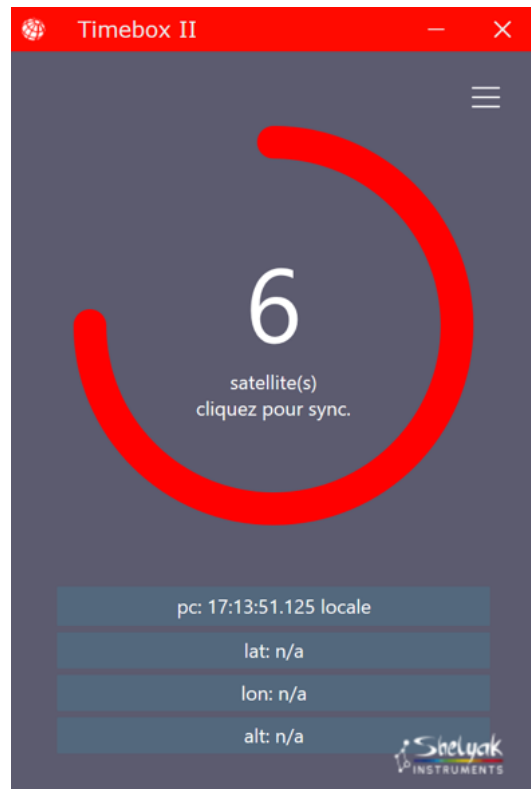


FIGURE 4.4 – Satellites detected

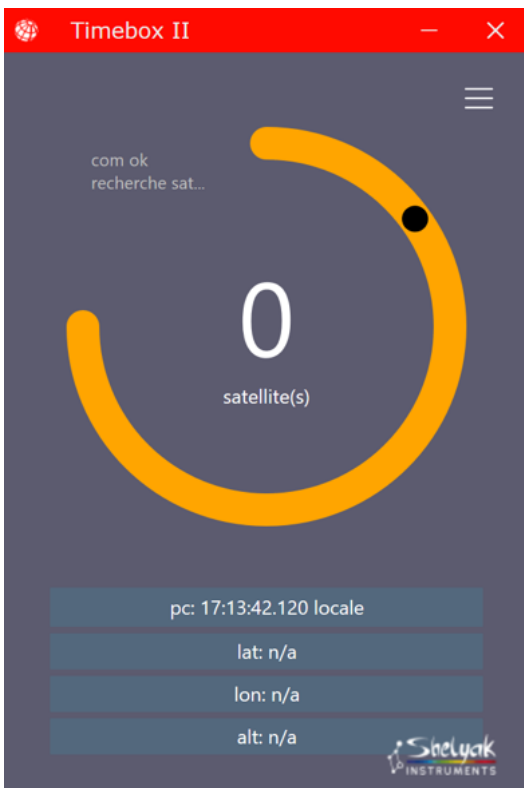


FIGURE 4.3 – TimeBox II is connected

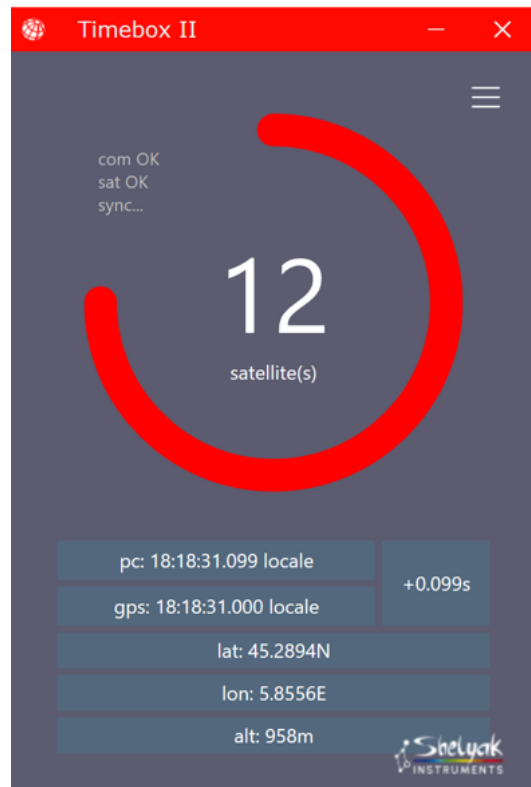


FIGURE 4.5 – Synchronisation on going



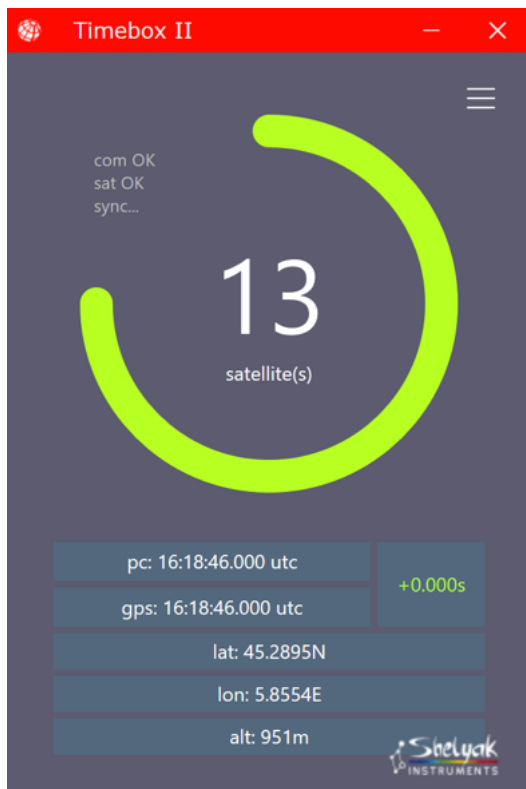


FIGURE 4.6 – PC clock is synchronised

GNSS time then begins (synchronisation can in fact be started manually or automatically). Depending on the time difference between the PC and GNSS, synchronisation may take more or less time (up to a few minutes). The software’s objective is to ensure a maximum time difference of 2 milliseconds. As long as the deviation is greater than 2 milliseconds, the circle remains red. As soon as the deviation falls below 2 milliseconds, the circle changes to green. (fig. 4.6).

*When the circle is GREEN, this indicates that your PC’s clock is under control, so you can start your observations with complete peace of mind.*

When the software updates the PC clock, this is indicated by a ‘flash’ in the area of the main window showing the difference between the two times.

Of course, you must leave the software open to keep the PC clock synchronised with the GNSS.

## 4.1 Software Options

In usual operation, use is straightforward, and corresponds to the steps described above. But the software also has a number of options that allow you to adapt it to your needs.

These options are accessible from the ‘hamburger menu’ at the top right of the main window (the three little horizontal lines - fig. 4.7).

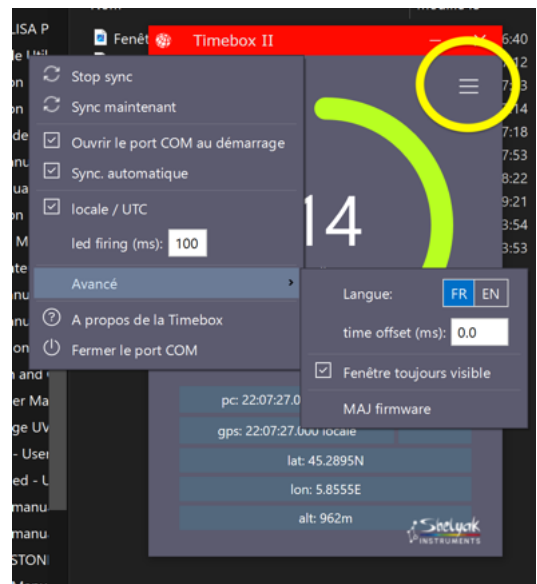


FIGURE 4.7 – Access to the menu (red circle)

Let’s take a look at these options.

### 4.1.1 Stop synchronisation

You can stop synchronisation at any time by clicking on ‘Stop Sync’. Of course, synchronisation is also interrupted if you exit the software.

You can restart synchronisation by clicking on ‘Start Sync’.

### 4.1.2 Synchronize now

The synchronisation algorithm is very progressive, to avoid major ‘time jumps’ in the PC clock. Under normal circumstances, this is a guarantee of accuracy, but if at the time of the first connection the offset between the PC clock and the GNSS is significant, the correction may take some time (up to several minutes). In this case, and if you are not making sensitive observations, you can force synchronisation by clicking ‘Sync now’. Within seconds, your PC will be on GNSS time (green circle).

### 4.1.3 Automatic COM Port Opening

If you are still using TimeBox II in the same configuration, you can ask the software to connect automatically by ticking the ‘Open COM port at start-up’ box. This avoids the step of connecting to the COM port.

### 4.1.4 Automatic Synchronisation

In the same way, you can start synchronisation automatically when you connect. To do this, tick the ‘Automatic sync’ box. Combined with the automatic

opening of the COM port, this means that synchronisation starts fully automatically as soon as the software is launched.

#### 4.1.5 Switch to local / UTC time

The times (PC and GNSS) are displayed either in Universal Time (UTC) or in local time. You can switch from one to the other by checking/unchecking this option.

You can also switch from one to the other by clicking on one of the times in the main window.

#### 4.1.6 PPS LED Duration

By default, the PPS (Pulse Per Second) LED follows the GNSS signal, which beats precisely to the second, with a pulse duration of 100 ms. In some cases, it is useful to be able to change the firing duration (without changing the firing instant, of course). You can change this value in the 'LED firing (ms)' field. The new value will be memorised (even when you quit the software) until you change it again.

*Note : the software must be restarted for the new value to be taken into account*



FIGURE 4.8 – Time shift of -3.7ms

## 4.2 Advanced Fonctions

In addition to these 'basic' options, there are also a number of advanced ones.

### 4.2.1 Select language

Choose your language here (English or French).

### 4.2.2 Intentional time shift

The software constantly monitors the difference between the PC clock and the GNSS, the ultimate aim being to enable astronomical images to be dated accurately. However, depending on your equipment, it is possible – and even probable – that there will be a time lag between the 'absolute' GNSS time and the date/time written in the image header. This offset can be measured by making an image sequence on the TimeBox II LED, which can be considered as a valid reference (GNSS PPS signal). All you have to do then is read the time recorded in the images in which you observe the LED lighting up. It is possible to observe a time difference of a few milliseconds.

The TimeBox II software can be used to correct such an offset by indicating in the 'Time offset (ms)' field. The value indicated (in milliseconds) may be positive or negative, and may be decimal.

When such an offset is recorded, it appears clearly above the offset between PC and GNSS. For example, in the figure 4.8 an offset of -3.7 ms has been forced.

### 4.2.3 Window always visible

It may be useful during your observation to keep an eye on the TimeBox II software at all times - at the very least to check that the circle is still green (a sign of synchronisation better than 2 ms).

To do this, you can tick the 'Window always visible' option.

### 4.2.4 Firmware Upgrade

TimeBox II incorporates a microcontroller with firmware. The microcontroller is an RP2040, marketed by the Raspberry Foundation and used in the Raspberry Pi Pico.

This system allows simple programming, the same as the Raspberry Pi Pico, if you are familiar with this type of component. Simply switch the microcontroller to 'programming' mode, and TimeBox II will appear in your file explorer as a USB drive named 'RPI-RP2'.

To switch TimeBox II to programming mode, click on the 'Update firmware' option and watch for RPI-RP2 to appear in your file explorer (it's almost immediate).

The firmware comes in the form of a file with the .uf2 extension. Simply 'copy and paste' this file into the 'RPI-RP2' drive, and after a few seconds the drive will disappear.

Your TimeBox II is then updated with the new firmware!

## 4.3 TimeBox II remote control

We've made sure that TimeBox II can be used remotely, meaning that it can be used without having to disconnect and reconnect the USB connector. Even the firmware can be updated remotely!

### 4.3.1 The Reset Button

The Reset button on TimeBox II is used to interrupt synchronisation, in the same way as the 'Stop Sync' option (it must be held down for at least 2 seconds).

When synchronisation is interrupted, the message 'No satellites, click to search' appears. Simply click on this message to restart synchronisation.



FIGURE 4.9 – Have good observations!