AMSAT, IARU & The Cubesats

Dr. Tom Clark, W3IWI
w3iwi@amsat.org

Cubesat Conference
San Luis Obispo
April, 2004
Who is AMSAT?

- We’ve been designing, building and flying small satellites for 35+ years.
- Our efforts are all done by volunteers.
- AMSAT-NA serves North America, with affiliates in other countries.
- You can visit some of the AMSATs at:
  - [http://www.amsat.org/](http://www.amsat.org/)
  - [http://www.uk.amsat.org/](http://www.uk.amsat.org/)
  - [http://www.projectoscar.net/](http://www.projectoscar.net/)
AMSAT’s Volunteers are eager to help YOU

- Help you to find mentors – local and around the world:
  - Spacecraft and experiment design
  - Construction of flight hardware
- Provide Design Review teams
- Help you with the licensing/coordination process
- Literature and WWW information – examples:
AMSAT’s Mission Statement

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow amateur radio societies. We encourage technical and scientific innovation and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT BoD, Feb 2004
AMSAT’s Vision

Our Vision is to deploy High Earth Orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.

AMSAT BoD, Feb 2004
Who's Who ??

Amateur/Education Groups  Allocation/Assignment Authority

AMSAT-xx

Cubesat Groups

Universities, etc

COORDINATION

FCC (USA)

M.P.T. etc

TREATIES

IARU

(Int’l Amateur Radio Union)

ITU

(Int’l Telecomm’n Union)
April, 2004 Cubesat Meeting

VHF = 144.025 MHz, in the middle of the weak-signal “moonbounce” window!

Why do we need coordination??

Pakistan’s First Satellite Badar-1

Badr-1 - Pakistan’s first indigenously developed Satellite was launched in 1990 from China aboard a Long March rocket. The satellite successfully completed its designed life.

Mission Objectives:

- To acquire know-how for indigenous development of satellites and to create infrastructure for future satellite development activities.
- To test the performance of indigenously developed satellite subsystems in space environment.
- To perform experiments in real-time voice and data communications between two user ground stations.
- To demonstrate store-and-forward type message communication.
- To educate the country’s academic, scientific and amateur community in the tracking and use of low-earth-orbiting satellites.

Configuration

- Structure: 26-Facet Polyhedron
- Thermal Design: Passive
- Mass: 52 kg
- Solar Panels: 17 Square Facets
- Average Conditioned Power: 12.5 Watts
- Down Link: VHF
- Up Link: UHF
- Telemetry Channels: 32
- Sensor: Temperature, current, voltage
- Data Transmission Rates: 1200, 600, 300, 150 BAUDS
- DCE Memory Bank: 8 KBYTE
Why do we need coordination ??

More historical examples:
- SARA (Radio Astronomy listening to Jupiter, 1991)
- SWATCHSat (SWATCH Watches – voice messages, 1999)
- MAROC (Morocco – Remote Sensing, 2001)
Why do we need coordination??

♦ After BADR-1 and SARA, AMSAT-NA’s Board asked the question:
   
   JUST WHAT IS AN AMATEUR SATELLITE ???

♦ We decided the answer involved some simple rules:
  ♦ Amateur Radio requires non-commercial
  ♦ Must meet all legal rules (FCC/ MPT, ITU registry)
  ♦ Must have an amateur radio involvement and interest
  ♦ Downlink format and content should be publicly available
  ♦ Amateur community should be told of mission
  ♦ Frequency/modulation should be coordinated with IARU

♦ These were incorporated into the IARU “rules”
  ♦ See http://www.iaru.org/satellite/sat-freq-coord.html
The Shoehorn Problem

Two frequency ranges are “easy” with lots of existing hardware and a strong world-wide network of amateurs to support satellite missions:

- **2 Meters**: ITU permits 144.0 – 146.0 MHz
  
  But the 2 Meter band is busy everywhere in the world, so IARU (with AMSAT’s concurrence) has set aside sub-band of 145.80 – 146.00 for Satellites

- **70 cm**: ITU & IARU permit 435.0 – 438.0 MHz
## 2 Meters 145.8-146.0 MHz

### Operational Satellites

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Frequency</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL-1</td>
<td>145.925 MHz</td>
<td></td>
</tr>
<tr>
<td>QPE-1</td>
<td>145.925 MHz</td>
<td></td>
</tr>
<tr>
<td>AS-1</td>
<td>145.925 MHz</td>
<td></td>
</tr>
</tbody>
</table>

### Non-Operational Satellites

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Frequency</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO-1</td>
<td>145.925 MHz</td>
<td></td>
</tr>
<tr>
<td>AO-2</td>
<td>145.925 MHz</td>
<td></td>
</tr>
<tr>
<td>AO-3</td>
<td>145.925 MHz</td>
<td></td>
</tr>
</tbody>
</table>

### Frequency Coordination Requests

<table>
<thead>
<tr>
<th>Requester</th>
<th>Frequency</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR-1</td>
<td>145.925 MHz</td>
<td></td>
</tr>
</tbody>
</table>

### Logbook Transmission

- **K799**
- **K999**
- **K000**
- **K999**
- **K999**

---

**Note:**

1. Frequency assignments are subject to change.
2. Satellites listed in order of priority for coordination.
3. Initial locations not taken into account.
### 2 Meters 145.8-146.0 MHz
(As of Jan. 2004)

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Mode</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>FALCONSAT 3</td>
<td>PKT</td>
<td>145.84 GMSK AX.25 9600</td>
</tr>
<tr>
<td>PCSAT 2</td>
<td>PKT</td>
<td>145.827 AFSK/PM AX.25 1200</td>
</tr>
<tr>
<td>MSx</td>
<td>BON</td>
<td>145.800 1 kHz BW</td>
</tr>
<tr>
<td>SCPC</td>
<td>145.865 NBFM</td>
<td></td>
</tr>
<tr>
<td>XPORT</td>
<td>145.850-145.89</td>
<td></td>
</tr>
<tr>
<td>VUSAT</td>
<td>BON</td>
<td>145.936, 145.860</td>
</tr>
<tr>
<td>XPORT</td>
<td>145.870-145.930</td>
<td></td>
</tr>
<tr>
<td>IARU COORDINATION COMPLETE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IARU COORDINATION REQUESTED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEROPE</td>
<td>SOCP</td>
<td>145.835 AFSK/PM 1200</td>
</tr>
<tr>
<td>P3E</td>
<td>BON</td>
<td>GB, 145.912, GB, 145.957 PSK 4/0</td>
</tr>
<tr>
<td>RUDAK</td>
<td>RUDAK</td>
<td>145.837</td>
</tr>
<tr>
<td>XPORT</td>
<td>145.845-145.945</td>
<td></td>
</tr>
<tr>
<td>BLUESAT</td>
<td>SOCP</td>
<td>145.98 AFSK/PM</td>
</tr>
<tr>
<td>SOCP</td>
<td>145.90, 145.92 AFSK/PM digi/ater</td>
<td></td>
</tr>
<tr>
<td>HAUSAT 1</td>
<td>SOCP</td>
<td>145.84 PM</td>
</tr>
<tr>
<td>ION</td>
<td></td>
<td>Frequency selection assistance requested</td>
</tr>
<tr>
<td>KUTESat Pathfinder</td>
<td>145.835 BW-4 MHz emission unspecified</td>
<td></td>
</tr>
<tr>
<td>SEEDS</td>
<td>SOCP</td>
<td>145.835 BW-4 MHz emission unspecified</td>
</tr>
<tr>
<td>Nubble</td>
<td>SOCP</td>
<td>AX.25 AFSK/PM 1200 / GMSK 9600</td>
</tr>
<tr>
<td>Frequency selection assistance requested</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CubeSat IX</td>
<td>SOCP</td>
<td>145.835 AFSK/PM 1200</td>
</tr>
<tr>
<td>ACE</td>
<td>SOCP</td>
<td>145.86 or 145.87</td>
</tr>
<tr>
<td>SOCP</td>
<td>145.89 or 145.91</td>
<td></td>
</tr>
<tr>
<td>RX ONLY</td>
<td>145.80-145.00</td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>Band</td>
<td>Channel</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------</td>
<td>---------</td>
</tr>
<tr>
<td>435.0-438.0 MHz</td>
<td>70cm</td>
<td></td>
</tr>
</tbody>
</table>

**April, 2004 Cubesat Meeting**

- **70cm 435.0-438.0 MHz**
70cm  435.0-438.0 MHz
As of Jan. 2004

<table>
<thead>
<tr>
<th>CALLSIGN</th>
<th>TYPE</th>
<th>FREQUENCY</th>
<th>ALLOCATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO-49</td>
<td>PCT</td>
<td>437.325</td>
<td>38.4 KHz</td>
</tr>
<tr>
<td>70cm</td>
<td></td>
<td>435.0-438.0 MHz</td>
<td></td>
</tr>
<tr>
<td>ARISS</td>
<td>PCT</td>
<td>437.5-438.0 MHz</td>
<td></td>
</tr>
<tr>
<td>ION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUSAT 2</td>
<td>PCT</td>
<td>436.26-436.29 MHz</td>
<td></td>
</tr>
<tr>
<td>VUSAT 1</td>
<td>BCN</td>
<td>436.840</td>
<td>9600</td>
</tr>
</tbody>
</table>

**JARU COORDINATION COMPLETE**

**JARU COORDINATION REQUESTED**

<table>
<thead>
<tr>
<th>CALLSIGN</th>
<th>TYPE</th>
<th>FREQUENCY</th>
<th>ALLOCATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>EROPE</td>
<td>PCT</td>
<td>437.445</td>
<td>437.445</td>
</tr>
<tr>
<td>P3E</td>
<td>XPDR</td>
<td>436.05-436.10 D</td>
<td></td>
</tr>
<tr>
<td>BLUESAT</td>
<td>PCT</td>
<td>436.925</td>
<td>436.925</td>
</tr>
<tr>
<td>HAUSAT 1</td>
<td>PCT</td>
<td>436.840</td>
<td>436.840</td>
</tr>
<tr>
<td>ION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KUTCE 1</td>
<td>PCT</td>
<td>436.175</td>
<td>436.175</td>
</tr>
<tr>
<td>SEEDS 9</td>
<td>BCN</td>
<td>434.0</td>
<td>434.0</td>
</tr>
<tr>
<td>Nucleo</td>
<td>SCPC</td>
<td>436.44 VHF/1200</td>
<td></td>
</tr>
<tr>
<td>Cubesat X</td>
<td>BCN</td>
<td>437.447</td>
<td>437.447</td>
</tr>
<tr>
<td>ICube 2</td>
<td>PCT</td>
<td>436.860</td>
<td>436.860</td>
</tr>
<tr>
<td>AOS</td>
<td>SCPC</td>
<td>438.175</td>
<td>438.175</td>
</tr>
<tr>
<td>QUAKE SAT</td>
<td>SCPC</td>
<td>436.875</td>
<td></td>
</tr>
<tr>
<td>CUTE-1</td>
<td>SCPC</td>
<td>436.875</td>
<td></td>
</tr>
<tr>
<td>Cubesat X</td>
<td>SCPC</td>
<td>436.875</td>
<td></td>
</tr>
<tr>
<td>DUT SAT</td>
<td>SCPC</td>
<td>437.475</td>
<td></td>
</tr>
</tbody>
</table>

**OTHER SATELLITES WE'VE HEARD ABOUT**

- QUAKE SAT: SCPC 436.875
- CUTE-1: SCPC 436.875
- Cubesat X: SCPC 436.875
- DUT SAT: SCPC 437.475

**LEGEND**

- **TRANSMITTING**: transmitting or receiving
- **RECEIVING**: transmitting or receiving
- **ARIS**: exceptions to JARU band plan coordinated worldwide
- **NO LAUNCH SCHEDULED**: no launch scheduled
- **COORDINATION DECLINED**: coordination declined
IARU Coordination Information is available at:

- http://www.iaru.org/satellite
  - Coordination info, forms: http://www.iaru.org/satellite/sat-freq-coord.html
  - General Info, Email contact is mailto:satcoord@iaru.org

- To see current status of requests http://www.amsat.org.uk/iaru

- http://www.amsat.org
  - Supporting Info, FAQ, Forms, Spreadsheets, etc.
    - Link Budgets: http://www.amsat.org/amsat/software/spreadsheet
    - FAQ: http://www.amsat.org/amsat/intro/using-ham-freqs.html
**IARU Amateur Satellite Frequency Coordination**

List of Satellite projects for which frequencies have been coordinated.

- Click on the detail button for more details.

<table>
<thead>
<tr>
<th>Sat Name</th>
<th>Supporting Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oscar Echo</td>
<td>AMSAT-NA</td>
</tr>
<tr>
<td>Falconsat 3</td>
<td>US Air Force Academy</td>
</tr>
<tr>
<td>ICEcube1 &amp; 2</td>
<td>Cornell University</td>
</tr>
<tr>
<td>Merope</td>
<td>Montana State University</td>
</tr>
<tr>
<td>NCube</td>
<td>Norwegian Univ of Space &amp; Technology</td>
</tr>
<tr>
<td>PCSAT2</td>
<td>US Navy Academy</td>
</tr>
<tr>
<td>BLUEsat</td>
<td>University of New South Wales</td>
</tr>
<tr>
<td>KMWSat</td>
<td>AMSAT-NZ</td>
</tr>
<tr>
<td>HAUSAT-1</td>
<td>Hankuk Aviation University - Seoul</td>
</tr>
<tr>
<td>VUSat</td>
<td>AMSAT- India</td>
</tr>
<tr>
<td>ION</td>
<td>University of Illinois</td>
</tr>
<tr>
<td>KUTESat-Pathfinder</td>
<td>University of Kansas</td>
</tr>
<tr>
<td>SEEDS</td>
<td>Dept of Aerospace Eng - Nihon Univ Japan</td>
</tr>
<tr>
<td>Cubesat XI-V</td>
<td>Intelligent Space Systems Lab - Univ of Tokyo</td>
</tr>
<tr>
<td>CP1</td>
<td>Cal Poly Aerospace Engineering</td>
</tr>
<tr>
<td>CP2</td>
<td>Cal Poly Aerospace Engineering</td>
</tr>
<tr>
<td>SACRED</td>
<td>University of Arizona at Tuscon</td>
</tr>
<tr>
<td>Rincon</td>
<td>University of Arizona at Tuscon</td>
</tr>
<tr>
<td>YaamSat</td>
<td>National Applied Research Laboratories, Taiwan</td>
</tr>
<tr>
<td>Ralphie &amp; Sparkle</td>
<td>New Mexico State University Amateur Radio Club</td>
</tr>
<tr>
<td>ANDE</td>
<td>US Naval Academy Amateur Radio Club</td>
</tr>
<tr>
<td>Mea Huaka'i</td>
<td>University of Hawaii</td>
</tr>
<tr>
<td>NMSUSat</td>
<td>New Mexico State University</td>
</tr>
</tbody>
</table>
# IARU Amateur Satellite Frequency Coordination

**List of Satellite requests which have formally requested coordination.**

## IARU – As of 4/4/04

<table>
<thead>
<tr>
<th>Sat Name</th>
<th>Supporting Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 3E</td>
<td>AMSAT-DL</td>
</tr>
<tr>
<td>CanX-2</td>
<td>Institute for Aerospace Studies-Toronto University</td>
</tr>
<tr>
<td>Pehuensat</td>
<td>AMSAT Argentina</td>
</tr>
</tbody>
</table>

**List of Satellite projects about which we have some information.**

<table>
<thead>
<tr>
<th>Sat Name</th>
<th>Supporting Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citizen Explorer 1</td>
<td>University of Colorado</td>
</tr>
<tr>
<td>unknown</td>
<td>Michigan Tech</td>
</tr>
<tr>
<td>UniSat3</td>
<td>La Sapienza University Roma</td>
</tr>
<tr>
<td>P5A Mars Mission</td>
<td>AMSAT-DL</td>
</tr>
<tr>
<td>ALMASAT</td>
<td>Universita di Bologna</td>
</tr>
<tr>
<td>RAFT</td>
<td></td>
</tr>
</tbody>
</table>
An Invitation to You from AMSAT

♦ The next annual AMSAT symposium will be held October 8-1, 2004 in Arlington, VA (DC suburbs).
♦ This is your opportunity to meet with the AMSAT community, including the operators of stations that you could use to track your satellite.
♦ AMSAT plans an Educational forum that would be a perfect place to present your project to “the world”.
♦ Also planned – a trip to the new Smithsonian Udvar-Hazy Aerospace Museum at Dulles Airport.
Thank you from AMSAT

♦ For more details on AMSAT, see http://www.amsat.org

♦ To contact me: mailto:w3iwi@amsat.org