Shannon

DETAILED DESCRIPTION OF TESTING & OPERATIONS

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I. Introduction

Lynk is developing a cellular-based small satellite communications network. The service would deploy an architecture of small satellite base stations in Low Earth Orbit ("LEO") to deliver GSM and/or LTE cellular capability [redacted] The payload effectively acts as a high-altitude cell tower. There is a need to perform testing on prototype equipment, which will provide important information regarding the performance of the radio frequency ("RF") links and the network/system control capabilities for a commercial service. Lynk desires to continue a series of very short tests in various locations in the United States [redacted] Lynk seeks authorization to test using specific spectrum ranges with specialized equipment operating at specified power densities at predetermined areas and times.

The host vehicle for the payload is a micro satellite to be launched in June 2021 on the SpaceX SRSX-5. During testing, Lynk's free flyer smallsat will point towards the Earth with its field of view sweeping across the Earth as the spacecraft flies in an approximately 500 km circular SSO orbit inclined at about 97 degrees.

[redacted]

This document describes the:

- RF transmitters,
- frequency use/channel plan with associated emission masks, and
- concept of operations.

II. Description of RF Payloads

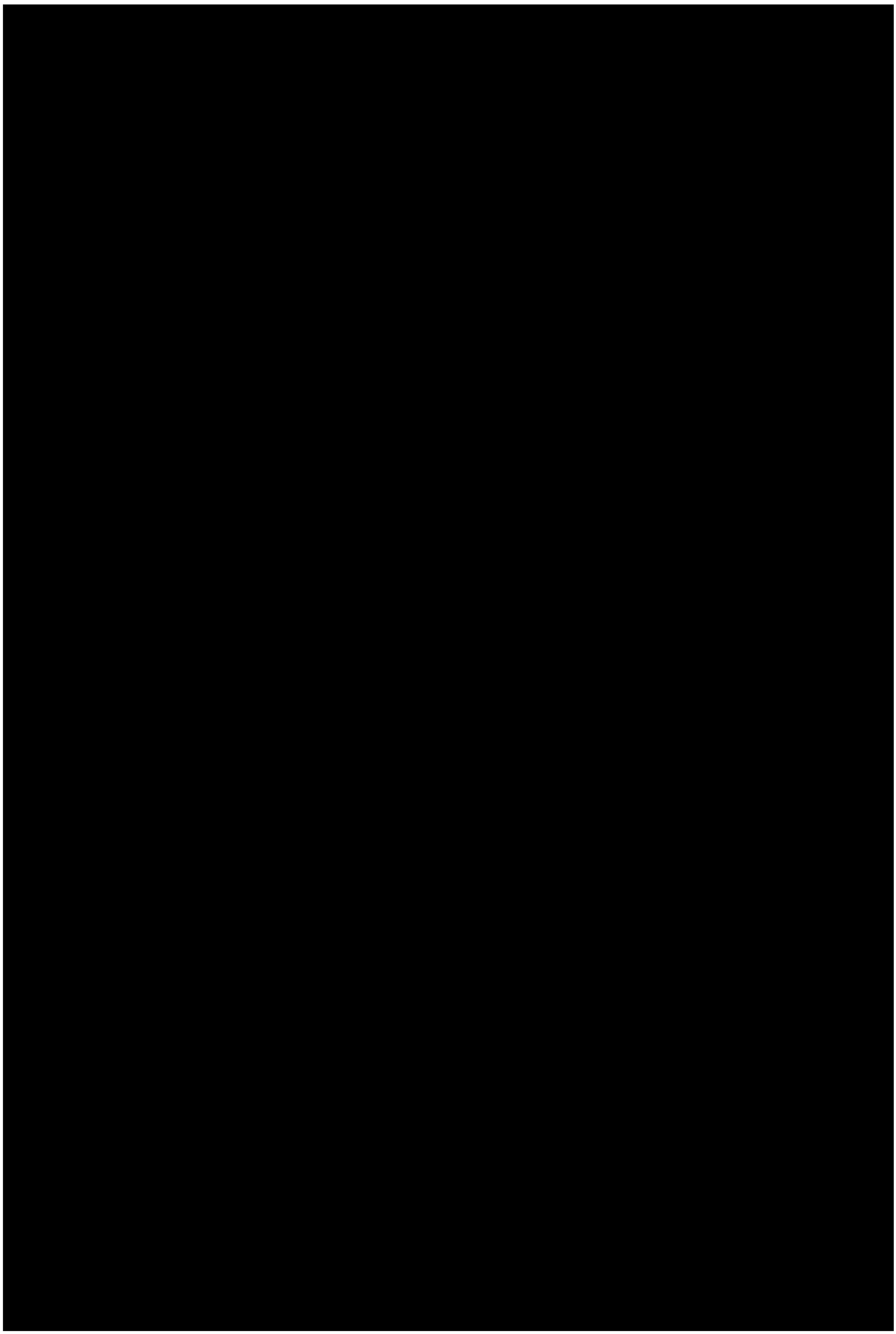
A. UHF Space-based Cellular Payload

[redacted]

B. L-band Space-to-Space TT&C Payload

The spacecraft space-to-space transmitters are one simplex and one duplex GlobalStar relay modules that use L-band frequencies. The modules are standard terrestrial terminals that are repurposed for use in orbit and can provide more timely TT&C functionality to monitor and command the spacecraft while on orbit. The simplex module is used to send near real time SMS based telemetry downlink to Lynk command and control; the duplex module allows for both telemetry file downlink and SMS based commanding of the spacecraft on the uplink.

The downlink T&C communications with the Lynk spacecraft will primarily occur via on-board GlobalStar simplex and duplex transmitter modules. [redacted]



C. S-band TT&C Payload

The S-band modules will communicate between the Lynk spacecraft and third-party operators' ground stations using licensed commercial TT&C ground stations already approved for similar use. These ground service operators maintain global shared networks, which include ground sites in the United States and other countries.

The third-party operators' ground stations are designed to provide TT&C services to small satellites in S-band commercial frequencies. [redacted]

III. Frequency Use and Channel Plan

A. GSM and LTE Frequency Plan

The payload will operate as a "cell tower in orbit" using either a single GSM duplex carrier or a single LTE deployment carrier set at any one point in time. [redacted]

[redacted]

[redacted]

For GSM, the 200 kHz duplex carrier falls in either the GSM 850 [redacted].

	Uplink Portion (MHz)		Downlink Portion (MHz)	
GSM Band	**Low End**	**High End**	**Low End**	**High End**
GSM 850	824.2	848.8	869.2	893.8
[redacted]				

Table 2 - Relevant GSM Band frequency ranges for transmit and receive

And the LTE carrier may, therefore, fall in one of the following LTE Bands.

	Uplink Portion (MHz)		Downlink Portion (MHz)	
LTE Band No.	Low End	High End	Low End	High End
[redacted]				
26	814	849	859	894
[redacted]				

Table 3 - Relevant LTE Band frequency ranges for transmit and receive

[redacted]

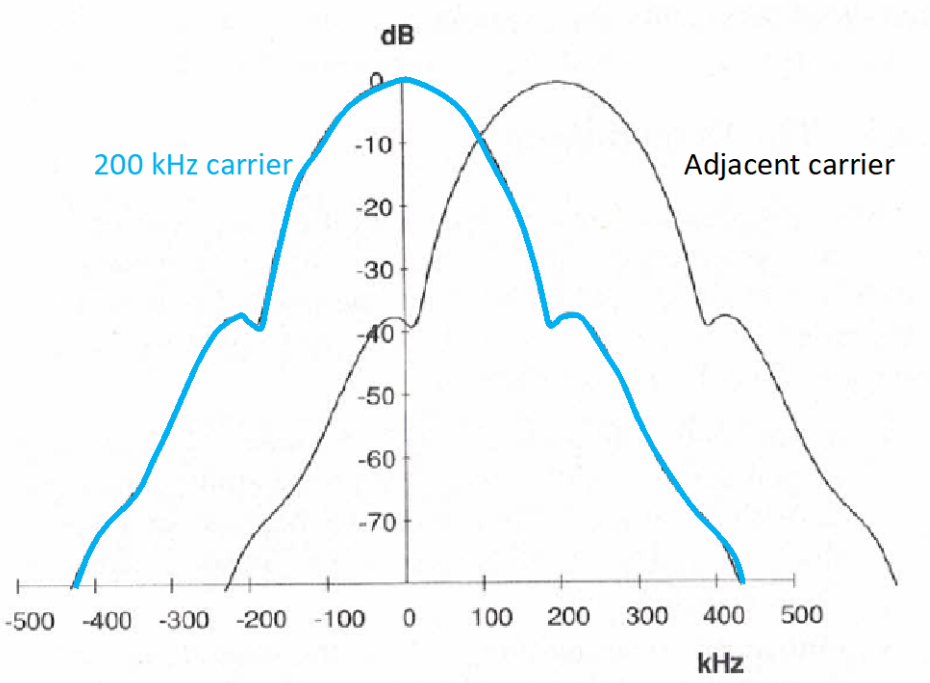
All two-way communications tests are planned for frequency division duplex ("FDD") operations, where the uplink and downlink portions of a band are paired and separated by a fixed frequency offset. Table 4 describes how the uplink and downlink channels used in the available bands will be separated.

Band	UL to DL offset (MHz) (e.g. uplink freq. minus downlink freq.)
[redacted]	
LTE 26, GSM 850	-45
[redacted]	

Table 4 - Separation of uplink and downlink channels in FDD system for LTE and GSM bands

1. GSM Spectrum Mask

GSM communications tests will be conducted on carrier frequencies that are 200 kHz wide with data modulating GMSK at a 270.8333 kbps bit rate (and symbol rate). The GSM transmit signal energy bandwidth is illustrated in Figure 6. The mask reaches -90 dB below the peak of the signal 500 kHz away from the center frequency.



GMSK GSM spectrum showing ACI Level in a 200 kHz channel

Figure 6 – Emission mask for a GSM, GMSK modulated signal

2. LTE Spectrum Mask

LTE communications tests can be conducted in spectrum deployments spanning multiple bandwidths. Regardless of deployment, LTE technologies deploy Resource Blocks ("RBs") that are 180 kHz wide. Each RB is composed of twelve 15 kHz subcarriers performing OFDMA using QPSK, or higher order, modulation. Depending on the bandwidth deployment, the number of resource blocks may vary. Lynk expects typical deployments to be 1.4 MHz wide blocks (1.08 MHz wide bandwidth), but deployments could be 3, 5, 10, 15, or 20 MHz wide. In all cases the LTE or GSM satellite base station operations are consistent with the expectations of the phone when in use with terrestrial towers.

Table 5 illustrates the utilized bandwidth for LTE.

	LTE Block Deployment Scenarios					
Deployment BW (MHz)	**1.4**	**3**	**5**	**10**	**15**	**20**
Resource Blocks	6	15	25	50	75	100
Necessary BW (MHz)	1.08	2.7	4.5	9	13.5	18

Table 5 - Possible bandwidth deployments for LTE

Figure 7 illustrates the LTE signal energy bandwidth.

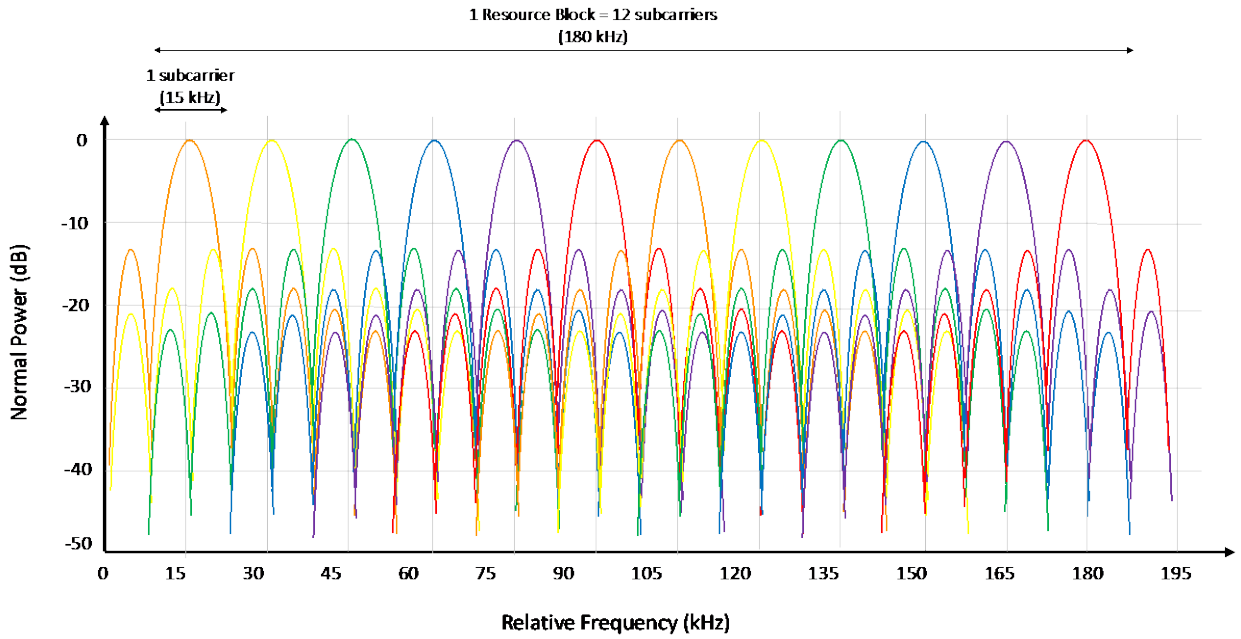


Figure 7 - Emission mask for LTE OFDM signals

B. L-band Frequency Plan

The GlobalStar modules will serve as the primary method for spacecraft commanding and spacecraft telemetry. The L-band GlobalStar antenna is a small patch mounted to the zenith deck of the Lynk spacecraft. The simplex and duplex modems will be utilized for T&C during the periods when the spacecraft deck—i.e., the side opposite to the earth pointing antenna—is pointing away from the earth, which is the normal operating mode of the Lynk spacecraft. The modems will communicate with GlobalStar's constellation.

C. S-band Frequency Plan

The S-Band SatLab transceiver module and Lynk's S-Band transceiver module use identical but separate transmit and receive antennas. Each antenna is a small patch (55 by 55 mm) that is mounted to the nadir deck of the Lynk spacecraft and a small distance from the UHF payload mission antenna. The SatLab transmitter will use GMSK modulation, whereas the custom transmitter will use QPSK/OQPSK. Data rates and occupied bandwidth will be comparable. The custom transceiver is based on the SDRs and processors used elsewhere in the payload.

The S-band modules will permit a second method for spacecraft commanding and spacecraft telemetry. They also provide higher data rate and timely T&C delivery, which is desirable for uploading new code scripts and downloading large log files.

The S-band modules can be turned off for coordination activities with other S-band users, and if necessary, commanded off via GlobalStar T&C, which can use time-based commands to disable the S-band modules or to activate a kill switch in the Lynk spacecraft, terminating power to the S-band modules.

1. SatLab S-band Transceiver Spectrum Mask

The SatLab transmitter will operate at a BT=0.5, however, the vendor's power spectrum and tabular data (illustrated in Figure 8) shows representative performance with a BT=0.35 Gaussian Filter at three normalized power levels and using a PRBS9 sequence, 512 kbps channel rate and at 2245 MHz carrier center frequency.

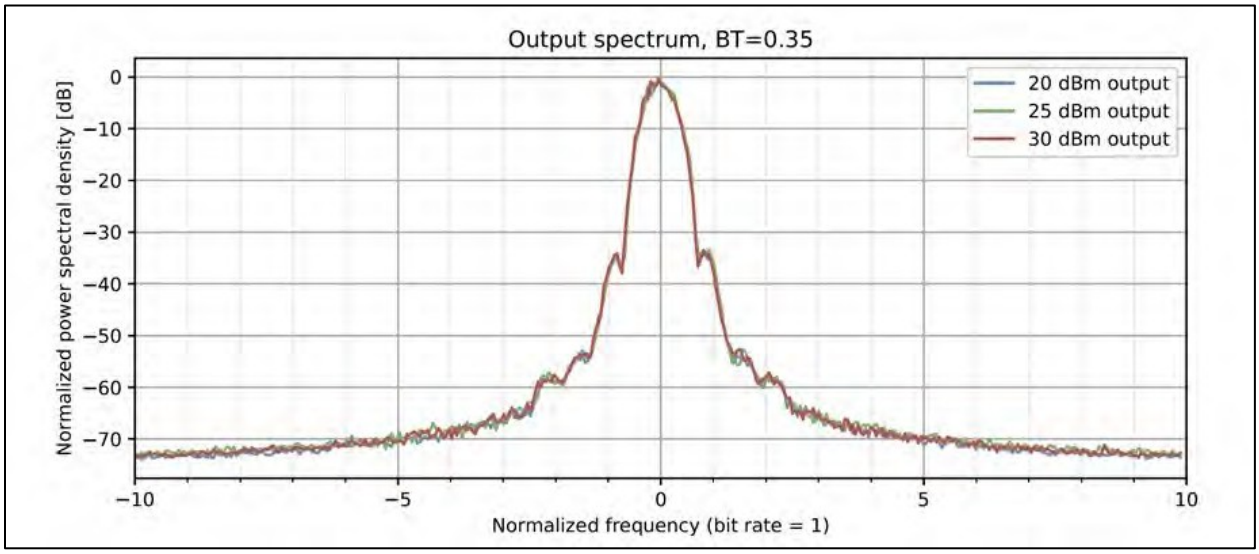


Figure 8 - Emission mask for an S-band modulated signal

[redacted]

2. Lynk S-band Module Spectrum Mask

The Lynk S-band transmitter will generate QPSK/OQPSK modulated signals across an occupied bandwidth of 675 kHz and at a net data rate of 500 kbps. Figure 9 below shows the emission mask for the modulated QPSK bit stream from the Lynk radio, which has a 35% rolloff

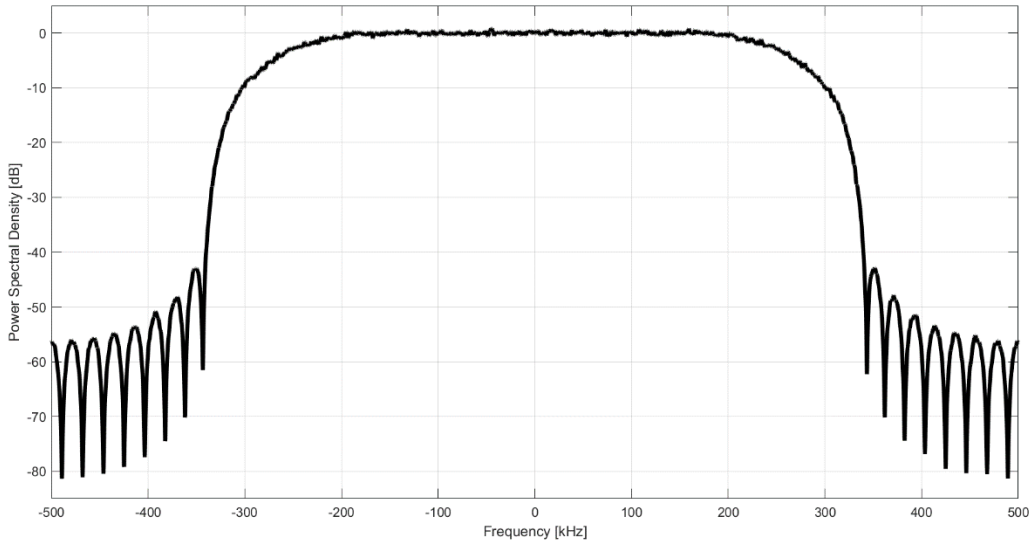


Figure 9 - Emission mask of Lynk S-Band transmitter

[redacted]

IV. Concept of Operations

The Lynk satellite will launch on a Space-X Falcon-9 Rideshare, SRSX-5, in June 2021. The satellite will be deployed in a 500 km SSO orbit (10:30 AM LTAN) approximately circular in shape. After separation from the launch vehicle, the battery inhibits will be released, and the spacecraft will power on and begin sending regularly stamped telemetry packets using the GlobalStar modem.

Lynk will then begin operating the spacecraft and conducting initial check out and commissioning. After commissioning the spacecraft will begin payload operations. All TT&C pathways will be tested to assure access to the spacecraft under all anticipated conditions.

Figure 10 below represents the spacecraft's ground track, which shows a 24-hour ground track of the orbit described above.

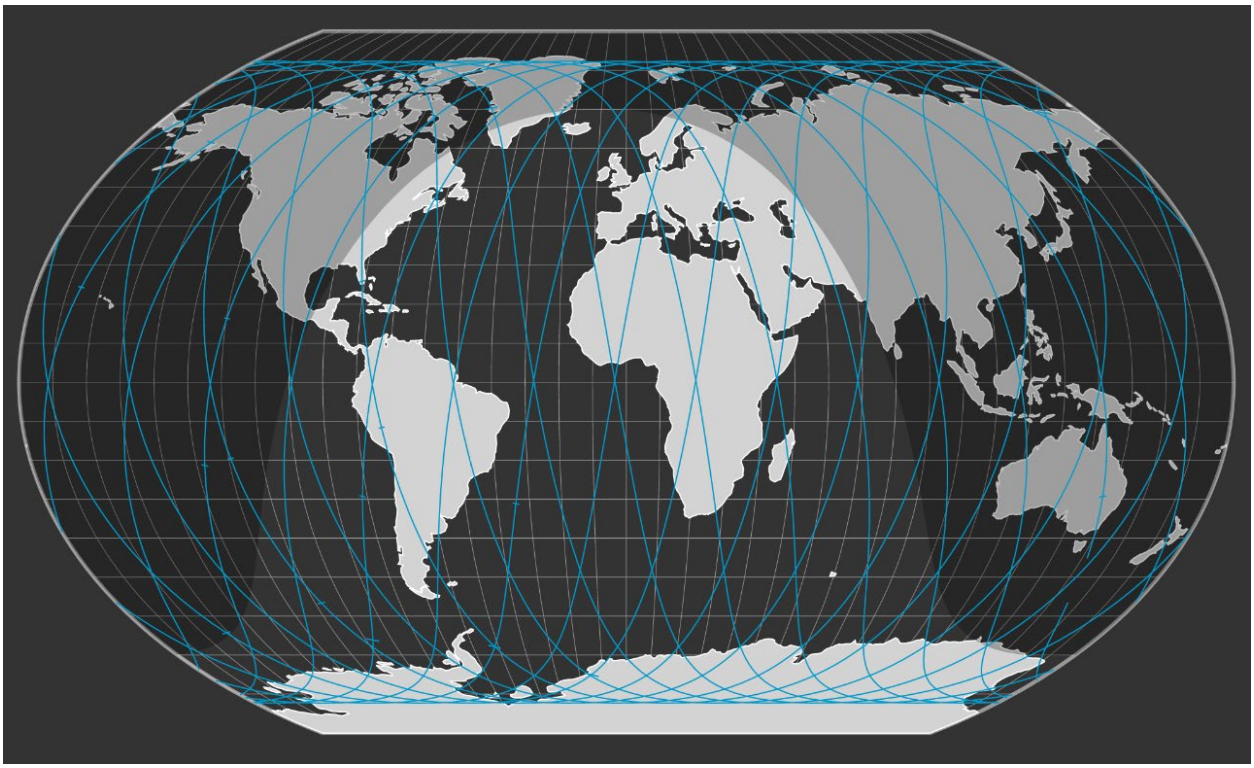
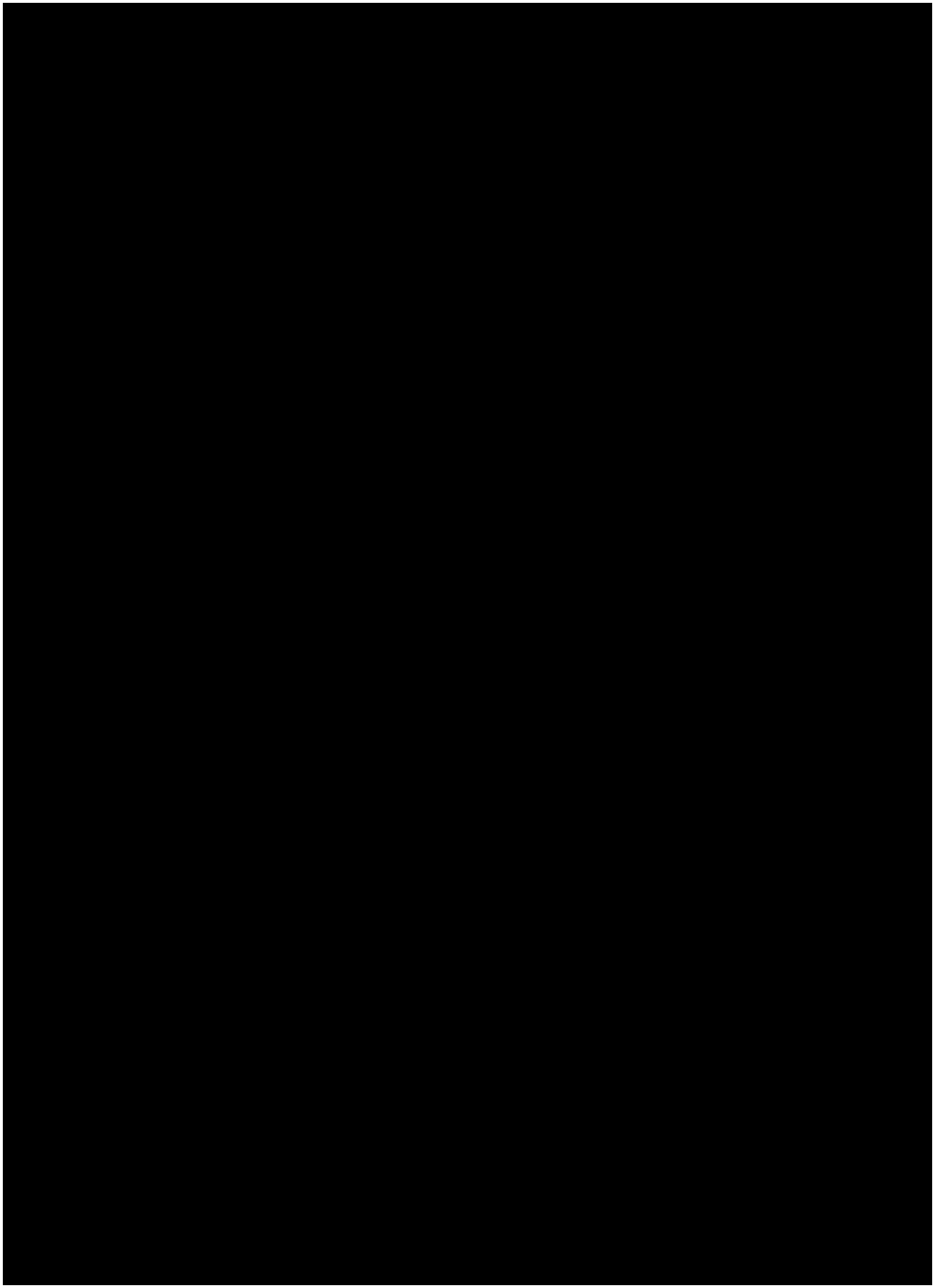


Figure 10 - Illustration of a 24-hour ground track for the spacecraft in an SSO orbit



A. On-site Cellular Operations

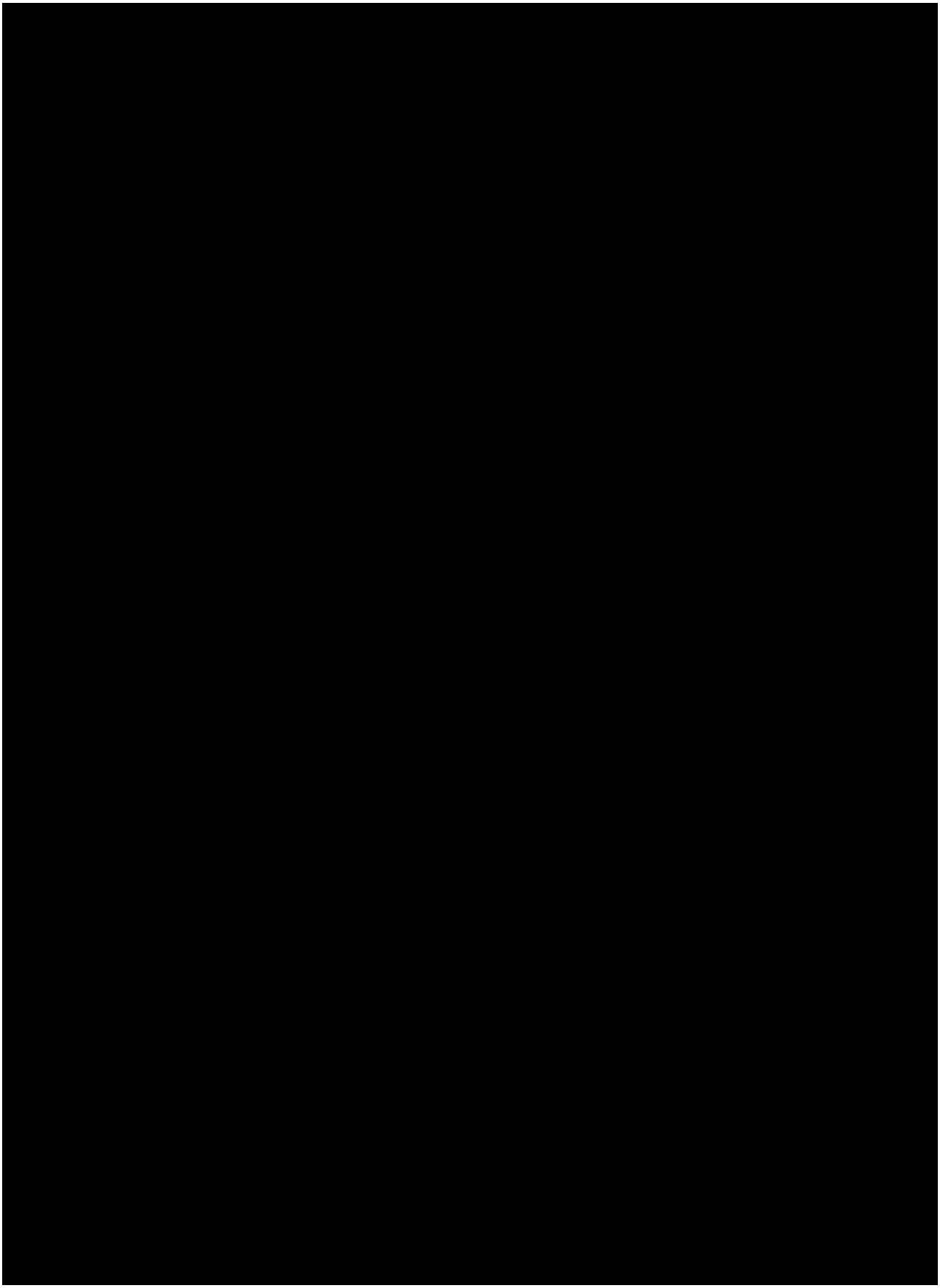
[redacted]

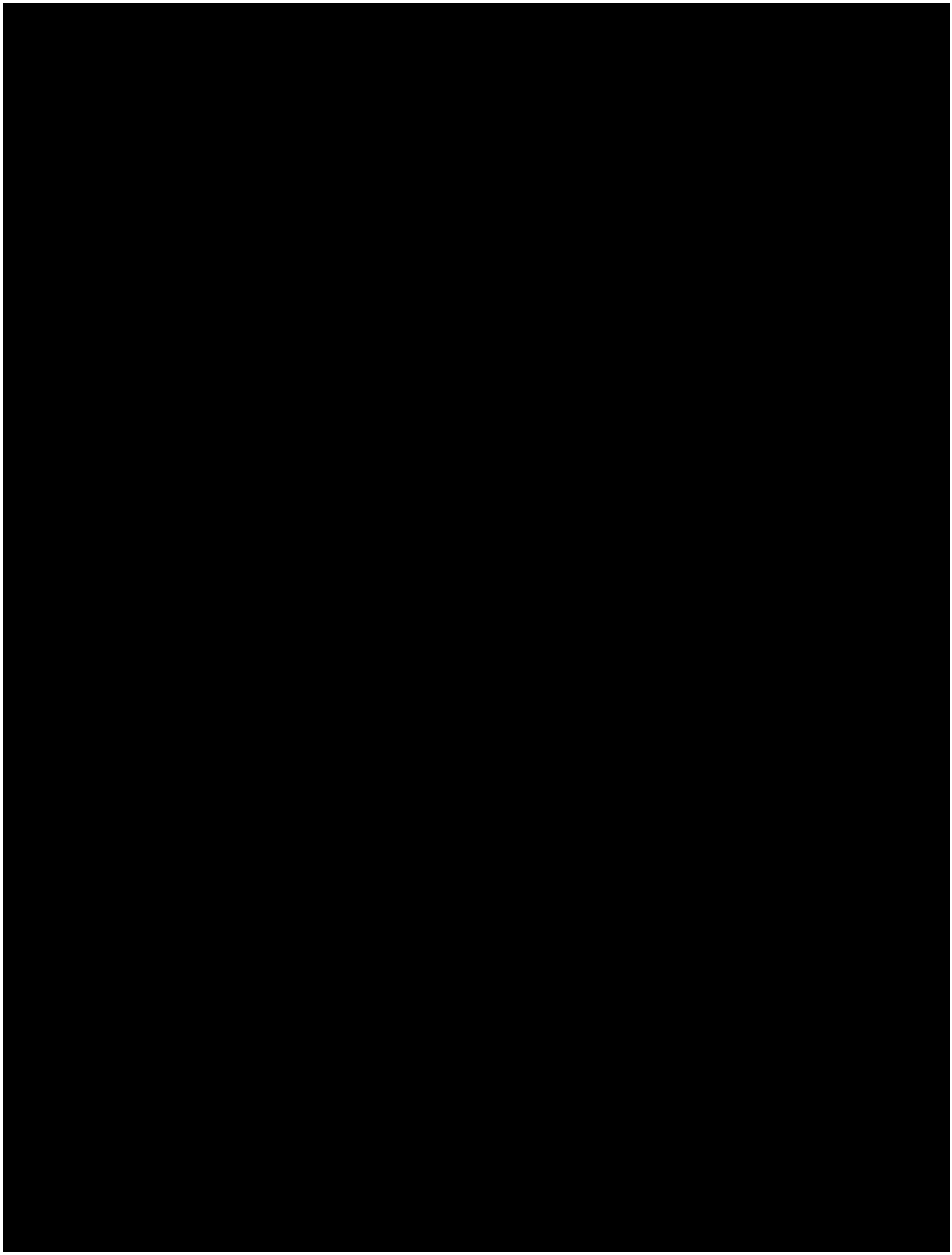
Before operating at any test site, [redacted] Lynk will have received written permission from a participating MNO, who has the in-country licenses to the requested spectrum and awareness of the relevant trans-border considerations. [redacted] Lynk's testing will utilize spectrum from their existing licenses. A typical letter of support is provided below: Example MNO Letter of Support for Testing.

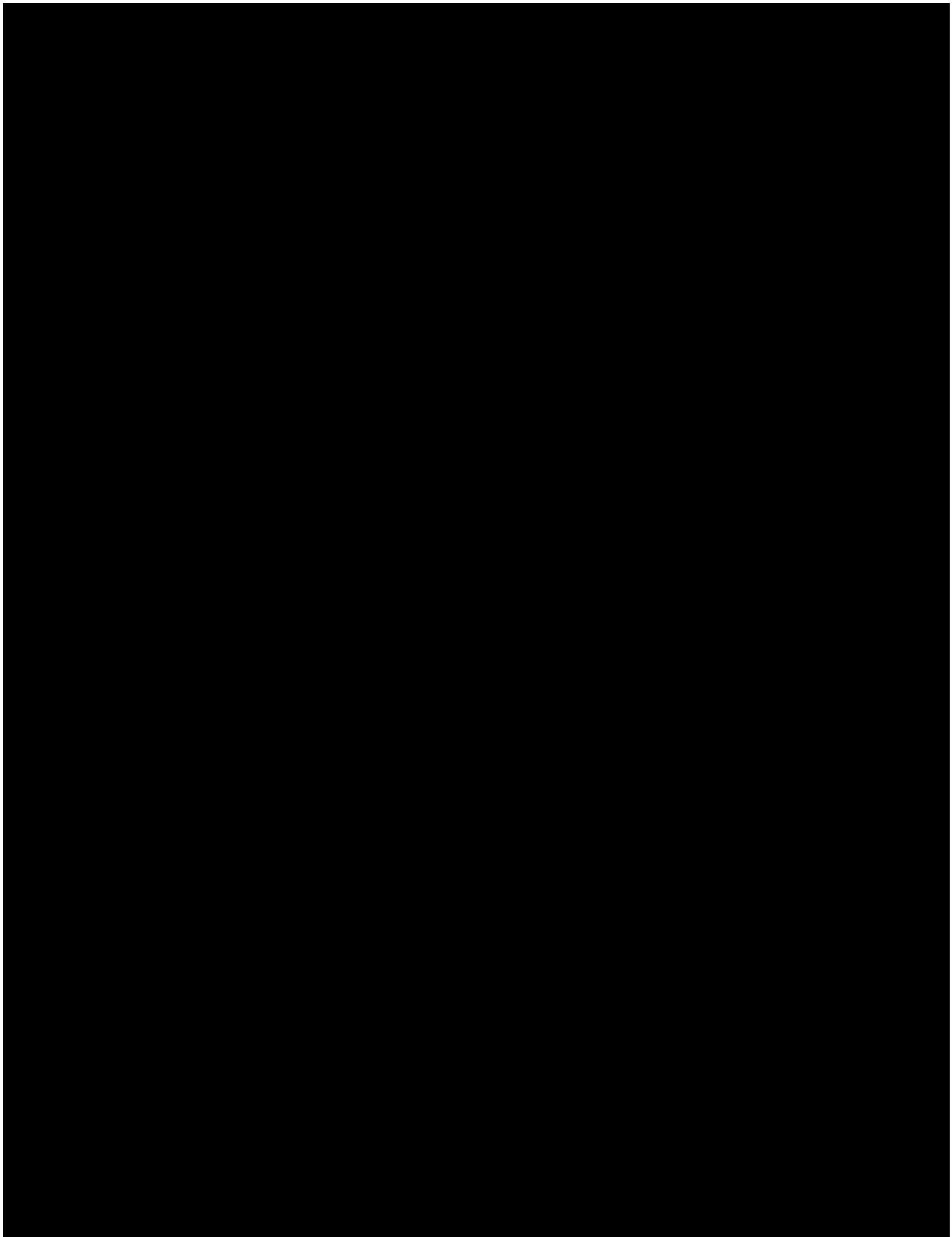
Lynk has been working with testing partners to select sites that are positioned strategically such that trans-border interference is eliminated when testing the Lynk payload. [redacted]

[redacted]

[redacted]







C. Example MNO Letter of Support for Testing

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October 2, 2019

VIA U.S. MAIL ONLY
Federal Communications Commission
Office of Engineering and Technology
445 12th Street, SW
Washington, D.C. 20554

Attention: Chief Engineer OET

Regarding: Lynk Global, Inc., f/k/a UbiquitiLink STA for Testing of Satellite Payload

Dear Madam/Sir:

It is our understanding that Lynk Global, Inc. is seeking FCC authorization (either through an STA or an experimental license to conduct experiments with its satellite payload in the 850 and 900 MHz bands [Block & Channel designations below] at specified locations in the U.S. with standard mobile devices for a one-year period commencing approximately January 1, 2020. These tests are on a non-interference basis as part of their development process and will also lead to prospective overseas uses of this satellite payload.

As the FCC licensee for a portion of this spectrum, we have no objections to non-commercial tests for a limited period of time in our band as described below.

Frequencies	Uplink Portion: 824.2 MHz to 848.8 MHz Downlink Portion: 869.2 MHz to 893.8 MHz
Locations	Centered at 35.9498 N, 110.0844 W (Northeast Arizona, Navajo Nation)

We participated with Lynk Global on its prior test (Call Sign: WN9XQS, File No. 1247-EX-ST-2018) in February, 2019. During that experiment, SBI's network received no measurable harmful interference from the Lynk Global payload. We anticipate participating in the next experiment, will be monitoring our network for any signs of interference and will inform Lynk Global in the event we detect any harmful interference.

Sincerely,

Guy Turley
Vice President/Chief Technical Officer
Smith Bagley Inc., dba Cellular One of North East Arizona ("SBI")

cc: International Bureau, Chief