

# CPC-800 XLT: GPS Module Failures

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## Introduction

I purchased my CPC-800 XLT in September of 2015 and quickly became enamored with its clear optics, GOTO capabilities, and the convenience of its built-in GPS receiver.

In fact, many computerized telescopes are equipped with a GPS module that automatically sets the date, time, and location of the telescope. This convenient feature is hardly critical because there's also a means of setting these parameters manually from the hand controller. But the GPS feature *is* handy.

One day after operating flawlessly for about ten months, my CPC-800 refused to lock onto the GPS satellites. Why is unclear, but this was certainly discouraging. The telescope was under warranty. But the thought of crating up the scope for return to the factory was thoroughly unappealing!

This problem manifested itself as the NexStar+ hand controller endlessly displaying: "Wait for GPS or BACK to edit or ENTER to accept" *without progressing* to the next step of displaying the "Select Method" message as it normally would.

I learned to work around the problem by turning off the GPS receiver and entering the date and time into the hand controller manually. The telescope retains its most recent geographic coordinates, so the tedious task of setting those was not required. All in all - not a big deal - and everything else continued to work normally.

But not being one to leave well enough alone, I naturally felt the need to start taking things apart! I discovered how to bring the GPS back to life, and eventually developed a reset procedure after the GPS failed a second time – also after about ten months of normal operation.

Exposing the innards of your expensive telescope may seem intimidating, but fear not – resetting the GPS module is actually quite simple once you know how. I describe the procedure below. The procedure does require some reasonable care, disassembly of your telescope, and elementary electrical knowledge. So proceed carefully and at your own risk.

I should emphasize however, that my experience is limited to this single CPC-800 XLT telescope purchased in September 2015. I don't have insider information, a vast knowledge base of specific Celestron telescope models, nor can I say how widespread this issue is. Earlier (and later) models of the telescope may contain a different GPS module than what is described here<sup>2</sup>.

## Why me?

Of course! I asked that question “*why me?*” - and started on-line research to see if others had experienced this problem. The answer was a resounding yes – *but!*

Several older reports on [cloudynights.com](http://cloudynights.com) and other telescope user forums described cases of these GPS receivers failing to function properly after a period of time. They indicated the failures were caused by an old or discharged backup battery within the GPS module itself.

The GPS receiver chip saves ephemeris data with the goal of using that to decrease the sync time on subsequent uses. This data is preserved in internal memory of the GPS chip with the battery supplying backup power. The batteries were said to be small, rechargeable lithium cells that would be replenished during normal operation of the telescope, but that might sometimes discharge after long stretches of storage.

Some users had successfully restored the GPS module by leaving the telescope powered-on for several days (recharging the battery). Some users resorted to replacing the battery, which is soldered into the GPS module, while others replaced the entire GPS module at greatly inflated replacement-part prices! Most of these reports were at least several years old when I first encountered the issue.

The recharging procedure was ineffective for me – even after several days of recharging, the GPS failed to sync no matter how long the telescope sat under clear skies. I was unlikely to replace the GPS module since I suspected the problem was likely a “glitch” rather than a hard failure. And armed with these anecdotal reports, I felt that replacing the battery was worth a try.

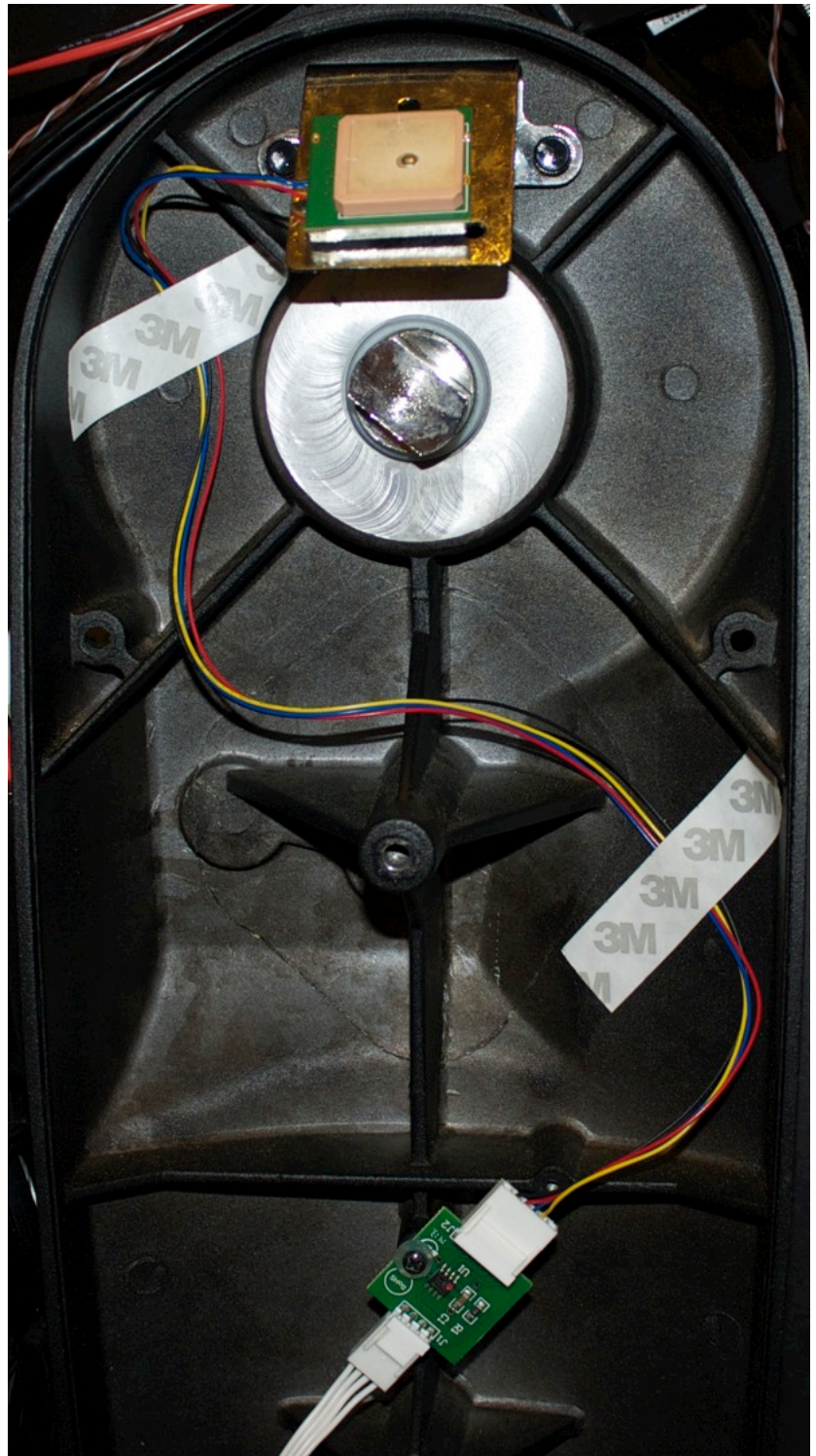
And then there’s that “but” part - I discovered that the GPS module in my telescope *had no battery!* It had a *super capacitor* instead.

## The GPS module

I found the GPS module easily enough after removing the plastic cover of the right fork arm (the one with the handle). There's also a small interface board in the fork arm. The GPS module is mounted on a metal bracket as seen near the top of the photograph.

The part of the GPS module that is pointing up in Figure 1 is the antenna that "sees" the satellites. There's a metal shield on the backside of the module, which is stuck to the shiny metal mounting bracket by extremely aggressive, double-sided foam tape. The bracket is screwed into the fork arm by plastic thumbscrews and held above the screw bosses by nylon washers.

I removed the GPS module from its bracket by carefully prying it up with a thin pocketknife blade. This required some patients! I warped the shield a little in the process but this is a minor concern. Next time I'd do a little more cutting and a bit less prying! The shielded side of the module is seen close-up in Figure 2. The module is about 34 mm square.



**Figure 1 - The GPS module is located near the top of the right fork arm (the one with the handle). The beige square is the antenna. An interface module is also visible.**



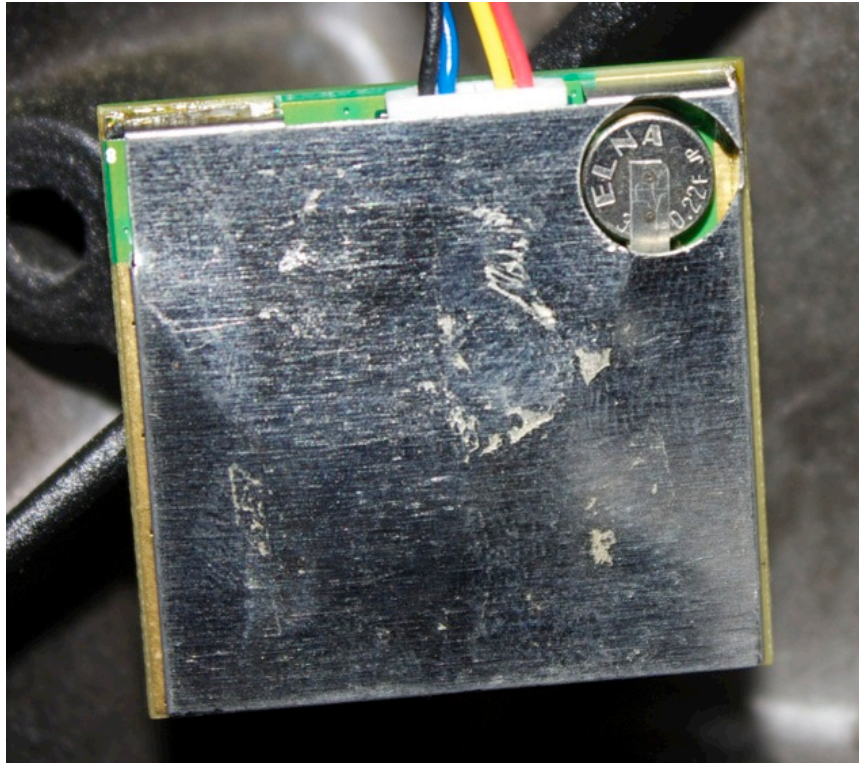


Figure 2 - Shielded side of the GPS module. The super-capacitor is near the cable connector. The markings “0.22F” indicate that this is a capacitor – not a battery. The solder tab obscures some of the markings. A stock photo of the capacitor is also shown for reference.

There’s a hole in the shield through which the “battery” is clearly visible. But as I said, the “battery” isn’t a battery at all. The markings - “3.3v 0.22F” indicate the part is actually a 0.22 *Farad* capacitor with a maximum voltage rating of 3.3 volts.

Small in size and super in capacitance, the 0.22 Farad capacitor is capable of storing enough energy to serve as a backup power source for the GPS chip, and it’s used in this circuit instead of a battery. Time was that capacitors of such magnitude were unheard of. Now they’re readily available for low-power backup power applications such as this.

I measured the capacitors voltage with no power applied to the telescope before proceeding. It was about 2.9 volts. In retrospect – that seems like a reasonable value to sustain the GPS memory. But I had no schematic, little else to go on, and nothing to lose by replacing the capacitor.

The capacitor markings were sufficient to order a suitable replacement from Digi-Key Electronics ([www.digikey.com](http://www.digikey.com)). The replacement part is an Elna America DCK-3R3E224U-E, Digi-Key part number 604-1007-ND, and cost less than two dollars (exclusive of shipping).

At this point replacing the capacitor was really a shot in the dark – but it worked! The CPC-800 started behaving normally again. I measured the voltage across the new capacitor, and it was still about 2.9 or 3 volts. Odd – no significant change? Anyhow, I was happy and considered this “case closed”!

## Case closed?

Case closed...until the problem popped up again some ten months later. It made no sense that the capacitor would fail a second time. I wondered *what on Earth* was going on?

It still seemed unlikely that the GPS chip was damaged. The module ordinarily worked reliably, easily locking onto satellites and returning time and location information to the rest of the system. And previously replacing the capacitor definitely fixed things up for many months.

Somehow I thought - through a firmware bug or some unlikely sequence of events, or perhaps after a certain period of storage - the GPS chip enters an indeterminate state. These types of problems are difficult to track down. I can understand something like this slipping through Celstron's quality control.

My theory continued. If the GPS chip was in an indeterminate state - then what was needed was a way of rebooting it from scratch - like removing its power. But I'd already done that! Simply removing power from the module wasn't enough. The super capacitor continued its job of backing up the internal memory of the GPS chip - preserving its messed-up state!

So probably - there was nothing wrong with the old capacitor in the first place. Rather, I had inadvertently reset the GPS by removing its backup power source. It wasn't the new capacitor that fixed things; it was the fact that the GPS chip was unpowered while the capacitor was being replaced. So what's the real solution then? Simply discharging the capacitor! That should clear any state information stored within the GPS chip and enable a fresh start.

But shorting-out the 0.22 Farad capacitor probably is *not* a good idea. It's 0.22 *Farads* after all, and storing energy is the capacitors purpose. Discharging a capacitor of that magnitude suddenly would cause a current surge that might possibly be damaging to the capacitor or to the nearby GPS chip. It would be safer to discharge the capacitor through a resistor to limit the discharge current.

I decided to discharge the capacitor through a 47-ohm resistor that I happened to have on hand. 47 ohms limits the peak current flow to about a maximum of 70 mA if the capacitor were fully charged to say, 3.3 volts. 70 mA should be pretty safe. Just about any resistance in the range of 47 to 100 ohms or so would limit the discharge current to a reasonable value. The exact resistance isn't critical. But the value does determine how much time is required to discharge the capacitor to a sufficiently low voltage necessary to clear the GPS memory. I guessed that a final voltage of anything below about 0.6 volts would be guaranteed to do that. Choosing too large a resistor would mean the discharge time could be hours!

When discharging the capacitor through a resistor, the two components form an R-C circuit. The time constant of an R-C circuit is simply its resistance multiplied by its capacitance, and in this case that's  $0.22 \times 47$ . Both quantities are in basic units, which makes the math simple. That comes out to 10.34 second (one electrical time constant of an R-C circuit is the time necessary to charge/discharge a circuit to 63% of it's final value, in this case - zero volts). The capacitor was

initially charged to about 2.9 volts, so two time constants should drop the voltage to about 0.4 volts. 20 seconds ought to do it.

I held the 47-ohm resistor across the positive side of the capacitor and the GPS shield for about 30 seconds for good measure (the negative end of the capacitor is connected to the shield in this GPS module, so the resistor is effectively across the capacitor). Eureka! Upon sticking the GPS module back on its bracket and powering up the telescope (in my back yard with a clear view of overhead satellites), the GPS was up and running!

The module contains a red LED, which flashes and then illuminates solidly when it links up with the satellites. Before the reset procedure it would flash continuously - never syncing up. Afterwards, it illuminated solidly within less than two minutes, and the hand controller was then ready to perform normal alignments.

When I stuck the GPS module back to its bracket with new mounting tape, I noticed that the bracket had several holes, one of which could be aligned with the hole in the GPS shield. I thought that by aligning these holes I would have the future ability to easily contact the capacitor without removing the GPS module from the shiny metal bracket at all, and this paid off later!

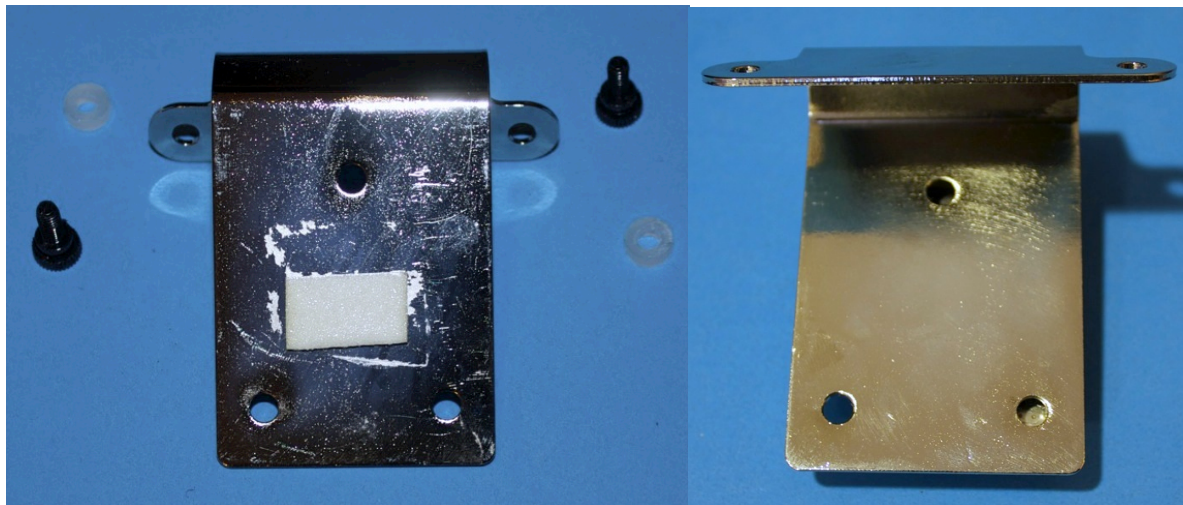


Figure 3 – On the left: mounting bracket with a small piece of new double-sided mounting tape, ready to accept the GPS module. The plastic thumbscrews and nylon washers for securing the bracket are also shown. On the right: the bracket is seen from the rear after reattaching the GPS module. Notice, the capacitor is visible through the lower-right hole in this photograph.

I used the telescope over a period of several weeks thereafter and the GPS worked fine. It continued to do so for another nine or ten months before the problem *reappeared*! I then reset the GPS using this procedure, which once again restored it to proper operation. This time the entire procedure took about 1/2 hour, as I didn't need to remove the GPS at all – I simply touched the resistor to the capacitor (exposed through the aligned holes) and to the GPS shield.

The “why” part of this story remains a mystery and I'll probably never know the cause, beyond my intuition that it's a result of some firmware bug or unexpected combination of input conditions.

## Step by step procedure for resetting your GPS module

Obtain a small axial-lead resistor roughly in the range of 47 to 100 ohms. A 1/4 watt @ 47 ohms like the one I had handy will do. A 1/2 watt resistor is larger and will be easier to hold. The tolerance and power rating are not critical. Resistors cost pennies each. Shipping will dominate, so you might as well buy a small assortment of resistors from Amazon or eBay if you wish. If you have no idea of how to buy a resistor, search digikey.com for part number CF12JT47R0CT-ND to see a representative part. If you use a 100-ohm resistor, the discharge time will be closer to a minute.

*Make sure **no power** is applied to the telescope.*

Remove the handle from the fork arm and remove the plastic fork arm cover. Two, 5 mm hex socket head screws hold the handle, while the plastic cover is held by four, 3 mm screws. You'll need metric Allen wrenches for these.

Gently slice through and pry up the mounting tape between the GPS receiver module and the mounting bracket, and remove the GPS module. Proceed methodically trying not to warp the thin metal GPS shield.

Examine the GPS carefully through the hole in the shield, looking for markings on the capacitor. If you don't see something like "0.22F" as shown in Figure 2, then you may have the battery version of the GPS module and if so - *must not* short that battery out! In that case, you may need to replace the battery instead. I cannot say how that will turn out, as I haven't dealt with that version of the GPS module.

Assuming you have the capacitor version...

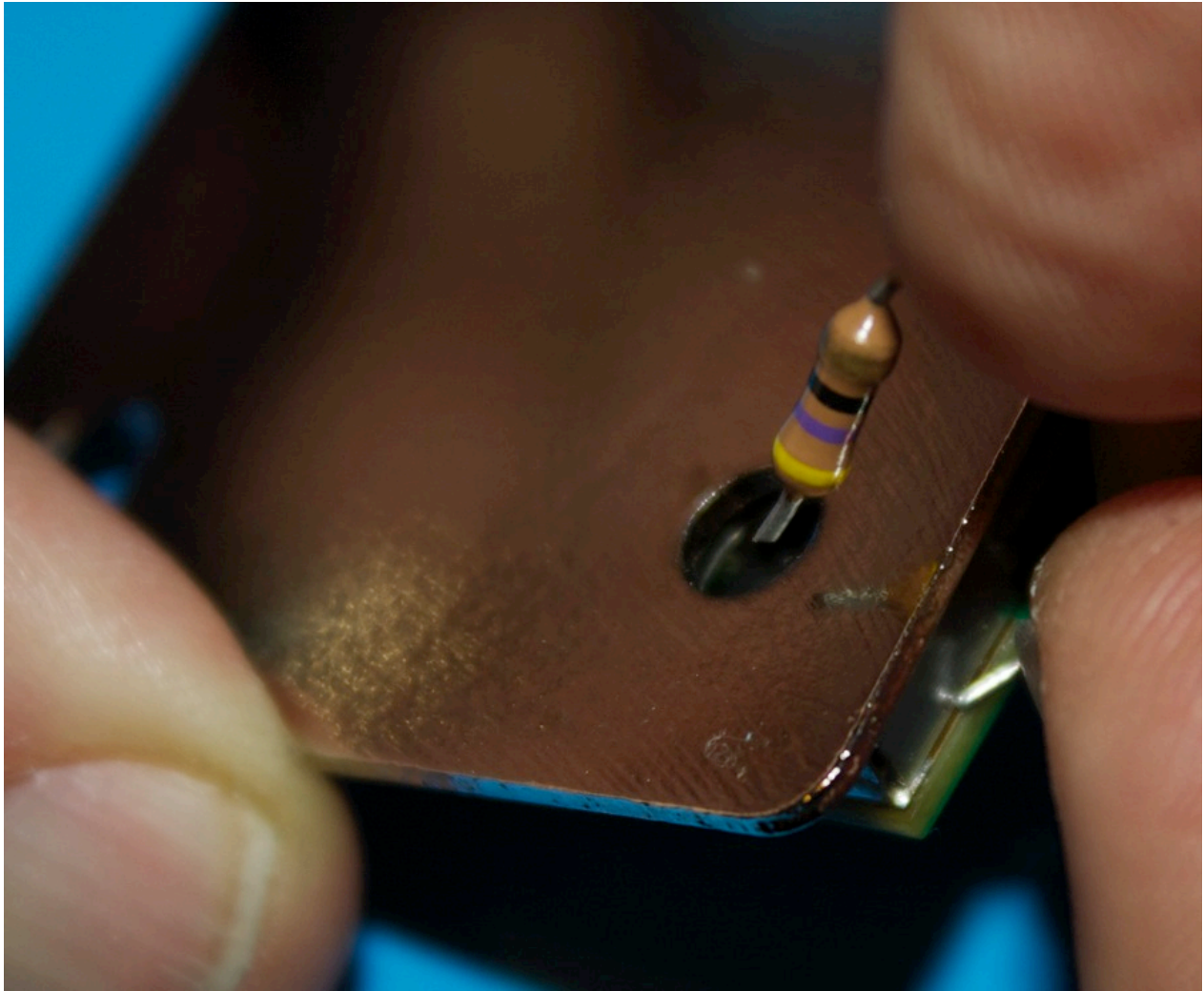
Cut one lead of the resistor very short – 1/8". This is the end that will touch the capacitor. Leave the other end uncut and bend it roughly as shown in Figure 4. This end will touch the GPS module shield. The resistor body then serves as an insulator making it difficult to accidentally short-circuit the capacitor directly to the shield.

While holding the long end of the resistor lead touching the GPS shield, insert the short end through the hole in the shield to contact the capacitor. Hold the resistor in place for at least thirty seconds – being sure that the resistor ends are making contact to both the shield and the center of the capacitor. The resistor must contact the GPS shield, not the mounting bracket.



Figure 4 – A suitable axial-lead resistor. This one is 47 ohms, 1/4 watt.





**Figure 5 - Discharging the capacitor.** In this photograph, the capacitor is accessed through a hole in the mounting bracket, but initially it may be necessary to remove the GPS module from the bracket in order to contact the capacitor. Note, the mounting bracket and the shield are not connected. The resistor must contact the GPS shield.

Re-attach the GPS receiver to the mounting bracket using new double-sided foam mounting tape. When you do – align the hole in the GPS shield with the hole in the mounting bracket so you won't need to unstick the GPS from its mounting bracket in the future. I see no need to use a giant piece of mounting tape. A small piece will do as in Figure 3.

Reassemble the telescope. (You can leave the plastic arm off until you verify that things are working again.)

Apply power to the telescope and see if the GPS links. If not, remember that you need to *turn the GPS back on* from the utilities menu of the hand controller if you previously turned it off. Re-install the plastic fork arm cover.



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<sup>1</sup> The author is an electronics engineer and hobbyist with nearly four decades of experience tinkering with, taking apart, designing, and building electronics circuits.

<sup>2</sup> I participated in a thread at TeamCelestron.com - <http://www.teamcelestron.com/viewtopic.php?f=55&t=1234&start=30#p15373>, where the following comment was posted by a Celestron Engineer on February 9, 2018:

*“Actually there have been at least 3 different versions of the GPS module. Once we have something that works we don’t change unless we are forced to change, usually because whoever was making them stopped making them. The current modules went end of life 3 months ago, and we bought enough to last until we can get some new modules in their place. It is one of the things I am working on this week.”*