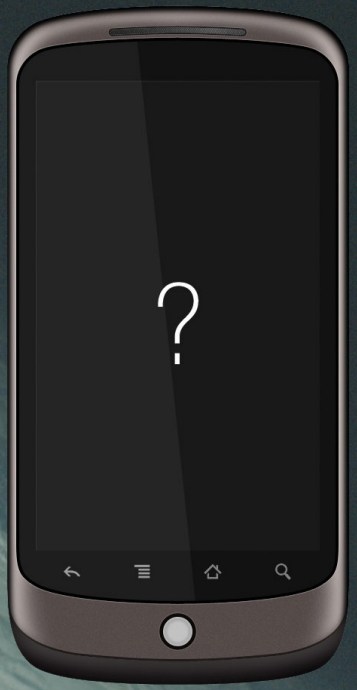
P H O N E S A T



CAN WE TURN A PHONE IN TO A SATELLITE?

25th July 2011

Outline

- Why a Cell Phone Satellite?
- Space Qualification Testing
- Rocket Testing
- Balloon Testing
- Next Steps
- Applications
- Questions

Why Phone Based Satellite?

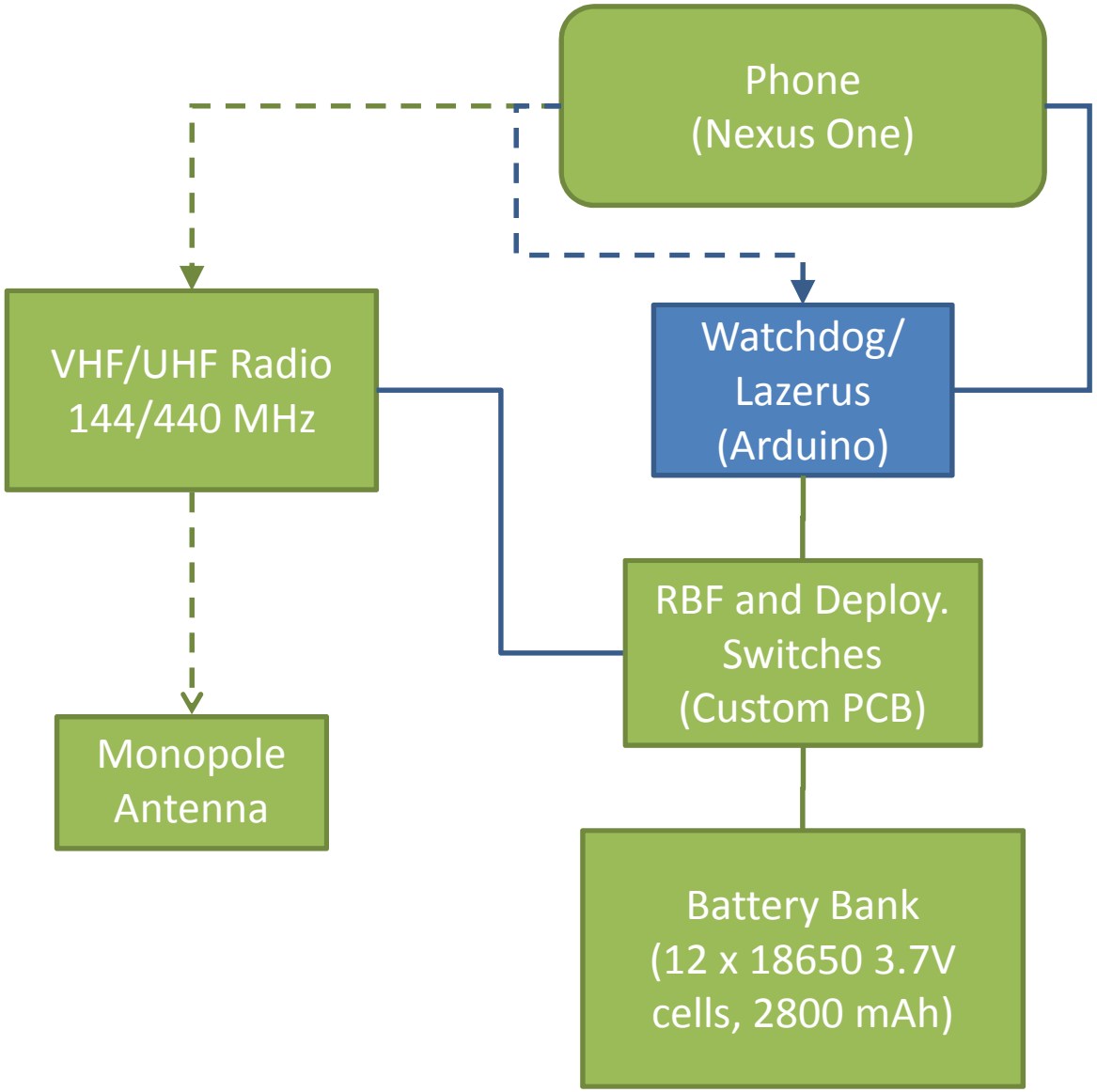
- All key capabilities of a satellite are in a phone [this was not the case 5 years ago]
- A cell phone based satellite costs ~$5k in parts, and launch $50-70k; c.f. ~$5m for lowest cost NASA missions today.
- With a 100x reduction in cost, could there be a vast array of new potential applications?

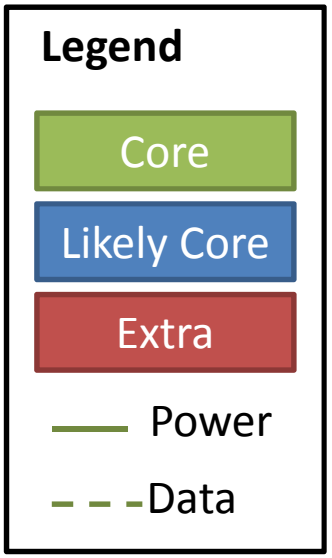
Why Not Laptop/Other Electronics?

- Phone has 90% of capabilities of s/c; laptop does not e.g. no accelerometers, no GPS, no rate gyros, no radio
- Phone is more compact and lighter
- Phone brings home the point that space is easier

PhoneSat 1: System Architecture

Spacecraft 1.0
Concept A
- With UHF radio
- & Hardware battery override
- & Watchdog/Lazerus





Phone software overview

- Android 2.1 Operative System
- SL4A - Scripting Layer for Android
- Current scripts written in Python

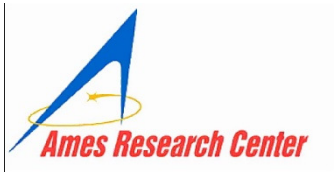
- Help from several Googlers on their 20% time:
  - System Health Test code from Jason Holt
  - Video >30 min code from Charles Chen
  - Python code help from Damon Kohler

Phone software overview

- Nexus One sensors - accelerometer, gyroscope, magnetometer and GPS @ 60Hz
- Take pictures 0.2 Hz
- Bluetooth receiving IMU data @ 10 Hz
- Video application for flight
- SD card

KEY POINTS

- Screen on – Pictures and Video
  - Delay for BT information
- Code for Sensors and GPS and code for BT in parallel
  - Video application without limit
    - Audio stops at 1:11:35 hrs

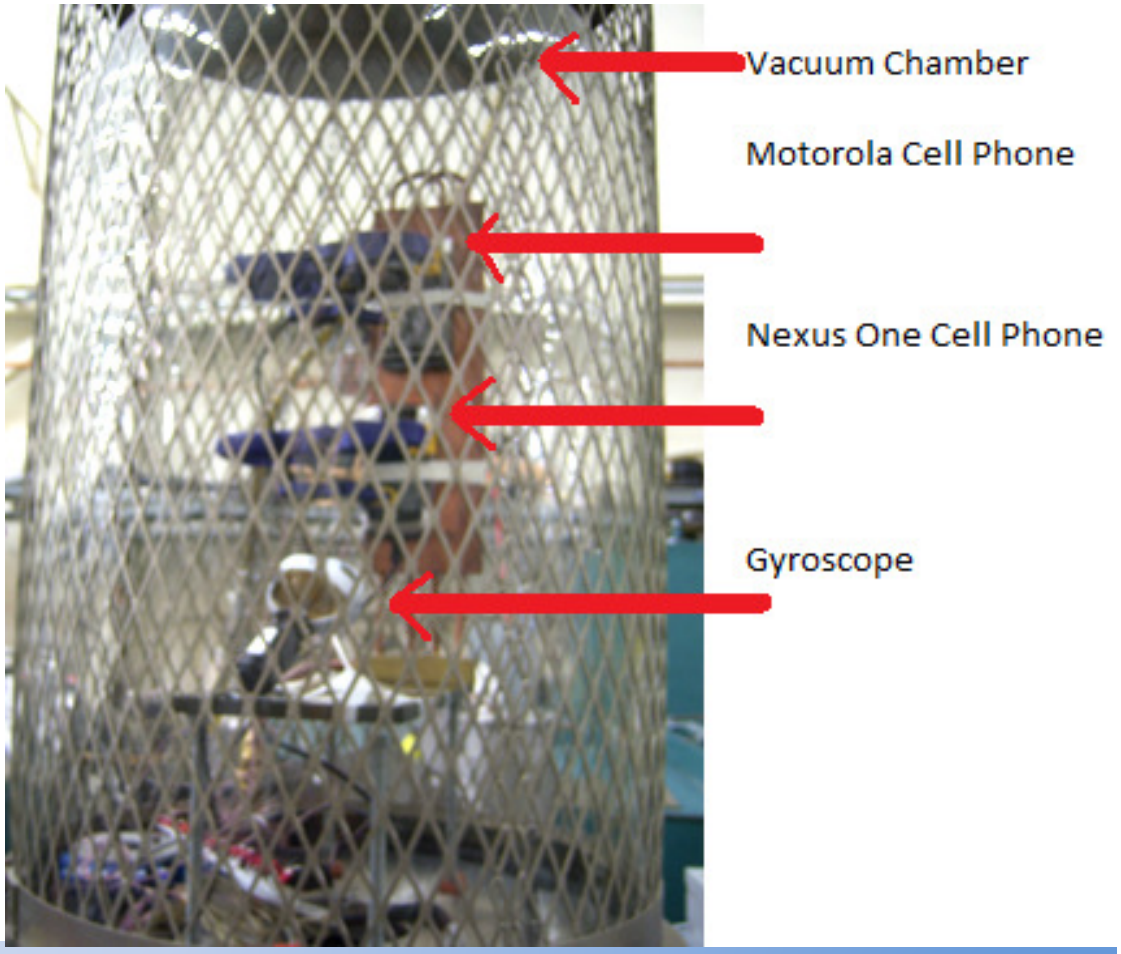


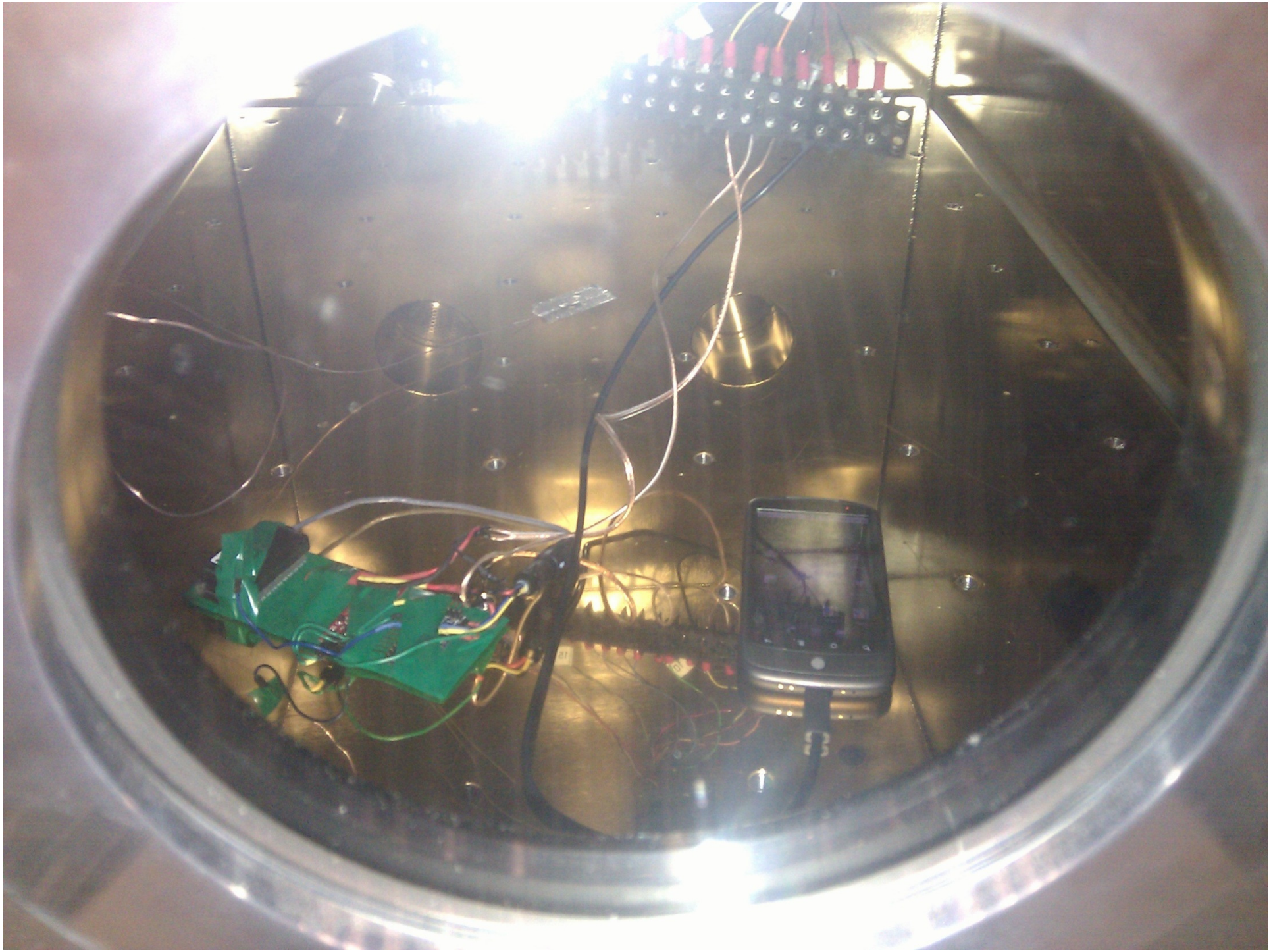
Space Qualification Testing

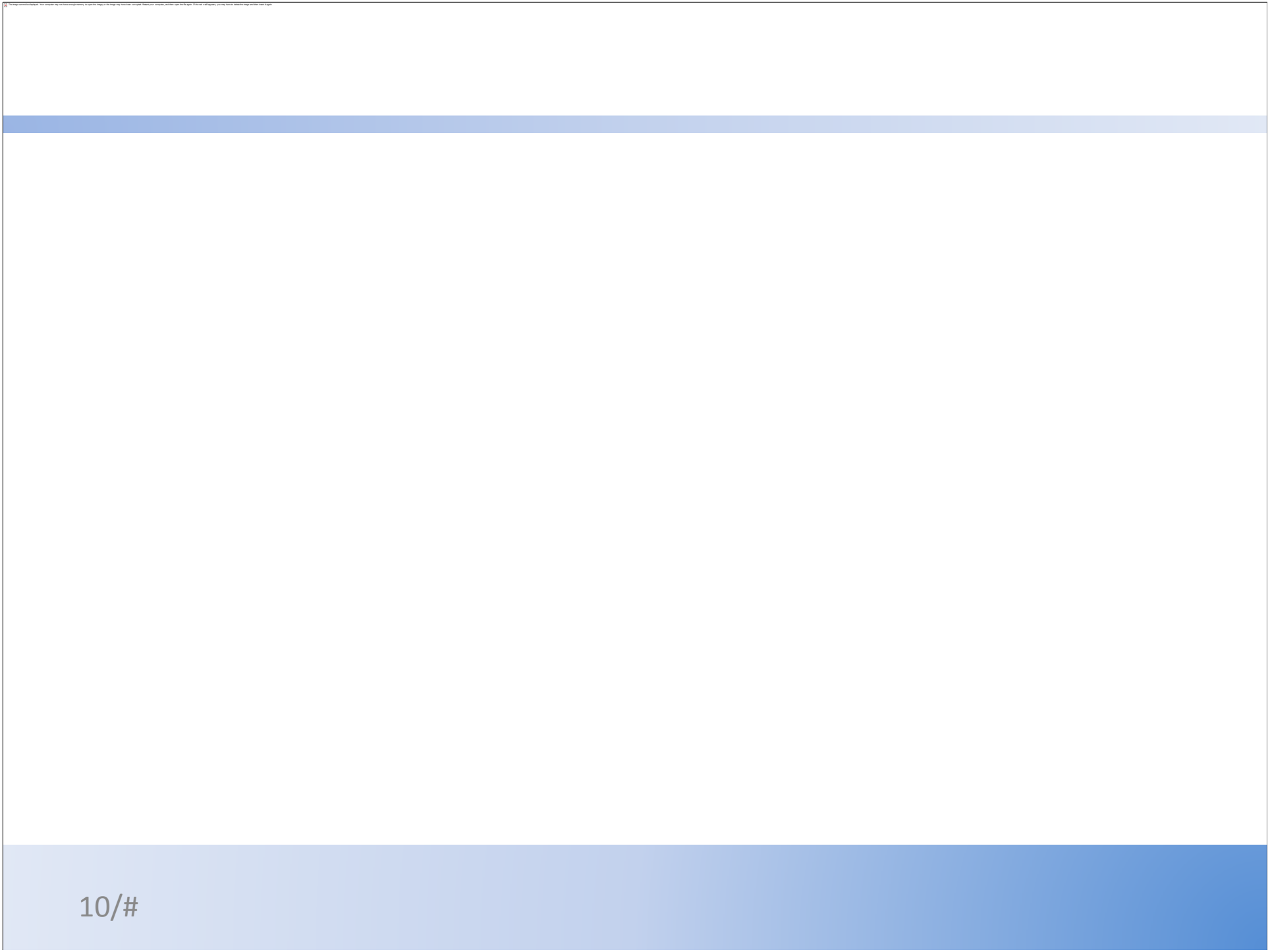
Vacuum and Thermal Testing

- 10^{-3} Torr
- -30° --> +40° C cycling

- 1 Gyroscope
- 1 Nexus One mobile phone
- 1 Motorola mobile phone







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NASA

Rocket Launches

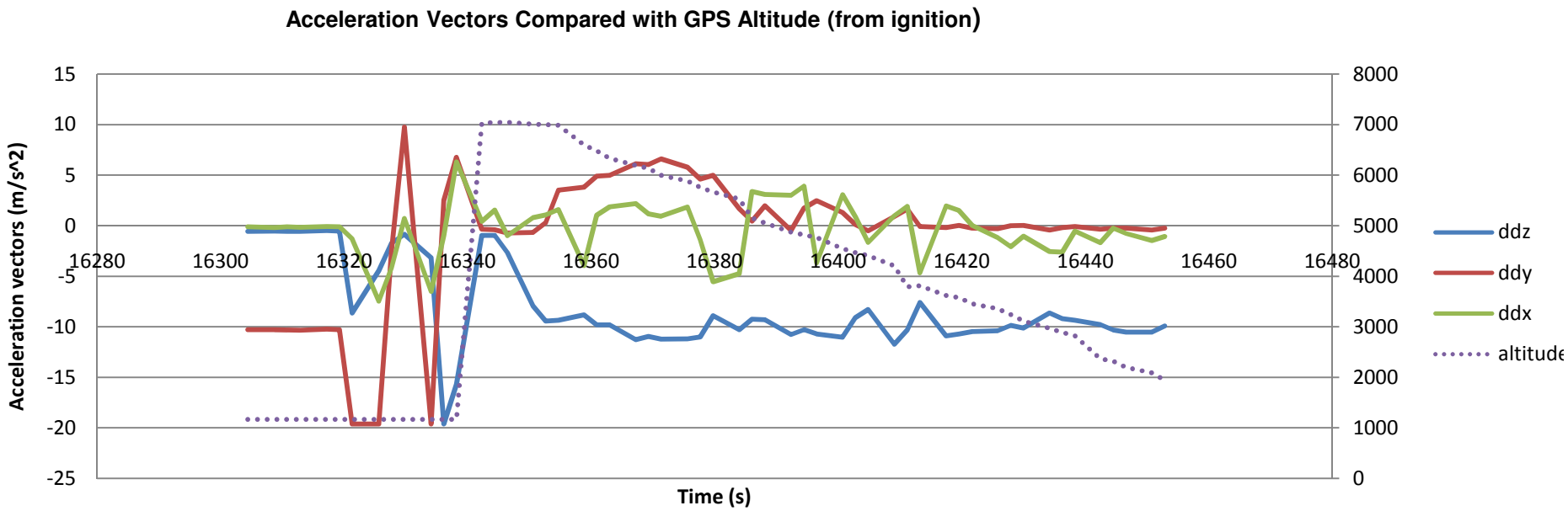
Launches

"Rocket Mavericks"

- Flight 1: 23 July, 2010
  - 70 km Altitude Rocket (but did not reach altitude)
  - Our payload: Nexus One
- Flight 2: 24 July, 2010
  - 10 km Altitude Rocket
  - Our Payload: 2 Nexus One, 1 IMU, Arduino, external Bluetooth

Launch 1: high altitude; fail

Launch 1: high altitude: fail



Rocket Details:

10 m tall

500 kg

Planned for:

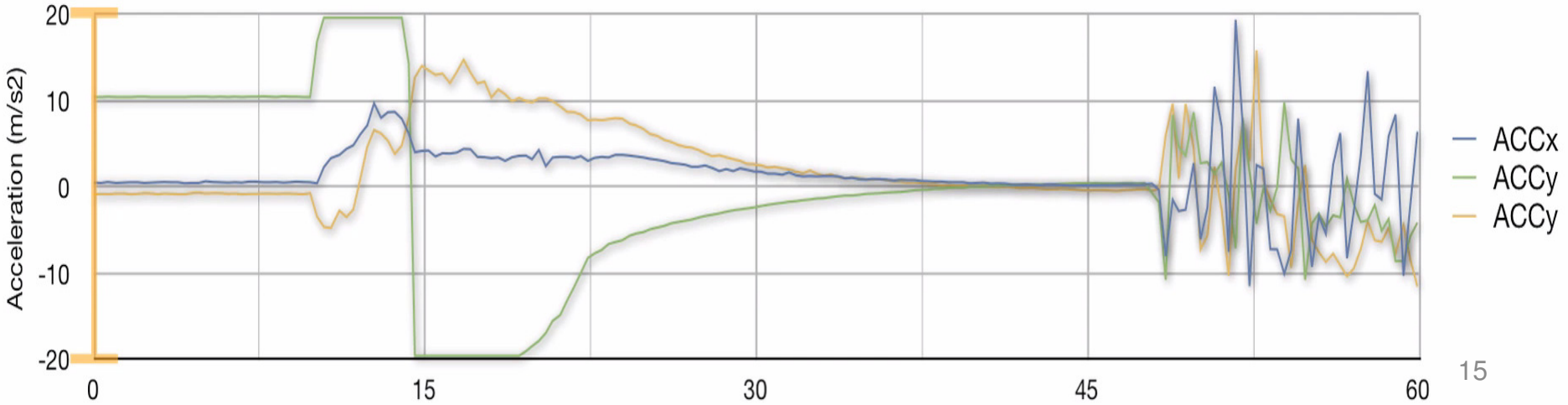
-**<u>70 km</u>** (18 sec burn)

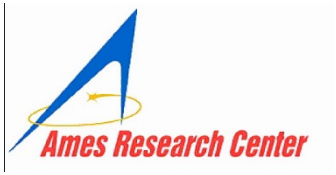
-12-15 G

Actual:

- **<u>9 km</u>**
- 10 G (>1000 G on impact)

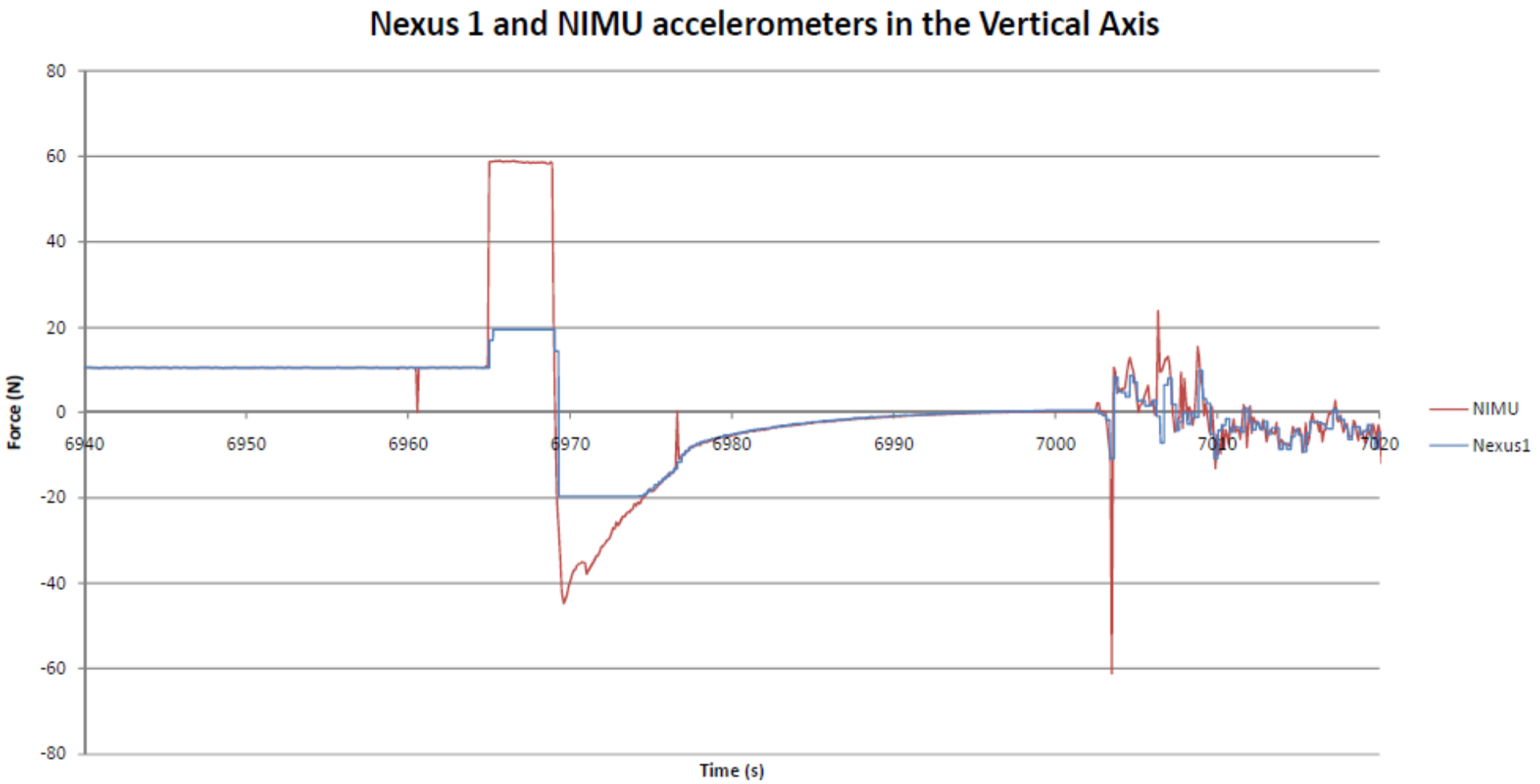

Rocket-Cam
Most significant force from
gravity
Ground-Cam


Acceleration (m/s2)
20
10
0
-10
-20
0
15
30
45
60
ACCx
ACCy
ACCy

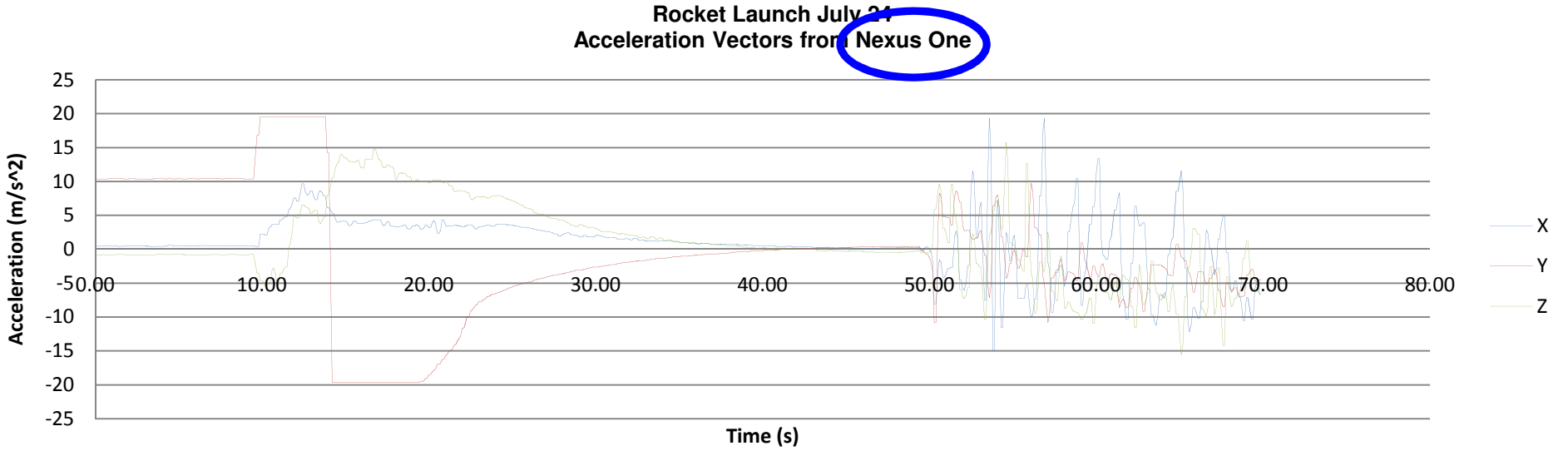


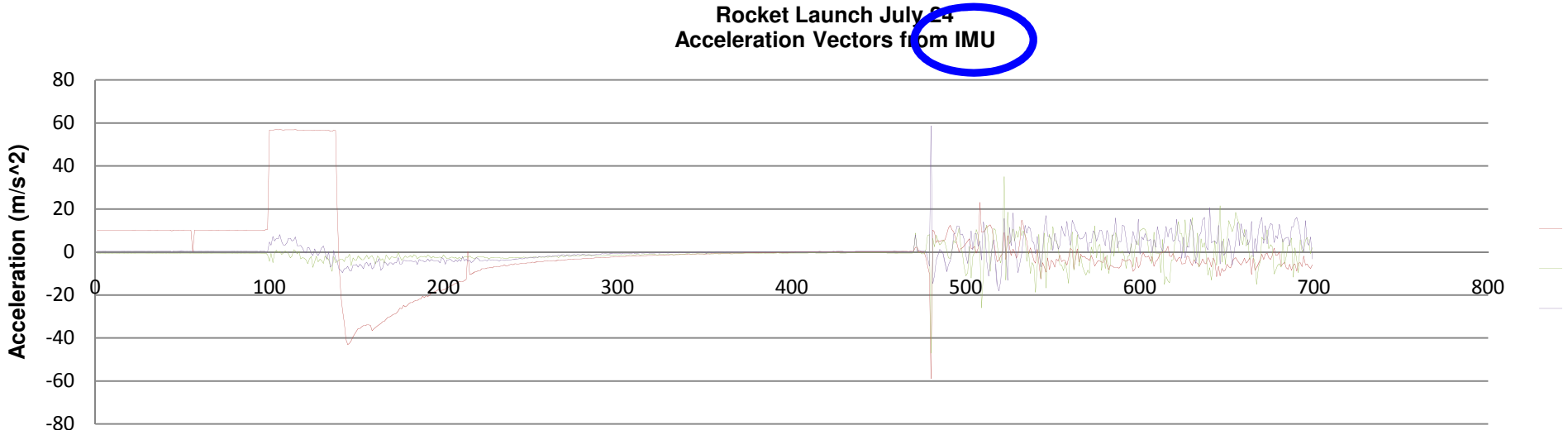
Data Analysis

Launch 2: Acceleration

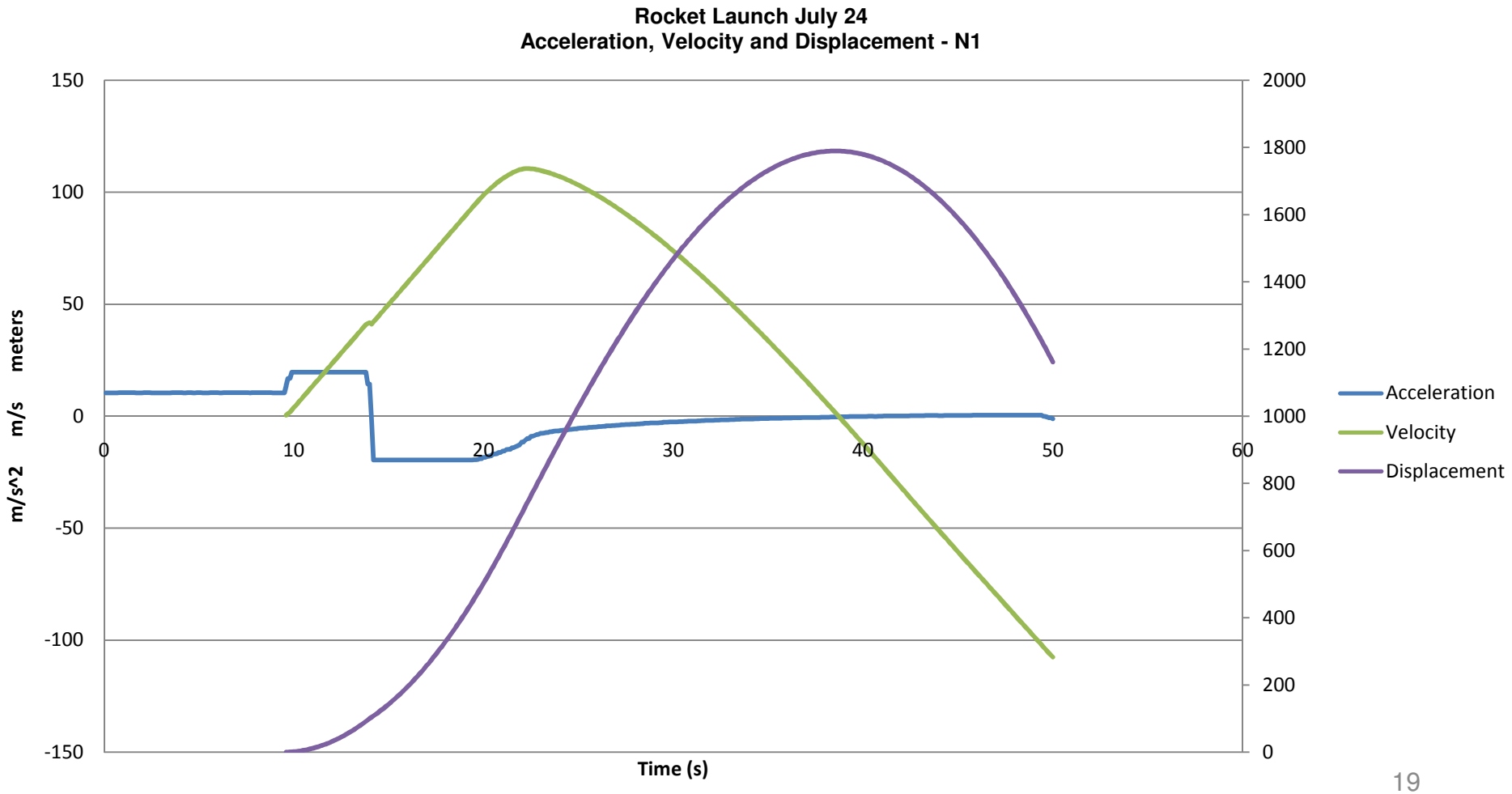


Launch 2: Acceleration

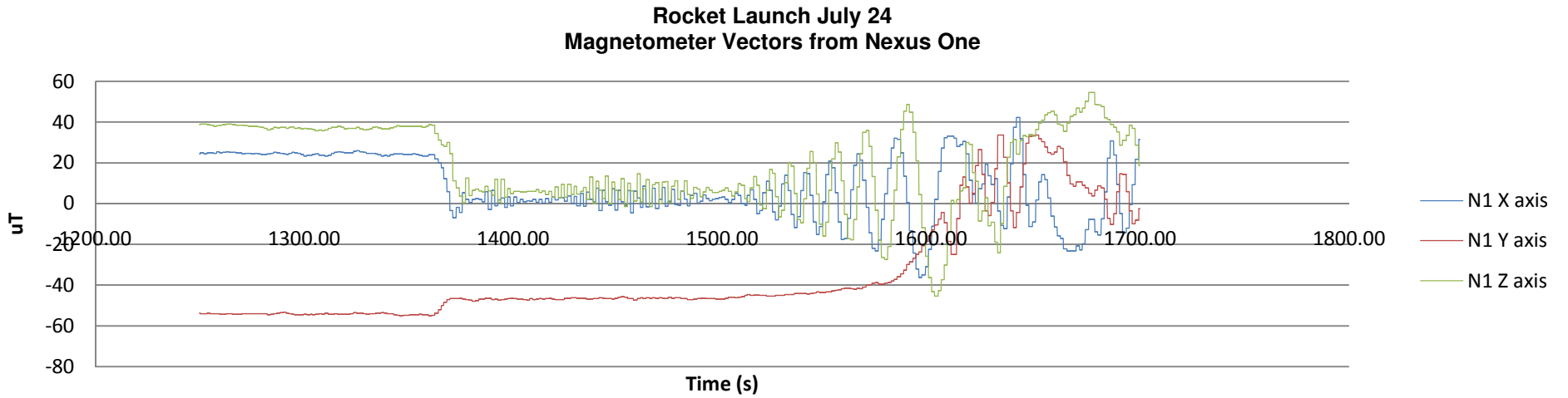


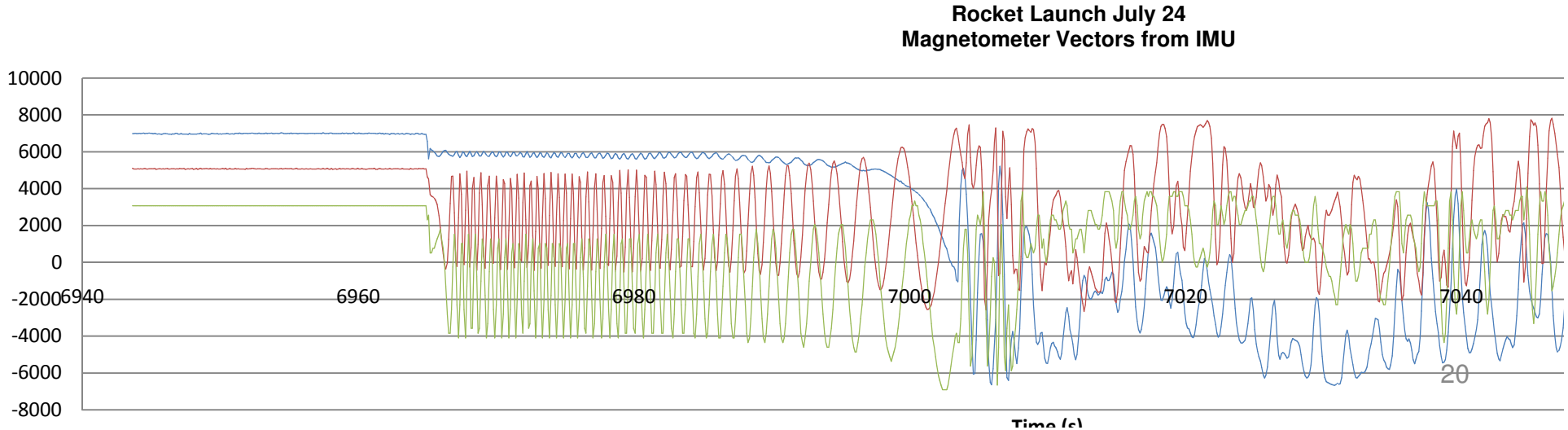


Launch 2: Accel. Vel. Disp.



Launch 2: Magnetometers





Launch 2: GPS Trajectory

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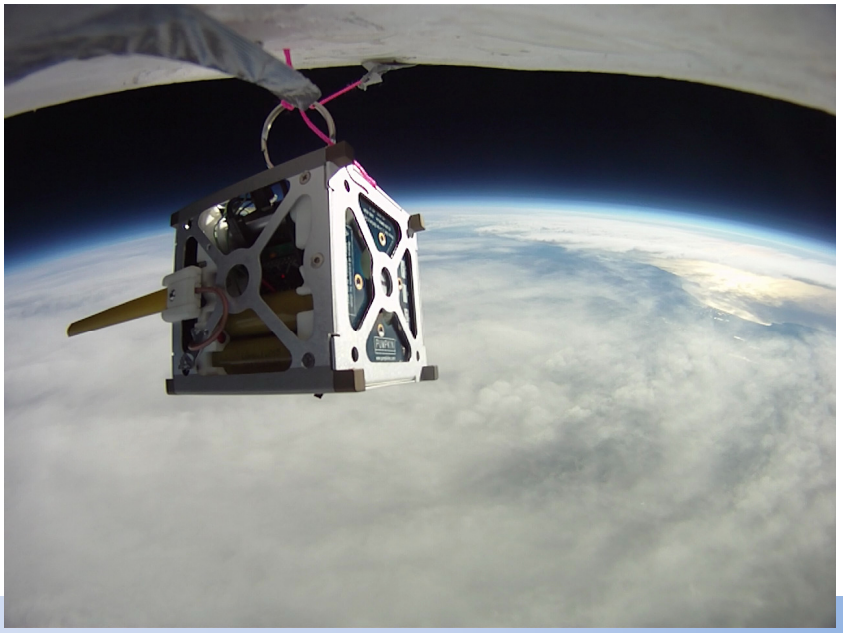
Balloon Launches



Next Steps

Next Tests

1. 1000 hr thermal vacuum test
2. Low Earth Orbit

    1. Launch 3x PhoneSat 1.0 in December
        1. Taurus II --> 280x280km orbit
        2. Duration 3 weeks
        3. Cost: $250k

    2. Launch 1x PhoneSat 2.0 in March 2012
        1. Falcon 9/Dragon --> 450x300km orbit
        2. Duration: 3-6 months
        3. Cost: free through Elana programme

First Flight Requirements

Minimalist requirements for first mission:

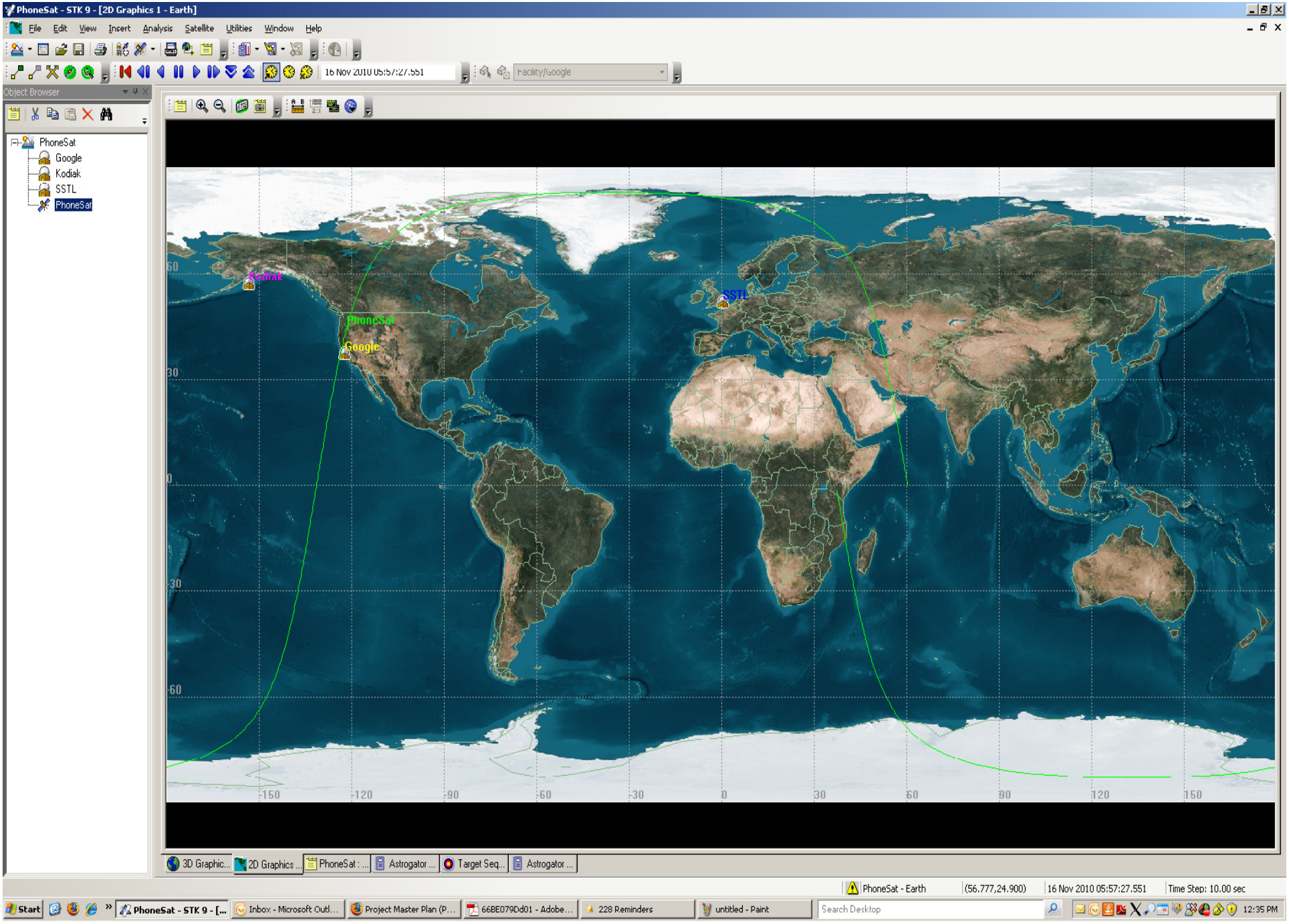
1. Send 1 image taken by the phone to ground

2. Parts cost shall not exceed $10,000

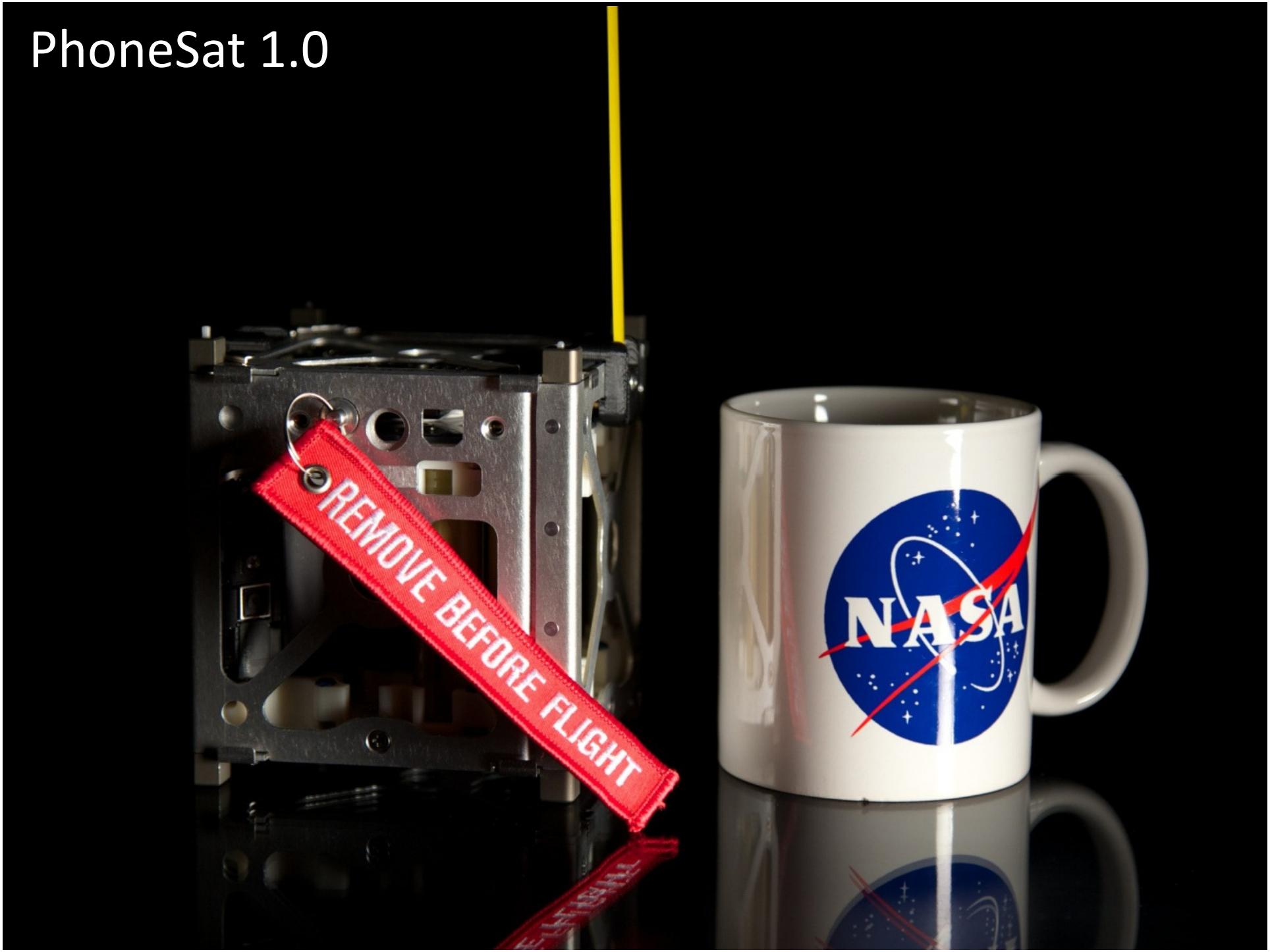
3. Work for >1 orbit

4. Send minimum health data from phone to ground

5. Schedule <3 months from ATP to flight readiness


PhoneSat - STK 9 - [2D Graphics 1 - Earth]
File Edit View Insert Analysis Satellite Utilities Window Help
Object Browser
PhoneSat
Google
Kodiak
SSTL
PhoneSat
Kodiak
SSTL
PhoneSat
Google
60
30
0
-30
-60
-150 -120 -90 -60 -30 0 30 60 90 120 150
3D Graphic...
2D Graphics ...
PhoneSat : ...
Astrogator ...
Target Seq...
Astrogator ...
PhoneSat - Earth
(56.777,24.900)
16 Nov 2010 05:57:27.551
Time Step: 10.00 sec
Start
PhoneSat - STK 9 - [...
Inbox - Microsoft Outl...
Project Master Plan (P...
66BE079Dd01 - Adobe...
228 Reminders
untitled - Paint
Search Desktop
12:35 PM

PhoneSat 1.0



And, what if sats cost $30k?

Personal Satellites?
Place to space test hardware
Swarmed satellites
Wifi to remote regions?
CO_2 monitoring?
Synthetic Aperture Radar?
…

Vision

… Space as a software-dominant domain?