DoubleSShot
Avionics Requirements

Revision November 26, 2010

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1 BACKGROUND

The *Sugar Shot to Space* program has, as its ultimate goal, the objective of launching a rocket that will fly to the edge of space, specifically 100 kilometres. This goal, to be achieved through a project deemed *ExSShot*, will utilize sugar-based amateur propellant, and as such will represent a major achievement in the history of amateur rocketry. *DoubleSShot* is a sub-scale project in support of this goal, serving as a capability demonstrator, dimensionally scaled to 2/3 that of the proposed *ExSShot* space rocket. *DoubleSShot* is slated to reach an altitude of no less than 33 km. On-board instrumentation will gather and convey key information during the flight to allow ground-based observers to monitor and safely recover the rocket following its epic journey. Various sensors data will be stored in on-board memory for post-flight retrieval and evaluation, providing important data to facilitate planning of the follow-up *ExSShot* mission.

2 SCOPE

This document describes the requirements for the avionics systems of the DoubleSShot vehicle. The avionics system controls the timing and recording of all virtually all activities throughout the DSS trajectory.

The avionics communicates with the mission control crew via using a hard wired interface during ground operations and an RF interface during flight operations. The avionics monitors and records incoming data from a suite of sensors for temperature and pressure, vibration, acceleration and rate, as well as absolute positioning via GPS. The avionics is also responsible for controlling the timing of the 2nd phase ignition and recovery system deployments. During flight critical data elements are streamed to the RF Down- link to Mission Control. Post flight the avionics recovery beacon transmits signals to aid the recovery team.

3 REFERENCES

No.	Title	Date	Author
1	DoubleSShot Technical Requirements	2010/11/27	R. Nakka
2	PSU-AESS Notes on coordinates, units, and notation	Oct 27 1999	T.Brandon
3	SugarShot Telemetry Protocol	TBD	TBD
4	*DoubleSShot* Standard Atmosphere Properties	2010/09/30	R. Nakka

4 REQUIREMENTS

Figures 4-1 and 4-2 provide notional block diagrams of the Avionics system(s) and interfaces.

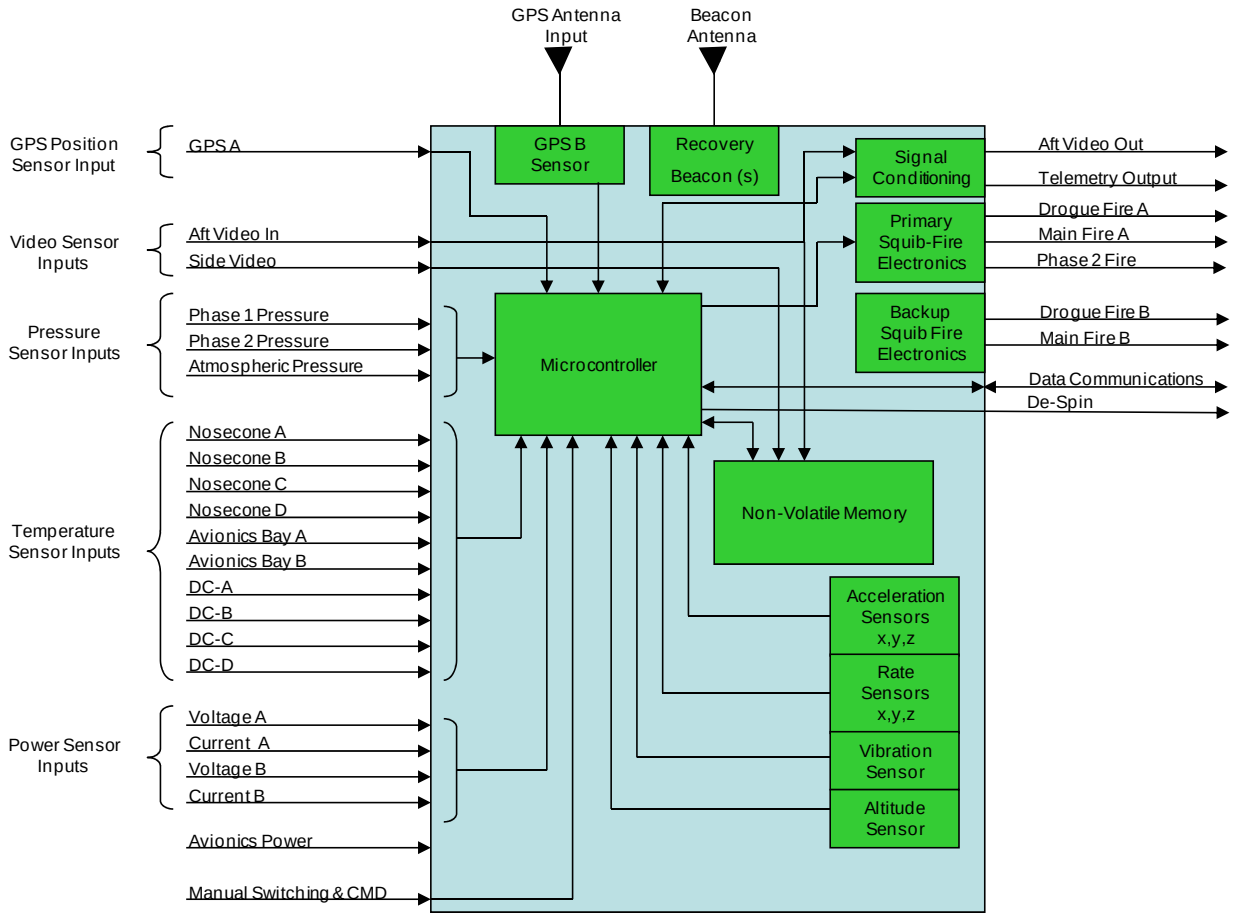
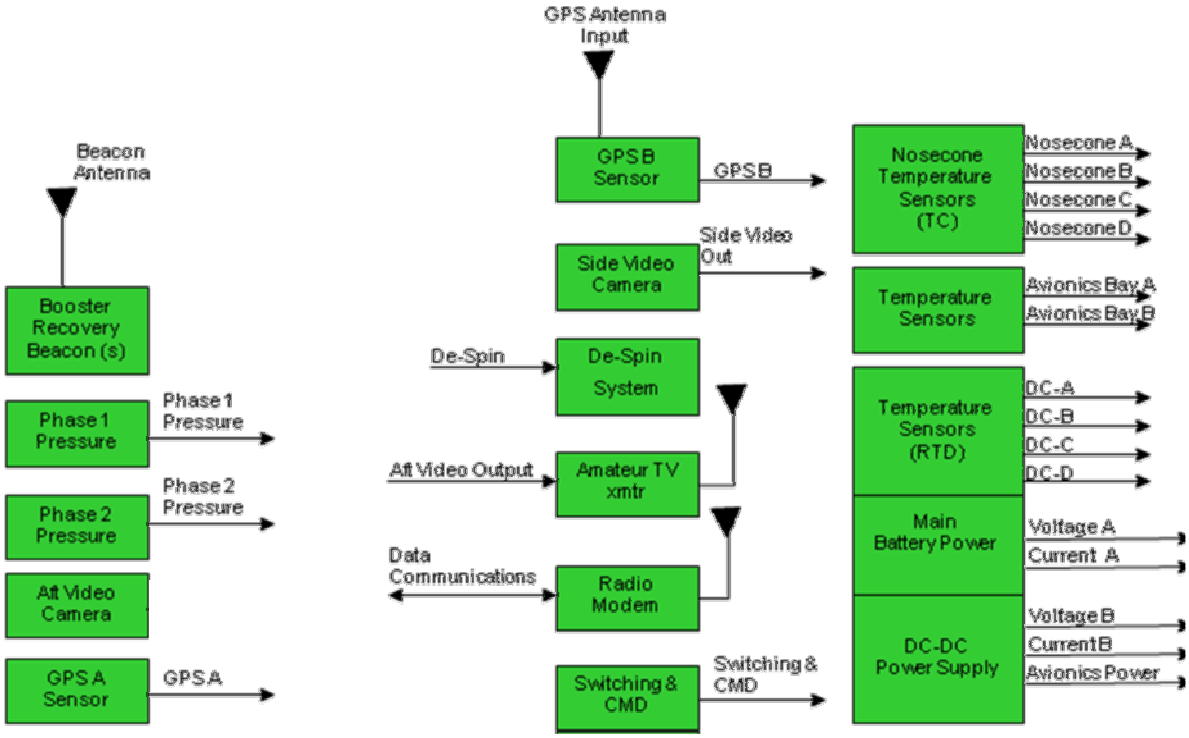


Figure 4-1 Notional Forward Avionics Assembly



Aft Systems Fwd Systems

Figure 4-2 Ancillary Avionics Support Systems

4.1 Inputs

4.1.1 Acceleration Sensors

The avionics shall measure and record positive and negative acceleration in the coordinate system as shown in Figure 4.1.1 Coordinate System. The acceleration sensors shall be located in the avionics section.

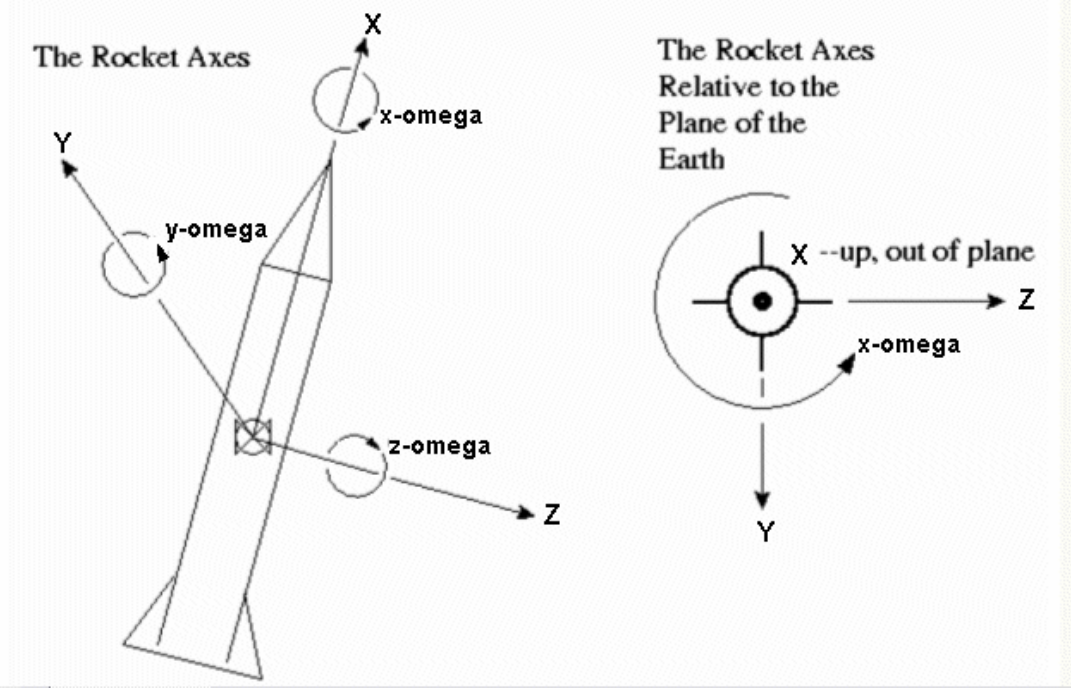


Figure 4.1.1 Coordinate System

TABLE 4.1.1 Coordinate System Definitions		
SYMBOL	MEANING	UNIT
x	Longitudinal Position	meters
y	Lateral y position	meters
z	Lateral z position	meters
x-omega	Roll axis	radians
y-omega	Pitch Axis	radians
z-omega	Yaw Axis	radians

The avionics shall provide for high and low resolution acceleration measurements.

The low resolution shall cover a range of +/-50 gee minimum at a resolution of 0.5 gee minimum.

The high resolution shall cover a range of +/- 6 gee minimum resolution of 0.1 gee minimum.

4.1.2 Rate Sensors

The avionics shall measure and record the positive and negative spin rate about each axis depicted in Figure 4.1.1. The rate sensors shall be located in the avionics section.

The z-axis sensor shall cover a range of 20 cps minimum at a resolution of 0.1 cps minimum.

The x-axis and y-axis sensor shall cover a range of 1 cps minimum at a resolution of 0.1 cps.

4.1.3 Voltage & Current Sensors

The avionics shall measure and record the voltage & current sensor inputs provided by critical flight batteries and/or power supplies to within range +/- 2.0%.

4.1.4 Temperature Sensors

The avionics package shall measure and record a minimum of 10 temperature sensors as defined in Table 3.1.4 Temperatures Sensors.

Table 3.1.4 Temperature Sensors

Number	Function	Type	Temperature
1	Nosecone A	K	5°C to 700°C
2	Nosecone B	K	5°C to 700°C
3	Nosecone C	K	5°C to 700°C
4	Nosecone D	K	5°C to 700°C
5	Avionics bay A	RTD	5°C to 210°C
6	Avionics bay B	RTD	5°C to 210°C
7	DC-A	RTD	5°C to 210°C
8	DC-B	RTD	5°C to 210°C
9	DC-C	RTD	5°C to 210°C
10	DC-D	RTD	5°C to 210°C

4.1.5 Pressure Sensors

The avionics package shall measure and record the combustion chamber pressure sensor of the motor phases during operation and throughout the flight.

The chamber pressure sensors shall cover a minimum range of 10 to 1200 psig at a resolution of 2 psig.

The avionics package shall measure and record the atmospheric pressure sensor of the vehicle throughout the vehicle's trajectory.

The atmospheric sensor(s) shall cover a minimum range of 1.0 kPa (1.0 Pa goal) to 101.325 kPa

4.1.6 Vibration Sensors

The avionics package shall monitor and record the vehicle vibration sensor range 10—100 Hz, resolution 2 Hz. The vibration sensor shall be located in the avionics section.

4.1.7 Video Sensors

The avionics shall record external aft and side facing high definition high definition color video during the flight. The video sensors shall be located in the avionics section.

4.1.8 Position Sensors

The avionics shall record vehicle position of two independent GPS sensor feeds. GPS sensor B shall operate to an altitude of 115 km minimum with an update rate of 1pps.

GPS sensor A will be located in the booster section. GPS sensor B shall be located in the avionics section.

Altitude shall be monitored and recorded by a third sensor located in the avionics section. It shall operate to a minimum altitude of 50 km +/- 2 %.

4.2 Outputs

The avionics package shall provide an output signal to fire the 2nd phase after TBD seconds.

The avionics/payload package shall provide signal and power for both drogue and main deployment. Squibs will fire at minimum 1250 m A for 0.5 second greater than 2 volts s .

A 1 V pk-to-pk composite output signal of the aft facing video stream shall be output for the Amateur TV transmitter.

The avionics shall provide a signal(s) to operate the de-spin system.

4.3 Recovery

Radio frequency recovery beacon s shall be incorporated to aid locating the booster and avionics sections on the 70 cm or 2m band. Redundant booster and payload recovery beacons shall be incorporated to aid locating the downed vehicle.

The avionics recovery beacon shall be designed to operate a minimum of 72 hrs (low power) and ~8-16 hrs after touchdown (high power).

The primary beacons shall transmit the GPS position. As an objective the redundant recovery beacons may transmit GPS position.

4.4 Telemetry Downlink Data

The avionics/payload package shall have the ability to downlink data to mission control during all non-flight and flight operations using both RF and hard-wire links (interface & protocol IAW SugarShot TM Protocol) IAW Table 4.4Telemetry Data.

The avionics/payload package shall have the ability to uplink data to mission control during all non-flight and flight operations using both RF and hard-wire links (interface & protocol IAW SugarShot TM Protocol) IAW Table 4.4 Telemetry Data.

Table 4.4 Telemetry Data

Item	Signal	RF Uplink	RF Downlink	Wired Uplink	Wired Downlink	Rate PPS	Priority
1	Chamber pressure		X		X	100	1
2	Internal temperature(s)		X		X	1	3
3	Separation status		X		X	1	1
4	Chute status		X		X	1	2
5	GPS readings		X		X	1	1
6	Barometric altitude		X		X	1	1
7	Acceleration		X		X	100	3
8	Rotation/spin (gyro, magnetic field etc.)		X		X	1	3
9	Aerodynamic stress		X		X	1	3
10	Fin flutter		X		X	1	3
11	Battery monitor		X		X	1	1
12	Despin monitor		X		X	1	3
13	Video		X		X	cont	3
14	Battery monitors all and shore power and disconnect from shore.		X		X	1	1
15	2^{nd} phase arming status		X		X	1	1
16	Safe/arm 2^{nd} phase		X		X	1	

17	Blow chutes (flight abort)	X				1	
18	Main On/off switching function			X		1	

4.5 Memory Storage

4.5.1 Non-volatile memory

The avionics/payload package shall digitally record all data IAW Table 4.5for post-recovery retrieval.

Table 4.5 Storage Requirements

No.	System	Storage Capacity	In/Ext Control
1	Video A	3 hrs	Ext
2	Video B	3 hrs	Ext
3	GPS A	3 hrs	Int
4	GPS B	3 hrs	Int
5	Nosecone A	3 hrs	Int
6	Nosecone B	3 hrs	Int
7	Nosecone C	3 hrs	Int
8	Nosecone D	3 hrs	Int
9	Avionics bay A	3 hrs	Int
10	Avionics bay B	3 hrs	Int
11	DC- A I&V	3 hrs	Int
12	DC-B I&V	3 hrs	Int
13	DC-C I&V	3 hrs	Int
14	DC-D I&V	3 hrs	Int
15	Acceleration x, y, z	3 hrs	Int
16	Rate x, y, z	3 hrs	Int
17	3rd Altitude	3 hrs	Int
18	Chute Status	3 hrs	Int & Ext
19	2nd Phase Igniter Status	3hrs	Int & Ext

4.6 Communication Links

The hardwired communication link shall be compatible with a standard commercial laptop with both USB and RS232 operating Windows XP or similar.

The avionics shall permit reprogramming and memory read/erase functions via the wired communication interface without disassembly.

The avionics shall have a manually switched power interface to the DC Power Supply system.

The avionics shall provide an external control to begin flight recording for the main memory system.

4.7 Reliability

A fully redundant independent system shall provide fail safe signal and power for both drogue and main deployment. High reliability to be achieved through use of high quality components and flight testing.

4.8 Maintainability

The avionics/payload package shall be designed and built as a modular system to facilitate maintenance and integration with the flight vehicle.

The avionics/payload package shall as many off-the-shelf modules and assemblies as possible to reduce the need to develop custom components.

The avionics/payload package shall be designed to be fully recoverable and reusable. Mean Time to Repair shall be 2 hrs.

Mean Time to Replace/Refresh batteries shall be 3 hours.

4.9 Size & Weight & Power

The avionics package(s) shall be IAW mass targets of Appendix A.

The size of the avionics shall not exceed requirements in Appendix B.

The avionics/payload package shall be capable of being powered by external power pre-launch.

The avionics/payload package shall provide signal and power facilities for the client payload.

The avionics shall consume a maximum of TBD Watts when operated off the TBD VDC internal supply.

The avionics shall consume a maximum of TBD Watts when operated off the TBD VDC external supply.

The avionics shall utilize externally actuated power & Safe/Arm switches for all power and squib systems.

The avionics shall fit within the volume specified in appendix B.

4.10 Environment

The avionics/payload package shall be designed and tested to withstand a force of 35 Gs.

The avionics/payload package shall be designed and tested to withstand a temperature range of -40°C to 100°C. Operational 5°C to 60°C.

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The avionics/payload package shall be designed and tested to pressures from 1.0 kPa to 101.325 kPa

Appendix A: Mass Targets

No.	Item	Note	Mass		Ystation
			(grams)	(lbs)	(mm)
1	Nozzle	complete	2065	4.55	5263
2	Mid-bulkhead (less Delay Plug)	complete	1669	3.68	3410
3	Forward bulkhead	complete	573	1.26	1786
4	Aft casing	painted	5759	12.70	4337
5	Forward casing	painted	6159	13.58	2576
6	Aft casting tubes	assembly	3490	7.69	4337
7	Forward casting tubes	assembly	1928	4.25	2576
8	Aft casing thermal barrier		425	0.94	4337
9	Forward casing thermal barrier		425	0.94	2576
12	Closure attachment screws, nozzle		72	0.16	5206
13	Closure attachment screws, midbulk		144	0.32	3410
14	Closure attachment screws, fwd bulk		72	0.16	1800
15	Pyrogen (aft chamber)		100	0.22	3480
16	Pyrogen (fwd chamber)	4	100	0.22	1785
47	Pressure transducer		100	0.22	1750
49	Delay plug		1016	2.24	3456
10	Propellant, aft chamber		45060	99.34	4345
11	Propellant, forward chamber		45060	99.34	2560
17	Aft Avionics Bay	painted	435	0.96	1615
18	Recovery compartment	painted	870	1.92	1208
19	Motor coupler		185	0.41	1742
20	Aft tapered coupler		148	0.33	1498
21	Forward tapered coupler		148	0.33	1478
22	Nosecone coupler		112	0.25	929
40	Nosecone	painted	1156	2.55	620
45	fins	4	1276	2.81	4950
23	Pyro Separation Link		250	0.55	1488
29	Booster chute		450	0.99	1285
30	Drogue chute	1	185	0.41	1210
31	Main parachute	1	250	0.55	1100
32	drogue tether	2	450	0.99	1210
33	main tether		200	0.44	1010
34	Pyro Release Device		100	0.22	1010
48	tether anchor fittings		150	0.33	1400
26	Capsule Recovery beacon incl. battery		200	0.44	800
28	Booster Recovery beacon incl. battery		200	0.44	1615
35	Main computer		100	0.22	800

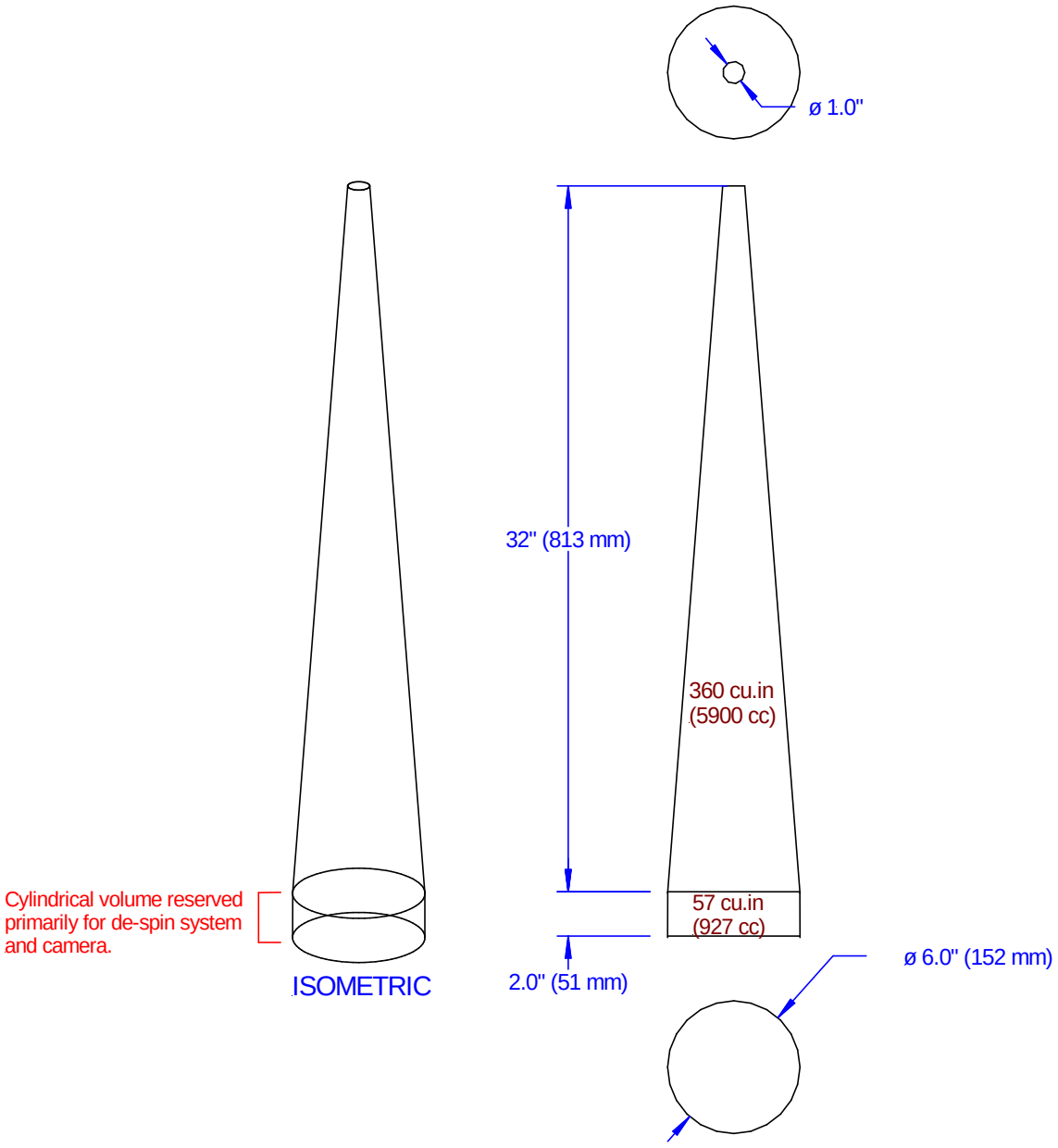
36	Primary Chute Controller		70	0.15	800
37	Telemetry transmitter & antenna		300	0.66	800
38	GPS unit & antenna		150	0.33	800
42	thermal sensors		50	0.11	800
43	thermal board		20	0.04	800
44	vibration sensor	incl. battery	20	0.04	1615
46	Power supply, avionics		1000	2.20	800
50	Backup Chute Controller		50	0.11	800
51	Backup Chute Controller power supply		50	0.11	800
24	Booster Camcorder		186	0.41	1615
52	Camera mirror & fairings		50	0.11	1615
55	Payload Cap. camcorder		100	0.22	955
56	Payload Cap. Camcorder support structure		50	0.11	955
39	de-spin system		500	1.10	955
25	Camcorder support structure		80	0.18	1615
27	Recovery beacon supports		60	0.13	1615
41	Avionics (fwd) support structure		150	0.33	800
53	Wiring & connectors		500	1.10	-
54	Miscellaneous		750	1.65	-
57					

Total liftoff mass	125218	grams	276.05
Dry mass	35098	grams	77.38
Dry mass (less delay plug)	34081	grams	75.13
Recovery mass, Booster	26725	grams	58.92
Recovery mass, Payload Capsule	7156	grams	15.78
Avionics	2310	grams	5.09
Vehicle mass fraction	**0.720**	(target 0.720)	

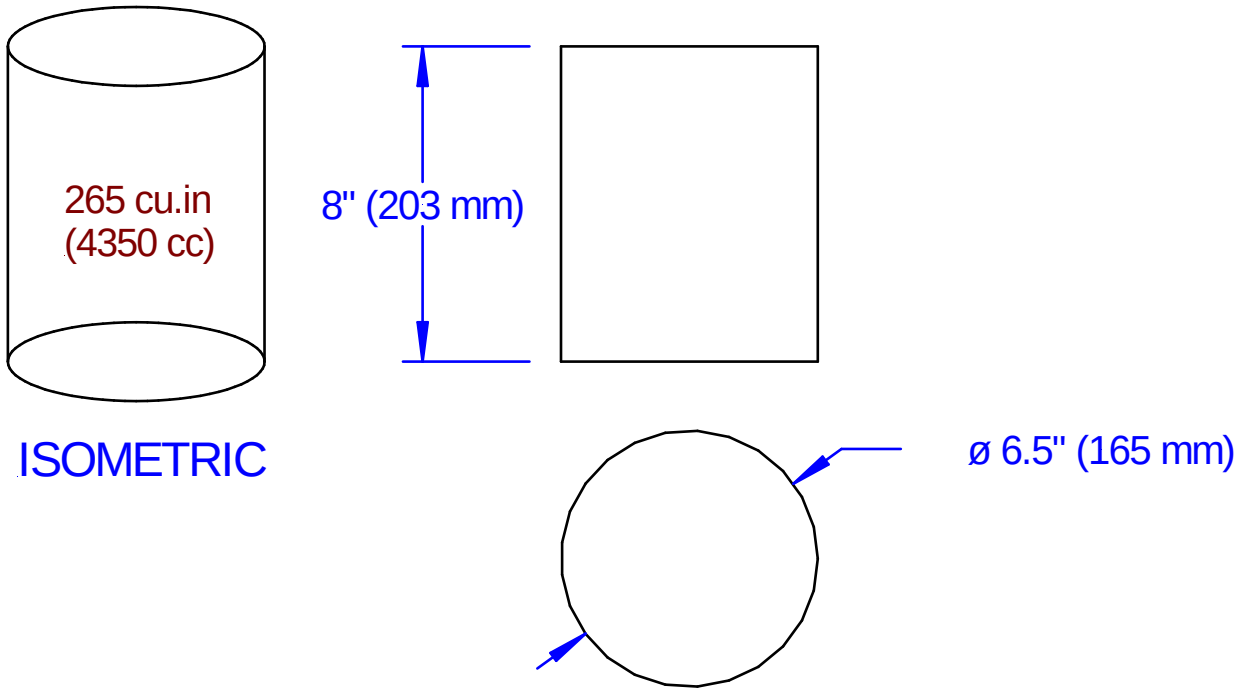
ITERATION #1 26-Nov-10		
Item	Launch mass kg	lbs
Booster (dry)	26.72	58.92
Booster (fueled)	118.06	260.28
Payload Capsule	7.16	15.78
Breakdown:		
Propellant	90.12	198.68
Motor	24.10	53.12
Airframe*	4.33	9.55
Recovery system	2.04	4.49
Avionics	2.21	4.87
De-spin system	0.50	1.10
Cameras	0.39	0.85
Support structure	0.290	0.64
Miscellaneous incl. wiring	1.250	2.76
Total =>	125.22	276.05
Mass fraction	**0.720**	

* excludes motor casings

Appendix B: Avionics Envelope



Forward Payload Bay volumes



Aft Payload Bay volume