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
Orbital Prediction

Nova for Windows

Yaesu G-5500 Rotor
Satellite Control

Software Based

Communications Terminal
Doppler Tuner
Orbital Prediction
Signal Analyzer

Satellite Radio
Power Divider
Band Pass Filter
2m Pre-amp
Signal Analyzer Receiver

A/D Converter

Rotor Controller

Polarity Switch

2m Antenna
Elevation Rotor
70cm Antenna
70cm Pre-amp
2m Pre-amp
Coaxial Surge Protector
Azimuth Rotor
Satellite Control

M² Antennas with Icom Preamps

Icom 910-H Satellite Radio

TeraTerm Terminal Program
Signal Analysis

Software Based

- Communications Terminal
- Doppler Tuner
- Orbital Prediction
- Signal Analyzer

Satellite Radio
- Power Divider
- Band Pass Filter
- 2m Pre-amp
- Signal Analyzer Receiver
- A/D Converter
- Rotor Controller
- Polarity Switch

2m Antenna
- Elevation Rotor
- 70cm Antenna
- 2m Pre-amp
- Coaxial Surge Protector
- Azimuth Rotor

70cm Pre-amp
Signal Analysis

Band Pass Filter

Preamp

SDR-14 Radio Receiver

SpectraVue
SOC Operations

Uplink: 437.445 MHz          Downlink: 145.980 MHz

Modes: FM, SSB, CW, PSK and AFSK PACKET
## Link Budget

<table>
<thead>
<tr>
<th>Item</th>
<th>Source</th>
<th>Uplink</th>
<th>Downlink</th>
<th>Units</th>
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<td>145.980</td>
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<td>Input</td>
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<td>0</td>
<td>dBW</td>
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<tr>
<td>Transmitter Line Loss:</td>
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<td>Transmitter Antenna Gain:</td>
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<tr>
<td>Space Loss:</td>
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<tr>
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<td>23</td>
<td>dBK</td>
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<td>10</td>
<td>dBi</td>
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<tr>
<td>Receive Line Loss:</td>
<td>Estimate</td>
<td>-3</td>
<td>-10</td>
<td>dB</td>
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<tr>
<td>Receive Preamp Gain:</td>
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<tr>
<td>Required $E_b/N_o$</td>
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<td>10</td>
<td>dB</td>
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<td>40</td>
<td>dB</td>
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<tr>
<td>Link Margin</td>
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<td>20</td>
<td>30</td>
<td>dB</td>
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## Link Budget

<table>
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<tr>
<th>Item</th>
<th>Uplink</th>
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<td>bits</td>
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<tr>
<td>Required $E_b/N_o$</td>
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<td>10</td>
<td>dB</td>
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<tr>
<td>$E_b/N_o$</td>
<td>30</td>
<td>25</td>
<td>dB</td>
</tr>
<tr>
<td>$E_b/N_o$ with Preamp Gain</td>
<td>30</td>
<td>40</td>
<td>dB</td>
</tr>
<tr>
<td>Link Margin</td>
<td>20</td>
<td>30</td>
<td>dB</td>
</tr>
</tbody>
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Station Testing

- ECHO
- ARISS
- Sapphire
- QuakeSat
- CUTE-1
Station Testing

NOAA POES

Polar

Operational

Environmental

Satellites
Spacecraft Parameters

Orbit: Sun Synchronous
Inclination: 98.7°
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?

Montana State University
Space Science & Engineering Lab

Space Operations Center