Project Ellie: Hokies go to the Edge of Space

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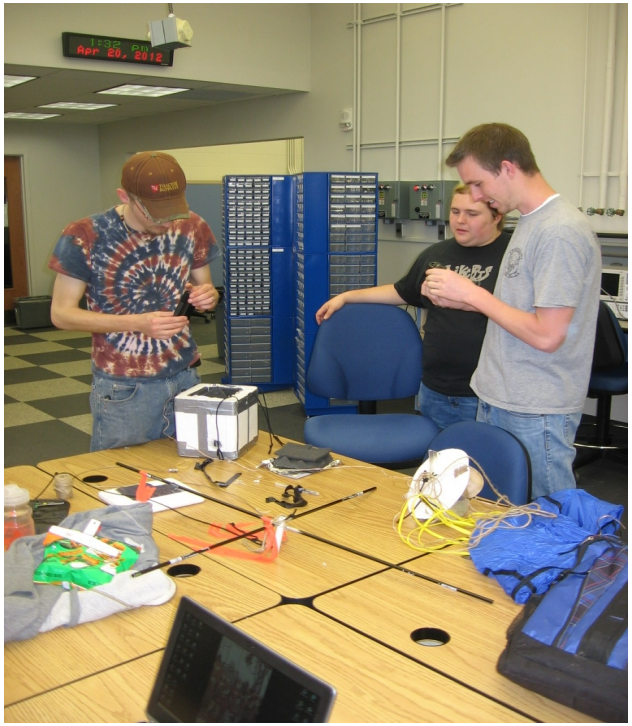
The Team

The team consisted of students from a range of engineering disciplines and academic levels who were in ECE2984: Exploration of the Space Environment.

Organization

- **Weekly team meetings**
  - Team assigned tasks.
  - Meetings reported progress.
  - An internal website was set up to facilitate communication.
- **Each team member had a defined launch day task.**
  - Launch day check list developed.
- **Dry run**
  - Inflated balloon
  - Integrated payload and rigging
  - Tested chase team equipment and operations
- **Avoid last minute changes.**
  - “Test like you fly”



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Regulations

- **These regulations were taken from the U.S. Federal Aviation Regulations (FAR), part 101.1:**
  - Payload must be under 2.73 kg.
  - Launch must be more than 10 mi from a major airport.
  - Balloon must be less than 1.8 m in diameter.
  - Secondary balloon/payload separation mechanism required.
  - There must be a radar reflector.

These regulations drove the initial selection of a 1.3 kg payload.

Camera Selection

- **Considerations:**
  - Video quality
  - Battery life
  - Storage capacity
  - Weight
  - Ability to withstand environment

http://www.coolhunting.com/assets_c/2011/09/contour-roam11-thumb-442x352-31491.jpg

The Contour ROAM camera was selected because it had a small mass of 0.14 kg and it was built to withstand harsh conditions.

The camera was tested for battery life and memory utilization. Battery life dictated 3 sec/frame rather than full motion video.

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Balloon Selection

- **Two balloon sizes were examined, 600 g and 1200 g.**
  - Theoretically the 600 g balloon produced enough lift to reach 30 km.
  - Analysis showed the 1200 g balloon would exceed the objective, the 1200 g balloon was selected.

1200 g Balloon Analysis

Mass of Payload (kg)	1.70
Mass of Balloon (kg)	1.20
Diameter at Launch (m)	1.98
Diameter at Burst (ft)	30.00
Lift (kg)	4.26
Neck Lift (kg)	3.06
Residual Lift (kg)	1.36
Bursting Altitude (km)	47.8
Ascent Velocity (m/s)	5.31
Time until Bursting (hr)	2.50

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Parachute Selection

Two parachute sizes were selected for testing: a 1.2 m (4 ft) parachute and a 1.5 m (5 ft) parachute.

The 1.5 m parachute was chosen after drop tests with a weighted payload box.

Parachute Analysis

Payload and Rigging Mass (kg)	Speed (m/s)	Parachute Diameter
1.59	7.00	0.9 m (3ft)
1.59	5.25	1.2 m (4ft)
1.59	4.20	1.5 m (5ft)
1.59	3.50	1.8 m (6ft)
1.59	2.89	2.1 m (7ft)

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Communication and Sensor Package

Communications Payload

- TinyTrak-4 Automatic Position Reporting System (APRS) modem
- Byonic-4 GPS (usable to 84 km altitude)
- ICOM IC V-80 144 MHz amateur radio
- Crossed dipole antenna (avoids nadir null)
- Performed link signal power analysis.

Sensor package

- ATMEGA328P 8 bit processor and data logger
- Sensors : Barometric pressure (Bosch MP085)
  Exterior temperature (TI TMP120)
  Interior temp, gyro, accelerometer, magnetometer
  (Sparkfun SEN-10724)

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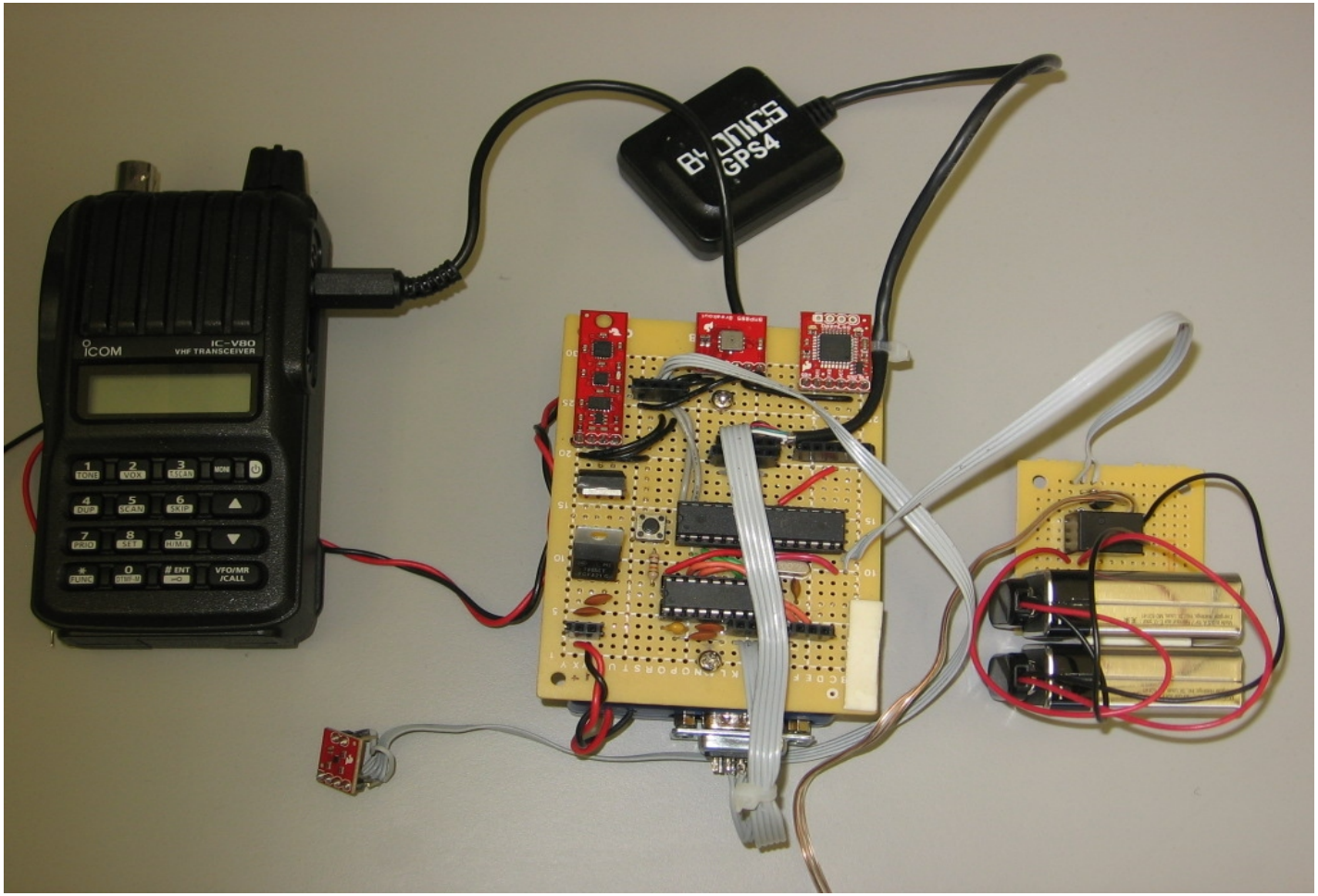
Communications Payload



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Chase Teams

- **Three chase teams were organized equipped with:**
  - An APRS radio.
  - Computer with tracking software.
  - Yagi antenna for ground search.

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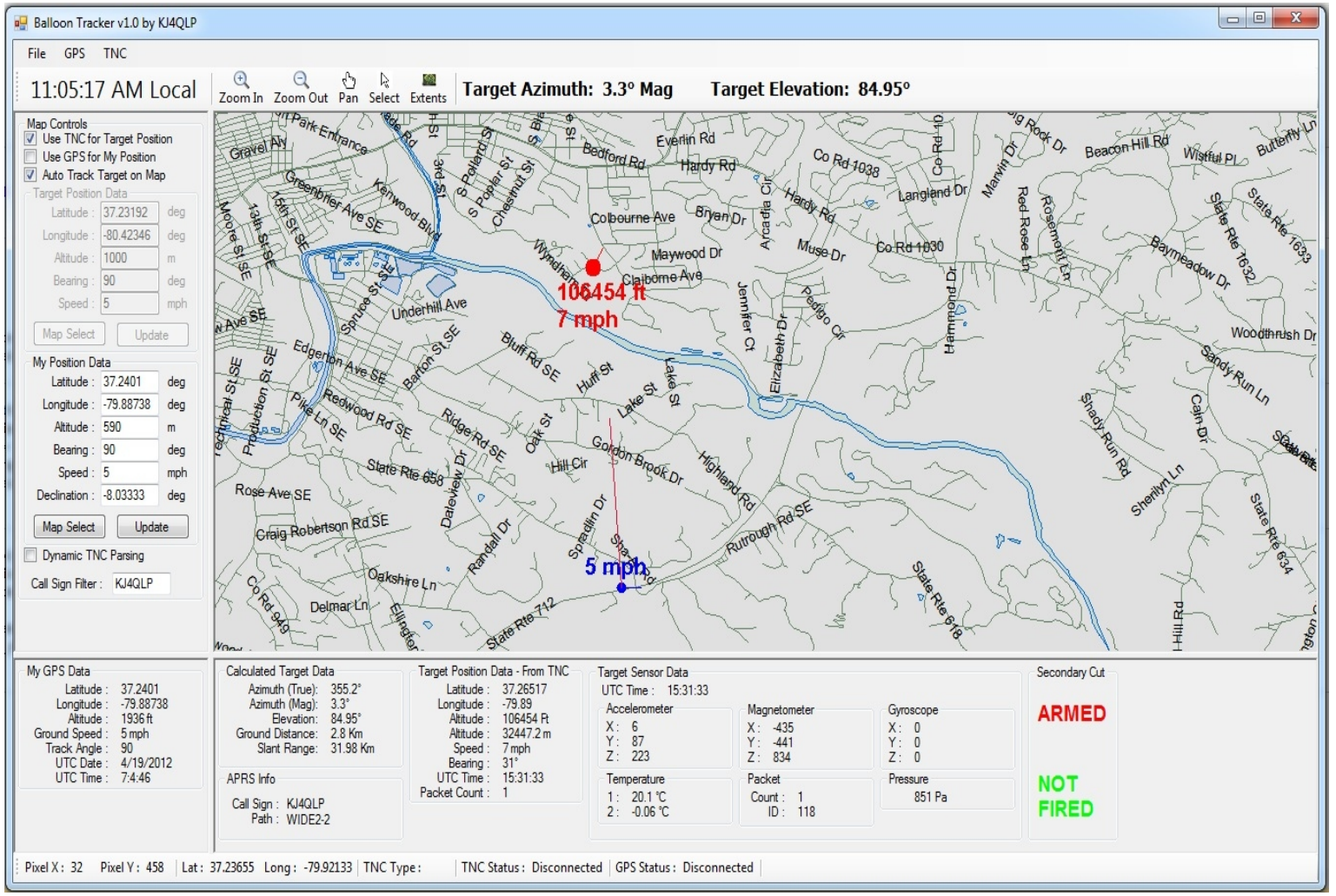
Tracking Software



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Launch Day

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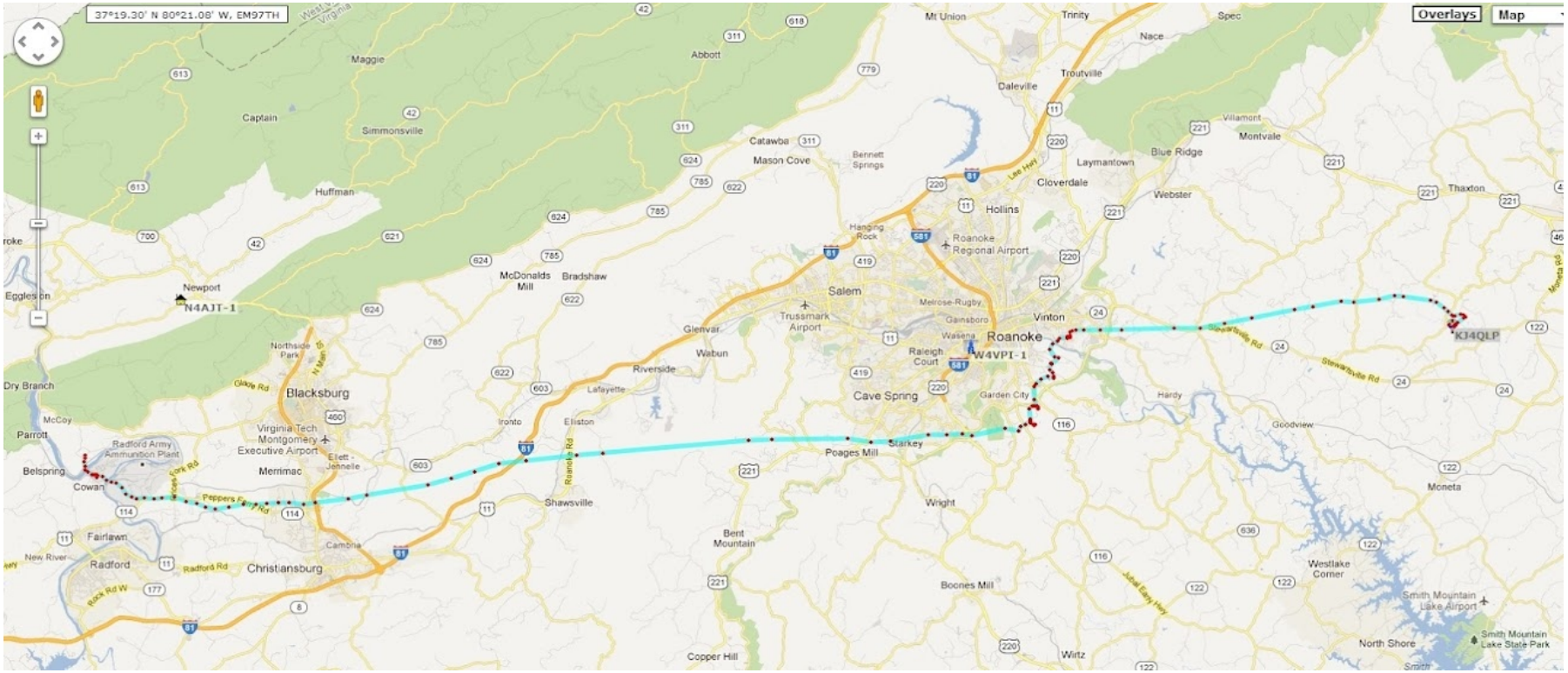
The Chase



Mission Results

- Ellie went to 32.7 km!
- The flight lasted roughly 2.5 hours.
- The balloon popped at a diameter of 18.52 ft, not 30 ft.
- Nearly 10,000 pictures were taken.

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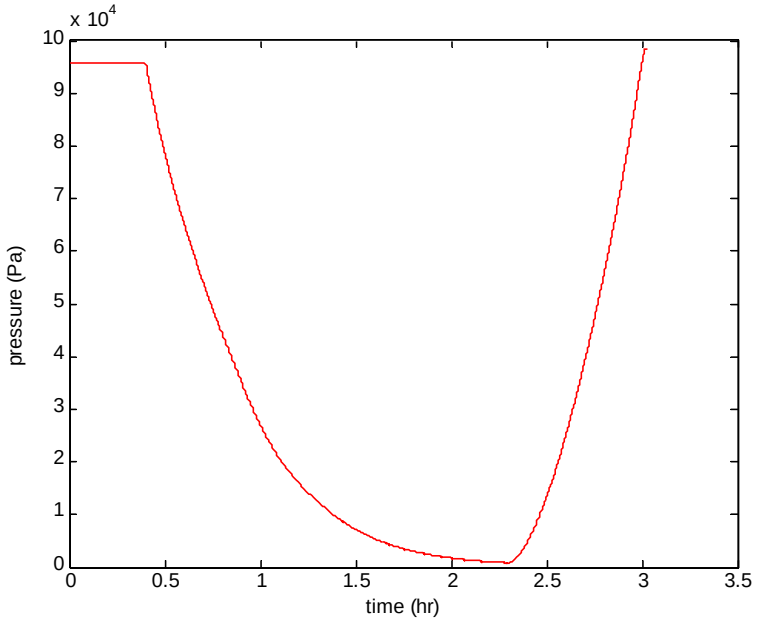
Data Analysis

The pressure sensor selected was limited to approximately 9.0 km.

If the burst altitude is estimated from this sensor, it estimates an altitude of 26.6 km which is less than the measured altitude.

A sensor suited to lower pressures is needed for future missions.

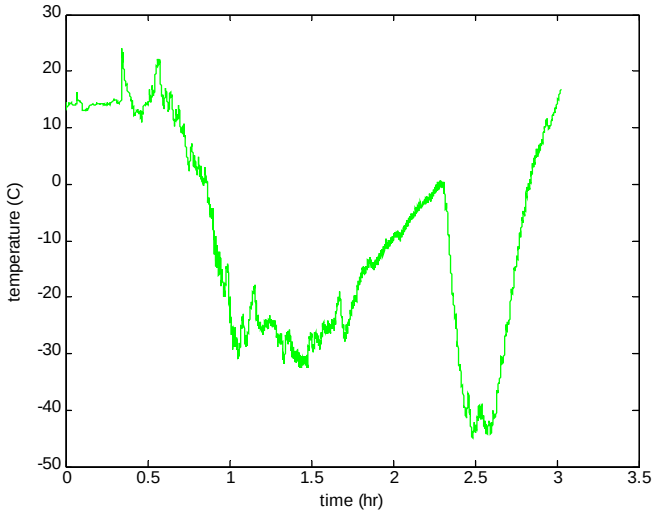
Atmospheric Pressure vs. Mission Time



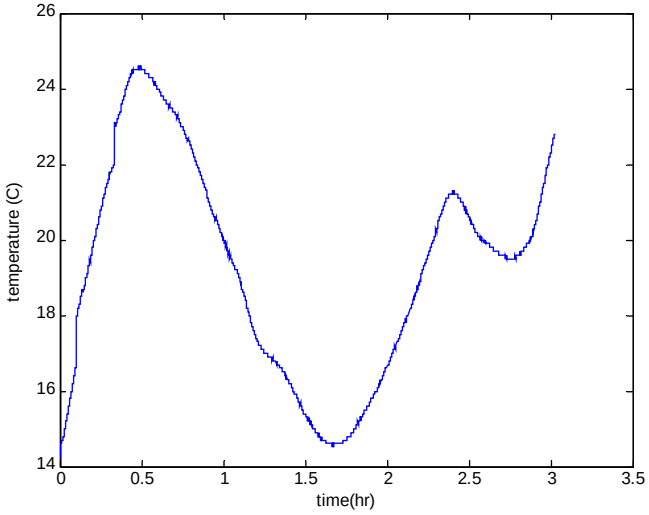
Data Analysis

- **The external temperature sensor was specified down to -40°C**
  - A minimum of -45°C was recorded
  - A sensor suited to lower temperatures would be worth investigating in the future

External Temperature



Internal Temperature



Lessons Learned

- **A good project can engage students**
- **The team is important**
- **Planning and testing are critical**
- **Analyzing is a must when testing isn't possible**
- **The clocks in the data loggers and cameras should be synchronized**
- **Have someone who can climb trees!**
  - A cut down mechanism for the payload would be helpful.

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Conclusions

- **Goals for the future:**
  - Organize a new mission each year
  - Explore more varied sensors
  - Do testing with the Space@VT research group
  - Break a altitude record!