

# Space Operations Center at Montana State University

Team Lead: Keith Mashburn





# Overview



- Share knowledge and experiences of ground station design
- Discuss various regulatory procedures and timeline
- Briefly discuss our equipment selections and layout
- Discuss ground station testing options and availability



# Mission Statement



- To provide an adequate communications link to command and control amateur satellites as they orbit the Earth
- To receive, process, and store satellite data for future decoding and analysis
- To use commercially manufactured amateur radio equipment and accessories
- To establish an environment in which anyone can understand and take part in satellite communications



# Regulations



## International Telecommunications Union

- Complete 27 month notification for space communications **2 MONTHS**
- Complete 5 month notification to update satellite status **1 WEEK**

## International Amateur Radio Union

- Complete application for satellite frequency coordination **1 MONTH**
- Allow ample time for IARU processing and modifications **2.5 YEARS**

## University Policy

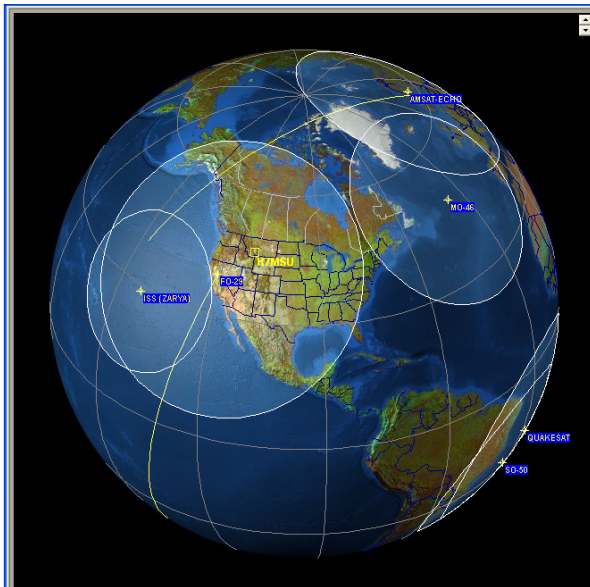
- Complete application for antenna/tower placement **6 MONTHS**
- Coordinate with Facilities Planning Committee for approval **1 YEAR**



# Functions



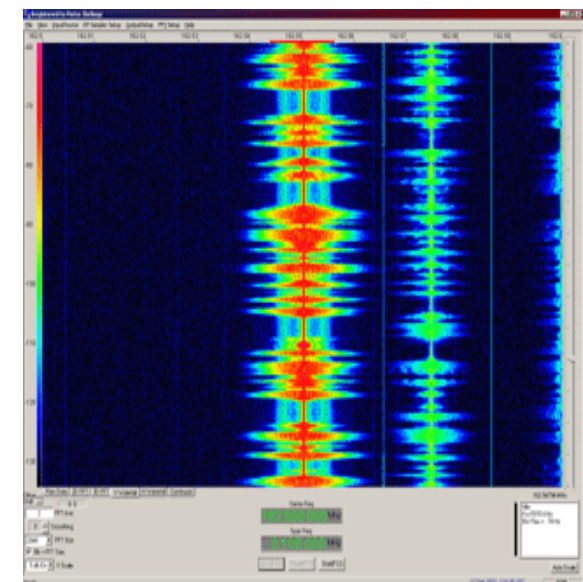
## Orbital Prediction



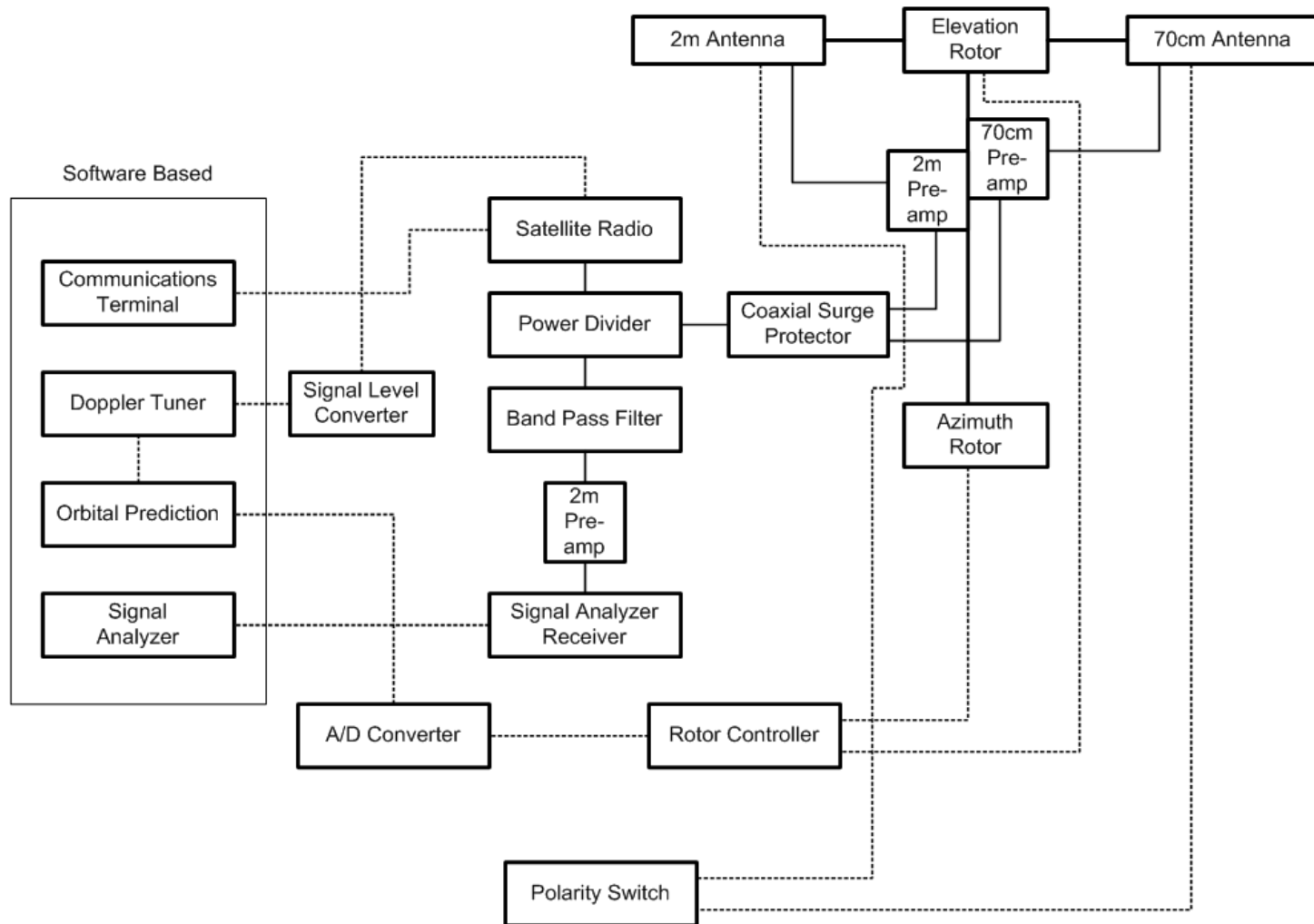
## Satellite Control



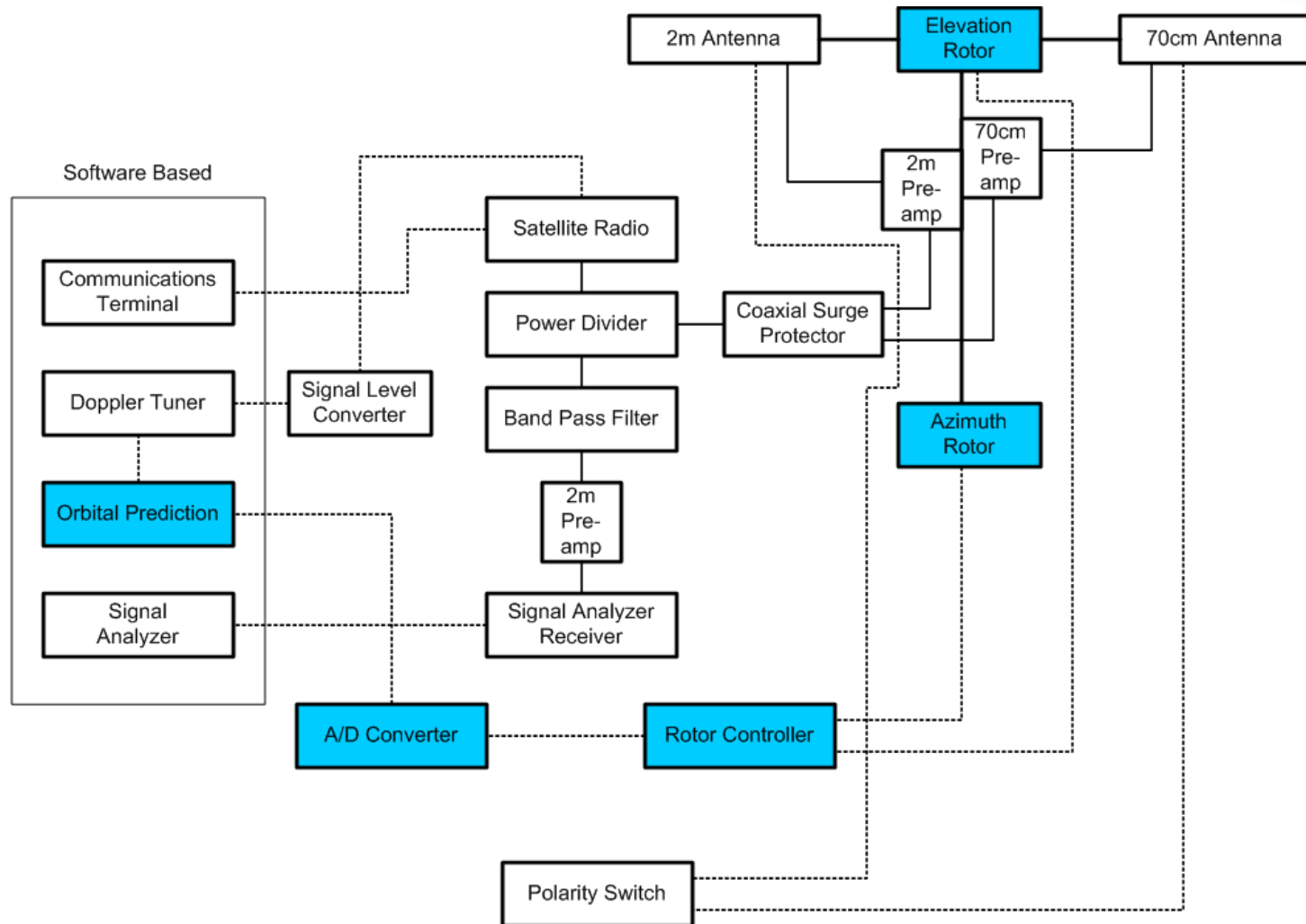
## Signal Analysis



# Station Layout

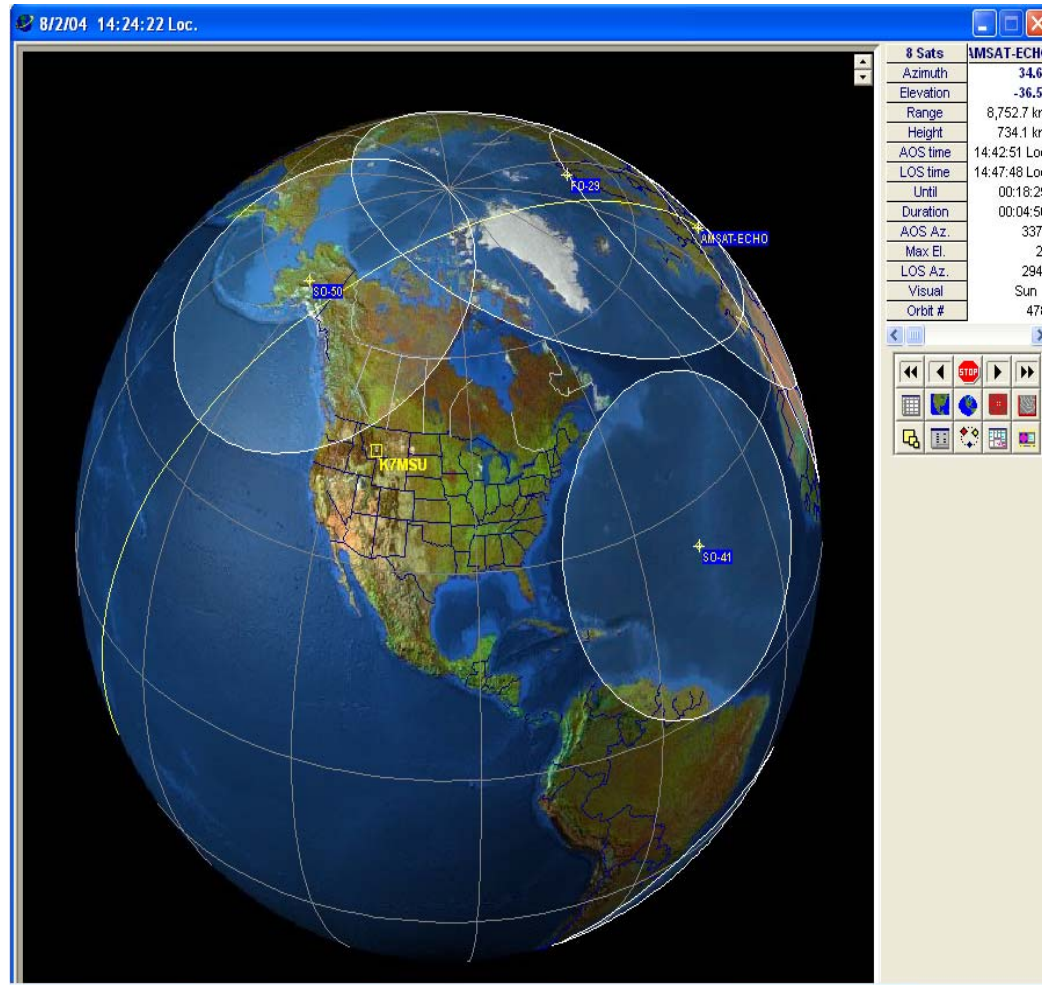


# Orbital Prediction





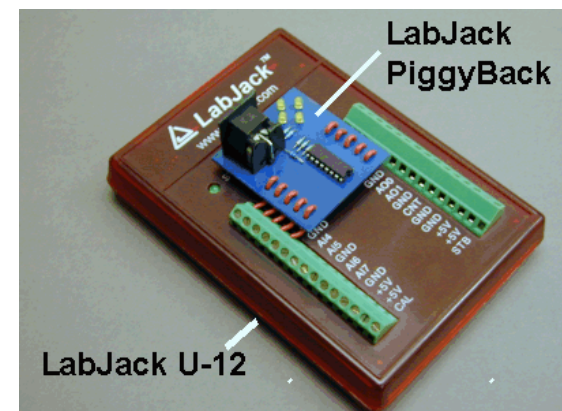
# Orbital Prediction



Nova for Windows

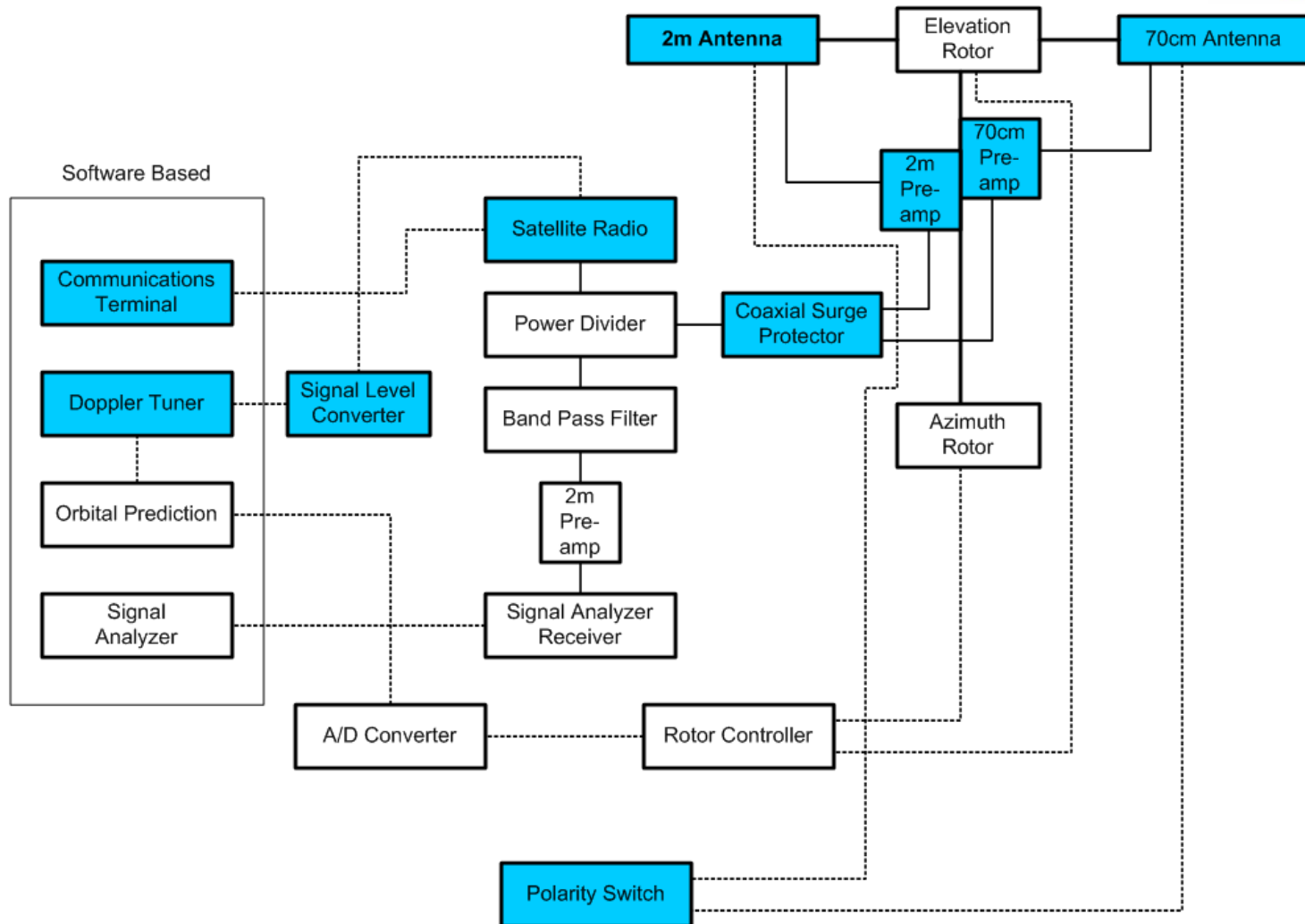


Yaesu G-5500 Rotor





# Satellite Control





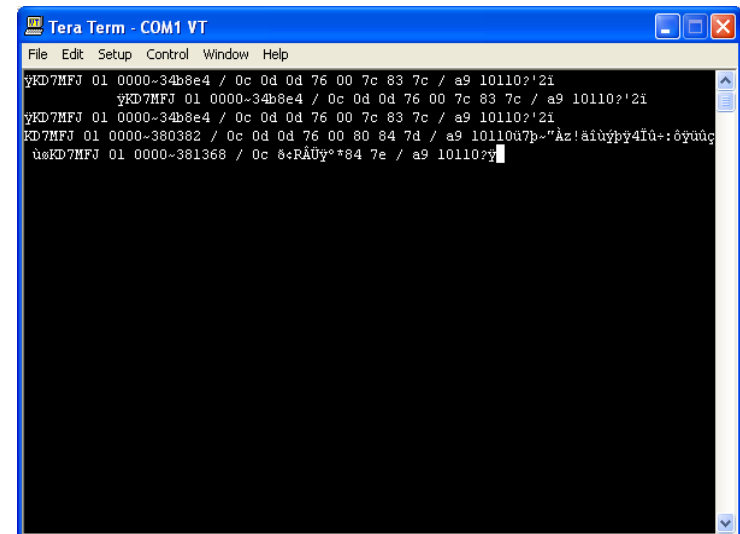
# Satellite Control



M<sup>2</sup> Antennas with Icom Preamps

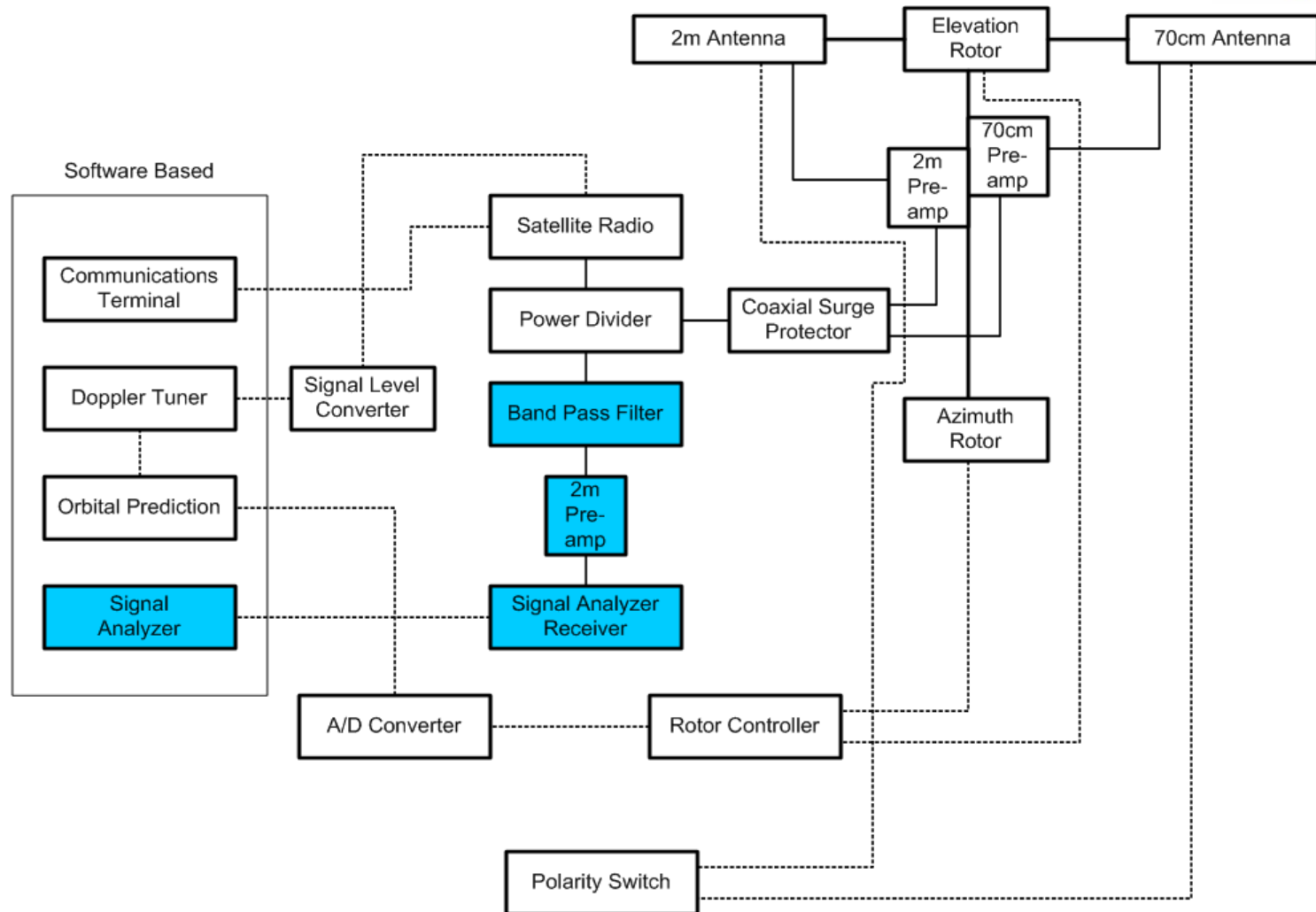


Icom 910-H Satellite Radio



TeraTerm Terminal Program

# Signal Analysis



# Signal Analysis



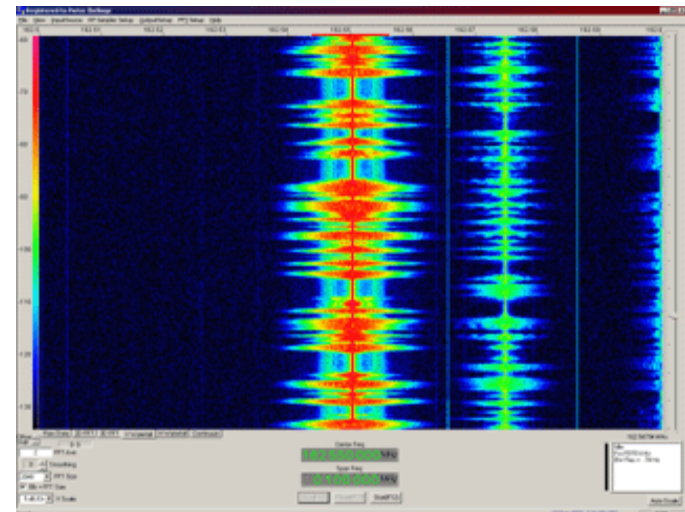
Band Pass Filter



SDR-14 Radio Receiver



Preamp



SpectraVue

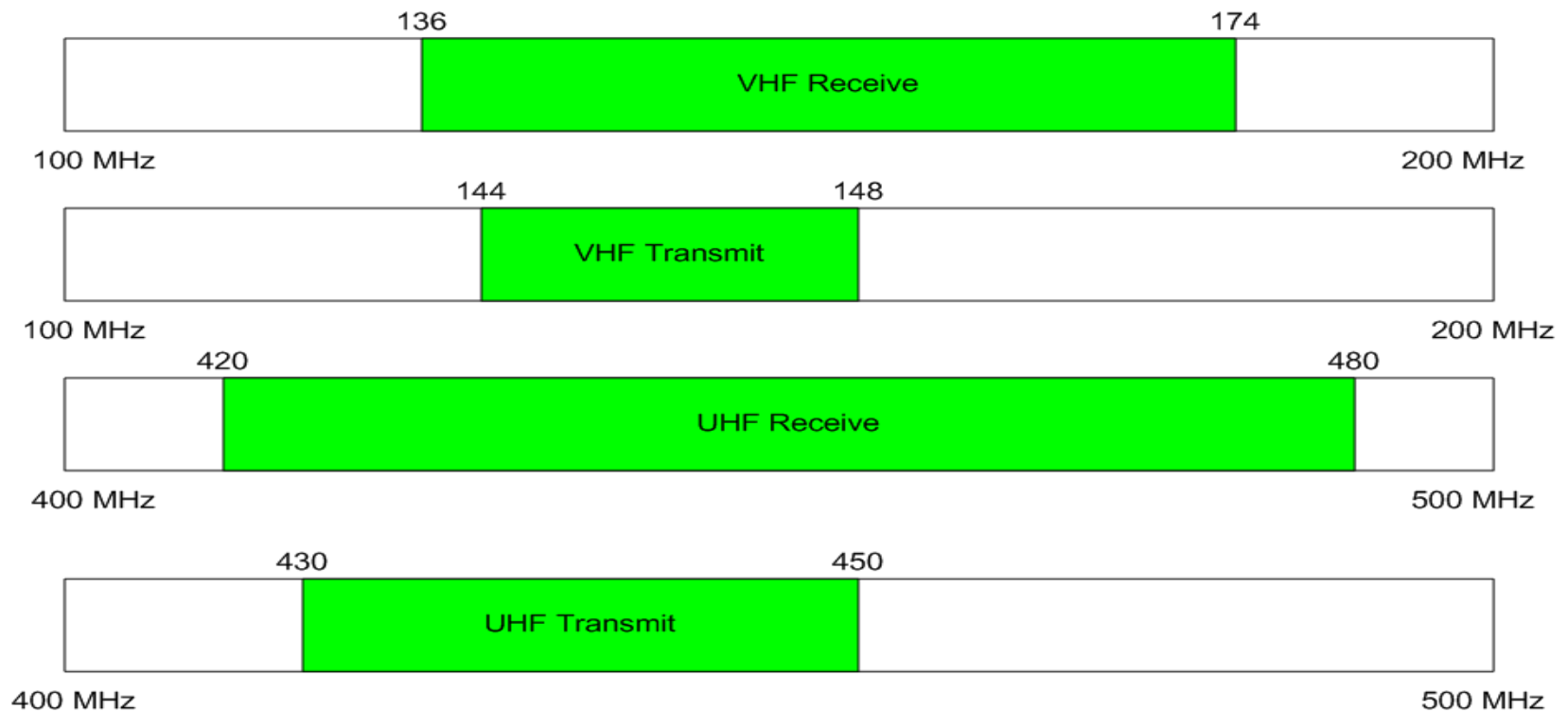


# SOC Operations



Uplink: 437.445 MHz

Downlink: 145.980 MHz



Modes: FM, SSB, CW, PSK and AFSK PACKET



# Link Budget

Item	Source		Uplink		Downlink		Units
Frequency	Input		437.445		145.980		MHz
Transmission Path Length:	Estimate		2264		2264		km
Transmitter Power:	Input		19		0		dBW
Transmitter Line Loss:	Estimate		-10		-3		dB
Transmitter Antenna Gain:	Estimate		12		-10		dBi
Space Loss:	Estimate		-152		-142		dB
System Noise Temperature:	Estimate		30		23		dBK
Receive Antenna Gain:	Estimate		-10		10		dBi
Receive Line Loss:	Estimate		-3		-10		dB
Receive Preamp Gain:	Estimate		0		15		dB
Receive Antenna Pointing Loss:	Estimate		-3		-3		dB
Data Rate:	Input		1200		1200		bps
Boltzmann's Constant:	Constant		-228.6		-228.6		dB
Implementation Loss:	Estimate		-5		-5		dB

Required BER	Input		$10^{-3}$		$10^{-3}$		bits
Required $E_b/N_o$	Estimate		10		10		dB

$E_b/N_o$	Result		30		25		dB
EIRP	Result		21		-13		dBW
$E_b/N_o$ with Preamp Gain	Result		30		40		dB

Link Margin	Result		20		30		dB
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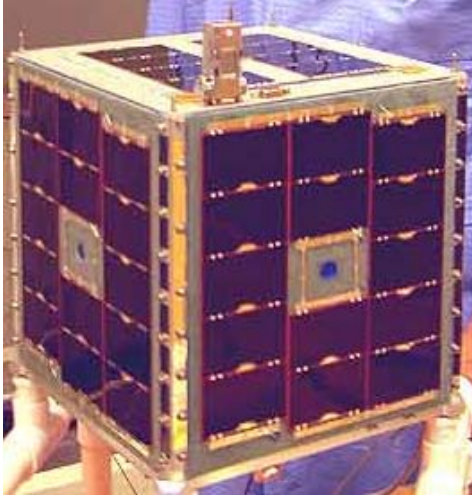


# Link Budget



Item	Uplink		Downlink		Units
Transmitter Power	75		1		Watts
Data Rate	1200		1200		bps
Required BER	$10^{-3}$		$10^{-3}$		bits
Required $E_b/N_o$	10		10		dB
$E_b/N_o$	30		25		dB
$E_b/N_o$ with Preamp Gain	30		40		dB
Link Margin	20		30		dB

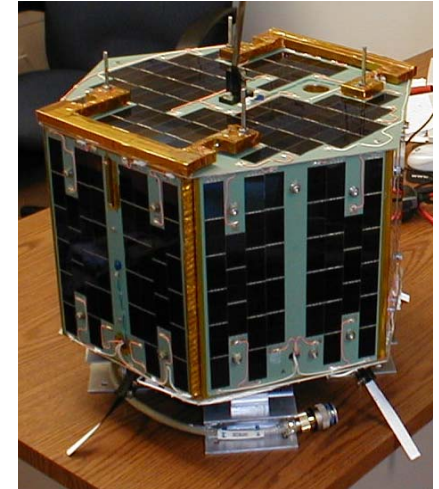
# Station Testing



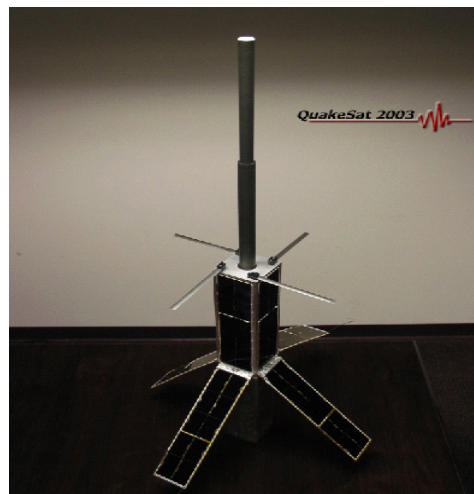
ECHO



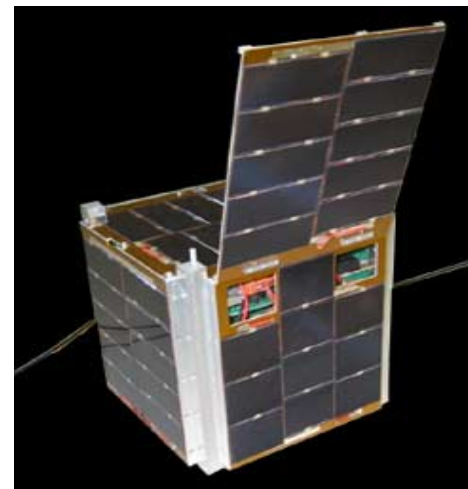
ARISS



Sapphire



QuakeSat



CUTE-1



# Station Testing



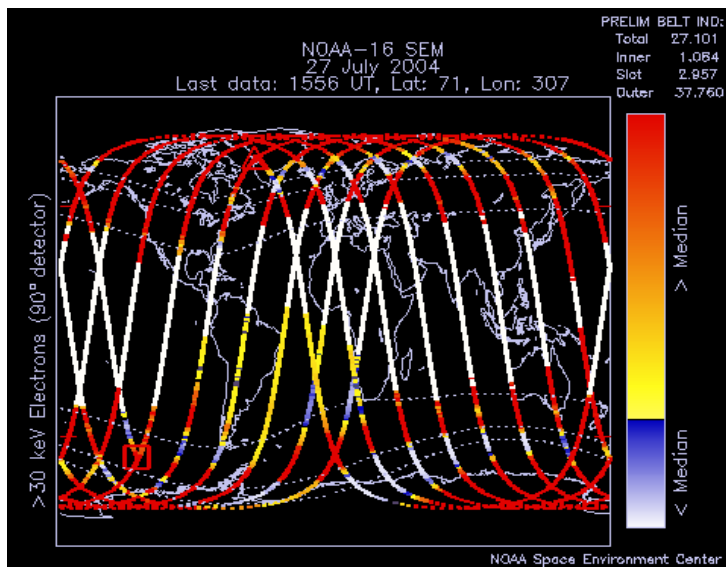
## NOAA POES

Polar

Operational

Environmental

Satellites





# NOAA POES Testing



## Spacecraft Parameters

Orbit:	Sun Synchronous
Inclination:	98.7 <sup>0</sup>
Altitude:	812 km
Period:	101 min
BTX Power:	1 watt
Modulation:	SPSK
Data Rate:	8.32 Kbps
Antenna Polarization:	Linear



# Lessons Learned



- Start University Facilities/Planning coordination **EARLY**
- **Double check** all Facilities requirements to ensure compliance
- Always plan extra time for tower and cable installation
- Ensure assembly drawings correspond with delivered parts
- Maintain extensive records during rotor calibration
- Don't be afraid to ask for help from other local amateurs



# Acknowledgments



I would like to give a special thanks to:

**Mr. Al Zoller (N7UB)**

AMSAT, LM1505 Area Coordinator





# Questions?



# Space Operations Center

