Before the
U.S. DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Washington, D.C. 20230

In the Matter of	)	
	)	
Title VI of the Omnibus Budget	)	NTIA
Reconciliation Act of 1993,	)	Special Publication 94-27
Preliminary Spectrum Reallocation	)	
Report	)	

To: The Assistant Secretary for Communications and Information

COMMENTS OF THE RADIO AMATEUR SATELLITE CORPORATION

The Radio Amateur Satellite Corporation (AMSAT) respectfully submits these comments on the NTIA's Special Publication 94-27, Preliminary Spectrum Reallocation Report, February 1994, prepared under Title VI of the Omnibus Budget Reconciliation Act of 1993.

BACKGROUND

AMSAT is a not-for-profit District of Columbia corporation established in 1969. Together with our affiliated organizations in other countries, we have constructed, launched and operated approximately 27 satellites to date in the amateur-satellite service, of which the majority are presently still in operation.

These currently operational spacecraft include high-altitude, Molniya-type orbit transponder satellites capable of sustaining two-way communication over terrestrial paths well in excess of 10,000 miles (AMSAT-OSCAR 10 and AMSAT-OSCAR 13), numerous low-earth-orbit (LEO) digital store-and-forward packet radio satellites, scientific and educational payload satellites, LEO analog transponder satellites, and several spacecraft featuring combinations of these types of payloads.

Additional satellites for the amateur-satellite service are planned or are presently under construction by AMSAT and its affiliate organizations in the United States and Argentina, Australia, Chile, Finland, Germany, Israel, Italy, Japan, Korea, Mexico, Russia and the United Kingdom. These groups are frequently associated with universities or have access to government or industry facilities in their countries. Indeed, owing to the worldwide and cooperative nature of amateur radio, the construction of satellites for the amateur-satellite service has emerged as a principal means of technology transfer to developing countries. One not-for-profit organization, Surrey Satellite Technologies Ltd., associated with the University of Surrey in the United Kingdom, has built or aided in the construction of eight such satellites, with more on the way. AMSAT itself is currently working with amateur satellite construction groups in nearly a dozen countries to build the fourth and most advanced in a series of elliptical orbit amateur satellites we call "Phase 3D". The next ten to twenty years is certain to see a further proliferation of this highly beneficial activity, with commensurate demands on frequency spectrum available to the amateur-satellite service.

SUMMARY OF THE PROBLEM

As the NTIA Preliminary Report states,

> "Title VI requires that reallocation decisions avoid excessive disruption of amateur service licensees. The amateur and amateur-satellite services benefit the public at large, especially during natural disasters and emergencies, when normal communication channels are lost. . . Because of the importance of specific frequencies in the range 2400-2402 MHz for amateur satellite operations, these frequencies were excluded from consideration."

AMSAT commends NTIA for excluding 2400-2402 MHz from the proposed reallocation, as these frequencies are of vital importance to spacecraft operations in the amateur-satellite service, for satellites in current use as well as those under construction. However, in the readily foreseeable future, AMSAT anticipates greatly increased demand for amateur satellite operations in that portion of the spectrum, far more than can reasonably be accommodated within a 2 MHz band. It is certainly too restricted to accommodate such wideband techniques as fast-scan television, even if compression techniques are employed. AMSAT hopes to be able to employ such modes on future spacecraft. The 10 MHz wide 1260-1270 MHz uplink-only amateur-satellite service allocation is available for such applications, and a similar bandwidth is needed as a downlink at 2400 MHz. In view of these anticipated future needs of this service, especially for space-to-earth downlinks with relatively weak signal strengths on the earth's surface, we urge that this sub-band be expanded to 2400-2410 MHz.

In addition, the Preliminary Report proposes a band at 2417-2450 MHz to be shared by the amateur and amateur-satellite services. While it may be possible to accommodate some earth-to-space uplinks in this range, we are very concerned that, in the metropolitan and suburban areas where most licensed amateurs live, interference levels from microwave ovens and ISM devices would be severe enough to render the frequencies in question very difficult to use for satellite applications. It would also be unsuitable for experimental weak-signal amateur operation such as earth-moon-earth and long-haul tropospheric work. This potentially valuable type of work is currently concentrated at 2300-2310 MHz, specifically near 2304 MHz.

Finally, please bear in mind that unlike commercial satellite services for which the use of geostationary spacecraft is most common, the amateur-satellite service utilizes satellites in low or highly elliptical orbits. For this reason, amateur satellite frequency allocations must be coordinated internationally so that they are available for use on a worldwide basis. The comments to follow elaborate on these and other points we wish to bring to NTIA's attention concerning the NTIA's Preliminary Report.

The amateur-satellite service presently utilizes and expects to significantly expand its use of the 2.4 GHz band. For various reasons, this band is a prime area of the spectrum for amateur communication experiments and applications. Due primarily to the extremely high cost of geostationary satellites, the amateur-satellite service presently does not utilize such spacecraft. Therefore, satellites in the amateur-satellite service are in lower or elliptical orbits that cover virtually the entire earth, albeit not all regions simultaneously. Consequently, the frequencies used by amateur satellites must be available worldwide. Thus, unlike terrestrial applications or those involving geostationary satellites, allocations of spectrum to the amateur-satellite service must be made consistently throughout the world, rather than on a national or regional basis. Therefore, any decisions with regard to allocations for the amateur-satellite service made in the United States must be coordinated with other governments. Otherwise, the results are likely to prove useless for the purposes for which they are intended. A case in point is the 3400-3410 MHz amateur-satellite service allocation currently provided for in the ITU Table of Allocations. This segment is stated as being available, but in Regions 2 and 3 only. Since it is not available in Region 1, it has not yet been employed for amateur-satellite use. In fact, this is the only band between 21 MHz and 24 GHz not being considered for inclusion in the Phase 3D spacecraft now under construction.

With this background, AMSAT offers the following comments on the NTIA's Preliminary Spectrum Reallocation Report.

Level of Usage of the 2.4 GHz Band

Although current amateur and amateur satellite use of the 2.4 GHz band may be light by standards used to judge other parts of the spectrum, use is expected to increase in the next few years. Like other users of the radio spectrum, amateurs tend to move from lower frequencies to higher frequencies as time passes and the state-of-the-art advances. NTIA is asked to judge current and future amateur use of the spectrum by the same standards that are applied to other current and potential users. With that thought in mind, we will outline current and future amateur satellite usage of the 2.4 GHz portion of the spectrum. But first we wish to point out that the amateur satellite community has pioneered the use of the 2300-2450 MHz band for amateur satellites since the early 1970's. AMSAT-OSCAR 7, launched in 1974, carried a beacon on 2304.1 MHz. In addition, UOSAT-OSCAR 9 built at the University of Surrey in the U.K. and launched in 1981, contained beacons on 2401 and 10,470 MHz.

Current Usage

Several amateur satellites currently utilize the 2.4 GHz band:

1. AMSAT-OSCAR 13, launched in 1988, has a downlink on 2400.711-2400.747 MHz with a beacon at 2400.650 MHz. Use of this downlink has seen increasing use, especially over the past year, since the failure of the satellite's 435 MHz transmitter which was paired with an uplink on 1270 MHz. 2. UOSAT-OSCAR 11, built at the University of Surrey in the U.K. and launched in 1984, carries a beacon on 2401.5 MHz which continues to function.

3. PACSAT (AO-16), one of the four MICROSATs built in the U.S. in the late 1980's and launched in January 1990, contains a beacon on 2401.1 MHz which still functions.

4. DOVE (DO-17), another of the MICROSATs, has a beacon on 2401.220 MHz. This has proved invaluable in attempts to rescue this satellite from mission-threatening situations involving interference to the 144 MHz command receiver from the satellite's 145.825 MHz downlink transmitter. Often, the 2.4 GHz downlink has been the only means to confirm the satellite's acceptance of commands.

5. The French built Arsene amateur satellite includes a 16 kHz wide downlink at 2446.500 MHz. Unfortunately, that transmitter failed several months after launch. Before that failure, a number of amateurs around the world reported hearing this downlink.

Near-term Plans

The most immediate planned amateur satellite use of the 2.4 GHz band is for Phase 3D. This large amateur satellite is scheduled for launch on the second engineering test flight of the Ariane 5 launch vehicle, currently under development by the European Space Agency. This launch is scheduled for April 1996. Phase 3D will include a number of uplinks and downlinks in amateur-satellite service bands from 21 MHz to 24 GHz. At 2.4 GHz, one of the principal downlinks is planned, along with an experimental uplink. These are to utilize the following specific frequencies:

Downlink	2400.500 - 2400.900 MHz
Uplink	2400.100 - 2400.500 MHz

Consideration is being given to moving this experimental uplink, perhaps to the vicinity of 2410 or 2450 MHz. The latter would enable evaluation of the potential interference, in orbit, of various ISM devices including microwave ovens.

Long-Term Plans

The amateur-satellite service can be expected to make significant use of the 2.4 GHz band, especially for downlinks, over the next ten to twenty years.

The intense crowding taking place on the lower VHF and UHF amateur bands necessitates the use of the higher bands by amateur satellites. Particularly bad is the situation in the 144-146 MHz band, which is the only portion of the VHF spectrum presently allocated to the amateur-satellite service on a primary basis by the ITU. The ready availability of inexpensive equipment intended for the amateur market has resulted in extensive use of this band by nonamateurs for personal and commercial communications in many countries, especially in Asia and the Pacific Rim - despite ITU regulations to the contrary. First-hand observations by radio amateur astronauts flying in the Space Shuttle and cosmonauts aboard MIR have confirmed that this is a significant and growing problem for amateur space communications. Even in the U.S., where non-amateur use is not the problem that it is elsewhere, the 144-146 MHz band is becoming increasingly congested by various types of amateur terrestrial usage. This intense use is making the band increasingly difficult to use, especially for the relatively weak signal satellite downlinks.

A similar situation is developing in the 435-438 MHz band allocated on a secondary basis by the ITU to the amateur-satellite service. In many parts of the world, use of this band for satellite uplinks is rendered virtually impossible at times by the presence of high-powered radar stations such as PAVE PAWS. This has proven especially true with respect to digital applications such as packet radio and earth-to-space command links.

One of the internal problems facing amateur radio is the proliferation of modes of operation, many inherently wideband in nature as well as the increasing number of amateurs since institution, by FCC, of the code-free license. Figures indicate that the number of licensed amateurs in the U.S. is growing at the rate of 7_ percent per year, with most of that growth concentrated in the no-code Technician License.

A mode of operation, growing in popularity, is fast-scan amateur television. Several manufacturers currently offer low cost amateur television transmitters for the 420-450 MHz band. As no such commercial amateur television equipment is manufactured for any of the higher amateur bands, this band is receiving the brunt of amateur television operation. Since amateur FM repeaters occupy almost all of the 440 to 450 MHz range, and 420 to 430 MHz is not available everywhere in the U.S., most amateur television operation takes place between 430 and 440 MHz. Many of these commercial amateur TV transmitters, and most home constructed units, transmit signals 8 MHz in width (both sidebands), often causing interference to reception of amateur satellites in the 435 to 438 amateur-satellite service band as well as to weak signal work taking place near 432 MHz. This problem is greatly exacerbated in the many other countries of the world where only 430-440 MHz, or parts thereof, is available for amateur operation.

As a result of this worsening situation in the lower frequency bands, groups planning and implementing amateur satellites in the future will have to use the higher frequency allocations. The specific selection of bands must, however, take into consideration the economic status and technical expertise of potential users worldwide, not merely those in the United States or in other highly developed countries. Amateur satellites are completely different from satellites built for other applications. In the case of commercial or government satellites, while the spacecraft is being constructed and prepared for launch, suitable ground station equipment is being developed and deployed. Usually, both of these are funded and directed by the same company or government agency. This assures that the ground equipment will be in place when the space segment comes on line and that the two will be compatible with one another. This is not true with amateur satellites. In this case, the space segment is constructed by a specific amateur group such as AMSAT, or a collection of such groups. In planning the satellite, the constructors attempt to understand the current and future capabilities and needs of individual amateurs throughout the world. This often means that they must compromise in the design of the satellite, frequently choosing lower frequency bands and lower speed data rates than would be optimal otherwise.

With the aforementioned crowding in the 145 and 435 MHz amateur bands, future amateur satellites will depend heavily on the next higher bands, 1.2 and 2.4 GHz. The amateur-satellite service allocation in the 1.2 GHz region, 1260-1270 MHz, is designated for use as uplinks only. Under ITU regulations, the lowest available frequency range for amateur satellite downlinks above 438 MHz is 2400-2450 MHz. As noted previously, the 3400-3410 MHz amateur-satellite service allocation in not available worldwide. The next highest downlink allocation is 5830-5850 MHz. Because of the congestion on the lower bands and the economic and technical considerations on the higher bands, it is the 2400 MHz band which will bear the greatest burden of supporting the growth of the amateur-satellite service over the next ten to twenty years. It is difficult to see how it can do so if only 2 MHz of spectrum is available.

Currently, the amateur-satellite service allocation in the 2.4 GHz region is 2400-2450 MHz, both in the FCC and international tables. It would appear that to efficiently use the 10 MHz wide 1.2 GHz uplink assignment, a like assignment at 2.4 GHz would be reasonable and necessary.

While there is a commonality of interest between amateurs who use weak signal modes such as earth-moon-earth or long haul terrestrial means of propagation, and those amateurs participating in satellite operation, use of common or nearby frequencies by these two groups often leads to mutually destructive interference. Furthermore, relatively narrow allocations, available on a primary basis, is the best approach of accommodating and encouraging both of these potentially valuable activities. Currently, most amateur weak signal work done in the 2.4 GHz band is done in the vicinity of 2304 MHz, although in some countries other frequencies are employed due to non-availability of the 2300-2310 MHz segment to amateurs. Like satellite operation, although to a lesser extent, weak signal operation is best accomplished on common worldwide allocations. This is especially true of earth-moon-earth operation. Needless to say, successful earth-moon-earth operation requires the utmost in performance of all elements of the system from high power amplifiers, receive pre-amplifiers and antennas. Unfortunately, wide frequency separations between transit and receive frequencies, necessitated by varying allocations, often leads to less than optimum equipment performance, especially in the case of antennas.

Advanced Technology Planning and Experimentation

New satellite and ground-based telecommunications systems being authorized by the FCC have benefitted from the advances made in experiments developed for use in the amateur-satellite service. To cite one example, the LEO satellite systems now being authorized by the FCC use packet radio hardware and software technologies originally developed by the amateur radio community for use in the amateur-satellite service, particularly for the amateur MICROSATs and the University of Surrey's UOSATs.

As an extension of this spinoff concept, the amateur-satellite community is evolving standards for high-speed digital data and digital video transmission using compression technologies that are ideally suited for small satellite applications. In order to test and implement this type of technology, frequency allocations with adequate bandwidth are essential. The 2.4 GHz frequency band is the best suited frequency band for the downlink for this type of experimental digital communications. The communications transponders used would pair uplinks at 1260-1270 MHz with downlinks in the 2400-2410 MHz frequency band.

Amateur satellite groups are also doing pioneering work in the development of high efficiency, high-power amplifiers for this portion of the radio spectrum. Linear 2.4 GHz amplifiers with efficiencies as high as 40 percent have already been developed by the amateur community. AMSAT's Phase 3D spacecraft will carry solid-state amplifiers for the 2.4 GHz amateur-satellite band capable of in excess of 100 watts of RF power output and over 10 kilowatts of effective radiated power.

These technologies under development by amateur groups, when taken together and with an adequately wide 2.4 GHz amateur-satellite allocation, will provide powerful demonstrations of low-cost digital video and data transmission techniques. These technical approaches differ from direct broadcast technologies because they are bi-directional and will involve different multiple amateur uplink stations. Both time-division and code-division multiple access techniques are under consideration.

In addition to experimentation with digital video and high-speed packet data links, several amateurs have expressed an interest in investigating low-cost spread spectrum techniques. Spread spectrum communications experiments are important because they may lead to feasible methods of spectrum sharing by various commercial satellite and terrestrial services, applications currently under consideration by the FCC.

Interference Considerations

We have already mentioned interference experienced in the amateur-satellite service as a result of high powered devices such as radars and interference arising from amateur and non-amateur use of the 144-146 and 435-438 MHz bands. Some interference from radars is also present in the 1260-1270 MHz uplink band. The 2.4 GHz band presents a unique challenge in that ISM devices, principally microwave ovens, are present. Microwave ovens are particularly troublesome for amateurs because they are found in most homes, and most amateurs operate in residential areas. For this reason, amateur and amateur-satellite operation should be afforded a part of the band as far away from that occupied by ISM devices as possible. NTIA is reminded that, following a study done for the Voice of America, the U.S. sought an allocation at WARC-

92 for broadcast-satellite service (sound) from 2310-2360 MHz - as far away, in that band, from the 2450 MHz ISM center frequency as possible. AMSAT wonders how close to 2450 MHz the majority of microwave ovens remain. We would welcome any data NTIA may have on the subject.

Recommendations

In the light of the above considerations, AMSAT recommends that no less than 10 MHz, from 2400-2410 MHz, be set aside on a primary basis for the amateur and amateur-satellite services. In addition, as much of the band from 2410-2450 MHz as possible should be allocated to the amateur and amateur-satellite services at least on a secondary basis. This will serve the needs of various amateur modes such as amateur television, as well as providing frequency space for possible amateur satellite uplinks which are not likely to be as sensitive to interference from wideband amateur terrestrial applications or from ISM devices as are amateur satellite downlinks.

AMSAT also urges that a small slice of spectrum (1 to 2 MHz), somewhere in the 2.3-2.4 GHz region be allocated to the amateur service on a primary basis to accommodate terrestrial and earth-moon-earth weak signal operation. For the reasons discussed earlier, this segment should not lie within the 2400-2410 MHz segment to be used for satellite work. Owing to the extremely weak signal strengths involved, it should be located as low as possible in the band in order to avoid destructive interference from ISM devices operating around 2450 MHz.

RESPECTFULLY SUBMITTED,

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By________________________

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