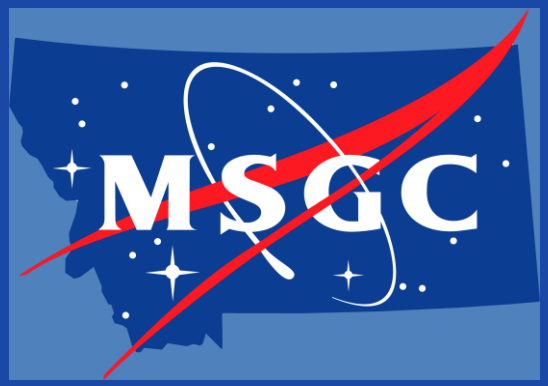

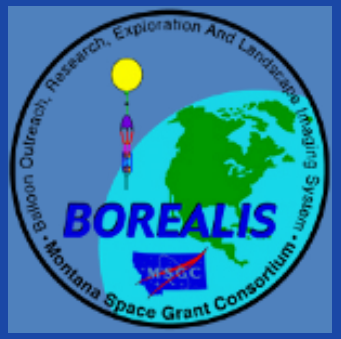

Repurposing an Iridium Network Satellite Modem into a Two-Way Balloon Tracking and Communication System

-

Scott Miller

Montana State University

MSGC BOREALIS

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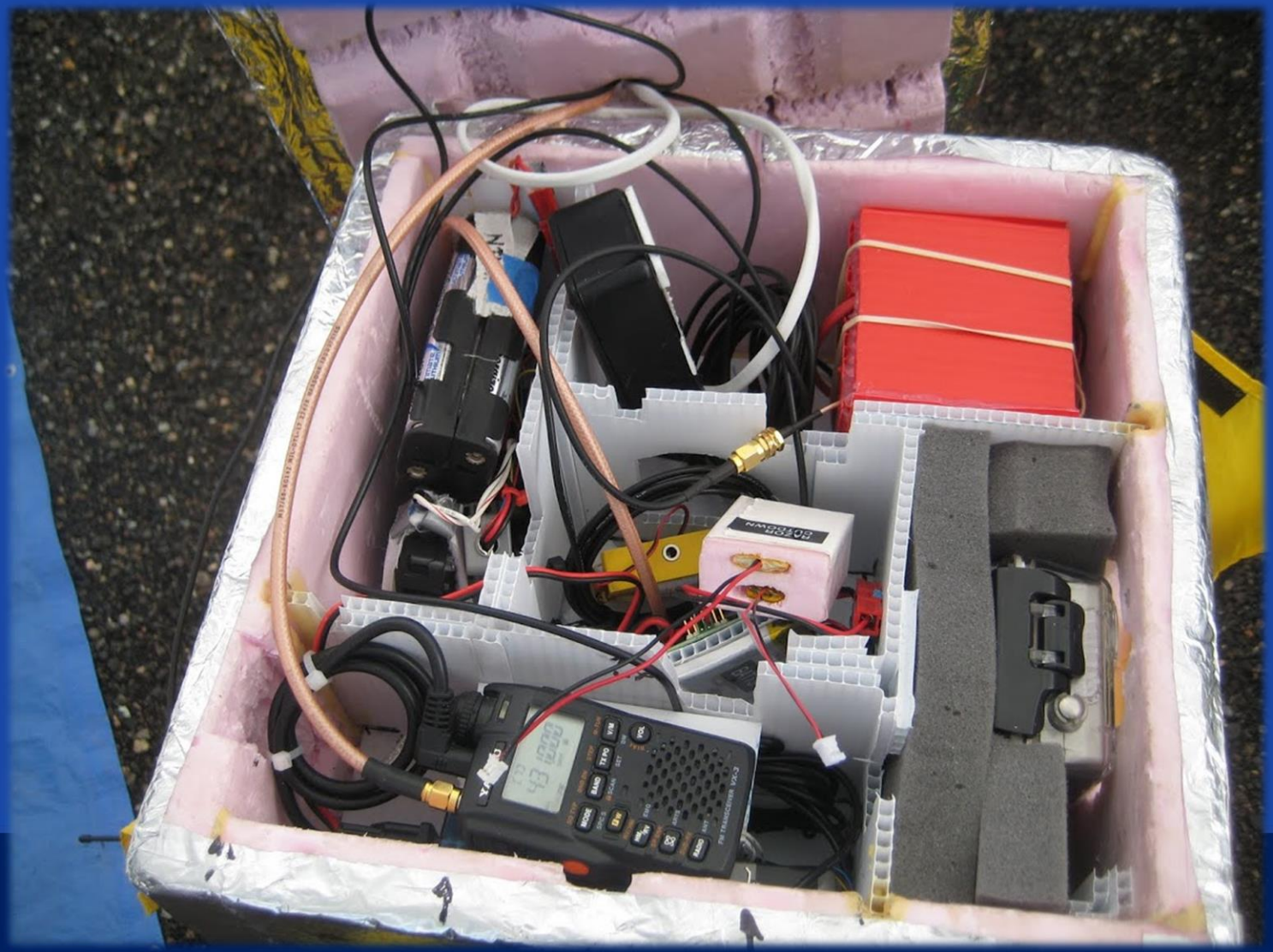
Outline of this talk

- **Previous tracking system and challenges**
- Intro to satellite modem
- Configuration of support systems
- Final tracking system overview
- Additional modem capabilities
- Outcomes of the project

Previous flight system

- Amateur radio based, APRS system (2 radios)
- DTMF decoding for in-flight control
- SPOT satellite beacon
- Burst flights or cut down flight termination
- Reporting of launch location and altitude to FAA

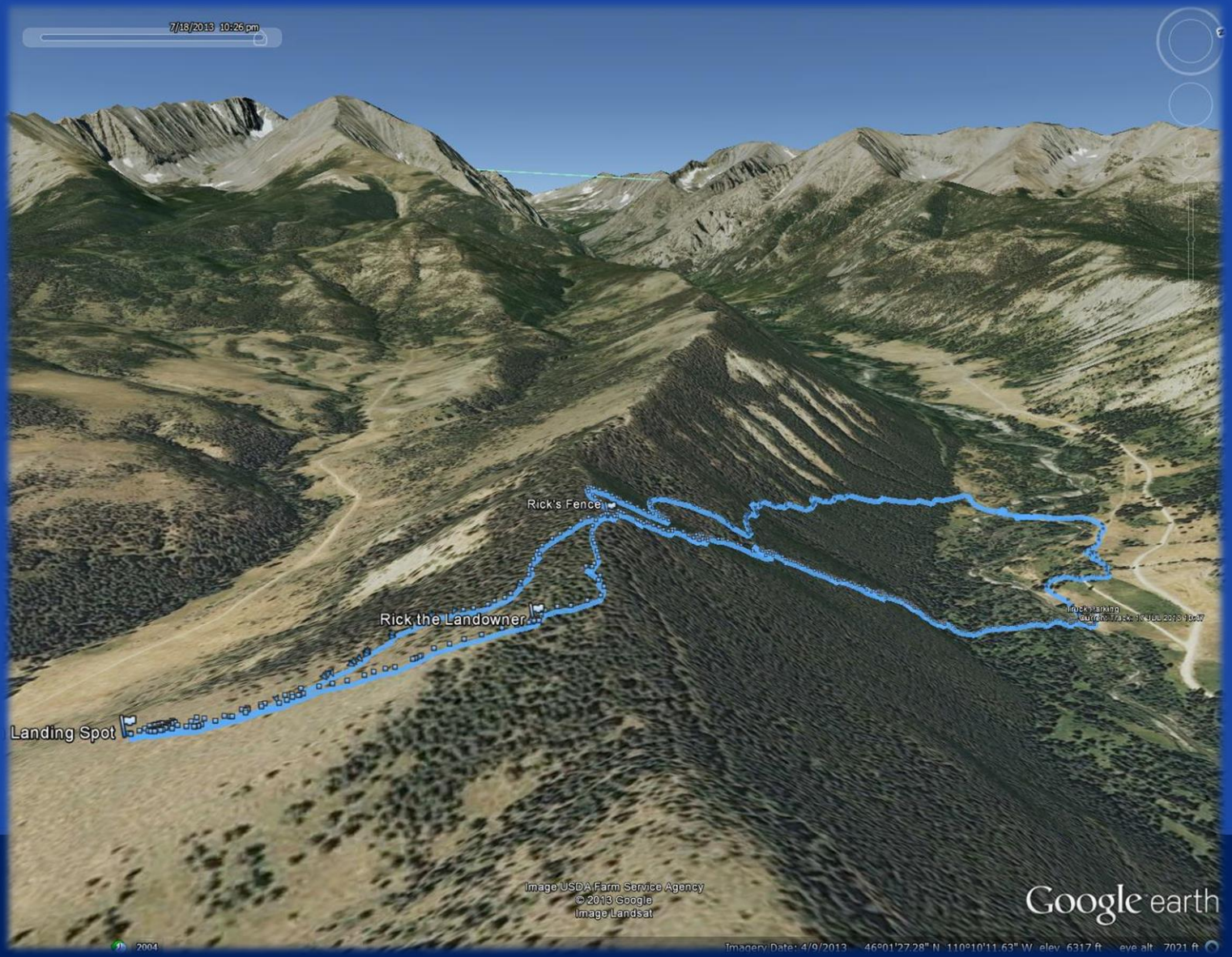
Previous tracking system – Amateur radio



Previous tracking system – SPOT beacon

Typical Montana recovery geography

Less typical recovery geography



Challenges for previous system

- Amateur radio
  - Loss of reporting during the final moments of flight
  - Less detailed reporting of location to the FAA
  - DTMF decoding sometimes unreliable
  - Heavy / large system
- SPOT beacon
  - Only works up to an altitude of 20,000 ft
  - Must have a clear view of the sky for reporting

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Why a satellite modem?

- Need for an online reporting website
  - Online APRS tracking issues
  - Easy access to data
  - Reporting to the FAA
- Used by scientific ballooning organizations such as Columbia Scientific
- All-in-one GPS and two-way communications

NAL 9602-LP satellite modem

NAL 9602-LP satellite modem

Capabilities

- Short Burst Data (SBD) packets
  - 340 bytes per message sent
  - 270 bytes per message received
- Power usage
  - 200 mA average transmit current
  - 45 mA average receive current
  - 3.6 – 5.3 or 6.0 – 32.0 input voltage range
- Environmental
  - Operating temperature range -40^{o} to 185^{o} F

Cost

Equipment	
Item	**Cost**
NAL 9602-LP	$600
Dual band antenna	$300
Cables	$150

Service	
Item	**Cost**
Turn on service	$700
Monthly fee	$13
First 30 bytes	$0.04
> 30 bytes	$0.0015 / byte

Average flight ~$25

What needs to be set up?

- Our take: website with location data
  - Report location and altitude data
- Main server
  - IP registered with Iridium
  - Receive data and run code
- Physical considerations
  - Mounting, antenna placement
  - Power supply

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System set up

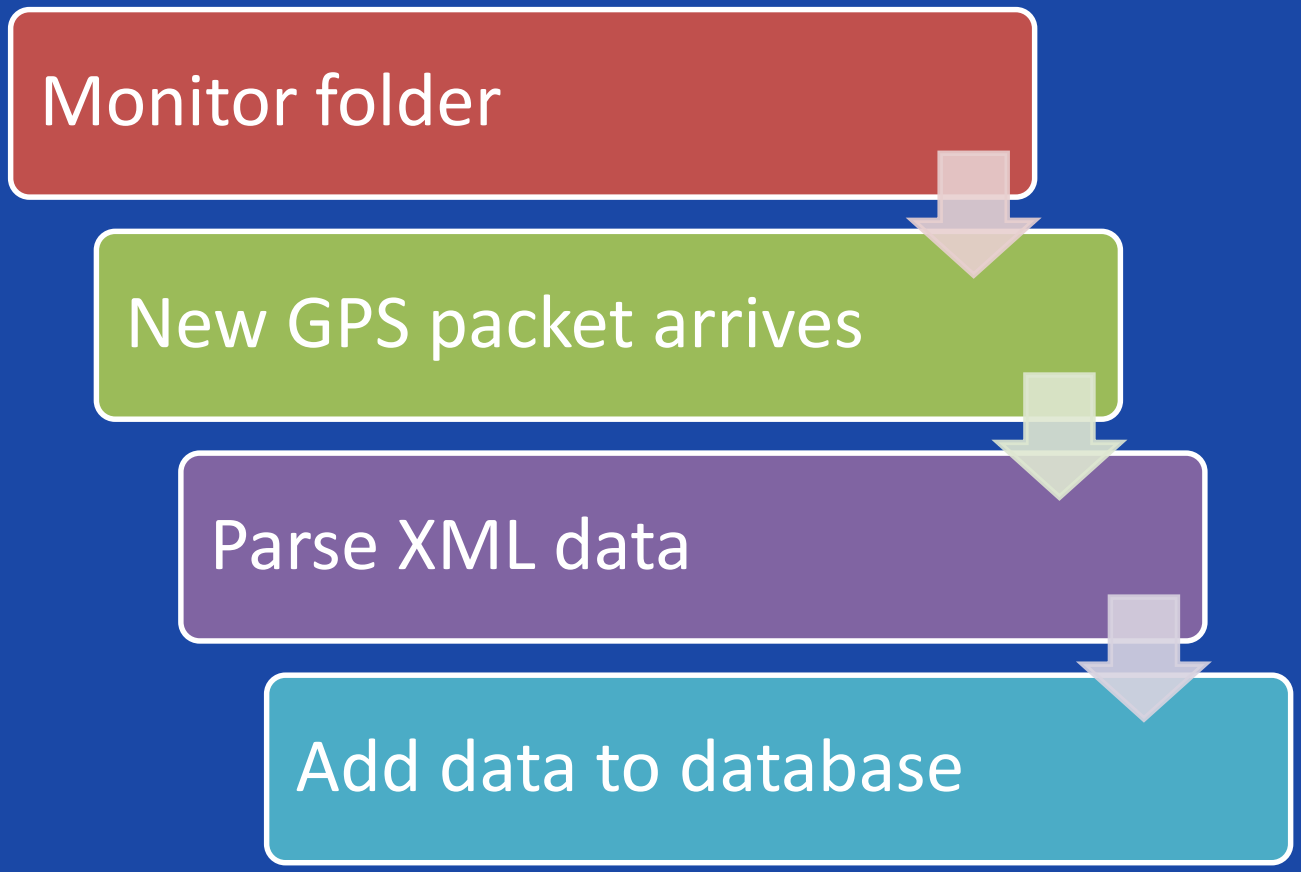
- Our vision was to plot location reports on Google Maps as they are received, and have this easily accessible over the internet.
- Required several items on server:
  - NAL service
  - Webserver
  - Database
  - Data interpretation code

Webserver and database

- Can be done many ways, we chose an all-in-one solution: XAMPP
- X – Windows, Mac, or Linux
- A – Apache webserver
- M – MySQL database
- P – PHP server-side code
- P – Perl, unused

Next – homework!

Receiving data



Receiving data

```
    <type>NAL GPS Report 5</type>
</meta>
<nalGpsReport5>
    <time>2013-07-31T15:10:49.5Z</time>
    <lat>46.3612667</lat>
    <lng>-109.0443833</lng>
    <alt>21820</alt>
    <gndVel>18.36</gndVel>
    <course>294.10</course>
    <verVel>-4.52</verVel>
```

XML code

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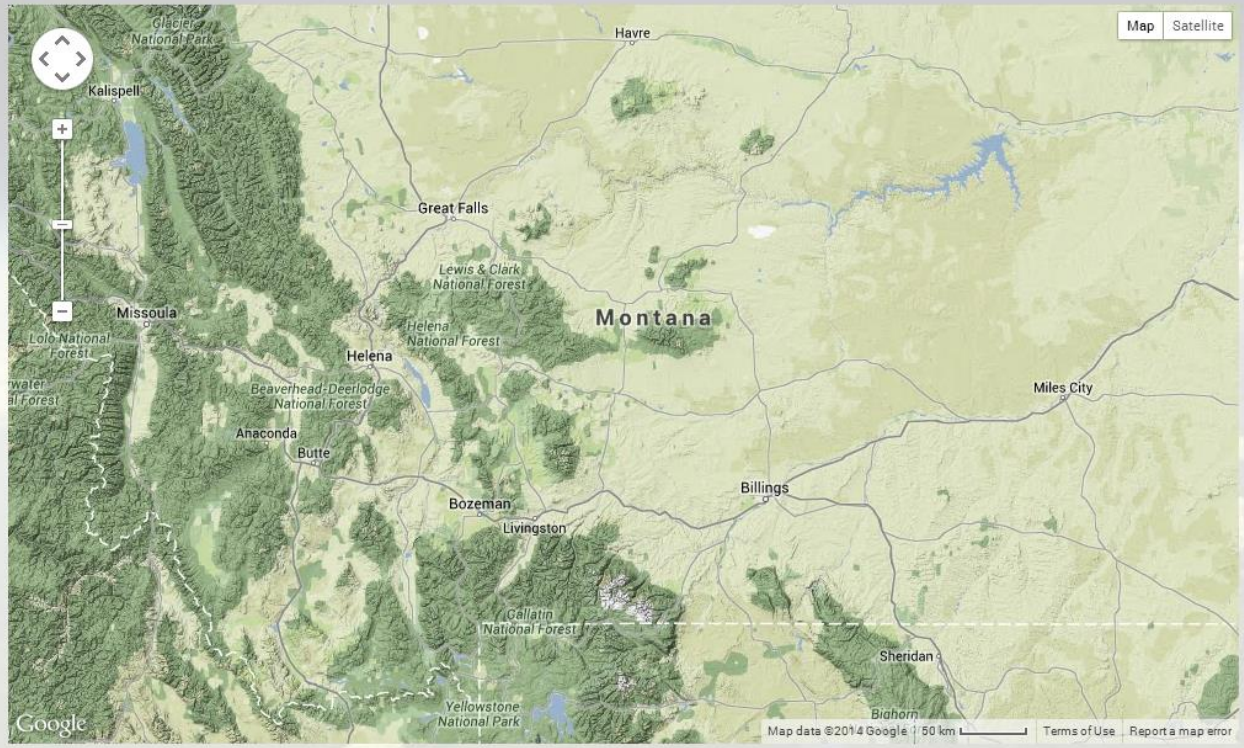
BOREALIS Balloon Tracking

Tracking | Previous Flights | About | Contact

Current Flight Data

Incoming GPS data points are plotted automatically

☑ Auto-center/zoom map with each update? (Uncheck to explore map)



Time-UTC	Date	Latitude	Longitude	Alt-m	Alt-ft	V_Vel-m/s	V_Vel-ft/s

Previous Flight Data

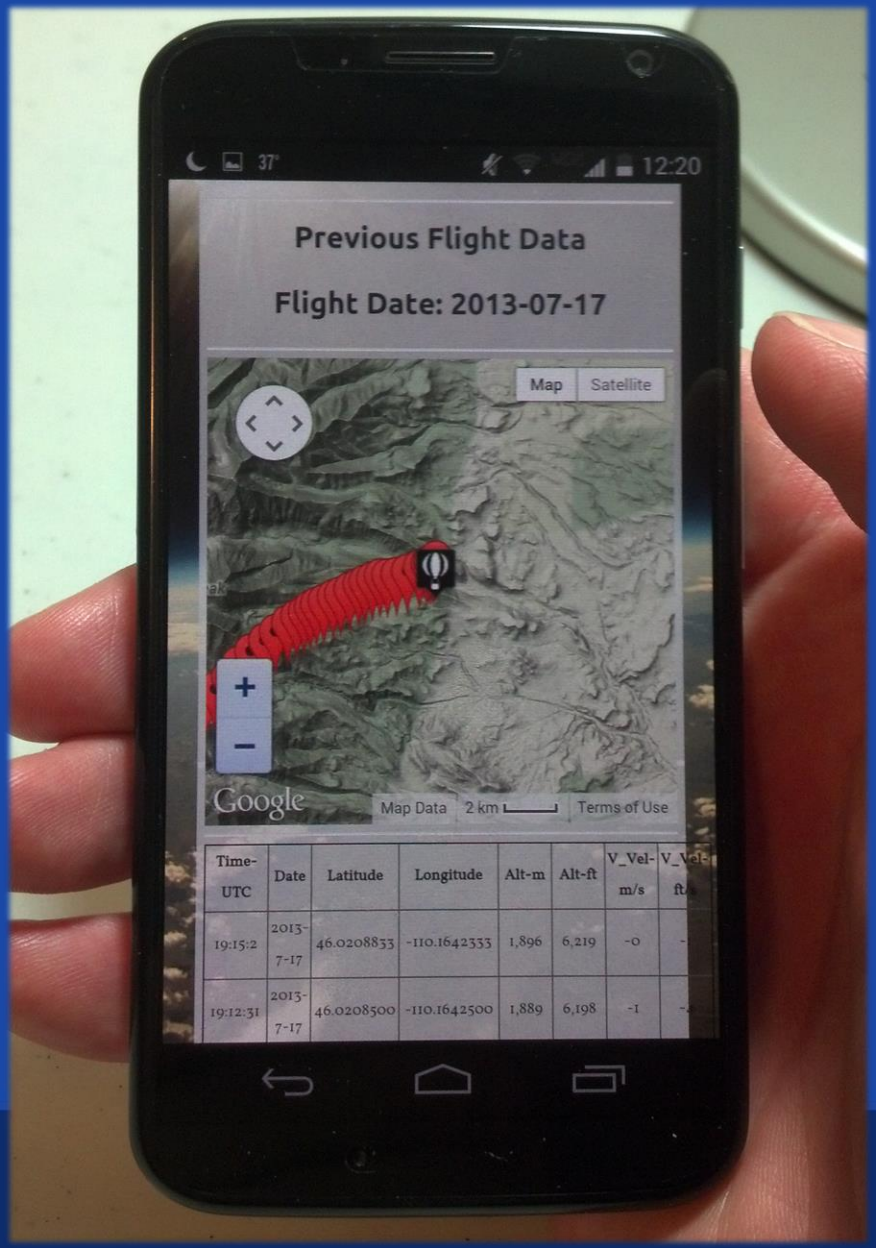
Flight Date: 2013-07-23

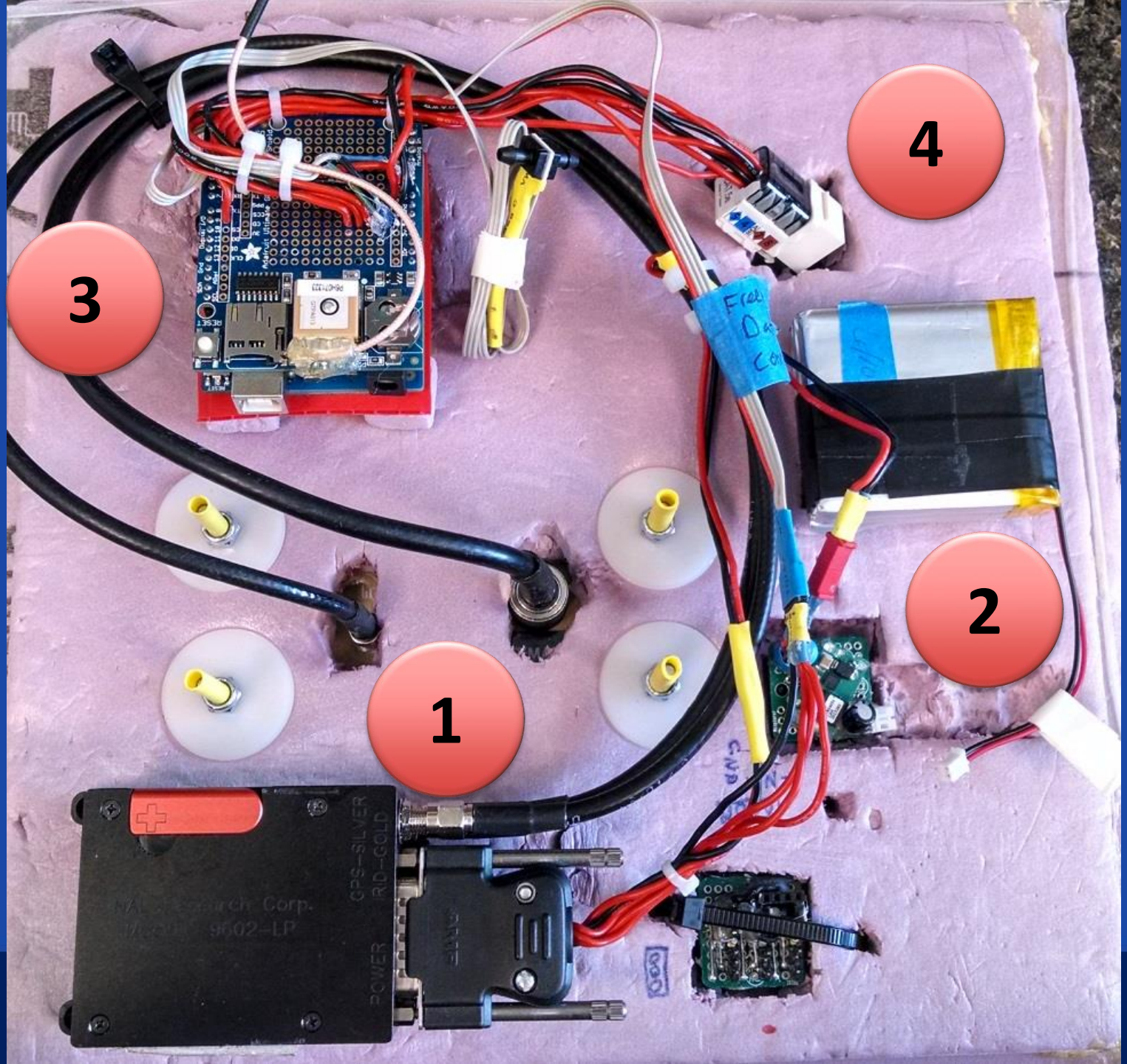
Time-UTC	Date	Latitude	Longitude	Alt-m	Alt-ft	V_Vel-m/s	V_Vel-ft/s
17:31:45	2013-7-23	46.1652167	-109.1096333	1,234	4,050	-0	-2
17:31:16	2013-7-23	46.1652333	-109.1096500	1,237	4,059	0	0
17:30:3	2013-7-23	46.1652333	-109.1096500	1,233	4,047	0	1
17:29:34	2013-7-23	46.1652333	-109.1096500	1,234	4,047	-0	-1
17:29:3	2013-7-23	46.1652333	-109.1096500	1,235	4,050	0	1
17:28:31	2013-7-23	46.1652167	-109.1096833	1,232	4,042	-0	-1
17:28:4	2013-7-23	46.1652333	-109.1096667	1,236	4,055	-0	-0
17:27:32	2013-7-23	46.1652333	-109.1096667	1,234	4,049	0	0

Previous Flight Data

Flight Date	Link to Data	Test | Actual
2014-06-20	Click Here	A
2014-06-19	Click Here	T
2014-06-18	Click Here	T
2014-06-12	Click Here	A
2014-06-11	Click Here	T
2014-06-05	Click Here	T
2014-04-19	Click Here	A
2014-04-18	Click Here	T
2014-04-17	Click Here	T
2014-04-10	Click Here	T
2014-04-09	Click Here	T
2014-03-27	Click Here	T
2014-03-19	Click Here	T
2014-02-26	Click Here	T
2014-02-06	Click Here	T
2013-09-29	Click Here	A
2013-09-27	Click Here	T
2013-08-07	Click Here	T
2013-07-31	Click Here	A
2013-07-30	Click Here	T
2013-07-29	Click Here	T
2013-07-26	Click Here	T

Final website design:




4
3
2
1
GPS—SILVER
RD—GOLD
POWER
9602-LP

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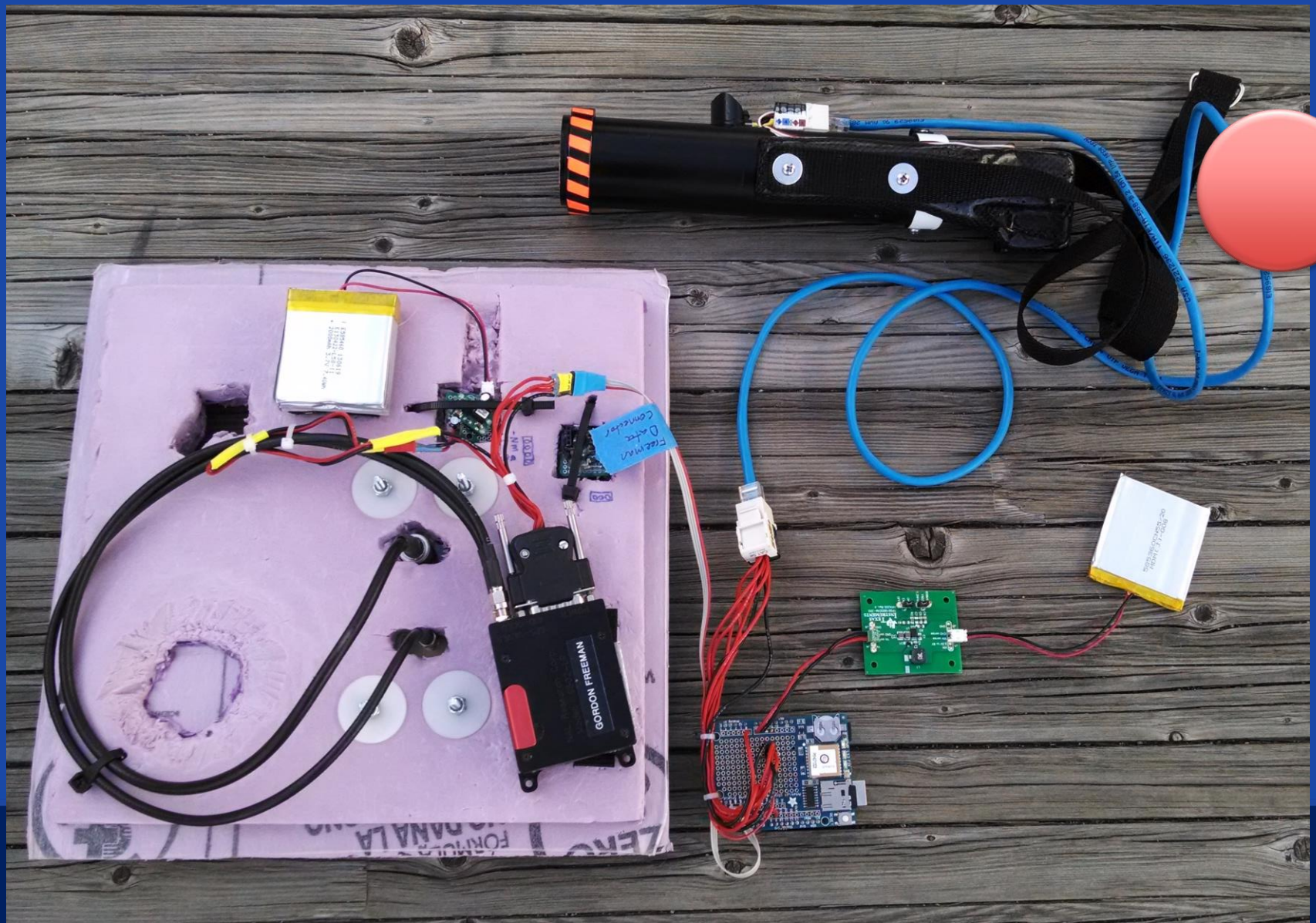
Control of experiments in-flight



Transmitting non-location based data

Outline of this talk

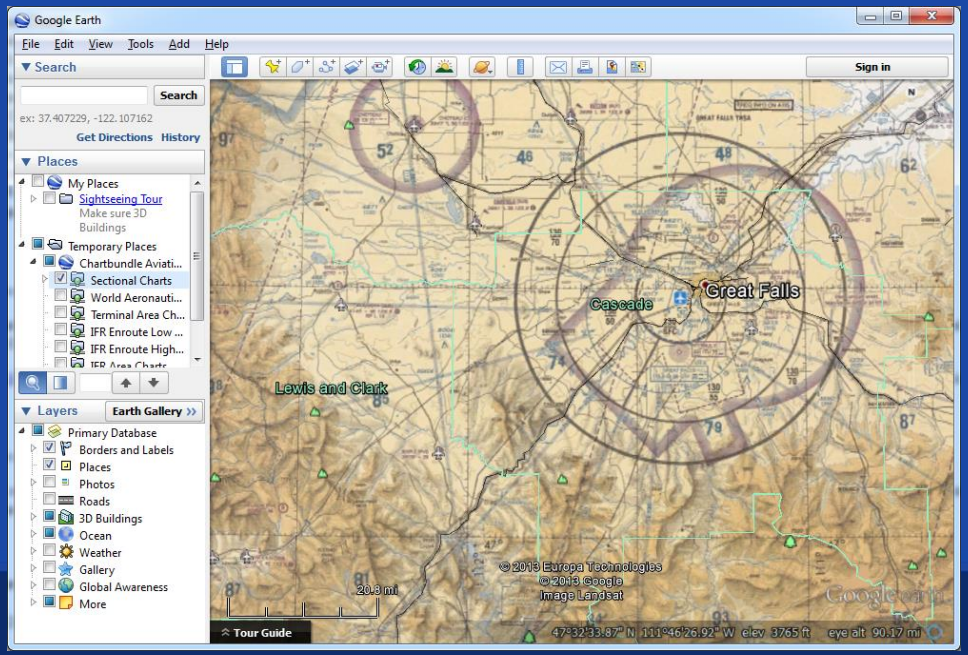
- Previous tracking system and challenges
- Intro to satellite modem
- Configuration of support systems
- Final tracking system overview
- Additional modem capabilities
- **Outcomes of the project**

Outcomes of project

- We have received positive feedback from the FAA on our website
- The satellite modem has successfully flown on 9 flights
- We have used the system to operate a helium vent and flight termination system on 4 flights
- NAL 9602 is very durable and can transmit and receive data when the antenna is pointed towards the ground

What still needs to be done?

- Integration of airspace maps
- Automatic descent profile plotting and forecasting
- Real-time graphs / data presented alongside GPS information
- Automatic launch/burst/landing markers
- Automatic sending of SBD packets / secure web interface



Thank You for your time!

A special thank you to:

- MSGC / BOREALIS / MSU
- Berk Knighton and Randy Larimer
- My Presidential Emerging Scholars sponsor
- The wonderful team of future engineers I was able to work with
- Jeremy Gay – MSU Physics IT

Lessons learned

- uBlox GPS chipset (inside modem) “altitude mode”
- EMI from GoPro cameras
- Little example code / tech heavy datasheets

Challenges along the way:

Challenges along the way:

Challenges along the way: