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Report

FCC Part 56(e)

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Approvers List

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Revision History

Rev	Date	Change Description	Pages Affected
–	7/15/2011	Initial Release	All

0.1 Table of Contents

0.2 Reference Documents

Document Ref	**Title**
300-006	Re-entry analysis

1.0 Part 56e definition [1]

Title 47: Telecommunication

Part 4 – Experimental Radio Service (other than broadcast)

Subpart B – Applications and Licenses

5.63 Supplementary statements required.

(e) Except where the satellite system has already been authorized by the FCC, applicants for an experimental authorization involving a satellite system must submit a description of the design and operational strategies the satellite system will use to mitigate orbital debris, including the following information:

1.1 Part 56(e) (1)

(1) A statement that the space station operator has assessed and limited the amount of debris released in a planned manner during normal operations, and has assessed and limited the probability of the space station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal;

Orbital Debris has been mitigated by ensuring a maximum casualty area of < 8m^2 and using standard NASA-STD-8719.14 Analysis. NASA Debris Assessment Software (DAS) v2.0.1 was used to calculate the risk of collision with objects >10cm during the spacecraft orbit. The probability for CSSWE collision was found to be p<0.0000, meeting the NASA-STD-8719.14 requirement 4.5-1 of p<0.001. A detailed report showing software output is available [4].

1.2 Part 56(e) (2)

(2) A statement that the space station operator has assessed and limited the probability of accidental explosions during and after completion of mission operations. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy. This demonstration should address whether stored energy will be removed at the spacecraft's end of life, by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy, or through other equivalent procedures specifically disclosed in the application;

As specified by the CubeSat Design Specification rev. 12 [2], no additional debris may be created (2.1.2), no pyrotechnics are permitted (2.1.3), no pressure vessels over 1.2 atm may be used (2.1.4), and total chemical energy stored may not exceed 100 W-hr. CSSWE does not have any pyrotechnics or pressure vessels and the maximum stored chemical energy is 8.4 W-hr. Analysis for our battery and mission has shown that our battery capacity will

decline to 5.9 W-hr after 17 months [3]. The battery will continue to degrade with time, leaving less stored energy capacity in the satellite.

1.3 Part 56(e) (3)

(3) A statement that the space station operator has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations. Where a space station will be launched into a low-Earth orbit that is identical, or very similar, to an orbit used by other space stations, the statement must include an analysis of the potential risk of collision and a description of what measures the space station operator plans to take to avoid in-orbit collisions. If the space station operator is relying on coordination with another system, the statement must indicate what steps have been taken to contact, and ascertain the likelihood of successful coordination of physical operations with, the other system. The statement must disclose the accuracy—if any—with which orbital parameters of non-geostationary satellite orbit space stations will be maintained, including apogee, perigee, inclination, and the right ascension of the ascending node(s). In the event that a system is not able to maintain orbital tolerances,*i.e.* , it lacks a propulsion system for orbital maintenance, that fact should be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellite or satellites. Where a space station requests the assignment of a geostationary-Earth orbit location, it must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location, such that the station keeping volumes of the respective satellites might overlap. If so, the statement must include a statement as to the identities of those parties and the measures that will be taken to prevent collisions;

CSSWE relies on passive re-entry for post-mission disposal. NASA Debris Assessment Software (DAS) v. 2.0.1 has shown that CSSWE is compliant with NASA-8719.14 requirement 4.6.1 by re-entry via natural forces within 25 years [4].

1.4 Part 56(e) (4)

(4) A statement detailing the post-mission disposal plans for the space station at end of life, including the quantity of fuel—if any—that will be reserved for post-mission disposal maneuvers. For geostationary-Earth orbit space stations, the statement must disclose the altitude selected for a post-mission disposal orbit and the calculations that are used in deriving the disposal altitude. The statement must also include a casualty risk assessment if planned post-mission disposal involves atmospheric re-entry of the space station. In general, an assessment should include an estimate as to whether portions of the spacecraft will survive re-entry and reach the surface of the Earth, as well as an estimate of the resulting probability of human casualty.

CSSWE has no propulsion and relies on natural forces to de-orbit within 25 years (as stated above). NASA DAS has been used to calculate a risk of human casualty of 1:153,600 (meets NASA-STD-8719.14 requirement 4.7-1 of 1:10,000 risk of casualty). A detailed report showing software output is available [4].

2.0 References

[1] Electronic Code of Federal Regulations. Part 56 definition: <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=9e71bcbaff264a155129913862fdf1fb&rgn=div8&view=text&node=47:1.0.1.1.6.2.239.7&idno=47>. Retrieved 7-15-2011.

[2] CubeSat Design Specification, Revision 12. <http://cubesat.org/images/developers/cds_rev12.pdf> Retrieved 7-15-2011.

[3] Dahlke, Ian. "Battery Verification Study" Internal document. University of Colorado, created Dec 2010.

[4] Gerhardt, David. "Re-entry Analysis". Internal document. University of Colorado, created Oct 2010.