to 1Mrad are being used. However, the breadboard is being constructed from commercial equivalents. The main board will be enclosed in a 30 mil aluminum box.

The breadboard employs an 8086 processor, 1Mb RAM and 64Kb ROM. An ACTEL FPGA handles memory access, error correction, data acquisition, spacecraft time, performs watchdog functions and interfaces with the RF transmitter/receiver. For flight the ACTEL A1280XL will be used. To facilitate prototyping two A1020s are being used instead.

The main board also performs analog signal conditioning for the payload magnetometer, temperature sensors and sun sensor. All of the analog data will be read by a 12-bit Analog-to-Digital converter.

In an effort to minimize power consumption the analog circuitry will be powered off about 90% of the time on a rapid cycling basis so that it will not affect data collection. Additionally the static processor and memory will be halted between data samples.

4.3 Magnetometer and Attitude Sensor

A 3-axis magnetometer will be accurately aligned relative to the spacecraft axes. The satellite will have been released with spin principally around the axis of the cylinder that is designed to have the largest moment of inertia. A damping mechanism will be included so that the spin will decay to rotation only around this axis. In order to determine the fields in absolute coordinates both the two angles defining the direction of the spin axis and the phase of the rotation must be known.

The direction of the spin axis can be determined by using the magnetometer and a sun sensor in combination and noting that the spin axis should remain fixed over an orbit. When the satellite is within ~2R_E of the earth the magnetic field is accurately known and only minimally variable. The magnetic field along the axis should remain constant as the satellite spins. The ratio of that field and the known magnitude of earth's field is the cosine of the angle between the spin axis and the field axis. The other two components will vary sinusoidally with the phase of the rotation angle. The maximum occurs in the plane defined by the magnetic field and spin axis directions. Using a sun sensor the phase of the rotation relative to the satellite-sun line can be determined and therefore the absolute direction of the satellite spin axis.

While it is reasonable to extrapolate that the spin axis remains fixed as the satellite moves around its orbit, it is not possible to know the spin rate with sufficient accuracy to determine the phase of the rotation at the time that a measurement is taken. Therefore, the sun sensor will be used while the magnetometer measurements are being made to determine the rotation phase angle.

The sun sensor will look radially outward from the satellite. It will consist of a slit and a sharply defined photodiode. We expect that the angular accuracies of the magnetic field measurements will be better than two degrees.

A flux-gate magnetometer will be utilized. A specific design has not been selected. However, Applied Physics Systems 553 has adequate sensitivity, weighs 20 grams and uses 200mW of power. Radiation hardness is not known but the fundamental flux-gate mechanism is insensitive to radiation. This system is strongly temperature sensitive, ~1nT/°C. A temperature sensor and thermal compensation must be included. The circuitry is being designed for 0.5nT or 1% accuracy whichever is less stringent.

Historically, magnetic field sensitivity is attained by sufficient magnetic cleanliness on the spacecraft. While the fact that very little power

upon keeping paired conductors close together. This stringent ... eliminating current loops. We anticipate considerable testing and ad- justment of the mechanical properties of the electronics before b... able to define a configuration and a magnetometer location.

4.4 Design Summary

Thus far neither satellite structure nor thermal balance have b... considered in any detail. The mass of the structure will be estimate... comparable to mass of the components. Some of the satellites ca... eclipsed for up to four hours. We have included sufficient batteri... maintain electrical operation during this time. Thermal shielding ... be required to maintain operating temperatures during this time.

The major power consuming component on the main board is ... 12-bit ADC which in continuous operation requires 595mW. As m... tioned above we plan to run this on a 10% duty cycle so that the po... consumption will be cut to 60mW. Similarly some of the other com... nents can be run on 10 or 20% duty cycles while others such as ... clock must run continuously. Taking these factors into account ... average power consumption on the main board will be 340mW. Ba... on the Applied Physics Systems magnetometer power consump... for continuous operation would be about 300mW. Average power c... sumption by the RF system is negligible since it is used for su... small fraction of the time. Thus the total average power consump... estimate is 640mW as compared to the 1W generated by the solar c...

The mass of the components in the breadboard version of the m... board have been weighed at 140g and the aluminum enclosure a... 60g. The shielded solar cells weigh 40g and the magnetometer a... 20g. The five AA equivalent batteries weigh 125g. The estimated we... of the RF system suggested above is 40g. Thus the total compon... mass is 325g. With an allowance for structure somewhat smaller t... the component mass the total mass is under the 1kg target.

5. Satellite Launch and Release

Several vehicles were considered for launching the constella... into the final orbit. The best suited candidate was determined to be ... Pegasus XL from Orbital Sciences Inc. Because of its relatively ... cost, each plane could be launched on its own vehicle. If a la... launch vehicle were used, several plane changes would be requi... The large fuel requirements for these burns could significantly red... any gains in launch performance.

5.1 Launch Scenario

The launch sequence is made up of four steps that will end with ... insertion of the satellites into a range of orbits. The first step is to ... the Pegasus XL to launch the bus into a 200 km altitude circular p... ing orbit. At this time the bus will separate from the Pegasus ... continue to the final orbit. Step two consists of a STAR 27E ... motor to raise apogee to 5 R_E. After the completion of this burn ... STAR kick motor would be jettisoned and a hydrazine rocket wo... perform the remaining burns. The third step is a hydrazine burn ... raises perigee to 1.4 R_E. The final burn occurs during the releas... the satellites. A more detailed description is outlined below.

Using the Pegasus XL it is possible to lift 465 kg into a 200 ... altitude parking orbit (Orbital Sciences, 1997). At this point the ... would separate from the Pegasus and continue to the final orbit. ... separation mechanism standard on the Pegasus has a mass of 1... allowing the bus to have a mass of 453 kg. The change in velo...