

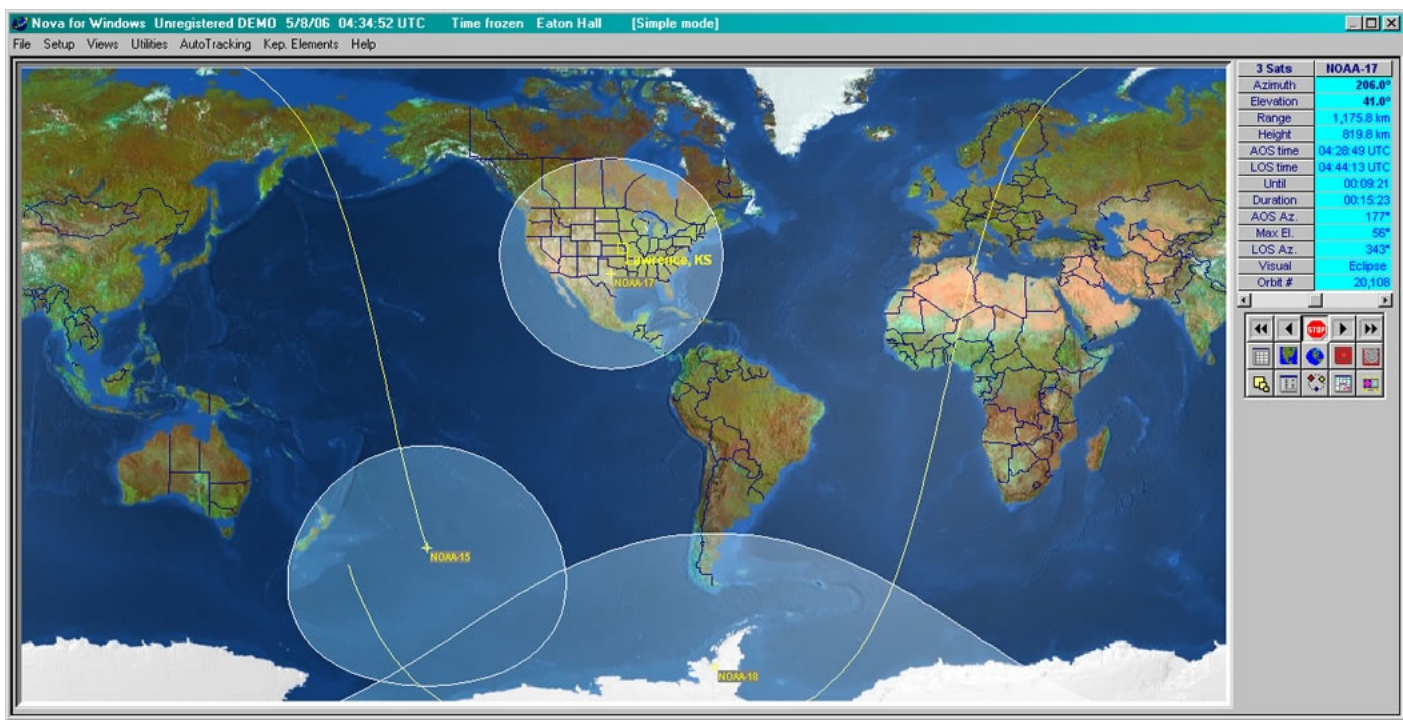
# NOAA Weather Satellite Imaging

EECS 502 Senior Design Team, 2006

Bill Dower  
Eric Mbaka  
Mark Roland  
Vijo Varghese



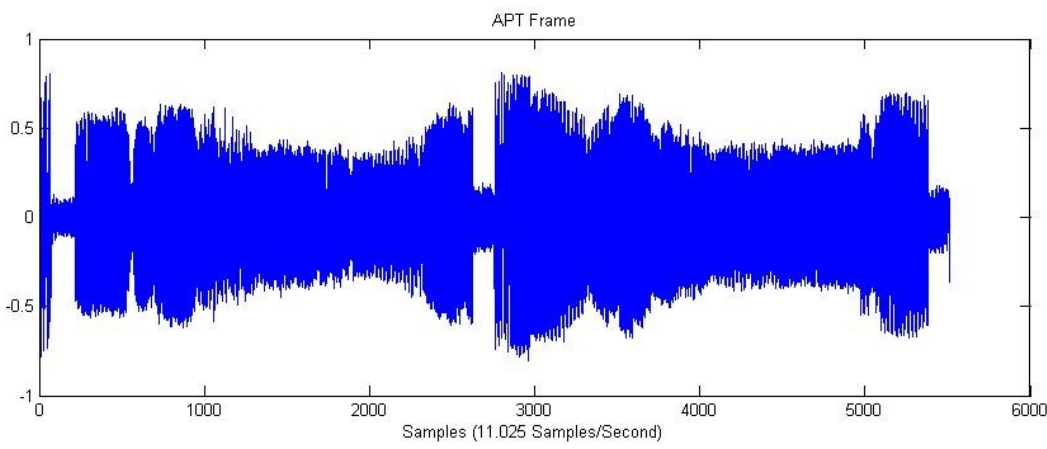
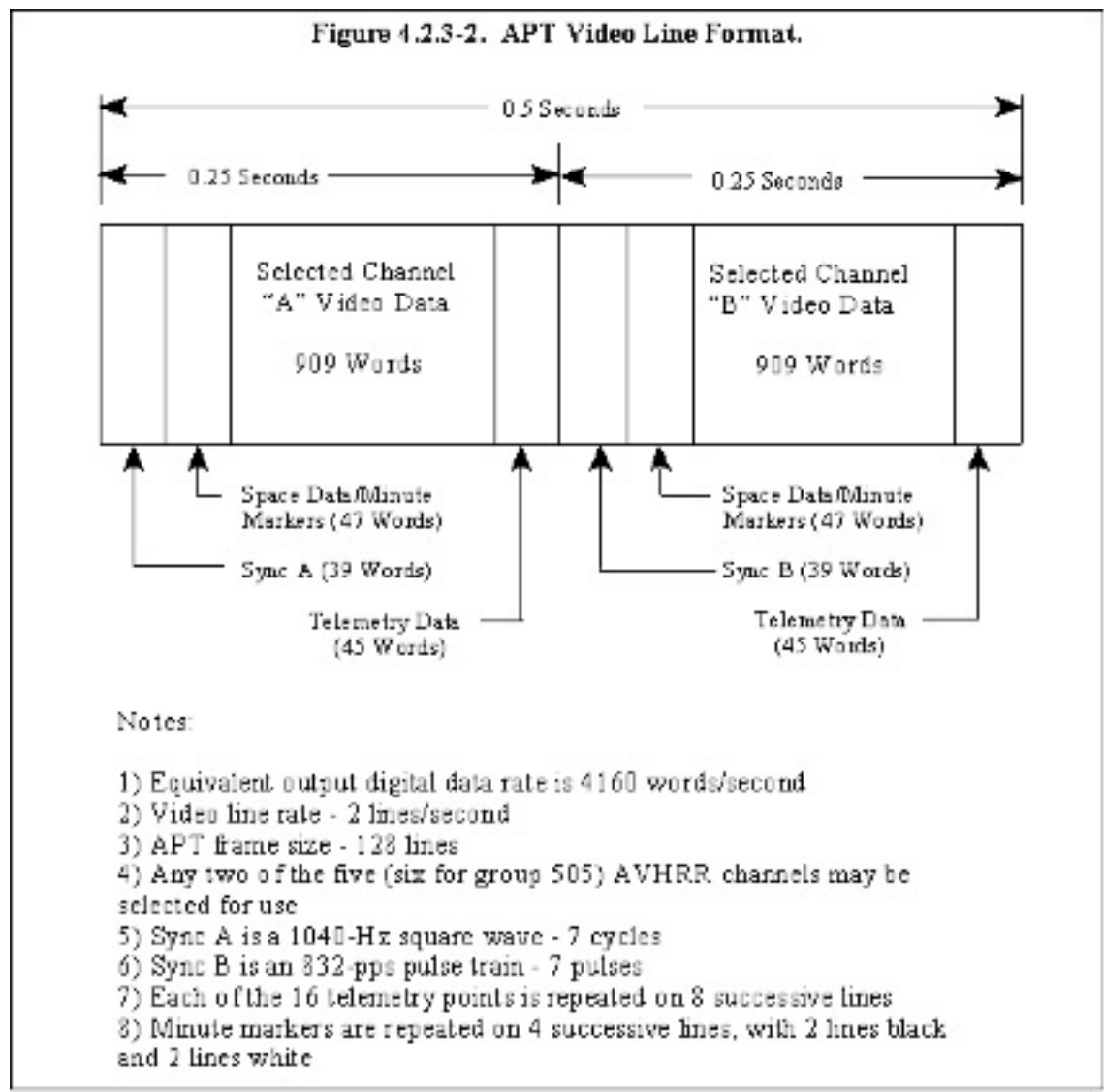
The control station was located indoors beneath the antenna. At the control station, the coaxial line coming from the antenna was connected to a receiver designed especially for the NOAA weather satellite bands. The receiver used here was the Hamtronics R139 Weather Fax Receiver. This receiver has 5 different frequencies that are tuned to receive signals from NOAA 15, 17, and 18. The receiver performs FM demodulation and provides an output to a speaker and a mono input jack that may be plugged into a sound card. Free software called “Nova” was used to track the satelllites so that it would be known when a satellite was overhead and recordings could be made.



Screenshot from Nova satellite tracking software

## Signal Processing

The audio that comes out of the receiver is in the Automatic Picture Transmission (APT) format. This signal is constructed as the satellite flies overhead and scans the strip of Earth directly below. The satellite then turns what it sees into an amplitude modulated signal. It takes the satellite half of a second to scan one strip, and the satellite transmits these strips continuously. Each strip contains two images; one image is composed from the visible spectrum and the other is composed from the infrared spectrum. In addition to the picture, each frame contains

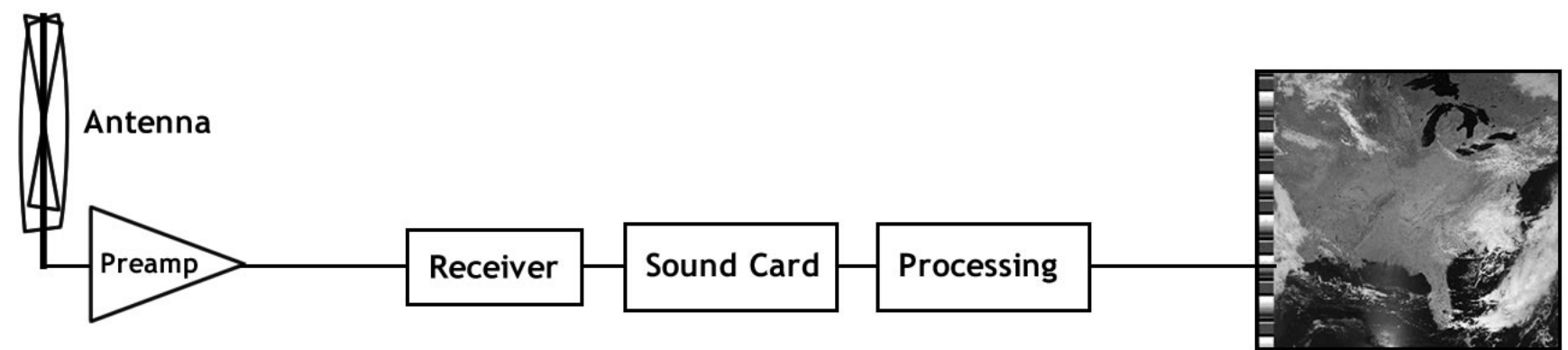


ABOVE: Audio waveform from one frame of an APT signal lasting exactly half of a second

LEFT: The technical specifications for the APT Video Line Format as provided in the NOAA KLM user's maunaul

## Project Overview

The goal of this project was to build a weather station capable of receiving and processing weather imaging data from the National Oceanic and Atmospheric Administration’s Polar Operational Environmental Satellites. This project is a unique development in the weather satellite imaging field because the signal processing was accomplished by writing open source code that will allow future weather hobbyists to better understand the translation of audio to image.

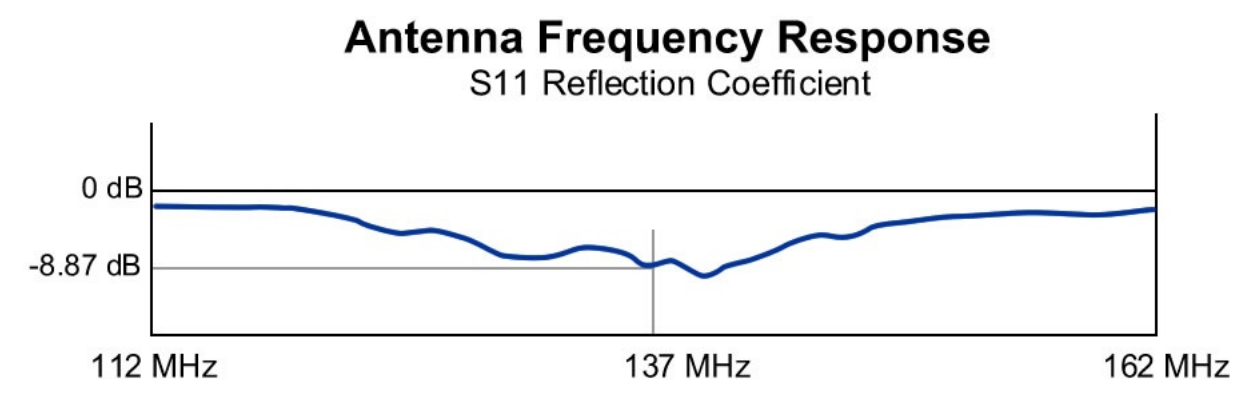


## Receiving

In order to receive the signals sent from the satellites an antenna with a resonant frequency of 137 MHz must be attached to the receiver. One antenna design that is particularly suited to this application because it can receive signals from any position in the sky without a tracking mechanism is the quadrifilar helix antenna. This antenna is composed of two loops in quadrature phase and can be constructed using common components from a hardware store like copper tubing, PVC pipe, and coaxial cable. A preamp was placed at the base of the antenna in order to boost the signal strength before being sent through a long length of coaxial cable to the control station.



Mark Roland, Eric Mbaka, Vijo Varghese, Bill Dower with the Quadrifilar Helix Antenna atop Eaton Hall.

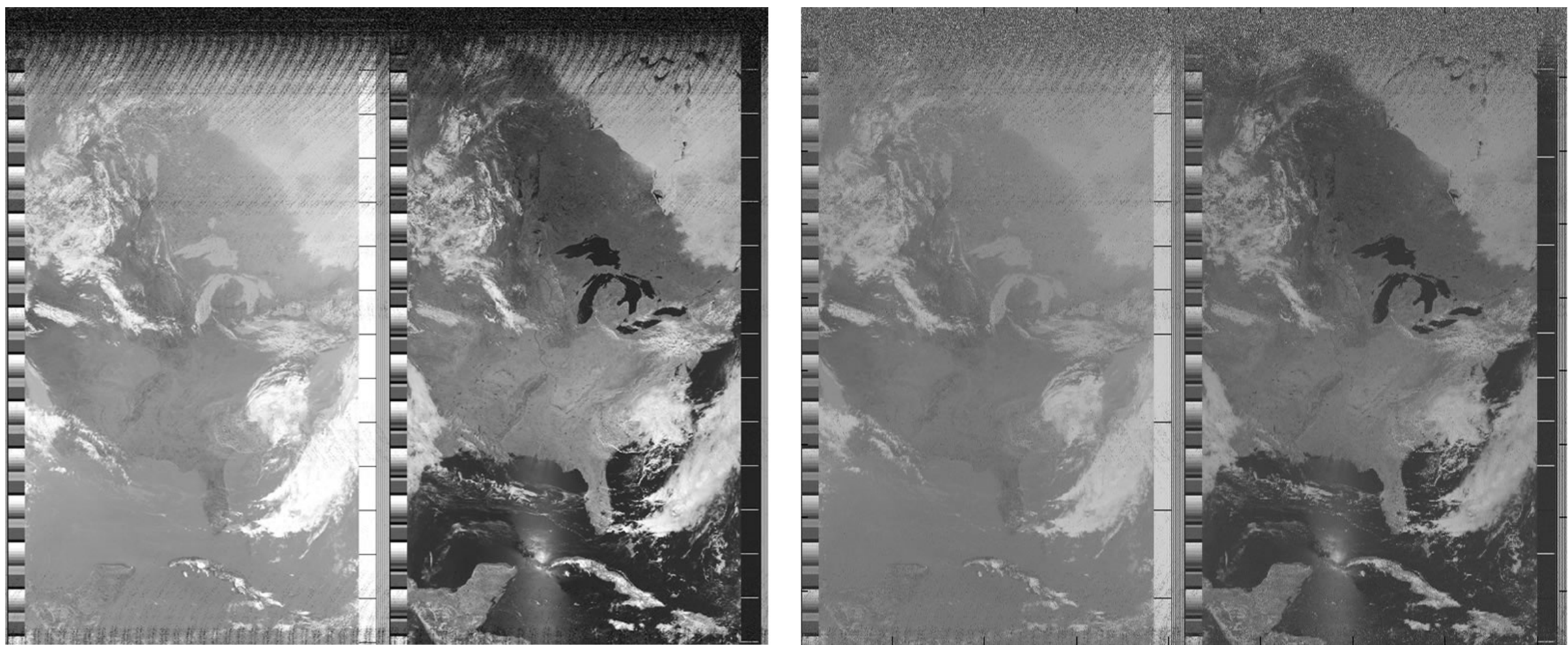
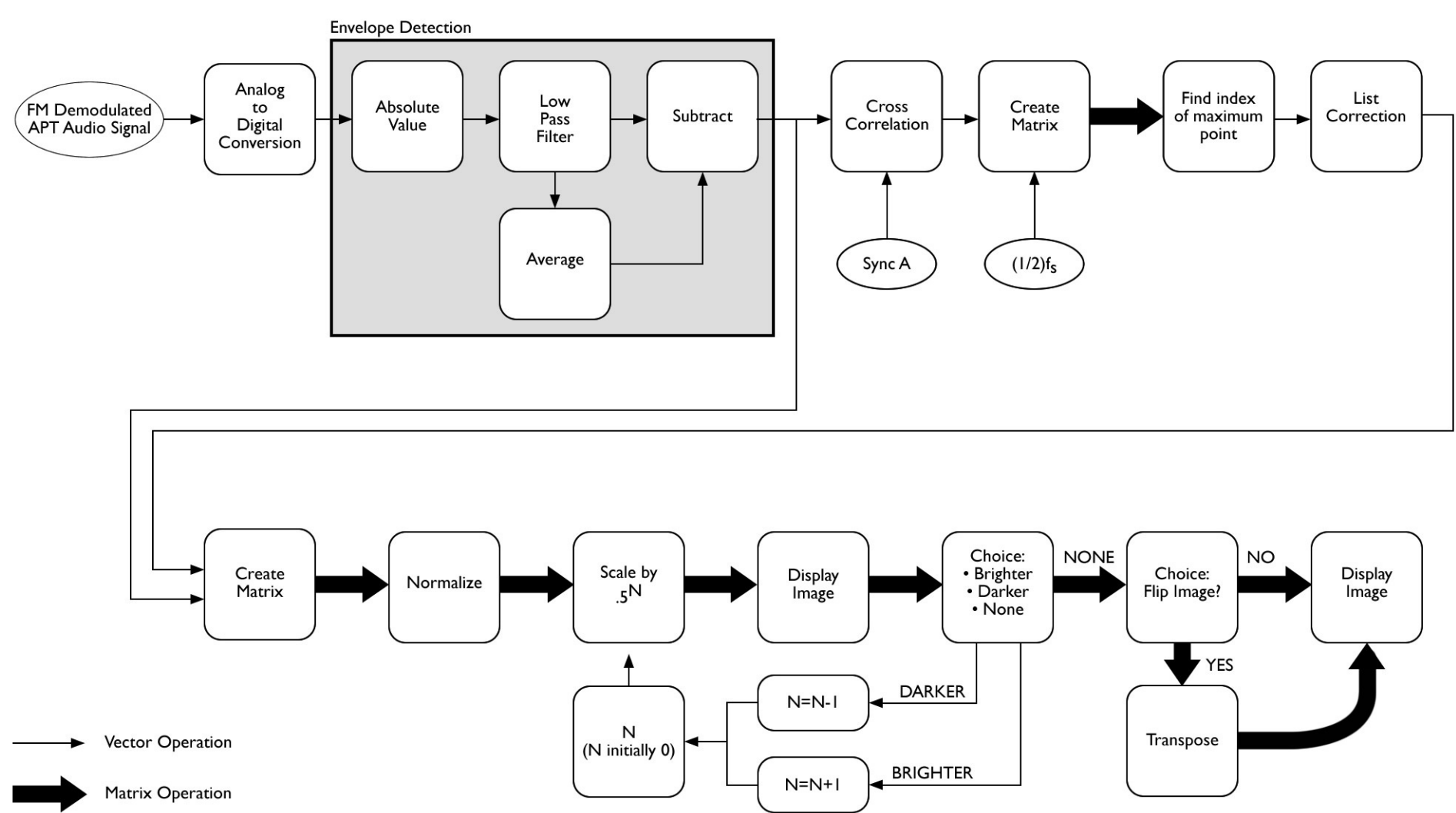


This graph shows that there is a dip in reflected power at 137MHz and that the antenna was successfully built to receive the desired signals.

synchronization pulses, telemetry data and minute markers. These extra data markers can be used for map overlays and thermal imaging. Signals can be received as long as the satellite is above the horizon and within line of sight at the receiving station. Reception time can last up to 15 minutes and provide an image covering from Cuba to Canada and more than half the width of the United States.

There is a variety of ways to decode the APT signal. Free software exists for this purpose, however the programs offer no insight into the decoding process. This weather station uses a custom programmed decoding process that has been implemented in the MATLAB programming environment.

To begin the decoding process the signal is imported into MATLAB as a .wav file recorded at a 11.025 kHz sampling rate. Next, the envelope is extracted from the AM audio signal; this new signal is a vector that contains the information in its most raw form. This signal is cross-correlated with a generated waveform that matches the APT Sync A specifications. The result of the correlation is a vector with maximum values located at the beginning of each APT frame and is used to turn the data vector into a data matrix. After normalizing the data matrix to 255, MATLAB functions are used to display the matrix as an 8-bit greyscale image.



These are decoded APT images that clearly display the eastern portion of the United States. The left image was decoded using WXtoImg Software. The right image was decoded using a custom process in MATLAB. As you can see they are almost perfectly identical.

At this point a few more steps are included to optimize the image. For several reasons like the position of the sun and cloud cover, the image may not have adequate contrast. Our program provides an opportunity for the user to adjust the contrast. Finally, since it is possible for satellites to travel south-to-north the image may come out “upside down”, so one last prompt is given so that the user may flip the image.

## Summary

The goal of this project was to build a weather station capable of receiving and decoding satellite images from the NOAA POE satellites without using closed-source software. Several challenges were overcome during this project including antenna construction, a mechanically failing pre-amp, demodulating the the AM signal, and seperating the vector data into a coherent matrix. By comparing the images generated from a closed-source software program and this project’s MATLAB process, it can be concluded that this project successfully met its goals.

## Weather Satellite Imaging Resources

GEOS POES Program (<http://goespoes.gsfc.nasa.gov/poes/index.html>)  
NOAA KLM User’s Guide (<http://www2.ncdc.noaa.gov/docs/klm/html/c4/sec4-2.ht>)  
Nova Satellite Tracking Software (<http://www.nlsa.com>)  
WXtoImg Software (<http://www.wxtoimg.com>)  
WXSat Software (<http://www.hffax.de>)  
QFH Antenna Design ([http://perso.wanadoo.es/dimoni/ant\\_qha.htm](http://perso.wanadoo.es/dimoni/ant_qha.htm))  
Entire Project Findings at <http://www.markroland.com/APT>

