THE RF TECHNICAL DETAILS IN THIS LICENSE RENEWAL REQUEST ARE UNCHANGED FROM THE LATEST PRIOR WJ2XXN (0827-EX-CN-2018) LICENSE.

The AeroCube-10 program consists of two nanosatellites 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).

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 10 x 10 x 15 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 has shown that the atmospheric probes have a radar cross section of a 1U CubeSat equal to AeroCube-2 (2007, NORAD ID: 31133) and AeroCube-3 (2009, NORAD ID: 35005). 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 is therefore 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 is a 4W output at 808 nm with a 1 degree full-width-half-max beam divergence.

The AeroCube-10b spacecraft replaces the payload volume area use 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. 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 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.

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 m^2/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 used here at Aerospace predicts item 1) will not survive re entry, leaving items 2) and 3) as the only potential objects to hit the ground and their impact kinetic energy is less than the 15 J threshold. Therefore, the risk of human casualty is less than 1:10,000 requirement. The tantalum, a high-density material is required to radiation shield the uCPT instrument.

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 the 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 was 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 is the sole operator of the satellites and all experiments on board.

We are currently requesting a license extension because the AeroCube-10 satellites are still performing well and the science is very good. In addition, their longevity in space is its own useful data point for the miniature satellite community. We request an additional 24 months of licensing.