Atmospheric and Space Technology Research Associates
Experimental License Application
File No.: 0634-EX-CN-2023

Explanation of Experiment

Atmospheric and Space Technology Research Associates (Atmospheric) is seeking an experimental license for the operations of a rapid revisit cloud imaging satellite, known as RROCI-2[1]. This satellite is an experiment being conducted for the US Space Force to determine how the satellite can improve in-theater weather imagery over the currently available technologies. The RROCI-2 satellite is a 12U satellite which is scheduled to launch in January 2024 on SpaceX's Transporter 10.

Atmospheric has been in the business of science and engineering for over 18 years. Atmospheric will own, operate, and control RROCI-2 for the duration of its mission.

Background and Timing of Launch

In 2021, Atmospheric submitted an almost identical experimental license application[2], 0867-EX-CN-2021 for the operation of its RROCI satellite, to serve the same purpose as is being proposed for RROCI-2. The original satellite application was granted experimental license WM2XEU in August 2022, and modified to correct the orbital elevation in November 2022.

The first RROCI satellite launched on Transporter 6 on January 3, 2023, but it was never deployed from the launch vehicle, so RROCI is not on orbit. It met its demise when the launch vehicle returned to earth.

This application seeks authorization to operate a satellite with essentially the same parameters as the satellite licensed under WM2XEU: the imaging system is the same, the TT&C radios and payload data transfer systems are the same, the orbital elevation is the same. The beacon is different because the original beacon system is no longer available. The conjunction warning plan previously approved will be used again, and the Orbital Debris Assessment Report and deorbiting plan approved previously remain the same as those that were previously approved by the Commission when it granted authorizations for WM2XEU.

After the demise of RROCI, the US Space Force issued a follow-on contract to Atmospheric to build, launch, and operate RROCI-2. Atmospheric had some additional components to be able to build a second satellite, which it is doing on an expedited timeframe. Atmospheric recognizes that the federal review process of satellite applications can be lengthy, however, the launch slot in January 2024 is available, and so Atmospheric is trying to finish all of the engineering and regulatory work in time to meet the December 2023 integration date for the launch in January 2024.

Technical Synopsis

- Spectrum Needed: 8025-8225 MHz – primary downlink, 100 Mbps data rate
  2217 MHz – backup downlink, 2 Mbps data rate, and

[1] Pronounced "Rocky".
[2] The only differences are that there is a different beacon to be used and the orbital elevation will be 525 km.

1618.75 -1626 MHz – beacon

- Time of Use: downlink transmissions expected once per orbit
- Orbital Period: about 95 minutes, sun-synchronous, polar orbit
- Satellite Elevation: 525 KM
- Orbital Inclination: 97.4 °
- Federal Contract #: SSC FA8808-23-9-0001
- Emission Designators: X band: 200MG1D – downlink of payload data
  S band: 4M00G1D – downlink of payload data, back up link
  Beacon: 35K0G1D – beacon transmissions

Description of Experiment

Atmospheric 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, Atmospheric developed the RROCI system to advance the science of cloud imagery for weather predictions. RROCI-2 is a 12U satellite which has been designed to incorporate multiple cameras with a satellite downlink and an electronic propulsion system. RROCI-2 will be orbiting the earth in a sun-synchronous orbit and capture still imagery at a rapid framerate. Atmospheric 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. A modified imagery license that covers the operations of RROCI-2 will be submitted to the FCC shortly. Because the FCC review process can require more time than the imagery license application review, and because time is short, it is necessary to submit this experimental license application to the FCC before the NOAA imagery license modification has been completed.

RROCI-2 is scheduled to launch on SpaceX Transporter 10, which will release its satellite payloads at 525 km.

The cameras generate imagery files totaling about 12 gigabits of data on every orbit around the globe. The polar orbit will take RROCI-2 over an earth station operated by Kongsberg Satellite Systems (KSAT) in Svalbard which is expected to be used for early command and control operations. Additional passes over the RBC Signals near-polar ground stations in Deadhorse, Alaska will be used for downlinking of imagery. RROCI-2 is compatible with the entire KSAT-Lite ground station network. RROCI-2 is expected to downlink an orbit's worth of imagery each time it passes over one of these earth stations. 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-2 is programmed so that its X band downlink radio is turned off unless it is downlinking images to an earth station. The radio link is essential to the demonstration of this innovative technology developed by Atmospheric.

Atmospheric's instructions to the satellite will be sent over secure VPN from Atmospheric's headquarters (mission control) to one of the global KSAT ground stations or to the station in Deadhorse, Alaska. Those instructions will be uplinked to RROCI-2. Atmospheric will not operate its own uplink to its satellite. Atmospheric 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 Space Force. The uplink frequency will be 2085.5 MHz.

RROCI-2 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-2 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-2 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 ground stations as well.

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

RF Link Budgets						
Parameter	**Symbol**	**X-band Downlink**	**S-band Uplink**	**WFDL Downlink**	**Units**	**Comments/Notes**
Spacecraft Orbital Altitude		525	525	525	km	Input Spacecraft Altitude
Downlink Frequency	f	8.200	2.085	2.217	GHz	Input Spacecraft Frequency
Wavelength	λ	0.037	0.144	0.135	m	λ = c/f
Transmit Power	P_T	0.6	10.0	2.0	Watt	Input Transmit RF Output Power
Transmit Power	$P_{T(dB)}$	27.8	40.0	33.0	dbm	$P_{T(dB)} = 10 \log (P_T) + 30$
SC Antenna Gain	G_T	11.0	36.8	5.5	dbi	Input SC Antenna Gain
Passive Loss	L_I	-1.0	-2.0	-2.0	dbi	Input SC Passive RF Loss (Cable + Diplexer)
Equivalent Isotropic Radiated Power	EIRP	37.8	74.8	36.5	dbm	Spacecraft EIRP = $P_{T(dB)} + G_T + L_I$
Ground Station Elevation Angle	Alpha	11.0	5.0	0.0	deg	Input Elevation Look Angle from the GS to SC
Slant Range	SR	1690.5	2142.6	2640.6	km	Calculation of Slant Range to SC
Free Space Dispersion Loss	L_S	-175.3	-165.4	-167.8	dB	Calculation of Free Space Dispersion
System Axial Ration Loss	$AR_{LOSS(dB)}$	-0.3	-0.3	-0.3	dB	Calculation of System Polarization Loss
Total Atmospheric Loss	A_T	-0.3	-1.0	-1.0	dB	ITU S-band Atmos Loss for 99% availability (est)
Ground Station G/T	G/T	26.5	-31.5	12.6	db/K	KSAT-Lite Ground Station G/T
Total Received Power / T	P_R	-111.6	-125.1	-121.7	dBm/K	$P_R = EIRP + L_S + AR_{Loss} + A_T + G/T$
Boltzmann's Constant	k	-198.6	-198.6	-198.6	dBm/Hz-K	Constant
Total Received Power / kT	$P_{R(db\text{-}Hz)}$	87.0	73.5	76.9	dB-Hz	$P_{R(dB\text{-}Hz)} = P_R - k$

Table 1. Link Budgets for radio links to and from RROCI-2

Beacon Operations:

RROCI-2 will have a satellite beacon radio that communicates with the Iridium satellite constellation. The purpose of the beacon is to make the satellite easier to track. This beacon replaces the Globalstar beacon that was incorporated into RROCI.

The Iridium system is configured such that the radios use dynamic channel selection. The band specified in this application will allow the beacon to use any available channel within the band, in accordance with the protocols built into the Iridium system. The radio signals use only 460 mW of output power, with gain of 4.5 dBi, resulting in an ERP of 1.91 W.

Downlink Protocol for Imagery Data:

The cameras generate imagery files totaling about 12 gigabits of data on every orbit around the globe. The downlink operation is expected to take approximately 5 minutes, out of a 10 minute window when the satellite can see the earth station. Most downlink operations are scheduled to use high latitude earth stations because of the frequency of orbital passes over those earth stations. RROCI-2 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 Atmospheric.

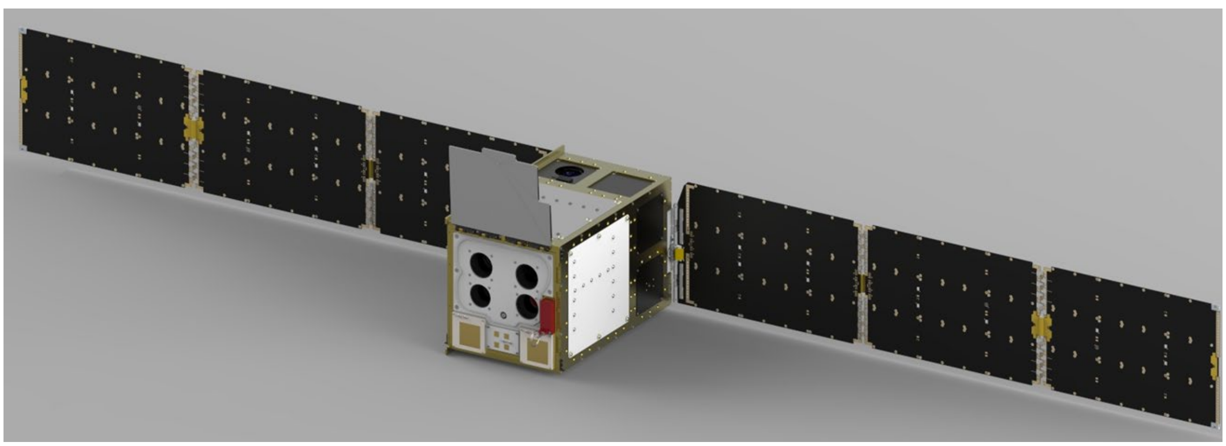

Figure 1: an image of RROCI on the workbench at the Atmospheric facilities

Length of Satellite Operations

Atmospheric 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 Atmospheric 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 can 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 95 minutes. The X band downlink may be in use 4-6 times per day over the ground stations, as needed. The X band radio will only be in use for about 5 minutes of each pass over a ground station. RROCI-2 will not downlink images on each pass over each ground station, and its X band radios will be turned off when it is not passing over a ground station. The ground stations were selected to give RROCI-2 the best opportunity to demonstrate that it is capturing key information and sharing that information promptly.

The S Band link is expected to be in use about once a week for demonstration of capabilities, for testing the backup 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. Atmospheric would be glad to update the FCC in the event of some issues with the X band link.

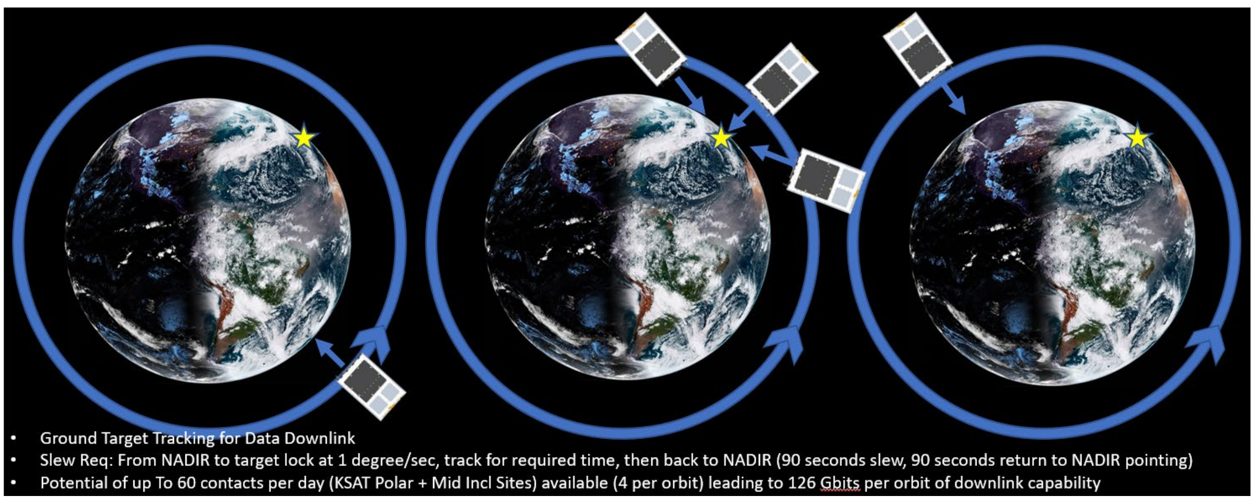

Figure 2. Theoretical image of the anticipated orbit of RROCI

All of the ground stations are listed in Table 2, below. Most of the proposed ground station operations were reviewed and considered in the review of Atmospheric's original application 0867-EX-CN-2021. There are no changes to the ground operations that were proposed and reviewed when WM2XEU was granted. This application seeks to add ground station operations in Deadhorse, Alaska.

Satellite launch schedule

Atmospheric's RROCI-2 is scheduled to launch on a SpaceX rocket in January 2024. As noted elsewhere in this exhibit, the integration date will be in December 2023. Therefore, Atmospheric hopes to have a license in hand in time for the satellite to be integrated into the rocket.

Ground Station Information

As noted above, Atmospheric has entered into contracts with KSAT and RBC Signals for ground station operations. KSAT is a Norwegian company with a US subsidiary. It operates satellite ground stations in all corners of the globe. However, its polar ground stations may have limited use for the imagery data, so additional ground station services were secured in Deadhorse, Alaska. The ground stations that Atmospheric will use are listed in Table 2, below, with the caveat that Svalbard and Troll will only be used for commissioning the satellite:

Name of station, city and country	**Lat**	**Long**	**X band**	**S band**	**#of contacts w/satellite per day, time of each**
Svalbard, Norway	78-13-47 N	15-23-53 E	Beamwidth = 0.69 ° Gain: 47.01 dBi	Beamwidth = 2.56 ° Gain: 37.13 dBi	Contacts = ~ 14 x / day Duration - ~ 10 min / contact
Awarua, New Zealand	46-31-45 S	168-22-52 E	Beamwidth = 0.69 ° Gain: 47.01 dBi	Beamwidth = 2.56 ° Gain: 37.13 dBi	Contacts = ~ 1 x / day Duration - ~ 10 min / contact
Punta Arenas, Chile	52-56-17 S	70-51-28 W	Beamwidth = 0.69 ° Gain: 47.01 dBi	Beamwidth = 2.56 ° Gain: 37.13 dBi	Contacts = ~ 1 x / day Duration - ~ 10 min / contact
TrollSat, Queen Maud Land, Antarctica	72-00-06 S	2-31-32 E	Beamwidth = 0.69 ° Gain: 47.01 dBi	Beamwidth = 2.56 ° Gain: 37.13 dBi	Contacts = ~ 2 x / day Duration - ~ 10 min / contact
Long Beach, California USA	33-49-27 N	118-08-47 W	Beamwidth = 0.69 ° Gain: 47.01 dBi	Beamwidth = 2.56 ° Gain: 37.13 dBi	Contacts = ~ 2 x / day Duration - ~ 10 min / contact
Deadhorse, Alaska, USA	70-11-27 N	148-26-07 W	Beamwidth = 0.69 ° Gain: 47.01 dBi	Beamwidth = 2.56 ° Gain: 37.13 dBi	Contacts = 10 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 Long Beach earth station

<u>LTAN</u>
22:30 (10:30 am LTDN)

<u>Information Being Submitted with this Application</u>

<u>ODAR</u>: In June 2022, in response to FCC questions regarding the operation of RROCI, specifically the deorbit plan for the satellite, Atmospheric reviewed the ODAR on file for the RROCI satellite operations – 0867-EX-CN-2021. That ODAR received extensive review both for the initial application and when Atmospheric sought a modification to WM2XEU, at an orbital elevation of 525 km. Atmospheric has rerun the NASA DAS program, using the latest version of the software. The RROCI-2 satellite is in compliance.

<u>Deorbit Plan:</u> The deorbit plan submitted in June 2022 and approved for 0867-EX-CN-2021 remains the same. The deorbit plan is attached to this exhibit as **Attachment A**.

<u>Conjunction Warnings Response Plan</u>: On May 27, 2022, in response to inquiries from the FCC regarding the proposed operations of RROCI-1 while its application 0867-EX-CN-2021 was under review, Atmospheric submitted a conjunction warnings response plan to explain in detail how it

would react to warnings regarding potential on-orbit collisions with space particles, orbital debris, or other satellites. Atmospheric will follow that plan. The Conjunction Warnings Response Plan is attached hereto as **Attachment B** to this exhibit.

ITU API: Atmospheric is submitting an API for the operations of RROCI-2, which includes its planned downlinks to ground station operations in Deadhorse, Alaska.

NTIA Space Record Data: Atmospheric has prepared a new NTIA Space Record Data Form that includes the updated beacon (Iridium, rather than Globalstar) and the ground station in Deadhorse, Alaska.

ITU Cost Recovery Letter: Atmospheric is submitting an additional ITU Cost Recovery Letter with this application, confirming its commitment to cover any costs that the ITU might impose for its evaluation of RROCI-2 or the publication of information regarding RROCI-2.

Stop Buzzer POC

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Conclusion

Atmospheric is seeking a new experimental license for its RROCI-2 satellite operations, one that will look very much like the previously granted WM2XEU, for operations at an orbital elevation of 525 km in a circular, sun synchronous orbit.

The proposed spectrum use will be the same as the operations authorized under WM2XEU, except for the beacon. There are no changes to the power levels or frequencies for the download of data or TT&C operations.

Atmospheric holds an imagery license from NOAA. The existing imagery license will be modified to cover the operations of RROCI-2. The modified license will be submitted promptly once it is granted by NOAA.

RROCI-2 will be deorbited at the end of its mission. The deorbit planning shows that the satellite will burn up completely upon reentry. The deorbiting plan has been reviewed and was approved with the grant of WM2XEU, and there are no changes.

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

Attachment A: Deorbit Plan

Atmospheric and Space Technology Research Associates

Experimental License Application: 0634-EX-CN-2023

Background:

Atmospheric and Space Technology Research Associates (Atmospheric) provided detailed information on a deorbit plan for its original satellite RROCI-1.

The currently proposed RROCI-2 satellite has the same deorbit plan as the deorbit plan that was approved by the FCC for RROCI-1 under WM2XEU.

The timing of various stages of the deorbit process, and the use of propulsion, are shown in Table 1, below. It is a three step deorbiting process, with two steps using thrust (Steps 1 and 3) and Step 2 using drag to decay RROCI-2's orbit.

Stage		Delta V	Engine	Duration (days)
Step 1	Thrust down from 525 km to 430 km	52.8	MPPT	16
Step 2	Natural coast arc from 430 km to 380 km	28.3	Drag	453
Step 3	Thrust from 380 km to Deorbit	179.4	MPPT	29

Table 1. Deorbit stages for RROCI-2

Atmospheric took heed of the need to avoid thrust (and so simplify tracking for NASA) when RROCI-2's deorbiting process passes through the orbit of the International Space Station. Therefore, the deorbiting process uses drag where appropriate.

The MPPT is a "continuous thrust" thruster. It will be used at the altitudes noted in Table 1, above, during the deorbit period.

Launch Information:

Launch date: SpaceX has set the launch date for this rideshare rocket, Transporter 10, in January 2024.

Orbital Apogee: SpaceX will release the rideshare satellites at an orbit of 525 km.

Conclusion:

If the FCC needs further details, please contact Anne Cortez, Esq. 520-360-0925 or alc@conspecinternational.com, counsel for Atmospheric as soon as possible.

Attachment B: RROCI-2 Conjunction Warnings Response Plan

Atmospheric and Space Technology Research Associates (Atmospheric)

Experimental License application: 0634-EX-CN-2023

This Conjunction Warnings Response Plan was originally prepared and submitted to the FCC, and approved by the FCC for experimental license WM2XEU, when Atmospheric applied for the operations of RROCI-1. The same plan, as previously reviewed and approved, will be used for RROCI-2. The question and answer format below provides the information that Atmospheric submitted to address questions raised by the FCC previously.

To ensure the best possible outcomes for RROCI-2 and all other satellites and objects in the same orbit, this plan anticipates a thorough and prompt response to all conjunction warnings that are issued for RROCI-2 by 18 SDS.

Commanding the thruster:

The spacecraft has the explicit ability to command the MPPT to fire after commanding the ADCS to achieve an appropriate orientation. I.e., the operation / firing of the MPPT is independent of other SC operations, and is contingent only on power being available to energize the MPPT.

The command is the following:

```
mutation { fireThrusterCycle(numCycles: 1) }@192.168.1.70:8400
```

The `numCycles` defines how many firing cycles to execute.

The `MPPT-service` configures the MPPT unit parameters on startup to be:

- Preferred firing cycle of 1,6,2,5,4,3
- Firing rate of 1000 ms
- Inductor Charge Time of 60uS (for vacuum operation)

FCC Questions:

Please indicate that in the event the RROCI-2 will need to perform collision avoidance that you will send the necessary commands to the spacecraft for it to propulsively maneuver to a safe location. Will the trajectory of any maneuvers also be screened for possible conjunctions prior to execution of any maneuver?

Atmospheric will send the necessary commands for it to propulsively maneuver to a safe location.

Atmospheric will have the 18th SDS screen the trajectory of the proposed maneuver to ensure that the maneuver will not cause any further possible conjunctions.

FCC Question:

Please define the risk thresholds and lead time limits that inform whether and when an avoidance maneuver is required, the sequence of events from when a CDM is received to the time a collision avoidance maneuver is executed, etc. with expected timeframes.

The risk thresholds that prompt a CDM from 18 SDS will trigger the Atmospheric conjunction response plan. Here is the procedure that Atmospheric will follow when a Conjunction Data Message (CDM) is received:

a. Review the message and send the RROCI-2 ephemeris update to 18 SDS. This step is expected to be completed within one (1) hour of receipt of a CDM during regular work hours. Evenings and weekends, this step is expected to be completed within three (3) hours of receipt of a CDM.
b. If the collision avoidance message indicates that the other object has propulsion, the RROCI-2 team will contact the other satellite operator to discuss the proper response, This contact is expected to be completed within one (1) hour after the ephemeris data has been submitted to 18 SDS. Reaching a mutual plan may take additional time as the teams analyze options.
c. Calculate a new trajectory, based on analysis of options including attitude adjustment and/or propulsion to avoid the collision. This initial calculation is expected to be completed by 2-4 hours after receiving a CDM. If the other object has no propulsion, this calculation will be the starting point for response.
d. Send proposed new trajectory from maneuvers to 18th SDS for review. This step is expected to be completed approximately 2-4 hours after receiving a CDM.
e. Then, if the proposed new trajectory is approved by 18 SDS, when RROCI-2 reaches the closest ground contact time, Atmospheric will upload the corresponding commands in the minimum amount of time possible. 18 SDS specifies that its review of the new trajectories could take 8 hours or more from submission of the information. Given RROCI-2's orbital period of about 96 minutes, the earliest it might be possible to send a command to instruct the satellite to use propulsion to avoid a conjunction is about 13 hours after receipt of a CDM. Typically, the CDM provides an alert of a possible conjunction 72 hours prior to the prospective conjunction. While it may not always be possible to meet the 13 hour turnaround on a propulsion command, Atmospheric is committed to working quickly and thoroughly to ensure that its response to a CDM is promptly communicated to RROCI-2 to ensure protection of RROCI-2 and of other space vehicles.

The analysis for closest ground contact time could be on the order of hours, however there is no warm-up time for the thrusters. To summarize, the expected timeframe is a combination of the time of analysis and the time until ground contact which is on the order of hours (< 24 hours).

In the course of reviewing and responding to a CDM, if the risk of conjunction drops below the warning threshold, in other words the risk lessens to the point where the risk of conjunction would not trigger a warning because of improved data or because of some action in response, then subsequent steps may not need to be completed. For instance, if another satellite operator (whose satellite is the subject of the CDM sent to the RROCI-2 team) is responding to two CDMS and has to use propulsion to minimize its risk, and if that maneuver eliminates the risk warning to RROCI-2, then the RROCI-2 team will note the actions taken, update 18 SDS, and not take further action with regard to that warning, because the risk has been mitigated.

FCC Question:

Please state the expected ability of the spacecraft to successfully respond to a conjunction warning which requires a propulsive maneuver. Will the spacecraft be able to avoid a predicted collision using the included propulsive system? Is there a minimum amount of time before a potential collision that the RROCI-2 would be unable to effectively respond through use of a propulsive maneuver?

The current propulsion system can change our orbit altitude 1 km for every 8 hours of thrusting.

Given the CDM response procedure set forth above, RROCI-2 would not be able to effectively respond using propulsion if it received a warning only 13 hours or fewer before the projected collision. Some of that time is required for review of the proposed trajectory, which has to be performed by 18 SDS. However, since 18 SDS expects to send CDM's 72 hours before a projected collision, it is not anticipated that this would curtail RROCI-2's propulsive response to a CDM.

If the CDM requires an orbit altitude adjustment of more than 1 km, then the time for the propulsive response will need to be increased by more than 8 additional hours. This is why the RROCI-2 team plans to initiate its response promptly.

RROCI-2's engineering team has worked on two types of collision avoidance maneuvers. Not only can the satellite use propulsion, but the satellite's attitude can be adjusted to increase drag, slowing the apparent velocity of the orbit, and thereby avoiding the potential conjunction. This type of maneuver in response to a CDM would be subject to review and approval by 18 SDS before it was selected as the conjunction response.

In all circumstances, the Atmospheric response to a CDM will be to work swiftly to plan a new flight path for RROCI-2, as needed, and secure approval for that new flight path with 18 SDS, and then implement the corrective action as quickly as the commands can be transmitted to the spacecraft.

FCC Question:

Please confirm that you will be conducting coordination with inhabitable space stations during the deorbit/orbit lowering process.

Atmospheric will be conducting coordination with the necessary parties of inhabitable space stations during the deorbit process. The deorbit process will involve continuous thrust to slow down our spacecraft in order to lower the orbit.