Slide 1
I would like to spend a few minutes to talk about a g force sensor, or accelerometer, that OnSet Computing has made available. They call it the Pendant G logger.

Slide 2
This is small, self contained device. As you can see from the dimensions I've listed, it's not much lager than an old-fashioned box of matches. Since it is three axes, you can measure accelerations in the vertical direction and both horizontal directions. Its temperature rating is sufficient if it's left inside a near spacecraft module. You cannot attach this to the outside of a BalloonSat or module since temperatures typically drop to -60 degrees.

Slide 3
The maximum accelerations the Pendant G logger can measure works well for missions lofted by balloons. But the 3 G maximum acceleration is not high enough for a lot of rocket flights. The sensor inside can detect differences as small as 7% of a G. That's equivalent to tipping the logger by 1.4 degrees. You see, when the sensor is tipped, some of the acceleration (which can be due to the static force of gravity) disappears from one axis and shows up on another axis. You'll be able to tell if the change in acceleration is due to tipping or a true change in acceleration by noting if that in another axis the measured acceleration changes to compensate.

The microcontroller inside the Pendant G Logger can digitize measures as fast as 100 samples per second. The sample rate is set by the software you use to program the logger. The memory inside the logger is large enough for 64 k or 65,536 measurements. At a sampling rate of 100 Hertz, the logger will run out of memory in 10.9 minutes. Since a near space mission lasts closer to three hours than to ten minutes, you need to program the sensor to collect data closer to a rate of five Hertz, or five measurements per second maximum rate. I think once a second is sufficient.

Slide 4
The logger is fairly inexpensive. The $59 reader is needed to program the logger and download its data. So you can't just purchase the Pendant. But you could purchase multiple Pendants and just one reader. You can purchase the Pendant G logger and other Hobo dataloggers from the OnSet Computing website listed here.

Slide 5
Now let's take a look at some of the data the Pendant G logger can collect.

Slide 6
This a chart of the vertical acceleration (the Y-Axis) experienced by a near spacecraft during a flight. You'll notice there was more variation in the accelerations for the first forty minutes of the flight. That change occurred when the balloon reached the knee of its ascent. At the knee the balloon's vertical speed drops a few percent. So at the knee the balloon slows down and experiences less vertical shaking. This most likely is a result of the change in the balloon's coefficient of drag at high altitude. At burst the near

spacecraft experiences a lot of shaking and tumbling. The amount the near spacecraft experienced was close to the Pendant's maximum acceleration. There is no zero-gee for the near spacecraft at balloon burst. So relying on detecting zero-gee to detect balloon burst most likely will not work unless it can be measured for a fraction of a second.

One other thing to note is that the overall acceleration of the near spacecraft is slowing down. My next slide focuses on this effect.

Slide 7

In this slide I've averaged the acceleration of the balloon during its ascent and magnified the result. Notice there is a 7% decrease in the balloon's acceleration during the mission. Perhaps one percent of this can be attributed to the reduction in gravity at high altitude. I don't know where the other 6% comes from. I thought it might be sensor drift but I couldn't replicate it by letting the Pendant sit on the front porch. If it was a temperature effect than I would have expected the drift to change directions as the interior temperature dropped and then rose in the stratosphere.

Slide 8

The front to back, or one component of the horizontal acceleration, really shows the decrease in the variation of the balloon's acceleration at the knee. You'll also see that the shaking on descent decreases as the near spacecraft gets closer to the ground. I would imagine the shaking would be a lot less if the balloon was cut off.