DemoSat III Final Report

**T^X Sat**

*To measure telemetry data and transmit it in real time over a distance so that we may get a better idea of signal degradation and communications possibilities using as little power draw as possible Under 1 watt of transmission power.*

Francis Behen, CJ O’Hara, Kyle Rozen, Ross Young

Warren MacEvoy, Philip Kavanagh

Mesa State College

August 8, 2005
1.0 Mission Statement
To read telemetry data assemble it into packets and transmit it in real time to a ground station. A key goal of the mission was to learn more about signal degradation and communications possibilities using as little power draw as possible. To establish more about packet switching type radio communications. An additional goal was to find the best frequencies for long distance communications so that the atmosphere will not reflect the signals. To survive impact with no damage to radio or reading equipment and transmit data for the full duration of the flight.

2.0 Mission Requirements and Description
The mission as defined by the Demosat Project Directors reads as follows: “Develop methods for transmission using protocols, compression techniques, and commercially available hardware and frequencies.” For our mission we were required by EOSS (The organization launching and retrieving the balloons) to transmit over a distance at under 1 watt of transmit power. Since EOSS also uses armature radio transmission they stipulated that we must use a frequency assigned by them. We were to measure signal degradation as well as check accuracy of readings through radio transmission. We used a standard packet radio transmission protocol (AX25 or Amateur X25) and specially made antennas to maximize our potential for success. We attempted to establish a method of sending commands to the satellite so asking for specific readings. Due to problems with the packet environment this proved to be too difficult within the
time constraints so we had to eliminate that specific component of the mission. Since communication was the primary goal of the mission the specific types of data transmitted were of lesser importance. We selected internal temperature, pressure, acceleration (3 axis) relative humidity and if possible GPS Location. Due to a difference in the protocol mode of the transmitter for GPS location we were not able to include it. Our mission was designed to assist future missions so that we may send more important data. The goal was to maintain communication throughout the flight with an anticipated maximum distance of at least 20 miles on less than one watt (around .6 watts transmission power).

3.0 Payload Design

Our payload’s outer shell was created using foam core. Foam core is ideal because of its strength and insulating properties. We chose a standard near-cubical shape to optimize space. Inside of our payload casing and the most important piece of the project is the handheld radio which sends the packets to the base station and performs error correction operation. The radio that we decided on is the Kenmore TH-D7 A/E which sent to the TH-D700 A/E. One of the earliest decisions that we had to make was whether to use the original battery or to attach a new power supply. The battery that comes with the D7 A was a nickel cadmium battery and due to the low tolerance for cold and extreme conditions we decided on a foreign power supply. Our power supply consists of four Lithium 9 volt batteries. Two batteries are attached to the radio, one to the heating unit and one to the circuit board. We decided on such a rudimentary power supply because of past problems with more complex units. The radio transmits in AX 25 Packet Communications which holds to the same protocol as X25 packet communication which is a very common data transferring protocol. These packets are sent to our base station which decodes them and prints the information into a HyperTerminal where it is logged into an external text file for later review. Our heating unit is a standard chipset that was used in previous Mesa State demosat projects. We rewired the heater to get it to work. When the temperature drops below 0°C the circuit completes running current through a 20Ω resister creating plenty of heat. Our cold tests showed a box temperature of ≈ -3°C. This was well within operational limits for the entire project but we added a heater to keep everything at optimum performance. One of the reasons that the box was able to stay so warm was due to the two-layer construction, The outer layer is the
Foam-Core the inner layer is a standard insulation. This coated the entire box keeping it completely insulated from any negative elements. The most important part of our mission was the communications. The data that we read was not especially important. We included an inner temperature, humidity, pressure, and a 3 axis accelerometer. The readings we took measured mostly the strain and stress that were put on a payload so that we could have a better understanding of what conditions our equipment would be put through. To hold everything in place we used a softer foam. We selected this for the radio and the batteries. The softer foam has more give and thus keeps shock from being absorbed by the radio and the electronics. One of the most important pieces of the project was the antenna. This keeps signals from being transmitted towards areas where no transmission is necessary.
4.0 Student Involvement

Mesa State’s Demosat team consisted of Francis Behen Computer Science, CJ O’Hara, Kyle Rozen Computer Science, and Ross Young Computer Science. Francis was in charge of the microcontroller, both programming and wiring. Francis was also in charge of chip design. C.J. was in charge of the communications information and data collection and assisted in many other areas. CJ became ham certified for this project. Kyle Rozen was in charge of the antenna and box construction and also helped to solder and create the circuit board. Ross Young assisted in all areas.

5.0 Testing Results (0.5 – 1 page)

Our payload went through a significant amount of testing before launch. We tested each piece of the project individually before adding them to the project. The first test we had to run was the communications test. The first communications test we did involved two computers talking over the radio waves at a distance of about 20 Feet. This proved to us that the two-way communications structure that we had envisioned could in fact be realized. The second communications test involved the chip sending data from a potentiometer which was attached to the Basic X development board. After completing this we attempted to transmit to the MicroController to change duration between transmissions. We were unable, due to a protocol transfer problem, to get this part of our project to function. We decided that, under the time constraints, we wouldn’t have enough resources to complete this portion of the payload and so discontinued it. After we attached our MicroController to the circuit board we attached all of our sensors and programmed the Basic X Stamp to read and transmit data from them. The second area of testing was a sensor/cold test. We placed the payload in a cooler with 5 lbs. of dry ice and turned on the transmit feature. We took internal and external temperatures to get an idea of how much heat was going to be lost at extreme cold. Even as the temperature inside of the cooler reached negatives our project stayed relatively warm. Our cold test/sensor test was a success. All of our equipment stayed within operational temperatures. We decided to add a heater to keep all equipment at optimum temperature. After this we did a whip test to check the 3 axis accelerometer. The numbers that the radio was returning were fluctuating more than the figured amounts so we had to take it out and solder a new connection to stabilize the readings. We repeated the whip test with much better accuracy and were confident that our readings were accurate. The final test we ran was a long distance test. We were transmitting on a low frequency band (440.500) at extra low power, which was lower than our power transmission during flight. We were able to keep connection for in extra low power mode for 6 miles and were able to use a directional antenna to pull in a signal up to 10 miles away. The problem with our distance test was terrain. The only terrain we could find was mountainous and we needed line of site with the payload. Getting even 6 miles in this terrain was an accomplishment. The final distance test was actually performed after the launch took place. We were able to measure signal degradation occurring along a mountainous terrain.
6.0 Mission Results

Though we took many precautions and tested multiple times our project would not transmit data during the flight. After doing continuity checks on everything we discovered the problem. A weak solder snapped before launch creating a protocol breach within the radio transmission system. The receive line was no longer connected to the radio thus causing the radio to think that there was an error. AX 25 communications has a built in error correction mode which sends a short burst of information and expects to see it when it comes back. The problem is that since the receive line had snapped there wasn’t any way to check the data so it figured that there was no connecting computer and thus didn’t need to send data at all. This caused a complete system error and we were unable to receive any ground communications at all. Instead of just riding along in the chase we turned our radio to the EOS GPS frequency and were able to pinpoint the landing spot within a half of a mile. When we found a solution for the problem we experienced we decided to do the distance test (see section 5.0) to get a handle on how far our communications would have lasted. Since we had mountains in the way we were unable to test this exact data but we were able to test signal degradation along a harsh terrain. We found that we dropped signal several times along our path, each time when we went behind a hill or lost line of sight. With a strongly directional antenna we were able to pick up the low level signals and to receive small bursts of data over a 10 mile area.
Conclusions

Though our payload did not function the way we wanted it to we did discover interesting facts about ground level long distance communications. We found some solutions to problems we had in the field (changing antennas from an Omni-directional to a directional for instance) and with increased signal strength we would have been able to communicate over a much greater distance. Our working product could be very important to future demosat projects. We could take any number of readings and apply communications software to them so that the person operating the payload could get instant feedback on a project’s status.

Potential Follow-on Work

The Tx Sat payload is one that could be continued and used in different ways for future projects. This protocol could be used to send pictures directly from a digital camera or many other functions. A better board design and stronger solders would be ideal for future projects. The entire problem with this years attempt was one weak wire. Another improvement we would like to make next time is the ability to send as well as receive and the ability to incorporate our own GPS unit into the project. Any number of readings could be applied to this project and next time we also plan to take more interesting readings.

Benefits to NASA and Scientific Community

Our first project was simply to measure signal degradation over an area of 20 miles. Since our project didn’t transmit during flight we did our own test. The benefits to NASA and the scientific community includes the ability to transmit over a rough terrain picking up connections after a disconnect. This would benefit NASA for distanced communications over a rough terrain. At a little higher power you could use a similar set up to send pictures and readings from a rover to a landing station where the data could be re-transmitted to earth. Using AX25 communications you can transmit large amounts of data in a relatively short amount of time.

Lessons Learned (0.5 to 1 page)

The most important lesson that we learned was to double check every connection directly before launch. Had we done this we may have been able to fix the problem. Doing a continuity check before launch would have saved us a lot of trouble.