

**University of Minnesota – Twin Cities Modifications to
the Montana State University Telemetry System for
Stratospheric Eclipse Ballooning**

Benjamin S. Gadelmann, Austin J. Langford, Austin N.
Eiler, Ryan Bowers

University of Minnesota-Twin Cities, Minneapolis, Minnesota

James Flaten

*MN Space Grant Consortium (MnSGC) and U of MN – Twin
Cities, Minneapolis, MN, 55455, USA*

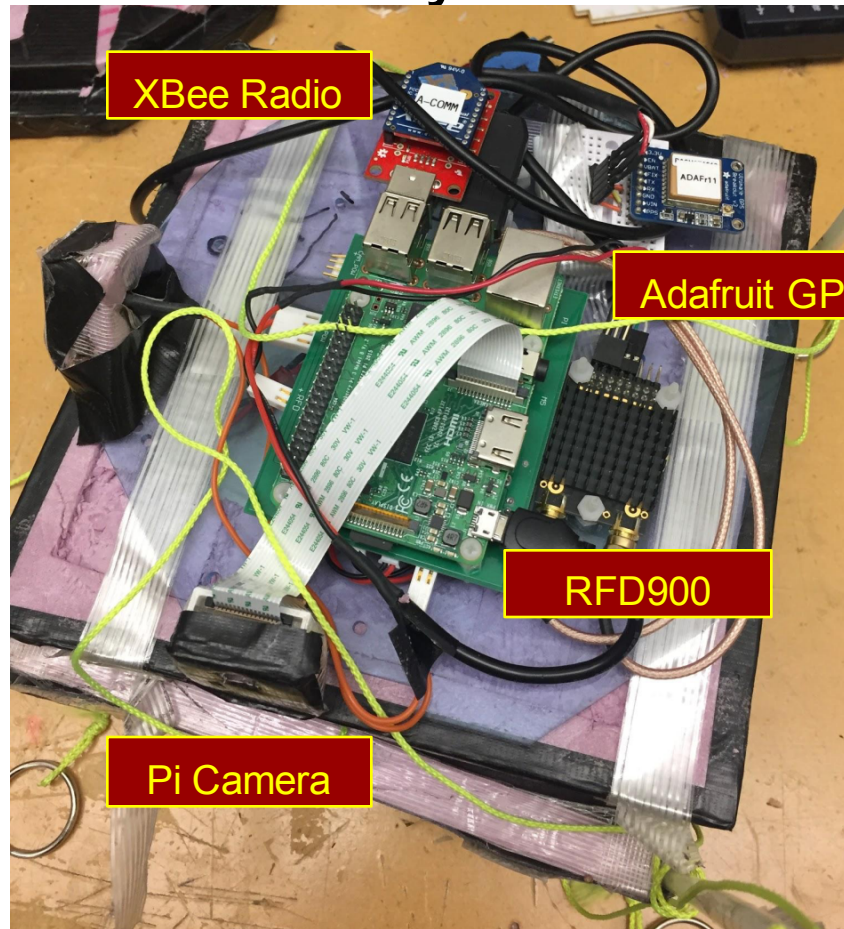


Introduction

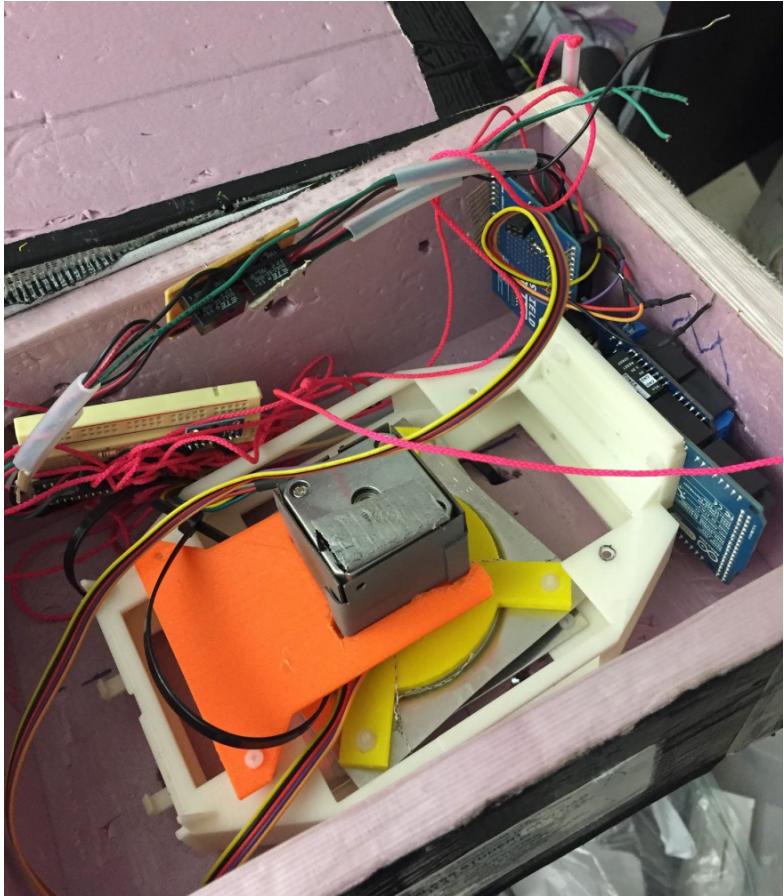
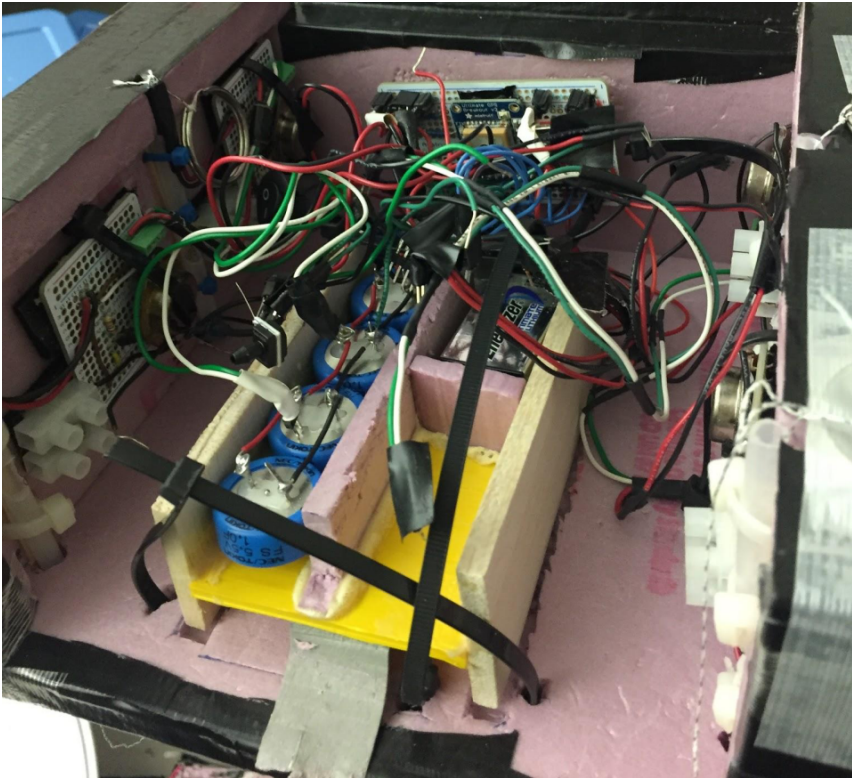
- Joined Montana State University as a “leadership” team in January 2016.
- We decided to make changes to system to add functionality and improve reliability.
- “Minnesota Tracking System” improves GPS update time of system, relays commands, and improves usability.



New Hardware for UMN System



Other Payloads with UMN System



Ground Station Hardware

- Original system left mostly intact.
- Updated radio firmware to allow for “downrange” ground stations
- Downrange stations let us be closer to the balloon at the peak of flight.
- Omnidirectional antenna picks up balloon up to 60 km.



New Software

- Began modifications to MSU system in summer 2016
- Team wanted uplink and downlink for tracking, etc
- Still image connection was used due to lots of downtime of radio link.



Tracking Updates

- Simultaneous tracking of multiple sources
 - Iridium
 - APRS
 - Direct through RFD
- Data Logging
- Automatic Device Detection
- New Servo Mapping

Antenna Tracker and RFD Controls

Incoming GPS Data:

	Value
Last Received Time	
Latitude	
Longitude	
Altitude	
Elevation Angle	
Bearing (From North)	
Line-of-Sight (km)	
Mag Declination	
Tracking Method	

Ground Station Data:

	Value
Latitude	
Longitude	
Altitude	
Center Bearing (N)	
Applied Bearing Offset	
Applied Tilt Offset	
Bearing Position	
Elevation Position	

Center Bearing (True):

Get Local (Arduino)

North Facing

East Facing

South Facing

West Facing

Manual Settings Entry:

Latitude (°):

Longitude (°):

Altitude (ft):

AutoTrack:

Disabled

Iridium

APRS

RFD900

Graphing and Logging:

Graph Runtime

Save Data

Internet Access

Connections:

Servos Connected

RFD Connected

Arduino Connected

APRS Connected

APRS Callsign:

Iridium IMEI:

Autotrack: Offline

[→ Update Settings](#)

[→ Recalibrate Center Bearing](#)

[→ Move Antennas to Center](#)

[→ Point at Most Recent Balloon Location](#)

[→ Launch Antenna Tracker](#)

RFD Controls

- RFD connection sends GPS packets and XBee messages from other payloads.
- Ground station software is multithreaded to support these activities.

Incoming GPS Data:

	Value
Last Received Time	17:53:29
Latitude	44.9758616667
Longitude	-93.2319816667
Altitude	928.79
Elevation Angle	39.56
Bearing (From North)	278.8
Line-of-Sight (km)	0.04
Mag Declination	0.24
Tracking Method	RFD

Ground Station Data:

	Value
Latitude	44.9758181
Longitude	-93.231584
Altitude	843.0
Center Bearing (N)	0
Applied Bearing Offset	0.0
Applied Tilt Offset	0.0
Bearing Position	0.0
Elevation Position	0.0

Identifier: Command: **START**
OFF

Received:

```
11:53:10 || Temp: (10.5, 50.9)
11:53:10 || GPS:17,53,11,44.9758766667,-93.2319133333,285.5,6
11:53:13
Sending test7123!
11:53:13 || Temp: (10.562, 51.0116)
11:53:13 || GPS:17,53,13,44.9758766667,-93.2319116667,285.5,6
11:53:13 || Temp: (10.687, 51.236599999999996)
11:53:14 || GPS:17,53,14,44.9758766667,-93.2319116667,285.5,6
Command Interrupted
11:53:17 || Camera: True, GPS: True, Xbee: False, Temp: True
11:53:17 || Temp: (10.687, 51.236599999999996)
11:53:17 || GPS:17,53,17,44.9758766667,-93.2319116667,285.4,6
11:53:20 || Temp: (10.437, 50.7866)
11:53:20 || GPS:17,53,20,44.9758766667,-93.231915,285.4,6
```

Stop Listening

ON

Request Status

Get Runtime Data

Autotrack: Offline

Other Tab Updates

The screenshot displays the 'Antenna Tracker and RFD Controls' software interface. It features a sidebar with navigation tabs: Settings, Tracker, Map View, RFD, Payloads, Still Images, and Manual Control. The main area is divided into several sections:

- Incoming GPS Data:** A table with columns for field names and values.
- Ground Station Data:** A table with columns for field names and values.
- Manual Coordinate Entry:** Fields for Latitude (°), Longitude (°), and Altitude (ft), each with an 'Update' button.
- Manual Angle Entry:** Fields for Bearing (°) and Elevation Angle (°), each with an 'Update' button.
- Sliders:** Controls for 'Pan Servo' and 'Tilt Servo' with a 'Start' button. A large red 'OFF' indicator is present at the bottom of this section.
- Trim:** A control panel with four directional buttons (up, down, left, right) and a 'Reset' button.

At the bottom center of the interface, the status 'Autotrack: Offline' is displayed in red text.

	Value
Last Received Time	
Latitude	
Longitude	
Altitude	
Elevation Angle	
Bearing (From North)	
Line-of-Sight (km)	
Mag Declination	
Tracking Method	

	Value
Latitude	
Longitude	
Altitude	
Center Bearing (N)	
Applied Bearing Offset	
Applied Tilt Offset	
Bearing Position	
Elevation Position	

Flight Software

- Flight software was restructured
- Multithreaded to remaining responsive
 - Relay XBee/RFD
 - Take photos
 - Retrieve GPS updates
 - Beacon
- Highly error tolerant
- Can trigger cutdown independent of Iridium



UMN Experiences

- Approximately 20 test flights



... with the flight units, and the best ways to use them

- Down Range Ground Stations (Gustavus)
- Coordinating launch site accordingly, to fly over ground station
- Getting Video Stream to internet, and what that told us about network needs in Nebraska
- Reliability of Systems
- Plan to fly three telemetry stacks

Trip Preparation

- Lake Landing (August 13th)
- Rebuild damaged units and test by August 18th.
- Familiarity with systems allowed us to be prepared



Nebraska



Future Work

- System is still useful after eclipse.
- We have more control over our balloons than ever.
- Working on implementing “light” version of ground station.
- Would use car mounted antenna and drive under balloon in flight.
- Allows for data to be sent live in flight



Questions?



GPS Decision

- Tested Adafruit Ultimate GPS Breakout, UBlox NEO6MV2, and Trimble Copernicus II.
- Adafruit was selected after testing.
- However, newer Adafruit GPS modules have firmware restricting their use above 18,000 meters.