Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Planet Labs Inc.	)	File No. SAT-MOD-20150802-00053
	)	Call Sign S2912
Application for Modification of its	)	
Authorization to Operate a Non-Geostationary	)	
Earth Imagery Satellite System	)	

OPPOSITION TO PETITION TO DISMISS, DENY OR HOLD IN ABEYANCE

Planet Labs Inc. ("Planet Labs") hereby opposes the ORBCOMM License Corp. ("ORBCOMM") Petition to Dismiss, Deny or Hold in Abeyance ("Petition") [1] the above-captioned license modification application ("Application").[2] Contrary to ORBCOMM's arguments, Planet Labs has demonstrated that its Application complies with the orbital debris regulations of the Federal Communications Commission ("FCC") and the collision risk threshold established by the National Aeronautics and Space Administration ("NASA"). No FCC regulation requires that satellite applicants seeking to deploy in low-Earth orbits identify or coordinate with every operational satellite theoretically impacted by the proposed deployment, as ORBCOMM suggests. Such requirements would be extraordinarily cumbersome and impractical.

Nonetheless, Planet Labs takes seriously its civic obligation to operate openly and responsibly in space and to ensure sustainable and universal access to low-Earth orbit, which is a limited and shared resource. The company makes its orbital ephemerides publicly available (http://ephemerides.planet-labs.com), as stated in the Application, and is open to working with

[1] ORBCOMM License Corp. Petition to Dismiss, Deny or Hold in Abeyance, File No. SAT-MOD-20150802-00053 (filed Jan. 19, 2016).

[2] Application of Planet Labs Inc., File No. SAT-MOD-20150802-00053 (filed Aug. 2, 2015).

all satellite operators that identify particular concerns about potential conjunctions with Planet Labs' satellites.

Planet Labs has conducted a high-fidelity collision risk analysis that specifically takes into account ORBCOMM's satellites. The analysis shows that the worst-case aggregate lifetime collision risk between the two systems is 0.00005, which is equivalent to one collision in 50,000 years of continuous operations and well below the NASA collision risk threshold of 0.001. Because ORBCOMM provides no credible basis to reject or otherwise delay action on the Application, Planet Labs requests that the FCC deny the Petition and expeditiously grant the Application.[3]

Background

Planet Labs holds an FCC license to operate a non-geostationary satellite orbit, remote sensing satellite system comprised of 67 operational satellites.[4] The Planet Labs satellite system, among other things, collects imaging data to facilitate analysis of agricultural yields, monitors natural resources, and aids first responders after natural disasters.[5]

On August 2, 2015, Planet Labs filed the Application seeking additional authority to launch a total of up to 600 technically identical satellites over a ten-year period with no more than 200 operational satellites at any point in time.[6] Planet Labs submitted, as part of the filing, a detailed orbital debris mitigation plan, which included a hyperlink to the company's publicly

[3] Planet Labs' first launch pursuant to this modification application is expected to be in May or June 2016.

[4] *See* Stamp Grant, Planet Labs Inc., SAT-MOD-20140912-00100 (granted Oct. 23, 2014).

[5] *See About*, Planet Labs, https://www.planet.com/about/ (last visited Feb. 1, 2016).

[6] *See* Application, Exhibit 43 at 1. Because of the low altitude of Planet Labs' satellites, periodic replenishment of the fleet is necessary to maintain continuous service.

available orbital ephemerides.[7] As stated in the Application, that data allows "other satellite operators [to] more accurately assess potential collision risks and avoid false positive warnings."[8] The plan also described the orbital maneuvers that Planet Labs could perform "using differential drag for phasing of the satellites along an orbital plan and for potential collision avoidance (if needed)."[9]

At the request of the FCC,[10] Planet Labs supplemented the Application providing information regarding the aggregate risk of accidental collision with catalogued space objects, both during operations and disposal based on NASA-STD 8719.14A, Section 4.5.2.1.[11] Planet Labs provided the specific risk values calculated from NASA's Debris Assessment Software ("DAS"), which is the NASA-approved method for assessing orbital collision risk, and a higher fidelity model, using the industry standard STK Conjunction Analysis Tool ("STK CAT").[12] Planet Labs also clarified in the supplement that: (i) more than 80 percent of its proposed satellites, *i.e.*, more than 480 satellites of the 600 proposed satellites (over the term of the license), would be launched in a circular, sun-synchronous orbit at an altitude of 475 km and an inclination of 97.3 degrees; and (ii) of the other satellites, which would be launched in orbits ranging from 350 km altitude up to 720 km altitude with the semi-major axis never exceeding

[7] *See id* (referencing http://ephemerides.planet-labs.com/).

[8] *See id*.

[9] *See id*. at 6-7. Additional detail regarding the satellite collision avoidance measures that Planet Labs could initiate is included in the attached Technical Appendix.

[10] *See* Letter from Jose P. Albuquerque, Chief, FCC Satellite Division, to Mike Safyan, Director of Launch and Regulatory, Planet Labs Inc. (Nov. 13, 2015).

[11] *See* Application, Accidental Collision Risk Assessment (filed Dec. 8, 2015) ("Planet Labs Collision Risk Assessment").

[12] The software is commercially available from Analytical Graphics, Inc. *See AGI Products Overview*, Analytical Graphics, Inc., http://www.agi.com/products/default.aspx (last visited Feb. 1, 2016).

7,031 km (660 km above sea level),[13] 56 of those satellites are manifested on a Falcon-9 launch vehicle (the "Flock 2c" satellites) and would be deployed in an elliptical orbit at an altitude of 720 x 450 km and an inclination of 98 degrees.[14] The FCC placed the Application on public notice on December 18, 2015.[15]

On January 19, 2016, ORBCOMM filed the Petition requesting that the FCC dismiss, deny or hold in abeyance the Application.[16] In the Petition, ORBCOMM argues that the Planet Labs has proposed to deploy "an undetermined number of Planet Labs satellite deployments in one or more orbital planes that would intersect with the authorized 47 degree-inclined 715 km target operational orbits" ORBCOMM's Generation 2 ("OG2") satellites.[17] Because the Application did not mention ORBCOMM or reference the OG2 satellites specifically, ORBCOMM concludes that the Application necessarily lacks sufficient analysis of the potential risk of collision with its satellites.[18] ORBCOMM further asserts that it could not conduct its own analyses because Planet Labs provided insufficient information regarding the number of satellites and their expected orbital deployments.[19] ORBCOMM urges Planet Labs to select

[13] *See* Application, Exhibit 43 at 1.

[14] *See* Planet Labs Collision Risk Assessment at 1.

[15] *See* Public Notice, Report No. SAT-01124 (Dec. 18, 2015).

[16] *See* Petition at 1.

[17] *Id*. at 1.

[18] *See id*. at 2. Relatedly, ORBCOMM argues that Planet Labs should have contacted ORBCOMM to discuss collision avoidance in light of the potential conjunction in the orbits of the satellite constellations of the two companies. *See id*. at 4.

[19] *See id*. at 2-3. In the Petition, ORBCOMM also criticizes Planet Labs for not having Global Positioning System ("GPS") receivers on its satellites to enhance location accuracy and onboard propulsion to facilitate collision avoidance maneuvers. *See id*. at 5.

different orbital deployments and states that it "would have no objection to a Planet Labs application for orbits that do not overlap with ORBCOMM's."[20]

Discussion

Planet Labs has provided sufficient information regarding the deployment of its satellite system.[21] Although ORBCOMM asserts that the information provided by Planet Labs regarding the number of satellites and their specific orbital deployment is vague, the FCC for years has allowed satellite applicants to identify ranges for both the number of satellites and their orbital deployments in the case where the proposed satellites will be launched as secondary payloads.[22] The flexibility accorded such applicants reflects the FCC's recognition that operators have different technological and business models and that the FCC should not dictate such choices, which could stifle innovation and market options.[23]

Planet Labs' orbital debris mitigation plan demonstrates that Planet Labs "has assessed and limited the probability of the space station becoming a source of debris by collisions with

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[20] *See id*. at 6.

[21] *See supra* notes 6 to 15 and accompanying text.

[22] *See, e.g.*, Stamp Grant, Planet Labs Inc., File No. SAT-LOA-20130626-00087 (granted Dec. 3, 2013); Stamp Grant, Skybox Imaging, Inc., File No. SAT-LOA-20120322-00058 (granted Sep. 20, 2012).

[23] *See, e.g., Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in A Reasonable & Timely Fashion, & Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996*, Report, 14 FCC Rcd 2398 ¶ 5 (1999) ("Our role is not to pick winners and losers, or to select the best technology...."); *Creation of Low Power Radio Service*, Report and Order, 15 FCC Rcd 2205 (2000) (Statement of Chairman William Kennard) ("[I]t is not the business of the FCC to pick winners and losers. We should empower consumers to decide what he or she prefers, rather than ruling out some options on our own and depriving the listener of making that choice for him- or herself."). For the same reasons, the FCC should reject ORBCOMM's suggestions that Planet Labs must use GPS receivers or be penalized for not using a propulsion system. *See also Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd 11567 ¶ 46 (2004) (rejecting requirements to impose orbital tolerance requirements for non-geostationary satellite systems because it would unfairly penalize systems without propulsion).

large debris or other operational space stations…" and "include[s] 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," as required by the Commission's rules.[24]

Planet Labs demonstrated that Flock 2c and its proposed system as a whole meets NASA-STD 8719.14A, Section 4.5.2.1. The NASA standard provides that "[f]or each spacecraft and launch vehicle orbital stage in or passing through [low-Earth orbit], the program or project shall demonstrate that, during the orbital lifetime of each spacecraft and orbital stage, the probability of accidental collision with space objects larger than 10 cm in diameter is less than 0.001."[25]

Planet Labs calculated these values using both NASA's approved risk assessment software, DAS, and the higher-fidelity STK CAT. DAS determines orbital collision risk based on a well-established statistical model that estimates the weighted cross-sectional area flux for the orbital debris environment exposure, based on the mission's initial orbit, area-to-mass ratio, and launch date.[26] The STK CAT analyzes collision risk by comparing the orbits of a proposed system against the orbits of all of the objects in the Space Object Catalog (or Space Catalog) maintained by the Department of Defense.[27]

Because of the comprehensiveness of both collision risk assessment programs, there is no value in separately identifying all satellites that have been considered in the collision analysis or, similarly, their respective operators. In fact, given that there are approximately 4,000 potentially

[24] 47 C.F.R. § 25.114(d)(14)(iii). Planet Labs also met the other requirements of the rule, which ORBCOMM does not challenge. *Id*. § 25.114(d)(14)(i),(ii) and (iv).

[25] *Process for Limiting Orbital Debris*, NASA-STD 8719.14A, Section 4.5.2.1.

[26] *See* attached Technical Appendix at 1.

[27] Planet Labs Collision Risk Assessment at 1.

active satellites in Earth orbit, doing so would be extraordinarily cumbersome and impractical.[28] In any event, nothing in the FCC's rules requires that satellite applicants, seeking to deploy in low-Earth orbits, identify or coordinate with every satellite theoretically impacted by the proposed deployment, as ORBCOMM suggests.[29]

To be sure, the rules provide that a more detailed collision risk assessment is required where systems are operating in "identical" or "very similar" low-Earth orbits.[30] But, the Planet Labs 720 x 450 km, 98 degree inclination elliptical orbit and the ORBCOMM 715 km, 47 degree inclination circular orbit are neither identical nor very similar.

Nonetheless, to address ORBCOMM's concern, Planet Labs has conducted a high-fidelity, collision risk analysis that specifically considers the 17 operational OG2 satellites.[31] The analysis, which is attached in the Technical Appendix, shows that over the lifetime of Flock 2c there would be an aggregate collision risk of 0.000025, which is equivalent to one collision in 100,000 years of continuous operations.[32] The low probability of collision is due in part to the rapid orbital decay of the Flock 2c satellites, ensuring that the apogee of the satellites will not exceed 715 km after 2.5 to 3.5 years in orbit, depending on the solar flux model used in the

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[28] *See, e.g.*, NASA, 19 Orbital Debris Quarterly News, no. 4, Oct. 2015, at 14. For similar reasons, it would be unrealistic and wasteful for a satellite applicant seeking to deploy in low-Earth orbits to assess potential conjunctions against all future launches (many of which do not have publicly available parameters) that could occur in the period between the filing of an application and the launch of the applicant's proposed satellites.

[29] *See* Petition at 3-4; *see also Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd 11567 ¶ 49 (2004) ("[T]he choice of orbit regime and specific orbital parameters is best left to the discretion of the operator in the majority of cases.").

[30] 47 C.F.R. § 24.114(d)(14)(iii); *see also Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd 11567 ¶ 50 (2004).

[31] *See* Petition at 4.

[32] *See* Technical Appendix at A-2.

analysis.[33] Planet Labs also conducted a worst-case analysis assuming that 120 satellites[34] are launched in the same elliptical orbit. The calculated aggregate risk of collision for that theoretical deployment is 0.00005, which also meets the NASA risk threshold.[35]

These results are consistent with expectations. The ORBCOMM and Flock 2c satellites are in different inclinations and have different apogee/perigee altitudes, meaning the resulting orbital paths can only come close to each other when the apsidal precision of a Flock 2c satellite and the nodal precision of an ORBCOMM satellite coincide at a single point.[36]

The FCC also should reject ORBCOMM's unsupported suggestions that Planet Labs is an irresponsible space actor. Planet Labs takes seriously its civic obligation to operate openly and responsibly in space and to ensure sustainable and universal access to low-Earth orbit, which is a limited and shared resource.[37] Planet Labs takes great care to ensure that its publicly available orbital ephemerides have a high degree of fidelity, substantially reducing false positive conjunction alerts and the need for operators to engage in orbital maneuvers to avoid possible collisions. For example, the company periodically collects two-way ranging data from a global network of ground stations and publishes updated orbital ephemerides hourly. The company is also a member, as is ORBCOMM, of the Space Data Association ("SDA"), which is a non-profit association of satellite operators, having the primary goals of facilitating "improvements in the

[33] *See id.*

[34] This is the maximum number of satellites that Planet Labs stated could be in an orbit different from Planet Lab's primary 475 km circular orbit. *See* Planet Labs Collision Risk Assessment at 1.

[35] *See* Technical Appendix at A-2.

[36] *See id.*

[37] Indeed, the company's Code of Ethics provides that Planet Labs is "committed to the peaceful and responsible use of outer space for the benefit of all life" and to "pursuing the collaborative and safe use of space." *See Planet Code of Ethics*, Planet Labs, https://www.planet.com/ethics/ (last visited Feb. 1, 2016).

safety and integrity of satellite operations through wider and improved coordination among satellites operators [and] improved management of the shared resources of the space environment."[38]

Planet Labs also takes other measures to minimize orbital debris risks, including: (i) never intentionally discarding satellite components in orbit; (ii) designing satellites to reenter the atmosphere within 25 years; (iii) striving to select low orbits which have more rapid orbital decay; and (iv) reporting all launches and orbits to the Air Force's Joint Space Operations Center ("JSpOC") and sharing tracking data to assist JSpOC in identifying the satellites upon deployment.[39]

Planet Labs appreciates that ORBCOMM has concerns over the safety of its orbital assets. But, it does not have property rights to the 715 km orbital altitude,[40] and FCC and international space policies encourage the shared and cooperative use of orbital resources.[41] The Falcon 9 launch is one of the few launches available in the United States in the available timeframe, and it is an important part of Planet Lab's launch risk mitigation strategy. Accordingly, Planet Labs cannot simply withdraw its request to launch into that orbit, as

[38] *See* SDA Overview, Space Data Association, http://www.space-data.org/sda/about/sda-overview/ (last visited Feb. 1, 2016). Although both Planet Labs and ORBCOMM are members of SDA, ORBCOMM did not reach out to Planet Labs prior to filing the Petition. Since the filing of the Petition, the parties have initiated discussions to address ORBCOMM's concerns.

[39] *See* Reply Comments of Planet Labs Inc., IB Docket No. 12-267, at 2 (filed March 2, 2015).

[40] *See, e.g.*, *Morning Star Satellite Company, L.L.C.*, 16 FCC Rcd 11550 ¶ 13 (IB 2001) ("No Commission licensee . . . receives any property rights to . . . any orbit location."); *Application of EchoStar North America Corporation*, 16 FCC Rcd 14262 ¶ 3 (IB 2001).

[41] *See, e.g.*, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies art. I, Jan. 27, 1967, 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205; Terms of Reference for the Inter-Agency Space Debris Coordination Committee (IADC), IADC-93-01 (rev. 11.3) (Apr. 2, 2015); *see also Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd 11567 (2004); *DIRECTV Enterprises, LLC*, Order and Authorization, 21 FCC Rcd 8028 ¶ 10 (IB 2006).

ORBCOMM believes.[42] Because Planet Labs has provided all relevant orbital information and demonstrated that collision risk associated with its system meets NASA risk thresholds, the FCC should deny the ORBCOMM Petition and expeditiously grant Planet Lab's Application.

Respectfully submitted,

/s/ Michael Safyan
Michael Safyan
Director of Launch and Regulatory Affairs
Planet Labs Inc.
346 9th St.
San Francisco, CA 94103

Dated: February 3, 2016

[42] *See* Petition at 6.

Technical Certification

I, Mike Safyan, Director of Launch and Regulatory Affairs of Planet Labs Inc., hereby certify under penalty of perjury that:

- I am the technically qualified person responsible for preparation of the technical and other information contained in this Opposition.
- I am familiar with Part 25 of the Commission's rules and NASA's orbital debris standards; and
- The statements made herein are complete and accurate to the best of my knowledge.

/s/Michael Safyan
Michael Safyan
Director of Launch and Regulatory Affairs
Planet Labs Inc.

February 3, 2016

Technical Appendix

Introduction and Industry Standards

NASA's Technical Standard NASA-STD-8719.14A[1] provides guidance on limiting the impact of orbital debris. The risk of a catastrophic collision during mission operations is addressed by *Requirement 4.5-1: Limiting debris generated by collisions with large objects when operating in Earth orbit*, and the risk of breakups due to collisions with small debris is addressed in *Requirement 4.5-2: Limiting debris generated by collisions with small objects when operating in Earth or lunar orbit*.

Under Section 4.5.4 of NASA-STD-8719.14A, the industry standard methods for assessing compliance are outlined, including an endorsement of NASA's Debris Assessment Software (DAS) as a primary reference for debris risk assessments. DAS calculates the risk of a collision over the operational lifetime by estimating the weighted cross-sectional area flux for the orbital debris environment exposure, based on the satellite mission's initial orbit, area-to-mass ratio and launch date. It therefore takes into account a statistical object environment model (ORDEM2000), and does not model individual satellites from the Space Catalog. ORDEM2000 includes environment data beyond the year 2030 derived from the output of NASA's LEGEND debris environment evolutionary model.[2] Using DAS to assess collision risk, as per NASA technical standards, Planet Labs calculates the statistical risk of collision to be below the requirement of 1:10,000.

Planet Labs has a number of senior staff that have previously worked in the fields of orbital debris mitigation, orbital modeling, space situational awareness, and conjunction assessment. Planet Labs has a deep understanding of the risks of operating in a congested space environment and takes concerns around safe space operations very seriously. Because there is a specific concern with the elliptical Flock 2c satellites crossing Orbcomm's OG2 altitude, Planet Labs has performed an additional analysis specifically addressing the risk between the Flock 2c and Orbcomm OG2 satellites.

High-Fidelity Model

The high-fidelity conjunction assessment between Orbcomm OG2 and Planet Labs satellites assumes the following input parameters:

- 17 Orbcomm satellites in a 715 x 715 km orbit at 47 degree inclination.
- a theoretical maximum of 120 Planet Labs satellites in the Flock 2c 450 x 720 km orbit at 98 degree inclination.
- 10 x 10 spherical coefficient gravity field.
- NRL-MSISE00 atmosphere model with Schatten predict solar flux.
- Cross-sectional areas of $4m^2$ and $0.2m^2$ for Orbcomm and Planet Labs satellites, respectively.

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[1] *Process for Limiting Orbital Debris*, NASA-STD-8719.14A, *available at* http://www.hq.nasa.gov/office/codeq/doctree/871914.pdf.

[2] Opiela, J., Johnson, N., *Improvements to NASA's Debris Assessment Software, available at* http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20070013703.pdf.

- Uncertainty covariance of 1000 m in along-track axis, and 100 m in radial and cross-track axes for all satellites.
- Alfonso method of probability of collision.

Over the relevant satellite lifetimes, there is a less than 5e-5 probability of a collision between the 17 Orbcomm and 120 Planet Labs satellites, which is the maximum number of Planet Labs satellites that would occupy the 720 x 450 km elliptical orbit. This is equivalent to one collision in 50,000 years of continuous operations when the orbits of both satellite fleets have the potential for a conjunction. For the 56 satellites planned to launch from a Falcon 9 in 2016 into the elliptical orbit, Planet Labs estimates a probability of collision of 2.5e-5 against the 17 Orbcomm satellites, or one in every 100,000 years of continuous operations. This result is consistent with expectations since the Orbcomm and Flock 2c satellites are in completely different inclinations and have different apogee/perigee altitudes. This means the resulting orbital paths can only come close to each other when the apsidal precision of Flock 2c and the nodal precession of Orbcomm happen to line the orbits up at a single point.

Orbit Decay

Flock 2c will be inserted into a 450 x 720 km orbit. The mean apogee will oscillate with an amplitude of approximately 15 km and period of 4 months. Due to orbital decay, the apogee will not exceed 715 km after 2.5 years, using the Schatten predict solar flux model. When using Schatten's -2 sigma solar flux model, which takes into account lower than expected solar activity, the satellites will take 3.5 years to reach the same benchmark.

Orbit Determination and Ephemerides

Planet Labs performs orbit determination on its fleet of satellites on an hourly basis to ensure it always has the best possible ephemeris of satellite trajectories and their predictions. The company regularly acquires two-way ranging data between the satellites and a global network of ground stations, and to help increase the accuracy of collision predictions, Planet Labs maintains an orbit catalog of its own, which is produced from this ranging data and is publicly published hourly to http://ephemerides.planet-labs.com/.

Collision Avoidance Maneuver

It is inevitable over time that high risk conjunctions will occur. Although Planet Labs satellites are not equipped with propulsion, Planet Labs is nonetheless capable of taking preventative actions. For all conjunctions with active, maneuverable satellites, Planet Labs will contact the potentially affected operator to initiate discussions and ensure that the operator has the best-available ephemeris for the Planet Lab satellites. If the conjunction is with any other object and has a small miss distance (and similarly small uncertainties), then the company will command the Planet Labs satellites into a minimum interaction area attitude configuration at the time of closest approach. Because the collision probability is a function of the combined hardbody radii of the two conjuncting objects, this simple attitude maneuver can result in a 30% reduction in risk of collision with a 1 m-sized object. It may also be feasible to use differential drag to avoid

conjunctions, given sufficient lead time.[3] For the 450 x 720 km orbit, launch date and predicted solar flux conditions, Planet Labs estimates the control authority of differential drag maneuvering to be ~3 km/day^2, using the NRL-MSISE00 atmosphere model. This degree of control is afforded by the 5:1 ratio in cross-sectional area between low-drag and high-drag modes thanks to the large deployed solar panels in relation to the body size.

[3] Foster, C., Hallam, H, Mason, J., *Orbit Determination and Differential-drag Control of Planet Labs Cubesat Constellations*, AAS/AIAA Astrodynamics Specialist Conference, Vail, Colorado, August 9-13, 2015, arXiv:1509.03270.

CERTIFICATE OF SERVICE

I, Teresita Valencia, hereby certify that on February 3, 2016, a true and correct copy of the above Opposition to Petition to Dismiss, Deny or Hold in Abeyance was sent by United States mail, first class postage prepaid, to the following:

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