PhoneSat 1.0 and PhoneSat 2.0 Beta Satellite Technical Description

Attachment to SpaceCap Application

The overall goal of the PhoneSat mission is to test and validate an ultra low-cost cubesat bus based on a smartphone and other Commercial Off-The-Shelf (COTS) technology. Three different cubesats will be launched from the same cubesat deployer and operate simultaneously while in orbit: PhoneSat 1.0 ("Graham"), PhoneSat 1.1 ("Bell") and PhoneSat 2.0 Beta ("Alexander").

The satellites will be launched as a secondary payload on the maiden flight of the Antares (formerly Taurus II) from Wallops Flight Facility, currently scheduled for September 22, 2012. They will be inserted into a nearly circular orbit at 270 km, on an inclination from the equator of 51 degrees. Due to the extremely low altitude of the orbit, all three satellites are expected to experience rapid orbital decay and completely burn up in the Earth's atmosphere approximately 10 days after launch. See the Orbital Debris Assessment Report for further details). Bell is solely powered by primary batteries and have an expected operational lifetime of approximately 10 days until the batteries are fully drained. Graham and Alexander are powered by batteries which are recharged by solar panels on each face. They can deplete their batteries within 3 days when all systems are powered on full. The Iridium modem module on Bell is powered by self contained batteries, independent of the rest of the spacecraft. These batteries will deplete and operation will cease in about 2 days.

Amateur beacon transmissions on 437.425 MHz will commence upon deployment of the satellites. Each satellite will transmit on a unique interval, so that the same frequency can be utilized with minimal collision of transmissions.

The dimensions of the spacecraft are consistent with CubeSat and P-POD standards. It is a single unit with the dimensions of 10 cm X 10 cm X 11.35 cm. The total mass of each satellite is as follows: Graham – 1.25 kg, Bell – 1.426 kg and Alexander – 1.30 kg.

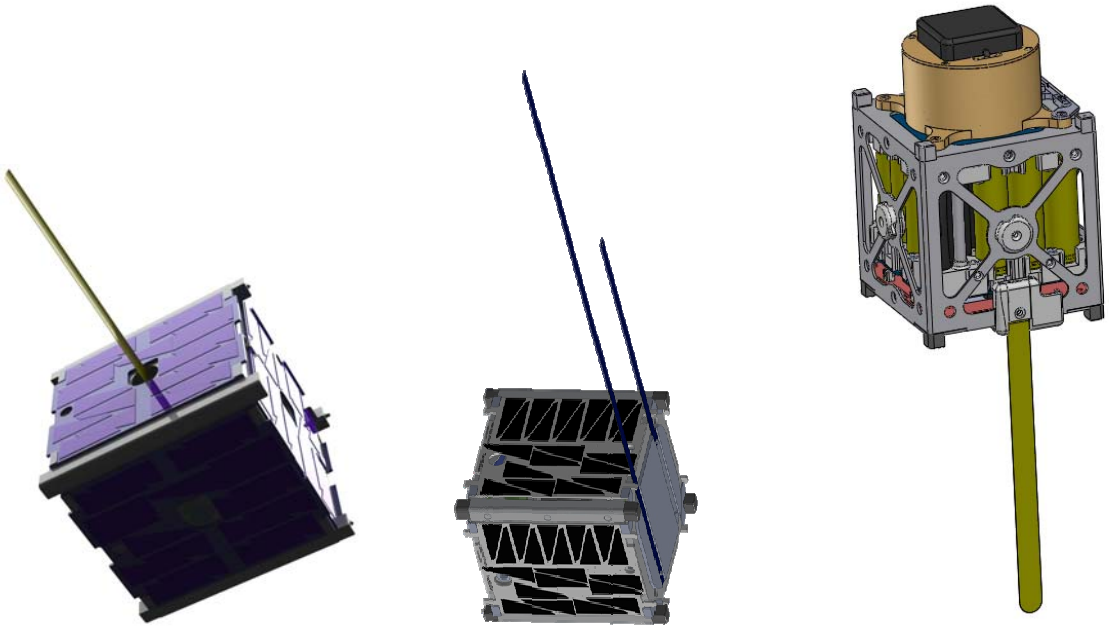

Figure 1: Alexander (Left), Graham (Middle), Bell (Right)

Bell contains the following systems:

Nexus One Smartphone: provides the onboard computer, data storage, 3-axis accelerometer, 3-axis magnetometer, and 5MP camera. The phone is the 'brains' of the satellite, and for the first tech demo mission, is also the payload.

Pumpkin 1U Frame: provides the space qualified structure and mounting surfaces.

Lithium Ion Batteries: 12 Lithium Ion batteries provide the only source of power,, they have 124 Wh of capacity.

UHF Beacon Radio: Transmit data packet approximately once every 30 seconds at 437.425 MHz, which can be collected by amateur radio operators around the world. The beacon uses a quarter wave monopole tape measure antenna to transmit. See link budget below.

Watchdog Board: A separate Arduino microcontroller watches the health of the phone and beacon radio and has the ability to either reset or turn off either component when anomalies are detected.

Iridium Modem: Bell includes the Iridium modem module that is 4.5cm long and 7.2 cm in diameter and is attached to the side (see Figure 1). The modem module is self contained; it has no electrical connection to the rest of the spacecraft. The modem driver circuit is activated by release of the satellite from the PPOD, via a foot switch which engages the surface of the PPOD spring base plate. After a 10 minute delay, transmission begins. It will transmit on 1616 MHz, once per 10 seconds, for about 2 days, then the batteries will be exhausted and it will terminate transmission.

Graham contains the following systems:

Pumpkin 1U Frame: provides the space qualified structure and mounting surfaces.

Power Supply: One Canon 930-BP battery, four photovoltaic panels, and four temperature sensors to monitor the temperature of the battery, solar panels and circuit boards inside the spacecraft.

Control and Data Handling (C&DH): Consists of multiple processors that interface with communications devices, onboard sensor monitoring processor, and Main Power Distribution Unit (MPDU) with a watchdog timer.

Iridium and Orbcomm Modems: One ORBCOMM Q1000-CPM modem with 45 cm antenna, and one Iridium 9602 modem with patch antenna, provide two way communications to mission operations.

UHF Beacon Radio: Transmit data packet approximately once every 30 seconds at 437.425 MHz, which can be collected by amateur radio operators around the world. The beacon uses a quarter wave monopole tape measure antenna to transmit. See link budget below.

Antenna Deployment System: The deployment of the UHF and Orbcomm antennas are controlled using a nylon retaining cord, which holds the antennas in place. In their stowed position, the antennas wrap around the body of the satellite. When antenna deployment occurs, the pyro circuit activates a heating element, which melts the nylon wire, releasing both antennas at once.

Attitude Control: Four-rod magnets will stabilize the satellite and bring it to the desired attitude (beacon antenna down, Orbcomm antenna up).

Alexander (PhoneSat 2.0 Beta) contains the following systems:

Nexus S Smartphone: provides the onboard computer, data storage, 3-axis accelerometer, 3-axis magnetometer, and 5MP camera. The phone is the 'brains' of the satellite as per before.

Pumpkin 1U Frame: provides the space qualified structure and mounting surfaces.

Power Supply: 4 Lithium Ion batteries in conjunction with 6 solar panels provide the source of power for the PhoneSat 2.0 Beta. The batteries have a capacity of 42 Wh, and the solar array will provide an average power of 1.5W.

Attitude Determination and Control System: Solar panels on each face act as a coarse sun sensor in conjunction with magnetometer, TLE's, gyroscope and orbit propagator provide 3-axis attitude determination. 3-axis reaction wheels and magnetorquers provide 3-axis control.

UHF Beacon Radio: Transmit data packet approximately once every 30 seconds at 437.425 MHz, which can be collected by amateur radio operators around the world. The beacon uses a quarter wave monopole tape measure antenna to transmit. See link budget below.

Microhard MHX2420: PhoneSat 2.0 Beta allows two-way communication with the ground station at Santa Clara University using this Microhard spread spectrum radio, frequency in the range of 2450 MHz. See link budget below.

Watchdog Board: A separate Arduino microcontroller watches the health of the phone and beacon radio and has the ability to either reset or turn off either component when anomalies are detected.

Link Budget: Beacon

Item	**Units**			
Orbit Altitude	km	270	270	270
Spacecraft Elevation Angle	deg	10	45	90
Frequency	GHz	0.437	0.437	0.437
Satellite Transmitter Power	Watts	1	1	1
Satellite Transmitter Power	dBW	0	0	0
Satellite Transmitter Line Loss	dBW	-2	-2	-2
Satellite Antenna Avg. Gain	dBi	-3	-3	-3
EIRP	dBW	-5	-5	-5
Propogation Path Length	km	1070.47	374.38	270.00
Space Loss	dB	-145.85	-136.73	-133.89
Polarization Loss	dB	-3	-3	-3
Peak G/S Antenna Gain	dBi	10.00	10.00	10.00
G/S Antenna Line Loss	dB	-2	-2	-2
G/S Antenna Beam Width	deg	30.00	30.00	30.00
G/S Antenna Pointing Error	deg	5	5	5
G/S Ant. Pointing Error Loss	dB	-0.33	-0.33	-0.33
G/S Ant. Gain w/Pointing Error	dB	7.67	7.67	7.67
System Noise Temperature	K	300	300	300
Data Rate	bps	1200	1200	1200
Eb/No	dB	26.85	35.98	38.82
Bit Error Rate		10^-5	10^-5	10^-5
Required Eb/No	dB-Hz	23.5	23.5	23.5
Implementation Loss	dB	-2	-2	-2
Margin	**dB**	**1.35**	**10.48**	**13.32**

Link Budget: MicroHard 2420 Radio

Item	**Units**			
Orbit Altitude	km	270	270	270
Spacecraft Elevation Angle	deg	10	45	90
Frequency	GHz	2.42	2.42	2.42
Satellite Transmitter Power	Watts	1	1	1
Satellite Transmitter Power	dBW	0	0	0
Satellite Transmitter Line Loss	dBW	-1	-1	-1
Satellite Antenna Avg. Gain	dBi	0	0	0
EIRP	dBW	-1	-1	-1

Item	**Units**			
Propogation Path Length	km	1160.39	415.14	300.00
Space Loss	dB	-161.42	-152.49	-149.67
Polarization Loss	dB	-3	-3	-3
G/S Antenna Diameter	m	3	3	3
G/S Antenna Efficiency		0.55	0.55	0.55
Peak G/S Antenna Gain	dBi	35.02	35.02	35.02
G/S Antenna Line Loss	dB	-2	-2	-2
G/S Antenna Beam Width	deg	2.89	2.89	2.89
G/S Antenna Pointing Error	deg	1	1	1
G/S Ant. Pointing Error Loss	dB	-1.43	-1.43	-1.43
G/S Ant. Gain w/Pointing Error	dB	31.59	31.59	31.59
System Noise Temperature	K	438	438	438
Data Rate	bps	115200	115200	115200
Eb/No	dB	17.74	26.67	29.49
Bit Error Rate		10^-5	10^-5	10^-5
Required Eb/No	dB-Hz	13	13	13
Implementation Loss	dB	-2.5	-2.5	-2.5
Margin	**dB**	**2.24**	**11.17**	**13.99**