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SAT-STA-20150821-00060
Spaceflight, Inc.
SHERPA

IE2015001561

Date & Time Filed: Aug 21 2015 7:13:16:996PM
File Number: SAT-STA-20150821-00060
Callsign:



** with conditions*

File # SAT-STA-20150821-00060
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From conditions see
To: conditions see

Approved by OMB
3060-0678

Approved: Stephen J. Duall
Stephen J. Duall
Chief, Satellite Policy Branch

FEDERAL COMMUNICATIONS COMMISSION
APPLICATION FOR SPACE STATION SPECIAL TEMPORARY AUTHORITY

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APPLICANT INFORMATION

Enter a description of this application to identify it on the main menu:
SHERPA space station STA

I. Applicant

Name:	Spaceflight, Inc.	Phone Number:	202-262-1825
DBA Name:		Fax Number:	
Street:	PO Box 1922	E-Mail:	IHornsby@SpaceflightIndustries.com
City:	Bellevue	State:	WA
Country:	USA	Zipcode:	98009
Attention:	Ms Indra Hornsby		

ATTACHMENT TO GRANT
Spaceflight Inc.
 IBFS File No. SAT-STA-20150821-00060

IBFS File No(s):	SAT-STA-20150821-00060 ¹	<p>GRANT – With Conditions</p>  <p>International Bureau Satellite Division</p>
Licensee/Grantee:	Spaceflight Inc.	
Satellite Name:	SHERPA	
Orbital Location: (required station-keeping tolerance)	NGSO in an elliptical orbit with a perigee altitude of 450 km, apogee altitude of 720 km, and 97.4° inclination.	
Administration:	United States of America	
Nature of Service:	Space Operations	
Scope of Grant:	Authority to operate ² one non-geostationary satellite for a period not to exceed 12 hours, in order to deploy the spacecraft described in the SHERPA manifest. ³	
Service Area(s):	Three earth stations ⁴ located in North Pole, Alaska, Tukwila, Washington, and Wallops Island, Virginia.	
Frequencies:	Command frequency: 450.2 MHz (Earth-to-space) Telemetry and Tracking frequency: 401.5 MHz (space-to-Earth)	
<p>Operations under this grant must comport with the legal and technical specifications set forth by the applicant or petitioner and with Federal Communication Commission’s rules not waived herein. This grant is also subject to the following conditions:</p> <ol style="list-style-type: none"> 1. All operations under this grant of special temporary authority must be on an unprotected and non-harmful interference basis, <i>i.e.</i>, Spaceflight must not cause harmful interference to, and shall not claim protection from interference caused to it by, any other lawfully operating station. 2. In the event of any harmful interference under this grant of special temporary authority, Spaceflight must cease operations immediately upon notification of such interference and must inform the Commission, in writing, immediately of such an event. 		

¹ The application was placed on public notice on Jan. 22, 2016. *Policy Branch Information Satellite Space Station Applications Accepted for Filing*, Public Notice, Report No. SAT-01130 (Jan. 22, 2016).

² See *infra*, condition 3.

³ See Letter from Jonathan L. Wiener, Goldberg, Godles, Wiener & Wright LLP, to Jose P. Albuquerque, Chief, Satellite Division, FCC International Bureau, Attach. at 1 (filed Nov. 2, 2015) (on file in IBFS File No. SAT-STA-20150821-00060) (listing 90 satellites for planned deployment from SHERPA); Letter from Henry Goldberg and Jonathan L. Wiener, Goldberg Godles, Wiener & Wright LLP, to Marlene H. Dortch, Secretary, FCC, at 1 (filed June 17, 2016) (indicating that the Pathfinder-1 satellite previously scheduled to be deployed by the SHERPA was removed from the manifest). An additional satellite, the SeeMe satellite, will be deployed from the eXCITe satellite three weeks after the deployment of the eXCITe spacecraft, but until then will remain part of the eXCITe spacecraft. See OET Experimental File No. 0540-EX-PL-2015, Exhibits, ODAR at 1-2 (granted April 25, 2016), grant later modified in other respects by OET Experimental File No. 0089-EX-ML-2016 (granted June 29, 2016). Spaceflight has stated that no additional spacecraft will be added to the manifest. See Letter from Tony Lin, Counsel, Hogan Lovells US LLP, to Marlene H. Dortch, Secretary, FCC, at Ex. B (filed July 26, 2016) (enclosing letter from H. Indra Hornsby, General Counsel, Spaceflight, Inc. to Mike Safyan, Director of Launch and Regulatory Affairs, Planet Labs, Inc., July 22, 2016).

⁴ Spaceflight has requested communications between the SHERPA spacecraft and three earth stations. See IBFS File Nos. SES-STA-20150824-00549, SES-STA-20150824-00550, and SES-STA-20150821-00051.

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3. We waive, on our own motion, Section 25.113(g) of the Commission's rules, requiring orbital deployment approval and operating authority to be applied for and granted prior to orbital deployment and operation of a space station.⁵ We find that the special circumstances presented here, including the short operational lifetime of the space station, and the similarity of the space station to an upper stage launch vehicle,⁶ justify waiver of the rule. Further, waiver of the rule would not undermine the policy objective of the rule. The Commission has described the intent of the rule to be "that the approval process [for space stations] involves a public interest review of proposed space station operation and debris mitigation plans before a space station is launched into orbit."⁷ Consistent with the intent of the rule, we have reviewed the description of space station operations and orbital debris mitigation plan submitted by Spaceflight, and make a finding that authorizing the space station is the public interest. In light of these specific circumstances, we conclude that waiver would serve the public interest. The rule is waived herein without prejudice to any future applications by Spaceflight, or by any other operators seeking authority to operate space stations designed to deploy satellites.
4. On May 11, 2016, ORBCOMM License Corp. (ORBCOMM) filed Informal Comments requesting that the Commission defer grant of this STA request.⁸ ORBCOMM objected to grant of STA on the basis that the SHERPA spacecraft and satellites planned for deployment from SHERPA would use altitudes and orbital planes that would intersect with the authorized 47 degree-inclined 715 km circular target operational orbits for its ORBCOMM Generation 2 Satellites.⁹ ORBCOMM's concern is that it will be required to perform an unacceptably large number of collision avoidance maneuvers, thereby impacting the service life of its satellites, as a result of potential collisions between its satellites and the SHERPA and SHERPA-deployed satellites.¹⁰ ORBCOMM is also concerned that the SHERPA and the SHERPA-deployed satellites may collide with each other, thus creating debris that would affect ORBCOMM.¹¹ We find that, based on the conditions placed on this authorization and on the additional information filed in the record, including technical analysis placed in the record by Planet Labs Inc. (Planet Labs) and confirmed by Spaceflight,¹² we can proceed with grant of Spaceflight's request for STA to operate the SHERPA spacecraft.
- a. With respect to ORBCOMM's concern with an unacceptably large number of collision avoidance maneuvers, the Commission authorizations granted to Spire and Planet Labs are conditioned

⁵ 47 CFR § 25.113(g).

⁶ An upper stage launch vehicle would not be licensed by the Commission, to the extent that the vehicle falls within the authority of the Federal Aviation Administration (FAA). See *Mitigation of Orbital Debris*, Notice of Proposed Rulemaking, 17 FCC Rcd 5586, 5592-93, paras. 14-15 (2002) (citing the Commercial Space Launch Act of 1984, as amended, 49 U.S.C. § 70101 *et seq.*, and the FAA's implementing regulations, codified at 14 CFR Ch. III, § 400 *et seq.*); see also *Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd 11567, 11611, para. 105 (2004) (noting the Commission's prior observation that "matters addressed under the Commercial Space Launch Act and its implementing regulations are most appropriately addressed by the FAA").

⁷ *Comprehensive Review of Licensing and Operating Rules for Satellite Services*, Further Notice of Proposed Rulemaking, 29 FCC Rcd 12116, 12155, para. 133 (2014).

⁸ ORBCOMM License Corp., Informal Comments at 1 (filed May 11, 2016) (on file in IBFS File No. SAT-STA-20150821-00060) (ORBCOMM Informal Comments).

⁹ *Id.* at 2.

¹⁰ *Id.* at 3-4.

¹¹ *Id.* at 2.

¹² See Letter from Tony Lin, Counsel, Hogan Lovells US LLP, to Marlene H. Dortch, Secretary, FCC, at 1, Exhs. A, B (filed July 26, 2016).

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on Spire and Planet performing certain actions in the event they receive a conjunction warning from the Joint Space Operations Center (JSpOC) or other source.¹³ These actions should assist ORBCOMM in reducing the number of collision avoidance maneuvers to an acceptable level. With respect to the concern with collisions among the spacecraft in the SHERPA mission, the analysis provided by Planet Labs concluded that the risk of in-plane collisions over a two year period for any pair of objects is 7.8×10^{-7} .¹⁴ In an *ex parte* letter filed on August 9, 2016, ORBCOMM argued that since there were 4,095 possible pairs of objects, the aggregate probability of in-plane collision would be 3.18×10^{-3} .¹⁵ However, of the satellites deployed from SHERPA, 56 will be operated by Planet Labs, which has stated that it will execute differential drag maneuvers to space its satellites.¹⁶ For purposes of analyzing collision risk, this action will effectively reduce the collision risk among Planet Labs' 56 satellite to zero. Another eight of the satellites planned for deployment will be operated by Spire, Inc., which has stated that its satellites can perform collision-avoidance maneuvers using differential drag and an on-board attitude determination and control system.¹⁷ Four other satellites are equipped with propulsion.¹⁸

b. We conclude therefore that although the collision risk as calculated by ORBCOMM correctly assesses risk based on multiple collision pairs, the figure derived by ORBCOMM overstates the actual risk because collisions involving any of these 68 objects will either be avoided entirely, or will be less likely than assumed in the Planet Labs' analysis. In order to derive a more realistic estimate of the aggregate probability of collision, we consider two different scenarios. In scenario 1, we assume that the 68 objects identified above do not collide among themselves. In scenario 2, we assume in addition that these 68 objects also do not collide with any of the other 23 objects. This allows us to conclude that, starting from the probability of collision for any pair of objects, as estimated by Planet Labs (7.8×10^{-7}), the aggregate probability of collision is bounded by 0.2×10^{-3} (scenario 2) and 1.4×10^{-3} (scenario 1).

c. This range does not include collision risk with respect to the "background" large object debris population. Exhibit A, Appendix B of the *ex parte* filing submitted by Planet Labs on July 26, 2016 contains such an analysis, prepared using NASA's Debris Assessment Software (DAS), for the entire SHERPA mission.¹⁹ Adding up the probabilities of collision calculated by Planet Labs for the 91 objects (ninety satellites plus SHERPA), we arrive at an aggregate probability of collision with the background of 0.34×10^{-3} . Therefore, we estimate the overall probability of collision for the entire SHERPA mission to be bounded by 0.54×10^{-3} and 1.7×10^{-3} . The Planet Labs analysis also included an estimate of the

¹³ See Planet Labs Inc., IBFS File No. SAT-MOD-20150802-00053 (granted Sept. 15, 2016); Spire Global, Inc., IBFS File No. SAT-LOA-20151123-00078 (grant-in-part and defer-in-part Oct. 14, 2016).

¹⁴ Letter from Tony Lin, Counsel, Hogan Lovells US LLP, to Marlene H. Dortch, Secretary, FCC, at 3 (filed July 26, 2016).

¹⁵ Letter from Walter H. Sonnenfeldt, Regulatory Counsel, ORBCOMM License Corp. & Vice President, Regulatory Affairs, ORBCOMM Inc. to Marlene H. Dortch, Secretary, FCC, at 4, n.7 (filed Aug. 9, 2016) (filed as "Response to 7/26/16 Planet Labs Letter").

¹⁶ Letter from Tony Lin, Counsel, Planet Labs, to Marlene H. Dortch, Secretary, FCC, at 1 (filed Aug. 24, 2016).

¹⁷ Application of Spire Global, Inc., File No. SAT-LOA-20151123-00078, Exhibit A at 5-6 (Nov. 23, 2015).

¹⁸ See OET Experimental File No. 0586-EX-PL-2015, Exhibits, Revised ODAR v.3.1 at 8-10 (granted Jan. 27, 2016) (describing propulsion system on the two identical Aerocube-7 spacecraft); OET Experimental File No. 0829-EX-PL-2014 Exhibits, Orbital Debris Assessment at 8 (granted Dec. 28, 2015) (describing propulsion system on the BlackSky Global Pathfinder satellites, including the Pathfinder-2 spacecraft) grant later modified in other respects by OET Experimental File No. 0053-EX-ML-2016 (granted April 11, 2016); Su-A Song, Yeona Yoo, Soyeon Koo, Seungkeun Kim, and Jinyoung Suk, *System Design and Dynamic Analysis for Sail Deployment for Cube Satellite CNUSAIL-1*, 54th AIAA Aerospace Sciences Meeting, AIAA SciTech (2016), <http://dx.doi.org/10.2514/6.2016-0964> (describing planned solar sail propulsion for Chungnam University's CNUSAIL-1 spacecraft).

¹⁹ Letter from Tony Lin, Counsel, Hogan Lovells US LLP, to Marlene H. Dortch, Secretary, FCC, Exh A. at 10-59 (filed July 26, 2016).

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probability of collision of any of the 91 objects in the SHERPA mission and any of the ORBCOMM satellites.²⁰ This calculation is relevant in assessing the burden that will be imposed on ORBCOMM as a result of maneuvers required to avoid collisions. However, we have not included it in our estimate of the overall probability of collision because such collisions will be avoided.

5. Spaceflight must take all steps within its control to ensure that it and the launch provider, SpaceX, abort the separation of the SHERPA deployer from the SpaceX Falcon 9 launch vehicle in the event that a SpaceX Formosat-5 launch mission anomaly precludes lowering the Falcon 9 second stage from the Formosat-5 720 km circular release orbit to the specified 450 x 720 km SHERPA release orbit.
6. Spaceflight must ensure that SHERPA will be deployed from the launch vehicle and will operate during times such that SHERPA radio-frequency operations will not interfere with Meteorological Satellite operations. For any SHERPA operations prior to November 30, 2016, NOAA has conducted an analysis, which was provided to Spaceflight on October 24, 2016. For any SHERPA operations scheduled for after November 30, 2016, Spaceflight must provide notification to the following point of contact at the earliest possible date prior to launch, so that additional orbit analysis can be accomplished.

Richard Kelley
Alion Science and Technology for U.S. Department of Commerce and NOAA/NESDIS
NOAA Satellite Operations Facility
Suitland, MD
phone 01.301.817.4636
rkelly@alionscience.com richard.kelley@noaa.gov

7. Prior to the start of operations, Spaceflight must contact the Air Force Spectrum Management Office and supply a stop buzzer point of contact (POC). This POC must be available any time testing is being performed.

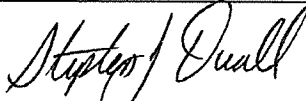
Air Force Spectrum Management Office
6910 Cooper Ave
Ft George G. Meade, Maryland

Jennifer Corzo
Phone: 301-225-3719
Jennifer.corzo.2@us.af.mil

8. This authorization is limited to operations of the SHERPA spacecraft and does not in any way grant authority for operations or express a view concerning the status of any satellite that will be deployed from SHERPA.
9. Spaceflight shall not integrate any satellite into the SHERPA deployer unless, for any space station on such satellite requiring FCC authorization, the operator has either obtained an FCC license for such space station, or in the case of an amateur space station, has submitted pre-launch notifications to the FCC, and the FCC has confirmed that the space station is considered documented pursuant to Section 97.5(a)(3) of the Commission's rules, 47 CFR § 97.5(a)(3).
10. SHERPA must not deploy any satellites in the event that a SpaceX Formosat-5 launch mission anomaly precludes lowering the Falcon 9 second stage from the Formosat-5 720 km circular release orbit to the specified 450 x 720 km SHERPA release orbit.
11. Operations of the SHERPA spacecraft must begin no later than 15 days following launch of the spacecraft. Upon commencement of operations, Spaceflight must file a notification within one (1) day

²⁰ See *id.* at 3.

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certifying to the Commission that the space station has been successfully placed in orbit and its operations fully conform to the terms and conditions of this authorization.		
Licensee/grantee is afforded thirty (30) days from the date of release of this action to decline the grant as conditioned. Failure to respond within this period will constitute formal acceptance of the grant as conditioned.		
This action is taken pursuant to Section 0.261 of the Commission's rules on delegated authority, 47 CFR § 0.261, and is effective upon release.		
Station licenses are subject to the conditions specified in Section 309(h) of the Communications Act of 1934, as amended, 47 U.S.C. § 309(h).		
Action Date: October 25, 2016		
Term Dates	From: see conditions	To: see conditions
Approved:	 Stephen J. Duall Chief, Satellite Policy Branch	

** SET ASIDE / REVERTED TO PENDING STATUS ON 11/23/16 **

2. Contact	
Name: Jonathan L. Wiener	Phone Number: 202-429-4900
Company: Goldberg Godles Wiener & Wright LLP	Fax Number: 202-429-4912
Street: 1229 19th Street, NW	E-Mail: jwiener@g2w2.com
City: Washington	State: DC
Country: USA	Zipcode: 20036 -2413
Attention:	Relationship: Legal Counsel
(If your application is related to an application filed with the Commission, enter either the file number or the IB Submission ID of the related application. Please enter only one.)	
3. Reference File Number or Submission ID	
4a. Is a fee submitted with this application?	
<input checked="" type="radio"/> If Yes, complete and attach FCC Form 159. If No, indicate reason for fee exemption (see 47 C.F.R. Section 1.1114).	
<input type="radio"/> Governmental Entity <input type="radio"/> Noncommercial educational licensee	
<input type="radio"/> Other (please explain):	
4b. Fee Classification CXW - Space Station (Non-Geostationary)	
5. Type Request	
<input type="radio"/> Change Station Location	<input type="radio"/> Extend Expiration Date <input checked="" type="radio"/> Other
6. Temporary Orbit Location	
7. Requested Extended Expiration Date	

<p>8. Description (If the complete description does not appear in this box, please go to the end of the form to view it in its entirety.)</p> <div style="border: 1px solid black; padding: 5px;"> <p>Spaceflight Inc., pursuant to Section 25.120 of the Commission's Rules, hereby requests Special Temporary Authority to permit it to communicate with a spacecraft, known as SHERPA, and corresponding earth stations for a duration of up to twelve (12) hours to take place in a single occurrence between January 15, 2016 and April 15, 2016.</p> </div>	
<p>9. By checking Yes, the undersigned certifies that neither applicant nor any other party to the application is subject to a denial of Federal benefits that includes FCC benefits pursuant to Section 5301 of the Anti-Drug Act of 1988, 21 U.S.C. Section 862, because of a conviction for possession or distribution of a controlled substance. See 47 CFR 1.2002(b) for the meaning of "party to the application"; for these purposes.</p> <p style="text-align: right;"> <input checked="" type="radio"/> Yes <input type="radio"/> No </p>	
<p>10. Name of Person Signing Indra Hornsby</p>	<p>11. Title of Person Signing General Counsel</p>
<p>12. Please supply any need attachments.</p>	
<p>Attachment 1: Request for STA</p>	<p>Attachment 2: ODAR</p>
<p>Attachment 3:</p>	<p>Attachment 3:</p>
<p style="text-align: center;">WILLFUL FALSE STATEMENTS MADE ON THIS FORM ARE PUNISHABLE BY FINE AND / OR IMPRISONMENT (U.S. Code, Title 18, Section 1001), AND/OR REVOCATION OF ANY STATION AUTHORIZATION (U.S. Code, Title 47, Section 312(a)(1)), AND/OR FORFEITURE (U.S. Code, Title 47, Section 503).</p>	

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THE FOREGOING NOTICE IS REQUIRED BY THE PAPERWORK REDUCTION ACT OF 1995, PUBLIC LAW 104-13, OCTOBER 1, 1995, 44 U.S.C. SECTION 3507.

REQUESTS FOR SPECIAL TEMPORARY AUTHORITY

Spaceflight Inc. ("Spaceflight"), pursuant to Section 25.120 of the Commission's Rules, hereby requests Special Temporary Authority ("STA") to permit it to communicate with a spacecraft, known as SHERPA, and corresponding earth stations for a duration of up to twelve (12) hours to take place in a single occurrence between January 15, 2016 and April 15, 2016.¹

As described in greater detail in the attached Technical Annex, SHERPA is a non-propulsive, free-flying spacecraft intended to deploy auxiliary spacecraft from each of five ports. SHERPA itself is proposed to be affixed to the payload on a Falcon 9 launch that is currently scheduled to occur within above-stated launch period. SHERPA will be placed in a sun synchronous elliptical orbit of 720 x 450 km, 97.4 degree inclination. After its deployment from the launch vehicle, SHERPA will initiate a sequence of procedures to begin the deployment of its own payload and the communication that is the subject of the instant requests will commence.

Spaceflight seeks authority to permit it to establish communications between SHERPA and three earth stations during the twelve-hour operational of the SHERPA payload.² The communications links, which will consist of two-way data transmissions, will permit the Spaceflight technical crew to track the launch and download status information from SHERPA. The proposed frequencies for communication to and from SHERPA are UHF frequencies authorized under the FCC's Table of Frequency Allocations for space operations.

The payload of SHERPA will consist of small spacecraft that are owned and to be operated by Spaceflight's customers. Each customer is expressly required under its agreement with Spaceflight to obtain all licenses, authorization, clearances, and permits that may be necessary to operate its individual spacecraft.

Spaceflight asserts that grant of the instant requests for Special Temporary Authority will be in the public interest. Such grant will permit Spaceflight to initiate a new and innovative deployment technology for small spacecraft, thereby providing a cost-efficient means for placing them into their designed orbits.

¹ Recent developments in the spacecraft launch industry have resulted in a number of launch delays and uncertainties as to when future launches will occur. The timeframe set forth above reflects the current launch period assigned for the Spaceflight launch. Spaceflight has not yet been assigned an exact date of the SHERPA launch. Accordingly, Spaceflight is herein seeking STA to cover a period of three (3) months. However, as described herein, the actual communications for which STA is sought will occur over a period of only twelve (12) hours. Spaceflight will notify the Commission as its launch period is narrowed to a particular day as soon as that information is confirmed to it by the launch provider.

² Spaceflight is submitting concurrently unique applications for space station STA to cover the communications of SHERPA and earth station STA to cover the ground station locations.

Technical Annex: Spaceflight SHERPA Spacecraft Description

The Spaceflight SHERPA spacecraft is a non-propulsive, free-flying spacecraft intended to deploy auxiliary spacecraft from each of five ports. The spacecraft is primarily composed of commercial off the shelf (COTS) hardware, with the core structure being a custom ESPA Grande ring. Auxiliary satellites are integrated to each port using simple plates and separated using proven separation systems, such as the Planetary Systems Corporation (PSC) Motorized Lightband (MLB) and the Innovative Solutions in Space (ISIS) QuadPack. The configuration, shown in Figure 1, is intended to deploy three microsattelites using MLBs as well as several CubeSats and nanosatellites from twenty-one (21) QuadPack dispensers. Each QuadPack holds 12U worth of CubeSat payload. A CubeSat, based on the Cal Poly CubeSat standard, has nominal dimensions 10 x 10 x 10 cm. SHERPA runs flight software on COTS Andrews Space CORTEX avionics and it is equipped with its own power and power distribution system to deploy each auxiliary spacecraft in a pre-programmed sequence. The primary mission is satisfied by successful deployment of each auxiliary payload. The confirmation of successful payload deployment is given by the transmission of telemetry containing SHERPA state vectors taken upon each discrete deployment event.

The SHERPA mission itself is expected to last approximately twelve (12) hours. At launch, SHERPA is integrated beneath the primary payload. The primary payload is launched into 720 km circular sun synchronous orbit and then separated. The upper stage, with SHERPA attached, executes a maneuver to lower the perigee of the orbit to 450 km and change the inclination to 97.4 degrees. At this orbit, SHERPA is separated from the upper stage. The separation event activates the SHERPA spacecraft through the closing of separation switches, which will turn on for the first time. After initialization, SHERPA begins a pre-programmed sequence of deployments. No uplink is necessary to begin deployments. For each deployment event time, position, and velocity (determined via GPS receiver) are logged in the form of a state vector to be transmitted. Upon completion of deployments, SHERPA transmits the telemetry to a ground station. SHERPA's communication system utilizes an onboard UHF radio with 4 antenna.

SHERPA batteries are expected to last for duration less than 20 hours until they're expended. Ultimately, SHERPA de-orbits through orbital decay due to atmospheric drag approximately 20 years after launch.

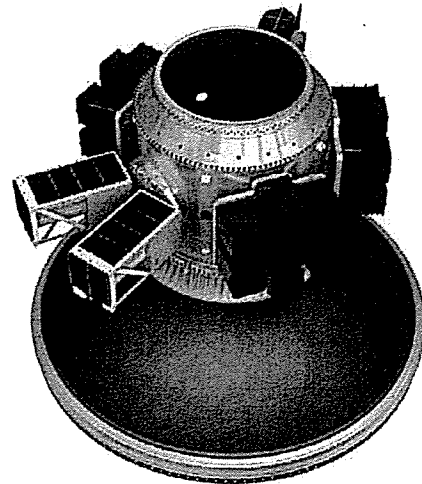


Figure 1. SHERPA Spacecraft shown integrated with the Payload Attach Fitting (below) and the Primary Payload Adapter (above)

Location	SHERPA (space segment)		North Pole, Alaska	Tukwila, Washington	NASA Wallops
Link direction	Downlink	Uplink	Uplink	Uplink	Uplink
Antenna Manufacturer	Spaceflight Systems Inc	M2 Antenna Systems Inc	M2 Antenna Systems Inc	M2 Antenna Systems Inc	MIT Lincoln Labs
Antenna Model	n/a	450CP34	450CP34	450CP34	n/a
Antenna Size	n/a	3.05-m boom length	3.05-m boom length	3.05-m boom length	18.3-m diameter
Number of Antennas	1	1	1	1	1
Address, City, State	Mobile, LEO Orbit: 720 x 450 km, 97.4° inclination	1625 Richardson Highway, North Pole, Alaska	3415 S 116th St #123, Tukwila, WA	Building U-25, Mainland Road Wallops Island, VA 23337	
Lat/Long coordinates in minutes,seconds	Mobile, LEO	64° 47' 37.0" N, 147° 32' 10.8" W	47° 29' 55.44" N, 122° 17' 23.64" W	37° 51' 18" N 75° 30' 47" W	
Site Elevation AMSL	Mobile, LEO	144 m AMSL	15.9 m AMSL	12.6 m AMSL	
Frequencies	401.5 MHz	450.2 MHz	450.2 MHz	450.2 MHz	
Output Power (W)	2 W	5 W	5 W	8 W	
ERP (W)	2.07 W	63 W	63 W	15,310 W	
Frequency tolerance	*	*	*	*	
Emissions (bandwidth of signal plus emission type)	825KG1D	27K6G1D	27K6G1D	27K6G1D	27K6G1D
Modulating Signal	A single channel containing digital information	A single channel containing digital information	A single channel containing digital information	A single channel containing digital information	A single channel containing digital information

*In lieu of frequency tolerance, the occupied bandwidth of the emission shall not extend beyond the band limits set