Atmospheric & Space Technology Research Associates (ASTRA)
Experimental License Application
File No.: 0867-EX-CN-2021

Explanation of Experiment – Updated with GlobalStar link Information

Atmospheric & Space Technology Research Associates (ASTRA) is seeking an experimental license from the FCC for operation of its 12U satellite which is scheduled to launch in March 2022.

ASTRA has been in the business of science and engineering for over 16 years. It currently holds a subcontract to conduct a demonstration for the US Air Force and Space Force of how ASTRA's Rapid Revisit Optical Cloud Imager (RROCI[1]) can improve in-theater weather imagery over the currently available technologies.

Technical Synopsis

- Spectrum Needed: 8025-8225 MHz – primary downlink, 100 Mbps data rate
  2217 MHz – backup downlink, 2 Mbps data rate
- Time of Use: downlink transmissions expected once per orbit
- Orbital Period: about 96 minutes, sun-synchronous, polar orbit
- Satellite Elevation: 642 KM
- Federal Contract #: SMC/CDIA FA8814-18-9-0002
- Emission Designators: X band: 200MG1D
  S band: 4M00G1D

GlobalStar Link Data:

Spectrum Needed: 1616.25 MHz
Time of Use: limited to about 10 minutes per week, at most
Satellite Elevation: 642 km
Receive Station: Globalstar satellite
Emission Designator: 2M50G1D

Globalstar use:

Spectrum Needed: 1616.25 MHz

In recent years, small sat missions have been using one-way phone systems supported by the GlobalStar constellation, akin to Iridium or some other satellite phone system. This link will be used for communicating very short state of health messages from the RROCI satellite to the GlobalStar constellation, as a tertiary link. ASTRA is incorporating one of these radios into its satellite as this type of beacon system. It will be tested during the early operation of the satellite, and after that, it is only expected to be used if the satellite experiences a hard reset on orbit.

[1] Pronounced "rocky"

The link will be in use a very limited amount of time. Following the satellite launch, the beacon will be in use during the set-up time and first few weeks of operation. The beacon will turn on every ten minutes, transmit for 12 seconds, and turn off. The transmission will be of 3 35-byte packets relaying the health of the satellite. Then, the system will turn off.

This pattern of one transmission every 10 minutes is planned for the first two weeks of on-orbit operation for RROCI. There is a possibility that the operation would continue for one additional week, if the data is needed. At that point, this beacon radio will be turned off. It will only be turned on again if the satellite computer system needs to go through a hard reboot, at which point the beacon will be turned on again for its 2% duty cycle transmissions every 10 minutes. After a reboot, the beacon system is only expected to operate for about a week.

The beacon system is one-way communication, so RROCI will not be receiving any signals from the Globalstar system.

RROCI will be communicating with the Globalstar HIBLEO4 constellation. Details of the 1616.25 MHz receiver on the satellite are difficult to locate, since the ground stations that were used were blanket licensed under the Globalstar authorization. We continue to seek details on the receive antennas, and additional information will be provided when possible. However, we should note that the Commission has this information in its files, since Globalstar holds an FCC authorization for the subject receive-only operations. Those files are not available to the public, however.

Description of Experiment

ASTRA has been developing advanced capabilities of imaging weather. This technology is of great interest to the US Air Force and US Space Force as they plan for future in-theater weather imagery support. After several successful rounds of research and development working under SBIR grants, ASTRA developed the RROCI system to advance the science of cloud imagery for weather predictions. RROCI is a 12U satellite which has been designed to incorporate multiple cameras with a satellite downlink and an electronic propulsion system. RROCI will be orbiting the earth in a sun-synchronous orbit and capture still imagery at a rapid framerate. ASTRA secured an imagery license from CRSRA at the Department of Commerce on September 1, 2021, which allows it to use its earth sensing imaging equipment.

The cameras generate imagery files totaling about 12 gigabits of data on every orbit around the globe. The polar orbit takes RROCI over an earth station operated by Kongsberg Satellite Systems (KSAT) in Svalbard. In addition to this primary station, RROCI is compatible with the entire KSAT-Lite ground station network, coordinating with operational facilities in Tromso, Norway. RROCI is expected to downlink an orbit's worth of imagery each time it passes over the polar earth station. The downlink operation is expected to take approximately 5 minutes, out of a 10 minute window when the satellite can see the earth station. RROCI is programmed so that its X band downlink radio is turned off unless it is downlinking images to the earth station. The radio link is essential to the demonstration of this innovative technology developed by ASTRA.

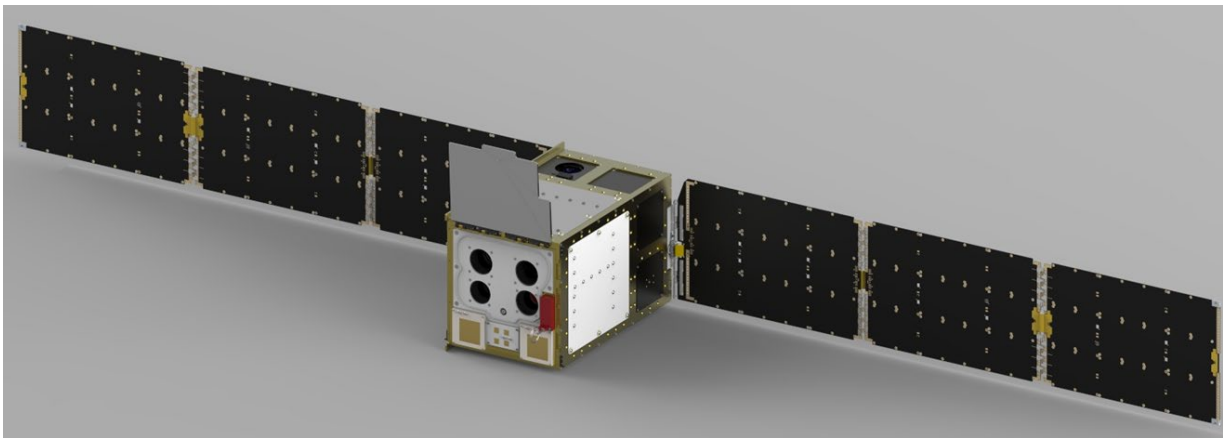

Figure 1: an image of RROCI on the workbench at the ASTRA facilities

ASTRA has entered into a contract with KSAT that will allow ASTRA to use the KSAT global ground station network for uplink communications to the satellite and that will receive the downlink signals from ASTRA's satellite. Because of the orbital pattern of the satellite, ASTRA is focused on using the northern polar ground station.

ASTRA's instructions to the satellite will be sent over secure VPN from ASTRA's headquarters (mission control) to one of the global KSAT ground station. Those instructions will be uplinked to RROCI. ASTRA will not operate its own uplink to its satellite. ASTRA is seeking this license for downlink operations only. The downlink operations are an essential component of the technology demonstration it is conducting for the US Air Force. The uplink frequency will be 2085.5 MHz.

RROCI has been designed with a backup downlink capability. That link operates in the S band with a center frequency at 2217 MHz. The capacity of the link is much lower, making it less appealing as a downlink solution. Nevertheless, the radio was incorporated into RROCI to ensure that there is a failsafe system that can show the performance of the satellite if the X band link does not work properly. RROCI is only expected to use the S band link about 20 times during the life of the experiment, presuming the X band link works as expected. The S band link is expected to send information down to the KSAT ground stations as well.

The link budgets for the radio operations are set forth in Table 1, below:

RF Link Budgets						
Symbol	X-band Downlink		S-band Uplink	WFDL Downlink	Units	Comments/Notes
	642	642	642	642	km	Input Spacecraft Altitude
f	8.075	8.075	2.086	2.217	GHz	Input Spacecraft Frequency
λ	0.037	0.037	0.144	0.135	m	λ = c/f
PT	3.0	3.0	10.0	2.0	Watt	Input Transmit RF Output Power
PT(dB)	34.8	34.8	40.0	33.0	dbm	PT(dB) = 10 log (PT) + 30
GT	9.6	9.6	36.8	5.5	dbi	Input SC Antenna Gain
LI	-1.0	-1.0	-2.0	-2.0	dbi	Input SC Passive RF Loss (Cable + Diplexer)
EIRP	43.4	43.4	74.8	36.5	dbm	Spacecraft EIRP = PT(dB) + GT + LI
Alpha	22.0	10.0	5.0	5.0	deg	Input Elevation Look Angle from the GS to SC
SR	1393.6	2027.5	2429.2	2429.2	km	Calculation of Slant Range to SC
LS	-173.5	-176.7	-166.5	-167.1	dB	Calculation of Free Space Dispersion
ARLOSS(dB)	-0.3	-0.3	-0.3	-0.3	dB	Calculation of System Polarization Loss
AT	-2.9	-2.9	-1.0	-1.0	dB	ITU S-band Atmos Loss for 99% availability (est)
G/T	26.3	26.3	-31.5	12.6	db/K	KSAT-Lite Ground Station G/T
PR	-107.0	-110.3	-126.2	-121.0	dBm/K	PR = EIRP + LS + ARLoss + AT + G/T
k	-198.6	-198.6	-198.6	-198.6	dBm/Hz-K	Constant
PR(db-Hz)	91.6	88.3	72.4	77.6	dB-Hz	PR(dB-Hz) = PR - k

Table 1. Link Budgets for radio links to and from RROCI

Length of Satellite Operations

ASTRA has a contract to operate this satellite for a year after launch. The application seeks authorization for a full two-year experimental license. The reason that ASTRA is seeking a 2-year license is that there is some possibility that its DoD customers will want to extend the contract for some additional period, whether a few weeks or months.

The satellite mission is engineered so that the satellite could function properly, maintaining its designated orbit for a full two years. Further, the satellite's propulsion system is adequate to support any necessary collision avoidance maneuvers during the operational period and still have sufficient capacity to deorbit the satellite at the end of its mission, whether that will be at the one-year mark or beyond.

Time of Use is Limited; Area of Operations is Limited

The satellite will orbit over the north pole every 97.4 minutes. It will be in view of the KSAT Svalbard earth station for 10 minutes on each pass. The X band transmitter is expected to be turned on, to link with the ground station, and to download imagery for 5 minutes of the 10 minutes the satellite is in sight of the ground station. The downlink will operate at 100 Mbps. The Svalbard station is the primary communication ground terminal, however the RROCI spacecraft will take advantage of additional stations in the KSAT Lite network if necessary.

The X band link is expected to be in use 14 times per day, over Svalbard. It may be in use 4-6 other times per day over the other ground stations, as needed. It is only in use for about 5 minutes of each pass over a ground station.

The S Band link is expected to be in use about once a week for demonstration of capabilities, for testing the back up system, and for supplemental downloading of information, if needed. This

would be over one ground station, about once a week, if the X band link is working properly. If the X band link fails, for some reason, the S band link is the backup system for downloading imagery, and, in the event of the X band failure, the S band link would be used regularly at each pass over each ground station. This is not expected. ASTRA would be glad to update the FCC in the event of some issues with the X band link.

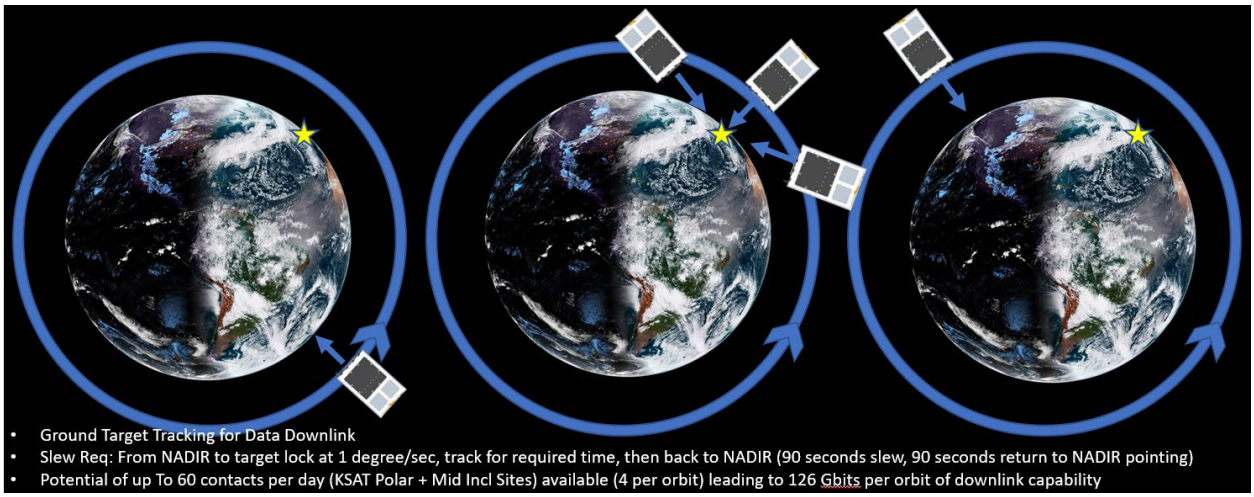

Figure 2. Theoretical image of the anticipated orbit of RROCI

The area of operations is limited as well, with primary operations focusing on the high latitude areas where KSAT has a ground station waiting to receive data from RROCI. All of the ground stations are listed in Table 2, below.

ASTRA has planned for its radios to be in use primarily over the Svalbard ground station, which will minimize the impact of the proposed operations over the US.

With proposed usage of only 5 minutes out of a 97.4-minute orbital period, the duty cycle is just over 5%. Further, it may be possible to schedule the 5 minutes of use, which could help deconflict usage of the ground station and reduce the possibility of harmful interference, although none is expected.

Satellite launch schedule

ASTRA is scheduled to launch on a SpaceX rocket in March 2022. SpaceX has only one launch in March that allows for ride-share, so ASTRA is seeking a license in time for it to be properly listed on the launch manifest.

Ground Station Information

As noted above, ASTRA has entered a contract with KSAT for the use of its ground station network. KSAT is a Norwegian company with a US subsidiary. It operates satellite ground stations in all corners of the globe. The ground stations that ASTRA will use are listed in Table 2, below:

Name of station, city and country	Lat (North)	Long (East)	X band	S band	#of contacts w/satellite per day, time of each
Svalbard, Norway	78.22987	15.39744	Beamwidth = 0.69 ° Gain: 47.01 dBi	Beamwidth = 2.73 ° Gain: 35.91 dBi	Contacts = ~ 14 x / day Duration - ~ 10 min / contact
Awarua, New Zealand	-46.5015	168.38736	Beamwidth = 0.69 ° Gain: 47.01 dBi	Beamwidth = 2.73 ° Gain: 35.91 dBi	Contacts = ~ 1 x / day Duration - ~ 10 min / contact
Punta Arenas, Chile	-53.09049	-70.92252	Beamwidth = 0.69 ° Gain: 47.01 dBi	Beamwidth = 2.73 ° Gain: 35.91 dBi	Contacts = ~ 1 x / day Duration - ~ 10 min / contact
TrollSat, Queen Maud Land, Antarctica	-71.98688	2.54823	Beamwidth = 0.69 ° Gain: 47.01 dBi	Beamwidth = 2.73 ° Gain: 35.91 dBi	Contacts = ~ 2 x / day Duration - ~ 10 min / contact
Long Beach, California USA	33.81599	-118.1855	Beamwidth = 0.69 ° Gain: 47.01 dBi	Beamwidth = 2.73 ° Gain: 35.91 dBi	Contacts = ~ 2 x / day Duration - ~ 10 min / contact

Table 2. Ground Station details

Sample technical data, this for the Long Beach, California earth station:

Antenna Location: 4022 E. Conant St., Long Beach, CA 90808
Antenna Owner: KSAT
S-Band RX G/T: 12.6 db/K
S-Band RX Frequency: 2200-2300 MHz
S-Band RX Bandwidth: 0-5 MHz
X-Band RX G/T: 26.3 db/K
X-Band RX Frequency: 8000-8400 MHz
X-Band RX Bandwidth: 650 MHz
S-Band TX Power: 10.0 W
S-Band TX Antenna Gain: 36.8 dbi
S-Band TX Frequency: 2025-2110 MHz

Figure 3. Google Earth Image of the Svalbard ground station

Figure 4. Google Earth Image of the Long Beach earth station

LTAN
11:00 pm (11:00 am LTDN)

Deorbit Plan

RROCI has an electronic propulsion system that can be used to direct the satellite. The current plan is to send commands to the satellite at the end of its mission, estimated at the one year mark, that will turn on the propulsion system and direct the satellite to progressively lower orbit until it is below 300 km, when it will begin the re-entry process. Those commands will be communicated to RROCI over the KSAT network.

Stop Buzzer POC

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ITU Cost Recovery Letter

Attached to this exhibit is a signed letter from ASTRA committing to its responsibilities for any cost recovery for ITU fees and expenses.

Orbital Debris Assessment Report

Attached to the application is the Orbital Debris Assessment Report required. The report shows that the satellite complies with all relevant parameters. This report was prepared with the NASA DAS 3.1.2 Orbital Debris Analysis Package.

ITU API – SpaceCap

Also attached to the application is the database file containing the SpaceCap submission for advanced publication information. Because this is an experimental use, ASTRA is seeking authorization under the provisions that allow for publication (4.4).

NOAA Imagery License

Also attached to the application is a copy of ASTRA's NOAA imagery license.

Conclusion

ASTRA is seeking an experimental license to operate a satellite downlink from its experimental RROCI satellite. ASTRA is conducting a demonstration for the US Air Force and US Space Force to allow them to evaluate ASTRA's weather imagery technology and compare it to currently available imagery.

ASTRA has an imagery license from NOAA. It is seeking a two-year experimental license, although the current operational plan is for the satellite demonstration to last one year.

RROCI will be deorbited at the end of its mission. The deorbit planning shows that the satellite will burn up completely upon reentry.

For questions about this application, please contact Anne E. Cortez, Esq., Washington Federal Strategies, 520-360-0925 or alc@conspecinternational.com.