Far Horizons

From high altitude ballooning to CubeSats at the Adler Planetarium

Mark Hammergren, PhD

Geza Gyuk, PhD

Overview

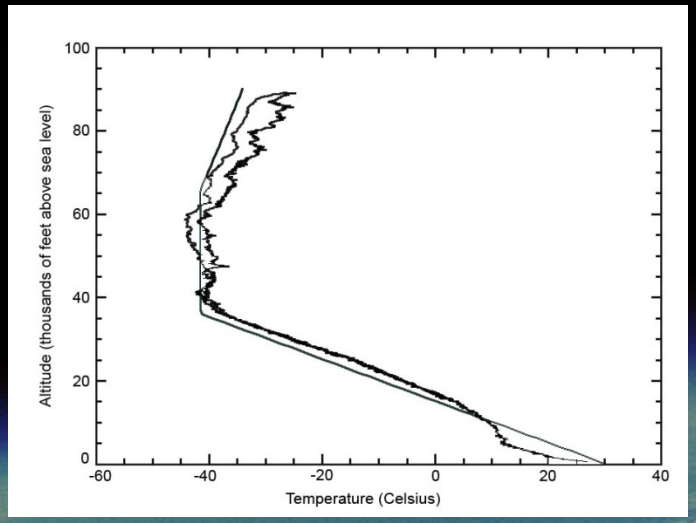
- The AdlerSpace group at the Adler Planetarium in Chicago was formed three years ago with the goal of **directly involving** our visitors and the general public in space exploration
- Initial plans were to build and operate CubeSats
- High altitude ballooning was seen as a way of developing individual and institutional expertise and infrastructure necessary for satellite work
- The Far Horizons ballooning program has since evolved into a very valuable part of our public outreach and education efforts, in its own right
- To date, we have launched 19 missions, most of them involving volunteers and students in all phases of the design, construction, launch and recovery of balloon experiments
- We maintain our interest in orbital missions, and are aggressively pursuing plans to begin CubeSat work next year

Far Horizons Support Hardware

- General payload configuration derived from designs in Paul Verhage's Near Space manuals
- Key element is GPS / APRS transmitter
  - Byonics Micro-Trak 8000, 2M, 8W with Garmin GPS-18 receiver
  - Big Red Bee Beeline GPS 2M HP with Trimble Lassen IQ GPS
- Kenwood TM-D700A vehicle-mount radio
- PC-based UI-View32 APRS software / Undertow Software Precision Mapping Streets and Traveller
- Kaymont Sounding balloons (usually 1200 – 1500 g)
- Rocketman parachute

Experimental Hardware

- Rack-mount internal frame for experiment cards (though some concern this was detuning our GPS antenna)
- Parallax Basic Stamp 2 Homework Board used to read sensors and record data (onto EEPROMS or flash drive)
- Student-built experiments have included:
  - Variety of temperature / pressure / light sensors
  - Geiger counter
  - Digital cameras (triggered by Basic Stamp)
- Video cameras
  - Aiptek IS-DV2
  - Canon Vixia HF10 HD
- GPS position/altitude provides wind speed and ascent/descent rate profile
  - Atmospheric drag during descent can be used to determine air density



Typical flight profile

Ascent:

- Relatively uniform speed ~ 800 -1300 fpm
- Max. altitude around 90 - 100,000 ft.
  - Atm. Pressure ~ 0.01 atm
- Duration around 90 minutes

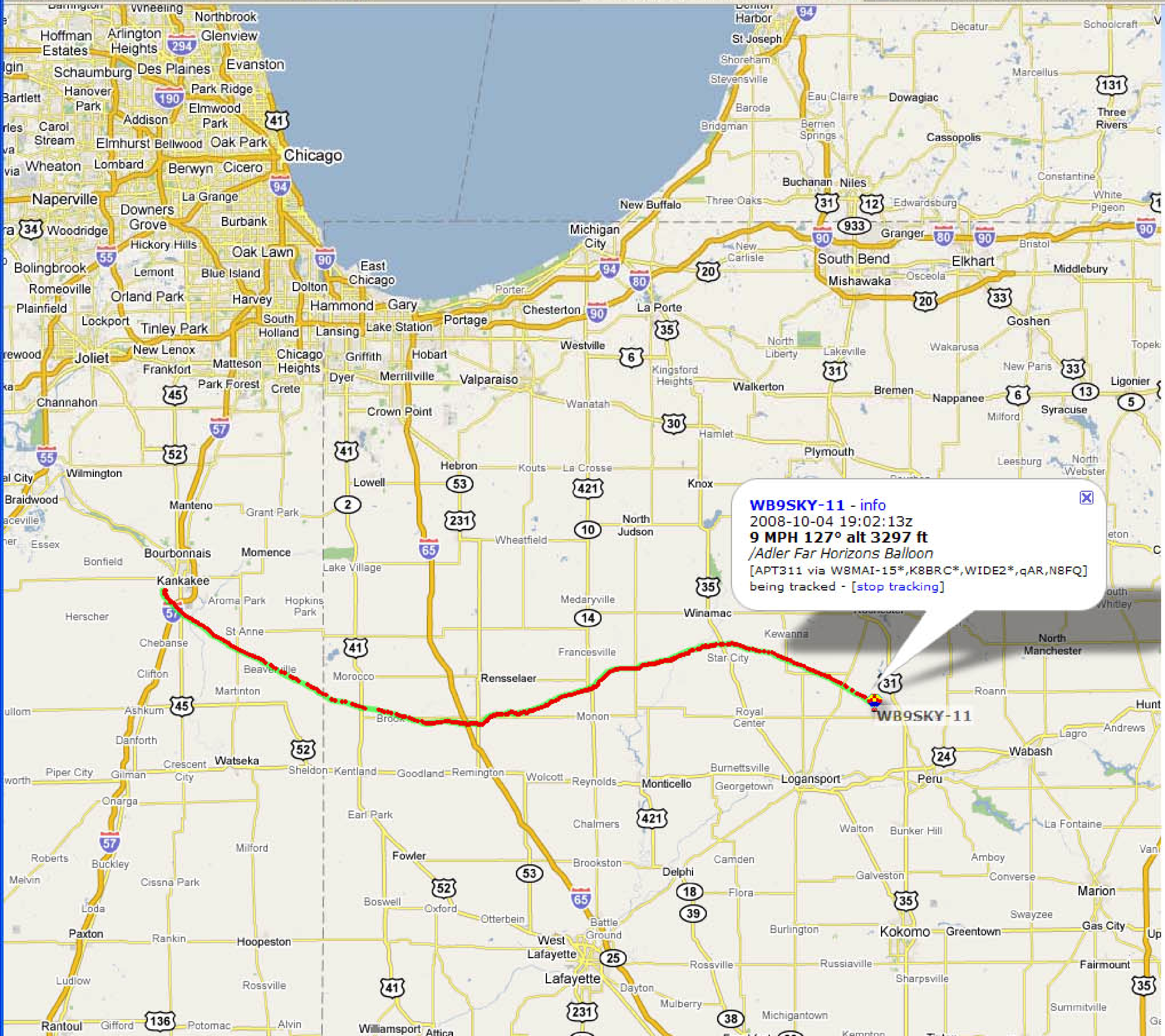
Descent:

- Initial descent rate after burst ~100 mph
- Descent slows with increasing air density
- Duration around 30 minutes

http://aprs.fi/?call=WB9SKY-11&dt=1223078400&mt=m&z=10&timerange=3600

Most Visited | Gary-Chicago-Milwauke... | 7-Day Forecast for Lati... | ProxyIt!

Inbox - 'AT&T Yahoo! Mail' | Google | Location of WB9SKY-11 - ... | http://aquarid....saf/usg282.txt



aprs.fi - KC9LIG - Log out

Show last:
1 hour

Track callsign: [Clear / Show all]
WB9SKY-11 Search [?]

Address, city or Locator: [Clear]
Search [?]

WB9SKY-11:
Updated: 2008-10-04 19:02:13z
Position: 40°53'31" N 86°12'25" W
Showing (browser local time):
from: 2008-10-04 00:00:00z
to: 2008-10-05 00:00:00z

Select a day (6 months history):
2008: 965 points

Other SSIDs: WB9SKY-15

Other views:

- Station info
- Raw packets
- Status packets - Beacon packets
- Messages - Bulletin board
- Prefix browsing
- Google Earth KML [?]
- Preferences

Information:

Blog · APRS stations currently moving · Database statistics · Linking to aprs.fi · AIS sites · Change log · Planned changes · Credits and thanks

stopped

What's up on aprs.fi

Ice floes in Lake Michigan in February

(taken at ~100,000 ft., 02/23/2008)

Student Programs

- Astro Science Workshop
  - summer program for high school students funded by NSF
- Teen Astronomers Camp
  - middle school summer program
- Summer internships for undergraduates
  - funded by Illinois Space Grant Consortium
- Illinois Math and Science Academy mentorship
  - Two high school students, one day a week during the school year

Benefits of a ballooning program (1)

- Development / logistics:
  - Relatively low cost per mission
    - (< $250 expendable supplies per launch)
  - Total reusable hardware costs < $1000
  - Short development schedule per mission
    - Teen Astronomers Camp runs for 5 days, from (simple) experiment construction through launch and recovery
    - Students / volunteers are involved and invested in every aspect of the mission

Benefits of a ballooning program (2)

- Pedagogical:
  - Student work is hands-on, mission success depends on their effort
  - Students collect real data
  - Launch and recovery – and data analysis – are exciting and inspiring

Benefits of a ballooning program (3)

- Professional:
  - Permit you to develop dynamic and engaging courses
  - Programs are attractive to funding agencies
  - High-visibility, interesting to the public
    - Full-page coverage in Chicago Tribune, video featured on Today Show
  - Build transferrable skills

Peeps in Space!

(as seen on YouTube)

The Future: Ballooning

- Far Horizons balloon program will continue as an important element of our work
- Promote public distribution of effort in hardware / software design and construction
  - Analogous to Open Source model or “Citizen Science” initiatives: “Citizen Engineering”
  - Current projects include:
    - Cutdown system
    - 900 MHz high-speed two-way datalink
    - Custom tracking software incorporating real-time touchdown location prediction

The Future: Satellites

- CubeSat effort will begin within the next year
  - First satellite will be an Earth imager
    - Issue: how to promote “Citizen Engineering” of satellites and maintain ITAR compliance?
    - Basic principles of this first effort:
      - Use as many COTS components as possible
      - Improve communications coverage
        - Visitor interaction with satellite will require frequent communications
        - Need to support network of ground stations
        - Build a station with international academic partner optimized for geographic location
    - Issue of attitude stabilization in proper orientation for 1U CubeSat
      - Drive slow tumble with magnetorquer / reaction wheel, time exposures using sun / Earth sensors

Visit the Far Horizons blog:

- http://farhorizons.wordpress.com/