

**Modification to Add S-Band Authorization
and Notification of Additional Satellites
File No. 0194-EX-PL-2014 (Call Sign WH2XDU)**

Tyvak Nano-Satellite Systems Inc. (“Tyvak”) files this application to modify its existing authorization for authority to operate experimental non-geostationary (“NGSO”) low earth orbit (“LEO”) CubeSat satellites.¹ Specifically, Tyvak requests authority to conduct payload communications downlink (space-to-Earth) transmissions in the 2.2 GHz S-band.

For clarity, the Cubesats authorized by Tyvak’s existing experimental license have always included an S-band payload for data downlink transmissions. The operation of the S-band payload, however, was originally going to remain entirely under the control of NASA. Therefore, the regulatory authority to operate the S-band payload was to be secured by NASA through NTIA.²

Tyvak has now agreed to undertake additional experimental Cubesat missions on behalf of both U.S. Government and non-U.S.-government entities beyond the NASA sponsored Proximity Operations Nano-Satellite Flight Demonstration (“PONSFD”) project that was the subject of Tyvak’s initial application. During these additional missions, Tyvak will control all operations of the satellites, including the operation of the S-band payload downlink. Therefore, Tyvak provides herein the supplemental technical information required to add authorization for S-band operations to Tyvak’s existing license.

Tyvak also herein notifies the Commission that it plans to launch and operate additional CubeSat satellites to carry out further experiments beyond those covered by the PONSFD project that was the subject of Tyvak’s initial application. The additional satellites will be substantially similar or identical to Tyvak’s existing satellites and will be fully compliant with the terms of Tyvak’s existing experimental license. The additional satellites will be used to continue Tyvak’s investigation and demonstration of satellite capabilities including GPS occultation, earth sensing, Cubesat maneuverability, station keeping, and satellite flight training. The first of these additional satellites is scheduled for launch in October 2015.

I. NARRATIVE INFORMATION REQUIRED BY FCC FORM 442

Tyvak provided a full description of the operation of its CubeSat communications system in its initial application. For the purpose of this modification, Tyvak supplements the existing

¹ Tyvak Nano-Satellite Systems LLC, Application for Authority for Ground Testing, Launch, and Operation of Experimental Non-Geostationary Low Earth Orbit Satellites, File No. 0194-EX-PL-2014, Call Sign WH2XDU (granted March 4, 2014) (“*PONSFD Application*”).

² Tyvak included a request for S-band authority in its initial application, *see id.*, but, based on consultation with NASA, amended the application on June 13, 2014 to remove references to S-band from the application.

information with discussion pertaining specifically to the S-band communications capabilities of the spacecraft and Earth stations.

Question 6C. Showing that Existing Communications Facilities are Inadequate

For the PONSFD program that was the subject of Tyvak’s initial application, the 2,200-2,290 MHz S-band, was chosen at the direction of NASA to enable downlink directly from the satellites to pre-existing NASA Earth stations using these frequencies and thus no alternative existing facilities were available adequate. Subsequent satellites in this experimental program follow the design of the initial PONSFD satellites, including the use of S-band transmitters for payload downlink. It would be highly inefficient in both time and expense to abandon the satellite design—and accumulated operational data—after a single mission. Thus, Tyvak seeks to continue to use the S-band for the remainder of this 5-year experimental program.

Question 10. Transmitting Equipment to be Installed, Including Manufacturer, Model Number and Whether the Equipment is Experimental in Nature

S-Band Communications System

The CubeSats’ S-band communications system will operate using simplex communications within the 2,200-2,290 MHz frequency band to downlink recorded payload data to S-band Earth stations operated by third parties pursuant to a contract with Tyvak.

The Tyvak UHF Earth station at the Irvine Mission Operations Center (“MOC”) or Tyvak-affiliated UHF stations at other locations will issue commands in the UHF-band to trigger the satellite to transmit payload data. Although all commands to spacecraft are delivered by the MOC via UHF, Tyvak uses time-delay instructions to ensure that all downlink transmissions in the S-band are initiated only when over the appropriate S-band Earth station.

The Tyvak MOC will have no transmission or reception capabilities in the S-band. The S-band Earth stations will relay received communications to the Irvine MOC over a Virtual Private Network (“VPN”).

CubeSat Communications Parameters	Value
Emission Designator	1M00G1DDN
Service	Digital Data
Band	2,200-2,290 MHz
Requested Bandwidth	1MHz
Modulation	QPSK
Data Rate	1 Mbps
Polarization	RHCP
Antenna Type	Patch

CubeSat Communications Parameters	Value
Antenna Gain	+2 dBic (Max)

Table 1: Tyvak CubeSat S-Band Communications Parameters

As with the UHF transmission system described in the initial application, the CubeSats will communicate with the S-band ground stations only when they are within line-of-sight and have received a communication directing the spacecraft to initiate transmissions. As a consequence, the spacecraft will utilize the 2,200-2,290 MHz spectrum band only when in contact with specified Earth stations and potentially conflicting uses of the band in other regions of the world are not relevant to this application.

The figure below provides the updated system diagram and S-band components.

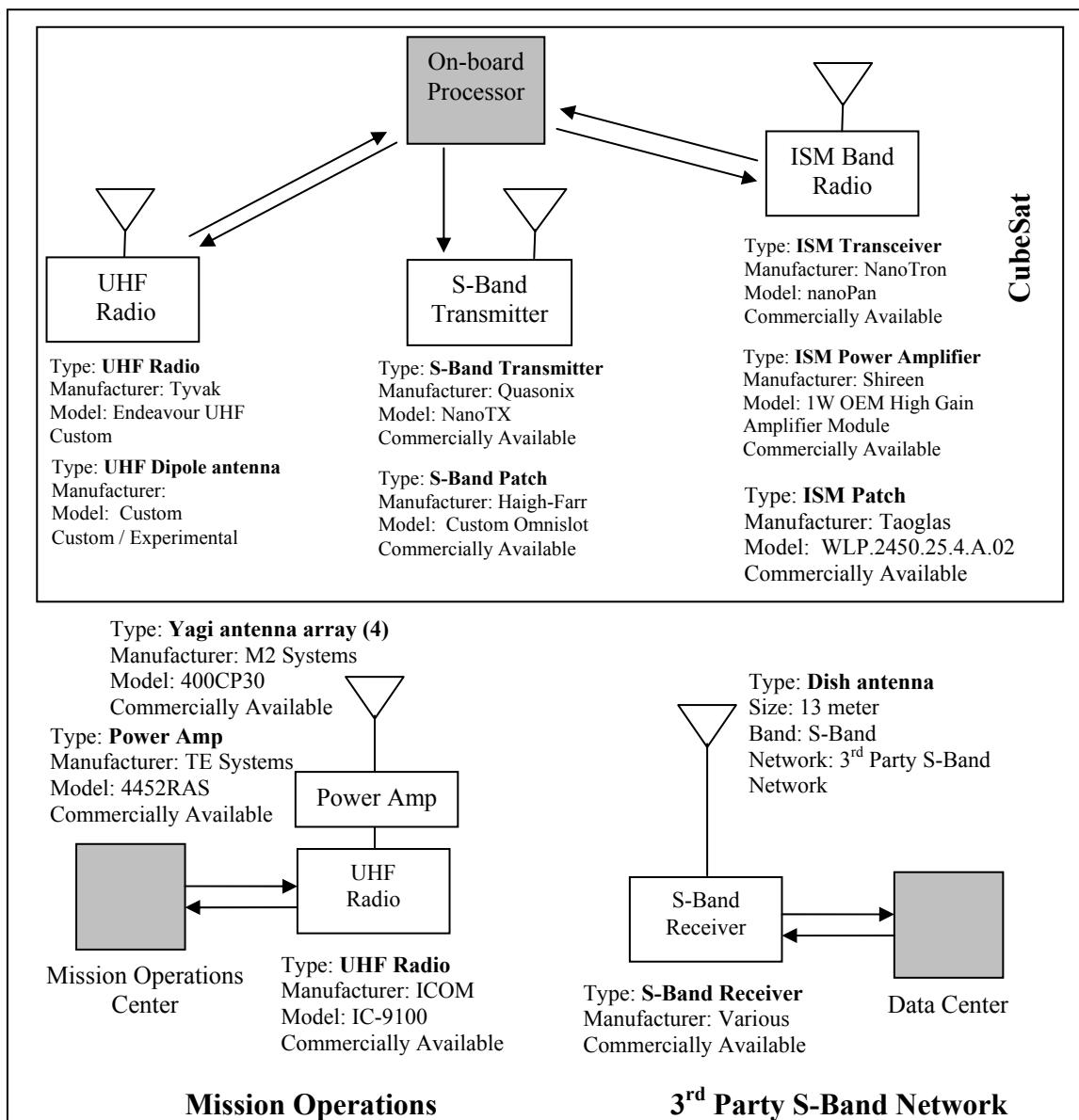


Figure 1: CubeSat System Communications Components

S-Band Transmitter

The payload downlink S-band system uses a microstrip patch antenna developed by Haigh-Farr. The antenna is RHCP with a gain greater than 2dBic at the boresight and a bandwidth of 12 MHz with a voltage standing wave ratio (“VSWR”) of less than 2:1.

The antenna possesses a maximum gain perpendicular to the surface normal to the patch. A generalized antenna gain contour plot is provided below representing the S-band patch.³

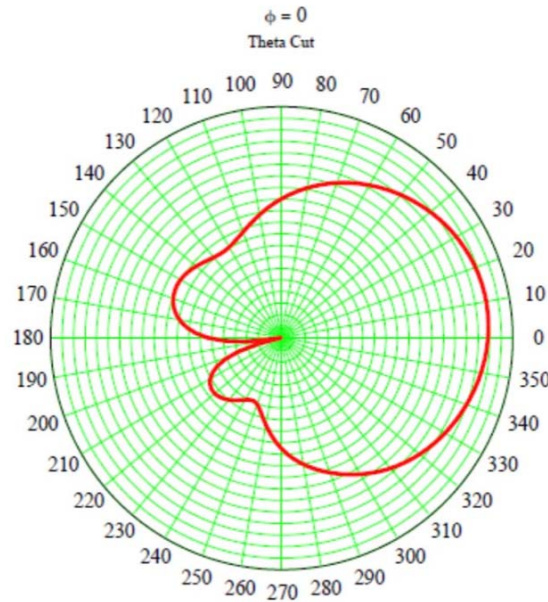


Figure 2: CubeSat S-band Antenna Gain Plot

Question 4: Antenna Registration Form; Operation of Directional Antenna

Tyvak seeks authority to test the S-band payload link at its Irvine, CA facility beginning in August 2015. All testing will be in a carrier current (*i.e.*, closed-loop) configuration and will produce only unintentional emissions. Under the Commission’s rules, unintentional radiators operating in the frequency range between 9 kHz to 30 MHz must comply with the radiated emission limits for intentional radiators as provided in 47 C.F.R. § 15.209.⁴ As Tyvak’s test program may marginally exceed these limits, Tyvak seeks experimental authority herein for emissions in the appropriate ranges at the Tyvak facility.

³ 47 C.F.R. § 25.114(d)(3).

⁴ 47 C.F.R. § 15.109(e).