



SOUTHERN
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19 March 2018

Mr. Joseph Hill
Office of Experimental Technology
Federal Communications Commission
Washington, DC

Mr. Hill:

I am writing to you on behalf of Kubos Corporation of Denton, TX in regard to the experimental license application for its CubeSat, *Hamilton-1*. The FCC file number for this application is 0489-EX-CN-2017. This statement is a revision to a previous statement provided on 26 September 2017.

Kubos intends Hamilton-1 to transmit data from LEO at a frequency of 449.9 MHz while passing over Kubos's ground station in Denton. FCC has asked for a rationale behind this choice of frequency, and a statement of non-interference to terrestrial services operating in the same frequency band. These will be provided below, along with an additional supporting precedent.

Rationale. The satellite is not considered an amateur spacecraft as it is an experimental vehicle operated by a commercial entity (Kubos Corp.) for research, development, and technology demonstration purposes. Its operators are paid employees of Kubos Corporation, and the satellite is not intended to for use by members of the general public. Hence, it was felt that the amateur satellite band at 435 - 438 MHz was not an appropriate downlink frequency for the spacecraft.

The FCC Table of Frequency Allocations International footnote 5.286 and United States footnote US87 both describe a band from 449.75 – 450.25 MHz that may be used by Federal and non-Federal stations for the space operation, space telecommand, and space operation service, subject to agreement under ITU 9.21. Kubos intends Hamilton-1 to transmit within that band, on 449.9 MHz, on a non-interference basis.

Non-Interference Requirement. Section 4.4 of the ITU Radio Regulations states:

"Administrations of the Member States shall not assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference to, and shall not claim protection from harmful interference caused by, a station operating in accordance with the provisions of the Constitution, the Convention and these Regulations."

Kubos will not seek or claim protection for Hamilton-1 from harmful interference caused by stations operating in accordance with the Radio Regulations. Below, we will show that Hamilton-1 does not cause harmful interference by comparing its received field strength to that of approved commercial intentional radiators already on the ground.

Compliance. A commonly-used equation to approximate the relationship between power and field strength is¹

$$PG/(4\pi d^2) = E^2/(120\pi)$$

or

$$E = \sqrt{30PG/d^2}$$

where P is transmitter power in Watts, G is the numerical gain of the transmitting antenna relative to an isotropic source, d is the distance of the measuring point from the electrical center of the antenna in meters, and E is the field strength in Volts/meter.

$4\pi d^2$ is the surface area of the sphere centered at the radiating source whose surface is d meters from the source. 120π is the characteristic impedance of free space in Ohms.

¹ For derivation, see <https://www.craf.eu/useful-equations/conversion-formulae/>

The Hamilton-1 CubeSat has a radio with a transmit power of 0.5 Watts, and an omnidirectional antenna with unity gain (G=1). At its minimum distance of 600 km (6×10^8 meters) from the Earth's surface, the received field strength is

$$\sqrt{30 \times 0.5 \text{ W} \times 1 / 36 \times 10^{16}} = 0.000000006454972 \text{ V/m} = 0.00645 \text{ } \mu\text{V/m}$$

Title 47 of the Code of Federal Regulations, part 15, lists the radio emission limits for "intentional radiators" - devices like cell phones, walkie-talkies, garage door openers, television remote controls, etc. From CFR 47 part 15, section 209:

(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	3

The allowable field strength for an intentional radiator on 449 MHz is $200 \text{ } \mu\text{V/m}$ – approximately 31,000 times greater than the CubeSat's received field strength on the ground. It is *practically impossible* for the CubeSat's transmissions to cause harmful interference to terrestrial services, when approved consumer devices already on the ground intentionally radiate a signal that is four orders of magnitude stronger.

International Considerations. The ITU provides power-flux density limits for non-geostationary satellites in the Radio Regulations, chapter VI, articles 21 – 22. However, these limits apply to space stations transmitting above a frequency of 1 GHz. At the 449.9 MHz frequency where Hamilton-1 will transmit, the ITU does not provide any guidance with regard to PFD limits.

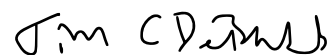
Fortunately, the CubeSat will only transmit when passing over the Applicant's ground station in Denton, Texas, USA. Its orbit is low enough that its emissions will only be received in the United States and Mexico, and nowhere beyond ITU region 2. In regard to potential interference with Mexican operation, we believe the analysis provided above will suffice. The Mexican government agency charged with regulating commercial electronic devices is the Norma Oficial Mexicana, or NOM. A review of relevant NOM standards (especially NOM-EM-016-SCFI-2015) revealed many safety-related requirements, but failed to return any radiated-emission limits as specific as in 47 CF 15 part 209. Indeed, according to Underwriters Laboratory, there are no mandatory EMC requirements in effect in Mexico.²

Precedent. The FCC has granted an experimental license to another commercial CubeSat operator, Blue Canyon Technologies of Boulder, CO, USA for its RAVAN spacecraft (see FCC file no. 0368-EX-PL-2016). RAVAN broadcasted on a nearly identical frequency (448 MHz), with a nearly-identical radio and antenna, from a nearly-identical 600-km orbit, to that which Kubos is planning for Hamilton-1. Like Hamilton-1, RAVAN "shall not claim harmful interference to, and shall not claim protection from harmful interference caused by, a station operating within the radio regulations."

FCC granted an experimental license to Blue Canyon Technologies for RAVAN on 12 August 2016. Given this license grant, Kubos feels that an experimental license for Hamilton-1 to transmit from LEO under nearly the same circumstances should also be approved.

We hope this background helps FCC resolve the interference questions regarding Hamilton-1. Please don't hesitate to contact me (timd@southernstars.com) on behalf of Kubos Corporation, if you have any additional questions.

Sincerely,



Tim C. DeBenedictis

² https://mexico.ul.com/wp-content/uploads/sites/23/2014/06/Mexico_Market_Access_Services_MX_EN.pdf