Receive Only Earth Station

Team Eagle Eye

Overview

- Team Roles
- System Concept
- System Architecture
- Major Subsystems
- Lessons Learned

Team Roles

Leslie Brabham – EE - Project Leader

Joshua Pyles – EE - Motor Control Team Lead

Richard Tubbesing – EE - Motor Control Team

Richard Day – EE - Feed Team Lead

Anthony Bonds – EE - Feed Team

David Franklin – SE - Software Team Lead

Matthew Alombro – EE - Software Team

Learning Outcomes:

LO D

System Concept

- Eagle Eye Receive Only Earth Station
  - Monitor, Track and Identify Satellites Based Upon Signal Spectra
  - Ability to download and save received satellite spectra
  - Will NOT transmit or upload data to satellites
  - Modular capability

Learning Outcomes:

LO C

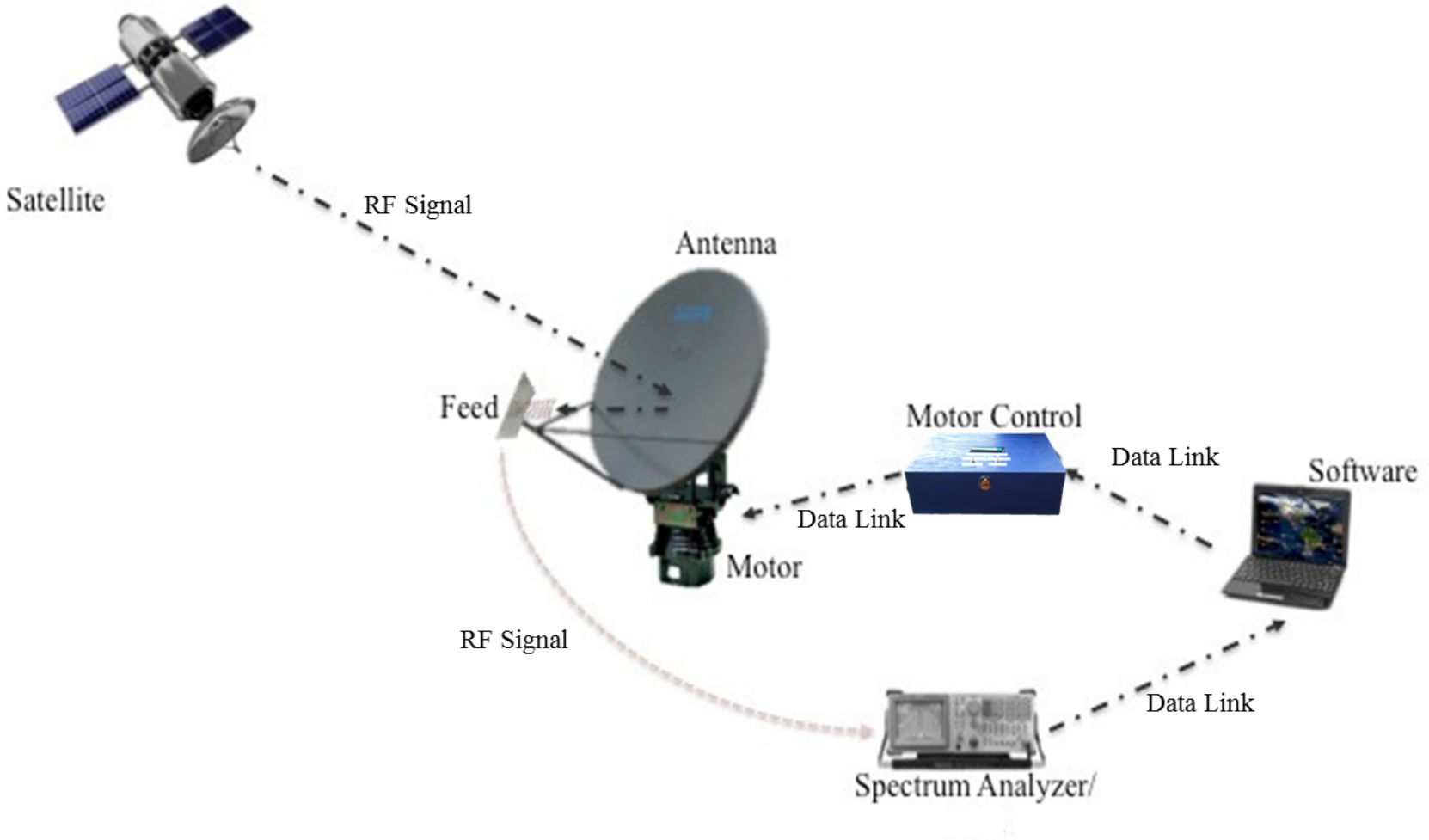
LO E

LO F

LO H

LO I

System Architecture



Major Subsystems

Motor Control

- Control the movement and direction of the Yaseu motor with a micro-controller

Software

- Links the user and motor control in deciding the dish antenna direction

Feed

- Successfully receive a satellite signal for future engineering applications

Motor Control

Motor Control: Overview

Major Components:

- Yaesu G-5500 rotator control box or the Original Control Unit (OCU)
- K3NG rotator controller based off of an Arduino Mega
- Two, alternating current, single phase motors

Prime Focus:

- Integrate the OCU with the K3NG controller to allow a personal computer (PC) running orbit modelling software to control the azimuth (AZ) and elevation (EL) of the dish using feedback.

Motor Control: Major Decisions

- Type of controller:
  - Initially bought microcontroller and circuit board
    - Microcontroller had code flashed onto it
    - Printed Circuit Board had foot prints for component placement
  - Microcontroller and printed circuit board idea was abandoned
    - Instead:
      - Open sourced code
      - Arduino

Motor Control: Major Decisions continued

- Type of variable speed controller design
  - A speed controller that chops the frequencies
    - Cant use basic components
    - Advanced controller is expensive and too time consuming to build
  - Attenuate the input voltage
    - Variable transformers cost to much
    - Cheapest and fastest way to attenuate is to use resistors

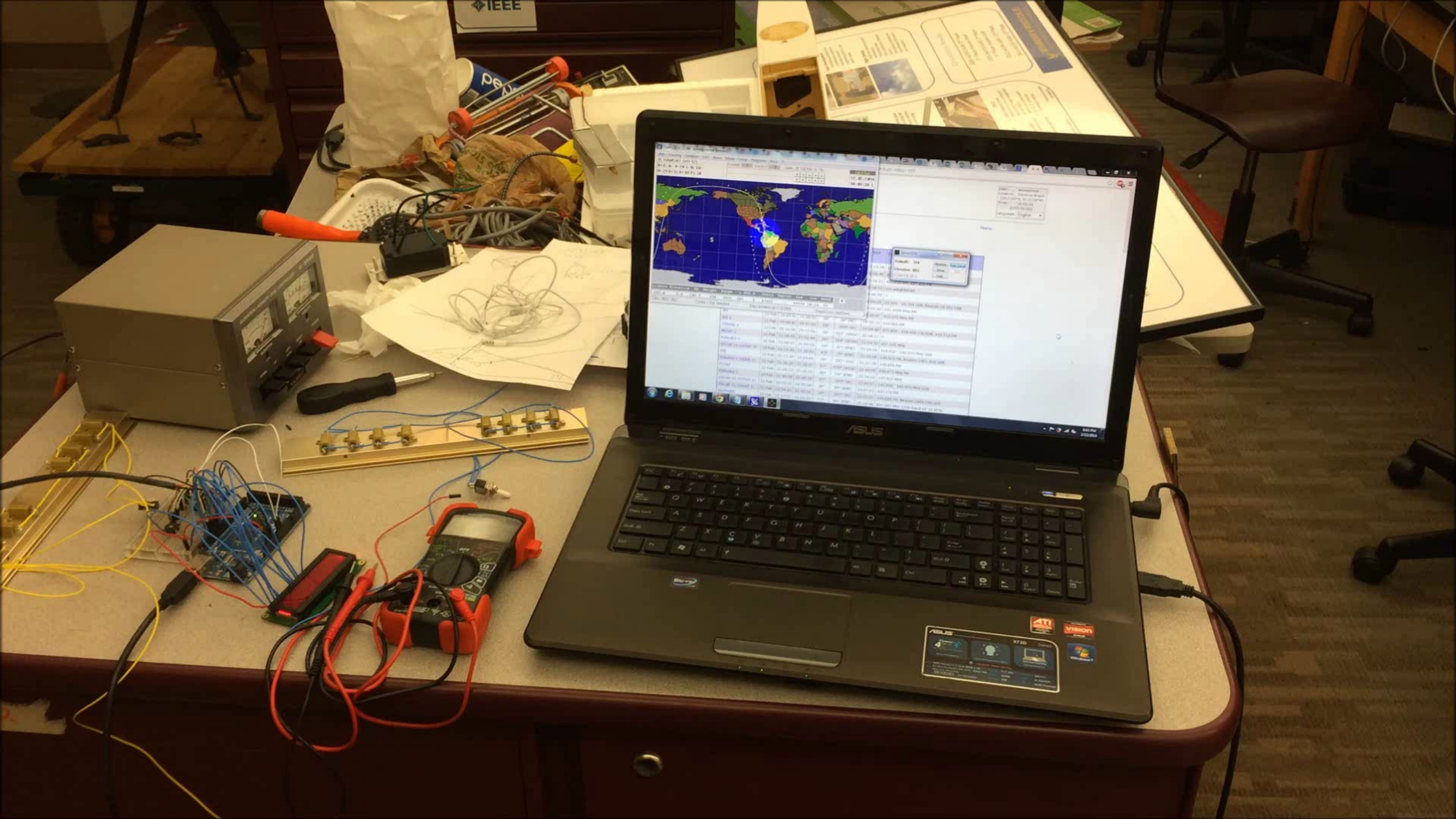
Motor Control: Testing & results

Testing

- Motors controllable via PC
- Tracking
- Speed Control

Results

- Motor direction controlled via serial commands from personal computer
- Dish AZ and EL position successfully controlled by orbit modeling software
- Motor slew rate slowed via two toggle switches one for AZ and one for EL



Motor Control: Budget

Component	Price	Requested to Buy	Requested Cost	Description
VK5DJ Components (not used)	$218.95	1	$218.95	Original Microcontroller
Arduino Mega 2560	$50.00	0	$0.00	Microcontroller
LSM303DLM	$10.00	1	$10.00	Accelerometer/Magnetometer board
Resistors	$1.06	0	$0.00	5 ohm, 5 watt
LCD	$20.00	0	$0.00	2 row, 16 column
Motors	$640.00	0	$0.00	Azimuth and Elevation Rotators
Total:			$228.95	

Motor Control: Lessons Learned

- Thoroughly research for possible solutions before moving forward
- When planning on using an existing design, see if the source code is available
- Avoid ordering parts from overseas when possible
- Apply “Engineering Factor” when budgeting time
  - Learned to be about a factor of three for motor control

Software

Learning Outcome:

LO L

Software Overview:

Three major components:

Graphical User Interface

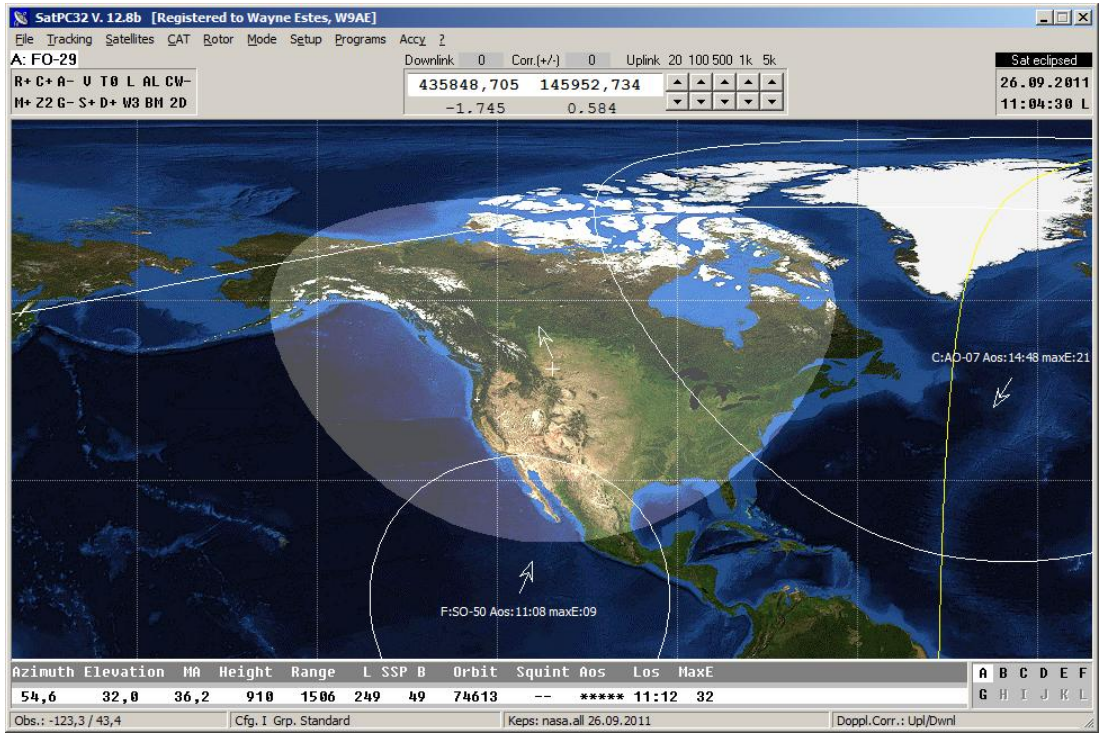
- Current Available Satellites

SATPC32

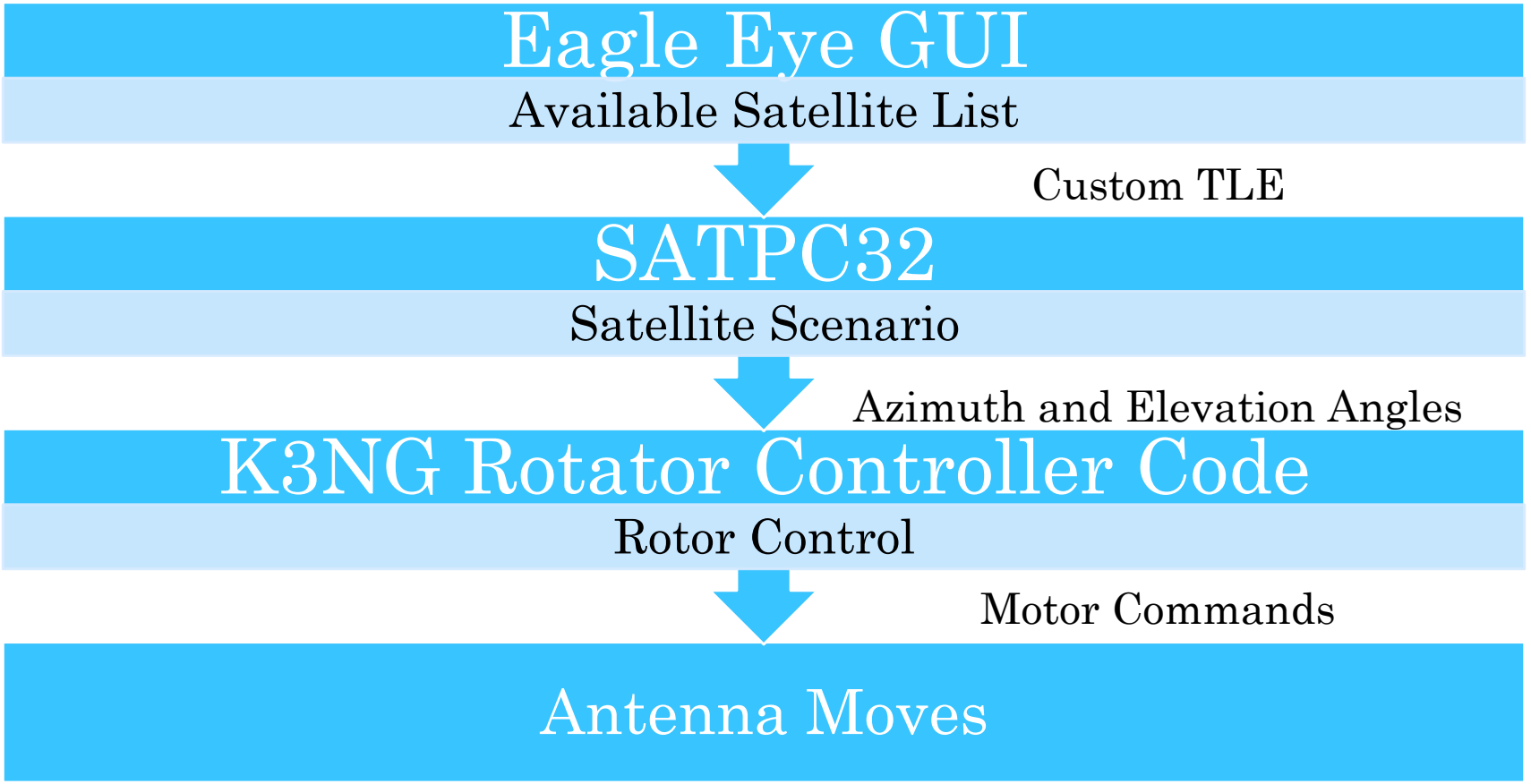
- Orbit Modeling Software

K3NG Rotator Controller Code

- Motor Control/Command



Software Flow:



Software: Major Decisions

Orbit modeling software:

- Orbitron to SATPC32

Software: Testing & Results

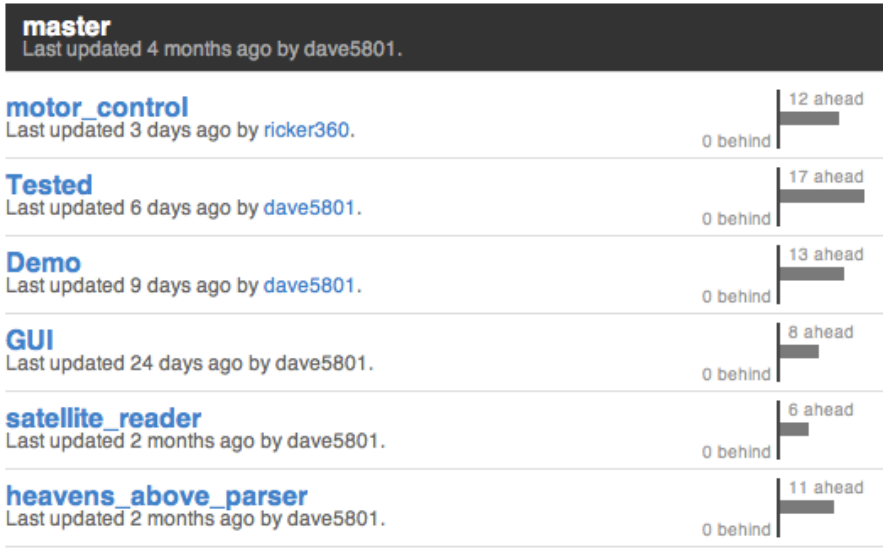
- Blackbox testing
  - Limited user input
  - User selects button, then check for desired results
- Code walkthroughs
  - Conducted with members of Team Birdinator
  - Identified key errors
  - Satellites were not being properly matched with TLE
  - TLE file was not being written correctly to SATPC32
- Results
  - Satellites properly matched with TLE master list
  - TLE file written successfully to SATPC32
  - SATPC32 opens directly to Satellite selection (user does not have to go searching)
  - Motor control performs as expected

Software Budget

Component	Price	Requesting to Buy	Requested Cost	Manufacturer	Part Number	Description
SATPC32 Software	$50.00	0	$0.00	Erich Eichmann	N/A	Satellite Tracking Software
Personal computer	$1000.00	0	$0.00	N/A		A Portable Computer
Total Software Budget			$0.00			

Software: Lessons Learned

- Code inspections are critical
- Coordinate testing with other components
- Overlooked logistical constraints: Internet connectivity requirement
- Version control: branching
  - Better to create branches based on specific purpose instead of individual classes

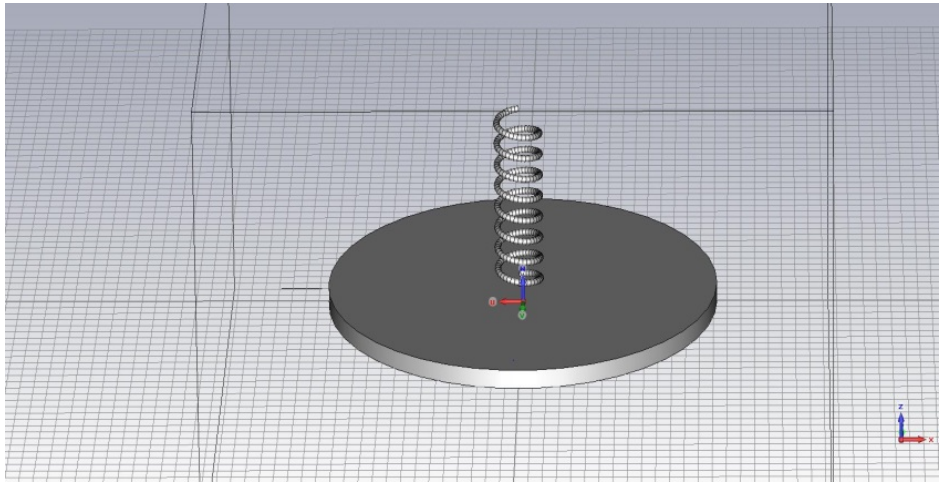


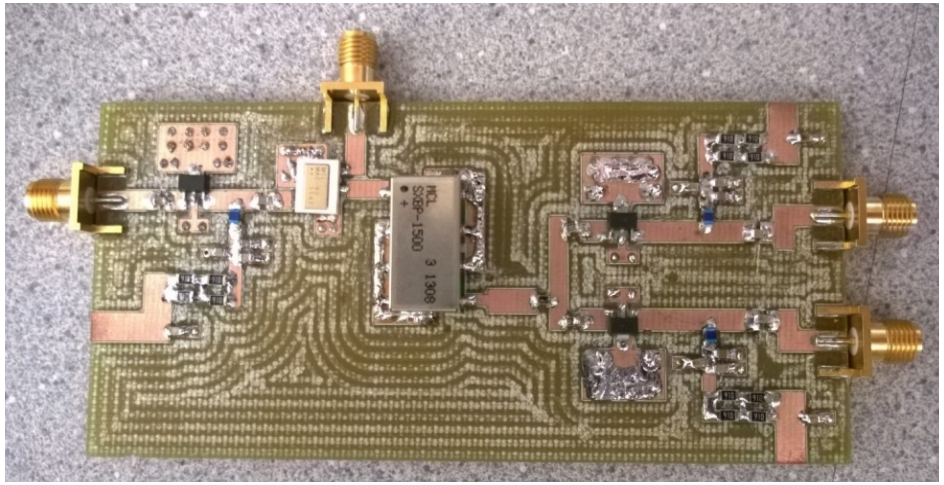
Feed

Feed Overview:

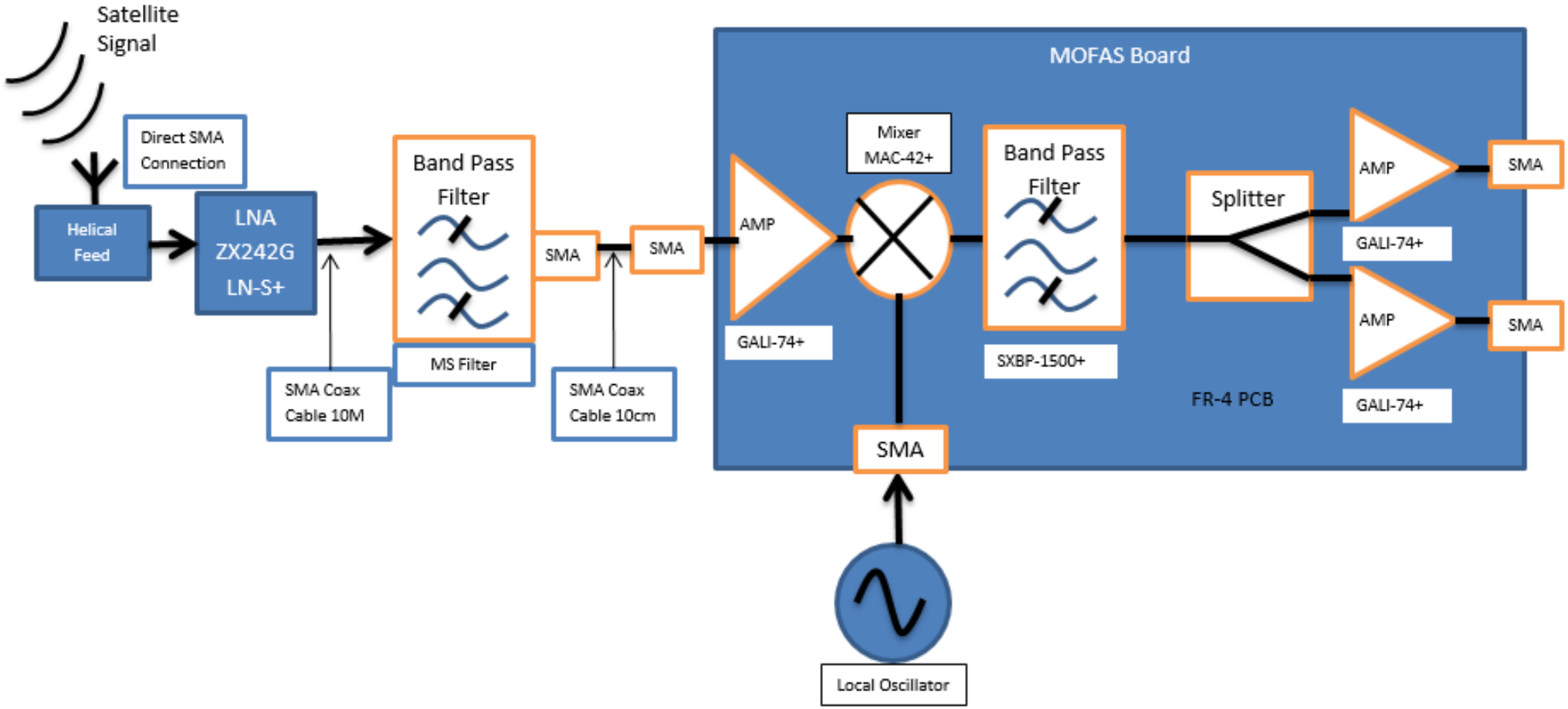
Major Components:

- Feed Antenna
- Downconverter
- Coaxial cable





Feed: System Block Diagram



Feed: Major Decisions

- Feed type:
  - Helix, Horn, Patch, septum
- Frequency of interest:
  - 2.25 GHz with a 10 Mhz bandwidth
- Quality of components:
  - Bad quality introduces loss
  - Components must be cost effective

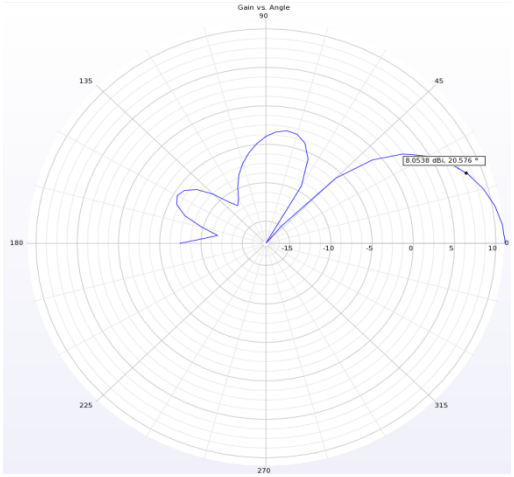
Decision Factor		Horn Feed	Helical Feed	Patch Feed	Septum Feed
Criteria	Wt	Rating			
Cost	3	1	3	3	1
Durability	3	2	1	2	2
Size	1	2	1	3	2
Implementation	3	1	3	2	1
Ease of Design	3	2	3	2	1
Bandwidth	2	1	3	2	1
Radiation Pattern	2	1	3	2	1
Directivity	3	3	2	1	3
Weighted Scores		33	**49**	41	30

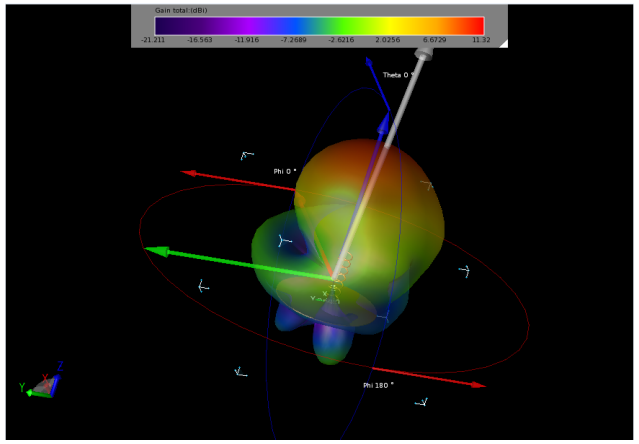
Which Feed antenna to build?
The feed shall be versatile and allow a wide range of frequencies to be received. It will also connect to the offset arm focused directly at the dish.
▶**Winner: Helical Feed**

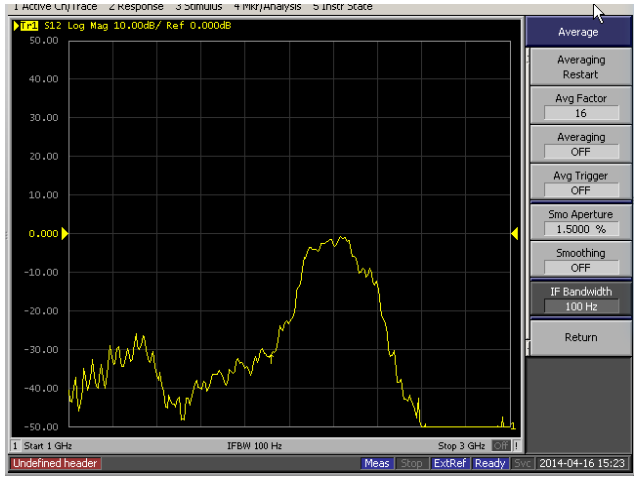
Criteria	Definition
Cost	The overall price of materials and design expenditures needed to produce a working feed
Durability	The feed's ability to withstand outdoor conditions
Size	The overall dimensions of the finished working product
Implementation	How easy is it to integrate the subsystem into the larger macrosystem
Ease of Design	The amount of calculations and parameter needed to implement the feed design
Bandwidth	The range of frequencies the feed can handle
Radiation Pattern	How well the feed antenna can receive signals
Directivity	How well is the beam focused
Weighted Scores	The weight ranges from one to three with 1 as the least important to 3 as most important. These values are a relationship between the weights of each criterion. The rating weights each option against each other for each criterion with 0 as poor and 3 as great. The weighted score is the sum-product of each decision factor.

Feed: Testing & Results

- Simulation Parameters
- Y-Factor Testing
- Radiation Pattern Testing
- Component Gain/Loss
- System Noise Temperature







Learning Outcomes:

LO A

LO B

LO K

Part Number	Distributor	Designator	Part Type	Description	Unit Cost	Qty	Sub Cost	
3DXJ9	Grainger	HVAC Tubing	Cap tube	Copper tube, 12 ft	$18.71	1	18.71	
ACX2079-ND	Digikey	Coaxial SMA Connector	SMA elbow	90 degree angle SMA connector	$9.94	4	$39.76	
311-91ERCT-ND	Digikey	Yageo RC1206JR-0791 RL	Resistor	91 Ohm 1/4w 1206 size	$0.01	100	$1.00	
409-5651-1-ND	Digikey	Murata LQW2BAS18N J00L	Inductor	18 nh SR @ 3.1 GHz 0806 size	$0.39	25	$9.75	
409-5654-1-ND	Digikey	Murata LQW2BAS27N J00L	Inductor	27 nh SR @ 2.6 GHz 0806 size	$0.39	25	$9.75	
SXBP-1500+	Minicircuits	Bandpass Filter	Filter	Bandpass filter 1350MHz to 1650 MHz	$17.95	1	$17.95	
MAC-42+	Minicircuits	Frequency Mixer	Mixer	Mixer 300 MHz to 12 GHz, LO levels 4 to 17 dBm	$6.95	10	$69.50	min order
GALI-74+	Minicircuits	Monolithic Amplifiter	Amplifier	3 dB Amplifier	$2.35	20	$47.00	min order
LSM303DLM	Pololu	Accelerometer	Accelerometer	Compass and Accelerometer Carrier w/ voltage regulators	$9.95	1	$9.95	
709-1111-ND	Digikey	Johanson DIGI-805	capaciter kit	capacitor kit all 0805	$54.00	1	$54.00	
473-1005-ND	Digikey	MG Chemicals	FR4 board	12"x12" 60 mil FR4 board	$18.00	1	$18.00	Provided to us
j502-ND	Digikey	Emerson	SMA connector	pcb mount SMA connector	$5.00	6	$30.00	Provide to us
CC174S-3	L-COM	RG174 Coaxial Cable	Coaxial Cable	RG174 SMA Male/ Male 3ft	$20.15	4	$80.60	
-	Rogers Corporation	RO4003 Dielectric Material	Roger 4003 Dielectric	Dielectric Material	-	-	-	Provided to us
ZX242G LN-S+		LNA	Low-Noise Amplifier		$49.99	1	$49.99	Provided to us

Feed Budget

Additional items:

- Spectrum Analyzer - $2,700.00 (Borrowed from school)
- VNA - $12,000 (Utilized for Testing)
- HP8656B Signal Generator - $700 (Borrowed from school)

Total Cost excluding items above: ***$405.97***

Feed: Lessons Learned

- Start with key values needed and design system around that
- Understand system as a whole, what is needed to get signal from one end to the other
- Know how to read equipment properly
- Know what to expect
- Testing testing testing

ROES: Demo Day

- Pointed Antenna to XM Satellite
- Signal Spectra Confirmed

Lessons Learned & Improvements for Future

Lessons Learned:

- Thorough Antenna Background
- Integrated System Testing

Improvements for Future:

- Permanent Antenna Location
- Accessibility to Test equipment

Thank You

- Dr. Helfrick
- Dr. Barott
- Dr. Seker
- Jorge Torres
- Mr. Potash
- Fellow Capstone Students

Questions?