AeroCube-10 FCC Mission Statement

The AeroCube-10 mission consists of two nanosatellites, called AeroCube-10a and 10b that will demonstrate 1) precision satellite-to-satellite pointing, 2) deployment of atmospheric probes for in-situ measurement of air density, 3) small-spacecraft proximity operations using propulsion from a steam thruster (no docking is planned), and 4) solar cell performance degradation experiment that will correlate data from radiation sensors tuned to the energy levels suspected of causing damage to a drop in solar cell power output.

The AeroCube-10 satellites have been developed by The Aerospace Corporation (Aerospace) for our purpose of conducting experiments in space per our charter as a private, non-profit corporation operating a Federally Funded Research and Development Center in support of the US Air Force (contract number FA8802-19-C-0001). All payload components were developed by Aerospace for our purpose of conducting in-space technology demonstration experiments.

The AeroCube-10 satellites each which weigh approximately 2.1 kg and are 11 x 11 x 17 centimeters in dimension. They will be launched on an Antares 230/Cygnus Commercial Resupply Service mission to the International Space Station (ISS) with an estimated launch date of April 2019. The orbit will be circular between 400 km to 500 km altitude with an inclination of 51.6°.

Each of the two AeroCube-10 satellites has star trackers and other attitude control verification imagers. The primary purpose of the cameras is for attitude control determination and verification. The waiver we have received from NOAA specifies that we are not required to obtain a NOAA license nor even to notify NOAA regarding the use of cameras on satellites flown in our capacity as a private, non-profit FFRDC, which applies in this case.

The AeroCube-10a spacecraft has two payloads. The first is a dispenser with a magazine of 29 identical atmospheric probes. Each probe weighs 16 grams and consist of three 98 mm diameter aluminum sheets at 90 degrees to each other, effectively forming a sphere. The intent is to be lightweight and have a constant cross section, independent of orientation to the velocity direction so that atmospheric drag can be measured in-situ. RF modeling predicts that the atmospheric probes will have a radar cross section equal to 1U CubeSats, which have been tracked on-orbit many times (for example, AeroCube-2 (2007, NORAD ID: 31133)). The probes are dispensed individually upon command and DAS2.0.2 predicts that each has a lifetime of 0.74 years when deployed from the highest altitude of 500 km. The Total Object-Time for the complement of probes according to DAS2.0.2 is 20.24 years. The second payload is an optical beacon. It is used to verify that the AeroCube-10a satellite is indeed pointing at the AeroCube-10b. It consists of a 4W laser diode with a 1 degree full-width-half-max beam divergence.

The AeroCube-10b spacecraft replaces the payload volume area used for the dispenser on the 10a satellite with three different payloads. One is a steam propulsion unit identical to the one in AeroCubes-7b and 7c (WI2XBG). It will dispense water vapor to create a 4 mN thrust to change the range between the two satellites. It holds up to 30 grams of water and can affect, best case a

10 meter per second delta velocity. Water is non-toxic and the pressure inside the steam propulsion unit is at atmospheric pressure, so it is not a pressure vessel. The other is an electron and proton spectrometer called the micro-Charged Particle Telescope (uCPT). It will measure radiation flux impinging on the satellite, in specific energy levels that are suspected to cause solar cell degradation. The third payload is a sensor that will confirm when the optical beacon is impinging on the satellite. It is a light sensor, tuned to the optical beacon and amplified because the intensity is predicted to be faint.

At the higher end of the orbit altitude range (500 km), DAS 2.0.2 predicts an orbital lifetime of less than 3 years (area-to-mass ratio of ~0.025 m2/kg) and a spacecraft probability of collision with space objects larger than 10 cm in diameter during the orbital lifetime of the spacecraft of less than 0.000001, which is below the 0.001 threshold required (see “AC10 DAS202 Output” exhibit). DAS 2.0.2 analysis predicts that three objects will reach the ground after reentry: 1) a 316-stainless steel uCPT cover, 2) six tantalum uCPT baffles and 3) a tantalum uCPT Vault Shield with impact kinetic energies of 82, 0.0003 and 8 Joules, respectively. However, a higher fidelity analysis program used at The Aerospace Corporation for other customers predicts that item 1) will not survive reentry. Therefore, the risk of human casualty is less than 1:10,000 requirement and only one object is conservatively estimated by DAS 2.0.2 to hit the ground with an energy of 8J. Note that in accordance with the FCC preference that no objects survive reentry without a good reason and if so, with minimal energy, the uCPT scientists, whom require some tantalum to radiation shield the instrument detector, worked with the engineers to design a shield that is sufficient and is reentry friendly.

Each of the two AeroCube-10 satellites has two radios for redundancy. The AdvRadio is built by The Aerospace Corporation around a Texas Instruments CC1101 transceiver chip. It operates at a fixed 914.7 MHz frequency (see “AdvRadio bandwidth” Exhibit) and outputs 1.3 W. The second radio is also built by The Aerospace Corporation and is called the AeroCube Software Defined Radio (SDRadio). It also operates at a fixed 914.7 MHz frequency (see "SDRadio bandwidth" Exhibit) and outputs 1.3 W. Each radio attaches to an omnidirectional patch antenna on the AeroCube-10 body with a 0 dBi gain. Only one radio is on at a time.

When the AeroCube-10 satellites are ejected, they will power on. However, the radio will be in receive mode only. As each satellite flies over a ground station, the station will continuously beacon towards the satellite. When the satellite radio hears the beacon, along with the proper serial number code, it will respond and a link will be established. At that point, the ground station will ask the satellite for information, typically payload data or onboard telemetry. The satellite will respond by downlinking the requested information. When the link is lost due to the satellite passing out of view and the satellite was transmitting, the satellite will try up to 3 seconds to complete the last packet transmitted. The satellite will then revert to a passive receive mode and wait for the next beacon from a ground station.

We would like to use two types of ground stations to communicate with the AeroCube-10 satellites. The first is a 5-meter diameter dish antenna at The Aerospace Corporation in El Segundo, CA. At 914.7 MHz, it has 30 dB gain, 5 deg beamwidth and uses a complementary radio with a 9W amplifier. The second ground station is a portable 2-meter diameter dish. This has 22 dB gain, a 15 deg beamwidth and uses a complementary radio with a 9W amplifier. This portable station would be located in an RF quiet area that improves the ground footprint of the ground station network. A typical satellite pass is 8 minutes long, twice per day - so the system spends a lot of time not in use. The antenna parameters and ground station locations are shown in the exhibit "FAA sketch and antenna figures."

This license is being requested under 47 CFR Part 5.3 (c) for "experiments under contractual agreement with the United States Government." The experimental radio service as requested is defined under 47 CFR Part 5.5 as "for purposes of providing essential communications for research projects that could not be conducted without the benefit of such communications." Aerospace will be the sole operator of the satellites and all experiments on board.