

Radio Spectrum Considerations for CubeSats

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Spectrum Regulation in the U.S.

- Federal government spectrum users, including NSF, are regulated by the National Telecommunications and Information Administration (NTIA), Office of Spectrum Management. NTIA is part of the Department of Commerce
 - > <http://www.ntia.doc.gov/osmhome/osmhome.html>
- Everyone else (including commercial, private, academic, amateur, state/local governments, etc.) is regulated by the Federal Communications Commission (FCC)
 - > <http://www.fcc.gov>



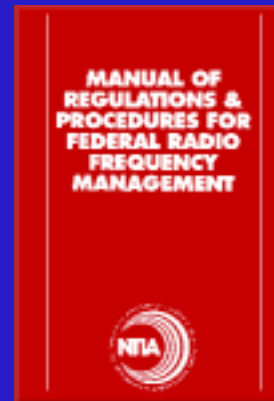
FCC Rules

- The FCC rules are contained in Title 47 of the Code of Federal Regulations
 - > Available on Government Printing Office Web site, but difficult to access entire rule parts as a single document
 - > National Spectrum Managers Association provides convenient access to the latest complete GPO-derived volumes
 - <http://www.nsma.org/CFR.htm>
 - > Potentially relevant rule parts:
 - Part 25 Satellite Communications
 - Part 5 Experimental Radio Service
 - Part 97 Amateur Radio Service



NTIA Rules

- Rules covering Federal government radio stations are contained in the *Manual of Regulations and Procedures for Federal Radio Frequency Management*
 - > <http://www.ntia.doc.gov/osmhome/redbook/redbook.html>



Should NSF CubeSats be Licensed as Federal or non-Federal Systems?

- **Funded by NSF, a Federal government agency**
- **Built and launched by non-Federal entities**
- **Could be Federally-licensed *if* NSF has close stop-button control over emissions**
- **Depending on the control arrangements, CubeSats could be either Federal or non-Federal**
 - > **In the short term, decision should be based on whichever method results in most efficient and expedient licensing**
 - > **In the long term, an appropriate non-Federal-government option that could benefit a broader U.S. CubeSat community should be one objective**



Satellite-Specific Regulation

- **Because satellite downlink signals will transcend national borders, coordination of frequency use becomes an international matter**
 - > **Coordination through the International Telecommunication Union (ITU)**
- **Some aspects of satellite coordination can require very long lead times, especially for major long-term systems**
- **Orbital debris concerns can be a MORE significant regulatory hurdle than spectrum licensing**

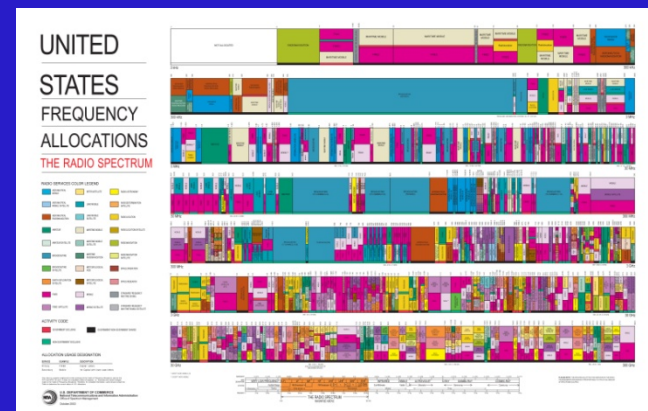


Radio Services and Allocations

- Specific uses of the radio spectrum are divided into one of approximately 26 defined radio services
- Each frequency in the radio spectrum is allocated to one or more services
- The service definitions are contained in the FCC rules (47 CFR 2.1), the NTIA manual (Chapter 6), and are based upon the definitions in the ITU *Radio Regulations*
- The services most relevant to the NSF-funded CubeSat projects are the Earth exploration-satellite service (EESS), the meteorological-satellite service (metsat), and the space research service (SRS)

For an electronic database of radio spectrum allocations, see:

<http://www.unwantedemissions.com/alloc/allfrq.aspx>



Earth Exploration-Satellite Service

- A radiocommunication service between earth stations and one or more space stations, which may include links between space stations, in which:
 - > information relating to the characteristics of the Earth and its natural phenomena including data relating to the state of the environment is obtained from active sensors or passive sensors on earth satellites; similar information is collected from active sensors or passive sensors on Earth satellites:
 - > airborne or earth-based platforms; such information may be distributed to earth stations within the system concerned; platform interrogation may be included. This service may also include feeder links necessary for its operation.



Meteorological-Satellite Service

- An Earth exploration-satellite service for meteorological purposes.



Space Research Service

- A radiocommunication service in which spacecraft or other objects in space are used for scientific or technological research purposes.



Amateur-Satellite Service

- ***Amateur service***
 - > A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest [97.3(a)(4)]
- ***Amateur-satellite service***
 - > A radiocommunication service using space stations on earth satellites for the same purposes as those of the amateur service
- **Some CubeSats have made use of amateur radio bands for communications requirements**



FCC Rules Regarding Amateur Operators and Pecuniary Interests

§ 97.113 Prohibited Transmissions

(a) No amateur station shall transmit:

...

(3) Communications in which the station licensee or control operator has a pecuniary interest, including communications on behalf of an employer...

- ARRL – the national association for Amateur Radio, has issued guidelines on the appropriate use of amateur radio
 - > www.arrl.org/news/files/ARRL_AppropriateUseGuidelines.pdf



Benefits of Amateur-Satellite Service

- Coordinated with assistance of the International Amateur Radio Union (IARU)
 - > Important and useful information available at <http://www.iaru.org/satellite/>
 - > See in particular the documents on amateur satellites and on controlling satellites (the latter has information that applies to all satellites)
- No lengthy FCC applications
- Fewer technical restrictions
 - > For example, fewer restrictions on power flux density
- Can involve amateurs to, e.g., provide an expanded network of Earth stations for data downlinks, as a reception challenge, or as a communications benefit (on-board transponder/repeater)
- Readily available equipment
- Emphasis on innovation when developing custom equipment
- Can provide technical development opportunities for students and grow the rank of highly technically proficient amateurs



Drawbacks of Amateur Bands

- **Not all CubeSat projects will necessarily include the involvement of one or more unpaid amateur licensees/control operators of the spacecraft communications system**
 - > **Control operator: An amateur operator designated by the licensee of a station to be responsible for the transmissions from that station to assure compliance with the FCC Rules**
- **Amateur radio is licensed on an individual basis, not to an institution or system**
- **The use of amateur bands solely as a means for bypassing appropriate authorization requirements is not a solution**



Regulations Covering Amateur-Satellite Space Stations

- Covered in 47 CFR 97.207
- 97.207(c): The following frequency bands and segments are authorized to space stations:
 - > The 17 m, 15 m, 12 m, and 10 m bands, 6 m, 4 m, 2 m, and 1 m bands; and
 - > The 7.0-7.1 MHz, 14.00-14.25 MHz, 144-146 MHz, 435-438 MHz, 1260-1270 MHz, and 2400-2450 MHz, 3.40-3.41 GHz, 5.83-5.85 GHz, 10.45-10.50 GHz, and 24.00-24.05 GHz segments
- 97.207(g) contains rules for pre-space notifications to the FCC, which must be made:
 - > “within 30 days after the date of launch vehicle determination, but no later than 90 days before integration of the space station into the launch vehicle.”



ISM and Unlicensed Devices

- Under some circumstances, radio transmitters can be operated as Industrial, Scientific, and Medical (ISM) devices (Part 18) or “Unlicensed Devices” (Part 15) without a specific license from the FCC
- Not an option for satellites, however, according to Part 25:
 - > **25.102(a)** No person shall use or operate apparatus for the transmission of energy or communications or signals by space or earth stations except under, and in accordance with, an appropriate authorization granted by the Federal Communications Commission
- So unfortunately neither satellites nor associated Earth stations can use Part 18 or Part 15 as a method to bypass FCC authorizations



Experimental Radio Service

- Regulated under Part 5 of the FCC rules
- 5.3 Scope of Service
 - > Stations operating in the Experimental Radio Service will be permitted to conduct the following type of operations:
 - (a) Experimentation in scientific or technical radio research
 - ...
 - (c) Communications essential to a research project
- 5.71 License Period
 - > The regular license period for stations in the Experimental Radio Service is either 2 or 5 years...
- Experimental licenses are administered by the FCC's Office of Engineering and Technology
- A satellite-based experimental station would need to be coordinated with both OET and the FCC's International Bureau, which regulates satellite emissions
- Strictly non-interference basis, subject to shut-off



Special Temporary Authorization

- A shorter-term option under the experimental radio service is a Special Temporary Authorization (STA)
- Can be applied to space and earth stations
- An STA can be issued in cases in which a need is shown for operation of a station for six months or less
- Rules governing STAs are in 47 CFR 5.61
- An STA may be more expeditious than an experimental license



Considerations for ALL Satellite Systems

- **ITU *Radio Regulations* require a method by which satellite transmitters can be shut off:**
 - > **RR 22.1 Space stations shall be fitted with devices to ensure immediate cessation of their radio emissions by telecommand, whenever such cessation is required under the provisions of these Regulations.**
- **The ITU must be notified in advance of all satellite transmitters**
 - > **Many satellite operators are not abiding by these notification requirements**



Bottom-Line Thoughts, Near-Term Licensing

- **Planned projects already invested in amateur radio should confirm that the planned operations are in accordance with the rules governing the amateur-satellite service**
 - > **Such systems must be controlled by an unpaid amateur licensee, and should be aligned with the purposes of the amateur service**
- **Projects not presently pursuing amateur bands should consider filing for an experimental radio service authorization or an STA**



Long-Term

- The popularity of CubeSat projects and their ongoing needs for radio spectrum support justify pursuing long-term solutions that may benefit all future CubeSat operators
- One possibility is pursuing through the U.S. regulators and the ITU, the “designation” of one or more specific bands for picosat use
 - > Designation would most likely be in the form of one or more footnotes to the Table of Frequency Allocations, applicable to one or more bands presently allocated to related space-based services
- This process can take a very long time.
 - > Would require an FCC proceeding and coordination with NTIA
 - > International designation through the ITU will take YEARS
 - Initial steps to work this through the ITU process are being undertaken



One Band Designation Possibility?

- 460 – 470 MHz
- Allocated to the meteorological-satellite and Earth exploration-satellite services on a secondary basis*
- In the U.S., a PFD limit of -152 dBW/m²/4 kHz
 - > Note that this is a spectral power flux density limit. Transmitters with larger bandwidth are allowed more power
 - > Limit corresponds to ~ 0.7 W per MHz of bandwidth for a satellite at 600 km altitude

*For allocation details, query the following page for 465 MHz:

- > <http://www.unwantedemissions.com/alloc/allfrq.aspx>



Initial Conclusions (Subject to Revision)

- **Best Near-Term Solution**
 - > Investigate experimental licensing or STAs through FCC
- **Best Long-Term Solution**
 - > Pursue designation of one or more suitable bands as “picosat” bands
- All conclusions in this presentation may (probably will) change based upon ongoing discussions

