Before the

FEDERAL COMMUNICATIONS COMMISSION
Washington, DC. 20554

In the Matter of	**)**
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Mitigation of Orbital Debris	**) IB Docket No. 02-54**
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To: The Commission

COMMENTS of Emily E. Clarke
Project OSCAR Board Member and Vice President
Amateur Radio Licensee W0EEC

The following are comments from Emily E. Clarke, member of the Board of Directors of Project OSCAR[1], Vice President of Project OSCAR and an amateur radio licensee. Comments are primarily directed to the issue of debris mitigation planning for satellites that have bona fide amateur and educational missions as defined in § 97.3(a)(5) and § 97.207 of the Commission's rules.

OSCAR Missions

From the outset of the Amateur Satellite service with the launch of the original orbiting satellite carrying amateur radio (OSCAR) satellite in 1961[2], amateurs using satellites to experiment has provided both scientific and recreational benefit to the

[1] Project OSCAR is a 501(c)(3) California corporation founded in 1957 with the expressed purpose to launch the first amateur satellite.
[2] At times referred to as OSCAR 1

amateur radio service and the public at large. Current missions include Morse code, voice and digital communications that relay earth-to-earth transmissions, relay scientific and health information and provide space to earth transmissions that provide spacecraft and scientific information.

These spacecraft are small (typically less than 30kg[3] and as small as 2kg[4]) and are generally built on very small budgets by amateur builders or educational institutions. In both cases, building and ultimately launching amateur satellites provides educational opportunities for future engineers who will likely go on to use that experience to further a career in the aerospace industry or other industry of national interest.

Amateur satellites are typically launched into low Earth orbits (LEO) or highly elliptical orbits (HEO) that are shared with other communications services. LEO orbits are typically circular orbits that range from 700km to 1500km and may be injected into a polar[5] or highly inclined orbit[6]. HEO orbits typically range from 4000km at perigee to 35,00km at apogee inclined to 30-50 degrees[7], which places them inside the Clarke belt where commercial geosynchronous satellites reside.

OSCAR Costs

The costs for building amateur satellites are not funded by commercial interests but rather by amateur radio operators who donate time, materials and funds to build and

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[3] Typically OSCAR 7 and OSCAR 8. Microsatellites are typically much smaller (12kg and below.)
[4] Cubesats and nanosats
[5] Typically OSCAR 7 and OSCAR 27
[6] No US OSCAR satellite has been launched into this type of orbit however international satellites Saudi OSCAR 41 and 50, and Radio Sputnik 15 are typical of this orbit type.
[7] OSCAR 10 and OSCAR 13.

launch them. Educational satellites may be funded by grants from government, industry and other benefactors. In both cases, budgets for these types of satellites are extremely low when compared to commercial, military and other government funded satellites. Amateur satellites are generally launched as secondary payloads that share costs with other payloads based on weight and footprint. Thus amateur satellite size and weight are critical to control costs.

US OSCAR Fleet Description

Since the launch of the original OSCAR satellite US amateurs have built and launched 21 OSCAR satellites[8]. Of these, 6 were university projects and 5 were affiliated in some form or another with the US military. Out of the total fleet, 5 have re-entered the earth's atmosphere and 5 remain operational, leaving a balance of 11 non-operational spacecraft.

US OSCAR Satellite Debris Information

The total mass of the 17 OSCAR spacecraft in orbit is approximately 924kg. Of this 920kg, LEO satellites constitute approximately 210kg and HEO satellites constitute the remaining 710kg[9]. The Commission should contrast this to Iridium satellites, which are considered a "small" commercial spacecraft. Iridium has launched 66 satellites plus 5 backups into a constellation of low earth orbits with a total mass of 34,315kg[10] or

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[8] OSCARs 1,2,3,4,6,7,8,10,13,16,18,27,33,37,38,40,43,44,45 and 51. OSCAR 39 is not in this group as an amateur satellite as it was primarily a military satellite that had a very small amateur payload. AO-27 is in this group even though it was a commercial satellite as it is now entirely in the amateur service. Also see Appendix A.

[9] OSCAR 10 (80kg) and OSCAR 40 (630kg)

[10] Andrews Technical Services, Iridium 90 datasheet, April 2002

approximately 37.2 times the mass of the entire OSCAR fleet. However this is somewhat deceiving because one satellite, AO-40, represents 630kg. The remaining 16 US OSCAR satellites represent only 290kg or about 1/118th the mass of the Iridium constellation.

The volume of space occupied by OSCAR satellites is also a factor when considering debris mitigation. OSCAR satellites are very small and typically do not extend solar cell panels[11] whereas commercial satellites extend large panels near and beyond the spacecraft after launch. The area occupied by the orbiting OSCAR fleet is approximately 38.9 cubic meters.

While no firm statistics on Iridium dimensions are public, one might make an estimate based on weight that the basic spacecraft is 200cm x 100cm x 100cm or 20 cubic meters. To this add another 200cm x 100cm x 10cm for each of the two extended solar panels, increasing the total volume to 24 cubic meters. Multiply this by 71 spacecraft and the Iridium fleet occupies 1704 cubic meters of area. Again, if you remove AO-40 from the OSCAR fleet statistics, the remaining 16 satellites occupy ~5.0 cubic meters or about 1/340th that of Iridium.

Why Are These Factors Important?

NASA Guidelines (NSS 1740.14 § 1.3) indicate that the evaluation of orbital debris mitigation plans must be balanced against mission requirements and the need to control costs. However part of that assessment must also include a space environmental impact assessment. Much as the US Air Force uses a “Big Sky – Little Bullet” philosophy with regards moving jet aircraft through the forward edge of a tactical

[11] OSCAR 40 carried extendable solar panels that were never deployed.

battlefield, any debris mitigation assessment must also consider that the smaller the satellite, the smaller the risk of a strike. So clearly size and mass are mitigating factors.

NASA estimates the risk of impact for LEO satellites to be 10^{-6} to 10^{-5} for the 500 to 1500km orbital range[12]. However these statistics were developed with no consideration as to size and mass. So if one assumes these estimates were developed for a satellite constructed similarly to Iridium (i.e. a "small" commercial satellite[13]), the likelihood of one spacecraft striking another is decreased when the mass and size are smaller. The size and mass of a typical OSCAR microsatellite is 50 to 75 times smaller, so one can now consider that the strike probability now jumps to approximately 10^{-7} to 10^{-6} since the volume of space occupied by the satellite is smaller by a similar amount. Therefore it seems appears both unfair and unbalanced to hold OSCAR satellites to the same rules as larger commercial satellites in the context of NSS 1740.14 § 1.3.

OSCAR Launches Currently Under Development

Currently there are two planned US launches in the next 10 years. Both satellites are expected to be launched into HEO orbits roughly 3000km to 35000km inclined between 20 and 40 degrees. These orbits will place the spacecraft into an area where the risk of collision is infinitely small. The spacecraft are expected to have a mass less than 100kg and occupy a space approximately 1.62 cubic meters which is far below the size of most commercial satellites like Iridium. Operational life expectancy is projected to be 12 years which compares favorably to the projected 5 years for an Iridium satellite.

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[12] NSS 1740.14 § 5.2
[13] Sarfield, Liam et. al

There are no US LEO OSCAR launches planned by AMSAT at this time.

Recommendations

It is the recommendation of this writer that the Commission, in it's final ruling, grant AMSAT and it's US affiliates an exemption to the requirement to file orbital debris mitigation plans for a period of not less than 15 years. This would allow AMSAT to continue to build and launch the two OSCAR satellites currently planned and under development without imposing any additional hardship on the amateur satellite community. After that grace period expires, it is recommended that the Commission reconsider requirements to file an orbital debris mitigation plan based on criteria that may be pertinent at that time.

This grace period will also allow AMSAT and it's US affiliates to research, develop and test de-orbit and/or parking technology that will not severely impact the costs and weight of amateur satellites and avoid imposing a hardship on current projects under development. Considering the small number of planned launches this seems to be a fair and balanced approach with virtually no risk to the Commission's goals.

It is further recommended that after the grace period expires, the Commission modify it's rules for small amateur and educational satellites to require debris mitigation after a period of orbital time based on size and mass, not based on an arbitrary number such as 25 years that may be meaningless when taken in the context of size and mass of other spacecraft. This would enable OSCAR satellites to be placed in orbits that will still provide useful service. The rationale for this recommendation is that small amateur and educational satellites have an area and mass much than commercial satellites, have

lower strike probabilities and are more severely impacted in cost, weight and size by a requirement to include additional technology to de-orbit and or park.

It is also recommended that the Commission acknowledge that size and mass are a part of the debris strike probability equation that should be considered when requiring or evaluating any mitigation plan, and that small size and mass are in and of themselves a form of mitigation. This recommendation also compels the Commission to consider these factors when developing meaningful strike predictions based on the Commission's own expert guidelines. The Commission should be fair and balanced when granting mitigation requirements including de-orbit/parking exemptions, and should consider them on a case-by-case only after the grace period has expired.

Respectfully submitted

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Emily E. Clarke
December 17, 2004

Appendix A – US OSCAR Satellite Information

OSCAR Number	Launch Year	Status	Orbit Type	Weight (kg)	Dimensions (cm)			Volume (Cubic M)	Notes
1	1961	Deorbited	LEO	4.5	34	30	40	0.41	
2	1963	Deorbited	LEO	4.5	34	30	40	0.41	
3	1965	Non-Operational	LEO	16.3	43	60	15	0.39	
4	1965	Deorbited	LEO	18.1	Unk	Unk	Unk	Unk	
6	1972	Non-Operational	LEO	16	43	60	15	0.39	
7	1974	Operational	LEO	28.6	36	38	33	0.45	
8	1978	Non-Operational	LEO	27.2	38	38	33	0.48	
10	1983	Non-Operational	HEO	80	60	40	20	0.48	
13	1988	Deorbited	HEO	92	60	40	20	0.48	
16	1990	Operational	LEO	13	22.6	22.6	22.3	0.11	
18	1990	Non-Operational	LEO	13	22.6	22.6	22.3	0.11	
27	1993	Operational	LEO	13	15	15	15	0.04	Primarily a Commercial Satellite
33	1998	Non-Operational	LEO	12	39	39	39	0.59	
34	1998	Non-Operational	LEO	57	36	36	36	0.46	Launched from STS-95
37	2000	Non-Operational	LEO	6	15	15	15	0.04	
38	2000	Non-Operational	LEO	23	36	36	36	0.46	
40	2000	Non-Operational	HEO	630	223	223	68	33.81	
43	2001	Deorbited	LEO	91	94	94	94	8.30	
44	2001	Operational	LEO	10	30	30	30	0.27	
45	2001	Non-Operational	LEO	22	38	43	43	0.70	
51	2004	Operational	LEO	10	22.6	22.6	22.3	0.11	