

Approaching the Final Frontier

# Near Space

## Experiments for Your Near Spacecraft

**N**ow that you have a near space (NS) craft, what experiments can you perform with it? Since it has a simple tracker — not a flight computer — there are some limitations. There are many experiments that function on their own; however, before you can process your science results, you need to understand the format of the data transmitted by the Tiny Trak 3 in your NS craft.

### Tiny Trak 3 Data Format

The Tiny Trak 3 is a PIC-based radio modem, although it might be better to call it an MO, since it does not demodulate radio transmissions. When programmed for amateur NS use, the Tiny Trak 3 uses data fields from two GPS sentences — the GPGGA and GPRMC. Elements from both sentences are combined into the Tiny Trak 3's posit. You can think of a posit as a condensed position and status report. As such, a Tiny Trak 3 posit contains enough data for you to perform some amateur science without carrying anything else inside of your NS craft.

The older Tiny Trak 2 works well as the NS avionics, but you should consider at least replacing its PIC microcontroller with the newer Tiny Trak 3 version.

The Tiny Trak 3 posit contains a time stamp that is not found in the posits of the Tiny Trak 2. The time stamp is very useful when analyzing your data. There is a way to get around this that we'll cover at the end of this month's column.

### A Sample Tiny Trak 3 Output

Example 1 shows the highest altitude posit received from one of my NS craft during a mission last year.

On this particular mission, my module transmitted posit reports every 60 seconds. The mission's science data was stored onboard for retrieval after recovery. This method of storing science data onboard has several benefits. For one, my important

science data is not contaminated with packets from local hams and chase crews. Believe me, it can take several hours to clean up an APRS log. The second benefit is that there are no dropped packets to contend with. APRS is designed to be a robust communication method; however, packets are only transmitted once and there is no verification that they were received (this is important to consider, since the receiver is usually a moving target). As a result, posits are occasionally not received on the ground. This is not a problem for determining the landing zone of the NS craft, as there are still plenty of received posits, but, if you're sending science data over APRS, the missing data can be a real aggravation.

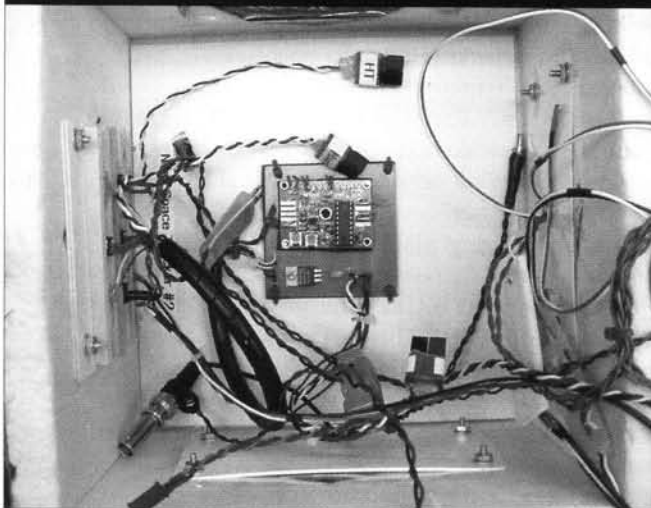
### Format of the Tiny Trak 3

So what does the sample posit say? The posit from the Tiny Trak 3 uses the following format:

callsign, routing information, time, latitude, longitude, direction, speed, and altitude.

The FCC (Federal Communications Commission) issues you a callsign after you earn your amateur radio license. The callsign is unique to you and is used for identification.

The Tiny Trak 3, safely anchored in its reusable lunchbag near space module.



```
KD4STH-11>APT310,WIDE3-3:/143130h4313.72N/11721.12W>272/029/A=111840
```

Example 1

The callsign remains fixed for the entire mission of the NS craft (if not for every one of its missions). The -11 after the callsign is unique to packet radio and is called an SSID. Packet stations use SSIDs so that a licensed amateur radio operator can own several packet stations that run simultaneously. The SSID is used to identify the station transmitting the packets. In the example above, the -11 SSID is used to identify the transmitting station as a balloon.

The next field indicates which version of APRS is being used by the TNC (Tiny Trak 3, in this case). This field stays constant for the Tiny Trak 3.

The routing information — in this example, “WIDE3-3” — indicates how many “bounces” a packet signal is allowed. Packet signals can be digi-peated. This occurs when a packet station that is set up to do digi-peating receives the posit report from your NS craft and retransmits it. The “-3” indicates that the posit report is allowed to be digi-peated a maximum of three times. The proper number of repeats appropriate for your module is determined by the standards used by packet radio operators in your area. Contact your local APRS user community before entering your WIDE setting. Both the callsign and routing information are programmed into the Tiny Trak 3 before launch.

The time stamp in the posit is derived from the GPS receiver and is given as time — UTC (think Greenwich Mean Time). The time stamp format is HHMMSS, with the hours given in 24-hour time. There are no commas between the hours, minutes, and seconds. The field ends with “h.”

Latitude and longitude are given as degrees and minutes. Notice that there are no delimiters between the degrees and minutes. The minutes

of latitude contain a decimal point. The field ends in the letter “N,” indicating that the field is latitude north; the “W” in the latitude field indicates west. There is a slant separating the latitude and longitude fields.

The next two fields are pulled from the GPRMC sentence.

The first is the heading of the GPS receiver (the direction that the GPS is traveling). Since the GPS is attached to the NS craft and its balloon — which is prey to the ambient winds — this field is also the direction of the wind. The heading is measured by true north, not magnetic north.

The second GPRMC field is the speed at which the GPS receiver is traveling. This is also the wind speed. The unit of speed from a GPS receiver is given in knots. A slash is used to separate the heading and speed fields.

The last field is altitude, measured in feet. The Tiny Trak 3 converts the altitude units from the GPS receiver from

meters into feet. The altitude field is indicated by the “A=” preceding the altitude.

This is all there is to the Tiny Trak posit report. If you'd like more information on the format of posit reports, consult the APRS Protocol Reference site (<http://web.usna.navy.mil/~bruning/aprs.html>).

## Processing Tiny Trak 3 Posits

Now that you know the format of the posits that you have received from the NS craft, let's discuss how to process the data after a mission; this is called post-processing. Did you think the mission was over once

This is a small excerpt of the cleaned up log.

```
12,49,29,42,57,90,117,00,77,000,000,004481
12,49,59,42,57,89,117,00,76,119,006,004832
12,50,30,42,57,89,117,00,77,126,004,005416
12,51,29,42,57,92,117,00,66,111,009,006656
12,51,59,42,57,96,117,00,54,078,010,007279
```

## Example 2

```
KD4STH-11>APT310,WIDE3-3:/143130h4313.72N/11721.12W>272/029/A=111840  
KD4STH-11>LIME,WIDE3-2:/143130h4313.72N/11721.12W>272/029/A=111840
```

## Example 3

```
143130h4313.72N/11721.12W>272/029/A=111840
```

you got home? Either you or one of your crew members will have saved a TNC log of the flight. It is a copy of all the APRS traffic during the mission. This is a text file, so it's readable with a text editor, like Wordpad (it may be too large for Notepad).

Open the TNC log with the text editor of your choice. The first thing you'll notice is that there is a great deal of traffic from chase crews and local hams. In fact, most of the text you see has nothing to do with the posits from your NS craft. Make yourself a cup of tea because you're going to be editing the TNC log for some time.

The first step is to delete lines of text that did not originate from your Tiny Trak 3. Delete every sentence that does not begin with your callsign. Save your file frequently.

If a digi-peater was within range, you'll see some posits that were repeated before getting to your APRS station. In those cases, you'll see something that looks like the data in Example 2.

Notice that, except for the destination field, the second posit is identical to the first one. Realizing this, our next step is to delete all of the repeated posits. I prefer to do this manually to ensure accuracy. Before making deletions, look carefully at the posits. There may be times when you only see the repeated posit, not the original one. Be sure that you don't delete the repeated posit if your TNC log does not contain the original posit. Save your work again.

Next, get rid of the callsign and routing information. In

Example 2, this means:

```
KD4STH-11>APT310,WIDE3-3:/
```

Here's where the Find/Replace feature comes in handy. In WordPad, select "Edit," then "Replace." In the "Find What" field, type the callsign and route text. Leave the "Replace With" field blank. Now click "Replace All."

Sit back and watch your PC make editing changes at warp factor six. You may notice that there were some damaged or repeated posits that didn't contain the information in the "Find What" field. You'll have to clean these up manually, unless you have lots of repeated posits. Save your work again.

Now you are left with sentences that look like that in Example 3.

Use the "Replace All" option to replace the following characters with a comma:

```
h  
N/
```

```
W>  
/A=  
/
```

Be sure to do the last two in the order indicated and to save your work after every replacement.

Now you have posits that look like that in Example 4.

The last step is to add commas between the hours, minutes, seconds, and minutes of latitude and longitude. Again, I have found that it is more accurate to do this manually. Don't forget to save the changes frequently.

Your final result will be a text file that looks like Example 5.

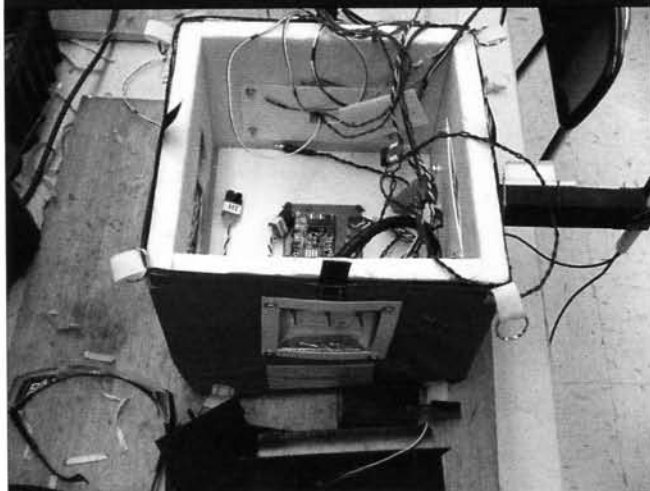
Congratulations — the hard work is over and the fun stuff begins.

You're now ready to import the text file into a spreadsheet. I'll explain how I do this in Excel. Even if you use another spreadsheet, you should find the procedure to be similar.

When you open the text file in Excel, it will ask how the text file is formatted. Tell the Text Import Wizard that the file is delimited and, in the second screen, specify that only commas delimit the file. On the third screen, click the Finish button. Look over the spreadsheet and verify that there were no errors in formatting the TNC log.

If you find an error, back out of the file without saving it, make the necessary changes to the modified text file, and then repeat the process of importing the file back into Excel. If you're happy with the results, save the file. Now let's produce some science.

Inside the near space module. The sturdy sides insulate and protect the data logger so that your information stays secure.



## Amateur Science Experiments and Engineering

There are two levels of experiments and engineering that you can do with your current NS craft. This month, we'll examine the first, which uses only the raw posits from the Tiny Trak 3. Next month, we'll look into experiments that combine a stand-alone data logger with the posits.

Here are some of the simplest science and engineering results you can generate with your spreadsheet of posits:

- Altitude of the NS craft over time.
- Ascent rate as a function of altitude.
- Wind speed as a function of altitude.
- Wind direction as a function of altitude.
- Descent speed as a function of altitude.

To generate these charts, begin by creating a new column in the spreadsheet called "MET" (Mission Elapsed Time).

This is the time since the launch

143130,4313.72,11721.12,272,029,111840

Example 4

14,31,30,43,13.72,117,21.12,272,029,111840

Example 5

of the NS craft. If you didn't record the exact time, you can estimate it fairly accurately with the altitude fields of the spreadsheet. In the MET column, add the result of the hour's cell, divided by 60, to the minute's cell and the result of the second's cell, divided by 60. The equation looks something like this:

$$= (H/60) + M + (S/60)$$

in Excel:

$$= (+B3/60) + C3 + (D3/60)$$

Paste this equation into a couple of cells and determine the time of launch in minutes since midnight, UTC. Let's say that you determine launch to have occurred at 640 minutes after midnight, UTC. Modify the equation by subtracting the launch time, so that your equation now looks like this,

$$= (H/60) + M + (S/60) - 640$$

in Excel:

$$= (+B3/60) + C3 + (D3/60) - 640$$

Copy and paste the final formula

into every cell in the MET column.

With the MET column completed, you can create the "Ascent Rate" column. In the second cell of this new column, subtract the current altitude (CA) from the previous altitude (PA). Divide this by the difference of current MET (CM) subtracted from the previous MET (PM). This equation divides the change in altitude by the change in time, yielding an ascent rate. The equation will look like this:

$$= (+CA - PA) / (CM - PM)$$

for Excel:

$$= (+H4 - H3) / (D4 - D3)$$

Copy and paste this equation into every cell of the Ascent Rate column.

Before creating your charts, delete any calculated cells that are in error because of missing data. You'll see impossibly high rates when the equation tries to use an altitude or time from empty cells.

If you're not familiar with speed

measured in units of knots, then create a new column for mph data called "Speed." In this column, multiply the speed (S) measured in knots by 1.15. The equation will look like this:

$$= S * 1.15$$

for Excel:

$$= +J3 * 1.15$$

Copy and paste this equation into every cell of the column.

## Create Your Charts

There are two charts I want to discuss in detail. On the "Altitude Over MET" chart, notice that the climb of the NS craft is very constant, except for a funny transition around 20,000 to 30,000 feet. For some reason, the balloon changes its ascent rate around this altitude. Before and after this transition, the climb remains uniform. Also notice the plunge after balloon burst. The parachute is opened constantly during descent, but, because of the low air density in NS, the first part of the descent is far more rapid. The increasing air density slows the module down as it approaches the ground.

In the "Wind Speed Over Altitude" chart, look for the jet stream. Around an altitude of 40,000 feet, the wind speed will peak. Depending on how close you got to the center of the jet stream, these winds can exceed 100 mph. Just wait until you chase a NS craft that is traveling at 120 mph! Fortunately, you'll notice that the jet stream is very narrow. It doesn't take the module very long to rise above the jet stream and slow down.

More advanced charts can be created using spherical trig to calculate NS craft range azimuth and elevation from the launch site as a function of MET or altitude. We'll look into this in a future column.

If you used a Tiny Trak 2 for your mission, you can still get useful data with a little more effort. Just remember the frequency for data transmission that was programmed into the Tiny Trak 2. After you create the MET field, increment each MET cell by the time between transmissions. To determine the location of missing posits, create a chart of altitude over MET.

Remember that the ascent into NS is smooth, so abrupt changes in altitude show where your spreadsheet is missing posits. Increment the MET cells involved with abrupt altitude changes until the final chart has a smooth altitude over time. Once this is done, you can create your charts as discussed above.

In next month's column, we'll compare a variety of data loggers, learn how to program them to collect the data required, and convert some of this data into easy-to-understand charts. **NV**