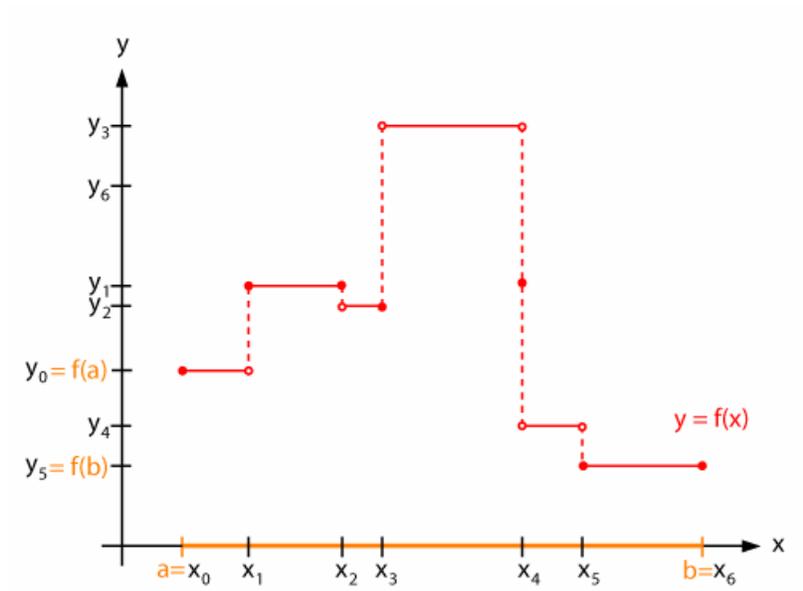Colorado Space Grant Consortium
Independent Study Credit
Final Report

<u>Your Name Here</u>

CubeSat
Primary Communications

Team Lead
Scott Olson

Advisor
Brian Sanders

November 27, 2007

1.0 Student Background (0.5 page)

I am currently enrolled in the Electrical Engineering program, and have the status of sophomore. I am former military where I held the role as communication signals analyst and radio operator. Follow on occupation placed me in the defense industry working with the NRO and NSA on communication systems.

I have very little experience with software programming and circuit design but have taken classes related to both and will continue to do so. I have a working understanding of how communication systems work and a knowledge of the coding modulation schemes used in commercial and governmental communication systems

My ambitions of this project are specific to finishing the primary communication system construction and successfully establishing a communications link between the Hermes CubeSat and COSGC ground station. Additionally, I intend to take the experience from this project and apply it to follow on personal interests and occupations.

2.0 Overview of Semester Work and Assignments (0.5 page)

The assigned work for the Primary Communications (PCOMM) team is diverse ranging from RF testing and link budgeting to microcontroller implementation. Since the system was not in the infancy stage when I joined with Space Grant I have been in the perpetual stage of familiarizing myself with the PCOMM system. This initially was the only assignment placed on me, and this gradually expanded. Early on I took interest in the construction of the TNC and attempted to focus my time in that area. I focused a lot of time on how the TNC worked and the skills needed to complete the task.

Firm assignments came in the form of feedback from the semester reports. My main assignments were the familiarization of the TNC and code, Ax.25 protocol, PCOMM FBD, and mission requirements. Also, the senior members of the Communications team either left during the semester, or will be leaving at the end of this semester. So there was a large emphasis on semester documentation and turnover.

3.0 Detailed Description of Work Completed (3 to 10 pages)

Early on in the semester spent quite a bit of time determining how the PCOMM system was to work. Overall, the system is easy to understand and there is nothing unusual about the signal flow process.
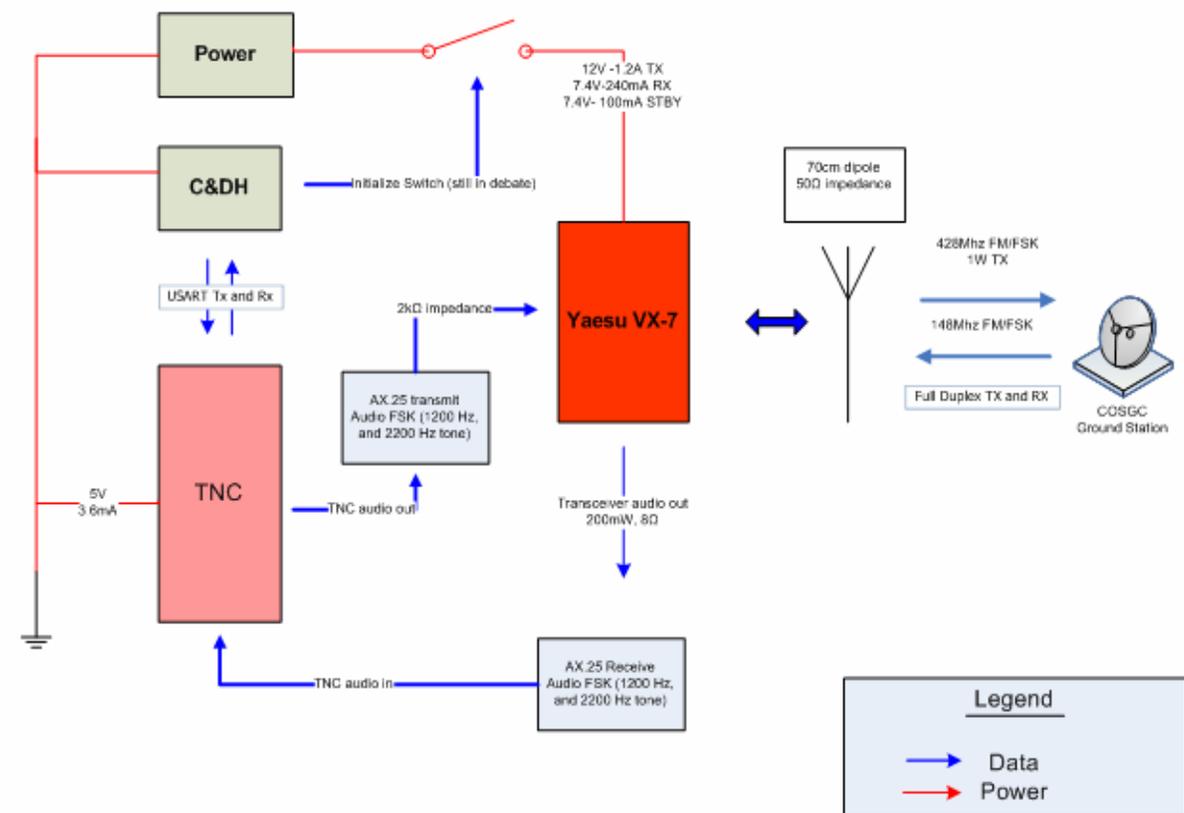
Figure 1

The above is the current FBD for PCOMM. The components that are missing are due to recent discussion about possible radiation interference. I will utilize this FBD to overview the work I have done with PCOMM thus far.

Antenna materials, deployment, and orientation

James Gorman is the primary source for antenna orientation setup due to his modeling software. The original design of the antenna, and still current, is a 70cm wavelength dipole, cut to quarter wavelength size. The problem with this is the orientation of the antenna with respect to Boulder. There exists a great probability of reducing our communications window because the dipole's null will be pointing at Boulder during parts of the orbit. The alternative to this dipole is a "L" shaped antenna which is more omni directional. Both of these antennas will hopefully be tested over the summer. The "L" shape decreases the overall gain, but increases our field of view over Boulder.   I have been involved with the discussion of this antenna use with Jim Love, and James Gorman.

Additionally, the antenna deployment system and material are in the discussion process as well. One of the difficulties of the Material is that the antenna will be folded against itself for a variable amount of time prior to launch. The material

needs to maintain it's ability to correctly spring back into place when deployed. Daria Kotys, has been a source for CubeSat for recommending which material might supply better properties. She is on the contact list which will be passed onto the summer crew.

Yaesu Vx-7R

The radio for the most part has not be used except to ensure that it works, and to estimate the amount of heat it will expel. It has been decided that the radio will need to have the ability to accept commands to change frequency in the cause of an upset affecting the frequency of the radio.

The manual included with the radio does not include the technical specification for the device, so Yaesu needed to be contacted. The technical manual containing the needed information is part number EH009M90B and costs $16.50. Jim or Lisa is in the process of ordering the manual.

TNC

The TNC has been the center piece needed to really move the entire communications system into the next stage of testing. This is also where most of my work has really focused. Unfortunately this is also where a majority of my frustration has occurred.

Early in the semester I started reading through the documentation of the TNC in the PCOMM folder. Most of this material was outdated, and I found this out a couple of weeks into the semester. Once realizing this, I was redirected to the SVN repository and downloaded the TNC schematic from there. Also, this is where the TNC code was located as well. This is the only documented source of the TNC and the code was not well commented. This is where my work on the TNC started.

Here is a brief explanation of the TNC schematic(figure2), I numbers particular parts I needed some explanation on and parts that will take on different functions not yet implemented.
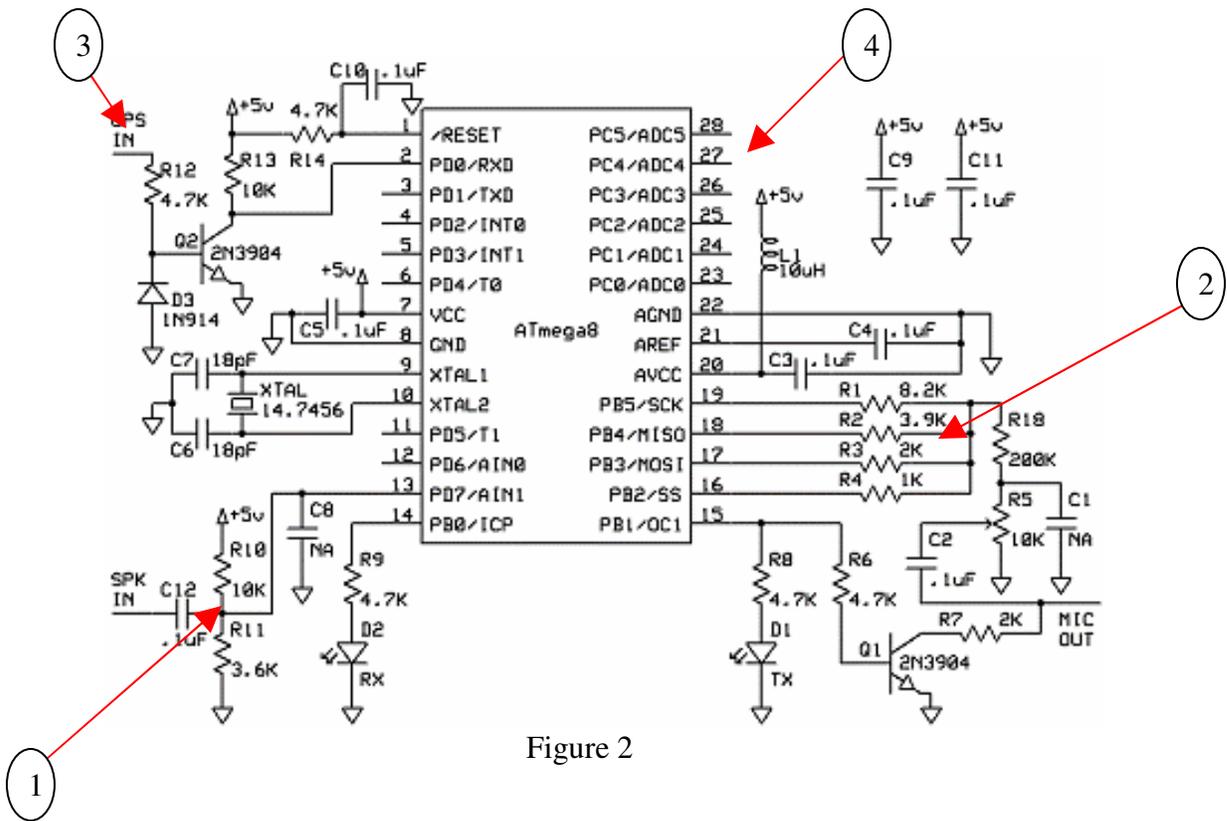
Figure 2

1) This is the input (Ground Station to CubeSat) from the transceivers audio feeding into the comparator port of the AVR. The input signal has a DC bias adjusting the zero crossing position of the input sine wave to about 1.3V. This input signal is then compared to an internal reference of about 1.25V. Thus when the sinusoid falls below 1.25V, a software interrupt is triggered. This method of sampling is a zero cross method.
2) These output signals create the D to A converter using a ladder resistor setup. The max output when ports 19, 18, 17, 16 are high will be 5 volts, and 0 volts when they are low. The rate at which the signals switch are time varied according to frequency.
3) The circuit component originally worked with the APRS system, but was removed because it is not used for our circuit.
4) This portion of the AVR is currently unused, but will probably take on the responsibility of frequency control for the transceiver.

The source of this schematic I believe was originally derived from the website: http://www.knology.net/~gdion/whereavr.html

The source code for this circuit is posted as well, but for our system the code, thought originating from this website, does not resemble this websites code now.

I have not contributed to the TNC programming to this point, this will be a summer focus and discussed in the later sections of this report .

Though I have not programmed specifically for the TNC, I have acquired the WINAVR, and AVR Studio software packages in the attempted to hone my C programming skills, and see how the registers on the AVR's are manipulated. I'll will attempt to acquire the STK500 soon so I can actually start programming.

External Activities

Though there is much work to do pertaining to the TNC, much of the coding I am not familiar with, and it was changing at a fairly rapid pace. It was not practical for me to work on it during it's times of speedy transition. I redirected myself at this point and focused on the Ax.25 packet protocol standard. This standard has been well documented, and many links can be found online. My study focused on the necessary control indicators that go into the packets, putting a gist of the activity in a powerpoint slide. At this time, software is responsible for formatting C&DH data into the AX.25 packets. However, I felt I had a good understanding of how it would work since I could relate it to previous work experience.

I turned this write-up into Brian at my latest meeting on April 6th. Currently Software has not had the time review the work I gave them.

Work since last report

Since the last report on April 6th, I have re-focused my attention to the TNC, and finshed the writeup on the Ax.25 protocol. The powerpoint show was almost finished at the last meeting, and I think it was completely finished within the week following the meeting. Also, I have taken many notes with Scott Olson about who his contacts are and what topics each can help with. Also, Scott summarized what was found in the frequency coordination forms, and who could help advise me to finish it (if he doesn't get it done before the semester ends).

Within the last couple of weeks I have realized that I will be responsible for the Microwave comm. system over the summer. I have discussed this with Dan, and we are planning a meeting on Wednesday of finals week.

4.0   Work to Be Completed (1 – 2 pages)
There is much work to be completed over the summer. An outline from the end of semester presentation describes what is expected from the summer crews.

PCOM Omnidirectional decision

PCOM Frequency Allocation
PCOM Transceiver RadHard

PCOM TNC familiarization

PCOM TNC initial development

HSCOM ground station interference/location

HSCOM antenna decision

HSCOM antenna deployment

HSCOM modem integration

Also, this is just the summer workload. I still need to coordinate with James Gorman about the TNC code, and finalize all his thought on where he was planning on taking the design. Though the TNC does not take up the June or July timeframe on the PPT summer schedule, I think this will probably occupy most of my time this summer.

Additional work, besides getting the TNC to communicate with C&DH, includes deciding on the means for designing a circuit to control the radios frequency. At this point, the radios cover will need to be removed, and some of the components to be stripped. Also, the Radio's technical manual should be ordered soon, if it isn't ordered already.

The HSCOM system, which I am unfamiliar with, should not be difficult to work with. There will be members of the DemoSat team working this summer (Sean at least) which I will be able to tap for assistance.

5.0   Conclusions and Results

I don't feel that PCOM made many leaps or bounds this semester. When I first joined the team, I was told that this was going to be the semester where we would be testing equipment, and radio ranges for communications. Though this wasn't really the case for our team, many encouraging missions were accomplished for our team.

My experiences with the CubeSat systems have been extremely positive. I relate many of the things I have done in my previous classes to how they work on a live project like CubeSat. Specifically, I feel that my main core classes in calculus, circuits, and programming are reinforced by working here. For my final project in my Digital Logic class, I attempted to persuade my lab partner to help make the TNC using the FPGA. I thought I was comfortable enough and understood

enough about the TNC and FPGA that the project wouldn't be so difficult (maybe to an extent).

I also learned that all occupations will have those things you want to do, and the things you have to do. Frequency coordination is something you have to do, or is at least a good idea. I found it frustrating, along with Scott Olson, to be reliant upon external entities and organizations for help because you don't have the proper tools to do it yourself. I found myself in the position of not having the proper tools to help many times during the semester. Once in that position, I felt that I either needed to focus on what it was I didn't know, and attempt to learn that, or refocus on something that I can do and might be more productive doing. This was apparent with the TNC throughout the semester. At the beginning I felt that I could provide some assistance with it's coding. I however could not keep up with those who were working on it, and I felt like I was actually hindering the progress. At this point, I decided to refocus my attention onto something that I new a bit better.

Overall, I spent a great deal of time trying to learn how the comm. system was supposed to function. There were many great things I learned from antenna material and orientation to microcontroller functionality and applications. I feel like I want to get hands on with what I'm learning now, and this time I will spend working on the project over the summer it will help out the most.

6.0	Lessons Learned and Advisor Feedback

The biggest lesson learned this semester was the fact that people don't like to document there work. There needs to almost be a scheduled weekly time to do just that, a *documentation time out*. One of the hardest things I realized early on in the semester was that I needed to be very cautious what I was reading (and still is). I ended up wasting about a week or two just on documents stating the construction of a device when that device had actually been re-designed, and the documents were not destroyed or did not note the change.

Also, I noted this in the previous lessons learned required for Lisa, but I think that space grant has enough AVR and radio smart persons that an "outreach" of type can be held in these two categories. One outreach can be used to introduce the microcontroller processes to newbie engineers, or High Schooler's. With respect to the radios we can see if Space Grant can host a Ham Licensing day and have amateur radio testers come to the University on a Saturday or Sunday and test for licensing.

7.0 Hours and Outreach

Start	End	Hours
1/8/2007	1/14/2007	0
1/15/2007	1/21/2007	0
1/22/2007	1/28/2007	0
1/29/2007	2/4/2007	6
2/5/2007	2/11/2007	6
2/12/2007	2/18/2007	8
2/19/2007	2/25/2007	9
2/26/2007	3/4/2007	8
3/5/2007	3/11/2007	5
3/12/2007	3/18/2007	4
3/19/2007	3/25/2007	8
3/26/2007	4/1/2007	14
4/2/2007	4/8/2007	8 Outreach Apr 4th
4/9/2007	4/15/2007	9
4/16/2007	4/22/2007	8
4/23/2007	4/29/2007	7
4/30/2007	5/6/2007	Maybe 8-12

8.0 Grade

I believe I rate an "A" for my semester at Space Grant. I enjoyed the Independent study through the program and spent many hours a week here proving that. Had I started with this study at the beginning of the semester, I would have been held to only six hours a week and less the spring break. My time sheet indicates that I spent nearly 8 hours a week from when I can on to this project till now and that is because there is really an endless amount of work that one can find themselves in. I continually worked on projects I wanted to help with, and wanted to take on a larger part of each thing I worked on than I probably should. I always sought for additional tasks where I could be valuable.