W8UM High Altitude Balloon Tracking Program

John Palmisano, KB8OIS

The Value of a Collegiate Amateur Radio Club in Circumventing a "Seriously Bad Path"

W8UM High-Altitude Balloon Tracking Program, University of Michigan, Ann Arbor

Supported with a Grant from Amateur Radio Digital Communications.

High-altitude balloons, both amateur and "spy," have recently garnered the attention of the United States government. Meanwhile, classes in engineering, aerospace and weather are introducing students to an assortment of exciting high-altitude balloon (HAB) projects. This popularity in HAB experimentation is becoming increasingly evident on APRS.fi (APRS internet server database).

In addition to any academic prerequisites, the only FCC requirement is the student (or instructor) must possess, at the minimum, a Technician Class FCC amateur radio license. With that license, the student can now "beacon away." This first experience with HAB will also demonstrate how far a packet, from a "low" power transmitter, can travel once the balloon exceeds heights of 30,000 feet and how much congestion that packet can cause if the WIDEn-N Path or Packet Rate are not appropriately configured. In each case, respectively, APRS.fi will generate the following warnings:

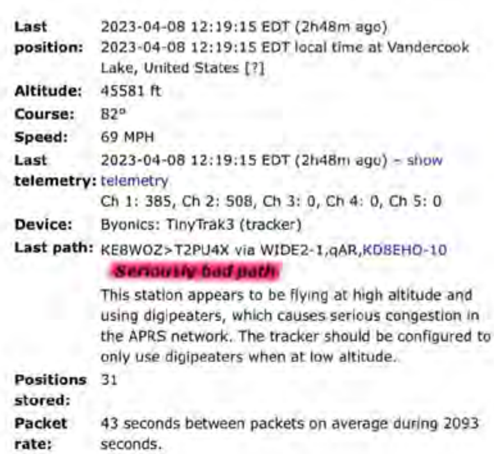
1. "Seriously bad path, the station appears to be flying at high altitude and using digipeaters, which causes serious congestion in the APRS network."
2. "This station is transmitting packets at a very high rate, which causes serious congestion in the APRS network. This could be considered an abuse of the network resources."

> *"amateur and 'spy'"*

Several years earlier, students at the University of Michigan received both error messages, followed by numerous unsolicited emails, after one of their first HAB attempts.

Consider that a RF packet (1,200 Baud), sent from a home or auto may travel a distance of 15 miles. That same packet originating from a balloon at 30,000' would have a "line-of-sight" footprint of approximately 212 miles. A balloon at 60,000' has a "line-of-sight" footprint of approximately 300 miles and a balloon at 100,000', 387 miles. If we estimate the average height of a ground station antenna, that would be DIGI-peating the received signal at 20 feet, its "line-of-sight" footprint would be about five miles. A WIDE2-1 path, as used in Example 1, would account for one more hop, outside the footprint (and in) and only marginally increasing the footprint by several miles. The key is that each hop will multiply a packet's propagation in all directions. So, every station within that 387-mile diameter circle (centered on the balloon) is already receiving the balloon packets directly. When any of those ground stations resend that packet, nearly all stations would receive a second, "unnecessary," packet. Congestion of the APRS network then occurs.

When the balloon is generally below 10,000 feet, the lower transmit power makes packet reception more difficult,



Last position:	2023-04-08 12:19:15 EDT (2h48m ago) 2023-04-08 12:19:15 EDT local time at Vandercook Lake, United States [?]
Altitude:	45581 ft
Course:	82°
Speed:	69 MPH
Last telemetry:	2023-04-08 12:19:15 EDT (2h48m ago) – show telemetry Ch 1: 385, Ch 2: 508, Ch 3: 0, Ch 4: 0, Ch 5: 0
Device:	Byonics: TinyTrak3 (tracker)
Last path:	KE8WOZ>T2PU4X via WIDE2-1,qAR,KD8EHO-10 Seriously bad path This station appears to be flying at high altitude and using digipeaters, which causes serious congestion in the APRS network. The tracker should be configured to only use digipeaters when at low altitude.
Positions stored:	31
Packet rate:	43 seconds between packets on average during 2093 seconds.

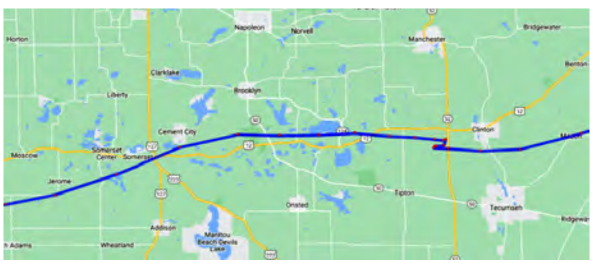
Example 1. APRS.fi website highlights a "serious bad path" was observed which could cause serious congestion of the APRS network.

Robert F. Heytow Memorial Radio Club

www.k9ya.org
telegraph@k9ya.org

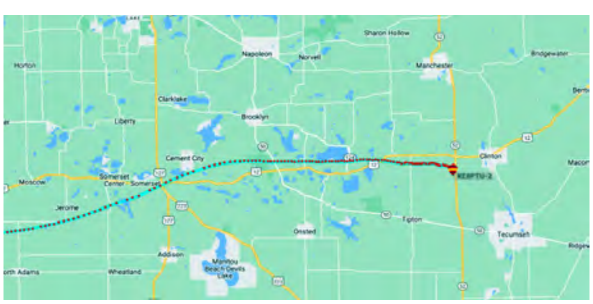
Example 2. APRS.fi website demonstrating that "frequent" RF beacons (red dots), from the -2 SSID balloon, can be uploaded onto APRS.fi without incurring network congestion.

thus a WIDE1-1 or WIDE2-1 would be recommended. The ability to change Path settings, based on altitude, is available on newer HAB transmitters. Although the logic to transmit packets at a rapid rate and to have those packets repeated to as many stations as possible is understandable, but the impact of doing so must also be considered. The students wanted to know how they could locate their balloon if they needed to wait several minutes for the next packet? The simplest method is to include a second transmitter set to a non-APRS frequency. The sole purpose of the second transmitter is to facilitate balloon retrieval by foxhunting the balloon's payload once it has landed. But could this method be improved?



Example 3. Top: Balloon tracking via the primary 144.390 MHz APRS frequency.

Members of the W8UM High-Altitude Balloon Tracking Program, supported in part with a grant from Amateur Radio Digital Communications, worked to devise a unique method to achieve this need for frequent HAB beaconing. Our questions were: a) could the satellite antenna rotor (Alpha-Spid Controller) be used to track the HAB directly via its transmitting radio frequency? b) could transmitting, more frequently, on a non-APRS transmit frequency be practical? c) could APRS position reports received from another frequency be exported into APRS.fi to provide a visual representation of the balloons travel? and d) would this facilitate in balloon recovery?



Example 3. Bottom: Balloon tracking via a second non-APRS transmitter showing additional position reporting (red dots). This content was exported to APRS.fi via W8UM without interfering with APRS.

The project used WB2OSZ's DIREWOLF (software TNC) to parse several data streams from different sources (APRS-IS, 144.390 MHz and the secondary frequency) to have the satellite AZ-EL antenna rotor track the HAB's flight. WB2OSZ was very helpful with this effort.

APRS station **KE8PTU-2** - show graphs

Comment: *Team_Lima_Secondary_Tracker*
Mic-E message: *In service*
Location: 42°03.53' N 84°00.99' W - locator EN72XB84AD - **show map**
2.5 miles West bearing 249° from Clinton, Lenawee County, Michigan, United States [?]
5.3 miles Northwest bearing 316° from Tecumseh, Lenawee County, Michigan, United States
36.1 miles Northwest bearing 319° from Toledo, Lucas County, Ohio, United States
53.1 miles West bearing 250° from Detroit, Wayne County, Michigan, United States
Last position: 2023-04-08 11:16:27 EDT (3d 5h47m ago)
2023-04-08 11:16:27 EDT local time at Clinton, United States [?]
Altitude: 82815 ft
Course: 320°
Speed: 22 MPH
Last telemetry: 2023-04-08 11:16:27 EDT (3d 5h47m ago) - show telemetry
Ch 1: 417, Ch 2: 1019, Ch 3: 0, Ch 4: 0, Ch 5: 0
Device: Byonics: TinyTrak3 (tracker)
Last path: KE8PTU-2>T2PS5S via qAO,W8UM-2
Positions stored: 226
Packet rate: 11 seconds between packets on average during 549 seconds.
This station is transmitting packets at a very high rate, which causes serious congestion in the APRS network. This could be considered an abuse of the network resources.
Other SSIDs:

Example 4. APRS.fi "high packet-rate" error message received that can be ignored.

Fast forward to 2023. (Example 2.) On this one balloon, the -1 SSID (Secondary Station ID) is the primary transmitting beacon (144.390 MHz; beaconing every two minutes) while the -2 SSID, the secondary transmitter (144.350 MHz) beacons every 10 seconds. In Example 2, the -1 balloon icon is shown to lag the real-time balloon position, -2. The red dots representing the RF packets received directly from the balloon. Using this process, frequent HAB beaconing can be achieved and visually displayed on APRS.fi without congestion of the APRS network.

For comparison (Example 3, Top) shows the two-minute beacons, red dots, from SSID -1, while Example 3, Bottom) shows the 10-second beacons (red dots) during the same time from SSID -2. Although APRS.fi did indicate an error message on SSID -2 (Example 4.) "This station is transmitting packets at a very high rate," this can be thankfully ignored because the uploaded packets originated from the secondary frequency (only monitored by W8UM). There was no congesting the 144.390 MHz North American APRS frequency and the APRS-IS system can easily handle the traffic.

Hopefully, this technique of receiving packets directly from a secondary transmitter and then exporting to APRS.fi will prove to be beneficial during all future HAB flights. ■

W8UM High-Altitude Balloon Tracking Program Members: Co-Authors, Rob Giuliano, KB8RCO; Michael Fluegemann, KE8AQW; Rajiv Govindjee, KN6SXI; John Palmisano, KB8OIS

Robert F. Heytow Memorial Radio Club

www.k9ya.org
telegraph@k9ya.org